Attachment 1

Revisions to Draft EIR Volume I and Volume II

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REVISIONS TO THE DRAFT EIR

This attachment identifies revisions to the Draft EIR that clarify or amplify or make insignificant modifications in an adequate EIR, consistent with CEQA Guidelines, section 15088.5, subdivision (b).

None of the modifications to the Draft EIR contained in this Attachment 1 are due to either of the following, as defined by CEQA Guidelines, section 15088.5, subdivision (b):

(1) A feasible project alternative or mitigation measure considerably different from others previously analyzed that would clearly lessen the environmental impacts of the project, but the project's proponents decline to adopt it.

(2) The draft EIR was so fundamentally and basically inadequate and conclusory in nature that meaningful public review and comment were precluded.

For Draft EIR sections that have a relatively small number of revisions, the revisions are presented below, by section. For the revisions, strikethrough is used to indicate deletions and underline is used to indicate additions.

For Draft EIR sections that have a relatively large number of revisions, the entire revised section is presented to facilitate easier public use of the revised information. These include the following:

- **Table ES-1**
- **Section 3.1.6 Summary of Available Hydrology Information for the Proposed Project**
- **Section 3.2 Water Quality**
- **Section 3.3 Aquatic Resources**
- **Section 3.12 Historical Resources and Tribal Cultural Resources**
- **Section 3.19 Aesthetics**
- **Section 3.20 Recreation**
- **Appendix C Water Quality Supporting Technical Information**
- **Appendix S Recreation Supporting Technical Information**

Entire revised sections do not include strikethrough and underline.

For recirculated Draft EIR Sections 3.9 *Air Quality* and Section 3.10 *Greenhouse Gas Emissions and Energy* please refer to Volume III, Attachment 2.

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EXECUTIVE SUMMARY

Volume I Executive Summary – Proposed Project Location, Figure ES-2 Proposed Project Boundary − California Portion on page ES-3:

Since issuance of the Draft EIR, the KRRC has clarified that the Proposed Project “Limits of Work” include the following:

- 34 small areas ranging from 0.02 acres to 6.5 acres in size, with most parcels less than 0.03 acres, all of which are located within the altered 100-year floodplain of the Middle Klamath River between Iron Gate Dam (river mile [RM] 193) and Humbug Creek (RM 174) and have existing legally-established habitable structures that may require relocation or elevation prior to dam removal;
- 1,300 linear feet of the south shore of Copco No. 1 Reservoir inclusive of the adjacent twelve parcels that possess existing habitable structures, which potentially could be impacted by slope failure during or immediately following reservoir drawdown;
- 480 linear feet of Copco Road (unpaved) located on the north shore of Copco No. 1 Reservoir which has the potential to experience slope failure during or immediately following reservoir drawdown.

The EIR Project Boundary, which is inclusive of the Proposed Project Limits of Work, as well as PacifiCorp owned and managed lands immediately surrounding the Lower Klamath Project (“Parcel B lands”) that would be transferred as part of the Proposed Project, has been updated accordingly. The proposed updates to the Limits of Work are relatively minor and are all included below in an updated Figure ES-2 *Proposed Project Boundary − California Portion*. The updated Proposed Project Boundary shown in Figure ES-2 applies to all figures in EIR Volume I that include the Project Boundary.

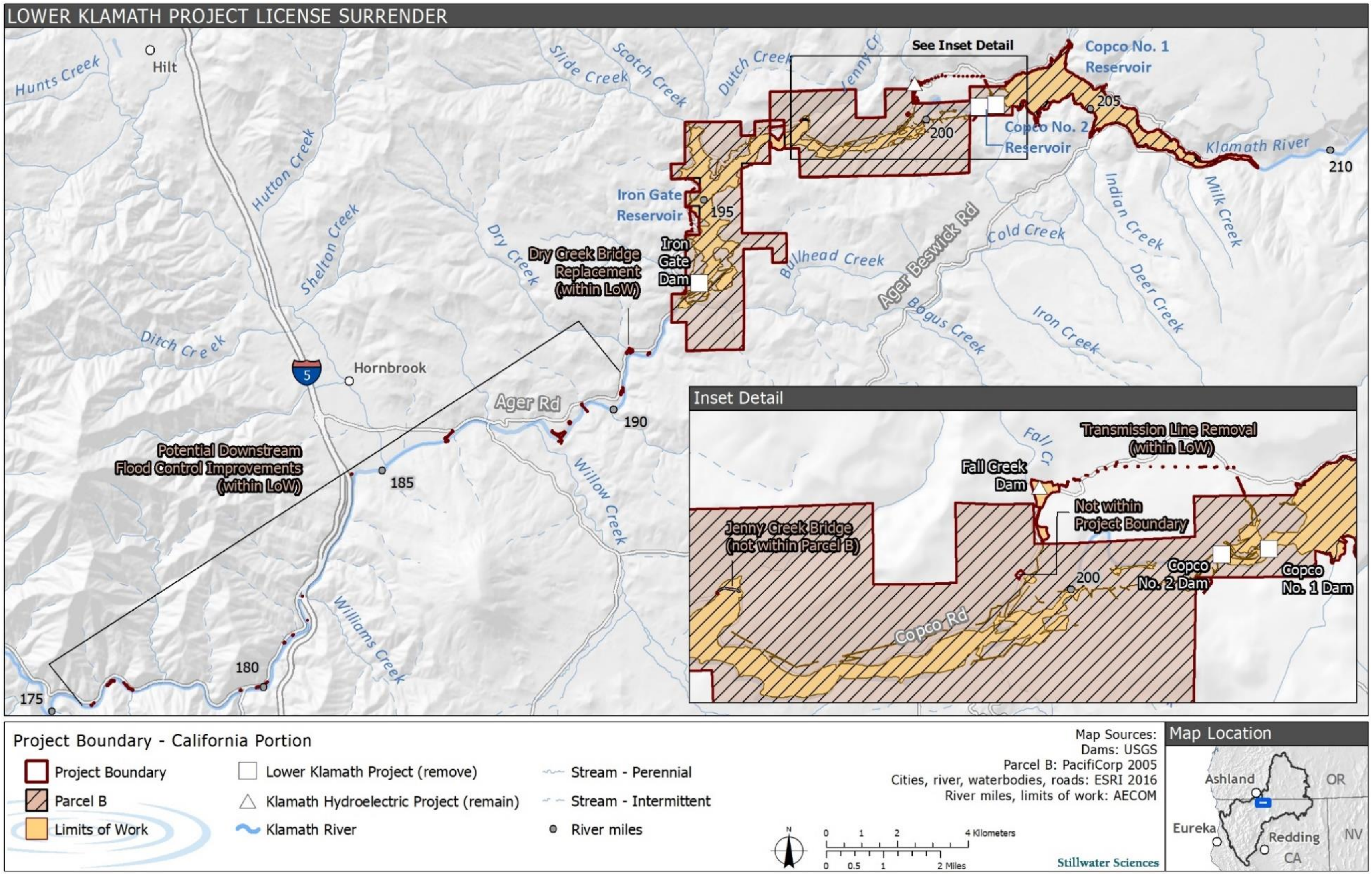

Figure ES-2. Proposed Project Boundary − California Portion.

Volume I Executive Summary – Proposed Project – Reservoir Drawdown, paragraph 1 on page ES-5:

Copco No. 1 Reservoir would be drawn down first (~~November–March of dam removal year 1~~ <u>November of dam removal year 1 to March of dam removal year 2</u>)[1], followed by J.C. Boyle (Oregon) and Iron Gate reservoirs (January–March of dam removal year 2). Copco No. 2 Reservoir is substantially smaller than the other three ~~dams~~ <u>reservoirs</u> and the KRRC proposes to drawdown this reservoir ~~after~~ <u>before</u> Copco No. 1 Dam has been breached to final grade in May of dam removal year 2.

Volume I Executive Summary – Proposed Project – Reservoir Drawdown, paragraph 2 on page ES-5:

During Iron Gate Dam removal, the embankment dam crest would be retained at a level to accommodate the passage of a ~~100-year flood event~~ <u>1 in 150 probable seasonal flow</u>.

Volume I Executive Summary – Proposed Project – Reservoir Sediment Deposits and Erosion During Drawdown, paragraph 4 on page ES-5:

Reservoir Sediment Deposits and Erosion During Drawdown

There would be an estimated 15.1 million cubic yards (14.6 million tons) of sediment stored in the J.C. Boyle, Copco No. 1, and Iron Gate reservoirs by 2020 (USBR 2012). Between 2020 and 202<u>2</u>~~1~~ (i.e., <u>revised</u> dam removal year 2, when drawdown is anticipated to primarily occur) the sediment volume present behind the dams would increase by approximately <u>162,000</u>~~81,300~~ cubic yards in Copco No. 1 Reservoir <u>(1.97% increase)</u> and approximately ~~1~~<u>2</u>00,000 cubic yards in Iron Gate Reservoir <u>(3.51% increase)</u> based on estimates of annual sedimentation rates for each reservoir (USBR 2012). The increase in sediment volume between 2020 and 202<u>2</u>~~1~~ would be an order of magnitude less than the <u>total</u> uncertainty of the 2020 total sediment volume estimates <u>and the annual sediment deposition rates (i.e., approximately 2,000,000 cubic yards for Copco No. 1 and Iron Gate Reservoirs).</u>~~, so~~ <u>Therefore,</u> the 2020 sediment volumes provide a reasonable estimate ~~for 2021 and thus~~ for the Proposed Project. Copco No. 2 Reservoir does not retain appreciable amounts of sediment, because of its smaller size and location, and would not appreciably contribute to sediment transport during the drawdown of the reservoirs.

Volume I Executive Summary – Summary of Proposed Project Effects, Potential Impacts, and Potential Cumulative Impacts – Significant and Unavoidable Impacts, last paragraph on page ES-11:

Below is a summary, by resource area, of impacts found to be 'significant and unavoidable' with or without mitigation (Table ES-1). Please note ~~the KRRC proposes to further develop~~ <u>that many of these impact determinations are based</u>

on the limited scope of the exception to federal preemption for Clean Water Act section 401 water quality certification. Where measures are within the State Water Board's water quality certification authority, where the State Water Board can reasonably anticipate that other federal agencies will require and enforce mitigation measures, or where the KRRC has agreed to implement the measures, the measures are considered feasible mitigation measures. It is only such mitigation measures that the State Water Board takes into consideration in determining significance of a potential impact. Where there is no reasonable basis to conclude that a recommended measure will be adopted or will be enforceable, the document does not consider the measure to be feasible under CEQA Guidelines, section 15126.4, subdivision (a)(2). The resulting impact determinations are conservative from a public disclosure standpoint.

As summarized in the KRRC's most recent water quality certification application, the KRRC has committed to additional measures to protect resources outside the State Water Board's authority since issuance of the initial Draft EIR, and continue with the further development of Proposed Project actions relating to certain state and local regulatory requirements for several resource areas that fall outside of State Water Board's water quality certification authority.

The State Water Board anticipates implementation of additional measures (e.g., good neighbor agreements between the KRRC and relevant state or local agencies, recommended measures in this EIR, and any modifications developed through the FERC process that provide the same or better level of protection for the resource in question) would reduce impacts. The EIR notes where such protection would eliminate the potential for a significant impact. However, the State Water Board cannot ensure implementation of good neighbor agreements, recommended measures included in this EIR, or modifications anticipated to be developed through the FERC process. Therefore, the State Water Board has identified impacts that rely on implementation of such agreements or recommended measures in this EIR as significant and unavoidable.

Volume I Executive Summary – Summary of Proposed Project Effects, Potential Impacts, and Potential Cumulative Impacts – Significant Unavoidable Adverse Impacts, paragraph 4 on page ES-12:

Terrestrial Resources

- Short-term impacts on special-status plants from construction-related activities within the Limits of Work;
- Short-term and long-term impacts on special-status wetland plants surrounding the reservoirs due to removal of Copco No. 1, Copco No. 2, and Iron Gate reservoirs;
- Short-term impacts on special-status mammals (bats~~, gray wolf,~~ and American badger) from construction-related activities within the Limits of Work;

- Short-term impacts on nesting birds from construction-related noise and habitat removal within and surrounding the Limits of Work;
- Short-term impacts on willow flycatcher from construction-related noise disturbance and habitat removal at Copco No. 1 and Iron Gate reservoirs;
- ~~Short-term impacts on bald and golden eagles from construction-related noise and nesting habitat alterations at Copco No. 1, Copco No. 2, and Iron Gate reservoirs;~~
- Short- and long-term impacts on special-status bats, maternity roosts, and hibernacula from construction noise and loss of roosting habitat at existing Lower Klamath Project facilities; and
- Short-term impacts on sensitive habitats and special-status terrestrial wildlife and plant species from construction activities on Parcel B lands.

Volume I Executive Summary – Summary of Proposed Project Effects, Potential Impacts, and Potential Cumulative Impacts – Significant Unavoidable Adverse Impacts – Public Services, paragraph 1, first bullet on page ES-14:

- Short term increases ~~Increases~~ in public service response times for emergency fire, police, and medical services due to construction and demolition activities, including construction-related traffic; and

Volume I Executive Summary – Summary of Proposed Project Effects, Potential Impacts, and Potential Cumulative Impacts – Effects Found to be Beneficial, water quality bullet items on page ES-15:

Water Quality

- Short-term increases in suspended sediments under the Proposed Project in combination with the 2017 court-ordered flushing and emergency dilution flows or the 2019 BiOp Flows; and
- Short-term water quality effects of the Proposed Project in combination with wildfires.

Volume I Executive Summary – Alternatives to the Proposed Project – No Project Alternative, paragraph 4 on page ES-16:

Additionally, in the short term, the No Project Alternative would not result in any change from the existing management conditions, except regarding flow and certain interim water quality and habitat measures as noted in this paragraph. Neither ~~T~~the 2017 court-ordered flushing and emergency dilution flow releases nor the 2019 BiOp Flows downstream of Iron Gate Dam (U.S. District Court 2017) would modify flow releases compared to the existing condition. Some KHSA Interim Measures (IMs) would cease.

Volume I Executive Summary – Alternatives to the Proposed Project – No Project Alternative, paragraph 5 on page ES-16:

In addition to the KHSA IMs, there are various restoration efforts in the Klamath Basin to improve water quality, which are discussed in *Cumulative Effects* (Section 3.24). The effects of these efforts, including efforts aimed at meeting Klamath River total maximum daily loads (TMDLs), are not analyzed for the short term under the No Project Alternative because the basin response to the restoration ~~measures~~ efforts to meet the TMDLs during the short term is too speculative.

Volume I Executive Summary – Alternatives to the Proposed Project – Continued Operations with Fish Passage Alternative, paragraph 3 on page ES-17:

Conditions would include flows required by the NMFS and USFWS 2013 Joint Biological Opinion for the Klamath Irrigation Project (2013 BiOp Flows), 2017 court-ordered flushing and emergency dilution flows, and the current operational flow requirements for the Klamath Irrigation Project (2019 BiOp Flows), and design and implementation of a Reservoir Management Plan.

Volume I Executive Summary – Alternatives to the Proposed Project – Three Dam Removal Alternative, paragraph 1 on page ES-18:

The alternative assumes that USBR's flow release requirements for Iron Gate Dam would continue to be required as federal Endangered Species Act requirements (i.e., 2013 BiOp Flows and 2017 court-ordered flushing and emergency dilution flows, or 2019 BiOp Flows).

Volume I Executive Summary – Alternatives to the Proposed Project – Two Dam Removal Alternative, paragraph 2 on page ES-19:

This alternative assumes that USBR's flow requirements would be the same as those required under the current federal Endangered Species Act requirements (i.e., 2013 BiOp Flows and 2017 court-ordered flushing and emergency dilution flows, or 2019 BiOp Flows) and considers conditions with and without the 2017 court-ordered flushing and emergency dilution flows for potential impacts related to fish disease.

Volume I Executive Summary – Alternatives to the Proposed Project – No Hatchery Alternative, paragraph 1 on page ES-20:

No Hatchery Alternative

The No Hatchery Alternative is the same as the Proposed Project, except that modification and operation of Fall Creek Hatchery would not occur, and the Iron Gate Hatchery operations would end upon dam removal instead of continuing with reduced production for eight years following removal of the dams, as under the Proposed Project. Under this alternative, all production of salmonids would be discontinued after hatchery releases occur in the fall of dam removal year 1 and the reduced production goals for the Proposed Project would not occur. Construction activities would include all those identified under the Proposed Project, except that: Iron Gate Hatchery facilities would be completely removed; and, Fall Creek Hatchery would not be refurbished and would not reopen. Water diversions to operate the hatcheries would not be needed. This alternative would reduce construction-related impacts associated with the reopening of Fall Creek Hatchery, modifications to provide water, and installation of a new fish ladder at Iron Gate Hatchery.

In the short-term, the No Hatchery Alternative would reduce the amount of fall-run Chinook and coho salmon present for California Native American tribes that currently use salmon in their diet and consider salmon to be an important part of their culture. This potential short-term impact to the fishery would be greater under the No Hatchery Alternative than under the Proposed Project, because under the Proposed Project the hatcheries would continue to supplement natural adult returns (albeit at a reduced rate of production) until after seven generations or cohorts of fish have been hatched with the benefit from expanded habitat and improved water quality conditions. In addition to supplementing available fish directly, hatchery operation is anticipated to accelerate recolonization of new habitat. The short-term reduction in the fishery due to elimination of hatchery-produced fall-run Chinook and coho salmon under the No Hatchery Alternative would represent a material impairment of the Klamath Riverscape as a resource and a substantial restriction of tribal access to the fishery relative to existing conditions. While the~~The~~ No Hatchery Alternative would further the underlying restoration purpose and objectives, ~~although~~ the alternative would not meet Objective 2 (In a timely manner, to advance the long-term restoration of the natural fish population in the Klamath Basin, with particular emphasis on restoring the salmonid fisheries used for subsistence, commerce, tribal cultural purposes, and recreation) as quickly as under the Proposed Project.

Volume I Executive Summary – Issues to be Resolved, paragraph 2 on page ES-24:

All reaches of the Klamath River from the Oregon-California state line to the mouth of the Klamath River are listed as impaired for one or more water quality parameters, including, but not limited to, elevated water temperature, organic enrichment/low dissolved oxygen, nutrients, and microcystin (see also Table 3.2-3). Long-term declines in Klamath Basin fisheries have been observed for wild fall-run Chinook salmon, spring-run Chinook salmon, steelhead, coho salmon, and Pacific lamprey (see also Table 3.3-2). The declines in coho salmon in the Klamath Basin have contributed to the listing of this species as threatened under the Endangered Species Act. Based on the aforementioned information, and numerous other studies and analyses described in detail in Section 3.2 *Water Quality*, Section 3.3 *Aquatic Resources*, Section 3.4 *Phytoplankton and*

Periphyton, and Section 3.12 *Historical Resources and Tribal Cultural Resources*, ~~I~~it is clear that the Klamath River has significantly degraded water quality and aquatic resources. ~~, and that these~~ The ongoing impacts to water quality and aquatic species in the Klamath River stem from the cumulative effects of a multitude of changing basin conditions including construction and operation of the Lower Klamath Project hydroelectric facilities, other basin-specific hydrologic modifications, changing ocean conditions, and land use changes ~~multiple factors including operation of the hydroelectric facilities.~~, and these impacts have created hardships for commercial fisheries and tribal communities that depend on these fisheries as an important cultural resource.

Volume I Executive Summary – Alternatives to the Proposed Project – Issues to be Resolved, paragraph 4 on page ES-24:

The KRRC proposes to further develop Proposed Project actions related to certain state and local regulatory requirements that fall outside of the State Water Board's water quality certification authority. The State Water Board anticipates that implementation of additional measures, (~~e.g.,~~ measures that are ultimately recommended through the good neighbor agreements between the KRRC and relevant state or local agencies, KRRC's ultimate commitment to implement certain recommended measures in this EIR, and any modifications developed through the FERC licensing process, (which includes recommendations or conditions from other federal and state agencies, that would provide the same or better level of protection for the resource in question) would ultimately reduce a number of the Proposed Project's impacts to less than significant levels.

The EIR notes where such protection would be anticipated to eliminate the potential for a significant impact (see Table ES-1 footnote no. 3). However, the State Water Board cannot ensure implementation of anticipated - but not final - good neighbor agreements, recommended measures included in this EIR, or modifications anticipated to be developed through the FERC process. Therefore, the State Water Board has conservatively identified impacts that rely on FERC's adoption of measures included in implementation of such agreements, other conditions that may be imposed by FERC, or recommended mitigation measures in this EIR as significant and unavoidable. The resulting impact determinations are conservative from a public disclosure standpoint.

Volume I Executive Summary, Table ES-1 Summary of Impacts and Mitigation Measures on pages ES-26 to ES-67:

Table ES-1. Summary of Impacts and Mitigation Measures.

PP = Proposed Project; NP = No Project Alternative; PR = Partial Removal Alternative; CO = Continued Operations with Fish Passage;

2R = Two Dam Removal Alternative; 3R = Three Dam Removal Alternative; NH = No Hatchery Alternative

*** Indicates a Significant and Unavoidable Impact that would be reduced to No Significant Impact with Mitigation if one or more Recommended Measures were to be implemented. Due to federal preemption, the State Water Board cannot guarantee the implementation of Recommended Measures. See also footnote no. 3 to this table.**

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Water Quality								
Potential Impact 3.2-1. Short-term and long-term alterations in water temperatures due to conversion of the reservoir areas to a free-flowing river.								
Hydroelectric Reach to the confluence with the Salmon River	S	L	PP, PR, 2R, 3R, NH					
Middle Klamath River downstream from the Salmon River, Lower Klamath River, Klamath River Estuary, Pacific Ocean nearshore environment	S	L		PP, PR, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.2-2. Short-term and long-term alterations in seasonal water temperatures in the Klamath River Estuary due to morphological changes induced by dam removal sediment release and subsequent deposition in the estuary.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Potential Impact 3.2-3. Increases in suspended sediments due to release of sediments currently trapped behind the dams.								
	S			NP, CO			PP, PR, 2R, 3R, NH	
		L		PP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	**Time Frame[1]**		**Beneficial**	**No Significant Impact[2]**	**Mitigation**	**No Significant Impact with Mitigation**	**Significant and Unavoidable**	**Significant and Unavoidable with Mitigation**
Potential Impact 3.2-4. Increases in suspended material from stormwater runoff due to pre-construction, dam deconstruction and removal, and restoration activities in the Hydroelectric Reach and the Middle Klamath River immediately downstream of Iron Gate Dam.								
	S				WQ-1, TER-1, HZ-1	PP, PR, 2R, 3R, NH		
Potential Impact 3.2-5. Long-term alterations in mineral (inorganic) suspended material from the lack of continued interception and retention by the dams.								
		L		PP, PR, 2R, 3R, NH				
Potential Impact 3.2-6. Long-term alterations in algal-derived (organic) suspended material from the lack of continued interception and retention by the dams.								
		L		PP, PR, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.2-7. Short-term increases in sediment-associated nutrients due to release of sediments currently trapped behind the dams.								
	S			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.2-8. Long-term alterations in nutrients from the lack of interception and retention by the dams and conversion of the reservoir areas to a free-flowing river.								
Annual interception and retention of total nutrients		L		PP, PR, 2R, 3R, NH				
Potential seasonal release of dissolved nutrients		L	PP, PR, 2R, 3R, NH					

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.2-9. Short-term increases in oxygen demand and reductions in dissolved oxygen due to release of sediments currently trapped behind the dams.								
Hydroelectric Reach and Middle Klamath River from Iron Gate Dam to the Salmon River	S			NP, CO			PP, PR, 2R, 3R, NH	
Middle Klamath River downstream from the Salmon River, Lower Klamath River, Klamath River Estuary	S			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.2-10. Long-term alterations in dissolved oxygen concentrations and daily variability due to conversion of the reservoir areas to a free-flowing river.								
Hydroelectric Reach and the Middle Klamath River immediately downstream of Iron Gate Dam (daily fluctuations)		L		PP, PR, 2R, 3R, NH				
Hydroelectric Reach and the Middle Klamath River immediately downstream of Iron Gate Dam (elimination of summer and fall extremes)		L	PP, PR, 2R, 3R, NH					

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Hydroelectric Reach and Middle Klamath River (winter and spring)		L		PP, PR, 2R, 3R, NH				
Lower Klamath River, Klamath River Estuary, and Pacific Ocean nearshore environment		L		PP, PR, 2R, 3R, NH				
Potential Impact 3.2-11. Alterations in pH and daily pH fluctuations due to a conversion of the reservoir areas to a free-flowing river.								
Hydroelectric Reach at Oregon-California state line	S	L		PP, PR, 2R, 3R, NH				
Hydroelectric Reach from Copco No. 1 Reservoir to Iron Gate Dam	S	L	PP, PR, 2R, 3R, NH					
Middle Klamath River, Klamath River Estuary, Pacific Ocean nearshore environment	S	L		PP, PR, 2R, 3R, NH				
Potential Impact 3.2-12. Alterations in chlorophyll-a and algal toxins due to a conversion of the reservoir areas to a free-flowing river.								
	S	L	PP, PR, 2R, 3R, NH					

Geographic or Other Additional Information (as needed)	**Time Frame[1]**		**Beneficial**	**No Significant Impact[2]**	**Mitigation**	**No Significant Impact with Mitigation**	**Significant and Unavoidable**	**Significant and Unavoidable with Mitigation**
Potential Impact 3.2-13. Human exposure to inorganic and organic contaminants due to release and exposure of reservoir sediment deposits.								
	S	L			WQ-2, WQ-3	PP, PR, 2R, 3R, NH		
Potential Impact 3.2-14. Freshwater aquatic species exposure to inorganic and organic contaminants due to release of sediments currently trapped behind the dams.								
	S	L		PP, PR, 2R, 3R, NH				
Potential Impact 3.2-15. Short-term increases in inorganic and organic contaminants from hazardous materials associated with construction and restoration activities in the Hydroelectric Reach and the Middle Klamath River immediately downstream of Iron Gate Dam.								
	S				WQ-1, TER-1, HZ-1	PP, PR, 2R, 3R, NH		

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.2-16. Short-term impacts to aquatic biota from herbicide application during restoration of the reservoir areas.								
	S				WQ-4	PP, PR, 2R, 3R, NH		
Potential Impact 3.2-17. Short-term and long-term influence of changes in Iron Gate and Fall Creek hatchery production on Klamath River and Fall Creek water quality.								
Water quality in the Middle Klamath River downstream of Iron Gate Hatchery	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Water temperature and dissolved oxygen in Fall Creek downstream of Fall Creek Hatchery	S			NP, CO, NH			PP, PR, 2R, 3R	
Water quality (except water temperature and dissolved oxygen) in Fall Creek downstream of Fall Creek Hatchery		L		PP, NP (S only), PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.2-18. Short-term impacts on water quality from construction activities on Parcel B lands.								
	S	L			WQ-1, TER-1, HZ-1	PP, PR		
Potential Impact 4.2.2-1 Seasonal alterations in water temperature due to continued impoundment of water in the reservoirs.								
J.C. Boyle Peaking Reach from the Oregon-California state line to Copco No. 1 Reservoir	S	L	CO	NP (S only)				
Hydroelectric Reach from Copco No. 1 Reservoir to Iron Gate Dam and the Middle Klamath River to the confluence with the Salmon River	S	L		NP (S only), CO				
Middle Klamath River downstream of the confluence with the Salmon River, the Lower Klamath River, and the Klamath River Estuary, and the Pacific Ocean nearshore environment	S	L		NP (S only), CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.2-2. Seasonal increases in algal-derived (organic) suspended material due to continued impoundment of water in the reservoirs.								
Hydroelectric Reach from J.C. Boyle Reservoir to the upstream end of Copco No. 1 Reservoir	S	L		NP (S only), CO				
Hydroelectric Reach from Copco No. 1 Reservoir to Iron Gate Dam, the Middle and Lower Klamath River, and the Klamath River Estuary	S	L		NP (S only), CO				
Potential Impact 4.2.2-3 Increases in suspended material due to implementation of 2017 court-ordered flushing and emergency dilution flows or 2019 BiOp surface flushing flows downstream of Iron Gate Dam.								
	S	L		NP (S only), CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.4.2-1. Short-term increases in suspended material and contaminants from stormwater runoff due to construction activities associated with replacement and construction of new fish passage facilities.								
Hydroelectric Reach and the Middle Klamath River immediately downstream of Iron Gate Dam	S			CO	WQ-1, TER-1, HZ-1			
Potential Impact 4.2.2-4. Annual interception and retention of nutrients and seasonal release of nutrients due to continued impoundment of water in the reservoirs.								
Hydroelectric Reach and Middle Klamath River (annual interception and retention of nutrients)	S	L		NP (S only), CO				
Hydroelectric Reach and the Middle Klamath River (seasonal release of nutrients)	S	L		NP (S only), CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.2-5. Seasonal low dissolved oxygen concentrations due to continued impoundment of water in the reservoirs.								
Hydroelectric Reach and the Middle Klamath River	S	L		NP (S only), CO				
Middle Klamath River downstream of Seiad Valley, the Lower Klamath River, and the Klamath River Estuary	S	L		NP (S only), CO				
Potential Impact 4.2.2-6. Seasonal high pH and daily pH fluctuations due to continued impoundment of water in the reservoirs.								
Hydroelectric Reach and the Middle Klamath River	S	L		NP (S only), CO				
Middle Klamath River downstream of Seiad Valley the Lower Klamath River, and the Klamath River Estuary	S	L		NP (S only), CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.2-7. Seasonal increases in chlorophyll-a and algal toxins due to continued impoundment of water in the reservoirs.								
Hydroelectric Reach from J.C. Boyle Reservoir to upstream end of Copco No. 1 Reservoir	S	L		NP (S only), CO				
Hydroelectric Reach from Copco No. 1 Reservoir to Iron Gate Dam, the Middle and Lower Klamath River, and the Klamath River Estuary	S	L		NP (S only), CO				
Potential Impact 4.2.2-8. Human and freshwater aquatic species' exposure to inorganic and organic contaminants due to continued impoundment of water in the reservoirs.								
	S	L		NP (S only), CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Aquatic Resources								
Potential Impact 3.3-1. Effects on coho salmon critical habitat quality and quantity due to short-term sediment releases and long-term changes in habitat quality and quantity due to dam removal.								
	S				AQR-1 and AQR-2	PP, PR, 2R, 3R, NH		
		L	PP, PR, 2R, 3R, NH					
Potential Impact 3.3-2. Effects on Southern Resident Killer Whale critical habitat quality due to short-term and long-term alterations to salmon populations due to dam removal.								
	S	L		PP, PR, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.3-3. Effects on eulachon critical habitat quality due to short-term sediment releases due to dam removal.								
	S	L		PP, PR, 2R, 3R, NH				
Potential Impact 3.3-4. Effects on Chinook and coho salmon Essential Fish Habitat (EFH) quality and quantity due to short-term sediment releases and long-term changes in habitat quality and quantity due to dam removal.								
	S				AQR-1 and AQR-2	PP, PR, 2R, 3R, NH		
		L	PP, PR, 2R, 3R, NH					

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.3-5. Effects on groundfish Essential Fish Habitat (EFH) quality due to short-term sediment releases and long-term changes in habitat quality due to dam removal.								
	S	L		PP, PR, 2R, 3R, NH				
Potential Impact 3.3-6. Effects on pelagic fish Essential Fish Habitat (EFH) quality due to short-term sediment releases and long-term changes in habitat quality due to dam removal.								
	S	L		PP, PR, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.3-7. Effects on the fall-run Chinook salmon population due to short-term sediment releases and long-term changes in habitat quality, habitat quantity, and hatchery operations due to dam removal.								
	S			PP, PR, 2R, 3R, NH				
		L	PP, PR, 2R, 3R, NH					
Potential Impact 3.3-8 Effects on the spring-run Chinook salmon population due to short-term sediment releases and long-term changes in habitat quality, habitat quantity, and hatchery operations due to dam removal.								
	S			PP, PR, 2R, 3R, NH				
		L	PP, PR, 2R, 3R, NH					

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.3-9. Effects on coho salmon populations due to short-term sediment releases and long-term changes in habitat quality, habitat quantity, and hatchery operations due to dam removal.								
	S			PP, PR, 2R, 3R, NH				
		L	PP, PR, 2R, 3R, NH					
Potential Impact 3.3-10. Effects on the steelhead population due to short-term sediment releases and long-term changes in habitat quality, habitat quantity, and hatchery operations due to dam removal.								
	S			PP, PR, 2R, 3R, NH				
		L	PP, PR, 2R, 3R, NH					

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.3-11. Effects on the Pacific lamprey population due to short-term sediment releases and long-term changes in habitat quality and quantity due to dam removal.								
	S			PP, PR, 2R, 3R, NH				
		L	PP, PR, 2R, 3R, NH					
Potential Impact 3.3-12. Effects on the green sturgeon population due to short-term sediment releases and long-term changes in habitat quality due to dam removal.								
	S	L		PP, PR, 2R, 3R, NH				
Potential Impact 3.3-13. Effects on Lost River and shortnose sucker populations due to short- and long-term changes in habitat quality and quantity due to dam removal.								
	S	L		PP, PR, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.3-14. Effects on the redband trout population due to short-term sediment releases and long-term changes in habitat quality and quantity due to dam removal.								
	S			PP, PR, 2R, 3R, NH				
		L	PP, PR, 2R, 3R, NH					
Potential Impact 3.3-15. Effects on the eulachon population due to short-term sediment releases and long-term changes in habitat quality due to dam removal.								
	S	L		PP, PR, 2R, 3R, NH				
Potential Impact 3.3-16. Effects on the longfin smelt population due to short-term sediment releases and long-term changes in habitat quality due to dam removal.								
	S	L		PP, PR, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.3-17. Effects on species interactions between introduced resident fish species and native aquatic species due to short- and long-term changes in habitat quality and quantity due to dam removal.								
	S	L	PP, PR, 2R, 3R, NH					
Potential Impact 3.3-18. Effects on aquatic species from interactions among fish species due to short- and long-term changes in habitat quantity due to dam removal.								
	S	L		PP, PR, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.3-19. Effects on freshwater mollusks populations due to short-term sediment releases and long-term changes in habitat quality due to dam removal.								
M. falcata, G. angulata, and freshwater clams	S	L		PP, PR, 2R, 3R, NH				
Anodonta spp.	S	L		2R, 3R			PP, PR, NH	
Potential Impact 3.3-20. Effects on fish species from alterations to benthic macroinvertebrates due to short-term sediment releases and long-term changes in habitat quality due to dam removal.								
	S			PP, PR, 2R, 3R, NH				
		L	PP, PR, 2R, 3R, NH					

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.3-21. Effects on aquatic resources due to short-term noise disturbance and water quality alterations from construction and deconstruction activities.								
	S	L		PP, PR, 2R, 3R, NH				
Potential Impact 3.3-22. Effects on aquatic species due to short-term noise disturbance and water quality alterations from deconstruction activities and long-term fish screen upgrades from the relocation of the City of Yreka Water Supply Pipeline.								
	S	L		PP, PR, 2R, 3R, NH				
Potential Impact 3.3-23. Effects on anadromous salmonid populations due to short-term and long-term Bogus Creek flow diversions for the Iron Gate Hatchery.								
	S			NP, CO, NH	AQR-3	PP, PR, 2R, 3R		
		L			AQR-3	PP, PR, 2R, 3R		

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.3-24. Effects on anadromous salmonid populations due to short-term and long-term Fall Creek flow diversions for the Fall Creek Hatchery.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R. NH				
Potential Impact 4.2.3-1 Effects on coho salmon critical habitat quality and quantity due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				
Potential Impact 4.2.3-2 Effects on Southern Resident Killer Whale critical habitat quality due to alterations to salmon populations due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.3-3. Effects on eulachon critical habitat quality due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				
Potential Impact 4.2.3-4. Effects on Chinook and coho salmon Essential Fish Habitat (EFH) quality due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				
Potential Impact 4.2.3-5. Effects on groundfish Essential Fish Habitat (EFH) quality due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.3-6. Effects on pelagic fish Essential Fish Habitat (EFH) quality due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				
Potential Impact 4.2.3-7. Effects on the fall-run Chinook salmon population due to continued operations of the Lower Klamath Project.								
	S			NP, CO				
		L	CO					
Potential Impact 4.2.3-8. Effects on the spring-run Chinook salmon population due to continued operations of the Lower Klamath Project.								
	S			NP, CO				
		L	CO					

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.3-9. Effects on coho salmon populations due to continued operations of the Lower Klamath Project.								
	S			NP, CO				
		L	CO					
Potential Impact 4.2.3-10. Effects on the steelhead population due to continued operations of the Lower Klamath Project.								
	S			NP, CO				
		L	CO					
Potential Impact 4.2.3-11. Effects on the Pacific lamprey population due to continued operations of the Lower Klamath Project.								
	S			NP, CO				
		L	CO					

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.3-12. Effects on the green sturgeon population due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				
Potential Impact 4.2.3-13. Effects on Lost River and shortnose sucker populations due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				
Potential Impact 4.2.3-14. Effects on the redband trout population due to continued operations of the Lower Klamath Project.								
	S			NP, CO				
		L	CO					
Potential Impact 4.2.3-15. Effects on the eulachon population due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.3-16. Effects on the longfin smelt population due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				
Potential Impact 4.2.3-17. Effects on species interactions between introduced resident fish species and native aquatic species due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				
Potential Impact 4.2.3-18. Effects on aquatic species from interactions among fish species due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.3-19. Effects on freshwater mollusks populations due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				
Potential Impact 4.2.3-20. Effects on fish species from alterations to benthic macroinvertebrates due to continued operations of the Lower Klamath Project.								
	S	L		NP (S only), CO				
Potential Impact 4.2.3-21. Alterations to aquatic habitat from implementation of California Klamath Restoration Fund/Coho Enhancement (IM2).								
Coho salmon, fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, freshwater mussels, and benthic macroinvertebrates	S	L	NP (S only), CO					

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Redband trout, shortnose and Lost River suckers, green sturgeon, eulachon, and southern resident killer whales	S	L		NP (S only), CO				
Potential Impact 4.4.3-1 Effects on aquatic resources due to short-term noise disturbance and water quality alterations from fishway construction activities.								
	S				WQ-1, HZ-1	CO		
Phytoplankton and Periphyton								
Potential Impact 3.4-1 Short-term increase in growth of nuisance and/or noxious phytoplankton blooms due to increases in sediment-associated nutrients from release of sediments currently trapped behind the Lower Klamath Project dams.								
	S			PP, NP, PR, CO 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.4-2 Alterations in the spatial extent, temporal duration, transport, or concentration of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins due to dam removal and elimination of reservoir habitat.								
Hydroelectric Reach through the Klamath River Estuary	S	L	PP, PR, 2R, 3R, NH					
Pacific Ocean nearshore environment	S	L		PP, PR, 2R, 3R, NH				
Potential Impact 3.4-3. Short-term increase in growth of nuisance periphyton species due to increases in sediment-associated nutrients from release of sediments currently trapped behind the Lower Klamath Project dams.								
	S			PP, NP, PR, CO 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.4-4. Alterations in the growth of nuisance periphyton species in the Hydroelectric Reach due to increased nutrients and available low-gradient channel margin habitat formed by conversion of the reservoir areas to a free-flowing river and the elimination of hydropower peaking operations.								
Hydroelectric Reach from the Oregon-California state line to Copco No. 1 Reservoir	S	L		PP, PR, 2R, 3R, NH				
Hydroelectric Reach from Copco No. 1 Reservoir to Iron Gate Dam	S	L					PP, PR, 2R, 3R, NH	
Potential Impact 3.4-5. Alterations in biomass of nuisance periphyton species due to increased nutrients from upstream dam removal and conversion of the reservoir areas to a free-flowing river.								
Middle and Lower Klamath River and the Klamath River Estuary		L		PP, PR, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.4-1 Variations in nuisance periphyton species abundance downstream of Iron Gate Dam due to implementation of 2017 court-ordered flushing and emergency dilution flows.								
Middle Klamath River from Iron Gate Dam to the Shasta River	S		NP					
Middle Klamath River downstream of the confluence with the Salmon River and the Lower Klamath River	S			NP				
Potential Impact 4.4.4-1 Long-term occurrence of nuisance and/or noxious phytoplankton blooms in the reservoirs.								
Hydroelectric Reach, Middle and Lower Klamath River, and the Klamath River Estuary		L		CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.4.4-2 Long-term colonization of nuisance periphyton in riverine reaches.								
Hydroelectric Reach		L		CO				
Middle Klamath River from Iron Gate Dam to the Shasta River		L	CO					
Middle Klamath River downstream of the confluence with the Salmon River and the Lower Klamath River		L		CO				
Terrestrial Resources								
Potential Impact 3.5-1 Construction-related impacts on wetland and riparian vegetation communities.								
	S			NP	TER-1	PP, PR, 2R, 3R, NH		
	S				TER-1 and TER-5	CO		

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.5-2 Short-term and long-term impacts on wetland and riparian vegetation communities along existing reservoir shorelines due to reservoir drawdown.								
	S	L		PP, NP (S only) PR, CO, 2R, 3R NH				
Potential Impact 3.5-3. Short-term and long-term impacts on wetland habitat downstream of the Lower Klamath Project dams due to erosion or sediment deposition.								
	S	L		PP, NP (S only) PR, CO, 2R, 3R NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.5-4. Effects on riparian habitat downstream of the Lower Klamath Project dams due to short-term and long-term erosion or sediment deposition.								
	S			PP, PR, 2R, 3R, NP, CO, NH				
		L	PP, PR, 2R, 3R, NH	CO				
Potential Impact 3.5-5. Short-term and long-term impacts on native vegetation due to increased invasive plant species establishment.								
	S	L		PP, NP (S only), CO		PR, 2R, 3R, NH		
Potential Impact 3.5-6. Short-term and long-term impacts on culturally significant species in riparian and wetland habitats.								
	S			NP	TER-1	PP, PR, 2R, 3R, NH, CO		
		L		PP, PR, 2R, 3R, NH, CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.5-7. Short-term impacts on special-status plants and rare natural communities from construction-related activities.*								
Rare natural communities	S			PP, NP, PR, CO, 2R, 3R, NH				
Special-status	S			NP			PP, PR, CO, 2R, 3R, NH	
Potential Impact 3.5-8. Short-term and long-term impacts on special-status plants from reservoir removal.*								
	S	L		NP (S only), CO			PP, PR, 2R, 3R, NH	
Potential Impact 3.5-9. Short-term impacts on special-status terrestrial invertebrates from construction-related activities.								
	S			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.5-10. Short-term impacts on special-status amphibian, reptiles, and mammals from construction activities.*								
Amphibians, reptiles, and gray wolf	S			NP	TER-2, TER-3, and TER-6	PP, PR, CO, 2R, 3R, NH		
Bats and American badger	S			NP			PP, PR, CO, 2R, 3R, NH	
Potential Impact 3.5-11. Short-term impacts on nesting birds from construction-related noise and habitat alterations.*								
	S			NP			PP, PR, CO, 2R, 3R, NH	

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.5-12. Effects on willow flycatcher from short-term construction-related noise and short-term and long-term habitat alterations.*								
	S			NP			PP, PR, CO, 2R, 3R, NH	
Riparian habitat in the former location of Copco No. 1 and Iron Gate reservoirs		L	PP, PR, 2R, 3R, NH	CO				
Potential Impact 3.5-13. Short-term impacts on bald and golden eagles from construction-related noise and habitat alterations.								
	S			NP	TER-7	PP, PR, CO, 2R, 3R, NH		
Potential Impact 3.5-14. Short-term and long-term impacts on bats from construction noise and loss of roosting habitat.*								
	S	L		NP (S only)			PP, PR, CO, 2R, 3R, NH	

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.5-15. Short-term and long-term impacts on northern spotted owl and critical habitat from construction-related noise and habitat alterations.								
	S	L		PP, NP (S only) PR, CO, 2R, 3R, NH				
Potential Impact 3.5-16. Effects on special-status amphibians and reptiles in riverine habitats from short-term high suspended sediment concentrations and flows and long-term changes in water quality.								
Pacific tailed frog, southern torrent salamander, northern red-legged frog, and western pond turtle	S			PP, NP, PR, CO, 2R, 3R, NH				
Foothill yellow-legged frog egg masses, if present	S			CO, NP			PP, PR, 2R, 3R, NH	
All special-status amphibians and reptiles		L	PP, PR, 2R, 3R, NH	CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.5-17. Effects on benthic macroinvertebrates from short-term dewatering and sedimentation and long-term alterations to habitat.								
	S			PP, NP, PR, CO, 2R, 3R, NH				
		L	PP, PR, 2R, 3R, NH	CO				
Potential Impact 3.5-18. Short-term impacts on amphibian and reptile in riverine habitats from sedimentation.								
	S			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.5-19. Impacts on native amphibians from loss of reservoir habitat.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Potential Impact 3.5-20. Short-term and long-term impacts on western pond turtle and amphibians from reduced BMI populations.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Potential Impact 3.5-21. Short-term and long-term impacts on birds and bats from loss of aquatic reservoir and shoreline vegetative habitat.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.5-22. Short-term and long-term impacts on western pond turtle from loss of aquatic habitat.								
	S	L		NP (S only), CO	TER-4	PP, PR, 2R, 3R, NH		
Potential Impact 3.5-23. Long-term effects on deer from alterations to winter range habitat.								
		L	PP, PR, 2R, 3R, NH	CO				
Potential Impact 3.5-24. Effects on terrestrial species from herbicide use during reservoir restoration activities.								
Special-status plants and wildlife	S			PP, NP, PR, CO, 2R, 3R, NH				
Rare natural communities, wetlands, and riparian vegetation		L	PP, PR, 2R, 3R, NH	CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.5-25. Effects on wildlife from increased habitat for salmonids and changes in hatchery production.								
	S	L	PP, PR, 2R, 3R, NH	NP (S only), NH, CO				
Potential Impact 3.5-26. Impacts on special-status wildlife from Bogus Creek flow diversions.								
	S			NP, NH, CO	AQR-3	PP, PR, 2R, 3R		
Potential Impact 3.5-27. Impacts on special-status wildlife from Fall Creek flow diversions.								
	S			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.5-28. Impacts on sensitive habitats and special-status terrestrial wildlife and plant species from construction activities on Parcel B lands.								
		L			WQ-1, TER-1, and TER-4			PP, PR, 2R, 3R, NH, CO
Potential Impact 3.5-29. Long-term effects on wildlife from alteration of wildlife movement corridors.								
Increased wildlife movement opportunities		L	PP, PR, 2R, 3R, NH	CO				
Wildlife-friendly fencing		L		PP, PR, 2R, 3R, NH				
Potential Impact 3.5-30. Long-term effect on terrestrial wildlife from an increase in the distribution of salmon-derived nutrients upstream of Iron Gate, Copco No. 1 and Copco No. 2 dams.								
		L	PP, PR, NH, CO	2R, 3R				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.5-1. Effects of 2017 court-ordered flushing and emergency dilution flows and 2019 BiOp flows released from Iron Gate Dam on foothill yellow-legged frog and western pond turtle breeding.								
Hydroelectric Reach (foothill yellow-legged frogs)	S						NP, CO	
Hydroelectric Reach (western pond turtles)	S			NP, CO				
Flood Hydrology								
Potential Impact 3.6-1 Reservoir drawdown and dam removal could result in short-term increases in downstream surface water flows and result in exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding.								
	S			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	**Time Frame[1]**		**Beneficial**	**No Significant Impact[2]**	**Mitigation**	**No Significant Impact with Mitigation**	**Significant and Unavoidable**	**Significant and Unavoidable with Mitigation**
Potential Impact 3.6-2 Under the Proposed Project recreational facilities currently located on the banks of the existing reservoirs would be removed following drawdown and could change flood hydrology.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Potential Impact 3.6-3. The long-term FEMA100-year floodplain inundation extent downstream from Iron Gate Dam could change between river miles 193 and 174, potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding.								
Exposing structures to a substantial risk of damage due to flooding		L					PP, PR, 2R, 3R, NH	
Exposing people and/or structures to a substantial risk of flooding related to flood forecasting		L		PP, PR, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.6-4. The FEMA 100-year floodplain inundation extent downstream from J.C. Boyle Dam could change between the California-Oregon state line and Copco No. 1 Reservoir, potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding.								
		L		PP, PR, 2R, 3R, NH				
Potential Impact 3.6-5. The release of sediment stored behind the Lower Klamath Project dams and resulting downstream sediment deposition under the Proposed Project could result in potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.6-6. Dam failure could flood areas downstream of the Lower Klamath Project.								
	S			PP, NP, PR, 2R, 3R, NH, CO				
		L	PP, PR, 2R, 3R, NH	CO				
Potential Impact 4.2.6-1. The FEMA 100-year floodplain inundation extent downstream from Iron Gate Dam could change due to 2017 flow requirements, potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding.								
	S	L		NP (S only), CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.2.6-2. The FEMA 100-year floodplain inundation extent downstream from J.C. Boyle Dam could change due to 2017 flow requirements between the California-Oregon state line and Copco No. 1 Reservoir, potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding.								
	S	L		NP (S only), CO				
Groundwater Resources								
Potential Impact 3.7-1. Groundwater levels in existing wells adjacent to the reservoirs could decline in response to the decrease in reservoir surface-water elevations if the dams, and therefore reservoirs, are removed.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	**Time Frame[1]**		**Beneficial**	**No Significant Impact[2]**	**Mitigation**	**No Significant Impact with Mitigation**	**Significant and Unavoidable**	**Significant and Unavoidable with Mitigation**
Potential Impact 3.7-2. The Proposed Project could interfere with groundwater recharge and adversely affect surface water conditions in the Klamath River.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Water Supply and Water Rights								
Potential Impact 3.8-1 Dam removal could change the amount of surface water flow available for diversion under existing water rights in the mainstem Klamath River within the Hydroelectric Reach and downstream from Iron Gate Dam.								
	S	L		PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.8-2. Dam removal could change the amount of surface water flow available for diversion from Upper Klamath Lake and/or Keno Reservoir to California water users in the USBR Klamath Irrigation Project.								
	S	L		PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.8-3. Release of stored sediment during reservoir drawdown could change Klamath River geomorphology and affect water intake pumps downstream from Iron Gate Dam.								
	S			NP, CO	WSWR-1	PP, PR, 2R, 3R, NH		
Potential Impact 3.8-4. Relocation of the City of Yreka water supply pipeline after drawdown of Iron Gate Reservoir could affect water supply.								
	S			NP, CO	WSWR-2	PP, PR, 2R, 3R, NH		

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.8-5. Removal and potential replacement of recreational facilities currently located on the banks of the existing reservoirs could affect water supply and/or water rights.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Potential Impact 4.2.8-1. Water availability changes from coordinated operations under 2017 flow requirements.								
	S	L		NP (S only), CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Air Quality								
Potential Impact 3.9-1. Exceedance of the Siskiyou County Air Pollution Control District (SCAPCD) emissions thresholds in Rule 6.1 (Construction Permit Standards for Criteria Air Pollutants).								
	S			NP, CO	AQ-1, AQ-2, AQ-3, AQ-4, AQ-5		2R, 3R	PP, PR, NH
Potential Impact 3.9-2. Substantially conflict with or obstruct implementation of the California Regional Haze Plan.								
	S			NP, CO	AQ-1, AQ-2, AQ-3, AQ-4, AQ-5	PP, PR, NH	2R, 3R	
	L			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	**Time Frame[1]**		**Beneficial**	**No Significant Impact[2]**	**Mitigation**	**No Significant Impact with Mitigation**	**Significant and Unavoidable**	**Significant and Unavoidable with Mitigation**
Potential Impact 3.9-3. Short-term cumulative increase in criteria pollutants for which the Siskiyou County Air Pollution Control District (SCAPCD) is non-attainment.								
	S			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.9-4. Short-term exposure of sensitive receptors to substantial toxic air contaminant concentrations.								
	S			NP, CO	HZ-1	PP, PR, NH	2R, 3R	
Potential Impact 3.9-5. Short-term exposure to objectionable odors near construction sites.								
	S			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Greenhouse Gas Emissions								
Potential Impact 3.10-1. Generation of direct GHG emissions from construction activity and operations.								
	S			NP	ENR-1	PP, PR, NH	CO, 2R, 3R	
	L			PP, NP, PR, 2R, 3R, NH			CO	
Potential Impact 3.10-2. Generation of direct GHG emissions from reservoir sediments during drawdown that would exceed a no net increase threshold.								
	S			NP, CO			PP, PR, 2R, 3R, NH	
Potential Impact 3.10-3. Generation of direct GHG emissions from conversion of the reservoir areas to riverine, wetland, and terrestrial habitat types, that would exceed a no net increase threshold.								
	L			NP, CO			PP, PR, 2R, 3R, NH	

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.10-4. Generation of indirect GHG emissions from continued power production for the PacifiCorp PCA.								
	S, L			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.10-5. Result in the wasteful, inefficient, or unnecessary consumption of energy resources during project construction or operations.								
	S, L			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.10-6. Result in a substantial impact on local and regional energy supplies and/or on requirements for additional capacity.								
	S, L			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.10-7. Conflict with or obstruct a state or local plan for renewable energy or energy efficiency.								
	S, L			NP, CO			PP, PR, 2R, 3R, NH	
Geology, Soils, and Mineral Resources								
Potential Impact 3.11-1. Reservoir drawdown could result in changes to geologic hazards, such as seismic or volcanic activity.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Potential Impact 3.11-2. Soil disturbance associated with heavy vehicle use, excavation, and grading could result in erosion during removal activities.								
	S			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.11-3. Reservoir drawdown could result in hillslope instability in reservoir rim areas.								
J.C. Boyle Reservoir	S			PP, NP, PR, CO, 2R, 3R, NH				
Copco No. 1 Reservoir	S			NP, CO	GEO-1	PP, PR, 2R, 3R, NH		
Iron Gate Reservoir	S			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.11-4. Reservoir drawdown could result in short-term instability of embankments at the earthen dams (Iron Gate and J.C. Boyle).								
	S			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.11-5. Reservoir drawdown could result in substantial short-term sediment deposition in the Klamath River downstream of Iron Gate Dam due to erosion of reservoir sediment deposits and a long-term change in sediment supply and transport due to dam removal.								
Middle Klamath River from Iron Gate Dam to Cottonwood Creek	S			NP, CO			PP, PR, 2R, 3R, NH	
Middle Klamath River downstream of Cottonwood Creek, Lower Klamath River, and Klamath River Estuary	S			PP, NP, PR, CO, 2R, 3R, NH				
Hydroelectric Reach, Middle and Lower Klamath River, and Klamath River Estuary		L	PP, PR, 2R, 3R, NH	NP, CO				
Pacific Ocean nearshore environment	S	L		PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.11-6. Reservoir drawdown could result in increased bank erosion in the Klamath River downstream of Iron Gate Dam.								
	S			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.11-7. Reservoir removal could reduce or eliminate the availability of a known mineral resource or a locally important mineral resource recovery site.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Historical Resources and Tribal Cultural Resources								
Potential Impact 3.12-1. Pre-dam-removal activities that involve disturbance of the landscape, including construction or improvement of associated roads, bridges, water supply lines, staging areas, disposal sites, hatchery modifications, recreation site removal and/or development, and culvert construction and improvements could result in potential exposure of or damage to known Tribal Cultural Resources through ground-disturbing construction and disposal activity and increased access to sensitive areas.								
	S	L		NP (S only)	TCR-1, TCR-2, TCR-3, TCR-4			PP, PR, CO, 2R, 3R, NH

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.12-2. Drawdown of Iron Gate, Copco No. 1, and Copco No. 2 reservoirs could result in shifting, erosion, and exposure of known or unknown, previously submerged Tribal Cultural Resources.								
	S	L		NP (S only), CO	TCR-1, TCR-2, TCR-3, TCR-4			PP, PR, 2R, 3R, NH
Potential Impact 3.12-3. Reservoir drawdown could result in erosion or flood disturbance to Tribal Cultural Resources located along the Klamath River.								
Hydroelectric Reach between J.C. Boyle Dam and Copco No. 1 Reservoir	S	L		PP, NP, PR, CO, 2R, 3R, NH				
Middle Klamath River from Iron Gate Dam to Humbug Creek	S	L		NP, CO	TCR-1, TCR-2, TCR-3			PP, PR, 2R, 3R, NH

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Middle Klamath River downstream of Humbug Creek and Lower Klamath River excluding the Yurok Reservation (approximately RM 0 to RM 45)	S	L		PP, NP, PR, CO, 2R, 3R, NH				
Yurok Reservation (approximately RM 0 to RM 45) along Lower Klamath River and Klamath River Estuary	S	L		NP, CO	TCR-5	PP, PR, 2R, 3R, NH		
Potential Impact 3.12-4. Project activities associated with removal of Iron Gate, Copco No. 1, and Copco No. 2 dams could result in physical disturbance to known or unknown Tribal Cultural Resources from blasting or other removal techniques.								
	S	L		NP (S only)	TCR-1, TCR-2, TCR-3, TCR-4			PP, PR, CO, 2R, 3R, NH

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.12-5. Ground disturbance associated with reservoir restoration, recreation site removal and/or development, and disposal site restoration could physically disturb known Tribal Cultural Resources. Additionally, ongoing road and recreation site maintenance has the potential to disturb known Tribal Cultural Resources.								
	S	L		NP (S only)	TCR-1, TCR-2, TCR-3, TCR-4			PP, PR, CO, 2R, 3R, NH
Potential Impact 3.12-6. During and following reservoir drawdown activities at Iron Gate, Copco No. 1, and Copco No. 2 reservoirs there is an increased potential for looting of Tribal Cultural Resources (short term and long term).								
Iron Gate Reservoir and Copco No. 1 Reservoir	S	L		NP, CO	TCR-2, TCR-4			PP, PR, 2R, 3R, NH
Copco No. 2 Reach	S	L		NP, CO	TCR-2, TCR-4			PP, PR, 3R, NH

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.12-7. Short-term erosion caused by high-intensity and/or duration precipitation events could cause exposure of or disturbance to known or unknown Tribal Cultural Resources within the reservoir footprints immediately following reservoir drawdown and prior to vegetation establishment/full stabilization of sediment deposits.								
	S			NP, CO	TCR-1, TCR-2, and TCR-3		PP, PR, 2R, 3R, NH	
Potential Impact 3.12-8. Long-term (post-removal) impacts to Tribal Cultural Resources as a result of dam removal from increased looting opportunities and from surface and subsurface erosion of Tribal Cultural Resources.								
Prior to land transfer		L		CO			PP, PR, 2R, 3R, NH	

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
After land transfer		L			TCR-1, TCR-2, TCR-3, TCR-6, TCR-7, and TCR-8	PP, PR, 2R, 3R, NH		
Potential Impact 3.12-9. Klamath Cultural Riverscape Contributing Aspect – Combined effects on the Klamath River fishery of dam removal, changes in hatchery production, and increased habitat for salmonids.								
	S			PP, NP, PR, CO, 2R, 3R			NH	
		L	PP, PR, 2R, 3R, NH	CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.12-10. Klamath Cultural Riverscape Contributing Aspect: Ability of tribes to use the Middle and Lower Klamath River for ceremonial and other purposes due to alterations in riverine water quality and changes in the extent of nuisance and/or noxious blue-green algae blooms.								
	S	L	PP, PR, 2R, 3R, NH	NP (S only), CO				
Potential Impact 3.12-11. Potential impacts to Copco No. 1 Dam, Copco No. 2 Dam, and Iron Gate Dam, their associated hydroelectric facilities, and the Klamath River Hydroelectric Project District as a whole.								
J.C. Boyle Reservoir and associated hydroelectric facilities	S	L		NP (S only)			PP, PR, CO, NH	
Copco No. 1 Dam and associated hydroelectric facilities	S	L		NP (S only)			PP, PR, CO, 2R, 3R, NH	
Copco No. 2 Dam and associated hydroelectric facilities	S	L		NP (S only)			PP, PR, CO, 3R, NH	

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Iron Gate Dam and associated hydroelectric facilities	S	L		NP (S only)			PP, PR, CO, 2R, 3R, NH	
Klamath River Hydroelectric Project District	S	L		NP (S only)			PP, PR, CO, 2R, 3R, NH	
Potential Impact 3.12-12. Potential impacts to submerged historic-period archaeological sites upon reservoir drawdown and exposure providing new access opportunities for artifact collecting and unauthorized excavation.								
	S	L		NP (S only), CO	TCR-2 and TCR-3			PP, PR, 2R, 3R, NH
Potential Impact 3.12-13. Drawdown of Iron Gate, Copco No. 1, and Copco No. 2 reservoirs could shift, erode, or expose historic-period archaeological resources resulting in increased potential for damage and looting.								
	S	L		NP (S only), CO	TCR-2 and TCR-3			PP, PR, 2R, 3R, NH

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.12-14. Reservoir drawdown could result in short-term erosion or flood disturbance to historic-period cultural resources located along the Klamath River.								
Middle Klamath River from Iron Gate Dam to Humbug Creek	S			NP, CO	TCR-3			PP, PR, 2R, 3R, NH
Hydroelectric Reach excluding Iron Gate Dam, Middle Klamath River downstream of Humbug Creek, Lower Klamath River, Klamath River Estuary	S			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.12-15. Project activities associated with removal of Iron Gate, Copco No. 1, and Copco No. 2 dams could result in physical disturbance to historic-period cultural resources from blasting or other removal techniques.								
	S			NP	TCR-3			PP, PR, CO, 2R, 3R, NH

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.12-16. Ground disturbance associated with reservoir restoration, recreation site removal and/or development, and disposal site restoration could physically disturb historic-period cultural resources. Additionally, ongoing road and recreation site maintenance may have the potential to disturb known historic-period cultural resources.								
	S			NP	TCR-2 and TCR-3			PP, PR, CO, 2R, 3R, NH
Paleontologic Resources								
Potential Impact 3.13-1. The Proposed Project could result in substantial adverse effects on, or destruction of, High Potential Paleontologic Resources through exposure or slope failure.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Land Use and Planning								
Potential Impact 3.14-1. Removal of the reservoirs, construction-related traffic, and/or land transfer could change connectivity between areas of a community.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Potential Impact 3.14-2. The Proposed Project would not conflict with an applicable land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect in a manner that would prevent the avoidance or mitigation result sought to be achieved by the plan, policy, or regulation.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Agriculture and Forestry Resources								
Potential Impact 3.15-1. Conversion of farmland to non-agricultural use or conflict with Williamson Act land or agricultural zoning.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Potential Impact 3.15-2. Conversion of forest lands to non-forest use or conflict with forest zoning.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Potential Impact 3.15-3. Indirect conversion of farmland to non-agricultural use or forest land to non-forest use.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.15-4. Other changes in the existing environment that could result in conversion of farmland to non-agricultural use or conversion of forest land to non-forest use.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Population and Housing								
Potential Impact 3.16-1. Inducing substantial unplanned population growth in an area, either directly or indirectly.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.16-2. Displacement of substantial numbers of existing people or housing, necessitating the construction of replacement housing elsewhere.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Public Services								
Potential Impact 3.17-1. Increased public service response times for emergency fire, police, and medical services due to construction and demolition activities.								
	S			NP	HZ-1, TR-1	PP, PR, 2R, 3R, NH		CO

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.17-2. The Proposed Project’s elimination of a long-term water source for wildfire services could substantially increase the response time for suppressing wildfires*	S			PP, NP, PR, CO, 2R, 3R, NH				
		L		NP, CO			PP, PR, 2R, 3R, NH	
Potential Impact 3.17-3. Potential effects on school services and facilities.								
	S	L		PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Utilities and Service Systems								
Potential Impact 3.18-1. The Proposed Project could result in the construction of new wastewater treatment facilities, or expansion of existing facilities, due to inadequate capacity to serve the Proposed Project's anticipated demand, and where the construction of such facilities could cause significant environmental impacts.								
	S	L		PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.18-2. The Proposed Project could require or result in the construction of new stormwater drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental impacts.								
	S	L		PP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.18-3. The Proposed Project could exceed permitted landfill capacity to accommodate the project's solid waste disposal needs.								
	S	L		PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.18-4. The Proposed Project could violate applicable statutes and regulations related to solid waste.								
	S	L		PP, NP, PR, CO, 2R, 3R, NH				
Aesthetics								
Potential Impact 3.19-1. Loss of Open Water Vistas.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.19-2. Changes in Flows and Channel Morphology.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Potential Impact 3.19-3. Changes in Visual Water Quality.								
Turbidity and reduced clarity	S			PP, NP, PR, CO, 2R, 3R, NH				
Reduced algal blooms		L	PP, PR, 2R, 3R, NH	CO				
Potential Impact 3.19-4. Visual changes resulting from reservoir drawdown and restoration including temporarily bare/unvegetated banks.								
	S			NP, CO			PP, PR, 2R, 3R, NH	
		L		PP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.19-5. Visual changes resulting from the removal of Lower Klamath Project dams and associated facilities and improvements to or construction of new infrastructure.								
Removal of Lower Klamath Project dams and associated facilities		L		PP, PR, 2R, 3R, NH, CO				
Improvements to and construction of new infrastructure		L		PP, PR, 2R, 3R, NH, CO				
Potential Impact 3.19-6. Short-term visual impacts of construction activities/equipment.								
	S			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.19-7. The Project's construction or security lighting could result in new sources of substantial light or glare that would adversely affect nighttime views in the area.								
	S			NP, CO			PP, PR, CO, 2R, 3R, NH	
Recreation								
Potential Impact 3.20-1. Effects on existing recreational facilities and opportunities due to access restrictions, noise, dust, and/or sediment release resulting from construction activities.								
	S			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.20-2. Long-term changes to or loss of reservoir-based recreation activities and facilities due to removal of Iron Gate and Copco No. 1 reservoirs.								
		L		PP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.20-3. Significant increase in the use of regional recreational facilities due to loss of Iron Gate and Copco No. 1 reservoirs, such that substantial physical deterioration or acceleration of deterioration of the regional facilities would occur.								
	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Potential Impact 3.20-5. Changes to or loss of river conditions that support whitewater boating.								
Middle and Lower Klamath River	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Hell's Corner Reach	S	L		NP (S only)			PP, PR, CO, 2R, 3R, NH	

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.20-6. Changes to or loss of other river-based recreation including fishing.								
Middle Klamath River between Iron Gate Dam (RM 193.1) and Humbug Creek (RM 174.3)	S	L		PP, NP (S only), PR, CO, 2R, 3R, NH				
Hydroelectric Reach, Middle Klamath River downstream of Humbug Creek (RM 174.3), and the Lower Klamath River	S	L	PP, PR, 2R, 3R, NH, CO	NP (S only)				
Potential Impact 3.20-7. Effects on Wild and Scenic River resources, designations, or eligibility for listing.								
Designated California Klamath River wild and scenic river segment, and eligible and suitable California Klamath River wild and scenic river section	S			PP, NP, PR, CO, 2R, 3R, NH				
Designated California Klamath River wild and scenic river segment, and eligible and suitable California Klamath River wild and scenic river section		L	PP, PR, 2R, 3R, NH	CO				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Hazards and Hazardous Materials								
Potential Impact 3.21-1. Proposed construction-related activities could result in substantial exposure to hazardous materials through the routine transport, use, or disposal of hazardous materials.								
	S			NP	HZ-1	PP, PR, CO, 2R, 3R, NH		
Potential Impact 3.21-2. Proposed construction-related activities could result in substantial exposure to hazardous materials through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment.								
	S			NP	HZ-1	PP, PR, CO, 2R, 3R, NH		

Geographic or Other Additional Information (as needed)	**Time Frame[1]**		**Beneficial**	**No Significant Impact[2]**	**Mitigation**	**No Significant Impact with Mitigation**	**Significant and Unavoidable**	**Significant and Unavoidable with Mitigation**
Potential Impact 3.21-3. Proposed construction-related activities could result in substantial exposure to hazardous materials through emissions or handling of substances or waste within one-quarter mile of an existing or proposed school.								
	S			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.21-4. The Proposed Project could be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, could result in substantial exposure to hazardous materials.								
	S			NP	HZ-1	PP, PR, CO, 2R, 3R, NH		

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.21-5. The Proposed Project could result in, for a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, a substantial safety hazard for people residing or working in the project area due to a risk of traffic accidents.								
	S	L		PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.21-6. The Proposed Project could result in, for a project within the vicinity of a private airstrip, a substantial safety hazard for people residing or working in the project area due to a risk of traffic accidents.								
	S	L		PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.21-7. Proposed construction-related activities could impair implementation of, or physically interfere with, an adopted emergency response plan or emergency evacuation plan.								
	S			NP	TR-1	PP, PR, 2R, 3R, NH	CO	
Potential Impact 3.21-8. Proposed construction-related activities and/or removal of the Lower Klamath Project reservoirs could substantially increase the public's risk of loss, injury or death associated with wildland fires.								
	S			PP, NP, PR, CO, 2R, 3R, NH				
		L		CO			PP, PR, 2R, 3R, NH	

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Transportation and Traffic								
Potential Impact 3.22-1. Proposed construction-related traffic could potentially result in a substantial increase in traffic in excess of the capacity or design of the road improvements or impairs the safety or performance of the circulation system, including transit, roadways, bicycle lanes and pedestrian paths.								
	S			NP	TR-1	PP, PR, 2R, 3R, NH	CO	
Potential Impact 3.22-2. Proposed construction-related traffic could potentially conflict with an applicable congestion management program, including, but not limited to level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways that would result in increased risk of harm to the public.								

Geographic or Other Additional Information (as needed)	**Time Frame[1]**		**Beneficial**	**No Significant Impact[2]**	**Mitigation**	**No Significant Impact with Mitigation**	**Significant and Unavoidable**	**Significant and Unavoidable with Mitigation**
				NP	TR-1	PP, PR, 2R, 3R, NH	CO	
Potential Impact 3.22-3. Proposed construction-related traffic could result in substantially increasing hazards due to a design feature (e.g., sharp curves or narrow lanes) or incompatible uses (e.g., oversized construction equipment) that would result in an increased risk of harm to the public.								
	S			NP	TR-1	PP, PR, 2R, 3R, NH	CO	
Potential Impact 3.22-4. The Proposed Project could result in inadequate emergency access that would result in an increased risk of harm to the public.1								
	S			NP	TR-1	PP, PR, 2R, 3R, NH	CO	

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.22-5. Construction-related activities could potentially conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities resulting in an increased risk of harm to the public.								
	S			NP	TR-1	PP, PR, 2R, 3R, NH	CO	
Potential Impact 3.22-6. The Proposed Project could potentially result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks.								
	S	L		PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 4.4.22-1 Trap and haul operational traffic could potentially result in a substantial increase in traffic in excess of the capacity or design of the road improvements or impairs the safety or performance of the circulation system, including transit, roadways, bicycle lanes and pedestrian paths, or otherwise result in an increased risk of harm to the public due to an increase in traffic.								
		L		CO, 2R				
Noise								
Potential Impact 3.23-1. Use of standard construction equipment could exceed Siskiyou County General Plan criteria for maximum allowable noise levels from construction equipment.								
	S			NP			PP, PR, CO, 2R, 3R, NH	

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.23-2. Construction activities at Copco No. 1 Dam could cause short-term increases in daytime and nighttime noise levels affecting nearby residents.								
	S			NP			PP, PR, CO, 2R, 3R, NH	
Potential Impact 3.23-3. Construction activities at Copco No. 2 Dam could cause short-term increases in noise levels affecting nearby residents.								
	S			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.23-4. Construction activities at Iron Gate Dam could cause short-term increases in nighttime noise levels affecting nearby residents.								
	S			NP			PP, PR, CO, 2R, 3R, NH	

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.23-5. Reservoir restoration activities at Copco No. 1 and Iron Gate could result in short-term increases in noise levels affecting nearby residents.								
	S			NP			PP, PR, CO, 2R, 3R, NH	
Potential Impact 3.23-6. Blasting activities at Copco No. 1, Copco No. 2, and Iron Gate Dams could increase daytime vibration levels affecting nearby residents.								
	S			NP			PP, PR, CO, 2R, 3R, NH	
Potential Impact 3.23-7. Transporting waste to off-site landfills and construction worker commutes could cause increases in traffic noise along haul routes affecting nearby residents.								
	S			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.23-8. Construction activities associated with the Downstream Flood Control project component (moving or elevating legally established structures with flood risk) could produce noise and vibration associated with construction activities.								
	S			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 3.23-9. Construction activities associated with implementation of Mitigation Measure WSWR-1 (modify water intakes) could produce noise and vibration associated with construction activities.								
	S			PP, NP, PR, CO, 2R, 3R, NH				

Geographic or Other Additional Information (as needed)	Time Frame[1]		Beneficial	No Significant Impact[2]	Mitigation	No Significant Impact with Mitigation	Significant and Unavoidable	Significant and Unavoidable with Mitigation
Potential Impact 3.23-10. Construction activities associated with the deepening or replacement of existing groundwater wells adjacent to the reservoirs could produce noise and vibration affecting nearby residents.								
	S			PP, NP, PR, CO, 2R, 3R, NH				
Potential Impact 4.5.23-1. Trap and haul-related noise.								
	S			2R				

1 S = short-term potential impact; L = long-term potential impact; time frames for "S" and "L" are defined by alternative and resource area.

2 No significant impact—potential effect either would not cause any adverse alterations to existing conditions or would cause alterations but they would not result in a significant adverse effect (includes determinations of no impact, less than significant impact, no change from existing adverse conditions, no change from existing conditions).

3 * Indicates a Significant and Unavoidable Impact that would be reduced to No Significant Impact with Mitigation if one or more Recommended Measures were to be implemented. Due to federal preemption the State Water Board cannot guarantee the implementation of Recommended Measures. The associated significant and unavoidable impacts include Potential Impacts 3.5-7, 3.5-8, 3.5-10, 3.5-11, 3.5-12, 3.5-14, and 3.17-2.

References

References cited as part of text included in the Executive Summary list of revisions:

USBR. 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River dam removal and basin restoration, Klamath River, Oregon and California, Mid-Pacific Region. Technical Report No. SRH-2011-02. Prepared for Bureau of Reclamation, Mid-Pacific Region, Technical Service Center, Denver, Colorado.

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2 PROPOSED PROJECT

Volume I Section 2.2 Proposed Project – Project Location, Figure 2.2-5 Proposed Project Boundary – California Portion on page 2-7:

Since issuance of the Draft EIR, the KRRC has clarified that the Proposed Project "Limits of Work" include the following:

- 34 small areas ranging from 0.02 acres to 6.5 acres in size, with most parcels less than 0.03 acres, all of which are located within the altered 100-year floodplain of the Middle Klamath River between Iron Gate Dam (river mile [RM] 193) and Humbug Creek (RM 174) and have existing legally-established habitable structures that may require relocation or elevation prior to dam removal;
- 1,300 linear feet of the south shore of Copco No. 1 Reservoir inclusive of the adjacent twelve parcels that possess existing habitable structures, which potentially could be impacted by slope failure during or immediately following reservoir drawdown;
- 480 linear feet of Copco Road (unpaved) located on the north shore of Copco No. 1 Reservoir which has the potential to experience slope failure during or immediately following reservoir drawdown.

The EIR Project Boundary, which is inclusive of the Proposed Project Limits of Work, as well as PacifiCorp owned and managed lands immediately surrounding the Lower Klamath Project ("Parcel B lands") that would be transferred as part of the Proposed Project, has been updated accordingly. The proposed updates to the Limits of Work are relatively minor and are all included below in an updated Figure 2.2-7 *Proposed Project Boundary − California Portion*. The updated Proposed Project Boundary shown in Figure 2.2-7 applies to all figures in EIR Volume I that include the Project Boundary.

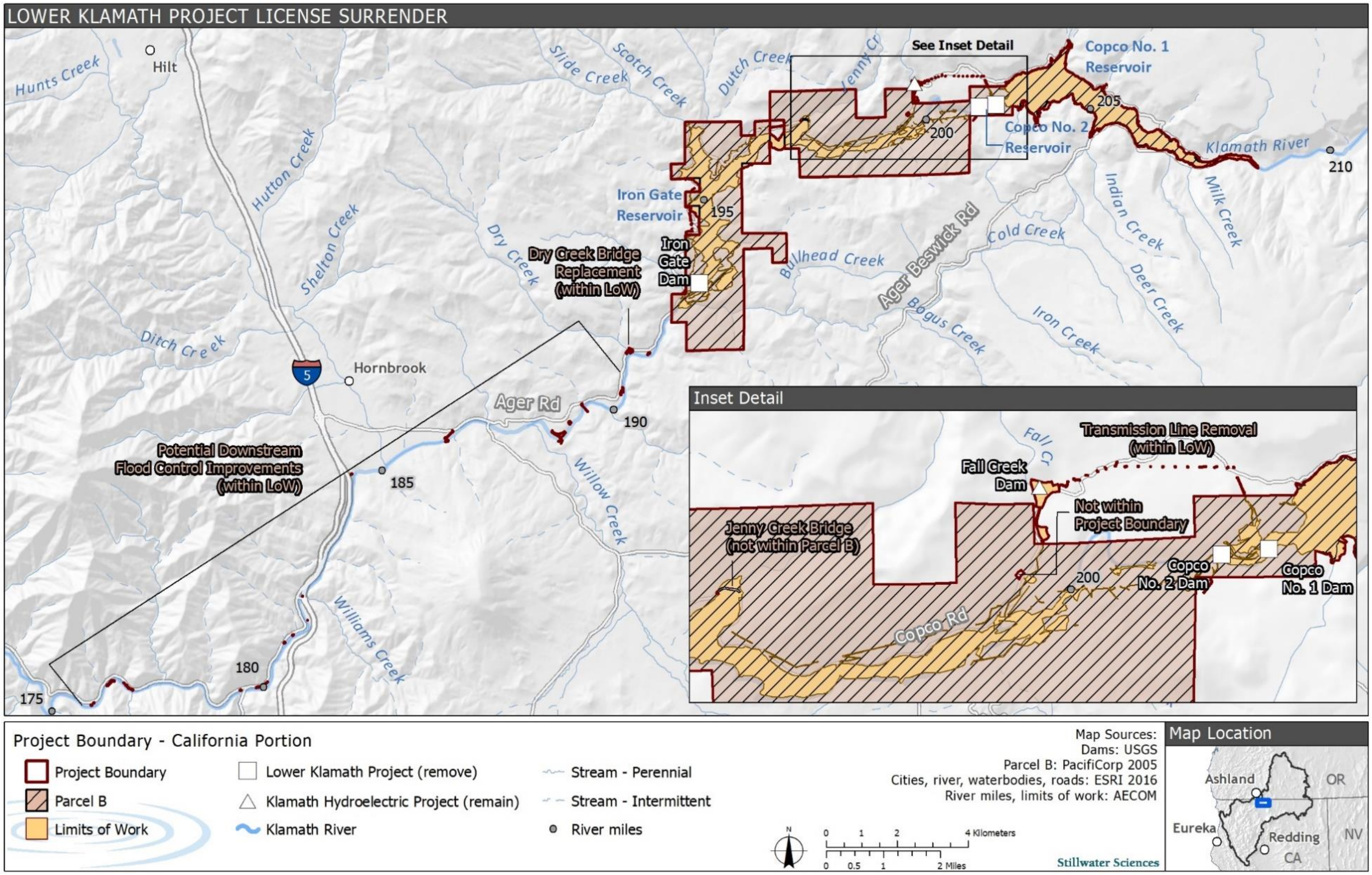

Figure 2.2-7. Proposed Project Boundary – California Portion.

2.3 Existing Lower Klamath Project Features

Volume I Section 2.3 Proposed Project – Existing Lower Klamath Project Features, Table 2.3-1. Lower Klamath Project Dam and Powerhouse Components on page 2-8:

Table 2.3-1. Lower Klamath Project Dam and Powerhouse Components.

	J.C. Boyle	Copco No. 1	Copco No. 2	Iron Gate
Dam type	Concrete and earthfill embankment	Concrete	Concrete	Earthfill embankment
Dam maximum height	68 feet	133 feet	32 feet	189 feet
Dam crest length	430 feet	410 feet	305 feet	740 feet
Reservoir surface area	350 acres	972 acres	~~N/A~~5.2 acres[1]	942 acres
Reservoir storage volume[2]	2,267 acre-feet	33,724 acre-feet	70 acre-feet	50,941 acre-feet
Type of facility to allow water to flow past dam under existing conditions	Overflow spillway with control gates ~~and diversion culvert~~	Overflow spillway with ~~larger~~ control gates ~~and modified diversion tunnel~~	Overflow spillway with control gates	Uncontrolled overflow spillway and diversion tunnel

Source: Appendix B: *Definite Plan* unless otherwise noted. Note that component dimensions have been adjusted from those reported in FERC 2007 and USBR 2012a based on available data (e.g., as-built drawings, aerial photographs, topographic information).

[1] PacifiCorp 2015.

[2] Volumes reflect the total storage volume following dam construction, and do not reflect only the active storage amounts.

2.6 Project Background

2.6.1 Water ~~Conflicts~~ History in the Klamath River Basin

Volume I Section 2.6.1 Proposed Project – Project Background – Water Conflicts in the Klamath River Basin, paragraph 1 on page 2-20:

Water-related disputes, including competing uses for water, water quality concerns, and impacted fisheries (commercial, tribal, and recreational) are difficult issues in the Klamath Basin. Below are some highlights of major water-related milestones and issues in the Klamath Basin over approximately the last few decades and are not intended to be a comprehensive history of water use and/or management in the basin:

1957	Klamath River Basin Compact between the states of Oregon and California, ratified by the states and consented to by Act of Congress including integrated and comprehensive development of water use for equitable distribution between the two states and the Federal Government, with uses identified for domestic, irrigation, protection and enhancement of fish, wildlife and recreational resources, industrial and hydroelectric power production, and for navigation and flood prevention.
1975	Comprehensive basin plan adopted for the Klamath River in California including multiple beneficial use designations such as cold freshwater habitat, aquatic organism migration, spawning, reproduction, and/or early development for protected fish, water contact recreation, agricultural supply, and hydropower generation.
1988	Lost River and shortnose sucker listed as endangered under the ESA
1996	Klamath River from the California/Oregon state line to Iron Gate Dam and from the confluence with the Scott River to the Klamath River Estuary added to the Clean Water Act Section 303(d) list for nutrients and temperature. Klamath River from its confluence with the Trinity River to the Klamath River Estuary added to the Clean Water Act Section 303(d) list for sediment. Klamath River from Iron Gate Dam to its confluence with the Scott River added to the Clean Water Act Section 303(d) list for organic enrichment/low dissolved oxygen.
1997	Coho salmon listed as Federally threatened under the Endangered Species Act (ESA).
~~1998~~	~~Lost River and shortnose sucker listed as endangered under the ESA.~~
1998	Klamath River from the California/Oregon state line to Iron Gate Dam and from the confluence with the Scott River to the Klamath River Estuary added to the Clean Water Act Section 303(d) list for organic enrichment/low dissolved oxygen. Klamath River from Iron Gate Dam to its confluence with the Scott River added to Clean Water Act Section 303(d) list for nutrients and temperature.
2001	(Spring) For the first time ever at a Federal reclamation (USBR) project, water deliveries from Upper Klamath Lake to Klamath Irrigation Project irrigators (and wildlife refuges) in California and Oregon did not occur in order to comply with requirements to protect ESA-listed fish (Lost River and shortnose suckers in the Upper Klamath Lake and coho salmon in the Lower Klamath River) during a severe drought (Braunworth et al. 2002).
2002	(Late summer/fall) Major fish die-off in in the Lower Klamath River of more than 33,000 adult salmon (primarily fall-run Chinook salmon) and steelhead during a disease outbreak (CDFG 2004).
2002	Coho salmon listed as threatened under the California ESA (CESA).

2003	Native American cultural use adopted as a beneficial use of the Klamath River from the Seiad Valley Hydrologic Subarea downstream to the Klamath Glen Hydrologic Subarea.
2004	First documented toxic bloom of the blue-green algae (cyanobacteria) *Microcystis aeruginosa* in Copco No. 1 Reservoir (Kann and Corum 2006).
2005	Public health warnings to avoid contact with water in Copco No. 1 and Iron Gate reservoirs due to toxic algae blooms began being posted annually.
2006	Low abundance of Klamath Basin Chinook salmon lead to severe restrictions on commercial and recreational harvest along 700 miles of the California and Oregon coast, as well as major reductions in Klamath River recreational and tribal fisheries. Broad commercial and recreational restrictions on the coast because of Klamath Basin Chinook returns were repeated in 2008, 2009, 2010, 2016, and 2017, including complete closure of commercial and recreational fisheries.
2006	Copco No. 1, Copco No. 2, and Iron Gate reservoirs identified by the USEPA for inclusion on the Clean Water Act Section 303(d) list for blue-green algae (cyanobacteria)-produced microcystin toxin as an additional cause of water quality impairment.
2010	Water deliveries from Upper Klamath Lake to Klamath Irrigation Project irrigators (and wildlife refuges) in California and Oregon significantly reduced in order to comply with requirements to protect ESA-listed suckers and provide flow augmentation for ESA-listed coho downstream of Iron Gate Dam, given dry hydrologic conditions.
2010	The Klamath Tribes limited their harvest of suckers to ceremonial use for the 25th consecutive year and experienced their 93rd ~~92nd~~ year without access to salmon.

2.7 Proposed Project

Volume I Section 2.7 Proposed Project – Proposed Project, paragraph 1 on page 2-26:

Table provides the proposed schedule for facilities drawdown and removal along with associated Proposed Project activities before and after removal. Drawdown timing for J.C. Boyle, Copco No. 1, and Iron Gate reservoirs was selected to minimize impacts to salmonids and other aquatic species. Based on the distribution and life-history timing of aquatic species in the Klamath Basin, only a portion of fish populations are likely to be present in the mainstem Klamath River during the reservoir drawdown period~~s~~ ~~of greatest sediment transport~~ between January and March (Figure 2.7-1), which is also the period of greatest sediment transport (see Section 3.2.5 *Water Quality – Potential Impacts and Mitigation* Potential Impact 3.2-3). During this time, ~~M~~most species are in tributaries which would be unaffected by the Proposed Project, or are further downstream ~~during this time~~ where river conditions would be less influenced by sediment transport by the Proposed Project due to dilution by tributary inflows. Additionally, the timing of drawdown coincides with periods of naturally high suspended sediment in the Klamath River, to which aquatic species have adapted through avoidance and tolerance.

Volume I Section 2.7 Proposed Project – Proposed Project, Table 2.7-1 Proposed Lower Klamath Project Schedule on page 2-27:

Table 2.7-1. Proposed Lower Klamath Project Schedule.

Task	Pre-dam Removal Years 1-3	Dam Removal Year 1												Dam Removal Year 2												Post-Dam Removal Year 1												Post-Dam Removal Years 2-5	Post-Dam Removal Years 6-10
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Pre-dam removal activities																																							
Seed collection, propagation, container plant material procurement																																							
Pre-construction activities (e.g., staging area preparation)[1]																																							
Invasive exotic vegetation (IEV) control																																							
Iron Gate Hatchery modifications including water supply replacement[2]																																							
Fall Creek Hatchery modifications including water supply[2]																																							
Construction access road, bridge, and culvert improvements[3]																																							
Recreation area facilities removal																																							
Flood improvements																																							
Yreka water supply[4]																																							
J.C. Boyle Dam																																							
~~Modify canal p~~Prepare for drawdown[1]																																							
Power generation[1]																																							
Drawdown																																							
Dam removal																																							
Power generation facilties removal																																							
Transmission line demolition																																							
Copco No. 1 Dam																																							
Modify diversion tunnel, prepare for drawdown[1]																																							
Power generation[1]																																							
~~Dam modifications~~							--	--	--	--	--	--	--																										
Drawdown[5]																																							
Dam removal																																							
Power generation facilities demolition[1,6]												NEW					NEW																						
Transmission line demolition[7]																																							
Copco No. 2 Dam																																							
Power generation[1]																																							
Drawdown[1,8]																																							
Dam removal																																							
Power generation facilities demolition																																							
Transmission line demolition																																							
Iron Gate Dam																																							
Power generation[1]																																							
Dam modifications																																							
Drawdown[9]																																							
Dam removal																																							
Fish holding tanks and spawning building demolition[10]																																							
Power generation facilities demolition																																							
Transmission line demolition[11]																																							
Restoration																																							
Fluvial sediment and habitat[12]																																							
Revegetation activities																																							
Aerial pioneer crop seeding																																							
Salvage and plant existing riparian veg																																							
Pole cutting installation 2021																																							
Pole cutting installation 2022																																							
New recreation area facilities development																																							

Dark grey shading indicates planned activities. Stippled shading represents planning for activities still under development.

1 Definite Plan Section 8.6 Construction Schedule does not explicitly list these tasks. Timing for these tasks provided in KRRC (2018).

2 While the specific timeline is not proposed, Iron Gate Hatchery and Fall Creek Hatchery must be operational prior to reservoir drawdown.

3 Definite Plan - Section 8.6 Construction Schedule does not explicitly list all of the proposed road access improvement items, however they would occur before, during, and after dam removal, as needed.

4 Proposed pipeline relocation would have to occur before Iron Gate Dam removal. The KRRC proposes that the outage associated with the final connections would preferably occur during the winter to avoid disruption to Yreka's water supply.

5 Scheduled from November 3 to March 8.

6 Scheduled from September 30 to December 7.

7 Scheduled from June 18 to July 30.

8 Copco No. 2 Dam drawdown will occur on one day (May 1, ~~2021~~ 2022)

9 Scheduled from January 1 to March 2.

10 Scheduled from January 4 to June 7.

11 Scheduled for one week from June 1 to June 7.

12 Refers to movement of additional sediment in the reservoir footprints to provide tributary connectivity and create wetlands, floodplain and off-channel habitat features. Also includes placement of large woody debris (LWD) features.

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Volume I Section 2.7 Proposed Project – Proposed Project, Figure 2.7-1 Distribution and Life-History Timing of Aquatic Species in the Klamath Basin on page 2-29:

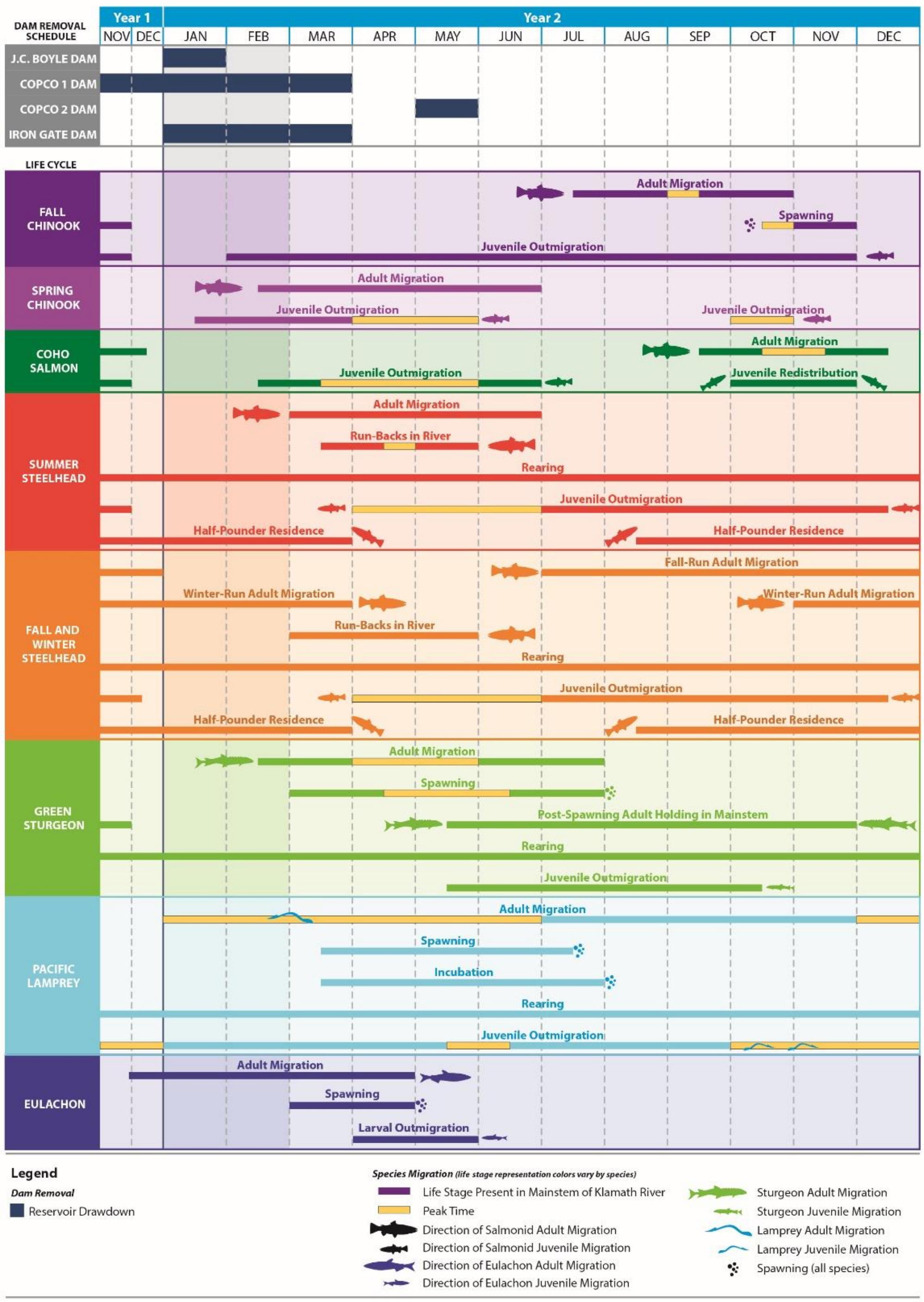

Figure 2.7-1. Dam Removal Schedule and Distribution and Life-History Timing of Aquatic Species in the Klamath Basin. Modified from CDM Smith.

2.7.1 Dam and Powerhouse Deconstruction

2.7.1.2 Copco No. 1 Dam and Powerhouse

Volume I Section 2.7.1.2 Proposed Project – Proposed Project – Dam and Powerhouse Deconstruction – Copco No. 1 Dam and Powerhouse, Table 2.7-2 Copco No. 1 Dam and Powerhouse Decommissioning and Removal Proposal on page 2-31:

Table 2.7-2. Copco No. 1 Dam and Powerhouse Decommissioning and Removal Proposal.

Feature[1]	KRRC Proposal
Concrete Dam	Remove to elevation 2,463.5 feet, which is 20 feet below original river channel bottom
Spillway Gates and Operators, Deck, Piers	Remove
Penstocks	Remove
Powerhouse Intake Structure	Remove
Gate Houses on Right Abutment	Remove
Diversion Control Structure	Remove[2]
Diversion Tunnel ~~Portals~~[3]	Retain ~~the tunnel~~ and plug ~~the tunnel portals~~ with reinforced concrete
Powerhouse (including mechanical and electrical equipment)	Remove
Powerhouse Hazardous Materials (transformers, batteries, insulation)	Remove
Four 69-kv Transmission Lines (3.03 miles total) (including poles and transformers)	Remove
Switchyard	Remove
Warehouse and Residence[4]	Remove

1 Feature as presented in Appendix B: *Definite Plan – Table 5.3-1*.

2 The existing diversion control structure sits just upstream of Copco No. 1 Dam and includes gate hoists, stems, and wire ropes, which would be demolished along with unstable concrete as part of modifying the existing diversion structure prior to reservoir drawdown. Proposed features to modify the existing diversion control structure (i.e., new downstream tunnel gate and portal, new upstream blind flanges) would be removed as part of reservoir drawdown and dam deconstruction.

3 Refers to the Diversion Tunnel shown in Figure 2.7-2. The existing concrete plug in the diversion tunnel would be removed prior to reservoir drawdown. The tunnel would be retained for use as the low-level outlet during reservoir drawdown. Following reservoir drawdown, the tunnel portals would be plugged with reinforced concrete.

4 Refers to the Maintenance Building and the North and South Residences shown in Figure 2.7-2.

Volume I Section 2.7.1.2 Proposed Project – Proposed Project – Dam and Powerhouse Deconstruction – Copco No. 1 Dam and Powerhouse – Construction Access and Road Improvements – Road and Bridge Improvements/Replacements, paragraph 4 on page 2-32:

- Access Road from Long Gulch Recreational Facility to Lakeview Road—some road surface rehabilitation during construction.
- ~~Access Road from Overlook Point Recreational Facility to Copco Road—some road surface rehabilitation during construction.~~

2.7.1.3 Copco No. 2 Dam and Powerhouse

Volume I Section 2.7.1.3 Proposed Project – Proposed Project – Dam and Powerhouse Deconstruction – Copco No. 2 Dam and Powerhouse – Deconstruction Activities, paragraph 2 on page 2-40:

The KRRC's Proposed Project would remove the Copco No. 2 Dam, the unnamed reservoir associated with the Copco No. 2 Dam (hereinafter referred to as Copco No. 2 Reservoir), the Copco No. 2 Powerhouse, and their associated structures and equipment (Table 2.7-4). Additional details are presented in the KRRC's Definite Plan *(*Appendix B: *Definite Plan – Section 5 Dam Removal Approach)*. The KRRC proposes to remove the Copco No. 2 ~~d~~Dam, the associated structures, and drain the reservoir in dam removal year 2 by lowering the reservoir water surface elevation, constructing

Volume I Section 2.7.1.3 Proposed Project – Proposed Project – Dam and Powerhouse Deconstruction – Copco No. 2 Dam and Powerhouse – Deconstruction Activities, Table 2.7-4. Copco No. 2 Dam and Powerhouse Removal Proposal on page 2-42:

Table 2.7-4. Copco No. 2 Dam and Powerhouse Removal Proposal.

Feature[1]	KRRC Proposal
Concrete Dam	Remove
Spillway Gates, Structure	Remove
Power Penstock Intake Structure and Gate	Remove
<u>Conveyance and Overflow Spillway</u> Tunnel~~Portals~~<u>s</u>[2]	Retain the tunnels, plug the tunnel portals with reinforced concrete
Embankment Section and Right Sidewall	Remove
Basin Apron and End Sill	Remove
Remnant Cofferdam Upstream of Dam	Remove
Wood-stave Penstock	Remove
Concrete Pipe Cradles	Remove
Steel Penstock, Supports, Anchors	Remove

Feature[1]	KRRC Proposal
Powerhouse (including mechanical and electrical equipment)	Remove
Powerhouse Hazardous Materials (transformers, batteries, insulation)	Remove
Powerhouse Control Center Building, Maintenance Building, Oil and Gas Storage Building	Remove
69-kV Transmission Line, 0.14 mile	Remove
Switchyard	Retain – the switchyard is not part of the Proposed Project
Tailrace Channel	Backfill
Copco Village (including former cookhouse/bunkhouse, garage/storage building, bungalow with garage, 3 modular houses, 4 ranch-style houses, and school house/community center)	Remove

[1] Feature as presented in Appendix B: *Definite Plan – Table 5.4-1*.
[2] Refers to Conveyance Tunnel and Overflow Spillway Tunnel shown in Figure 2.7-2.

Volume I Section 2.7.1.3 Proposed Project – Proposed Project – Dam and Powerhouse Deconstruction – Copco No. 2 Dam and Powerhouse – Construction Access and Road Improvements, paragraph 1 on page 2-43:

The KRRC proposes to return roads used for the Proposed Project to an acceptable state (i.e., their pre-project condition), including mitigating any potential reduction in function attributed to the dam removal work.

2.7.1.4 Iron Gate Dam and Powerhouse

Volume I Section 2.7.1.4 Proposed Project – Proposed Project – Dam and Powerhouse Deconstruction – Iron Gate Dam and Powerhouse – Deconstruction Activities, paragraph 1 on page 2-46:

The KRRC proposes to remove Iron Gate Dam and its associated facilities following spring runoff of dam removal year 2 (approximately June 1). The embankment dam crest would be retained at a level needed for flood protection, with a minimum flood release capacity of approximately 4,200 cfs in June, ~~7,000~~3,000 cfs in July (reservoir water surface elevation 2,242.3 feet) and 3,000 cfs in August and September (reservoir water surface elevation 2,194.3 feet), in order to accommodate the passage of at least a 1 percent probable flood for that time of year. Excavation of the embankment section at Iron Gate Dam would not begin before June 1 of dam removal year 2, and it would be complete by September 30 to minimize the risk of flood overtopping. During excavation, rockfill would be temporarily stockpiled for placement on the downstream slope of a temporary cofferdam. Throughout excavation, access would be provided to the gate control house at the base of the intake tower for flow control.

2.7.2 Reservoir Drawdown

Volume I Section 2.7.2 Proposed Project – Proposed Project – Reservoir Drawdown, paragraph 3 on page 2-57:

According to the KRRC's Reservoir Drawdown and Diversion Plan (Appendix B: *Definite Plan*), the drawdown of Copco No. 1 and Iron Gate reservoirs would be managed through automated gate control systems with operator oversight, where inputs to determine the amount of gate opening at each reservoir would include continuous measurement of reservoir levels by remote sensor. The gate control system would incrementally open (or close) the gate to increase (or decrease) flow through the diversion tunnels (14-foot by 16-foot each) to maintain ~~the reservoir~~ drawdown of the reservoirs at an approximately constant rate. This ~~will~~ would allow the project to maintain embankment and reservoir rim stability even as reservoir inflows vary. For example, flows may vary due to storms or changes in upstream reservoir releases.

Volume I Section 2.7.2 Proposed Project – Proposed Project – Reservoir Drawdown, paragraph 4 on page 2-57:

Once the Copco No. 1 and Iron Gate reservoirs have been fully drawn down, the diversion control gates would remain in the fully open position to limit reservoir refilling during storm events. Any storm inflows large enough to cause ~~partial~~ complete refilling of these reservoirs would ~~pass through~~ activate the spillway at each dam. ~~, unless~~ If ~~spillway~~ outflows reach a pre-determined level (13,000 ~~-~~cfs for Copco No. 1 and 15,000 cfs for Iron Gate), then ~~. If these levels are reached~~ the diversion control gates would be closed (or partially closed) until the flow drops below this level to avoid high water levels that would impact the Copco No. 2 Powerhouse (which could still be operating until May 1), or that would result in flows downstream of Iron Gate Dam that are greater than the 10-year peak flow.

As noted above, removal of Copco No. 1 Dam sections and Copco No. 2 Dam would begin after May 15 of dam removal year 2, and removal of Iron Gate would occur between June 1 and September 30 of dam removal year 2, such that during the spring snowmelt period the dams would retain their existing flood capacity. During ~~dam~~ removal of all four dams, ~~the drawdown of~~ Iron Gate Reservoir would need to maintain enough capacity to pass a 1 percent probable flood ~~for that time of year~~, in order to reduce the potential for flow to overtop the Iron Gate Dam embankment. The following minimum flood release capacities by month would be maintained during drawdown of Iron Gate Reservoir:

- June—approximately ~~7,700~~ 4,200 cfs
- July—approximately ~~7~~ 3,000 cfs
- August/September—approximately 3,000 cfs

Volume I Section 2.7.2 Proposed Project – Proposed Project – Reservoir Drawdown, paragraph 5 on page 2-57:

As noted above, removal of Copco No. 1 Dam sections and Copco No. 2 Dam would begin after May 15 of dam removal year 2, and removal of Iron Gate would occur between June 1 and September 30 of dam removal year 2. During ~~dam~~ removal of all four dams, ~~the drawdown of~~ Iron Gate Reservoir would need to maintain enough capacity to pass a 1 percent probable flood ~~for that time of year~~, in order to reduce the potential for flow to overtop the Iron Gate D~~d~~am embankment. The following minimum flood release capacities by month would be maintained during drawdown of Iron Gate Reservoir:

- June—approximately ~~7,700~~4,200 cfs
- July—approximately ~~7~~3,000 cfs
- August/September—approximately 3,000 cfs

Volume I Section 2.7.2 Proposed Project – Proposed Project – Reservoir Drawdown, paragraph 1 on page 2-58:

Drawdown of J.C. Boyle Reservoir would be initially controlled by the capacity of the opened spillway, followed by the capacity of the opened power intake. Once the reservoir stabilizes with spillway and intake fully open, the diversion culverts would be opened, and drawdown would only be controlled by the capacity of the diversion culverts, which is approximately 6,000 cfs at the spillway elevation. For storm flows that fully refill the reservoir before deconstruction, higher discharge rates would be experienced over the spillway. Removal of J.C. Boyle Dam itself (dam excavation) would begin in mid-June of dam removal year 2, such that the dam would retain its existing flood capacity during the peak snowmelt period. Drawdown of J.C. Boyle Reservoir would maintain a minimum flood release capacity of 3,500 cfs, in order to accommodate the passage of at least a 1 percent probable flood for May through September and prevent flood overtopping of the dam embankment during dam removal.

Volume I Section 2.7.2 Proposed Project – Proposed Project – Reservoir Drawdown, paragraph 2 on page 2-58:

The resulting range of release flows due to drawdown of the three larger reservoirs is provided in ~~Table 2.7-8~~ Table 2.7-9. Release flows would add water to the otherwise existing flows in the river (i.e., Keno Reservoir releases and tributary inflows). The percent increase in the Klamath River caused by the minimum average and maximum average release flows compared to the 2-year and 10-year peak flows in the Klamath River at individual locations for each reservoir are also detailed in ~~Table 2-7.8~~ Table 2.7-9. The 2-year and 10-year peak flows are calculated from the available USGS flow gage data in the Klamath River below J.C. Boyle Dam for J.C. Boyle Reservoir, in the Klamath River downstream of Fall Creek at the upstream end of Copco No. 1 Reservoir, and in the Klamath River downstream of Iron Gate Dam for Iron Gate Reservoir. Details for the release flow modeling and the associated assumptions are provided in Section 3.6.5.1 *Flood Hydrology* of this EIR.

2.7.3 Reservoir Sediment Deposits and Erosion During Drawdown

Volume I Section 2.7.3 Proposed Project – Proposed Project – Reservoir Sediment Deposits and Erosion During Drawdown, paragraph 3 on page 2-60:

Sediment accumulated in the Lower Klamath Project reservoirs is primarily composed of silt-sized particles of organic material from dead algae, silt, and clay (fine sediment) with lesser amounts of cobble and gravel (coarse sediment) (USBR 2012a). Figures 2.7-7, 2.7-8, and 2.7-9 show the spatially distributed average sediment thickness in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs, and Figures 2.7-5 and 2.7-6 show the associated bathymetry in Copco No.1 and Iron Gate reservoirs. ~~The distribution of sediment deposits varies within each of the reservoirs~~. Distance from the dam, water depth, and distance from the source (i.e., mainstem Klamath River and tributaries) explain the spatial distribution of sediment accumulated in each impoundment. In J.C. Boyle Reservoir, sediment accumulation occurs primarily ~~resides~~ in the area nearest the dam, with measured sediment thicknesses ranging from 0 to 2 feet in the middle and upper portions of the reservoir to over 18 to 20 feet near the dam (Figure 2.7-7). ~~Figure 2.7-7 presents the estimated average sediment thickness throughout the reservoir based on measurements.~~ J.C. Boyle Reservoir does not contain substantial reservoir sediment deposits upstream of approximately 4,000 feet of the dam, likely due to higher water velocities causing sediment to bypass this area (USBR 2010). The upper 5,000 feet of J.C. Boyle Reservoir, near the inlet, primarily hosts coarse grained sediment, with only local accumulations of fine-grained sediment (USBR 2010).

There is substantial sediment accumulation (8 to 10 feet) in Copco No. 1 Reservoir within approximately 4,000 feet of the dam (Figure 2.7-8). Less sedimentation occurs in shallower water in more upstream areas and around the reservoir periphery (Figure 2.7-8). Tributaries to the reservoir do not contribute substantial sediment (USBR 2010). This spatial pattern of sediment accumulation in Copco No. 1 Reservoir is affected by the historical river channel, with higher total accumulation in deeper water over the historical bed. Approximately 4,000 feet upstream of the dam, sediment accumulation reduces to 6 to 8 feet and then to 4 to 6 feet within about 3,000 feet of the reservoir inlet. These sediment accumulation patterns reflect a transition to shallower water (Figure 2.7-5). Only the upper 6,200 feet of the Copco No. 1 Reservoir has significant deposits of coarse-grained sediment (USBR 2010).

The sediment accumulation pattern in Iron Gate Reservoir (Figure 2.7-9) is similar to Copco No.1 Reservoir, with the highest total sediment accumulation (4 to 5 feet) in deeper water (Figure 2.7-6) within approximately 5,000 feet of the dam. Iron Gate Reservoir has numerous tributaries that discharge significant sediment volumes into the reservoir.~~Both Copco No. 1 and Iron Gate reservoirs have generally even distributions of sediment with thicknesses increasing towards the dams. Figures 2.7-8 and Figure 2.7-9 show the estimated average sediment thickness based on position in the reservoir. The measured thickness of Copco No. 1 Reservoir sediment ranges from approximately 1.2 feet to approximately 10 feet.~~ The maximum deposition within the thalweg (original river channel) of Iron Gate Reservoir is approximately~~ around~~ 5 feet, with a maximum measured deposition thickness of ~~nearly 10~~9.2 feet in the Jenny Creek arm of the reservoir (see Table 5-13 of USBR 2012b).~~, while t~~ The minimum measured sediment thickness is approximately 0.3 feet near the upstream end of the reservoir (see Table 5-12 of USBR 2012b). Similar to Copco No. 1, only the upper 6,000 feet of the reservoir has a significant percentage of sand (USBR 2010).

In February 2018, KRRC collected eleven sediment cores at Copco No. 1 Reservoir to characterize and analyze the stability of the sediment deposits present around much of the rim of the reservoir and within the reservoir bed, and three sediment cores at Iron Gate Reservoir to characterize past landslides and to inform design of the replacement water supply pipeline for the City of Yreka (EIR Appendix B: *Definite Plan – Appendix E*). No sediment cores were collected at J.C. Boyle Reservoir. Although the coring data were collected for a separate purpose, results from the 2018 subsurface investigations by KRRC confirm the results of prior studies (Shannon and Wilson 2006; USBR 2010) that characterized the reservoir sediment deposits as primarily fine materials (organics, silt, clay) including diatomite, with lesser amounts of coarse materials including sand, cobble, and gravel (Appendix B: *Definite Plan – Appendix E*). Results from KRRC's 2018 subsurface investigations indicate that the reservoir deposits are underlain by volcanic bedrock. Overall, the 2018 sediment core data do not change the estimates of reservoir sediment deposits under existing conditions or at the time of dam removal, nor do they change the anticipated degree or pattern of sediment erosion that would occur during drawdown, as discussed below.

Volume I Section 2.7.3 Proposed Project – Proposed Project – Reservoir Sediment Deposits and Erosion During Drawdown, paragraph 1 on page 2-65:

The current volume and weight of sediment for each reservoir is presented in Table 2.7-10~~9~~. The uncertainty in the sediment volume estimates is due to interpolation between the 28 to 31 drill holes in each reservoir (USBR 2012a). ~~While the uncertainty in the sediment volume estimate is noticeable, t~~The analysis of sediment erosion potential for the reservoirs is not sensitive to the degree of uncertainty in the volume estimates. Whether the actual reservoir sediment volumes are on the higher end or the lower end of the uncertainty estimate, the dam removal approach and the significance of potential impacts due to sediment transport during reservoir drawdown would remain the same. Sediments as they are deposited in the reservoirs are generally presented in terms of volume, since the sediment volume was measured by the sediment cores taken in each reservoir. However, sediments are typically discussed in terms of mass once they are transported from the reservoir footprints, since the sediment mass would remain constant.

Volume I Section 2.7.3 *Proposed Project – Proposed Project – Reservoir Sediment Deposits and Erosion During Drawdown, paragraph 3 on page 2-65:*

Sediment jetting would be focused in the six areas where restoration actions are proposed within the Copco No. 1 Reservoir footprint (see enumerated areas for wetlands, floodplains, and off-channel habitat features, and associated yellow triangles depicting areas of tributary connectivity, in Figure 2.7-11) and the three areas where restoration actions are proposed within the Iron Gate Reservoir footprint (see enumerated areas for wetlands, floodplains, and off-channel habitat features, and associated yellow triangles depicting areas of tributary connectivity, in Figure 2.7-12).

Volume I Section 2.7.3 *Proposed Project – Proposed Project – Reservoir Sediment Deposits and Erosion During Drawdown, footnote 12 on page 2-65:*

[12] Since submitting the original application, KRRC has revised its projection for the year of primary drawdown to be ~~2021~~2022, rather than 2020 (KRRC 2019a). Between 2020 and ~~2021~~2022, the sediment volume present behind the dams is expected to increase by approximately 19,600 cubic yards per year (39,200 cubic yards for two years) in J.C. Boyle Reservoir, 81,300 cubic yards per year (162,600 cubic yards for two years) in Copco No. 1 Reservoir, and 100,000 cubic yards per year (200,000 cubic yards for two years)~~approximately 81,300 cubic yards in Copco No. 1 Reservoir and approximately 100,000 cubic yards in~~ Iron Gate Reservoir based on estimates of annual sedimentation rates for each reservoir (USBR 2012b). The expected increase in sediment volume between 2020 and ~~2021~~2022 is an order of magnitude less than the range of the 2020 total sediment volume estimates, so model results using the 2020 sediment volumes would still be applicable to the Proposed Project.

2.7.4 Restoration Within the Reservoir Footprint

2.7.4.2 Reservoir Restoration Features

Volume I Section 2.7.4.2 Proposed Project – Proposed Project – Restoration Within the Reservoir Footprint – Reservoir Restoration Features, paragraph 1 on page 2-72:

Sediment jetting would be focused in the six areas where restoration actions are proposed within the Copco No. 1 Reservoir footprint (see enumerated areas for wetlands, floodplains, and off-channel habitat features, and associated yellow triangles depicting areas of tributary connectivity, in Figure 2.7-11) and the three areas where restoration actions are proposed within the Iron Gate Reservoir footprint (see enumerated areas for wetlands, floodplains, and off-channel habitat features, and associated yellow triangles depicting areas of tributary connectivity, in Figure 2.7-12).

Volume I Section 2.7.4.2 Proposed Project – Proposed Project – Restoration Within the Reservoir Footprint – Reservoir Restoration Features, Figure 2.7-11 Restoration Actions Identified for the Copco No. 1 Reservoir Area (Appendix B: Definite Plan − Appendix H) caption on page 2-75:

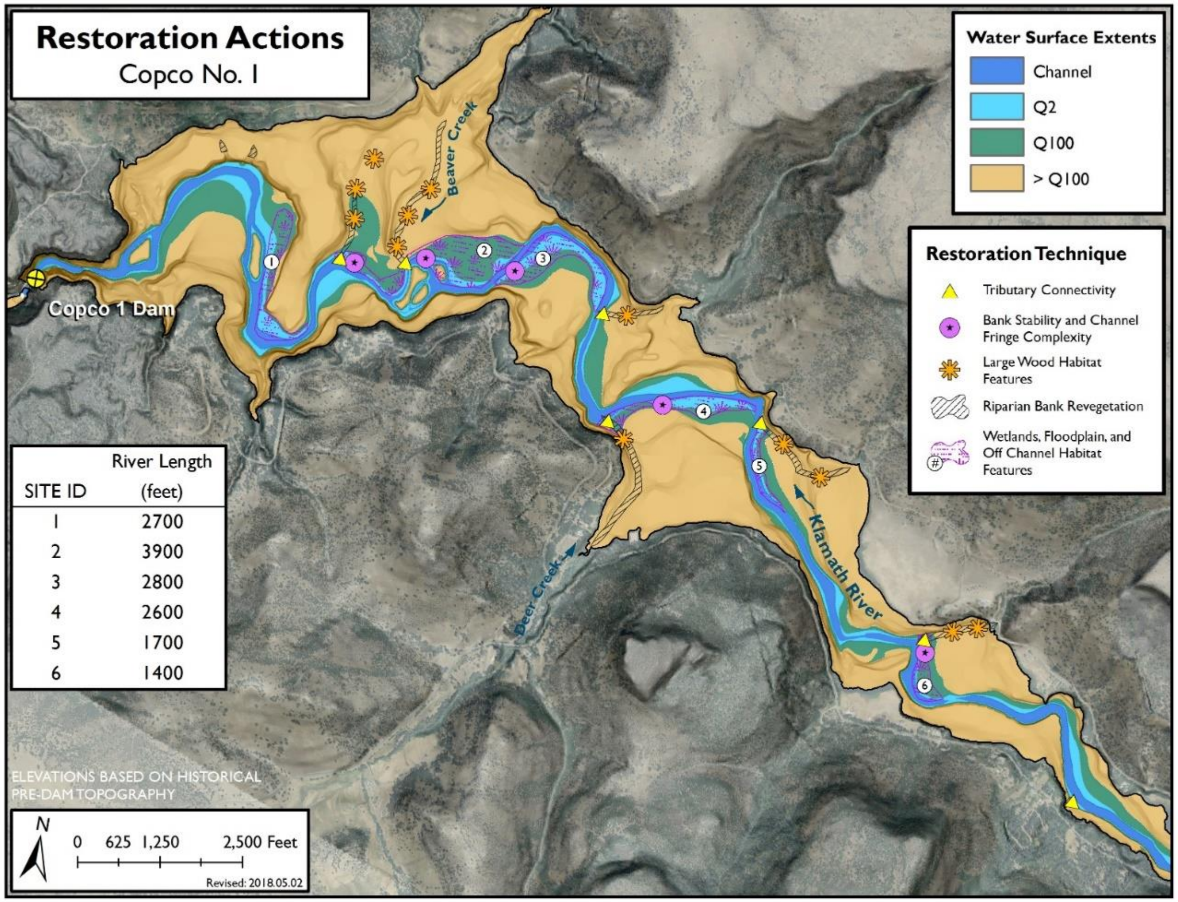

Figure 2.7-11. Conceptual Restoration Actions Identified for the Copco No. 1 Reservoir Area (Appendix B: *Definite Plan − Appendix H*).

Volume I Section 2.7.4.2 Proposed Project – Proposed Project – Restoration Within the Reservoir Footprint – Reservoir Restoration Features, Figure 2.7-12. Restoration actions identified for the Iron Gate Reservoir area (Appendix B: Definite Plan − Appendix H) caption on page 2-76:

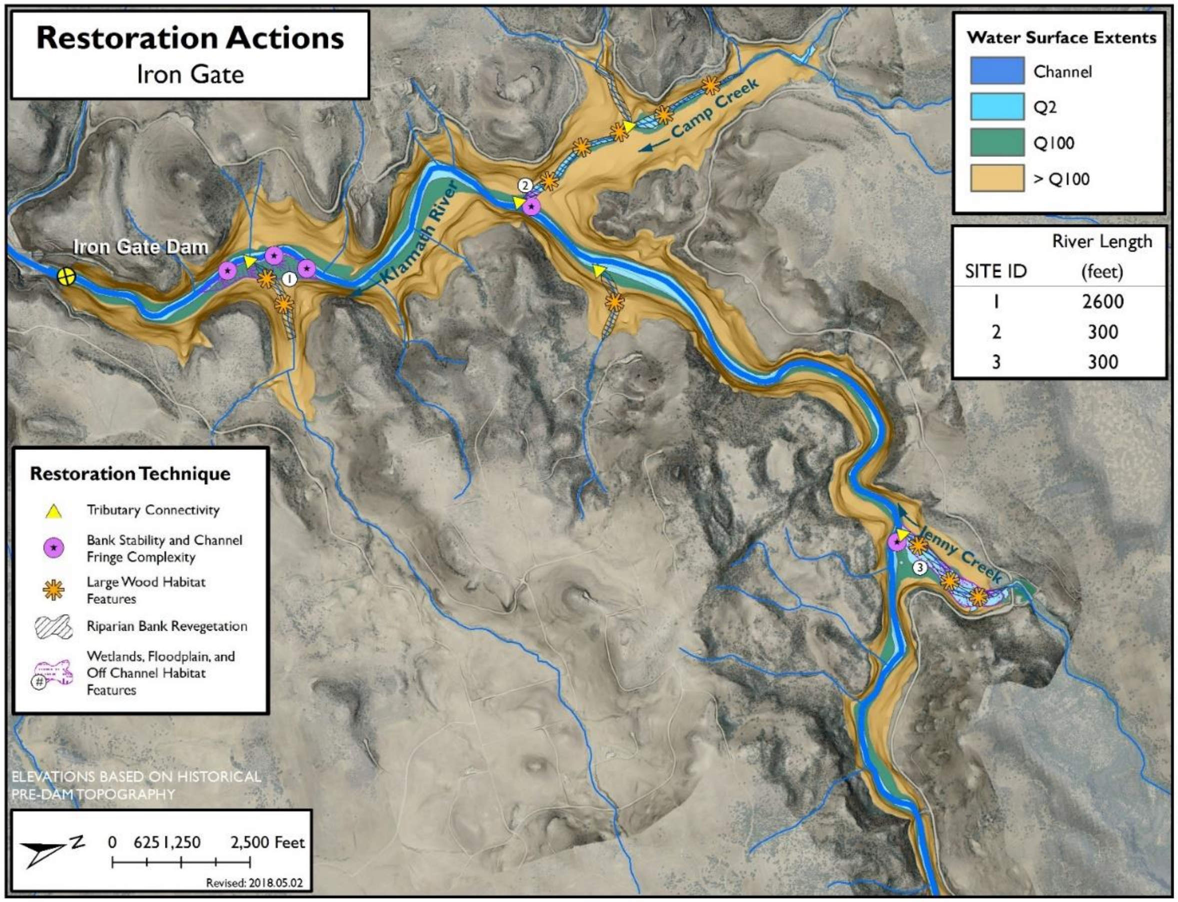

Figure 2.7-12. Conceptual Restoration Actions Identified for the Iron Gate Reservoir Area (Appendix B: *Definite Plan − Appendix H*).

2.7.6 Hatchery Operations

2.7.6.1 Iron Gate Hatchery

Volume I Section 2.7.6.2 Proposed Project – Proposed Project – Hatchery Operations – Iron Gate Hatchery, paragraph 1 on page 2-78:

This water would operate the Iron Gate Hatchery incubation building, two 300-foot adult holding ponds, three 400-foot raceway, and an auxiliary adult fish ladder and trap ~~(to replace the one removed from the base of Iron Gate Dam during demolition)~~.

2.7.6.2 Fall Creek Hatchery

Volume I Section 2.7.6.2 Proposed Project – Proposed Project – Hatchery Operations – Fall Creek Hatchery, paragraphs 1 and 2 on page 2-81:

The KRRC also proposes to reopen the nearby Fall Creek Hatchery, as directed by NMFS and CDFW (2018). The KRRC proposes to reopen Fall Creek Hatchery with upgraded facilities (e.g., install circular tanks, UV treatment system, renovate existing raceways, upgrade plumbing, etc.) for raising coho salmon and Chinook salmon yearlings within the existing facility footprint and an area adjacent to the upper raceways (Figure 2.7-15). Additional space requirements needed for most operations (e.g., vehicle parking, pertinent buildings, tagging trailer, etc.) can be accommodated on existing developed or disturbed areas around the hatchery and powerhouse, but the settling pond would need to be located outside of this area. The settling pond would be constructed on one of ~~two~~ three potential nearby sites located on Parcel B lands downstream of the Fall Creek Hatchery, including a location at the existing lower raceways at the hatchery, with a minimally buried or at-grade conveyance pipeline transporting flows from the hatchery to the settling pond. Selection of the settling pond site is pending cultural resources investigations and consultation with tribes with historical and cultural connection to the area.

To operate the Fall Creek Hatchery, up to 10 cfs of water would be diverted from the PacifiCorp Fall Creek powerhouse return canal downstream of the City of Yreka's diversion facility at Fall Creek Dam A. Hatchery water would be diverted from Fall Creek Dam B through a pipeline to Dam A during periods when the powerhouse return canal is not flowing. The KRRC has proposed to use 0.33 cfs from the optional diversion point located upstream of the City of Yreka's Dam B on Fall Creek. The KRRC proposes to use water from the optional diversion for egg incubation at Fall Creek Hatchery and proposes that this diversion would be part of the 10 cfs maximum diversion for operation of the hatchery. While the Definite Plan specifies diverted water would be returned to Fall Creek at the fish ladder located in the lower tank area or the settling pond location (Appendix B: *Definite Plan −Section 7.8.3*), an October 2018 update specifies the upper rearing tank would discharge diverted water directly to Fall Creek, the lower rearing tank would discharge to the fish ladder adjacent to the tank, and the settling pond would discharge to Fall Creek further down, but upstream of the USGS 11512000 gage on Fall Creek (S. Leonard, AECOM as KRRC Technical Representative, pers. comm., ~~October~~ November 2018). Fall Creek diverted water would be gravity fed and plumbed to each rearing location and all circular tanks. Specific diversion rates from Fall Creek would be as follows:

Volume I Section 2.7.6.2 Proposed Project – Hatchery Operations – Fall Creek Hatchery, paragraph 3 on page 2-81:

Fall Creek from the three hatchery discharge points (i.e., upper tank, fish ladder near the lower tank, and settling pond) upstream of the compliance point for the City of Yreka diversion, the USGS 11512000 gage on Fall Creek approximately 1,000 feet upstream of Daggett Road (S. Leonard, AECOM as KRRC Technical Representative, pers. comm., ~~October~~ November 2018).

Volume I Section 2.7.6.2 Proposed Project – Proposed Project – Hatchery Operations – Fall Creek Hatchery, paragraph 1 on page 2-82:

Total hatchery production goals for Fall Creek Hatchery are presented in Table 2.7-13. Following the eight-year period, Fall Creek Hatchery would cease operations. ~~As Fall Creek Hatchery is part of PacifiCorp's Klamath Hydroelectric Project No. 2082, the existing Fall Creek hatchery facilities are subject to the terms of any new FERC action for Project No. 2082.~~ It is currently unclear whether the Fall Creek Hatchery facility would be decommissioned in place, demolished, or partly or fully repurposed after the eight-year operational period. If Fall Creek Hatchery is opened as currently proposed, its modifications and operations would fall within the terms of any FERC decommissioning license.

Volume I Section 2.7.6.2 Proposed Project – Proposed Project – Hatchery Operations – Fall Creek Hatchery, Figure 2.7-15 on page 2-83:

Figure 2.7-15. Fall Creek Hatchery Existing Features and Proposed Modifications. Specific details regarding the location of facilities at the re-opened hatchery are subject to minor changes within the Limits of Work.

2.7.7 City of Yreka Water Supply Pipeline Relocation

Volume I Section 2.7.6 Proposed Project – Proposed Project – Hatchery Operations – Fall Creek Hatcher, Figure 2.7-15 on page 2-83:

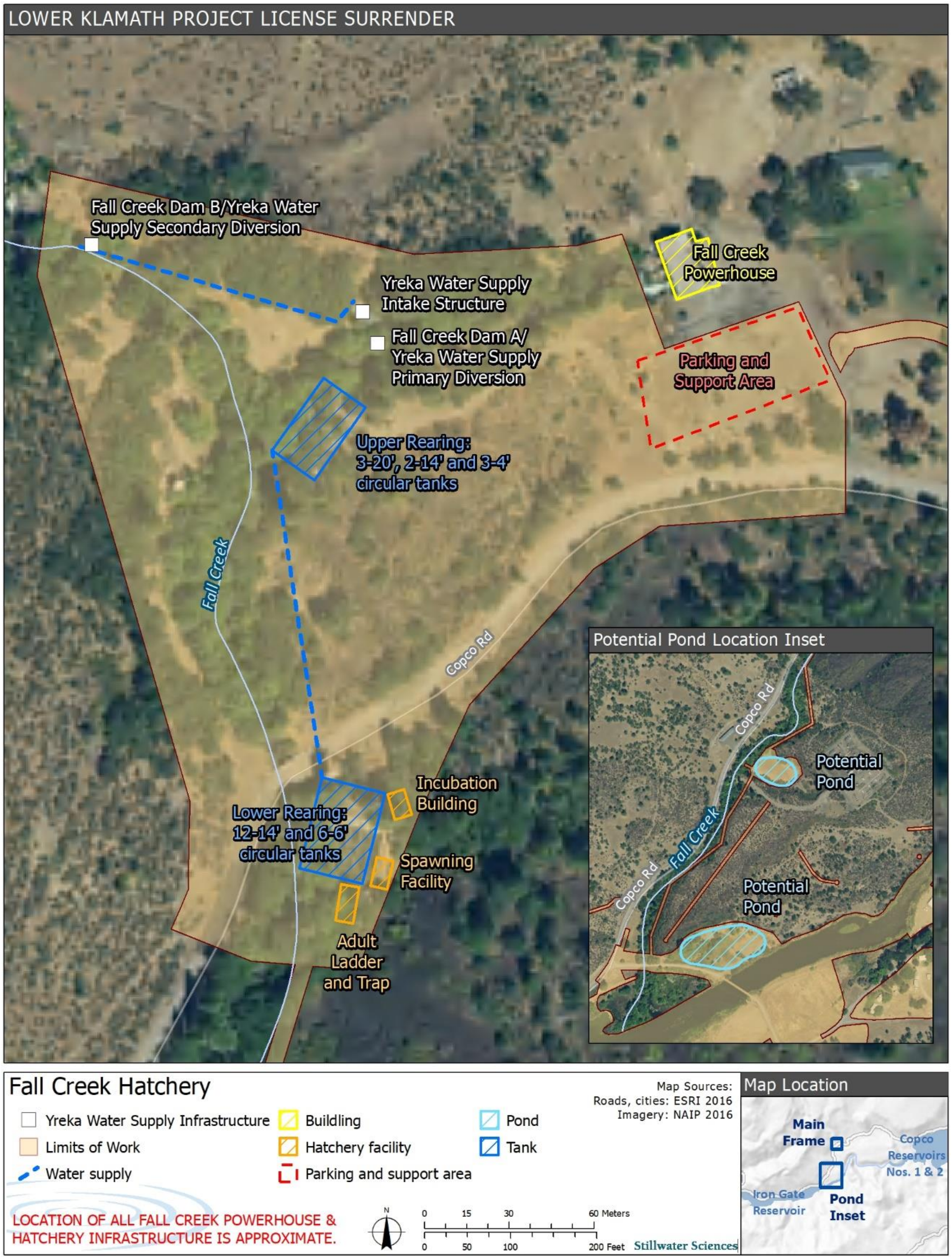

Figure 2.7-15. Fall Creek Hatchery Existing Features and Proposed Modifications. Specific details regarding the location of facilities at the re-opened hatchery are subject to minor changes within the Limits of Work.

Volume I Section 2.7.7 Proposed Project – Proposed Project – City of Yreka Water Supply Pipeline Relocation, paragraphs 1 and 2 on page 2-85:

Additionally, the existing flat panel fish screens for the water supply intakes at Dams A and B may not meet current regulatory agency screen criteria for anadromous fish (USBR 2012a). These fish screens would have to meet the criteria from NMFS, USFWS, and CDFW, and would require updates, if found to be non-compliant. The KRRC recently has proposed to include a permanent fish passage barrier at the Fall Creek Hatchery, located approximately 200 to 300 feet downstream of both Dams A and B (KRRC 2019b), such that there would be no need for updates to the City of Yreka's Dam A or B existing diversion intake structures.

Conceptual level buried and aerial relocation crossings of the pipeline across the Klamath River have been identified for feasibility and further evaluation. It is desired that any buried crossing should have adequate cover to compensate for the vertical scour during dam removal and the subsequent variations in the river flows and longitudinal profile. As the construction of the relocated crossing needs to happen prior to Iron Gate Dam removal, the cover over the pipe would likely have to exceed 12 feet. An open-cut construction approach would therefore, potentially require significant sediment and rock excavation under water and is not considered as a viable option. Considering this, the KRRC has identified and is proposing one of the following three options for the reconstruction of the Klamath River crossing of the Yreka pipeline:

1. A new buried pipeline by micro-tunneling in the immediate vicinity of the existing waterline crossing.
2. A new aerial pipeline on a dedicated utility pipe crossing in the immediate vicinity of the existing waterline crossing.
3. A new buried pipeline and an aerial pipeline crossing on a new ~~the existing timber traffic~~ bridge along Daggett Road located approximately 2,000 feet upstream of the existing waterline crossing. The new bridge would be of similar length and width as the existing bridge and would be located adjacent to the existing bridge on a revised road alignment.

The alignments for the three options are illustrated in Figure 2.7-17 and detailed in Appendix B: *Definite Plan*.

2.7.8 Other Project Components

Volume I Section 2.7.8 Proposed Project – Proposed Project – Other Project Components, Table 2.7-14. Summary of Other Project Components on page 2-52:

Framework and initial requirements; Phase ~~1~~I assessment in 2018

Volume I Section 2.7.8.5 Proposed Project – Proposed Project – Other Project Components – Cultural Resources, paragraph 3 on page 2-95:

The Draft Cultural Resources Plan, submitted with the Definite Plan ~~CITE~~, describes Section 106 consultation completed by the date of submission and led by KRRC,~~ and PacifiCorp,~~ acting as FERC's non-federal representative~~s~~, for carrying out consultation pursuant to Section 106, ~~and~~ as well as the status of consultation with affected tribes and other tribal organizations. PacifiCorp is also a non-federal representative for FERC, but has not been actively involved in the consultation process.

Volume I Section 2.7.8.7 Proposed Project – Proposed Project – Other Project Components – Water Quality Monitoring and Construction BMPs, paragraph 1 on page 2-98:

The water quality parameters measured at each of the monitoring locations in the Water Quality Monitoring Plan is summarized in Table 2.7-18. Time-series (continuous) water quality and stream discharge data along with discrete water quality samples would be collected to assess the water quality impacts of the Proposed Project. The Water Quality Monitoring Plan also contains laboratory testing of reservoir sediment samples collected ~~in~~ by KRRC from November 28, 2017 to December 1, 2017 ~~by the USGS~~ to develop an SSC versus turbidity relationship for the reservoir sediments, including a laboratory protocol for the SSC/turbidity relationship to identify the accuracy and reliability of the relationship along with any uncertainties and specific field verification testing necessary during dam removal.

2.7.9 KHSA Interim Measures

Volume I Section 2.7.9 Proposed Project – Proposed Project – KHSA Interim Measures, Table 2.7-19. KHSA Interim Measures Relevant to California Under Existing Conditions and the Proposed Project, row 1 (IM1 – Interim Measures Implementation Committee [IMIC]) column 5 (Proposed Project) on page 2-103:

Would not continue and cease to exist when the KHSA is fully implemented
~~Would continue separate from the Proposed Project~~[2]

2.7.10 Land Disposition and Transfer

Volume I Section 2.7.10 Proposed Project – Proposed Project – Land Disposition and Transfer, paragraph 1 on page 2-108:

The Proposed Project includes the transfer of PacifiCorp lands immediately surrounding the Lower Klamath Project ("Parcel B lands") (Figure 2.7-18) from PacifiCorp to the KRRC prior to dam removal (this transfer is the subject of the KRRC's ~~*a separate*~~ *Joint Application for Approval of License Amendment and License Transfer* submitted to FERC ~~application~~ on September 23, 2016). The

Proposed Project then provides that following dam removal, the KRRC would transfer Parcel B lands to the states, or to a designated third-party transferee. The lands would thereafter be managed for public interest purposes (e.g., tribal mitigation, river-based recreation, wetland restoration, etc.) (KHSA Section 7.6.4). Pursuant to the KHSA, decisions about the land transfer would occur following dam removal, and the outcome of who the lands will ultimately be transferred to and what they will be used for is uncertain. While this draft EIR analyzes the disposition and transfer of Parcel B lands at a general level, the specific impacts associated with the transfers and any future land uses remain uncertain.

2.9 References

Volume I Section 2.9 Proposed Project – References, pages 2-111 through 2-113, includes the following revisions:

Braunworth, W. S., and T. Welch, R. Hathaway. 2002. Water allocation in the Klamath Reclamation Project, 2010: an assessment of natural resource, economic, social, and institutional issues with a focus on the Upper Klamath Basin. Special Report 1037 dated December 2002.

CDFG (California Department of Fish and Game). 2004. September 2002 Klamath River fish-kill: final analysis of contributing factors and impacts. Northern California-North Coast Region. Redding, California.

Kann, J., and S. Corum. 2006. Summary of 2005 toxic Microcystis aeruginosa trends in Copco and Iron Gate reservoirs on the Klamath River, CA. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon and the Karuk Tribe Department of Natural Resources for the Karuk Tribe Department of Natural Resources, Orleans, California.

KRRC (Klamath River Renewal Corporation). 2019a. Preliminary wetland impacts and restoration schedule – Copco and Iron Gate. Prepared by KRRC Technical Representatives: AECOM Technical Services Inc., Oakland, California, CHM Smith, Portland, Oregon, and River Design Group, Corvallis, Oregon.

KRRC. 2019b. Request for section 401 water quality certification; application for surrender of license for major project and removal of project works; FERC Project No. 2082-063 and 14803-001 (Lower Klamath Project). Prepared by KRRC, Berkeley, California for State Water Resource Control Board, Sacramento, California.

NMFS (National Marine Fisheries Service). 2006. Decision in the matter of Klamath Hydroelectric Project, FERC Project Number 2082. Docket Number 2006-NOAA Fisheries Service-0001, September 27, 2006. Alameda, California.

Available at:
http://www.fws.gov/yreka/P2082/20060927/2Klamath_DNO_Final.pdf.

PacifiCorp. 2015. Licensed hydropower development recreation reports, FERC Form 80. Docket no. P-2082. Prepared for FERC.

USBR (U. S. Bureau of Reclamation). 2010. Klamath River Sediment Sampling Program, Phase I – Geologic Investigations. September.

Other references cited as part of text included in the Section 2 list of revisions:

FERC (Federal Energy Regulatory Commission). 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027, FERC/EIS-0201F. Washington, D.C., Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing. https://www.ferc.gov/industries/hydropower/enviro/eis/2007/11-16-07.asp

KRRC (Klamath River Renewal Corporation). 2018. Comments on Draft Water Quality Certification for Klamath River Renewal Corporation's Lower Klamath Project, Federal Energy Regulatory Commission Project No. 1480. Prepared by KRRC, San Francisco, California for State Water Resources Control Board, Sacramento, California.

NMFS and CDFW (National Marine Fisheries Service and California Department of Fish and Wildlife). 2018. Technical Staff Recommendation for Klamath River Hatchery Operations in California Post-Dam Removal. Arcata, California.

USBR (U. S. Bureau of Reclamation). 2012a. Detailed Plan for Dam Removal – Klamath River Dams, Klamath Hydroelectric Project, FERC License No. 2082, Oregon – California. July 2012. Available from:
https://www.fws.gov/yreka/klamrest.html.

USBR. 2012b. Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado. Available from: https://www.fws.gov/yreka/klamrest.html.

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3 ENVIRONMENTAL SETTING, IMPACTS, AND MITIGATION

3.1 Introduction

3.1.6 Summary of Available Hydrology Information for the Proposed Project

After circulation of the Draft EIR, the applicable biological opinion and the operational flow requirements for the Klamath River changed and changes to this section to address those changes are printed in this Final EIR section. None of the changes result in significant new information in the EIR under the meaning of CEQA Guidelines, section 15088.5, subdivision (a):

> New information added to an EIR is not 'significant' unless the EIR is changed in a way that deprives the public of a meaningful opportunity to comment upon a substantial adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect (including a feasible project alternative) that the project's proponents have declined to implement.

However, the changes were numerous enough that reprinting the section rather than simply including a list of revisions was warranted to improve clarity and readability of the document.

The 2012 KHSA EIS/EIR evaluated the potential environmental impacts of removing J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams. As part of the analyses, Klamath River flows were modeled for periods before, during, and after dam removal in a number of technical studies referenced in the 2012 KHSA EIS/EIR[1], as well as in the environmental document itself. Flow assumptions for the model largely were based on the forecasted operations of the USBR's Klamath Irrigation Project, located in the Upper Klamath Basin. In the 2012 KHSA EIS/EIR, implementation of the Klamath Basin Restoration Agreement (KBRA) (see Section 2.6.3 *Klamath Settlement Agreements*) was considered to be a "connected action" to dam removal. Thus, the model used NMFS 2010 Biological Opinion flows (2010 BiOp Flows) for analysis of the scenario where dams would remain in place, and it modified 2010 BiOp flows based on KBRA operations criteria for the Klamath Irrigation Project (KBRA Flows) for analysis of the scenario where dams would be removed (USBR and CDFG 2012). The KBRA expired on December 31, 2015 due to a lack of Congressional authorization.

[1] Key technical studies are the Klamath River total maximum daily loads (TMDL) Final Staff Report (North Coast Regional Board 2010) and the Hydrology, Hydraulics, and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration (USBR 2012a).

Separate and independent of the Proposed Project, the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) issued a Joint Biological Opinion for the Klamath Irrigation Project in 2013 specifying the hydrology requirements for the Klamath River (2013 BiOp Flows) and the standard to which the USBR Klamath Irrigation Project operated at that time (NMFS and USFWS 2013). Accordingly, the 2013 BiOp Flows served as the USBR Klamath Irrigation Project operational flow requirements for the Klamath River and specified the minimum flow requirements downstream of Iron Gate Dam at the time of the Notice of Preparation for the Lower Klamath Project EIR (i.e., December 22, 2016) and the Draft EIR considered the potential effects of dam removal using the 2013 BiOp Flows to represent existing hydrology for the period May 2013 to March 2019.

The estimated Klamath River flows under 2013 BiOp operations criteria (2013 BiOp Flows) were compared to the flows modeled for the 2012 KHSA EIS/EIR, which adopted KBRA operations criteria (KBRA Flows), to determine whether 2013 BiOp Flows were sufficiently similar that hydrologic model outputs developed for the 2012 KHSA EIS/EIR would still be applicable. The comparison references and builds upon an analysis conducted in the 2012 KHSA EIS/EIR Supplemental Information Report (SIR) (USBR 2016) for the same purpose. USBR (2016) concluded that the relatively small flow differences between 2013 BiOp and KBRA Flows would not substantively alter the conclusions in the 2012 KHSA EIS/EIR for those environmental resources that would be affected by flows (i.e., water quality, aquatic resources, flood risk, recreation). While the specific timing of flows and the likelihood of exceeding a specific flow during individual months changes between the 2013 BiOp and KBRA flows, the range of 2013 BiOp Flows is within the range of modeled KBRA Flows approximately 99.9 percent of the time at Keno and Iron Gate dams, so the previously modeled results are sufficiently representative of the range of flow conditions under 2013 BiOp Flows. Modeled 2013 BiOp Flows less than or greater than modeled KBRA Flows would occur too infrequently (i.e., 0.01 percent of the time or less) to substantially alter the range of flow conditions in the Klamath River or previous model results using KBRA Flows. Additional details are provided in Section 3.1.6.2 *Comparison of Klamath River Flows under 2013 BiOp Operational Criteria versus KBRA Operational Criteria*.

In 2017, a court order required USBR to implement three specific flows in the Klamath River in addition to the 2013 BiOp Flows, as measured immediately downstream of Iron Gate Dam: annual winter-spring surface flushing flows, biennial winter-spring deep flushing flows, and spring-summer emergency dilution flows (U.S. District Court 2017). The court also required that USBR re-initiate consultation with NMFS and the USFWS regarding the effects of the Klamath Irrigation Project operations on coho salmon in the Klamath River and Lost River and shortnose suckers in the Upper Klamath Basin (U.S. District Court 2017).

The flow-related analyses in this EIR acknowledge the re-initiation of consultation on the 2013 BiOp Flows by considering the 2017 court-ordered flushing and emergency dilution flow requirements downstream of Iron Gate Dam as interim flow requirements until completion of formal consultation. The 2017 court-ordered flushing and emergency dilution flows were not modeled as part of existing hydrology conditions for the Proposed Project, because they went into effect in February 2017, after the December 2016 Notice of Preparation was filed. The 2017 court-ordered flushing and emergency dilution flows are analyzed in several locations in this EIR, including, but not limited to, Section 3.24 *Cumulative Effects*, Section 4.2 *No Project Alternative*, and Section 4.4 *Continued Operations with Fish Passage Alternative*, where the aforementioned two alternatives assume that Iron Gate Dam would remain in place.

After the issuance of the Lower Klamath Project Draft EIR on December 27, 2018, the applicable biological opinion and the operational flow requirements for the Klamath River changed again in March 2019, when the new biological opinions were issued by NMFS (2019) and USFWS (2019). The 2019 Biological Opinion flows (2019 BiOp Flows) are now the current operational flow requirement for the Klamath River. The 2019 BiOp Flows are analyzed in the Lower Klamath Project Final EIR as a second CEQA baseline, representing flows under newly defined existing conditions. Inclusion of two existing conditions (i.e., baseline) hydrology regimes in the Lower Klamath Project Final EIR is consistent with CEQA Guidelines section 15125, subdivision (a).

The estimated Klamath River flows under the 2019 BiOp Flows were also compared to the previously modeled KBRA Flows to determine whether 2019 BiOp Flows were sufficiently similar that hydrologic model outputs developed for the 2012 KHSA EIS/EIR would still be applicable. While the specific timing of flows and the likelihood of exceeding a specific flow during individual months changes between the 2019 BiOp and KBRA flows, the range of 2019 BiOp Flows is within the range of modeled KBRA Flows approximately 99.0 percent of the time at Keno Dam and approximately 99.9 percent of the time at Iron Gate Dam, so the previously modeled results are sufficiently representative of the range of flow conditions under 2019 BiOp Flows. Modeled 2019 BiOp Flows outside the range of modeled KBRA Flows at Keno Dam are exclusively due to 2019 BiOp Flows being less than minimum KBRA Flows, with 2019 BiOp Flows never exceeding KBRA Flows. Modeled 2019 BiOp Flows outside the range modeled KBRA Flows would occur too infrequently (i.e., 0.1 percent of the time or less at Keno Dam and 0.01 percent of the time or less at Iron Gate Dam) to substantially alter the range of flow conditions in the Klamath River or previous model results using KBRA Flows.

Based on the above discussion, the sediment transport model developed for the 2012 KHSA EIS/EIR would produce nearly identical suspended sediment concentrations during the main drawdown period between January and May if it was run using 2013 BiOp Flows or 2019 BiOp Flows, because the 2013 BiOp, 2019 BiOp, and KBRA Flows are similar for all water year types (generally within a few percentage points). The detailed analysis presented below assesses the magnitude, timing, and distribution of flows across multiple water years to verify that the range of flows modeled under KBRA Flows are still appropriate for analyses in this EIR.

3.1.6.1 Klamath River Flows under the 2013 BiOp Operations Criteria for the Klamath Irrigation Project

Under the 2013 BiOp Flows, current and future (2013 to 2023) operations of the Klamath Irrigation Project in the Upper Klamath Basin include irrigation deliveries consistent with historic operations (subject to water availability), while maintaining Upper Klamath Lake and Klamath River hydrologic conditions that avoid jeopardizing the continued existence of listed species and adverse modification of designated critical habitat (NMFS and USFWS 2013). Operations under the 2013 BiOp Flows include two distinct, real-time water management approaches during the fall/winter (October through February) and spring/summer (March through September) periods. The fall/winter and spring/summer water management approaches prioritize different goals during the two periods, but they are designed to meet the ecological needs of the Upper Klamath Lake ESA-listed Lost River sucker and shortnose sucker and ESA-listed coho salmon downstream of Iron Gate Dam, while also maintaining full irrigation deliveries in accordance with existing contracts, contingent upon available water supplies.

In general, Klamath River flows during fall/winter and spring/summer are formulaically calculated as specified in the 2013 BiOp to create variable river flows downstream of Iron Gate Dam that approximates the natural hydrology, while ensuring minimum flows are met. The 2013 BiOp Flow requirements are expressed as flows at Iron Gate Dam because the dam is the compliance point for Klamath River flows under the 2013 BiOp. Flows at Iron Gate Dam during fall/winter are determined based on hydrologic indicators of upper Klamath Basin conditions and 2013 operational criteria (e.g., ecological requirements). At the beginning of the spring/summer period (i.e., March 1), an Environmental Water Account (EWA) is calculated to determine the volume of water available from Upper Klamath Lake for Klamath River flows between March 1 and September 30. The EWA volume is updated on the first of April, May, and June to refine the estimate of water volume available for Klamath River flows from July through September. During the later portion of the spring/summer period (i.e., July through September), Klamath River flows are based on the remaining EWA volume and 2013 BiOp operational criteria, including maintaining minimum flows downstream of Iron Gate Dam. Minimum flows downstream of Iron Gate Dam under the 2013 BiOp Flows are presented in Table 3.1-1.

Table 3.1-1. Minimum Klamath River Discharge below Iron Gate Dam under the 2013 BiOp Flows.

Month	Iron Gate Dam Average Daily Minimum Target Flows (cfs)
January	950
February	950
March	1,000
April	1,325
May	1,175
June	1,025
July	900
August	900
September	1,000
October	1,000
November	1,000
December	950

Source: NMFS and USFWS 2013

The 2013 BiOp Flows are primarily formulaically determined by the 2013 BiOp operations criteria, but the 2013 BiOp also includes provisions to vary from the formulaic approach for determining the Klamath River flows to address high flow events, emergency situations, high disease rates, or high water temperatures in the Klamath River downstream of Iron Gate Dam. The 2013 BiOp includes a process for deviations from the 2013 BiOp formulaic use of EWA water, but it does not specify changes in flows that would occur to address ecological objectives, and it requires each proposed deviation to show that it would result in improved ecological conditions for listed species and would not cause an adverse effect to listed species or critical habitat (NMFS and USFWS 2013).

3.1.6.2 Comparison of Klamath River Flows under the 2013 BiOp Operational Criteria and the KBRA Operational Criteria

In the 2012 KHSA EIS/EIR, the projected Klamath River flows were modeled using the Water Resources Integrated Modeling System (WRIMS) coupled with a RiverWare-based model called the Klamath Dam Removal Model (KDRM) (USBR 2012a, 2016). The coupled model was used to analyze the Klamath River conditions using either the 2010 BiOp Flows or the KBRA Flows based on the KBRA operations criteria for the Klamath Irrigation Project. The 2010 BiOp and the KBRA Flows are generally very similar, particularly from January through May when flows are effectively the same between the two flow scenarios (USBR 2012a). The estimated Klamath River flows under the 2013 BiOp Flows were modeled using an updated and modified WRIMS model (USBR 2012b). The WRIMS model used to evaluate the 2013 BiOp Flows is also known as the

Klamath Basin Planning Model (KBPM) and the modeled flow results are sometimes referred to as the “2013 BO” in USBR documents (USBR 2012b, 2016).

In the Draft Environmental Impact Report (EIR), modeled Klamath River flows under the 2013 BiOp and the KBRA operations criteria are compared based on the time period analyzed by USBR (2016), with monthly flow exceedances downstream of Iron Gate Dam and Keno Dam calculated for the 29-year period from 1980 to 2009. However, modeled KBRA Flows from the USBR sediment transport modeling (USBR 2012a) overlap with 2013 BiOp Flows for a longer period, with a 31-year analysis period from 1980 to 2011. The range of potential flow conditions in the Klamath River is better represented by a longer analysis period, so the following comparison of modeled 2013 BiOp and KBRA flows is updated from the Draft EIR to use the 1980 to 2011 modeled KBRA Flows from the USBR sediment transport modeling (USBR 2012a) along with the corresponding 1980 to 2011 modeled 2013 BiOp Flows. As a result, the specific values of annual and monthly average 2013 BiOp and KBRA flows and the monthly flow exceedances below are slightly different from those presented in the Draft EIR, but the overall trends and conclusions of the comparison between 2013 BiOp and KBRA flows remain the same.

Modeled Klamath River flows under the 2013 BiOp and the KBRA operations criteria are nearly identical (i.e., less than 30 cfs different) when examined on an average annual basis, with flows downstream of Iron Gate Dam averaging approximately 1,896 cfs and 1,923 cfs, respectively, during the 1980 to 2011 comparison period when both modeled 2013 BiOp and KBRA Flows are available. The average annual 2013 BiOp and KBRA Flows downstream of Keno Dam from 1980 to 2011 are also nearly identical (i.e., less than 15 cfs different), averaging approximately 1,401 cfs and 1,387 cfs, respectively. While the modeled flows upstream and downstream of the Hydroelectric Reach are within 1.0 to 1.4 percent on an average annual basis, there is a larger difference between the average monthly 2013 BiOp and KBRA flows over the entire 1980 to 2011 comparison period (Tables 3.1-2 and 3.1-3). The most prominent difference is that the 2013 BiOp Flows when compared to KBRA Flows generally require higher flows in the fall months (October through December) and allow lower flows in the summer months (June through August). Downstream of Iron Gate Dam, fall 2013 BiOp Flows average approximately 200 cfs (8 to 19 percent) more than fall KBRA Flows; summer 2013 BiOp Flows average approximately 100 cfs (6 to 16 percent) less than summer KBRA Flows (Tables 3.1-2 and 3.1-3).

Variations in the average monthly 2013 BiOp and KBRA Flows between years are also compared using statistical tests (i.e., paired heteroscedastic t-tests) of the average monthly 2013 BiOp and KBRA Flows for the 31-years between 1980 and 2011, with probability values (p-values) less than 0.05 indicating a significant difference and p-values and less than 0.01 indicating a highly significant difference. (Note: heteroscedastic refers to a dataset with unequal variability or scatter across a set of predictor variables and is generally appropriate for flow data.) At both Iron Gate and Keno dams, p-values demonstrate the average monthly 2013 BiOp and KBRA Flows are statistically different during multiple months throughout the year, especially during fall months (Tables 3.1-2 and 3.1-3). Consistent with the average monthly flow comparison for all years above (i.e., the 31-year average of the average monthly flows), the calculated p-values show that differences between average monthly 2013 BiOp and KBRA Flows at Iron Gate Dam are highly significant during the fall months of October and November and range from highly significant to significant during the summer months of July and August, respectively. P-values also indicate average monthly 2013 BiOp and KBRA Flows at Iron Gate Dam are significantly different during February and highly significantly different during April. There are also highly significant and significant changes in the average monthly 2013 BiOp and KBRA Flows at Keno Dam, but these changes primarily occur during fall months (October through December) (Table 3.1-3). The calculated p-values document differences between average monthly 2013 BiOp and KBRA Flows at Keno Dam are highly significant in October and November and significant in December. Average monthly 2013 BiOp and KBRA Flows at Keno Dam also are highly significantly different in April, but there is no significant difference between average monthly 2013 BiOp and KBRA Flows at Keno during other months (i.e., January through March and May through September). The differences in 2013 BiOp Flows versus KBRA Flows reflect the joint goal of NMFS and USFWS to protect ESA-listed fish that rely on a shared but finite aquatic resource (most notably, the two endangered sucker species in Upper Klamath Lake and threatened coho salmon in the Klamath River below Iron Gate Dam) (NMFS and USFWS 2013).

Table 3.1-2. Average Monthly Flow at Iron Gate Dam From 1980 to 2011 for 2013 Joint Biological Opinion and KBRA Operations Criteria.

Month	Average Monthly Flow Downstream of Iron Gate Dam		Differences (2013 BiOp vs. KBRA Flows)		p-value
	KBRA Operations Criteria	2013 BiOp Operations Criteria			
	(cfs)	(cfs)	(cfs)	(percent)	--
Oct	1069	1260	190	18	2.0E-07
Nov	1147	1367	220	19	2.2E-05
Dec	1579	1699	120	8	0.089
Jan	2032	2021	-10	-1	0.87
Feb	2590	2446	-144	-6	0.042
Mar	3384	3290	-94	-3	0.32
Apr	3344	3072	-272	-8	0.0024
May	2461	2524	63	3	0.48
Jun	1924	1804	-119	-6	0.20

Month	Average Monthly Flow Downstream of Iron Gate Dam		Differences (2013 BiOp vs. KBRA Flows)		p-value
	KBRA Operations Criteria	2013 BiOp Operations Criteria			
	(cfs)	(cfs)	(cfs)	(percent)	--
Jul	1299	1095	-203	-16	0.0037
Aug	1122	1054	-68	-6	0.023
Sep	1190	1163	-27	-2	0.27

Data source: USBR 2010, 2019a.

Table 3.1-3. Average Monthly Flow at Keno Dam From 1980 to 2011 for 2013 Joint Biological Opinion and KBRA Operations Criteria.

Month	Average Monthly Flow Downstream of Keno Dam		Differences (2013 BiOp vs. KBRA Flows)		p-value
	KBRA Operations Criteria	2013 BiOp Operations Criteria			
	(cfs)	(cfs)	(cfs)	(percent)	--
Oct	684	885	200	29	2.9E-07
Nov	743	966	223	30	1.6E-04
Dec	1040	1204	165	16	0.018
Jan	1437	1409	-28	-2	0.67
Feb	1843	1768	-75	-4	0.23
Mar	2601	2548	-53	-2	0.50
Apr	2607	2394	-213	-8	0.0033
May	1835	1952	117	6	0.15
Jun	1456	1374	-82	-6	0.38
Jul	886	772	-114	-13	0.11
Aug	745	749	4	1	0.90
Sep	814	825	11	1	0.69

Data source: USBR 2010, 2019a.

Figures 3.1-1 and 3.1-2 present monthly flow exceedances for modeled 2013 BiOp and KBRA Flows downstream of Iron Gate Dam and Keno Dam, respectively, for the 31-year period from 1980 to 2011, where this period encompasses water year types ranging from very dry to very wet. Flows with a 1 to 99 percent probability of occurring at Iron Gate or Keno dam are shown in the monthly flow exceedance curves, but they do not display the upper maximum flows (i.e., exceedance probability less than 1 percent) or lower minimum flows (i.e., exceedance probability greater than 99 percent) that may occur under 2013

BiOp and KBRA operations criteria. Figures 3.1-1 and 3.1-2 also present the results of the paired heteroscedastic t-tests of the average monthly 2013 BiOp and KBRA Flows for the period 1980 to 2011, with highly significant differences between the average monthly 2013 BiOp and KBRA Flows shown in bright yellow and significant differences between the average monthly 2013 BiOp and KBRA Flows shown in light yellow. Monthly flow exceedance plots are particularly useful for comparing differences between modeled 2013 BiOp and KBRA Flows for different water year types (i.e., wet, median, and dry year types) since exceedance curves present the probability a flow would occur. Here, a wet year type is defined as the highest 10 percent of flows, such that wet year flows are characterized by those at the 10 percent exceedance point in Figures 3.1-1 and 3.1-2 (i.e., typical wet year flows would be exceeded 10 percent of the time). Similarly, a median year is characterized by flows at the 50 percent exceedance point, while a dry year is characterized by flows at the 90 percent exceedance point. While Table 3.1-2 and Table 3.1-3 summarize modeled *average* monthly flows and the significance of the differences between these flows under the 2013 BiOp and KBRA operations criteria, the monthly flow exceedance plots in Figures 3.1-1 and 3.1-2 present a more in-depth comparison of the range of possible flows by month and their probability of occurring under the two operations scenarios.

The overall range of 2013 BiOp and KBRA Flows is generally similar between the two curves such that modeling using KBRA Flows would typically simulate a similar range of flows, but the monthly flow exceedance plots indicate there is either a temporal shift in the distribution of flows expected within a given month or a shift in the water year type distribution between 2013 BiOp and KBRA Flows (Figures 3.1-1 and 3.1-2). A temporal shift in the distribution of flows expected within a given month is indicated by comparing modeled 2013 BiOp and KBRA Flows across different months. For example, the first panel in Figure 3.1-1 shows that flows in the Klamath River downstream of Iron Gate Dam in October under the 2013 BiOp Flows would be 50 to 400 cfs greater than under the KBRA Flows, regardless of whether it is a wet year (i.e., 10 percent exceedance), a median year (i.e., 50 percent exceedance), or a dry year (i.e., 90 percent exceedance). In October, the modeled 2013 BiOp Flows at Iron Gate Dam range from slightly less than 2,000 cfs to approximately 1,000 cfs, which is different from the range of modeled KBRA Flows in October, but similar to the range of modeled KBRA Flows in September. The KBRA Flow exceedance curve for the month of September ranges from slightly less than 1,600 cfs to slightly less than 1,000 cfs with a similar shape as the October 2013 BiOp Flows, except during wetter years (i.e., less than 10 percent exceedance) when the September KBRA Flows remain fairly similar, but October 2013 BiOp Flows continue to increase. Thus, the October 2013 BiOp Flows typically represent a one-month temporal shift of the September KBRA Flows. Similar shifts in the monthly distribution of flows also occur in July and August downstream of Iron Gate Dam where the range and shape of the July 2013 BiOp Flows are within approximately 150 cfs or less of the August KBRA Flows (Figure 3.1-1).

The shift in the distribution of flows by water year type is characterized by whether the flow within individual months is higher during some water year types and lower during other water year types when comparing between 2013 BiOp and KBRA Flows. Variations between the modeled 2013 BiOp and KBRA Flows during different water year types is evaluated by comparing the flows at the 10 percent exceedance for wet years, 50 percent exceedance for median years, and 90 percent exceedance for dry years. At both Iron Gate and Keno dams from July through September, the modeled 2013 BiOp Flows are less than modeled KBRA Flows during wet years (i.e., 10 percent exceedance), while the 2013 BiOp Flows are greater than or similar to KBRA Flows during dry years (i.e., 90 percent exceedance) (Figures 3.1-1 and 3.1-2). The lower middle left panel of Figure 3.1-1 highlights this trend during July at Iron Gate Dam where the wet year 2013 BiOp Flow is approximately 700 cfs less than the KBRA Flow, the median year 2013 BiOp Flow is approximately 100 cfs less than the KBRA Flow, and the dry year 2013 BiOp Flow is approximately 150 cfs greater than the KBRA Flow. At both Iron Gate and Keno dams, June is a unique month where there is both a monthly temporal shift in the range of flows (i.e., KBRA Flows in May range from approximately 1,100 to 6,000 cfs, while 2013 BiOp Flows in June range from approximately 5,600 cfs to 1,000 cfs) and a water year type shift (i.e., 2013 BiOp Flows are greater than KBRA Flows in wet years [e.g. 10 percent exceedance], less in median years [e.g., 50 percent exceedance], and approximately the same in dry years [e.g., 90 percent exceedance]).

While a temporal shift in flow across months or a shift in the distribution of flow by water year type indicates 2013 BiOp Flows during wet, median, and dry years are typically within the range of KBRA Flows, peak 2013 BiOp Flows are potentially greater than peak KBRA Flows during extremely wet years (i.e., exceedance probability less than 2 percent). During January and February, the peak 2013 BiOp Flows are approximately 850 to 1,000 cfs (i.e., 7 to 8 percent) greater than peak KBRA Flows (Figures 3.1-1 and 3.1-2). The peak 2013 BiOp Flows would be outside of the range of KBRA Flows and modeling using KBRA Flows would not characterize these peak flows, but these flows would be unlikely to occur (i.e., exceedance probability less than 2 percent) so their potential influence on Klamath River hydrology would be limited. The range of 2013 BiOp Flows, including peak flows, during March through December is within the range of KBRA Flows, so modeling using KBRA Flows would represent the range of 2013 BiOp Flows during these months.

Despite the aforementioned differences between the modeled 2013 BiOp and KBRA Flows, the KBRA Flows represent 99.9 percent of 2013 BiOp Flows in the Klamath River at Iron Gate and Keno dams. Modeled 2013 BiOp Flows outside the range modeled KBRA Flows occur too infrequently (i.e., 0.01 percent of the time or less at Keno and Iron Gate dam) to substantially alter the range of flow conditions in the Klamath River. While flow exceedance curves representing typical flow conditions (i.e., 1 to 99 percent exceedance) would not capture the extremely infrequent modeled 2013 BiOp Flows outside the range modeled KBRA Flows, a comparison of the 2013 BiOp and KBRA maximum and minimum monthly flow exceedance further highlights that typical 2013 BiOp Flows are sufficiently represented by KBRA Flows. Modeled 2013 BiOp Flows are generally within the range of KBRA Flows except for extremely wet years (i.e., exceedance probability less than 2 percent) since maximum monthly KBRA Flows are similar to or slightly greater than the maximum monthly 2013 BiOp Flows for flow exceedances of 2 to 10 percent (representing wetter water years), and the minimum monthly KBRA Flows during drier years (i.e., greater than 90 percent exceedance) are less than the corresponding minimum monthly 2013 BiOp Flows (Figures 3.1-3(a) and (b)). Flow exceedances where the minimum 2013 BiOp Flows are less than minimum KBRA Flows (e.g., minimum flow exceedances 20 percent or less at Iron Gate Dam) or the maximum 2013 BiOp Flows are greater than the maximum KBRA Flows (e.g., maximum flow exceedances 25 to 10 percent at Keno and Iron Gate dams) are due to shifts in the distribution of flows by water year type as previously discussed. Differences between the minimum or maximum monthly 2013 BiOp and KBRA Flows between flow exceedances less than 5 percent or greater than 95 percent would be contained within the overall range of KBRA Flows, thus the range of 2013 BiOp Flows is still typically bracketed by the range of KBRA Flows.

It is reasonable to assume the outputs of hydrologic models using the KBRA Flows represent the majority of the range of results of hydrologic models using the 2013 BiOp Flows because 99.9 percent of modeled 2013 BiOp Flows at Iron Gate and Keno dams are within the range of modeled KBRA Flows. Peak 2013 BiOp Flows during January and February would not be captured by modeled KBRA Flows due to peak 2013 BiOp Flows during these months being greater than modeled KBRA Flows, but the probability of these flows occurring is low (i.e., less than 2 percent). Farther downstream of Iron Gate Dam, Klamath River flow estimates are only affected by assumptions regarding tributary inflows (accretions) that are not affected by operations of the Klamath Irrigation Project[2]. While variations may exist in timing between 2013 BiOp and KBRA Flows, the range of model results would be similar if the 2013 BiOp Flows were used in the hydrologic model rather than the KBRA Flows, since the KBRA Flows typically bracket the 2013 BiOp Flows.

In summary, the hydrologic model outputs previously developed using the KBRA Flows for the 2012 KHSA EIS/EIR are sufficient to estimate conditions under 2013 BiOp Flows. As explained above, the primary differences are temporal shifts in the flow distribution within some months and changes in expected flows

[2] PacifiCorp coordinates operations with the USBR and operates the Lower Klamath Project in compliance with the 2013 BiOp for the Klamath Irrigation Project. The 2013 BiOp does not require independent releases from the Lower Klamath Project to supply the minimum flow requirements downstream of Iron Gate Dam.

in different water year types. The previous KBRA Flows typically bracket the range of 2013 BiOp Flows, supporting the conclusion that the prior modeling using the KBRA Flows sufficiently represents the range of potential effects of Klamath River flows under the 2013 BiOp Flows.

Consequently, this EIR considers the potential effects of dam removal under the Proposed Project by applying existing hydrology information presented in the 2012 KHSA EIS/EIR, as well as in the numerous technical studies that were foundational to that effort. However, potential changes in the previous analysis and technical studies resulting from the differences between 2013 BiOp and KBRA Flows are evaluated and discussed, as necessary.

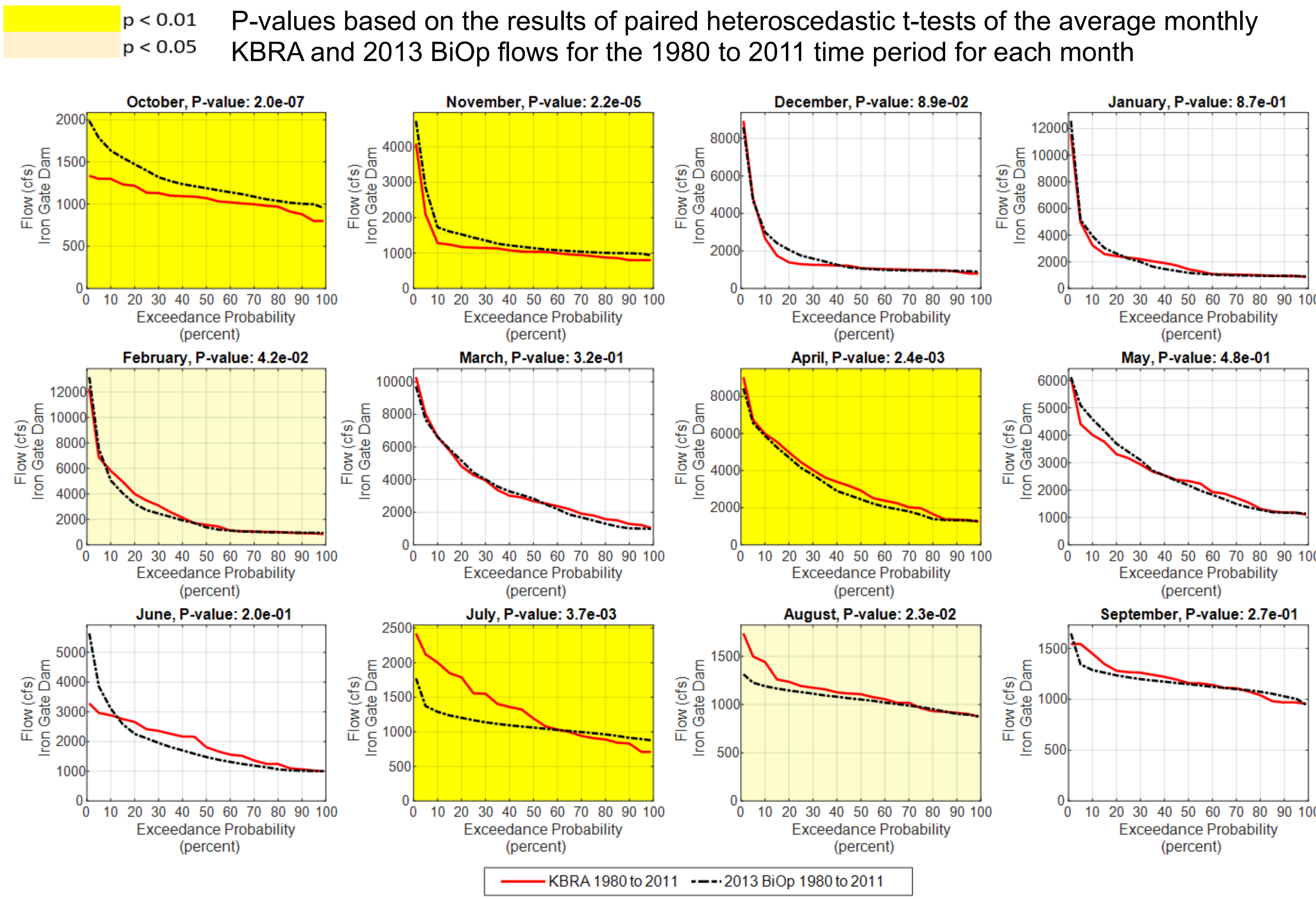

Figure 3.1-1. Monthly Flow Exceedance Curves at Iron Gate Dam for the KBRA Flows (KBRA) and 2013 Joint Biological Opinion Flows (2013 BiOp) Based on Modeled Flows from 1980 to 2011. Data Source: USBR 2010, 2019a. Note: The Scale of the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Year Types Are Characterized by Flows at the 10, 50, 90 Percent Exceedance, Respectively.

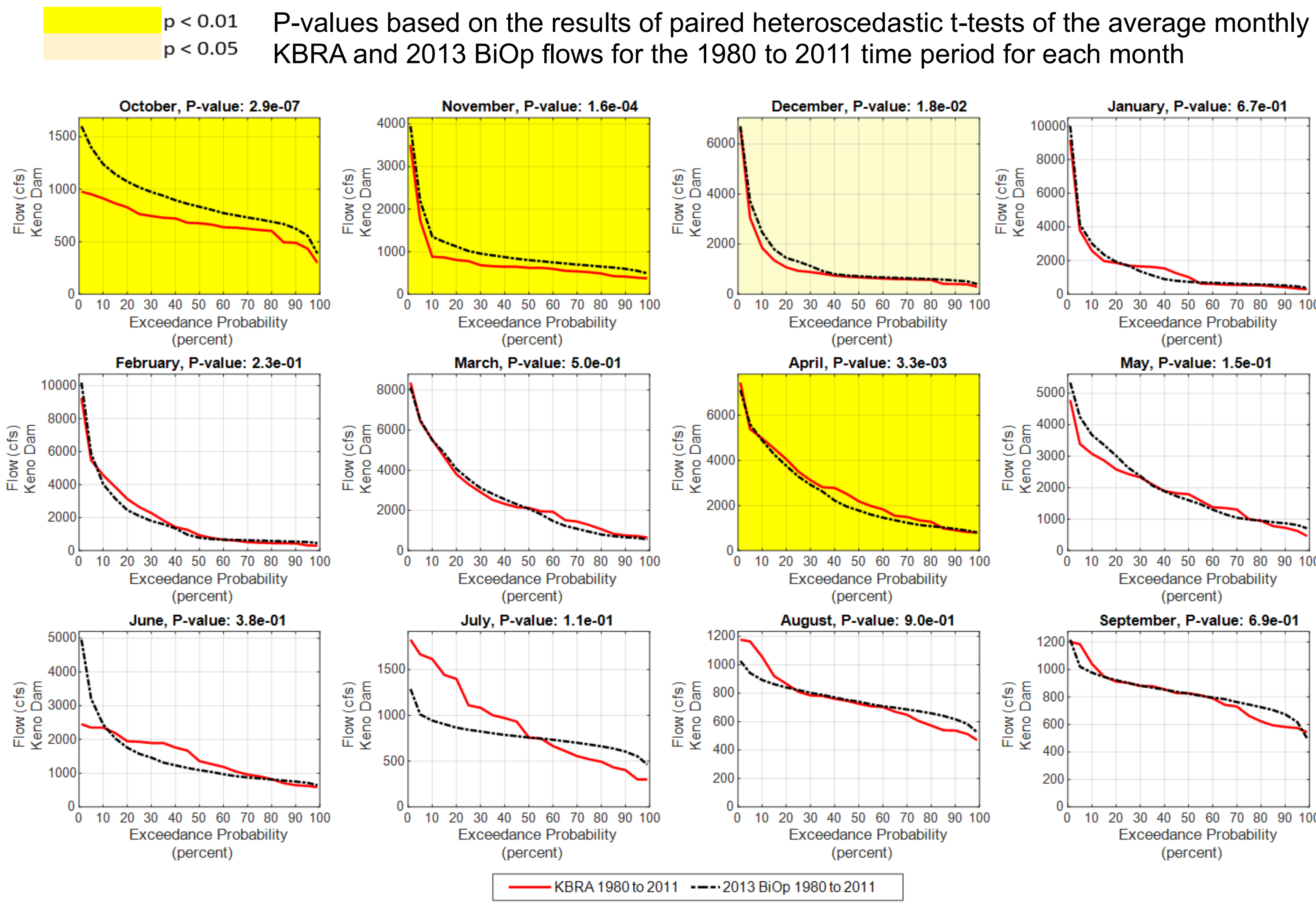

Figure 3.1-2. Monthly Flow Exceedance Curves at Keno Dam for the KBRA Flows (KBRA) and 2013 Joint Biological Opinion Flows (2013 BiOp) Based on Modeled Flows from 1980 to 2011. Data Source: USBR 2010, 2019a. Note: The Scale of the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Year Types Are Characterized by Flows at the 10, 50, 90 Percent Exceedance, Respectively.

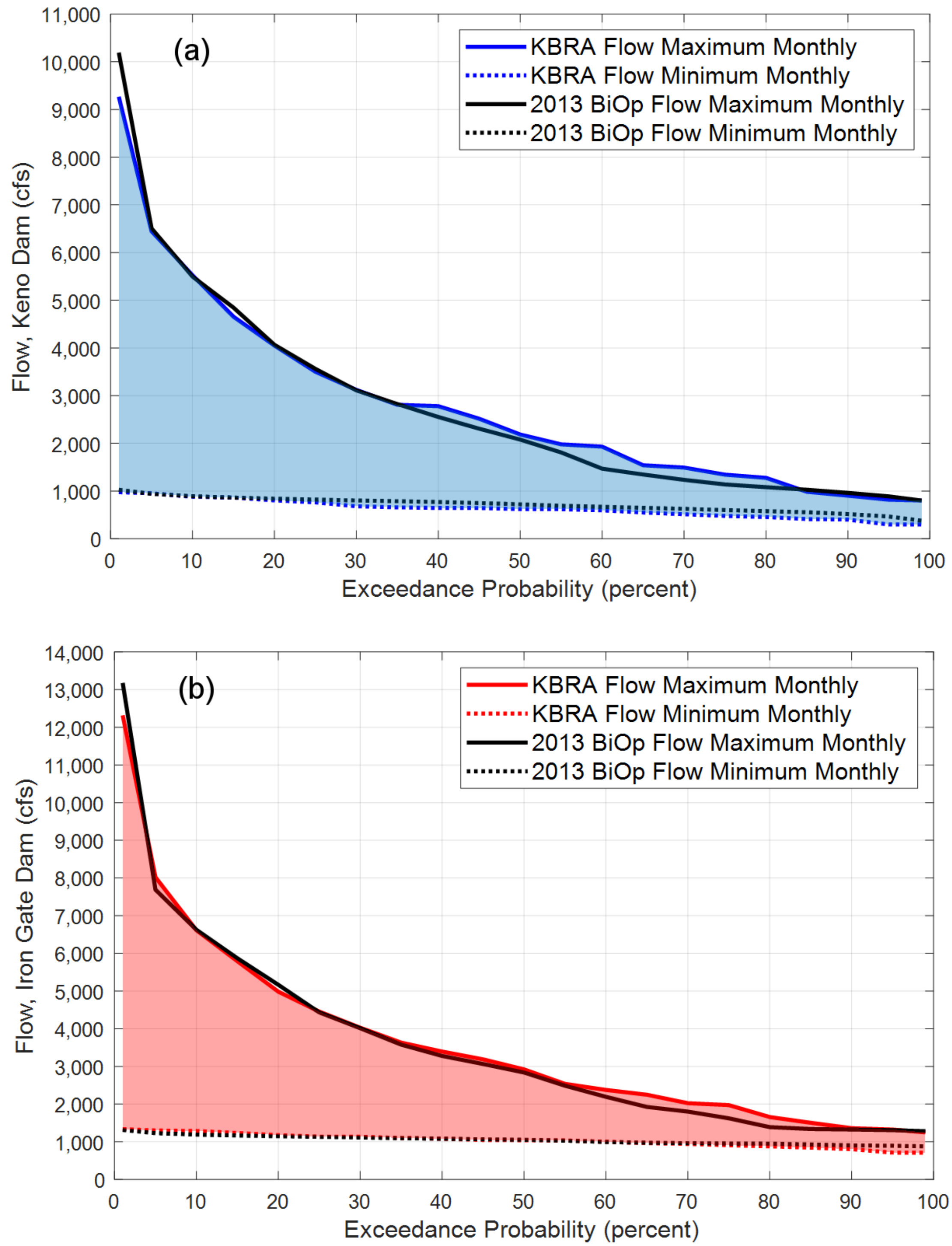

Figure 3.1-3. Comparison of the Maximum and Minimum Monthly Exceedance Curves for the 2013 Joint Biological Opinion (2013 BiOp) and KBRA Flows From 1 to 99 Percent Exceedance Flows at (a) Keno Dam (b) Iron Gate Dam. Data Source: USBR 2010, 2019a.

3.1.6.3 Klamath River Flows under the 2019 BiOp Operations Criteria for the Klamath Irrigation Project

Under the 2019 BiOp Flows, current and future (2019 to 2024) operations of the Klamath Irrigation Project in the Upper Klamath Basin include irrigation deliveries consistent with historical operations (subject to water availability) and flood control purposes, while maintaining Upper Klamath Lake and Klamath River hydrologic conditions that avoid jeopardizing the continued existence of listed species and adverse modification of designated critical habitat (NMFS 2019; USFWS 2019). Operations under the 2019 BiOp Flows include two distinct, real-time water management approaches during the fall/winter and spring/summer periods. The specific time frame associated with the two periods varies slightly between management of flows in the Klamath River and water deliveries by the Klamath Irrigation Project, with fall/winter corresponding to October through February and spring/summer corresponding to March through September for the Klamath River flows. The seasonal time periods for the Klamath Irrigation Project would not alter the management of the Klamath River flows, so they are not discussed further. The fall/winter and spring/summer water management approaches prioritize different goals during the two periods, but they are designed to meet the ecological needs of the Upper Klamath Lake ESA-listed Lost River sucker and shortnose sucker and ESA-listed coho salmon downstream of Iron Gate Dam, while also maintaining full irrigation deliveries in accordance with existing contracts, contingent upon available water supplies.

In general, Klamath River flows during fall/winter and spring/summer are formulaically calculated as specified in the 2019 BiOp to create a hydrograph downstream of Iron Gate Dam that approximates a natural flow regime, while ensuring minimum flows are met. The 2019 BiOp Flow requirements are expressed as flows at Iron Gate Dam because the dam is the compliance point for Klamath River flows under the 2019 BiOp. Flows at Iron Gate Dam during fall/winter and the beginning of spring/summer are determined based on hydrologic indicators of upper Klamath Basin conditions and 2019 operational criteria (e.g., ecological requirements). During the beginning of the spring/summer period (i.e., the first of the month from March through June), an Environmental Water Account (EWA) also is calculated to determine the volume of water available from Upper Klamath Lake for Klamath River flows between March 1 and September 30, including flow releases to manage disease or improve habitat for aquatic resources downstream of Iron Gate Dam. During the later portion of the spring/summer period (i.e., July through September), Klamath River flows are based on the remaining EWA volume and 2019 BiOp operational criteria, including maintaining minimum flows downstream of Iron Gate Dam. Minimum flows downstream of Iron Gate Dam under the 2019 BiOp are presented in Table 3.1-4 and are the same as those specified under the 2013 BiOp.

Table 3.1-4. Minimum Klamath River Discharge below Iron Gate Dam under the 2019 BiOp Flows.

Month	Iron Gate Dam Average Daily Minimum Target Flows (cfs)
January	950
February	950
March	1,000
April	1,325
May	1,175
June	1,025
July	900
August	900
September	1,000
October	1,000
November	1,000
December	950

Source: NMFS 2019; USFWS 2019.

The 2019 BiOp also includes provisions to vary from the formulaic approach for determining the Klamath River flows to address high flow events, emergency situations, or specific ecological objectives. The 2019 BiOp Flows include specific provisions for disease mitigation and habitat flows:

- Releasing approximately 50,000 acre-feet from Iron Gate Dam in a manner that best meets coho salmon needs (e.g., disease mitigation, habitat) in below average to dry years, as defined by the March 1 and/or April 1 EWA volume.
- Releasing an “opportunistic” surface flushing flow from Iron Gate Dam of at least 6,030 cfs for a 72-hour period during the spring period (March 1 to April 15) if hydrologic conditions allow in average to wet years, as defined by the March 1 and April 1 EWA volume.
- Attempting to release deep flushing flows (i.e., 11,250 cfs for 24 hours) when hydrologic conditions and public safety allow, including, but not limited to, Upper Klamath Lake storage to allow for sufficient Link River Dam release capacity, Upper Klamath Lake storage sufficient to protect sucker needs, substantial accretions, and Klamath River tributary discharge that does not result in public safety or property concerns.
- Releasing an additional volume of 20,000 acre-feet for enhanced May/June flows in years in which the April 1 EWA is greater than 400,000 acre-feet (407,000 acre-feet in years 2020, 2022, and 2024) and less than 576,000 acre-feet.

3.1.6.4 Comparison of Klamath River Flows under the 2019 BiOp Operational Criteria and the KBRA Operations Criteria

In the 2012 KHSA EIS/EIR, the projected Klamath River flows were modeled using the Water Resources Integrated Modeling System (WRIMS) coupled with a RiverWare-based model called the Klamath Dam Removal Model (KDRM) (USBR 2012a, 2016). The coupled model was used to analyze the Klamath River conditions using either the 2010 BiOp Flows or the KBRA Flows based on the KBRA operations criteria for the Klamath Irrigation Project. The 2010 BiOp and the KBRA Flows are generally very similar, particularly from January through May when flows are effectively the same between the dams remaining in place (i.e., “dams in”) and dams removed (i.e., “dams out”) flow scenarios (USBR 2012a). The estimated Klamath River flows under the 2019 BiOp Flows were modeled using the Klamath Basin Planning Model (KBPM), an updated and modified WRIMS model (USBR 2019b).

Modeled Klamath River flows under the 2019 BiOp and the KBRA operations criteria are nearly identical (i.e., less than 30 cfs different) when examined on an average annual basis, with flows downstream of Iron Gate Dam averaging approximately 1,898 cfs and 1,924 cfs, respectively, during the 1980 to 2011 comparison period when both modeled 2019 BiOp and KBRA Flows are available. The average annual 2019 BiOp and KBRA Flows downstream of Keno Dam from 1980 to 2011 are also nearly identical (i.e., less than 20 cfs different), averaging approximately 1,403 cfs and 1,387 cfs, respectively. While the modeled flows upstream and downstream of the Hydroelectric Reach are within 1.2 to 1.4 percent on an average annual basis, there is a larger difference between the average monthly 2019 BiOp and KBRA Flows over the entire 1980 to 2011 comparison period (Table 3.1- and Table **3.1-6**). The most prominent difference is that the 2019 BiOp Flows when compared to KBRA Flows generally require higher flows in the fall months (October through November) and allow lower flows in the summer months (June through July). Downstream of Iron Gate Dam, fall average monthly 2019 BiOp Flows are approximately 150 cfs more than fall average monthly KBRA Flows (i.e., 10 to 29 percent); summer average monthly 2019 BiOp Flows are approximately 275 cfs less than summer average monthly KBRA Flows (i.e., 19 to 22 percent) (Table 3.1- and Table **3.1-6**). During the other months of the year, average monthly 2019 BiOp Flows are less than 10 percent different from the average monthly KBRA Flows.

Variations in the average monthly 2019 BiOp and KBRA Flows between years are also compared using paired heteroscedastic t-tests of the average monthly 2019 BiOp and KBRA Flows for the 31-years between 1980 and 2011, with probability values (p-values) less than 0.05 indicating a significant difference and p-values and less than 0.01 indicating a highly significant difference. At both Iron Gate and Keno dams, p-values demonstrate the average monthly 2019 BiOp and KBRA Flows are statistically different during multiple months throughout the year, especially during fall and summer (Tables 3.1-5 and 3.1-6) Similar to the average monthly flow comparison for all years above (i.e., the 31-year average of the average monthly flows), the calculated p-values show differences between average monthly 2019 BiOp and KBRA Flows at Iron Gate Dam are highly significant during September, October, and November (i.e., fall months) and range from highly significant in June and July to significant in August (i.e., summer months). P-values also indicate average monthly 2019 BiOp and KBRA Flows at Iron Gate Dam are significantly different during March, which are likely due to implementation of surface flushing flow releases by the 2019 BiOp. There also are highly significant and significant changes in the average monthly 2019 BiOp and KBRA Flows at Keno Dam. The calculated p-values indicate differences between average monthly 2019 BiOp and KBRA Flows at Keno Dam are highly significant in October and November (i.e., fall months) and range from highly significant in June to significant in July (i.e., summer months). Average monthly 2019 BiOp and KBRA Flows at Keno Dam also are significantly different in February and highly significantly different in March. The highly significant difference in March is likely due increases in Keno Dam flow releases to meet the 2019 BiOp surface flushing flow requirement downstream of Iron Gate Dam. The differences in 2019 BiOp Flows versus KBRA Flows reflect the joint goal of NMFS and USFWS to protect ESA-listed fish that rely on a shared but finite aquatic resource (most notably, the two endangered sucker species in Upper Klamath Lake and threatened coho salmon in the Klamath River below Iron Gate Dam) (NMFS 2019; USFWS 2019).

Table 3.1-5. Average Monthly Flow at Iron Gate Dam From 1980 to 2011 for 2019 Biological Opinion and KBRA Operations Criteria.

Month	Average Monthly Flow Downstream of Iron Gate Dam		Differences (2019 BiOp vs. KBRA Flows)		p-value
	KBRA Operations Criteria	2019 BiOp Operations Criteria			
	(cfs)	(cfs)	(cfs)	(percent)	--
Oct	1069	1179	109	10	8.7E-04
Nov	1147	1348	201	17	8.6E-08
Dec	1579	1655	76	5	0.300
Jan	2032	2168	136	7	0.071
Feb	2590	2698	108	4	0.120
Mar	3384	3599	215	6	0.029
Apr	3344	3086	-259	-8	0.056
May	2461	2348	-113	-5	0.097
Jun	1924	1557	-367	-19	1.5E-04
Jul	1299	1050	-249	-19	4.9E-04
Aug	1122	1042	-80	-7	0.011
Sep	1190	1102	-88	-7	3.9E-04

Data source: USBR 2010, 2019c.

Table 3.1-6. Average Monthly Flow at Keno Dam From 1980 to 2011 for 2019 Biological Opinion and KBRA Operations Criteria.

Month	**Average Monthly Flow Downstream of Keno Dam**		**Differences (2019 BiOp vs. KBRA Flows)**		**p-value**
	KBRA Operations Criteria	**2019 BiOp Operations Criteria**			
	(cfs)	**(cfs)**	**(cfs)**	**(percent)**	**--**
Oct	684	828	144	21	4.8E-05
Nov	743	960	217	29	8.2E-07
Dec	1040	1133	93	9	0.200
Jan	1437	1573	136	9	0.083
Feb	1843	2011	168	9	0.015
Mar	2601	2847	246	9	0.0044
Apr	2607	2386	-221	-8	0.067
May	1835	1779	-55	-3	0.380
Jun	1456	1139	-317	-22	0.0013
Jul	886	716	-169	-19	0.017
Aug	745	733	-12	-2	0.700
Sep	814	776	-38	-5	0.120

Data source: USBR 2010, 2019c.

Figures 3.1-4 and 3.1-5 present monthly flow exceedances for modeled 2019 BiOp and KBRA Flows downstream of Iron Gate Dam and Keno Dam, respectively, for the 31-year period from 1980 to 2011, where this period encompasses water year types ranging from very dry to very wet. Flows with a 1 to 99 percent probability of occurring at Iron Gate or Keno dam are shown in the monthly flow exceedance curves, but they do not display the upper maximum flows (i.e., exceedance probability less than 1 percent) or lower minimum flows (i.e., exceedance probability greater than 99 percent) that may occur under 2019 BiOp and KBRA operations criteria. Figure and Figure also present the results of the paired heteroscedastic t-tests of the average monthly 2019 BiOp and KBRA Flows for the period 1980 to 2011, with highly significant differences between the average monthly 2019 BiOp and KBRA Flows shown in bright yellow and significant differences between the average monthly 2013 BiOp and KBRA Flows shown in light yellow. Monthly flow exceedance plots are particularly useful for comparing differences between modeled 2019 BiOp and KBRA Flows for different water year types (i.e., wet, median, and dry year types) since exceedance curves present the probability a flow would occur. Here, a wet year type is defined as the highest 10 percent of flows, such that wet year flows are characterized by those at the 10 percent exceedance point in Figures 3.1-4 and 3.1-5 (i.e., typical wet year flows would be exceeded 10 percent of the time). Similarly, a median year is characterized by flows at the 50 percent exceedance point, while a dry year is characterized by flows at the 90 percent exceedance point. While Tables 3.1-5 and 3.1-6 summarize modeled *average* monthly flows and the significance of the differences between these flows under the 2019 BiOp and KBRA operations criteria, the monthly flow exceedance plots in Figures 3.1-4 and 3.1-5 present a more in-depth comparison of the range of possible flows by month and their probability of occurring under the two operations scenarios.

The overall range of 2019 BiOp and KBRA Flows is generally similar between the two curves such that modeling using KBRA Flows would typically simulate a similar range of flows, but there frequently is a shift in the water year type distribution between 2019 BiOp and KBRA Flows (Figures 3.1-4 and 3.1-5). The shift in the distribution of flows by water year type is characterized by whether the flow within individual months is higher during some water year types and lower during other water year types when comparing between 2019 BiOp and KBRA Flows. Variations between the modeled 2019 BiOp and KBRA Flows during different water year types primarily is evaluated by comparing the exceedance curve flows at the 10 percent exceedance for wet years, 50 percent exceedance for median years, and 90 percent exceedance for dry years. At both Iron Gate and Keno dams from December through May, the modeled 2019 BiOp Flows are generally similarly distributed throughout the various water year types with only small changes to the flow during some water year types. As an example, modeled 2019 BiOp Flows at Iron Gate Dam in January (upper right corner of Figure 3.1-4) tend to be lower than KBRA Flows during very wet water years (i.e., less than 5 percent exceedance), higher than KBRA Flows during wetter water years (i.e., 5 to 30 percent exceedance), and similar to KBRA Flows during median through dry water years (i.e., 30 to 90 percent exceedance). Higher Klamath River flows under the 2019 BiOp Flows than under the KBRA Flows at Iron Gate Dam in March during wet to median water years (i.e., 10 to 50 percent exceedance) is largely due to the 2019 BiOp requirement to release 6,030 cfs for a 72-hour period during the spring period (March 1 to April 15) when hydrologic conditions allow in wet to median water years.

While 2019 BiOp Flows from December through May are generally similar to KBRA Flows with shifts in the flow during only select water year types, 2019 BiOp Flows during June through November exhibit shifts from KBRA Flows during most water year types. However, the type of shifts from KBRA to 2019 BiOp Flows between water year types is different between June through September and October through November. During June through September, 2019 BiOp Flows tend to be lower than KBRA Flows during wetter through median years and higher than or similar to KBRA Flows during drier years. During October through November, 2019 BiOp Flows are consistently greater than KBRA Flows, but the magnitude is often relatively small (i.e., less than 100 cfs or less than 10 percent of the KBRA Flow). As an example of the June through September shift, modeled 2019 BiOp Flows at Iron Gate in July (lower mid-left of Figure 3.1-4) are less than modeled KBRA Flows during wetter and median water years (i.e., less than 70 percent exceedance), similar to modeled

KBRA Flows during median to drier water years (i.e., 70 to 80 percent exceedance), and greater than modeled KBRA Flows during drier water years (i.e., greater than 80 percent exceedance). As an example of the October through November shift, modeled 2019 BiOp Flows at Iron Gate in October (upper left of Figure 3.1-4) are consistently greater than modeled KBRA Flows for all water year types, but modeled 2019 BiOp Flows for wet (i.e., 10 percent exceedance), median (i.e., 50 percent exceedance), and dry (i.e., 90 percent exceedance) water years are only greater than modeled KBRA Flows by approximately 40 cfs, 60 cfs, and 120 cfs, respectively.

Despite the aforementioned differences between the modeled 2019 BiOp and KBRA Flows, the range of possible 2019 BiOp Flows in the Klamath River at Iron Gate and Keno dams typically would be represented by KBRA Flows since the range of 2019 BiOp Flows is within the range of modeled KBRA Flows approximately 99.0 percent of the time at Keno Dam and approximately 99.9 percent of the time at Iron Gate Dam. Modeled 2019 BiOp Flows outside the range of modeled KBRA Flows at Keno Dam are exclusively due to 0.1 percent of 2019 BiOp Flows being less than minimum KBRA Flows, while modeled 2019 BiOp Flows outside the range of modeled KBRA Flows at Iron Gate Dam are exclusively due to 0.01 percent of 2019 BiOp Flows being greater than maximum KBRA Flows. These modeled 2019 BiOp Flows outside the range of modeled KBRA Flows occur too infrequently (i.e., 0.1 percent of the time or less at Keno Dam and 0.01 percent of the time or less at Iron Gate Dam) to substantially alter the range of flow conditions in the Klamath River. While flow exceedance curves representing typical flow conditions (i.e., 1 to 99 percent exceedance) would not capture the extremely infrequent modeled 2019 BiOp Flows outside the range modeled KBRA Flows, a comparison of the 2019 BiOp and KBRA maximum and minimum monthly flow exceedance further highlights that typical 2019 BiOp Flows are sufficiently represented by KBRA Flows. Modeled 2019 BiOp Flows at Keno Dam are generally within the range of KBRA Flows since the maximum monthly KBRA Flows at Keno Dam during extremely wet years (i.e., 1 percent exceedance) are greater than the corresponding maximum monthly 2019 BiOp Flows, and the minimum monthly KBRA Flows at Keno Dam during drier years (i.e., 90 to 95 percent exceedance) are less than the corresponding minimum monthly 2019 BiOp Flows (Figure 3.1-6(a)). Minimum monthly 2019 BiOp Flows during extremely dry years (i.e., 1 percent exceedance) would not be represented by KBRA Flows, but these low flows would infrequently occur. Modeled 2019 BiOp Flows at Iron Gate Dam are generally within the range of KBRA Flows since the maximum monthly KBRA Flows at Iron Gate Dam during extremely wet years (i.e., 1 percent exceedance) are greater than the corresponding maximum monthly 2019 BiOp Flows and the minimum monthly KBRA Flows at Iron Gate Dam during dry years (i.e., greater than 90 percent exceedance) are less than the corresponding minimum monthly 2019 BiOp Flows (Figure 3.1-6(b)). At both Keno and Iron Gate dams, the higher maximum monthly 2019 BiOp Flows compared to the maximum monthly KBRA Flows (e.g., maximum flow exceedances from 10 to 45 percent) are largely due to the 2019

BiOp requirement at Iron Gate Dam to release 6,030 cfs for a 72-hour period during March 1 to April 15 in wet to median years (i.e., 10 to 50 percent exceedance) when hydrologic conditions allow. Flow exceedances where the minimum monthly 2019 BiOp Flows at Iron Gate Dam are less than minimum monthly KBRA Flows at Iron Gate Dam (e.g., minimum flow exceedances from 50 to 70 percent) are due to shifts in the distribution of flows by water year type as previously discussed. Differences between the minimum or maximum monthly 2019 BiOp and KBRA Flows would be contained within the overall range of KBRA Flows from 1 to 95 percent at Keno Dan and 1 to 99 percent at Iron Gate Dam, thus the range of 2019 BiOp Flows is still typically bracketed by the range of KBRA Flows.

It is reasonable to assume the outputs of hydrologic models using the KBRA Flows represent the typical range of results of hydrologic models using the 2019 BiOp Flows since the typical range of 2019 BiOp Flows is within the range of KBRA Flows, with modeled 2019 BiOp Flows within the range of modeled KBRA Flows 99.0 percent of the time at Keno Dam and 99.9 percent of the time at Iron Gate Dam. Peak 2019 BiOp Flows with a 1 percent exceedance probability during December through April would be captured by modeled KBRA Flows since peak 2019 BiOp Flows with a 1 percent exceedance probability are less than modeled KBRA Flows during this time. Extremely infrequent peak 2019 BiOp Flows (i.e., less than 1 percent exceedance probability) would not be captured by modeled KBRA Flows due to these extremely infrequent peak 2019 BiOp Flows being greater than modeled KBRA Flows, but the probability of these flows occurring is extremely low (i.e., less than 1 percent). Farther downstream of Iron Gate Dam, Klamath River flow estimates are only affected by assumptions regarding tributary inflows (accretions) that are not affected by operations of the Klamath Irrigation Project[2]. While variations may exist between the frequency of certain flows occurring under 2019 BiOp and KBRA Flows, the range of model results would be similar if 2019 BiOp Flows were used in the hydrologic model rather than KBRA Flows, since KBRA Flows typically bracket 2019 BiOp Flows.

In summary, the hydrologic model outputs previously developed using the KBRA Flows for the 2012 KHSA EIS/EIR are sufficient to estimate conditions under 2019 BiOp Flows. As explained above, the primary difference between 2019 BiOp and KBRA Flows is a shift in the expected flows during different water year types such that late fall months generally have higher Klamath River flows and summer/early fall months generally have lower flows during wet or median years and higher flows during drier years. The previous KBRA Flows typically bracket the range of 2019 BiOp Flows, supporting the conclusion that the prior modeling using the KBRA Flows sufficiently represents the range of potential effects of Klamath River flows under the 2019 BiOp Flows.

Consequently, this EIR considers the potential effects of dam removal under the Proposed Project by applying existing hydrology information presented in the

2012 KHSA EIS/EIR, as well as in the numerous technical studies that were foundational to that effort. However, potential changes in the previous analysis and technical studies resulting from the differences between 2019 BiOp and KBRA Flows are evaluated and discussed, as necessary.

p < 0.01
p < 0.05

P-values based on the results of paired heteroscedastic t-tests of the average monthly KBRA and 2019 BiOp flows for the 1980 to 2011 time period for each month

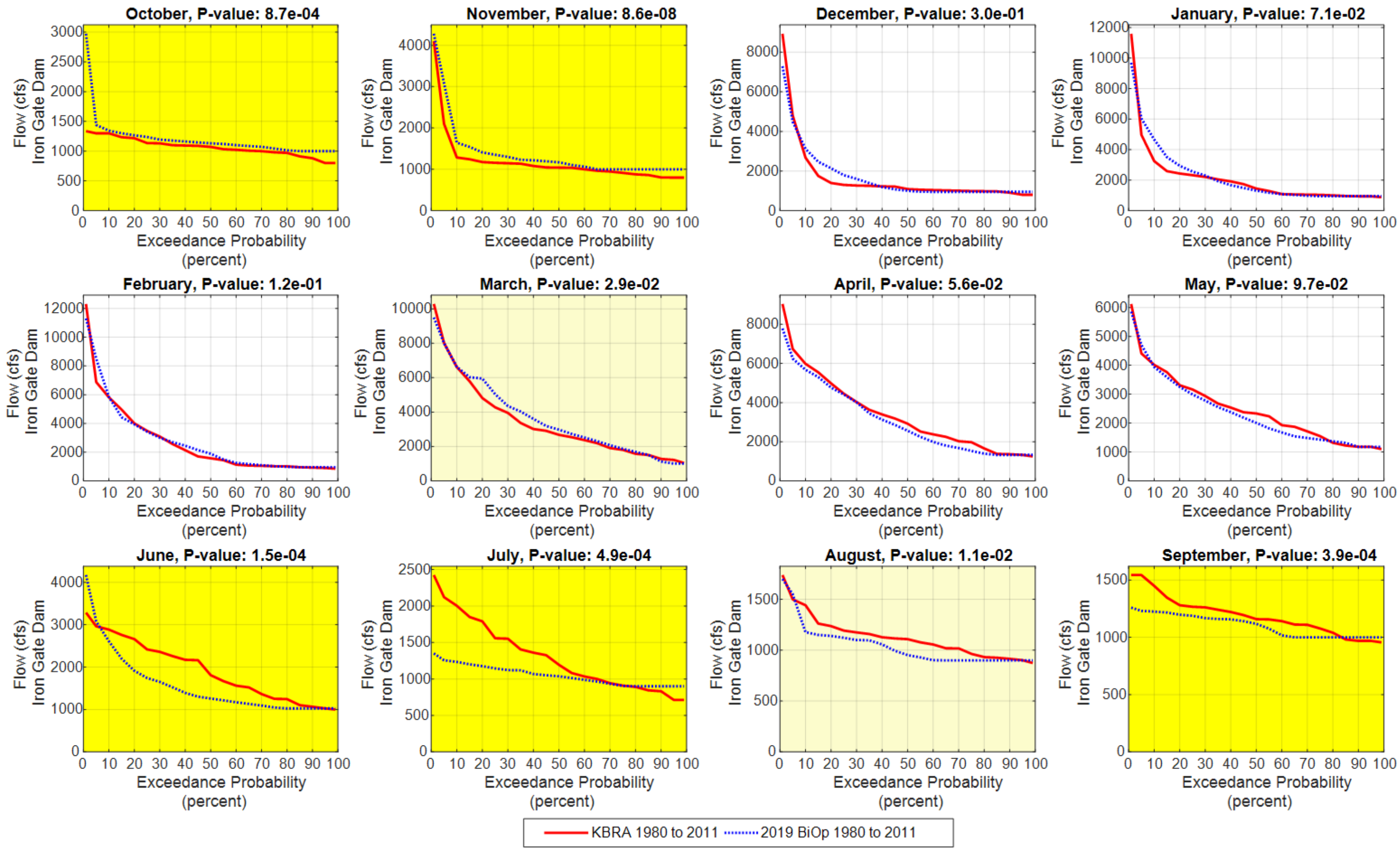

Figure 3.1-4. Monthly Flow Exceedance Curves at Iron Gate Dam for the KBRA Flows (KBRA) and 2019 Biological Opinion Flows (2019 BiOp) Based on the Modeled Flows from 1980 to 2011. Data Source: USBR 2010, 2019c. Note: The Scale of the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Year Types Are Characterized by Flows at the 10, 50, 90 Percent Exceedance, Respectively.

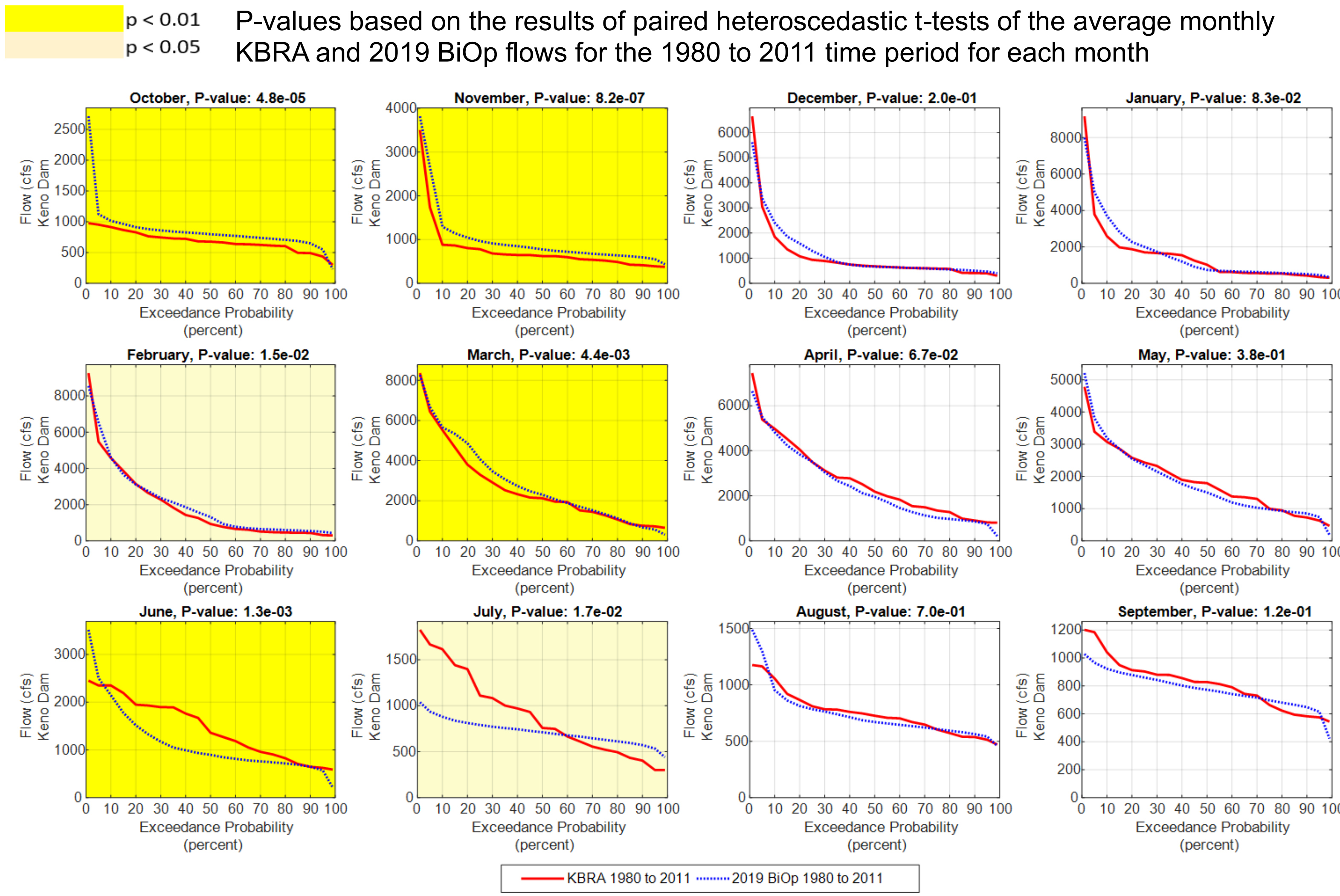

Figure 3.1-5. Monthly Flow Exceedance Curves at Keno Dam for the KBRA Flows (KBRA) and 2019 Biological Opinion Flows (2019 BiOp) Based on Modeled Flows from 1980 to 2011. Data Source: USBR 2010, 2019c. Note: The Scale of the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Year Types Are Characterized by Flows at the 10, 50, 90 Percent Exceedance, Respectively.

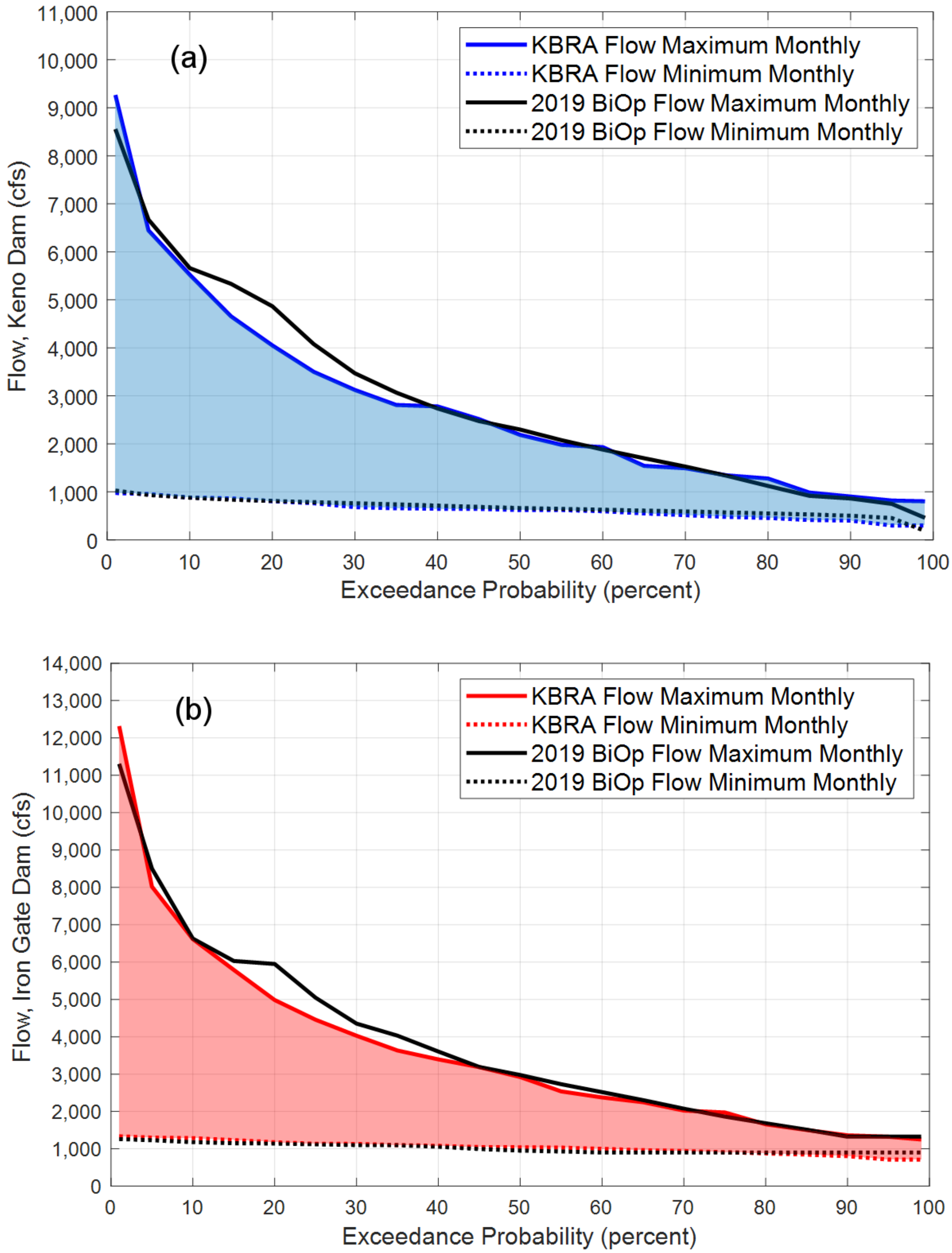

Figure 3.1-6. Comparison of the Maximum and Minimum Monthly Exceedance Curves for the 2019 Biological Opinion (2019 BiOp) and KBRA Flows From 1 to 99 Percent Exceedance Flows at (a) Keno Dam (b) Iron Gate Dam. Data Source: USBR 2010, 2019c.

3.1.7 References

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3.2 Water Quality

This section focuses on potential water quality effects due to the Proposed Project. Other sections of this EIR discuss *Flood Hydrology* (Section 3.6), *Groundwater* (Section 3.7), and *Water Supply/Water Rights* (Section 3.8).

Many comments were received during the NOP public scoping process relating to water quality (see Appendix A). A number of comments focused on the potential effects of dam removal on Klamath River water quality, including short-term exceedances of federal, state, and/or tribal water quality objectives and the potential for release of contaminants contained within reservoir sediments. With respect to long-term impacts on water quality, several comments noted that analyses in the EIR need to consider dam removal, as well as alternatives where dams remain in place, within the context of the existing Klamath River total maximum daily loads (TMDLs). There were numerous comments regarding the potential for dam removal to alleviate existing impaired conditions for water temperature, dissolved oxygen, and blue-green algae[3] and associated algal toxins. Conversely, some commenters indicated their belief that the Lower Klamath Project reservoirs improve water quality by serving as a sink for phosphorus and reducing downstream summertime water temperatures, or otherwise improving water quality in an unspecified manner. Additional summary of the water quality comments received during the NOP public scoping process, as well as the individual comments, are presented in Volume II Appendix A.

After circulation of the Draft EIR, numerous additional comments were received regarding water quality (see Volume III), and changes to the section in response to those comments are flagged in the comment responses and then printed in this Final EIR section. None of the changes result in significant new information in the EIR under the meaning of CEQA Guidelines, section 15088.5, subdivision (a):

> New information added to an EIR is not ‘significant’ unless the EIR is changed in a way that deprives the public of a meaningful opportunity to comment upon a substantial adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect (including a feasible project alternative) that the project’s proponents have declined to implement.

However, the changes were numerous enough that reprinting the section rather than simply including a list of revisions was warranted to improve clarity and readability of the document.

3.2.1 Area of Analysis

The Area of Analysis for water quality includes multiple reaches of the Klamath River, as listed below and shown in Figure 3.2-1.

[3] Blue-green algae are a type of phytoplankton that are naturally found in lakes, streams, ponds, and other surface waters which can produce toxic compounds (e.g., microcystin) that have harmful effects on fish, shellfish, mammals, bird, and people (USEPA 2014). Though blue-green algae are technically cyanobacteria, they are commonly referred to as algae. For readability, and to reduce confusion, this EIR refers to cyanobacteria as blue-green algae except when a cited reference specifically uses the term cyanobacteria.

Upper Klamath Basin

- Hydroelectric Reach[4] (upstream end of J.C. Boyle Reservoir to Iron Gate Dam)

Mid-Klamath Basin

- Klamath River from Iron Gate Dam downstream to the confluence with the Salmon River
- Klamath River from the confluence with the Salmon River to the confluence with the Trinity River

Lower Klamath Basin

- Lower Klamath River from the confluence with the Trinity River to the estuary
- Klamath River Estuary
- Pacific Ocean nearshore environment

Table 3.2-1 lists the river mile locations of the above reaches and of features relevant to the water quality Area of Analysis.

[4] Note that the portion of the Hydroelectric Reach that extends into Oregon (i.e., from the Oregon-California state line [RM 214.1] to the upstream end of J.C. Boyle Reservoir) is only being considered to the extent that conditions in this reach influence water quality downstream in California.

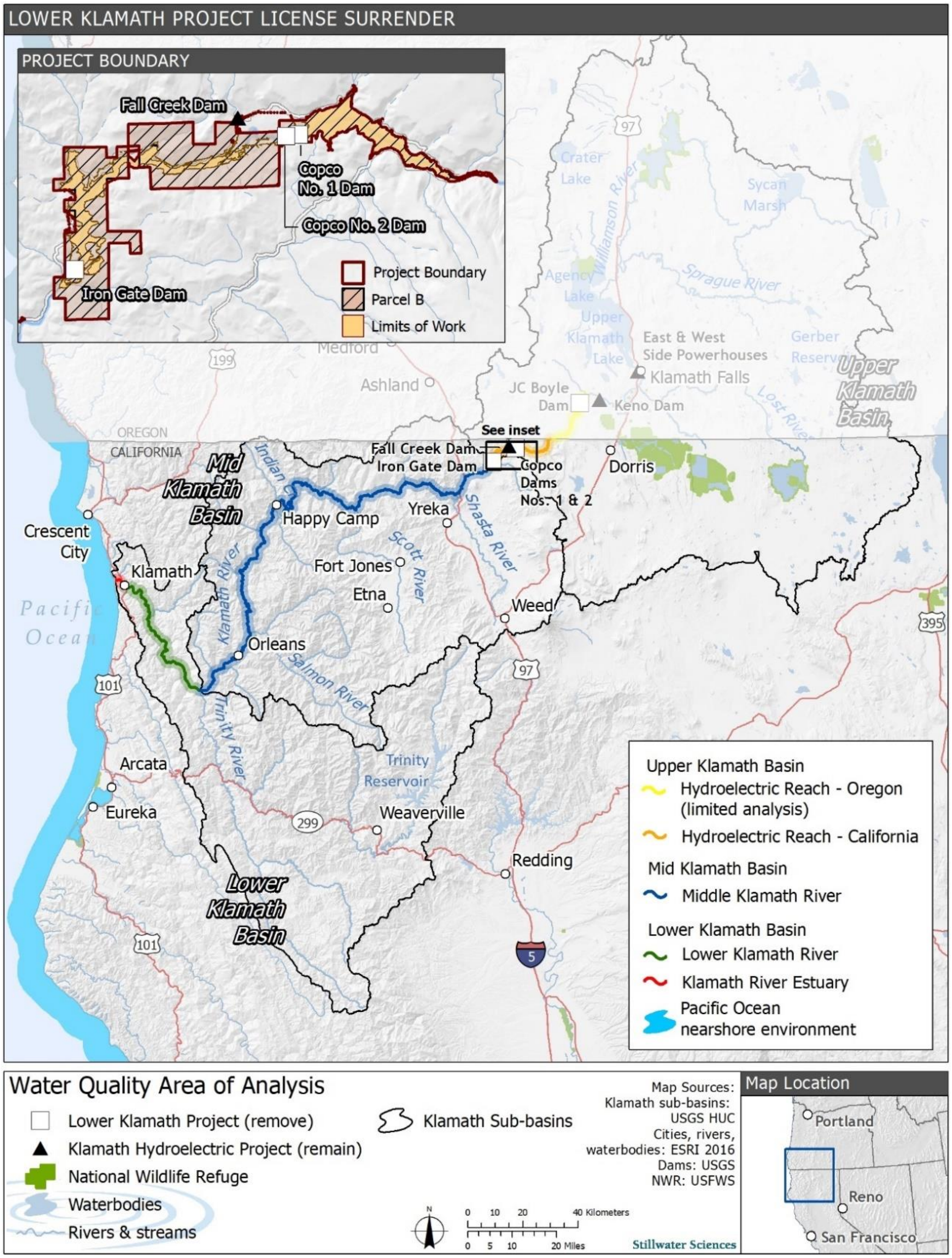

Figure 3.2-1. Klamath River Reaches Included in the Area of Analysis for Water Quality.

Table 3.2-1. River Mile Locations of Klamath River Features Relevant to the Water Quality Analysis.

Feature	River Mile[1]
Upper Klamath Basin	
J.C. Boyle Reservoir	229.8 to 233.3
Oregon-California state line	214.1
Copco No. 1 Reservoir	201.8 to 208.3
Copco No. 2 Reservoir	201.5 to 201.8
Iron Gate Reservoir	193.1 to 200.0
Mid-Klamath Basin	
Klamath River confluence with Shasta River	179.5
Klamath River confluence with Scott River	145.1
Seiad Valley	132.7
Klamath River confluence with Salmon River	66.3
Orleans	58.9
Hoopa Valley Tribe Reservation lands	44.8 to 45.8
Weitchpec	43.6
Lower Klamath Basin	
Yurok Reservation Lands	0 to 45
Klamath River confluence with Trinity River	43.3
Klamath River confluence with Turwar Creek	5.6
Klamath River Estuary	0 to 3.9

Notes:

[1] River Mile (RM) refers to distance upstream of the mouth of the Klamath River. RM's have been updated from the Detailed Plan (see Appendix B: *Detailed Plan*) to those of the Definite Plan (see Appendix B: *Definite Plan – Section 1.4*).

3.2.2 Environmental Setting

This section provides a description of the environmental setting for water quality resources in the Area of Analysis, including a brief overview of water quality processes in the Klamath Basin to inform subsequent impact analyses.

3.2.2.1 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, corresponding to periods of higher flows and colder water temperatures. Warmer air temperatures and drier conditions occur from April to October, corresponding to periods of lower flows and warmer water temperatures. The Upper Klamath Basin has naturally elevated levels of phosphorus that combine with human activities (e.g., wetland draining, agriculture, ranching, logging, water diversions), to increase concentrations of nutrients (nitrogen and phosphorus) and suspended sediment, to degrade water quality parameters (e.g., water temperature, pH, dissolved oxygen). This, in turn, affects the water quality entering California. Within California, the Middle and Lower Klamath River is composed of generally steep, mountainous terrain (see Section 3.11 *Geology, Soils, and Mineral Resources*). Historically, 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 stream flows, increased concentrations of suspended sediment and nutrients in watercourses, and increased summer water temperatures.

The presence and operations of the Lower Klamath Project facilities in the Klamath Hydroelectric Reach affect many aspects of water quality in the Klamath River. In general, the most common effects of hydroelectric project operations on water quality result from changes in the physical structure of the aquatic ecosystem. The dams alter the flow patterns in a river by slowing the transport of water downstream and modifying the timing and magnitude of flows on a short-term basis. Dams intercept and retain sediment, organic matter, nutrients, and other constituents that would otherwise be transported downstream. Dams additionally alter seasonal water temperatures when compared to free-flowing stream reaches.

In general, effects on water quality from hydroelectric project operations include:

<u>River and reservoir water temperatures.</u> 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 canals, pipelines, or penstocks. These changes influence the amount of heat entering and leaving waterbodies (such as from solar radiation and nighttime cooling), which influences the water temperature. As large reservoirs are often deep, they can retain their water temperature for weeks or months, thereby shifting the natural water temperature patterns in river reaches downstream of the reservoirs. For example, water released from reservoirs in the late spring 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 early 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 layer of water forms on the reservoir surface (the epilimnion), which overlies colder, denser water (the hypolimnion) (Figure 3.2-2). This process, called thermal stratification, often persists for months. In late fall, thermal stratification typically breaks down as the surface water layer cools and wind mixing of the water column occurs. This process is called reservoir turnover (Figure 3.2-2).

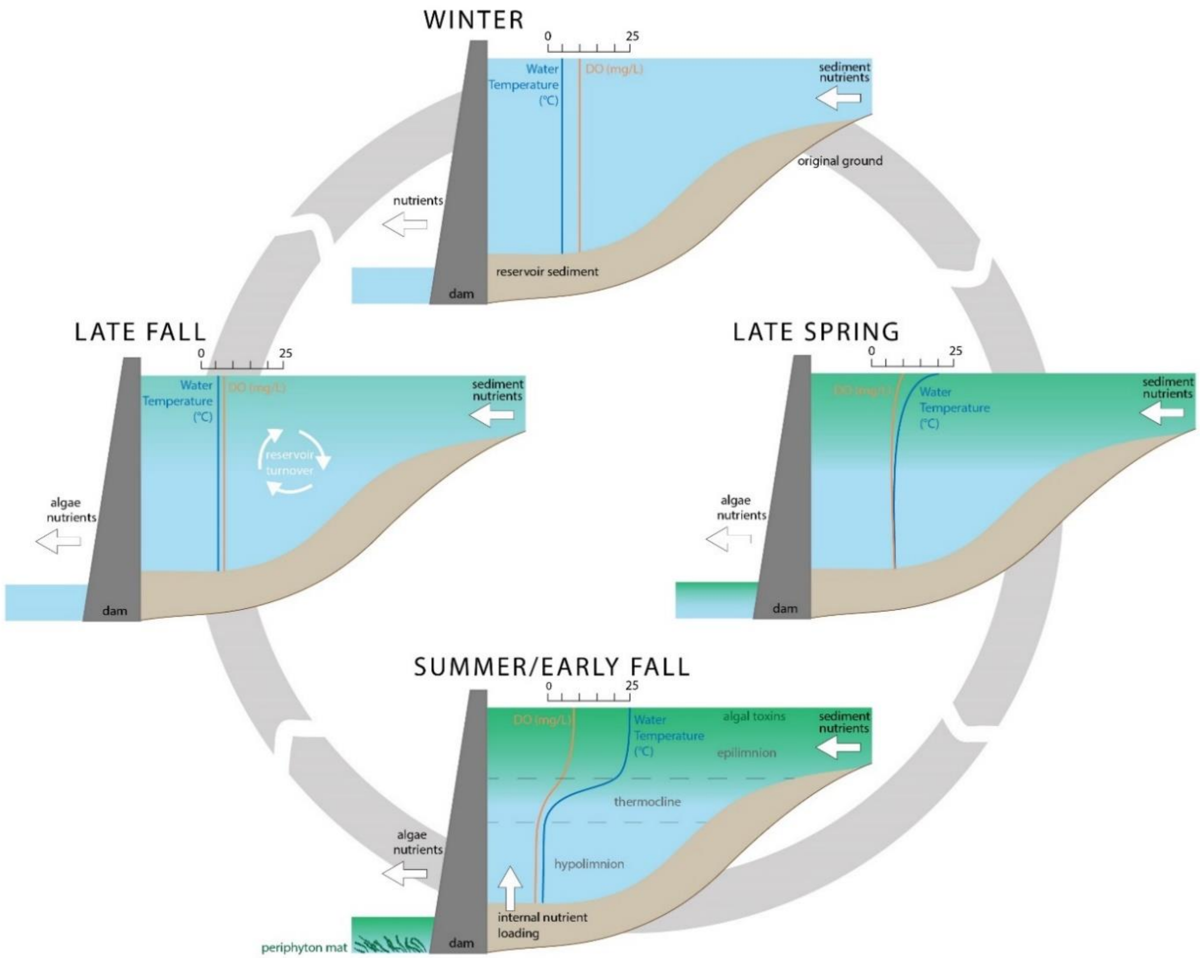

Figure 3.2-2. General Seasonal Pattern of Thermal Stratification, Dissolved Oxygen Concentrations, and Algae Blooms in Relatively Deep, Productive Reservoirs in Temperate Climates, With Darker Green Shading In Surface Waters Representing a Higher Intensity of Algae Growth.

- **Reservoir mixing and dissolved oxygen.** The water column in the deepest portions of most large reservoirs has a characteristic thermal and chemical structure. With thermal stratification (in summer and early 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 (anoxic) (Figure 3.2-2). Releases of this deeper, oxygen-depleted water from the bottom of the reservoir can cause serious problems for downstream fish and other aquatic biota if released waters are not re-oxygenated through the outlet facilities and/or powerhouse or other means.
- **Phytoplankton in reservoirs.** As large reservoirs have long retention times for water and thermally stratify in the summer months, they often provide ideal conditions for the growth of phytoplankton in the epilimnion. Phytoplankton are microscopic organisms, including algae, bacteria, protists, and other single-celled plants, that float in the water column of fresh and salt waters and obtain energy via photosynthesis. Depending upon available nutrients, extensive seasonal phytoplankton blooms can develop in these reservoirs (Figure 3.2-2). Phytoplankton photosynthesis during the day releases dissolved oxygen and consumes carbon dioxide. At night, phytoplankton respiration consumes dissolved oxygen and releases carbon dioxide. This can result in wide daily swings in dissolved oxygen and pH, which is stressful to aquatic biota. A naturally weakly buffered system like the Klamath River (i.e., alkalinity typically less than 100 mg/L as calcium carbonate [$CaCO_3$]; PacifiCorp [2004a], Karuk Tribe of California [2010a]) is especially prone to wide daily pH swings due to phytoplankton photosynthesis and respiration. Under nutrient-rich conditions, harmful blooms of phytoplankton composed of blue-green algae (also referred as cyanobacteria) can occur. Blue-green algae can produce algal toxins, which are also referred to as cyanotoxins (e.g., cyclic peptide toxins such as microcystin that adversely affects liver function and alkaloid toxins such as anatoxin-a and saxitoxin that adversely affect the nervous system). Algal toxins can be harmful to a wide range of organisms including exposed fish, shellfish, livestock, and humans. If not removed from the reservoir water column (e.g., by a mechanical/physical barrier like an intake barrier/ thermal curtain), releases of reservoir impounded waters can transport phytoplankton and/or toxins to downstream waters (Figure 3.2-2) and phytoplankton blooms can die abruptly (“crash”), releasing algal toxins into the water column. The subsequent decomposition of organic matter associated with dead phytoplankton can create periods of low dissolved oxygen in reservoir bottom waters, along with peaks of algal toxins, which adversely impact environmental and human health conditions (Figure 3.2-2). Additional information on phytoplankton and its impacts on water quality (including nitrogen fixation) can be found in *Section 3.4 Phytoplankton and Periphyton*.
- **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 the combined total phosphorus retention in Iron Gate and Copco No. 1 reservoir sediments equal to approximately 11 percent of the total phosphorus inflow and the combined total nitrogen retention in Iron Gate and Copco No. 1 reservoir sediments equal to approximately 12 percent of the total nitrogen inflow. Dissolved nutrients (e.g., ortho-phosphorus, nitrate, and ammonium) entering a reservoir can be used directly by phytoplankton (which includes blue-green algae) when growing conditions are conducive. When phytoplankton die, they settle to the bottom of reservoirs and contribute nutrients and organic matter to the sediments. Under low dissolved oxygen (i.e., anoxic) conditions, nutrients contained within bottom sediments can be released back into the water column, creating a source of nutrients internal to the reservoir itself, in addition to the nutrients entering the reservoir from upstream sources. This is particularly important for phosphorus and results in highly enriched reservoir bottom waters during periods of stratification. Dissolved nutrients in the reservoir water column can be released downstream during late summer and fall before reservoir turnover occurs, potentially resulting in a secondary (fall) phytoplankton bloom (which includes blue-green algae). During reservoir turnover in fall when stratification breaks down, nutrient rich waters are mixed throughout the reservoir water column, further releasing dissolved nutrients downstream of the dam (Figure 3.2-2).

- **Sediment deposition in reservoirs**. The characteristically slow-moving waters within large reservoirs result in the deposition of sediments that enter the reservoir from the surrounding watershed (Figure 3.2-2). While large reservoirs interrupt the natural transport of both coarse sediments (e.g., sand, gravel, cobble, boulders) and fine sediments (e.g., clay, silt), contaminants found in the bottom sediments of reservoirs are typically transported from the watershed with fine sediments, which include both inorganic material and organic particulate matter. Trace metals are mostly attached to inorganic material (e.g., clays and silts). Organic contaminants, such as pesticides and dioxin, are adsorbed to (i.e., attached to the surface of) organic particulate matter, such as dead vegetation and phytoplankton.
- **Periphyton growth downstream of reservoirs.** Slow transport of water downstream and modified timing and magnitude of river flows can affect the growth of periphyton downstream of hydroelectric dams. Periphyton are aquatic freshwater organisms, including algae and bacteria that live attached to underwater surfaces such as rocks on a riverbed. Periphyton are important base components of the food web in riverine systems. Periphyton can influence riverine water quality by affecting nutrient cycling and diel (i.e., 24-hour cycle) fluctuations in dissolved oxygen and pH. Natural scouring of periphyton populations can be diminished downstream of large dams due to altered flows and interception of coarse sediment movement by the dam, leading to seasonal occurrence of large periphyton mats that can cause water quality problems and provide abundant habitat

for fish parasites (see also Section 3.3.4.5 *Fish Disease and Parasites* and Section 3.4.2.2 *Periphyton*).

The following sections summarize general existing water quality conditions in the water quality Area of Analysis. Existing conditions are generally defined as physical, chemical, and biological characteristics of water in the Area of Analysis at the time of the NOP (i.e., 2016). Water quality parameters analyzed in this EIR are represented by data collected within the past 10 to 17 years (i.e., 2000 to 2017). Additional detail, including data from multiple agency and tribal monitoring programs throughout the Klamath Basin, is presented in Appendix C.

3.2.2.2 Water Temperature

Water temperatures in the Klamath Basin vary seasonally and by location. The North Coast Regional Water Quality Control Board (North Coast Regional Board) has determined that existing receiving water temperatures in the Klamath River are already too warm to support several designated beneficial uses, including cold freshwater habitat (COLD), rare, threatened, or endangered species (RARE), and migration of aquatic organisms (MIGR) annually during late summer/early fall (North Coast Regional Board 2010). All reaches of the Klamath River from the Oregon-California state line to the mouth of the Klamath River are listed as impaired for elevated water temperature on the Clean Water Act (CWA) Section 303(d) list. As a result, the North Coast Regional Board has developed TMDLs for water temperature in the Klamath River. A quantitative Klamath River TMDL model was created to determine what natural water temperature conditions would be in the Klamath River, and then the model was used to determine how flow modifications, water withdrawals, and other human activities alter water temperatures, forming the basis of the TMDLs (see Appendix D). The Klamath River TMDL allocates specific water temperature loads for Copco No. 1 and Iron Gate reservoirs, as discussed below. Properly functioning thermal refugia[5] are necessary to meet the Basin Plan water temperature objectives, as these areas of colder water in the mainstem Klamath River moderate naturally high summer water temperature conditions by providing places where fish can escape warmer temperatures. These thermal refugia support beneficial uses such as migration of salmonids (North Coast Regional Board 2011).

In the Hydroelectric Reach, water temperatures are influenced by the presence of the Lower Klamath Project facilities. The relatively shallow depth and short hydraulic residence times do not support thermal stratification in J.C. Boyle

[5] Thermal refugia are typically identified as areas of cool water created by inflowing tributaries, springs, seeps, upwelling hyporheic flow, and/or groundwater in an otherwise warm stream channel offering refuge habitat to cold-water fish and other cold-water aquatic species (North Coast Regional Board 2011). Cold-water fish utilize thermal refugia for cold water habitat when ambient river temperatures exceed their preferred temperature range.

Reservoir (FERC 2007; Raymond 2008a, 2009a, 2010a) and thus this reservoir does not directly alter summertime water temperatures in further downstream reaches (NRC 2004). However, current bypass operations at the J.C. Boyle Dam affect water temperatures in the river immediately downstream from the dam. While natural diel (24-hour) water temperature variations occur in the river, bypass operations between J.C. Boyle Dam (river mile [RM] 229.8) and the J.C. Boyle Powerhouse (RM 225.2) result in water temperatures that are typically cooler from May to September and warmer from November to March than ambient river temperatures upstream or downstream (PacifiCorp 2004a). Decreases in the daily water temperature (i.e., cooler water temperature than upstream of J.C. Boyle Reservoir) and the range of daily water temperature variations occur in the J.C. Boyle Bypass Reach during the summer/fall because warmer reservoir discharges are diverted around this reach (see also Section 2.3.1 *J.C. Boyle Dam Development*) and cold groundwater springs enter the river and dominate remaining flows (PacifiCorp 2004a; Kirk et al. 2010). Water temperatures in the J.C. Boyle Bypass Reach can decrease by 9 to 27°F when bypass operations are underway due to the influence of the springs (Kirk et al. 2010). In the J.C. Boyle Peaking Reach, which is downstream of the J.C. Boyle Bypass Reach, the flow diverted around the J.C. Boyle Bypass Reach rejoins the Klamath River (see Figure 2.3-1). At the upstream end of the J.C. Boyle Peaking Reach, the natural, cold groundwater input into the J.C. Boyle Bypass Reach, combined with fluctuations in river flow due to hydroelectric power operations in the J.C. Boyle Peaking Reach also produces an observed increase in daily water temperature range above the natural diel water temperature fluctuations (Kirk et al. 2010). For example, daily water temperature in the J.C. Boyle Peaking Reach in 2002 varied by approximately 3 to 13˚F during hydroelectric power operations, while daily water temperature varied by approximately 1 to 2˚F during non-peaking flows. Based on available data, the influence of the springs dominates water temperature in this reach; for example, while daily variations in water temperature increased during peaking operations, water temperatures in the J.C. Boyle Peaking Reach still decreased by 9 to 16˚F compared to upstream of J.C. Boyle Reservoir (PacifiCorp 2004a; FERC 2007).

Further downstream in the J.C. Boyle Peaking Reach, near the confluence of the Klamath River and Shovel Creek (Figure 2.2-3), there are natural hot springs that contribute flows to the mainstem river. The natural hot springs were not found to result in consistent substantial warming of the Klamath River based on two sets of measurements made in November and December 2017 (KRRC 2018). Water temperature data collected upstream and downstream of the confluence of the Klamath River and Shovel Creek showed a 1.4˚F increase in the downstream direction during the November 2017 measurement, but a 0.2˚F decrease during the December 2017 measurement (KRRC 2018).

Iron Gate and Copco No. 1 reservoirs are the two deepest reservoirs in the Hydroelectric Reach. These reservoirs thermally stratify each year beginning in April/May and the warmer surface and cooler bottom waters do not mix again until October/November (FERC 2007; Raymond 2008a, 2009a, 2010a; Asarian and Kann 2011). 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 Hydroelectric Reach are generally cooler than would be expected under natural conditions, and summer and fall water temperatures are generally warmer (Figure 3.2-3; North Coast Regional Board 2010; Asarian and Kann 2013). In the Hydroelectric Reach, maximum temperatures, generally occur in late July and regularly exceed the range of chronic effects temperature thresholds (approximately 55 to 68°F) for full salmonid support in California (North Coast Regional Board 2010).

To alleviate the late summer/fall warming caused by Lower Klamath Project reservoirs under existing conditions, the Klamath River TMDL specifies a zero water temperature increase above natural water temperatures in the Hydroelectric Reach. However, to account for the anthropogenic heat load entering the Hydroelectric Reach from upstream sources and to acknowledge that even without the presence of the reservoirs, the Klamath River would be expected to naturally change temperature through the reaches currently occupied by the reservoirs, the TMDL sets the allowable increase in daily average (and daily maximum) water temperatures at 0.9°F (0.5°C) for Copco No. 1 and Copco No. 2 reservoir tailraces and 0.18ºF (0.1ºC) for the Iron Gate Reservoir tailrace (North Coast Regional Board 2010). Additionally, the Klamath River TMDL specifies a portion of Copco No. 1 and Iron Gate reservoirs must provide suitable water temperature and dissolved oxygen conditions for cold-water fish during the critical summer period—thus maintaining a “compliance lens” within the reservoirs that can support cold-water fish. In 2015, PacifiCorp installed a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11. While the primary purpose of the curtain is to isolate surface waters that have high concentrations of blue-green algae (cyanobacteria) such that extensive summer and fall blooms are not readily released downstream to the Middle and Lower Klamath River (see further discussion in Potential Impact 4.2.2-2), PacifiCorp reports that the curtain also provides a secondary benefit of isolating warmer surface waters and draws deeper cooler water for release to the Klamath River downstream of Iron Gate Dam (PacifiCorp 2016a, 2017a, 2018a). Results from the intake barrier/thermal curtain studies indicate that modest 1 to 2°C (1.8 to 3.6°F) water temperature improvement is possible (PacifiCorp 2016a, 2017a), although data do not indicate that this measure could achieve compliance with the Thermal Plan or to meet the Klamath River TMDLs temperature requirement in the Middle Klamath River (North Coast Regional Board (2010). Additionally, water temperature improvements from operation of the intake barrier/thermal curtain would be potentially limited by the need to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards, with the curtain completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018a).

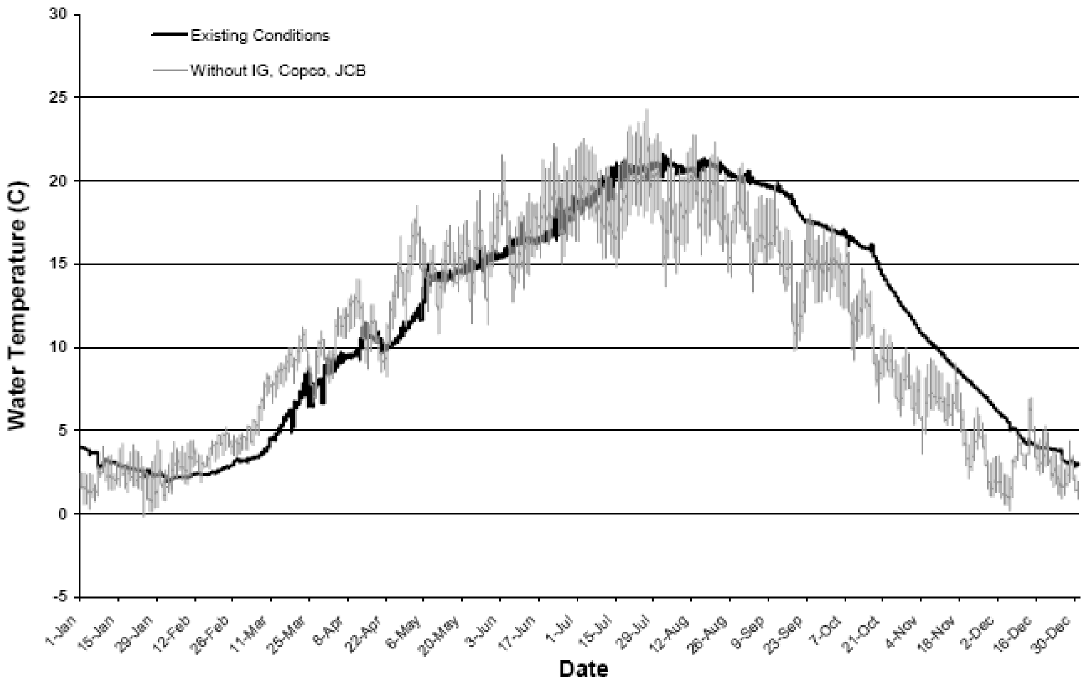

Figure 3.2-3. Simulated Hourly Water Temperature Downstream from Iron Gate Dam Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Dams. Source: PacifiCorp 2005a.

The seasonal water temperature pattern of the Hydroelectric Reach is similar in the Klamath River immediately downstream from Iron Gate Dam, where water released from Iron Gate Dam is 1.8 to 4.5°F (approximately 1 to 2.5°C) cooler in the spring and approximately 4 to 18°F (approximately 2 to 10°C) warmer in the summer and fall as compared to modeled conditions without the Lower Klamath Project dams (PacifiCorp 2004a; Dunsmoor and Huntington 2006; North Coast Regional Board 2010). In addition to this “thermal lag”, immediately downstream from Iron Gate Dam water temperatures tend to exhibit relatively low variability due to the influence of the reservoir’s water releases (Karuk Tribe of California 2009, 2010a, 2010b, 2011, 2012, 2013; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019; Asarian and Kann 2013). The Iron Gate Dam intake structure is designed to withdraw water from the surface to approximately 35 feet (10 meters) below the Iron Gate Reservoir full pool elevation, so the dam typically is releasing water from the epilimnion during periods when the reservoir is stratified. The design and operation of the Iron Gate Dam intake structure results in the water temperature in the Klamath River immediately downstream of Iron Gate Dam being similar (i.e., within a few degrees or less) to the water temperature measured approximately 10 to 30 feet below the surface of Iron Gate Reservoir near the dam (PacifiCorp 2004a; FERC 2007). After deployment of PacifiCorp’s intake barrier/thermal curtain, the water temperature in the Klamath River immediately downstream of Iron Gate Dam was most similar to the water temperature measured approximately 16 feet below the surface of Iron Gate Reservoir (PacifiCorp 2017a). Water temperature data collected since 2009 as part of KHSA Interim Measure 15 (see also Table 2.7-12) indicate that water temperature trends under the 2013 BiOp Flows are consistent with those under the pre-2013 BiOp Flows. For example, Asarian and Kann (2013) found that mean and maximum water temperature between 2001 and 2011 peaked each year between July and August with a maximum temperature of approximately 75°F. Although the 2013 BiOp increased minimum flows during July compared to pre-2013 BiOp Flows, water temperature downstream of Iron Gate Dam peaked in July/August during 2013 to 2018 under 2013 BiOp Flows, with a maximum temperature of approximately 75°F in mid/late July to early/mid-August in all six years (Watercourse Engineering, Inc. 2014, 2015, 2016, 2017, 2018, 2019). Water temperature trends under the 2019 BiOp Flows cannot be compared with those under the pre-2013 BiOp Flows and the 2013 BiOp Flows since water temperature data from the Klamath River, including KHSA IM 15 data, after the 2019 BiOp Flows became the applicable flow criteria (i.e., April 1, 2019) has not been reviewed and approved for distribution. Water temperature trends under the 2019 BiOp Flows are expected to be similar to those under 2013 BiOp Flows due to the similarities in 2019 BiOp Flows and 2013 BiOp Flows (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* and Section 4.2.1.1 *[No Project Alternative] Alternative Description – Summary of Available Hydrology Information for the No Project Alternative*).

Farther downstream, the presence of the Lower Klamath Project exerts less influence on water temperatures, and the Klamath River is more influenced by solar energy, the natural heating and cooling regime of ambient air temperatures, and tributary inputs of surface water. Meteorological influences on water temperature result in increasing temperature with distance downstream from Iron Gate Dam in the summer and fall months (Basdekas and Deas 2007; Asarian and Kann 2013). For example, daily average temperatures between June and September are approximately 1.8 to 7.2°F higher near Seiad Valley (RM 132.7) than those just downstream from Iron Gate Dam (Karuk Tribe of California 2009, 2010a, 2010b, 2011, 2012, 2013) (see Appendix C for more detail). At the Salmon River confluence with the Klamath River (RM 66.3), the effects of the Lower Klamath Project on water temperature are significantly diminished. Downstream from the Salmon River, the influence of the Lower Klamath Project dams on water temperature in the Klamath River is not discernable from the modeled data (PacifiCorp 2005a; Dunsmoor and Huntington 2006; North Coast Regional Board 2010; Perry et al. 2011; Risley et al. 2012).

Downstream from the Salmon River (RM 66), summer water temperatures begin to decrease slightly with distance as coastal weather influences (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 Klamath River (Asarian and Kann 2013). In general, however, water temperatures in this reach still regularly exceed salmonid thermal preferences (less than 68ºF) during summer months. Asarian and Kann (2013) reported that the average daily maximum water temperature[6] between 2001 and 2011 was 73.4ºF or higher between July through August from the Salmon River (RM 66) to Turwar Creek (RM 5.6). Daily maximum summer water temperatures have been measured at values greater than 78.8°F just upstream of the confluence with the Trinity River (Weitchpec [RM 43.6]), decreasing to 76.1°F near Turwar Creek (RM 5.6) (YTEP 2005; Sinnott 2010a). Maximum temperatures in the Klamath River downstream from Iron Gate Dam to the Klamath River Estuary regularly exceed the range of chronic (sublethal) effects temperature thresholds[7] (55.4 to 68°F) for full salmonid support in California (North Coast Regional Board 2010; Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019; Hanington 2013; Hanington and Ellien 2013) (see Appendix C for more detail).

Water temperatures in the Klamath River Estuary are linked to meteorological conditions (e.g., solar radiation, coastal fog), temperatures and flows entering the estuary, salinity of the estuary and resulting density stratification, and the timing and duration of sand berm formation 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 saltwater 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 64.4 to 76.5°F (Wallace 1998; Hiner 2006; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019). Input of cool ocean water and fog along the coast minimizes extreme water temperatures much of the time (Scheiff and Zedonis 2011).

3.2.2.3 Suspended Sediments

For the purposes of the Lower Klamath Project EIR, "suspended sediment" refers to settleable suspended material in the water column. Bed materials, such as gravels and larger substrates, are discussed in Section 3.11.2.4 *Sediment Load*. Two types of suspended material are important to water quality in the Klamath River: algal-derived (organic) suspended material and mineral (inorganic) suspended material. Sources of each type of suspended material differ, as do

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[6] The average daily maximum water temperature is calculated by determining the daily maximum water temperature for each day with at least 80 percent complete data (38 out of 48 individual 30-minute measurements present), then averaging the daily maximum water temperature for each day from 2001 to 2011.
[7] Chronic (sub-lethal) effects temperature thresholds are detailed in Appendix 4 of North Coast Regional Board (2010).

spatial and temporal trends for each, within the Upper, Middle, and Lower Klamath river reaches.

Suspended material concentrations tend to decrease through the Hydroelectric Reach (PacifiCorp 2004b), where interception, decomposition, and retention of organic suspended materials occur in the Lower Klamath Project reservoirs. Additionally, dilution from coldwater springs below J.C. Boyle assists in decreasing organic suspended material concentrations. However, seasonal increases in organic suspended material can occur in Copco No. 1 and Iron Gate reservoirs due to large summertime phytoplankton blooms, which can adversely affect water quality beneficial uses (PacifiCorp 2004b; Raymond 2008a, 2009a, 2010a; Watercourse Engineering, Inc. 2011b, 2012, 2013, 2014, 2015, 2016) (see Appendix C, Section C.2.1 for more detail).

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). Inorganic suspended materials (i.e., silts, clays with diameters less than 0.063 mm) are primarily transported during high flow events and generally settle out in the Lower Klamath Project reservoirs such that water column concentrations decrease with distance downstream in this 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 greater than 0.063 mm) from the tributaries. In the Hydroelectric Reach, J.C. Boyle, Copco No.1, and Iron Gate reservoirs trap sediment and suspended material, reducing suspended sediment concentrations immediately downstream of their respective dams. Copco No. 2 Reservoir does not trap appreciable amounts of sediment or suspended material (USBR 2011) or reduce suspended sediment concentrations downstream of its dam, since the immediately upstream Copco No. 1 Dam traps upstream sediment and the relatively small volume of Copco No. 2 Reservoir (i.e., 70 acre-feet) prevents suspended material from settling out inside the reservoir. On the scale of the entire Klamath Basin, the trapping of fine sediments and suspended materials does not appear to be a critical function of the Lower Klamath Project reservoirs with respect to the overall cumulative sediment delivery including downstream tributaries (see also Section 3.11.2.4 *Sediment Load*), since a relatively small percentage (3.4 percent) of total sediment supplied to the Klamath River on an annual basis originates from the Upper and Middle Klamath River (i.e., from J.C. Boyle Dam to the confluence with the Shasta River). Beneficial uses in the Hydroelectric Reach are currently not impaired due to inorganic suspended material (North Coast Regional Board 2011).

Trapping of fine sediments and suspended materials by the Lower Klamath Project reservoirs reduces suspended sediment concentrations immediately downstream of Iron Gate Dam (RM 193.1), thus inorganic suspended material concentrations are generally low in this reach. However, in the summer months, organic suspended materials can increase in the Klamath River between Iron

Gate Dam and Seiad Valley (RM 132.7) due to the transport of in-reservoir algal blooms to downstream reaches of Klamath River, resuspension of previously settled organic materials, and degradation (i.e., senescence) of periphyton communities along the stream (YTEP 2005; Sinnott 2008; Armstrong and Ward 2008; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017). The relative magnitude of the contribution from the different sources of organic (algal-derived) suspended material in the Klamath River has not been and cannot be quantified from the available data since the measurements did not attempt to distinguish between the potential sources. Near the confluence with the Scott River (RM 145.1) concentrations of organic suspended materials tend to decrease with distance as phytoplankton gradually settle out of the water column farther downstream or are diluted by tributary inputs (see Appendix C for more detail).

Inorganic suspended sediments downstream of Iron Gate are mainly contributed by major tributaries to the mainstem during winter and spring (Armstrong and Ward 2008). The three tributaries that contribute the largest amount of suspended sediment to the Klamath River are located below Iron Gate Dam and include: the Scott River (RM 145.1) (607,300 tons per year or 10 percent of the cumulative average annual delivery from the basin); Salmon River (RM 66) (320,600 tons per year or 5.5 percent of the cumulative average annual delivery from the basin) (Stillwater Sciences 2010); and, the Trinity River (3,317,300 tons per year or 57 percent of the cumulative average annual delivery from the basin) (Stillwater Sciences 2010) (see Appendix C for more detail). Additionally, steep terrain and land use activities such as timber harvest and road construction near the Klamath River and its tributaries result in high sediment loads during high-flow periods.

3.2.2.4 Nutrients

Levels of nutrients, including nitrogen and phosphorus, are affected by the geology of the Klamath Basin, upland productivity and land uses, and a number of physical processes affecting aquatic productivity within reservoir and riverine reaches. The two major upstream sources of nutrients to the water quality Area of Analysis are Upper Klamath Lake, which inputs nitrogen and phosphorus (Kann and Walker 1999; ODEQ 2002; PacifiCorp 2004b; Deas and Vaughn 2006; FERC 2007; Sullivan et al. 2008; Asarian et al. 2010) and the Lost River Basin (via the Klamath Straits Drain and the Lost River Diversion Channel), which inputs nutrients and organic matter (Lytle 2000; Mayer 2005; Sullivan et al. 2009; Sullivan et al. 2011; Kirk et al. 2010).

On an *annual* basis, nutrients typically decrease slightly through the Hydroelectric Reach due to settling of particulate matter and associated nutrients in Copco No. 1 and Iron Gate reservoirs, and dilution by the coldwater springs located downstream of J.C. Boyle Reservoir (Asarian et al. 2010; North Coast

Regional Board 2010; Oliver et al. 2014)[8]. Annual total nitrogen (TN) inputs to Copco No. 1 and Iron Gate reservoirs range from approximately 2,026 to 3,443 metric tons TN between May 2005 and May 2007, with an annual TN retention of approximately 259 to 419 total metric tons TN. Thus, the annual TN retention in Copco No. 1 and Iron Gate reservoirs is approximately 12 percent (419 of 3,443 metric tons TN) from May 2005 to May 2006 and 13 percent (259 of 2,026 metric tons TN) from May 2006 to May 2007 (Asarian et al. 2009). The annual total phosphorus (TP) inputs to Copco No. 1 and Iron Gate range from approximately 210 to 335 metric tons TP between May 2005 and May 2007, with an annual TP retention of approximately 28 to 30 total metric tons TP. Thus, annual TP retention in Copco No. 1 and Iron Gate reservoirs is approximately 9 percent (30 of 335 metric tons TP) from May 2005 to May 2006 and 13 percent (28 of 210 metric tons TP) from May 2006 to May 2007 (Asarian et al. 2009). Overall, on an annual basis, external loading of nutrients from the Upper Klamath River appears to be the dominant source of total nutrients to the Hydroelectric Reach and the Lower Klamath Project reservoirs and is also responsible for the majority of total nutrients being transported downstream of the reservoirs.

However, on a *seasonal* basis, TP, and to a limited degree the ammonia contribution to TN, can increase in the Hydroelectric Reach due to the release (export) of dissolved forms of phosphorus (ortho-phosphorus) and nitrogen (ammonium) from reservoir sediments during summer and fall when reservoir bottom waters are anoxic (Kier Associates 2006; Kann and Asarian 2007; Stillwater Sciences 2009; Asarian et al. 2009, 2010; Oliver et al. 2014). Such internal loading of nutrients on a seasonal basis is common in reservoirs that thermally stratify and become anoxic for several weeks to months during summer and fall. In Copco No. 1 and Iron Gate reservoirs, total combined TP retention is approximately negative 8 percent during the main reservoir phytoplankton growing season (i.e., approximately May to September), with the negative combined TP retention during this period indicating a net export of TP. The total combined TN retention in Copco No. 1 and Iron Gate reservoirs is approximately 23 percent during the main reservoir phytoplankton growing season (i.e., approximately May to September). The higher TN retention during summer months is attributed to settling of organic matter and algal material, denitrification, and/or ammonia volatilization (Asarian et al. 2009, 2010). While TN retention is seasonally higher in Copco No. 1 and Iron Gate during the main reservoir phytoplankton growing season, the ammonia concentration downstream of Iron Gate increases during this period from approximately 0.01 to 0.05 mg/L until peaking in October and November at approximately 0.1 to 0.2 mg/L due to the anoxic conditions in the lower section Iron Gate Reservoir (Asarian et al. 2010) (see Appendix C for additional details). Seasonal nutrient releases occur during

[8] The total nitrogen (TN) and total phosphorus (TP) nutrient concentrations in the natural coldwater springs are low, at approximately 0.22 mg/L TN (almost exclusively dissolved) and 0.06 to 0.08 mg/L TP (mostly dissolved) (Asarian et al. 2010).

periods of in-reservoir phytoplankton growth, and, in the case of TP, can result in downstream transport of bioavailable nutrients to the Lower Klamath River where they can stimulate growth of periphyton (aquatic freshwater organisms attached to river bottom surfaces). Additional information on effects of the Lower Klamath Project to phytoplankton and periphyton can be found in Section 3.4 *Phytoplankton and Periphyton*.

Seasonal variations in concentrations of TN and TP occur in the Klamath River downstream of Iron Gate Dam due to a combination of nutrient storage and release from the water column and reservoir sediments, varying water concentrations at the elevation of the penstock intakes, residence times, and possible atmospheric losses through denitrification (for TN only) (Asarian and Kann 2011). In the summer and fall, TN and TP loads from Iron Gate Reservoir dominate nutrient loading to the Lower Klamath River compared to inputs from downstream tributaries, because tributary flows are relatively low during these seasons (Armstrong and Ward 2008). Downstream from the Lower Klamath Project, TP values typically range 0.1 to 0.25 milligrams per liter (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 less than 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). TP and TN concentrations in the Klamath River during summer through early fall vary with flow, with the highest concentrations tending to occur during low flow years (e.g., 2001 to 2004) and the lowest concentrations tending to occur during high flow years (e.g., 2006, 2010, 2011) (Asarian and Kann 2013). Dissolved nitrogen (nitrate) shows substantial variability among years (Asarian and Kann 2013).

Further variations in TN occur in the Middle and Lower Klamath river reaches due to a combination of tributary dilution and in-river nutrient spiraling processes by phytoplankton and periphyton. Nutrient concentrations are generally much lower in tributaries, with the exception of TP, TN, and soluble reactive phosphorus in the Shasta River and TN and nitrate in the Scott River at the outlet of Scott Valley (Asarian and Kann 2013). In-river nutrient spiraling processes by phytoplankton and periphyton involve cycling of nutrients by uptake during growth, storage in biomass, and release during biomass decay. These nutrient spiraling processes strongly affect nitrogen concentrations in flowing rivers. Removal processes such as denitrification and/or assimilation and storage related to biomass uptake decrease dissolved nitrogen concentrations in the river (Mulholland 1996; Butcher 2008; Asarian et al. 2010; Asarian and Kann 2013). Late-seasonal recycling of nutrients downstream occurs as active phytoplankton and periphyton growth wanes and may result in more bioavailable nutrients in the river. 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[9] (i.e., phytoplankton and/or periphyton growth) 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 phytoplankton and periphyton growth than nutrients are, particularly in the vicinity of Iron Gate Dam (FERC 2007; HVTEPA 2008; Asarian et al. 2010) (see Appendix C and Section 3.4 *Phytoplankton and Periphyton* for additional details).

Downstream from the confluence with the Salmon River, nutrient concentrations continue to decrease in the Klamath River due to tributary dilution and nutrient retention. Contemporary data (2001 to 2015) indicate that TP concentrations in this portion of the river are generally 0.05 to 0.1 mg/L with peak values occurring in September and October. Contemporary data indicate that, on a seasonal basis, TN increases from May through November with peak concentrations (greater than 0.5 mg/L) typically observed between August and October (YTEP 2004a, 2005; Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Asarian et al. 2010; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; Asarian and Kann 2013; HVTEPA 2013; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014; Oliver et al. 2014). Under these existing conditions, 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 (HVTEPA 2008).

Nutrient levels in the Klamath River 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 to October) and TN levels are consistently below 0.7 mg/L (June to October) (Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). While the Basin Plan water quality objective for biostimulatory substances is narrative rather than numeric (North Coast Regional Board 2011), as with upstream reaches, measured nutrient levels in the Klamath River Estuary typically exceed the half-saturation constant (0.003 mg/L for phosphorus [Tetra Tech 2009] and 0.014 mg/L for nitrogen [Tetra Tech 2009]) but may, at times, promote algal growth at levels that cause nuisance effects or adversely affect beneficial uses.

3.2.2.5 Dissolved Oxygen

Dissolved oxygen is the amount of oxygen gas dissolved in water. Oxygen enters water by direct incorporation from the atmosphere, through rapid mixing of water with air (e.g., turbulent mixing in fast flowing stream reaches), or as a waste product of photosynthesis by aquatic organisms. Water temperature and the volume of moving water can influence dissolved oxygen concentrations in water. Dissolved oxygen concentrations in the Klamath River depend on several

[9] Primary productivity is the synthesis of organic compounds by organisms through either photosynthesis or chemosynthesis.

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.

During summer, the Lower Klamath Project reservoirs' surface waters exhibit varying levels of dissolved oxygen mainly driven by phytoplankton, especially large blue-green algae blooms, in the reservoirs. During daylight hours, phytoplankton produce dissolved oxygen (through photosynthesis), resulting in super-saturation of dissolved oxygen. During nighttime hours, phytoplankton consume dissolved oxygen (through respiration) contributing to dissolved oxygen levels that can be below Basin Plan objectives.

The relatively long and shallow J.C. Boyle Reservoir (in Oregon) does not thermally stratify (see also Section 3.2.2.2 *Water Temperature*). While reaeration in the steep gradient of the Upper Klamath River between Keno Dam and J.C. Boyle Reservoir can increase dissolved oxygen in the Klamath River to near saturation levels, high biological oxygen demand in water entering J.C. Boyle Reservoir during summer months can still reduce dissolved oxygen levels as the water slows in the relatively low gradient of the reservoir (Raymond 2008a, 2009a, 2010a). While J.C. Boyle Reservoir does not thermally stratify, there are still large summertime variations in dissolved oxygen with depth observed in J.C. Boyle Reservoir that result in bottom waters in the reservoir having lower dissolved oxygen concentrations than surface waters (Raymond 2009a, 2010a; see Appendix C, Figure C-29 for more detail). This variation can affect dissolved oxygen concentrations further downstream in the California portion of the Hydroelectric Reach.

Copco No. 1 and Iron Gate reservoirs thermally stratify beginning in April/May and do not mix again until October/November (FERC 2007). During summer months, dissolved oxygen in Copco No. 1 and Iron Gate in the layer of water at the surface (epilimnion) is generally at, or in some cases above, saturation, while levels in hypolimnetic waters (the layer at the bottom) reach minimum values near 0 mg/L by July (see Appendix C for more detail). While the lowest surface dissolved oxygen concentrations in Copco No. 1 Reservoir generally co-occur with maximum water temperatures in July and August, the lowest surface dissolved oxygen concentrations in Iron Gate Reservoir tend to occur in October (see Appendix C, Figure C-32). The low surface dissolved oxygen levels and their occurrence later in the season at Iron Gate Reservoir may be associated with respiration of ongoing seasonal algal blooms in surface waters in this reservoir, as well as decomposition of organic matter derived from upstream sources. Very low dissolved oxygen levels in hypolimnetic (i.e., bottom) waters and sediments in mid-summer through fall in both reservoirs are due to the decomposition of dead algae cells from seasonal in-reservoir algal blooms as well as the decomposition of organic matter from upstream sources (Raymond 2009a, 2010a; Asarian and Kann 2013). Low dissolved oxygen concentrations in bottom waters generally persist longer in Iron Gate Reservoir than Copco No. 1 Reservoir since Copco No. 1 Reservoir experiences complete water-column mixing during approximately mid-October to early November, but Iron Gate Reservoir tends to mix approximately a month later, in late November to early December (see Appendix C, Figure C-32) (Raymond 2009a, 2010a; Asarian and Kann 2011).

In addition to the biological oxygen demand of the water column, there is also a sediment oxygen demand that influences dissolved oxygen levels in the water column of lakes, reservoirs, and rivers (Doyle and Lynch 2005). Sediment oxygen demand is the rate at which dissolved oxygen is removed from the water column by the decomposition of organic matter in streambed or lake/reservoir sediments. An analysis of oxygen demand in sediment cores sampled in 2002 from Copco No. 1 and Iron Gate reservoirs indicates that sediment oxygen demand in these waterbodies ranges from 1.0 to 2.0 grams of oxygen per square meter per day (g O_2/m^2/day) (FERC 2007), which is on the high end of values measured in other California reservoirs that typically range from approximately 0.1 g O_2/m^2/day to 1.4 g O_2/m^2/day (Beutel 2003).

Based upon measurements collected in the Middle Klamath River approximately 1,000 feet downstream from Iron Gate Dam, dissolved oxygen concentrations in this location regularly fall below 8.0 mg/L[10] and the Basin Plan minimum dissolved oxygen criteria of 85 to 90 percent saturation (depending on season and location) (Karuk Tribe of California 2001, 2002, 2003, 2007, 2009, 2010a, 2010b, 2011, 2012, 2013; Asarian and Kann 2011, 2013; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017). Daily fluctuations in dissolved oxygen (ranging from 1 to 3 mg/L per day) measured in the Klamath River approximately 1,000 feet downstream from Iron Gate Dam have been attributed to daytime algal photosynthesis and nighttime bacterial respiration in the upstream reservoirs (Karuk Tribe of California 2002, 2003; YTEP 2005; North Coast Regional Board 2010; Asarian and Kann 2011, 2013). Measured dissolved oxygen concentrations at this monitoring site are the net result of daily dissolved oxygen variations in the water being discharged from Iron Gate Dam along with mechanical aeration in the Klamath River and photosynthesis and respiration by organisms between the location where water is discharged from Iron Gate Dam and the monitoring site, but the magnitude of dissolved oxygen contributions from processes in the Klamath River between the reservoir discharge location and the monitoring site compared to the magnitude

[10] The Hoopa Valley Tribe surface-water quality objective for dissolved oxygen for COLD beneficial use is 8.0 mg/L (see

Table 3.2-).

of contributions from the upstream reservoirs have not been quantified. Although PacifiCorp has operated a turbine venting system since 2010 that mechanically adds oxygen to water as it is passed through the powerhouse turbines and before it is discharged to the Middle Klamath River, low dissolved oxygen saturation values continue to occur immediately downstream of the dam during late summer through fall (August through November) every year (PacifiCorp 2013a, 2014b, 2015a, 2016b, 2017b; Karuk Tribe of California 2012, 2013). Data from 2017 indicate that when dissolved oxygen decreased to 70 percent saturation in September at the monitoring site approximately 1,000 feet downstream of Iron Gate Dam, reaeration to greater than the applicable Basin Plan minimum dissolved oxygen saturation criterion (i.e., 85 percent saturation) occurred within approximately 2 to 3 miles downstream of Iron Gate Dam (PacifiCorp 2018b).

Farther downstream in the mainstem Klamath River, near Seiad Valley, dissolved oxygen concentrations tend to be higher but variable, with mean daily values ranging from approximately 6.5 mg/L to supersaturated concentrations of approximately 11.5 mg/L from June through November (Karuk Tribe of California 2001, 2002, 2003, 2007, 2009, 2010a, 2010b, 2011, 2012, 2013; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). At Seiad Valley, 31 percent of dissolved oxygen continuous data showed less than 8.0 mg/L between June and October during 2001 to 2011. During this period, the dissolved oxygen concentrations were less than 90 percent saturation in 25 percent of the continuous data and less than 85 percent saturation in 9 percent of measurements (Asarian and Kann 2013). Longitudinal variations in dissolved oxygen from Iron Gate Dam to Seiad Valley are most pronounced in the fall when dissolved oxygen concentrations are low immediately downstream of Iron Gate Dam and increase to saturation (or supersaturation) by Seiad Valley (Karuk Tribe of California 2013).

Dissolved oxygen concentrations from Orleans to Turwar in the Klamath River are also variable, with typical daily values ranging from approximately 6.5 mg/L to supersaturated concentrations of 11.5 mg/L during summer through fall (Karuk Tribe of California 2001, 2002, 2003, 2007, 2009, 2010a, 2010b, 2011, 2012, 2013; Ward and Armstrong 2010; North Coast Regional Board 2010; Asarian and Kann 2011, 2013; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). Near the confluence with the Trinity River and at Turwar, diel fluctuations in dissolved oxygen concentrations were observed resulting in dissolved oxygen greater than 8.0 mg/L during part of the day, but dissolved oxygen below 8.0 mg/L for several hours on multiple consecutive days to weeks during late summer/early fall (YTEP 2005; Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015; Asarian and Kann 2013; Hanington 2013; Hanington and Ellien 2013) (see Appendix C for additional details).

Dissolved oxygen concentrations in the Klamath River 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 (less than 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. Data during the period of 2009 to 2015 in the lower Klamath River Estuary (approximately RM 0.5) indicate that dissolved oxygen usually ranges from 7 mg/L to supersaturated concentrations of approximately 11 mg/L during summer and fall, with minimum levels near 5 mg/L (Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015; Hanington 2013; Hanington and Ellien 2013; Hanington and Cooper-Carouseli 2014) (see Appendix C for additional details).

3.2.2.6 pH

The pH of surface water is controlled by atmospheric carbon dioxide as well as the photosynthetic and respiratory processes of organisms in the water. pH controls the form that some chemical compounds take and mediates the chemical speciation of other compounds in the water (e.g., ammonia/ammonium, minerals, metals). In addition, pH influences the concentration of un-ionized ammonia and the ammonium ion in the water column (North Coast Regional Board 2010). The ability of a system to buffer changes in pH from natural and anthropogenic sources is measured by the total alkalinity of the water. Typical alkalinity of freshwater ranges from 20 to 200 mg/L, with levels below 100 mg/L indicating limited buffering capacity and an increased susceptibility to changes in pH. Levels below 10 mg/L indicate that the system is poorly buffered and very susceptible to changes in pH (Stillwater Sciences 2009).

The Klamath River is a weakly buffered system (i.e., has typically low alkalinity less than 100 mg/L as calcium carbonate [$CaCO_3$]; PacifiCorp [2004a], Karuk Tribe of California [2010a]), so it is susceptible to photosynthesis-driven daily and seasonal swings in pH. In the Hydroelectric Reach, pH varies with both depth in the reservoirs and season, as changes in rates of photosynthesis and respiration alter pH of the water. Vertical profile measurements of pH in Iron Gate and Copco No. 1 reservoirs between March and November 2000 to 2005 and June through November 2007 indicate that pH decreases with depth in both reservoirs (Figure 3.2-4; see Appendix C for additional details). The vertical distribution of pH values in both Lower Klamath Project reservoirs is attributed to photosynthesis of floating phytoplankton in surface waters (which increases pH) and respiration in bottom waters (which decreases pH) (Raymond 2008a; Asarian and Kann 2011). The dissolved oxygen vertical profiles in the Lower Klamath Project reservoirs further supports the role of phytoplankton in influencing pH with supersaturated dissolved oxygen concentrations in surface waters from photosynthesis and low dissolved oxygen in bottom waters from respiration (Figure 3.2-4).

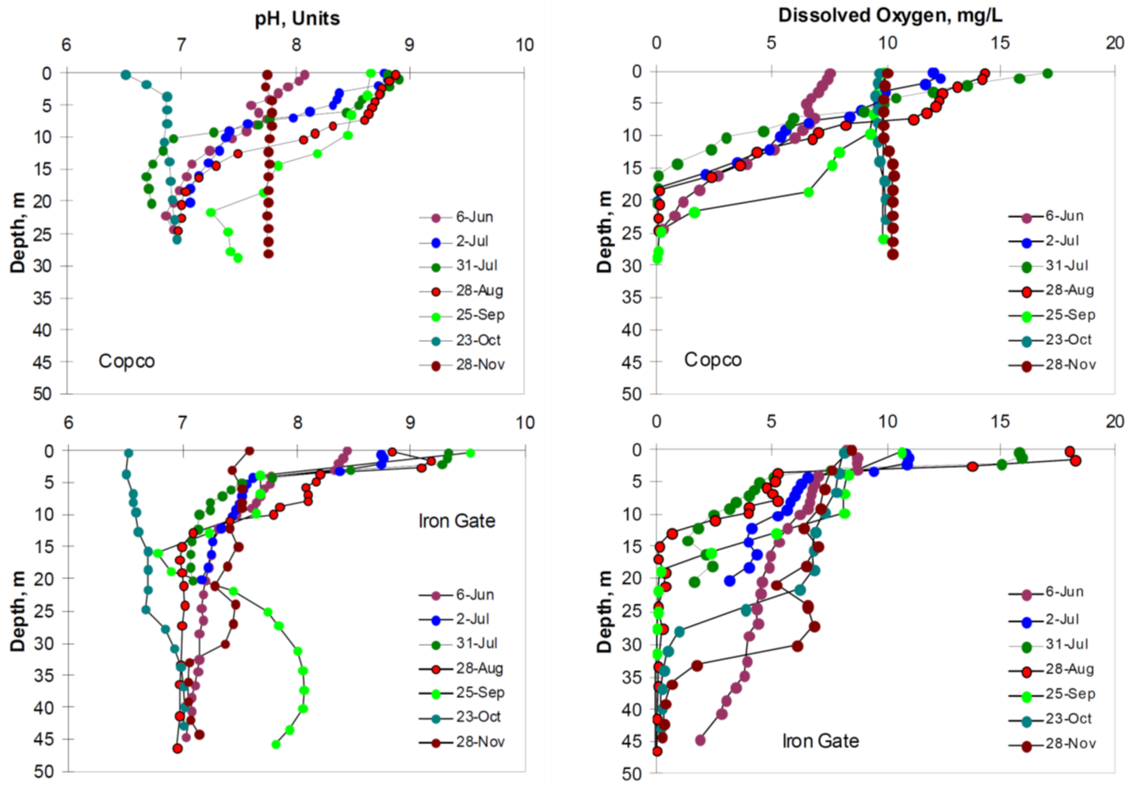

Figure 3.2-4. Vertical Profiles of pH and Dissolved Oxygen Measured During 2007 in Copco No 1. Reservoir at the Log Boom (top plot) and Iron Gate Reservoir at the Log Boom (bottom plot). Source: Adapted from Raymond 2008a.

Approximately 30 percent of samples collected in Copco No. 1 Reservoir and 5 to 20 percent of samples[11] collected in Iron Gate Reservoir surface waters (here, less than eight meters deep) exhibited pH values greater than 8.5 standard units (s.u.) (PacifiCorp 2008a), which is the Basin Plan instantaneous maximum pH objective (North Coast Regional Board 2011). In contrast, pH samples collected in bottom waters (here, greater than 20 meters) of both reservoirs tend to be lower, with approximately 17 percent of samples (68 of 391) collected in Copco No. 1 Reservoir and 22 percent of samples (135 of 613) collected in Iron Gate Reservoir exhibiting pH values less than 7.0 s.u. Other studies document peak

[11] PacifiCorp (2008a) Table 5.2-11 specifies the number of samples with pH greater than 8.5 as 25 of 485 total samples, equating to approximately 5 percent of samples. However, the table lists the percent of samples with pH greater than 8.5 as 19.6 percent. This appears to be a typographical error that cannot be resolved with the available information in PacifiCorp (2008a).

pH values (8.5 to 9.2 s.u.) near the reservoir surfaces during summer months (Raymond 2010a; Watercourse Engineering, Inc. 2012, 2013, 2014, 2015, 2016), while lower values (5.4 to 8.0 s.u.) have been documented near reservoir bottoms, without a consistent temporal trend amongst the reservoirs. Longitudinally within the Hydroelectric Reach, the lowest pH values have been recorded downstream from J.C. Boyle Reservoir (in Oregon) and the highest values in Copco No. 1 and Iron Gate reservoirs (Raymond 2008a, 2009a, 2010a).

In the Middle Klamath River, there are seasonally high pH values, with the highest pH values generally occurring during late-summer and early-fall months. Daily cycles in pH also occur in these reaches, with pH usually peaking during later afternoon or early evening following the period of maximum photosynthesis (North Coast Regional Board 2010; Asarian and Kann 2013). Hourly pH variations measured in the Klamath River downstream of Shasta River during a 48-hour period between July 28 to July 30, 1997 show the daily change in pH ranging from approximately 0.8 to 1.5 s.u. (Deas and Orlob 1999). The daily range of pH (i.e., daily maximum pH minus daily minimum pH) generally peaks between late July and early September, corresponding to daily cycles of photosynthesis and respiration, which also peak between late July and early September (Asarian and Kann 2013). The Basin Plan instantaneous maximum pH objective of 8.5 s.u. is regularly exceeded in the Middle and Lower Klamath River (FISHPRO 2000; Karuk Tribe of California 2002, 2003; YTEP 2005; FERC 2007; USFWS 2008; North Coast Regional Board 2010, 2011; Asarian and Kann 2013; Watercourse Engineering, Inc. 2012, 2013, 2014, 2015, 2016, 2017) (see Appendix C for more detail). The most extreme pH exceedances typically occur from Iron Gate Dam to approximately Seiad Valley, with pH values generally decreasing with distance downstream (FERC 2007; Karuk Tribe of California 2007, 2009, 2010a, 2010b, 2011, 2012, 2013; Asarian and Kann 2013) (see Appendix C for more detail). Analysis of data from 2001 to 2011 indicates that for June through October, 35 percent of pH measurements exceeded 8.5 s.u. between Iron Gate Dam and the confluence with the Shasta River, and 11 percent of pH measurements exceeded 8.5. s.u. at Orleans. pH greater than 9.0 s.u. was most frequently recorded at Iron Gate Dam (nine percent for September) and was rare (less than 0.1 percent) at mainstem locations below Seiad Valley (Asarian and Kann 2013).

During the summer months, pH values also are elevated in the Lower Klamath River from the confluence with the Trinity River downstream to approximately Turwar Creek (FISHPRO 2000; Karuk Tribe of California 2002, 2003, 2007, 2009, 2010a, 2010b, 2011, 2012, 2013; YTEP 2005; USFWS 2008; North Coast Regional Board 2010, 2011; Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017; Asarian and Kann 2013) (see Appendix C for more detail). In the Klamath River Estuary, pH typically ranges from approximately 6.9 and 9.0 s.u. with peak values also occurring during the summer months, though values below 6.9 s.u. have occasionally been measured (YTEP 2005; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017). Daily variations in pH are typically on the order of 0.5 s.u., 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 (YTEP 2005).

3.2.2.7 Chlorophyll-*a* and Algal Toxins

As primary producers, phytoplankton and periphyton are critical components of river and lake ecosystems (see also Section 3.4 *Phytoplankton and Periphyton*). Their presence and abundance affect food web dynamics as well as physical water quality parameters (e.g., dissolved oxygen, pH, turbidity, and nutrients). Physical water quality parameters are affected by phytoplankton and periphyton through rates of photosynthesis, respiration, and decay of dead phytoplankton and periphyton cells (Horne and Goldman 1994). Phytoplankton and periphyton species in the water quality Area of Analysis include a number of different species that may have very different effects on water quality and water chemistry. With respect to phytoplankton, a 2007 field study of river and lake/reservoir sites from Upper Klamath Lake to the Klamath River at Turwar found that the major groups present include diatoms (70 percent of total biovolume), cyanobacteria [blue-green algae] (28 percent of total biovolume), and green algae (1 percent of total biovolume) (Raymond 2008b). In a lake or reservoir environment, diatoms (i.e., unicellular, photosynthetic microalgae) typically dominate in spring then decrease due to zooplankton[12] grazing and the onset of water column stratification, which results in the diatoms settling out of the water column below the lake or reservoir surface layer (epilimnion). Cyanobacteria, also referred to as "blue-green algae," are photosynthetic bacteria and can often be a nuisance aquatic species, occurring as large seasonal blooms that alter surrounding water quality. In a lake or reservoir environment, blue-green algae dominance increases during late summer and early fall because their ability to control their buoyancy enables blue-green algae to remain near the surface during lake or reservoir stratification, thereby obtaining light for photosynthesis better than diatoms (Raymond 2008b, 2009b, 2010b; Asarian and Kann 2011; McDonald and Lehman 2013; Visser et al. 2016). Dense blooms of blue-green algae that can remain at the water surface also reduce the light available for photosynthesis and growth of other phytoplankton species, like diatoms and green algae, that cannot control their buoyancy (Miller et al. 2010).

Some blue-green algae species produce algal toxins, which are also referred to as 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 (WHO 1999). Incidence of visual disturbance, nausea, vomiting, muscle weakness, and acute liver failure have

[12] Heterotrophic plankton that prey on diatoms.

been reported in humans exposed to algal toxins (Butler et al. 2012). For example, four hours of recreational water exposure to 48.6 micrograms per liter (ug/L) of microcystin (one of the more common algal toxins found in Iron Gate and Copco reservoirs) is documented to cause abdominal pain, headache, sore throat, vomiting, nausea, dry cough, diarrhea, blistering around the mouth, and pneumonia (USEPA 2015). The California Cyanobacteria and Harmful Algal Bloom (CCHAB) Network, a multi-agency workgroup formerly called the Statewide Blue-Green Algae Working Group, has developed guidance for responding to harmful algal blooms (HABs), cyanotoxin (algal toxin) threshold levels for protection of human health, and cyanotoxin posting requirements for recreational waters (State Water Board et al. 2010, updated 2016). Species present in the Klamath River capable of producing microcystin include *Microcystis aeruginosa* and *Anabaena flos-aquae*[13], while species present in the Klamath River in the genus *Anabaena* can produce anatoxin-a and saxitoxin. The potentially microcystin and anatoxin-*a* producing *Oscillatoria sp.* was identified in the October 1975 survey of an algal bloom in Iron Gate Reservoir (USEPA 1978), but based on more recent data this algal species exhibits generally low abundance in the reservoirs and the Klamath River (Raymond 2008b, 2009b, 2010b; Asarian et al. 2014, 2015; Genzoli and Kann 2017). Microcystin-producing species in the genera *Gloeotrichia* and *Planktothrix* along with other algal toxin-producing species in the genera *Limnothrix* and *Pseudanabaena* also have been detected in the Klamath River, but these species have never been found to dominate the algal community (Kann and Asarian 2006; Genzoli and Kann 2017; E&S Environmental Chemistry, Inc. 2018a, 2018b). More complete listings of specific toxins produced by genera of blue-green algae worldwide are provided in Lopez et al. (2008) and ODEQ (2011).

For microcystin specifically, thresholds in drinking water or recreational waters for the protection of human health have been developed primarily using the results of animal studies (USEPA 2015). The State Water Board, California Department of Public Health (CDPH), and California Environmental Protection Agency's (CalEPA) Office of Environmental Health and Hazard Assessment (OEHHA) "Caution Action" posting threshold for the protection of human health in recreational waters is 0.8 micrograms per liter (ug/L) of microcystin (State Water Board et al. 2010, updated 2016).

[13] While *Anabaena flos-aquae* are capable of producing microcystin (Lopez et al. 2008), it is widely assumed that detected concentrations of microcystin are due to *Microcystis aeruginosa* rather than *Anabaena flos-aquae* due to the lower abundance of *Anabaena flos-aquae* compared to *Microcystis aeruginosa*. The relative proportion of microcystin contributions from *Anabaena flos-aquae* versus *Microcystis aeruginosa* has not been documented for the Klamath Basin.

Additional discussion of algal species, including algae suspended in the water column (phytoplankton) and algae attached to bottom sediments or channel substrate (periphyton), is provided in Section 3.4 *Phytoplankton and Periphyton*.

Chlorophyll-*a*, a pigment produced by photosynthetic organisms, is often used as a surrogate measure of algal biomass. Historically, seasonal algal blooms and elevated chlorophyll-*a* concentrations have been observed in the Hydroelectric Reach, including a 1975 survey in Iron Gate Reservoir documenting algal blooms in March, July, and October, including diatoms and blue green algae. The blue-green algae species *Aphanizomenon sp.* and *Oscillatoria sp.* were identified in the July and/or October 1975 Iron Gate Reservoir surveys, with the potentially microcystin and anatoxin-a producing *Oscillatoria sp.* as the most abundant of the five phytoplankton species identified in the October 1975 algal bloom. However, no *Microcystis aeruginosa* or *Anabaena flos-aquae* were identified during the three sampling dates in 1975 (USEPA 1978). More contemporary data indicate that chlorophyll-*a* levels in Copco No. 1 and Iron Gate reservoirs can be two to ten times greater than those in the mainstem Klamath River (Flint et al. 2005; Kann and Corum 2009; North Coast Regional Board 2010; Asarian and Kann 2011; Watercourse Engineering, Inc. 2016) (Figure 3.2-5; see Appendix C for more detail).

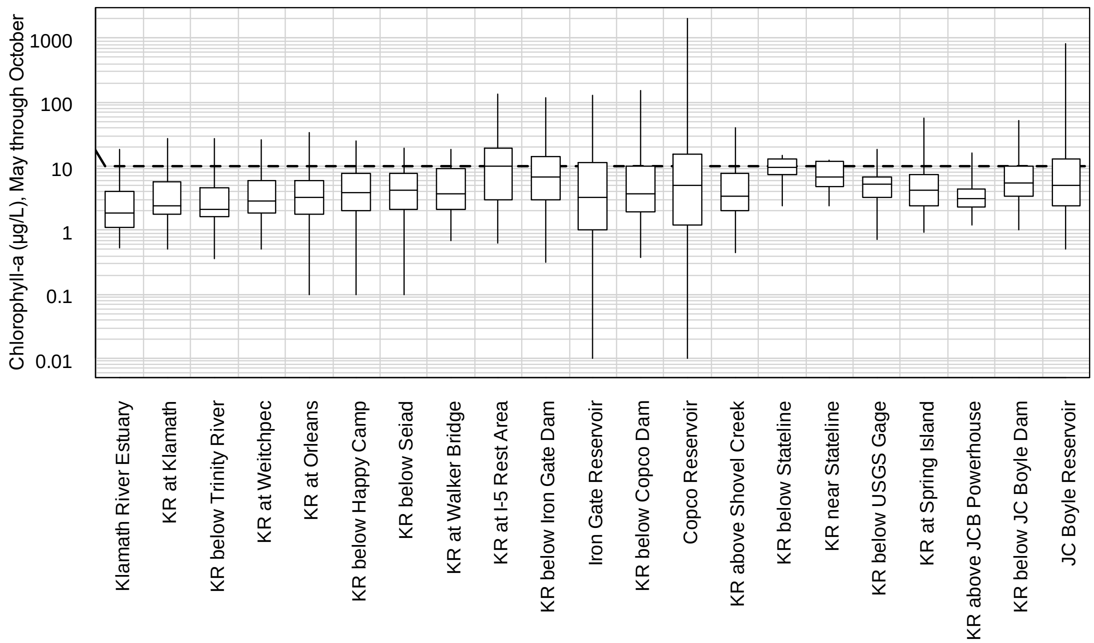

Figure 3.2-5. Longitudinal Analysis of Summer Through Fall (May to October) KHSA Interim Measure 15 (IM15) Chlorophyll-*a* Concentrations from 2000 to 2017 Along the Klamath River and in the Upper 10 Meters of the Lower Klamath Project Reservoirs. Whiskers Extend from Minimum to Maximum Value, Boxes Extend From the First to the Third Quartile, and the Horizontal Line Indicates the Median of the Dataset at Each Site. Note the Logarithmic Scale. The Dashed Horizontal Line is the Chlorophyll-*a* Klamath River TMDL Target (i.e., 10 ug/L). Chlorophyll-*a* Data from Stations That Shifted Locations Between Years Are Plotted Together (e.g., KR at Walker Bridge). Source: PacifiCorp 2003, 2004d, 2005b, 2007, 2008b, 2009b, 2010b, 2011, 2012, 2013b, 2014c, 2015b, 2016c, 2017c.

Summer and early fall chlorophyll-*a* measurements for the period 2000 to 2017 show a higher range of concentrations in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs compared to the Hydroelectric Reach upstream of Copco No. 1 Reservoir or downstream of the Klamath River Walker Bridge station. Chlorophyll-*a* concentrations are generally higher at the reservoir surface and decrease with depth in the reservoir. Peak chlorophyll-*a* concentrations during algal blooms are generally higher in Copco No. 1 Reservoir than in Iron Gate Reservoir, with some exceptions (Asarian and Kann 2011). Overall, chlorophyll-*a* in the Klamath River tends to decrease downstream of Iron Gate Dam, but concentrations can occasionally remain approximately the same or increase during intense algal blooms in Iron Gate and Copco No. 1 reservoirs (Ward and Armstrong 2010; Asarian and Kann 2013; Watercourse Engineering, Inc. 2013, 2014, 2015, 2016, 2017). Chlorophyll-*a* concentrations downstream of Iron Gate Dam also exhibit seasonal variation, with concentrations increasing in summer months and decreasing in fall and winter (Asarian and Kann 2013) (see Appendix C for additional details). Chlorophyll-*a* concentrations downstream of Iron Gate Dam tend to be low during winter months (Asarian and Kann 2011).

In 2015, PacifiCorp installed a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11 with the primary purpose of isolating surface waters that have high concentrations of blue-green algae (cyanobacteria) and potentially limiting the release of Iron Gate Reservoir water containing extensive summer and fall blue-green algae blooms downstream to the Middle and Lower Klamath River. The curtain also provides a potential secondary benefit of isolating warmer, less dense near-surface waters while withdrawing cooler, denser, and deeper waters from the reservoir for release to the Klamath River downstream (see Section 3.2.2.2 *Water Temperature)* (PacifiCorp 2018a). Water quality measurements during 2015 and 2016 when the intake barrier/thermal curtain was in use indicate that the curtain reduces entrainment of blue-green algae into the Iron Gate Powerhouse intake and subsequent release downstream into the Klamath River (PacifiCorp 2016a, 2017a). However, water quality monitoring data from 2017 and 2018 downstream of Iron Gate Dam show multiple exceedances of the Klamath TMDLs phytoplankton chlorophyll-a target (i.e., 10 ug/L) and multiple microcystin posting limits (e.g., 6 ug/L for CCHAB Warning TEIR I; Table 3.2-10) (Watercourse Engineering, Inc. 2018, 2019). An analysis of the intake barrier/thermal curtain performance during 2017 or 2018 has not been published and PacifiCorp continues to test and refine the intake barrier/thermal curtain design and operations, but available data do not indicate that this measure would prevent releases from Iron Gate Dam that exceed water quality standards (Table 3.2-4) or would consistently achieve the Klamath TMDLs phytoplankton chlorophyll-*a* target of 10 ug/L for Copco No. 1 and Iron Gate reservoirs during the May to October growth season (North Coast Regional Board 2010). Additionally, potential reductions in the entrainment of blue-green algae, chlorophyll-*a* concentrations, and microcystin concentrations downstream of Iron Gate Dam from operation of the intake barrier/thermal curtain would be potentially limited by the need to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards, with the curtain completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018a).

Phycocyanin, a pigment produced by blue-green algae, has been measured between May and November at some monitoring sites in the Klamath River downstream of Iron Gate Dam since 2007. At the Klamath River monitoring sites Iron Gate (RM 193.1) and Seiad Valley (RM 132.7), phycocyanin data from 2007 to 2014 is typically low from May through early July, increases to a peak in early to mid-September, and decreases until reaching low levels again by the end of October to early November (Asarian and Kann 2013). Phycocyanin concentrations generally coincide with chlorophyll-*a* concentrations for the portion of the Klamath River at Seiad Valley. Farther downstream in the Klamath River upstream of Tully Creek (RM 38.8) and at Turwar (RM 5.8), phycocyanin also is typically low from May through early July, but it increases more gradually and peaks in late-September before decreasing to low levels again at the end of October. Phycocyanin generally decreases in the downstream direction from Iron Gate Dam to Orleans, but there is an increase in phycocyanin at Weitchpec before again decreasing in the downstream direction to Turwar. The longitudinal decrease in phycocyanin was most pronounced between Iron Gate and Seiad Valley and Seiad Valley and Orleans (Genzoli and Kann 2016).

High levels of the cyanotoxin microcystin occur during summer months in Copco No. 1 and Iron Gate reservoirs (Kann and Corum 2009; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017; Otten et al. 2015; Otten 2017). In Copco No. 1 Reservoir, peak microcystin concentrations between 2006 and 2015 exceeded the CCHAB (2010, updated 2016) 0.8 ug/L threshold for the protection of human health in recreational waters by over 10,000 times. Watercourse Engineering (2011a) found extremely high concentrations (1,000 to 73,000 ug/L) during summer algal blooms in both Copco No. 1 and Iron Gate reservoirs during 2009 (see Appendix C for more detail). Consistent with previous findings, public health sampling data from 2015 show microcystin peaking between 12,000 and 16,000 ug/L in Copco No. 1 Reservoir during algal blooms in the summer and microcystin peaking from 64 to 770 ug/L in Iron Gate Reservoir (Watercourse Engineering, Inc. 2016). Microcystin concentrations are generally low from J.C. Boyle Reservoir to Copco No. 1 Reservoir, higher between Copco No. 1 Reservoir and Iron Gate Reservoir, and then generally decrease with distance downstream from Iron Gate Reservoir (Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017; Genzoli and Kann 2017; Otten 2017).

Microcystin concentrations downstream of Iron Gate Dam to the Klamath River Estuary are spatially and temporally variable (see Appendix C for more detail). The longitudinal and temporal variations in microcystin concentrations from upstream of Copco No. 1 Reservoir to Turwar along with genetic analysis of *Microcystis aeruginosa* in Copco No. 1 Reservoir, Iron Gate Reservoir, and multiple Klamath River sites downstream of Iron Gate Dam indicate that Iron Gate Reservoir is the principal source of *Microcystis aeruginosa* cells to the Middle and Lower Klamath River (Otten et al. 2015). The timing of peak microcystin concentrations in Iron Gate Reservoir corresponds to peak concentrations in the Klamath River downstream of Iron Gate Dam, consistent with the reservoir as the source (Otten et al. 2015). This evidence indicates that *Microcystis aeruginosa* populations from Iron Gate Reservoir contribute to *Microcystis aeruginosa* public health exceedances in the Klamath River downstream of Iron Gate Reservoir (see Section 3.4.2.3 *[Phytoplankton and Periphyton] Hydroelectric Reach*). While cyanobacteria [blue-green algae] that potentially produce algal toxins have been observed in calm, slow-moving habitats along shorelines and protected coves and backwaters during low-flow periods in the Middle and Lower Klamath River under existing conditions (Fetcho 2008; Raymond 2008b; Kann and Corum 2009; Kann et al. 2010a; Genzoli and Kann 2016, 2017), Otten et al. (2015) found no evidence of endemic *Microcystis aeruginosa* populations that would produce algal toxins (i.e., microcystin) in the flowing regions of the Klamath River upstream or downstream of Copco No. 1 and Iron Gate reservoirs. Longitudinal decreases in *Microcystis aeruginosa* cell density and microcystin concentrations in open-channel and shoreline samples from the Klamath River downstream of Iron Gate Dam (RM 193.1) to upstream of the Klamath River Estuary suggest that water velocity and constant mixing in the river are not supportive of blue-green algae reproduction and algal toxin production, although microcystin concentrations between downstream of Iron Gate Dam and Orleans (RM 58.9) in July through October can exceed established public health thresholds (e.g., 0.8 ug/L) (Otten et al. 2015; Genzoli and Kann 2017). For example, microcystin concentrations in the Klamath River during the period 2010 to 2015 from Orleans (RM 58.9) to Klamath (RM 5.9) range from less than 1.0 ug/L to approximately 12.0 ug/L, with the highest concentrations usually occurring at Weitchpec (RM 43.6) and decreasing with distance downstream (Gibson 2016), although microcystin is occasionally higher at Orleans (RM 58.9) than Weitchpec (RM 43.6) (see Appendix C for additional detail).

Baseline monitoring for potential risk to public health from microcystin toxins was established in 2008. Public health monitoring within the Copco No. 1 and Iron Gate reservoirs and along the mainstem of the Klamath River is conducted collaboratively by PacifiCorp, Karuk Tribe, and Yurok Tribe. Monitoring occurs at various intervals from May through November. If river conditions exceed public health standards for toxic algae the area is posted with a health advisory sign.

Guidelines for posting health advisories have varied since 2008 and currently are provided by the State Water Board et al. (2010, updated 2016) for water in California. SWRCB posting levels are listed as Caution, Warning, and Danger at microcystin concentrations of 0.8, 6, and 20 ug/L, respectively, with toxin producing cells densities greater than 4,000 cells/mL or “blooms, scums, or mats” resulting in posting at the Caution level.

The Karuk Tribe (Kann 2014) and Yurok Tribe (YTEP 2016) each adopted public health guidelines for recreational waters at levels equal to or more stringent than those adopted by the State Water Board. Annual results from baseline monitoring programs along used to determine postings of public health advisories are compiled by Klamath Basin Monitoring Program (KBMP) and used to inform the Blue Green Algae Tracker available on the KBMP website (www.kbmp.net).

Microcystin can also bioaccumulate in aquatic biota. During July through September 2007, 85 percent of tissue samples collected from yearling fall-run Chinook salmon in Iron Gate Hatchery, yellow perch in Copco No. 1 and Iron Gate reservoirs, and mussels at Klamath River locations downstream of Iron

Gate Dam exhibited microcystin bioaccumulation, with the total microcystin congeners ranging from less than detection levels to 2,803 ng/g, reported as wet weight (Kann 2008a). Microcystin congeners were detected in yellow perch fillet and liver samples, but microcystin congeners were only detected in Chinook liver samples (Kann 2008a). Microcystin bioaccumulation was not detected in muscle tissue or liver samples collected during October 2007 from eleven adult Chinook salmon and eight adult steelhead captured at eight locations in the Klamath River downstream of Iron Gate Dam (CH2M Hill 2009a). While microcystin bioaccumulation was detected in mussel samples between July and September 2007, microcystin bioaccumulation was not detected in mussel tissue samples collected in November 2007, suggesting that depuration (i.e., biological purging of algal toxins from living tissue) occurred after *Microcystis aeruginosa* cell densities and microcystin concentrations declined in late October (Kann 2008a). In contrast to the 2007 fish data, microcystin bioaccumulation was not detected in any samples collected during 2008 from resident fish or mussels in the vicinity of Copco No. 1 and Iron Gate reservoirs (CH2M Hill 2009b). Microcystin was not detected in any of the 272 muscle tissue samples (i.e., 166 yellow perch samples, 30 crappie samples, and 76 rainbow trout samples) collected during four seasonal sampling events in 2008 (i.e., May to June, July, September, and November) from 257 resident fish (duplicate tissue samples were obtained from 15 fish) captured in Copco No. 1 and Iron Gate reservoirs and in the river upstream of Copco No. 1 Reservoir or downstream of Iron Gate Dam or in any of the 14 mussel tissue samples from upstream of Copco No. 1 Reservoir and downstream of Iron Gate Reservoir (CH2M Hill 2009b). Fish livers were not tested for microcystin during 2008. Microcystin was not detected in muscle tissue or liver samples collected during two sample events in 2009 (i.e., August and September) from 43 yellow perch captured in Copco No. 1 and Iron Gate reservoirs (PacifiCorp 2010a). However, microcystin was detected in tissue samples of freshwater mussels in the Klamath River from monthly sampling events in 2009 from July to October and December (Kann et al. 2010b). Microcystin bioaccumulation also was measured during 2010 in muscle tissue and liver samples from 20 Chinook salmon, 25 steelhead, and 3 coho salmon collected at five locations downstream of Iron Gate Dam from September through November. Microcystin was detected in 3 of 7 Chinook livers collected in September 2010 near Happy Camp, in 1 of 7 Chinook livers collected in October near Happy Camp, and in 1 of 15 steelhead livers collected in October near Weitchpec, with no microcystin was detected in any other fish tissue sample. Other measured algal toxins (i.e., anatoxin-a, domoic acid, or okadaic acid) were not detected in any Klamath River fish samples (Kann et al. 2013). Estuarine and marine nearshore effects (e.g., sea otter deaths) from blue-green algae exposure have been reported in other California waters; however, none have been documented to date for the Klamath River Estuary or marine nearshore (Miller et al. 2010).

The levels of microcystin bioaccumulation measured in fish and mussel tissue samples collected during July through September 2007 (i.e., less than detection levels to 2,803 ng/g, reported as wet weight) exceeded the public health guidelines defined by Ibelings and Chorus (2007) (i.e., Acute Tolerable Intake: 1,900 ng/g for an adult, 250 ng/g for a child; Seasonal Tolerable Daily Intake: 300 ng/g for an adult, 40 ng/g for a child; Lifetime Tolerable Daily Intake: 30 ng/g for an adult, 4 ng/g for a child, all as wet weight), indicating ingestion of the fish or mussels would potentially pose a health hazard to humans (Kann 2008a). While microcystin levels were less than the method detection limit for all salmonid muscle tissue and liver samples in October 2007, the method detection limit for these microcystin bioaccumulation tests on salmonids (i.e., 100 to 240 ng/g, reported as dry weight) overlapped with or was greater than the Lifetime Tolerable Daily Intake public health guideline (i.e., 120 ng/g dry weight for an adult and 16 ng/g dry weight for a child) defined by Ibelings and Chorus (2007). Thus, there was a potential chronic (i.e., long-term) health hazard to humans for the October 2007 salmonid samples if microcystin concentrations in the salmonid muscle tissue were between the method detection limit and the Tolerable Daily Intake (CH2M Hill 2009a). Public health advisories were issued in 2009 and 2010 in the Klamath River from the Salmon River confluence to the Klamath River Estuary (including locations on the Yurok Reservation) for elevated microcystin levels in ambient and/or freshwater mussel tissue samples (Fetcho 2010; Kann et al. 2010a; Kann et al. 2010b). During 2010, there was no detectable risk to human health from microcystin bioaccumulation in salmonid fillets because the microcystin concentration in salmonid fillets was less than acute, seasonal, and Lifetime Tolerable Daily Intake public health guidelines. During September 2010, microcystin concentrations measured in salmonid livers were less than the public health guideline values. However, during October 2010, microcystin concentrations measured in salmonid livers were greater than multiple public health guideline values (e.g., Klasing and Brodberg 2008 2008; Butler et al. 2012; Mulvenna et al. 2012; Ibelings and Chorus 2007). Although fish livers are not typically consumed, these fish potentially posed a human health hazard due to the high microcystin concentrations (i.e., 121.20 to 152.40 ng/g) measured in the livers (Kann et al. 2013).

Overall, there was no acute or seasonal public health concern identified with eating salmonid fillets based upon the 2007 and 2010 data since microcystin was only detected in salmonid liver samples and salmonid liver is not typically eaten. However, there is potential for a chronic health hazard to humans from microcystin bioaccumulation in salmonids since the method detection limit during 2007 was greater than the Lifetime Tolerable Daily Intake, precluding the assessment of the lifetime public health risk. The method detection limit during 2010 was less than the Lifetime Tolerable Daily Intake and no microcystin was detected in 2010 salmonid fillet samples, so there was not a detectable chronic health hazard to humans in 2010 from microcystin bioaccumulation in salmonid fillets. Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project − Algal Toxins* presents a discussion of algal toxins as related to fish health.

Anatoxin-a has been detected in the Klamath River system, although the timing, distribution, and sources of anatoxin-a production in the Klamath River are not well understood. Anatoxin-a can be produced by number of blue-green algae [cyanobacteria] genera, including *Anabaena*[14], *Aphanizomenon, Cylindrospermopsis, Planktothrix, Oscillatoria*, and *Phormidium* (Chorus and Bartram 1999; Quiblier et al. 2013; USEPA 2014; Bouma-Gregson et al. 2018). In the Klamath River, anatoxin-a production is generally assumed to be due to *Anabaena flos-aquae*, but toxin production by some strains of *Anabaena flos-aquae* appears to be sporadic, and the circumstances which prompt toxin production are unknown. While toxin-producing phytoplankton are more well-studied, periphyton can also produce toxins, including anatoxin-a (Heath et al. 2011; Quiblier et al. 2013). In many California rivers and streams not impounded by dams, periphyton are assumed to be the primary sources of anatoxin-a (Fetscher et al. 2015), including species in the genera *Anabaena* and *Phormidium* in tributaries of the Eel River located south of the Klamath River (Asarian and Higgins 2018; Bouma-Gregson et al. 2018). The relative proportion of anatoxin-a contributions from phytoplankton versus periphyton in the Klamath Basin has not been documented.

In the Klamath River system, anatoxin-a was detected in Iron Gate Reservoir on September 3, 2005, in testing by the California Department of Health Services (Kann 2007a; Kann 2008b). Monitoring conducted for the Karuk Tribe during 2005, 2006, 2007, 2008 in Copco No. 1 or Iron Gate reservoirs did not detect anatoxin-a (Kann and Corum 2006, 2007, 2009; Kann 2007b). At Lower Klamath River monitoring sites, anatoxin-a was not detected above the reporting limit in water samples collected during 2008 and 2009 (Fetcho 2009, 2011). In recent years, anatoxin-a has been measured in the Klamath River downstream of Iron Gate Reservoir on several occasions, typically in the lower reaches including at monitoring sites near Weitchpec and Orleans (Otten 2017). While concentrations of *Anabaena flos-aquae* cells have continued to be monitored, anatoxin-a concentrations are not available for Lower Klamath Project reservoir and Klamath River sites in recent years.

3.2.2.8 Inorganic and Organic Contaminants

<u>Water Column Contaminants</u>

Data collected under the California Surface Water Ambient Monitoring Program (SWAMP) for the period 2001 to 2005 indicate that at eight monitoring sites from the Oregon-California state line to Turwar, the majority of inorganic constituents

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[14] Cyanobacteria in the genus *Anabaena* have been recently recategorized, with all planktonic species in the genus *Anabaena* renamed *Dolichospermum* and all benthic species remaining in the genus *Anabaena*. For example, the phytoplankton *Anabaena flos-aquae* was recently renamed *Dolichospermum flos-aquae.* However, this EIR continues to use the *Anabaena* name for both planktonic and benthic species since it was more frequently used in the literature cited and it is still commonly used in descriptions of this species.

(i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc) detected in the Hydroelectric Reach, Middle Klamath River, and Lower Klamath River were in compliance with water quality objectives. Aluminum concentrations ranged from 50.7 to 99.2 ug/L, so all samples were less than California primary drinking water standards[15] (1,000 ug/L), but some samples were slightly elevated above USEPA freshwater aquatic life standards (87 ug/L) along with USEPA and California secondary drinking water standards[16] (50 ug/L) (North Coast Regional Board 2008). Grab samples were analyzed for 100 pesticides, pesticide constituents, isomers, or metabolites; 50 polychlorinated biphenyl (PCB) congeners; and six phenolic compounds. Results indicated no PCBs and only occasional detections of pesticides (North Coast Regional Board 2008) (see Appendix C for more detail). The results of water quality studies during 2002 and 2003 at four USGS gage stations downstream of Iron Gate Dam indicate that, with the exception of nickel, magnesium, and calcium, the concentration of trace elements decreased as water flowed downstream, most likely because of binding to other particles and settling out of the water column (Flint et al. 2005) (see Appendix C for more detail).

Sediment Contaminants

To investigate the potential for toxicity of sediments in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs, Shannon & Wilson, Inc. (2006) collected 25 sediment cores in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs and analyzed them for a suite of potential contaminants. The sediment cores were collected as part of a larger study sponsored by the California State Coastal Conservancy (GEC 2006). The locations of the sediment cores were distributed throughout each reservoir, including locations on the historical Klamath River channel (on-thalweg) and surrounding submerged terraces or near tributary mouths (off-thalweg) along the edge of the historical Klamath River. Four locations (4 on-thalweg, 0 off-thalweg) were sampled in J.C. Boyle Reservoir, with maximum core depths ranging from 0.3 feet at the upstream end of the reservoir to 13.2 feet near the dam. Twelve locations (7 on-thalweg, 5 off-thalweg) were sampled in Copco No. 1 Reservoir with maximum core depths ranging from 1.5 feet at the upstream end of the reservoir to 12.1 feet near the middle of the reservoir. Nine locations (5 on-thalweg, 4 off-thalweg) were sampled in Iron Gate Reservoir with maximum core depths ranging from 0.7 feet at the upstream end of the reservoir to 7.8 feet within the Slide Creek/Camp Creek arm of the reservoir. During sediment core drilling, the sediments were evaluated to distinguish recent reservoir-deposited sediment from pre-reservoir sediment, with drilling logs noting the depth of different sediment horizons. Shannon & Wilson, Inc. (2006) used a composite

[15] Primary drinking water standards are limits for inorganic and organic contaminants to protect public health.
[16] Secondary drinking water standards are guidelines to prevent aesthetic effects (e.g., taste, odor, or color) or cosmetic effects (skin or tooth discoloration).

sampling[17] technique to represent field conditions for reservoir sediment deposits. Interval composite/depth interval sediment samples were generated from the sediment cores, including both the reservoir-deposited and pre-reservoir sediments, with the number of interval samples depending on the total depth of the sediment core. The sediment samples were analyzed 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 U.S. Army Corps of Engineers (USACE) Puget Sound Dredged Disposal Analysis Program (PSDDA) screening levels and only one sample exceeded applicable PSDDA 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. Dioxin is a collective term for a group of seventeen chemically related dioxin and furan compounds (see Appendix C for a list of all seventeen compounds). 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. The various dioxin and furan compounds have different relative toxicities, so a Toxic Equivalent Quotient (TEQ) is calculated by multiplying the measured concentrations of the individual compounds by its toxicity relative to 2,3,7,8- tetrachlorodibenzodioxin (2,3,7,8-TCDD) (i.e., its Toxicity Equivalent Factor) and summing the Toxicity Equivalent Factor weighted concentrations for each compound into one number that can be used to assess overall dioxin toxicity. A Toxic Equivalent Quotient (TEQ) is equal to a Toxic Equivalent Concentration and the two terms are used interchangeably in the literature, so they are both abbreviated as TEQ in this report. In the 2006 J.C. Boyle, Copco No. 1, and Iron Gate reservoir samples, measured levels were 2.48 to 4.83 pg/g TEQ (picograms per gram or parts per trillion [ppt] expressed as Toxic Equivalent Concentrations [TEQ] relative to 2,3,7,8 tetrachlorodibenzodioxin toxicity) and did not exceed USACE (1,000 pg/g TEQ), International Joint Commission for Great Lakes Science Advisory Board (10 pg/g TEQ), PSDDA (15 pg/g TEQ), or Washington State Department of Ecology (8.8 pg/g TEQ) (Shannon & Wilson, Inc. 2006, Dillon 2008, USEPA 2010) and the measured dioxin concentrations were within the estimated background dioxin concentrations (2 to 5 ppt TEQ) for non-source-impacted sediments throughout the U.S. and specifically in the western U.S. (USEPA 2010). However, the range of measured dioxin concentrations was slightly above the minimum for the U.S. Environmental Protection Agency fish and wildlife guidelines (2.5 to 210 pg/g

[17] Composite samples are created by combining and thoroughly mixing individual samples from different locations and treating the combined sample as a single sample for analysis. Composite samples are a standard method for determining average conditions.

TEQ) screening levels for human health and ecological receptors (Shannon & Wilson, Inc. 2006, Dillon 2008, USEPA 2010) (see Appendix C for more detail).

As part of the Klamath Dam Removal Secretarial Determination studies, a sediment evaluation was undertaken during 2009 to 2011 to evaluate potential environmental and human health impacts of the downstream release of sediment deposits currently stored behind the Lower Klamath Project dams[18]. Sediment cores were collected during 2009–2010 at 37[19] sites on the historical Klamath River channel (on-thalweg) and surrounding submerged terraces or near tributary mouths along the edge of the historical Klamath River (off-thalweg), distributed throughout J.C. Boyle Reservoir (Figure 2.6-4), Copco No. 1 Reservoir (Figure 2.6-5), Iron Gate Reservoir (Figure 2.6-6), and the Klamath River Estuary (Figure 3.2-6) (USBR 2010, 2011). Twelve sites (7 on-thalweg, 5 off-thalweg) were sampled in J.C. Boyle Reservoir with maximum core depths ranging from 0.3 feet near the middle of the reservoir to 18.7 feet near the dam. Twelve sites (7 on-thalweg, 5 off-thalweg) were sampled in Copco No. 1 Reservoir with maximum core depths ranging from 1.2 feet on an off-thalweg site downstream of the Beaver Creek arm of the reservoir to 9.7 feet on an off-thalweg location upstream of the Beaver Creek arm of the reservoir. Thirteen sites (8 on-thalweg, 5 off-thalweg) were sampled in Iron Gate Reservoir with maximum core depths ranging from 0.5 feet at the upstream end of the reservoir to 7.7 feet within the Jenny Creek arm of the reservoir. At each site, cores were inspected by on-site geologists to verify that the reservoir-deposited/pre-reservoir sediment contact had been reached for each core. Sediment cores were used to either create whole core composite[17] sediment samples or interval composite/depth interval composite sediment samples for laboratory analysis of potential contaminants with samples representing both the reservoir-deposited and pre-reservoir sediments. Area composite samples were also generated from sediment cores for the Klamath River Estuary. 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). The chemical

[18] There are currently 13.1 million cubic yards of sediment deposits stored within J.C. Boyle, Copco No. 1 and 2, and Iron Gate reservoirs (Table 2.7-7). Prior estimates of the sediment deposits were 14.5 million cubic yards (Eilers and Gubala 2003) and 20.4 million cubic yards (GEC 2006).
[19] Of the 37 sampling sites, two sites in J.C. Boyle, two in Copco No. 1, and three in Iron Gate Reservoir were analyzed for dioxins/furans, PCBs, and PBDEs.

composition of sediment and elutriate[20] sediment samples were analyzed, and bioassays were conducted on the sediment and elutriate sediment samples using fish and invertebrate national benchmark toxicity species (see below for discussion of the bioaccumulation component of this study).

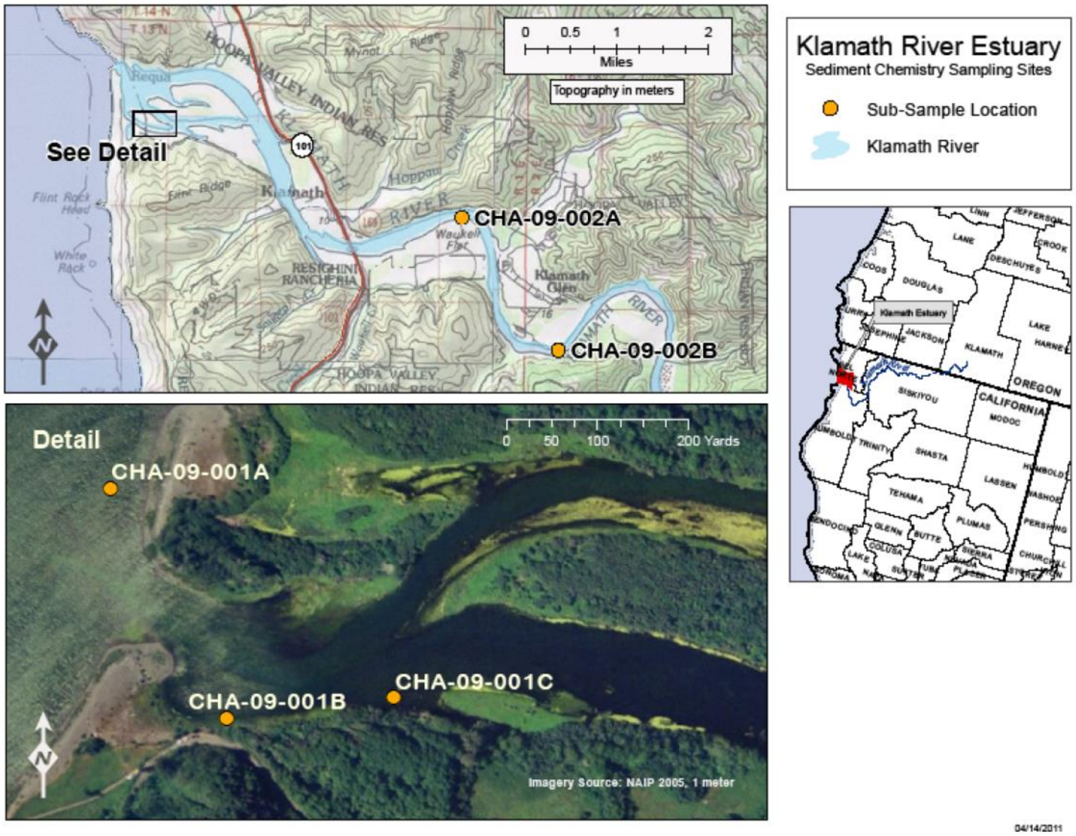


Figure 3.2-6. Klamath River Estuary Sediment Sampling Site Locations. Source: USBR 2011.

A relatively small number of chemicals of potential concern (COPCs) were identified in Lower Klamath Project reservoir sediment samples. Nickel, iron, and 2,3,4,7,8-pentachlordibenzofuran (PECDF) were detected in sediment in all three Lower Klamath Project reservoirs, while 4,4'-dichlorodiphenyltrichloroethane (DDT), 4,4'-dichlorodiphenyldichloroethane (DDD), 4,4'-

[20] Elutriate sediment samples were created from reservoir composite sediment samples mixed with reservoir water (e.g., one part sediment to four parts water). In general, elutriate tests are a standard approach that analyzes the chemical composition of the overlying water of the elutriate sediment sample in order to estimate potential chemical concentrations that may be released into the water from reservoir sediments during suspension. Standard elutriate tests do not reflect the full dilution of re-suspended sediments that would occur during dam removal.

dichlorodiphenyldichloroethylene (DDE), dieldrin, and 2,3,7,8-tetrachlorodibenzodioxin (TCDD) were detected only in J.C. Boyle sediments. No consistent pattern of elevated chemical composition was observed across discrete sampling locations within a reservoir, but sediment in J.C. Boyle Reservoir does have marginally higher iron concentrations and more detected COPCs in sediment when compared to Copco No. 1 and Iron Gate reservoirs and the Klamath River Estuary. Also, J.C. Boyle Reservoir exhibited more COPCs based on comparison to CalEPA, National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (USFWS), USEPA, and ODEQ freshwater ecological and human health screening levels (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 Appendix C, Section C.7.1.1 for more detail). Toxicity tests generally indicated low potential for sediment toxicity to benchmark benthic indicator species since the 10-day survival of these species in reservoir sediments was similar compared to laboratory controls, except in a single sample from J.C. Boyle Reservoir where a decrease in survival of the benthic midge *Chironomus dilutus* in the reservoir sediment sample (64 percent) (compared to the laboratory control at 95 percent) indicated a moderate potential for sediment toxicity. Additional bioaccumulation tests of reservoir sediment samples using two benthic organisms (i.e., *Corbicula fluminea* [Asian clams] and *Lumbricula variegates* [blackworms]) showed 100 percent survival with minimal weight changes in J.C. Boyle Reservoir sediments over the 28-day bioaccumulation test period, further supporting the conclusion that there was generally low potential for sediment toxicity to benthic species from reservoir sediments.

Lastly, analysis of the 2009 to 2010 USBR collected sediment core results (USBR 2010, 2011) from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs and the Klamath River Estuary indicate that total chromium and total nickel concentrations are higher in estuary sediments than in Lower Klamath Project reservoir sediments, but total arsenic, total copper, and total lead concentrations are higher in reservoir sediments than estuary sediments (Eagles-Smith and Johnson 2012). Total arsenic concentrations in the reservoir sediments samples range from 4.3 to 15 milligrams per kilogram, dry weight (mg/kg) in J.C. Boyle Reservoir, 6.3 to 13 mg/kg in Copco No. 1 Reservoir, and 7.4 to 10 mg/kg in Iron Gate Reservoir. Peak total copper concentrations in Lower Klamath Project reservoir sediments (9.8 to 38 mg/kg) are greater than total copper concentrations in Klamath River Estuary sediments (19 to 26 mg/kg) (Eagles-Smith and Johnson 2012). Total lead concentrations in reservoir sediments range from 2.8 to 25 mg/kg in J.C. Boyle Reservoir, 6.4 to 10 mg/kg in Copco No. 1 Reservoir, and 5.1 to 11 mg/kg in Iron Gate Reservoir (USBR 2011).

Comparison of the measured total arsenic, total copper, and total lead concentrations with the relevant human-health screening levels show that only total arsenic concentrations exceed USEPA total carcinogenic residential screening levels (0.39 mg/kg), USEPA total non-carcinogenic residential screening levels (22 mg/kg), and CalEPA California Human Health residential (0.07 mg/kg) and commercial (0.24 mg/kg) screening levels. Peak total copper concentrations are approximately two to three orders of magnitude less than USEPA total non-carcinogenic residential screening levels (3,100 mg/kg) and CalEPA California Human Health residential (3,000 mg/kg) and commercial (38,000 mg/kg) screening levels. Total lead concentrations are consistently less than USEPA total non-carcinogen residential screening levels (400 mg/kg) and CalEPA California Human Health residential (80 mg/kg) and commercial (320 mg/kg) screening levels (CDM 2011). There are no USEPA total carcinogenic residential screening levels for copper or lead.

Comparison of the measured total arsenic, total copper, and total lead concentrations with the relevant ecological screening levels shows that total arsenic and total copper concentrations exceeded some ecological screening levels, but total lead concentrations remained below the most stringent freshwater and marine ecological screening level (**freshwater**: Lowest Effect Level [31 mg/kg]; **marine**: T20 [chemical concentration corresponding to 20 percent probability of observing toxicity] [30 mg/kg]). Total arsenic concentrations in Lower Klamath Project reservoir and Klamath River Estuary sediments only exceeded lower NOAA Screen Quick References Table (SQuiRT) freshwater and marine screening levels for arsenic in sediment (**freshwater**: Threshold Effect Concentrations [9.79 mg/kg], Threshold Effects Level [5.9 mg/kg], Lowest Effect Level [6 mg/kg]; **marine**: T20 [chemical concentration corresponding to 20 percent probability of observing toxicity] [7.4 mg/kg], Threshold Effects Level [7.24 mg/kg], Effects Range-Low [8.2 mg/kg]) with no measured total arsenic concentrations in reservoir or estuary sediments above freshwater or marine probable effects concentrations (**freshwater**: Probable Effect Concentrations [33mg/kg], Severe Effect Level [33 mg/kg], Probable Effect Level [17 mg/kg]; **marine**: T50 [chemical concentration corresponding to 50 percent probability of observing toxicity] [20 mg/kg], Probable Effect Level [41.6 mg/kg], Effects Range-Medium [70 mg/kg]). Total copper concentrations in Lower Klamath Project reservoir and Klamath River Estuary sediments also only exceeded lower NOAA Screen Quick References Table (SQuiRT) freshwater and marine screening levels for copper in sediment (**freshwater**: Threshold Effect Concentrations [31.6 mg/kg], Threshold Effects Level [37.3 mg/kg], Lowest Effect Level [16 mg/kg]; **marine**: T20 [chemical concentration corresponding to 20 percent probability of observing toxicity] [32 mg/kg], Threshold Effects Level [18.7 mg/kg], Effects Range-Low [34 mg/kg]) with no measured total copper concentrations in reservoir or estuary sediments above freshwater or marine probable effects concentrations (**freshwater**: Probable Effect Concentrations [149 mg/kg], Probable Effect Level [197 mg/kg];

marine: T50 [chemical concentration corresponding to 50 percent probability of observing toxicity] [94 mg/kg], Probable Effect Level [108 mg/kg]).

Note that while total metal concentrations were measured in the existing sediment cores, metals are typically bound to fine sediments and exhibit limited bioavailability or aquatic toxicity. The amount of bioavailable metals released by sediments may vary significantly depending on the sediment (surface area, availability of sorption sites, organic material, and clay content) and water properties (temperature, dissolved organic compounds, suspended particles, pH, various inorganic cations and anions like those composing hardness and alkalinity) (USEPA 2007).

Contaminants in Aquatic Biota

Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project−Algal Toxins* presents a discussion of algal toxins (i.e., microcystin) in fish tissue. 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 throughout California. 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 a screening-level study of potential chemical contaminants in fish tissue in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs, 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; FERC 2007). 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.

Fish tissue samples also were collected in Copco No. 1 and Iron Gate reservoirs and analyzed for total mercury, selenium, and PCBs (Iron Gate Reservoir only) as part of a larger SWAMP study of contaminants in sport fish in California lakes and reservoirs (Davis et al. 2010). SWAMP data for Iron Gate and Copco No. 1 reservoirs indicate mercury tissue concentrations above the USEPA criterion of 300 nanograms per gram (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 to 4 orders of magnitude lower than OEHHA thresholds of concern (2,500 to 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).

To supplement existing fish tissue data and provide additional lines of evidence in the Klamath Dam Removal Secretarial Determination sediment evaluation (see *Sediment Contaminants* above and Appendix C – *Section C.7.1.1*), two species of field-caught fish (perch and bullhead) were collected during late September 2010 from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs and analyzed for contaminant levels in fish tissue (CDM 2011; see Appendix C – *Section C.7.1.1* for more detail). Results indicate that multiple chemicals were present in fish tissue (e.g., arsenic, DDE/DDT, dieldrin, mercury, mirex, selenium, and total PCBs; see Appendix C for a complete list of chemicals detected) (CDM 2011). Mercury exceeded tissue-based toxicity reference values for perch in Iron Gate Reservoir and bullhead samples in all three reservoirs (CDM 2011). Toxicity reference values are not available for several chemicals detected in invertebrate and fish tissue (CDM 2011, see Appendix C – *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).

Lastly, Copco No. 1 and Iron Gate reservoirs are included on the 303(d) list of impaired waterbodies for mercury based on elevated methylmercury concentrations in fish tissue for trophic level 4 fish (USEPA 2001; PacifiCorp 2004b; Davis et al. 2010; CDM 2011; State Water Board 2017). A mercury TMDL for Copco No. 1 and Iron Gate reservoirs has not been completed.

3.2.3 Significance Criteria

Significance criteria used for the evaluation of impacts on water quality are listed below. Designated beneficial uses and associated water quality objectives for the Klamath River in California are defined in the Basin Plan (North Coast Regional Board 2018), the Hoopa Valley Tribe Water Quality Control Plan (HVTEPA 2008), and the Yurok Tribe Water Quality Control Plan for the Yurok Indian Reservation[21] (YTEP 2004) (see Table 3.2-2).

Effects on water quality are considered significant if the Proposed Project would:

- Cause an exceedance of water quality standards as identified in the above documents in the areas addressed by the relevant plans;

[21] USEPA approval for treatment of the Yurok Tribe as a State for purposes of operating a water quality standard program has not yet occurred (CWA §§ 303(c)/401).

- Substantially exacerbate an existing exceedance of water quality standards as identified in the above documents in the areas addressed by the relevant plans;
- Cause water quality changes that would result in a failure to maintain existing beneficial uses at the levels currently supported, or result in a failure to maintain high quality waters at the highest level of water quality consistent with the maximum benefit to the people of the State, meaning:
  - The action degrades high quality waters to an extent inconsistent with recent beneficial uses or in a manner that would result in water quality below that required by an applicable water quality control plan; or
  - The action involves a discharge that either does not comply with best practicable treatment or does not employ controls that avoid nuisance or pollution and are consistent with the maximum benefit to the people of the State.
- Result in substantial adverse impacts on human health or environmental receptors.

Unless otherwise indicated in Section 3.2.3.1 *Thresholds of Significance*, for purposes of determining the significance of any potential water quality impacts, "substantial," as used in the significance criteria, means the effect on water quality and the support of beneficial uses (or human health or environmental receptors, as specified) is of considerable importance.

For the Lower Klamath Project water quality analysis, short-term is defined as the period during pre-dam removal activities, reservoir drawdown, dam removal, and associated sediment flushing events, which corresponds to pre-dam removal activities that would occur in the one to three years before dam removal, dam removal year 1, dam removal year 2, and post-dam removal year 1 (Table 2.7-1). Long-term is defined as occurring after post-dam removal year 1 (i.e., greater than three years after dam removal).

Significance criteria related to groundwater and flood hydrology (i.e., subsurface drainage, flooding, inundation) are addressed in Section 3.6 *Flood Hydrology* and/or Section 3.7 *Groundwater*.

Table 3.2-2. Designated Beneficial Uses of Water in the Water Quality Area of Analysis.

North Coast Regional Board (Basin Plan 2018)[1,2]	Hoopa Valley Tribe (HVTEPA 2008)[3]	Yurok Tribe (YTEP 2004)[3]
Aesthetics, Cultural, and Subsistence		
N/A	Wild and Scenic (W&S)	N/A

North Coast Regional Board (Basin Plan 2018)[1,2]	Hoopa Valley Tribe (HVTEPA 2008)[3]	Yurok Tribe (YTEP 2004)[3]
Native American Culture (CUL)	Ceremonial and Cultural Water Use (CUL)**	Cultural (CUL)
Subsistence Fishing (FISH)	N/A	N/A
Agricultural Water Supply		
Agricultural Supply (AGR)	Agricultural Supply (AGR)*	Agricultural Supply (AGR)
Commercial		
Commercial and Sport Fishing (COMM)	N/A	Commercial and Sport Fishing (COMM)
Shellfish Harvesting (SHELL)	N/A	N/A
Mariculture[4]/Aquaculture (AQUA)	N/A	N/A
Fish and Wildlife		
Warm Freshwater Habitat (WARM)	N/A	Warm Freshwater Habitat (WARM)
Cold Freshwater Habitat (COLD)	Cold Freshwater Habitat (COLD)	Cold Freshwater Habitat (COL)
Migration of Aquatic Organisms (MIGR)	Migration of Aquatic Organisms (MIGR)	Migration of Aquatic Organisms (MGR)
Spawning, Reproduction, and/or Early Development (SPWN)	Spawning, Reproduction, and/or Early Development (SPWN)	Spawning, Reproduction, and/or Early Development (SPN)
Estuarine Habitat (EST)	N/A	Estuarine Habitat (EST)
Marine Habitat (MAR)	N/A	Marine Habitat (MAR)
Wildlife Habitat (WILD)	Wildlife Habitat and Endangered Species (WILD)	Wildlife Habitat (WLD)
Preservation and Enhancement of Designated Areas of Special Biological Significance (ASBS) [4]	N/A	Preservation of Areas of Special Biological Significance (BIO)
Rare, Threatened, or Endangered Species (RARE)	Preservation of Threatened and Endangered Species (T&E)	Rare, Threatened, or Endangered Species (RARE)
Saline Habitat (SAL)	N/A	N/A
Potable Water Supply		
Municipal and Domestic Supply (MUN)	Municipal and Domestic Supply (MUN)*	Municipal and Domestic Supply (MUN)

North Coast Regional Board (Basin Plan 2018)[1,2]	Hoopa Valley Tribe (HVTEPA 2008)[3]	Yurok Tribe (YTEP 2004)[3]
Industrial Water Supply		
Industrial Service Supply (IND)	Industrial Service Supply (IND)	N/A
Industrial Process Supply (PROC)	Industrial Process Supply (PROC)	
Hydropower Generation (POW)	N/A	Hydropower Generation (PWR)
Navigation		
Navigation (NAV)	N/A	Navigation (NAV)
Replacement/Recharge		
Groundwater Recharge (GWR)	Groundwater Recharge (GWR)	Groundwater Recharge (GW)
Freshwater Replenishment (FRSH)	N/A	Freshwater Replenishment (FRSH)
Recreation		
Water Contact Recreation (REC-1), including Aesthetic Enjoyment[4]	Water Contact Recreation (REC-1)	Water Contact Recreation (REC-1)
Non-contact Water Recreation (REC-2), including Aesthetic Enjoyment[4]	Non-contact Water Recreation (REC-2)	Non-contact Water Recreation (REC-2)

Notes:

1 Beneficial Uses listed (existing and potential) apply to one or more Basin Plan specified hydrologic areas, sub-areas, or waterbodies within the Water Quality Area of Analysis, but they do not necessary apply all reaches within the Water Quality Area of Analysis.

2 Basin Plan designated Beneficial Uses apply to the entire Water Quality Area of Analysis, including the territorial marine waters of the State of California.

3 Tribal designated Beneficial Uses apply to the sections of the Water Quality Area of Analysis within the tribal boundaries.

4 These Beneficial Uses come from the Basin Plan's incorporation of the State Water Board's 2015 Ocean Plan, which applies to the territorial marine waters of the State of California.

Key:

N/A: Not applicable

* = Proposed Beneficial Use

** = Historical Beneficial Use

Table 3.2-3. Water Bodies Included on the 303(d) List within the Water Quality Area of Analysis.[1]

Water Body/Reach	Water Temperature	Sediment	Organic Enrichment/Low Dissolved Oxygen	Nutrients	Microcystin	Mercury	Aluminum
Hydroelectric Reach of the Upper Klamath River – Oregon-California state line to the upstream end of Copco No. 1 Reservoir	X		X	X			
Hydroelectric Reach of the Upper Klamath River – upstream end of Copco No. 1 Reservoir to Iron Gate Dam (excluding Copco No.1 and No. 2 and Iron Gate Reservoir)	X		X	X	X		
Copco No. 1 Reservoir	X				X	X	
Copco No. 2 Reservoir	X				X		
Iron Gate Reservoir	X				X	X	
Middle Klamath River – Iron Gate Dam to Scott River	X	X	X	X	X		X
Middle and Lower Klamath River – Scott River to Trinity River	X	X	X	X	X		
Lower Klamath River – Trinity River to Mouth	X	X	X	X			

[1] While there are additional water quality impaired waterbodies in the Klamath Basin, the waterbodies listed in this table are the ones that are directly relevant to the water quality analysis for the Proposed Project.

3.2.3.1 Thresholds of Significance

Thresholds of significance for this EIR are identified for water temperature, suspended sediment, nutrients, dissolved oxygen, pH, chlorophyll-*a* and algal toxins, and inorganic and organic contaminants. All of these are a water quality concern due to their potential to influence multiple designated beneficial uses and because hydroelectric project operations can affect these constituents (see Section 3.2.2.1 *Overview of Water Quality Processes in the Klamath Basin*). Table 3.2-4 through Table 3.2-10 provide the existing water quality objectives for: (1) the Basin Plan (North Coast Regional Board 2018), which incorporates the provisions of the Water Quality Control Plan for Ocean Waters of California (Ocean Plan) and the Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California

(Thermal Plan); (2) the Hoopa Valley Tribe Water Quality Control Plan (HVTEPA 2008); and (3) the Yurok Tribe Water Quality Control Plan for the Yurok Indian Reservation[21] (YTEP 2004). The water quality objectives are interpreted in this water quality analysis to determine the applicable thresholds of significance for this EIR since there are multiple overlapping water quality objectives, quantitative objectives are not available for some water quality parameters when objectives are narrative, and there is a lack of background information available to apply objectives that are relative to background conditions. Applicable numeric values used as thresholds of significance for the Lower Klamath Project analysis include water temperature, dissolved oxygen, and pH. There are multiple numeric standards for algal toxins potentially applicable for the Klamath River, so these various numeric standards are evaluated in the sub-section titled *Chlorophyll-a and Algal Toxins* (after Table 3.2-9) to identify the appropriate threshold of significance for algal toxins in this EIR. Numeric and narrative water quality objectives for various inorganic and organic contaminant were combined into a broad set of thresholds of significance as described below in the sub-section titled *Inorganic and Organic Contaminants* (after Table 3.2-11).

Other numeric values presented in Table 3.2-4 through Table 3.2-11, including 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 and Yurok Tribe ammonia and nitrate standards for the support of cold freshwater habitat and municipal beneficial uses, are not used as thresholds of significance. The California surface water quality objective for turbidity could not be used as a threshold of significance for suspended sediment since it is based on a comparison to naturally occurring background levels, but there is not readily available data on turbidity in the Klamath River. The threshold of significance for suspended sediment in this EIR is discussed below in the sub-section titled *Suspended Sediments* (after Table 3.2-9).

The California surface water quality objectives for nitrate (NO_3) and nitrate and nitrite (NO_3 + NO_2), along with the Hoopa Valley Tribe and Yurok Tribe nitrate water quality objective, are not appropriate thresholds of significance for nutrients in this EIR since they are based on supporting municipal beneficial uses (i.e., drinking water). These objectives 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 under the Proposed Project. Thus, other water quality objectives are evaluated to determine the threshold of significance for nutrients in this EIR, as discussed below in the sub-section titled *Nutrients* (after Table 3.2-9).

The Hoopa Valley Tribe criterion for chlorophyll-*a* as periphyton is not an appropriate threshold of significance for chlorophyll-*a* since it is based on periphyton growth rather than phytoplankton growth; periphyton growth is assessed in detail in Section 3.4 *Phytoplankton and Periphyton*, and it is only applicable to a short reach (at approximately RM 45) of the Klamath River upstream of the Trinity River. Thus, criteria are evaluated to determine the threshold of significance for chlorophyll-*a* in this EIR, as discussed below in the sub-section titled *Chlorophyll-a and Algal Toxins* (after Table 3.2-9).

The Hoopa Valley Tribe and Yurok Tribe have an ammonia toxicity objective based on pH and temperature (Table 3.2-7 and Table 3.2-8, respectively), but these objectives are not used as a threshold of significance for toxicity since available data suggests there are no actual ammonia toxicity events associated with the operation of the Lower Klamath Project (North Coast Regional Board 2010). Similarly, the Yurok Tribe has a nitrite water quality objective (Table 3.2-8), but available data does not suggest operation of the Lower Klamath Project influences nitrite concentrations in the Klamath River. Turbulent mixing and dissolved oxygen conditions in the Klamath River under the Proposed Project would promote the conversion of ammonia to nitrate or nitrite to nitrate and minimize the potential for ammonia or nitrite toxicity. The potential for short-term toxicity to aquatic organisms during reservoir drawdown, including consideration of ammonia toxicity, is addressed using bioassay results (see Section 3.2.4.7 *Inorganic and Organic Contaminants*).

Table 3.2-4. California Surface-Water Quality Objectives Relevant to the Proposed Project.

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.

Parameter	Description[1]
Temperature	Intrastate waters (Basin Plan) • No alteration of natural receiving water temperature of intrastate waters that adversely affects beneficial uses. • At no time or place shall the temperature of any **COLD** water be increased by more than 5°F above natural receiving water temperature. • At no time or place shall the temperature of **WARM** intrastate waters be increased more than 5°F above natural receiving water temperature. Interstate waters (Thermal Plan) • Elevated temperature waste discharges into **COLD** interstate waters are prohibited. • Thermal waste discharges having a maximum temperature greater than 2.8ºC (5ºF) above natural receiving water temperature are prohibited for **WARM** interstate waters. • Elevated temperature wastes shall not cause the temperature of **WARM** interstate waters to increase by more than 5°F above natural temperature at any time or place.
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 3.1a for minimum dissolved oxygen concentrations in mg/L) • From Oregon-California state line (RM 214.1) to the Scott River (RM 145.1), 90% saturation October 1-March 31 and 85% saturation April 1-September 30. • From Scott River (RM 145.1) to Hoopa Valley Tribe boundary (≈RM 45), 90% saturation year-round. • From Hoopa Valley Tribe boundary to Turwar (RM 5.6), 85% saturation June 1-August 31 and 90% saturation September 1-May 31. • For upper and middle Klamath River Estuary (RM 0-3.9), 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), dissolved oxygen 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	**MUN** 45 mg/L as NO_3 (equivalent to 10 mg/L for nitrate as N)[2]
Nitrate + Nitrite	**MUN** 10 mg/L as N [3]

Parameter	Description[1]
pH	The pH shall not be depressed below 6.5 units nor raised above 8.5 units, unless otherwise state below
	COLD, WARM Changes in normal ambient pH levels in fresh waters shall not exceed 0.5 units within the range specified above. **MAR, SAL** Changes in normal ambient pH levels shall not exceed 0.2 units
	The pH shall not be depressed below 7 units nor raised above 8.5 units for the Klamath River upstream of Iron Gate Dam, including Iron Gate and Copco No.1 reservoirs, the Klamath River in the Middle Klamath River Hydrologic Area downstream from Iron Gate Dam, and the Klamath River in the Lower Klamath River Hydrologic Area.
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, section 64444 (Table 64444-A), and listed in Table 3-1 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, section 64431 (Table 64431-A) and section 64444 (Table 64444-A) and listed in Table 3-1 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: North Coast Regional Board (2018) 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, as of December 20, 2018.

Table 3.2-5. Minimum Dissolved Oxygen Concentrations in mg/L Based on Percent Saturation Criteria (North Coast Regional Board 2010).

Dissolved Oxygen Concentrations (mg/L)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	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

Dissolved Oxygen Concentrations (mg/L)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
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												

Table 3.2-6. California Marine Water Quality Objectives Relevant to the Proposed Project.

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 1 (State Water Board 2015), 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 Chapter II, Table 1 (State Water Board 2015), 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: State Water Board (2015) unless otherwise noted.

[1] Water quality objectives for bacterial characteristics, radioactivity, and elevated temperature (thermal) wastes are not included, as these water quality parameters are not anticipated to be affected by the Proposed Project.

Table 3.2-7. Hoopa Valley Tribe Surface-Water Quality Objectives.

Parameter	Criteria/Description[1]
Ammonia (NH3, as mg/L N)	**COLD** Because ammonia toxicity to fish is influenced by pH, waters designated for the purpose of protection of threatened and endangered fish species in cold freshwater habitat shall meet conditions for ammonia based on maximum one-hour (acute) and 30-day average (chronic) concentrations linked to pH by the following formulas (HVTEPA 2008): Specific use numerical criteria: The one-hour average concentration of total ammonia nitrogen (in [milligrams nitrogen per liter] mg N/L) shall not exceed, more than once every three years on average, the CMC (acute criterion) calculated using the following equation. Where salmonid fish are present: $CMC = \frac{0.275}{1 + 10^{7.204-pH}} + \frac{39.0}{1 + 10^{pH-7.204}}$ The thirty-day average concentration of total ammonia nitrogen (in mg N/L) should not exceed, more than once every three years on average, the CCC (chronic criterion) calculated using the following equation. When fish early life stages are present: $CCC = \left(\frac{0.0577}{1 + 10^{7.688-pH}} + \frac{2.487}{1 + 10^{pH-7.688}}\right) x\ MIN\left(2.85, 1.45\ x\ 10^{0.028\ x\ (25-T)}\right)$ where T is the water temperature in Celsius.
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

Parameter	Criteria/Description[1]
Microcystis aeruginosa cell density	**MUN, REC-1** Less than 5,000 cells/mL for drinking water Less than 40,000 cells/mL for recreational water
Microcystin toxin Concentration	**MUN, REC-1** Less than 1 ug/L total microcystins[5] for drinking water Less than 8 ug/L total microcystins[5] for recreational water
Total potentially toxigenic cyanobacteria [blue-green algae] species [6]	**MUN, REC-1** Less than 100,000 cells/mL for recreational water
Cyanobacterial [blue-green algae] scums	**MUN, REC-1** There shall be no presence of cyanobacterial [blue-green algae] 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 which states, "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, but the stated numerical criteria are the operative criteria unless and until the Hoopa Valley Tribe completes the process of establishing the "natural conditions" reference condition. The procedure for defining natural conditions has not been finalized as of December 2018.

3 HVTEPA (2008) includes a natural conditions clause which states, "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 Valley Tribe definition of natural conditions, but the stated numerical criteria are the operative criteria unless and until the Hoopa Valley Tribe completes the process of establishing the "natural conditions" reference condition. The procedure for defining natural conditions have not been finalized as of December 2018.

4 30-day mean of at least two sample per 30-day period.

5 Total microcystins, as defined in the Hoopa Valley Tribe Surface-Water Objectives, is assumed to be equivalent to total microcystin for this EIR.

6 Includes: *Anabaena*, *Microcystis*, *Planktothrix*, *Nostoc*, *Coelosphaerium*, *Anabaenopsis*, *Aphanizomenon*, *Gloeotrichia*, and *Oscillatoria*.

Table 3.2-8. Yurok Tribe Surface-Water Quality Objectives Relevant to the Proposed Project.

Parameter[1]	Description
Ammonia	Levels of ammonia shall not be increased, in any body of water, by human related activity that could cause a nuisance or adversely affect the water to support specified beneficial uses. Specific use[2] numerical criteria[3]: The one-hour average concentration of total ammonia nitrogen (in [milligrams nitrogen per liter] mg N/L) shall not exceed, more than once every three years on average, the CMC[4] (acute criterion) calculated using the following equation. Where salmonid fish are present: $CMC = \frac{0.275}{1+10^{7.204-pH}} + \frac{39.0}{1+10^{pH-7.204}}$ The thirty-day average concentration of total ammonia nitrogen (in mg N/L) should not exceed, more than once every three years on average, the CCC[5] (chronic criterion) calculated using the following equation. When fish early life stages are present: $CCC = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}}\right) x\ MIN\left(2.85, 1.45\ x\ 10^{0.028\ x\ (25-T)}\right)$ where T is the water temperature in Celsius. In addition, the highest four-day average within the 30-day period should not exceed 2.5 times the CCC.
Biostimulatory Substances	Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths could cause a nuisance or adversely affect the water to support specified beneficial uses.
Dioxins	No dioxin compounds will be discharged to any water within the YIR[6] boundaries.

Parameter[1]	Description
Dissolved Oxygen	Dissolved oxygen concentrations shall not be altered by human caused activities that could cause a barrier to salmonid fish migration or adversely affect the water to support specified beneficial uses. Specific use[1] numerical criteria[3]: **Year-round objective in the water column** 7-day moving average of the daily minimum concentrations ≥ 8 mg/L **Intergravel objective during the incubation and emergence life stage** 7-day moving average of the daily minimum concentrations ≥ 8 mg/L **Water column objective during the incubation and emergence life stage** 7-day moving average of the daily minimum concentrations ≥ 11 mg/L.
Oil and Grease	Waters shall not contain oils, greases, waxes or other materials in concentrations that result in a visible film or coating on the surface of the water or on objects in the water that could cause a nuisance, or adversely affect the water to support specified beneficial uses.
Nitrate	Levels of nitrates in waters with municipal or domestic supply use shall not exceed 10 mg/L. In other bodies of water, the levels of nitrate shall not be increased by human related activity that could cause a nuisance, or adversely affect the water to support specified beneficial uses.
Nitrite	Levels of nitrites shall not be increased, in any body of water, by human related activity that could cause a nuisance, or adversely affect the water to support specified beneficial uses.
Pentachlorophenol (PCP)	No discharge of Pentachlorophenol will be allowed to any water body within the boundaries of the YIR. Any existing point or non-point source resulting in the presence of PCP shall be addressed as a non–compliance condition under the antidegradation plan.
Petroleum Hydrocarbons	No increase above background levels of petroleum hydrocarbons will be allowed due to human related activity in any water body within the YIR boundaries. Background levels shall be considered to be non-detect if baseline levels have not been established.
Pesticides	Pesticide concentrations, individually or collectively, shall not be detected by using the most recent detection procedures available. There shall be no detectable amount of pesticide concentrations found in bottom sediments. There shall be no detectable increase in bioaccumulation of pesticides in aquatic life.
pH	Changes related to human caused activities in normal pH levels shall not exceed 0.5 pH units [s.u.]. pH levels shall not be below 6.5 [s.u.] and not exceed 8.5 [s.u.] due to human caused activities.[2]

Parameter[1]	Description
Phosphates	Levels of phosphorous in any water body shall not be increased by human related activity above the levels that could cause a nuisance, or adversely affect the water to support specified 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 a nuisance, or adversely affect the water to support specified beneficial uses. In addition, the placing or disposal of soil and silt from any operation where such material could cause a nuisance or adversely affect the water to support specified beneficial uses is prohibited.
Settleable Materials	Waters shall not contain substances caused by human activities in concentrations that result in deposition of material that could cause a nuisance, or adversely affect the water to support specified beneficial uses.
Suspended Materials	Waters shall not contain suspended materials caused by human activities in concentrations that could cause a nuisance, or adversely affect the water to support specified beneficial uses.
Temperature	The natural receiving water temperature shall not be altered unless it is shown to the YTEP[7], and the YTEP concurs, that it does not affect beneficial uses. See Table 3.2-9 for water temperature specific use[2] numerical criteria[3].
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. Compliance with this objective will be determined by use of indicator organisms, analysis of species diversity, population density, growth anomalies, bioassays of appropriate duration and/or other appropriate methods as specified by USEPA's toxicity test guidance.
Turbidity	Waters shall be free of human caused changes in turbidity that could cause a nuisance, or adversely affect the water to support specified beneficial uses. 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. Turbidity shall not exceed 5 Nephelometric Turbidity Units (NTU) over background turbidity when the background turbidity is 50 NTU or less or have more than a 10 percent increase in turbidity when the background is greater than 50 NTU.[8]

Parameter[1]	Description
Other Chemical Constituents	Waters used for domestic or municipal supply shall not contain concentrations of chemical constituents in amounts which adversely affect such beneficial use.

Source: YTEP (2004) unless otherwise noted.

[1] Water quality objectives for bacteria, boron, floating materials, hardness, radioactivity, and elevated temperature (thermal) wastes are not included, as these water quality parameters are not anticipated to be affected by the Proposed Project. Analysis of potential impacts to riverbed substrate composition is discussed in Section 3.11 *Geology, Soils, and Mineral Resources*. Analysis of potential impacts to the ability of tribes to use water for ceremonial and other purposes is discussed in Section 3.12 *Historical Resources and Tribal Cultural Resources*. Analysis of potential impacts to color is discussed in Section 3.19 *Aesthetics*. Consideration of hydrology under the Proposed Project is discussed in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*. Specific hydrologic conditions for the alternatives are discussed in Section 4 *Alternatives*.

[2] Waters listed with the designated uses of preservation of biological habitat with special significance (BIO), cold freshwater habitat (COL), commercial and sport fishing (COM), cultural and ceremonial activities (CUL), migration of aquatic organisms (MGR), municipal and domestic supply (MUN), navigation (NAV), contact recreation (REC-1), rare, threatened, or endangered species habitat (RARE), spawning, reproduction, and development habitat (SPN) shall meet the criteria over the entire length of the stream including connecting tributaries and the Pacific Ocean where applicable within Yurok Tribal jurisdiction.

[3] Specific use numerical criteria for ammonia adopted from USEPA's 1999 update of ambient water quality criteria for ammonia (USEPA 1999) and Hoopa Valley Tribe's 2001 WQCP (HVTEPA 2008).

[4] CMC = Criteria Maximum Concentrations

[5] CCC = Criterion Continuous Concentration

[6] YIR = Yurok Indian Reservation.

[7] YTEP = Yurok Tribe Environmental Program

[8] Turbidity levels adopted from the State of Washington as specified in Bash et al. (2001).

Table 3.2-9. Yurok Tribe Water Temperature Numerical Criteria.[1]

Life Stage	Time Period (Estimated)	MWAT[2] (°C/°F)	MWMT[3] (°C/°F)	Inst. Max (°C/°F)
Adult Migration	Year-round	15/59	17/62.6	21/69.8
Adult Holding	May–Dec.	14/57.2	16/60.8	22/71.6
Spawning	Sept.–Apr.	11/51.8	13/55.4	22/71.6
Incubation/Emergence All Salmonids except Coho	Jan.–May	11/51.8	13/55.4	22/71.6
Incubation/Emergence Coho Salmon	Nov.–Jun.	10/50	12/53.6	22/71.6
Juvenile Rearing	Year-round	15/59	17/62.6	22/71.6
Smoltification	Jan.–Jun.	12/53.6	14/57.2	22/71.6

Source: YTEP (2004)

[1] Waters listed with the designated uses of preservation of biological habitat with special significance (BIO), cold freshwater habitat (COL), commercial and sport fishing (COM), cultural and ceremonial activities (CUL), migration of aquatic organisms (MGR), municipal and domestic supply (MUN), navigation (NAV), contact recreation (REC-1), rare, threatened, or endangered species habitat (RARE), spawning, reproduction, and development habitat (SPN) shall meet the criteria over the entire length of the stream including connecting tributaries and the Pacific Ocean where applicable within Yurok Tribal jurisdiction.

[2] Mean Weekly Average Temperature

[3] Mean Weekly Maximum Temperature

Suspended Sediments

California has established separate water quality objectives for the two closely-related water quality parameters: suspended sediment (the amount of silt, clay, and other small particles in the water column) and turbidity (the clarity or murkiness of the water due to small particles). California objectives for turbidity are based on comparing the clarity of the water currently to the clarity of the water under natural conditions (Table 3.2-4), where the Basin Plan defines natural conditions as conditions or circumstances affecting the physical, chemical, or biological integrity of water that are not influenced by past or present anthropogenic activities (North Coast Regional Board 2011). However, there are not readily-available data on what turbidity levels are in the Klamath River under natural conditions, so increases in turbidity above natural conditions cannot be calculated for the Proposed Project in the manner anticipated by the Basin Plan (i.e., relative to natural conditions). While measurements of suspended sediments and turbidity are related such that a relationship can be determined to estimate turbidity from suspended sediments, or vice versa, the relationship between suspended sediments and turbidity varies between watersheds due to variations in the suspended material properties (e.g., the size, shape, and refractive index of particles having different light scattering properties). Flow variations in a river may result in turbidity naturally fluctuating several orders of magnitude, but turbidity has also been observed to fluctuate by an order of magnitude or more when flows are relatively constant due variations in the suspended material properties being transported during different times (Bash et al. 2001). Both suspended sediment and turbidity data must be collected at one or more locations in a river over a sufficiently long time period to characterize the range of suspended sediment and turbidity conditions and determine the relationship between the two parameters in the river near those locations; there currently is not sufficient data to develop this relationship in the Klamath River, either for natural conditions or for existing background conditions (Stillwater Sciences 2009). Additionally, turbidity is only an indicator of suspended sediment effects on salmonids and other fish rather than a direct measure, so turbidity measurements may not accurately characterize the potential impact on salmonids (Bash et al. 2001) and suspended sediment concentrations would better characterize the potential impact of suspended sediments on salmonids. Thus, it is not possible to use the turbidity water quality objective directly, and accordingly the CEQA water quality impacts analysis uses the narrative sediment water quality objectives that include the evaluation of suspended material (i.e., suspended sediment concentrations), rather than the numeric turbidity standards.

Basin Plan water quality objectives for suspended material, settleable material, and sediment are narrative and require that waters not contain concentrations that cause nuisance or adversely affect beneficial uses (Table 3.2-4). While the Klamath River has multiple designated beneficial uses, the use most sensitive to water quality is the cold freshwater habitat (COLD) associated with salmonids (North Coast Regional Board 2011). In order to adequately analyze short-term and long-term impacts[22] of the Proposed Project on this beneficial use, the water quality impact analysis assesses the narrative suspended material water quality

[22] For the Lower Klamath Project water quality analysis, short term is defined as the period during pre-dam removal activities, reservoir drawdown, dam removal, and associated sediment flushing events, which corresponds to pre-dam removal activities that would occur in the one to three years before dam removal, dam removal year 1, dam removal year 2, and post-dam removal year 1 (Table 2.7-1). Long-term is defined as occurring after post-dam removal year 1 (i.e., greater than three years after dam removal.

objective using the predicted suspended sediment concentrations (SSCs)[23] for two to 50 years beginning with the initiation of drawdown in the Lower Klamath Project reservoirs. Predictions of SSCs during dam removal were determined as part of the extensive sediment transport modeling conducted for the Klamath Dam Removal Secretarial Determination process (USBR 2012). The narrative suspended material water quality objective was interpreted into a numeric SSC value for assessing potential impacts to the most sensitive beneficial use (COLD) by analyzing the magnitude and duration of SSCs that produce negligible, behavioral, sub-lethal, and lethal impacts to salmonids (Newcombe and Jensen 1996). Using a generalized "dose-response"[24] approach, the numeric SSCs threshold of significance for potential short-term impacts is 100 mg/L over a continuous two-week exposure period, as this exposure for the duration of two weeks would be a significant adverse impact to salmonids (see Appendix D, Section D.2 for detail).

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 Proposed Project on fisheries-related beneficial uses. This level of analysis is presented in Section 3.3 *Aquatic Resources* and appendices to the section. Further discussion of the particular impacts of suspended sediment on shellfish and estuarine and marine organisms is also presented in Section 3.3.5.1 *Suspended Sediment*.

In the Pacific Ocean nearshore environment, the narrative California marine water quality objectives (Table 3.2-6) are applied as the threshold of significance rather than the freshwater numeric SSCs threshold of significance of 100 mg/L

[23] For the purposes of this report, SSC is considered equivalent to Total Suspended Solids (TSS). SSC and TSS are generally similar (i.e., follow a 1:1 line of equal value), but TSS measurements tend to underestimate actual suspended material when the suspended material contains larger particles (i.e., sand-sized particles or greater) due to the TSS measurement methodology potentially underestimating larger particles that rapidly settle or clog measurement tools. SSC and TSS are more or less evenly distributed around the 1:1 line of equal value when particle sizes are smaller than 0.062 mm (i.e., silts or clays) and TSS is greater than approximately 5 mg/L (Gray et al. 2000). As needed, data from multiple sources reported as either TSS or SSC are used interchangeably, but TSS measurements may underestimate actual suspended material when sand-sized or larger particles comprise more than 25 percent of a sample mass. SSC is more commonly used in riverine systems while TSS is used for wastewater treatment plants.

[24] A "dose-response" approach analyzes how exposure to different concentrations over a range of time periods (i.e., hours, days, weeks, months) produces various impacts (i.e., negligible, behavioral, sub-lethal, and lethal) on the organism being evaluated.

over a continuous two-week exposure period. The freshwater numeric SSCs threshold of significance is not applied to the Pacific Ocean nearshore environment since mixing conditions would potentially result in rapid variations in SSCs and salmonids within the Pacific Ocean nearshore environment would have more of an opportunity to avoid elevated SSCs conditions compared to opportunities within the Klamath River. Due to the fact that turbulent mixing in the Pacific Ocean nearshore environment could result in rapid variations in physical characteristics, including SSCs, the threshold of significance in the marine environment for this EIR is whether the changes in the physical characteristics of the Pacific Ocean nearshore environment would be greater than occurring under natural (i.e., storm) conditions. Variations in the physical characteristics of the Pacific Ocean nearshore environment within the range occurring under natural (i.e., storm) conditions would be similar to existing conditions, so there would be no significant impact. Variations in the physical characteristics of the Pacific Ocean nearshore environment greater than the range occurring under natural (i.e., storm) conditions would potentially cause water quality changes that would result in a failure to maintain existing beneficial uses at the levels currently supported, resulting in a significant impact.

Nutrients

California has a narrative water quality objective for biostimulatory substances and does not stipulate numeric nutrient water quality standards for the COLD beneficial use (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 under the Proposed Project. The Hoopa Valley Tribe and Yurok Tribe also have nitrate standards for municipal beneficial uses (Table 3.2-7 and Table 3.2-8, respectively) that are similarly higher than nitrate concentrations measured in the Klamath Basin. The Yurok Tribe nitrite water quality objective is discussed under the sub-section *Inorganic and Organic Contaminants* below.

The narrative objective for biostimulatory substances in the Basin Plan applies to all North Coast waters. The California Klamath River TMDLs interpret the narrative biostimulatory substances objective for the Klamath River with numeric targets for nutrients, organic matter, chlorophyll-*a*, *Microcystis aeruginosa*, and microcystin. The numeric TMDL targets for nutrients (TP and TN) and organic matter vary by month and are established for the tailraces of Copco No. 2 and Iron Gate dams. The numeric TP targets range from 0.023 to 0.029 mg/L for May to October and 0.024 to 0.030 mg/L for November to April. The numeric TN targets range from 0.252 to 0.372 mg/L for May to October and 0.304 to 0.395 mg/L for November to April (North Coast Regional Board 2010). These are established as the monthly mean concentrations that allow achievement of in-reservoir water quality targets to attain the chlorophyll-*a* summer mean target of 10 ug/L, the *Microcystis aeruginosa* cell density target of 20,000 cells/mL, and the microcystin target of 4 ug/L (i.e., avoid nuisance algae blooms in Iron Gate and Copco No. 1 reservoirs) (North Coast Regional Board 2010; see also Appendix D, Section D.1 for a discussion of the “TMDL dams-in” modeling scenario [T4BSRN], which is the basis of these targets). Additionally, numeric TP and TN water quality objectives have been established by the Hoopa Valley Tribe (see Table 3.2-7) for the portions of the Klamath River within the Hoopa Valley Tribe Reservation lands (RM 44.8 to RM 45.8), with the mean TP and TN concentrations in any 30-day period from May to October not to exceed 0.035 mg/L TP and 0.2 mg/L TN (HVTEPA 2008).

At multiple locations in the Klamath River, the Klamath River TMDL model results indicate large daily variability in TP and TN in excess of the small range in the monthly TMDL targets, particularly during summer and early fall (generally June to October) (Tetra Tech 2009). As a result, the nutrient impact analysis for this EIR considers if there is a general downward (or upward) trend in TP and TN toward (or away from) the TMDL and Hoopa Valley Tribe (as applicable) numeric targets would occur and, qualitatively, the impact analysis interprets whether such a trend would support or alleviate the growth of nuisance and/or noxious phytoplankton or nuisance periphyton. In the Pacific Ocean nearshore environment, the applicable narrative water quality objective for nutrients would be from the California Ocean Plan that states that nutrient materials shall not cause objectionable aquatic growths or degrade indigenous biota (see Table 3.2-6). Thus, the threshold of significance for nutrients is the combination of a qualitative evaluation of potential changes in nutrients under the Proposed Project and an evaluation of whether potential responses in nuisance and/or noxious phytoplankton or nuisance periphyton would impact designated beneficial uses.

Chlorophyll-*a* and Algal Toxins

The Klamath River TMDLs establish a Lower Klamath Project phytoplankton chlorophyll-*a* target of 10 ug/L during the May to October growth season (North Coast Regional Board 2010). The Hoopa Valley Tribe chlorophyll-*a* criterion[25] (150 mg/m^2) relates to periphyton growth rather than phytoplankton growth or algae blooms and it is not discussed further in this section since periphyton growth under the Proposed Project is addressed in Section 3.4 *Phytoplankton and Periphyton*.

The California TMDL target (10 ug/L) is used as the chlorophyll-*a* threshold of significance for Copco No. 1 and Iron Gate reservoirs. Anticipated regular exceedances of these thresholds greater than would occur under existing conditions would constitute a significant impact for this analysis.

[25] Applicable to the short reach (approximately RM 45) of the Klamath River upstream of the Trinity River.

For algal toxins, the North Coast Regional Board Basin Plan has narrative water quality objectives for general toxicity that 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 (North Coast Regional Board 2018). The World Health Organization (WHO) has set numeric thresholds for recreational exposures of microcystin toxin at 4 ug/L for a low probability of adverse health effects, and 20 ug/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 [blue-green algae]. 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 Lower Klamath Project for *Microcystis aeruginosa* (less than 20,000 cells/mL) and microcystin toxin (less than 4 ug/L). In addition to the WHO and California Klamath River TMDLs numeric objectives for microcystin toxin thresholds, the CCHAB Network, comprised of the State Water Board, CDPH, and CalEPA OEHHA with participation by multiple federal, state, and local stakeholders, details primary and secondary cyanotoxin [algal toxin] trigger threshold levels for protection of human health in recreational waters in the *Draft Voluntary Statewide Guidance for Blue-Green Algae Blooms* (Table 3.2-10; State Water Board et al. 2010, updated 2016). The minimum primary cyanotoxin [algal toxin] trigger thresholds that would result in a waterbody being posted include 0.8 ug/L total microcystin toxins, detection of anatoxin-a (using an analytical method that detects less than or equal to 1 ug/L), or 1 ug/L cylindrospermopsin. The secondary trigger thresholds are 4,000 cells/mL of all toxin producing species- or site-specific indicators of cyanobacteria [blue-green algae] like blooms, scums, or mats (State Water Board et al. 2010, updated 2016). Additionally, the Hoopa Valley Tribe and Yurok Tribe have numeric objectives for algal toxins. The Hoopa Valley Tribe numeric objectives for algal toxins are less than 1 ug/L total microcystins[26] for drinking water and less than 8 ug/L total microcystins[26] for recreational water (see Table 3.2-7; HVTEPA 2008). The Yurok Tribe has multiple numeric objectives for algal toxins (i.e., microcystin) with the lowest threshold for posting being detection of microcystin (see Table 3.2-11; YTEP 2016).

[26] "Total microcystins", as defined in the Hoopa Valley Tribe Surface-Water Objectives, is assumed to be equivalent to "total microcystin" for this EIR.

Table 3.2-10. California Cyanobacteria Harmful Algal Bloom (CCHAB) Trigger Levels for Human Health.

Trigger Level	Primary Triggers[1]			Secondary Triggers	
	Total Microcystins (ug/L)	Anatoxin-a (ug/L)	Cylindrospermopsin (ug/L)	Total Potentially Toxigenic Cyanobacteria [blue-green algae] Species (cells/mL)	Site Specific Indicators of Cyanobacteria [blue-green algae]
Caution Action	0.8	Detection[2]	1	4,000	Blooms, scums, mats, etc.
Warning TIER I	6	20	4	-	-
Danger TIER II	20	90	17	-	-

Source: (State Water Board et al. 2010, updated 2016)

[1] Primary triggers are met when ANY toxin exceeds criteria

[2] Must use an analytical method that detects less than or equal to 1 ug/L Anatoxin-a

Table 3.2-11. Yurok Tribe Posting Guidelines for Blue-Green Algae Public Health Advisories

Public Health Advisory Level	*Microcystis aeruginosa* (cells/mL)	Total potentially toxigenic blue-green algae species (cells/mL)	Microcystin toxin Concentration (ug/L)
Caution	Detection	Detection	Detection
Level I Health Advisory Warning	≥ 1,000	≥ 100,000	≥ 0.8
Level II Health Danger Advisory	≥ 5,000	≥ 500,000	≥ 4.0

Source: YTEP (2016)

Since the less than 4 ug/L criterion for microcystin in recreational waters is common to the California Klamath River TMDL, WHO, and Yurok Tribe criteria, and it is less than the Hoopa Valley Tribe recreational criterion, 4 ug/L microcystin is used as the threshold of significance for the Lower Klamath Project EIR water quality analysis. The current lowest CCHAB and Yurok Tribe posting limit for microcystin (0.8 ug/L) is also considered in the analysis although application of the lower threshold would in no case change the significance determinations in this EIR.

While the threshold of significance for microcystin (i.e., algal toxins) is a numeric value, quantitative predictive tools for algal toxins are not available for assessment of the Proposed Project. Therefore, the algal toxin impact analysis is based on a qualitative assessment of whether the Proposed Project would result in exceedances of the criterion and adversely affect human health and recreational beneficial uses. Growth conditions for toxigenic suspended blue-green algae (e.g., nutrient availability, stable, slow-moving water) are considered as part of the qualitative analysis, where predicted changes in nutrient availability, water temperatures, and the availability of stable, slow-moving water (e.g., reservoir) conditions would correspondingly affect algal toxin concentrations.

Inorganic and Organic Contaminants

California has water quality objectives related to inorganic and organic contaminants, with numeric objectives for California's chemical constituents (listed in the Basin Plan [North Coast Regional Board 2018]), and chemical-specific water-column criteria for freshwater and marine aquatic life and human health, including bioaccumulative chemicals such as PCBs, methylmercury, dioxins, and furans (North Coast Regional Board 2018). The most stringent criteria are applied when more than one would be applicable (e.g., freshwater or marine in estuaries with brackish water). California's toxicity and pesticides objectives are narrative (Table 3.2-4).

Thresholds of significance for the 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 EIR analysis, establishment of toxicity and/or bioaccumulation potential for sediment contaminants relies upon thresholds developed through regional and state efforts in the Sediment Evaluation Framework for the Pacific Northwest (SEF) (Appendix D – *Section D.3*). 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 2018). 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 2018). Numeric chemical guidelines for the assessment and characterization of freshwater and marine sediments do not exist for California. 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 since dissolved chemicals are more bioavailable (i.e., able to interact with biological processes) and likely to cause toxicity than chemicals that are bound to sediments and less bioavailable (USEPA 2007). As part of the SEF approach used for the Klamath Dam Removal Secretarial Determination process, bioassays and sediment bioaccumulation tests were conducted to provide additional empirical evidence about the biological effects of inorganic and organic contaminants in reservoir sediment deposits. Bioassays and sediment bioaccumulation test results represent direct exposure to the undiluted reservoir sediments samples, so those results are interpreted based on the expected dilution of reservoir sediments once they are transported from the reservoir footprints under the Proposed Project and potential toxicity from bioassays and sediment bioaccumulation tests are only applied as thresholds of significance after consideration of dilution. Additional information regarding applicable sediment screening levels used for the Klamath Dam Removal Secretarial Determination sediment evaluation process is presented in CDM (2011).

With respect to inorganic and organic contaminants, impacts on water quality are considered significant if the Proposed Project would result in substantive adverse impacts on human health or environmental receptors (e.g., aquatic organisms) due to dam removal. Substantive adverse impacts on human health or environmental receptors is defined as exceedance of applicable chemical screening levels and/or laboratory toxicity results that indicate one or more chemicals are present at levels with potential to cause toxicity after consideration of dilution that would be representative of conditions in the Klamath River, Klamath River Estuary, and the Pacific Ocean nearshore environment during and following dam removal. The detection of one or more chemicals at concentrations with potential to cause only minor or limited adverse effects based on exceedances of applicable screening levels and/or laboratory toxicity results after consideration of dilution under the Proposed Project would be below the threshold of significance, thus constitute a less than significant impact. This evaluation is not intended to be equivalent to the SEF process.

Lastly, the Hoopa Valley Tribe and the Yurok Tribe have ammonia toxicity objective based on pH and temperature (Table 3.2-7). Available data suggests no actual ammonia toxicity events associated with the operation of the Lower Klamath Project (North Coast Regional Board 2010), and the turbulent mixing, increased river velocity and expected dissolved oxygen conditions in the river under the Proposed Project would promote an increase in nitrification (i.e., biological oxidation of ammonia and ammonium to nitrate) minimizing the potential for ammonia toxicity. Similarly, the Yurok Tribe has a nitrite water quality objective (Table 3.2-8), but available data does not suggest operation of the Lower Klamath Project influences nitrite concentrations in the Klamath River. Additionally, the rapid oxidation of nitrite to nitrate in the environment combined with the dissolved oxygen and turbulent mixing conditions in the Klamath River would result in any potential nitrite becoming nitrate under the Proposed Project. As a result, these specific objectives are not considered further. Potential short-term toxicity to aquatic organisms during reservoir drawdown, including consideration of ammonia and nitrite toxicity, is addressed using bioassay results (see Section 3.2.4.7 *Inorganic and Organic Contaminants*).

3.2.4 Impact Analysis Approach

Water quality impact analysis considers the Proposed Project's anticipated short-term and long-term water quality effects. For the Lower Klamath Project water quality analysis, short-term is defined as the period during pre-dam removal activities, reservoir drawdown, dam removal, and associated sediment flushing events, which corresponds to pre-dam removal activities that would occur in the one to three years before dam removal, dam removal year 1, dam removal year 2, and post-dam removal year 1 (Table 2.7-1). Long-term is defined as occurring after post-dam removal year 1 (i.e., greater than three years after dam removal).

As these are the areas of greatest potential impact and of most heightened public concern, the water quality analysis in this EIR focuses on the potential impacts of the Proposed Project 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.

While the timing of reservoir drawdown under the Proposed Project was selected to minimize environmental effects, significant short-term impacts are anticipated. In the short term, the water quality impacts are expected to be heavily driven by the release of fine sediment deposits currently stored behind the dams to the downstream river reaches, the Klamath River Estuary, and the Pacific Ocean nearshore environment. Mobilization of reservoir sediment deposits would be most intense during reservoir drawdown and the year following dam removal, when the majority of sediments would be eroded and transported by river flows (Stillwater Sciences 2008; USBR 2012, 2016) (see also Section 2.7.3 *Reservoir Sediment Deposits and Erosion During Drawdown*). Additionally, there is the potential for short-term water-quality impacts as a result of construction and restoration activities.

Long-term changes in water quality are primarily characterized by the shift from reservoir to river environments in the Hydroelectric Reach and the associated alterations in physical and chemical processes on water quality in this reach and downstream river reaches. Additionally, potential long-term water quality impacts associated with future land use and the transfer of Parcel B lands under the Proposed Project are considered qualitatively.

Multiple numeric models[27] are used for the water quality impact analyses because no one individual existing numeric model captures all of the water quality conditions anticipated for and encompassed by the Proposed Project (Appendix D, Section D.1). Numeric models include those developed by PacifiCorp for the FERC relicensing process for water temperature and dissolved

[27] Here "numeric models" refers to mathematical models that are developed to represent the physical, chemical, and biological conditions in waterbodies such as rivers, lakes, reservoirs, wetlands, estuaries, and the ocean.

oxygen, North Coast Regional Board models for development of the Klamath River TMDLs, and models used in the course of the Klamath Dam Removal Secretarial Determination studies. While modeling conducted as part of the Klamath Dam Removal Secretarial Determination studies used Water Year (WY) 2012 as the start of the period of analysis for hydrology (i.e., river flows), water temperature, and suspended sediment, the overall range of river flows remains generally consistent between WY 2012 and current conditions (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*) and other modeling assumptions for water temperature and suspended sediment have not changed in the interim. The California Klamath River TMDL models stemmed from a significant five-year effort by the North Coast Regional Board in collaboration with PacifiCorp and working jointly with USEPA Regions 9 and 10 and ODEQ. That work was subject to extensive peer review and public comment before adoption by the North Coast Regional Board. It was further reviewed and subject to additional public comment before being approved unanimously by the State Water Board. It was then subsequently reviewed and approved by the USEPA in December 2010.

Key concerns with respect to the California and Oregon TMDL models, which were raised during the respective public comment processes, include concerns regarding how the natural condition was determined, how model uncertainty was considered in the analysis, and need for additional years of data for calibration of the model. As discussed in North Coast Regional Board (2010) Appendix 10 *Public Comments & Responses*, the North Coast Regional Board found the uncertainty associated with the Klamath TMDL models to be minimal relative to the magnitude of the source load reductions needed to meet water quality standards in both Oregon and California and that any additional analysis would bring diminishing returns for determining implementation actions for the basin. The North Coast Regional Board indicated that if updates to the California model demonstrate that TMDL allocations and targets should be adjusted, the Regional Water Board staff would propose changes to the TMDL. To date, no such changes have been proposed. The North Coast Regional Board also provided extensive documentation describing the development of the modeled natural condition and indicated that the year chosen for developing the model and establishing the TMDL was selected because it included periods of critical low flow and poor water quality conditions, consistent with the margin of safety requirement and the goal of developing environmentally conservative allocations. While the Oregon portion of the model was calibrated using two model years, there were not sufficient data to evaluate the California portion of the model for the second year. The North Coast Board indicated that adding more model years to the model development process would not significantly change the model parameters, given the within-year variability in the Klamath River system (North Coast Regional Board 2010).

The following documents were assessed to determine if the Proposed Project has the potential to conflict with any local policies or ordinances protecting water quality or conflict with provisions of any adopted conservation plans:

- Del Norte County General Plan (Mintier & Associates et al. 2003):
  - Section 1 *Natural Resources/Conservation, Water Resources*, including Policies 1.B.1, 1.B.3, 1.B.6, 1.B.7, and 1.B.12.
- Humboldt County General Plan for Areas Outside of the Coastal Zone (Humboldt County 2017):
  - Water Resources Element, including Policies WR-P1, WR-P2, WR-P3, WR-P4, WR-P5, WR-P12, WR-P18, WR-P22, WR-P23, WR-P24, WR-P25, WR-P29, WR-P33, WR-P34, WR-P35, WR-P36, WR-P37, WR-P39, WR-P42, WR-P43, and WR-P45; Standards WR-S2, WR-S6, WR-S7, and WR-S9; and Implementation Measures WR-IM9, WR-IM14, WR-IM17, WR-IM19, WR-IM20, WR-P28 [sic], WR-IM29, WR-IM30, and WR-IM32.
- Siskiyou County General Plan:
  - Conservation Element (Siskiyou County 1973), including Section 4.H *Watershed and Water Recharge Lands*, Objective and Recommendations 2, 3, and 4; Section 4.I *The [Conservation] Plan*, 1, 4, 8, and Objectives 1, 3, and 5; and Section 5.C.3 *Environmental Impacts*, 1, 3, 5, and 7.
  - Land Use and Circulation Element (Siskiyou County 1980) and Land Use Update (Siskiyou County 1997).

The aforementioned policies, standards, implementation measures, and objectives are stated in general terms, consistent with their overall intent to protect water quality, water resources, and general watershed conditions. In evaluating the potential impacts to specific water quality parameters within the water quality Area of Analysis, including water temperature, suspended sediments, nutrients, dissolved oxygen, pH, chlorophyll-a and algal toxins, and inorganic and organic contaminants, the more general local policies listed above are inherently considered and addressed by the water quality parameter specific analyses in Section 3.2.5 *[Water Quality] Potential Impacts and Mitigation*.

Parameter-specific analysis methods are discussed below.

3.2.4.1 Water Temperature

The analysis of the Proposed Project's potential short-term and long-term impacts on water temperatures is informed by three quantitative models: the Klamath River Water Quality Model (KRWQM), the Klamath River TMDL model, and the RBM10 model. Each of these models includes a scenario that is similar to existing conditions (i.e., with the Lower Klamath Project dams in place) and scenarios with one or more dams removed that are similar to the Proposed Project and/or alternatives analyzed in Section 4 *Alternatives*. The KRWQM was developed for FERC relicensing of the Klamath Hydroelectric Project (PacifiCorp 2004a, 2005a), and the KRWQM version that was used to model water quality conditions in 2004 and 2005 (hereafter referred to as the 2004/2005 KRWQM) was later used to inform development of the Klamath River TMDL model. More recent 2019 KRWQM documentation (PacifiCorp 2019) indicates that PacifiCorp has developed an updated version of the KRWQM model, where the updates were primarily focused on Keno Reservoir. However, PacifiCorp (2019) does not present comparisons of dam removal scenarios, so the previous 2004/2005 KRWQM results cannot be replaced with the newer 2019 KRWQM results in the EIR analyses. The Klamath River TMDL model was developed to inform the Oregon and California TMDLs. The Klamath River TMDL model includes a “TMDL dams-in” scenario (T4BSRN), which approximates the condition where the Lower Klamath Project dams remain in place, as well as the TOD2RN (Oregon reaches) and TCD2RN (California reaches) scenarios (together the “TMDL dams-out” scenario) that assume the removal of the Lower Klamath Project (see Appendix D for more detail). The Klamath River TMDL model assumes full TMDL implementation for both the dams-in and dams-out scenarios (Tetra Tech 2009); however, the mechanisms for implementation and the timing required to achieve future TMDL compliance are currently speculative. Despite this assumption, the Klamath River TMDL model results are still a useful source of information with respect to the analysis of potential water temperature impacts under the Proposed Project, particularly in light of the TMDL model’s inclusion of the Klamath “TMDL natural conditions scenario” (T1BSR) that contextualizes water temperature background or natural levels as compared with existing conditions, the Proposed Project, and/or the alternatives. The Klamath River TMDL model assumes that the upstream Keno Dam is replaced by the historical natural Keno Reef in the “TMDL natural conditions” scenario (T1BSR), and the “TMDL dams-out” scenario (TOD2RN and TCD2RN), but not in the “TMDL dams-in” scenario (T4BSRN). Where this assumption applies, 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, which does not materially influence model applicability to inform impact determinations for the Proposed Project and alternatives identified in this EIR.

Since the 2004/2005 KRWQM and the Klamath River TMDL model do not include climate change projections or KBRA hydrology[28], one additional set of water temperature modeling results is used for this EIR. The RBM10 model was developed as part of the Klamath Dam Removal Secretarial Determination

[28] Quantitative comparisons between KBRA and the NMFS and USFWS 2013 Joint Biological Opinion for the Klamath Irrigation Project (2013 BiOp Flows) or KBRA and the NMFS and USFWS individual 2019 Biological Opinions (2019 BiOp Flows) indicate that KBRA Flows sufficiently bracket the range of 2013 BiOp Flows and 2019 BiOp Flows (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*), so RBM10 model results still generally represent the expected trends under the Proposed Project.

studies and includes the effects of climate change and KBRA hydrology on 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). The climate change predictions are used to give additional context to the temperature discussion, but they are not relied on for significance determinations. Future climate changes are not part of the existing condition against which this EIR compares potential impacts under the Proposed Project.

Additional details regarding available numeric models for analysis of long-term water temperature are presented in Appendix D. Table D-1 shows the reaches where 2004/2005 KRWQM, Klamath River TMDL, and RBM10 model results are used for the water quality analysis under the Proposed Project and each alternative and Table D-2 presents a comparison of assumptions and parameters for the available numeric models, including flow assumptions. Since no single existing model captures all of the elements analyzed for water temperature in this EIR, model outputs are used in combination to assess similar spatial and temporal trends in predicted water temperature where possible.

3.2.4.2 Suspended Sediments

Reservoir drawdown under the Proposed Project is anticipated to mobilize a large amount of sediment in the short term (USBR 2012). In light of this, the Proposed Project schedules reservoir drawdown during winter months when precipitation, river flows, suspended sediments, and turbidity are naturally highest (see Section 2.7 *Proposed Project*). This EIR uses quantitative modeling and analyses of drawdown to inform the analysis of drawdown's suspended sediment effects, as further described in this section. Additionally, this EIR evaluates the potential for the Proposed Project to affect suspended sediment concentrations over the long-term, using existing data sources and analyses.

Results from the sediment mobility analysis conducted by USBR (2012) for the Klamath Dam Removal Secretarial Determination process are used to provide estimates of short-term SSCs downstream of Iron Gate Dam under the Proposed Project. The sediment mobility analysis used existing suspended sediment data collected by the 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 (measured in mg/L) as a function of flow (measured in cfs) using the SRH-1D sediment transport model (Sedimentation and River Hydraulics–One Dimension Version 2.4) (Huang and Greimann 2010) and the SRH-2D sediment transport model (Sedimentation and River Hydraulics–Two Dimension Version 2.4) (USBR 2012, 2016). 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 settleable suspended material in the water column, including both inorganic (e.g., silt, clay, and sand) and organic (e.g., algae and plant) suspended material, is applied herein to the suspended sediment analysis. "Suspended sediments" and "suspended material" are used interchangeably to refer to the combined inorganic and organic suspended material. Sources of each type of suspended material differ, as do spatial and temporal trends for each, within the Upper, Middle, and Lower Klamath River reaches (Section 3.2.2.3 *Suspended Sediments*). Bed materials, such as gravels and larger substrates, are discussed in Geology and Soils Section 3.11.5 *Potential Impacts and Mitigation*.

The SRH-1D model assumes drawdown for Copco No. 1 Reservoir begins on November 1 and drawdown for J.C. Boyle, and Iron Gate reservoirs begins on January 1, consistent with the Proposed Project. Copco No. 2 was not explicitly considered in the SRH-1D model, since: 1) construction of Copco No. 2 dam was completed seven years after the substantially larger upstream Copco No. 1 dam was completed, where the larger dam effectively cut off the source of sediments that would have been transported into Copco No. 2 Reservoir and potentially stored over many years, and 2) Copco No. 2 Reservoir storage volume (70 ac-ft) is negligible compared with that of the upstream Copco No.1 (33,724 ac-ft) and J.C. Boyle (2,267 ac-ft) reservoirs, such that even if sediment deposits were to occur in Copco No. 2 Reservoir during drawdown of upstream Copco No. 1 and J.C. Boyle reservoirs, the smaller Copco No. 2 Reservoir would not meaningfully increase downstream SSCs during designated reservoir drawdown periods (see also Section 2.7.3 *Reservoir Sediment Deposits and Erosion During Drawdown*).

The Klamath River hydrology for the SRH-1D model was generated using the Index Sequential method, where historical flow data is used to generate a set of flows under future operational conditions (USBR 2012). Historical flows from 1961 to 2009 (i.e., 49 years of data) were used to estimate potential inflows to the Upper Klamath Lake and Klamath River in the future, then these inflows were routed down the Klamath River based on KBRA flow operations and requirements (i.e., KBRA Flows). As discussed in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, 2013 BiOp Flows and 2019 BiOp Flows are typically similar to KBRA Flows for all water year types (generally within a few percentage points) and 2013 BiOp Flows or 2019 BiOp Flows outside the range KBRA Flows occur too infrequently to substantially alter the range of flow conditions in the Klamath River. Thus, SRH-1D model predictions made using KBRA Flows are still appropriate for assessing Proposed Project impacts under 2013 BiOp or 2019 BiOp Flows. In SRH-1D modeling that continued for more than one year (i.e., two years or more), the hydrology in the start year was followed by the hydrology in subsequent years. If there were no subsequent hydrology data (i.e., 2009), the period of record was looped (i.e., 2009 hydrology would be followed by 1961 hydrology) to obtain hydrology for Klamath River inflows for the desired modeling period. For example, if a start year of 2001 was chosen for a two-year modeling period, the hydrology from 2001 and 2002 was used to generate the inflows in the Klamath River that then were routed through the Hydroelectric Reach and further downstream. If a start year of 2001 was chosen for a 51-year modeling period, the hydrology from 2001 to 2009 followed by the hydrology from 1961 to 2002 would be used to generate the inflows in the Klamath River that then were routed through the Hydroelectric Reach and further downstream (USBR 2012).

In addition to modeling the sediment transport during drawdown of the Lower Klamath Project reservoirs, sediment transport in the Klamath River from Iron Gate Dam to the Pacific Ocean for all years between WY 1961 and 2008 was modeled with SRH-1D to estimate the background SSCs in the Klamath River under existing conditions (USBR 2012). Incoming sediment concentrations supplied by tributaries downstream of Iron Gate Dam in the SRH-1D modeling of background SSCs were estimated from existing data on sediment transport and estimates of the sediment delivery rates from portions of the Klamath Basin were used to (Stillwater Sciences 2010; USBR 2012). Additionally, the SRH-1D modeled SSCs were compared with suspended sediment data collected by the USGS on the Shasta River near Yreka, California (USGS 11517500) from 1957 to 1960, on the Klamath River at Orleans, California (USGS 11523000) from 1957 to 1979 and on the Klamath River at Klamath, California (USGS 11530500) from 1974 to 1995 to verify the SRH-1D modeled SSCs sufficiently characterized the background SSCs in the Klamath River at Orleans and Klamath (USBR 2012).

With respect to the assumed reservoir drawdown rate, the USBR (2012) SSC modeling assumes a maximum drawdown rate of 2.25 to 3 feet per day (USBR 2012b) whereas the Proposed Project uses a maximum drawdown rate of 5 feet per day (Appendix B: *Definite Plan*). Stillwater Sciences (2008) modeled a range of drawdown rates (3, 6, and 9 feet per day) for removal of the Lower Klamath Project dams, which spans the aforementioned USBR (2012) and Proposed Project maximum drawdown rates. In Stillwater Sciences (2008), as the drawdown rate increases from 3 to 6 feet per day, the peak concentration of suspended sediments approximately doubles from 10,000 ppm [mg/L] to 20,000 ppm [mg/L], the concentration of suspended sediments decreases more rapidly over the course of days and weeks, and the duration of elevated concentrations decreases by several weeks. A similar response in estimated SSCs is expected for the USBR (2012) model output when increasing the maximum drawdown rate from 2.25 to 3 feet per day to 5 feet per day and accordingly, this response pattern is applied to the analysis of potential impacts due to SSCs, such that no new SSC modeling is required for the Proposed Project. While peak SSCs under the Proposed Project may be somewhat underestimated by the USBR (2012) modeled SSC results, the SSCs under the Proposed Project would still be within the inherent uncertainty of the USBR (2012) model (i.e., approximately a factor of two). Additionally, a more rapid decrease in suspended sediments and shorter duration of elevated SSCs under the faster drawdown in the Proposed Project would result in the USBR (2012) modeled SSC results underestimating the rate SSCs decrease and overestimate the duration of elevated concentrations in the river, thus the overall UBSR (2012) model results would provide a conservative estimate of the short-term impacts of dam removal on suspended sediments in the Klamath River.

The analysis of short-term suspended sediment-related impacts 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 broader scale of the Klamath Basin.

The long-term impact analysis of suspended materials uses existing data sources for TSS and turbidity sources to the Hydroelectric Reach and the Middle and Lower Klamath River (e.g., PacifiCorp 2004a, 2004b; YTEP 2005; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). Existing analyses of the potential effects of dam removal on long-term sediment supply (Stillwater Sciences 2010) are also considered.

3.2.4.3 Nutrients

Under the Proposed Project, short-term nutrient loads associated with high SSCs are assessed in a qualitative manner, considering the likelihood of sediment deposition in the Lower Klamath 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.

Additionally, the analysis uses Klamath River TMDL model runs to evaluate the general long-term trends (both spatial and temporal) for nutrients in the Hydroelectric Reach and the Middle and Lower Klamath River. The Klamath River TMDL model includes a “TMDL dams-in” scenario (T4BSRN), which approximates the condition where the Lower Klamath Project dams remain in place, as well as the TOD2RN (Oregon reaches) and TCD2RN (California reaches) scenarios (together the “TMDL dams-out” scenario) that assume the removal of the Lower Klamath Project (see Appendix D for more detail). The Klamath River TMDL model assumes full TMDL implementation for both the dams-in and dams-out scenarios (Tetra Tech 2009); however, the mechanisms for implementation and the timing required to achieve future TMDL compliance are currently speculative. Despite this assumption, the Klamath River TMDL model results are still informative with respect to the analysis of potential nutrient impacts under the Proposed Project, particularly since nutrient models were not developed for the FERC relicensing process. To place the Proposed Project analysis in context, results of the “TMDL dams-out” Oregon scenario (TOD2RN) and “TMDL dams-out” California scenario (TCD2RN) are generally interpreted with respect to starting assumptions (i.e., model boundary conditions) about nutrient concentrations. The Klamath River TMDL provides modeling results for all mainstem Klamath River reaches associated with the water quality nutrient analysis for this EIR (see Appendix D, Table D-1).

Long-term trends for nutrients under the Proposed Project are also assessed in this EIR using a prior study of potential nutrient dynamics under a “dams-out” scenario (Asarian et al. 2010). The prior study used nutrient measurements and hydrologic data for the Klamath River, to develop nutrient budgets for June through October of 2005 to 2008 for the free-flowing reaches of the Klamath River. The prior study included longitudinal trends in absolute and relative retention of TP and TN, and it 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 2005 to 2008 study used hydrologic and nutrient data collected by a variety of tribal, federal, and state agencies, and PacifiCorp. The nutrient budget estimates for 2005 to 2008 improve upon estimates made for the earlier period 1998 to 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 (not just TN and TP). As compared to the 1998 to 2002 period, the nutrient budget estimates for 2005 to 2008 also used improved accounting for peaking flows in the J.C. Boyle Bypass Reach. 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 No. 1 and Iron Gate reservoirs by Asarian et al. (2009).

3.2.4.4 Dissolved Oxygen

Both short-term and long-term effects on dissolved oxygen levels due to the Proposed Project are analyzed in this EIR. For short-term effects, results of numerical modeling conducted 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. The one-dimensional, steady-state spreadsheet model uses an approach similar in concept to the Streeter and Phelps (1925) dissolved oxygen-sag equation to incorporate the oxygen-demand offsets of tributary dilution and re-aeration in evaluating the different short-term oxygen demand parameters (e.g., BOD, immediate oxygen demand [IOD], and SOD). The 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 (i.e., when dissolved oxygen levels are 0 mg/L or greater). 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).

BOD and IOD are predicted in the spreadsheet model using empirically derived oxygen depletion rates for a particular SSC based on laboratory incubations conducted under the Klamath Dam Removal 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 (typical dry, median, and typical wet water years) considered for the USBR hydrology and sediment transport modeling assessment (see Section 3.2.4.2 *Suspended Sediments*).

The BOD/IOD spreadsheet model assumes drawdown for Copco No. 1 Reservoir begins on November 1 and drawdown for J.C. Boyle and Iron Gate reservoirs begins on January 1, consistent with the Proposed Project (USBR 2012). This would allow maximum SSCs to occur during winter months when flows are naturally high in the mainstem river (Stillwater Sciences 2008; USBR 2012). While Copco No. 1 and Iron Gate reservoirs exhibit varying degrees of thermal stratification and hypolimnetic anoxia during summer months (see Section 3.2.2.2 *Water Temperature*), all of the reservoirs tend to experience fully mixed conditions by November/December and remain mixed through April/May. Thus, drawdown beginning in November or January is expected to involve a well-oxygenated water column and inflowing water and, potentially, an oxic sediment top 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 Lower Klamath Project reservoirs during winter months (see Section 3.2.2.2 *Water Temperature* and Appendix C). The BOD/IOD spreadsheet model results encompass a six-month period following drawdown in order to estimate potential dissolved oxygen minimum concentrations corresponding to the period of greatest sediment transport in the river under the Proposed Project.

For long-term effects, existing information on water quality dynamics and physical, chemical, and biological drivers for dissolved oxygen concentrations in the Klamath River are used to inform the impacts analysis. Additionally, the analysis of the Proposed Project's potential short-term and long-term impacts on dissolved oxygen is informed by two quantitative models: the Klamath River Water Quality Model (KRWQM) and the Klamath River TMDL model. Both of these models include a scenario that is similar to existing conditions (i.e., with the Lower Klamath Project dams in place) and scenarios with one or more dams removed that are similar to the Proposed Project and/or alternatives analyzed in Section 4 *Alternatives*. The KRWQM was developed for FERC relicensing of the Klamath Hydroelectric Project (PacifiCorp 2004a, 2005a), and the KRWQM version that was used to model water quality conditions in 2004 and 2005 (i.e., 2004/2005 KRWQM) was later used to inform development of the Klamath River TMDL model. More recent 2019 KRWQM documentation (PacifiCorp 2019) indicates that PacifiCorp has developed an updated version of the KRWQM model, where the updates were primarily focused on Keno Reservoir. However, PacifiCorp (2019) does not present comparisons of dam removal scenarios, so the previous 2004/2005 KRWQM results cannot be replaced with the newer 2019 KRWQM results in the EIR analyses. The Klamath River TMDL model was developed to inform the Oregon and California Klamath River TMDLs. The Klamath River TMDL model includes a "TMDL dams-in" scenario (T4BSRN), which approximates the condition where the Lower Klamath Project dams remain in place, as well as the TOD2RN (Oregon reaches) and TCD2RN (California reaches) scenarios (together the "TMDL dams-out" scenario) that assume the removal of the Lower Klamath Project (see Appendix D for more detail). The

Klamath River TMDL model assumes full TMDL implementation for both the dams-in and dams-out scenarios (Tetra Tech 2009); however, the mechanisms for implementation and the timing required to achieve future TMDL compliance are currently speculative. Despite this assumption, the Klamath River TMDL model results are still a useful source of information with respect to the analysis of potential long-term dissolved oxygen impacts under the Proposed Project, particularly in light of the TMDL model's inclusion of a "natural condition".

Additional details regarding available numeric models for analysis of long-term dissolved oxygen are presented in Appendix D. Table D-1 shows the reaches where 2004/2005 KRWQM and Klamath River TMDL model results are used for the water quality analysis under the Proposed Project and each alternative and Table D-2 presents a comparison of assumptions and parameters for the available numeric models, including flow assumptions. Since no single existing model captures all of the elements analyzed for dissolved oxygen in this EIR, model outputs are used in combination to assess similar spatial and temporal trends in predicted dissolved oxygen where possible.

3.2.4.5 pH

Short-term effects of the Proposed Project on pH are assessed based on the current understanding of seasonal effects of the Lower Klamath Project reservoirs on pH within the Hydroelectric Reach and the Middle and Lower Klamath River downstream from Iron Gate Dam.

For long-term effects, existing data characterizing pH in the Hydroelectric Reach and the Middle and Lower Klamath River are used to inform the impacts analysis. Additionally, the analysis uses Klamath River TMDL model runs to evaluate the general long-term trends (both spatial and temporal) for pH in the Hydroelectric Reach and the Middle and Lower Klamath River. The Klamath River TMDL model includes a "TMDL dams-in" scenario (T4BSRN), which approximates the condition where the Lower Klamath Project dams remain in place, as well as the TOD2RN (Oregon reaches) and TCD2RN (California reaches) scenarios (together the "TMDL dams-out" scenario) that assume the removal of the Lower Klamath Project (see Appendix D for more detail). The Klamath River TMDL model assumes full TMDL implementation for both the dams-in and dams-out scenarios (Tetra Tech 2009); however, the mechanisms for implementation and the timing required to achieve future TMDL compliance are currently speculative. Despite this assumption, the Klamath River TMDL model results are still informative with respect to the analysis of potential pH impacts under the Proposed Project, particularly since pH models were not developed for the FERC relicensing process. To place the Proposed Project analysis in context, results of the "TMDL dams-in" Oregon scenario (TOD2RN) and "TMDL dams-in" California scenario (TCD2RN) are generally interpreted with respect to starting assumptions (i.e., model boundary conditions) about pH. The Klamath River TMDL provides modeling results for all mainstem reaches associated with the water quality pH analysis for this EIR (see Appendix D, Table D-1).

3.2.4.6 Chlorophyll-a and Algal Toxins

Potential impacts of the Proposed Project on the algal community (phytoplankton, aquatic macrophytes, and periphyton) in the Klamath River are discussed in Section 3.4 *Phytoplankton and Periphyton*. Chlorophyll-*a* water column concentrations are analyzed as a separate water quality parameter in the Lower Klamath Project EIR because chlorophyll-*a* is a surrogate measure of suspended algal biomass and phytoplankton chlorophyll-*a* is a target specific to the Lower Klamath Project reservoirs in the California Klamath River TMDLs (North Coast Regional Board 2010). The Hoopa Valley Tribe water quality objective for chlorophyll-*a* is a measure of attached (benthic) algal growth rather than phytoplankton (i.e., suspended algae) growth, so it is not discussed further in this EIR.

Sufficiently accurate quantitative predictive tools for chlorophyll-*a* are not available for the Lower Klamath Project EIR impact analysis. While the California Klamath River TMDLs model includes a chlorophyll-*a* component covering both periphyton and phytoplankton, comparison of the modeled and measured chlorophyll-*a* indicates that the model tends to over-predict chlorophyll-*a* under existing conditions, suggesting the model would over-predict chlorophyll-*a* under the “dams-out” scenario (Tetra Tech 2009). Thus, the Klamath River TMDL model is not used for the Lower Klamath Project EIR analysis. The phytoplankton chlorophyll-*a* target (10 ug/L) developed for the Lower Klamath Project reservoirs in the California Klamath River TMDLs is based on a Nutrient Numeric Endpoints (NNE) analysis. The phytoplankton chlorophyll-*a* target of 10 ug/L (i.e., reduction to) is a conservative estimate of mean summer chlorophyll-*a* concentrations due to phytoplankton required to move the system toward support of beneficial uses (Creager et al. 2006; Tetra Tech 2008).

Instead, this EIR’s chlorophyll-*a* impact analysis is based on a qualitative assessment of whether the Proposed Project would result in exceedances of the California 10 ug/L target for the Lower Klamath Project reservoirs and adversely affect beneficial uses with respect to water column concentrations of chlorophyll-*a*. Growth conditions for suspended algae (e.g., nutrient availability, impounded water) are considered as part of the qualitative analysis, where predicted changes in nutrient availability, water temperatures, and the availability of 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 the potential impacts of the Proposed Project on algal toxins as related to water quality standards and beneficial uses is also included in the water quality impacts analysis. There are no quantitative models predicting algal toxin trends under a dam removal scenario, thus the impact analysis is based upon trends in the density of toxin-producing blue-green algae, including *Microcystis aeruginosa,* to algal toxin concentrations (see Section 3.2.2.7 *Chlorophyll-a and Algal Toxins* and Appendix

C) discerned from data collected in the Hydroelectric Reach and the Middle and Lower Klamath River. This information is considered along with the potential for changes in habitat availability for *Microcystis aeruginosa* (or other toxin-producing blue-green algae) under the Proposed Project.

3.2.4.7 Inorganic and Organic Contaminants

The determination of potential toxicity and bioaccumulation with respect to aquatic species and humans under the Proposed Project is based on the evaluation of existing data characterizing inorganic and organic contaminants associated with both reservoir water quality and sediment deposits, with comparison to thresholds for human and aquatic species exposure.

In particular, the Klamath Dam Removal Secretarial Determination sediment evaluation process followed screening protocols of the Sediment Evaluation Framework (SEF), issued by the interagency Regional Sediment Evaluation Team (RSET) in 2009 and updated in 2018 (see Appendix C – *Section C.7*). The RSET is comprised of the USACE (Northwestern Division and Portland, Seattle, and Walla Walla Districts), the USEPA (Region 10), NOAA Fisheries (West Coast Region), USFWS (Pacific Region), ODEQ, Idaho Department of Environmental Quality, Washington Department of Ecology, and Washington Department of Natural Resources. The RSET developed the SEF to provide an approach for evaluating the suitability of sediments for placement in aquatic environments. The SEF involves a data screening assessment to compare reservoir sediment data to available and appropriate sediment maximum levels, screening levels, and bioaccumulation triggers established by the RSET. It also provides guidance for conducting elutriate chemistry (the chemistry of the water when sediments are put into suspension with the water), 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 to 2010 Klamath River sediment samples are used to inform the water quality impacts analysis related to inorganic and organic contaminants under the Proposed Project.

In the Klamath Dam Removal Secretarial Determination process, sediment data were compared to established sediment screening values in a step-wise manner to systematically consider potential impact pathways. Elutriate[29] sample data were also evaluated through comparison with a suite of regional, state and

[29] Elutriate sediment samples were created from reservoir composite sediment samples mixed with reservoir water (e.g., one part sediment to four parts water). In general, elutriate tests are a standard approach that analyzes the chemical composition of the overlying water of the elutriate sediment sample in order to estimate potential chemical concentrations that may be released into the water from reservoir sediments during suspension. Standard elutriate tests do not reflect the full dilution of re-suspended sediments that would occur during dam removal.

federal standards for water quality (CDM 2011). In this EIR, elutriate test results are considered in light of the dilution that would occur under actual conditions during reservoir drawdown.

Biological testing was also conducted during the Klamath Dam Removal Secretarial Determination process using the SEF approach, and the testing consisted of sediment and elutriate toxicity testing and tissue analyses, or other evaluations designed to provide more empirical evidence regarding the potential for sediment contaminant loads to have adverse impacts on receptors (RSET 2009, 2018). 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, 2018).

Results from sediment and elutriate sample toxicity bioassays and sediment bioaccumulation tests carried out for the Klamath Dam Removal 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 sample 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.

3.2.5 Potential Impacts and Mitigation

Unless otherwise noted, the potential impacts for each water quality parameter are presented in terms of the physical or chemical process that would potentially cause a change in the existing condition. This potential change is then described and analyzed against the applicable significance criteria in Section 3.2.3 *Significance Criteria*, including application of applicable thresholds described in Section 3.2.3.1 *Thresholds of Significance*.

3.2.5.1 Water Temperature

Potential Impact 3.2-1 Short-term and long-term alterations in water temperatures due to conversion of the reservoir areas to a free-flowing river.

Reservoirs and free-flowing rivers have different effects on water temperatures, and these can vary on a seasonal and annual basis with the size (surface area, depth) and shape of the waterbody (see discussion of general effects on water quality from hydroelectric project reservoirs in Section 3.2.2.1 *Overview of Water Quality Processes in the Klamath Basin*). This potential impact evaluates the changes in the water temperature regime that are expected under the Proposed Project against the significance criteria for temperature.

Hydroelectric Reach

KRWQM water temperature results within the Hydroelectric Reach from J.C. Boyle Reservoir to the Oregon-California state line are not available to characterize conditions similar to the Proposed Project (i.e., removal of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams). KRWQM results presented in PacifiCorp (2004a) estimate water temperature assuming removal of Keno Dam in addition to removal of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams. KRWQM water temperature results were not available for the Hydroelectric Reach in PacifiCorp (2005a). KRWQM results presented in PacifiCorp (2008a, 2014a) do not compare daily water temperature under existing conditions with daily water temperature with removal of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams (i.e., the Proposed Project). Klamath River TMDL model (see Appendix D) results indicate that if the Lower Klamath Project dams were to be removed ("TMDL dams-out, Oregon" [TOD2RN] scenario), water temperatures in the J.C. Boyle Peaking Reach at the Oregon-California state line (RM 214.1) would exhibit slightly lower daily maximum values (0.0 to 3.6°F) as compared to those predicted under the scenario where the dams remain in place ("TMDL dams-in" [T4BSRN] scenario) (Figure 3.2-7). Temperatures at these locations would also exhibit lower diel (i.e., 24-hour period) water temperature variation during June through September (Figure 3.2-7), and a general trend moving toward a more natural thermal regime (North Coast Regional Board 2010, data from electronic appendices of Asarian and Kann 2006b). The relative difference in diel water temperature variation between these two scenarios would be due to the elimination of peaking operations at J.C. Boyle Powerhouse and the associated large artificial temperature swings that occur in the Klamath River downstream.

Overall, the Klamath River TMDL model results indicate that in the short term and long term, the Proposed Project would decrease maximum summer/fall water temperatures. The Proposed Project would also result in less artificial diel water temperature swings in the J.C. Boyle Peaking Reach from the Oregon-California state line to Copco No. 1 Reservoir, returning the Klamath River to a more natural thermal regime compared with existing conditions. Elimination of both of these artificial temperature increases would better conform with the California Thermal Plan's prohibition on elevated temperature discharges (Table 3.2-4).

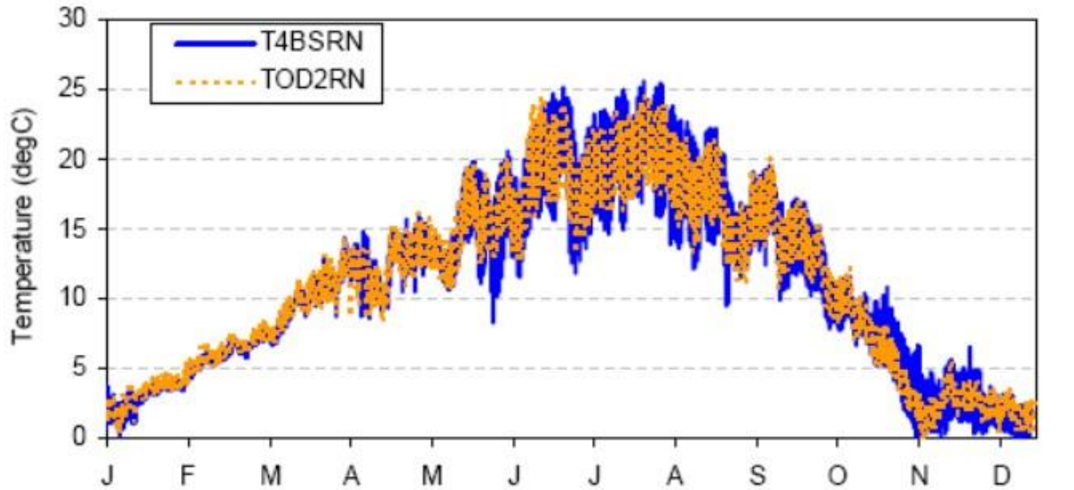


Figure 3.2-7. Predicted Water Temperature at the Oregon-California State Line (RM 214.1) for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional Board 2010.

Farther downstream of the J.C. Boyle Peaking Reach (i.e., from Copco No. 1 Reservoir to Iron Gate Dam), the presence of the Lower Klamath Project reservoirs currently decreases spring water temperatures as compared to modeled natural conditions by up to 7°C (13°F) and increases water temperatures as compared to modeled natural conditions by up to roughly 4°C (7°F) (Figure 3.2-3). The Klamath River TMDL model indicates that removal of the Lower Klamath Project under the Proposed Project would eliminate the seasonal temperature shift caused by the Lower Klamath Project reservoirs, returning the Klamath River to a more natural thermal regime. More specifically, the Klamath River TMDL model indicates that just downstream from Copco No. 1 and Copco No. 2 reservoirs (approximately RM 201), removal of the Lower Klamath Project dams would increase daily maximum temperatures to a more natural regime for a period in spring (May and June) and decrease daily maximum temperatures to a more natural regime in late summer/fall (August through October).

Note that the Klamath River TMDL model scenarios are useful for informing impacts associated with the Proposed Project and alternatives identified in Section 4 *Alternatives*, but they include as a starting assumption that there will be full implementation of the TMDLs. For example, the "TMDL dams-in" (T4BSRN) and "TMDL dams-out" (TOD2RN) scenarios for California both assume that water entering into California from Oregon meets California water quality standards for water temperature, organic enrichment/low dissolved oxygen, nutrients, pH, and microcystin. In other words, the starting point for the California models is that all necessary reductions in pollution to address the current impaired conditions at the Oregon-California state line for these constituents would already have been implemented upstream. The full TMDL compliance modeling assumption does not reflect the existing condition, and it would be speculative at this point to identify either the mechanisms necessary to implement the TMDLs or the timing required to achieve full compliance. However, besides the Lower Klamath Project facilities themselves, the temperature point sources (e.g., industrial discharges, sewage treatment plant discharges) located along the Klamath River between Lake Ewauna (approximately RM 257) to upstream of the Shasta River confluence (RM 179.5) have a negligible impact on water temperatures represented in the TMDL model (North Coast Regional Board 2010). Thus, removal of J.C. Boyle Reservoir and its associated hydropower peaking operations, as well as Copco No. 1, Copco No. 2, and Iron Gate reservoirs, dominates the model response. The Klamath River TMDL model illustrates that dam removal would rapidly and substantially move the Hydroelectric Reach towards achieving California TMDL compliance for water temperature.

Water temperature modeling conducted for the Klamath Dam Removal Secretarial Determination Studies (RBM10) provides generally similar results as the Klamath River TMDL model but includes consideration of future climate change and a KBRA flow regime (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* for an assessment of the KBRA Flows and 2013 BiOp Flows or KBRA Flows and 2019 BiOp Flows). Expected increases in summer and fall water temperatures in the Klamath Basin associated with climate change considerations are on the order of 1.8 to 5.4°F between 2012 and 2061 (Bartholow 2005; Perry et al. 2011). RBM10 model results show a projected shift in the annual temperature cycle that would slightly increase river temperatures in the spring and decrease river temperatures in the late summer/fall in the Hydroelectric Reach under the Proposed Project (Perry et al. 2011; USBR 2016), consistent with the general trend demonstrated by the Klamath River TMDL model results. Further discussion of RBM10 results is presented below for the Middle and Lower Klamath River.

Overall, dam removal under the Proposed Project would cause water temperatures in the Hydroelectric Reach[30] to align with historical anadromous migration and spawning periods for the Klamath River, warming earlier in the spring, and cooling earlier in the fall compared to existing conditions (see also Section 3.3.5.4 *Aquatic Resources – Water Temperature*). The return to a more natural thermal regime compared with existing conditions would align better with the California Thermal Plan's prohibition on increased temperature discharges above natural temperatures and would be beneficial.

[30] Under existing conditions, anadromous fish do not migrate into or spawn in the Hydroelectric Reach due to the fish passage barriers caused by the Lower Klamath Project dams. Under the Proposed Project, these barriers would be removed.

Because drawdown of the reservoirs would begin in winter and would be largely complete by spring prior to thermal stratification in the reservoirs, water temperature alterations caused by the Proposed Project in the Hydroelectric Reach as a whole would be beneficial in the short term. As noted above, dam removal would rapidly and substantially move the Hydroelectric Reach towards achieving California TMDL compliance.

In the long term, the Proposed Project would help to decrease temperatures in the late summer/fall in the Hydroelectric Reach as a whole when climate change is expected to increase summer and fall water temperatures in the Klamath Basin on the order of 1.8 to 5.4°F between 2012 and 2061 (Bartholow 2005; Perry et al. 2011).

In summary, under the Proposed Project, the anticipated increases in springtime water temperatures in the Hydroelectric Reach as a whole and decreases in diel temperature variation in the J.C. Boyle Peaking Reach from the Oregon-California state line to Copco No. 1 Reservoir, would return the Klamath River to a more natural thermal regime compared with existing conditions. The projected decreases in late summer/fall water temperatures in the Hydroelectric Reach as a whole also would return the Hydroelectric Reach to a more natural thermal regime compared with existing conditions and would align better with the California Thermal Plan's prohibition on increased temperature discharges above natural temperatures. These effects would be beneficial in the short term and would rapidly move the Hydroelectric Reach towards achieving California TMDL compliance. In the long term, the beneficial effects would also help to offset the impacts of climate change on late summer/fall water temperatures.

Middle and Lower Klamath River, Klamath River Estuary, and Pacific Ocean Nearshore Environment

Water temperature modeling results are available for the Middle and Lower Klamath River downstream of Iron Gate Dam from three separate modeling efforts: the PacifiCorp relicensing efforts (2004/2005 KRWQM); development of the California Klamath River TMDLs; and water temperature modeling conducted for the Klamath Dam Removal Secretarial Determination studies (RBM10). For more information on these models, please see Section 3.2.4.1 *Water Temperature* (overview) and Appendix D (detailed). The 2004/2005 KRWQM results comparing existing conditions (all Lower Klamath Project dams in place) to four without-project scenarios[31] for 2001 to 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

[31] The four without-project scenarios are: 1) without Lower Klamath Project dams and Keno Dam; 2) without Iron Gate Dam; 3) without Copco No. 1, Copco No. 2, and Iron Gate dams; and 4) without J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams (most similar to the Proposed Project).

warmer water from August through November (PacifiCorp 2004a; Dunsmoor and Huntington 2006). Just downstream from Iron Gate Dam, this translates to an approximately 2 to 5°F cooling during spring and an approximately 4 to 18°F warming during summer and fall (Figure 3.2-8). Immediately upstream of the confluence with the Scott River (RM 145.1), the difference between existing conditions and the dam removal scenario modeled using the 2004/2005 KRWQM indicates a lesser, albeit still measurable, warming of approximately 4 to 9°F for most of October and November (Figure). Because patterns in reservoir thermal structure for Iron Gate and Copco No. 1 reservoirs indicate that stratification generally starts 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 2004/2005 KRWQM results also indicate that reservoir thermal regimes under existing conditions act to reduce the magnitude of diel temperature variation compared with natural conditions in the river reaches immediately downstream from Iron Gate Reservoir (RM 193.1; see Figure) (Deas and Orlob 1999; PacifiCorp 2005a). 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 145.1; see Figure 3.2-9). The 2004/2005 KRWQM indicates that the overall water temperature influence of the Hydroelectric Reach is mostly attenuated by RM 66.3 at the confluence with the Salmon River (see Figure 3.2-10).

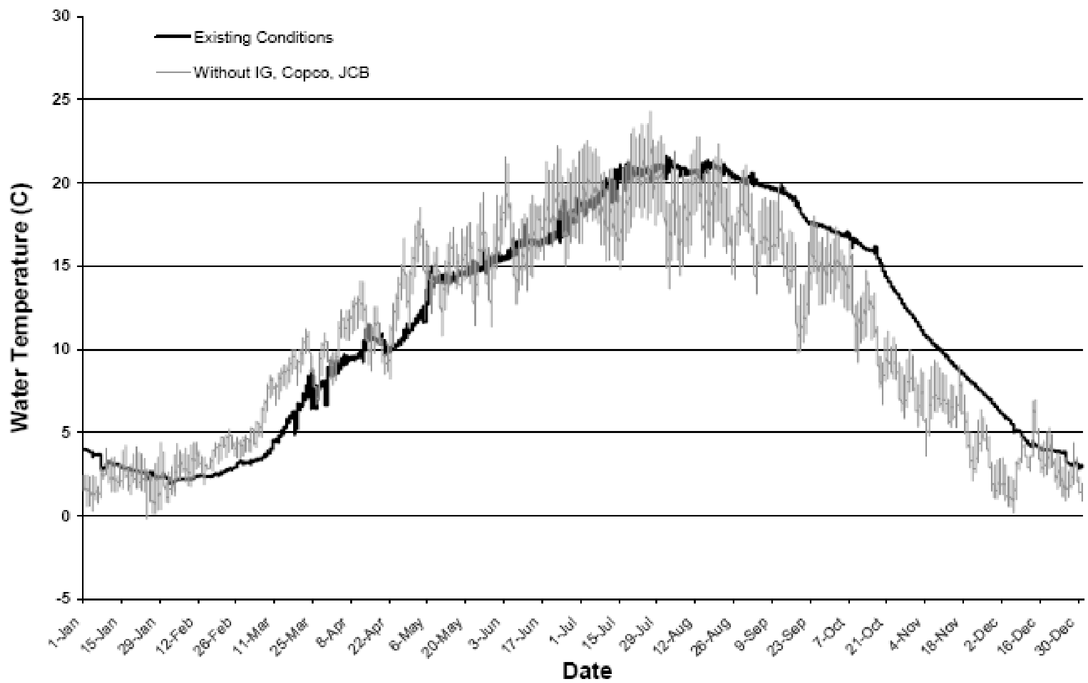


Figure 3.2-8. Simulated Hourly Water Temperature Downstream from Iron Gate Dam Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco No. 1, Copco No. 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2005a.

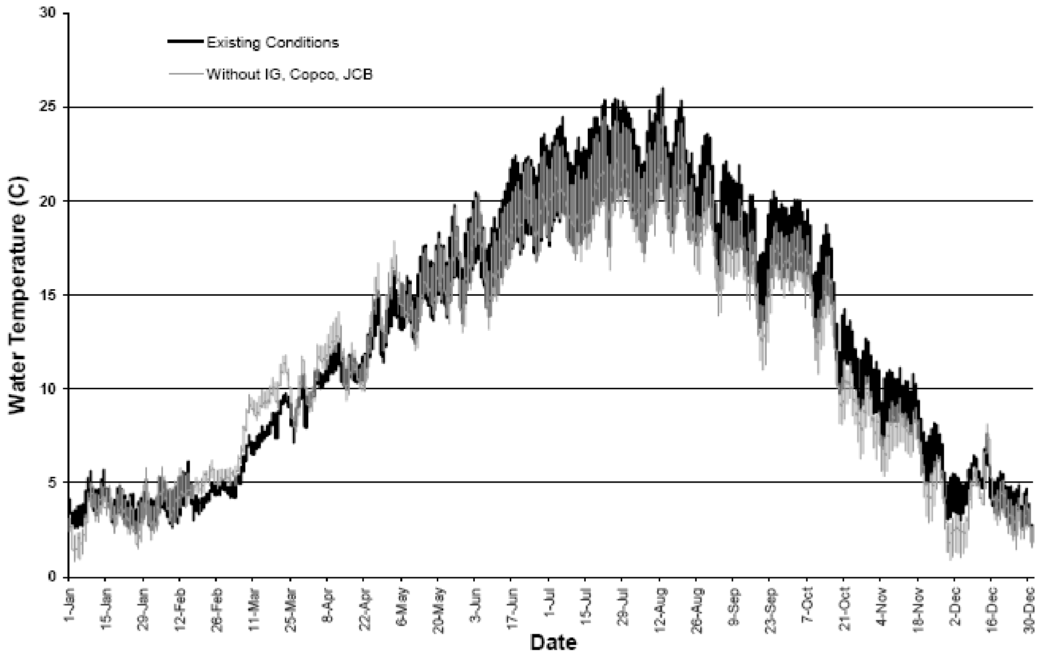


Figure 3.2-9. Simulated Hourly Water Temperature Immediately Upstream of the Scott River Confluence (RM 145.1) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco No. 1, Copco No. 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2005a.

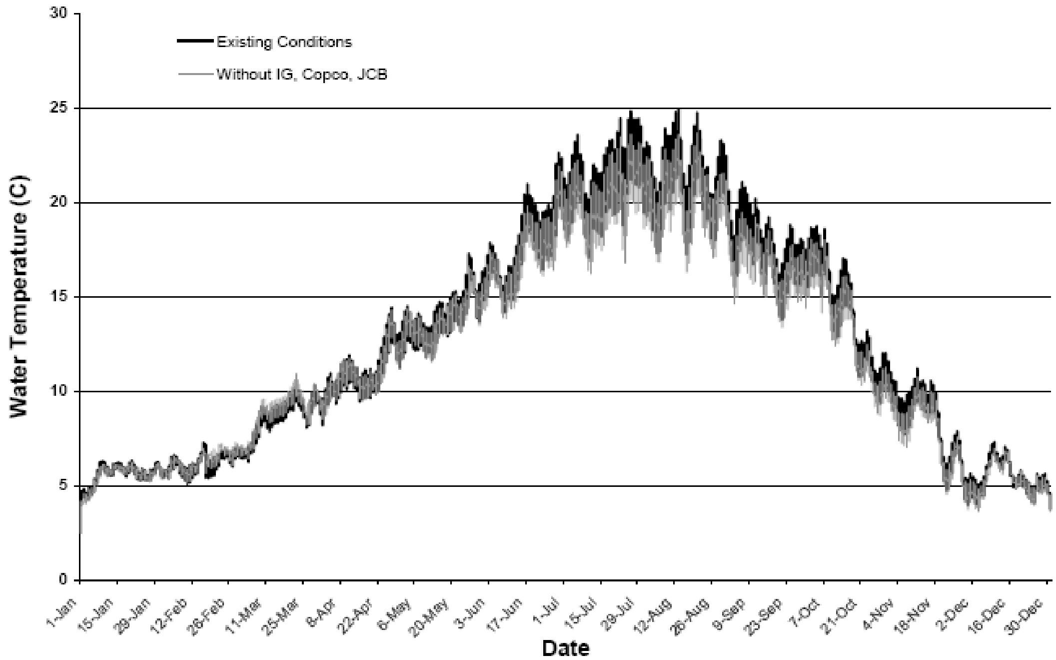


Figure 3.2-10. Simulated Hourly Water Temperature Upstream from the Salmon River Confluence (≈RM 66.3) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco No. 1, Copco No. 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2005a.

In agreement with 2004/2005 KRWQM results, Klamath River TMDL model results also indicate that if the Lower Klamath Project dams were to be removed ("TMDL dams-out, California" [TCD2RN] scenario), then water temperature in the Klamath River downstream from Iron Gate Dam would be lower (by 4 to 18°F) during August through November and higher (by 4 to 9°F) during January through March (dams remaining in place would be the "TMDL dams-in" [T4BSRN] scenario) (North Coast Regional Board 2010). The Klamath River TMDL model also predicts that diel variation in water temperature downstream from Iron Gate Dam during these same periods would be greater for a dam removal scenario ("TMDL dams-out, California" [TCD2RN]) than a dams in-place scenario ("TMDL dams-in" [T4BSRN]) because river water temperatures would be in equilibrium with, and would reflect, diel variation in ambient air temperatures rather than being dominated by the large thermal mass of, and stratification patterns in, the reservoirs. Note that the Klamath River TMDL model for both "dams-in" and "dams-out" scenarios assumes full implementation of the TMDLs, a condition that is currently highly speculative with respect to the mechanisms and timing required to achieve future compliance. However, besides the Lower Klamath Project facilities themselves, because the temperature point sources (e.g., industrial discharges, sewage treatment plant discharges) located along the Klamath River between Lake Ewauna (approximately RM 257) to upstream of the Shasta River confluence (RM 179.5) have a negligible impact on water temperatures represented in the Klamath River TMDL model (North Coast Regional Board 2010), removal of the Lower Klamath Project reservoirs dominates model response for the referenced point downstream of Iron Gate Dam. Further, although the Klamath River TMDL model assumes full implementation of the Scott River TMDL (North Coast Regional Board 2005) and the Shasta River TMDL (North Coast Regional Board 2006) for the “dams-out” scenario, it also assumes full implementation of these major tributary TMDLs for the “dams-in” scenario, such that in the reach downstream of Iron Gate Dam, the only difference between the two model scenarios is the removal of the Lower Klamath Project. Thus, even under the assumption of full TMDL compliance, the model illustrates that dam removal would rapidly and substantially move the Klamath River downstream of Iron Gate Dam towards achieving TMDL compliance.

As with 2004/2005 KRWQM, the Klamath River TMDL model indicates that the temperature effects of removing the Lower Klamath Project 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 (approximately RM 66.3) (North Coast Regional Board 2010; Dunsmoor and Huntington 2006). Therefore, under a dam removal scenario that also assumes full TMDL implementation (“TMDL dams-out, California” [TCD2RN] scenario), water temperatures would not be directly affected in the Middle Klamath River downstream from the confluence with the Salmon River and would not affect temperatures farther downstream in the Lower Klamath River, the Klamath River Estuary, or the Pacific Ocean nearshore environment.

As part of the Klamath Dam Removal Secretarial Determination studies, the effects of climate change and of KBRA Flows (which, as discussed in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* sufficiently bracket the range of flows under the existing condition*)* were included in projections for future water temperatures under the Proposed Project using the RBM10 model. RBM10 model results using climate change predictions from five GCMs indicate that future water temperatures under the Proposed Project and climate change would be 1.8 to 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 to 2001) estimates of 0.09°F per year, or approximately 4 to 5°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 on the order of 2 to 5°F between 2012 and 2061.

RBM10 results also indicate that, even with warming of water temperatures under climate change, the primary long-term effect of dam removal downstream of Iron Gate Dam is still anticipated to be the return of approximately 126 miles of the Middle Klamath River, from Iron Gate Dam (RM 193.1) to the Salmon River

(RM 66), to a more 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 Project, 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 Project, including the anticipated effect of climate change, would average approximately 4°F greater in May, while during October water temperatures would average approximately 7°F cooler. At the confluence with the Scott River, the differences would be diminished, but there would still be a slight warming in the spring (May) with average water temperatures approximately 2°F greater and a slight cooling in the fall (October) with average water temperatures approximately 4°F less. Water temperature changes from the Proposed Project would be less than 1°F at the confluence with the Salmon River (RM 66) in agreement with the Klamath River TMDL model results (Perry et al. 2011). Thus, despite the anticipated warming under climate change, long-term water temperature improvements under the Proposed Project would support continued achievement of the California temperature TMDLs for the mainstem Klamath River.

All of the existing water temperature model projections (2004/2005 KRWQM, TMDL, RBM10) indicate that dam removal under the Proposed Project would cause water temperatures in the Middle Klamath River to align better with historical anadromous migration and spawning periods for the Klamath River, warming earlier in the spring, and cooling earlier in the fall compared to existing conditions. Warmer springtime temperatures would result in fry emerging earlier, encountering favorable temperatures for growth sooner than under existing conditions, which could support higher growth rates and encourage earlier outmigration downstream, similar to what likely occurred under historical conditions, and reduce stress and disease (Bartholow et al. 2005; FERC 2007). In addition, fall-run Chinook salmon spawning in the mainstem Klamath River during fall would no longer be delayed (reducing pre-spawn mortality), and adult migration would occur in more favorable water temperatures than under existing conditions. Overall, these changes would result in water temperatures more favorable for salmonids in the mainstem Klamath River downstream from Iron Gate Dam (see also Section 3.3.5.4 *Aquatic Resources – Water Temperature*). While the return to a more natural thermal regime under the Proposed Project would potentially result in Klamath River water temperatures warming during portions of the year (e.g., 2 to 4ºF in May) due to the combined effects of climate change and the Proposed Project, a Chinook Salmon Expert Panel concluded that the Lower Klamath dam removal offers greater potential than the existing conditions for Chinook salmon to tolerate climate change and changes in marine survival (Goodman et al. 2011). Similarly, the Coho Salmon and Steelhead Expert Panel concluded that dam removal would provide greater mitigation to climate change for coho salmon and steelhead than existing conditions (Dunne et al. 2011). The return to a more natural thermal regime compared with existing conditions would align better with the California Thermal Plan’s prohibition on increased temperature discharges above natural temperatures and would be beneficial.

As drawdown of the Lower Klamath Project reservoirs would begin in winter and would be largely complete by spring prior to thermal stratification in the reservoirs, the water temperature alterations resulting from dam removal under the Proposed Project in the Klamath River downstream from Iron Gate Dam would occur, either partially or fully, within the first one to two years following dam removal and would be considered short-term benefits. As noted above, removal of the Lower Klamath Project Reservoirs would rapidly and substantially move the Klamath River downstream of Iron Gate Dam towards achieving TMDL compliance. Additionally, water temperature alterations due to the Proposed Project would continue beyond three years following dam removal so they would also be long-term benefits. The Proposed Project's temperature benefits on late summer/fall water temperatures may be of additional assistance in helping to offset the impacts of climate change on late summer/fall Klamath River water temperatures.

In summary, under the Proposed Project, the short-term and long-term increases in spring water temperatures, increased diel temperature variation, and decreases in late summer/fall water temperatures in the Middle Klamath River for the reach from Iron Gate Dam to the confluence with the Salmon River would be beneficial. There would be no impact for water temperatures in the Middle Klamath River downstream from the Salmon River, Lower Klamath River, Klamath River Estuary, or Pacific Ocean nearshore environment.

The Definite Plan (see Appendix B: *Definite Plan – Appendix M*) includes a Water Quality Monitoring Plan to assess the Proposed Project's impacts to water quality, and this plan includes temperature monitoring. The State Water Board has authority to review and approve any final Water Quality Monitoring Plan through its water quality certification under Clean Water Act Section 401. The State Water Board has issued a draft water quality certification which sets forth monitoring and adaptive management requirements for any Water Quality Monitoring Plan to meet, as Condition 1.[32] Additionally, the Oregon Department of Environmental Quality has issued a final water quality certification[33] that sets forth water quality monitoring and adaptive management conditions for points upstream of California. The effect of the Proposed Project on water temperature

[32] The State Water Board's draft water quality certification is available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_dwqc.pdf (Accessed December 11, 2018).

[33] The Oregon Department of Environmental Quality's final water quality certification is available online at: https://www.oregon.gov/deq/FilterDocs/ferc14803final.pdf (Accessed December 14, 2018).

is anticipated to be beneficial in both the short and long term, and this analysis of Potential Impact 3.2-1 does not further discuss the water quality monitoring and adaptive management conditions.

Significance

Beneficial for the Hydroelectric Reach and the Middle Klamath River to the confluence with the Salmon River, in the short term and in the long term

No significant impact for the Middle Klamath River downstream from the Salmon River, Lower Klamath River, Klamath River Estuary, and Pacific Ocean nearshore environment in the short term or the long term

Potential Impact 3.2-2 Short-term and long-term alterations in seasonal water temperatures in the Klamath River Estuary due to morphological changes induced by dam removal sediment release and subsequent deposition in the estuary.

Increased sediment deposition in the Klamath River Estuary due to sediment releases from dam removal may change the shape of the estuary in a way that could impact water temperatures. Such morphological changes could be from, for example, shifted bed elevations or changes to the contours of the bottom of the estuary. The amount of sediment deposition in the estuary as a result of dam removal is anticipated to be small, as sediment release would coincide with and be driven by high flows associated with dam removal; therefore, sediment deposition in the estuary associated with dam removal is not expected to be widespread, but it would occur in backwaters or vegetated areas, if at all (Stillwater Sciences 2008; USBR 2012) (see also Potential Impact 3.11-5). Morphological changes that decrease the depth of Klamath River Estuary waters or the volume of the estuary waters could result in more solar radiation being absorbed by a smaller water volume, which would tend to increase estuary water temperatures. Additionally, morphological changes that reduce estuary mixing conditions can produce more backwater or slack water areas within the estuary. This could effectively reduce the amount of water absorbing solar radiation in these areas and could result in localized warming of estuary water in those backwater or slack water areas. Sediment deposition also could result in morphological changes that 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. All of these morphological changes due to sediment deposition could potentially result in an increase in Klamath River Estuary water temperatures over the existing condition.

Estuary waters provide optimal habitat for juvenile salmonids that use the estuary to rear prior to returning to the Pacific Ocean. Additionally, the Klamath River Estuary is designated as critical habitat for Southern Oregon/Northern California Coast (SONCC) evolutional significant unit for coho salmon (NMFS 1999) and would benefit for cooler water temperatures. Sediment scouring would increase the estuary depth, the size of the estuary, the mixing conditions, and/or the size of salt wedge, so the volume of water absorbing solar radiation would increase and estuary water temperatures would not be expected to increase. Therefore, should sediment scouring occur in association with the Proposed Project, it would be unlikely to increase short-term or long-term water temperature conditions in the Klamath River Estuary.

Under existing conditions, high concentrations of silt and clay are transported through the estuary on an annual basis. Sediment sampling by USBR (2010) documented the absence of fine material in the estuary except in the backwater and vegetated areas (see Section 3.11.2.4 *Sediment Load* for more details). Modeling of sediment transport due to reservoir drawdown indicates that only fine sediments (silts, clays, and organics) would be transported to the estuary, and fine sediments would not deposit in significant quantities in the estuary (USBR 2012). If dam removal occurs under dry water years conditions, small volumes of fine sediment may deposit in the backwater and vegetated areas in the estuary due to lower river flows in dry water years (USBR 2012). However, even under this scenario, since limited sediment deposition is expected to occur in the Klamath River Estuary as a result of the Proposed Project (see Potential Impact 3.11-6), small morphological changes in the estuary that may occur due to dam removal sediment releases would not be likely to increase short-term estuary water temperatures in an manner that would cause or substantially exacerbate an exceedance of water quality standards or would result in a failure to maintain existing beneficial uses currently supported.

With respect to the potential for long-term impacts, estimates of baseline sediment delivery for the Klamath Basin indicate that sediment delivery rates would not change substantially under the Proposed Project (Stillwater Sciences 2010) (see also Potential Impact 3.11-5). Accordingly, there would be no long-term morphological changes in the estuary that would affect water temperatures under the Proposed Project.

As discussed above for Potential Impact 3.2-1, the State Water Board has issued a draft water quality certification which sets forth proposed water quality monitoring and adaptive management requirements for the Proposed Project, as Condition 1.[34]

Significance

No significant impact

[34] The State Water Board's draft water quality certification is available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_dwqc.pdf (Accessed December 11, 2018).

3.2.5.2 Suspended Sediments

For the purposes of the Lower Klamath Project EIR, "suspended sediment" refers to settleable suspended material in the water column. Bed materials, such as gravels and larger substrates, are discussed in Geology and Soils Section 3.11.5 *Potential Impacts and Mitigation*. Two types of suspended material are considered for water quality impacts in the Klamath River: 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, Middle, and Lower Klamath River reaches (see Section 3.2.2.3 *Suspended Sediments*).

Potential Impact 3.2-3 Increases in suspended sediments due to release of sediments currently trapped behind the dams.
Increases in suspended sediment due to release of reservoir sediments currently trapped behind the Lower Klamath Project dams are discussed by Klamath River reach below. As discussed in Section 3.2.4.2 *Suspended Sediments*, the analysis for this EIR interprets USBR (2012) modeled suspended sediment concentrations (SSCs) during and after reservoir drawdown, based on KRRC's proposed reservoir drawdown rates, where the latter would increase peak SSCs, increase the rate SSCs would decrease, and decrease the overall duration of elevated SSCs relative to the drawdown rates that were previously modeled (USBR 2012). While the USBR (2012) model results would underestimate peak SSCs relative to the KRRC's Proposed Project, the modeled SSCs provide a conservative estimate of the short-term impacts of suspended sediment releases due to dam removal since the underestimate of peak SSCs would still be within model uncertainty (i.e., approximately a factor of two) and model results would overestimate the duration of elevated SSCs.

Additionally, the Proposed Project would support erosion and transport of sediments deposited within the Copco No. 1 and Iron Gate reservoir footprints by using barge-mounted pressure sprayers to jet water onto newly exposed reservoir-deposited sediments as the water level decreases during drawdown, a process called sediment jetting. The barge-mounted pressure sprayers would use water from the reservoir, so sediment jetting would only be conducted when reservoir levels are sufficiently high to safely operate the barge and no sediment jetting would occur once reservoir drawdown is complete. Sediment jetting would maximize the erosion of reservoir-deposited sediments during drawdown within the six areas where restoration actions are proposed within the Copco No. 1 Reservoir footprint (see enumerated areas for wetlands, floodplains, and off-channel habitat features, and associated yellow triangles depicting areas of tributary connectivity, in Figure 2.7-11) and the three areas where restoration actions are proposed within the Iron Gate Reservoir footprint (see enumerated areas for wetlands, floodplains, and off-channel habitat features, and associated yellow triangles depicting areas of tributary connectivity, in Figure 2.7-12). Sediment jetting would also minimize the potential for reservoir sediment erosion and the associated increase in SSCs outside of the reservoir drawdown period by mobilizing sediments during drawdown. While sediment jetting would primarily transport reservoir deposited sediments that are already anticipated to be eroded during drawdown, some additional reservoir deposited sediments may be transported by the combination of drawdown and sediment jetting flows compared to only drawdown flows. The total sediment behind the dams by 2020[35] and the range of sediment volume anticipated to erode from each reservoir during dam removal was estimated by USBR (2012) as part of the sediment transport modeling. The range of sediment volume that potentially would be transported from sediment jetting during drawdown was estimated for Copco No. 1 and Iron Gate reservoirs from the approximate areas where the restoration actions would occur in the individual reservoirs (Figure 2.7-8 and 2.7-9) and the maximum and minimum sediment depths measured in the vicinity of those restoration actions. Sediment depths were measured in sediment cores taken by Shannon and Wilson (2006) and USBR (2009) and summarized in USBR (2012). Sediment jetting during drawdown would potentially transport between approximately 13 and 41 percent of the sediment volume expected to erode during dam removal (Table 3.2-12).

[35] Between 2020 and 2022 (i.e., dam removal year 2 when drawdown would primarily occur under the KRRC's revised schedule [KRRC 2019]), the sediment volume present behind the dams would increase by approximately 19,600 cubic yards per year (39,200 cubic yards for two years) in J.C. Boyle Reservoir, 81,300 cubic yards per year (162,600 cubic yards for two years) in Copco No. 1 Reservoir, and 100,000 cubic yards per year (200,000 cubic yards for two years) (USBR 2012). The increase in sediment volume between 2020 and 2022 is an order of magnitude less than the uncertainty of the 2020 total sediment volume estimates, so model results using the 2020 sediment volumes would still be applicable to the Proposed Project.

Table 3.2-12. Estimated Range of Sediment Volume Transported by Sediment Jetting During Drawdown Compared to Total Sediment Volume Anticipated to Erode with Dam Removal.

Reservoir	Total 2020 Sediment Volume[1,2,3] (cubic yards)	2020 Sediment Volume Erosion[3,4] (cubic yards)		Estimated 2020 Sediment Volume Transported by Sediment Jetting[3,5] (cubic yards)		Percentage of 2020 Sediment Volume Transported by Sediment Jetting (%)	
		Minimum	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Copco No. 1	8,250,000	3,713,000	6,270,000	970,000	1,278,000	15%	34%
Iron Gate	5,690,000	1,366,000	1,821,000	237,000	554,000	13%	41%

[1] Total 2020 sediment volume is from USBR (2012) which estimated the total sediment volume from the sediment cores taken in the individual reservoirs and projected to 2020 based on annual sedimentation rates for each reservoir.

[2] Between 2020 and 2021 (i.e., dam removal year 2 when drawdown would primarily occur), the sediment volume present behind the dams would increase by approximately 81,300 cubic yards in Copco No. 1 Reservoir and approximately 100,000 cubic yards in Iron Gate Reservoir based on estimates of annual sedimentation rates for each reservoir (USBR 2012). The increase in sediment volume between 2020 and 2021 would be an order of magnitude less than the uncertainty of the 2020 total sediment volume estimates, so model results using the 2020 sediment volumes would still be applicable to the Proposed Project.

[3] Rounded to nearest 10,000 cubic yards.

[4] Sediment volume erosion is based on the USBR (2012) estimated total 2020 sediment volume and erosion rates during drawdown. The maximum and minimum erosion rates for each reservoir (see Table 2.7-11) are based on hydrologic conditions recorded for the March to June flow volume at Keno gage on the Klamath River from water year 2001 (90 percent exceedance) and 1984 (10 percent exceedance). Sediment volume from individual reservoirs may not equal the total amounts indicated because masses taken from USBR (2012) were rounded to the nearest 10,000 tons.

[5] Sediment volume erosion transported by sediment jetting is estimated from the approximate areas where restoration actions would occur in the individual reservoirs (Figure 2.7-8 and 2.7-9) and the maximum and minimum sediment depth measured in the vicinity of those restoration actions.

SSCs that would occur during reservoir drawdown under the KRRC's Proposed Project would increase relative to the prior model results (USBR 2012) due to the influence of sediment jetting, while SSCs after drawdown completes are expected to be similar or less than the modeled SSCs since sediment jetting would increase transport of reservoir sediments during drawdown and less sediment would remain in the reservoir after drawdown. Variations in SSCs downstream of Copco No. 1 and Iron Gate reservoirs due to sediment jetting within the reservoir footprint are discussed in the relevant reaches below.

Hydroelectric Reach

Sediment transport modeling of the impacts of dam removal indicate high short-term SSCs in the Hydroelectric Reach under the Proposed Project (Stillwater Sciences 2008; USBR 2012, 2016). Modeled SSCs downstream of J.C. Boyle Reservoir would be high in the short term, but concentrations would be considerably less than those anticipated to occur downstream from Copco No. 1 and Iron Gate reservoirs due to the relatively small volume of the sediment deposits behind J.C. Boyle Dam (eight percent of total volume for the Lower Klamath Project, see also Tables 2.7-7 and 2.7-8). Model output indicates that SSCs immediately downstream of J.C. Boyle Dam under dry (WY 2004), median (WY 1968), and wet (WY 1999) water year types would exhibit peak values of 2,000 to 3,000 mg/L occurring within one to two months of reservoir drawdown. Model results indicate SSCs greater than 100 mg/L for two weeks or more would potentially occur downstream of J.C. Boyle Dam for one to three months under the Proposed Project, coinciding with the drawdown period. During these one to three months, modeled SSC exceed 100 mg/L over two weeks for several non-consecutive periods, with SSCs remaining above 100 mg/L for approximately two to seven consecutive weeks depending on the water year. The suspended sediments released from J.C. Boyle Reservoir would quickly move into the California portion of the Hydroelectric Reach. SSCs exceeding 100 mg/L for two consecutive weeks was selected as a threshold of significance because exposure for SSCs above 100 mg/L for two weeks would be a significant adverse impact to cold-water fishery species (i.e., salmonids, including rainbow trout) and associated designated beneficial uses, including cold freshwater habitat (COLD), rare, threatened, or endangered species (RARE), and migration of aquatic organisms (MIGR) in the Hydroelectric Reach (see Section 3.2.3.1 *Thresholds of Significance, Suspended Sediment*). Modeled SSCs downstream of J.C. Boyle Dam are greater than 100 mg/L for two consecutive weeks during drawdown, thus there would be a significant impact to SSCs in the short term in the Hydroelectric Reach due to increases in suspended sediment from releases of sediment trapped behind J.C. Boyle Dam. Modeled SSCs decrease to less than 100 mg/L within five to seven months following drawdown, and concentrations further decrease to less than 10 mg/L within six to 10 months following drawdown of J.C. Boyle Reservoir (Figure 3.2-11 through Figure 3.2-13).

The higher drawdown rate under the Proposed Project than under modeled conditions is expected to increase peak SSCs and decrease the duration of elevated SSCs compared to modeled SSCs (see Section 3.2.4.2 *Suspended Sediments*), but variations in modeled SSCs due to a higher drawdown rate would be unlikely to reduce the duration of SSCs above 100 mg/L to less than two consecutive weeks under all water years types. Peak SSCs would be expected to double from approximately 2,000 to 3,000 mg/L under modeled conditions to approximately 4,000 to 6,000 mg/L under the higher drawdown rate in the Proposed Project, based on a previous analysis how suspended sediments vary under different drawdown rates in Lower Klamath Project reservoirs (Stillwater Sciences 2008). A higher drawdown rate would also be expected to decrease the duration of elevated SSCs by approximately one to two weeks (Stillwater Sciences). Modeled SSCs greater than 100 mg/L downstream of J.C. Boyle Dam occur for up to seven consecutive weeks, depending on the water year type (see Figure 3.2-11 to Figure 3.2-13), so SSCs under the Proposed Project with a higher drawdown rate would be likely to remain greater than 100 mg/L for two consecutive weeks. However, SSCs after drawdown would potentially decrease to less than 10 mg/L more rapidly under the Proposed Project than estimated by the modeled SSCs. Overall, the short-term impact based on an analysis of modeled SSCs downstream of J.C. Boyle Dam would remain the same under the higher drawdown rate in the Proposed Project since SSCs is expected to exceed 100 mg/L for two consecutive weeks regardless of the drawdown rate.

In the year following dam removal year 2 (post-dam removal year 1), modeling indicates suspended sediments would not be greater than 100 mg/L over a continuous two-week period under all water-year types. In dry and normal water-year types, modeled suspended sediment concentrations were always below 100 mg/L during post-dam removal year 1. In wet water-year types, the modeled suspended sediment concentrations are usually less than 100 mg/L during post-dam removal year 1, but there is an approximately one-week period when modeled suspended sediment concentrations are greater than 100 mg/L associated with storm conditions. Modeling indicates the suspended sediment concentrations return to modeled background levels (i.e., existing conditions) under all water year types during post-dam removal year 1 (USBR 2012).

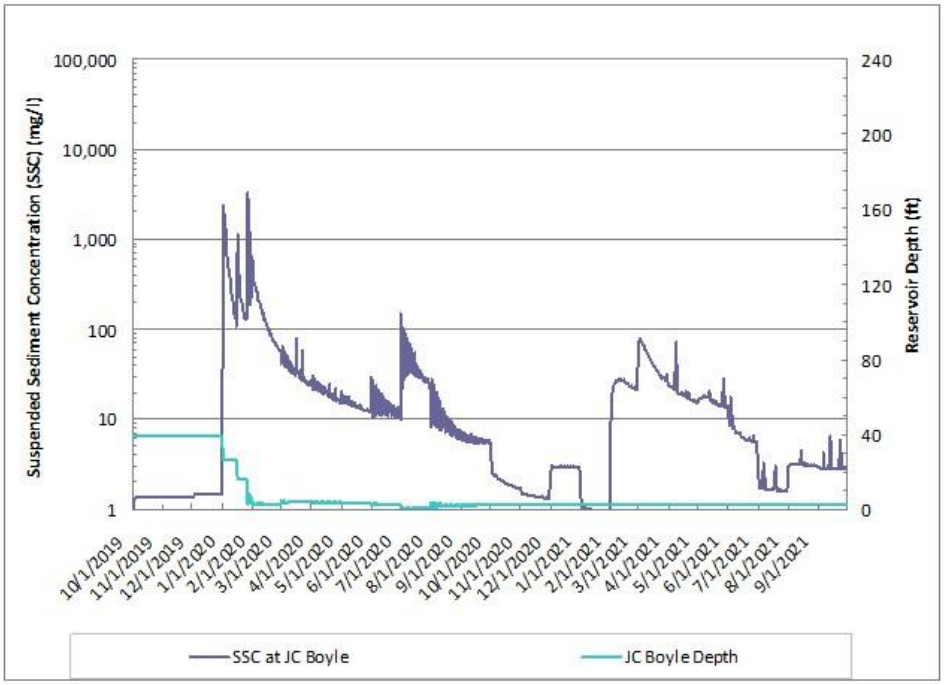


Figure 3.2-11. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Project Assuming Typical Dry Hydrology (WY2001). Dam removal year 1 is represented by the year 2019, dam removal year 2 is represented by the year 2020, and post-dam removal year 1 is represented by the year 2021.

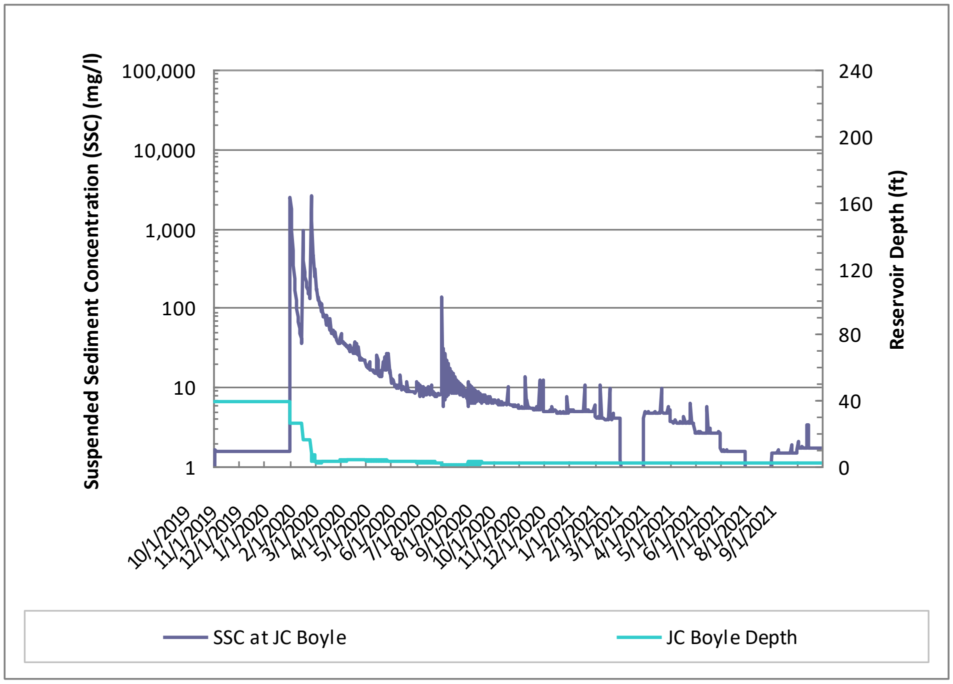


Figure 3.2-12. P-values based on the results of paired heteroscedastic t-tests of the average monthly KBRA and 2019 BiOp flows for the 1980 to 2011 time period for each month

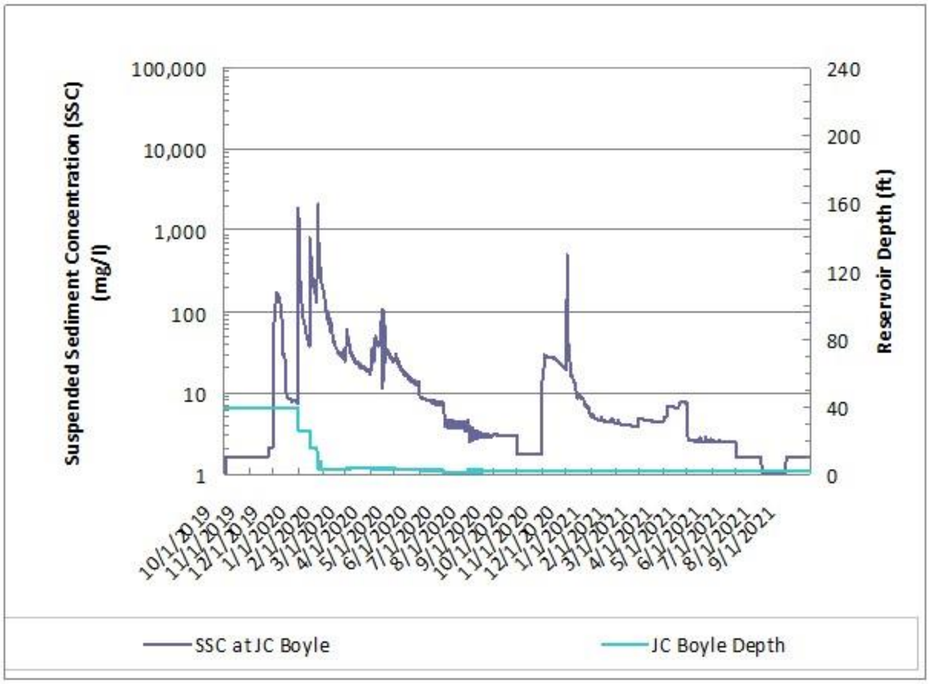


Figure 3.2-13. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Project Assuming Typical Wet Hydrology (WY1984). Dam removal year 1 is represented by the year 2019, dam removal year 2 is represented by the year 2020, and post-dam removal year 1 is represented by the year 2021.

Modeling of sediment concentrations downstream of Copco No. 1 Reservoir during drawdown also indicates short-term sediment concentrations would be high in the California portion of the Hydroelectric Reach due to dam removal (Figure). Modeled SSCs downstream of Copco No. 1 Reservoir in dry, average and wet water year types peaked at approximately 7,000 to 8,000 mg/L within one to two months of initiation of reservoir drawdown; SSCs then decrease to generally less than 1,000 mg/L by approximately one and a half to two and a half months after initiation of reservoir drawdown. During this period, the modeled SSCs would exceed the suspended sediments potential short-term significance threshold of 100 mg/L over a continuous two-week period. Predicted spikes in SSC after one to two months of reservoir drawdown correspond to increases in Klamath River flow through the Hydroelectric Reach due to spring storm events (Figure 3.2-14).

Similar to conditions immediately downstream of J.C. Boyle, higher maximum drawdown rate under the Proposed Project (i.e., 5 feet per day) would not alter the short-term impact determination since the higher drawdown rate under the Proposed Project would be unlikely to reduce the duration of SSCs above 100 mg/L to less than two consecutive weeks under all water years types. Peak SSCs would be expected to double from approximately 7,000 to 8,000 mg/L under modeled conditions to approximately 14,000 to 16,000 mg/L under the higher drawdown rate in the Proposed Project, based on a previous analysis how suspended sediments vary under different drawdown rates in Lower Klamath Project reservoirs (Stillwater Sciences 2008). The duration of modeled SSCs greater than 100 mg/L downstream of Copco No. 1 likely would decrease under the Proposed Project with a higher drawdown rate, but the overall all duration of SSCs greater than 100 mg/L would likely occur for two consecutive weeks or more. SSCs after drawdown would potentially decrease to less than 10 mg/L more rapidly under the Proposed Project than estimated by the modeled SSCs. Thus, the short-term impact, which is based on an analysis of modeled SSCs downstream of Copco No. 1 Dam, would remain the same under the higher drawdown rate in the Proposed Project since SSCs is expected to exceed 100 mg/L for two consecutive weeks regardless of the drawdown rate.

Sediment jetting is anticipated to also increase the magnitude of modeled SSCs downstream of Copco No. 1 during drawdown (USBR 2012), but it also would not alter the overall impact of suspended sediment in the Klamath River downstream of Copco No. 1 Dam during drawdown since the increase in SSCs due to sediment jetting would primarily occur during peak SSCs and sediment jetting would not increase the duration of SSCs greater than 100 mg/L by only mobilizing more sediment during the drawdown period. Klamath River flows during drawdown at Copco No. 1 Dam range from approximately 800 cfs in a Dry water year to 13,600 cfs in a Wet water year (see Appendix B: *Definite Plan – Section 4.6*). Assuming a sediment jetting flow of approximately 10 to 30 cfs (similar to sediment jetting flows used on the Mill Pond Dam removal project, Washington Department of Ecology [2016]). SSCs in sediment jetting flows would vary depending on the pressure of the water jet, the angle of the water jet, and the cohesiveness of the reservoir deposited sediments, but SSCs in sediment jetting flows would likely range from less than 1,000 mg/L to approximately 100,000 mg/L.

SSCs in the Klamath River downstream of Copco No. 1 during drawdown with sediment jetting compared to modeled SSCs without sediment jetting are estimated to typically increase by approximately 350 mg/L to 1,400 mg/L, but SSCs would potentially increase up to approximately 2,200 mg/L compared to modeled SSCs in the Klamath River during drawdown without sediment jetting. This projected increase in SSC is based on the estimated range of sediment volume to be transported by sediment jetting, the duration of drawdown when sediment jetting would occur, and the modeled flow and SSCs for the Klamath River and the estimated flow and SSCs for sediment jetting. The typical increase in SSCs would be the expected increase under the range of typical drawdown flows under all water year types, while the maximum increase in SSCs would only be likely to occur under Klamath River minimum flows during a dry water year. Additionally, the maximum increase in SSCs in the Klamath River downstream of Copco No. 1 is a conservative estimate since it assumes sediment jetting would mobilize all the sediment in the areas undergoing jetting in the approximately three-month drawdown period. In actuality, drawdown flows would mobilize a portion of that sediment, so the actual maximum increase in SSCs downstream of Copco No. 1 would likely be less than 2,200 mg/L.

While sediment jetting would increase the magnitude of SSCs during drawdown, most of the variations in the modeled SSCs during sediment jetting would be within the range of modeled SSCs and the increase in the magnitude would not extend beyond the drawdown period since sediment jetting would only occur during drawdown. Peak SSCs during drawdown under sediment jetting would potentially increase above the range of modeled SSCs with the maximum SSCs downstream of Copco No. 1 potentially increasing from approximately 14,000 to 16,000 mg/L under the higher maximum drawdown flows (i.e., 5 feet per day) to approximately 16,200 to 18,200 mg/L under the higher maximum drawdown flows with sediment jetting. The SSCs under drawdown flows with or without sediment jetting would exceed the suspended sediments potential short-term significance criteria of 100 mg/L over a continuous two-week period. While the magnitude of SSCs would increase during drawdown with sediment jetting, the magnitude of SSCs would potentially decrease after drawdown is complete since sediment jetting would mobilize more sediment than anticipated under drawdown flows alone. Within the general uncertainty of the modeled SSCs and estimates of SSCs with sediment jetting (see Table 3.2-12), the SSCs in the Klamath River downstream of Copco No. 1 with sediment jetting would be similar to or less than the modeled SSCs without sediment jetting after drawdown ends in March.

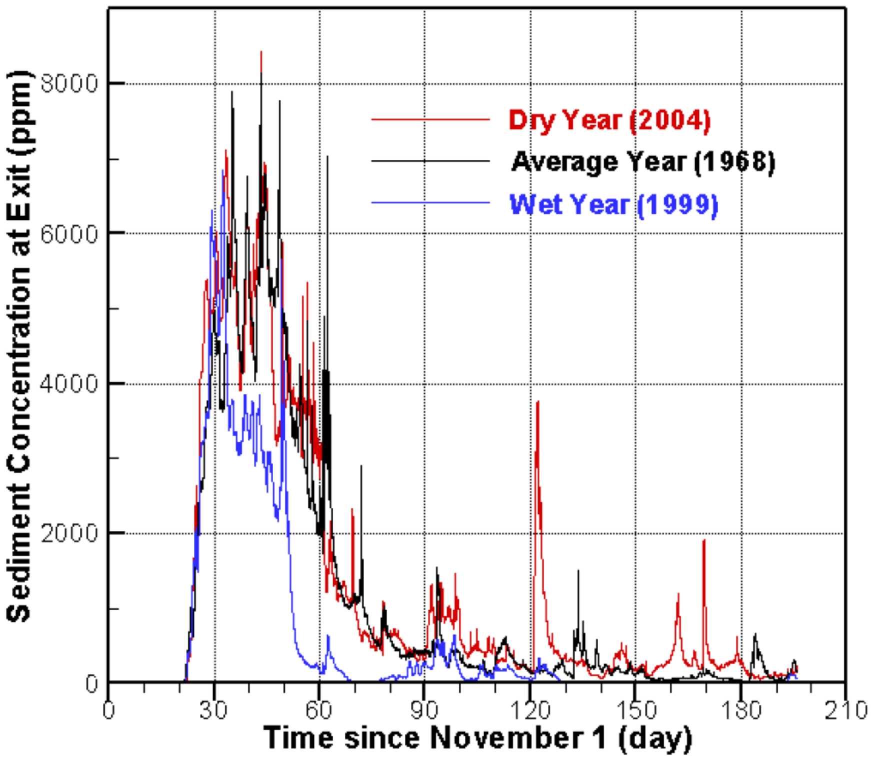


Figure 3.2-14. Sediment Concentration Downstream of Copco No. 1 Reservoir During Drawdown Using SRH-2D v3 Under Three Hydrological Scenarios. Drawdown began on November 15 and continued for six months. Source: USBR 2012.

Note that the shift in the Proposed Project Copco No. 2 drawdown timing from January 1 (Appendix B: *Detailed Plan*) to May 1 (Appendix B: *Definite Plan*) would not change the anticipated magnitude or timing of significant impacts due to elevated SSCs in the Hydroelectric Reach during dam removal year 2. SSCs associated with Copco No. 2 were not explicitly considered in the SRH-1D model, since 1) construction of Copco No. 2 dam was completed seven years after the substantially larger, upstream Copco No. 1 dam was completed, where the larger dam effectively cut off the source of sediments that would have been transported into Copco No. 2 Reservoir and potentially stored over time, and 2) Copco No. 2 Reservoir storage volume (70 ac-ft) is negligible compared with that of the upstream Copco No.1 (33,724 ac-ft) and J.C. Boyle (2,267 ac-ft) reservoirs, such that even if sediment deposits were to occur in Copco No. 2 Reservoir, either historically or during the Proposed Project drawdown of the upstream Copco No. 1 and J.C. Boyle reservoirs, the smaller Copco No. 2 Reservoir would not meaningfully increase downstream SSCs beyond currently predicted values for the period five to seven months following drawdown (May to July). Short-term increases in SSCs from removal of Iron Gate Dam are discussed for the Middle and Lower Klamath River (see below), since sediment releases from Iron Gate Reservoir would primarily impact the Klamath River downstream of the Hydroelectric Reach.

After reservoir drawdown, a significant amount of sediment is expected to remain within the reservoir footprints. Reservoir sediment field sampling and laboratory testing in 2012 (USBR 2012) and 2018 (Appendix B: *Definite Plan – Appendix H*) indicates that sediments remaining in the reservoir footprint would strengthen (i.e., harden) as they dry out, but wetting and drying cycles of unvegetated reservoir sediment would cause the sediment to produce erodible fine particles and aggregates. There is the potential for unvegetated sediments to cause significant short-term or long-term elevated SSCs during fall rain events if not stabilized with vegetation, especially from Iron Gate Reservoir where the highest levels of fine sediment and particles were produced in response to the laboratory wetting and drying cycles. These results are consistent with suspended sediment modeling results (USBR 2012) indicating that SSCs can periodically increase during post-dam removal year 1 due to storm conditions.

The Proposed Project includes revegetation of reservoir sediments remaining on the floodplain and the surrounding slopes after drawdown to stabilize the sediments and reduce the potential for short-term and long-term elevated SSCs. Stabilization of sediments through planting is expected to be effective since laboratory revegetation "grow tests" showed vegetation stabilized sediments from Copco No. 1 (Appendix B: *Definite Plan – Appendix H, Section 8.1.1 Reservoir Sediment Characteristics*). The Proposed Project Reservoir Area Management Plan (Appendix B: *Definite Plan – Appendix H*; see also Section 2.7.4 *Restoration Within the Reservoir Footprint*) includes activities to promote revegetation and sediment stabilization such as sediment preparation and amendment, irrigation, aerial seeding using pioneer seed mixes, planting of pole cuttings, acorns, and container plants, and adaptively re-seeding/re-planting areas that do not sufficiently establish following initial restoration activities.

During the drawdown period in January to March of dam removal year 2, aerial seeding would occur as the reservoir water level drops before the exposed reservoir sediments dry and form a surface crust. Pioneer seed mixes would contain a variety of riparian and upland common native species and possibly a small amount of sterile non-native species to enhance the initial erosion protection. The species included in the seed mix typically germinate early in the spring (March to April) and their germination would be sustained by dispersal over moist reservoir sediments during drawdown in the winter and early spring (January to March). Reservoir footprint areas that are re-inundated by larger storm events would be re-seeded after the water level recedes.

Aerial seeding would not result in any further disturbance of soil on the exposed reservoir terraces in the Hydroelectric Reach and the establishment of vegetation on the terraces would potentially reduce erosion of fine sediments. In areas not accessible by ground equipment because of rough terrain, steep slopes, and sediment instability, and as a potential alternative to aerial seeding, the Proposed Project may hydroseed from a barge located in Proposed Project reservoirs.[36]

During the dam removal period from March to December of dam removal year 2, additional revegetation efforts would be undertaken, including seed plantings, monitoring of plant growth and vegetation cover, re-seeding of areas with poor growth, continued installation of pole cuttings, and maintenance of existing and previously planted vegetation. Woody riparian species would be planted in the riparian areas to increase natural bank stability along with providing ecological benefits for fish. Irrigation systems would be installed along key segments of the river banks to expedite riparian bank zone development. Several repeated seedings and/or plantings would be adaptively performed as necessary during the first two years following reservoir drawdown in order to increase native vegetation coverage in underperforming areas.

In addition to planting and revegetation activities, the Proposed Project also includes creation of physical features or conditions (e.g., grading, swales, wetlands, floodplain roughness features, and river bank roughness features) that would stabilize remaining reservoir sediments deposits and reduce the potential for short-term and long-term increases in SSCs (Appendix B: *Definite Plan – Appendix H, Section 5.5 Description of Restoration Actions*). As detailed in the Proposed Project Reservoir Area Management Plan (see Section 2.7 *Proposed Project*), grading would only occur for reservoir deposited sediments between January and April of the drawdown year, with no grading below the historical ground surface prior to dam construction. In the newly exposed reservoir footprints under the Proposed Project, swales, wetlands, floodplain roughness features (e.g., partially buried brush or wood), and bank roughness features (e.g., large woody habitat) would be constructed to stabilize the remaining reservoir sediments, reduce velocities along the floodplain and riverbank that would increase suspended sediments, and reduce unnatural erosion that would potentially degrade water quality (i.e., by elevating suspended sediments) while still maintaining natural river processes. Creation of the other physical features and conditions are likely to be effective sediment stabilization and suspended sediment reduction methods because they slow down stormwater runoff, floodplain flows, and river flows along the river banks that would potentially cause elevated suspended sediments, allow for suspended sediments to settle out prior

[36] If it occurs, barge hydroseeding would be unlikely to exacerbate erosion impacts beyond the impacts of reservoir drawdown itself. Reservoir drawdown would extend potential wave-induced erosion impacts below the existing normal fluctuation zone with brief (i.e., hours to a day) periods of interaction with the "new shoreline" as drawdown continues. Barges tend to generate low wave heights due to their wide, flat bottoms and low operating speeds and any concentrated additional wave-induced erosion from barge hydroseeding would be limited to a shorter duration (i.e., over several hours within a single day) than that of wind-action on the slowly downward-moving reservoir surface.

to entering tributaries or Klamath River, and provide storage for sediment that may settle (CASQA 2003; Stubblefield et al 2006; Knox et al. 2008). The State Water Board's draft water quality certification requires submission of a Restoration Plan that incorporates the major elements discussed above regarding revegetation, and also other activities that can reduce sediment loading to the Klamath River over the long term, including grading, swales, and wetland construction.

Although revegetation of the reservoir sediment deposits would stabilize the sediment and reduce the potential for short-term and long-term elevated suspended sediment concentrations in the Hydroelectric Reach after vegetation begins to grow and establish (i.e., summer drawdown year 2 to post-dam removal year 1) and other restoration plan elements such as grading, swales, and wetland construction would reduce both short-term and long-term sediment loading, there still is the potential for short-term increases in SSCs in the months following reservoir drawdown prior to the establishment of vegetation to stabilize sediments. Laboratory tests of reservoir sediments determined repeated wetting (e.g., from rainfall) and drying of reservoir sediment deposits under conditions similar to those expected to occur in the reservoir footprints after drawdown would form easily erodible fine particles, so unvegetated sediments would potentially produce elevated SSCs during rainfall events (Appendix B: *Definite Plan – Appendix H, Section 8.1.1 Reservoir Sediment Characteristics*). Short-term potential increases in SSCs from rainfall on reservoirs sediments without established vegetation alone would be unlikely to result in SSCs greater than 100 mg/L for a continuous two-week period. However, the short-term potential increases in SSCs due to rainfall on reservoir sediments without established vegetation combined with the short-term increases in SSCs due to the release of reservoir sediments from behind the Lower Klamath Project dams would potentially result in SSCs greater than 100 mg/L for a longer duration than would occur due to only the short-term increases in SSCs from the release of reservoirs sediment from behind Lower Klamath Project dams, thus the short-term potential increases in SSCs from rainfall on reservoir sediments without established vegetation would have a significant adverse impact to salmonids and cause a substantial change in water quality (i.e., suspended sediment) that would result in a failure to maintain existing beneficial uses at the levels currently supported, resulting in a short-term significant impact to suspended sediments in the Hydroelectric Reach.

Physical removal of reservoir bottom sediments prior to drawdown is not feasible because dredging would remove only a maximum of 43 percent of erodible reservoir sediment, would only provide a marginal benefit to fish during drawdown with 57 percent of erodible sediment remaining, and would have a large environmental impact on terrestrial resources and possibly cultural resources (Lynch 2011). Slower drawdown to potentially mobilize less sediment or altering the timing of drawdown to lessen the potential of precipitation after drawdown and before plantings have stabilized sediments have also been suggested as potential approaches to reduce sediment impacts. However, both of these alterations would increase the time elevated SSCs would occur during sensitive fish life-stages, resulting in greater adverse impacts to designated beneficial uses and/or fish (see Section 4.1.1.4 *Elimination of Potential Alternatives that Would Not Avoid or Substantially Lessen Significant Environmental Effects of the Proposed Project*). Thus, the short-term significant impact of increased SSCs due to dam removal in the Hydroelectric Reach cannot be avoided or substantially decreased through feasible mitigation.

With respect to the potential for long-term increases in SSCs in the Hydroelectric Reach due to the Proposed Project, modeling indicates SSCs return to modeled background levels (i.e., existing conditions) under all water year types during post-dam removal year 1 (USBR 2012). Potential long-term increases in SSCs due to production of erodible sediments from the remaining reservoir sediment deposits would likely be almost to completely offset by long-term decreases in SSCs due to revegetation of remaining reservoirs sediment deposits. To address uncertainties associated with revegetation and sediment stabilization activities (e.g., variations in plant germination success, plant growth rate, seasonal precipitation, reservoir sediment changes), monitoring and adaptive management of these revegetation and sediment stabilization activities would occur under the Proposed Project (Appendix B: *Definite Plan – Appendix H, Section 6 Monitoring and Adaptive Management*). Monitoring of the remaining reservoir sediment deposits would be conducted yearly for post-dam removal year 1 to 5 to evaluate the effectiveness of these activities using yearly visual inspection (aerial and ground photos) as well as yearly Light Detection and Ranging (LiDAR) flights of the reservoir area to estimate changes in the remaining reservoir sediment deposits. Adaptive management under the Proposed Project would utilize the monitoring data, threshold metrics for evaluating whether actions would be needed, and potential actions to be undertaken if threshold metrics are not achieved. For example, aerial and ground photos would be used to evaluate the percent relative vegetation cover with additional vegetation seeding or planting occurring if vegetation cover does not meet annually specified average percent relative vegetation cover targets. Overall, monitoring and adaptive management would likely result in revegetation that stabilizes remaining reservoirs sediments, so long-term potential increases in SSCs due to production of erodible sediments from the remaining would be unlikely to result in elevated SSCs in the Klamath River and there would be a long-term less than significant impact on SSCs in the Hydroelectric Reach.

Slowly, over several decades, high winter flows in the Hydroelectric Reach are expected to gradually widen the floodplain in the reservoir footprints through natural fluvial processes (USBR 2012). Erosion associated with the widening of the floodplain is not anticipated to result in SSCs above modeled background levels (i.e., existing conditions) due to the anticipated slow pace of this change (i.e., decades), so long-term erosion and associated SSCs from widening of the floodplain would not cause an exceedance of water quality standards related to suspended sediments or cause changes in suspended sediments that would result in a failure to maintain existing designated beneficial uses at the levels currently supported. Therefore, there would be no significant impact to the Hydroelectric Reach in the long term due to the release of sediments currently trapped behind the Lower Klamath Project dams since SSCs are expected to resume modeled background levels (i.e., existing conditions) in the long term, regardless of the water year type present during the dam removal.

Middle and Lower Klamath River and Klamath River Estuary
Sediment transport modeling of the impacts of dam removal on suspended sediment also indicates high short-term loads immediately downstream from Iron Gate Dam under the Proposed Project (Stillwater Sciences 2008; USBR 2012, 2016). As described above, the Proposed Project involves drawdown for Copco No. 1 Reservoir beginning on November 1 and drawdown for J.C. Boyle and Iron Gate reservoirs beginning on January 1 (USBR 2012), which allows maximum SSCs to occur during winter months when flows and SSCs are naturally high in the mainstem river (see Appendix C, Figure C-15). Drawdown of Copco No. 2 occurs on May 1 (Appendix B: *Definite Plan*) under the Proposed Project, but Copco No. 2 Reservoir would not meaningfully increase downstream SSCs due to lack of sediment storage under current conditions and its small size relative to the upstream reservoirs, as discussed for the Hydroelectric Reach above.

Suspended sediment model predictions immediately downstream of Iron Gate Dam due to the release of sediments within J.C. Boyle, Copco No. 1, and Iron Gate reservoirs under the Proposed Project are presented in Figure 3.2-15 through Figure 3.2-17 for three water year types[37] (dry, median, wet) considered as part of the Klamath Dam Removal Secretarial Determination process. As discussed in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, model predictions made using hydrology assumptions adopted for the Klamath Dam Removal Secretarial Determination are still appropriate for assessing Proposed Project impacts since the 2013 BiOp Flows and 2019 BiOp Flows are typically similar to those used in the suspended sediment model for all water year types (generally within a few percentage points) and 2013 BiOp Flows or 2019 BiOp Flows outside the range modeled flows occur too infrequently to substantially alter the range of flow conditions in the Klamath River. Model predictions are discussed below and summarized in Table 3.2-13.

[37] SSCs downstream of Iron Gate Dam cannot be directly compared with the SSCs modeled downstream of Copco No. 1 Reservoir. SSC modeling downstream of Copco No. 1 Reservoir use different years to represent the three water year types than the SSC modeling downstream of J.C. Boyle Dam or Iron Gate Dam, so the specific hydrologic conditions (i.e., timing and magnitude of flow changes from storms) and resulting SSCs are different.

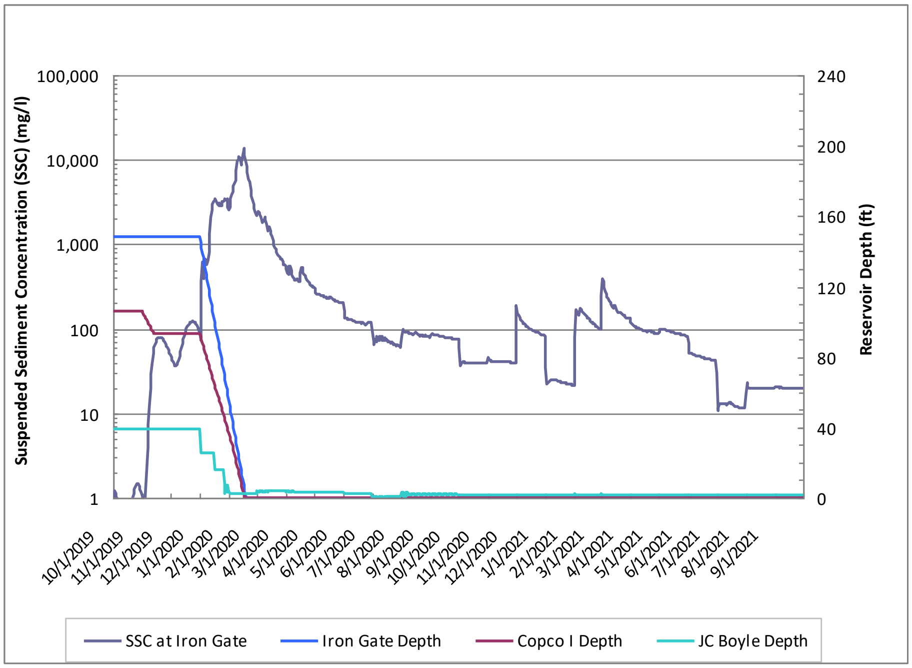


Figure 3.2-15. SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Project Assuming Typical Dry Hydrology (WY2001). Dam removal year 1 is represented by the year 2019, dam removal year 2 is represented by the year 2020, and post-dam removal year 1 is represented by the year 2021.

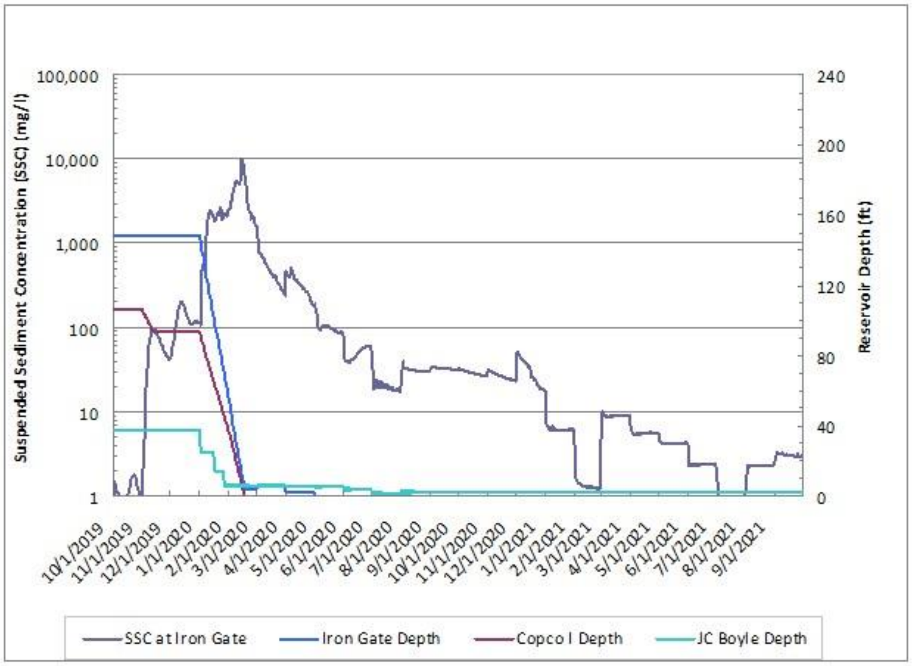


Figure 3.2-16. SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Project Assuming Median Hydrology (WY1976). Dam removal year 1 is represented by the year 2019, dam removal year 2 is represented by the year 2020, and post-dam removal year 1 is represented by the year 2021.

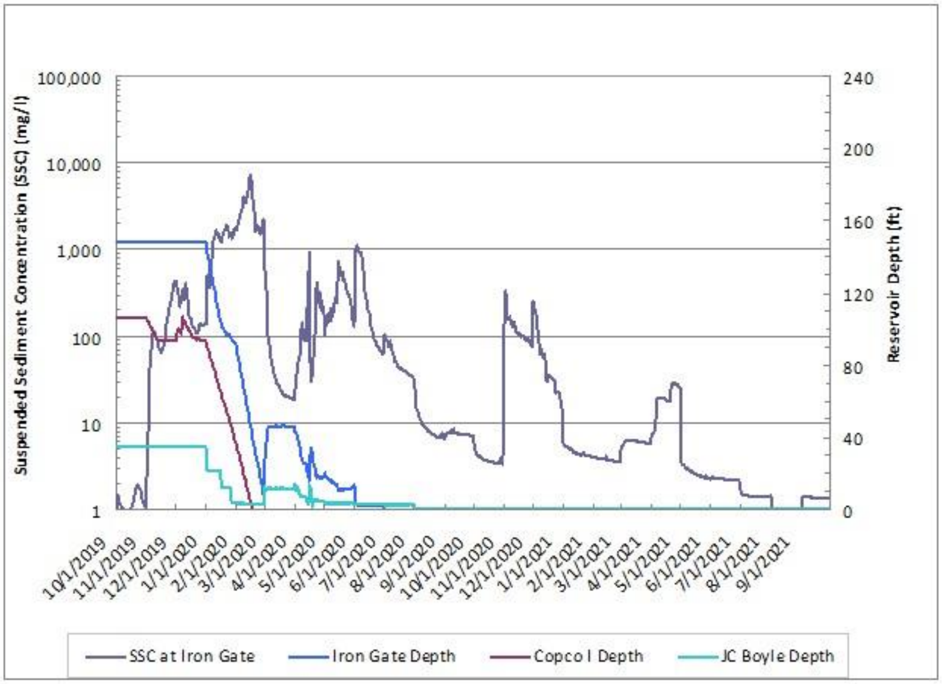


Figure 3.2-17. SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Project Assuming Typical Wet Hydrology (WY1984). Dam removal year 1 is represented by the year 2019, dam removal year 2 is represented by the year 2020, and post-dam removal year 1 is represented by the year 2021.

Table 3.2-13. Summary of Model Predictions for SSCs in the Klamath River Downstream from Iron Gate Dam for the Proposed Project During Dam Removal Years 1 and 2

Water Year Type	Peak SSC[1] (mg/L)	SSC-1,000 mg/L		SSC-100 mg/L		SSC-30 mg/L	
		Duration (Months)	Time Period[2]	Duration (Months)	Time Period[2]	Duration (Months)	Time Period[2]
Dry (WY2001)	13,600	3	January–March	6	January–June	10	January–October
Median (WY1976)	9,900	2	January–February	5	January–May	6	January–June
Wet (WY1984)	7,100	2	January–February and April–July	7	November–February and April–July	9	November–July

[1] Actual peak concentrations may greater than predicted peak concentrations due to the proposed 5 feet per day maximum drawdown rate for the Proposed Project (see also Section 3.2.4.2 *Suspended Sediments*).

[2] All months shown are during dam removal year 2.

For typical dry year (WY2001) hydrologic conditions, modeled SSCs in the Klamath River immediately downstream from Iron Gate Dam experience a relatively small increase to near 100 mg/L in mid-November of dam removal year 1 as Copco No. 1 undergoes early drawdown at a maximum rate of two feet per day. A second, relatively large increase (greater than 1,000 mg/L) would occur in early January of dam removal year 2 when Iron Gate and J.C. Boyle begin drawdown at rates of two to five feet per day and Copco No. 1 enters a second phase of drawdown, also at a rate of two to 5 feet per day. Concentrations remain very high (greater than 1,000 mg/L) for approximately three months from January through April of dam removal year 2 (see Figure 3.2-11), with peak values exceeding 10,000 mg/L for a short period (four to five days) in mid-February of dam removal year 2. SSCs generally return to less than 100 mg/L by July, and to concentrations near 30 mg/L by October of dam removal year 2. Predicted SSCs increase again to levels between 200 to 400 mg/L during winter and spring of post-dam removal year 1 (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 (to near 200 mg/L) in mid-December of dam removal year 1, and a large increase (greater than 1,000 mg/L) again in early January of dam removal year 2. Peak SSCs downstream from Iron Gate Dam are predicted to be somewhat 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 nearly the same volume of sediment out of the reservoir and downstream. Peak concentrations also occur in mid-February of dam removal year 2 for the median year hydrologic condition (see Figure 3.2-16). Predicted SSCs downstream from Iron Gate Dam remain very high (greater than 1,000 mg/L) for approximately two months following the beginning of drawdown in Iron Gate and Copco No. 1 reservoirs, from January through February of dam removal year 2. There is a slightly earlier return to SSCs less than 100 mg/L for the median year (WY1976), with concentrations decreasing by May of dam removal year 2 due to the higher Klamath River flow under a median year. Modeled SSCs decrease to less than 30 mg/L by June of dam removal year 2 and fluctuate between 10 mg/L and 100 mg/L through the remainder of dam removal year 2. Modeled SSCs do not exceed 100 mg/L for two consecutive weeks after June of dam removal year 2 since SSCs remain below 100 mg/L after June of dam removal year 2. The Proposed Project is not expected to increase SSCs above 100 mg/L for the typical median water year condition in post-dam removal year 1 (2021) with modeled SSCs always less than 100 mg/L, but SSCs may vary between approximately 1 and 100 mg/L in that year due to erosion of sediment deposits remaining in the reservoir footprint area. Thus, model results indicate SSCs would remain below the 100 mg/L for two consecutive weeks threshold of significance for SSCs after June of dam removal year 2.

Model predictions for typical wet year (WY1984) hydrologic conditions indicate a higher initial pulse of fine sediments following the Copco No. 1 Reservoir drawdown in early to mid-December of dam removal year 1, with concentrations at or near 400 mg/L. Model predictions indicate that for typical wet year conditions, the outlet capacity at Copco No. 1 Dam is exceeded during the same timeframe and the reservoir fills slightly (see Figure 3.2-17). Very high (greater than 1,000 mg/L) SSCs are experienced for approximately two months following the beginning of drawdown in the reservoirs, from January through February of dam removal year 2 (see Figure 3.2-17). SSCs reach approximately 7,100 mg/L, with peak values occurring in mid-February of dam removal year 2. SSCs generally return to less than 100 mg/L during the month of March, but then secondary peaks (approximately 1,000 mg/L) in SSCs occur in mid-April and June of dam removal year 2 for wet year (WY1984) hydrologic conditions. After the secondary peaks, SCCs again return to less than 100 mg/L by the beginning of July in dam removal year 2 and continues to decrease until SSCs are less than 30 mg/L by the end of July in dam removal year 2. Predicted SSCs increase again to levels between 200 to 400 mg/L during the end of dam removal year 2 (i.e., November) and the beginning of post-dam removal year 1 (2021) (i.e., January) before decreasing below 30 mg/L by February as high winter flows in the Klamath River flush sediments downstream that were not removed during drawdown. A secondary increase in SSCs to approximately 30 mg/L occurs around April to May in post-dam removal year 1 from a storm event, but rapidly decreases once Klamath River flows decrease.

As discussed for the *Hydroelectric Reach*, the shift in the Proposed Project Copco No. 2 drawdown timing from January 1 (Appendix B: *Detailed Plan*) to May 1 (Appendix B: *Definite Plan*) would not change the anticipated magnitude or timing of significant impacts due to elevated SSCs in the Hydroelectric Reach during dam removal year 2.

For all three water year types, predicted SSCs in the Middle and Lower Klamath River decrease to 60 to 70 percent of the Iron Gate Dam value by Seiad Valley (RM 132.7) and to 40 percent of the Iron Gate Dam value by about RM 58.9, downstream from Orleans (USBR 2012). SSCs in the Middle and Lower Klamath River and the Klamath River Estuary are predicted to resume modeled background levels (i.e., existing conditions) by the end of post-dam removal year 1 under all water year types, especially with revegetation of the reservoir sediments immediately following dam removal which would stabilize the sediment from erosion due to rainfall and reduce SSCs after drawdown compared to the modeled SSCs (USBR 2012). Modeled SSCs did not consider reductions in SSCs due to revegetation activities.

Modeled SSCs across the three water year types would have peak values of approximately 7,000 to 14,000 mg/L immediately downstream of Iron Gate Dam and these peak values would occur within two to three months of reservoir drawdown. Model results indicate SSCs in excess of 1,000 mg/L would occur on a timescale of weeks to months (see Table 3.2-13), 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 *[Suspended Sediments] Salmon River to Klamath River Estuary*). Predicted SSCs would remain greater than or equal to 100 mg/L for five to seven months following drawdown, and concentrations would remain greater than or equal to 30 mg/L for six to 10 months following drawdown (Table 3.2-13), as compared to suspended sediments downstream of Iron Gate Dam under existing conditions typically ranging from approximately 1 to 20 mg/L between May and December with only occasional peaks of approximately 56 to 437 mg/L (see Appendix C, Section C.2.2.2 *[Suspended Sediments] Salmon River to Klamath River Estuary*).

Similar to conditions downstream of J.C. Boyle and Copco No. 1, the higher maximum drawdown rate under the Proposed Project (i.e., 5 feet per day) than under modeled conditions is expected to increase peak SSCs and decrease the duration of elevated SSCs compared to modeled SSCs (see Section 3.2.4.2 *Suspended Sediments*), but variations in modeled SSCs due to a higher drawdown rate would be unlikely to reduce the duration of SSCs above 100 mg/L to less than two consecutive weeks under all water years types. Peak SSCs would be expected to double from approximately 7,000 to 14,000 mg/L immediately downstream of Iron Gate Dam under modeled conditions to approximately 14,000 to 28,000 mg/L under the higher drawdown rate in the Proposed Project, based on a previous analysis how suspended sediments vary under different drawdown rates in Lower Klamath Project reservoirs (Stillwater Sciences 2008). The higher drawdown rate would also potentially decrease the duration of elevated suspended sediments by approximately one to two weeks since suspended sediments decrease more rapidly after peak SSCs occur due to the increased transport of reservoir deposits at the higher drawdown rate (Stillwater Sciences 2008). While potential decreases in the duration of elevated suspended sediments under a higher drawdown rate would be unlikely to significantly alter the duration of SSCs greater than 1,000 mg/L (i.e., peak SSCs) downstream of Iron Gate, the duration of modeled SSCs downstream of Iron Gate Dam greater than 100 mg/L would likely occur as SSCs decrease more rapidly following a higher drawdown rate. Modeled SSCs downstream of Iron Gate Dam were greater than 1,000 mg/L for two to three weeks and greater than 100 mg/L for five to seven weeks (Table 3.2-13), so SSCs still would likely be greater than 100 mg/L for at least three consecutive weeks under the higher drawdown rate in the Proposed Project. SSCs after drawdown would potentially decrease to less than 10 mg/L more rapidly under the Proposed Project than estimated by the modeled SSCs due to the increased transport of reservoir deposits at the higher drawdown rate. Thus, overall, the short-term impact based on an analysis of modeled SSCs downstream of Copco No. 1 would remain the same under the higher drawdown rate in the Proposed Project since SSCs is expected to exceed 100 mg/L for two consecutive weeks regardless of the drawdown rate.

Similar to Copco No. 1 Reservoir, sediment jetting within the Iron Gate reservoir footprint is anticipated to increase the magnitude of modeled SSCs downstream of Iron Gate during drawdown, but it would not alter the overall impact of suspended sediment in the Klamath River downstream of Iron Gate Dam during drawdown since the increase in SSCs due to sediment jetting would primarily occur during peak SSCs and sediment jetting would not increase the duration of SSCs greater than 100 mg/L by mobilizing more sediment only during drawdown. Klamath River flows during drawdown at Iron Gate Dam range from approximately 1,000 cfs in a Dry water year to 24,500 cfs in a Wet water year (see Appendix B: *Definite Plan – Section 4.6*). A typical sediment jetting flow would be approximately 10 to 30 cfs with SSCs the flow likely ranging from less than 1,000 mg/L to approximately 100,000 mg/L, assuming the Proposed Project operations would be similar to sediment jetting flows used on the Mill Pond Dam removal project, Washington Department of Ecology [2016]).

Sediment jetting in the Iron Gate Reservoir footprint during drawdown is estimated to typically increase SSCs by approximately 270 mg/L to 1,200 mg/L compared to modeled SSCs without sediment jetting, but SSCs would potentially increase up to approximately 1,700 mg/L based on the estimated sediment volume to transport by sediment jetting, the duration of drawdown, and the flow and SSCs for the Klamath River and the sediment jetting. The typical increase in SSCs would be the expected increase under the range of typical drawdown flows under all water year types, while the maximum increase in SSCs would only be likely to occur under Klamath River minimum flows during a dry water year. Additionally, the maximum increase in SSCs from sediment jetting within the Iron Gate Reservoir footprint is a conservative estimate, since it assumes sediment jetting would mobilize all the sediment in the areas undergoing jetting. Drawdown flows would mobilize a portion of that sediment, so the actual maximum increase in SSCs would likely be less than 1,700 mg/L. SSCs in the Klamath River downstream of Iron Gate Dam would also be increased by sediment jetting activities in the Copco No. 1 reservoir footprint, so the overall SSCs increase in the Klamath River downstream of Iron Gate Dam from sediment jetting in both reservoirs during drawdown would typically range from 620 mg/L to 2,600 mg/L compared to modeled SSCs without sediment jetting, reaching up to approximately 3,900 mg/L if the maximum increase in SSCs from sediment jetting in Copco No. 1 and Iron Gate occurred simultaneously.

Sediment jetting would increase the magnitude of SSCs during drawdown, but most of the variations in the modeled SSCs during sediment jetting would be within the range of modeled SSCs and the increase in the magnitude would not extend beyond the drawdown period since sediment jetting would only occur during drawdown. Peak SSCs during drawdown under sediment jetting would potentially increase above the range of SSCs anticipated with the higher drawdown rate (i.e., 5 feet per day) with the maximum SSCs downstream of Iron Gate Dam potentially increasing from 14,000 to 28,000 mg/L (under only drawdown flows at a 5 feet per day drawdown rate) to approximately 17,900 to31,900 mg/L (under drawdown flows at a 5 feet per day drawdown rate with sediment jetting in both the Copco No. 1 and Iron Gate reservoir footprints). The SSCs under drawdown flows at the higher drawdown rate with or without sediment jetting would exceed the suspended sediments potential short-term significance criteria of 100 mg/L over a continuous two-week period. While the magnitude of SSCs would increase during drawdown with sediment jetting, the magnitude of SSCs would potentially decrease after drawdown is complete since sediment jetting would mobilize more sediment than anticipated under drawdown flows alone. Within the general uncertainty of the modeled SSCs and estimates of SSCs with sediment jetting (see Table 3.12-2), the SSCs in the Klamath River downstream of Iron Gate Dam with a higher drawdown rate (i.e., 5 feet per day) and sediment jetting would be similar to or less than the modeled SSCs without sediment jetting after drawdown ends in March.

Model results also indicate that tributary inflow would create dilution in the lower Klamath River that would decrease SSCs, so the SSCs at Seiad Valley (RM 132.7) would be 60 to 70 percent of the SSCs immediately downstream of Iron Gate Dam and SSCs at Orleans (approximately RM 59) would be 40 percent of the SSCs immediately downstream of Iron Gate Dam. However, modeled SSCs in the Middle and Lower Klamath River would be greater than 100 mg/L for two consecutive weeks or more during drawdown depending on the water year type (USBR 2012), thus there would be a substantial adverse impact on salmonids and beneficial uses throughout these reaches and in the Klamath River Estuary in the short term. After consideration of the changes in modeled SSCs due to a higher maximum drawdown rate (i.e., 5 feet per day) and sediment jetting, SSCs in the Middle and Lower Klamath River and the Klamath River Estuary still would likely remain greater than 100 mg/L for two consecutive weeks or more. Accordingly, SSCs in the Middle and Lower Klamath River and Klamath River Estuary due to release of reservoir sediments under the Proposed Project would be a substantial adverse impact on water quality in the short term and also result in a substantial adverse impact to salmonids and associated designated beneficial uses. A more detailed analysis of the anticipated suspended sediment impacts on key fish species, including salmonids, in the lower river is presented in Section 3.3.5.1 *Suspended Sediment.*

Sediment release associated with the Proposed Project would cause short-term increases in suspended material (greater than 100 mg/L for two or more consecutive weeks) that would cause an exceedance of water quality standards. Additionally, sediment release associated with the Proposed Project would cause water quality changes that would result in a failure to maintain existing beneficial uses at the levels currently supported due to non-attainment of applicable Basin Plan water quality objectives for suspended material in the Middle and Lower Klamath River and the Klamath River Estuary; and substantial water quality changes that would adversely affect the cold freshwater habitat (COLD), rare, threatened, or endangered species (RARE), and migration of aquatic organisms (MIGR) beneficial uses. Sediment release associated with the Proposed Project would also result in non-attainment of applicable Hoopa Valley Tribe and Yurok Tribe narrative suspended material, settleable material, and sediment water quality objectives applicable the portions of the Klamath River within tribal boundaries.

Consistent with conditions described above in the *Hydroelectric Reach*, the short-term significant impact of increased SSCs due to dam removal in the Middle and Lower Klamath River and the Klamath River Estuary cannot be avoided or substantially decreased through reasonably feasible mitigation.

As discussed above for the *Hydroelectric Reach*, SSCs are expected to resume modeled background (i.e., existing conditions) SSCs by the end of post-dam removal year 1 regardless of the type of hydrology (dry, normal, or wet conditions) present during the drawdown period (USBR 2012). Thus, in the long term there would be no significant impact due to elevated SSCs in the Middle and Lower Klamath River and the Estuary due to the release of sediments currently trapped behind the Lower Klamath Project dams.

Pacific Ocean Nearshore Environment

Sediment transport modeling predicted that 1.2 to 2.3 million tons of sediment (5.4 to 8.6 million cubic yards, or 36 to 57 percent of the total sediments deposited behind the dams by 2020) would be eroded from the reservoir areas upon dam removal (USBR 2012) (see also Tables 2.7-7 through 2.7-9). 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. The sediment transported by the Klamath River to the Pacific Ocean due to dam removal is expected to be less than the total amount transported in a typical wet year, but greater than that transported during a dry year. See Section 3.11.5 *[Soil, Geology, and Mineral Resources] Potential Impacts and Mitigation* and Figure 3.11-12 for further details.

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. While Goal 4 of the California MPLA 2016 Final Master Plan for the North Coast specifies protection of habitats identified by the California MLPA Master Plan Science Advisory Team, the MPLA 2016 Final Master Plan does not explicitly consider freshwater plumes as one of the habitat types (CDFW 2016).

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.

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.

After exiting the river mouth, the high SSCs (greater than 1,000 mg/L) transported by the Lower Klamath River would form a surface plume of less dense (i.e., less salty), 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 the sediment deposition pattern and location in the nearshore environment with exactitude. However, the general dynamics and transport mechanisms of fine sediment can be surmised based upon regional oceanographic and sediment plume studies.

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 climate cycles (Curran et al. 2002).

During several large flood events on the geographically near Eel River in the winter of 1997 and 1998, Geyer et al. (2000) found the following: (1) flood conditions were usually accompanied by strong winds from the southern quadrant; (2) the structure of the river plume was strongly influenced by the wind-forcing conditions; (3) during periods of strong southerly (i.e., downwelling favorable) winds, the plume [in the Pacific Ocean nearshore environment] was confined inside the 164 feet isobath (sea floor contour at 164 feet below the water surface), within about 4 miles of shore; (4) occasional northerly (upwelling favorable) winds arrested the northward motion of the plume and caused it to spread across the shelf; (5) transport of the sediment plume was confined to the inner shelf (water depths less than 164 feet), during both southerly and northerly wind conditions; (6) during southerly wind periods, fine, un-aggregated sediment was rapidly transported northward to at least 18 miles from the river mouth, but flocculated sediment was deposited within 0.6 to 6 miles of the river mouth; and (7) during northerly (upwelling favorable) winds, most of the sediment fell out within three miles of the mouth, and negligible sediment was carried farther offshore (Geyer et al. 2000). The Eel River mouth is 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 Pacific Ocean nearshore environment under the Proposed Project 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 one to two 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, before depositing along the continental shelf in the vicinity of the mouth of the Klamath River.

The narrative California marine water quality objectives (Table 3.2-6) are applied as the threshold of significance rather than the freshwater numeric SSCs threshold of significance of 100 mg/L over a continuous two-week exposure period since the Pacific Ocean nearshore environment is a marine environment and salmonids within the Pacific Ocean nearshore environment would have more of an opportunity to avoid elevated SSCs conditions compared to opportunities within the Klamath River. While elevated SSCs (10 to 100 mg/L) created in the nearshore plume would affect physical water quality characteristics specified in the Ocean Plan (e.g., visible floating particulates, natural light attenuation, the deposition rate of inert solids), the impacts would be within the range caused by historical storm events (i.e., less than that transported in a typical wet year). While the total amount of sediment delivered to the Pacific Ocean nearshore environment under the Proposed Project is within the historical range of annual sediment supplied to the Pacific Ocean nearshore environment by the Klamath River (USBR 2012; see Potential Impact 3.11-5), the duration of elevated SSCs under the Proposed Project would be greater than the range occurring under natural (i.e., storm) conditions. Natural storm conditions would be expected elevate SSCs in the Pacific Ocean nearshore environment on the time scale of days (Geyer et al. 2000), but SSCs would be elevated in the Pacific Ocean nearshore environment on the time scale of weeks to months based on duration of elevated SSCs modeled in the Klamath River downstream of Iron Gate Dam, at Seiad Valley (RM 132.7), and at Orleans (approximately RM 59) (USBR 2012). Thus, the elevated SSCs created in the nearshore plume under the Proposed Project in the short term would produce variations in the physical characteristics of the Pacific Ocean nearshore environment greater the duration occurring under natural (i.e., storm) conditions, potentially causing water quality changes that would result in a failure to maintain existing beneficial uses at the levels currently supported and resulting in a significant impact to the Pacific Ocean nearshore environment in the short term.

As discussed above for the Hydroelectric Reach and the Middle and Lower Klamath River and the Klamath River Estuary, model results indicate that the SSCs would resume modeled natural background levels by the end of post-dam removal year 1 regardless of the type of hydrology (dry, normal, or wet conditions) present during the drawdown period (USBR 2012). Thus, SSCs in the Pacific Ocean nearshore environment in the long term would be within the range of natural conditions, so the variations in the physical characteristics of the Pacific Ocean nearshore environment similar to natural conditions and there would be no significant impact on SSCs in the long term in the Pacific Ocean nearshore environment due to the release of sediments currently trapped behind the Lower Klamath Project dams. See Section 3.11.5 for analysis of sediment deposition along the nearshore environment due to dam removal.

In summary, the magnitude of SSCs released to the nearshore environment with the anticipated rapid dilution of an expanding sediment plume in the ocean is within the range of natural conditions, but the duration of elevated SSCs is greater than would occur under natural (i.e., storm) conditions. Therefore, elevated SSCs under the Proposed Project would potentially cause water quality changes that would result in a failure to maintain existing beneficial uses at the levels currently supported, thus short-term increases in SSCs in the Pacific Ocean nearshore environment under the Proposed Project would be significant and unavoidable impact.

The Definite Plan (see Appendix B: *Definite Plan – Appendix M*) includes a Water Quality Monitoring Plan to assess the Proposed Project's impacts to water quality, and this plan includes turbidity and suspended sediment concentration monitoring along with adaptive management requirements. Please note that the State Water Board has authority to review and approve any final Water Quality Monitoring Plan through its water quality certification under Clean Water Act Section 401. The State Water Board has issued a draft water quality certification which sets forth water quality monitoring, adaptive management, and compliance requirements for any Water Quality Monitoring Plan to meet, as Condition 1 and Condition 2.[38] Condition 2 acknowledges that the Proposed Project will have temporary (short-term) exceedances of water quality objectives associated with reservoir drawdown and the export of reservoir sediments into the Klamath River and Pacific Ocean. Restoration projects may exceed water quality objectives in the short term in light of the long-term water quality and ecosystem benefits they provide.

Additionally, the Oregon Department of Environmental Quality has issued a water quality certification[39] that sets forth water quality monitoring and adaptive management conditions for points upstream of California, including an assessment of baseline river conditions upstream of dam removal operations.

<u>Significance</u>

Significant and unavoidable in the short term for the Hydroelectric Reach, Middle Klamath River, Lower Klamath River, Klamath River Estuary, and Pacific Ocean nearshore environment

No significant impact in the long term for the Hydroelectric Reach, Middle Klamath River, Lower Klamath River, Klamath River Estuary, and the Pacific Ocean nearshore environment.

[38] The State Water Board's draft water quality certification is available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_dwqc.pdf (Accessed December 11, 2018).

[39] The Oregon Department of Environmental Quality's final water quality certification is available online at: https://www.oregon.gov/deq/FilterDocs/ferc14803final.pdf (Accessed December 14, 2018).

Potential Impact 3.2-4 Increases in suspended material from stormwater runoff due to pre-construction, dam deconstruction and removal, and restoration activities in the Hydroelectric Reach and the Middle Klamath River immediately downstream of Iron Gate Dam.
Under the Proposed Project, pre-construction activities with the potential to affect water quality include diversion tunnel modifications, road improvements, Iron Gate and Fall Creek hatchery modifications, Yreka pipeline modifications, and dam site preparation between June and November of dam removal year 1 (Table 2.7-1). Dam removal activities would begin in October of dam removal year 1 with removal of the Copco No. 1 Powerplant and would include demolition of the dams and their associated structures, power generation facilities, and transmission lines, installation of temporary cofferdams, hauling, recreation facilities removal, regrading of recreation access roads and parking areas, and other activities (Table 2.7-1). Immediately following dam removal, any potential non-natural fish barriers within the historical reservoir footprints would be modified as needed to enable volitional fish passage, which may include in-water work. Restoration activities would include irrigation system installation and maintenance, as well as active seeding, planting, and weed management in the reservoir footprint and disturbed upland areas within the Limits of Work (Table 2.7-1). For greater detail on these activities, please see Section 2.7 *Proposed Project*. All of the aforementioned activities could result in the disturbance of soil within the Limits of Work and result in loose sediment that could then be suspended in stormwater runoff during rainfall events. Please see Potential Impacts 3.2-16 and 3.22-2 for consideration of the accidental release of hazardous materials from construction equipment and/or vehicles under the Proposed Project.

Within the Limits of Work (Figures 2.2-5, 2.7-1, and 2.7-3), the Proposed Project includes the following construction and other ground-disturbing activities best management practices (BMPs) to reduce potential impacts to water quality in wetlands and other surface waters during construction and other ground-disturbing activities (Appendix B: *Definite Plan – Appendix J*):

- Pollution and erosion control measures will be implemented to prevent pollution caused by construction operations and to reduce contaminated stormwater runoff.
- Oil-absorbing floating booms will be kept onsite, and the contractor will respond immediately to aquatic spills during construction.
- Vehicles and equipment will be kept in good repair, without leaks of hydraulic or lubricating fluids. If such leaks or drips do occur, they will be cleaned up immediately.
- Equipment maintenance and/or repair will be confined to one location at each project construction site. Runoff in this area will be controlled to prevent contamination of soils and water.
- Dust control measures will be implemented, including wetting disturbed soils.

- A Stormwater Pollution Prevention Plan (SWPPP) will be implemented to prevent construction materials (fuels, oils, and lubricants) from spilling or otherwise entering waterways or waterbodies.

In addition, for the protection of wetlands, results of a wetland delineation would be incorporated into the Proposed Project design to avoid and minimize direct impacts on wetlands to the maximum extent feasible, and wetland areas adjacent to the construction Limits of Work would be fenced. As discussed in Potential Impact 3.5-1, there could be impacts to wetlands if the fencing does not include an appropriate buffer; implementation of Mitigation Measure TER-1, which stipulates a minimum 20-foot buffer requirement, would reduce potential short-term impacts on wetland communities to less than significant.

The BMPs identified above focus on general stormwater-related contamination, but their implementation is expected to also minimize or eliminate the potential for construction-related increases in suspended material that could enter wetlands and other surface waters located within the Limits of Work (Figures 2.2-5, 2.7-1, and 2.7-3), including the Hydroelectric Reach, tributaries of the Klamath River that enter this reach (as appropriate), or the Middle Klamath River immediately downstream of Iron Gate Dam. The Proposed Project does not, however, specifically identify BMPs for pre-construction, reservoir restoration, or upland restoration activities that would occur within the Limits of Work. Further, the proposed BMPs are not sufficiently comprehensive to avoid all potential violations of water quality standards or other degradation of water quality in affected portions of the wetlands, Hydroelectric Reach, tributaries to the Klamath River that enter this reach (as appropriate), or the Middle Klamath River immediately downstream of Iron Gate Dam, during these other periods of Proposed Project activity. Such violations of water quality standards or other related degradation of water quality would be a significant impact without mitigation. Implementation of mitigation measures WQ-1, TER-1, and HZ-1 would reduce any potential impacts not already addressed by the BMPs to less than significant.

Mitigation Measure WQ-1 Best Management Practices to reduce potential impacts to water quality due to pre-construction, dam removal, and restoration-related activities.
For the protection of all potentially affected waterbodies within the Limits of Work (see Figures 2.2-5, 2.7-2, and 2.7-4), the proposed construction BMPs (listed above) shall apply to all ground-disturbing activities occurring for the Proposed Project. Construction associated with these activities shall be subject to the BMPs required under the Construction General Permit.

<u>Significance</u>
No significant impact with mitigation

Potential Impact 3.2-5 Long-term alterations in mineral (inorganic) suspended material from the lack of continued interception and retention by the dams.

Under the Proposed Project, peak concentrations of mineral (inorganic) suspended material (silts and clays with a diameter less than 0.063 millimeters) during the winter/early spring (November through April) would likely continue to be associated with high-flow events following dam removal. Any long-term increases in mineral (inorganic) suspended material 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 (151,000 tons per year or 2.4 percent of the cumulative average annual delivery from the basin) is supplied to the Klamath River on an annual basis from the watershed upstream of Iron Gate Dam 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) (see also Section 3.11.2.4 *Sediment Load*). The majority of the mineral (inorganic) suspended material (6,086,471 tons per year or 97.6 percent of the cumulative average annual delivery from the basin) enters the Klamath River from tributaries downstream of Iron Gate Dam which is a pattern that is expected to continue following dam removal.

Long-term increases in suspended material from the lack of continued interception and retention of mineral (inorganic) suspended materials by the Lower Klamath dam are not expected to cause an exceedance or exacerbate an existing exceedance of a water quality standard or result in a failure to maintain a beneficial use. Accordingly, for the Hydroelectric Reach, the Middle and Lower Klamath River, the Klamath River Estuary, and the Pacific Ocean nearshore environment, there would be a less than significant long-term impact from removal of the dams on amounts or concentrations of mineral (inorganic) suspended material.

Significance

No significant impact

Potential Impact 3.2-6 Long-term alterations in algal-derived (organic) suspended material from the lack of continued interception and retention by the dams.

As discussed in Section 3.2.2 *Environmental Setting*, Section 3.4.2 *[Phytoplankton and Periphyton] Environmental Setting*, and Appendix C, Section C.2.1 *Upper Klamath Basin*, Upper Klamath Lake is a hypereutrophic system with considerable algae growth and suspended organic matter. Under existing conditions, the majority of the interception and retention of suspended material from upstream sources (Upper Klamath Lake, Klamath Straights Drain, Lost River) occurs in the Keno Impoundment/Lake Ewauna, with the largest relative decreases in TSS (total suspended solids) occurring between Link River and

Keno Dam (see Appendix C, Figure C-13). In addition to interception by the dams, concentrations of organic suspended material from upstream decrease in the rivers due to mechanical breakdown of dead and decaying algae in the turbulent river reaches between J.C. Boyle and Copco No. 1 reservoirs, and dilution from the springs downstream from J.C. Boyle Dam (see Appendix C, Section C.2.1). Mechanical breakdown and dilution from springs are ongoing processes that would continue under the Proposed Project.

Episodic increases (10 to 20 mg/L) in algal-dominated (organic) suspended material resulting from in-reservoir algal productivity are not expected to occur in the Hydroelectric Reach following dam removal (see Section 3.2.2.3 *Suspended Sediments*). At the upstream end of the Hydroelectric Reach (i.e., at the upstream of J.C. Boyle Reservoir) and prior to mechanical breakdown or dilution downstream of J.C. Boyle Dam, suspended materials may attain levels similar to those observed upstream of J.C. Boyle Dam under existing conditions during May through October (greater than 15 mg/L; see Appendix C) as algal-dominated organic suspended material is transported downstream. In the Hydroelectric Reach downstream of the J.C. Boyle Dam location to Iron Gate, mechanical breakdown in the existing and newly created free-flowing river reaches, along with dilution, would be likely to reduce concentration of algal-derived (organic) suspended material, but the exact magnitude of the reduction in algal-derived (organic) suspended material cannot be quantified with available data or models. Periphyton colonization and growth in the new free-flowing river portions of the Hydroelectric Reach (see Potential Impact 3.4-4 for more details) and potential macrophyte growth within slow-moving habitats in the Hydroelectric Reach may contribute to organic suspended material concentrations, but there are no data or models available for the Klamath River to quantify the magnitude of these potential increases in organic suspended material. Measurements of organic suspended sediment between 2001 and 2003 and median turbidity values over the long-term historical record (1950 to 2001) both follow a similar pattern, with values decreasing with distance downstream to J.C. Boyle Reservoir, indicating it is likely that the suspended sediment concentrations crossing the Oregon-California state line under the Proposed Project would not increase beyond typical existing conditions concentrations of 10 to 15 mg/L (see Section 3.2.2.1 and Appendix C, Section C.2).

While it is likely that mechanical breakdown and dilution within the Hydroelectric Reach would reduce algal-derived (organic) suspended material concentrations entering the Hydroelectric Reach, it is conservatively assumed that there would be no decrease in algal-derived (organic) suspended material within the Hydroelectric Reach since the reservoirs would no longer provide calm, slow-moving water conditions for algal-derived (organic) suspended material to settle out of the water column, and because potential increases in organic suspended material produced within the Hydroelectric Reach by possible periphyton and/or macrophyte growth cannot be quantified with available data and models. Thus, downstream of Iron Gate Dam, there potentially would be a slight relative long-term increase in algal-dominated (organic) suspended materials under the Proposed Project, due to the conservative assumption that there would be no decrease in suspended material through the Hydroelectric Reach.

Following completion of the Proposed Project, it is very unlikely that suspended material would be produced in the Hydroelectric Reach at levels that would increase summertime algal-dominated (organic) suspended material in the Middle and Lower Klamath River beyond a sustained 100 mg/L for two weeks, or a lower concentration sustained over a longer period of time that would result in an adverse impact on the most sensitive beneficial use (cold freshwater habitat [COLD]) (e.g., 15 mg/L for 90 consecutive days, assuming sublethal effects – indications of major physiological stress). Note that 100 mg/L for two weeks is the water quality criterion adopted for significant adverse impacts on the COLD beneficial use during reservoir drawdown (see Section 3.2.3.1 *[Water Quality] Thresholds of Significance*). If slight long-term increases in suspended materials did occur during transit through the Hydroelectric Reach, such increases would be well below the algal-derived suspended material previously produced in Copco No. 1 and Iron Gate reservoirs and would not exceed levels that would substantially adversely affect the COLD beneficial use, or any other existing designated beneficial use at the levels currently supported, exacerbate an existing exceedance of water quality standards, or result in a failure to maintain an existing beneficial use. Future potential adverse impacts to beneficial uses could be determined using a “dose-response” approach such as the one adopted for this analysis (i.e., 100 mg/L for two consecutive weeks, or a lower concentration sustained over a longer period of time) or another approach appropriate to conditions under a dam removal scenario.

Significance

No significant impact

3.2.5.3 Nutrients

Potential Impact 3.2-7 Short-term increases in sediment-associated nutrients due to release of sediments currently trapped behind the dams.

Hydroelectric Reach, Middle and Lower Klamath River, and Klamath River Estuary

As discussed in Section 2.7.3 *Reservoir Sediment Deposits and Erosion During Drawdown*, a significant portion of the sediment anticipated to be removed during reservoir drawdown is dead phytoplankton [algae] that have settled on the reservoir bottom. These sediments are very high in nutrients. Short-term increases in total nitrogen (TN) and total phosphorus (TP) concentrations in the Hydroelectric Reach, Middle Klamath River, Lower Klamath River, Klamath River Estuary, and the Pacific Ocean nearshore environment would occur because the transported sediments are nutrient-rich. However, minimal deposition of fine suspended sediments, including associated nutrients, would occur in the river channel and the estuary (USBR 2012; Stillwater Sciences 2008). Further, reservoir drawdown under the Proposed Project would occur during winter months when rates of primary production and microbially mediated nutrient cycling (e.g., nitrification, denitrification) are also expected to be low, such that nutrient uptake potential in the river reaches will be low during drawdown. Light limitation for primary producers that do persist during winter months is also likely to occur because of high turbidity; this would further decrease the potential for uptake of the TN and TP that are released along with reservoir sediment deposits. While there would be a temporary upward pulse in TP and TN away from the numeric TMDL targets, this pulse would not support the growth of nuisance and/or noxious phytoplankton or nuisance periphyton. Particulate nutrients released along with sediment deposits are not expected to be bioavailable, should be well-conserved during transport through the mainstem river and the estuary, therefore in the short-term sediment-associated TP and TN are not expected to result in a failure to maintain a beneficial use, or cause an exceedance or exacerbate an existing exceedance of a water quality standard. Overall, this short-term impact would be less than significant.

Pacific Ocean Nearshore Environment

Under the Proposed Project, fine sediments and associated nutrients released during reservoir drawdown would be dispersed as a buoyant river plume into the Pacific Ocean nearshore environment, where the sediments and associated nutrients would likely deposit along the continental shelf in the vicinity of the mouth of the Klamath River. Similar to conditions in the Klamath River and Klamath River Estuary, the biostimulatory effect of nutrient uptake from suspended or recently deposited fine sediments is expected to be low in the Pacific Ocean nearshore environment because reservoir drawdown would occur in winter when light availability is relatively low and primary productivity (i.e., phytoplankton growth) and microbially-mediated nutrient cycling are correspondingly low. In the summer following drawdown (dam removal year 2), resuspension of nutrients deposited on the continental shelf by coastal upwelling would make a negligible contribution to overall nutrient availability in the Pacific Ocean nearshore environment. This is because coastal upwelling near the mouth of the Klamath River supplies approximately 1,700 tons to 4,000 tons of nitrate per day per 100 meters of coastline, and approximately 225 tons to 450 tons of phosphate per day per 100 meters of coastline, using estimates for average California Current coastal upwelling near the Klamath River latitude (Bruland et al. 2001) and typical nutrient concentrations in coastal upwelling off the California coast (Bograd et al. 2009). Lower Klamath Project reservoir sediments would deposit between 1,200 tons to 5,500 tons of TN and 190 tons to 680 tons of TP along the continental shelf in the Pacific Ocean nearshore environment, based on the range of sediment TN (130 mg/kg to 2,800 mg/kg) and sediment TP (92 mg/kg to 370 mg/kg) from reservoir sediment cores (USBR 2011) and the range of sediment expected to erode during dam removal (1,460,000 tons to 2,310,000 tons; see also Section 2.7.3 *Reservoir Sediment Deposits and Erosion During Drawdown* and USBR [2012]). While only a fraction of the nutrients deposited on the continental shelf would have the potential to be resuspended during summer coastal upwelling, more nutrients would be supplied to marine nearshore surface waters by coastal upwelling in two days than the maximum amount of nutrients associated with the Lower Klamath Project reservoir sediments that would be mobilized during dam removal.

In addition to TN and TP, micronutrients in the Lower Klamath Project reservoir sediments could act as biostimulatory substances in the Pacific Ocean nearshore environment, where micronutrient availability can limit biological production in coastal waters (Bruland et al. 1991). Iron in the Lower Klamath Project reservoir sediments is the most abundant micronutrient that could influence phytoplankton productivity in the Pacific Ocean nearshore environment, since iron is important in photosynthetic and respiratory electron transport, nitrate reduction, and N-fixation (Morel et al. 1991; Bruland et al. 2001; Street and Paytan 2005). Iron is typically supplied at very low rates (0.04 tons to 0.10 tons per day per 100 meters of coastline) by coastal upwelling (Bruland et al. 2001; Bograd et al. 2009), such that river discharges are the primary source of iron to the California nearshore coastal environment (Bruland et al. 2001). During high-flow winter conditions, iron associated with riverine suspended particles is delivered to the continental shelf, and during summer, iron is remobilized by coastal upwelling (Chase et al. 2007). In coastal regions with large riverine inputs and a broad continental shelf, phytoplankton productivity in the Pacific Ocean nearshore environment is not considered to be iron-limited, since the combination of riverine supply and continental shelf storage can meet phytoplankton iron needs through particle resuspension (Chase et al. 2005; Lohan and Bruland 2006). Coastal regions with narrower shelves (less storage) and lower river discharge (less supply) can have iron-limited phytoplankton productivity (Hutchins and Bruland 1998; Bruland et al. 2001).

Studies of iron availability along the Oregon coast (Chase et al. 2007) and the central California coast between Monterey Bay and Point Reyes (Bruland et al. 2001) have found the shape of the continental shelf in those regions to be sufficiently large that enough iron can be stored from winter deposition that the Pacific Ocean nearshore environment is not iron-limited. Narrower continental shelf regions, like those found along the central California coast near Big Sur, have been found to be iron-limited (Bruland et al. 2001). The iron availability in the Pacific Ocean nearshore environment at the mouth of the Klamath River is unknown, but the shape of the continental shelf near the mouth of the Klamath River is similar to the shape of the continental shelf along the Oregon coast and central California coast between Monterey Bay and Point Reyes, suggesting that Pacific Ocean nearshore environment along the Klamath River is not iron-limited.

Estimates of typical sediment transport to the Pacific Ocean nearshore environment from the Mid- and Lower Klamath Basin downstream of Iron Gate Dam (Stillwater Sciences 2010) combined with estimates of the iron content of soils in the Mid- and Lower Klamath Basin (USGS NGS 2008) indicate that the total iron delivered to the nearshore coastal environment and the continental shelf near the Klamath River ranges from approximately 194,000 tons to 390,000 tons per year. Estimates of the amount of sediment expected to be released during dam removal (Table 2.7-11) combined with estimates of the iron content of the sediment trapped behind the Lower Klamath Project dams (8,200 mg/kg to 32,000 mg/kg; USBR 2011) indicate that an additional 23,000 tons to 62,000 tons of iron would be contributed to the Pacific Ocean nearshore environment by sediment released during dam removal. The 6 percent to 32 percent short-term increase in total iron loading to the Pacific Ocean nearshore environment as a result of Lower Klamath Project dam removal would not significantly alter iron nutrient conditions in the Pacific Ocean nearshore environment, since only a fraction of the iron would be resuspended by coastal upwelling and only a fraction of the resuspended iron would occur in a bioavailable form (Morel et al. 1991; Bruland et al. 2001; Buck et al. 2007).

Overall, the short-term increases in sediment-associated nutrients (TN and TP) would be less than significant because any biostimulatory effects would be limited in winter months by naturally low phytoplankton productivity and diluted in summer months by much higher background levels of resuspended nutrients supplied by coastal upwelling. Short-term increases in sediment-associated micronutrients (iron) also would be less than significant since iron-limitation of phytoplankton is not expected to occur in the Pacific Ocean nearshore environment near the mouth of the Klamath River, and the additional iron loading from Lower Klamath Project sediment deposits would be small compared to typical annual iron loading rates from natural erosion processes in the Mid- and Lower Klamath Basin. Thus, TP and TN in the reservoir sediment releases would not cause objectionable aquatic growths or degrade indigenous biota (see Table 3.2-6), and these nutrients are not expected result in a failure to maintain a beneficial use or cause an exceedance or exacerbate an existing exceedance of a water quality.

The Definite Plan (see Appendix B: *Definite Plan – Appendix M*) includes a Water Quality Monitoring Plan to assess the Proposed Project's impacts to water quality, and this plan includes monitoring of total nitrogen and total phosphorous. Please note that the State Water Board has authority to review and approve any final Water Quality Monitoring Plan through its water quality certification under Clean Water Act Section 401. The State Water Board has issued a draft water quality certification which sets forth monitoring and adaptive management requirements for any Water Quality Monitoring Plan to meet, as Condition 1.[40] Additionally, the Oregon Department of Environmental Quality has issued a water

[40] The State Water Board's draft water quality certification is available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_dwqc.pdf (Accessed December 14, 2018).

quality certification[41] that sets forth water quality monitoring and adaptive management conditions for points upstream of California. This EIR does not find that the effect of the Proposed Project on sediment-associated nutrients would be significant in either the short or the long term, and this analysis of Potential Impact 3.2-7 does not further discuss the water quality monitoring and adaptive management conditions.

Significance

No significant impact

Potential Impact 3.2-8 Long-term alterations in nutrients from the lack of interception and retention by the dams and conversion of the reservoir areas to a free-flowing river.

The two largest reservoirs in the Lower Klamath Project (Copco No. 1 and Iron Gate reservoirs) intercept and retain suspended material behind the dams, including nutrients (TP and TN) originating from upstream. Under the Proposed Project, these nutrients would be transported downstream and potentially be available for biological uptake (e.g., by periphyton [attached algae]). Analyses of the impacts of dam removal on nutrients have been conducted by PacifiCorp for its relicensing efforts (FERC 2007), the North Coast Regional Board for development of the California Klamath River TMDLs (North Coast Regional Board 2010), and the Yurok Tribe (Asarian et al. 2010) as part of an evaluation to improve previous nutrient budgets for the Klamath River and increase understanding of nutrient retention rates in free-flowing river reaches.

Hydroelectric Reach

The results of all the above-referenced evaluations (FERC 2007; North Coast Regional Board 2010; and Asarian et al. 2010) recognize the trapping efficiency of Copco No. 1 and Iron Gate reservoirs with respect to annual TP and TN, such that under the Proposed Project total nutrient concentrations in the Klamath River downstream from Iron Gate Dam would increase on an annual basis. However, the majority of the existing analyses results are focused on the Middle and Lower Klamath River downstream from Iron Gate Dam, rather than on the Hydroelectric Reach.

Modeling conducted for development of the California Klamath River TMDLs (North Coast Regional Board 2010) does provide some information applicable to the assessment of long-term impacts of the Proposed Project on nutrients at locations in the Hydroelectric Reach (Kirk et al. 2010). Klamath River TMDL model results indicate that if the Lower Klamath Project dams were to be removed ("TMDL dams-out, Oregon" [TOD2RN] scenario), TP and TN in the

[41] The Oregon Department of Environmental Quality's final water quality certification is available online at: https://www.oregon.gov/deq/FilterDocs/ferc14803final.pdf (Accessed December 14, 2018).

Hydroelectric Reach immediately downstream from J.C. Boyle Dam would increase slightly (by less than 0.015 mg/L TP and less than 0.05 mg/L TN) during summer months compared to existing conditions ("TMDL dams-in" [T4BSRN] scenario). This slight increase is due to the absence of nutrient interception and retention in both Keno Impoundment/Lake Ewauna and J.C. Boyle Reservoir. With respect to conditions in Keno Impoundment/Lake Ewauna, the Klamath River TMDL model assumes that the upstream Keno Dam is replaced by the historical natural Keno Reef in the "TMDL dams-out" scenario (TOD2RN and TCD2RN) but not in the "TMDL dams-in" scenario (T4BSRN). In the model, 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. While the Klamath River TMDL model assumption regarding Keno Reef does not materially influence model applicability to inform impact determinations for the Proposed Project and alternatives identified in this EIR, it could mean that the slight predicted increase in TP and TN under the modeled "TMDL dams-out" scenario (TOD2RN and TCD2RN) is an over-estimate under the Proposed Project, which does not propose any changes to Keno Dam, such that TP and TN concentrations in the Hydroelectric Reach immediately downstream from J.C. Boyle Dam would be the same as under existing conditions.

At the Oregon-California state line, the total nutrient supply also would be essentially the same under the Proposed Project as under existing conditions. The lack of hydropower peaking operations at J.C. Boyle Dam under the Proposed Project may result in decreased daily variation in TP and TN (North Coast Regional Board 2010). Overall however, the predicted nutrient changes are very small and thus this effect of the Proposed Project is not considered to be either a potential benefit or a potential impact. Further, the Klamath River 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 long-term nutrient transport in the Hydroelectric Reach downstream of the Oregon-California state line.

It is important to note that the Klamath River TMDL model scenarios are useful for informing impacts associated with the Proposed Project and alternatives identified in Section 4 *Alternatives*, but they include as a starting assumption that there will be full implementation of the TMDLs. For example, the "TMDL dams-in" (T4BSRN) and "TMDL dams-out" (TOD2RN) scenarios for California both assume that water entering into California from Oregon meets California water quality standards for water temperature, organic enrichment/low dissolved oxygen, nutrients, pH, and microcystin. In other words, the starting point for the California models is that all necessary reductions in pollution to address the current impaired conditions at the Oregon-California state line for these constituents would already have been implemented upstream. The full TMDL compliance modeling assumption does not reflect the existing conditions, and it would be speculative at this point to identify either the mechanisms necessary to implement the TMDLs or the timing required to achieve full compliance. However, the nutrient retention mechanism modeled for the reservoir reaches in the Klamath River TMDL would be the same even if model inputs for nutrients were increased to concentrations under existing conditions, such that the general trend indicated by the Klamath River TMDL model output (i.e., dam removal would slightly increase downstream transport of total nutrients) is still informative for conditions where full TMDL compliance has not occurred.

Based on available information, the slight nutrient increases in the Hydroelectric Reach would not be expected to result in exceedances of California North Coast Regional Board Basin Plan water quality objectives for biostimulatory substances beyond levels experienced under existing conditions. Further, the elimination of seasonal releases of dissolved forms of nutrients from anoxic reservoir bottom waters during periods of reservoir stratification would reduce nutrient availability for supporting large summer and fall phytoplankton blooms, including blue-green algae blooms, in Copco No. 1 and Iron Gate reservoirs (see also discussion for *Middle and Lower Klamath River and Klamath River Estuary*). While seasonal periphyton colonization would likely increase in this reach under the Proposed Project, the increases would be due to habitat increases (i.e., conversion of a reservoir into a riverine habitat) rather than nutrient increases (see Potential Impact 3.4-4). Further, the reservoir environment that supports the growth of nuisance phytoplankton blooms such as *Microcystis aeruginosa* and other blue-green algae would be eliminated under the Proposed Project (see Section 3.4 *Phytoplankton and Periphyton*), reducing the possibility of uptake of the slightly increased total nutrient concentrations by any nuisance and/or noxious phytoplankton blooms that might, however unlikely, occur in the riverine reaches that replace the reservoirs. The nuisance phytoplankton problem is mainly relevant for Copco No. 1 and Iron Gate reservoirs, where the longer residence times support seasonal nuisance phytoplankton blooms (see Section 3.4 *Phytoplankton and Periphyton*). Thus, under the Proposed Project, there would be a less than significant long-term increase in total nutrient levels in the Hydroelectric Reach from the lack of continued interception by the Lower Klamath Project dams and conversion of the reservoir areas to a free-flowing river, and a beneficial effect of eliminating seasonal releases of dissolved forms of nutrients from anoxic reservoir bottom waters.

Middle and Lower Klamath River and Klamath River Estuary
As described above in this potential impact analysis, Copco No. 1 and Iron Gate reservoirs currently intercept and retain suspended material behind the dams, including nutrients (TP and TN) associated with suspended material that originates upstream of the Hydroelectric Reach. Results of all the existing evaluations (FERC 2007; North Coast Regional Board 2010; Asarian et al. 2010) recognize the trapping function of the reservoirs with respect to TP and TN, and they provide results indicating that ending this trapping by converting the

reservoirs to free-flowing river reaches would, on an annual basis, result in a slight increase in *annual* TN and TP in the Middle and Lower Klamath River and the Klamath River Estuary. On a *seasonal* basis, the reservoirs can be a source of TP and TN in the form of dissolved nutrients (e.g., ortho-phosphorus, nitrate, and ammonium) to the Middle Klamath River, as nutrients contained within bottom sediments are released back into the water column under low dissolved oxygen conditions (see also Section 3.2.2.1 *Overview of Water Quality Processes in the Klamath Basin* and Figure 3.2-2). For example, in an analysis of nutrient dynamics in the Klamath River comparing the Klamath River TMDL model output against available empirical studies, while the *annual* modeled TP retention rate was approximately 6 percent for Iron Gate Reservoir and 1 percent for Copco No. 1, the model results indicated a *seasonal* TP release (2 percent to 40 percent) from Iron Gate Reservoir during late summer/fall, with the highest release (40 percent) occurring at reservoir fall turnover (see Figure 3.2-2 for a schematic of reservoir turnover), and a *seasonal* TP release (2 percent to 26 percent) from Copco No. 1 Reservoir during late summer/fall and into winter months. Similarly, albeit to a lesser degree, the *annual* modeled TN retention was approximately 18 percent for Iron Gate Reservoir, with a 4 percent *seasonal* release of TN in winter of the model year. For Copco No. 1, the annual modeled TN retention was 4 percent for Copco No. 1, with a *seasonal* release of 3 to 15 percent in winter months (North Coast Regional Board 2010, Appendix 3). Asarian et al. (2009) notes that the seasonal release of nutrients can occur periodically between the late summer and early winter, but on balance the annual retention of nutrients is greater than the seasonal releases.

Based on the Yurok Tribe analysis (Asarian et al. 2010), TP concentrations in the Middle and Lower Klamath River would increase by approximately 2 to 12 percent for the June through October period if the dams were to be removed, while increases in TN concentrations would be relatively larger, at an estimated 37 to 42 percent for June through October and 48 to 55 percent for July through September (see Figure 3.2-18). The Yurok Tribe 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). The two approaches used by the Yurok Tribe implicitly include nutrient recycling processes such as assimilative uptake for seasonal phytoplankton and periphyton growth and subsequent downstream release, as these processes were ongoing and inherently included in the retention estimates determined for existing conditions. The first (and only TP-applicable) approach indicated small increases in TP concentrations downstream from Iron Gate Dam under the Proposed Project, and a diminishment of this effect with distance downstream due to both tributary dilution and nutrient retention (i.e., uptake of nutrients). Both approaches yielded similar TN results, indicating relatively larger increases in TN concentrations than the TP concentration, following the same diminishment pattern due to dilution and nutrient retention.

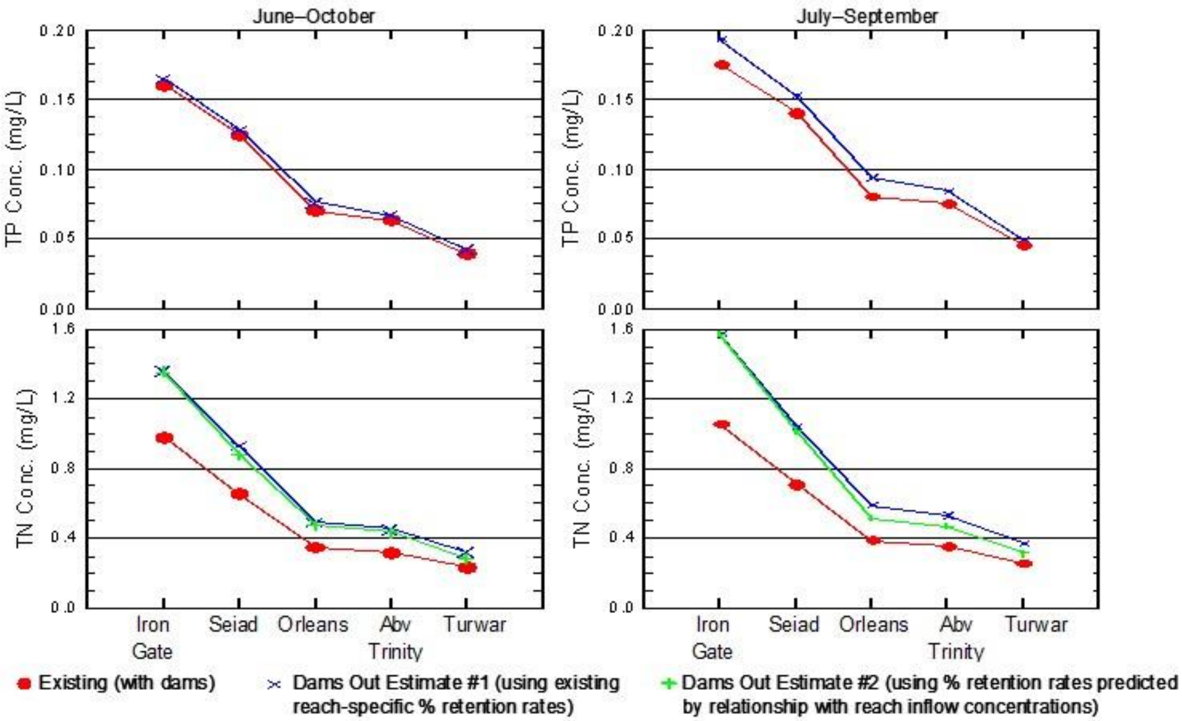


Figure 3.2-18. Comparison of Annual TP and TN Concentrations from Iron Gate Dam to Turwar (RM 5.6) for June–October and July–September 2007–2008: (a) Measured Current Conditions (Red Circle), (b) Dams-Out Estimate using Calculated Percent Retention Rates by Reach (Blue Cross), and (c) Dams-Out Estimate using Percent Retention Rates Predicted by the Empirical Relationship between Reach Inflow Concentration and Retention (Green Cross). Source: Asarian et al. 2010.

Unlike the Yurok Tribe analysis, the Klamath River TMDL modeling efforts include an assumption of full compliance with upstream TP and TN load allocations for California (North Coast Regional Board 2010). Despite this, results of the Klamath River TMDL model are in general agreement with PacifiCorp (FERC 2007) and Yurok Tribe (Asarian et al. 2010) analyses regarding dam removal impacts on nutrients, with very small annual increases in TP (0.01 to 0.015 mg/L) and relatively larger annual increases in TN (0.1 to 0.125 mg/L) immediately downstream from Iron Gate Dam due to dam removal. Increases in nutrients would diminish with distance downstream from Iron Gate Dam. It should be noted that while following the same relative trend as the Yurok Tribe analysis, the absolute increases predicted by the Klamath River TMDL model for the "TMDL dams-out" California scenario (TCD2RN) are much lower (e.g., 0.1 to 0.125 mg/L TN increase for the TMDL model vs. 0.1 to 0.5 mg/L TN increase for the Yurok Tribe analysis). This finding is in accord with the prediction in Asarian et al. (2010) that decreased nutrient input into California would decrease the annual TN and TP effect of dam removal.

Variability in TP and TN are predicted by the Klamath River TMDL model (see Appendix D) under the “TMDL dams-out” California scenario (TCD2RN) during summer months, presumably due to nutrient uptake dynamics by periphyton and macrophytes in the free-flowing river segments that would replace the reservoirs. The Klamath River TMDL model does not include denitrification as a possible nitrogen removal term in river segments since it was determined the rocky river bed and high dissolved oxygen concentrations would not be favorable for denitrification bacteria and the corresponding denitrification process (Tetra Tech 2009). The absence of denitrification in the TMDL model is expected to have a minimal influence on modeled TN concentrations since river conditions are not favorable for the process, but TN concentrations being transported into the Middle Klamath River under the Proposed Project may be over-predicted. 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 Klamath 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 Project (as compared with existing conditions, including TMDL compliance) are predicted by the Klamath River TMDL model; however, within the uncertainty of future nutrient dynamics these differences are not clearly discernable as increases or decreases. Klamath River TMDL model “dams-out” (TCD2RN) results indicate that while resulting mean (average) TP levels in any 30-day period from May to October would always meet the existing Hoopa Valley Tribe numeric water quality objective (0.035 mg/L TP) in all months at the Hoopa reach (approximately RM 45) of the Klamath River, the mean TN levels in any 30-day period from May to October would exceed the existing objective (0.2 mg/L TN) in May and portions of June by approximately 0.025 mg/L TN or less. The mean TN levels in any 30-day period for the modeled “natural conditions” (T1BSR) also exceed the Hoopa Valley Tribe existing TN water quality objective, but it would only exceed the TN objective for only several days in May and by less than 0.01 mg/L TN. However, the mean TN levels in any 30-day period from May to October for the modeled “dams-in” scenario (T4BSRN) comply with the existing objective throughout the applicable May to October period (North Coast Regional Board 2010). As noted previously, TN concentrations in the model may be over-predicted and therefore the Hoopa Valley Tribe objective may be met under the Proposed Project.

While there would be an increase in absolute nutrient concentrations entering the Middle Klamath River under the Proposed Project, phytoplankton, especially blue-green algae, would be limited in their ability to use those nutrients for growth and reproduction without calm reservoir habitat (Potential Impact 3.4-2). Further, the elimination of potential seasonal releases of dissolved forms of nutrients from anoxic reservoir bottom waters and into downstream reaches of the Klamath River would reduce nutrient availability for phytoplankton during the growing season. Overall, the slight increase in annual nutrient concentrations would not result in significant biostimulatory impacts on phytoplankton growth under the Proposed Project relative to existing conditions, and the elimination of potential seasonal releases of dissolved nutrients from the reservoir bottom waters would be beneficial.

For periphyton, despite the overall increases in absolute nutrient concentrations anticipated under the Proposed Project, the small but relatively greater increases in TN also may not result in significant biostimulatory impacts during the growth season (i.e., late spring through fall). Existing data regarding TN:TP ratios suggest the potential for the Klamath River to be N-limited to the extent that there is a nutrient limitation. However, concentrations of both nutrients are high enough in the Klamath River from Iron Gate Dam to approximately Seiad Valley (RM 132.7) (and potentially further downstream) that nutrients are not likely to be limiting primary productivity (e.g., periphyton growth) in this more upstream portion of the Middle Klamath River (FERC 2007; HVTEPA 2008; Asarian et al. 2010). In addition, N-fixing species dominate the periphyton communities in the lower portions of the Middle Klamath River as well as the Lower Klamath River where inorganic nitrogen concentrations are low (Asarian et al. 2010, 2014, 2015). Since these species can fix their own nitrogen from the atmosphere, increases in TN due to dam removal may not significantly increase algal biomass in these reaches (see also Section 3.4 *Phytoplankton and Periphyton*).

In general, although dam removal would result in a slight long-term increase in annual TP and TN away from the numeric targets, such an increase would not support the growth of nuisance and/or noxious phytoplankton or nuisance periphyton. Therefore, in the long term the lack of continued interception of TN and TP on an *annual* basis by the Lower Klamath Project dams and conversion of the reservoir areas to a free-flowing river would not result in a failure to maintain a beneficial use or cause an exceedance or exacerbate an existing exceedance of a water quality. Overall, this would be a less than significant long-term impact. The elimination of potential seasonal releases of dissolved nutrients from the reservoir bottom waters to downstream reaches of the Klamath River would be beneficial.

Pacific Ocean Nearshore Environment

Copco No. 1 and Iron Gate reservoirs currently intercept and retain suspended material behind the dams, including nutrients (TN, TP) and micronutrients (iron) that are potentially important for phytoplankton growth in the Pacific Ocean nearshore environment. Similar to conditions in the Middle and Lower Klamath River and Klamath River Estuary, under the Proposed Project the Pacific Ocean nearshore environment also would experience a small increase in total annual nutrient concentrations on an annual basis since nutrients would no longer be trapped upstream by the Lower Klamath Project dams. The slight nutrient increases would not be expected to result in exceedances of water quality objectives for biostimulatory substances beyond levels experienced under existing conditions for the reasons described under Potential Impact 3.2-7 in the Pacific Ocean nearshore environment (because in the winter any biostimulatory effect would be limited by low productivity and light availability and during summer, any increase in nutrients in the Pacific Ocean nearshore environment would amount to considerably less than the background supply of nutrients from coastal upwelling (Bruland et al. 2001; Bograd et al. 2009). Overall, under the Proposed Project, there would be a less than significant long-term increase in nutrients in the Pacific Ocean nearshore environment due to the lack of continued interception by the Lower Klamath Project dams and conversion of the reservoir areas to a free-flowing river.

Significance

No significant impact in the long term due to lack of annual interception and retention of total nutrients

Beneficial in the long term due to elimination of potential seasonal releases of dissolved nutrients

3.2.5.4 Dissolved Oxygen

Potential Impact 3.2-9 Short-term increases in oxygen demand and reductions in dissolved oxygen due to release of sediments currently trapped behind the dams.

Hydroelectric Reach

Under the Proposed Project, high SSCs are expected to occur along the reaches of the Klamath River downstream of reservoirs and within the Klamath Estuary during and following drawdown (see Potential Impact 3.2-3). Because reservoir sediment deposits contain unoxidized organic matter from algal detritus (see Section 3.2.2.3 *Suspended Sediments*), resuspension of these materials during reservoir drawdown is likely to reduce oxygen concentrations in downstream reaches until oxygen consumption is balanced by reaeration as the river continues to flow. To put it more in terms of biochemical processes, decomposition of algal detritus is facilitated by natural bacteria associated with reservoir sediments. Once suspended during dam removal and exposed to the water column, these sediments would result in an oxygen demand generated by microbial oxidation and as well as chemical oxidation of reduced mineral compounds in the sediment (e.g., sulfides), especially from deeper in the sediment profile.

To estimate the potential magnitude of oxygen depletion and recovery at various SSC levels along the Klamath River, a modeling approach was adapted from Streeter and Phelps (1925) including laboratory estimates of dissolved oxygen depletion from both the rapid or immediate oxygen demand (IOD) of oxygen-demanding substances such as ferrous iron, followed by the slower microbially mediated biological oxygen demand (BOD) (Stillwater Sciences 2011). Using modeled estimates of SSC corresponding to expected river discharges during three representative water year types (see Section 3.2.5.2), the analysis of this potential impact accounts for changes in oxygen demand and river reaeration with distance (i.e., travel time of suspended sediments) to estimate corresponding dissolved oxygen concentrations in the various reaches of the Klamath River. Because prior analyses indicated that IOD and BOD are generally met at all expected SSC levels within the Klamath River (Stillwater Sciences 2011), the analysis below does not separately address potential impacts to the Pacific Ocean.

Modeled short-term oxygen demand as a function of SSC is not available for the Hydroelectric Reach. However, the results for the mainstem Klamath River downstream from Iron Gate Dam can also be applied to the Hydroelectric Reach. As a worst-case scenario, the reduction in dissolved oxygen due to short-term oxygen demand from sediment release in the Hydroelectric Reach is assumed to be the same as those for the Middle and Lower Klamath River. This is a conservative assumption because peak SSCs downstream from J.C. Boyle Reservoir would be much lower and present for a shorter duration (2,000 to 3,000 mg/L occurring within one to two months of reservoir drawdown) than those predicted downstream from Iron Gate Dam (7,000 to 14,000 mg/L occurring within two to three months of reservoir drawdown) (Figure 3.2-11 through Figure 3.2-13). As is the case for the Middle Klamath River immediately downstream of Iron Gate Dam (see below), short-term reductions in dissolved oxygen due to release of sediment deposits within the Lower Klamath Project reservoir footprints would substantially exacerbate an existing exceedance of applicable water quality standards and therefore be a significant and unavoidable impact for the Hydroelectric Reach.

Middle and Lower Klamath River and the Klamath River Estuary

Based on results of short-term oxygen demand modeling of estimated SSCs across dam removal year 1 and 2 (see also Section 3.2.4.4), IOD downstream from Iron Gate Dam would be 0.0 to 8.6 mg/L and BOD would be 0.3 to 43.8 mg/L for all water year types considered (i.e., wet, median, dry) and for six months following initiation of reservoir drawdown (see Table 3.2-14). The highest predicted IOD and BOD levels are anticipated to occur during February of dam removal year 2, and they would correspond to the peak SSCs in the river (Figure 3.2-15 through Figure 3.2-17).

During dam removal year 1, with initial dissolved oxygen assumed to be on the order of 70 percent and 80 percent saturation in November and December, respectively, the low IOD and BOD from initial drawdown results in a less than 1 mg/L decrease in dissolved oxygen concentrations during these two months within the first mile downstream from Iron Gate Dam (Table 3.2-14), followed by gradual increases to near saturation at locations farther downstream. Under an assumption that high initial dissolved oxygen conditions persist into January through May of dam removal year 2, dissolved oxygen concentrations downstream from Iron Gate Dam would generally be greater than 5 mg/L despite the relatively high predicted IOD and BOD values (Table 3.2-14). Exceptions include predicted concentrations in February of dam removal year 1 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 191 to RM 193.1 (approximately 0 to 2 miles downstream from Iron Gate Dam) and would return to at least 5 mg/L by approximately RM 178 to 180 (within 12 to 15 miles of the dam), or near the confluence with the Shasta River (RM 179.5).

Recognizing that IOD/BOD model results are sensitive to initial dissolved oxygen concentrations (Stillwater Sciences 2011), an additional modeling simulation was conducted to examine results assuming complete anoxia (i.e., 0 percent saturation) during dam removal year 2 (January through May) as an initial condition at Iron Gate Dam. Modeled dissolved oxygen concentrations remained below 5 mg/L downstream to RM 145 near the Scott River confluence during February of Dry Water Years, and as far downstream as RM 121.7, or 10 miles downstream of Seiad Valley (RM 132) in Normal and Wet Water Years (Table 3.2-14). At other times, dissolved oxygen concentrations generally recover before RM 134, near Seiad Valley (RM 132).

The Basin Plan water quality objective for dissolved oxygen is expressed as percent saturation (90 percent saturation). Assuming average February (2009) water temperatures, the water quality objective for November through April would range from 9.6 mg/L to 10.6 mg/L. Based on oxygen demand model results assuming high initial dissolved concentrations in dam removal year 2, recovery to the Basin Plan water quality objective of 90 percent saturation would occur generally within the reach from Seiad Valley (RM 132.7) to the mainstem confluence with Clear Creek (RM 100), or within a distance of 62 to 93 miles downstream from Iron Gate Dam for all water year types. Assuming low initial dissolved oxygen concentrations, recovery to the Basin Plan water quality objective of 90 percent saturation would occur generally farther downstream and within the reach from Clear Creek (RM 100) to the mainstem confluence with the Salmon River (RM 66), or 93 to 127 miles downstream from Iron Gate Dam for all water year types.

Thus, upstream of the Salmon River on the Middle Klamath River, short-term increases in IOD and BOD and reductions in dissolved oxygen due to release of sediments currently trapped behind the Lower Klamath Project dams would be a significant impact because reductions in dissolved oxygen below Basin Plan water quality objectives of 90 percent saturation for November through April (see also Table 3.2-5) would cause an exceedance of a water quality objective and a failure to maintain a beneficial use (COLD). Because physical removal of reservoir bottom sediments prior to drawdown is not feasible (Lynch 2011), and dam removal alternatives to the Proposed Project that would alter the timing and amount of sediment mobilization would result in the same or greater adverse impacts to designated beneficial uses and/or fish (see Section 4.1.1.4 *Elimination of Potential Alternatives that Would Not Avoid or Substantially Lessen Significant Environmental Effects of the Proposed Project*), the short-term significant impact of increased IOD and BOD and decreased dissolved oxygen in the Middle Klamath River upstream of the Salmon River cannot be avoided or substantially decreased through reasonably feasible mitigation. Because re-aeration through the water surface is sufficient to satisfy the most conservative assumptions of low initial dissolved oxygen (0 percent saturation) combined with high initial IOD and BOD (February conditions of Normal and Wet Water Year hydrology), there would be no significant impact from reduced dissolved oxygen concentrations due to sediment releases at any locations downstream of the Salmon River confluence on the Middle Klamath River, including the Lower Klamath River and the Klamath River Estuary.

Table 3.2-14. 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 Project.

Date [1]	**Boundary Conditions at Iron Gate Dam**					**Model Output Assuming High Initial Dissolved Oxygen** [5]				**Model Output Assuming Zero Initial Dissolved Oxygen** [5]			
	Flow (cfs) [2]	**SSC (mg/L)** [3]	**IOD (mg/L)**	**BOD (mg/L)**	**Avg. Temperature (deg C)** [4]	**Initial Dissolved Oxygen Downstream of Iron Gate Dam (mg/L)** [6]	**Minimum Dissolved Oxygen (mg/L)**	**Location of Minimum Dissolved Oxygen (RM)** [7]	**Modeled Location at Which Dissolved Oxygen Returns to 5 mg/L (RM)** [7]	**Initial Dissolved Oxygen Downstream of Iron Gate Dam (mg/L)** [6]	**Minimum Dissolved Oxygen (mg/L)**	**Location of Minimum Dissolved Oxygen (RM)** [7]	**Modeled Location at Which Dissolved Oxygen Returns to 5 mg/L (RM)** [7]
Typical Wet Hydrology (WY 1984 Conditions Assumed)													
11/30	3,343	444	0.3	1.6	9.9	7.3	7.1	192.5	NA[8]	7.3	7.1	192.5	NA[8]
12/1	7,139	430	0.3	1.5	5	9.4	9.2	191.9	NA[8]	9.4	9.2	191.9	NA[8]
1/21	8,675	1,962	1.2	6.9	3.7	9.7	8.6	191.2	NA[8]	0.0	0.0	193.1	172.7
2/15	3,949	7,116	4.5	25.1	4.4	9.6	5.2	191.9	NA[8]	0.0	0.0	193.1	121.7
3/1	4,753	593	0.4	2.1	6.7	9.0	8.7	191.9	NA[8]	0.0	0.0	193.1	182.6
4/15	4,374	939	0.6	3.3	8.4	8.6	8.1	191.9	NA[8]	0.0	0.0	193.1	166.5

Date [1]	Boundary Conditions at Iron Gate Dam					Model Output Assuming High Initial Dissolved Oxygen[5]				Model Output Assuming Zero Initial Dissolved Oxygen[5]			
	Flow (cfs)[2]	SSC (mg/L)[3]	IOD (mg/L)	BOD (mg/L)	Avg. Temperature (deg C)[4]	Initial Dissolved Oxygen Downstream of Iron Gate Dam (mg/L)[6]	Minimum Dissolved Oxygen (mg/L)	Location of Minimum Dissolved Oxygen (RM)[7]	Modeled Location at Which Dissolved Oxygen Returns to 5 mg/L (RM)[7]	Initial Dissolved Oxygen Downstream of Iron Gate Dam (mg/L)[6]	Minimum Dissolved Oxygen (mg/L)	Location of Minimum Dissolved Oxygen (RM)[7]	Modeled Location at Which Dissolved Oxygen Returns to 5 mg/L (RM)[7]
5/15	4,169	711	0.4	1.5	17.4	7.0	6.7	192.5	NA[8]	0.0	0.0	193.1	134.2
Median Hydrology (WY 1976 Conditions Assumed)													
11/30	2,074	96	0.1	0.3	9.9	7.3	7.3	193.1	NA[8]	7.3	7.1	193.1	NA[8]
12/1	2,156	203	0.1	0.7	5	9.4	9.3	192.5	NA[8]	9.4	9.2	192.5	NA[8]
1/21	6,533	2,594	1.6	9.1	3.7	9.7	8.2	191.2	NA[8]	0.0	0.0	193.1	164.6
2/15	2,933	9,893	6.2	34.8	4.4	9.6	3.5	191.9	178.2	0.0	0.0	193.1	121.7
3/1	3,016	1,461	0.9	5.1	6.7	9.0	8.2	191.9	NA[8]	0.0	0.0	193.1	176.4
4/15	2,657	509	0.3	1.8	8.4	8.6	8.4	191.9	NA[8]	0.0	0.0	193.1	179.5
5/15	2,355	191	0.1	0.7	17.4	7.0	7.0	192.5	NA[8]	0.0	0.0	193.1	155.3

Date [1]	Boundary Conditions at Iron Gate Dam					Model Output Assuming High Initial Dissolved Oxygen[5]				Model Output Assuming Zero Initial Dissolved Oxygen[5]			
	Flow (cfs)[2]	SSC (mg/L)[3]	IOD (mg/L)	BOD (mg/L)	Avg. Temperature (deg C)[4]	Initial Dissolved Oxygen Downstream of Iron Gate Dam (mg/L)[6]	Minimum Dissolved Oxygen (mg/L)	Location of Minimum Dissolved Oxygen (RM)[7]	Modeled Location at Which Dissolved Oxygen Returns to 5 mg/L (RM)[7]	Initial Dissolved Oxygen Downstream of Iron Gate Dam (mg/L)[6]	Minimum Dissolved Oxygen (mg/L)	Location of Minimum Dissolved Oxygen (RM)[7]	Modeled Location at Which Dissolved Oxygen Returns to 5 mg/L (RM)[7]
Typical Dry Hydrology (WY 2001 Conditions Assumed)													
11/30	1,141	79	0	0.3	9.9	7.3	7.3	193.1	NA[8]	7.3	7.1	193.1	NA[8]
12/1	1,284	122	0.1	0.4	5	9.4	9.4	193.1	NA[8]	9.4	9.2	193.1	NA[8]
1/21	4,245	3,514	2.2	12.4	3.7	9.7	7.6	191.2	NA[8]	0.0	0.0	193.1	158.4
2/15	1,040	13,574	8.6	47.8	4.4	9.6	1.3	191.9	180.1	0.0	0.0	193.1	144.7
3/1	1,344	2,421	1.5	8.5	6.7	9.0	7.6	191.9	NA[8]	0.0	0.0	193.1	178.9
4/15	1,150	551	0.3	1.9	8.4	8.6	8.4	191.9	NA[8]	0.0	0.0	193.1	185.1
5/15	1,143	296	0.2	1.0	17.4	7.0	7.0	192.5	NA[8]	0.0	0.0	193.1	172.7

Source: Stillwater Sciences 2011

[1] Dam removal year 1 is represented by November and December, with dam removal year 2 represented by January through May.

[2] Predicted daily flow values from USBR hydrologic model output (USBR 2012). Daily flow values correspond to the peak suspended sediment concentration (SSC) for each month.

[3] Predicted peak suspended sediment concentration (SSC) by month from USBR model output (USBR 2012)

[4] Raw daily water temperature data for 2009 from https://www.pacificorp.com/energy/hydro/klamath-river/water-quality.html (PacifiCorp 2009a).

[5] Assumes 70% and 80% saturation during November and December of dam removal year 1, respectively, with either high (80%) or low (0%) initial dissolved oxygen during January through May of dam removal year 2

[6] Initial dissolved oxygen concentration downstream from Iron Gate Dam was calculated using average monthly water temperature, salinity = 0 ppt, and elevation = 707 m (2,320 ft).

[7] River miles (RM) listed are those used in Stillwater Sciences (2011). The river miles listed are different from those used in this EIR, because the river miles have been updated since 2011 based on slight changes in the river path.

[8] NA = not applicable because dissolved oxygen consistently remains greater than 5 mg/L at all locations downstream of Iron Gate Dam.

The Definite Plan (see Appendix B: *Definite Plan – Appendix M*) includes a Water Quality Monitoring Plan to assess the Proposed Project's impacts to water quality, and this plan includes turbidity and suspended sediment concentration monitoring along with adaptive management requirements. Please note that the State Water Board has authority to review and approve any final Water Quality Monitoring Plan through its water quality certification under Clean Water Act Section 401. The State Water Board has issued a draft water quality certification[42] which sets forth water quality monitoring, adaptive management, and compliance requirements for any Water Quality Monitoring Plan to meet, as Condition 1 *Water Quality Monitoring and Adaptive Management* and Condition 2 *Compliance Schedule.* Condition 2 acknowledges that the Proposed Project would have temporary (short-term) exceedances of water quality objectives associated with reservoir drawdown and the export of reservoir sediments into the Klamath River and Pacific Ocean. Restoration projects may cause exceedances of water quality objectives in the short term in light of the long-term water quality and ecosystem benefits they provide. Additionally, the Oregon Department of Environmental Quality has issued a water quality certification[43] that sets forth water quality monitoring and adaptive management conditions for points upstream of California, including an assessment of baseline river conditions upstream of dam removal operations.

Significance

Significant and unavoidable in the short term for Hydroelectric Reach and Middle Klamath River from Iron Gate Dam to the Salmon River

No significant impact in the short term for the Middle Klamath River downstream from the Salmon River, in the Lower Klamath River, or in the Klamath River Estuary

Potential Impact 3.2-10 Long-term alterations in dissolved oxygen concentrations and daily variability due to conversion of the reservoir areas to a free-flowing river.

Hydroelectric Reach

Modeling conducted for development of the Klamath River TMDLs indicates that in the long term under the "TMDL dams-out" scenario for Oregon reaches (TOD2RN), average dissolved oxygen concentrations in the Hydroelectric Reach downstream of J.C. Boyle Dam and at the Oregon-California state line would be the same or slightly greater during July through October than those under the

[42] The State Water Board's draft water quality certification is available at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_dwqc.pdf (Accessed December 14, 2018).

[43] The Oregon Department of Environmental Quality's final water quality certification is available at: https://www.oregon.gov/deq/FilterDocs/ferc14803final.pdf (Accessed December 14, 2018).

"TMDL dams-in" scenario (T4BSRN) (North Coast Regional Board 2010). The same pattern is predicted for 30-day mean minimum and 7-day mean minimum dissolved oxygen criteria. With respect to daily variability in dissolved oxygen, the Klamath River TMDL model predicts somewhat reduced variability under the "TMDL dams-out" scenario for California reaches (TCD2RN) as compared to the "TMDL dams-in" scenario (T4BSRN) (Figure 3.2-19). The predicted decreases in daily variability at the Oregon-California 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 J.C. Boyle Peaking Reach, slightly reducing this variability would not be considered a beneficial effect.

For the free-flowing reaches of the river replacing Copco No. 1 and Iron Gate reservoirs, long-term dissolved oxygen levels in the river would differ substantially from the super-saturation (i.e., greater than 100 percent saturation) that currently occurs in surface waters and the hypolimnetic oxygen depletion in that occurs in bottom waters of the reservoirs during the April/May through October/November period (see Section 3.2.2.5 *Dissolved Oxygen*). Dissolved oxygen in the free-flowing reaches of the river replacing the reservoirs would not exhibit such extremes and would instead show the typical dissolved oxygen concentrations of a flowing river. Long-term increases in summer and fall dissolved oxygen would be beneficial. Long-term dissolved oxygen levels or variability during winter and spring would not be significantly different under the Proposed Project compared to existing conditions, so the Proposed Project would not have the potential to cause or substantially exacerbate an exceedance of water quality standards or result in a failure to maintain existing beneficial uses currently supported, and would therefore have a less than significant impact on winter and spring dissolved oxygen concentrations for the Hydroelectric Reach.

Note that the Klamath River TMDL model scenarios are useful for informing impacts associated with the Proposed Project and alternatives identified in Section 4 *Alternatives*, but they include as a starting assumption that there will be full implementation of the TMDLs. For example, the "TMDL dams-in" (T4BSRN) and "TMDL dams-out" (TOD2RN) scenarios for California both assume that water entering into California from Oregon meets California water quality standards for water temperature, organic enrichment/low dissolved oxygen, nutrients, pH, and microcystin. In other words, the starting point for the California models is that all necessary reductions in pollution to address the current impaired conditions at the Oregon-California state line for these constituents would already have been implemented upstream. The full TMDL compliance modeling assumption does not reflect the existing conditions, and it would be speculative at this point to identify either the mechanisms necessary to implement the TMDLs or the timing required to achieve full compliance. However, the dissolved oxygen mechanism modeled in the Klamath River TMDLs would be the same even if model inputs for dissolved oxygen were changed to concentrations under existing conditions, such that the general trend indicated by the Klamath River TMDL model output (i.e., dam removal would eliminate the seasonal thermal stratification and phytoplankton bloom patterns that occur in the reservoirs under existing conditions and affect dissolved oxygen) is still informative for conditions where full TMDL compliance has not occurred.

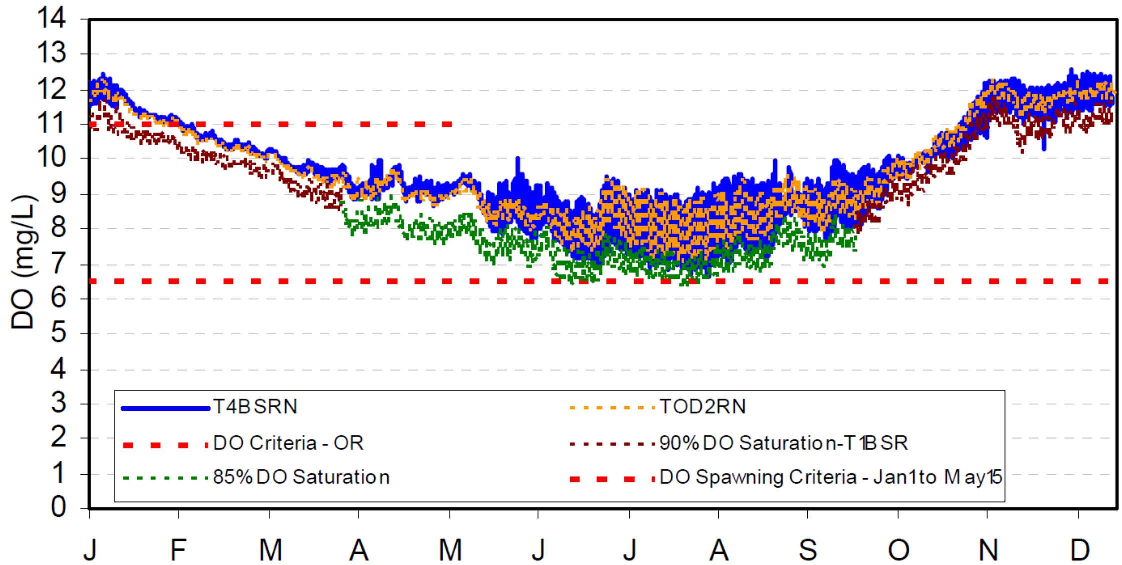


Figure 3.2-19. Predicted Dissolved Oxygen at the Oregon-California State Line (RM 214.1) for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional Board 2010.

Middle and Lower Klamath River, Klamath River Estuary, and Pacific Ocean Nearshore Environment

The 2004/2005 KRWQM results using 2001 to 2004 data indicate that substantial improvements in long-term dissolved oxygen may occur immediately downstream from Iron Gate Dam if the Lower Klamath Project dams are removed, with increases of three to four mg/L possible during summer and late fall (PacifiCorp 2005a). The 2004/2005 KRWQM output also predicts greater daily variations in dissolved oxygen concentrations downstream from Iron Gate Dam to the Trinity River confluence (RM 43.3) in the absence of the Lower Klamath Project 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 magnitude and spatial trends in total nitrogen and chlorophyll-*a* concentrations estimated by the 2004/2005 KRWQM were different than measured total nitrogen and chlorophyll-*a* concentrations. The 2004/2005 KRWQM total nitrogen concentrations remained essentially unchanged from Iron Gate Dam to the Klamath River Estuary, but field measurements showed that total nitrogen concentrations typically decrease between Iron Gate Dam and the Klamath River Estuary. Additionally, a comparison of modeled and measured chlorophyll-*a* concentrations indicated that the 2004/2005 KRWQM consistently overestimated the chlorophyll-*a* concentrations in the Iron Gate Dam to Klamath River Estuary reach of the Klamath River (Asarian and Kann 2006b), suggesting that the model was overestimating algal growth in the Klamath River. While the cause of the discrepancy between the modeled and measured total nitrogen and chlorophyll-*a* was not determined, the assumption of relatively high nutrient contributions from tributaries was identified as a potential source of the discrepancy (Asarian and Kann 2006b). Thus, the 2004/2005 KRWQM results likely consistently overestimate phytoplankton and periphyton growth in the Klamath River downstream of Iron Gate Dam and the associated dissolved oxygen production and respiration, and therefore the 2004/2005 KRWQM dissolved oxygen results would likely overestimate the daily variations in dissolved oxygen.

Like the 2004/2005 KRWQM model, the Klamath River TMDL model (see Appendix D) also indicates that under the “TMDL dams-out” scenario for California reaches (TCD2RN), long-term dissolved oxygen concentrations immediately downstream from Iron Gate Dam during July through November would be greater than those under the “TMDL dams-in” scenario (T4BSRN), 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 3.2-20). Although the Klamath River TMDL model assumes full TMDL compliance (see below discussion regarding applicability of this assumption for analysis of the Proposed Project), the “TMDL dams-in” scenario (T4BSRN) results follow the same basic trend as existing conditions dissolved oxygen concentrations immediately downstream of Iron Gate Dam, where concentrations regularly fall below 8.0 mg/L and the Basin Plan minimum dissolved oxygen criteria of 85 to 90 percent saturation (depending on season) (see also Section 3.2.2.5 *Dissolved Oxygen*). Under existing conditions, low dissolved oxygen concentrations during late summer and fall continue to occur immediately downstream of Iron Gate Dam despite ongoing turbine venting at the Iron Gate Powerhouse required under KHSA Interim Measure 3.

The Klamath River TMDL model also predicts that daily fluctuations in dissolved oxygen immediately downstream of Iron Gate Dam during June through October would be greater under the “TMDL dams-out” scenario for California reaches (TCD2RN) than the “TMDL dams-in” scenario (T4BSRN) (Figure 3.2-20), 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. Again, although the Klamath River TMDL model assumes full TMDL compliance (see below discussion regarding applicability of this assumption for analysis of the Proposed Project), the “TMDL dams-in” scenario (T4BSRN) results follow the same basic trend as existing conditions dissolved oxygen percent saturation immediately downstream of Iron Gate Dam, where concentrations regularly fall below the Basin Plan minimum dissolved oxygen criteria of 85 to 90 percent saturation during June through October (see also Section 3.2.2.5 *Dissolved Oxygen*).

Differences in long-term dissolved oxygen concentrations and percent saturation between the “TMDL dams-out” scenario and the “TMDL dams-in” scenario 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 132.7) and no differences by the confluence with the Trinity River (RM 43.3) (see Figure 3.2-20 to Figure 3.2-23). The Klamath River TMDL model trends are consistent with existing conditions for this reach (see also Section 3.2.2.5 *Dissolved Oxygen*).

At modeled locations, the Klamath River TMDL model indicates consistent compliance with the Basin Plan water quality objective of 85 percent saturation (see Figure 3.2-20 to Figure 3.2-23). Further downstream, near the confluence with the Trinity River (see Figure 3.2-23), results also indicate that while minimum values may occasionally dip below the current Hoopa Valley Tribe minimum water quality objective (8 mg/L, applicable at approximately RM 45), they would not fall below the 85 percent saturation objective modeled for the TMDL and would likely also not fall below the 90 percent saturation[44] Hoopa Valley Tribe objective[45]. Winter time (January through March) dissolved oxygen concentrations would be slightly lower under the Proposed Project but would not fall below Basin Plan minimum criteria for the winter season (90 percent saturation). The Klamath River TMDL model trends are consistent with existing conditions for this reach (see also Section 3.2.2.5 *Dissolved Oxygen*).

Note that the Klamath River TMDL model scenarios are useful for informing impacts associated with the Proposed Project and alternatives identified in Section 4 *Alternatives*, but they include as a starting assumption that there will be full implementation of the TMDLs. For example, the “TMDL dams-in” (T4BSRN) and “TMDL dams-out” (TOD2RN) scenarios for California both assume that water entering into California from Oregon meets California water quality standards for water temperature, organic enrichment/low dissolved oxygen, nutrients, pH, and microcystin. In other words, the starting point for the California models is that all necessary reductions in pollution to address the current impaired conditions at the Oregon-California state line for these constituents would already have been implemented upstream. The full TMDL compliance modeling assumption does not reflect the existing condition, and it would be speculative at this point to identify either the mechanisms necessary to

[44] This objective is not shown in Figure 3.2-23, but the general trend for 90 percent saturation can be estimated from the 85 percent saturation shown in the figure.

[45] As noted, there is no difference between the “TMDL dams-in” and “TMDL dams-out” scenarios by the confluence with the Trinity River where the Hoopa Valley Tribe’s water quality standards are applicable.

implement the TMDLs or the timing required to achieve full compliance. However, the dissolved oxygen mechanism modeled in the Klamath River TMDLs would be the same even if model inputs for dissolved oxygen were changed to concentrations under existing conditions, such that the general trend indicated by the Klamath River TMDL model output (i.e., dam removal would eliminate the seasonal thermal stratification and phytoplankton bloom patterns that occur in the reservoirs under existing conditions and affect dissolved oxygen) is still informative for conditions where full TMDL compliance has not occurred.

Under the Proposed Project, the magnitude of the increased daily fluctuations in dissolved oxygen immediately downstream from Iron Gate Dam predicted by the PacifiCorp and Klamath River TMDL modeling efforts contain some uncertainty since the role of photosynthesis and community respiration from periphyton growth in the free-flowing reaches of the river that would replace the reservoirs at the Lower Klamath Project is unknown because nutrient cycling and resulting rates of primary productivity under modeled existing conditions are uncertain (see Section 3.4 *Phytoplankton and Periphyton*). Although the magnitude of the increased variability is somewhat uncertain, the overall daily fluctuations in dissolved oxygen are expected to increase in the Middle Klamath River from immediately downstream of Iron Gate Dam to Seiad Valley under the Proposed Project, especially during summer and fall. Even with the increase in daily fluctuations, the dissolved oxygen concentrations from immediately downstream of Iron Gate Dam to Seiad Valley would remain above Basin Plan dissolved oxygen saturation objectives throughout the year, so the Proposed Project would have a less than significant impact on dissolved oxygen in the long term. Downstream of Seiad Valley, the daily fluctuations in dissolved oxygen under the Proposed Project would be similar to existing conditions with the dams and the Proposed Project would have no impact. In addition to the increase in daily fluctuations, the removal of the Lower Klamath Project under the Proposed Project would cause beneficial long-term increases in summer and fall dissolved oxygen in the Middle Klamath River immediately downstream from Iron Gate Dam. Long-term decreases in winter and spring dissolved oxygen in the Middle Klamath River would be less than significant since the dissolved oxygen concentration would remain above Basin Plan dissolved oxygen saturation objectives. Effects would diminish with distance downstream from Iron Gate Dam, such that there would be no measurable impacts on dissolved oxygen by transition to the Lower Klamath River (i.e., the confluence with the Trinity River) and no impacts to the Klamath River Estuary or the Pacific Ocean nearshore environment.

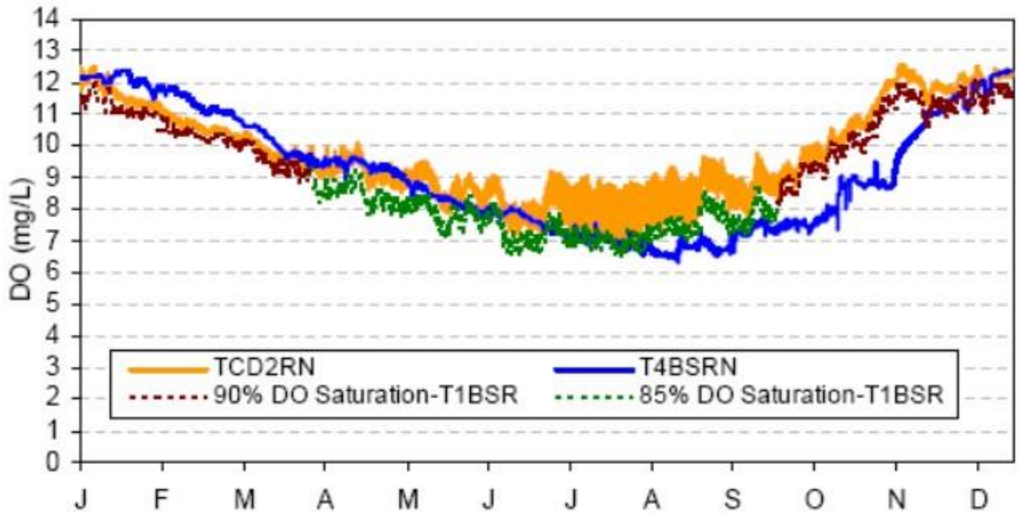


Figure 3.2-20. Predicted Dissolved Oxygen Downstream from Iron Gate Dam for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional Board 2010.

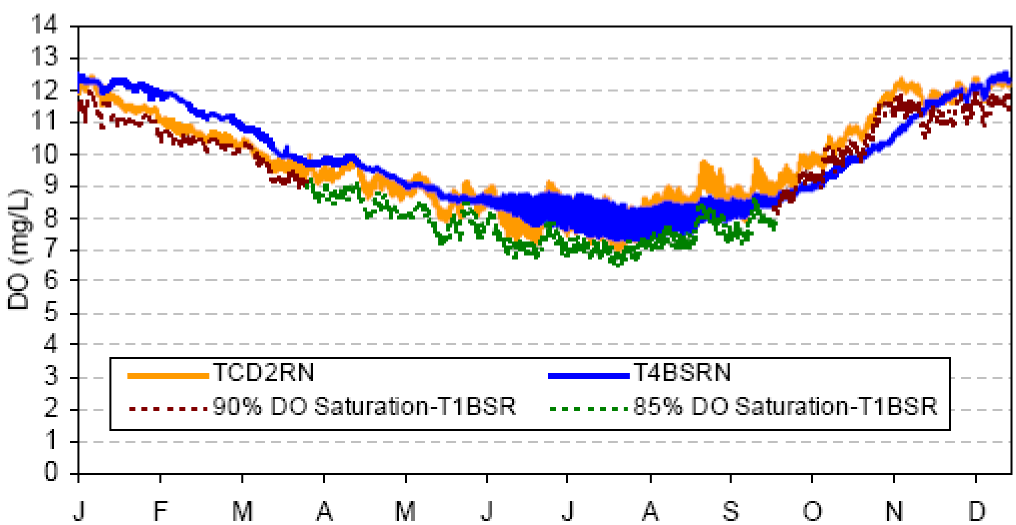


Figure 3.2-21. Predicted Dissolved Oxygen Downstream from the Mainstem Confluence with the Shasta River (RM 179.5) for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional Board 2010.

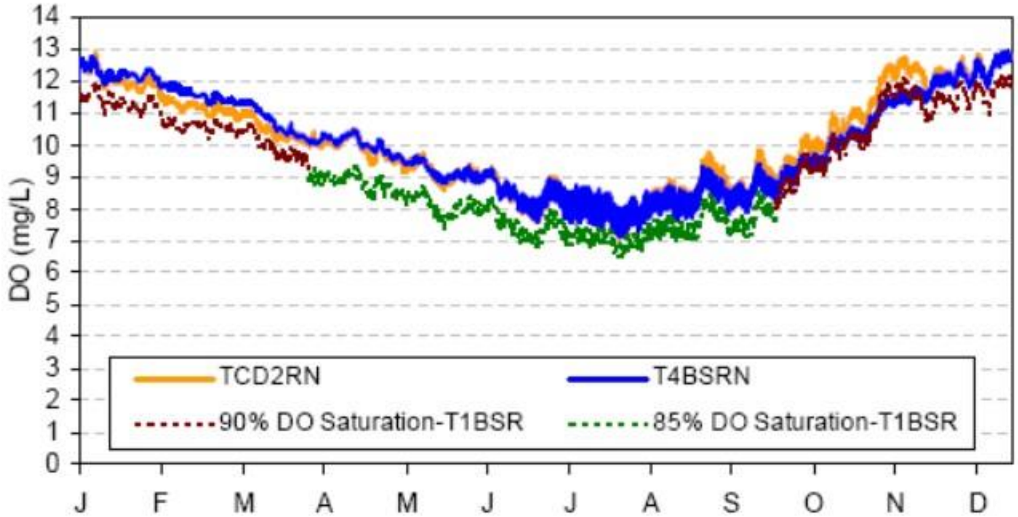


Figure 3.2-22. Predicted Dissolved Oxygen at Seiad Valley (RM 132.7) for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional Board 2010.

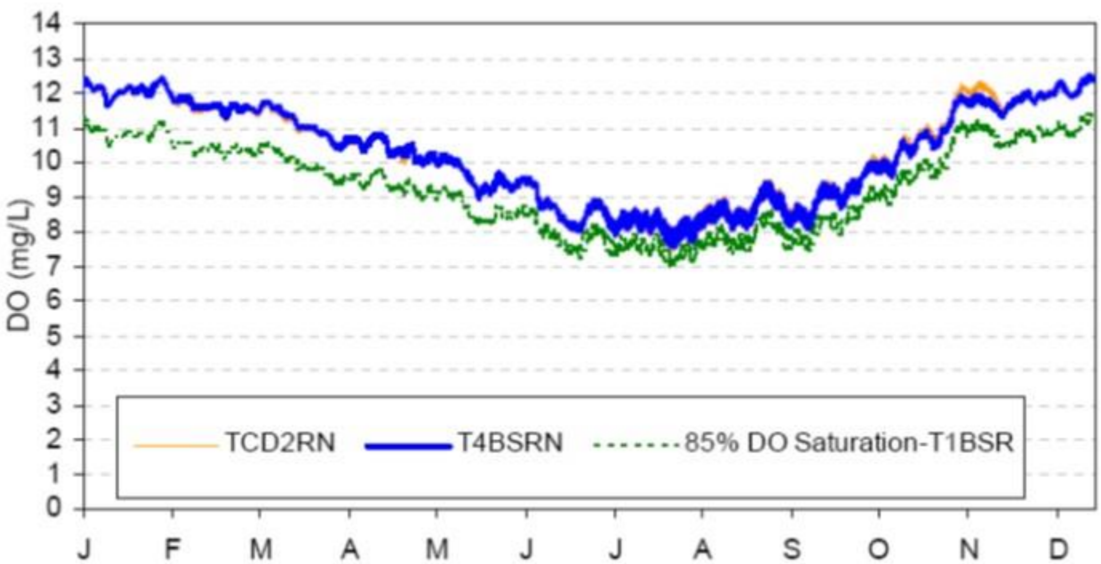


Figure 3.2-23. Predicted Dissolved Oxygen Just Upstream of the Confluence with the Trinity River (RM 43.3) for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional Board 2010.

Significance
No significant impact for daily fluctuations in the Hydroelectric Reach and the Middle Klamath River immediately downstream of Iron Gate Dam

Beneficial for elimination of summer and fall extremes in the Hydroelectric Reach and the Middle Klamath River immediately downstream of Iron Gate Dam

No significant impact for winter and spring concentrations in the Hydroelectric Reach and Middle Klamath River

No significant impact in the Lower Klamath River, Klamath River Estuary, and Pacific Ocean nearshore environment

3.2.5.5 pH

Potential Impact 3.2-11 Alterations in pH and daily pH fluctuations due to a conversion of the reservoir areas to a free-flowing river.
Surface water pH in the water quality Area of Analysis may be affected by changes in the amount of photosynthesis occurring during the summer and fall in the Klamath River. Conversion of the reservoir areas to a free-flowing river would change the available habitat for phytoplankton and/or periphyton, and changes in the growth patterns of these organisms would then change overall pH levels and variability in pH over a diel cycle (i.e., 24-hour period). The Hoopa Valley Tribe water quality objective for pH (7.0 to 8.5) is met the vast majority of the time under the Proposed Project (similar to the TMDL dams-out" [TCD2RN] scenario) for the Middle Klamath River at the reach of Hoopa jurisdiction (approximately RM 45), with a small number of predicted pH values of approximately 8.6 in summer months (July and August).

Hydroelectric Reach
While the Hydroelectric Reach is not currently identified as being impaired for pH specifically and the California Klamath River TMDLs do not include specific allocations or targets for pH itself, pH is identified as a secondary indicator of biostimulation, and pH impacts (i.e., exceedances of Basin Plan numeric pH objectives, see Table 3.2-3) are closely related to excessive nutrient inputs to the Klamath River (North Coast Regional Board 2010). pH values in Copco No. 1 and Iron Gate reservoirs can exceed the Basin Plan instantaneous maximum pH objective of 8.5 s.u., with large (0.5 to 1.5 s.u.) daily fluctuations occurring in reservoir surface waters during summertime periods of intense phytoplankton blooms (see Section 3.2.2.6 *pH*).

Modeling of pH conducted for development of the Klamath River TMDLs (Kirk et al. 2010; North Coast Regional Board 2010) provides information applicable to the assessment of long-term impacts of the Proposed Project on pH levels in the Hydroelectric Reach. Klamath River TMDL model results indicate that under the "TMDL dams-out" scenario for Oregon reaches (TOD2RN), pH at the Oregon-California state line would exhibit less daily variability during spring (March to

May) and fall (October to November) (see Figure 3.2-24) than the "TMDL dams-in" scenario (T4BSRN). Daily variability in river pH during the summertime (June to September) would be similar or somewhat greater under the "TMDL dams-out" scenario (TOD2RN) than the "TMDL dams-in" scenario (T4BSRN), with the slight increase likely due to periphyton growth in the free-flowing river reaches currently occupied by the upstream J.C. Boyle Reservoir and the cessation of hydropower peaking flows in the Peaking Reach that may play a role in preventing establishment of mats under existing conditions. The "TMDL dams-out" scenario (TOD2RN) model results at the Oregon-California state line would occasionally exceed 8.5 s.u. However, because the frequency of exceeding 8.5 s.u. under the "TMDL dams-out" scenario (TOD2RN) would generally be the same as under existing conditions, removal of the Lower Klamath Project dams under the Proposed Project would not result in a failure to meet the instantaneous maximum pH objective at the levels currently supported in either the short term or the long term and there would be no significant impact.

Note that the Klamath River TMDL model scenarios are useful for informing impacts associated with the Proposed Project and alternatives identified in Section 4 *Alternatives*, but they include as a starting assumption that there will be full implementation of the TMDLs. For example, the "TMDL dams-in" (T4BSRN) and "TMDL dams-out" (TOD2RN) scenarios for California both assume that water entering into California from Oregon meets California water quality standards for water temperature, organic enrichment/low dissolved oxygen, nutrients, pH, and microcystin. In other words, the starting point for the California models is that all necessary reductions in pollution to address the current impaired conditions at the Oregon-California state line for these constituents would already have been implemented upstream. The full TMDL compliance modeling assumption does not reflect the existing condition, and it would be speculative at this point to identify either the mechanisms necessary to implement the TMDLs or the timing required to achieve full compliance. Further, the changes in daily fluctuations for pH indicated by the Klamath River TMDL modeling efforts are not entirely certain because growth rates of periphyton (attached algae) that could influence pH through photosynthesis in the free-flowing reaches of the river replacing Copco No. 1 and Iron Gate reservoirs are not precisely known. However, because modeled pH peak values and daily variability would be influenced by increasing nutrient concentrations in both the "TMDL dams-in" (T4BSRN) (from phytoplankton growth in reservoirs) and "TMDL dams-out" (TOD2RN) (from periphyton growth in river reaches) scenarios, the comparative model output is still informative with respect to general trends under conditions where full TMDL compliance has not occurred.

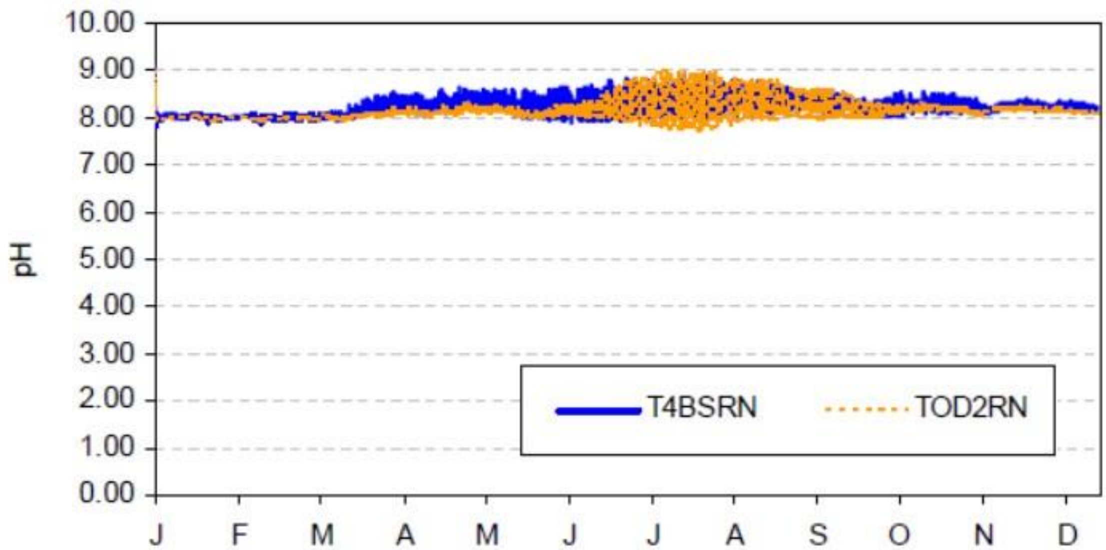


Figure 3.2-24. Predicted pH at the Oregon-California State Line (RM 214.1) for the Klamath River TMDL Scenarios Similar to the Proposed Project (TOD2RN Scenario) and the modeled existing conditions (T4BSRN Scenario). Source: North Coast Regional Board 2010.

The Proposed Project also would be expected to eliminate the occurrence of high pH (greater than 8.5 s.u.) and large daily fluctuations (0.5 to 1.5 s.u.) that occur in the surface waters of Copco No. 1 and Iron Gate reservoirs under existing conditions during periods of intense phytoplankton blooms (see Section 3.2.2.6 *pH*). The pH in the free-flowing reaches of the river replacing these reservoirs would not be likely to exhibit such extremes in daily pH and would not result in a failure to meet the existing instantaneous maximum pH objective at the levels currently supported and would be beneficial.

These beneficial pH changes, which would result from the conversion from a reservoir to a riverine system, would occur immediately following dam removal, in the spring of dam removal year 2. In contrast, the potential for the river reaches that replace Copco No. 1 and Iron Gate reservoirs to support periphyton growth along the river bed that increases variability in daily pH and potentially results in elevated pH values would be constrained in the short term because high SSCs and scour along the newly mobilized river bed during the winter and spring of dam removal year 2, and potentially also post-dam removal year 1, would limit establishment of extensive periphyton mats. Overall, in the short term, the Proposed Project would not result in a failure to meet the instantaneous maximum pH objective relative to the existing conditions in the reservoirs and would be beneficial.

In summary, based on Klamath River TMDL model results, dam removal under the Proposed Project would result in a similar frequency of exceeding 8.5 s.u. as existing conditions at the Oregon-California state line, and thus there would be no significant impact the short term and the long term. The decrease in high summertime daily pH fluctuations in the free-flowing reaches of the river that replace Copco No. 1 and Iron Gate reservoirs in the Hydroelectric Reach would not result in a failure to meet the instantaneous maximum pH objective at the levels currently supported and would be beneficial in the short term.

Middle and Lower Klamath River, Klamath River Estuary, and Pacific Ocean nearshore environment

Modeling of pH conducted for the development of the California Klamath River TMDLs also provides information applicable to the assessment of long-term impacts of the Proposed Project on pH in the Middle and Lower Klamath River. In general, results from the Klamath River TMDL model (see Appendix D) indicate that the "TMDL dams-out" (TCD2RN) scenario for California would result in relatively large daily variations in pH and generally high pH levels during summer and fall in the Middle Klamath River downstream from Iron Gate Dam (Figure 3.2-25); this pattern is characteristic of periphyton growth in river reaches. Although this condition would be in contrast to the "TMDL dams-in" (T4BSRN) scenario, where the Klamath River TMDL model predicts relatively low daily variation in pH in summer and fall (Figure 3.2-25), the higher daily pH variation and overall pH levels indicated for the "TMDL dams-out" (TCD2RN) scenario downstream from Iron Gate Dam are very similar to those under existing conditions (see Section 3.2.2.6 *pH*). This indicates that dam removal under the Proposed Project would not result in a failure to meet the instantaneous maximum pH objective relative to the levels currently supported downstream from Iron Gate Dam and there would be no significant impact.

Note that while the Klamath River TMDL model scenarios are useful for informing impacts associated with the Proposed Project and alternatives identified in Section 4 *Alternatives*, they include as a starting assumption that there will be full implementation of the TMDLs. For example, the "TMDL dams-in" (T4BSRN) and "TMDL dams-out" (TOD2RN) scenarios for California both assume that water entering into California from Oregon meets California water quality standards for water temperature, organic enrichment/low dissolved oxygen, nutrients, pH, and microcystin. In other words, the starting point for the California models is that all necessary reductions in pollution to address the current impaired conditions at the Oregon-California state line for these constituents would already have been implemented upstream. Although the "TMDL dams-out" (TCD2RN) scenario downstream of iron Gate Dam produces predicted pH values that are very similar to existing conditions, the full TMDL compliance modeling assumption does not, in fact, reflect the existing condition, particularly within the existing reservoirs. As described in Section 3.2.2.6 *pH,* the reservoirs are characterized by high daily variability and pH values that exceed 8.5 s.u. on a seasonal basis due to large phytoplankton blooms in summer and fall. Because the "TMDL dams-in" (T4BSRN) scenario shown in Figure 3.2-26 represents full compliance, it also displays evidence of limited phytoplankton production in the upstream reservoirs and hence lower pH peak values and daily variability as compared with existing conditions.

In general, because the changes in daily fluctuations for pH indicated by the Klamath River TMDL modeling efforts are not entirely certain, growth rates of periphyton (attached algae) that could influence pH through photosynthesis in the Middle and Lower Klamath River are not precisely known. However, because modeled pH peak values and daily variability would be influenced by increasing nutrient concentrations in both the “TMDL dams-in” (T4BSRN) (from phytoplankton growth in reservoirs) and “TMDL dams-out” (TCD2RN) (from periphyton growth in river reaches) scenarios, the comparative model output is still informative with respect to general trends under conditions where full TMDL compliance has not occurred.

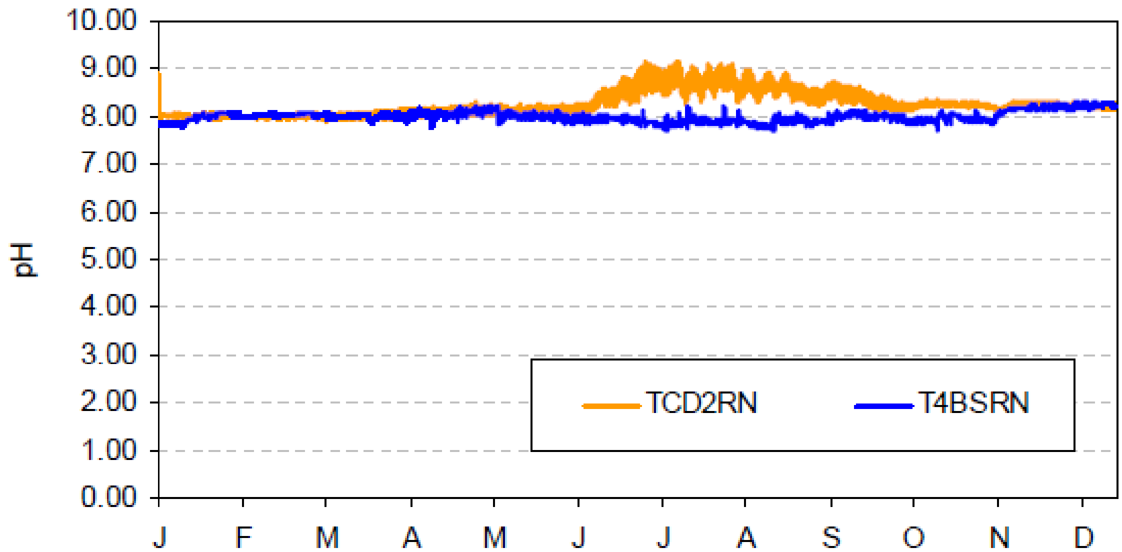


Figure 3.2-25. Predicted Klamath River pH Immediately Downstream from Iron Gate Dam for the Klamath River TMDL Scenarios Similar to the Proposed Project (TCD2RN Scenario) and the No Project Alternative (T4BSRN Scenario). Source: North Coast Regional Board 2010.

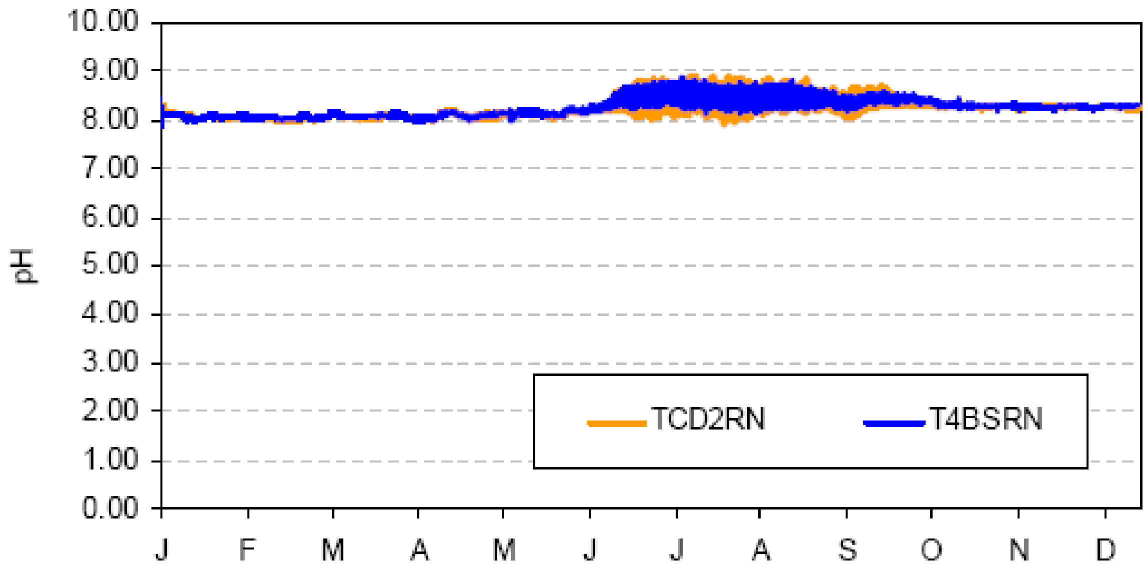


Figure 3.2-26. Predicted Klamath River pH upstream of the Scott River (RM 145.1) for the Klamath River TMDL Scenarios Similar to the Proposed Project (TCD2RN Scenario) and the No Project Alternative (T4BSRN Scenario). Source: North Coast Regional Board 2010.

As discussed above, the Proposed Project also would be expected to eliminate the occurrence of high pH (greater than 8.5 s.u.) and large daily fluctuations (0.5 to 1.5 s.u.) that occur in the surface waters of Copco No. 1 and Iron Gate reservoirs under existing conditions during periods of intense phytoplankton blooms, where the blooms can be transported downstream into the Middle Klamath River and adversely affect pH (see Section 3.2.2.6 *pH*). Consequently, under the Proposed Project pH in the Middle Klamath River immediately downstream of Iron Gate Reservoir would not be likely to exhibit extremes in daily pH due to seasonal phytoplankton blooms, which would reduce the potential for a failure to meet the instantaneous maximum pH objective at the levels currently supported and would be beneficial in the long term.

Klamath River TMDL modeling indicates that the Hoopa Valley Tribe water quality objective for pH (7.0 to 8.5) would be met the vast majority of the time under the Proposed Project (similar to the TMDL dams-out" [TCD2RN] scenario) for the Middle Klamath River at the reach of Hoopa jurisdiction (approximately RM 45), with a small number of predicted pH values of 8.5 or 8.6 in July and August. The Yurok Tribe water quality objective for pH (6.5 to 8.5) would be met at all times under the "TMDL dams-out" (TCD2RN) scenario for the Middle Klamath River at the reach of Hoopa jurisdiction (approximately RM 45). This suggests that dam removal under the Proposed Project would not increase the potential for exceedance of the instantaneous maximum pH objective relative to the existing conditions downstream from Iron Gate Dam.

While Klamath River TMDL modeling contains uncertainty about the periphyton response to dam removal within the Hydroelectric Reach and it assumes full TMDL compliance (see above discussion), monitoring data at multiple locations further downstream in the Middle and Lower Klamath River indicate that pH patterns over a 24-hour period are driven primarily by photosynthesis and respiration of periphyton (Ward and Armstrong 2010; Asarian et al. 2015; see Section 3.4.2.2 *Periphyton*) rather than phytoplankton. Since N-fixing species dominate the periphyton communities in the lower portions of the Middle Klamath River as well as the Lower Klamath River where inorganic nitrogen concentrations are low (Asarian et al. 2010, 2014, 2015), changes in nutrients due to dam removal are not expected to significantly alter the total periphyton biomass in these reaches (see Potential Impact 3.4-5). Thus, there is no evidence to indicate that there would be a change in pH relative to existing conditions that would have the potential to cause or substantially exacerbate an exceedance of water quality standards or result in a failure to maintain existing beneficial uses currently supported in these periphyton-dominated reaches, the downstream Klamath River Estuary, and the Pacific Ocean nearshore environment under the Proposed Project, and therefore there would be a less than significant impact to pH in the long term.

The beneficial pH changes in the Middle Klamath River immediately downstream of Iron Gate Dam that would result from the conversion from a reservoir to a riverine system in the upstream Hydroelectric Reach, would occur immediately following dam removal, in the spring of dam removal year 2. In contrast, the potential for this reach to support periphyton growth along the river bed that increases variability in daily pH and potentially results in elevated pH values would be constrained in the short term because high SSCs and scour along the newly mobilized river bed during the winter and spring of dam removal year 2, and potentially also post-dam removal year 1, would limit establishment of extensive periphyton mats. Overall, in the short term, the Proposed Project would reduce the potential for a failure to meet the instantaneous maximum pH objective relative to the existing conditions and would be beneficial.

The Definite Plan (see Appendix B: *Definite Plan – Appendix M*) includes a Water Quality Monitoring Plan to assess the Proposed Project's impacts to water quality, and this plan includes pH monitoring. Please note that the State Water Board has authority to review and approve any final Water Quality Monitoring Plan through its water quality certification under Clean Water Act Section 401. The State Water Board has issued a draft water quality certification which sets forth monitoring and adaptive management requirements for any Water Quality Monitoring Plan to meet, as Condition 1.[46] Additionally, the Oregon Department

[46] The State Water Board's draft water quality certification is available at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_dwqc.pdf (Accessed December 14, 2018).

of Environmental Quality has issued a water quality certification[47] that sets forth water quality monitoring and adaptive management conditions for points upstream of California. Because the effect of the Proposed Project on pH is anticipated to be beneficial or would not result in a significant impact in either the short and long term, this analysis of Potential Impact 3.2-11 does not further discuss the water quality monitoring and adaptive management conditions.

Significance

No significant impact for the Hydroelectric Reach at Oregon-California state line in the short term and long term.

Beneficial for the Hydroelectric Reach from Copco No. 1 Reservoir to Iron Gate Dam in the short term and long term.

No significant impact for the Middle Klamath River downstream of Iron Gate Dam, the Lower Klamath River, the Klamath River Estuary, and the Pacific Ocean nearshore environment in the short term and long term.

3.2.5.6 Chlorophyll-a and Algal Toxins

Potential Impact 3.2-12 Alterations in chlorophyll-*a* and algal toxins due to a conversion of the reservoir areas to a free-flowing river.

While fast-moving rivers do not provide good habitat for phytoplankton growth, slow-moving, calm water like the reservoirs created by Copco No. 1 and Iron Gate dams provide ideal habitat conditions for phytoplankton growth, especially blue-green algae species (see Section 3.2.2.7 *Chlorophyll-a and Algal Toxins*, Section 3.4.2.1 *Phytoplankton*, and Appendix C – Section C.6 *Chlorophyll-a and Algal Toxins*). Chlorophyll-*a* is a pigment produced by phytoplankton, including blue-green algae, so concentrations of chlorophyll-*a* are often used to evaluate whether there is excessive phytoplankton growth in rivers, lakes, or reservoirs. Most importantly, several types of blue-green algae produce algal toxins, especially during excessive growth of blue-green algae (i.e., blooms), that can have negative health impacts on animals and humans (see Section 3.2.2.7 *Chlorophyll-a and Algal Toxins*, Section 3.4.2.1 *Phytoplankton*, and Appendix C – Section C.6 *Chlorophyll-a and Algal Toxins*). Thus, the potential changes to chlorophyll-*a* and algal toxins due to conversion of the reservoir areas to a free-flowing river are evaluated to determine the potential impacts to water quality.

Hydroelectric Reach

Despite the slightly increased total nutrient concentrations anticipated under the Proposed Project in the Hydroelectric Reach (see Potential Impact 3.2-8), elimination of the slow-moving reservoir environment that currently supports

[47] The Oregon Department of Environmental Quality's final water quality certification is available at: https://www.oregon.gov/deq/FilterDocs/ferc14803final.pdf (Accessed December 14, 2018).

growth for toxin-producing nuisance blue-green algae (e.g., *Microcystis aeruginosa*) would decrease the occurrence of high seasonal concentrations of chlorophyll-a (concentrations greater than 10 ug/L) and periodically high levels of algal toxins (e.g., concentrations greater than 0.8 and/or 4 ug/L microcystin; see Section 3.2.3.1 *Thresholds of Significance*) generated by suspended blue-green algae (see Potential Impact 3.4-2). This would be a beneficial effect.

Note that while some periphyton species are capable of producing algal toxins, including microcystin and anatoxin-a (Heath et al. 2011; Quiblier et al. 2013; see Section 3.2.2.7 *Chlorophyll-a and Algal Toxins*), available data indicate that algal toxin presence (i.e., microcystin and anatoxin-a) in the Klamath River corresponds to high concentrations of phytoplankton blue-green algae cells (i.e., algae blooms of *Microcystis aeruginosa* for microcystin or *Anabaena flos-aquae* for anatoxin-a) (Kann and Corum 2006, 2007, 2009; Kann 2006, 2007a,b,c,d, 2008b; Jacoby and Kann 2007; CH2M Hill 2008; Kann et al. 2010a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017; Otten et al. 2015).

Drawdown of the reservoirs would begin in winter and would be largely complete by March/April (i.e., the beginning of the algal growth season) of dam removal year 2, so complete elimination of the reservoir environment under the Proposed Project would occur by the end of dam removal year 2. Thus, the decrease in high seasonal chlorophyll-*a* concentrations and periodic high algal toxin concentrations would also occur by the end of dam removal year 2 due to the elimination of reservoir habitat that supported algal growth. Therefore, reductions in chlorophyll-*a* and algal toxins in the Hydroelectric Reach would be a short-term benefit as well as a long-term benefit since the reduction would begin during dam removal year 2 and it would continue beyond post-dam removal year 1.

In the long term, the Proposed Project would not alter the transport of chlorophyll-*a* into the Hydroelectric Reach from upstream sources. Under existing conditions, chlorophyll-*a* concentrations measured upstream of J.C. Boyle Reservoir, including episodic large fluxes of chlorophyll-*a* associated with algal blooms, are generally similar to or less than chlorophyll-*a* concentrations in Copco No. 1 and Iron Gate reservoirs and immediately downstream of Iron Gate Dam. The Proposed Project does not include any changes to Klamath River conditions upstream of J.C. Boyle Reservoir, so chlorophyll-*a* measured at the upstream end of J.C. Boyle Reservoir would represent the maximum chlorophyll-*a* entering the Hydroelectric Reach under the Proposed Project. Turbulent-mixing conditions in the river are expected to continue to decrease chlorophyll-*a* in the Hydroelectric Reach between J.C. Boyle Dam and the upstream end of Copco No. 1 Reservoir under the Proposed Project, as is the case under existing conditions. The conversion of the reservoirs to free-flowing, turbulent river reaches would likely result in a slight decrease in chlorophyll-*a* through the Hydroelectric Reach under the Proposed Project compared to existing conditions. Thus, under the Proposed Project long-term chlorophyll-*a* concentrations in the Hydroelectric Reach due to transport of chlorophyll-*a* into this reach from upstream sources, including episodic large fluxes, would be similar to or less than existing conditions.

Middle and Lower Klamath River and the Klamath River Estuary

In addition to the decreases in the occurrence of high seasonal concentrations of chlorophyll-a (concentrations greater than 10 ug/L) and periodically high levels of algal toxins (concentrations greater than 0.8 and/or 4 ug/L microcystin; see Section 3.2.3.1 *Thresholds of Significance*) generated by toxin-producing nuisance blue-green algae that are described for the Hydroelectric Reach, transport and growth of *Microcystis aeruginosa* in the Middle and Lower Klamath River would be substantially reduced or eliminated in the absence of significant Lower Klamath Project reservoir blooms. Genetic and toxin analyses show that the *Microcystis aeruginosa* populations in Copco No. 1 and Iron Gate reservoirs are genetically distinct from each other and upstream populations, providing evidence that blue-green algae blooms in Iron Gate Reservoir are internally derived and not due to transport of *Microcystis aeruginosa* populations from Copco No. 1 Reservoir or further upstream (Otten et al. 2015). While algal toxins generated in Copco No. 1 could be transported downstream, Otten et al. (2015) document with genetic analysis that algal production in Iron Gate Reservoir is the principal source of *Microcystis aeruginosa* responsible for the observed public health exceedances occurring in the Klamath River downstream from Iron Gate Dam (see Section 3.2.2.7 *Chlorophyll-a and Algal Toxins*, Section 3.4.2.3 *[Phytoplankton and Periphyton] Hydroelectric Reach* and Appendix C, Section C.6 *Chlorophyll-a and Algal Toxins*). Therefore, removal of the reservoirs under the Proposed Project would eliminate *in situ* production of seasonal blue-green algae blooms and the associated algal toxins and chlorophyll-*a*. While algal toxins and chlorophyll-*a* produced in Upper Klamath Lake may still be transported downstream after dam removal, existing data indicate that microcystin concentrations in the Klamath River typically decrease to below California water quality objectives (see Section 3.2.3.1 *Thresholds of Significance*) by the upstream end of J.C. Boyle Reservoir, regardless of the microcystin concentration measured leaving the Upper Klamath Lake (Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017). Microcystin concentrations greater than California water quality objectives have been infrequently measured to increase in J.C. Boyle Reservoir adjacent to Topsy Campground compared to microcystin concentrations in the Klamath River upstream of the reservoir (Watercourse Engineering, Inc, 2016, 2017; E&S Environmental Chemistry 2018a), suggesting localized *Microcystis aeruginosa* growth and microcystin production within J.C. Boyle Reservoir. The potential for localized *Microcystis aeruginosa* growth within J.C. Boyle Reservoir and high microcystin concentrations in the reservoir that could be transported downstream of J.C. Boyle Dam (E&S Environmental Chemistry 2018a) would be eliminated under the Proposed Project since the slower-moving reservoir habitat in this reach would be eliminated under the Proposed Project. Thus, algal toxins and chlorophyll-*a* production upstream of J.C. Boyle Dam would not be expected to be transported into California and result in algal toxin or chlorophyll-*a* concentrations in a manner that would cause or substantially exacerbate an exceedance of water quality standards or would result in a failure to maintain existing beneficial uses currently supported.

As discussed for the Hydroelectric Reach, while some periphyton species are capable of producing algal toxins, available data indicate that the algal toxin presence (i.e., microcystin and anatoxin-a) in the Klamath River corresponds to high concentrations of phytoplankton blue-green algae cells (i.e., algae blooms of *Microcystis aeruginosa* for microcystin or *Anabaena flos-aquae* for anatoxin-a) (Kann and Corum 2006, 2007, 2009; Kann 2006, 2007a,b,c,d, 2008b; Jacoby and Kann 2007; CH2M Hill 2008; Kann et al. 2010a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017; Otten et al. 2015).

The water velocity and constant mixing in the Middle and Lower Klamath River generally create an environment that is not supportive of toxin-producing blue-green algae growth or reproduction (Genzoli and Kann 2017). While higher concentrations of blue-green algae cells and algal toxins have been measured in calm, slow-moving habitats along shorelines, protected coves, and backwaters along the Klamath River than in the faster-moving open channel river habitats (Kann et al. 2010a; Genzoli and Kann 2017), growth and/or reproduction of blue-green algae within these habitats have not been documented. Measurements of blue-green algae (e.g., *Microcystis aeruginosa*) and algal toxins (e.g., microcystin) along shoreline habitats occasionally exceed 2016 CCHAB secondary thresholds and WHO guidelines under existing conditions, but these high concentrations of blue-green algae cells and associated algal toxins are generally attributed to entrapment and accumulation of cells and toxins transported downstream from the reservoirs rather than growth and/or reproduction within these slow-moving shoreline habitats (Falconer et al. 1999; Kann et al. 2010a; State Water Board et al. 2010, updated 2016; Genzoli and Kann 2016, 2017). Furthermore, longitudinal decreases in the measured *Microcystis aeruginosa* cell densities and microcystin downstream of Iron Gate Dam in both slow-moving shoreline and open channel habitats suggest *Microcystis aeruginosa* cells and microcystin are being transported downstream into these shoreline habitats and phytoplankton growth is limited in these slow-moving shoreline habitats (Genzoli and Kann 2017). While algal toxins upstream of J.C. Boyle Dam would not be expected to be transported into California and the transport of algal toxins from the Lower Klamath Project reservoirs would be eliminated under the Proposed Project, these calm, slow-moving shoreline, protected cove, and backwater habitats in the Middle and Lower Klamath River, especially during low-flow periods, would potentially continue to provide suitable slow-moving blue-green algae habitat. Thus, some blue-green algae growth and algal toxin production may still occur in these Middle and Lower Klamath River habitats after dam removal. Overall, the magnitude of the algal toxin concentrations in these calm, slow-moving shoreline, protected cove, and backwater habitats in the Middle and Lower Klamath River under the Proposed

Project would be similar to or less than existing conditions since these habitats already have elevated algal toxin concentrations periodically under existing conditions (Kann et al. 2010a; Genzoli and Kann 2017) and the transport of blue-green algae (e.g., *Microcystis aeruginosa*) and algal toxins (e.g., microcystin) from reservoirs in the Hydroelectric Reach into the Middle and Lower Klamath River would be eliminated under the Proposed Project.

Drawdown of the reservoirs would begin in winter and would be largely complete by March/April (i.e., the beginning of the growth season) of dam removal year 2, so complete elimination of the reservoir environment that transports blue-green algae, algal toxins, and chlorophyll-*a* in the Middle and Lower Klamath River and the Klamath River Estuary would occur by the end of dam removal year 2 under the Proposed Project. Thus, the decrease in high seasonal chlorophyll-*a* concentrations and periodic high algal toxin concentrations would also occur by the end of dam removal year 2 in the Middle and Lower Klamath River and the Klamath River Estuary due to the elimination of the upstream reservoir habitat. Therefore, reductions in chlorophyll-*a* and algal toxins in the Middle and Lower Klamath River and the Klamath River Estuary would be a short-term benefit as well as a long-term benefit.

The Definite Plan (see Appendix B: *Definite Plan – Appendix M*) includes a Water Quality Monitoring Plan to assess the Proposed Project's impacts to water quality, and this plan includes monitoring of microcystin-producing blue-green algae cell counts. Please note that the State Water Board has authority to review and approve any final Water Quality Monitoring Plan through its water quality certification under Clean Water Act Section 401. The State Water Board has issued a draft water quality certification which sets forth monitoring and adaptive management requirements for any Water Quality Monitoring Plan to meet, as Condition 1.[48] Additionally, the Oregon Department of Environmental Quality has issued a water quality certification[49] that sets forth water quality monitoring and adaptive management conditions for points upstream of California. The effect of the Proposed Project on chlorophyll-*a* and algal toxins is anticipated to be beneficial in both the short and long term, and this analysis of Potential Impact 3.2-12 does not further discuss the water quality monitoring and adaptive management conditions.

[48] The State Water Board's draft water quality certification is available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_dwqc.pdf (Accessed December 11, 2018).

[49] The Oregon Department of Environmental Quality's final water quality certification is available online at: https://www.oregon.gov/deq/FilterDocs/ferc14803final.pdf (Accessed December 11, 2018).

Significance

Beneficial for the Hydroelectric Reach, the Middle and Lower Klamath River, and the Klamath River Estuary

3.2.5.7 Inorganic and Organic Contaminants

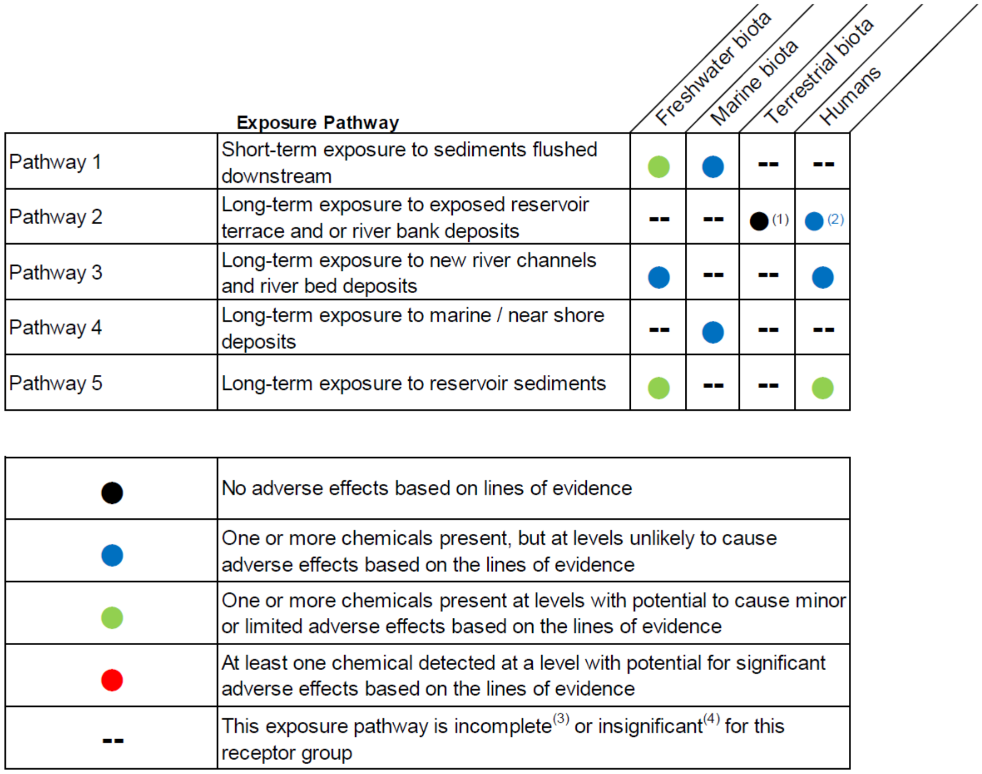
Potential Impact 3.2-13 Human exposure to inorganic and organic contaminants due to release and exposure of reservoir sediment deposits. This potential impact evaluates the potential human exposure to inorganic and organic contaminants in sediments remaining within the reservoir footprints and along the river banks in addition to potential inorganic and organic contaminant concentrations in the river water in the Hydroelectric Reach, the Middle and Lower Klamath River, and the Klamath River Estuary due to the release of sediments currently trapped behind the Lower Klamath Project dams. The two main ways people would be potentially exposed to inorganic or organic contaminants in reservoir sediments would be through direct contact with reservoir sediments or eating fish or shellfish exposed to inorganic or organic contaminants in reservoir sediments. Direct human exposure to reservoir sediments due to recreational uses (e.g., camping, fishing, rafting) are evaluated by comparing inorganic and organic contaminant levels measured in reservoir sediments with USEPA and CalEPA screening levels that are conservatively protective of human health, since those screening levels assume much greater exposure than would occur for reservoir sediments. Human exposure to inorganic and organic contaminants from eating fish or shellfish (e.g., mussels) is evaluated by comparison with available screening level values (SLVs) that assess whether contaminants in sediment would increase in fish or shellfish (i.e., bioaccumulate) to unhealthy levels for humans who eat them. While less likely than direct contact with remaining reservoir sediments after drawdown or eating fish exposed to inorganic and organic contaminants, people also would potentially be exposed to inorganic and organic contaminants from reservoir sediments in river water during drawdown when reservoir sediments and associated inorganic and organic contaminants were being transported. Human exposure to inorganic and organic contaminants from exposure to river water through consumption during drawdown and the transport of reservoirs sediments in the Klamath River is analyzed by comparing applicable human health drinking water standards[50] with the range of potential inorganic and organic contaminant concentrations in the elutriate samples, representing the highest potential concentration of these contaminants during drawdown. Comparison of the applicable human health drinking water standards with reservoir elutriate sample concentrations identified arsenic, aluminum, total PCB, chromium, and lead as detected potential chemicals of concern during reservoir drawdown (CDM 2011) and these are evaluated in more detail with consideration of actual

[50] Human Health drinking water standards are listed Table B-6 of the Screening-Level Evaluation of Contaminants in Sediments from Three Reservoirs and the Estuary of the Klamath River, 2009-2011 (CDM 2011), which is included by reference and provided in Appendix W of this EIR.

concentrations expected during drawdown below. In a review of records maintained by the State Water Board's Division of Water Rights and Division of Drinking Water, only two drinking water diversions were identified in the Klamath River below Iron Gate Dam: (1) CalTrans' Randolph E. Collier Northbound and Southbound Rest Areas located near Hornbrook; and (2) Klamath Community Services District in Del Norte County located near the mouth of the Klamath River. The analysis below addresses the potential drinking water impacts to the Klamath River between the Oregon-California state line to the Klamath River Estuary, with consideration of the Hydroelectric Reach between J.C. Boyle Reservoir and the Oregon-California state line only to the extent it would influence downstream conditions in California.

Hydroelectric Reach

Potential human health risks associated with exposure to remaining sediment deposits within the reservoir footprints (i.e., "exposed reservoir terraces" as defined by CDM [2011]) and river banks within the Hydroelectric Reach were evaluated using comparisons of the 2009 to 2010 Klamath Dam Removal Secretarial Determination reservoir sediment core data to USEPA and CalEPA residential soil screening levels, and calculation of human/mammal toxic equivalency values (TEQs) ("Exposure Pathway 2 and 3" in CDM [2011]) (Figure 3.2-27). The analysis of exposure pathways using the 2009 SEF screening levels was updated based on 2018 SEF screening levels, as appropriate (Appendix C – *Section C.7*).



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 3.2-27. Summary of Exposure Pathway Conclusions for Inorganic and Organic Contaminants. Source: CDM 2011.

As part of the Secretarial Determination process, the Water Quality Sub-Team identified USEPA soil screening levels and CalEPA California Human Health Screening Levels (CHHSLs) for soil as appropriate thresholds for determining the potential for sediment contaminants to adversely affect human health. USEPA residential exposure uses a 30-year exposure duration, 365 days per year exposure frequency with a soil ingestion rate of 200 mg/day for children over 6 years and 100 mg/day for adults over 24 years (USEPA 1991). CalEPA CHHSLs are based on the USEPA approach, with the residential exposure using a 30 year duration, 350 days per year exposure frequency with a soil ingestion rate of 200 mg/day for children over 6 years and 100 mg/day for adults over 24 years and the commercial exposure using a 25 year duration, 250 days per year exposure frequency with a soil ingestion rate of 200 mg/day for children over 6 years and 100 mg/day for adults over 24 years (Hristov et al. 2005). In the short term, human exposure to inorganic and organic contaminants in sediments deposited on exposed reservoir terraces and river banks within the Hydroelectric

Reach would be limited, short duration, non-residential exposure patterns (e.g., construction and restoration activities), resulting in less exposure to inorganic or organic contaminants (i.e., a lower ingestion rate of soil) than assumed for the USEPA and CalEPA screening levels. For example, construction/restoration worker exposure of 100 days per year for 5 years would result in only 4.8 percent of the CalEPA residential exposure. While the USEPA and CalEPA residential and commercial soil screening levels are used to evaluate the potential for adverse effects to humans, applying the USEPA and CalEPA screening levels considerably overstates the potential impact and the presence of a chemical at concentrations in excess of a USEPA and/or CalEPA screening level does not indicate that adverse impacts to human health would occur. Thus, the initial analysis of potential exposure and conclusions based on the USEPA and CalEPA screening levels would provide a very conservative estimate of potential adverse effects to humans and further interpretation of the comparisons of screening levels and inorganic and organic contaminant results, including an analysis of the exposure pathways, is necessary to assess the actual potential for human health impacts.

USEPA provides screening levels for both total carcinogenic (potentially cancer-causing) and total non-carcinogenic (not associated with cancer risk) contaminants. No reservoir sediment 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 No. 1 and Iron Gate reservoirs. Those forty-five samples also exceeded the CalEPA residential and commercial screening levels for arsenic, but they did not exceed the CalEPA screening levels for nickel.

For arsenic, sampled concentrations in the reservoirs ranged from 4.3 to 15 mg/kg (see Section 3.2.2.8 *Inorganic and Organic Contaminants* and Appendix C, Table C-6), which is within the range of available measured arsenic soil concentrations for the Klamath Basin. Arsenic ranges from 0.8 to 23 mg/kg in regional soil samples from the Mid- and Lower Klamath Basin outside of the reservoir areas with typical arsenic concentrations between 2 and 7 mg/kg (USGS NGS 2008). Arsenic may be naturally elevated in the Upper Klamath Basin, with arsenic ranging from approximately 0.6 to 43.0 mg/kg and average regional background arsenic concentrations of 3.99 mg/kg ± 5.03 mg/kg in the vicinity of Upper Klamath Lake (Sturdevant 2010; ODEQ 2013; Sullivan and Round 2016). In comparison, the USEPA total carcinogenic screening level for soils is 0.39 mg/kg and the CalEPA specifies a California Human Health residential soil (0.07 mg/kg) and a commercial soil (0.24 mg/kg) screening levels.

In the long term, the Proposed Project includes the transfer of PacifiCorp lands immediately surrounding the Lower Klamath Project (“Parcel B lands”) (Figure 2.7-18) from PacifiCorp to the KRRC prior to dam removal. The Proposed Project provides that the KRRC will transfer Parcel B lands to the respective states (i.e., California, Oregon), as applicable, or to a designated third-party transferee, following dam removal. The lands would thereafter be managed for public interest purposes (e.g., tribal mitigation, river-based recreation, wetland restoration, etc.) (KHSA Section 7.6.4). Pursuant to the KHSA, decisions about the land use would occur following dam removal, and the outcome of who the lands will ultimately be transferred to and what they will be used for is uncertain. Potential human exposure to arsenic measured in the Lower Klamath Project reservoir sediments under the Proposed Project would be less than that assumed for the USEPA or CalEPA screening levels since the reservoir footprint areas would be unlikely to support residential uses. Further, the exposure potential on the future public lands is likely to be considerably less than the exposure potential for residential uses. Limited, short duration, non-residential exposure patterns (e.g., recreational use) would result in less exposure to arsenic (i.e., a lower ingestion rate of soil). For example, recreational exposure of 10 to 90 days per year, every year for 30 years would result in only 3 to 25 percent of the residential exposure. Thus, overall the Proposed Project would be unlikely to result in short-term or long-term substantive adverse impacts on human health under possible “Exposure Pathway 2” due to arsenic.

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 and the CalEPA screening level is 1,600 mg/kg for residential exposure and 16,000 mg/kg for commercial exposure. 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 Lower Klamath Project 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. As discussed above for arsenic, the Parcel B lands would be transferred to the respective states as part of the Proposed Project and managed for public interest purposes, so potential human exposure to nickel measured in the Lower Klamath Project reservoir sediments under the Proposed Project would be less than that assumed for the USEPA or CalEPA screening levels. The exposure potential on the future public lands is likely to be considerably less than that for residential or commercial uses considered in USEPA and CalEPA screening levels, with recreational use resulting in only 3 to 25 percent of the residential exposure conservatively assuming 10 to 90 days per year, for 30 years exposure patterns. The highest concentrations of nickel were found in sediments from the Klamath River Estuary, which suggests that release of reservoir sediments downstream would not increase nickel concentrations in downstream reaches above existing conditions. Accordingly, the Proposed Project and release of sediments from behind the Lower Klamath Project dams is unlikely to increase the short-term or long-term exposure of humans to concentrations of nickel above Klamath Basin background levels and to result in substantive adverse impacts to human health under possible Exposure Pathway 2 from nickel.

There were 19 analytes measured during 2009 and 2010 that were not detected by laboratory tests; however, the laboratory analytical reporting limits were greater than the applicable human health screening levels (i.e., the standard laboratory tests used could not measure whether the analytes were present above human screening levels because the smallest amount the laboratory tests could detect [i.e., the reporting limit] for those analytes was greater than the human health screening level itself), including some PCBs, VOCs, and SVOCs (CDM 2011). While it is not possible to directly confirm that these compounds are above or below applicable human health screening levels, as described above for arsenic, potential human exposure to reservoir sediment deposits under the Proposed Project, in both the short-term and long-term, would involve limited, short duration, non-residential exposure patterns. Since these analytes were below levels of laboratory detection, and the potential exposure in the short and long-term would be less than the long-term residential levels of exposure, any undetected analytes would be unlikely to result in substantial adverse impacts on human health.

Elutriate concentration results (characterizing the potential chemical concentrations that may be released into the water from reservoir sediments during suspension) from the 2009 to 2010 sediment testing are used to evaluate human consumption exposure to inorganic and organic contaminants in river water during drawdown and transport of reservoirs sediments in the Klamath River. Elutriate concentration results represent the maximum potential concentration of contaminants in the Klamath River during drawdown since they do not take into account the mixing or dilution that would occur during transport of reservoir sediments (CDM 2011). Applicable human health drinking water standards are first compared with elutriate concentrations to provide an initial conservative assessment of human exposure to inorganic and organic contaminants, then elutriate concentrations with consideration of the expected dilution during drawdown are compared with the applicable human health drinking water standards to assess likely human exposure risk.

The dilution of inorganic and organic contaminant elutriate concentrations necessary during drawdown to meet applicable drinking water standards is determined from modeled SSCs since the SRH-1D sediment transport model uses drawdown flows similar to those expected under the Proposed Project in its estimates of SSCs. Variations in flow and dilution downstream of the reservoirs during drawdown would be inherently included in the modeled SSCs so variations in the contaminant concentrations with the potential to adversely impact human health would also be represented within these model results. The ratio of contaminant concentration to SSCs measured in laboratory elutriate tests is assumed to be equal to the ratio of the contaminant concentration to modeled SSCs in the Klamath River during drawdown (CDM 2011). Accordingly, the dilution would decrease as the SSCs increase and the range of dilution in the Klamath River during drawdown can be calculated from the range of maximum modeled SSCs.

In the Hydroelectric Reach downstream of J.C. Boyle to the upstream end of Copco No. 1 Reservoir, the maximum SSCs would range from 2,000 to 3,000 mg/L (see Potential Impact 3.2-3), so dilution of mobilized sediments with reservoir and river water is expected to range from 217- to 325-fold (i.e., concentration in the river would be 217 to 325 times less than the elutriate concentration) immediately downstream of J.C. Boyle during drawdown. In the remainder of the Hydroelectric Reach from the upstream end of Copco No. 1 Reservoir through Iron Gate Reservoir, short-term SSC generally increase in the downstream direction due to the larger sediment deposits in Copco No. 1 and Iron Gate reservoirs contributing to SSCs. The minimum dilution in the Klamath River would occur immediately downstream of Iron Gate Dam during drawdown, where the maximum SSCs would occur from release of sediments in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs. The minimum dilution downstream of Iron Gate Dam would range from 48- to 66-fold (CDM 2011). As a conservative estimate, the J.C. Boyle dilution is used from J.C. Boyle Dam to the upstream end of Copco No. 1 Reservoir and the expected dilution immediately downstream of Iron Gate is used from Copco No. 1 Reservoir to Iron Gate Dam for the analysis of human exposure to inorganic and organic contaminants in the Hydroelectric Reach. The actual SSCs in the Hydroelectric Reach in Copco No. 1 Reservoir to Iron Gate Dam potentially would be less than the maximum SSCs estimated below Iron Gate Dam based on modeled SSCs below the J.C. Boyle and Copco No. 1 dams (see Potential Impact 3.2-3), so the inorganic and organic contaminant concentrations and human exposure to those contaminants in the Hydroelectric Reach of the Klamath River would be less than those estimated using the maximum SSCs estimated below Iron Gate Dam.

Before consideration of dilution, aluminum, arsenic, chromium, lead, and total PCB are the only chemicals present in elutriate sediment sample results at concentrations above Basin Plan, national priority, and national non-priority human health water quality criteria for samples from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs (see Appendix W, Table B-6 for human health water quality criteria) (CDM 2011). After consideration of dilution, chromium, lead, and total PCB concentrations would be less than the most stringent human health drinking water standards in the Hydroelectric Reach from J.C. Boyle Dam to the upstream end of Copco No. 1 Reservoir since the dilution in that portion of the Hydroelectric Reach (217- to 325-fold) is greater than the dilution necessary to meet the most stringent human health drinking water standards for chromium (12-fold), lead (0.3-fold), and total PCB (45-fold). Even after consideration of dilution, aluminum and arsenic concentrations would be greater than the most stringent applicable drinking water standards in the Hydroelectric Reach from J.C. Boyle Dam to the upstream end of Copco No. 1 Reservoir, since the minimum dilution in this portion of the Hydroelectric Reach (217-fold) would be less the dilution necessary for aluminum (219-fold) and arsenic (13,635-fold). In the Copco No. 1 Reservoir to Iron Gate Dam portion of the Hydroelectric Reach after consideration of the range of dilution (48- to 66-fold), the concentrations of chromium and lead would be less than the most stringent applicable drinking water standards. However, aluminum, arsenic, and total PCB concentrations would be greater than the most stringent applicable drinking water standards in this portion of the Hydroelectric Reach, since the range of anticipated dilution immediately downstream of Iron Gate Dam would be less than the dilution for aluminum (219-fold), arsenic (13,635-fold), and total PCB (100-fold) (CDM 2011).

While human exposure to contaminants in Klamath River water would be limited due to restricted access within the Hydroelectric Reach during drawdown, human exposure to concentrations of aluminum, arsenic, and total PCB greater than applicable drinking water standards would potentially occur during drawdown due to elevated SSCs and sediment-associated inorganic and organic contaminants and potentially cause substantial adverse impacts on human health if river water were to be used during drawdown as a drinking water supply. Dilution in the Klamath River necessary to meet the most stringent applicable drinking water standards (i.e., 13,635-fold for arsenic) would occur once SSCs decrease below 47 mg/L. Modeled SSCs are greater than 47 mg/L in the Hydroelectric Reach for approximately six to ten consecutive months after drawdown begins (see Potential Impact 3.2-3), so exposure to inorganic and organic contaminants in reservoir sediments that would potentially cause substantial adverse impacts on human health also would occur in the Hydroelectric Reach for approximately six to ten months during this period. In dry water year types, modeled SSCs downstream of Iron Gate Dam increase above 47 mg/L for approximately five to six months during the winter and spring after dam removal due to high flow associated with storms (see Figure 3.2-15), thus there also would be potential human exposure to contaminant concentrations (i.e., arsenic) above the most stringent applicable drinking water standards during this period. This would be a significant impact. Implementation of Mitigation Measure WQ-2 would reduce this impact to a less than significant level. Modeled SSCs downstream of Iron Gate Dam are consistently below 47 mg/L after July of post-dam removal year 1, (see Figures 3.2-15 to 3.2-17), indicating potential human exposure to contaminant concentrations that could cause substantial adverse impacts would be negligible after July of post-dam removal year 1 and thus there would be no significant impact after this point in time.

Long-term human exposure to concentrations of aluminum, arsenic, and total PCB greater than applicable drinking water standards due to dam removal is not anticipated since modeled SSCs would return to background levels (i.e., existing conditions) and there would be negligible deposition of reservoir sediments and the associated inorganic and organic contaminants in Hydroelectric Reach. Potential human exposure to inorganic and organic contaminants is associated with elevated SSCs, thus modeling that indicates SSCs would return to background levels (i.e., existing conditions) by the end of post-dam removal year 1 under all water year types (see Potential Impact 3.2-3) also indicates that potential human exposure to contaminants would return to background levels in this time period. Additionally, sediment modeling indicates little to no deposition of the fine or coarser (e.g., sand) sediments in the Hydroelectric Reach (CDM 2011; USBR 2012), so there would be little to no potential exposure to reservoir sediments and associated contaminants due to deposition along the streambed.

As part of the Secretarial Determination process, the Water Quality Sub-Team identified ODEQ bioaccumulation SLVs as appropriate thresholds for determining the potential for sediment contaminants to bioaccumulate to the point where the contaminants adversely affect either the health of fish or other aquatic organisms, or the health of animals or humans that consume them. ODEQ bioaccumulation SLVs have been set for humans based on fish and shellfish consumption under both general/recreational and subsidence/tribal ingestion rates (ODEQ 2007). Bioaccumulation SLVs have not been set based on bioaccumulation within vegetation exposed to contaminants and the ingestion that vegetation. While ODEQ bioaccumulation SLVs are not applicable to water bodies in California, they provide a reference for comparison purposes. Toxicity equivalent quotients (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). Although site-specific background data is lacking, TEQs calculated for dioxin, furan, and dioxin-like PCBs are only slightly above regional background concentrations and thus have limited potential to cause adverse impacts to humans based on consumption of aquatic life exposed to sediment deposits from the river banks or streambed. This assessment is further supported by the limited duration contaminants would occur in the river water as they are transported with drawdown flows and the limited amount of deposition expected (see Potential Impact 3.11-5). 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).

Summary

Results from the 2009–2010 Klamath Dam Removal Secretarial Determination sediment chemistry analyses indicate potential human exposure to inorganic and organic contaminants in reservoir sediment deposits remaining within the reservoir footprints and along the river banks or through eating fish exposed to sediment deposits would be unlikely to result in substantive adverse impacts on human health in either the short-term or the long-term, but there is potential for short-term substantive adverse impacts on human health from exposure to inorganic and organic contaminants in reservoir sediments during drawdown due exposure to river water. For the Lower Klamath Project reservoir sediments remaining in the reservoir footprint and along the river banks, arsenic and nickel are the only compounds detected at levels exceeding USEPA and/or CalEPA residential screening levels to protect human health, but exposure to arsenic in these areas would be constrained by short-term activities and long-term future land use that would support only limited exposure patterns, such that human exposure to arsenic and nickel in sediments in the reservoir footprint would be a less-than-significant impact.

Evaluation of the bioaccumulation potential of inorganic and organic contaminants indicates there is limited potential for adverse impacts to humans from eating aquatic life exposed to sediment deposits from the river banks or streambed since the detected levels of dioxin, furan, and dioxin-like PCBs are only slightly above regional background concentrations. This assessment is further supported by the limited duration contaminants would occur in the river water as they are transported with drawdown flows and the limited amount of deposition expected (see Potential Impact 3.11-5). Thus, human exposure to these chemicals in aquatic life would be a less-than-significant impact.

For exposure to river water during drawdown, aluminum, arsenic, and total PCBs greater human health water quality criteria would potentially occur in the short term due to elevated SSCs and sediment-associated inorganic and organic contaminants and potentially cause substantial adverse impacts on human health; this would be a significant impact. Implementation of Mitigation Measure WQ-2 would reduce this impact to a less than significant level. There is little to no long-term potential for adverse impacts to human health from exposure to river water due the release of reservoir sediments and associated inorganic or organic contaminants trapped behind the Lower Klamath Project dams, so there would be no significant impact in the long term for human exposure to inorganic and organic contaminants in the Hydroelectric Reach.

Middle and Lower Klamath River and Klamath River Estuary

Downstream of Iron Gate Dam, short-term and long-term human exposure to contaminants from contact with residual sediments deposited on downstream river banks is possible and the mechanism for exposure would be the same as that for potential contaminants deposited on exposed reservoir terraces and river banks in the Hydroelectric Reach. Sediment deposition on the river floodplain and/or river banks is unlikely (see also Potential Impact 3.11-6), so the amount of sediment deposits on river floodplains and/or river banks are anticipated to be much lower than the amount exposed in the reservoir beds in the Hydroelectric Reach.

Relatively few compounds were detected in reservoir sediments exceeding human health screening levels for soil, with arsenic and nickel the only compounds exceeding USEPA and/or CalEPA residential screening levels to protect human health. The likelihood of substantial adverse impacts to human health from exposure to arsenic in reservoir sediments is low in the Middle and Lower Klamath River and the Klamath River Estuary since sediment modeling indicates sediment deposition on the river floodplain and/or river banks is unlikely (see also Potential Impact 3.11-6). Nickel concentrations in the Klamath River Estuary sediments were higher than those measured in reservoirs sediments, suggesting the release of reservoir sediments would not increase nickel concentrations in downstream reaches and the potential exposure to nickel in potential deposits of reservoir sediment in the Middle and Lower Klamath River and the Klamath River Estuary would likely be within background conditions.

However, in an abundance of caution, since land use along the Middle and Lower Klamath River floodplain includes residential or agricultural (i.e., row crop) land use or the potential for residential or agricultural (i.e., row crop) land use, where human soil exposure patterns may approach those specified by the USEPA and CalEPA residential screening levels, implementation of Mitigation Measure WQ-3 would be required to ensure that short-term and long-term human exposure to inorganic and organic contaminants due to release of sediments currently trapped behind the Lower Klamath Project dams to a less-than-significant impact.

Similar to the Hydroelectric Reach, there also is potential for human exposure to inorganic and organic contaminants in reservoir sediments from contact with river water during drawdown when reservoir sediments and associated inorganic and organic contaminants are being transported. Elutriate concentration results from 2009 to 2010 sediment testing along with an evaluation of the elutriate concentrations results with consideration of dilution in the Middle and Lower Klamath River and the Klamath River Estuary indicate the potential for human exposure to inorganic and organic contaminants greater than applicable human health drinking water standards that may cause substantial adverse impacts to human health. This would be a significant impact. As detailed above in the Hydroelectric Reach, the maximum potential human exposure exists immediately downstream of Iron Gate Dam during drawdown, where the maximum SSCs and the minimum dilution (48- to 66-fold) would occur. Additional tributary inflows to the Klamath River downstream of Iron Gate Dam would decrease the maximum SSCs and increase the dilution (see Potential Impact 3.2-3), so potential human exposure gradually decreases in the Middle and Lower Klamath River with distance downstream. In the Klamath River at Seiad Valley, the maximum modeled SSCs range from approximately 9,000 to 10,000 mg/L, so dilution is expected to range from approximately 65- to 72-fold in that section of the Middle Klamath River. The maximum modeled SSCs range from approximately 3,000 to 6,000 mg/L in the Klamath River at Orleans, resulting in dilution ranging from approximately 108- to 217-fold. In the Lower Klamath River at Klamath, the maximum modeled SSCs range from approximately 800 to 2,000 mg/L, so dilution ranges from 325- to 813-fold.

In the Middle Klamath River, the human exposure to inorganic and organic contaminants immediately downstream of Iron Gate Dam would be the same as analyzed above for the Hydroelectric Reach from Copco No. 1 Reservoir to Iron Gate Dam. Before consideration of dilution, aluminum, arsenic, chromium, lead, and total PCB are the only chemicals present in elutriate sediment samples results at concentrations above applicable drinking water standards for samples from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs (CDM 2011). After consideration of the dilution immediately downstream of Iron Gate Dam (48- to

66-fold), only aluminum, arsenic, and total PCB concentrations would be greater than the most stringent human health drinking water standards, since the anticipated dilution immediately downstream of Iron Gate would be less the maximum dilution necessary for aluminum (219-fold), arsenic (13,635-fold), and total PCB (100-fold), but the dilution immediately downstream of Iron Gate Dam would be greater than the maximum dilution necessary for chromium (12-fold) and lead (0.3-fold) (CDM 2011). While the maximum dilution necessary to meet the most stringent applicable human health drinking water standards would be met further downstream in the Middle and Lower Klamath for aluminum and total PCB as the dilution in the river increases, the dilution for arsenic would not be met in the Middle and Lower Klamath River and the Klamath River Estuary.

Elutriate sediment samples results from the Klamath River Estuary also show aluminum, arsenic, and total PCB concentrations greater than the most stringent applicable human health drinking water standards, indicating elevated concentrations of these chemicals occur under existing conditions in the Middle and Lower Klamath River and the Klamath River Estuary. However, the concentrations of these chemicals in the elutriate sediment samples results from the Klamath River Estuary are less than those measured in reservoir sediments. Arsenic concentrations in estuary elutriate sediment samples require a 999- to 2,726-fold dilution to meet the most stringent applicable human health drinking water standards, while aluminum requires a 14-fold dilution and total PCB requires a 1.0- to 1.5-fold dilution. Overall, human exposure to concentrations of aluminum, arsenic, and total PCB greater than applicable human health drinking water standards and existing conditions would potentially occur if river water were to be used during drawdown as a drinking water supply in the Middle and Lower Klamath River and the Klamath River Estuary. This would be a significant impact.

Similar to the Hydroelectric Reach, the dilution in the Middle and Lower Klamath River and the Klamath River Estuary necessary to meet the most stringent applicable human health drinking water standards (i.e., 13,635-fold for arsenic) would occur once SSCs decrease below 47 mg/L. As described for the Hydroelectric Reach, modeled SSCs immediately downstream of Iron Gate Dam are greater than 47 mg/L for approximately six to ten consecutive months after drawdown begins (see Potential Impact 3.2-3). While increased dilution with distance downstream of Iron Gate Dam would likely reduce the duration that SSCs exceed 47 mg/L and the duration of human exposure to elevated contaminant concentrations, this analysis conservatively applies the modeled SSCs immediately downstream of Iron Gate Dam for the entire Middle and Lower Klamath River and Klamath River Estuary. As such, the exposure to inorganic and organic contaminants in reservoir sediments that would potentially cause substantial adverse impacts on human health would occur in the Middle and Lower Klamath River and the Klamath River Estuary for approximately six to ten months after drawdown begins. In dry water year types, there also would be potential human exposure to contaminant concentrations (i.e., arsenic) above the most stringent applicable human health drinking water standards for approximately five to six months during the winter and spring after dam removal, since modeled SSCs immediately downstream of Iron Gate Dam increase during this period due to high flows associated with storms (see Figure 3.2-15). This would be a significant impact. Implementation of Mitigation Measure WQ-2 would reduce this impact to a less than significant level. Modeled SSCs downstream of Iron Gate Dam are consistently below 47 mg/L after July of post-dam removal year 1, (see Figure 3.2-15 to 3.2-17), indicating potential human exposure to contaminant concentrations that could cause substantial adverse impacts would be negligible after July of post-dam removal year 1 and thus there would be no significant impact after this point in time.

Long-term human exposure to concentrations of aluminum, arsenic, and total PCB levels greater than applicable human health drinking water standards due to dam removal is unlikely since modeled SSCs would return to background levels (i.e., existing conditions) and fine reservoir sediments and associated inorganic and organic contaminants would be unlikely to form sediment deposits in the Middle and Lower Klamath River and the Klamath River Estuary (see Potential Impact 3.11-5). Potential human exposure to inorganic and organic contaminants is associated with elevated SSCs, thus modeling that indicates SSCs would return to background levels (i.e., existing conditions) by the end of post-dam removal year 1 under all water year types (see Potential Impact 3.2-3) also indicates that potential human exposure to contaminants would return to background levels in this time period. Additionally, sediment modeling indicates fine reservoir sediments would be unlikely to settle along the riverbed in the Klamath River in the Middle and Lower Klamath River and the Klamath River Estuary (Stillwater Sciences 2008; USBR 2012) (see Potential Impact 3.11-5). Coarser reservoir sediment would potentially deposit between Iron Gate Dam and Cottonwood Creek (USBR 2012), but these sediments are not typically associated with appreciable contaminant levels due to their lack of organic matter and chemical properties (i.e., lower cation exchange capacities) (CDM 2011). Thus, there would be little to no potential long-term potential for adverse impacts to human health from exposure to river water due the release of reservoir sediments and associated inorganic or organic contaminants trapped behind the Lower Klamath Project dams, and there would be no significant impact in the long term for human exposure to inorganic and organic contaminants in the Hydroelectric Reach.

Implementation of mitigation measures WQ-2 and WQ-3 would reduce the short-term significant impact of human exposure to inorganic and organic contaminants in the Middle and Lower Klamath River and the Klamath River Estuary to less than significant.

Mitigation Measure WQ-2 − Modifications and monitoring for transient non-community and community water systems using the Klamath River for their water supply.

The KRRC shall consult with community water systems, transient non-community water systems, or other drinking water providers that use Klamath River surface water for drinking water to identify appropriate measures to reduce impacts associated with the Proposed Project's impacts to their Klamath River water supply, such that Proposed Project implementation shall not result in service of water that fails to meet drinking water quality standards. At least two months prior to initiating drawdown, the KRRC shall submit to the State Water Board a report detailing drinking water mitigation measures for each potentially affected supply and demonstrating that such measures are sufficient to protect drinking water supplies. KRRC shall amend the measures if required to protect drinking water supplies and shall implement them sufficiently prior to reservoir sediment releases to ensure protection of water supplies. Potential measures shall include, as appropriate: (1) providing an alternative potable water supply; (2) providing technical assistance to assess whether existing treatment is adequate to treat the potential increase in sediments and sediment-associated contaminants so as to meet drinking water standards; (3) providing water treatment assistance to adequately treat Klamath River water to remove SSCs and associated constituents that may impact human health; (4) ensuring that transient, non-community supplies are temporarily shut off for drinking; or (5) ensuring that water not intended for drinking is clearly marked as non-potable

Mitigation Measure WQ-3 − Monitoring and potential remediation of reservoir sediments deposited along the Middle and Lower Klamath River floodplain.

By December of post-dam removal year 1, the KRRC, upon notice from property owners, shall assess visibly obvious sediment deposits along the Klamath River from below Iron Gate Dam to the mouth of the Klamath River Estuary that may have been deposited during reservoir drawdown activities in areas with a residential or agricultural (i.e., row crop) land use or the potential for residential or agricultural land use. Visibly obvious sediment deposits shall be assessed by the KRRC to determine if they are consistent with physical sediment properties associated with Lower Klamath Project reservoir sediments. Visibly obvious sediment deposits consistent with physical sediment properties associated with Lower Klamath Project reservoirs shall be tested for arsenic or remediated without testing per requirements of this condition, below. If testing is initiated, soil samples in the vicinity of the deposited reservoir sediments on the river bank and/or floodplain shall also be tested for arsenic to determine the local background concentrations of arsenic. No additional actions or remediation shall be required if the measured arsenic concentrations in the deposited reservoir sediments are less than or equal to measured local background soil arsenic concentrations. If the concentration of arsenic in deposited reservoir sediments on the river banks and floodplain in the Klamath River exceed local background levels and USEPA or CalEPA human health residential screening levels, the deposited reservoir sediments shall be remediated to local background levels through removal of the deposited reservoir sediments or soil capping, if soil removal is infeasible or poses a greater risk than soil capping.

Within 30 days of a determination that a reported deposit does not require remediation, either because it is not consistent with reservoir sediment deposits or because testing does not indicate a need for further action, the KRRC shall submit a report to the Deputy Director, including location of the reported deposition, a summary of actions taken, and the grounds for the determination that further action is not required. If sampling occurred, the report shall include, at a minimum:

- Estimated quantity of reported sediment deposition;
- Sediment testing methods used to determine arsenic concentrations which shall include the number of sediment samples collected from both the reported sediment deposit and surrounding sediments; and
- Arsenic sediment testing results listing the amount of arsenic in reported deposits and surround sediments.

The Deputy Director shall have the authority to require additional testing or remediation.

Within 14 days of a following inspection of reported sediment deposition that requires further action, the KRRC shall submit a Sediment Deposit Remediation Plan to the Deputy Director for review and approval that shall include, at a minimum:

- Estimated location, and amount of reported sediment deposition;
- If testing occurred, the sediment testing methods used to determine arsenic concentrations which shall include the number of sediment samples to be collected from both the reported sediment deposit and surrounding sediments;
- If testing occurred, the arsenic sediment testing results listing the amount of arsenic in reported deposits and surround sediments; and
- Proposed remediation actions if arsenic is determined present above background levels.

The Deputy Director may require modifications to the Sediment Deposit Remediation Plan as part of its approval. The KRRC shall file the Deputy Director’s approval, together with any required modifications, with FERC. The KRRC shall implement the Sediment Deposit Remediation Plan upon receiving Deputy Director and any other required approvals. Any changes to the Sediment Deposit Remediation Plan shall be approved by the Deputy Director prior to implementation. The KRRC shall file a report of completion within 30 days of completing remediation activities. If the Sediment Deposit Remediation Plan includes arsenic testing, the KRRC shall report arsenic results to the Director within 15 days, and proceed with remediation actions.

Significance

No significant impact with mitigation

Potential Impact 3.2-14 Freshwater and marine aquatic species exposure to inorganic and organic contaminants due to release of sediments currently trapped behind the dams.

This potential impact evaluates the potential for any inorganic and organic contaminants in reservoir sediments to result in a substantial adverse impact to aquatic organisms when the sediments are released downstream of the dams into the Klamath River. The release of reservoir sediments has the potential to increase the exposure of aquatic species to any harmful material in the sediment by moving the sediments and associated contaminants to new places in the river; mixing the sediments and associated contaminants into the water column where aquatic life may interact with them; and, for some materials, creating conditions where contaminants may enter the food chain. Sediment testing indicates that the amounts of contaminants in the sediments is not high, but this analysis evaluates the level of risk and potential impacts in more detail with consideration of the conditions in the Klamath River under the Proposed Project, especially during drawdown.

Hydroelectric Reach

Organic and inorganic contaminants have been identified in the sediment deposits currently trapped behind the dams (see Section 3.2.2.8 *Inorganic and Organic Contaminants*). Under the Proposed Project, the short-term pathway of contaminant exposure for freshwater aquatic species includes exposure during sediment transit through the Hydroelectric Reach ("Exposure Pathway 1" in CDM [2011]), while long-term pathways include exposure from river bed deposits ("Exposure Pathway 3" in CDM [2011]) (Figure 3.2-27). The CDM (2011) analysis of exposure pathways using the 2009 SEF screening levels has been updated based on 2018 SEF screening levels, as appropriate (Appendix C – *Section C.7*).

One path for short-term exposure to inorganic and organic contaminants for freshwater aquatic species would be associated with the transport of elevated suspended sediment concentrations (SSCs) through the Hydroelectric Reach during reservoir drawdown. Due to the relatively small volume of the sediment deposits behind J.C. Boyle Dam (approximately eight percent of total volume for the Lower Klamath Project, see also Tables 2.7-9 and 2.7-10), short-term SSCs in the Hydroelectric Reach between J.C. Boyle Dam and the upstream end of Copco No. 1 Reservoir would be considerably less than those anticipated to occur downstream of Iron Gate Reservoir (see Potential Impact 3.2-3). The ratio of the contaminant concentration to SSCs measured in laboratory tests is assumed to be equal to the ratio of the contaminant concentration to SSCs in the Klamath River during drawdown, so the amount of dilution necessary to meet water quality standards would vary based on changes in SSCs during drawdown.

Variations in flow and dilution downstream of the reservoirs during drawdown would be inherently included in the modeled SSCs since the model utilizes expected drawdown flows in its estimate of SSCs. Thus, the maximum dilution necessary to meet water quality standards for aquatic species would be calculated using the maximum SSCs.

In the Hydroelectric Reach downstream of J.C. Boyle to the upstream end of Copco No. 1 Reservoir, the maximum SSCs would range from 2,000 to 3,000 mg/L (see Potential Impact 3.2-3), so dilution of mobilized sediments with reservoir and river water is expected to range from 217- to 325-fold immediately downstream of J.C. Boyle during drawdown. Within the remainder of the Hydroelectric Reach from the upstream end of Copco No. 1 Reservoir through Iron Gate Reservoir, short-term SSCs would be relatively greater than upstream of Copco No. 1 Reservoir, generally increasing in the downstream direction due to the larger sediment deposits in Copco No. 1 and Iron Gate reservoirs contributing to SSCs. The minimum dilution in the Klamath River would occur immediately downstream of Iron Gate Dam during drawdown, where higher peak SSCs from release of sediments in Copco No. 1 and Iron Gate reservoirs would result in dilution ranging from 48- to 66-fold. As a conservative estimate, this analysis uses the J.C. Boyle dilution only for the J.C. Boyle Dam to the upstream end of Copco No. 1 Reservoirs portion of the Hydroelectric Reach and the dilution expected immediately downstream of Iron Gate Dam for the remainder of the Hydroelectric Reach when evaluating the dilution necessary to meet water quality standards for contaminant results. The actual SSCs in the Hydroelectric Reach in Copco No. 1 Reservoir to Iron Gate Dam potentially would be less than the maximum SSCs estimated below Iron Gate Dam based on modeled SSCs below the J.C. Boyle and Copco No. 1 dams (see Impact 3.2-3), so the inorganic and organic contaminant concentrations and the aquatic species exposure to those contaminants in the Hydroelectric Reach of the Klamath River would be less than those estimated using the maximum SSCs estimated below Iron Gate Dam.

Sediment chemistry data from 2006 collected from 25 cores representing both reservoir-deposited and pre-reservoir sediments within the historical Klamath River channel (“on-thalweg”) and on historical riverbanks and terraces along the edge of the Klamath River (“off-thalweg”) in J.C. Boyle, Copco No. 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 also Section 3.2.2.8 *Inorganic and Organic Contaminants*). While two-dimensional sediment transport modeling of Copco No. 1 Dam and Reservoir during drawdown indicates that sediments would be mobilized from across the reservoir footprint, the sediments in the historical Klamath River channel would be the most likely to erode (USBR 2012) and thus the sediment chemistry of the on-thalweg sediment cores is more likely to be representative of eroded sediment conditions.

An additional 37 sediment cores were collected in 2009 to 2010 in the Lower Klamath Project reservoirs for the Klamath Dam Removal Secretarial Determination process to evaluate the sediment characteristics of reservoir-deposited and pre-reservoir sediments in the historical Klamath River channel ("on-thalweg") and terrace ("off-thalweg") locations at a finer spatial resolution. Testing results for the 2009 to 2010 cores indicate no exceedances of applicable screening levels, indicating a low risk of toxicity to freshwater sediment-dwelling organisms in the Hydroelectric Reach under the Proposed Project. Results from acute (10-day) sediment bioassays for exposure to undiluted reservoir sediments and elutriate samples for midges (*Chironomus dilutus*) and amphipods (*Hyalella azteca*), two national benchmark toxicity species, indicate generally equal 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).

While J.C. Boyle reservoir sediment results suggest potential toxicity to freshwater benthic organisms, the conditions in the bioassays would be very unlikely to occur during drawdown and dam removal in the Hydroelectric Reach downstream of J.C. Boyle Dam, so there is an overall low likelihood of acute toxicity to benthic organisms due to releases of reservoir sediments. The bioassays evaluated the survival of freshwater benthic organisms in composite[17] sediments from individual reservoirs, but undiluted composite sediments from the reservoirs would be very unlikely to occur outside of the reservoir footprints during drawdown and dam removal. Sediments from the reservoirs would mix with water and incoming suspended sediments from tributaries as they move downstream under the Proposed Project, exposing downstream aquatic biota to a diluted, "average" sediment composition rather than pure reservoir sediments. Under current conditions, the total volume of erodible sediments in Copco No. 1 and Iron Gate reservoirs (7.4 million and 4.7 million cubic yards, respectively; see also Tables 2.7-7 through 2.7-9) is considerably greater than that of J.C. Boyle Reservoir (1 million cubic yards; see also Tables 2.7-7 through 2.7-9), further diminishing the potential influence of J.C. Boyle Reservoir sediments on biota exposure. Additionally, fine sediments released during drawdown and dam removal would be transported by large water volumes, and sediment modeling indicates that fine sediments would be unlikely to settle along the riverbed in the Klamath River in the Hydroelectric Reach (Stillwater Sciences 2008; USBR 2012) and thus unlikely to result in riverine, floodplain, or estuarine sediment deposits that resemble existing conditions in the reservoirs.

More specifically, dilution would be expected to range from 217- to 325-fold downstream of J.C. Boyle Dam to the upstream end of Copco No. 1, so benthic organism exposure to inorganic and organic contaminants in J.C. Boyle Reservoir sediments would be much less during drawdown under the Proposed Project than in the bioassays. The intensity of exposure compared to the bioassays would be further reduced due to considerable additional mixing occurring within the Hydroelectric Reach from the current Copco No. 1 Reservoir to Iron Gate Dam. While dilution would decrease downstream of Copco No. 1 due to higher SSCs, the mixing of sediments from J.C. Boyle and Copco No. 1 along with additional mixing of water from Copco No. 1 would reduce the overall intensity of exposure to J.C. Boyle reservoir sediments. In the absence of undiluted sediment deposits from J.C. Boyle Reservoir, freshwater benthic organisms in the Hydroelectric Reach are unlikely to experience the same intensity of exposure to reservoir sediments as in the bioassays that suggested potential for toxicity (CDM 2011). Overall, the freshwater sediment bioassays indicate a low likelihood of acute toxicity to benthic organisms in the Hydroelectric Reach of the Klamath River due to sediment release under the Proposed Project.

Elutriate concentration results (characterizing the potential chemical concentrations that may be released into the water from reservoir sediments during suspension) from the 2009 to 2010 sediment testing also provide important context for evaluating the potential effects of in-water column exposure to inorganic and organic contaminants from reservoir sediments on aquatic freshwater species. Elutriate sediment sample chemistry results indicate that, before consideration of dilution, ammonia, aluminum, chromium, copper, lead, and mercury are the chemicals present at concentrations above Basin Plan, national priority, and national non-priority fresh water quality criteria for samples from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs (CDM 2011). Human health freshwater water quality criteria were also evaluated (CDM 2011) and those results are analyzed above in Potential Impact 3.2-13. Dilution of mobilized sediments with reservoir and river water is expected to range from 217- to 325-fold downstream of J.C. Boyle Dam to the upstream end of Copco No. 1 Reservoir and 48- to 66-fold immediately downstream of Iron Gate during drawdown. Thus, the elutriate sediment sample concentrations for all the chemicals currently present at concentrations above water quality criteria (i.e., ammonia, aluminum, chromium, copper, lead and mercury) would be below the freshwater water quality criteria with dilution in the portion of the Hydroelectric Reach from J.C. Boyle Dam to the upstream end of Copco No. 1 Reservoir. Inorganic and organic contaminants would be unlikely to cause adverse effects to freshwater aquatic species in the J.C. Boyle Dam to the upstream end of Copco No. 1 Reservoir portion of the Hydroelectric Reach since the dilution required to meet the most stringent criterion is 22-fold (i.e., the elutriate concentration would have to be 22 times higher than the water quality standard concentration to exceed criterion) for ammonia, 125-fold for aluminum, 0.2-fold for chromium, 2.3-fold for copper, 2.1-fold for lead, and 1.3-fold for mercury. However, the dilution in the Copco No. 1 Reservoir to Iron Gate Dam portion of the Hydroelectric Reach would be less than upstream, reaching a minimum of 48- to 66-fold at Iron Gate Dam due to release of additional sediment from Copco No. 1 and Iron Gate reservoirs and higher SSCs. Elutriate sediment sample concentrations in the Copco No. 1 Reservoir to Iron Gate Dam portion of the Hydroelectric Reach would be below the freshwater water quality criteria for ammonia, chromium, copper, lead, and mercury after consideration of dilution with no potential to cause substantial adverse impacts on freshwater aquatic species.

For aluminum, the expected dilution at Iron Gate Dam is less than the dilution required for three of the six elutriate sediment samples to meet the most stringent freshwater criterion (87 ug/L) with those three samples requiring a 50- to 125-fold dilution. While some inorganic forms of aluminum can be toxic to aquatic organisms at high and low pH, insoluble and nontoxic forms of aluminum prevail in the environment under typical conditions (pH ranging from six to eight s.u. and alkalinity greater than 100 mg/L). The pH conditions at drawdown are not anticipated to be in the range that would cause inorganic aluminum to become toxic. Thus, any residual free (toxic) aluminum present in reservoir waters during drawdown is likely to form compounds with the dissolved organic matter abundant in eutrophic (nutrient-rich) waters such as the Lower Klamath Project reservoirs, rendering the aluminum non-bioavailable and nontoxic. Thus, water column toxicity due to the concentration of inorganic or organic substances under the Proposed Project is unlikely (CDM 2011) and would not result in substantial adverse impacts on environmental receptors.

Elutriate sediment sample bioassay results for J.C. Boyle Reservoir 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). Elutriate sediment sample bioassay results indicate no statistically significant reduction of mean 96-hour rainbow trout survival for exposure to samples from Copco No. 1 and Iron Gate reservoirs, tested at one percent and 10 percent elutriate concentrations, but a significant reduction from Copco No. 1 Reservoir at 100 percent elutriate concentrations and from Iron Gate Reservoir at 50 percent and 100 percent elutriate concentration. Of these, the one percent and 10 percent concentrations 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, even during dry water years (CDM 2011).

Long-term exposure to reservoir sediments that are mobilized as a result of dam removal would not result in substantial adverse impacts on aquatic species due to negligible deposition of these sediments in Hydroelectric Reach and the overall infrequency and low magnitude of exceedances of screening levels for inorganic and organic contaminants. Sediment modeling indicates that the fine grain nature of the sediments (i.e., silts and clays) and the generally high gradient river channel within the Hydroelectric Reach would result in little to no deposition of the fine or coarser (e.g., sand) sediments in the Hydroelectric Reach of the Klamath River (CDM 2011; USBR 2012).

Additionally, no consistent pattern of elevated chemical distribution was observed across the reservoir samples, with only eight chemicals detected in the 77 samples that exceeded one or more available screening level (see Section 3.2.2.8 *Inorganic and Organic Contaminants*). Nickel was the only one of those eight chemicals that exceeded both SEF screening levels in all three reservoirs. However, nickel is higher in Klamath River Estuary sediments (representing current Klamath Basin background conditions) than reservoir sediments, so reservoir sediments would not elevate nickel concentrations above background conditions. The absence of a consistent pattern of elevated chemical concentrations in reservoir sediment samples supports the conclusion that mixing and dilution of mobilized sediments during drawdown would reduce the overall chemical concentrations in the water column and any sediment deposits and further reduce exposure potential in the newly formed river channels of the Hydroelectric Reach (CDM 2011).

Combined, results from the Shannon & Wilson, Inc. (2006) study and the 2009–2010 Klamath Dam Removal Secretarial Determination study (CDM 2011) indicate that currently one or more chemicals are present in the Lower Klamath Project reservoir sediments at levels with potential to cause minor or limited adverse impacts on freshwater aquatic species. However, chemicals present in the Lower Klamath Project reservoir sediments are expected to be mixed and diluted below water quality standards reducing the likelihood of causing even minor or limited adverse impacts on freshwater aquatic species in the short term. In the long term, one or more chemicals are present, but at levels unlikely to cause substantial adverse impacts on environmental receptors. Therefore, under the Proposed Project, the short-term and long-term impacts on freshwater aquatic species from exposure to sediment-associated inorganic and organic contaminants during sediment release and transit, and from potential downstream river-channel deposition, in the Hydroelectric Reach, would be a less-than-significant impact.

Middle and Lower Klamath River

Organic and inorganic contaminants have been identified in the sediment deposits currently trapped behind the dams (see Section 3.2.2.8). Under the Proposed Project, the short-term pathway of contaminant exposure for freshwater aquatic species includes exposure during sediment transit through the Middle and Lower Klamath River ("Exposure Pathway 1" in CDM [2011]), while long-term pathways include exposure from river bed deposits ("Exposure Pathway 3" in CDM [2011]). The CDM (2011) analysis of exposure pathways using the 2009 SEF screening levels has been updated based on 2018 SEF screening levels, as appropriate (Appendix C – *Section C.7*).

As detailed above for the Hydroelectric Reach, sediment chemistry data from 25 cores collected from Lower Klamath Project reservoirs in 2006 and from an additional 37 sediment cores collected in 2009 to 2010 indicate generally low levels of metals, pesticides, chlorinated acid herbicides, PCBs, VOCs, SVOCs, cyanide, and dioxins (Shannon & Wilson, Inc. 2006; see also Section 3.2.2.8 *Inorganic and Organic Contaminants*) and no exceedances of applicable screening levels, indicating a low risk of toxicity to freshwater sediment-dwelling organisms in the Middle and Lower Klamath River under the Proposed Project. Acute (10-day) sediment bioassays for exposure to undiluted reservoir sediments and elutriate samples for midges (*Chironomus dilutus*) and amphipods (*Hyalella azteca*), two national benchmark toxicity species, indicate generally equal survival in reservoir sediments as compared with laboratory control samples, except for J.C. Boyle Reservoir sediments (see discussion in the Hydroelectric Reach above). Similar to the Hydroelectric Reach, the conditions in the bioassays would be very unlikely to occur during drawdown and dam removal in the Klamath River downstream of Iron Gate Dam because the downstream aquatic biota would be exposed to a diluted "average" sediment composition rather than pure reservoir sediments analyzed in the bioassays. As such, the potential toxicity of J.C. Boyle Reservoir sediments on downstream biota would be significantly reduced compared to the bioassays, especially downstream of Iron Gate Dam due to considerable mixing and dilution within the Hydroelectric Reach. Additionally, any natural background sediments or flows from tributaries (e.g., Bogus Creek, Shasta River) entering the Klamath River downstream of Iron Gate Dam would further mix and dilute sediments, reducing exposure relative to the bioassays. Fine sediments released during drawdown and dam removal would be transported and unlikely to settle along the riverbed in the Klamath River downstream of Iron Gate Dam (USBR 2012; Stillwater Sciences 2008), so any potential riverine, floodplain, or estuarine sediment deposits that resemble existing conditions in the reservoirs are very unlikely. In the absence of undiluted sediment deposits from J.C. Boyle Reservoir, freshwater benthic organisms downstream of Iron Gate Dam are unlikely to experience the same intensity of exposure to reservoir sediments as in the bioassays that suggested potential for toxicity (CDM 2011). Overall, the freshwater sediment bioassays indicate a low likelihood of acute toxicity to benthic organisms in the Middle and Lower Klamath River due to sediment release under the Proposed Project.

As previously discussed for the Hydroelectric Reach, elutriate concentration results from 2009 to 2010 also provide important context for evaluating the potential effects of in-water column exposure to inorganic and organic contaminants from reservoir sediments on aquatic freshwater species. Elutriate sediment sample chemistry results indicate that, before consideration of dilution, ammonia, aluminum, chromium, copper, lead, and mercury are the chemicals present at concentrations above Basin Plan, national priority, and national non-priority fresh water quality criteria for samples from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs (CDM 2011). However, dilution of mobilized sediments with reservoir and river water is expected to range from 48- to 66-fold immediately downstream of Iron Gate during drawdown, with further dilution occurring downstream from Iron Gate Dam due to tributary inflows. Elutriate sediment sample concentrations of ammonia, chromium, copper, lead and mercury would be below the freshwater water quality criteria after consideration of dilution immediately downstream of Iron Gate Dam with no potential to cause substantial adverse impacts on freshwater aquatic species since the dilution required to meet the most stringent criterion is 22-fold for ammonia, 0.2-fold for chromium, 2.3-fold for copper, 2.1-fold for lead, and 1.3-fold for mercury.

For aluminum, the expected dilution downstream of Iron Gate Dam is less than the dilution required for three of the six elutriate sediment samples to meet the most stringent freshwater criterion (87 ug/L) with those three samples requiring a 50- to 125-fold dilution. While some inorganic forms of aluminum can be toxic to aquatic organisms at high and low pH, insoluble and nontoxic forms of aluminum prevail in the environment under typical conditions (pH ranging from six to eight s.u. and alkalinity greater than 100 mg/L). The pH conditions at drawdown are not anticipated to be in the range that would cause inorganic aluminum to become toxic. Thus, any residual free (toxic) aluminum present in reservoir waters during drawdown is likely to form compounds with the dissolved organic matter abundant in eutrophic (nutrient-rich) waters such as the Lower Klamath Project reservoirs, rendering the aluminum non-bioavailable and nontoxic. Thus, water column toxicity due to the concentration of inorganic or organic substances under the Proposed Project is unlikely (CDM 2011).

Elutriate sediment sample bioassay results indicate no statistically significant reduction of mean 96-hour rainbow trout survival for exposure to samples from Copco No. 1 and Iron Gate reservoirs, tested at one percent and 10 percent elutriate concentrations, but a significant reduction from Copco No. 1 Reservoir at 100 percent elutriate concentrations and from Iron Gate Reservoir at 50 percent and 100 percent elutriate concentration. Of these, the one percent and 10 percent concentrations 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, even during dry water years (CDM 2011).

Long-term exposure to reservoir sediments that are mobilized as a result of dam removal downstream of Iron Gate Dam are similar to those analyzed in the Hydroelectric Reach and release of reservoir sediments is unlikely to result in substantial adverse impacts on aquatic species due to minimal deposition of these sediments in the downstream river channel and the overall infrequency and low magnitude of exceedances of screening levels for inorganic and organic contaminants. No consistent pattern of elevated chemical distribution was observed across the reservoir samples, with only eight chemicals detected in the 77 samples that exceeded one or more available screening level (see Section 3.2.2.8 *Inorganic and Organic Contaminants*). Nickel was the only one of those eight chemicals that exceeded both SEF screening levels in all three reservoirs. Nickel is higher in Klamath River Estuary sediments (representing current Klamath Basin background conditions) than reservoir sediments, so reservoir sediments would not elevate nickel concentrations above background conditions. The absence of a consistent pattern of elevated chemical concentrations in reservoir sediment samples supports the conclusion that mixing and dilution of mobilized sediments during drawdown would reduce that overall chemical concentrations in the water column and any sediment deposits and further reduce exposure potential in the Middle and Lower Klamath River (CDM 2011).

Overall, one or more chemicals are currently present in the Lower Klamath Project reservoir sediments at levels with potential to cause minor or limited adverse impacts on freshwater aquatic species in the short term, based results from the Shannon & Wilson, Inc. (2006) study and the 2009–2010 Klamath Dam Removal Secretarial Determination study (CDM 2011), but chemicals present in the Lower Klamath Project reservoir sediments are expected to be mixed and diluted below water quality standards, reducing the likelihood of any substantial adverse impacts on freshwater aquatic species in the short term. In the long term, one or more chemicals are present, but at levels unlikely to cause substantial adverse impacts based on available evidence. Therefore, under the Proposed Project, the short-term and long-term impacts on freshwater aquatic species from exposure to sediment-associated inorganic and organic contaminants during sediment release and transit, and from potential downstream river-channel deposition, in the Middle and Lower Klamath River, would be a less-than-significant impact.

Klamath River Estuary and Pacific Ocean Nearshore Environment
Under the Proposed Project, pathways of contaminant exposure for estuarine and marine aquatic species include short-term exposure during sediment transport through the Klamath River Estuary and Pacific Ocean nearshore environment (”Exposure Pathway 1” in CDM [2011]), as well as the potential for long-term exposure following deposition in the Pacific Ocean nearshore environment (“Exposure Pathway 4” in CDM [2011]). See Potential Impact 3.11-6 for further discussion of sediment deposition patterns in the Pacific Ocean nearshore environment.

For the 2009–2010 Klamath Dam Removal Secretarial Determination study, there were no exceedances of the 64 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[51] and 2,3,4,7,8-PECDF[52] (CDM 2011). The concentrations of detected inorganic or organic contaminants in Lower Klamath

[51] Dieldrin is a pesticide developed in the 1940s as an alternative to DDT and widely used during the 1950s until early 1970s on crops such as corn and cotton. Its use on crops ceased in 1972 and its other use, killing termites, ceased in 1987, but it is still in the environment due to its past use and slow breakdown in soil (USDHHS 2002).
[52] 2,3,4,7,8-PECDF is a chlorodibenzofuran (i.e., dioxin-like) compound that can be released during burning of material, including wood, coal, and oil for home heating and production of electricity. It is also produced during the manufacture of some chlorinated chemicals and consumer products, such as wood treatment chemicals (e.g., creosote), some metals, and paper products (USDHHS 1994).

Project reservoir sediments were below the concentrations measured in Klamath River Estuary sediments for chromium and nickel, so the release of reservoir sediments from behind the Lower Klamath Project dams would not elevate estuarine concentrations of these inorganic or organic contaminants or increase exposure for freshwater aquatic species relative to existing conditions. In reservoir sediments total chromium concentrations ranged from 18 to 48 mg/kg and total nickel concentrations ranged from 18 to 33 mg/kg, but in Klamath River Estuary sediments total chromium concentrations ranged from 96 to 97 mg/kg and total nickel concentrations were consistently 110 mg/kg. Marine screening levels are designed to be protective of direct toxicity to benthic and epibenthic organisms, corresponding to a “no adverse effects level,” so the majority of sediment sample results from 2009 and 2010 indicate a low risk of toxicity to sediment-dwelling organisms. Additionally, the Proposed Project would result in substantial mixing and dilution during sediment release and transit through the Klamath River estuarine and/or Pacific Ocean nearshore environment, exposing downstream aquatic biota to an “average” water column concentration rather than a reservoir- or site-specific concentration, further reducing the potential for toxicity. The standard laboratory tests used could not measure whether 33 analytes were present above marine screening levels because the smallest amount the laboratory tests could detect (i.e., the reporting limit) for those analytes was greater than the marine screening level itself (CDM 2011). Because it is not possible to determine whether these analytes are present in reservoir sediments either above or below levels of concern, the Lower Klamath Project EIR analysis relies upon the results of integrative bioassays (described below) to determine the potential for short-term sediment toxicity to estuarine and marine aquatic species during sediment transport through the Klamath River Estuary and Pacific Ocean nearshore environment.

Sediment bioassays from a single upper Klamath River Estuary sample included in the 2009–2010 Klamath Dam Removal Secretarial Determination study indicate greater survival (89 to 99 percent survival) of national benchmark toxicity species (midge [*Chironomus dilutus*] and amphipod [*Hyalella azteca*]) in the estuary sediment sample as compared with the laboratory control samples (81 to 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 to 94 percent, respectively) and greater survival for *Hyalella azteca* (99 percent vs. 80 to 94 percent, respectively). The toxicity tests of estuary and reservoir sediments show the existing background toxicity of estuary sediments is similar to the toxicity of reservoir sediments, so under the Proposed Project, sediment transport during drawdown and potential exposure to inorganic and organic contaminants in the reservoir sediments are unlikely to cause acute toxicity relative to background conditions in the estuary. For the Pacific Ocean nearshore environment under the Proposed Project, a comparison of the applicable marine water and sediment screening levels for ocean conditions with elutriate chemistry results (prior to consideration for mixing and dilution) and sediment chemistry results does not indicate likely toxicity (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 screening level values (SLVs) for marine fish. Note that ODEQ bioaccumulatory screening levels are not strictly applicable in the California marine offshore environment, but they are indicative of potentially bioaccumulative compounds.

Regarding analysis through the pathway of suspended sediment exposure, elutriate chemistry results indicate that several chemical concentrations in the elutriate samples from J.C. Boyle, Copco No. 1, Iron Gate reservoir sediments and Klamath River Estuary sediments 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 impacts (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 (CDM 2011). The chemicals with the greatest potential to cause adverse impacts due to their elutriate sample concentrations (e.g., copper) are, under field conditions associated with this exposure pathway, expected to bind to particulate matter and no longer be bioavailable, and therefore are unlikely to contribute substantially to elevated concentrations of dissolved forms in the water column. Further, 48- to 66-fold dilution of river water and associated suspended sediments is expected to occur immediately downstream of Iron Gate Dam with further dilution occurring downstream and in the marine environment. The dilution required to meet the most stringent marine water quality criteria for the detected elutriate chemicals ranges from 0.1- to 40-fold with the exception of phosphorus, so the expected dilution during dam removal would be greater than that required to meet marine water quality criteria. Phosphorous would require 1,299 to 5,399-fold dilution to meet the most stringent marine water quality criterion (0.1 ug/L[53]), but phosphorus is generally considered to be non-toxic (CDM 2011). Potential effects of elevated phosphorus concentrations in the estuarine and marine environment due to sediment releases during dam removal are discussed further under Potential Impact 3.2-7.

Although not conducted specifically for estuarine or marine organisms, additional lines of evidence from the 2009–2010 Klamath Dam Removal Secretarial Determination study support the conclusion that exposure to inorganic and organic compounds in sediments released from the reservoirs under the

[53] National Recommended Water Quality Criteria for Non-Priority Pollutants, Marine Criterion Continuous Concentration [chronic].

Proposed Project are unlikely to result in substantial long-term adverse impacts on estuarine and marine near shore aquatic species. These include the evaluation of elutriate toxicity bioassay results for rainbow trout, sediment toxicity bioassay results for benthic invertebrate national benchmark species, comparisons of tissue-based toxicity reference values (TRVs) to chemical concentrations in laboratory-reared freshwater clams and worms exposed to field collected sediments (see prior discussion of Proposed Project potential impacts on freshwater aquatic species), and comparisons of tissue-based TRVs and toxicity equivalent quotients (TEQs) to chemical concentrations in field-collected fish tissue.

Under the Proposed Project, the short-term and long-term impacts of sediment release, transit through the Klamath River Estuary, and deposition in the Pacific Ocean nearshore environment on aquatic species due to low-level exposure to sediment-associated inorganic and organic contaminants would be less-than-significant.

The Definite Plan (see Appendix B: *Definite Plan – Appendix M*) includes a Water Quality Monitoring Plan to assess the Proposed Project's impacts to water quality, and this plan includes potential toxicity monitoring, but no toxicity monitoring activities are currently included. The proposed Water Quality Monitoring Plan notes that the identified potential toxicity monitoring activities would only be performed if the additional testing is required by the State Water Board. The State Water Board has authority to review and approve any final Water Quality Monitoring Plan through its water quality certification under Clean Water Act Section 401. The State Water Board has issued a draft water quality certification which sets forth monitoring and adaptive management requirements for any Water Quality Monitoring Plan to meet, as Condition 1[54]. Additionally, the Oregon Department of Environmental Quality has issued a water quality certification[55] that sets forth water quality monitoring and adaptive management conditions for points upstream of California. The effect of the Proposed Project on inorganic and organic contaminants is anticipated to be less than significant in both the short and long term, and this analysis of Potential Impact 3.2-14 does not further discuss the water quality monitoring and adaptive management conditions.

[54] The State Water Board's draft water quality certification is available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_dwqc.pdf (Accessed December 11, 2018).

[55] The Oregon Department of Environmental Quality's final water quality certification is available online at: https://www.oregon.gov/deq/FilterDocs/ferc14803final.pdf (Accessed December 11, 2018).

Significance
No significant impact

Potential Impact 3.2-15 Short-term increases in inorganic and organic contaminants from hazardous materials associated with construction and restoration activities in the Hydroelectric Reach and the Middle Klamath River immediately downstream of Iron Gate Dam.
Under the Proposed Project, pre-construction activities that would potentially affect water quality include diversion tunnel modifications, road improvements, Iron Gate and Fall Creek hatchery modifications, Yreka pipeline modifications, and dam site preparation between June and November of dam removal year 1 (Table 2.7-1). Immediately following dam removal, non-natural fish barriers would be modified to enable volitional fish passage. Facility removal activities would begin in October of dam removal year 1 with removal of the Copco No. 1 Powerplant, including demolition of the dams and their associated structures, power generation facilities, and transmission lines, installation of temporary cofferdams, hauling, recreation facilities removal, regrading of recreation access roads and parking areas, and other activities (Table 2.7-1). Short-term restoration activities would include irrigation system installation and maintenance, as well as active seeding, planting, and weed management in the reservoir footprint and disturbed upland areas within the Limits of Work (Table 2.7-1). For greater detail on these activities, please see Section 2.7 *Proposed Project*. The aforementioned activities could result in the disturbance of reservoir sediment deposits remaining within the reservoir footprints and result in inorganic and organic contaminants in those sediments entering the Klamath River. Additionally, use of heavy construction equipment and construction-related vehicles involves gasoline, other petroleum fuels, hydraulic and lubricating fluids and other materials, which have the potential to contaminate waters should they be captured in site stormwater runoff or due to accidents. Please see Potential Impact 3.2-4 potential stormwater-related impacts to water quality and Potential Impact 3.22-2 for consideration of the accidental release of hazardous materials from construction equipment and/or vehicles under the Proposed Project.

As discussed in Potential Impact 3.2-4, the Proposed Project includes construction and other ground-disturbing BMPs to reduce potential impacts to water quality in wetlands and other surface waters during construction (Appendix B: *Definite Plan – Appendix J*). Those BMPs focus on general stormwater-related contamination as well as fuels, oils, and lubricants; however, their implementation would also minimize or eliminate the potential for increases in inorganic and organic contaminants that could enter wetlands and other surface waters located within the Limits of Work (Figures 2.2-5, 2.7-2, and 2.7-4), including the Hydroelectric Reach, tributaries of the Klamath River that enter this reach (as appropriate), or the Middle Klamath River immediately downstream of Iron Gate Dam due to construction and other ground-disturbing activities. However, the Proposed Project does not specify BMPs for pre-construction, reservoir restoration, or upland restoration activities. Further, the proposed

BMPs are not sufficiently comprehensive to avoid all potential violations of water quality standards or otherwise degrade water quality in affected portions of the wetlands, Hydroelectric Reach, tributaries to the Klamath River that enter this reach (as appropriate), or the Middle Klamath River immediately downstream of Iron Gate Dam, during these other periods of Proposed Project activity. Thus, short-term increases in inorganic and organic contaminants from hazardous materials associated with construction and restoration activities would potentially result in substantial adverse impacts on human health or environmental receptors and there could be significant impacts without mitigation to water quality in the Hydroelectric Reach and the Middle Klamath River immediately downstream of Iron Gate Dam. Implementation of Mitigation Measures WQ-1, TER-1, and HZ-1 would reduce this impact to less than significant.

Significance
No significant impact with mitigation

Potential Impact 3.2-16 Short-term impacts to aquatic biota from herbicide application during restoration of the reservoir areas.
The Proposed Project Reservoir Restoration Plan includes active seeding and planting of vegetation in drained reservoir areas to stabilize the surface of the sediment and minimize erosion from exposed terrace surfaces following drawdown (Appendix B: *Definite Plan – Appendix H*). An invasive exotic vegetation (IEV) management plan would be implemented to control terrestrial invasive exotic plant species. As part of the management plan, IEV surveys would be undertaken prior to dam removal year 1 and year 2 and non-herbicide methods of integrative pest management (e.g., manual weed pulling, mowing or cutting, mechanical eradication by tilling in larger areas, grazing, shading, and solarization) would be used first to remove IEVs within the Limits of Work. As a last resort and only when other methods prove to be ineffective or potentially cause more harm than benefit within the environment, herbicides would be used to control the growth of invasive exotic vegetation species, with application by wicking or brushing occurring during dam removal year 2.

Herbicide use to control invasive exotic vegetation species has the potential to contaminate the Klamath River through runoff or drift without proper selection, handling, and application. KRRC has proposed to avoid this risk to the extent possible by only using herbicides after non-chemical control methods have proven ineffective or may cause more harm than benefit to the environment. The only herbicides used would be those approved for use by the Bureau of Land Management (BLM), California Department of Fish and Wildlife (CDFW), North Coast Regional Board, USFWS, and NMFS in California. If herbicide application becomes the necessary method for effective IEV control, the KRRC would consider only those application methods with the least side-effects to native vegetation and wildlife and would base application methods on plant reproduction, structure, and growth. Monitoring and management of invasive plant species would continue after dam removal year 2 with the potential for further herbicide application, if the latter offers the most effective methods for control and eradication of noxious weeds (Appendix B: *Definite Plan – Appendix H*).

While the Proposed Project includes strategies to avoid and minimize runoff that is toxic to aquatic biota from herbicide application, the Reservoir Restoration Plan included in the Definite Plan (see Appendix B: *Definite Plan – Appendix H*) lacks specificity regarding certain herbicide formulations and application practices that could result in short-term aquatic toxicity within the Hydroelectric Reach during reservoir restoration activities, which would constitute a substantial adverse impact on aquatic biota and thus would be a significant impact.

Under the Proposed Project, the Reservoir Restoration Plan would be further developed by KRRC working with the appropriate agencies through the FERC process, and it would be subject to State Water Board approval. In addition, it would also be appropriate for the Final Reservoir Restoration Plan to include Mitigation Measure WQ-4, which provides further protections for aquatic biota in relation to control of terrestrial invasive exotic plant species via herbicide application.

Mitigation Measure WQ-4 Herbicide Characteristics and Application Approach.
Aquatic formulations of glyphosate (e.g., Glyfos Aquatic, Rodeo) are developed for use in sensitive protected environments such as habitat restoration sites and wetlands. If glyphosate is chosen as a suitable herbicide for IEV management, then an aquatic formulation shall be used and glyphosate formulations containing the surfactants POEA or R-11 shall be avoided to reduce risks to amphibians and other aquatic organisms. Additionally, glyphosate shall not be applied when weather reports predict precipitation within 24 hours of application, before or after. If another herbicide is chosen, it shall meet the characteristics of low soil mobility and low toxicity to fish and aquatic organisms and shall be applied using 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 as specified in BLM (2010).

Significance
No significant impact with mitigation

3.2.5.8 General Water Quality

Potential Impact 3.2-17 Short-term and long-term influence of changes in Iron Gate and Fall Creek hatchery production on Klamath River and Fall Creek water quality.
Under the Proposed Project, the Iron Gate Hatchery facilities would be modified from existing conditions and the nearby Fall Creek Hatchery would be reopened (see Section 2.7.6 *Hatchery Operations* for more details). As part of the

Proposed Project, the existing adult fish ladder and holding tanks at the base of Iron Gate Dam and the cold-water supply and aerator for the hatchery would be removed, while other hatchery features would remain in place and would be altered for limited operations during dam removal year 2 and the subsequent seven years post-dam removal (eight years total) (see Section 2.7.6.1 *Iron Gate Hatchery* for more details). Fall Creek Hatchery has not been used to produce fish since 2003, so existing facilities would be upgraded for raising coho salmon and Chinook salmon as part of reopening Fall Creek Hatchery, and new facilities (e.g., a settling pond, vehicle parking, pertinent buildings, tagging trailer, etc.) would be constructed (see Section 2.7.6.2 *Fall Creek Hatchery* for more details). As with Iron Gate Hatchery, it would operate for eight years in total, starting in dam removal year 2. As the hatchery facilities would operate for eight years and then close, for this potential impact, short-term is defined as through the eight-year period of operation, and long-term is defined as the period thereafter.

Total hatchery production under the Proposed Project would be reduced from current levels. Iron Gate Hatchery Chinook salmon smolt production goals would be reduced to 3,400,000 under the Proposed Project and fall-run Chinook and coho yearling salmon and steelhead production goals would be reduced to zero since they would no longer be produced at Iron Gate Hatchery (Table 2.7-13). In tandem with fish production decreases at Iron Gate Hatchery, production at Fall Creek Hatchery would increase from zero under existing conditions to 75,000 coho yearlings and 115,000 Chinook yearlings. No Chinook smolts and no steelhead would be produced at Fall Creek Hatchery (see also Section 2.7.6.2 *Fall Creek Hatchery*). While the hatchery production goals have been set, the ability to meet the production varies annually based on adult returns and hatchery performance. At Iron Gate Hatchery, the fall-run Chinook salmon yearling smolt goals and coho salmon yearling smolt goals have been achieved on average since 2005 but fall-run Chinook salmon age zero smolts are typically approximately one million smolts less than production goals (K. Pomeroy, CDFW, pers. comm., 2018) and no steelhead have been released since 2012 (NMFS and CDFW 2018). After considering the actual production achieved, hatchery operations under the Proposed Project would constitute a reduction in production from existing conditions of approximately 87 percent for yearling fall-run Chinook salmon smolts, 20 percent for fall-run Chinook salmon age zero smolts, 100 percent for steelhead, and zero percent for coho salmon smolts (see Section 3.3.5.6 *Fish Hatcheries* for more details).

Hatcheries potentially alter water temperature through increasing exposure to direct sunlight (e.g., in raceways or settling ponds) and ambient air temperatures. Hatcheries also potentially increase suspended material, turbidity, and nutrients in streams by discharging water containing organic solids from uneaten commercial pelletized feed and fish waste. Hatchery discharges may also alter dissolved oxygen, pH, and salinity in streams by discharging water with dissolved oxygen, pH, or salinity different than the streams into which the discharge is released. Differences in dissolved oxygen can be due to hatchery fish respiration, biochemical oxygen demand (BOD) from organic solids associated with fish feed, biological growth (e.g., algae and bacteria) in the hatchery and settling ponds or use of chemicals to manage hatchery conditions (e.g., fish disease). Use of water treatment chemicals, drugs, and/or vaccines to treat illnesses within hatchery fish or prevent detrimental fungal or bacterial conditions also has the potential to alter inorganic and organic contaminant concentrations in receiving waters (ICF 2010). The impacts of hatchery operations and discharges of hatchery effluent on Klamath River water quality would be similar or would decrease under the Proposed Project compared to existing conditions, as current production goals would be reduced, resulting in an overall decrease in potential suspended material, nutrient, or water treatment chemical releases in the system as a whole.

More specifically, under the Proposed Project, water temperature effects from Iron Gate Hatchery in the Klamath River downstream of this hatchery would likely be similar to existing conditions since lower production and proposed modifications at the hatchery would not significantly alter the area of the raceways and settling tanks that are exposed to sunlight or air temperatures. However, suspended material, turbidity, nutrients, dissolved oxygen, pH, salinity, and inorganic and organic chemical contaminants (including aquaculture drugs) from the combined operation of Iron Gate Hatchery and Fall Creek in the Klamath River downstream of Iron Gate Hatchery would decrease under the Proposed Project compared to existing conditions since lower fish production would require less feed and less frequent use of chemicals to manage hatchery conditions.

Feed is a major source of organic material, nutrients, and BOD; review of current hatchery sampling data shows that Iron Gate Hatchery discharges approximately 2,500 pounds of total nitrogen (TN) per year, 500 pounds of total phosphorus (TP) per year and 14,000 pounds of organic matter per year measured as biochemical oxygen demand (BOD) (North Coast Regional Board 2017). These amounts represent 0.03 percent of the overall loading of TN and TP and 0.02 percent of the overall loading of organic matter to the Klamath River every year (North Coast Regional Board 2017). Reductions in fish production and feed at Iron Gate Hatchery under the Proposed Project also would correspond to a reduction in TN, TP, and carbonaceous biological oxygen demand (CBOD)[56] loads from the hatchery. Thus, while Iron Gate Hatchery currently exceeds its TMDL allocation of zero net discharge of nitrogen, phosphorous and biochemical oxygen demand, these existing exceedances to the Klamath River would be reduced under the Proposed Project for eight years of hatchery operations and would then be eliminated.

[56] Carbonaceous biochemical oxygen demand (CBOD) is used instead of BOD to evaluate the organic matter loads in the Klamath River TMDL California Compliance Conditions. BOD is equal to the CBOD plus the nitrogenous biochemical oxygen demand (NBOD).

The chemicals and aquaculture drugs that the Iron Gate Hatchery facility uses, or can use under the Proposed Project, for the treatment and control of disease include oxytetracycline, florfenicol, formalin, providine-iodine complex, hydrogen peroxide, potassium permanganate, and sodium chloride (salt) (North Coast Regional Board 2017). Chemicals and aquaculture drugs used under existing conditions, or approved for use under the Proposed Project, for anesthesia include MS-222/Finquel, and carbon dioxide (North Coast Regional Board 2017). All the chemicals approved for use at Iron Gate Hatchery currently or under the Proposed Project are Food and Drug Administration (FDA) Center Veterinary Medicine (CVM) approved, low regulatory priority (LRP) compounds, or deferred decision (DD) chemicals (Table 3.2-15). The Iron Gate Hatchery is currently required to ensure that chemicals are properly stored and disposed of and that any accidentally spilled materials are contained, cleaned, and disposed of properly (North Coast Regional Board 2017). Any use, storage, or disposal of chemicals and/or aquaculture drugs would be reduced under the Proposed Project for eight years of hatchery operations and would then be eliminated.

Overall, the decrease in total hatchery fish production would maintain or improve water quality conditions downstream of Iron Gate Hatchery as compared to existing conditions, so there would be no significant impact on water quality downstream of Iron Gate Hatchery in the short term or long-term due to changes in fish production under the Proposed Project.

For the stretch of river that is between the Fall Creek Hatchery downstream to Iron Gate Hatchery, there would be a net increase in hatchery-related discharges as compared to the existing condition, because Fall Creek Hatchery is currently not operating. The reopening of Fall Creek Hatchery and production of fish at the hatchery for eight years (i.e., dam removal year 2 and the subsequent seven years post-dam removal) under the Proposed Project would potentially alter the short-term (dam removal year 2 through post-dam removal year 1) and long-term (after post-dam removal year 1) water quality conditions in Fall Creek downstream of the hatchery (Figure 2.7-15). The fish ladder would continuously discharge water from the rearing tanks, except during periods of cleaning, feeding, or chemical use to treat fish illnesses (i.e., therapeutics). The settling pond is proposed for construction on one of two potential nearby sites[57] and would discharge all water from the rearing ponds after cleaning, feeding, or therapeutic use along with all water from the incubation and spawning operations. Fall Creek water quality below Fall Creek Hatchery would be primarily influenced by the hatchery discharges downstream of the settling pond (maximum of approximately 0.35 mile upstream of Fall Creek's confluence with the Klamath River) but Fall Creek water quality potentially would also be

[57] Selection of the settling pond site is pending cultural resources investigations and consultation with tribes with historical and cultural connection to the area (see also Section 2.7.6.2 *Fall Creek Hatchery*).

influenced by hatchery discharges up to the adult fish ladder (approximately 0.87 mile upstream from Fall Creek's confluence with the Klamath River).

Fall Creek Hatchery operations and effluent discharge would potentially alter water temperature downstream of the hatchery discharge points, but the change in water temperature would be minimal. Water temperature data from 11 hatcheries and concurrent water temperature measurements upstream and downstream of the hatchery discharge indicate the average change in water temperature downstream of the hatchery discharge ranged from -0.5ºF to 2.2ºF, with a 0.1ºF or less change in water temperature downstream of more than half of the hatcheries (ICF 2010). While the water temperature impacts of most hatcheries were limited, there were three instances (i.e., 1 percent of all available data) where the water temperature downstream of a hatchery was 5ºF greater than the water temperature upstream, including one occasion at Iron Gate Hatchery in June 2008. In all three instances, hatchery discharge was warmer than the upstream water temperature, but it was less than the downstream water temperature, suggesting that factors in addition to hatchery operations may have influenced water temperature in the stream (ICF 2010). Fall Creek Hatchery is generally shady and therefore unlikely to have the same solar radiation impacts as Iron Gate Hatchery. However, there is the potential for the hatchery to elevate temperatures

Overall, Fall Creek Hatchery discharges potentially would alter water temperature between -0.5ºF to 2.2ºF, and there is significant potential that Fall Creek Hatchery discharges would result in exceedances of water quality standards for water temperature. Fall Creek is an interstate water originating in Oregon, so potential water temperature increases in the stream from hatchery discharges would result in an exceedance of the Thermal Plan water temperature water quality standard for interstate waters that prohibit the discharge of elevated temperature waters into **COLD** interstate waters (Table 3.2-4) and there would be a significant and unavoidable impact without mitigation to water temperature in Fall Creek due to Fall Creek Hatchery under the Proposed Project. While water temperature data in the Klamath River upstream and downstream of the confluence of Fall Creek is unavailable to determine the influence of Fall Creek water temperature on Klamath River water temperatures, the average monthly water temperature in Fall Creek is typically colder than the average monthly water temperature of the Klamath River upstream of Copco No. 1 during April through September (FERC 2007). Thus, Fall Creek would potentially be a source of cold water to the Klamath River during portions of the year and an increase in Fall Creek water temperature due to Fall Creek Hatchery discharges potentially would result in an increase in Klamath River water temperature. While the increase in Fall Creek water temperature and subsequent potential increase in Klamath River water temperature due to hatchery discharges would be small, any increase in water temperature would exceed Thermal Plan water temperature water quality standard for **COLD** interstate waters and there potentially would be a significant and unavoidable impact without mitigation on water temperature in the Hydroelectric Reach of the Klamath River due to Fall Creek Hatchery under the Proposed Project. Although the water temperature of Fall Creek Hatchery discharges would potentially elevate Fall Creek and Klamath River water temperatures, the increase likely would occur at most for several hours per day during the summer and fall when discharge water temperatures would peak and the increase in water temperatures would not continuously occur throughout the 8-year period of operation.

Fall Creek Hatchery discharges potentially would increase suspended material in Fall Creek by discharging water containing organic solids from uneaten commercial pelletized feed and fish waste, but those increases remain less than the suspended sediment thresholds of significance. The measured maximum net TSS resulting from the discharge of 19 existing CDFW hatcheries ranged from less than 5.0 mg/L to 25.6 mg/L, with TSS equal to or greater than 5 mg/L in hatchery discharges occurring at 12 of the 19 hatcheries (ICF 2010). At those 12 hatcheries, TSS was equal to or greater than 5 mg/L less than once a year (1 out of 57 measurements at Iron Gate Hatchery) to approximately twice per year (13 out of 120 measurements at Hot Creek Hatchery). Additionally, the TSS was measured directly in the hatchery discharge, so the TSS within the receiving waterbody (i.e., just downstream of the hatchery discharge point) would be less due to dilution (ICF 2010). The range of potential suspended material in Fall Creek Hatchery discharges would likely be similar to existing CDFW hatcheries, so the potential for hatchery discharges to cause nuisance or adversely affect beneficial uses by introducing suspended material, settleable material, or sediments in excess is based on data regarding existing hatcheries. In line with data from existing CDFW hatcheries and expected dilution in the receiving waterbodies, suspended material in hatchery discharges would remain below the numeric SSC[58] threshold of significance for suspended sediments. Thus, Fall Creek Hatchery discharges under the Proposed Project would have a less than significant impact on suspended sediments in the short term and long term in Fall Creek and in the Klamath River downstream of its confluence with Fall Creek.

Nutrient concentrations in hatchery discharges likely would increase nutrients in Fall Creek downstream of the settling ponds and to a lesser extent downstream of the adult fish ladder, based on nutrient data from existing CDFW hatcheries. In the six existing CDFW hatcheries with nutrient data, the measured nutrients ranged from 0.07 to 5.6 mg/L TN, 0.008 to 5.2 mg/L nitrate, 0.02 to 0.25 mg/L TP, and less than 0.01 to 0.28 mg/L orthophosphate (ICF 2010). The range of measured nitrate concentrations indicates that there is no potential for hatchery discharges to exceed nitrate primary drinking water standards in streams. The existing CDFW hatchery data also documents that nutrient concentrations in hatchery discharges usually vary little from nutrient concentrations in the hatchery source water (i.e., upstream water not influenced by the hatchery), with

[58] For the purposes of this report, SSC is considered equivalent to TSS (see Section 3.2.3.1 *Thresholds of Significance* for additional details).

higher nutrient concentrations in hatchery discharges occurring infrequently. Visual observations from 10 hatcheries that record potential nuisance growth conditions in receiving waters (i.e., streams) did not note nuisance biostimulatory responses, such as discoloration, bottom deposits, visible films/sheens, or objectionable growth (i.e., fungi or slimes) downstream of hatchery discharges (ICF 2010). Fall Creek Hatchery discharges likely would increase nutrient concentrations in Fall Creek[59] and in the Klamath River downstream of its confluence with Fall Creek, but those increases would not be expected to result in exceedances of North Coast Regional Board Basin Plan water quality objectives for biostimulatory substances.

Fall Creek Hatchery discharges may also alter dissolved oxygen in streams by discharging water with dissolved oxygen concentrations different than the receiving waters due to fish respiration or biochemical oxygen demand (BOD) from organic solids, discharging water with organic solids that contribute BOD to streams and reduces dissolved oxygen downstream of the hatchery, and biological growth (e.g., algae and bacteria) in the hatchery and settling ponds. The analysis of dissolved oxygen data from existing CDFW hatcheries, including Iron Gate Hatchery, does not present dissolved oxygen percent saturation in the hatchery discharges, so it is not possible to evaluate hatchery discharges relative to Basin Plan dissolved oxygen water quality objectives. Dissolved oxygen in existing CDFW hatchery discharges usually were greater than 7.0 mg/L, but eight hatcheries had at least one occurrence of dissolved oxygen less than 7.0 mg/L (ICF 2010). In two out of nine measurements, Iron Gate Hatchery discharge dissolved oxygen was less than 7.0 mg/L, with the minimum dissolved oxygen reaching 6.3 mg/L (ICF 2010). While hatcheries manage dissolved oxygen concentrations for fish using flow control, passive aeration devices, and mechanical aeration, there is a low potential for dissolved oxygen below 7.0 mg/L (ICF 2010) that may correspond to dissolved oxygen percent saturation being less than Basin Plan dissolved oxygen water quality objectives. Dissolved oxygen percent saturation varies with water temperature, so dissolved oxygen can be below 7.0 mg/L during peak summer water temperature conditions, yet still meet the Basin Plan dissolved oxygen water quality objectives of 85 percent saturation. Thus, Fall Creek Hatchery discharges would have a low potential for causing dissolved oxygen percent saturation to be less than Basin Plan dissolved oxygen water quality objectives in Fall Creek downstream of the hatchery or in the Klamath River downstream of the confluence with Fall Creek.

[59] One data point exists for nutrient concentrations in Fall Creek measured in October 1999 when the Fall Creek Hatchery was still in operation. However, due to the difference in production goals and proposed new facilities (i.e., settling ponds), it is likely this data would overestimate background nutrient conditions in Fall Creek and potentially overestimate nutrient conditions in Fall Creek upon the resuming of Fall Creek Hatchery operations.

While Fall Creek Hatchery discharges would have a low potential for causing dissolved oxygen percent saturation to become less than Basin Plan dissolved oxygen water quality objectives, dissolved oxygen percent saturation in Fall Creek may infrequently decrease below Basin Plan dissolved oxygen water quality objectives and thus there would be significant impact without mitigation on dissolved oxygen in the short term and long term from hatchery discharges under the Proposed Project.

Fall Creek Hatchery discharges are unlikely to alter pH in streams based on pH monitoring data from existing CDFW hatcheries. The incremental change in pH between upstream and downstream monitoring data was less than 0.5 s.u. downstream of all hatcheries where downstream pH data was available (ICF 2010). Hatchery discharges had pH greater than 8.5 s.u. or less than 6.5 s.u. in only four out of the 12 CDFW hatcheries, with no exceedances occurring at Iron Gate Hatchery (ICF 2010). Thus, Fall Creek Hatchery discharges under the Proposed Project would be unlikely to alter pH in Fall Creek or the Klamath River downstream of its confluence with Fall Creek by 0.5 s.u. or more or result in pH less than 6.5 units or greater than 8.5 units and there would be a less than significant impact without mitigation on pH in Fall Creek and the Klamath River due to Fall Creek Hatchery operations and discharges under the Proposed Project.

Fall Creek Hatchery discharges would potentially increase the concentration of inorganic and organic contaminants in Fall Creek downstream of the settling ponds due to the use of water treatment chemicals, drugs, and vaccines to treat illnesses within hatchery fish (i.e., therapeutics) or prevent detrimental fungal or bacterial conditions. Chemical use in hatcheries typically occurs for several hours using immersion bath or flushing water through one or more components of the hatchery facilities for general treatments, while therapeutics are usually applied in small water volumes or fish feed for a short duration of several minutes up to one hour (ICF 2010). All water from the rearing ponds after cleaning, feeding, or therapeutic use along with all water from the incubation and spawning operations would be discharged from the hatchery settling pond (Figure 2.7-15), so potential increases in inorganic and organic contaminants would be limited to downstream of the settling pond (maximum of approximately 0.35 miles upstream of Fall Creek's confluence with the Klamath River).

Potential chemicals used in CDFW hatcheries in general, the reason for their use, and the regulatory status of the chemicals are summarized in Table 3.2-15. Copper sulfate had been historically used in hatcheries for general treatments, but its use has been discontinued in all CDFW hatcheries (ICF 2010). All the chemicals currently used are Food and Drug Administration (FDA) Center Veterinary Medicine (CVM) approved, investigational new animal drugs (INAD), low regulatory priority (LRP) compounds, or deferred decision (DD) chemicals (Table 3.2-15). FDA approved drugs have been determined to be safe for the treated fish, humans who might consume the treated fish, and the environment when used in accordance with label instructions for proper usage. FDA INAD are used under exemption only, with annual renewals and numerous FDA requirements for their use. FDA LRP compounds are considered comparatively little risk to aquatic organisms, human consumers, or the environment, such that regulatory action is unlikely to occur as long as an appropriate grade of the compound is used for listed indications at the prescribed levels according to good management practices and local environmental requirements are met. FDA DD chemicals are those already approved by the USEPA in aquaculture settings (Bowker et al. 2014). Since proposed production at Fall Creek Hatchery would involve two of the three fish species/ life stages currently raised at Iron Gate Hatchery (i.e., coho and Chinook yearlings), this analysis assumes that chemicals that would potentially be used at Fall Creek Hatchery are similar to chemicals that are currently used, or can be used, at Iron Gate Hatchery (North Coast Regional Board 2017) (Table 3.2-17).

Table 3.2-15. Potential Treatment and Therapeutic Chemicals Used at California Department of Fish and Wildlife Hatcheries in General, Iron Gate Hatchery, and Potentially at Fall Creek Hatchery.

Chemical Name	Use at CDFW Hatcheries[1]	Use at Iron Gate Hatchery and Potential Use at Fall Creek Hatchery[2]	Regulatory Status[1]
Acetic acid	Control of external parasites		FDA LRP compound
Carbon dioxide (gas)	Anesthetic	X	FDA LRP compound
Sodium bicarbonate (baking soda)	Anesthetic		FDA LRP compound
Formalin (formaldehyde)	Fungus and parasite treatment	X	FDA approved
Povidone-iodine (PVP iodine)	Disinfectant for eggs	X	FDA LRP compound
Potassium permanganate	Control of external parasites and bacteria	X	FDA DD chemical; USEPA registered pesticide with approved use in aquaculture
Hydrogen peroxide	Control of fungal and bacterial infection	X	FDA approved
Chloramine-T (*N*-chloro tosylamide)	Control of external gill bacteria		FDA INAD
Terramycin (oxytetracycline)	Antibiotic	X	FDA approved
Aquaflor (florfenicol)	Antibiotic	X	FDA approved

Chemical Name	Use at CDFW Hatcheries[1]	Use at Iron Gate Hatchery and Potential Use at Fall Creek Hatchery[2]	Regulatory Status[1]
Penicillin G	Control and prevention bacterial infections		FDA approved
Romet-30 (sulfadimethoxine-ormetoprim)	Antibiotic		FDA approved
MS-222 (tricane mesylate)	Anesthetic		FDA approved

[1] ICF 2010.
[2] Source for Iron Gate Hatchery information is North Coast Regional Board (2017). For Fall Creek Hatchery, the list of chemicals is assumed to be the same since two of the three fish species/life stages currently raised at Iron Gate Hatchery (i.e., Chinook smolts) would be raised at Fall Creek Hatchery under the Proposed Project.

Notes:
FDA = Food and Drug Administration
INAD = investigational new animal drugs
LRP = low regulatory priority
DD = deferred decision
USEPA = U.S. Environmental Protection Agency

The potential for chemical concentrations in hatchery discharges to exceed the Basin Plan narrative toxicity water quality objective (Table 3.2-4), drinking water criteria, including California Department of Public Health (DPH) maximum contaminant levels (MCLs), or otherwise degrade water quality in streams was evaluated for existing CDFW hatcheries by comparing chemical use concentrations and measurements of chemicals in undiluted hatchery discharge water with CDFW Pesticide Unit guidance aquatic toxicity values and a CDFW Pesticide Investigation Unit toxicity assessment that determined short-term acute test methods (i.e., lethality end point) and chronic test methods (i.e., growth and reproduction end point) (ICF 2010). The CDFW Pesticide Investigation Unit toxicity assessment has been used previously by Regional Water Quality Control Boards to develop NPDES permit numerical effluent limits considered protective of applicable narrative toxicity objectives. Based on the frequency and duration of use in hatcheries, the expected rate of dilution and degradation in the environment, and reported hatchery discharge concentrations, the ICF (2010) analysis concludes acetic acid, carbon dioxide, sodium bicarbonate, PVP iodine, oxytetracycline, florfenicol, penicillin G, Romet-30, and MS-222 all pose a low risk of exceeding CDFW guidance values that are protective of aquatic life, thus the potential for substantial adverse effects on human health or environmental receptors is very low. Available data indicates formalin, potassium permanganate, hydrogen peroxide, and Chloramine-T may exceed CDFW guidance values in undiluted hatchery water, but the analysis concludes the potential for substantial adverse effects from these chemicals on aquatic life-related beneficial uses and other less sensitive designated beneficial uses is very low since potentially elevated concentrations of the chemicals in undiluted hatchery discharges would be expected to rapidly degrade in the aquatic environment, or be diluted within the zone of complete mixing in the receiving waters (ICF 2010). As the discharge will be downstream of the City of Yreka's Fall Creek diversion for drinking water, the discharge should pose no risk to that water supply.

Chemicals that would potentially be used at Fall Creek Hatchery are likely to be similar to chemicals that are currently used, or can be used, at Iron Gate Hatchery, given that proposed production at Fall Creek Hatchery would involve two of the three fish species/ life stages currently raised at Iron Gate Hatchery (i.e., coho and Chinook yearlings). Installation of an ultraviolet light (UV) treatment system for water used in egg incubation at Fall Creek Hatchery, as specified for the Proposed Project, would likely reduce chemical use relative to other CDFW hatcheries without UV treatment systems. Additionally, potential influences of hatchery discharges on Fall Creek and the Klamath River downstream of its confluence with Fall Creek would occur for eight years (i.e., dam removal year 2 and the subsequent seven years post-dam removal) since Fall Creek Hatchery is assumed to operate for only this duration under the Proposed Project. Thus, potential increases in inorganic and organic contaminants in Fall Creek and in the Klamath River downstream of its confluence with Fall Creek due to general treatment or therapeutic chemicals in Fall Creek Hatchery discharges also would have a low risk of substantially adversely impacting aquatic life or other designated beneficial uses in the short term and long term and there is a less than significant impact without mitigation on inorganic and organic contaminants in the short term and long term under the Proposed Project from Fall Creek Hatchery discharges.

In summary, the combined impact of Fall Creek and Iron Gate hatchery operations under the Proposed Project would have no significant impact below Iron Gate Hatchery's discharges, since production would be reduced, decreasing impacts on Klamath River water quality from hatchery operations relative to existing conditions. Fall Creek Hatchery would have a significant impact without mitigation on water temperature in Fall Creek and potentially the Klamath River as it would potentially alter water temperature by -0.5 to 2.2°F and any increase in water temperature would exceed the Thermal Plan water temperature water quality standard for **COLD** interstate waters. Dissolved oxygen percent saturation in Fall Creek may infrequently occur at levels below Basin Plan dissolved oxygen water quality objectives due to Fall Creek Hatchery discharges and thus there would be significant impact without mitigation on dissolved oxygen in the short term and long term from hatchery discharges under the Proposed

Project. While Fall Creek Hatchery operations and discharges would alter suspended materials, and inorganic and organic contaminant concentrations downstream of hatchery discharges, there would be no significant impact on suspended sediments, pH, chlorophyll-a and algal toxins, or inorganic or inorganic and organic contaminants in Fall Creek or the Klamath River downstream of Fall Creek in the short term or long-term under the Proposed Project.

In order to comply with Sections 301, 302, 303, 306, and 307 of the Clean Water Act (CWA), and with applicable requirements of California law, the Proposed Project would implement the conditions specified by the State Water Board in the Section 401 water quality certification. In addition to the Proposed Project Fish Hatchery Plan (see also Section 2.7.6; Appendix B: *Definite Plan – Section 7.8.3 Proposed Fish Hatchery Plan*), the draft water quality certification issued by the State Water Board specifies that, prior to operation of the Iron Gate and Fall Creek hatcheries, the Licensee shall, for each hatchery, obtain coverage under and comply with the *Cold Water Concentrated Aquatic Animal Production Facility Discharges to Surface Waters, National Pollutant Discharge Elimination System* permit (NPDES No. 135001) or subsequent NPDES permits issued by the North Coast Regional Board.

Several measures were considered to remediate water temperature increases in Fall Creek to avoid a significant impact. Fall Creek Hatchery settling pond and adult fish ladder discharges directly from Fall Creek diversion point could discharge to the Klamath River rather than Fall Creek. Fall Creek is typically cooler than the Klamath River, so Fall Creek Hatchery settling pond discharges would likely still be cooler than the Klamath River even with small amounts of warming of Fall Creek water through the hatchery. Thus, redirecting Fall Creek Hatchery settling pond discharges from Fall Creek to the Klamath River likely would not increase the temperature of interstate waters. Adult fish ladder discharges under the Proposed Project would have gone through the rearing ponds, so they may experience some warming and they may also increase the temperature of interstate waters. Thus, the adult fish ladder discharges would also need to be re-plumbed such that adult fish ladder discharges would be directly taken from the Fall Creek Hatchery diversion point on the Fall Creek powerhouse canal return flow to prevent warming. It is unclear given the available information about the plumbing of the Fall Creek Hatchery whether diverting flows from the Fall Creek Hatchery diversion point directly to the adult fish ladder and having all flows for the rearing tanks go to the settling pond for eventual discharge directly to the Klamath River is even generally feasible or cost-effective (i.e., this distance of pipe is unlikely to be cost effective for temporary hatchery modifications. Additionally, due to prolific tribal cultural resources in the vicinity of Fall Creek Hatchery this measure is likely infeasible. Furthermore, diverting flows from Fall Creek would reduce high-quality habitat for anadromous fish spawning for a longer stretch of the creek. Thus, this measure was not pursued as a feasible mitigation measure.

Chillers may also reduce water temperatures in Fall Creek Hatchery discharges so that water temperature in discharges is always less than the water temperature of receiving waters (in this case, Fall Creek). However, the temporary operations of the hatchery combined with the electricity cost of a chiller(s) was, like the distance for additional piping, found not to be feasible, and this mitigation measure was likewise not pursued.

Significance

No significant impact in the short term and long term for water quality in the Middle Klamath River downstream of Iron Gate Hatchery

Significant and unavoidable in the short term for water temperature and dissolved oxygen in Fall Creek downstream of Fall Creek Hatchery

No significant impact in the long term for water quality (except water temperature and dissolved oxygen) in Fall Creek downstream of Fall Creek Hatchery

Potential Impact 3.2-18 Impacts on water quality from construction activities on Parcel B lands.

As discussed in Section 2.7-10 *Land Disposition and Transfer*, as part of the Proposed Project, Parcel B lands would be transferred to the states (i.e., California and Oregon), as applicable, or to a designated third-party transferee, following dam removal. The outcome of the future Parcel B land transfer is speculative with regard to land use; while the lands would be managed for the public interest, this could include open space, active wetland and riverine restoration, river-based recreation, grazing, and potentially other uses.

It is likely that there would be at least some construction for recreation facilities, active restoration, fencing, trail-building, or other land management activities. To the extent there are construction activities, these could involve the same types of potential short-term impacts to water quality as described in Potential Impact 3.2-4, which would be a significant impact. Use of construction best management practices are feasible and implementation of these can reduce the erosion and sediment issues associated with construction to less than significant.

Therefore, the impact of minor construction on suspended sediments in the future associated the transfer of Parcel B lands and future land use on them would be less than significant with mitigation measures WQ-1, TER-1, and HZ-1, which include BMPs for the area. These measures represent protection under a broad range of construction projects, both in-water and in the dry, and are likely to cover the range of construction activities that would support the various public land uses anticipated under the KHSA. If implemented as part of construction activities under future land uses, these measures would avoid potential violations of water quality standards or other water quality degradation in affected portions of wetlands and other waterbodies and would reduce impacts to less than significant.

In the long term, if managed grazing activities were to occur beyond the level occurring under existing conditions, this could result in erosion-related significant impacts on water quality. However, managed grazing activities would incorporate project-specific measures to reduce potential water quality impacts, including storm water management, streambank setbacks, or exclusionary livestock fencing. Managed grazing activities are required to meet the requirements of the non-point source discharge policy, the prohibition against unpermitted discharges, and the North Coast Regional Water Quality Control Board’s Agricultural Lands Discharge Program. These require compliance with BMPs designed to meet state water quality requirements (North Coast Regional Board 2018a). Managed grazing activities that implement such project-specific measures would be expected to have a less than significant impact on water quality in the long term. Future land use activities that involve active wetland and riverine restoration would be likely to result in long-term benefits to water quality.

Significance

No significant impact with mitigation in the short term or long term

3.2.6 References

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3.3 Aquatic Resources

This section describes existing conditions of aquatic resources in the Klamath Basin; analyzes potential impacts that the Proposed Project would have on these aquatic resources and the recovery of listed fish species; and includes measures to avoid or mitigate any significant adverse impacts to fish, aquatic mammals, freshwater mussels, and aquatic macroinvertebrates. Commercial fisheries are discussed in Section 5.3.1 *Regional Economic Impacts*, and potential impacts to recreational fisheries opportunities are in discussed Section 3.20 *Recreation*. The tribal significance of fisheries and potential impacts are discussed in Section 3.12 *Historical Resources and Tribal Cultural Resources*. Floating and attached algae are addressed in Section 3.4 *Phytoplankton and Periphyton*, and wetlands and riparian vegetation and wildlife species (including amphibians and reptiles) are addressed in Section 3.5 *Terrestrial Resources*.

The objectives of the Proposed Project include advancing the long-term restoration of the natural fish populations in the Klamath Basin through water quality improvements, habitat expansion, and a reduction in existing disease rates among salmonids (Section 2.1 *Project Objectives*). Many comments were received by the State Water Board during the public scoping process relating to aquatic resources (see Appendix A), and several of the comment topics were controversial. Some commenters expressed concern that the Proposed Project will not, or is not likely to, meet the stated objectives, or that the costs of implementation (financial and otherwise) are too great to justify the potential for gain. Numerous commenters asserted that hundreds of miles of habitat would become available to salmonids should the dams be removed, and many commenters asserted evidence of historical salmon migrations to Upper Klamath Lake. In contrast, a number of comments identified potential fish passage obstructions located within the portion of the mainstem Klamath River that is currently inundated by the Lower Klamath Project reservoirs. Many comments further stated the belief that coho salmon were not historically found in the Klamath Basin, while others stated that coho salmon were not found in the mid- or upper Klamath Basin due to natural passage barriers. Numerous comments described the fishery benefits that could result from dam removal, including increased habitat access and reduced fish disease, while other comments described the fishery benefits that could result from leaving the dams in place and using fish ladders to support passage and hatchery operations to offset habitat losses. Many public comments contended that the Lower Klamath Project dams are responsible for the reduction in salmon populations in the Klamath Basin, while a roughly equal number of comments indicated that other factors are responsible for the observed population declines, including predation by sea lions, tribal harvest, and fishing pressure from foreign fishing fleets. Comments were also received regarding the relationship between marine mammals, such as Southern Resident Killer Whales and sea lions, and the Chinook salmon fishery in the Klamath watershed, including comments that dam removal could benefit the mammals by increasing abundance of their prey. Additional summary of the aquatic resource comments received during the public scoping process, as well as the individual comments, are presented in Volume II Appendix A.

After circulation of the Draft EIR, numerous additional comments were received regarding aquatic resources (see Volume III), and changes to the section in response to those comments are flagged in the comment responses and then printed in this Final EIR section. None of the changes result in significant new information in the EIR under the meaning of CEQA Guidelines, section 15088.5, subdivision (a):

> New information added to an EIR is not 'significant' unless the EIR is changed in a way that deprives the public of a meaningful opportunity to comment upon a substantial adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect (including a feasible project alternative) that the project's proponents have declined to implement.

However, the changes were numerous enough that reprinting the section rather than simply including a list of revisions was warranted to improve clarity and readability of the document.

3.3.1 Area of Analysis

The Area of Analysis for aquatic resources considers the range of environments that could be affected by the Proposed Project. The Area of Analysis includes most portions of the Klamath Basin, excluding the Lost River watershed, and most of the Trinity River. Although the Area of Analysis for aquatic resources includes much of the Upper Klamath Basin in Oregon, these areas are included only to the extent to which they affect California aquatic resources. As the lower 1/4 to 1/2 mile of the Trinity River could be used as a refuge by Klamath River fish attempting to avoid exposure to sediment pulses associated with dam removal, this portion of the Trinity River is also considered in the analysis as part of the Klamath Basin, the Area of Analysis includes the Klamath River Estuary and the nearshore portions of the Pacific Ocean.

This aquatic resources analysis includes an assessment of potential impacts within and across five study reaches of the Klamath River separated by changes in basin physiography (e.g., Upper and Lower Klamath basins), the presence of Lower Klamath Project facilities, and the degree of marine influence (Figure 3.3-1). The five study reaches within the Area of Analysis for aquatic resources are as follows:

1. Upper Klamath River and Connected Waterbodies

   a. Tributaries to Upper Klamath Lake (Sprague, Wood, and Williamson rivers)
   b. Upper Klamath Lake and Agency Lake
   c. Keno Impoundment/Lake Ewauna
   d. Upper Klamath River upstream of the influence of J.C. Boyle Reservoir to Keno Dam
   e. Tule Lake and Lost River between Anderson Rose Dam and Tule Lake
2. Upper Klamath River − Hydroelectric Reach
   a. J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate reservoirs
   b. J.C. Boyle Bypass and Peaking reaches
   c. Copco No. 2 Bypass Channel
   d. Tributaries to the Upper Klamath River (e.g., Jenny, Spencer, Shovel, and Fall creeks)
3. Middle and Lower Klamath River
   a. Middle Klamath River from Iron Gate Dam downstream to the confluence with Trinity River
   b. Major tributaries to the Middle Klamath River (e.g., Shasta, Scott, and Salmon Rivers)
   c. Minor tributaries to the Middle Klamath River (e.g., Bogus, Beaver, Humbug, and Cottonwood creeks)
   d. Lower Klamath River from the confluence with the Trinity River to the estuary
   e. Lower portion of the Trinity River
4. Klamath River Estuary
5. Pacific Ocean Nearshore Environment
   a. California portion of the Klamath River Management Zone (KMZ, Oregon-California state line south to Horse Mountain [40° 05’ 00” N. latitude])

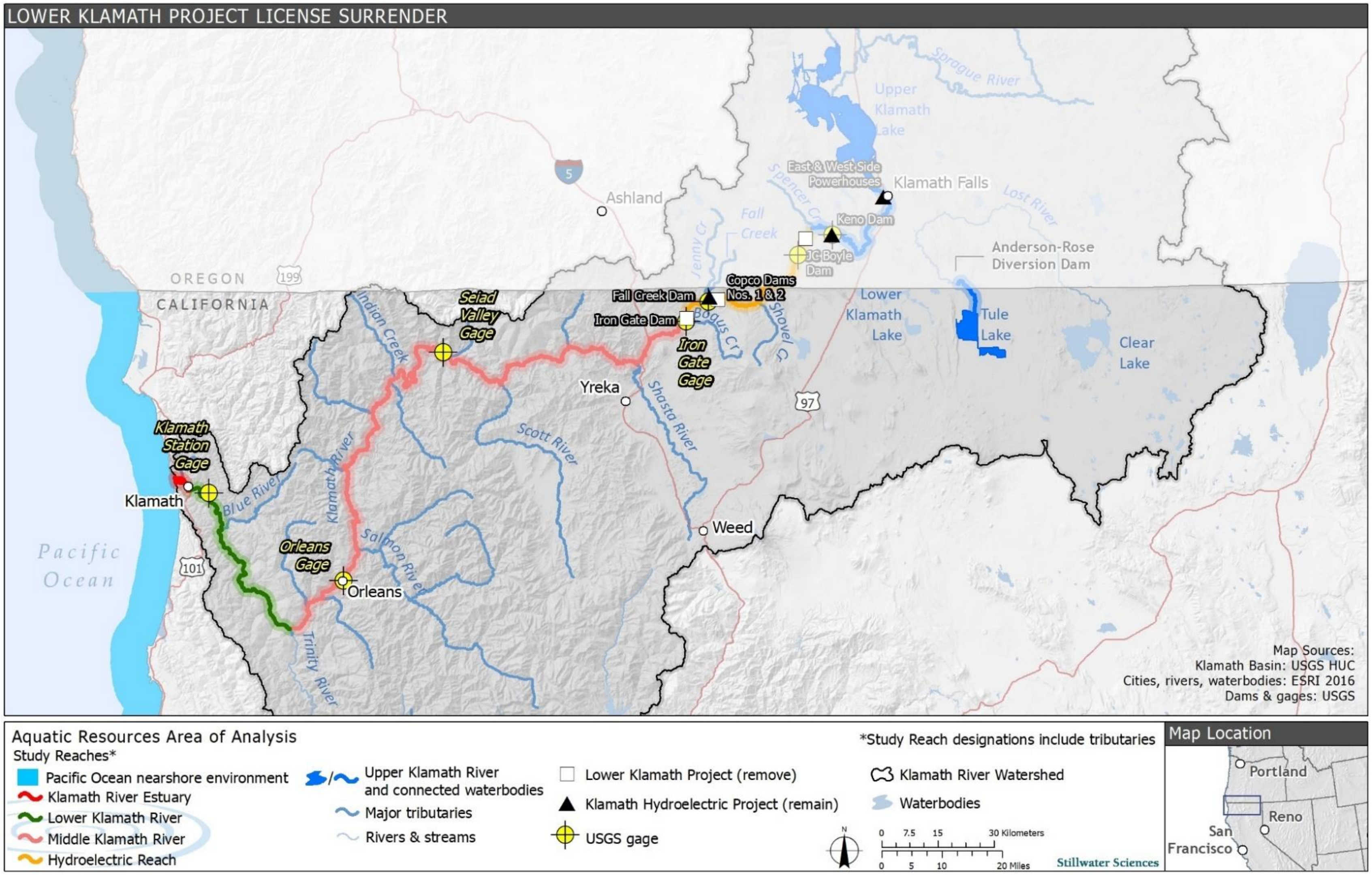

Figure 3.3-1. Study Reaches within the Area of Analysis for Aquatic Resources.

3.3.2 Environmental Setting

This section describes existing conditions in the Area of Analysis for aquatic resources, including discussion of aquatic species (Section 3.3.2.1 *Aquatic Species*); physical habitat in the waterbodies (Section 3.3.2.2 *Physical Habitat Descriptions*); and important factors affecting aquatic resources that the Proposed Project would influence, if implemented (Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project*).

Each aquatic species description includes a brief summary of the current and historical distribution, life-history patterns, and habitat requirements. The narrative is subdivided into anadromous fish, resident riverine fish, non-native fish species, estuarine species, freshwater mollusks, benthic macroinvertebrates, and marine mammals.

The description of physical habitat contains a summary of water quality and other factors that may limit aquatic resource production in the waterbodies in the Area of Analysis, and it describes the species that occur in the California portion of these waterbodies. This section also describes designated critical habitat for species listed under the federal ESA and Essential Fish Habitat (EFH) managed under the Magnuson-Stevens Fishery Conservation and Management Act occurring within the California portion of the aquatic resources Area of Analysis.

Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project* provides a more detailed description of existing conditions for factors that potentially could have a major influence on aquatic resources. These factors form the basis for Section 3.3.5 *[Aquatic Resources] Potential Impacts and Mitigation*.

3.3.2.1 Aquatic Species

Numerous aquatic species use the California portion of the Klamath Basin during some or all of their lives. The large number of species prohibits an individual evaluation of each species. Instead, the assessment of potential impacts and/or benefits of the Proposed Project within California on aquatic species is based on an analysis of target species that possess a legal status or importance for tribal, commercial, or recreational fisheries, and for which there are sufficient data to support the analysis. Appendix J: *Special-status Plant, Fish, and Wildlife Scoping Lists* Table J-1 includes a summary of all special-status aquatic fish documented in the Project vicinity. Special status species included in the analysis are summarized in Table 3.3-1, and all the target species (including others without special status) selected for analysis are discussed below.

Table 3.3-1. Special-status Aquatic Species Documented in the Vicinity of the Proposed Project and Included in Aquatic Resources Analysis.

Common Name *Scientific Name*	**Status[a] Federal/ State/Forest Service, Bureau of Land Management**	**Query Sources**	**Distribution**	**Habitat Association**
Fish				
Shortnose sucker *Chasmistes brevirostris*	FE/SE, SFP/-- Designated critical habitat	CNDDB USFWS	Resident fish observed in the Upper Klamath Basin. In California, they are found in the Klamath River downstream to Copco No. 1 Reservoir and Iron Gate Reservoir.	Warm slow-moving waters or lakes. Spawning occurs along shorelines of lakes or tributaries.
Lost River sucker *Deltistes luxatus*	FE/SE, SFP Designated critical habitat within Area of Analysis	CNDDB USFWS	Resident fish observed in the Upper Klamath Basin. In California, they are found in the Klamath River downstream to Copco No. 1 Reservoir and Iron Gate Reservoir.	Warm slow-moving waters or lakes. Spawning occurs along shorelines of lakes or tributaries.
Coho salmon, southern Oregon/northern California coasts ESU *Oncorhynchus kisutch*	FT/ST/-- Designated critical habitat within Area of Analysis	USFWS	Within the Area of Analysis anadromous fish occurring downstream in the mainstem Klamath River and tributaries downstream of Iron Gate Dam	Streams; spawns in gravel riffles

Common Name ***Scientific Name***	**Status[a] Federal/ State/Forest Service, Bureau of Land Management**	**Query Sources**	**Distribution**	**Habitat Association**
Chinook salmon - upper Klamath and Trinity Rivers ESU *Oncorhynchus tshawytscha*	--/SSC/FSS	CNDDB	Within the Area of Analysis anadromous fish occurring downstream in the mainstem Klamath River and tributaries downstream of Iron Gate Dam	Streams; spawns in gravel riffles
Upper Klamath-Trinity River Spring Chinook *Oncorhynchus tshawytscha*	--/SCE/--		Within the Area of Analysis anadromous fish occurring downstream in the mainstem Klamath River and tributaries downstream of Iron Gate Dam	Streams; spawns in gravel riffles
Coastal cutthroat trout *Oncorhynchus clarki*	--/SSC/FSS	CNDDB	Within the Area of Analysis coastal cutthroat trout are distributed primarily within smaller tributaries to the lower 22 miles of the Klamath River mainstem above the estuary, but also within tributaries to the Trinity River.	Shaded streams with water temperatures below 64.4˚F and small gravel for spawning
Summer-run steelhead trout *Oncorhynchus mykiss irideus*	--/SSC/--	CNDDB	Within the Area of Analysis anadromous fish distributed throughout the Klamath River and in its tributaries, downstream from Iron Gate Dam	Streams; spawns in gravel riffles

Common Name ***Scientific Name***	**Status[a] Federal/ State/Forest Service, Bureau of Land Management**	**Query Sources**	**Distribution**	**Habitat Association**
Longfin smelt *Spirinchus thaleichthys*	FC/ST, SSC/--	CNDDB	Within the Area of Analysis anadromous fish found in Klamath River Estuary	Adults in large bays, estuaries, and nearshore coastal areas; migrate into freshwater rivers to spawn; salinities of 15–30 ppt
Eulachon *Thaleichthys pacificus*	FT/--/-- Designated critical habitat within Area of Analysis	CNDDB	Within the Area of Analysis anadromous fish found in Klamath River Estuary	Adults in large bays, estuaries, and nearshore coastal areas; migrate into freshwater rivers to spawn.
Aquatic Mollusks				
Montane peaclam *Pisidium ultramontanum*	–/–/FSS	CNDDB	Within the Area of Analysis, they have been found in Upper and Lower Klamath Basin	Mollusk found in spring-influenced streams, lakes, and pools and strongly associated with sands or small clean gravels

Common Name ***Scientific Name***	**Status[a] Federal/ State/Forest Service, Bureau of Land Management**	**Query Sources**	**Distribution**	**Habitat Association**
Mammals				
Killer whale *Orcinus orca* Southern Resident DPS	FE/– Critical habitat (Designated)	NMFS	Pacific Ocean	Coastal habitats of temperate waters, including bays

[a] Status codes:

Federal
- FE = Listed as endangered under the federal Endangered Species Act
- FT = Listed as threatened under the federal Endangered Species Act
- FPE = Federally proposed as endangered
- FPT = Federally proposed as threatened
- FC = Federal candidate species
- FD = Federally delisted
- PD = Federally proposed for delisting
- BGEPA = Federally protected under the Bald and Golden Eagle Protection Act
- FSS = Forest Service Sensitive species
- BLMS = Bureau of Land Management Sensitive Species

State
- SE = Listed as Endangered under the California Endangered Species Act
- ST = Listed as Threatened under the California Endangered Species Act
- SCE = State Candidate Endangered
- SD = State Delisted
- SSC = CDFW Species of Special Concern
- SFP = CDFW Fully Protected species
- BOFS = Considered a sensitive species by the California Board of Forestry under the California Forest Practice Rules (14 CCR §895.1)

<u>Fish</u>

Numerous fish species use the California portion of the Klamath Basin during some portion or all of their lives. Native fishes found in riverine environments, some of which are listed under the federal or state ESAs, include salmonids, lamprey, sturgeon, suckers, minnows, dace, sculpin; and in the estuary, anchovy, gunnel, pipefish, eulachon, smelt, stickleback, and gobies occur. Species that have been introduced into the Klamath Basin include non-native yellow perch (*Perca flavescens*), largemouth bass (*Micropterus salmoides*), spotted bass (*Micropterus punctulatus*), sunfish (*Lepomis spp*), and catfish (*Siluriformes spp*).

Anadromous Fish Species

The Klamath Basin provides habitat for many species of anadromous fish – fish that migrate between salt and fresh water. Many Klamath River anadromous fish are salmonids, but there are also green sturgeon (*Acipenser medirostris*), Pacific lamprey (*Entosphenus tridentatus*), American shad (*Alosa sapidissima*) (discussed under *Non-native Fish Species* below), and eulachon (*Thaleichthys pacificus*) (discussed under *Estuarine Species* below). Additionally, CDFW operates the Iron Gate Hatchery directly downstream of Iron Gate Dam for salmonid production, as described in more detail in Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project – Fish Hatcheries*.

Anadromous fish species within the Klamath Basin have nearly all declined compared to their historical abundance (Table 3.3-2). Although historical data are not available for green sturgeon, the population appears to be more stable than other fish species. Based on reports of green sturgeon captures in the Yurok Tribal Chinook salmon gill-net fishery, Van Eenennaam et al. (2006) conditionally suggests that the Klamath River green sturgeon population appears strong and stable but cautions against conclusions based on short time frames relative to the green sturgeon's long-life span.

Table 3.3-2. Historical and Recent Status of Adult Klamath River Anadromous Fish.

Species/Location	Historical Run Estimate[1]	Recent Run Size Estimate	Source
Pacific Lamprey			
Basin Wide	N/A	4,750–13,000[2]	Goodman and Reid 2012
Shasta River	N/A	250–1,000[2]	Goodman and Reid 2012
Scott River	N/A	250–1,000[2]	Goodman and Reid 2012
Salmon River	N/A	1,000–2,500[2]	Goodman and Reid 2012
Trinity River	N/A	2,000–5,000[2]	Goodman and Reid 2012
Steelhead			
Basin Wide	400,000[3]	Spring-, Summer-, and Fall-Run – 110,000[4] Winter-Run – 20,000[4]	Historical (Leidy and Leidy 1984) Recent (Busby et al. 1994)
Scott River	N/A	146–419[5]	CDFW 2013
Trinity River Fall-Run (Naturally Produced)[6]	N/A	2,454–9,205[7]	CDFW 2016a
Trinity River Fall-Run (Hatchery Produced)[6]	N/A	4,460–46,379[7]	CDFW 2016a
Iron Gate Hatchery	N/A	<10–400[7]	CDFW 2018c and Moyle et al. 2017
Coho Salmon			
Basin Wide	15,400–20,000	2,796–41,270[8]	Historial (Moyle et al. 1995) Recent (Ackerman et al. 2006)
Iron Gate Hatchery	N/A	70–1,296[9]	Giudice and Knechtle 2018
Bogus Creek	N/A	6–446[9]	Knechtle and Chesney 2016a, Dennis et al. 2017, 2018
Shasta River	N/A	9–255[10]	CDFW 2015a, Chesney and Knechtle 2016, 2017
Scott River	N/A	63–2,752[11]	Knechtle and Chesney 2016b
Mid-Klamath Tributaries[12]	N/A	169–307[13]	PacifiCorp 2018a
Trinity River (Naturally Produced)[6]	N/A	65–4,457[9]	Kier et al. 2018
Trinity River (Hatchery Produced) [6]	N/A	590–17,448[9]	Kier et al. 2018

Species/Location	Historical Run Estimate[1]	Recent Run Size Estimate	Source
Fall-Run Chinook Salmon			
Basin Wide	500,000	27,369–316,754[14]	Historical (Moyle 2002) Recent (CDFW 2019)
Bogus Creek	N/A	868–12,930[14]	CDFW 2019
Salmon River	N/A	1,058–5,493[14]	CDFW 2019
Scott River	N/A	1,279–12,470[14]	CDFW 2019
Shasta River	20,000–80,000	1,348–29,544[14]	Historical (Moyle 2002) Recent (CDFW 2019)
Trinity River	N/A	4,901–65,893[14]	CDFW 2019
Trinity River Hatchery[15]	N/A	1,543–17,553[14]	CDFW 2019
Iron Gate Hatchery[15]	N/A	2,587–40,015[14]	CDFW 2019
Spring-Run Chinook Salmon			
Basin Wide	100,000	6,438–35,244[9]	Historical (Moyle 2002) Recent (CDFW 2018d)
Salmon River	N/A	166–1,593[9]	CDFW 2018d
Trinity River[16]	N/A	2,599–22,733[9]	CDFW 2018d
Trinity River Hatchery[16]	N/A	1,380–6,821[9]	CDFW 2018d
Green Sturgeon			
Basin-wide	Unknown	127–453[17]	Adams et al. 2007
Coastal cutthroat			
Basin-wide	Unknown	Unknown, but likely stable[18]	Moyle et al. 2017

Species/Location	Historical Run Estimate[1]	Recent Run Size Estimate	Source
Eulachon			
Basin-wide	650,000[19]	0–1000[20]	NMFS 2017a

N/A: Not available.

[1] "Historical" is considered pre-1900's, unless otherwise noted.
[2] Based on data from 2009–2012
[3] Estimate from 1960. Anadromous fish numbers were already in decline in the early 1900s (Snyder 1931)
[4] Based on data from 1977–1991
[5] Based on data from 2007–2012
[6] "Naturally produced" refers to progeny of fish that spawned in the river; "hatchery produced" refers to hatchery releases
[7] Based on data from 2006–2015
[8] Basin wide run size is estimated based on expanded harvest data from 1999–2005 and is naturally produced coho salmon and does not account for hatchery produced fish.
[9] Based on data from 2008–2017
[10] Based on data from 2007–2016
[11] Based on data from 2007–2015
[12] Mid-Klamath Tributaries include Cottonwood, Horse, Middle, and Seiad creeks
[13] Based on data from 2015–2017
[14] Based on data from 2009–2018
[15] CDFW (2019) does not identify natural and hatchery produced fall-run Chinook salmon, values reported for Trinity River Hatchery and Iron Gate Hatchery are based on fish that spawned at the hatchery
[16] CDFW (2018d) does not distinguish wild and hatchery origin spring-run Chinook spawning naturally, values reported for Trinity River Hatchery are based on fish that returned to the hatchery.
[17] Values for green sturgeon are based on harvest data from 1985–2003
[18] Coastal cutthroat are reported to be widely distributed in medium to high densities in nearly all lower Klamath tributaries downstream of Mettah Creek but no population numbers are available.
[19] The only reliable landings data for Eulachon in the Klamath River is from 1963, when a total of 650,000 fish were reported to have been landed. Based on the limited nature of the data we cannot estimate the fraction of the harvest relative to the total run (escapement).
[20] Eulachon were thought to be extinct from the Klamath River after 1998; however, a small run was reported in 2004 and more recent sampling efforts from 2011–2014 have reported increasing numbers.

Anadromous Salmonids

Anadromous salmonids in the Klamath River include fall-run[60] and spring-run Chinook salmon (*Oncorhynchus tshawytscha*); coho salmon (*Oncorhynchus kisutch*); fall-, winter-, and summer-run steelhead (*Oncorhynchus mykiss*); and coastal cutthroat trout (*Oncorhynchus clarki clarki)*. Anadromous salmonids share similar life-history traits, but the timing of their upstream migrations, timing of outmigration[61], 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 (called redds) and deposits eggs. The number of eggs deposited by female anadromous salmonids generally increases with fish size where larger females deposit more eggs. Depending on the species, age, and size of the fish the number of eggs deposited can range from 200–17,000 (Moyle 2002, Moyle et al. 2017). After depositing eggs, her mate, or mates, 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 from and a protective mound of gravel and cobble over the eggs. The female will continue the mound-building process and defend her nest location. Most anadromous male and female salmonids die after completing spawning, although steelhead and coastal cutthroat may survive spawning, re-enter the ocean, and return to spawn the following year(s).

The salmonid 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 and feed off their yolk sac until it is depleted. Egg-to-emergence survival is related to fine sediment infiltration, water temperature, and the fitness of the eggs. The fry that survive to emerge from the redds seek slow shallow areas near shoreline or vegetative cover, feed on benthic macroinvertebrates, gradually moving into deeper and faster water as they grow. Anadromous salmonids are generally considered "juveniles" when they have grown to a fork length of approximately 55 millimeters (about 2.2 inches)[62].

Juveniles feed opportunistically on macroinvertebrates, crustaceans, and smaller fish, and grow on their way downstream. Downstream migration is increased during spring rain events. As discussed in detail in subsequent sections, survival of fry and juvenile life stages is related to disease, parasites, food availability, predation risk, water temperature, and habitat availability (e.g., refuge from high

[60] Run is a migration of salmon up a river from the sea.
[61] Outmigration is the migration of juvenile salmonids from rivers downstream to the estuary and ocean.
[62] Fork length is the length of a fish measured from the tip of the snout to the end of the middle caudal fin rays.

flows). Within the Klamath River juvenile salmonids seek refuge from high flows and turbidity during winter in off-channel features such as side-channels and ponds, and during summer locate thermal refuge within cool water at the confluence with tributaries (in addition to thermal relief during nighttime cooling). Juvenile salmonids may also rear for some time in the estuary feeding prior to entering the ocean. Before entering brackish or saltwater, juveniles must undergo a physiological process called smoltification, which is the series of physiological changes allowing juveniles to adapt from living in fresh water to living in seawater. 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 to nearby waterbodies does occur. Different salmon species and populations (and even the same populations from year to year) have highly variable straying rates, with hatchery origin spawners straying at a higher rate (Lasko et al. 2014). Straying may be the result of a multitude of factors, including as a response to environmental conditions or disturbance events, or exploration of new habitats for suitability. Survival of adults in the marine environment is related to fishing pressure, food availability, and predation risk (e.g., marine mammals). When adults return to natal streams upstream migration success is related to availability of adequate instream flows, turbidity, water temperature (for spring- and summer-runs), disease and parasites, fishing pressure, and passage obstacles (both natural and man-made). Between 1998 and 2008, smolt-to-adult-return-ratios (SAR) for coho salmon at Iron Gate Hatchery ranged from 0.04 percent to 2.66 percent with an average of 0.99 percent (CDFW and PacifiCorp 2014). Fall-run Chinook salmon smolts from Iron Gate Hatchery implanted with coded wire tags had return rates ranging from 0.006 to 0.914 percent with an average return rate of 0.178 percent during the period of 1990 through 2015, while Chinook salmon yearlings during the same period had return rates ranging from 0.009 to 1.058 percent with an average return rate of 0.352 percent (Giudice and Knechtle 2018). From 1988 to 2003, the SAR for fall Chinook released from the Trinity River hatchery ranged from 0.12 percent to 3.19 percent with an average of 1.61 percent (California HSRG 2012). For Trinity River spring-run Chinook salmon, yearling releases have averaged just over twice the survival of smolt releases (0.54 percent vs. 1.11 percent). The range of SARs for smolts was from 0.004 percent in 1989 to 2.27 percent in 1999. The SAR range for yearlings was from 0.08 percent in 1990 to 3.30 percent in 1999.

Specific details of life history and distribution are described in the following sections for each anadromous salmonid species.

<u>Chinook Salmon</u>

Two Chinook salmon Evolutionarily Significant Units (ESUs) currently occur in the Klamath Basin downstream of Iron Gate Dam—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 two rivers. A status review in 1999 determined that neither ESU warranted listing under the federal ESA (NMFS 1999a). The Upper Klamath and Trinity Rivers ESU is listed as a CDFW Species of Special Concern and a USDA Forest Service Sensitive Species.

Another petition to list Chinook salmon in the Upper Klamath and Trinity Rivers ESU under the ESA was submitted to NMFS in January 2011 (CBD et al. 2011). In the petition, NMFS 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 (DPS) 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, NMFS 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. As a result, NMFS formed a Biological Review Team (BRT) to assess the biological status of the species and determine if listing under the ESA is 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[63] 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 two of the three spring-run population units that were evaluated (Salmon River and South Fork Trinity River). The BRT concluded that although current levels of abundance are low when compared to historical estimates of abundance, the current abundance levels did 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 DPS within the Upper Klamath and Trinity River ESU. This finding was based in part on genetic evidence that indicates

[63] Escapement is the portion of a salmon population that does not get caught by commercial or recreational fisheries and returns to their freshwater spawning habitat or hatchery of origin.

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 distinct and geographically separated groups of Chinook salmon populations in the Upper Klamath and Trinity River basins; and that spring-run and fall-run Chinook salmon life histories have evolved independently, but in parallel, within both the Salmon and Trinity rivers. In addition, spring-run and fall-run populations in the Salmon River were nearly genetically indistinguishable and spring-run and fall-run populations in the South Fork Trinity River 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 (ocean entry in early spring within a few months of emergence) and stream type (ocean entry during spring of their second year of life) 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.

However, recently published research by Prince et al. (2017) questions the basis of treating the fall-run and spring-run Chinook salmon in the Upper Klamath and Trinity River ESU as a single ESU, which was based on overall genetic structure that is primarily defined by geography. The genomic results of Prince et al. indicate that premature migration observed in spring-run Chinook salmon is defined by a single genetic variation, questioning the basis of conventional ESU designations which assume that genetic structure is primarily defined by geography.

In response to new information from Prince et al. (2017), and the overall decline of spring-run Chinook salmon, in November 2017, the Karuk Tribe and the Salmon River Restoration Council submitted a petition to NMFS to list as threatened or endangered the Upper Klamath and Trinity Rivers ESU or, alternatively, create a new ESU to describe Klamath spring-run Chinook salmon and list the new ESU as threatened or endangered under the ESA. In February 2018, NMFS announced a 90-day finding on this petition (NMFS 2018a). NMFS found that the petition presents substantial scientific information indicating the petitioned actions may be warranted. NMFS will conduct a status review of the Chinook salmon in the Upper Klamath and Trinity rivers to determine if the petitioned actions are warranted. No final decision has been published to date.

In July 2018, the Karuk Tribe and Salmon River Restoration Council submitted a petition to the California Fish and Game Commission to list the Upper Klamath Trinity River Spring Chinook as an endangered species under the California Endangered Species Act (CESA). In February 2019, the California Fish and Game Commission designated the Upper Klamath Trinity River Spring Chinook a candidate for listing while the petition undergoes review.

Regardless of the status of a determination on whether spring-run and fall-run Chinook salmon comprise a single ESU, these two runs have different life history strategies (NRC 2004), and therefore are considered distinct in this analysis. A more detailed discussion of the two run types is described below.

Fall-Run Chinook Salmon

Fall-run Chinook salmon are currently distributed throughout the Klamath River downstream from Iron Gate Dam. Upstream adult migration through the estuary and Lower Klamath River peaks in early September and continues through late October (Moyle 2002, FERC 2007, Strange 2008) (Table 3.3-3). 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. Table 3.3-3 provides a generalized life history periodicity for fall-run Chinook salmon life stages, with additional timing provided in Appendix E.3.1.1.

Table 3.3-3. Life-history Timing of Fall-run Chinook Salmon in the Klamath River Basin Downstream of Iron Gate Dam. Peak activity is indicated in black.

Life Stage	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
All Types																								
Incubation																								
Emergence																								
Adult migration																								
Spawning																								
Type I																								
Rearing																								
Juvenile outmigration																								
Type II																								
Rearing																								
Juvenile outmigration																								
Type III																								
Rearing																								
Juvenile outmigration																								

Fall-run Chinook salmon in the Klamath Basin exhibit three juvenile life-history types: Type I (ocean entry at age 0[64] 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) (Table 3.3-3). 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* (a blue-green algae species that is potentially toxic to fish, as discussed in detail below and in Section 3.4 *Phytoplankton and Periphyton*). 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 in the mainstem Klamath River downstream from these tributaries during migratory periods, although a few fish are occasionally observed in other areas (Stillwater Sciences 2009a). Based on data from 2005 to 2014 (CDFW 2015b), the Salmon River contributions to the overall escapement of spring-run Chinook salmon ranged from 1 to 12 percent of the total escapement, and from 1 to 20 percent of the natural escapement. To date, no spring-run Chinook salmon 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 current abundance is low compared with historical abundance (Table 3.3-2), the Chinook salmon population (which includes hatchery fish) appears 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 2,000 fish and 1,000 fish, respectively). 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).

[64] 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.

The BRT (Williams et al. 2011) found the decline in spring-run salmon especially troubling given that historically 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-run Chinook salmon spawned in the tributaries of the Upper Klamath Basin (Moyle 2002, Hamilton et al. 2005, Hamilton et al. 2016) with large numbers of spring-run Chinook salmon spawning in the basin upstream of Klamath Lake in the Williamson, Sprague, and Wood rivers (Snyder 1931). Genetic studies of Chinook in the Klamath-Trinity basin, including analysis of archeological samples from the upper Klamath Basin, support the historical prevalence of spring-run Chinook salmon in tributaries upstream of Klamath Lake and identify genetic differences between spring-run and fall-run phenotypes (Prince et al. 2017, Thompson et al. 2018). Large runs of spring-run Chinook salmon also historically 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 were eliminated by the completion of Copco No. 1 Dam in 1917 (Snyder 1931). The cause of the decline of the Klamath River spring-run Chinook salmon prior to Copco No. 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 the early 1900's. Dams (e.g., Iron Gate Dam and Lewiston Dam) have eliminated access to much of the historical spring-run spawning and rearing habitat and are partly responsible for the extirpation of at least seven spring-run populations from the Klamath-Trinity River system (Myers et al. 1998). For example, the construction of Dwinnell Dam on the Shasta River in 1926 was soon followed by the disappearance of the spring-run 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 it does not appear to be 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) (Table 3.3-4). Snyder (1931) also describes a run of Chinook salmon occurring in the 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 begins in 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. 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-run 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). Table 3.3-4 provides a generalized life history periodicity for spring-run Chinook salmon life stages, with additional timing provided in Appendix E.3.1.2.

Table 3.3-4. Life-history Timing of Spring-run Chinook Salmon in the Klamath River Basin Downstream of Iron Gate Dam. Peak Activity is Indicated in Black.

Life Stage	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
All Types																								
Incubation																								
Emergence																								
Adult migration in mainstem																								
Adult entrance into tributaries																								
Spawning																								
Type I																								
Rearing																								
Juvenile outmigration																								
Type II																								
Rearing																								
Juvenile outmigration																								
Type III																								
Rearing																								
Juvenile outmigration																								

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 (an 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). Approximately half were identified to be hatchery age-1 juvenile fall-run Chinook salmon, and the rest 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 adults and juveniles 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).

<u>Coho Salmon</u>

Coho salmon within the Klamath Basin are included within the Southern Oregon/Northern California Coast (SONCC) coho salmon ESU, which is listed as federally threatened (NMFS 1997a). SONCC coho salmon designated critical habitat includes the Klamath River downstream of Iron Gate Dam, including the estuary (NMFS 1999b). This ESU includes all naturally spawning populations between Punta Gorda, California and Cape Blanco, Oregon, which encompasses the Trinity and Klamath basins (NMFS 1997a). 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). The Pacific Fishery Management Council (PFMC) considers potential impacts from fishing when setting retention limits each year. The annual coho salmon exploitation rate (proportion of a population that is caught during a year) averaged approximately 5 percent from 2000 to 2013. California waters were open to coho salmon fishing prior to 1998, but currently, coho salmon fishing in California is restricted to tribal harvest under federal reserved fishing rights in the Klamath River. California's statewide prohibition of coho salmon fishing maintains consistently low impacts from freshwater recreational fisheries on SONCC coho salmon (NMFS 2014).

Coho salmon are native to the Klamath Basin. Williams et al. (2006) described nine historical coho salmon populations within the Klamath Basin: the Upper Klamath River, Shasta River, Scott River, Salmon River, Middle 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). Note that the designation of these population units varies from the Area of Analysis study reach designations used in this EIR.

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 of those providing written records in recognizing that 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 them from other salmon species. Available data suggests that coho salmon were in both mainstem and tributary reaches of the Klamath River upstream to and including Spencer Creek at RM 232.6 (NRC 2004, as cited in NMFS 2007a, Hamilton et al. 2005). While noting that the evidence of historic presence between Fall and Spencer creeks was not conclusive, the 2006 Administrative Law Judge trial-type hearing under Section 241 of the Energy Policy Act of 2005 (NMFS 2006a) determined that coho salmon were abundant at Fall Creek, and that suitable habitat in the Hydroelectric Reach included Spencer, Fall, Beaver, Deer, Shovel, Scotch and Jenny creeks, as well as the main stem of the Klamath River itself.

The final SONCC Coho Salmon Recovery Plan was published on September 9, 2014 (NMFS 2014). Estimated extinction risk is designated as high for the Lower and Upper Klamath River populations, and moderate for the Middle Klamath River population. Estimated extinction risks of the Shasta, Scott, and Salmon river populations are designated as high, moderate, and high, respectively. Extinction risks for the Lower and Upper Trinity River populations are designated as high and moderate, respectively, while the South Fork Trinity River population is designated as high. Williams et al. (2006) describes population units to support recovery planning for the listed SONCC ESU. Analysis of coho salmon in this EIR considers impacts and benefits for each of the nine population units in the Klamath Basin separately but makes a significance determination for all population units combined within the Klamath Basin to be consistent with the approach to assessing other aquatic species populations, and to be consistent with the NMFS 2014 Southern Oregon/Northern California Coast (SONCC) Recovery Plan, which assesses all of the coho salmon in the Klamath River Basin as part of the same ESU.

The 2016 five-year status review of SONCC coho salmon (NMFS 2016a) indicated that the ESU's extinction risk has increased since the last status review in 2011. Drought conditions had persisted in four of the prior five years and were ongoing. These conditions are unprecedented in the time since SONCC coho salmon have been listed and were found likely to have resulted in reduced juvenile survival and stressful rearing conditions in nearly all parts of the ESU's range. Those juveniles that survived the freshwater conditions were also found likely to have faced poor ocean conditions, the results of which would only be apparent after these year classes return as adults.

Coho salmon are currently widely distributed in the Klamath River downstream from Iron Gate Dam (RM 193.1) (NRC 2004, Dennis et al. 2017, 2018), which blocks the upstream migration of coho salmon to historically available habitat in the upper watershed. To minimize and mitigate for adverse effects to coho salmon, PacifiCorp prepared a Habitat Conservation Plan (HCP) for its interim operations of the Klamath Hydroelectric Project (PacifiCorp 2012). This HCP underlines the conservation strategy and measures that PacifiCorp will undertake to address anticipated effects on SONCC coho salmon and their habitat in the Klamath Basin. Per the HCP, PacifiCorp provides funding for the California Klamath Restoration Fund/Coho Enhancement Fund (CEF) as an Interim Measure (IM2). As of January 2018, PacifiCorp has provided funding of over $4,900,000 into the CEF. Between 2009 and 2017, NMFS and CDFW selected 42 projects (with a value of approximately $4.3 million) to benefit coho salmon (PacifiCorp 2018). These projects have been conducted at the mouths of 72 tributaries as well as in Seiad Creek, Scott River, Denny Ditch, Shasta River, Huseman Ditch, McBravey Creek, Fort Goff Creek Stanshaw Creek and Lower Hoopaw Creek. Over 2,000 feet of channel has been restored, over 163,000 ft^2 of off-channel ponds have been created, three fish screens have been installed, 73 passage barriers have been removed, access has been improved to over 71 miles of coho salmon habitat, 7 miles of riparian fencing have been installed, 29 water leases have been implemented to improve flows to nearly 36 miles of stream, and 71,000 ft^2 of other habitat enhancement projects have been implemented. PacifiCorp has developed a partnership with the National Fish and Wildlife Foundation (NFWF) to administer the fund, and this allows grant recipients to apply for additional funding from other grant programs. Using this process, grantees have leveraged an additional $7.7 million matching funds for coho salmon restoration projects as of 2017. A Technical Review Team was formed in 2012 and meets annually to review existing projects funded under the Coho Enhancement Fund and to recommend possible adaptive management changes.

Coho salmon use 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, NMFS 2010a).

Adult coho salmon in the Klamath Basin migrate upstream from September through late December, with migration peaking in October and November (Table 3.3-5). Spawning occurs mainly in November and December, with fry emerging from the gravel in the spring, three to four months after spawning, depending on water temperature (Trihey and Associates 1996, NRC 2004) (Table 3.3.-5). Table 3.3-5 provides a generalized life history periodicity for coho salmon life stages, with additional timing provided in Appendix E.3.1.3.

Table 3.3-5. Life-history Timing of Coho Salmon in the Klamath River Basin Downstream of Iron Gate Dam. Peak Activity is Indicated in Black.

Life Stage	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
Incubation																								
Emergence																								
Rearing																								
Juvenile redistribution																								
Juvenile outmigration																								
Adult migration																								
Spawning																								

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 off-channel ponds, non-natal tributaries to the Klamath River, downstream portions of 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 downstream from tributaries into the mainstem Klamath River as smolts 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 SONCC coho salmon and degradation of their habitat include logging, road building, grazing, mining, urbanization, stream channelization, dams, wetland loss, beaver trapping, artificial propagation, overfishing, water withdrawals, and unscreened diversions for irrigation (NMFS 1997a). In 2007, NMFS published a Klamath River Coho Salmon Recovery Plan to comply with the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006. This level of recovery planning is not as intensive or thorough as the recovery planning process required under the ESA (which to date had not been completed). The 2007 plan includes the following actions identified as high priority for recovery:

- Restore access for coho salmon to the Upper Klamath Basin by providing passage upstream of 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.

Many of the actions identified in the 2007 plan have been, or are in the process of being, addressed: the Proposed Project in this EIR would address restoration of access for coho salmon; the Trinity River Restoration Program is currently being implemented; and, many private landowners and water users are restoring coho access and habitat to stream reaches and they are addressing forestry practices that could harm fish. Fish disease issues are being researched and addressed, most recently in 2013 when the NMFS and USFWS issued a joint Biological Opinion (2013 BiOp; NMFS, and USFWS 2013) for the USBR's Klamath Irrigation Project operations, as described in detail in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*. While the 2013 BiOp is for operations upstream of the Lower Klamath Project, the conditions of the 2013 BiOp form an important part of the existing condition for coho salmon downstream of Iron Gate Dam, and, as discussed below, are intended to reduce coho disease rates. In this joint BiOp, NMFS consulted on coho salmon, while USFWS consulted on listed suckers (discussed below under *Lost River and Shortnose Suckers*).

In the 2013 BiOp, NMFS concluded that the effect of proposed USBR Klamath Irrigation Project operations on flows would result in habitat reductions for coho salmon juveniles in the mainstem Klamath River. To offset these negative effects, the 2013 BiOp includes flow release requirements to reduce disease incidence for coho salmon in the Klamath River downstream of Iron Gate Dam. The formulaic approach to flow releases designed to benefit coho salmon, as described in the 2013 BiOp, prioritizes a volume of water set-aside in an Environmental Water Account (EWA) for releases in the spring, and minimum daily flow targets in April through June to meet Hardy et al. (2006) recommended ecological base flows (discussed further in Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project*). The 2013 BiOp found that Klamath Irrigation Project operations were not likely to diminish habitat for coho salmon fry and juveniles in the Upper Klamath, Middle Klamath, Shasta, and Scott river populations to an extent that would reduce life history diversity.

In their 2013 BiOp analysis of the Klamath Irrigation Project operations, NMFS concluded that the proposed flow releases would result in coho salmon disease risks that are lower than observed period of record conditions, yet higher than under natural flow conditions (NMFS and USFWS 2013). Of all the adverse effects of the proposed Klamath Irrigation Project operations, NMFS concluded that risk of fish disease due to the myxozoan parasite *Ceratomyxa shasta* (*C. shasta*) is the most significant for coho salmon, since *C. shasta* is a key factor limiting salmon recovery in the Klamath River (e.g., Foott et al. 2009). The adaptive management element of the USBR's Klamath Irrigation Project proposed operations was intended to minimize disease risks to coho salmon during average to below average water years if EWA surplus volume is available. Lastly, NMFS concluded that the proposed minimum daily flows below Iron Gate Dam in April to June would limit the increase in disease risks posed to coho salmon from Klamath Irrigation Project operations. The Klamath Irrigation Project directs flow requirements in the Klamath River below Iron Gate Dam by releases from the Lower Klamath Project's Iron Gate Dam consistent with the 2013 BiOp issued on the Klamath Irrigation Project. By lowering the disease risk, NMFS asserted that coho salmon abundance would likely improve over the next ten years for the Upper Klamath, Middle Klamath, Shasta, and Scott river populations.

However, the first years of 2013 BiOp implementation included severe drought conditions, and although the USBR was operating the Klamath Irrigation Project in accordance with the 2013 BiOp, the infection rate for *C. shasta* in the Klamath River downstream of Iron Gate Dam greatly exceeded the incidental take maximum (U.S. District Court 2017a). As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, this led to a court order requiring USBR to implement three specific flows in the Klamath River, as measured immediately downstream of Iron Gate Dam: annual winter-spring surface flushing flows, biennial winter-spring deep flushing flows, and spring-summer emergency dilution flows (U.S. District Court 2017a–c). The court also required that USBR re-initiate consultation with NMFS and the USFWS regarding the effects of the Klamath Irrigation Project operations on coho salmon in the Klamath River and Lost River and shortnose suckers in the Upper Klamath Basin (U.S. District Court 2017a–c). The flow-related analyses in this EIR acknowledge the re-initiation of consultation on the 2013 BiOp Flows by considering the 2017 court-ordered flushing and emergency dilution flow requirements downstream of Iron Gate Dam as interim flow requirements until completion of formal consultation. The court-ordered flushing flows and emergency dilution flows are not part of existing conditions for the Proposed Project, because they went into effect after the Notice of Preparation was filed by the State Water Board in December 2016, and because the data evaluating the effectiveness of the flows and their potential impacts were not sufficiently robust to support analyses in the Draft EIR. The court-ordered flushing and emergency dilution flows are detailed in Section 4.2.1.1 *[Alternative Description] Summary of Available Hydrology Information for the No Project Alternative* as part of the No Project Alternative because they would likely only apply if Iron Gate Dam were to remain in place or the disease nidus remains. These flows are also discussed in Section 4.4 *Continued Operations with Fish Passage Alternative*.

After the issuance of the Lower Klamath Project Draft EIR on December 27, 2018, the applicable biological opinion and the operational flow requirements for the Klamath River changed again in March 2019, when the new biological opinions were issued by NMFS (2019) and USFWS (2019a). The 2019 BiOp Flows are now the current operational flow requirement for the Klamath River. The 2019 BiOp Flows are analyzed in the Lower Klamath Project Final EIR as a second CEQA baseline, representing flows under conditions defined and implemented during final EIR development. Inclusion of two baseline hydrology regimes in the Lower Klamath Project Final EIR is consistent with CEQA Guidelines section 15125 (a). The 2019 BiOp flow requirements include annual surface flushing flows of at least 6,030 cubic feet per second (cfs) for 72 hours at Iron Gate Dam between March 1 and April 15, and the potential for dilution flows and/or enhanced spring flows should conditions allow.

Steelhead

Steelhead are highly adaptive salmonids, with multiple life histories (Hodge et al. 2016). Klamath Basin summer steelhead and winter steelhead populations both belong to the Klamath Mountain Province ESU, which is not listed under the ESA. The NMFS (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.

Summer Steelhead

The Klamath Mountain Province ESU of summer steelhead is a CDFW Species of Special Concern and is distributed throughout the Klamath River downstream from Iron Gate Dam and in its tributaries. This species historically used habitat upstream of Upper Klamath Lake prior to the construction of Copco No. 1 Dam (Hamilton et al. 2005). However, some populations such as the Salmon River summer steelhead have declined significantly in the past several decades (Quiñones et al. 2013), and in general summer steelhead populations in the ESU are currently in low abundance (Moyle et al. 2017). Based on available escapement data from summer direct observation surveys, approximately 55 percent of summer steelhead spawn in the Trinity River and other lower-elevation tributaries (CDFW and USDA Forest Service 2002, unpubl. data). Most remaining summer steelhead are believed to spawn in tributaries between the Trinity River (RM 43.3) and Seiad Creek (RM 132.7), with high water temperatures limiting their use of tributaries to the Klamath River farther upstream (NRC 2004). Adult summer steelhead use the mainstem Klamath River primarily as a migration corridor to access holding and spawning habitat in tributaries.

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 (USFWS 1998) (Table 3.3-6). 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). Table 3.3-6 provides a generalized life history periodicity for summer steelhead life stages, with additional timing provided in Appendix E.3.1.4.

Table 3.3-6. Life-history Timing of Summer Steelhead in the Klamath River Basin Downstream of Iron Gate Dam. Peak Life-history Periods are Shown in Black.

Life Stage	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Incubation																								
Emergence																								
Rearing																								
Juvenile outmigration																								
Half-pounder residence																								
Adult migration in mainstem																								
Adult holding in tributaries																								
Spawning																								
Run-backks																								

Juvenile summer steelhead in the Klamath Basin may rear in freshwater for up to three 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[65] tributaries (particularly during periods of poor water quality) for one 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 2010). Juvenile outmigration occurs primarily during spring. 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 include degraded habitats, passage impediments, 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, and 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. 2005). Butler et al. (2010) found that 93 percent of the 41 *Oncorhynchus mykiss* specimens excavated from archeological sites above Upper Klamath Lake were anadromous (indicating occurrence of steelhead historically upstream of Upper Klamath Lake). 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 2010). They spawn mainly in tributaries throughout the Klamath River Basin downstream of Iron Gate Dam, and occasionally within the mainstem (NRC 2004). Winter steelhead migrate upstream primarily from January through April (USFWS 1998), with peak spawn timing in February and March (ranging from January to April) (NRC 2004) (Table 3.3-7). Adults may repeat spawning in subsequent years after returning to the ocean in the spring following spawning. Immature ”half-pounders” return after a short (<1 year) ocean residence each year in September through March and typically use the mainstem Klamath River to feed until returning to the ocean (NRC 2004),

[65] Tributary other than the one in which it was born.

although they also use larger tributaries such as the Trinity River (Dean 1994, 1995). Table 3.3-7 provides a generalized life history periodicity for spring-run Chinook salmon life stages, with additional timing provided in Appendix E.3.1.4.

Table 3.3-7. Life-history Timing of Fall-and Winter-run Steelhead and Rainbow Trout in the Klamath River Basin Downstream of Iron Gate Dam. Peak Life-history Periods are Shown in Black.

Life Stage	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
Incubation																								
Emergence																								
Rearing																								
Juvenile outmigration																								
Half-pounder residence																								
Fall-run adult migration																								
Winter-run adult migration																								
Spawning																								
Run-backs																								

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 age-1 juveniles have been captured in outmigrant traps in spring and summer in tributaries to the Klamath River upstream of Seiad Creek (CDFG 1990a, b). These fish are likely rearing in the mainstem or non-natal tributaries before outmigrating to the ocean 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 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).

<u>Coastal Cutthroat Trout</u>
Klamath River coastal cutthroat trout belong to the Southern Oregon/California Coasts ESU. Coastal cutthroat trout within the Area of Analysis for aquatic resources is listed as a CDFW Species of Special Concern and a USDA Forest Service Sensitive Species. In a 1999 status review, NMFS 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 22 miles of the Klamath River mainstem upstream of the estuary (NRC 2004), but also within tributaries to the Trinity River (Moyle et al. 1995).

Coastal 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-run steelhead in the Klamath River (NRC 2004). Both resident and anadromous life histories are observed in coastal cutthroat trout in the Klamath Basin. Anadromous adults enter the river to spawn in the fall. Moyle (2002) noted that upstream migration in northern California spawning streams tends to occur from August to October after the first substantial rain. Generally, spawning of anadromous and resident coastal cutthroat trout may occur from September to April (Moyle 2002). “Sea-run” adults spend some time in the ocean without fully adopting a fixed anadromous life history may either return to rivers in summer to feed or return in September or October to spawn and/or possibly overwinter (NRC 2004). Cutthroat with a resident life history remain in freshwater for their entire lives and may use mainstem and/or tributary habitats.

Juvenile coastal cutthroat trout may spend anywhere from one to three years in freshwater to rear. Anadromous or sea-run juveniles outmigrate during April through June, at the same time as Chinook salmon juvenile downstream migration (Moyle 2002, NRC 2004). These 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 a mean of 27 days, based on a mark-recapture study.

Pacific Lamprey

Pacific lamprey are the only anadromous lamprey species in the Klamath Basin. Pacific lamprey, along with three other lamprey species found in California, Oregon, Washington and Idaho, were 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 resume the review Pacific lamprey are anticipated as more information is obtained. Although no historical abundance data are available, recent estimates are that there are annual runs of over 4,000 Pacific lamprey in the Klamath Basin (Goodman and Reid 2012, Table 3.3-2).

Pacific lamprey are found in Pacific Ocean coast streams from Alaska to Baja California. They occur throughout the mainstem Klamath River downstream from Iron Gate Dam and its major tributaries including: Trinity, Salmon, Shasta, and Scott River basins (Stillwater Sciences 2009a). Although the evidence is inconclusive as to whether Pacific lamprey were historically present upstream of Iron Gate Dam, the record of evidence shows that access to habitat would benefit Pacific lamprey by providing additional spawning and rearing grounds (NMFS 2006a). 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 on their own volition during all months of the year, with peak upstream migration occurring from December through June (Stillwater Sciences 2009a) (Table 3.3-8, life history timing detailed in Appendix E.3.1.5). As adults, Pacific lamprey do not feed in freshwater. 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 throughout the mainstem Klamath River from Iron Gate downstream to the estuary (FERC 2007). 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 (FERC 2007). Ammocoetes remain in freshwater for five to seven years (with slower growing individuals leaving at older ages) before emerging from the substrate and beginning their “transformer” life stage. During the transformer life stage, metamorphosis begins, and Pacific lamprey begin to develop eyes and sharp teeth (Clemens 2019). Once metamorphosis is complete, juveniles migrate downstream to the ocean where they will spend one to three years in the marine environment (with no documented cause of variability in marine residency), where they parasitize a wide variety of ocean fishes, including Pacific salmon, flatfish, rockfish, and pollock (Close et al. 2010). For more species information see Close et al. (2010), Stillwater Sciences (2009a), and PacifiCorp (2004a).

Table 3.3-8. Life-history Timing of Pacific Lamprey in the Klamath River Basin Downstream of Iron Gate Dam. Peak Activity is Indicated in Black.

Life Stage	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Incubation																								
Rearing																								
Juvenile outmigration																								
Adult migration																								
Spawning																								

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, reduced larval habitat by increasing water velocity and/or reducing sediment deposition areas when sediment is trapped at dams, 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 are an anadromous species that occurs in coastal marine waters from Mexico to the Bering Sea. NMFS has identified two DPSs: (1) the Northern Green Sturgeon DPS, which is not listed as threatened or endangered but is on NMFS' Species of Concern list and which includes populations spawning in coastal watersheds from the Eel River north, and (2) the Southern Green Sturgeon DPS, listed as threatened under the federal ESA and encompassing coastal or Central Valley populations spawning in watersheds south of the Eel River (NMFS 2006b). Although the Southern Green Sturgeon DPS is considered a separate population from the Northern Green Sturgeon 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 Northern Green Sturgeon DPS (Adams et al. 2002). Although Southern Green Sturgeon DPS may enter other west coast estuaries to feed in the summer and fall, there has been no documentation of them entering the Klamath River or its estuary (USBR 2010). No Northern Green Sturgeon DPS 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 tagged Klamath River fish if they had ventured there (McCovey 2011a). No Southern Green Sturgeon DPS tagged in the Sacramento/San Joaquin and/or San Francisco Bay region have ever been detected in the Klamath River. Southern Green Sturgeon DPS 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 2011a). Based on the available evidence it appears unlikely that sturgeon from the Southern Green Sturgeon DPS currently occur within the Klamath River or nearshore environment. Therefore, the rest of this section pertains only to the Northern Green Sturgeon DPS.

Northern Green Sturgeon DPS 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 four years on average after around age-16, for approximately eight spawning efforts in a lifetime (Klimley et al 2007). Green sturgeon enter the Klamath River to spawn from March through July (Table 3.3-9). Green sturgeon spawn primarily in the lower 67 miles of the mainstem Klamath River (downstream from Ishi Pishi Falls, directly upstream of the confluence with the Salmon River), in the Trinity River, and occasionally in the lower Salmon River (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, approximately 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 between RM 13 and RM 66.3 through November prior to migrating downstream to the ocean. Table 3.3-9 illustrates the periodicity of green sturgeon in the Klamath River. Additional timing detail is provided in Appendix E.3.1.6.

Table 3.3-9. Life-history Timing of Green Sturgeon in the Klamath River Basin Downstream of Iron Gate Dam. Peak Activity is Indicated in Black.

Life Stage	**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
Incubation/emergence																								
Rearing																								
Juvenile outmigration																								
Adult migration																								
Spawning																								
Post-spawning adult holding																								

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 one to three years in the Klamath River Basin 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).

Adult green sturgeon that have held over the summer in the Klamath River after spawning appear to migrate downstream to the ocean in conjunction with increases in discharge in the fall. Attenuation of high flows downstream from Iron Gate Dam as a result of USBR Klamath Irrigation Project operations 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). Historically Klamath River below Iron Gate Dam was relatively responsive to discharge increases related to rainfall events, and the timing of peak flows changed significantly following implementation of USBR Klamath Irrigation Project operations on the Klamath River (Balance Hydrologics, Inc. 1996). When compared to pre- Klamath Irrigation Project operations, existing flows in October are higher and flows in late spring and summer are lower (Balance Hydrologics, Inc. 1996).

Resident Riverine Fish Species

<u>Rainbow and Redband Trout</u>

Rainbow trout 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 No. 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). Coastal rainbow trout are widely distributed downstream of Iron Gate Dam, including occasionally within the mainstem Klamath River, and predominately within every major tributary and most smaller tributaries with perennial flow as well. Their habitat requirements, sensitivities to disease and water quality are the same as those described above for steelhead. Rainbow trout are distinguished from steelhead by a life history that is limited to freshwater. Juveniles rear in mainstem and tributary habitat from two to three years before reaching sexual maturity (with faster growing individuals maturing sooner), and adults spawn in tributaries.

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. These fish are a popular recreational fishery. The Upper Klamath

Basin supports the largest and most functional adfluvial[66] redband trout population of Oregon's interior basins (Hamilton et al. 2011). In the Hydroelectric Reach, most redband trout spawning is thought to occur in Spencer and Shovel creeks. Redband trout migrate among habitats, mainstem, tributaries, and reservoirs to meet their life-history requirements. Redband trout are considered resistant to *C. shasta* or other diseases potentially brought upstream by anadromous fishes (Hamilton et al. 2011).

Redband trout in the upper Klamath River currently risk potential entrainment at Project facilities. A study addressing the potential for entrainment at Project facilities found that several tens of thousands of resident fish are estimated to be entrained annually at each of the Project facilities (CH2M Hill 2003). The majority of these fish are likely nonnative species; however, redband trout also have the potential to be entrained. Furthermore, records from canal salvage operations at the J.C. Boyle power canal show resident trout are entrained and possibly killed each year in Project canals (DOI 2007).

For more information on rainbow and redband trout, see USFWS (1998); USFWS (2000); Behnke (2002); Moyle (2002); NRC (2004); PacifiCorp (2004a); Starcevich et al. (2006); and Messmer and Smith (2007).

<u>Resident Lampreys</u>
In addition to the anadromous Pacific lamprey, described above, at least three resident species are present in the California portion of the Klamath Basin (PacifiCorp 2006, Hamilton et al. 2011):

- Northern California brook lamprey (*Entosphenus folletti*);
- Western brook lamprey (*Lampetra richardsoni*); and
- Klamath River lamprey (*Lampetra similis*).

No lamprey species are listed as threatened or endangered on either the California or Federal ESA lists (CDFW 2018a). However, all three resident species are listed in California as Species of Special Concern (Moyle et al. 2015). All resident 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 for two to seven years (USFWS 2004). After they transform into adults, the non-parasitic species (Northern California brook lamprey, western brook lamprey) do not feed, while the parasitic Klamath River lamprey 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

[66] Life history strategy in which adult fish spawn and juveniles subsequently rear in streams but migrate to lakes for feeding as subadults and adults.

the Trinity River, and in the Link River of the Upper Klamath Basin (Lorion et al. 2000, as cited in Close et al. 2010).

In the Klamath River Basin, Western brook lamprey are known to occur only in Hunter and McGarvey creeks, near the mouth of the Klamath River (Close et al. 2010). Early studies of Western brook lamprey were conducted outside of California (Moyle et al. 2015), and therefore there is no information on the life history, distribution, or abundance of this species in the Klamath River Basin prior to the construction of the Lower Klamath Project. Because they are known to occur only in streams near the mouth of the Klamath River, the effects from the existing dams would be confined to flow alteration in the mainstem, to the extent that Western brook lamprey use the mainstem for dispersal or other life history events.

Northern California brook lamprey (also known as the Modoc brook lamprey) are found upstream of Iron Gate Dam (Close et al. 2010). They have been reported from a tributary to the Lost River in the Clear Lake Basin and are potentially also found in Fall Creek (Close et al. 2010). Moyle et al. (2015) report that Northern California brook lamprey are known to occur in Willow and Boles creeks above Clear Lake Reservoir. Northern California brook lamprey was not described as a separate species until 1976 (based on museum specimens) and was not recognized as a species by the American Fisheries Society until 2013 (Moyle et al. 2015). Therefore, there is no information on the life history, distribution, or abundance of this species prior to the construction of the Lower Klamath Project. Moyle et al. (2015) states that the only known populations are above large reservoirs, which suggests that they are isolated from other populations. Moyle et al. (2015) reports that dams and diversions on the upper Klamath River and Lost River alter downstream flows and habitats, potentially negatively affecting the downstream populations.

Cyprinids

The native blue chub (*Gila coerulea)* and tui chub (*Gila bicolor*) are both found in the Klamath Basin, including Lost River, Lower Klamath Lake, Tule Lake, and Iron Gate and Copco No. 1 reservoirs (CH2M Hill 2003). These species prefer habitat with quiet water, well-developed beds of aquatic plants, and fine sediment or sand bottoms. Although blue and tui 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 68°F. These fish are omnivores, they feed on sediment detritus, and can play an important role in nutrient cycling through the excretion of nutrients into the water column in forms available to primary producers (e.g., phytoplankton). Both species of chub found in the Klamath Basin spawn from April through July, in shallow rocky areas in temperatures of 59 to 64.4°F (Moyle 2002). Presumably dams and diversions have benefitted both of these species by increasing the availability of its preferred warmer, low-velocity habitat.

Sculpin

Several sculpin species are found in coastal streams and rivers from Alaska to southern California. Several species of sculpin are known to occur in the California portion of Klamath River and its estuary, including Pacific staghorn (*Leptocottus armatus*), prickly (*Cottus asper*), slender (*Cottus tenuis*), sharpnose (*Clinocottus acuticeps*), coastrange (*Cottus aleuticus*), and marbled (*Cottus klamathensis*). Of these, only the marbled and slender sculpins are known to occur upstream of Iron Gate Dam (Carter and Kirk 2008). Mainstem Klamath River habitat may be important to sculpin populations as it can provide an important migration corridor from the estuary to upstream riverine reaches (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 dependent on the estuary for part of their early life history (White and Harvey 1999). The marbled sculpin 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 68°F 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 of water and in velocities around 23 centimeters per second (approximately 0.36 gallons per minute) (Moyle 2002). Slender sculpin were likely historically common in the Williamson, Sprague, Sycan, and Lost rivers and in Upper Klamath Lake (Bentivoglio 1998, cited in NRC 2004). Bentivoglio (1998) collected sculpins throughout the upper basin in 1995–1996 and found slender sculpins only in the lower Williamson River and a few in Upper Klamath Lake. Little is known about the species' biological requirements (NRC 2004). Sharpnose sculpin are primarily found in marine and brackish conditions, although they can tolerate freshwater (Love 2011). As such, they are likely restricted to the Klamath River Estuary and possibly the lower mainstem Klamath River.

Lost River and Shortnose Suckers

The Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*) are endemic to the Upper Klamath Basin of southern Oregon and northern California (Moyle 2002). These species share similar distribution and habitat requirements, and thus are typically managed together. The Lost River sucker and the shortnose sucker are listed as endangered under the ESA (USFWS 1988) and are endangered under CESA. A Revised Recovery Plan for the Lost River sucker and Shortnose sucker (revised recovery plan) was published in 2013 (USFWS 2012b). The final designation of critical habitat for both species was published by the USFWS on December 11, 2012 (USFWS 2012a). Both species are also fully protected species under California Fish and Game Code Section 5515(a)(3)(b)(4) and (6), respectively. Assembly Bill Number 2640 (Wood 2018) added Section 2081.11 to the Fish and Game Code to allow the take of both sucker species resulting from impacts attributable to the decommissioning and removal of the Lower Klamath Project facilities, so long as the take will not result in jeopardy for the species, is minimized, and mitigation incorporates information from sampling efforts.

The 2013 revised recovery plan (USFWS 2012b) identifies a recovery unit for both of these species within the California portion of the Area of Analysis: the reservoirs along the Klamath River downstream of Keno Dam (including Iron Gate and Copco reservoirs), known as the Klamath River Management Unit. Populations in the Klamath River Management Unit are comprised mostly of adults (USFWS 2012b). The USFWS (2012b) recovery plan considers these populations as “sink populations”, as they are not likely self-sustaining because of low recruitment due to the lack of access to spawning habitats, citing Moyle (2002), and NRC (2004). Extensive sampling was conducted by Oregon State University (Desjardins and Markle 2000) in J.C. Boyle, Copco No. 1 and Iron Gate reservoirs during 1998 and 1999 using multiple gear types (trammel nets, beach seines, cast nets, trap nets, backpack electrofishing, and otter trawls). Sampling gears, seasons and locations were selected to maximize the collection of suckers and different sucker life stages, and thus the results may not be representative of the larger fish community. Adult suckers were sampled for in 1997, 1998 and 1999 (with trammel nets), while larval and juvenile suckers were only sampled in 1998 and 1999. Over three years of study, a total of 50 shortnose sucker adults were collected in J.C. Boyle Reservoir, 165 in Copco No. 1 Reservoir and 22 in Iron Gate Reservoir. Lost River suckers were present in J.C. Boyle Reservoir and Copco No. 1 Reservoir, but at much lower numbers, with just one collected in Copco No.1 Reservoir and two in J.C. Boyle Reservoir. Larval suckers (species unknown) were more abundant with 275 collected over two years in J.C. Boyle Reservoir, 8,729 in Copco No. 1 Reservoir, and 1,177 in Iron Gate Reservoir. A total of 23 juveniles were collected in J.C. Boyle Reservoir and 3 in Copco No.1 Reservoir. In all, shortnose sucker represented 1 percent (1998) and 2 percent (1999) of the trammel net catch in J.C. Boyle Reservoir, 12 percent (1998) and 14 percent (1999) in Copco No.1 Reservoir and 0.3 percent (1998) and 2 percent (1999) in Iron Gate Reservoir. Juveniles were only a significant portion of the seine net catch in J.C Boyle Reservoir, representing 17 percent of the catch in 1998 and 9 percent in 1999. In larval trawls, sucker larvae represented only 0.2 to 5 percent of the catch in all reservoirs in 1998, but those percentages increase to 27 percent (J.C. Boyle Reservoir), 44 percent (Copco No.1 Reservoir) and 30 percent (Iron Gate Reservoir) in 1999.

To minimize and mitigate for adverse effects to both sucker species, PacifiCorp prepared an HCP for its interim operations of the Klamath Hydroelectric Project (i.e., prior to dam removal) (PacifiCorp 2013). This HCP includes the conservation strategy and measures that PacifiCorp would undertake to address anticipated effects on suckers and their habitat in the Klamath Basin. The conservation measures outlined follow a two-pronged approach: (1) manage the shutdown of East- and West-side powerhouses (which are part of the Klamath Hydroelectric Project in Oregon, see Figure 3.3-1) in such a way as to minimize effects on listed suckers, resulting in additional benefits by reducing possible entrainment, ramping events, and false attraction to powerhouse tailraces; and (2) improve habitat conditions for listed suckers by facilitating/funding specific enhancement projects, a sucker conservation fund, and the Nature Conservancy's (TNC) Williamson River Delta Restoration Project.

In the 2013 BiOp (NMFS and USFWS 2013), USFWS consulted on both sucker species. USFWS concluded that the proposed USBR Klamath Irrigation Project operations affects both Lost River and shortnose suckers. In the Klamath River Management Unit, USFWS concluded that effects of the proposed operations on both species are likely small in comparison to other effects because there are fewer suckers present in the reservoirs, so effects are primarily limited to changes in water quality (USFWS 2007).

Existing threats to the sucker populations include: the damming of rivers, instream flow diversions, hybridization (e.g., between shortnose sucker and Klamath largescale suckers [*Catostomus snyderi*]), 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 (USFWS 1993). 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).

Miller and Smith (1981) claimed that sucker hybridization was most pronounced in the Lower Klamath Project reservoirs, and Markle et al. (2005) reported hybridization between small scale sucker and both Lost River and shortnose suckers in the Hydroelectric Reach. Hybridization prompted Buettner et al. (2006) and others to caution against supporting migration of individuals from Iron Gate and Copco reservoirs into the Upper Klamath Lake population.

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 Lost River up to Anderson-Rose Dam (USFWS 1993), and the Klamath River downstream of Iron Gate Reservoir (USFWS 1993). Shortnose suckers occur in Gerber Reservoir and its tributaries, but Lost River suckers 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). Spawning locations appear to be both substrate and flow dependent (although specific preferred flow velocities are unknown), with an apparent preference for gravel substrates (where eggs incubate in the interstices). When spawning occurs over cobble and armored substrate, eggs fall between crevices or are swept downstream and lost (Buettner and Scoppettone 1990). Larval Lost River and shortnose suckers spend relatively little time in tributary streams, migrating to lake habitat 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 use a wide variety of habitat including near-shore areas with or without emergent vegetation and off-shore habitat (Hamilton et al. 2011).

<u>Smallscale Sucker</u>

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. The larger adults observed approach lengths of 20 inches and fish measuring 18 inches have been aged through scale analysis as being approximately 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 conducted by PacifiCorp and ODFW in the J.C. Boyle Peaking Reach revealed the existence of a population of smallscale suckers in moderate velocity habitat, and they were the most prevalent species in the majority of the collected samples (W. Tinniswood, pers. comm., June 2011). J.C. Boyle Dam blocks the migration of smallscale suckers to potential spawning habitat in Spencer Creek. Currently, spawning occurs in the mainstem of the Klamath River where smallscale suckers are subject to flow fluctuations that can strand and dry the eggs during power peaking[67] operations (Dunsmoor 2006). Electrofishing in Jenny Creek revealed adult smallscale suckers occupying deep, moderate-velocity habitat among boulders (W. Tinniswood, pers. comm., June 2011).

[67] Power peaking is rapid changes in flow associated with hydropower generation.

Non-native Fish Species

Introduced non-native fish species threaten the diversity and abundance of native fish species through competition for resources, predation, interbreeding with native populations, and causing potential physical changes to the invaded habitat (Moyle 2002). Non-native fish species occurring within the Area of Analysis are described below, including descriptions of interactions with native fish species.

Yellow Perch

Yellow perch (*Perca flavescens*) prefer weedy rivers and shallow lakes. They are found in reservoirs and ponds along the Klamath River, and are a popular recreational fishery. Optimal temperature for growth is between 71.6 and 80.6°F but yellow perch can survive in temperatures up to 86 to 89.6°F. They can also survive low levels of dissolved oxygen (less than one milligram per liter [mg/L]) but are most abundant in areas with low turbidity, 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, including younger yellow perch, white bass, and smelt (Knight et al. 1984); and may also prey on larval suckers (USFWS 1993). The preferred habitat of the yellow perch includes large beds of aquatic plants for spawning and foraging; habitat that is common in Lower Klamath Project reservoirs. Their spawning takes place in 44.6 to 66.2°F 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. All are a popular recreational fishery, especially the bass species. Largemouth bass and sunfish prefer lakes, ponds, or low-velocity habitat in rivers, and are mostly found in Lower Klamath Project reservoirs upstream of Iron Gate Dam. They prefer habitats with aquatic vegetation and will spawn in a variety of substrates. They prefer water temperatures above 80.6ºF. Juvenile and adult largemouth bass tend to feed on larger invertebrates and fish (Moyle 2002), potentially including suckers (USFWS 1993). 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).

Catfish

Several species of catfish have been introduced into the Klamath Basin, including channel catfish (*Ictalurus punctatus*), black bullhead (*Ameiurus melas*), brown bullhead (*Ameiurus nebulosus*), and yellow bullhead (*Ameiurus natalis*) (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 32 to 98.6°F, but their optimum temperature range is 68 to 91.4°F. 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 within the California portion of the Area of Analysis (FERC 2007) found in clear, cold lake and stream habitats. They prefer temperatures between 57.2 and 66.2°F but can survive in temperatures ranging from 33.8 to 78.8°F. 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*) have 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.

American Shad

American shad are an introduced, anadromous fish species found in the Klamath River downstream of Ishi Pishi Falls, and are a popular sport fish. They feed primarily on plankton, mostly mysids and copepods, and occasionally on small fishes such as smelt. Adult American shad spend three to six years in the ocean before returning to spawn in the Klamath River (Pearcy and Fisher 2011). The preferred spawning habitat of the American shad includes sandy or pebbly substrate, water temperatures between 59 and 64.4°F, and where water velocities are less than 0.7 m/s (approximately 2.3 feet per second) (Moyle 2002).

Estuarine Species

The estuary is the mixing zone for freshwater and saltwater from the ocean. The balance of freshwater to saltwater changes over the course of the day with tides and is also strongly influenced by river flows. Due to this, both marine and freshwater species can often be found in different portions of the estuary at various times. All anadromous fish pass through the estuary during their migrations from freshwater to the ocean and back again, and salmonid smolts may rear in the estuary for varying periods of time, prior to moving into the ocean. Surveys in the freshwater portion of the estuary commonly find Klamath speckled dace (*Rhinichthys osculus klamathensis*), Klamath smallscale sucker (*Catostomus rimiculus*), prickly sculpin, and Pacific staghorn sculpin. Other fairly common species include northern anchovy (*Engraulis mordax*), saddleback gunnel (*Pholis ornate*), and bay pipefish (*Syngnathus leptorhyncus*). Other species in the estuary include federally-listed eulachon, state-listed longfin smelt (*Spirinchus thaleichthys*) (described below), non-native Mississippi silversides (*Menidia beryllina*), surf smelt (*Hypomesus pretiosus*), three-spined stickleback (*Gasterosteus aculeatus*), and several species of gobies. Impacts to the estuarine species were assessed based on effects on specific sensitive species such as eulachon and EFH for groundfish and pelagic fish, as described in the Essential Fish Habitat subsection of Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project*.

Eulachon

Eulachon 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 NMFS 2010b). The Yurok Tribe consider eulachon a "Tribal Trust Species," and the fish has major cultural significance (Larson and Belchik 1998). 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 (NMFS 2009a). On March 18, 2010, NMFS listed the southern DPS of eulachon as threatened under the ESA (NMFS 2010b). Final critical habitat was designated in October of 2011 and includes the Klamath River Estuary (NMFS 2011). NMFS has issued a draft recovery plan (NMFS 2016b) and has formed a Eulachon Recovery Team to support recovery planning.

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 in Humboldt County (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 caught 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, 1989, and 1998. After 1998, eulachon 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 since the 1980's. 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 (McCovey 2011b). More recently, 40 adult eulachon were captured in spring 2012 (McCovey 2012), and 112 in spring 2012 (McCovey and

Walker 2013) by Yurok Indian tribal biologists in presence/absence surveys, using seines and dip nets in the Klamath River.

According to the 2016 status review update of southern DPS eulachon (Gustafson et al. 2016), adult spawning abundance of the southern DPS of eulachon has increased since the listing occurred in 2010. A number of data sources indicate that eulachon abundance in some subpopulations within the southern DPS was substantially higher in 2011 through 2015 compared to indications of very low abundance in 2005 through 2010. The improvement in estimated abundance in the Columbia, Naselle, Chehalis, Elwha, and Klamath rivers, relative to the time of listing, reflects both changes in biological status and improved monitoring (Gustafson et al. 2016).

Historically, eulachon runs in northern California were said to start as early as December and January and peak in abundance during March and April. Large numbers of eulachon migrated upstream in March and April to spawn, but they rarely moved more than eight miles inland (NRC 2004). Eulachon spawn at an age of three to five years, and usually die after spawning (Larson and Belchik 1998). Spawning occurs in gravel riffles, with hatching about a month later. The larvae generally move downstream to the estuary following hatching (Larson and Belchik 1998).

Longfin Smelt

Longfin smelt are a state-listed threatened species and a CDFW Species of Special Concern throughout their range in California. 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 two-year lifespan, although three-year-old fish have been observed (Moyle 2002). They typically live in bays and estuaries and have sometimes been observed in the nearshore ocean from San Francisco Bay to Prince William Sound, Alaska, including the Klamath River. Longfin smelt prefer salinities of 15 to 30 parts per thousand (ppt), although they can tolerate salinities from freshwater to full seawater. They prefer temperatures of 60.8 to 64.4°F and generally avoid temperatures higher than 68°F. Longfin smelt may occur in the Klamath River throughout the year. They would only be expected to use the estuary, the lowest reaches of the river, and infrequently in the Pacific Ocean nearshore. 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 44.6 to 58.1°F. Embryos hatch in approximately 40 days in 44.6°F water temperature (approximately 25 days in 51°F water) and are quickly swept downstream by the current to more brackish areas. The importance of ocean rearing is unknown. Longfin smelt were common in the Klamath River Estuary during 1978–1989, but the population has significantly declined since. In 1992, two were found in the Klamath River Estuary, and in 2001 only one adult longfin smelt was collected (CDFG 2009).

Freshwater Mollusks

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. The juvenile freshwater mussels 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 are also a food of cultural significance for the Karuk Tribe (Westover 2010) and The Klamath Tribes. 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.

Four species of native freshwater mussels have been observed within the Klamath Basin (FERC 2007, Westover 2010). PacifiCorp surveys conducted in 2002 and 2003 found Oregon floater (*Anodonta oregonensis*), California floater (*Anodonta 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) also 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. Byron and Tupen (2017) surveys also conducted during in 2002 and 2003 upstream of Iron Gate Dam documented Oregon floater and western ridged mussel in the Keno Reach, Oregon floater in the J.C. Boyle Peaking Reach, and both species in the mainstem Klamath River between Copco No. 2 Reservoir and J.C. Boyle Dam.

Downstream of Iron Gate Dam, Davis et al. (2013) found that *Anodonta sp.* occurred only in the farthest upstream survey sites; western ridged mussel was present in most reaches and often at high densities, and western pearlshell mussel was present in high numbers downstream of the confluence with the Salmon River. All surveyed mussel populations declined in abundance with increasing distance downstream of Iron Gate Dam, due to more mobile substrate. The Shasta River was the only tributary to the Klamath River with Oregon floater, California floater, and western ridged mussel all detected. Western ridged mussel and western pearlshell mussel were more common in reaches farther downstream in the Klamath River from Iron Gate Dam, probably due to thicker shells which allow them to withstand scouring in high flow events.

A full understanding of western ridged mussels former and current distribution is difficult to assemble due to the lack of data, 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 western ridged mussels dominates its mussel community, unlike other rivers in the Pacific Northwest (Westover 2010).

Western pearlshell mussels have also been observed within the Klamath Basin downstream from Iron Gate Dam, though in lesser abundance than other mussel species (Westover 2010). Western pearlshell mussels occupies habitats with low water velocity (e.g., pools and near banks) and pockets within bedrock and cobble (Howard and Cuffey 2003).

Anodonta spp. (commonly referred to as “floaters”) are more tolerant of lake conditions than other native mussel species (Nedeau et al. 2005) and have been observed in Lower Klamath Project reservoirs. Floaters are also more tolerant of siltier substrates, as their thin shells allow individuals to “float,” or rest on top of silt-dominated streambeds. Byron and Tupen (2017) found that low-energy areas where finer sediments accumulate and where hydrology is consistent were most suitable for *Anodonta spp.*

Western ridged mussels are the largest and most common type of freshwater mussel found within the Klamath Basin (Nedeau et al. 2005). They are 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). Byron and Tupen (2017) found that they appeared to prefer faster waters and, consequently, coarser substrates such as medium- and coarse sands. Even areas with boulder and bedrock substrates had pockets of finer materials in which *G. angulata* were aggregated. Commonly, *G. angulata* were found buried to depths of 15 centimeters and often stacked atop one another. In general, *G. angulata* were always buried at least 80 percent, with only the tops of shells visible (Byron and Tupen 2017). Known fish hosts of juvenile *G angulata* include hardhead (*Mylopharodon conocephalus*), Pit sculpin (*Cottus pitensis*), and tule perch (*Hysterocarpus traski*), but a full list of host fish species for western ridged mussels are unknown (Jepsen et al. 2010). However, Mageroy (2016) found that *G. angulata* hosts in Canada included primarily sculpin species (*Cottus* spp.) but that northern pikeminnow (*Ptychocheilus oregonensis*), leopard dace (*Rhinichthys falcatus*), and longnose dace (*Rhinichthys cataractae*) are potential hosts as well. Therefore, it appears that the species has significant range of hosts.

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 (FERC 2007). One of the clam species, the montane peaclam (*Pisidium ultramontanum)*, has special status as a federal species of concern and a USDA Forest Service 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 historic 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) (FERC 2007). On USDA Forest Service 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 (one to three years) compared to freshwater mussels (typically 10 to 15 years although in some cases 100 or more 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. Based on their restricted distribution to areas outside of Klamath River reaches that could be affected by the Proposed Project, no further analysis was undertaken for freshwater snails for this EIR.

Benthic Macroinvertebrates

Benthic macroinvertebrates (BMI) are small aquatic animals and the aquatic larval stages of insects. They lack a backbone, are visible with the naked eye and are found in and around water bodies during some period of their lives. BMI 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; crustaceans such as crayfish, amphipods and isopods; clams and snails; aquatic worms; and other major invertebrate groups. Many BMI are the primary consumers in riverine food webs, feeding on primary producers—algae, aquatic plants, phytoplankton, bacteria, as well as leaves and other organic 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 BMI are secondary consumers, feeding on the primary consumers. BMI are the primary food source for most freshwater fish species, and therefore, changes in abundance, distribution, or community structure can affect fish populations. BMI are also used as general indicators of water quality. This is assessed based upon the relative abundance or diversity of each group (taxa) and their tolerance of water quality impairment or habitat degradation. BMI are also particularly sensitive to changes in fine and coarse sediment, which would occur during the Proposed Project. A diminished food supply can limit growth of salmonids, and this is especially true at higher temperatures because as water warms, a fish's metabolic rate increases and it needs more food to sustain growth (Brett 1971, McCullough 1999). Growth is critical to juvenile salmonids because a larger size fish often has a survival advantage during the overwintering period, smolt outmigration, and ocean residence. If fish are chronically exposed to warm water temperatures and food availability is low, growth rates are reduced and fish experience physiological stress, often resulting in increased mortality from disease, parasites, and predation. However, in a productive system with high densities of BMI 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 for PacifiCorp's Klamath Hydroelectric Project evaluated BMI populations in the Klamath River from Link River Dam to the Shasta River and within Fall Creek in 2002 and 2003 (FERC 2007). These studies show that BMI are abundant, with typical densities of 4,000 to 8,000 individuals per square meter. BMI densities in the fall of 2002 ranged from approximately 2,200 per square meter in the Copco No. 2 Bypass Reach of the Klamath River to approximately 21,600 per square meter below Keno Dam (FERC 2007). Abundance of BMI in both the J.C. Boyle Peaking Reach of the Hydroelectric Reach and the Middle Klamath River downstream of Iron Gate Dam was as low as approximately 500 per square meter in the spring of 2003. The Lower Klamath Project reservoirs had high abundance of BMI, but low diversity, and were dominated by species tolerant of impaired water quality conditions.

The Yurok Tribe conducted studies in 2005 and 2008 (Burks and Cowan 2007) evaluating the biological community of the Klamath River within the Yurok Indian Reservation (RM 0 to RM 43.3) through BMI surveys. Data collected during these studies were used to calculate an Index of Biological Integrity (IBI)—composite scores generated by assigning values to variables, such as species richness, percent intolerant individuals, percent predator individuals, and others.

The Index of Biological Integrity values generated in 2005 indicated that two of the nine sites on the Klamath River within the Yurok Indian Reservation were in the "impaired" range (i.e., score of 52 or below), and the majority of the other sites were in "fair" condition (i.e., score of 53 to 60) (Burks and Cowan 2007). In 2008, the Index of Biological Integrity values suggested a slight improvement in stream health, with the majority of sites scoring in the "good" range (i.e., score of 61 to 80) (Sinnott and Hanington 2008).

Marine Mammals

Pinnipeds (seals and sea lions), and Southern Resident Killer Whales potentially occur within the Pacific Ocean nearshore environment, off Northern California. Redwood National Park lists harbor seals (*Phoca vitulina richardsi*), California sea lions (*Zalophus californianus*), Steller sea lions (*Eumetopias jubatus*), and Northern elephant seals (*Mirounga angustirostris*) as occurring at least seasonally in the vicinity of the Klamath River Estuary. Elephant seal diets consist primarily of rays, sharks, pelagic squid, ratfish, and Pacific hake, and are not expected to consume salmonids, but other pinnipeds and Southern Resident Killer Whales may feed on adult salmon from the Area of Analysis. In particular, pinnipeds are a documented predator within the Klamath River Estuary and nearshore environment. During radio telemetry studies, Strange (2007a, 2007b, 2008) found that between 14 and 33 percent of tagged Chinook salmon were consumed by pinnipeds (primarily California sea lions). However, the Chinook salmon tagged in those studies were disoriented and potentially fatigued as a result of being captured, anesthetized, and handled, and were therefore more vulnerable to predation. In these studies, most of the observed predation occurred within minutes to hours of release.

In a study of pinniped predation in the Klamath River Estuary using visual observations in August through mid-November 1998 (Williamson and Hillemeir 2001), approximately 3,077 adult salmon were consumed (including fall-run Chinook salmon, spring-run Chinook salmon, coho salmon, and steelhead). Most predation was on fall-run Chinook salmon (2,559 consumed) and was equivalent to 2.6 percent of the estimated fall-run Chinook salmon run that year. An estimated 438 spring-run Chinook, 63 coho salmon, and 110 steelhead were also consumed. California sea lions were the primary predator, and Pacific harbor seals, and Steller sea lions were also observed feeding upon salmonids. Efforts such as “seal bombs” have been used to reduce pinniped predation on salmonids in the estuary but have not been observed to be effective (Strange 2008).

<u>Southern Resident Killer Whale</u>

The Southern Resident Killer Whale (*Orcinus orca*) DPS is listed as endangered under the ESA (NMFS 2005). This DPS primarily occurs in the inland waters of Washington State and southern Vancouver Island, 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, NMFS 2005). Survival and fecundity of Southern Resident Killer Whales are correlated with Chinook salmon abundance (Ward et al. 2009, Ford et al. 2009). 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, but none from the Klamath River Basin. More recent studies have confirmed that salmon from the Klamath River are consumed, although in small numbers (Hanson 2015). During early spring, summer, and early fall months Southern Resident Killer Whale are present in Washington inland waters where their diet consists primarily of Chinook salmon. During late fall, winter, and early spring, Southern Resident Killer Whale move into the outer coast of Washington, Oregon, and California where their ranges and movements are less well known (NMFS 2006c). Limited observations indicate that they will make occasional and short-duration winter visits to the California Coast, where their diet is apparently primarily chum, Chinook and coho salmon, augmented with smaller numbers of steelhead and sockeye based on limited data (Hanson 2015). No data are available to determine the contribution of salmon from the Klamath River Basin to their overall diet, but it is believed to be small (<1 percent) on an annual basis given the work of Hanson et al. (2010) and Hanson (2015).

3.3.2.2 Physical Habitat Descriptions

Upper Klamath River and Connected Waterbodies

Aquatic habitat in the Upper Klamath Basin includes both lacustrine (lake) and riverine (river) habitats and 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, Butler et al. 2010, Hamilton et al. 2016), as discussed in detail in Section 3.3.5.8 *Aquatic Habitat*.

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 formed by Keno Dam, which regulates water surface elevations in the impoundment to facilitate agricultural diversions. Lake Ewauna connects to Upper Klamath Lake via the Link River.

Upper Klamath Lake and Lake Ewauna are affected by poor water quality conditions. During the summer months, these waterbodies 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 nine lasting for several weeks are associated with large algal blooms occurring in the lake (Kann 2010). On a diel (i.e., 24-hour) basis, algal photosynthesis can elevate pH levels during the day, with changes exceeding two pH units over a 24-hour period. During November through April, pH levels in Upper Klamath Lake are near neutral (Aquatic Scientific Resources 2005).

Implementation of the Proposed Project would result in the reintroduction of anadromous fish into Upper Klamath Lake and Lake Ewauna and their tributary streams. 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 and other migratory fish, including resident and 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. Although Lost River and shortnose suckers (in addition to other sucker species), 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

(USBR 2002). Plans are being developed to have the fishway rebuilt to criteria for suckers, lamprey, and for larger anadromous salmonid runs (T. Reaves Gilmore, USBR, pers. comm., October 2018).

The Williamson and Wood rivers are the largest and second largest tributaries to Upper Klamath Lake, respectively. 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, 2016). 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).

Upper Klamath River − Hydroelectric Reach

The Hydroelectric Reach, from the upstream extent of J.C. Boyle Reservoir to Iron Gate Dam, includes four reservoirs (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate) and two riverine reaches. Several coldwater tributaries enter the Klamath River and reservoirs in this reach. The reservoirs are productive and nutrient rich and tend to have warm surface waters during the summer months, with mean daily temperatures sometimes reaching 73ºF (FERC 2007). During the late spring/early summer, water quality in Copco No. 1 and Iron Gate reservoirs declines, becoming quite poor due to warm surface waters and annual blooms of the blue-green algae species *Aphanizomenon flow-aquae, Anabaena flos-aquae,* and *Microcystis aeruginosa* (see also Section 3.4 *Phytoplankton and Periphyton*). *Microcystis aeruginosa,* and to an unknown extent *Anabaena flos-aquae,* produce toxins that can 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 *Phytoplankton and Periphyton*). This has resulted in Copco No. 1 and Iron Gate reservoirs being posted with health advisory warnings against human and animal contact with the water by local health officials every summer since 2005.

The 21-mile long riverine reach between J.C. Boyle and Copco No. 1 reservoirs is divided into two reaches: the 4.6-mile long J.C. Boyle Bypass Reach, which receives bypass flows from J.C. Boyle Dam, and the 17-mile long Peaking Reach, which receives variable flow from hydroelectric operations (see also Section 2.3.1 *J.C. Boyle Dam and Associated Facilities*). The downstream 6.2 miles in California is designated by CDFW as a Wild Trout Area with the whole reach managed by CDFW for wild trout, including angling restrictions and reduced stocking, and habitat enhancements targeted for native trout (CDFG 2005). The reach from the J.C. Boyle Powerhouse to the Oregon-California state line is designated as a National Wild and Scenic River. Approximately 100 cubic feet per second (cfs) is released from J.C. Boyle Dam to the Bypass Reach through a minimum flow outlet and the fish 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 zero to over 3,000 cfs, depending on operations (FERC 2007). Peaking operations can occur daily, or cycles may extend over several days, depending on water availability, power demands, and whitewater boating needs. The 1.4-mile Copco No. 2 Bypass Reach has flows of about 5 cfs provided by Copco No. 2 Dam. Both of these riverine reaches provide complex physical habitat suitable for salmonid spawning and rearing.

A number of tributary streams join the Klamath River in this reach, including Spencer, Shovel, Fall, Spring, and Camp creeks. These streams provide suitable coldwater spawning and rearing habitat for fish (including potentially salmon and steelhead).

As described in detail in Section 3.20.2.3 *Lower Klamath Project Reservoir-Based Recreation*, 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 No. 1 and Iron Gate reservoirs, especially for yellow perch (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 thought to not be self-sustaining populations or to be contributing to populations in upstream areas (Hamilton et al. 2011). 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 (Hamilton et al. 2011).

Middle and Lower Klamath River

The Klamath River flows unobstructed for 190 river miles downstream from Iron Gate Dam before entering the Pacific Ocean. Downstream from Iron Gate Dam, the Klamath River has a gradient of approximately 0.25 percent and four major tributaries enter this reach: Shasta, Scott, Salmon, and Trinity rivers.

The Klamath Basin downstream from Iron Gate Dam provides hundreds of miles of suitable habitat for anadromous and resident fish. Recreational fishing within this area is popular for steelhead and Chinook salmon, and tribal fishing is common for Chinook salmon with gillnets, and Pacific lamprey with basket traps. Freshwater mussels are also common in this reach. Most of the anadromous salmonid species spawn primarily in the tributary streams, although fall-run Chinook salmon and coho salmon do spawn in the mainstem. The mainstem also serves as a migratory corridor and as rearing habitat for juveniles of many salmonid species (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 3.2.2.5 *Dissolved Oxygen* and 3.2.2.6 *pH*), and disease outbreaks during spring. Aquatic 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 Board 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).

Klamath River Estuary

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 also serves as breeding and foraging habitat for marine and estuarine species. These species include, but are not limited to Pacific herring (*Clupea pallasii*), surf smelt, longfin smelt, eulachon, top smelt, starry flounder (*Platichthys stellatus*) and other flatfish, Klamath speckled dace, Klamath smallscale sucker, prickly sculpin, Pacific staghorn sculpin, northern anchovy, saddleback gunnel, and bay pipefish. Recreational fishing for Chinook salmon is popular in the estuary, as well as tribal fishing for Chinook salmon with gillnets and Pacific lamprey with hooks.

Pacific Ocean Nearshore Environment

The Pacific Ocean nearshore environment includes the Klamath River Management Zone (KMZ), the California portion of which extends from the Oregon-California state line south to Horse Mountain (40° 05’ 00” N. latitude) and out three nautical miles from the coast. Physical habitat within this environment includes sandy beach, rocky intertidal, and a sand-dominated seafloor at depths less than 200 ft within one mile of the coast, ranging to depths greater than 500 ft on the continental shelf. During winter high flows fine sediment deposits on the seafloor shoreward of the 196-feet isobath along the coast, with greater quantities depositing in close proximity to the mouth of the Klamath River. After fine sediment loading onto the continental shelf during river floods, fluid-mud gravity flows typically transport fine sediment offshore. Summer coastal upwelling naturally resuspends some of the river sediments that are transported to the nearshore environment and deposited on the continental shelf, especially those deposited during the previous winter (Ryan et al. 2005, Chase et al. 2007; see Potential Impact 3.2-8).

The Pacific Ocean nearshore environment supports a wide array of fish species and serves mostly as foraging habitat for marine and anadromous species. These species include, but are not limited to all of the anadromous fish listed previously, as well as federally threatened Southern DPS green sturgeon, Pacific halibut (*Hippoglossus stenolepis*), Pacific herring, surf smelt, longfin smelt, eulachon, top smelt, starry flounder and other flatfish, northern anchovy, saddleback gunnel, lingcod (*Ophiodon elongates*), rockfish species (*Sebastes spp.)*. Within the Pacific Ocean nearshore, recreational and commercial fishing for Chinook salmon, halibut, lingcod, and rockfish species is common.

3.3.2.3 Habitat Attributes Expected to be Affected by the Proposed Project

The Proposed Project would affect the physical, chemical, and biological components of aquatic habitat within portions of the Klamath Basin. These effects would result from changes in suspended sediment, bedload sediment, water quality, water temperature, disease and parasites, habitat availability, 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. Some of the changes would be short-term, and others permanent. The overarching long-term effect would be to bring the habitat closer to a more natural riverine system, from the current reservoir and reservoir-influenced baseline.

Appendices E and F provide more detailed technical descriptions of suspended sediment and bedload sediment under existing conditions. Anticipated changes in water quality under the Proposed Project are discussed in greater detail in Section 3.2 *Water Quality*, and a description of the effects of implementing the Proposed Project on algae is found in Section 3.4 *Phytoplankton and Periphyton*.

Suspended Sediment

Suspended sediment dynamics would be altered by the Proposed Project within the Hydroelectric Reach and reaches downstream of Iron Gate Dam. Existing conditions with respect to algal-derived (organic) suspended material and mineral (inorganic) suspended material in the Klamath River upstream and downstream from Iron Gate Dam are summarized in Section 3.2.2.3 *Suspended Sediments* and in Appendix C.

Hydroelectric Reach

Organic suspended material originating from Upper Klamath Lake (in Oregon) is the predominant form of suspended material entering the Hydroelectric Reach. Interception, decomposition, and retention of suspended materials in the Lower Klamath Project reservoirs, as well as dilution from coldwater springs downstream of J.C. Boyle Dam, can decrease organic suspended material concentrations in this reach; however, seasonal increases in organic suspended material also occur in Copco No. 1 and Iron Gate reservoirs due to large summertime phytoplankton blooms (see Section 3.2.2.3 *Suspended Sediments* and Appendix C – *Section C.2.1* for more detail). 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, and Fall Creek), which are primarily transported during high flow events and generally settle out in the Lower Klamath Project reservoirs. On the scale of the entire Klamath Basin, the trapping of fine sediments and suspended materials does not appear to be a critical function of the Lower Klamath Project reservoirs with respect to the overall cumulative sediment delivery including downstream tributaries (see also Section 3.11.2.4 *Sediment Load*), since a relatively small percentage (3.4 percent) of total sediment supplied to the Klamath River on an annual basis originates from the Upper and Middle Klamath River (i.e., from J.C. Boyle Dam to the confluence with the Shasta River).

Middle and Lower Klamath River
In general, available data (existing conditions) (detailed in Appendix C.2.2.1) indicate that suspended sediment concentrations (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 (M. Belchik, Fisheries Biologist, Yurok Tribe, pers. comm., August 2008). Large rivers such as the Klamath River, Columbia River, and Sacramento River have large fluctuations in SSCs even under unimpaired conditions, and aquatic species have adapted to survive in this environment. Appendix E provides a detailed analysis of the effects of suspended sediment on aquatic species downstream from Iron Gate Dam under existing conditions.

During all water year types, SSCs of the magnitude and duration modeled under existing conditions (multiple months with concentrations over 50 mg/L) are expected to cause major stress to migrating adult and juvenile salmonids primarily during winter and early spring (Newcombe and Jenson 1996, see also Appendix E). Under existing conditions, Iron Gate Dam traps most suspended sediment from upstream sources, and downstream of Iron Gate Dam SSCs generally increase in a downstream direction from the contribution of tributaries (Appendix C.2).

Klamath River Estuary
Under existing conditions, SSCs within the Klamath River Estuary (modeled at Klamath Station at RM 5; Figure 3.3-1) are relatively high compared to SSCs observed farther upstream due to SSC contribution of major tributaries downstream of Iron Gate Dam (Appendix E). The Lower Klamath River downstream from the Trinity River confluence to the estuary is currently listed as sediment-impaired under Section 303(d) of the Clean Water Act (CWA) (North Coast Regional Board 2010). Modeling in the Klamath River (from Seiad Valley at approximately RM 132.7 downstream to the Klamath Station at RM 5)

indicates that under normal conditions SSCs are relatively high during winter and spring (typically 50 to 100 mg/L), and lower (less than 10 mg/L) during summer. Under existing extreme conditions (wet water year) SSCs are generally 10 to 100 mg/L in summer and fall, with peaks between 100 and 1,000 mg/L during winter and spring.

Pacific Ocean Nearshore Environment
Under existing conditions, a plume of Klamath River water extends into the Pacific Ocean 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 (Farnsworth and Warrick 2007). 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 riverine SSC events contribute to the plume, especially during floods. In northern California, plume zones are primarily north of river mouths because longshore currents and prevailing winds are northward during periods of strong runoff (Geyer et al. 2000, Pullen and Allen 2000). River plumes and the associated habitat conditions they create support 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, De Robertis et al. 2005).

Bed Elevation and Grain Size Distribution
Section 3.11.2.4 *Sediment Load* and Appendix F of this EIR describe sediment dynamics and channel conditions in the Area of Analysis and assess changes in channel bed elevation and sediment grain size in response to increased bedload supply and transport for existing conditions and under the Proposed Project. The sections below provide a brief summary of the analyses of bedload supply, transport, and channel change provided elsewhere. Bedload supply and transport are vital to the creation and maintenance of functional aquatic habitat. Natural river dynamics include transportation of coarse sediment (e.g., sand, gravel, cobble, and boulder) downstream. 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 and movement of coarse sediment are necessary for the long-term maintenance of aquatic habitats. Salmonids evolved to depend on continued sediment delivery to provide substrate suitable for spawning and early rearing in streams and rivers. These natural processes have been disrupted in the Klamath River since the construction of dams.

Under existing conditions, dams have disrupted geomorphic and vegetative processes that can form channels and create spawning grounds downstream from Iron Gate Dam, by trapping sediment and preventing its transport downstream (Buer 1981, PacifiCorp 2004a, KRBFTF 1991). Since the construction of the Lower Klamath Project, sediment and gravel have been intercepted by Lower Klamath Project reservoirs, with Iron Gate Dam cutting off sediment supply from the Upper Klamath Basin. The resultant reduction in spawning gravels downstream of 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 developed (but never implemented) gravel augmentation programs for spawning gravel downstream from Iron Gate Dam (Buer 1981). Per the Interim Operations Habitat Conservation Plan for Coho Salmon (PacifiCorp 2012), PacifiCorp developed and implemented a plan to augment gravel immediately downstream of Iron Gate Dam beginning in 2014 (PacifiCorp 2014). Gravel augmentation occurred immediately downstream of Iron Gate Dam in 2014, 2016, and 2017, with approximately 4,600 cubic yards total placed downstream of the dam as of December 2017 (PacifiCorp 2018b). The placed gravel has moved downstream by high flows (PacifiCorp 2018b), although additional details on the extent of downstream movement have not been reported (and were not required under the HCP).

Water Quality

Section 3.2.2 *[Water Quality] Environmental Setting* provides information regarding existing conditions for water quality from J.C. Boyle Reservoir to the Klamath River Estuary, including those parameters that can directly affect beneficial uses for aquatic species (i.e., water temperature, suspended sediments, dissolved oxygen, pH, and algal toxins such as microcystin). Multiple waterbodies in the Area of Analysis, including the mainstem of the Klamath River, are listed under section 303(d) of the CWA for a variety of water quality parameters such as water temperature, sediment, nutrients, dissolved oxygen, pH, ammonia, chlorophyll-*a*, and microcystin (North Coast Regional Board 2011). 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 toxin concentrations are also addressed in Section 3.2 *Water Quality* and Section 3.4 *Phytoplankton and Periphyton*.

Water Temperature

The Klamath River, from Keno Dam to the Klamath River Estuary, has been listed as impaired for water temperature (North Coast Regional Board 2011; see Section 3.2 *Water Quality* and Appendix C.1 of this EIR for discussion of existing water temperature conditions). Water temperatures in the Klamath River are of special concern as they are unsuitable in the lower mainstem for anadromous salmonids at times during the summer (Bartholow 2005). Acute thermal effects for salmonids are expected to occur as mean daily water temperatures begin to exceed 68°F (Bartholow 2005). These elevated temperatures are especially detrimental to anadromous species during the warmer portions of the year (ODEQ 2002). Bartholow (2005) expressed concern that if observed increases in water temperature over the last several decades in the mainstem Klamath River downstream from Iron Gate Dam, which may be related to the cyclic Pacific Decadal Oscillation, continue, some stocks may decline to levels insufficient to ensure survival of the population. Klamath River salmonids are generally more tolerant of high-water temperatures than salmonids from other basins (FERC 2007, Foott et al. 2012). Moreover, NMFS (2006a) concluded that available evidence indicates that juvenile steelhead can withstand incrementally higher temperatures exceeding 71.6°F 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 resulting in a reduction of the diversity in the timing of migration (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 (ODEQ 2002).

Upper Klamath River and Connected Waterbodies
Both Upper Klamath Lake and the Keno Impoundment/Lake Ewauna are relatively shallow and temperatures in both are generally warm during the late spring through early fall (FERC 2007). In the summer, instantaneous maximum water temperatures of 71.6 to 75.2°F are common in the upper three to six feet of Upper Klamath Lake, and temperatures can approach a maximum of 86°F near the surface (PacifiCorp 2004c). Although prolonged exposure to these high temperatures could be lethal for some species, the water temperature remains within tolerance criteria for migrating adult anadromous salmonids during migratory periods (i.e., not during summer) (Dunsmoor and Huntington 2006, Hamilton et al. 2011). Anadromous salmonids successfully navigated through Upper Klamath Lake to spawn in the Upper Klamath Basin prior to their access being blocked by the Lower Klamath Project. In addition, thermal refugia are available in this reach where fish can avoid high water temperatures. Upper Klamath Lake supports a population of redband trout that moves into cooler tributary habitats during 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).

The Keno Impoundment/Lake Ewauna exhibits warm water temperatures in the summer, with instantaneous maximum water temperatures frequently exceeding 77°F (Sullivan et al. 2009, USGS 2010; both as cited in Hamilton et al. 2011). The USEPA (2003) mean weekly maximum temperature (MWMT) criteria for migrating adult salmonids is 68°F. Warm water temperatures are also present in the Klamath River downstream from Keno Dam. However, from November through mid-June, the reach from Link River Dam to Keno Dam is cooler (below 68°F) 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; however, maximum water temperatures (71.6 to 77°F) are still within the preferred range for warm- and some cold-water species found in the Upper Klamath Basin (yellow perch, catfish, sunfish, largemouth bass, and spotted bass).

Upper Klamath River − Hydroelectric Reach

Water temperatures in the Hydroelectric Reach are generally warm in the Lower Klamath Project reservoirs from late spring through early fall, but tributaries in this reach are generally cool. Additionally, there are several springs in the California portion of the Hydroelectric Reach, located along the edges of Copco No. 1 and Iron Gate reservoirs, that contribute an unquantified amount of flow to the reservoirs (FERC 2007). Average monthly water temperatures within reservoirs from 2001 to 2004 ranged from just over 41°F in November to more than 71.6°F in June through August (FERC 2007), with thermal stratification in Copco No. 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). Temperatures in the J.C. Boyle Bypass Reach are cooled by the contribution of 200 to 250 cfs of groundwater at a relatively constant 51.8 to 53.6°F within the reach (PacifiCorp 2006, Kirk et al. 2010). The 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).

Further downstream in the Peaking Reach, near the confluence of the Klamath River and Shovel Creek (Figure 3.3-1), there are natural hot springs that contribute flows to the mainstem river. The natural hot springs were not found to result in consistent substantial warming of the Klamath River based on two sets of measurements made in November and December 2017 (KRRC 2018). Water temperature data collected upstream and downstream of the confluence of the Klamath River and Shovel Creek showed a 1.4°F increase in the downstream direction during the November 2017 measurement, but a 0.2°F decrease during the December 2017 measurement (KRRC 2018). Water temperatures in Shovel Creek itself are generally low year-round, with reported values consistently below 59°F in the summer (PacifiCorp 2004a). Water temperatures recorded in Shovel Creek in late fall/early winter 2017 were 46°F (on November 1) and 39.9°F (December 5) (KRRC 2018).

Temperature data for other tributaries entering the Hydroelectric Reach are based on a limited study period (between 2001 and 2003) (PacifiCorp 2004c). Fall Creek, which flows into Iron Gate Reservoir, is generally cold year-round and does not exceed 57.2°F during the summer (PacifiCorp 2004c). Temperatures in Jenny Creek, which also flows into Iron Gate Reservoir, vary seasonally, ranging from less than 50°F in the spring to more than 71.6°F in July and August

(PacifiCorp 2004c). As noted above, temperatures in Shovel Creek are generally low year-round and do not exceed 59°F in the summer (PacifiCorp 2004c). Spencer Creek temperatures are low during spring (<59°F) and are generally below 64.4°F but can exceed 68°F for short durations (PacifiCorp 2004c).

Iron Gate and Copco No. 1 reservoirs are the two deepest reservoirs in the Hydroelectric Reach. These reservoirs thermally stratify each year beginning in April/May and the warmer (64.4°F to 73.4°F) surface and colder (46.4°F to 62.6°F) bottom waters do not mix again until October/November (see also Section 3.2.2.2 *Water Temperature*). Surface waters in these reservoirs reach maximum temperatures exceeding 77°F during the summer (PacifiCorp 2004c). Colder water temperatures occur at depths greater than six to ten meters below the reservoir surfaces during periods when the reservoirs are stratified (see Appendix C, Section C.1.1.1 and Figure C-1) (PacifiCorp 2004c, Asarian and Kann 2011). The powerplant intakes in both reservoirs are relatively shallow, at approximately nine to ten meters below the surface, such most of the reservoirs' discharge waters are from the warmer surface waters. Consequently, discharges from Copco No. 1 and Iron Gate reservoirs increase late summer/fall water temperatures downstream of Iron Gate Dam by approximately 4˚F to 18˚F (approximately 2˚C to 10˚C) (see also *Middle and Lower Klamath River*). Further, even though Copco No. 1 and Iron Gate reservoirs retain large volumes (approximately 9,000 acre-feet and 23,000 acre-feet, respectively) of colder bottom waters during periods of stratification, these waters are typically hypoxic (dissolved oxygen less than 2 mg/L), particularly in Copco No. 1 Reservoir (Appendix C, Section C.4.1.1). Although summertime water temperatures documented in the Hydroelectric Reach are within the tolerance ranges of the species observed there (e.g., perch, bass), these temperatures regularly exceed the range of chronic effects temperature thresholds (approximately 55 to 68°F [13 to 20°C]) for full salmonid support in California (North Coast Regional Board 2010).

Middle and Lower Klamath River

The large thermal mass of the stored water in Copco No. 1 and Iron Gate reservoirs delays the natural warming and cooling of riverine water temperatures on a seasonal basis such that spring water temperatures in the Middle Klamath River immediately downstream of Iron Gate Dam are generally cooler than would be expected under natural conditions, and summer and fall water temperatures are generally warmer (Figure ; see also Section 3.2.2.2 *Water Temperature*). This "thermal lag" diminishes downstream from Iron Gate Dam, and there is no noticeable alteration in water temperatures by just upstream of the Salmon River confluence. Summer weather conditions can be very hot from June through September and rising ambient air temperatures can lead to increased water temperatures (Hamilton et al. 2011). Downstream from Iron Gate Dam, monthly mean temperatures in the river are 37.4 to 42.8°F in January and 68 to 72.5°F in July and August and the monthly average daily maximum temperature is commonly greater than 73.4 °F (Bartholow 2005). Substantial losses of juvenile salmonids have occurred during their migration through the Lower Klamath River, and losses were especially severe during low-water years with periods of sustained high-water temperatures. Exposure to high water temperature reduces the resistance of these fish to disease and other stressors (Scheiff et al. 2001, Ray et al. 2014). Consequently, during periods of high-water temperature juvenile salmonids have been observed to crowd into areas with suitable water temperature such as at tributary confluences (thermal refugia). Summary statistics compiled by the United States Environmental Protection Agency (USEPA) indicate that water temperatures at locations between Iron Gate Dam and the Klamath River's confluence with the Scott River range from about 60.8 to 71.6°F in June, and from 60.8 to 78.8°F in July (FERC 2007). From May through September (peaking in June–August) summer water temperatures in the Lower Klamath Basin 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 41 to 53.6°F from December through April (Hiner 2006). Warmer air temperatures and lower flows in summer and fall months result in increased water temperatures ranging from 68 to 75.2°F (Wallace 1998) or greater than 75.2°F (Hiner 2006). When flows become low during some summer conditions, water temperatures in the Klamath River Estuary sometimes exceed criteria for optimal growth, and occasionally are warm enough to result in potential mortality for Chinook salmon, coho salmon, and steelhead (Stillwater Sciences 2009a). However, observed warm water conditions in the Klamath River Estuary are typically short in duration, due to input of cool ocean water and a high prevalence of coastal fog. Water temperatures in the Pacific Ocean nearshore environment are moderated by the Pacific Ocean currents and patterns that appear unrelated to the contribution of the Klamath River.

Disease and Parasites
Fish diseases, specifically the myxozoan parasites *Ceratomyxa shasta* (*C. shasta*) and *Parvicapsula minibicornis (P. minibicornis),* regularly result in substantial mortality of Klamath River salmon (Fujiwara et al. 2011, Bartholomew and Foott 2010); however, 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). These parasites and diseases occur throughout the watershed but appear to cause the most severe mortality in the mainstem Klamath River downstream from Iron Gate Dam where *C. shasta* has been observed to result in high rates of mortality in salmon (True et al. 2013). Ich and columnaris occasionally result in substantial mortality (e.g., the 2002 fish kill of primarily adult Chinook salmon, as discussed below).

Both *C. shasta* and *P. minibicornis* spend part of their life cycle in an invertebrate host and another part in a fish host (Figure 3.3-2). 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* and *P. minibicornis* actinospores into the water column. Actinospores are generally released when temperatures rise above 50°F and remain viable from three to seven days at temperatures from 51.8 to 64.4°F, 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. The river channel downstream from Iron Gate Dam has been atypically stable since dam construction and 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 (Fujiwara et al. 2011). Ray et al. (2014) evaluated *in situ* juvenile salmonid exposure using sentinel cages. Studies found that increasing parasite concentrations and water temperatures were positively associated with the proportion of juvenile fish that experienced infection and mortality. Spore concentration and water temperature were more important determinants of exposure and mortality of juvenile Chinook and coho salmon, than was river flow. However, Ray and Bartholomew (2013) observed an inverse relationship between flow and actinospore transmission; higher flows (water velocities) appeared to result in lower transmission rates. The location of peak actinospore concentrations varies among years, and Som et al. (2016a) report that the most frequent location of the peak in concentrations occurs near the confluence of Beaver Creek.

Figure 3.3-2. Lifecycle of *Ceratomyxa Shasta*. Source: NMFS 2012.

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 (Figure 3.3-2) (Bartholomew and Foott 2010). Som et al. (2016a) states that myxospores released from adult salmon carcasses contribute the bulk of myxospores to the system; mostly from carcasses upstream of the confluence with the Shasta River.

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 it is frequently found among mats of filamentous periphytic algal species (e.g., Cladophora) that traps fine sediment and detritus (Bartholomew and Foott 2010).

The highest densities of polychaetes have been observed in slow-flowing and more stable, depositional habitats (e.g., pools with sand) (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). Malakauskas et al. (2013) performed flume experiments to evaluate flow requirements for dislodging polychaetes. Their results suggested resilience of polychaetes to flow-mediated disturbance and indicated that substrate size has a great influence on resilience of polychaetes to disruption (smaller particles, greater susceptibility). Malakauskas et al. (2013) found that sufficiently high sheer velocities (>140 cm/s) dislodge polychaetes from both rock substrate and fine sediment. Bartholomew et al. (2018) attributed the observed lowest polychaete densities and prevalence of *C. shasta* infection in 2017 (as compared to all previous years of monitoring) in part to the high magnitude and sustained duration of peak discharge in 2016 and 2017, and in part to low spring water temperatures. 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 (Shea et al. 2016).

Susceptibility to *C. shasta* is also influenced by the genetic type of *C. shasta* encountered by the fish (Som et al. 2016a). 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 a genetic analysis, the *C. shasta* genotypes were characterized as Type 0, Type I, Type II, and Type III (Table 3.3-10). In the Williamson River, although parasite densities had been found to be high, sentinel Chinook salmon were resistant to infection because the genotype specific to Chinook salmon was absent (Hurst et al. 2012).

Table 3.3-10. *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

***C. shasta* Genotype**	**Distribution**	**Affected Species**	**Notes**
Type II	Klamath Lake, Upper and Lower Klamath Basin	coho salmon in Lower Klamath Basin and non-native rainbow trout	The “biotype” found in the Upper Klamath Basin does not appear to affect coho salmon in sentinel studies
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

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-run Chinook salmon (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*. Because the parasites are endemic to the watershed, the native salmonid populations have some level of resistance to the disease.

Upper Klamath River and Connected Waterbodies

Many of the diseases and parasites described above can occur in the Upper Klamath River. *C. shasta* and *P. minibicornis* are both known to occur in the Upper Klamath Basin (NMFS 2006a), 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). Habitat in the lower Williamson River supporting high polychaete densities (and thus parasite densities) includes stable flows and large deposits of sand-silt and fine benthic organic matter (Stocking and Bartholomew 2007). However, in the section of the river upstream of J.C. Boyle Reservoir, *C. shasta* does not have the same serious effects as it does downstream from Iron Gate Dam, because of the genotype of the parasite (Type 0, II, and III) 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 upstream of the dams evolved with these parasites (Hamilton et al. 2011). 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), including: (1) close proximity of myxospore-shedding carcasses (concentration of carcasses); (2) abundant polychaete populations that are found in stable habitats; (3) suitable water temperatures (greater than 59°F) 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 (Hamilton et al. 2011), and the NMFS (2006a, USFWS/NMFS Issue 2(B)) concluded that the movement of anadromous fish upstream of Iron Gate Dam presents a relatively low risk of introducing pathogens to resident fish (e.g., redband trout, cutthroat trout).

Upper Klamath River − Hydroelectric Reach

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 the Lower Klamath 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). In order for an area to develop as an infectious zone, several factors need to coincide, including microhabitats with low velocity, and stable flows, which are rare within this reach (Bartholomew and Foott 2010).

Middle and Lower Klamath River

In the Klamath River downstream of Iron Gate Dam, 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 actinospore exposure, particularly from May through August (Beeman et al. 2008, Bartholomew and Foott 2010). This portion of the river contains dense populations of polychaetes within low-velocity habitats with *Cladophora* (a filamentous green periphytic algae), sand-silt, and fine 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 (Som et al. 2016b). 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 in the reach from Shasta River to Seiad (Stocking and Bartholomew 2007, Bartholomew and Foott 2010, Bartholomew et al. 2017). The zone of greatest infection (nidus) has varied during annual monitoring from 2006 through 2017. Bartholomew et al. (2017, 2018) conducted sentinel fish exposures studies to measure mortality of juvenile Chinook with *C. shasta* infections at index sites in the mainstem Klamath River. Bartholomew et al. (2017, 2018) report that the 2016 infectious zone was the most extensive since monitoring began in 2006 and extended from the I-5 Bridge (RM 182.1) downstream to Orleans (RM 59), with the greatest losses observed near Orleans. In 2017, the zone retracted to the reach from the I-5 Bridge downstream to Seiad Valley (RM 132.7), with the greatest sentinel fish loss and spore abundance near Beaver Creek (RM 163.4). Other references to the existing disease nidus downstream from Iron Gate Dam refer to the reach described above.

Despite potential resistance to *C. shasta* and *P. minibicornis* in native populations, salmon exposed to high levels of the parasite may be more susceptible to disease—particularly juvenile salmon, and more so at higher (>59ºF [>15ºC]) water temperatures. In summarizing data collected from 2005 through 2008, Bartholomew and Foott (2010) reported that juvenile Chinook and coho salmon migrating downstream had infection rates as high as 90 percent and 50 percent, respectively. During April to August 2009 True et al. (2010) found 54 percent of juvenile Chinook salmon in the Klamath River upstream of the confluence with the Trinity River had parasitic infection from *C. shasta*, and 85 percent were infected with *P. minibicornis*. Water temperatures were not reported. During April to August 2012 True et al. (2013) found 30 percent of juvenile Chinook salmon in the Klamath River upstream of the confluence with the Trinity River had parasitic infection from *C. shasta*, and 69 percent were infected with *P. minibicornis.* True et al. (2013) reported that both *C. shasta* prevalence of infection increased in 2012 compared to 2011 (2011 results not reported). Environmentally, 2012 consisted of a relatively normal temperature profile for the Klamath River. No manipulated pulse flow from Iron Gate Dam (as in 2011) or extended period of precipitation (as in 2010) occurred. True et al. (2013) concluded that the typically warm river temperatures (59–75.2°F) observed in May–July, coupled with earlier high *C. shasta* actinospore densities (May versus June in 2011) in the infectious zone, resulted in an increase in annual infection prevalence compared to the previous monitoring year. Overall, the 2012 annual infection prevalence for juvenile Chinook salmon during outmigration was relatively moderate compared to historical levels observed for the monitoring program (2006–2011). True et al. (2017) and Voss et al. (2018) used the quantitative polymerase chain reaction (qPCR) analysis technique and histology to measure myxosporean parasite infection of juvenile Chinook salmon in the Klamath River. Voss et al. (2018) reported lower rates of *C. shasta* infection in 2017 (5 percent) and 2018 (11 percent) than the high levels observed during 2016 (27 percent). The researchers report the mean *C. shasta* prevalence of infection (POI) for natural (non-hatchery) fish from 2009–2018 is 27 percent and has ranged from a low of 4 percent in 2012, to 75–76 percent during the drought years of 2014–2015. Voss et al. (2018) suggest that the increase in POI observed in 2018 could be due to lower flows and slightly higher spring water temperatures. Environmental conditions were very favorable for fish in 2017 (True et al. 2017), therefore Voss et al. (2018) were not surprised to see an increase in POI in the drier year of 2018. Following surface flushing flows in 2019 POI in juvenile Chinook salmon captured in the Klamath River in the reach from Shasta to Scott River confluences ranged from 60 percent in late April to 80 percent in early May (USFWS 2019b).

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 mortality rates were between 35 and 70 percent in the Klamath River near Iron Gate Dam. Their studies also suggested that higher spring discharge increased smolt survival (Beeman et al. 2008).

Between May and July 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). Visible 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. Weekly prevalence of *C. shasta* infection for all sites combined ranged from 15 to 56 percent, with the peak observed in fish captured in late May. Expanding from the trap efficiency data the authors estimated 45 percent of the population passing Big Bar was infected with *C. shasta.* Weekly prevalence of *P. minibicornis* infection for all sites combined ranged from 36 to 93 percent with the peak observed in fish captured on mid-June. Expanding from the trap efficiency data the authors estimated 94 percent of the population passing Big Bar was infected with *P. minibicornis.* The authors concluded that the high incidence of dual myxozoan infection (98 percent of *Ceratomyxa* infected fish), and associated pathology suggested that most of the *C. shasta* infected juvenile Chinook salmon would not survive. 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 1998 and June 2000 fish kills. CDFG (2000) estimated 10,000 to 300,000 individuals, mostly young-of-year, killed in the June 2000 event. CDFG (2000) stated that, “we did not attempt to systematically or statistically quantify total [young of the year] chinook and steelhead mortality. CDFG’s initial assessment of mortality in the “tens of thousands” range should be considered a very conservative minimum. I [CDFW staff] believe many more fish died than we originally observed during our surveys because of the time period involved (mid-to-late June; approximately three weeks) and the apparent high rate of scavenging (dead fish being quickly consumed and therefore unavailable for observation). It is probable that a number on an order of magnitude greater (i.e., >100,000 to 300,000) may be more realistic.”

The cause of the 2000 fish kill was believed to be infection with *C*. *shasta* and columnaris. For comparison, in 2010 through 2012, years with lower river temperatures and conditions less conducive to disease infection, prevalence of *C. shasta* in emigrating juvenile Chinook salmon during the peak migration period was less than 30 percent (True et al. 2013).

For adult salmon, disease has been less frequent and of a different nature. Ich, a protozoan parasite that spreads horizontally from fish to fish (Figure 3.3-3), 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). For adult salmon the effects of Ich and columnaris are generally not as harmful as the observed effects of the myxozoan parasites on juveniles, although the 2002 fish kill in the Lower Klamath River provided dramatic evidence of the ability of Ich and columnaris to cause significant adult salmon mortality, with more than 33,000 adult salmon and steelhead lost during a disease outbreak (CDFG 2004). 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 the analysis in CDFG (2004), the total fish estimate of 34,056 fish was a conservative estimate, and the CDFG analysis indicate the actual losses may have been more than double that number. 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 outbreak 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). While high temperatures may have contributed to the fish kill, temperatures were not unusually high in 2002 when compared to the historical record (Belchick et al. 2004). There is little historical data on dissolved oxygen, but it has been monitoring since 2001—and dissolved oxygen concentrations were similar in 2001 and 2002. During the 2002 fish kill, dissolved oxygen concentrations did not fall below 6.0 mg/L and were eliminated as a potential cause (Belchick et al. 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. Belchick et al. (2004) states that “consideration of all pertinent data led to the conclusion that in 2002 a relatively robust run of adult fall Chinook entered the Klamath River approximately one week earlier than usual. Environmental conditions in the River at the time of the 2002 fall-run Chinook salmon run were characterized by low flow rates and volume, and an apparent lack of migration cues to proceed upriver. The resultant migration delay, crowded conditions, and warm water temperatures provided an ideal environment for the proliferation of Ich and columnaris.

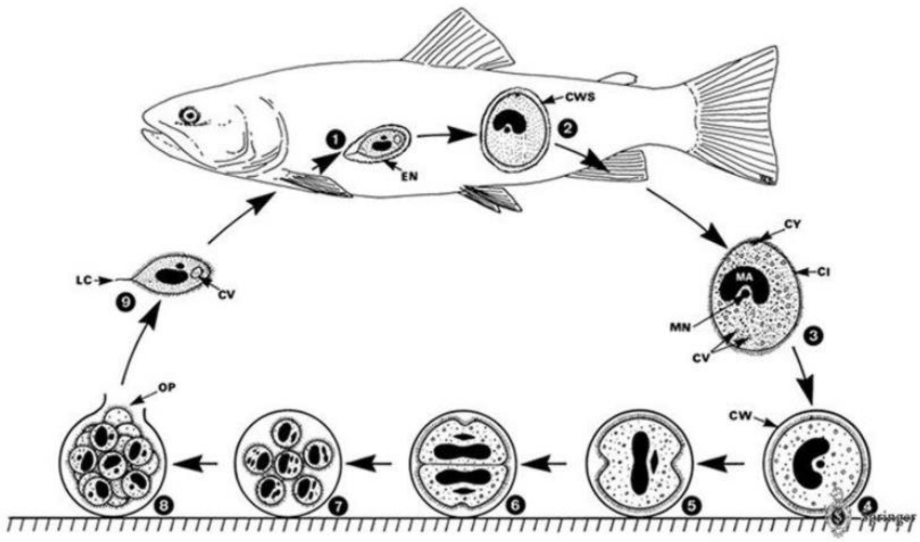

Figure 3.3-3. Lifecycle of *Ichthyophthirius Multifis* (Ich). In stages 1 and 2 the adult parasite lives within the fish host; in stage 3 the adult parasite is motile outside of the host fish and attaches to a bottom substrate before dividing into an immature form; in stages 4 through 8 the immature form divides numerous times and is then released as stage 9, the infective stage of the parasite. Source: Strange 2010.

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 (2007) concluded that the Klamath Hydroelectric Project has likely contributed to conditions that foster disease and lead to salmon losses in the Middle and Lower Klamath River by (1) increasing the density of spawning adult fall-run 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* and *P. minibicornis*; and (3) contributing to water quality conditions that increase the stress level of juvenile and adult salmonids 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 dissolved oxygen and pH associated with algal blooms in project reservoirs; and (3) effects of exposure to elevated levels of microcystin produced from microcystis blooms in Klamath Hydroelectric Project reservoirs, which may also result in direct mortality. Dissolved oxygen and pH dynamics, including dissolved oxygen concentrations that do not meet the Basin Plan minimum dissolved oxygen criteria and pH concentrations that exceed the Basin Plan instantaneous maximum of 8.5 s.u., for the Hydroelectric Reach, the Middle and Lower Klamath River, and the Klamath River Estuary, are discussed in Section 3.2.2.5 *Dissolved Oxygen* and Section 3.2.2.6 *pH.* A discussion of fish exposure to microcystin toxin in the Hydroelectric Reach and the Klamath River downstream from Iron Gate Dam is presented below in Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project – Algal Toxins*.

Seasonal production of ammonia occurs in the hypoxic (dissolved oxygen less than 2 mg/L) or anoxic (no dissolved oxygen) bottom waters of Copco No. 1 and/or Iron Gate reservoirs on a seasonal basis. But, no actual ammonia toxicity events have been reported in the reservoirs or in the Middle Klamath River downstream from Iron Gate Dam, and no acute or chronic toxicity exceedances of Basin Plan criteria for ammonia have been observed in the river (Appendix C – *Sections C.3.11* and *C.3.2.1*).

In 2013, NMFS and USFWS issued a joint BiOp (NMFS and USFWS 2013) of the proposed operations of the Klamath Irrigation Project by the USBR in Klamath County in Oregon, and Siskiyou and Modoc counties in California. In this 2013 BiOp, NMFS concluded that flow variability would increase mainstem Klamath River flows when precipitation and snow melt is occurring in the Upper Klamath Basin, which would help to dilute actinospore concentrations and/or disturb polychaetes and their habitats. Malakauskas et al. (2013) performed flume experiments to evaluate flow requirements for dislodging polychaetes. Their results highlight the resilience to flow-mediated disturbance. Their findings indicated substrate size has a great influence of resilience of polychaetes to disruption (smaller particles, greater susceptibility), and that when sheer velocities are sufficient dislodgment of polychaetes occurs. In addition, the 2013 BiOp found that flow variability would provide dynamic fluvial environments in the mainstem Klamath River that may impair polychaete fitness, reproductive success, or infection with *C. shasta* and *P. minibicornis*. Compared to observed conditions during the period of record, NMFS concluded that proposed operations of the Klamath Irrigation Project under the 2013 BiOp would increase the magnitude and frequency of peak flows, which would likely decrease the abundance of polychaetes in the spring and summer following a channel maintenance flow event (NMFS and USFWS 2013). The proposed operations of the Klamath Irrigation Project would increase the magnitude and frequency of channel maintenance flows between 5,000 and 10,000 cfs relative to the observed period of record (e.g., the Klamath Irrigation Project would have an estimated two-year flood frequency of 5,454 cfs whereas the observed period of record had 5,168 cfs). This conclusion is also supported by the analysis of Shea et al. (2016), who examined the flow history in the Klamath River relative to sediment mobilization. The increase in magnitude and frequency of channel maintenance flows between 5,000 and 10,000 cfs would likely decrease the abundance of polychaetes in the spring and summer following a channel maintenance flow event (NMFS and USFWS 2013, Alexander et al. 2016, Som et al. 2016b). In the 2013 BiOp, NMFS concluded that the increase in magnitude and frequency of channel maintenance flows between 5,000 and 10,000 cfs would likely decrease the actinospore concentrations relative to the observed period of record when the channel maintenance flow event occurs in the spring, particularly in May and June.

However, the first years of 2013 BiOp implementation included severe drought conditions, and although the USBR was operating the Klamath Irrigation Project in accordance with the 2013 BiOp, the infection rate for *C. shasta* in the Klamath River downstream of Iron Gate Dam greatly exceeded the incidental take maximum (U.S. District Court 2017a). As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, this led to a court-order requiring USBR to provide, as necessary, three specific flows in the Klamath River, as measured immediately downstream of Iron Gate Dam: annual winter-spring surface flushing flows, biennial winter-spring deep flushing flows, and spring-summer emergency dilution flows, if needed (U.S. District Court 2017a–c). The court-ordered flushing flows and emergency dilution flows are not modeled as part of existing conditions hydrology under the Proposed Project. As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, the 2017 court-ordered flows included a requirement to ensure that certain high flows are reached each winter, and they also included an emergency dilution requirement if juvenile fish disease reached high levels in the infection nidus. The emergency dilution flows were used in 2018. In March 2019, the court-required re-initiation of USBR consultation with NMFS and USFWS was completed and new biological opinions (BiOps) were issued by NMFS (2019) and USFWS (2019a). The 2019 BiOp flow requirements include annual surface flushing flows of at least 6,030 cubic feet per second (cfs) for 72 hours at Iron Gate Dam between March 1 and April 15, and the potential for dilution flows and/or enhanced spring flows should water be available and disease conditions support their use. Dilution flows also occurred in June 2019 under the new BiOp flow requirements.

Klamath River Estuary and Pacific Ocean Nearshore Environment
While disease and parasites occur in the Klamath River Estuary and Pacific Ocean nearshore environment, 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, but there is no evidence or observations of disease effects in this environment to date.

Fish Hatcheries

Under existing conditions, there are two fish hatcheries located along the Klamath River: Fall Creek Hatchery and Iron Gate Hatchery. Fall Creek Hatchery was built in 1919 by the California Oregon Power Company in Fall Creek, near its confluence with the Klamath River (RM 200.3), as compensation for the loss of spawning grounds that occurred with the construction of Copco No. 1 Dam. Fall Creek Hatchery facilities were last used by CDFW periodically from 1979 to 2003 to raise Chinook salmon yearlings. Fall Creek Hatchery yearlings were released into the Klamath River at Iron Gate Hatchery. Although many of the Fall Creek Hatchery facilities remain operable, the hatchery has not produced fish since 2003 when all fish production was moved to Iron Gate Hatchery.

Iron Gate Hatchery is part of the Lower Klamath Project and was originally constructed in 1962 as mitigation for blockage of fish passage caused by the construction of Iron Gate Dam. Iron Gate Hatchery facilities are located approximately 0.5 miles downstream of Iron Gate Dam, adjacent to the Bogus Creek tributary. CDFW operates Iron Gate Hatchery with the following annual production goal (CDFW and PacifiCorp 2014):

- 75,000 yearling coho salmon (age-1 releases during spring)
- 900,000 yearling fall-run Chinook salmon (age-1 releases during fall)
- 5,100,000 fall-run Chinook salmon smolts (age-0 releases during spring)
- 200,000 yearling steelhead (age-1 releases during spring)

However, the ability to meet the above production goals varies annually based on adult returns and hatchery performance. Coho salmon production has averaged 73,281 yearlings (nearly achieving production goals) for the 24-year period from 1993–2016 while adult returns have averaged 982 fish over the last 56 years (Giudice and Knechtle 2018). More recently juvenile coho salmon production has averaged 70,444 yearlings for the period of 2009–2018 (K. Pomeroy, CDFW, pers. comm., 2018). Although adult coho salmon returns to Iron Gate Hatchery are highly variable between years, recent coho salmon returns to Iron Gate Hatchery have significantly and steadily declined. During the period of 2008–2017, coho salmon returns averaged 501 fish with only two years where returns to Iron Gate Hatchery exceeded the 56-year average (Giudice and Knechtle 2018).

From 1991 through 2017 actual fall-run Chinook salmon yearling production has averaged 973,574 (exceeding production goals), and actual smolt production from 1991 through 2018 has averaged 4,593,220 (around a half-million fewer smolts than the goal on average) (K. Pomeroy, CDFW, pers. comm., 2018). Based on coded wire tagging between 1990 and 2015, adult returns of smolts has averaged 0.178 percent, and returns of yearlings has averaged 0.352 percent (Giudice and Knechtle 2018). Despite higher survival of yearling releases, the substantially higher number of smolt releases results in most hatchery adult returns being fish released as age-0 smolts. The fall-run Chinook salmon hatchery spawner return goal is 8,000 fish. Total Chinook salmon returns to Iron Gate Hatchery between 1978 and 2018 ranged from 2,558 to 72,474 and averaged 15,625 fish (CDFW 2019). Recent returns of adult Chinook salmon to Iron Gate Hatchery have been similar to the long-term average, with an average of 15,625 adult Chinook salmon returning over the period of 2009–2018 (CDFW 2019). Adult steelhead (fall- and spring-run) returns to Iron Gate Hatchery averaged 1,064 fish for the period of 1963–2016 (CDFW 2016b). More recent returns have been much lower with an average of 82 adult steelhead returning to Iron Gate Hatchery for the period of 2007–2016 (CDFW 2016b). Returns have been declining, and in 2016 no adult steelhead returned to the hatchery (CDFW 2016b). The low adult returns of steelhead have resulted in no production of steelhead yearlings from Iron Gate Hatchery since 2013.

It appears that progeny from Iron Gate Hatchery releases have contributed significantly to the ocean and in-river fisheries since the late 1960s (PacifiCorp 2004a). PacifiCorp (2004a) estimates that based on smolt-to-adult survival studies conducted on Iron Gate fall Chinook salmon, the Iron Gate Hatchery production contributes about 50,000 fish annually to the Chinook salmon, coho salmon, and steelhead fisheries, in addition to escapement back to the hatchery.

The net effect of hatchery releases on naturally occurring stocks is difficult to assess, with both positive and negative consequences potentially occurring due to a multitude of factors including, brood stock source, system carrying capacity, timing of release, degree of competition, and environmental selection pressures (NMFS 2017b), as discussed below. Potential benefits of hatchery releases include increases in adult abundance supporting fisheries and increased marine-derived nutrient transfer to freshwater systems from returning hatchery-origin adults (NMFS 2017b). Potential negative effects include genetic risks, competition and predation, hatchery facility effects on water quality, effects of weirs and other hatchery infrastructure, masking of current wild population status due to the presence of large numbers of hatchery-origin fish, incidental fishing pressure, and disease transfer from hatchery to wild fish. CDFW (2014) noted that in the Klamath River, adverse hatchery-related effects pose a very high stress to all life stages of natural salmon populations because hatchery origin adults make up greater than 30 percent of the total number of adults. Data from Ackerman et al. (2006) indicate that substantial straying of Iron Gate Hatchery fish may be occurring into important tributaries of the Middle Klamath River. Hatchery strays in the Klamath River (primarily of Chinook salmon) have the potential to reduce the reproductive success of natural salmonid populations (Mclean et al. 2003, Chilcote 2003, Araki et al. 2007) and negatively affect the diversity of the populations via outbreeding depression[68] (Reisenbichler and Rubin 1999). Returns of adult salmon to Iron Gate Hatchery, and fall-run Chinook salmon in particular, influence aquatic resources in the Middle and

[68] Outbreeding depression is the displacement of locally adapted genes in a wild population.

Lower Klamath River. Iron Gate Hatchery (RM 192.4) has a profound influence on Klamath River fall Chinook salmon in the vicinity of the hatchery. Kinziger et al. (2013) found the proportion of naturally spawning fall Chinook salmon of origin decreased with distance from the hatchery. Natural origin Chinook sampled in Bogus Creek (RM 192.6), Shasta River (RM 179.5), and the Scott River (RM 145.1) had decreasing proportions of hatchery genetics with increasing distance from the hatchery. The influence of Iron Gate Hatchery genetics on fall Chinook salmon is greatly diminished by the confluence with the Scott River.

A Hatchery Genetic Management Plan (HGMP) for the Iron Gate Hatchery (CDFW and PacifiCorp 2014) recently redefined the operation of this hatchery from a mitigation hatchery to one now operated to protect and conserve the genetic resources of the Upper Klamath population unit of the SONCC coho salmon ESU. Included in the HGMP are defined monitoring and evaluation activities to evaluate effects of the hatchery activities on the abundance, productivity, spatial structure, and diversity of the SONCC coho salmon and the magnitude or relative impact of the hatchery program on other actions that influence SONCC coho salmon.

Fall-run Chinook salmon returns to Iron Gate Hatchery and the blockage created by Iron Gate Dam, concentrate spawners and post-spawn carcass densities between Iron Gate Dam and the Shasta River confluence. As described in the *Disease and Parasites* section above, 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 release of Chinook salmon smolts and yearlings from Iron Gate Hatchery also affects disease interactions. The release from Iron Gate Hatchery overlaps temporally and spatially with the period of high infection potential, and studies suggest that therefore a high proportion of the Iron Gate Hatchery Chinook salmon stock can become infected with *C. shasta* and *P. minibicornis* (Som et al. 2016a). The hatchery-released juvenile fish that become infected and experience mortality lower in the Klamath River may become another source of myxospores to the Lower Klamath River.

The Chinook salmon released to the Klamath River annually also likely result in deleterious effects on natural spawning populations, including competitive pressure between hatchery-derived and natural origin fish in the limited habitat areas (e.g., thermal refugia) used by rearing juveniles in the Klamath River (NMFS 2010a). Iron Gate Hatchery releases Chinook salmon from the middle of May to the end of June, a period when discharge from Iron Gate Dam is in steep decline and water temperatures are rapidly rising, which may create competition between hatchery and natural fish (Chinook salmon, coho salmon, and steelhead) for food and limited resources, especially limited space and resources in thermal refugia (NMFS 2010a). Negative hatchery effects due to competition, leading to displacement and lower growth, are well documented (Flagg et al. 2000, McMichael et al. 1997). Large releases of hatchery juveniles have also been shown to increase predation on and reduce survival of naturally produced juvenile salmonids (Kostow 2009). In the Clackamas River, Oregon, hatchery steelhead released in the upper basin resulted in an exceedance of system carrying capacity, resulting in negative outcomes for natural-origin fish (Kostow et al. 2003 and Kostow and Zhou 2006) and up to a 50 percent decline in the number of recruits per spawner and a 22 percent decline in the maximum number of natural-origin recruits. These trends appear to have reversed after releases of hatchery fish were discontinued in 2000. Such density-dependent negative effects of hatchery-released fish can extend even into the marine environment, especially during periods of poor ocean conditions (Beamish et al. 1997, Sweeting et al. 2003).

Algal Toxins

Algae produced in Upper Klamath Lake and the reservoirs in the Klamath Hydropower Reach (Copco No. 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 *Microcystis aeruginosa*, produce toxins that can cause irritation, sickness, or in extreme cases, death to exposed organisms (see Section 3.2.2.7 *Chlorophyll-a and Algal Toxins* and Appendix C.6). Algal toxins produced by *Microcystis aeruginosa* are prevalent in Upper Klamath Lake and the Keno Reservoir and these sources would remain under the Proposed Project. While direct links to fish health are still somewhat unclear, data collected 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.

While the Proposed Project would not affect the occurrence of algal toxins in Upper Klamath Lake, the following summary is provided to characterize ongoing research regarding the effects of microcystin toxin on native fish species in the Klamath Basin. A reconnaissance study was conducted in Upper Klamath Lake to evaluate the presence, concentration, and dynamics of microcystin exposure in Lost River sucker and shortnose suckers. 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 gastrointestinal lesions in juvenile suckers sampled from around the lake, although organ damage was 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 *Aphanizomenon flos-aquae* and colonies of *Microcystis aeruginosa*. 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). Based on these observations, NMFS and USFWS (2013) cited high microcystin levels as a “possible high threat” to Lost River and shortnose suckers in the 2013 joint NMFS and USFWS Biological Opinion. Further research conducted by Saraf et al. (2018) found that early life stage fish exposed to natural levels of microcystin had reduced larval survival rates, premature hatching, yolk sac edema, and stunted growth rates. Additionally, early life stage fish exposed to natural levels of microcystin experienced cardiotoxic effects which resulted in poor heart development and reduced survival (Saraf et al. 2018).

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 reported in multiple studies with variable results depending on season, location, and fish species (Fetcho 2006; Kann 2008; CH2M Hill 2009a,b; Prendergast and Foster 2010; Kann et al. 2010 a,b; Kann et al. 2013; Fetcho 2011). During July through September 2007, 85 percent of fish and mussel tissue samples collected from the Klamath River, including samples from Iron Gate and Copco No. 1 reservoirs, exhibited microcystin bioaccumulation, with the total microcystin congeners ranging from less than detection levels to 2,803 ng/g (Kann 2008). While it is not known whether the levels of microcystin bioaccumulation measured in 2007 were harmful to fish and/or mussel populations, levels exceeded the public health guidelines defined by Ibelings and Chorus (2007), indicating that ingestion of the fish or mussels would potentially pose a health hazard to humans (Kann 2008). Within Copco No. 1 and Iron Gate reservoirs, samples of muscle and liver tissues from resident fish (e.g., yellow perch [*Perca flavescens*] and crappie [*Pomoxis nigromaculatus*]) exhibited detectable levels of two of eight microcystin congeners (i.e., chemically different forms of microcystin) in muscle and liver tissues of 36 yellow perch samples during September 2007 (Kann 2008). Unbound or “free” microcystin (the form of microcystin that could be further bioaccumulated if the fish were to be ingested by humans or other predators) 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). In 2010, algal toxins were found in salmonid tissues collected from the Middle Klamath River near Happy Camp (Kann et al. 2013). In contrast, data from 2008 and 2009 did not show microcystin bioaccumulation in the tissue and liver samples from fish collected from Copco No. 1 and Iron Gate reservoirs (CH2M Hill 2009, PacifiCorp 2010).

Further downstream in the Lower Klamath River, Fetcho (2006) reported that liver and muscle tissue samples from five Chinook salmon taken from the Klamath River at or near Weitchpec (near RM 43.3) in 2005 did not contain detectable levels of microcystin. However, two steelhead liver samples, collected on October 3, 2005 did contain measurable levels of microcystin at trace and 0.54 ug/g concentrations. 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 (the form of microcystin that could be further bioaccumulated if the fish were to be ingested by humans or other predators) were found (CH2M Hill 2009b). Because fish livers are not typically consumed, those fish exhibiting elevated microcystin levels in liver tissue may not have posed a public health concern with respect to consumption.

While it is not known whether the levels of microcystin measured in the Lower Klamath River fish tissue samples were harmful to fish populations, the range of concentrations (up to approximately 2,800 ng/g) indicate that direct effects to fish health due to microcystin exposure such as stress and/or disease are a possibility (Kann et al. 2013). 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. The variation in fish tissue results in Copco No. 1 and Iron Gate reservoirs and the Klamath River downstream from Iron Gate Dam across multiple studies suggests that a combination factors is likely to influence the concentration of microcystin in fish tissue, including patchy distributions of algal blooms within the Lower Klamath Project reservoirs and the downstream Klamath River, the ability of fish to move in and out of algal bloom areas where microcystin is likely most prevalent, and food web interactions that may result in differing degrees of bioaccumulation depending on the fish species.

Microcystin can also bioaccumulate in the tissue of mussels 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 132.7) 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 132.7), 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. As noted above, 85 percent of fish and mussel tissue samples collected during July through September 2007 in the Klamath River, including Iron Gate and Copco No. 1 reservoirs, exhibited microcystin bioaccumulation (Kann 2008). While it is not known whether the levels of microcystin measured in the Lower Klamath River mussel tissue samples were harmful to mussel populations, 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 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 No. 1 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 No. 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).

Aquatic Habitat and Instream Flows

Instream flows influence habitat availability for aquatic species. USBR manages Upper Klamath Lake to meet the requirements of the biological opinions issued by NMFS for protection of coho salmon in the Klamath River and USFWS for protection of shortnose and Lost River suckers in Upper Klamath Lake, which are incorporated into contract requirements for USBR's Klamath Irrigation Project. The 2013 BiOp Flows served as the operational flow requirement for the Klamath River at the time of the Notice of Preparation for the Lower Klamath Project EIR (i.e., December 22, 2016) and the Draft EIR considered the potential effects of dam removal using the 2013 BiOp Flows to represent existing hydrology for the period May 2013 – March 2019. The flow-related analyses in this EIR acknowledge the re-initiation of consultation on the 2013 BiOp Flows by considering the 2017 court-ordered flushing and emergency dilution flow requirements downstream of Iron Gate Dam as interim flow requirements until completion of formal consultation. The 2017 court-ordered flushing and emergency dilution flows are not part of existing conditions hydrology for the Proposed Project, because they went into effect in February 2017 after the December 2016 Notice of Preparation was filed. The applicable biological opinion for the Klamath River is now the 2019 BiOp (NMFS 2019, USFWS 2019a). The 2019 BiOp Flows are analyzed in the Lower Klamath Project Final EIR as a second CEQA baseline, representing flows under new conditions defined and implemented during Final EIR development. Inclusion of two baseline hydrology regimes in the Lower Klamath Project Final EIR is consistent with CEQA Guidelines section 15125 (a). For additional detail, see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*.

The Klamath Irrigation Project affects instream flows in the Klamath River downstream of Upper Klamath Lake, including the California portion of the Area of Analysis for aquatic resources. Studies to determine how fish habitat changes with flow have been conducted in portions of the Klamath River, including two reaches between J.C. Boyle Reservoir and Iron Gate Dam, for selected life stages of rainbow trout (BLM 2002) and seven locations between Iron Gate Dam and the Klamath River 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 aquatic species habitat in various portions of the Klamath. Where specific information is not available for a species or area, the analysis contained herein uses hydrologic changes, species habitat requirements, and comparisons with those species for which there is specific information to qualitatively assess changes in flow-related habitat. This information was used to evaluate how the Proposed Project might result in changes to the amount of flow-related habitat. It was not possible to rely on the hydrologic record of the past decade 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 (e.g., minimum Upper Klamath Lake elevations, minimum flows downstream from Iron Gate Dam). These changes are described in the 2013 BiOp for the Klamath Irrigation Project (NMFS and USFWS 2013), and the instream flows under existing conditions are described in Table 3.6-8 in Section 3.6.2.2 *Basin Hydrology*.

The natural hydrograph (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). There are no measured river discharge data downstream from Keno Dam prior to implementation of USBR's Klamath Irrigation Project. However, modeled flows downstream of Iron Gate Dam that explicitly remove the Klamath Irrigation Project flow component offer a reasonable approximation of natural discharge downstream of Keno Dam (USBR 2005). Model results indicate that the historical, natural hydrograph for the Klamath River and its tributaries was characterized by high spring flows triggered by melting snow, typically near the end of April, followed by receding flows during summer months, and the base flow condition by September (NRC 2004). This recurring seasonal flow pattern influenced the adaptations of native aquatic organisms, as reflected in the timing of their key life history stages (NRC 2004). Given the diversity of flows inherent to the natural hydrograph, the Klamath River historically supported a range of riverine habitats and allowed the various anadromous fish species and life history strategies to evolve over time.

Upper Klamath River and Connected Waterbodies

USBR manages Upper Klamath Lake to meet the requirements of the 2013 BiOp (NMFS and USFWS 2013)[69] and its contract requirements for USBR's Klamath Irrigation Project (USBR 2010). Aquatic habitat and instream flows in the Upper Klamath River upstream of the influence of J.C. Boyle Reservoir are not thoroughly analyzed for this EIR, since aquatic species within California are not heavily influenced by these flows other than through the operation of the USBR's

[69] As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, following implementation of the 2013 BiOp a court-order required USBR to implement three specific flows in the Klamath River: winter-spring surface flushing flows, winter-spring deep flushing flows, and spring-summer emergency dilution flows (U.S. District Court 2017a–c). The court-ordered flushing flows and emergency dilution flows are not part of existing conditions for the Proposed Project, because they went into effect after the Notice of Preparation was filed by the State Water Board in December 2016.

Klamath Irrigation Project, where the latter is controlled through the requirements of the 2013 BiOp (see below discussions).

Upper Klamath River − Hydroelectric Reach

Under its existing license, PacifiCorp operates the J.C. Boyle Powerhouse as a peaking facility, meaning that water is run through the powerhouse to generate electricity cyclically depending on water availability and power demand. Rapid changes in flow associated with hydropower peaking operations, can result in inhospitable conditions for aquatic species downstream. Peaking operations at J.C. Boyle Powerhouse result in fluctuating flows in the Hydroelectric Reach of the Upper Klamath River that vary based on power generation needs. For example, substantial changes in flow (from 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 No. 1 Reservoir). These flow fluctuations in this reach can also result in rapid temperature changes between 5 and 59°F during the summer months (ODEQ 2010). These 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 (NMFS 2006a), it was found that this reach had lower macroinvertebrate drift rates than would occur without the hydroelectric project operations.

Middle and Lower Klamath River

As described in Section 3.1.6.1 *Klamath River Flows under the Klamath Irrigation Project's 2013 BiOp*, the 2013 BiOp provided minimum flows downstream of Iron Gate Dam for the protection of coho salmon. The 2013 BiOp also included an Environmental Water Account (EWA) with provisions for flow alterations to protect ESA-listed species, including the release of dilution/flushing water from Upper Klamath Lake to reduce juvenile coho salmon disease below Iron Gate Dam. The 2013 BiOp Flows served as the operational flow requirement for the Klamath River at the time of the Notice of Preparation for the Lower Klamath Project EIR (i.e., December 22, 2016) and the Draft EIR considered the potential effects of dam removal using the 2013 BiOp Flows to represent existing hydrology for the period May 2013–March 2019. As described in Section 3.1.6.3 *Klamath River Flows under the Klamath Irrigation Project's 2019 BiOp*, the 2019 BiOp, which is the current operational flow requirement for the Klamath River, also provides minimum flows downstream of Iron Gate Dam for the protection of coho salmon and an EWA with provisions for release of flushing flows, and the potential for release of dilution flows and/or enhanced spring flows, from Upper Klamath Lake to reduce juvenile coho salmon disease below Iron Gate Dam. Additional detail on flows and habitat in the Middle and Lower Klamath River are provided in Section 3.6.2.2 *Basin Hydrology*.

Klamath River Estuary and Pacific Ocean

Aquatic habitat within the Klamath River Estuary is highly influenced by freshwater inflows from upstream, and physical processes in the estuary such as sand-berm dynamics at the river mouth. The Klamath River Estuary spans approximately four to five miles upstream of the mouth. Wallace (1998) notes the formation of a sill at the river mouth in late summer or early fall causing a standing water backup up to six miles upstream. During high tides, saltwater was observed in the summer and early fall from the mouth upstream, ranging approximately 2.5 to four miles depending on the time period in which samples were taken (Wallace 1998).

Water temperatures in the Klamath River Estuary are related to temperatures and flows entering the estuary, the presence and location of a saltwater wedge, and the timing and duration of the formation of a sand berm across the estuary mouth. The saltwater wedge is formed when the estuary mouth is open and denser saltwater from the ocean sinks below the lighter fresh river water; the resulting wedge moves up and down the estuary with the daily tides. The saltwater 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. Input of cool ocean water and fog along the coast minimizes extreme water temperatures much of the time (see also Section 3.2.2.2 *Water Temperature*).

Critical Habitat

The ESA requires that USFWS and NMFS designate critical habitat[70] for the listed species they manage. Critical habitat has been designated for four species within the California portion of the Area of Analysis for aquatic resources: coho salmon, shortnose suckers, Lost River suckers, and eulachon. The endangered population of Southern Resident Killer Whales that includes Klamath River salmon in its diet is also discussed here, and critical habitat for green sturgeon is discussed as well, despite the exclusion of Klamath River from the critical habitat designation.

Coho Salmon

Critical habitat for the SONCC coho salmon ESU was designated on May 5, 1999 and includes the water, substrate, off-channel habitat, and adjacent riparian zones of estuarine and riverine reaches accessible to listed coho salmon between Cape Blanco, Oregon and Punta Gorda, California. Marine areas were excluded from the final critical habitat designation. “Accessible reaches” are

[70] 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.”

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 (NMFS 1999b).

Features of critical habitat considered essential for the conservation of the SONCC ESU (NMFS 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 NMFS (1999b) as follows: "In addition to these factors, NMFS also focuses on the known physical and biological features (PCEs) within the designated area that are essential to the conservation of the species and that may require special management considerations or protection. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation."

Shortnose Sucker and Lost River Sucker

The final designation of critical habitat for shortnose and Lost River suckers was published by the USFWS on December 11, 2012 (USFWS 2012a). The proposed critical habitat area is within Klamath and Lake Counties, Oregon, and Modoc County, California. Critical habitat units include: (1) approximately 146 stream miles and 117,848 acres of lakes and reservoirs for Lost River sucker; and (2) approximately 128 stream miles and 123,590 acres of lakes and reservoirs for shortnose sucker (USFWS 2012a).

The 2013 Revised Recovery Plan (USFWS 2012b) identifies a recovery unit for both shortnose and Lost River within the California portion of the Area of Analysis: the reservoirs along the Klamath River downstream of Keno Dam (including Copco No. 1, Copco No. 1, and Iron Gate reservoirs), known as the Klamath River Management Unit.

When proposing critical habitat, USFWS considers the physical and biological features essential to the conservation of the species which may require special management considerations or protection. 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 designation are as follows: (1) water in sufficient depths and quantity; (2) spawning and rearing habitat; and (3) areas that contain abundant food (USFWS 2012b). The 2013 Revised Recovery Plan (USFWS 2012b) cites predominant threats to these suckers as lack of spawning habitat, continued loss of habitat, lake elevation fluctuations that reduce access to vegetated habitat, water diversions, competition and predation by introduced species, hybridization with other sucker species, isolation of remaining habitats, and drought. Degradation of water quality resulting from timber harvest, dredging activities, removal of riparian vegetation, and livestock grazing may also cause problems for these species (USFWS 2012b).

Green Sturgeon
In 2009, NMFS 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 360 ft) 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 (NMFS 2009b). The Northern DPS of green sturgeon, the only DPS documented to occur in the Klamath Basin, is not federally listed and therefore critical habitat has not been designated for this DPS.

Eulachon
Critical habitat for the Southern DPS eulachon in the Klamath River was designated by NMFS on October 20, 2011 (NMFS 2011). NMFS 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. NMFS did not include any nearshore marine or offshore areas in the Eulachon critical habitat designation. NMFS did not identify any unoccupied areas as being essential to conservation and thus, did not designate any unoccupied areas as critical habitat. Tribal lands were excluded from designation after evaluating the impacts of designation and benefits of exclusion associated with Tribal land ownership and management by the Tribes. NMFS excluded from designation all lands of the Lower Elwha Tribe, Quinault Tribe, Yurok Tribe, and Resighini Rancheria. These lands were excluded because designating these Tribes' Indian lands as critical habitat would have an impact on federal policies promoting Tribal sovereignty and self-governance. In the Lower Klamath River, designated critical habitat extends from the mouth of the Klamath River upstream to Omogar Creek, a distance of 10.7 miles, excluding tribal lands. 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, NMFS designated critical habitat for Southern Resident Killer Whales (NMFS 2006c). Critical habitat includes all waters seaward from a contiguous line delimited by the 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. No critical habitat for Southern Resident Killer Whales occurs within the Area of Analysis for aquatic resources. However, the PCEs for Southern Resident Killer Whales includes: (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.

Within the Area of Analysis, the PDE for “prey species” is relevant. During winter, two of the three pods of Southern Resident Killer Whales (named the K and L Pods) frequent the outer west coast of the United States as far south as California, eating Columbia/Snake River, Central Valley, Puget Sound, Fraser River, and other coastal stocks of Chinook salmon. While Southern Resident Killer Whales have been shown to consume Klamath River Chinook Salmon, the Klamath River is considered by NMFS and WDFW tenth out of the 17 priority Chinook Salmon populations for Southern Resident Killer Whales (NMFS 2018b, NMFS and WDFW 2018).

Essential Fish Habitat (EFH)

EFH is designated for commercially fished species under the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (Magnuson-Stevens Act). The Magnuson-Stevens Act (section 3) defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Adverse effects occur when EFH quality or quantity is reduced by a direct or indirect physical, chemical, or biological alteration of the waters or substrate, or by the loss of (or injury to) benthic organisms, prey species and their habitat, or other ecosystem components. The Magnuson-Stevens Act requires federal fishery management plans, developed by NMFS 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 non-fishing activities. To protect EFH, federal agencies are required to consult with NMFS on activities that may adversely affect EFH.

EFH has been designated for three species of salmon, 83 groundfish species, and five pelagic species in the Area of Analysis for aquatic resources. EFH includes freshwater, estuarine and marine waters for salmon, and marine waters for coastal pelagic and groundfish species. More specific descriptions of EFH are provided below.

Chinook and Coho Salmon

Coho and Chinook salmon are managed under the Magnuson-Stevens Act and EFH is described in Amendment 14 to the Pacific Coast Salmon Fishery Management Plan (PFMC 2012). 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 the Trinity River to Lewiston Dam. 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

EFH for Pacific Coast groundfish includes all waters and substrate within areas with a depth less than or equal to 1,914 fathoms (approximately 3,500 meters) shoreward to the mean higher high-water level or the upstream 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[71] (370 km off coast) and above the thermocline where sea surface temperatures range from 50 to 78.8ºF. 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 River Estuary and coastline would be included as EFH for these species.

3.3.3 Significance Criteria

The Proposed Project could affect aquatic resources directly or indirectly, and through a variety of mechanisms. These effects could be additive or offsetting. In determining the significance criteria, the Lower Klamath Project EIR analysis considers the total effect of the factors described above on native fish populations and their habitat in relation to the Proposed Project. These impacts could vary substantially in intensity, severity, geographic extent, population-level impact, 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

[71] Exclusive economic zone is a sea zone prescribed by the United Nations Convention on the Law of the Sea over which a state has special rights regarding the exploration and use of marine resources.

how much of the species' potential habitat is affected. Population-level impact refers to the proportion of the total population that is expected to be affected. As described above in Section 3.3.2.1 *Aquatic Species [coho salmon]*, Williams et al. (2006) described nine population units of coho salmon in the Klamath Basin to support recovery planning for the listed coho salmon SONCC ESU. Analysis of coho salmon in this EIR considers impacts and benefits for each of the nine population units in the Klamath Basin separately but makes a significance determination for all population units combined within the Klamath Basin to be consistent with the approach to assessing other aquatic species populations, and to be consistent with the NMFS 2014 Southern Oregon/Northern California Coast (SONCC) Recovery Plan, which assesses all of the coho salmon in the Klamath River Basin as part of the same ESU. Duration refers to how long the effect is anticipated to persist (hours, days, months, or years), and considers resiliency of the population to the impact (e.g., resilient populations recovery more quickly to impacts). Criteria for determining significant impacts on aquatic resources are also informed by Appendix G of the CEQA Guidelines (California Code of Regulations title 14, section 15000 et seq.).

The Lower Klamath Project EIR considers short- and long-term effects to aquatic resources. For the Proposed Project aquatic resources impact analysis, short term is defined as less than five years following dam removal (unless otherwise indicated), which includes the periods of reservoir drawdown, dam deconstruction, and early restoration activities. A period of five years was selected as short-term, because for most aquatic resources this represents one to two generations. Long term is defined as more than five years following dam removal (unless otherwise indicated), which in most cases is more than two generations.

In the short term, effects of the Proposed Project would be significant if they:

- Substantially reduce the abundance of a year class for aquatic species, based on a comprehensive analysis that includes numeric analysis where available, qualitative analysis, and other relevant information. Any reduction of 50 percent or greater of a year class is necessarily a substantial reduction.
- Substantially decrease the quality or availability of habitat for a native aquatic species, based on a comprehensive analysis that includes numeric analysis where available, qualitative analysis, and other relevant information. Any reduction in habitat area of 50 percent or greater is necessarily a substantial reduction.
- Substantially decrease the quality of designated PCEs, or availability of designated critical habitat under the ESA, or EFH under the Magnuson-Stevens Act, based on a comprehensive analysis that includes numeric analysis where available, qualitative analysis, and other relevant information. Any reduction in habitat area of 50 percent or greater is necessarily a substantial reduction.

In the long term; five years after removal of all dams, effects of the Proposed Project would be significant if they:

- Substantially reduce the abundance of an adult population or year class for aquatic species in any one generation, based on a comprehensive analysis that includes numeric analysis where available, qualitative analysis, and other relevant information. Any reduction of 50 percent or greater of a year class is necessarily a substantial reduction.
- Substantially decrease the quality or availability of habitat for a native aquatic species, based on a comprehensive analysis that includes numeric analysis where available, qualitative analysis, and other relevant information. Any reduction in habitat of 50 percent or greater is necessarily a substantial reduction.
- Substantially decrease the quality of designated PCEs, or availability of designated critical habitat under the ESA, or EFH under the Magnuson-Stevens Act, based on a comprehensive analysis that includes numeric analysis where available, qualitative analysis, and other relevant information. Any reduction in habitat of 50 percent or greater is necessarily a substantial reduction.

3.3.4 Impact Analysis Approach

This section provides an overview of the methods used in the evaluation of aquatic resources. This section is organized to describe methods used to evaluate effects on physical habitat (e.g., from suspended sediment, bed elevation, water quality, etc.), as well as the methods used to address effects on biological process such as fish disease and parasites. Methods are also described to specifically address aquatic habitat, critical habitat, Essential Fish Habitat (EFH), and communities that respond to environmental impacts unique from fish species such as freshwater mussels and benthic macroinvertebrates.

The following sources were assessed to determine the scope of existing local policies relevant to the Proposed Project:

- Del Norte County General Plan (Mintier & Associates et al. 2003):
  - Section 1 (Natural Resources/Conservation), Policies 1.A.1, 1.A.6, 1.A.14, 1.B.1, 1.C.1, 1.C.2, 1.C.3, 1.C.4, 1.E.2, 1.E.3, 1.E.8, 1.E.9, 1.E.11, 1.E.12, 1.E.28, and 1.E.29
- Humboldt County General Plan for Areas Outside of the Coastal Zone (Humboldt County 2017):
  - Conservation and Open Space Element, Water Resources Element, Policies BR-P4, BR-P11, BR-P12, BR-S2, BR-S4, BR-S6, WR-P5, WR-P23, WR-P39, and WR-P46
- Klamath County Comprehensive Plan (Klamath County 2010):
  - Goal 5 (Open Space, Scenic, and Historic Area and Natural Resources), Policy 16

- Siskiyou County General Plan (Siskiyou County 1980):
  - The Conservation Element (Siskiyou County 1973), Wildlife Habitat, Objectives 1, 5–8
  - The Land Use Element (Siskiyou County 1997), Policy 41.13

Most of the aforementioned policies (and objectives) are stated in generalized terms, consistent with their overall intent to protect aquatic resources, including special-status aquatic species. By focusing on the potential for impacts to specific aquatic resources within the Area of Analysis, consideration of the more general local policies listed above is addressed through the specific, individual analyses presented in Section 3.3.5 *[Aquatic Resources] Potential Impacts and Mitigation*.

The following sources were assessed to determine the scope of existing HCPs relevant to the Proposed Project and potential for overlap with the Primary Area of Analysis for Aquatic Resources: (a) PacifiCorp's Interim Operations Habitat Conservation Plan for the Klamath Hydroelectric Project (PacifiCorp 2012) and (b) Green Diamond Forest Habitat Conservation Plan (Green Diamond Resource Company 2018). These HCPs also provide generalized terms for protection of aquatic resources, including special-status aquatic species. Consideration of the HCPs is inherently addressed by the individual analyses presented in Section 3.3.5 *[Aquatic Resources] Potential Impacts and Mitigation*, which focus on the potential for impacts to specific special-status aquatic species and other aquatic resources defined in Area of Analysis.

3.3.4.1 Suspended Sediment

Suspended sediment can have a multitude of effects on aquatic species, including direct lethal impacts, or sublethal effects on behavior and physiology. The most commonly observed effects of suspended sediment on fish reported in the scientific literature include: (1) avoidance of turbid waters in homing adult anadromous salmonids, (2) avoidance or alarm reactions by juvenile salmonids, (3) displacement of juvenile salmonids, (4) reduced feeding and growth, (5) physiological stress and respiratory impairment, (6) damage to gills, (7) reduced tolerance to disease and toxicants, (8) reduced survival, and (9) direct mortality (Newcombe and Jensen 1996). Information on both concentration and duration of suspended sediment is necessary for understanding the potential severity of its effects on salmonids (Newcombe and MacDonald 1991). Herbert and Merkens (1961) stated that "there is no doubt that many species of fresh-water fish can withstand extremely high concentrations of suspended solids for short periods, but this does not mean that much lower concentrations are harmless to fish which remain in contact with them for a very long time." Effects of suspended sediment on fish may be exacerbated if pollutants or other stressors (e.g., water temperature, disease) are present as well.

As described in Appendix E of this EIR, the potential effects of suspended sediment on anadromous fish species for the Proposed Project were assessed using the SRH-1D model (Huang and Greimann 2010, as summarized in USBR 2012). The SRH-1D model provides an estimate of SSCs at different points on the Klamath River on a daily average estimate. This information is used to assess the impacts of SSCs on fish in dam removal years 1 and 2, based on the concentration and duration of exposure using an approach described by Newcombe and Jensen's (1996). Newcombe and Jensen (1996) reviewed and synthesized 80 published reports of fish responses to suspended sediment in laboratories, streams, and estuaries and established a set of equations to calculate "severity of ill effect" (SEV) indices. A suite of six equations were developed that evaluate the effects of suspended sediment (at various concentrations, durations of exposure, and particle sizes) on various taxonomic groups of fishes and life stages of species within those groups. These effects are compared to those that fish would be expected to encounter under existing conditions, as described in Section 3.6.1 *Summary of Available Hydrology Information for the Proposed Project*.

For each simulation year in the 48-year record, the duration of SSCs at a range of concentrations 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, three scenarios were selected for analysis, with the goal of defining a most likely impacts on fish scenario for the potential impacts to fish, as well as a reasonable range of potential impacts, encompassed by extremes—a "least impacts on fish scenario" and a "worst impacts on fish scenario." These represent the sediment concentrations for the median, the lowest 10 percent, and highest 10 percent of years in the available hydrological record.

- **Most-likely impacts on fish:** This scenario represents the conditions that are most likely to occur for each species and life stage—that is to say SSCs and durations with a 50 percent (median) exceedance probability for the mainstem Klamath River downstream from Iron Gate Dam. This means that there is an equal chance that the SSCs would be higher or lower than described. Exceedance probabilities were based on modeling SSCs for all water years from 1961 to 2009 under the Proposed Project.
- **Least impacts on fish:** This scenario represents the least impacts on fish from potential sediment-related impacts to a species and life stage. It uses suspended sediment concentrations and durations with a 90 percent exceedance probability. This means that under this rare, least-impacts-on-fish scenario the probability of these concentrations and durations being equal to or less than this level for each assessed species and life-stage in

any one year is 10 percent, and the probability of them being exceeded is 90 percent.

- **Worst impacts on fish:** This scenario represents the worst impacts on fish of potential sediment-related impacts to the species and life stage. It uses SSCs and durations with a 10 percent exceedance probability. This means that under this rare, worst-impacts-on-fish scenario the probability of these concentrations and durations being equal to or greater than this level for each assessed species and life-stage in any one year is 10 percent, and the probability of them being less than this level is 90 percent.

The likelihood, however, that conditions under the Proposed Project would track the aforementioned scenarios precisely for each species is slim. It is more likely that different species and different life stages would be exposed to different SSCs and durations within the ranges described. For example, there are relatively few instances in modeled hydrologic record in which the median "most-likely impacts on fish" condition would occur in the same water year for all life-stages of a given species, and even fewer instances in which the median condition would occur in the same water year for all species and all life-stages. For the "least impacts on fish" and "worst impacts on fish" scenarios, the predicted SSCs and durations would be unlikely to occur (10 percent probability) during nearly all water years in the modeled hydrologic record. There are even fewer, and potentially no, instances in which the "least impacts on fish" and "worst impacts on fish" scenarios for SSCs and durations would occur in the same water year for all life-stages of a given species, and no instances in which they would occur in the same water year for all species and all life-stages.

An alternative analytic approach was considered using predicted SSCs and exposure durations associated with a particular water year type. However, it was determined that this approach had too much potential to exaggerate or understate the range of possible impacts, as it did not provide sufficient granularity in terms of the range of possible conditions experienced by particular species and/or life stages.

In assessing impacts, the above scenarios were applied for each species, and for each life stage of that species, taking into account when the species and what percent of the population is likely to be present in the Klamath River mainstem (including avoidance behavior). This EIR analysis describes the range of potential impacts to various life stages of aquatic species including relative mortality rates and sublethal impacts and were evaluated against the relevant significance criteria.

3.3.4.2 Bed Elevation and Grain Size Distribution

As described in Section 3.11 *Geology, Soils, and Mineral Resources* and Appendix F of this EIR, the analysis of potential changes in channel bed elevations and grain size distribution in response to increased bedload supply and transport also relied upon output from the SRH-1D model (Huang and Greimann 2010, USBR 2012). The changes were evaluated for a range of hydrologic conditions for short-term changes (using a 2-year timeframe) and long-term changes (including analysis of 5, 10, 25, 50 years in the future) changes using a range of flows taken from historical hydrology. For bedload dynamics two years following the changes associated with dam removal is considered sufficient for assessing short-term impacts. Long-term simulations were not conducted for the Klamath River upstream of Iron Gate Dam based on observations that the bedload sediment conditions in that reach are relatively stable and persistent, and therefore at the end of 2 years following dam removal would be representative and would persist through time, allowing for mild fluctuations as a function of hydrology rather than project effects (USBR 2012).

The effects determination used analysis of the model results 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 harmful to aquatic resources and were evaluated against the relevant significance criteria.

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 Project, are not within California, and are not evaluated further in this EIR. Link River Dam and Keno Dam would remain in place and would continue to affect hydrology and sediment transport as they do currently.

3.3.4.3 Water Quality

The analysis of potential short-term (0−5 years) and long-term (5 or more years) water quality-related effects on fish under the Proposed Project is based on the water quality impacts analysis (see Section 3.2.5 *[Water Quality] Potential Impacts and Mitigation*) for parameters to which fish are sensitive (e.g., suspended sediment concentrations [SSCs], dissolved oxygen, pH), as well as effects determinations for state and approved tribal designated beneficial uses that are directly related to fish.

This EIR evaluates the potential effects of sediment-associated toxins on fish under the Proposed Project by 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 3.2.4.7 *Inorganic and Organic Contaminants*. Alterations in water quality occurring as a result of dam removal under the Proposed Project that are projected to decrease (or increase) habitat suitability or to result in direct effects on aquatic species are evaluated against the relevant significance criteria.

3.3.4.4 Water Temperature

The EIR uses water temperature output from three quantitative models (see Section 3.2.4.1 *[Impact Analysis Approach] Water Temperature* and Appendix D for details regarding the water temperature models) to evaluate the potential impacts related to changes in water temperature on species within each study reach of the Area of Analysis. Water temperature modeling results were compared to the thermal tolerances of focal species and associated life stages to determine relative suitability for these species under the Proposed Project. Thermal tolerances of focal salmonid species were defined for critical life-history stages using the widely accepted MWMT (Table 3.3-11). Alternative metrics, such as average daily water temperature, were considered to exceed the threshold only when greater than the MWMT, with the understanding that comparisons of differing metrics while not precise, are useful in determining the likelihood of temperature thresholds being met or exceeded. Criteria were selected based on USEPA (2003) guidelines for salmonids, specific to life-history stage.

Table 3.3-11. Salmonid Water Temperature Criteria.

Salmonid Life-history Stage	MWMT (°C)	MWMT (°F)
Adult Migration	20	68
Adult Migration plus Non-Core[1] Juvenile Rearing	18	64.4
Core[2] Juvenile Rearing	16	60.8
Spawning, Egg Incubation, and Fry Emergence	13	55.4

[1] Non-Core is defined as moderate to low density salmon and trout rearing usually occurring in the mid or lower part of the basin ("moderate" and "low" not specially defined).
[2] Core is defined as areas of high-density rearing ("high" is not specifically defined) (USEPA 2003).

Changes in water temperature occurring as a result of dam removal that were predicted to decrease (or increase) habitat suitability or result in direct effects on aquatic species were evaluated against the relevant significance criteria.

3.3.4.5 Fish Disease and Parasites

Fish diseases, specifically *C. shasta* and *P. minibicornis*, have periodically contributed to substantial mortality for Klamath River salmonids (discussed in detail in Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project*). 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 invertebrate host (annelid polychaete worm *Manayunkia speciosa*); therefore, differences in river habitat conditions that are predicted under the Proposed Project are anticipated to affect the abundance of these parasites and their infection rates in Klamath Basin salmonids. 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, including:

- 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 salmon spawning areas
- Water temperatures higher than 59°F

Ich and columnaris may also occasionally have a substantial impact on aquatic resource (e.g., 2002 fish kill, CDFW 2004). Factors that could, if co-occurring, lead to high Ich and columnaris infection rates of fish, including:

- Exceptionally low flows
- Water temperatures higher than 59°F
- High densities of fish (such as adult Chinook salmon migrating upstream in the fall and holding at high densities in pools).

The potential effects of the Proposed Project on fish disease were evaluated based on the predicted effect of dam removal on the environmental factors that drive disease infection rates. The predicted outcome for increased or decreased fish disease and mortality were evaluated against the relevant significance criteria.

3.3.4.6 Aquatic Habitat

To assess the effect of the Proposed Project on available aquatic habitat, changes to habitat area were assessed for each life stage qualitatively, using available data on suitable habitat area upstream of existing barriers predicted to be affected by the alternatives, habitat requirements, and expected changes in instream flows under the alternatives. Qualitative analyses in this EIR rely 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. Changes in aquatic habitat quality and quantity occurring as a result of dam removal were evaluated against the relevant significance criteria.

3.3.4.7 Critical Habitat

NMFS has designated critical habitat for coho salmon, Southern Resident Killer Whales, and eulachon, and USFWS has designated critical habitat for shortnose and Lost River suckers. Within critical habitat, NMFS and USFWS 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 (NMFS 2006c). 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 for aquatic resources and how those changes would affect the PCEs (for those species for which PCEs have been designated) for that critical habitat in the short- and long-term; and were evaluated against the relevant significance criteria for critical habitat.

3.3.4.8 Essential Fish Habitat

The effects of the Proposed Project and 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 for aquatic resources and whether those changes would have short- and long-term negative or beneficial effects on this habitat in terms of its quantity and quality; and were evaluated against the relevant significance criteria for EFH.

3.3.4.9 Freshwater Mollusks

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 mollusks (especially mussels and clams). Therefore, the analysis of impacts associated with the Proposed Project focuses 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 their similar distribution to other freshwater mollusks, similar habitat requirements, their longer life-span, and lack of information regarding the effects of sediment on clams and other mollusks. 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 Project. Changes in habitat quality and quantity predicted for mussels and clams, as well as predictions of potential direct impacts (mortality), were evaluated against the relevant significance criteria.

3.3.4.10 Benthic Macroinvertebrates

Benthic macroinvertebrates (BMI) are the primary food source for most freshwater fish species, and therefore, changes in abundance, distribution, or community structure can affect fish populations (see Section 3.3.2.1 *[Aquatic Species] Benthic Macroinvertebrates*). Suspended sediment and turbidity can cause stress to 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 Project 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 Project 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 Area of Analysis for aquatic resources.

The effects on BMIs were based on water quality determinations (e.g., dissolved oxygen, toxicity) (see Section 3.2 *Water Quality*) and evaluated in the same manner as described for fish and mollusks. Changes in habitat quality and quantity predicted for BMIs, as well as predictions of potential direct impacts (mortality), were evaluated against the relevant significance criteria.

3.3.5 Potential Impacts and Mitigation

The Proposed Project would affect the physical, chemical, and biological components of habitat within portions of the Klamath Basin. These effects would result from changes in suspended sediment, bedload sediment, water quality, water temperature, disease and parasites, habitat availability, 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. Some of the changes would be short-term, and others permanent. This section first describes the Proposed Project’s anticipated effects on these key ecological attributes that could affect aquatic resources. As was the case under the descriptions of key attributes under the Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project*, this section includes, as relevant, specific analysis relevant to specific segments of the Area of Analysis. More detailed technical descriptions of the Proposed Project's projected effects on suspended sediment, bedload sediment, and potential impacts on aquatic species, can be found in Appendices E and F of this EIR. Based on the analysis of effects to key ecological attributes, this section then goes on to discuss specific impacts and evaluate them under the significance criteria, discuss mitigation measures, and determine impact significance.

3.3.5.1 Suspended Sediment

Suspended sediment effects under the Proposed Project are summarized here, and are described in more detail in Potential Impact 3.2-3 *Short-term increases in suspended sediments due to release of sediments currently trapped behind the Lower Klamath Project dams*, and Appendix E. As discussed below, suspended sediment analysis interprets model output from USBR (2012) with modifications in light of proposed changes to the drawdown rate that would increase the peak sediment concentrations and decrease the duration of such elevated concentrations.

Hydroelectric Reach

Sediment transport modeling of the impacts of dam removal indicate high short-term SSCs in the Hydroelectric Reach under the Proposed Project (USBR 2012, 2016). Modeled SSCs downstream of J.C. Boyle Reservoir would be high (>1,000 mg/L) in the short term, but concentrations would be considerably less than those anticipated to occur downstream from Copco No. 1 and Iron Gate reservoirs due to the relatively small volume of the sediment deposits behind J.C. Boyle Dam (eight percent of total volume for the Lower Klamath Project). The suspended sediments released from J.C. Boyle would quickly move into the California portion of the Hydroelectric Reach. Elevated suspended sediments in the Hydroelectric Reach during reservoir drawdown would be a significant and unavoidable impact (see Potential Impact 3.2-3). Predicted SSCs decrease to less than 100 mg/L within five to seven months following drawdown, and concentrations further decrease to less than 10 mg/L within six to 10 months following drawdown of J.C. Boyle Reservoir.

Modeling of sediment concentrations downstream of Copco No. 1 Reservoir during drawdown also indicates short-term sediment concentrations would be high (>5,000 mg/L) in the California portion of the Hydroelectric Reach due to dam removal. Predicted spikes in SSC after one to two months of reservoir drawdown correspond to increases in Klamath River flow through the Hydroelectric Reach due to spring storm events, and within six to 10 months following drawdown would decrease to levels that exist under existing conditions (e.g., <100 mg/L).

Middle and Lower Klamath River

Under the Proposed Project, full removal of the Lower Klamath Project reservoirs would result in the release of 5.3 to 8.6 million cubic yards (1.2 to 2.3 million tons) of sediment stored in the reservoirs into the Klamath River downstream from Iron Gate Dam (USBR 2012), resulting in higher SSCs than would normally occur under existing conditions. Reservoir drawdown (lowering of reservoir water surface elevation) is expected to commence in dam removal year 1, and to be completed in dam removal year 2 (Section 2.7.2 *Reservoir Drawdown*). Based on the suspended sediment modeling (USBR 2012), SSCs are expected to exceed 1,000 mg/L directly downstream of Iron Gate Dam for around two to three continuous months, with the potential for peak concentrations exceeding 5,000 mg/L for hours or days, depending on hydrologic conditions during dam removal. Model results indicate SSC would be highest during the period of greatest reservoir drawdown (January through mid-March of dam removal year 2), as erodible material behind the dams is mobilized downstream (see Potential Impact 3.2-3). During normal to dry water years, modeled SSCs would begin to decline in late March of dam removal year 2 and would continue declining through early summer of dam removal year 2 (USBR 2012). If it is a wet year, it may take longer to drain the reservoirs and high (>250 mg/L) concentrations may extend until June. Differences between the modeled conditions and the Proposed Project would be expected to increase the magnitude of peak SSCs but decrease the duration of elevated SSCs compared to modeled SSCs (see Potential Impact 3.2-3). The Proposed Project incorporates a higher maximum drawdown rate (i.e., 5 feet per day compared to 3 feet per day) and sediment jetting during drawdown that would transport more erodible material, so less erodible material would be available to be transported after drawdown concludes and SSCs potentially would decline more rapidly after drawdown. However, modeled SSCs are used as a conservative estimate of the duration of elevated SSCs. The SSCs would be near background conditions for all water year types within the first year following removal. Tributaries between the Hydroelectric Reach and the estuary contribute a significant amount of both water and suspended sediments to the Klamath River mainstem (USBR 2012). This causes the influence of Lower Klamath Project reservoir sediment releases to decline in the downstream direction. At Iron Gate Dam (Figure 3.2-11 through 3.2-13), where SSCs are artificially low under existing conditions (because of sediment trapping by the dam) SSCs would remain elevated above existing conditions throughout the first 2 years, and in the long term would decrease (as reservoir deposited sediments evacuated) to return to levels slightly higher than the current levels as sediment naturally transports downstream. At Orleans, where SSCs under existing conditions are higher because of inputs of tributaries, under a most-likely impact on fish scenario, the effects of the Proposed Project would be similar to existing conditions by late April when SSCs from the Proposed Project are predicted to decrease. Under a worst impacts on fish scenario SSCs are projected to remain somewhat elevated above existing conditions until October during the year of dam removal. By Klamath Station (downstream of confluence with Trinity River) SSCs under existing conditions are higher than at the upstream sites as a result of sediment input from tributaries. As a result, SSCs from the Proposed Project and those under existing conditions would be similar under all scenarios by late spring of the year of dam removal.

Klamath River Estuary

As a result of the influence of Lower Klamath Project reservoir sediment releases declining in a downstream direction, the difference between SSCs from the Proposed Project and those under existing conditions would be relatively minor in the Klamath River Estuary (USBR 2012). The SSCs and durations under the most-likely impacts on fish scenario would be similar to those that occur under existing extreme conditions (10 percent exceedance) and resemble those that would be expected to occur about one in 10 years on average under existing conditions. Under the worst impacts on fish simulation, SSCs and durations would be slightly higher (around 10 percent) than those for the existing extreme conditions during the winter of dam removal.

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 mainstem river SSCs is expected to occur in the nearshore under the Proposed Project. Based on data from 110 coastal watersheds in California, where nearshore SSCs were measured at greater than 100 mg/L during the El Niño winter of 1998 (Mertes and Warrick 2001), peak SSCs leaving the Klamath River Estuary from upstream sources including the Proposed Project may be diluted by 1 to 2 orders of magnitude; for example from greater than 1,000 mg/L to greater than 10–100 mg/L. Therefore, 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 Potential Impact 3.2-3, during several large flood events on the geographically proximal Eel River in the winter of 1997 and 1998, Geyer et al. (2000) found that: 1) flood conditions were usually accompanied by strong winds from the southern quadrant; 2) the structure of the river plume was strongly influenced by the wind-forcing conditions; and 3) during periods of strong southerly (i.e., downwelling favorable) winds, the plume was confined inside the 164-ft isobath (i.e., sea floor contour at around 164-ft below the water surface), within about 4 miles of shore. Based upon Eel River plume studies and current knowledge of northern California oceanographic patterns, the fine sediment discharged to the Pacific Ocean nearshore environment under the Proposed Project 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 would 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 farther offshore and spread more widely, including within some or all of the Klamath River Management Zone. 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), the effects are likely to be within the range of concentrations and duration 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, De Robertis 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 Pacific Ocean nearshore environment bottom substrates, any SSCs elevations associated with the Proposed Project are not anticipated to have effects on species distinguishable from existing conditions.

3.3.5.2 Bed Elevation and Grain Size Distribution

The potential effects of increased bedload supply and transport on channel bed elevations and grain size under the Proposed Project are described in Appendix F and summarized in Potential Impact 3.11-5. As a result of the Proposed Project, the bedload transport processes that salmon evolved with and depend upon to provide substrate suitable for spawning and early rearing in streams and rivers (that are currently interrupted by the Lower Klamath Project dams) would be restored to a more natural condition.

3.3.5.3 Water Quality

Upper Klamath River and Connected Waterbodies

Dam removal activities under the Proposed Project 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.

However, existing water quality problems have the potential to negatively impact anadromous salmonids' ability to access waters upstream of the Hydroelectric Reach under the Proposed Project. 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 NMFS and USFWS to prescribe interim trap-and-haul measures in their Section 18 Prescriptions for the Klamath Hydroelectric Project (DOI 2006) to transport primarily adult fall-run Chinook salmon past Keno Impoundment/Lake Ewauna during periods when conditions would be harmful to salmonids. This would entail seasonal, upstream trap and haul for primarily fall-run adult Chinook salmon around the Keno Impoundment/Lake Ewauna when dissolved oxygen and water temperatures 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. In the downstream Keno Impoundment/Lake Ewauna, dissolved oxygen reaches very low levels (less than 1 to 2 mg/L) during July through October of most years as algae transported from Upper Klamath Lake settle out of the water and decay (see Figure 3.4-9 in Appendix C.4.1.1). During most years, the Keno Impoundment/Lake Ewauna reach of the Klamath River (Link River Dam to Keno Dam) maintains dissolved oxygen concentrations greater than 6 mg/L from mid-November through mid-June (Appendix C.4.1.1). These dissolved oxygen concentrations 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 Section 3.2.2.5 *Dissolved Oxygen*). Under KHSA Section 7.5.1, the Secretary of the Interior shall initiate a study to evaluate disposition of Keno Dam, including fish passage. Eventual attainment of the Oregon (ODEQ 2002, 2010) and California (USEPA 2008) TMDLs for dissolved oxygen (and other water quality parameters that would improve dissolved oxygen [i.e., pH, chlorophyll-*a*]) would improve water quality in the Keno Impoundment/Lake Ewauna and potentially eliminate water quality as a potential limitation to fall-run Chinook salmon migration, and therefore the need for trap and haul activities around these waterbodies. However, full TMDL compliance does not reflect the existing condition and it would be speculative at this point to identify either the mechanisms necessary to implement the TMDLs or the timing required to achieve full compliance.

<u>Upper Klamath River – Hydroelectric Reach</u>

As described in Potential Impact 3.2-9, dam removal would result in short-term increases in oxygen demand and corresponding reductions in dissolved oxygen within the Hydroelectric Reach, with anoxia (0 mg/L) possible during reservoir drawdown periods when suspended sediment concentrations are at their peak (January to March of dam removal year 2). This would be a significant and unavoidable impact. In the long term, the Proposed Project would result in somewhat reduced daily fluctuations in dissolved oxygen in the Peaking Reach from the Oregon-California state line to Copco No. 1 Reservoir, which may be due to elimination of hydropower peaking operations (Potential Impact 3.2-10). Dissolved oxygen in the free-flowing river reaches replacing the reservoirs would no longer experience the extreme conditions of super-saturation (i.e., greater than 100 percent saturation) in surface waters and hypolimnetic oxygen depletion in bottom waters of Copco No. 1 and Iron Gate reservoirs during the April/May through October/November period, which would be generally beneficial.

Under the Proposed Project, pH in the Hydroelectric Reach would no longer experience high levels (pH greater than 9) during seasonal algal blooms in the surface waters of Copco No. 1 and Iron Gate reservoirs (Potential Impact 3.2-11). pH in the free-flowing reaches of the river replacing the reservoirs would not exhibit such high levels, instead possessing a more typical riverine signal. While daily fluctuations in pH could occur due to periphyton growth in the river reaches previously occupied by Lower Klamath Project reservoirs, the increases are expected to consistently meet water quality objectives to support beneficial uses and would therefore be beneficial.

Middle and Lower Klamath River

Sediment release associated with dam removal under the Proposed Project would cause short-term increases in oxygen demand and corresponding reductions in dissolved oxygen (Potential Impact 3.2-9) in the Middle Klamath River. During reservoir drawdown periods when suspended sediment concentrations are at their peak (January to March of dam removal year 2), dissolved oxygen concentrations would drop to very low levels (potentially 0 mg/L) immediately downstream from Iron Gate Dam and, depending on background conditions at the time of reservoir drawdown, would remain below 5 mg/L until approximately the confluence with the Shasta River (RM 179.5), or as far downstream as RM 121.7 (approximately 10 miles downstream of Seiad Valley [RM 132]). Recovery to the North Coast Basin Plan water quality objective of 90 percent saturation (i.e., 10–11 mg/L) is anticipated to occur in the reach from Seiad Valley to the mainstem confluence with Salmon River (RM 66), and would therefore not affect dissolved oxygen in the Lower Klamath River, the Klamath River Estuary or the Pacific Ocean nearshore environment.

Removal of the Lower Klamath Project dams under the Proposed Project and conversion of the reservoir reaches to a free-flowing river would result in long-term seasonal (July through November) increases in dissolved oxygen for the reach immediately downstream from Iron Gate Dam (Potential Impact 3.2-10), which would be beneficial relative to existing conditions. Increased diel (i.e., 24-hour period) variability in dissolved oxygen would also occur in the reach immediately downstream of Iron Gate Dam to approximately Seiad Valley (RM 132.7), with modeled concentrations consistently in compliance with the Basin Plan water quality objective of 85 percent saturation. Long-term effects of dam removal on dissolved oxygen would diminish with distance downstream from Iron Gate Dam, with similar or the same predicted dissolved oxygen concentrations and similar magnitude and duration of diel fluctuations by Seiad Valley (RM 132.7) and no differences by the confluence with the Trinity River (RM 43.3).

Under the Proposed Project, pH in the Middle Klamath River downstream from Iron Gate Dam (particularly upstream of the Shasta River confluence [RM 179.5]) during late-summer and early-fall months (August–September) would experience generally high pH (8 to slightly greater than 9 s.u.) and large daily variations in pH during periods of high photosynthesis (Potential Impact 3.2-11). The magnitude of photosynthesis and community respiration from periphyton growth in the Middle Klamath River under the Proposed Project is not entirely certain, but differences in pH between the Klamath TMDL model “TMDL dams-in” (T4BSRN) and “TMDL dams-out” (TOD2RN) scenarios decrease in magnitude with distance downstream from Iron Gate Dam, and are considerably dampened by the Scott River confluence (RM 145.1).

3.3.5.4 Water Temperature

Upper Klamath River – Hydroelectric Reach

Under the Proposed Project, the Hydroelectric Reach would no longer be dominated by hydropower peaking events and flows would more closely mimic the natural hydrograph. Elimination of peaking operations at J.C. Boyle Powerhouse would result in water temperatures in the J.C. Boyle Peaking Reach at the Oregon-California state line (RM 214.1) that exhibit slightly lower daily maximum values (0.0–3.6°F) and lower diel (i.e., 24-hour period) water temperature variation during June through September as compared to a "dams-in" condition, with temperatures moving toward the natural thermal regime (see also Potential Impact 3.2-1).

In the absence of the Lower Klamath Project reservoirs, hydraulic residence time (summarized in Table 3.6-4) in this reach would likely decrease to less than a day, and water temperature suitability for native aquatic species would be improved (Hamilton et al. 2011). Removal of the Lower Klamath Project reservoirs would 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, potentially resulting in a gain in flow to the Klamath River of up to approximately 6,200 acre-feet/year (USBR 2011). Whether this increase would contribute to increased instream flows or be used upstream to supplement irrigation deliveries is uncertain, so this EIR discloses the potential increase but does not rely on it for conclusions (see also Section 3.8.4 *[Water Supply/Water Rights] Impacts Analysis Approach*). 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 (Hamilton et al. 2011), conducive to the growth of salmonids. To assess whether hot springs near the Shovel Creek confluence with the Klamath River heat the water to an extent that it would be necessary to assess impacts to fisheries, water temperatures were recorded in Shovel Creek on November 1, 2017, and were 3.3°F cooler than in the mainstem Klamath River (46°F in Shovel Creek), and 0.6°F cooler on December 5, 2017 (39.9°F in Shovel Creek) (KRRC 2018). On the same dates, water temperature data was collected both upstream and downstream of the Klamath Hot Springs, located in the Klamath River downstream of the confluence with Shovel Creek. Water temperatures on November 1, 2017 were 1.4°F warmer downstream of the hot springs, and 0.2°F cooler on December 5, 2017; no evidence of appreciable warming as a result of the hot springs was observed on these dates (KRRC 2018).

Temperature conditions would also improve farther downstream in the Hydroelectric Reach. From Copco No. 1 Reservoir to Iron Gate Reservoir, removal of the Lower Klamath Project reservoirs would result in a decrease in water temperatures during the summer and fall (discussed in detail in Potential Impact 3.2-1). The effects of changes in temperature regimes within this reach would be similar to those discussed in detail below for the Middle and Lower Klamath River.

Removing the Lower Klamath Project dams would allow access to tributaries upstream of Iron Gate Dam that could provide additional 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 (Cunanan 2009) would improve water quality by restoring the nutrient cycling and aeration processes provided by a natural channel. These improvements resulting from implementing the Proposed Project would help to offset the anticipated late summer/fall stream water temperature increases resulting from climate change (see Potential Impact 3.2-1).

Middle and Lower Klamath River

The thermal lag caused by water storage in Lower Klamath Project reservoirs and the associated increased thermal mass would be eliminated in the Lower Klamath River under the Proposed Project (see Potential Impact 3.2-1). 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).

Fall-run Chinook salmon in the Klamath River are observed to primarily spawn in mid-October through early November when water temperatures are generally below 59°F (15°C) (Bartholow and Henriksen 2006). Therefore, under the Proposed Project cooler water temperatures during fall are anticipated to result in a shift in the median date of spawning from mid-October to mid-September (Figure 3.3-4). The shift in earlier spawning is predicted to result in a more rapid, and earlier date of emergence (Figure 3.3-4, FERC 2007). Under the Proposed Project, cooler water temperatures during fall and warmer springtime temperatures would result in fry emerging earlier (Sykes et al. 2009), encountering favorable temperatures for growth sooner than under existing conditions (Figure 3.3-4), which could support higher growth rates and encourage earlier outmigration downstream similar to what likely occurred under historical conditions, and 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 (as reviewed by Hoar 1988). In addition, fall-run Chinook salmon spawning in the mainstem during fall would have less of a risk of d delayed spawning related to water temperature (Bartholow and Henriksen 2006, FERC 2007), potentially reducing pre-spawn mortality in at least some years, and adult migration would occur in more favorable water temperatures than under existing conditions (Figure 3.3-5). 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 3.3-5) 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 Project 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 3.3-5).

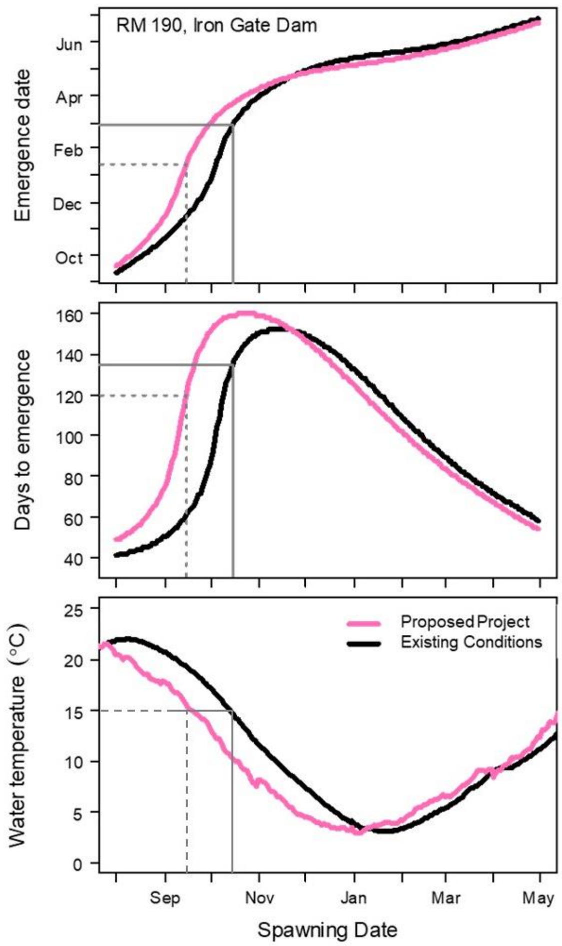

Figure 3.3-4. Modeled time Series of Average Daily Mean Water Temperature (lower panel) Predicted at Iron Gate Dam (RM 193.1) Under the Proposed Project and Existing Conditions. In the lower panel median date of spawning at 15ºC is shown for existing conditions (solid gray line) and Proposed Project (dashed gray line). 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 (accumulated heat related to development) after spawning. In the middle panel days to emergence is shown for existing conditions (solid gray line indicates timing based on existing conditions) and Proposed Project (dashed gray line indicates timing based on Proposed Project). In the upper panel median emergence date is shown for existing conditions (solid gray line indicates timing based on existing conditions) and Proposed Project (dashed gray line indicates timing based on Proposed Project). Source: Water temperature modeling based on Perry et al. (2011); emergence timing based on unpublished analysis conducted by R. Perry, USGS, June 2012. Provided in pers. comm. from Mark Hampton, CDFW, June 2012.

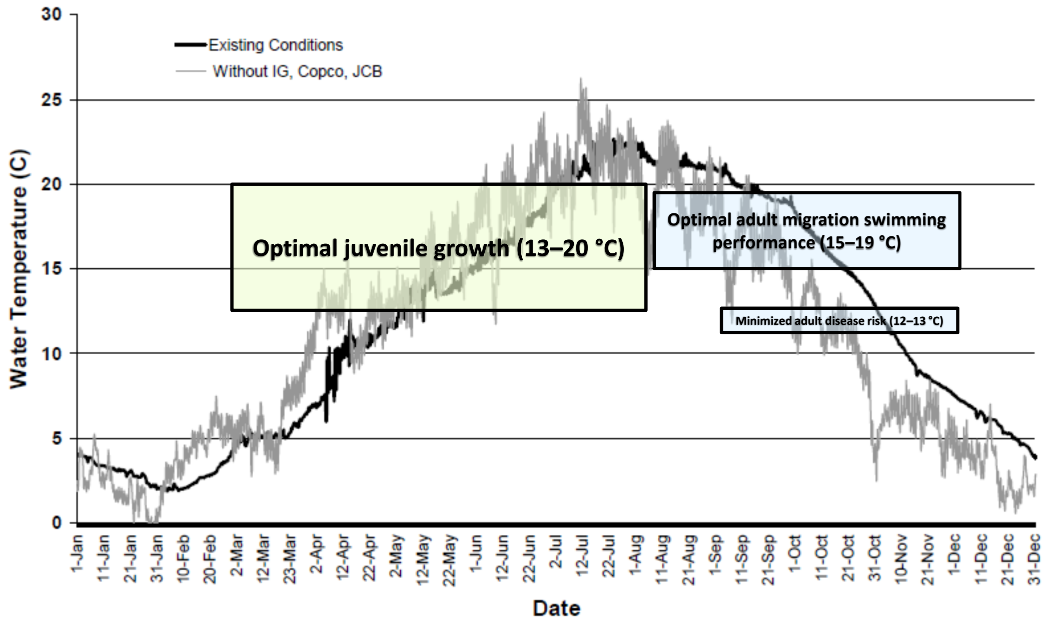

Figure 3.3-5. PacifiCorp (2005) simulated Hourly Water Temperatures Below Iron Gate Dam Based on a Dry Water Year (WY 2002) for Existing Conditions Compared to the Proposed Project (without Lower Klamath Project dams), and USEPA (2003) Water Temperature Criteria for Salmonid Growth and Migration. Note that simulated water temperatures are presented as hourly data, whereas USEPA criteria are expressed as mean weekly maximum temperature (MWMT).

However, the FERC EIS (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 apparent 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 Project. 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 Project would be beneficial for fish (Figure 3.3-5). 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 Project 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 Lower Klamath Project reservoirs (as discussed in Hamilton et al. 2011) show that the temperature difference with and without dams would be greatest directly downstream from Iron Gate Dam but could extend an additional 120 to 130 river miles downstream. Estimated decreases in stream temperature with dam removal relative to existing conditions are likely to be smaller with continued climate change; however, temperature conditions for aquatic resources would be much improved under the Proposed Project as compared to existing conditions (see Potential Impact 3.2-1).

Klamath River Estuary and Pacific Ocean Nearshore Environment
The influence of the Proposed Project on water temperature would likely decrease with distance downstream from Iron Gate Dam, and it is unlikely that dam removal under the Proposed Project would have detectable effects on water temperatures in the Klamath River Estuary and Pacific Ocean nearshore environment (see Potential Impact 3.2-1).

3.3.5.5 Fish Disease and Parasites

The Proposed Project would be expected to reduce impacts on salmon from fish disease. As discussed in detail in Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project*, currently the greatest disease-related mortality is for juvenile salmonids due to *C. shasta* and *P. minibicornis* in the Middle Klamath River downstream from Iron Gate Dam. Among all of the salmon life stages, 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 juvenile salmonid infection by *C. shasta* and *P. minibicornis* include availability of habitat (pools, eddies, and sediment) for the polychaete worm intermediate host *(Manayunkia speciosa)*; microhabitat characteristics (static flows and low velocities); congregations of spawned adult salmon with high spore counts; polychaete proximity to spawning areas; planktonic food sources for polychaete from Lower Klamath Project reservoirs; and water temperatures greater than 59°F (Bartholomew and Foott 2010). For adult salmon, Ich and columnaris have occasionally resulted in substantial mortality, 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). This section addresses changes to these disease factors anticipated under the Proposed Project and predicted affects for juvenile and adult salmonid life stages.

Under current conditions (2000 through 2018) adult salmon carcasses in the 5.6 mile (9.0 km) reach downstream of Iron Gate Dam to the Shasta River average 5,127 carcasses per year, with an estimated average density of 916 carcasses per mile (570 carcasses per km) (S. Gough, USFWS, pers. comm., June 2019). Within the area directly downstream of Iron Gate Dam (within 0.3 mi [0.5 km]), carcass estimates have averaged 396 (ranging from a low of 17 to a high of 1,592); corresponding to a density averaging 1,321 carcasses per mile [3,183 carcasses per km], and ranging from 57 carcasses per mile (99 carcasses per km) to 5,307 carcasses per mile (3,184 carcasses per km) (S. Gough, USFWS, pers. comm., June 2019).

Removal of Iron Gate Dam and the three upstream facilities would reduce the concentration of adult salmon and carcasses that presently occurs downstream of Iron Gate Dam to the Shasta River. Greater dispersal of spawning adult salmon would reduce their proximity to existing dense populations of polychaetes. FERC's analysis (FERC 2007) concluded that restoring access to reaches upstream of 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. As discussed in detail in Section 3.3.5.9 Potential Impact 3.3-7, under the Proposed Project, estimated Chinook salmon abundance upstream of Iron Gate Dam to Keno Dam is predicted to increase by a median of 10,000 Chinook salmon (Hendrix 2011) within an estimated 80 miles of suitable spawning habitat within tributaries and the mainstem (DOI 2007, Cunanan 2009). Although Chinook salmon spawning is not expected to be evenly distributed, this could result in carcass density upstream of Iron Gate Dam of around 125 carcasses per mile (78 carcasses per km). Even if spawning is unevenly distributed, a much lower carcass density than currently observed downstream of Iron Gate Dam is anticipated owing to access to substantial amounts of additional habitat.

Under the Proposed Project juvenile salmon spawned and reared upstream of Iron Gate Dam would be exposed to actinospores within the mainstem Klamath River for a longer period than salmon spawned and reared downstream, since the migration distance to the Klamath River Estuary is greater. For example, juvenile salmonids produced from Spencer Creek (RM 232.6) would migrate 40 miles further within the mainstem Klamath River than juveniles produced from Bogus Creek (192.6). Assuming the median migration rate of 18.4 miles/day reported for radio tagged Chinook salmon smolts, these fish would be exposed to actinospores for just over two days longer than fish produced from downstream of Iron Gate Dam. Infection rate is partly a function of exposure duration (True et al. 2013), and thus this specific risk factor (duration of exposure) may be higher for fish produced upstream of Iron Gate Dam than juveniles produced downstream with a shorter duration of exposure. However, many other factors affect also influence disease risk, as discussed below.

Under the Proposed Project, sediment bedload transport rates would increase downstream from the current location of Iron Gate Dam which currently includes habitats with large populations of polychaetes. Under existing conditions, 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 132.7) (Bartholomew and Foott 2010). In addition, while the area of significant sediment deposition under the Proposed Project is located upstream of Cottonwood Creek, sediment transport rates would 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, resulting in reduced actinospore releases.

Warm water temperatures increase risk of disease transmission. 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 effects on water quality and habitat 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. Based on existing data it appears that a reduction in temperature during late summer and fall would have the effect of reducing disease rates (Bartholomew and Foott 2010). Reduced disease in the mainstem is anticipated to benefit outmigrating smolts that are currently exposed at high rates in disease hotspots.

FERC (2007) concluded that more rapid cooling of river temperatures in the fall with the Lower Klamath 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 suggest that earlier warming of the river system could trigger juvenile salmonids to out migrate earlier. This is consistent with findings that the cumulative exposure of temperature is more important predictors of migration of juvenile Chinook salmon than flow or length-of-day (Sykes et al. 2009). As previously described, increased water temperatures in the spring would likely result in earlier emergence and growth and encourage earlier migration downstream. 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 migration downstream and improved growth would likely mean most outmigrants would avoid periods of high disease infection of juvenile salmon (Bartholow et al. 2005).

Flows also play an important role in the regulation of disease in the Klamath River. Elimination of Lower Klamath Project reservoirs under the Proposed Project would not result in major flow alterations as flows in the Klamath River are regulated through mandatory federal conditions imposed on the Klamath

Irrigation Project located upstream of J.C. Boyle. However, elimination of the Lower Klamath Project would create more flow variability downstream of Iron Gate Dam due to peak flows from storm events no longer being retained in Lower Klamath Project reservoirs. While there would be a loss of flow variability in the portion of the Lower Klamath River downstream of J.C. Boyle Dam due to cessation of peaking operations, flows would continue to be controlled by Keno Dam and the 2019 BiOp (described below), and they would be within the range of historical conditions. As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, 2017 court-ordered flushing and emergency dilution flows were required downstream of Iron Gate Dam in 2017 and 2018, with the intent of reducing disease in the Middle and Lower Klamath River by mobilizing bedload sediments to disrupt the periphyton intermediate host. The court-ordered flows are not modeled as part of existing conditions hydrology under the Proposed Project. As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, the 2017 court-ordered flows included a requirement to ensure that certain high flows are reached each winter, and they also included an emergency dilution requirement if juvenile fish disease reached high levels in the infection nidus. The emergency dilution flows were used in 2018. In March 2019, the court-required re-initiation of USBR consultation with NMFS and USFWS was completed and new biological opinions (BiOps) were issued by NMFS (2019) and USFWS (2019a). The 2019 BiOp flow requirements include annual surface flushing flows of at least 6,030 cubic feet per second (cfs) for 72 hours at Iron Gate Dam between March 1 and April 15, and the potential for dilution flows and/or enhanced spring flows should water be available and disease conditions support their use. Dilution flows also occurred in June 2019 under the new BiOp flow requirements. While there has not been sufficient time to collect data characterizing the efficacy of the flushing flows since they were initiated in 2017, the necessity to use dilution flows in 2018 and 2019 suggests that flushing flows are insufficient on their own to resolve the issue of fish disease downstream of Iron Gate Dam. Because polychaete populations are located outside of the main flow along the margins of the river (Bartholomew and Foott 2010), variable flows disrupt this habitat. Therefore, removal of the Lower Klamath Project dams would disrupt microhabitat conditions and is expected to reduce polychaete populations (Stocking and Bartholomew 2007, Bartholomew and Foott 2010) and presumably, reduce infection rates within polychaete populations both in the short and long term (Hetrick et al. 2009).

Periphyton (attached algae) provides habitat for the intermediate host of *C. shasta* and *P. minibicornis*, and thus its abundance and distribution under the Proposed Project would also affect disease in the Klamath River. Some of the Proposed Project’s anticipated effects would tend to support increased attached algal growth (i.e., periphyton growth), while others would tend to reduce it compared with existing conditions. Under the Proposed Project, additional periphytic growth including *Cladophora* is anticipated within the Hydroelectric Reach in the long term (see Potential Impact 3.4-5). This is because while the existing reservoirs foster growth of phytoplankton algae, in a riverine system, phytoplankton's ecological advantage is reduced, and attached aquatic vegetation including periphyton would tend to increase. In the absence of other factors, this could possibly increase the prevalence of the intermediate host for *C. shasta* and *P. minibicornis*. However, dam removal would also create other conditions that tend to offset the growth of aquatic vegetation including periphyton. These conditions include a restoration of bedload sediment transport, increased flow variability, and a more normal (and variable), riverine temperature regime with substantially cooler fall water temperatures. FERC (2007) concluded that restoring natural sediment transport processes would likely contribute to the scour of periphyton 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 Section 3.4.5.2 *Periphyton*).

The current infectious nidus (reach with high infectivity) for *C. shasta* and *P. minibicornis* is located in the Klamath River downstream of Iron Gate Dam, where returning adult spawners congregate. Removal of the Lower Klamath Project dams would allow anadromous salmonids to move upstream in the mainstem Klamath River and tributaries upstream of Iron Gate Dam. With Iron Gate Dam blocking upstream fish passage and trapping sediment, 2017 court-ordered flushing flows were released from this dam in 2017 and 2018 for the purpose of disrupting the nidus downstream of this dam and reducing disease risk. The 2019 BiOp Flows, which are the current operational flow requirement for the Klamath River, also include flushing flows. As described above, the change in flow regime has not, in isolation, been successful in avoiding high disease concentrations, as evidenced by dilution flows that were used subsequent to the flushing flows in both 2018 (under the 2017 court order) and 2019 (under the new 2019 BiOp flow requirements). Under the Proposed Project, it is anticipated that the nidus would no longer form downstream of Iron Gate Dam, and the risk of a new nidus forming upstream is low, in the absence of the flushing flow requirements for the reasons described above. Because the flushing flow requirements ensure a minimum level of bedload-sediment movement in winter to disrupt the disease cycle, the likelihood of reduction in disease risk would be enhanced by including the additional flow releases.

Although the conditions leading to the nidus forming downstream of Iron Gate Dam would be ameliorated, some disease factors would continue under the Proposed Project, including eight years of additional Iron Gate Hatchery operations that would potentially result in continued (through post-dam removal year 10) congregations of mostly adult fall-run Chinook salmon in the reach from Iron Gate Dam downstream to Seiad Valley (Section 3.3.5.6 *Fish Hatcheries*). Under the Proposed Project, if a nidus were to remain in the vicinity of Iron Gate Hatchery, or theoretically were to form within newly accessible upstream habitat (however unlikely), flushing and emergency dilution flow releases (as previously required by the 2017 court order) and flushing flows and the potential for dilution flows and/or enhanced spring flows (as currently required by the 2019 BiOp Flows) may be required from a new upstream location to achieve the same ecological benefits (i.e., disruption of nidus).

In the reach from Keno Dam to Iron Gate Dam, under the Proposed Project both the 2017 court-ordered flushing flows and the 2019 BiOp Flows would ensure a minimum level of bedload-sediment movement to disrupt polychaete habitat and thus the disease cycle. Both flow regimes require flushing flows of 6,030 cfs for 72 hours, as measured at Iron Gate Dam. Based on accretion flows in the Upper Klamath River (Section 3.6.2.2 *Basin Hydrology*), this equates to approximately 4,500 to 5,000 cfs released at Keno Dam to achieve the flow requirement at Iron Gate Dam. Although detailed scour analysis has not been conducted in this reach, based on the work of Shea et al. (2016) for the reach downstream of Iron Gate Dam, and the particle sizes, channel geometry and channel slope in the reach (Section 3.11.2.2 *Geomporphology*), flows of 4,500 to 5,000 cfs are anticipated to mobilize surface substrate sufficiently to disrupt polychaete habitat downstream of Keno Dam, and especially downstream of J.C. Boyle Dam (due to increased accretion in that reach).

Based on available information, it is unlikely that a new infectious nidus would be re-created upstream. The current infectious zone and high parasite loads below Iron Gate Dam are the result of a synergistic effect of numerous factors that occur within the current disease zone in the Klamath River from the reach from Shasta River downstream to Seiad Valley (FERC 2007, Hamilton et al. 2011, Bartholomew and Foott 2010). These factors include: (1) close proximity of myxospore-shedding carcasses (concentration of carcasses); (2) abundant polychaete populations that are found in stable habitats; (3) suitable water temperatures (greater than 59°F) 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 (Hamilton et al. 2011). The likelihood of those synergistic factors developing upstream of Iron Gate Dam would be reduced as carcasses would likely be more dispersed in the watershed than occurs in the restricted habitat downstream of Iron Gate Dam (Foott et al. 2012). Iron Gate Dam is both the limit of anadromy, and the site of the current fish hatchery that accounts for a substantial proportion of all adult returning fish annually. As discussed under Section 3.3.5.3 *Water Quality*, the Keno Impoundment/Lake Ewuana has the potential to be a habitat barrier during most years for fall-run Chinook due to poor water quality during the late summer, and therefore NMFS and USFWS prescribed fish passage measures for the Keno Impoundment/Lake Ewuana for the Klamath Hydroelectric Project relicensing to be used during periods of poor water quality (DOI 2007, NMFS 2007b). If fish passage were not provided at Keno Impoundment/Lake Ewuana, upstream migrating adults would presumably locate spawning habitat downstream of the impoundment. Although few adult fall-run Chinook salmon would have a natal cue to migrate past this location, congregations of fall-run Chinook salmon could occur downstream of Keno Impoundment during some periods. If these congregations become large this would increase the risk of nidus forming at that location. In comparison, downstream of Iron Gate Dam thousands of adults have a natal cue to return to the hatchery, and congregations regularly occur during the fall. The conditions that result in a nidus forming downstream of Iron Gate Dam are less likely to occur under the Proposed Project, either downstream or upstream of Iron Gate Dam.

Historically, it appears spawning concentrations of Upper Klamath Basin Chinook salmon were located primarily in the Sprague River (Lane and Lane Associates 1981). Spring-run Chinook salmon, and fall-run Chinook salmon (if water quality conditions improved in the Keno Impoundment/Lake Ewuana, or if fish passage were provided) could spawn in the Sprague River again under the Proposed Project, increasing the risk of a nidus forming there. However, there is no information indicating that high densities of polychaetes occur in the Sprague River (Foott et al. 2012). 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 at this location under the Proposed Project either.

There is some concern regarding a disease zone in the lower Williamson River downstream from the confluence with the Sprague River, where there are currently high parasite densities observed (Hurst et al. 2012). However, there are no fish passage obstacles, holding pools, or other unique environmental factors anticipated to result in large congregations of adult migrants at this location (M. Hereford, ODFW, pers. comm., May 2019). In addition, maximum temperatures in the Williamson River do not exceed the disease threshold of 59°F in all years (Bartholomew and Foott 2010, Hamilton et al. 2011). Overall, the risk of a juvenile salmon disease response in the Williamson River would be lower than existing conditions in the Middle Klamath River, but not negligible in all water years (S. Foott, USFWS, pers. comm., 2012).

Removal of the Lower Klamath Project dams would allow anadromous salmonids to move upstream in the mainstem Klamath River and tributaries upstream of Iron Gate Dam, altering disease dynamics between anadromous salmonids and resident species upstream of Iron Gate Dam. However, available information indicates that fish passage would not increase the risk of disease for resident species that occur upstream of Iron Gate Dam (NMFS 2006a). Pathogens (e.g., *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 and downstream from Iron Gate Dam would not increase the risk of introducing new pathogens to resident trout residing upstream of Iron Gate Dam (NMFS 2006a). In addition, native Klamath River trout are generally resistant to *C. shasta*. Recently several new *C. shasta* genotypes have been discovered in the Klamath River (described in Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project*). Disease risk is related to host genotype specificity (Atkinson and Bartholomew 2010). 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. In addition, the Chinook Salmon Expert Panel convened to attempt to answer specific questions related to the Proposed Project compared with existing conditions (Goodman et al. 2011), concluded that the Proposed Project offers greater potential than the existing conditions in reducing disease-related mortality in Klamath River Chinook salmon. Overall, movement of anadromous salmonids into the Upper Klamath Basin presents a relatively low risk of introducing pathogens to resident fish (NMFS 2006a, USFWS/NOAA Fisheries Service Issue 2(B)).

3.3.5.6 Fish Hatcheries

As described under Section 2.7.6 *Hatchery Operations*, under the Proposed Project, the Fall Creek Hatchery would be reopened, and both the Iron Gate Hatchery and Fall Creek Hatchery would continue to operate for a period of eight years following dam removal (through post-dam removal year 7, Table 3.3-11), with the following production goals (Appendix B: *Definite Plan – Section 7.8.3*):

- 3,400,000 fall-run Chinook salmon age 0 smolts at Iron Gate Hatchery (released in spring)
- 115,000 fall-run Chinook salmon age 1 yearling smolts at Fall Creek Hatchery (released in fall)
- 75,000 age 1 yearling coho salmon smolts at Fall Creek Hatchery (released in spring)

Although the ability to meet the production goals varies annually based on adult returns and hatchery performance, since 2005 the current fall-run Chinook salmon yearling smolt goals, and current coho salmon yearling smolt goals have been achieved on average, whereas fall-run Chinook salmon age 0 smolts are typically about a million smolts shy of current production goals (K. Pomeroy, CDFW, pers. comm., 2018). Considering actual production achieved, hatchery operations under the Proposed Project would constitute a reduction in production goals from existing conditions of around 87 percent for yearling fall-run Chinook salmon smolts, 20 percent for fall-run Chinook salmon age 0 smolts, 100 percent for steelhead (although no steelhead have been released since 2012), and no change in production goals for coho salmon smolts. Moving production and releases from Iron Gate Hatchery to Fall Creek Hatchery is not anticipated to have a discernable effect on aquatic resources.

A Hatchery Genetic Management Plan (HGMP) for the Iron Gate Hatchery (CDFW and PacifiCorp 2014) recently redefined the operation of this hatchery from a mitigation hatchery to one now operated to protect and conserve the genetic resources of the Upper Klamath population unit of the SONCC coho salmon ESU. Included in the HGMP are defined monitoring and evaluation activities to evaluate effects of the hatchery activities on the abundance, productivity, spatial structure, and diversity of the SONCC coho salmon and the magnitude or relative impact of the hatchery program on other actions that influence SONCC coho salmon. Operation of the Fall Creek Hatchery would therefore be managed with a particular focus on supporting recolonization of coho salmon in newly accessible habitat.

For the first eight years following dam removal, the effect of hatchery production on aquatic resources would be similar to existing conditions, as described in Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project*. The continuation of production (albeit reduced) would affect adult returns for fall-run Chinook and coho salmon, as described for species specific aquatic resource impacts in Section 3.3.5.9 *Aquatic Resource Impacts*.

The elimination of hatchery production eight years after Lower Klamath Project dam removals under the Proposed Project would affect aquatic resources in the Area of Analysis. When production is ceased (post-dam removal year 7), adult coho salmon progeny of hatchery releases would potentially continue to return through post-dam removal year 9 (three-year old returns released as age 1), and hatchery adult fall-run Chinook salmon through post-dam removal year 10 (four-year old returns released in post-dam removal year 7) (Table 3.3-11). After post-dam removal year 3, fewer coho and Chinook salmon adults would possess a natal cue to return to the location of Iron Gate Hatchery (and none after post-dam removal year 10), because there would be fewer smolts released there starting in dam removal year 2, and no artificial supplementation of the population from that location after post-dam removal year 7. In addition, during post-dam removal years 7 through 10 for fall-run Chinook salmon and dam removal years 7 through 9 for coho salmon hatchery adults would continue to return to Iron Gate or Fall Creek hatcheries (natal cue) but would not be collected. For this three to four-year period, straying of hatchery adults into areas of natural spawning may increase. Straying has the potential to reduce the reproductive success of natural salmonid populations (Mclean et al. 2003, Chilcote 2003, Araki et al. 2007) and negatively affect the genetic diversity of the populations (Reisenbichler and Rubin 1999). Based on the current low numbers of adult returns of coho salmon, increased straying into Fall Creek for a few years is unlikely to have a substantial effect. Fall-run Chinook salmon adults straying into Bogus Creek and Fall Creek may be high during this period, but there would also be greater access to newly available habitat, likely dispersing adults over a greater area and reducing potential impacts.

The current infectious nidus for salmonid smolts (i.e., reach with highest infectivity) for *C. shasta* and *P. minibicornis* appears to be the result of the synergistic effect 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). Som et al. (2016a), citing “a decade of monitoring” and the work of Foott et al. (2016) conclude that Iron Gate Hatchery (via homing returns) and Iron Gate Dam (via migration barrier) influence the current concentration of adult carcasses upstream of the Shasta River confluence, which contribute the bulk of myxospores that continue the parasites life cycle within the nidus. Juveniles released from Iron Gate Hatchery may also contribute to the infectious nidus (Som et al. 2016a), as hatchery-released juvenile fish that become infected and experience mortality further downstream in the Klamath River and potentially become another source of myxospores threatening aquatic resources in the Lower Klamath River. The greater dispersal of release locations of smolts (Iron Gate Hatchery and Fall Creek Hatchery) starting in post-dam removal year 1 would reduce density of juveniles in that year, and reduce congregations of adults by post-dam removal year 3, and therefore reduce the risk of the infectious nidus forming in the Middle Klamath River in the short- and long-term.

Table 3.3-12. Hatchery releases and adult returns under the Proposed Project.

Species		**Dam Removal Year**		**Post-dam Removal Year**							
		1	**2[a]**	**1**	**2**	**3**	**4**	**5–7[b]**	**8**	**9**	**10**
Chinook salmon	Produced	N smolts from existing habitat and existing H smolts (age 0 in spring and age 1 in fall)	N smolts from existing habitat and reduced H smolts	N smolts from new habitat and reduced H smolts	N and reduced H smolts	N and reduced H smolts	N and reduced H smolts	N and reduced H smolts	N smolts	N smolts	N smolts
	Returning	N and H adults (age 3–4) downstream of Iron Gate Dam	N and H adults access new habitat	N and H adults	N and H adults	N adults from new habitat (progeny of post-dam removal year 1 outmigration) and reduced H adults	N and reduced H adults	N and reduced H adults	N and reduced H adults	N and reduced H adults	N adults and last H adults (age 4, progeny of post-dam removal year 7 outmigration)

Species		Dam Removal Year		Post-dam Removal Year							
		1	2[a]	1	2	3	4	5–7[b]	8	9	10
Coho salmon	Produced	N smolts from existing habitat and H smolts (age 1)	N smolts from existing habitat and H smolts	N smolts from new habitat and H smolts from Fall Creek	N and H smolts	N and H smolts	N and H smolts	N and H smolts	N smolts	N Smolts	N smolts
	Returning	N and H (age 3) downstream of Iron Gate Dam	N and H adults access new habitat	N and H adults	N and H adults	N adults from new habitat (progeny of post-dam removal year 1 outmigration) and H adults	N and H adults	N and H adults	N and H adults	N and last H adults (progeny of post-dam removal year 7 outmigra tion)	N adults

[a] Early drawdown of Copco No. 1 begins in dam removal year 1. Drawdown of all reservoirs occurs and dams are removed in dam removal year 2 (see Table 2.7-1). Reduced hatchery releases begin in dam removal year 2 and continue for eight years until post-dam removal year 7.

[b] Final year of hatchery releases occurs in post-dam removal year 7.

H smolt from hatchery releases or adult progeny of hatchery release

N smolt from natural spawning or adult progeny of natural spawning

Overall, dispersing hatchery operations in the short term and discontinuing hatchery operations after eight years following Lower Klamath Project dam removal would reduce the risk of nidus forming in the mainstem Klamath River in the short- and long-term. In addition, hatchery juveniles would no longer be released after post-dam removal year 7 during natural smolt outmigration. Therefore, it is anticipated that the Proposed Project would result in reduced impacts to aquatic resources due to fish disease and parasites in the short- and long-term. Population and other impacts of altered hatchery operations vary for aquatic species and are discussed for specific impacts below.

3.3.5.7 Algal Toxins

The removal of the Lower Klamath Project reservoirs, particularly the larger Copco No. 1 and Iron Gate reservoirs, would decrease or eliminate excessive growth of phytoplankton, and in particular large seasonal blooms of blue-green algae and associated toxins (e.g., microcystin), by eliminating large areas of quiescent habitat where these phytoplankton species currently thrive. In the nutrient-rich Klamath River system, the elevated water temperatures and increased light levels that occur during the summer and early fall under existing conditions result in seasonal blue-green algae blooms in the phytoplankton and periphyton Area of Analysis, and especially the Hydroelectric Reach (Section 3.4.2.3 *Hydroelectric Reach*). As analyzed in Potential Impact 3.4-2, the Proposed Project would dramatically decrease the amount of optimal (calm, slow-moving reservoir) habitat available to support nuisance and/or noxious phytoplankton species, resulting in a corresponding decrease in phytoplankton blooms, alleviating high seasonal concentrations of algal toxins and associated bioaccumulation of microcystin in fish and freshwater mollusk tissue for species downstream of the Lower Klamath Project reservoirs.

While some microcystin may be transported to downstream reaches of the Klamath River from large blooms occurring in Upper Klamath Lake, the levels would not be nearly as high as those experienced under existing conditions, because seasonal blooms in Copco No. 1 and Iron Gate reservoirs are the primary source of *Microcystis aeruginosa* to the Middle and Lower Klamath River (see Section 3.4.2 *Phytoplankton*). Overall, bioaccumulation of algal toxins in freshwater mollusk and fish tissue would be expected to decrease in the mainstem Klamath River from the Hydroelectric Reach to the Klamath River Estuary.

3.3.5.8 Aquatic Habitat

As described in Section 2.1 *Project Objectives*, a primary purpose of the Proposed Project is to increase habitat availability for anadromous salmonids in the Klamath River, for the benefit of the salmonid populations and the recreational, commercial, and cultural uses related to the health of the salmon fishery. The Proposed Project is intended to increase the amount of aquatic habitat by removing migration barriers, and also to improve the quality of the habitat, as related to the operation of the existing hydroelectric facilities. There is some disagreement among experts as to the amount of habitat that Chinook salmon and steelhead would be able to reach, based primarily[72] on the impact of water quality problems in the Lake Ewauna/Keno Reservoir reach and in Upper Klamath Lake, discussed in greater detail in Upper Klamath River and Connected Waterbodies, immediately below. Because coho salmon are not expected to migrate to these reaches, the same concern does not affect estimates of additional coho habitat.

It is worth noting that based on comments received during the public scoping process (Appendix A), it appears that there is concern from some about the historic distribution of salmonids in the Klamath River Basin, with individuals asserting that historical geomorphic features or water quality may have limited upstream migration prior to dam construction (see below paragraph). However, as this document is an analysis of habitat availability upon implementation of the Proposed Project, including consideration of existing and projected future river conditions, this EIR does not further address questions of the historic distribution of salmonids in the Klamath River Basin.

A few commenters (Appendix A) have suggested that a reef existed at the location of Copco No. 1 Dam that would have limited anadromous salmon passage. Boyle (1976) describes an andesite “reef” at the location of Copco No. 1 Dam prior to dam construction and reservoir inundation. He observed evidence of a historical lake formed by this reef that extended approximately five river miles upstream. While the reef may have been a barrier to migration of Chinook salmon when it was originally formed, Boyle is clear that the reef was one of the oldest exposed formations found in the Siskiyou Mountains, and that this barrier and lake existed in the geologic history. At the time of Copco No. 1 Dam construction, no impediments to upstream Chinook salmon migration were described by Boyle. Boyle (1976) describes large runs of salmon at the site of Copco No. 1 in the early 1900’s, and details that a fish ladder was considered for construction at Copco No. 1 Dam, but in coordination with California Fish and Game Commission a fish hatchery was proposed for Fall Creek in lieu of passage. Further, historical records reviewed by Hamilton et al. (2005) and Hamilton et al. (2016), and genetic information obtained from archaeological sites analyzed by Butler et al. (2010), indicate that prior to the construction of Copco No. 1 Dam, Chinook salmon (fall- and spring-run based on observed and documented timing) were abundant in, and spawned in, tributaries of the Upper Klamath Basin (i.e., upstream of the described reef and eventual location of Copco No. 1 Dam), Shovel and Spencer creeks, as well as the Sprague, Williamson, and Wood rivers. This conclusion was further recognized in a trial-type hearing concerning federal fisheries requirements in *Klamath Hydroelectric Project* (FERC Project No. 2082, Docket # 2006-NMFS-0001) (Sept. 29, 2006)

[72] Both dams that would remain under the Proposed Project (Keno Dam and Link River Dam), have fish passage facilities.

(hereinafter “NMFS 2006a”). Thus, it appears that there was no “reef” forming a barrier to fish migration at the time Copco No. 1 was built.

The habitat quantity and quality that would be accessible under the Proposed Project within the Area of Analysis are described below for each of the key reaches.

Upper Klamath River and Connected Waterbodies

Removal of the four hydroelectric dams eliminates all of the impassable dams that prevent salmon from accessing an estimated 360 miles of potential anadromous fish habitat upstream of Upper Klamath Lake and Keno Impoundment/Lake Ewauna, with key habitat tributaries being the Woods, Williamson and Sprague rivers (Huntington 2006, DOI 2007, NMFS 2007b). However, FERC’s (2007) analysis of habitat access for anadromous fish with fish passage excluded these 360 miles of potential anadromous fish habitat based upon poor water quality conditions in Upper Klamath Lake and Keno Impoundment/Lake Ewauna during summer months. The Chinook Salmon Expert Panel (Goodman et al. 2011) also concluded that substantial gains in Chinook salmon abundance for areas upstream of 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 Salmon and 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 in the Upper Klamath River. Note that as discussed above (Section 3.3.2.2 *Physical Habitat Descriptions*), fish passage improvements at Keno Dam are currently being discussed by the USBR.

These concerns for anadromous salmonid migration and spawning overstate the seasonal habitat limitations of Keno Impoundment/Lake Ewauna and Upper Klamath Lake because of the manner in which the seasonal water quality impairments intersect with steelhead, spring-run Chinook, and certain fall-run Chinook life histories.

Regarding Upper Klamath Lake’s availability as habitat/migration corridor, a study by Maule et al. (2009) strongly suggests that Upper Klamath Lake habitat can support salmonids, except during the summer (June through September). Maule et al. (2009) 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 existing 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). Maule et al. (2009) concluded that there was little evidence of physiological impairment that would preclude this stock from being reintroduced into the Upper Klamath Basin. In addition, the dominant life history of fall-run Chinook salmon (Type I) outmigrate to the ocean in spring and would not rear during the stressful summer period in the Upper Klamath Basin. Type II and Type III life history would rear during summer and outmigrate during either fall (Type II) or spring (Type III). Thus, conditions for juvenile fall-run Chinook emigration through Upper Klamath Lake appear favorable. Due to the spring migration period for adult and juvenile spring-run Chinook salmon and steelhead, the migratory life stages would generally avoid the period of poor water quality in Upper Klamath Lake as well. Cool groundwater spring inputs in the Williamson River and on the west side of Upper Klamath Lake would likely provide thermal refugia for the non-migratory juvenile salmonid rearing life stages.

Similar to the severe water quality impairments in Upper Klamath Lake, the serious water quality issues in Keno Impoundment/Lake Ewauna are not year-round. Both DOI and NMFS have long recognized the issue of seasonally poor water quality typically between June 15 and November 15 in Keno Impoundment/Lake Ewauna. This is a time period when nearly all adult fall- and some (later portion) spring-run Chinook salmon would be migrating upstream. When water quality is poor both DOI and NMFS, as part of the Klamath Hydroelectric Project relicensing, prescribed the transfer of primarily adult fall-run Chinook salmon upstream of the Keno Impoundment/Lake Ewauna for the purposes of restoration and safe, effective, and timely passage (DOI 2007, NMFS 2007b). If fish passage were not provided, upstream migrating adults would presumably locate spawning habitat downstream.

Upper Klamath River – Hydroelectric Reach

This reach would be fundamentally altered under the Proposed Project, with the removal of the dams and associated reservoirs, and the restoration of riverine systems and habitat connectivity. Under the Proposed Project anadromous fish (Chinook salmon, steelhead, coho salmon, and Pacific lamprey) access would be restored to an estimated 80 miles of habitat within the mainstem Klamath River and tributaries upstream of Iron Gate Dam and downstream of Keno Dam (DOI 2007, Cunanan 2009). Primary tributary habitat that would be available for salmonids includes Fall, Jenny, Shovel, and Spencer creeks. In addition to the tributaries and the current reaches of the mainstem, the 80 miles of habitat includes restoration of 21.2 miles of currently inundated mainstem and tributary riverine habitat (Cunanan 2009) for resident and anadromous fish. The current reservoirs inundate sections of the river that had high sinuosity and complex channels that historically provided high quality salmonid spawning and rearing habitats (Hetrick et al. 2009). Modeling indicates that the river would return to a similar channel morphology following dam removal, ad discussed in Appendix F. In addition, proposed habitat restoration within the reservoir areas (described in Section 2.7.4 *Restoration Within the Reservoir Footprint*) is designed to slow water velocities along the bank and thus has the potential to create backwater and rearing habitat for coho salmon. Proposed habitat restoration components include manually creating connectivity to tributaries, incorporating floodplain habitat features (e.g., side channels), creating bank-line complexity to slow water velocities, and placing large wood habitat features (Appendix B: *Definite Plan*).

Under the Proposed Project, short-term alterations to the hydrograph would result from the release of water stored in the Lower Klamath Project reservoirs. Based on modeling results, this release is expected to last about three months, from January 1 into mid-March of dam removal year 2, but could vary depending on hydrologic conditions (USBR 2012), increasing the magnitude of flows downstream from the dams during the drawdown period. River flows would be expected to remain below the 10-year flood event.

In the long term, flows would increase not only in the bypass reaches, but also in 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).

Increases in flows resulting from changes in peaking operations at J.C. Boyle Dam 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 Lower Klamath 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 hydroelectric peaking operations (e.g., stranding, displacement, reduced food production, and increased stress) would no longer occur.

Middle and Lower Klamath River

As described above, reservoir drawdown under the Proposed Project would result in increased flows for about four months once drawdown begins. Over the long term, the Proposed Project 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, USBR 2012), daily, seasonal, and annual flow variability would increase. It is anticipated that restoration of the hydrologic function of the river system under the Proposed Project would support the creation of habitat diversity and maintain biophysical attributes of the Klamath River (Stanford et al. 1996, Poff et al. 1997).

The Proposed Project would substantially decrease the transit time of water in the Hydroelectric Reach, because it would no longer be impounded by the reservoirs, resulting in a shift in the timing of the occurrence of low flow periods to earlier in summer than currently occurs (Balance Hydrologics Inc. 1996, NRC 2004). 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 (USBR 2012). 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

Hydrologic and hydraulic modeling results (described in Section 3.6.2.3 *Flood Hydrology*) indicate that because of the influence of the tributaries entering the Klamath River downstream from Iron Gate Dam, the flow changes for the Proposed Project would not substantially affect the flows entering the estuary. Specifically, Potential Impact 3.6-1 and Potential Impact 3.6-3 provide further discussion and information on this effect. Therefore, the Proposed Project would not affect flow-related fisheries habitat in the estuary or the Pacific Ocean.

3.3.5.9 Aquatic Resource Impacts

Potential Impact 3.3-1 Effects on coho salmon critical habitat quality and quantity due to short-term sediment releases and long-term changes in habitat quality and quantity due to dam removal.

In the short term, under the Proposed Project, designated critical habitat supporting SONCC coho salmon would be degraded from elevated SSCs and sediment deposition downstream of Iron Gate Dam (see Section 3.3.5.1 *Suspended Sediment* and Appendix E of this EIR, and Section 3.3.5.2 *Bed Elevation and Grain Size Distribution* and Appendix F of this EIR). The specific features of critical habitat and designated PCEs considered essential for the conservation of the SONCC ESU that would be adversely impacted in the short term include spawning substrate, water quality, and safe passage conditions. Quality of spawning substrate for coho salmon downstream of Iron Gate Dam would be substantially degraded during the spawning season following dam removal, while most of the spawning habitat occurring in tributaries would remain unaltered by the Proposed Project (Appendix E). Water quality in the mainstem Klamath River downstream of Iron Gate Dam would be substantially degraded in the short term from increased suspended sediment and decreased dissolved oxygen, resulting in a substantial reduction in rearing and migration habitat suitability for juvenile and smolt coho salmon during the winter and spring following dam removal (Appendix E). Passage conditions would be impaired for adult upstream migrants during the fall and winter of dam removal from both increased suspended sediment, and the risk of sediment deposits at tributary confluences (Appendices E and F). Passage conditions would be impaired for coho salmon smolts during spring following dam removal from increased suspended sediment (Appendix E). Based on the substantial short-term decrease in quality of the features of critical habitat and PCEs supporting SONCC coho salmon, there would be a significant impact to coho salmon critical habitat under the Proposed Project in the short term.

However, the Proposed Project includes aquatic resource measures AR-1 (Mainstem Spawning) and AR-2 (Juvenile Outmigration) to reduce the short-term effects of SSCs on coho salmon PCEs of critical habitat. In addition, mitigation measures AQR-1 and AQR-2 (described below), would be required to increase certainty of the effectiveness of the aquatic resource measures AR-1 and AR-2 and to reduce the short-term significant adverse impacts of the Proposed Project on coho salmon critical habitat. Aquatic resource measures submitted as part of the Proposed Project are summarized in Section 2.7.8.1 *Aquatic Resource Measures* and detailed in Appendix B: *Definite Plan – Appendix I*. AR-1 includes the development and implementation of a monitoring and adaptive management plan to offset the impacts of Lower Klamath Project dam removal on mainstem spawning habitat. AR-1 actions include a 2-year tributary confluence monitoring effort and addressing sediment and debris obstructions that block volitional upstream passage from the Klamath River into tributaries. Monitoring would occur periodically for the two years following dam removal. Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (No. 11516530) within the first two years following reservoir drawdown would trigger a monitoring effort. Mitigation Measure AQR-1 Mainstem Spawning (detailed below) further specifies that monitoring shall also be conducted following a significant flow event, even if that flow event occurs more than two years following dam removal. Aquatic Resource Measure AR-1 also includes a spawning habitat evaluation on the Klamath River and tributaries in the Hydroelectric Reach. Most coho salmon spawning occurs in tributaries, and very few coho salmon have been observed spawning in the mainstem Klamath River. Therefore, the spawning habitat actions of AR-1 are focused on offsetting impacts of the Proposed Project on Chinook salmon and steelhead. However, due to the similar spawning habitat requirements of coho salmon to both species, these actions would benefit coho salmon as well. If spawning habitat conditions following dam removal do not meet target metrics[73] developed to offset the anticipated loss of Chinook salmon and steelhead redds due to the Proposed Project, AR-1 specifies that spawning gravel augmentation would be completed within the mainstem, with additional spawning habitat actions within tributaries. These tributary spawning habitat restoration actions would be completed in Jenny Creek, Shovel Creek, Fall Creek, and/or Spencer Creek and could include removal of artificial fish passage barriers, or placement of large woody debris to trap and retain spawning gravels. Mitigation Measure AQR-1 Mainstem Spawning (detailed below) further specifies the range of actions that shall be conducted in tributaries to offset impacts to critical habitat. Implementation of the Proposed Aquatic Resource Measure AR-

[73] Spawning gravel in the amount of 44,100 yd^2 for fall Chinook salmon and 4,700 yd^2 for steelhead

1 along with Mitigation Measure AQR-1 would reduce the short-term potential impacts of SSCs on coho salmon spawning habitat in dam removal year 2 by improving access to tributary habitat where impacts from SSC on habitat in the mainstem can be avoided, and by augmenting spawning gravel, ensuring that suitable spawning habitat in mainstem and tributaries is available following dam removal. Given implementation of AR-1 and AQR-1, suitable coho salmon spawning habitat quality and quantity would not be substantially reduced as a result of the Proposed Project.

Proposed Aquatic Resource Measure AR-2 includes three primary actions: 1) salvaging mainstem overwintering juvenile salmonids prior to reservoir drawdown; 2) maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River; and 3) developing a water quality monitoring network, trigger thresholds, and plan for salvaging and relocating juvenile fish from tributary confluence areas to cold water tributaries or nearby off-channel ponds. Implementation of proposed Aquatic Resource Measure AR-2 would reduce the short-term effects of SSCs on rearing habitat for coho salmon juveniles in the mainstem during dam removal by actively transporting up to 500 juvenile coho salmon from vulnerable mainstem areas to off-channel ponds protected from the effects of the Proposed Project, thus offsetting water quality impacts to critical habitat. Other native fish captured during the seining and trapping effort, such as juvenile steelhead and juvenile Chinook salmon would be relocated into tributary streams adjacent to the salvage locations. Proposed Aquatic Resource Measure AR-2 would also reduce the potential short-term effects of SSCs to migratory habitat for coho salmon smolts by maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River. Monitoring would occur regularly for the two years following dam removal. Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (No.11516530) within the first two years following reservoir drawdown would trigger a monitoring effort. Mitigation Measure AQR-2 Juvenile Outmigration (detailed below) further specifies that monitoring shall also be conducted following a significant flow event, even if that flow event occurs more than two years following dam removal. In addition, proposed Aquatic Resource Measure AR-2 would reduce the potential short-term effects of SSCs to migratory habitat for coho salmon smolts by rescuing and transporting smolts if mainstem SSC are high, and water temperatures within tributaries are too poor to provide safe refuge (a decision to be made in regular consultation with the Aquatic Technical Work Group [ATWG[74]]). These measures would effectively provide juvenile coho salmon short-term refuge in suitable habitat as an alternative to exposure to temporarily degraded critical habitat from periods of high SSC in the mainstem habitat following dam removal.

[74] The ATWG would be comprised of agency and tribal fisheries scientists to review the aquatic resource (AR) mitigation measures included in the Proposed Project.

Based on the wide distribution of coho salmon critical habitat within tributaries, implementation of the KRRC's proposed aquatic resource measures (AR-1 and AR-2), and implementation of the mitigation measures (AQR-1 and AQR-2) developed for this EIR (where both sets of measures were designed to offset short-term impacts to PCEs of critical habitat), there would not be a substantial decrease in the quality of a substantial proportion of habitat for coho salmon critical habitat in the short term. Therefore, the Proposed Project would have no significant impact on coho salmon critical habitat in the short term.

In the long term, the Proposed Project would increase the amount of habitat available to coho salmon upstream of currently designated critical habitat and improve water quality and bedload characteristics in the mainstem Klamath River within current critical habitat.

The Proposed Project would restore access for Upper Klamath River coho salmon populations to the Hydroelectric Reach. The 2006 administrative trial-type hearings evaluating fish passage mandatory conditions found that the record of evidence is inconclusive as to whether coho salmon's historical distribution extended upstream as far as Spencer Creek, but that the evidence definitively shows that based on historical records and tribal accounts coho salmon used habitat as far upstream as Fall Creek (NMFS 2006a). Based on Hamilton et al. (2005), the Proposed Project would expand coho salmon distribution to include historical high-quality spawning and rearing habitat along the mainstem Klamath River and all tributaries upstream at least as far as Spencer Creek, including in Jenny, Shovel, and Fall creeks. Together, this compromises around 80 miles of suitable potential habitat within the Hydroelectric Reach (DOI 2007, Cunanan 2009). Access to suitable habitat upstream of Iron Gate Dam would increase the availability of spawning sites, result in additional food resources, and provide access to areas of better water quality.

NMFS may consider whether to designate the newly available habitat as critical habitat as part of its five-year status review or as a separate reconsideration of the critical habitat designation for the species (J. Simondet, NMFS, pers. comm., 2011). But, it is speculative at this point to prejudge the outcome of any such consideration, so the EIR does not find that the anticipated coho habitat expansion would necessarily result in an increased in the amount of designated critical habitat.

As discussed in detail in Potential Impact 3.2-1, 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 would result in Klamath River water temperatures that exhibit more natural diel (i.e., 24-hour period) variation and are more in sync with historical migration and spawning periods. These changes would result in water temperatures that are more favorable for salmonids in the mainstem Klamath River in the long term, thus improving the water quality PCE of critical habitat. Removal of the Lower Klamath Project dams and associated 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. Under the Proposed Project, increased bedload supply and transport following dam removal would increase the supply of gravel downstream from the removed dams as far downstream as Cottonwood Creek (see Appendix F). In the long term this would likely improve critical habitat for coho salmon by reducing median substrate to a size more favorable for spawning (USBR 2012).

Overall, these changes would be a substantial increase in the quality and quantity of coho salmon critical habitat in the long term. Therefore, the Proposed Project would be beneficial for coho salmon critical habitat in the long term.

Mitigation Measure AQR-1 – Mainstem Spawning.
Implementation of Action 1 of proposed Aquatic Resource Measure AR-1 (tributary-mainstem connectivity) shall be implemented in the tributaries identified in Action 1 of AR-1, as well as all newly created stream channels that were previously inundated by Project reservoirs prior to drawdown. As described in Appendix B: *Definite Plan – Appendix I*, implementation of Action 1 of proposed Aquatic Resource Measure AR-1 would be conducted for at least two years following dam removal, including following a 5-year flow event if the event were to occur within that two years. This mitigation measure (AQR-1) ensures that in addition to the monitoring that shall be conducted as described for AR-1, monitoring shall also be conducted within one month following a 5-year flow event regardless of how many years since dam removal have passed, and if fish passage obstructions are identified, they shall be removed as described in AR-1 (Appendix B: *Definite Plan – Appendix I*). In addition, implementation of Action 1 of proposed Aquatic Resource Measure AR-1 shall include an evaluation and proposal of other actions to improve spawning and rearing habitat in tributaries to the Klamath River that meet the spawning targets identified in AR-1, which may include: installation of large woody material, riparian planting for shade coverage, wetland construction or enhancement, and cattle exclusion fencing.

Mitigation Measure AQR-2 – Juvenile Outmigration.
Implementation of Action 2 of proposed Aquatic Resource Measure AR-2 (tributary-mainstem connectivity monitoring) shall be implemented in the tributaries identified in Action 2 of AR-2 as well as all newly created stream channels that were previously inundated by Lower Klamath Project reservoirs prior to drawdown. As described in Appendix B: *Definite Plan – Appendix I*, implementation of Action 2 of AR-2 would be conducted for at least two years following dam removal, including following a 5-year flow event, if the event were to occur within that two years. This mitigation measure (AQR-2) ensures that in addition to monitoring described under AR-2, monitoring shall also be conducted within one month following a 5-year flow event regardless of how many years

since dam removal have passed, and requires that if fish passage obstructions are identified in relation to the Proposed Project, they shall be removed as described in AR-2 (Appendix B: *Definite Plan – Appendix I*).

Significance

No significant impact with mitigation to coho salmon critical habitat in the short term

Beneficial for coho salmon critical habitat in the long term

Potential Impact 3.3-2 Effects on Southern Resident Killer Whale critical habitat quality due to short-term and long-term alterations to salmon populations due to dam removal.

The Klamath River contributes to critical habitat for Southern Resident Killer Whales through its contribution of salmon to their food supply (included as a PCE). The Proposed Project would not affect the geographic extent of critical habitat for this species, as it is located in the state of Washington. In the short term, salmon population abundance is anticipated to reduce under the Proposed Project, as described in Potential Impacts 3.3-7, 3.3-8, and 3.3-9. In the long term, the Proposed Project is expected to increase salmon populations (as described in Potential Impacts 3.3-7, 3.3-8, and 3.3-9), which could increase food supply for Southern Resident Killer Whales. However, data on the Southern Resident Killer Whale diet indicate that based on the migratory range and behavior of the population, the Klamath River salmon are anticipated to provide less than one percent of the diet of Southern Resident Killer Whales in most months under current and future conditions. While Southern Resident Killer Whales have been shown to consume Klamath River Chinook salmon: the Klamath River is considered by NMFS and WDFW tenth out of 17 priority Chinook salmon populations for Southern Resident Killer Whales (NMFS 2018b, NMFS and WDFW 2018). If Chinook salmon abundance increases as predicted under the Proposed Project (EIR Section 3.3.5.9 Aquatic Resource Impacts), then Klamath River Chinook salmon could become a larger contributor to the diet of Southern Resident Killer Whale DPS. If this occurs as predicted, the Proposed Project would be a benefit to critical habitat for Southern Resident Killer Whales. Based on the low proportion of the Sothern Resident Killer Whale diet being composed of salmon from the Klamath River under existing conditions, the Proposed Project would not be likely to substantially impact the habitat quality (i.e., food supply) of Southern Resident Killer Whales in the short term or long term. Therefore, the Proposed Project would have no significant impact to Southern Resident Killer Whale critical habitat in the short term and long term.

Significance

No significant impact to Southern Resident Killer Whale critical habitat in the short term

No significant impact to Southern Resident Killer Whale critical habitat in the long term

Potential Impact 3.3-3 Effects on eulachon critical habitat quality due to short-term sediment releases due to dam removal.
In the short term, under the Proposed Project, PCEs of critical habitat supporting eulachon would be degraded, including short-term adverse effects of suspended sediment (see Section 3.3.5.1 *Suspended Sediment* and Appendix E) primarily on spawning and egg incubation habitat, and adult and larval migration habitat (NMFS 2011) during eulachon spawning, and adult and larval migration period (primarily January through April). Eulachon are highly adapted to migrating and spawning during periods of increases suspended sediment, and suspended sediment released under the Proposed Project is predicted to be at levels similar to what occurs under existing conditions within the Klamath River Estuary, at least during infrequent storm events.

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 (less than two percent). Although the Proposed Project could result in short-term reductions in habitat quality detrimental to PCEs (potentially spawning substrate composition during the year of dam removal) under a worst impacts on fish scenario, a negligible amount (less than two percent) of eulachon critical habitat would be affected for a short duration. Therefore, impacts to eulachon critical habitat would not be significant in the short term.

In the long term, SSCs would be similar to those under existing conditions. Natural bedload transport processes would resume, as the dams would no longer trap sediment supplied from areas upstream of Iron Gate Dam (see Appendix F). Channel bed elevations and grains size in the estuary and ocean would not be appreciably affected, because of the small contribution of the area upstream of Iron Gate Dam to the total bedload in the system. Water quality benefits resulting from the Proposed Project would largely have dissipated upstream of the estuary, and therefore, water quality in the estuary would be expected to remain un-altered in the long term (WQST 2011). Therefore, there would be no impact to eulachon critical habitat in the long term.

Significance
No significant impact to eulachon critical habitat in the short term

No significant impact to eulachon critical habitat in the long term

Potential Impact 3.3-4 Effects on Chinook and coho salmon Essential Fish Habitat (EFH) quality and quantity due to short-term sediment releases and long-term changes in habitat quality and quantity due to dam removal.
In the short term, under the Proposed Project, Chinook and coho salmon Essential Fish Habitat (EFH) is identical for both species and would be degraded from elevated SSCs and sediment deposition downstream of Iron Gate Dam (see Section 3.3.5.1 *Suspended Sediment* and Appendix E of this EIR, and Section 3.3.5.2 *Bed Elevation and Grain Size Distribution* and Appendix F of this EIR). The specific features of EFH that would be adversely impacted in the short term include water quality necessary for successful adult migration and holding, spawning, egg-to-fry survival, fry rearing, smolt migration, and estuarine rearing of juvenile Chinook and coho salmon. Water quality in the mainstem Klamath River downstream of Iron Gate Dam would be substantially degraded in the short term from increased suspended sediment and decreased dissolved oxygen, resulting in a substantial reduction in rearing and migration habitat suitability for juvenile and smolt Chinook and coho salmon during the winter and spring following dam removal (Appendix E). Passage conditions would be impaired for adult upstream Chinook and coho salmon migrants during the fall and winter of dam removal from both increased suspended sediment, and the risk of sediment deposits at tributary confluences (Appendices E and F). Quality of spawning substrate for Chinook and coho salmon downstream of Iron Gate Dam would be substantially degraded during the spawning season following dam removal, while most of the spawning habitat occurring in tributaries would remain unaltered by the Proposed Project (Appendix E). Passage conditions would be impaired for Chinook and coho salmon smolts during spring following dam removal from increased suspended sediment (Appendix E). Based on the substantial short-term decrease in quality of EFH for Chinook and coho salmon, there would be a significant impact to Chinook and coho salmon EFH under the Proposed Project in the short term.

However, the Proposed Project includes aquatic resource measures AR-1 (Mainstem Spawning) and AR-2 (Juvenile Outmigration) to reduce the short-term effects of SSCs on Chinook and coho salmon EFH. In addition, mitigation measures AQR-1 and AQR-2 (described above for Potential Impact 3.3-1), would be required to increase certainty of the effectiveness of the aquatic resource measures AR-1 and AR-2 and reduce the potential for short-term significant adverse impacts of the Proposed Project on Chinook and coho salmon EFH. Aquatic resource measures are summarized in Section 2.7.8.1 *Aquatic Resource Measures* and detailed in Appendix B: *Definite Plan – Appendix I*. Proposed Aquatic Resource Measure AR-1 includes the development and implementation of a monitoring and adaptive management plan to offset the impacts of Lower Klamath Project dam removal on mainstem spawning habitat. Proposed Aquatic Resource Measure AR-1 actions include a 2-year tributary confluence monitoring effort and addressing sediment and debris obstructions that block volitional upstream passage from the Klamath River into tributaries. Monitoring would occur regularly for the two years following dam removal. Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (No. 11516530) within the first two years following reservoir drawdown would trigger a monitoring effort. Mitigation Measure AQR-1 Mainstem Spawning (described in detail in Potential Impact 3.3-1), developed for this EIR, further specifies that monitoring shall also be conducted following a significant flow event, even if that flow event occurs more than two years following dam removal. Proposed Aquatic Resource Measure AR-1 also includes a spawning habitat evaluation on the Klamath River and tributaries in the Hydroelectric Reach. If spawning habitat conditions following dam removal do not meet target metrics[75] developed to offset the anticipated loss of Chinook salmon and steelhead redds due to the Proposed Project, spawning gravel augmentation would be completed within the mainstem, with additional spawning habitat actions within tributaries. Tributary spawning habitat restoration actions to be completed in Jenny Creek, Shovel Creek, Fall Creek, and/or Spencer Creek could include removal of artificial fish passage barriers, or placement of large woody debris to trap and retain spawning gravels. Mitigation Measure AQR-1 Mainstem Spawning further specifies the range of actions that shall be conducted in tributaries to offset impacts to EFH. Implementation of proposed Aquatic Resource Measure AR-1 and Mitigation Measure AQR-1 would reduce the short-term impacts of SSCs on Chinook and coho salmon EFH in dam removal year 2 by improving access to tributary habitat where impacts from SSC on habitat in the mainstem can be avoided, and by augmenting spawning gravel to ensure that an equivalent amount of spawning habitat is available following dam removal. Therefore, it is anticipated that, in the short term, fewer Chinook and coho salmon would spawn in the mainstem prior to and following the dam removal, and suitable spawning gravel access would be maintained.

Proposed Aquatic Resource Measure AR-2 includes three primary actions: (1) salvaging mainstem overwintering juvenile salmonids prior to reservoir drawdown; (2) maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River; and (3) developing a water quality monitoring network, trigger thresholds, and plan for salvaging and relocating juvenile fish from tributary confluence areas to cold water tributaries or nearby off-channel ponds. Implementation of proposed Aquatic Resource Measure AR-2 would reduce the short-term effects of SSCs on Chinook and coho salmon EFH in the mainstem during dam removal by actively transporting up to 500 juvenile coho salmon from vulnerable mainstem areas to off-channel ponds protected from the effects of the Proposed Project. Other native fish captured during the seining and trapping effort, such as juvenile Chinook salmon would also be relocated into tributary streams adjacent to the salvage locations, thus off-setting water quality impacts to Chinook and coho salmon EFH. In addition, proposed Aquatic Resource Measure AR-2 would reduce the short-term effects of SSCs to migratory Chinook and coho salmon EFH by rescuing and

[75] Spawning gravel in the amount of 44,100 yd^2 for fall Chinook salmon and 4,700 yd^2 for steelhead

transporting smolts if mainstem SSC are high, and water quality conditions within tributaries are too poor to provide safe refuge (a decision to be made in regular consultation with the ATWG). Proposed Aquatic Resource Measure AR-2 would also reduce the potential short-term effects of SSCs to migratory habitat for Chinook and coho salmon smolts by maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River. Monitoring would occur regularly for the two years following dam removal. Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (No.11516530) within the first two years following reservoir drawdown would trigger a monitoring effort. Mitigation Measure AQR-2 Mainstem Spawning (described in detail in Potential Impact 3.3-1) further specifies that monitoring shall also be conducted following a 5-year flow event, even if that flow event occurs more than two years following dam removal. These actions would effectively reduce the number of salmon juveniles and smolts potentially exposed to periods of high SSC in the mainstem habitat following dam removal, and therefore reduce the proportion of the population experiencing sub-lethal effects or mortality in temporarily degraded habitat.

Based on the wide distribution and use of tributaries by both juvenile and adult Chinook and coho salmon, implementation of the KRRC's proposed aquatic resource measures (AR-1 and AR-2), and implementation of mitigation measures (AQR-1 and AQR-2) developed for this EIR (where both sets of measures were designed to offset short-term impacts to Chinook and coho salmon EFH), there would not be a substantial decrease in the quality of a large proportion of Chinook and coho salmon EFH in the short term. Therefore, the Proposed Project would have no significant impact on Chinook and coho salmon EFH in the short term.

In the long term, bedload supply and transport following dam removal would increase supply of gravel downstream from the dam as far downstream as Cottonwood Creek (see Appendix F). This would potentially improve EFH for Chinook and coho salmon by reducing median substrate to a size more favorable for spawning (USBR 2012). In the long term, the Proposed Project would also 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 currently designated EFH), improved water quality, increased sediment transport, and decreased prevalence of disease, would be beneficial to EFH for Chinook and coho salmon in the long term.

Significance

No significant impact with mitigation to Chinook and coho salmon EFH in the short term

Beneficial for Chinook and coho salmon EFH in the long term

Potential Impact 3.3-5 Effects on groundfish Essential Fish Habitat (EFH) quality due to short-term sediment releases and long-term changes in habitat quality due to dam removal.

EFH for Pacific Coast groundfish includes all waters and substrate within areas with a depth less than or equal to 3,500 meters (1,914 fathoms [ftm]) shoreward to the mean high-water level or the upriver extent of saltwater intrusion. Within the Area of Analysis for aquatic resources, this includes the Klamath River Estuary and Pacific Ocean nearshore environment.

In the short term, under the Proposed Project, 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 Pacific Ocean nearshore environment bottom substrates (Section 3.3.5.1 *Suspended Sediment*). EFH in the Klamath River Estuary could be affected by elevated SSCs for about four months during the winter following dam removal, during which time many groundfish species could be spawning. 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 (potentially > 1,000 mg/L) downstream from Iron Gate Dam would still be substantial and would be higher than the extreme values estimated by the sediment transport model for existing conditions (see Section 3.3.5.1 *Suspended Sediment*). However, increased suspended sediment is not anticipated to substantially decrease the quality of groundfish EFH, which is adapted to periodic pulses of high sediment. In addition, the area of EFH for groundfish affected by the Proposed Project within the Klamath River Estuary is a very small proportion (<1 percent) of the total EFH designated for groundfish along the Pacific Coast. Therefore, impacts to groundfish EFH from the Proposed Project would have no significant impact in the short term.

In the long term, SSCs would be similar to those under existing conditions. Water quality benefits resulting from the Proposed Project would largely have dissipated upstream of the estuary, and therefore, water quality in the estuary would be expected to remain similar to existing conditions. Therefore, there would no impact to groundfish EFH from the Proposed Project in the long term.

<u>Significance</u>

No significant impact to groundfish EFH in the short term

No significant impact to groundfish EFH in the long term

Potential Impact 3.3-6 Effects on pelagic fish Essential Fish Habitat (EFH) quality due to short-term sediment releases and long-term changes in habitat quality due to dam removal.
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 50 to 78.8°F. Within the Area of Analysis for aquatic resources, this includes the Pacific Ocean nearshore environment. Substantial dilution of the mainstem river SSCs is expected to occur in the nearshore under the Proposed Project, and therefore the SSCs in the nearshore ocean would be expected to be similar to what would occur during existing extreme conditions. Pelagic fish are highly adapted to periods of increased suspended sediment and have the ability to swim away from areas of temporary poor habitat quality. In addition, the area for EFH for pelagic fish affected by the Proposed Project within the near-shore environment is a very small proportion (less than one percent) of the total EFH designated for pelagic species along the Pacific Coast. Overall, there would be no substantial reduction in the quality of pelagic fish EFH, and thus there would be no significant impact to pelagic fish EFH from the Proposed Project in the short term or long term.

Significance
No significant impact to pelagic fish EFH in the short term

No significant impact to pelagic fish EFH in the long term

Potential Impact 3.3-7 Effects on the fall-run Chinook salmon population due to short-term sediment releases and long-term changes in habitat quality, habitat quantity, and hatchery operations due to dam removal.
The potential for the Proposed Project to significantly increase the salmonid population in the Klamath River, including the fall-run Chinook salmon population, is an underlying purpose for the Proposed Project (KHSA 2016, Appendix B: *Definite Plan*). Therefore, as described in Section 2.7 *Proposed Project*, the drawdown timing for J.C. Boyle, Copco No. 1, and Iron Gate reservoirs under the Proposed Project was selected to minimize impacts from sediment release following dam removal under the Proposed Project to aquatic species, including fall-run Chinook salmon. Based on the distribution and life-history timing of fall-run Chinook salmon in the Klamath Basin, only a portion of Chinook salmon adults, juveniles, and smolts are likely to be present in the mainstem Klamath River during the periods of greatest sediment transport between January and March. Most individuals are in tributaries, or further downstream during this time where concentrations would be diluted by tributary inflows. Additionally, the timing of drawdown coincides with periods of naturally high suspended sediment in the Klamath River, to which fall-run Chinook salmon have adapted by avoiding and tolerating.

This potential impact section begins with a summary of the available analysis predicting the response of the fall-run Chinook salmon population to the

Proposed Action in the short- and long-term. The section then discusses in detail the potential short-term and long-term changes from the Proposed Project in each of the five study reaches within the Area of Analysis.

Quantitative modeling of fall-run Chinook salmon populations predict that the Proposed Project would increase Chinook salmon abundance. Modeling of dam removal and existing conditions by Oosterhout (2005) suggests that dam removal would substantially increase Chinook full-run 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) life-cycle model (Evaluation of Dam Removal and Restoration of Anadromy, EDRRA) approach is considered the most intensive and robust conducted to date, because it explicitly addressed the Proposed Project, 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 EDRRA to forecast the abundance of ocean and stream-type Chinook salmon (Type I and Type III life history strategies) for both the Proposed Project and continuation of existing conditions for the years 2012 to 2061. The EDRRA model did not incorporate potential climate change effects. The EDRRA Chinook salmon life cycle model assumes that current management rules (fishery control rule) established by the Pacific Fishery Management Council (PFMC) for management of Klamath River Chinook salmon would remain in place throughout the 50-year period of analysis. The PFMC has regulatory jurisdiction over salmon fishing within the 317,690-square mile exclusive economic zone from three miles to 200 miles off the coast of Washington, Oregon, and California. 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 Project. 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 (40,700 fish) for both alternatives despite the fact that Klamath Basin spawning distribution would be extended by hundreds of miles under the Proposed Project (as described below) and would therefore presumably have a higher escapement target. Therefore, in the EDRRA model, harvest and escapement targets to sustain the population are being managed optimally under existing conditions, whereas under the Proposed Project the escapement target is likely lower than would be required to fill newly accessible habitat. If the PFMC changes management under the Proposed Project based on additional access to spawning and rearing habitat, the harvest and escapement targets could be higher than predicted by the EDRRA model.

The EDRRA model assumes a flow regime under the Proposed Project based on the 2010 BiOp flows (NMFS 2010a), and implicitly incorporates water quality and disease by modeling a smolt survival rate that varies based on flows. The model assumes habitat restoration actions in the Upper- and Mid-Klamath basins, and it further assumes that these actions would take time to become effective. This EIR's analysis selectively uses the EDRRA modeling results that characterize conditions prior to habitat restoration because habitat restoration in the Upper- and Mid-Klamath basins is not included as part of the Proposed Project (aside from habitat restoration in Lower Klamath Project reservoirs). The EDDRA model also assumes active reintroduction efforts described in Hooton and Smith (2008), which 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. Active reintroduction of fall-run Chinook salmon is not currently planned following dam removal under the Proposed Project. Instead, natural volitional reintroduction is anticipated under the Proposed Project and would require a longer time to meet the production levels predicted by the EDRRA model and reported by Hendrix (2011).

The EDRRA model assumes that Iron Gate Hatchery production does not occur under the Proposed Project. Therefore, the eight years of hatchery releases of Chinook salmon, after Lower Klamath Project dam removal, albeit at reduced production goals compared with existing conditions, would somewhat offset the lack of active reintroduction included in the EDRRA model.

From 1978 through 2016, returns of fall-run Chinook salmon adults to the Iron Gate Hatchery have ranged from 2,558 (in 1980) to 72,474 (in 2001), and averaged 16,559 (CDFW 2016b). During the same period, natural returns in the Klamath River (excluding Trinity River returns) ranged from 6,957 to 91,757 fall-run Chinook salmon, with an average of 31,379 fish (CDFW 2016a). While natural returns typically outnumber hatchery returns, the proportion of the Chinook salmon escapement composed of Iron Gate Hatchery returns has historically been substantial (approximately 35 percent of age 3 adults, KRTT 2011, 2013, 2015). Under the Proposed Project, fall-run Chinook salmon smolt releases will decrease by 8 percent relative to current production (2009 through 2017), and yearling releases will decrease by 88 percent relative to current production (2009 through 2017). Based on coded wire tag adult returns (discussed in Section 3.3.2.3 *[Habitat Attributes Expected to be Affected by the Proposed Project] Fish Hatcheries*), these reductions will result in 534 fewer adult returns from smolt releases, and 3,018 fewer adult returns from yearling releases. Based on the same coded wire tag survival to smolt estimates for smolt and yearling releases, recent (2009 through 2017) adult returns are estimated to average 10,009 adult per year and would average 6,457 adult hatchery returns under the Proposed Project, with an estimated 35 percent reduction in adult hatchery returns relative to recent returns. Based on these reductions, it is possible that between post-dam removal years 3 and 10 (Table

3.3-11) an average of 3,552 fewer fish could return on an annual basis due to reduced hatchery releases.

The elimination of the goal of releasing around 3.5 million Chinook salmon smolts and yearlings annually after eight years (post-dam removal year 7) would be anticipated to result in a reduction in adult hatchery returns to the Klamath River. Most adult returns are age 3 (around 75 percent), with some age 4 (around 23 percent), and a few age 5 (less than 2 percent) (KRTT 2011, 2013, 2015). As a result, progeny of hatchery releases are anticipated to return as adults continuing mostly through post-dam removal year 10 (four-year old returns, progeny of final releases in post-dam removal year 7). The first adult returns from the progeny of naturally spawning fall-run Chinook salmon in newly accessible habitat upstream of the location of Iron Gate Dam would be expected in post-dam removal year 3 (3-year old returns, progeny of post-dam removal year 1; Table 3.3-3). Therefore, between post-dam removal years 3 and 10, both hatchery returns and returns from newly accessible habitat would occur, potentially increasing the rate of reintroduction comparable to the effect of active reintroduction assumed in the EDRRA model. Impacts associated with hatcheries operations in relation to water diversions and minimum bypass flows for fish passage is discussed in Potential Impact 3.3-23 (Iron Gate Hatchery) and Potential Impact 3.3-24 (Fall Creek Hatchery).

The amount of time required for the fall-run Chinook salmon population in the Klamath River to reach capacity under the Proposed Project would be a function of adult returns that volitionally recolonize new habitat, although there is no accurate means to predict how much longer it would take to reach full capacity without the active reintroduction modeled using EDRRA. Recolonization success and rate is a function of fish straying into newly available habitats (Pess 2009). For Chinook salmon, stray rates are around six percent (Hendry et al. 2004), and 95 percent of strays migrate less than 20 miles from their natal area (Quinn and Fresh 1984, Quinn et al. 1991). However, following major changes in environmental conditions (e.g., dam removal, high SSC), salmonid stray rates have been observed to increase. For example, Leider (1989) reported steelhead stray rates increasing from 16 percent to 45 percent during recolonization of streams following the Mt. Saint Helens eruption. The time period of colonization (historical or new habitat) has been reported to occur within five to thirty years, with most falling between one to two decades (Withler 1982, Bryant 1999, Burger et al 2000, Glen 2002, Pess et al. 2003, Milner et al. 2008, Kiffney et al. 2009). Rapid (less than one year) recolonization was observed for fall-run Chinook salmon following fish ladder installation at Landsburg Dam on the Cedar River, Washington (Kiffney et al. 2009) and within months of removal of Condit Dam on the White Salmon River, Washington (Allen et al. 2016). Fall-run Chinook salmon were observed to recolonize habitat upstream of the former location of the Elwha Dam within the first year of dam removal, and within five years of dam removal a majority of returning adults were spawning in newly accessible habitat upstream of the former dam location (Weinheimer et al. 2018).

A ladder was placed on the Landsburg Dam in 2003, and Chinook salmon immediately (i.e., the first fall following ladder installation) accessed areas upstream of the dam, with juveniles of both species being observed during snorkel surveys the following year. By 2011, Chinook salmon occurred throughout nearly all accessible habitat upstream of the dam.

It is likely that following dam removal under the Proposed Project, recolonization of the 80 miles of habitat downstream of Keno Dam would be rapid, with a longer timeframe for habitat in the Upper Klamath River and connected waterbodies (and contingent on fish passage being provided at Keno Impoundment/Lake Ewauna). The EDRRA model prediction is that with dam removal there would be substantially more (median increase greater than 10,000) returning adult Chinook salmon in the Klamath Basin than without dam removal, where the prediction is based solely on access to habitat between Iron Gate and Keno dams.

Median escapements to the Klamath Basin are predicted to be higher (median increase greater than 30,000) with the Proposed Project than under existing conditions. The potential for ocean harvest is also predicted to be greater with the Proposed Project due to increased Chinook salmon adults in ocean. This logically would decrease the probability of low escapement leading to fishery closures under the Proposed Project. Modeling results of Hendrix (2011) indicated uncertainty in Chinook salmon stock recruitment dynamics due to the uncertainty in predicting smolt production based on habitat conditions, as well as uncertainty in escapement and harvest abundance forecasts based on habitat conditions. Despite the uncertainty, the results indicate that the Proposed Project would result in higher relative abundance of Chinook salmon.

In addition to the quantitative EDRRA modeling results, FERC (2007) and Hamilton et al. (2011) synthesized all available information and 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 Basin.

Further, to help determine if the Proposed Project would 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 KHSA (2016) stakeholders to assist with assessing the effects of the KHSA compared with existing conditions (Goodman et al. 2011). The Chinook Salmon Expert Panel concluded that Lower Klamath Project dam removal (and habitat restoration actions associated with the KBRA) would be a major step forward in conserving target fish populations in the Klamath Basin. The Chinook Salmon Expert Panel predicted that, based on the information provided to them, it was possible that Lower Klamath Project dam removal 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 Chinook Salmon Expert Panel concluded that Lower Klamath Project dam removal offers greater potential than the existing conditions for Chinook salmon to tolerate climate change and changes in marine survival (Goodman et al. 2011). While the Chinook Salmon Expert Panel agreed that there was also evidence for potential dramatic increases in abundance associated with potential fish passage upstream of Keno Dam as well, they cautioned that achieving substantial gains in Chinook salmon abundance and distribution in the Klamath Basin is contingent upon successfully resolving key factors that would continue to affect the population, including water quality in Upper Klamath Lake and Keno Reservoir, disease, colonization of the Upper Klamath River Basin, harvest and escapement, hatchery interactions, predation by resident fish, climate change, instream flows, and impacts from dam removal. The anticipated influence of the Proposed Project on these factors (among others) within specific reaches is described below.

Upper Klamath River and Connected Waterbodies
As discussed above under 3.3.5.8 *Aquatic Habitat*, under the Proposed Project, removal of the Lower Klamath Project dams would allow fall-run Chinook salmon to regain access to around 360 miles within the upper Klamath River upstream of Upper Klamath Lake (DOI 2007, Hamilton et al. 2005, 2016). 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, 2016). 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-fed areas with relatively cold water that would be resistant to climate change-induced water temperature increases (Hamilton et al. 2011).

As discussed under Section 3.3.5.3 *Water Quality*, the Keno Impoundment/Lake Ewuana has the potential to be a habitat barrier during most years for fall-run Chinook due to poor water quality during the late summer, and therefore NMFS and USFWS prescribed fish passage measures for the Keno Impoundment/Lake Ewuana as part of the Klamath Hydroelectric Project relicensing to be used during periods of poor water quality (DOI 2007, NMFS 2007b). If fish passage were not provided, fall-run Chinook salmon would be limited to the additional habitat access in the Hydroelectric Reach, as described in detail below. Over the long term, seasonal dissolved oxygen in the Keno Impoundment/Lake Ewauna would also be expected to improve as TMDL implementation projects continue. While it would be speculative at this point to identify the timing or scope of such improvements, it is reasonable to assume that the multiple water quality improvement projects would work to shorten the season of impairment in the reach (allowing early and/or later migrants to reach upstream spawning habitat) and to reduce the number of years in which Keno Impoundment/Lake Ewauna's poor water quality forms a barrier to migration.

Upper Klamath River – Hydroelectric Reach

The Proposed Project would restore fall-run Chinook salmon access 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), totaling around 80 miles of potential habitat within the Hydroelectric Reach, including 21.2 miles of habitat currently inundated by Lower Klamath Project reservoirs (DOI 2007, Cunanan 2009). Historically, Chinook salmon (both fall- and spring-run) spawned and were abundant within this habitat (NMFS 2006a, Hamilton et al. 2016). Prior to construction of Iron Gate Dam, Coots and Wales (1952) observed about 300 Chinook salmon spawning in the Copco No. 2 Bypass Reach at around eight cfs, with additional spawning habitat available at the time of survey.

Adults would be able to access this reach starting in September of dam removal year 2 (Table 2.7-1). By fall of dam removal year 2, elevated SSCs from dam removal would have subsided (USBR 2012). Because of this, fall-run Chinook salmon would not be exposed to the elevated SSCs that would occur during dam removal in this reach. Most of the sediment stored within the river channels currently inundated by Lower Klamath Project reservoirs would likely be eroded by the end of spring of dam-removal year 2. The maximum deposition anticipated is minor (less than 0.5 foot), within pockets of the river reaches between reservoirs, settling into pool and other low-velocity habitats as water velocities decrease. This would constitute a negligible and temporary (less than six months following reservoir drawdown in dam removal year 1) reduction in the quality of habitat and would occur prior to the first adult salmon accessing newly available habitat in post-dam removal year 1.

River channel habitat within the reservoir reaches would be primarily low gradient habitat which is of critical importance for salmon spawning and rearing. For example, FERC (2007) described 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, spawning, and rearing habitat for anadromous salmonids.

Modeling (USBR 2012) indicates 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 in the bed within former reservoir sections could initially inhibit spawning success. The bed material within the reservoirs and from Iron Gate Dam 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 (USBR 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 five years following dam removal (see Section 3.6.5.1 *Flood Hydrology*).

Habitat currently within inundated Lower Klamath Project reservoir that would be exposed following dam removal under the Proposed Project is anticipated to be used during the first spawning migration after dam removal (fall of dam removal year 2). A similar rapid recolonization of formally reservoir inundated habitat was observed at two dam removal sites in southern Oregon. Following removal of Savage Rapids Dam on the Rogue River in 2009, 91 redds from within the bounds of the former reservoir were documented where no redds had existed previously in 2010 (the first fall spawning season following dam removal), and more the following year (ODFW 2011). Following removal of the Gold Ray Dam on the Rogue River in 2010, 37 redds were documented from within the bounds of the former reservoir the fall after dam removal, with over twice that many the following year (ODFW 2011).

The Proposed Project would establish flow and water quality conditions that more closely mimics natural conditions by incorporating more variability in daily flows (described in Section 3.6.5.1 *Flood Hydrology*). The reservoir drawdowns would also 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).

In addition, as described in detail in Section 3.3.5.5 *Fish Disease and Parasites*, it is unlikely that the disease conditions that currently exist downstream of Iron Gate Dam would develop upstream of Iron Gate Dam under the Proposed Project.

Middle and Lower Klamath River

In the short term in this reach, the Proposed Project would decrease dissolved oxygen and release dam-stored sediment downstream to the Lower Klamath River. In the long term, the Proposed Project would restore a flow and sediment regime that more closely mimics natural conditions in the long term. Suspended sediment effects on fall-run Chinook salmon under the Proposed Project are described in detail in Appendix E.3.2.1 and summarized here.

During the fall and winter of dam removal year 1, under the least impacts on fish, most-likely impacts on fish, or worst impacts on fish scenario, no impact from suspended sediment is anticipated for all adult fall-run Chinook salmon migrating or spawning within tributaries to the Klamath River, or for juveniles rearing within tributaries (Appendix E, Table E-8). Under the most-likely impacts on fish or worst impacts on fish scenario, complete loss of eggs from the dam removal year 1 brood year deposited in the mainstem in fall of dam removal year 1 is predicted. Based on 556ac surveys from 1999 through 2009 (Magneson and Wright 2010), an average of around 2,100 redds could be affected in the mainstem. As described in detail in Appendix E.3.2.1, based on escapement estimates in the Klamath Basin from 2001 through 2009 (CDFG 2010, unpublished data) on average this would be around eight percent of all anticipated fall-run Chinook salmon redds in the Klamath River Basin in the fall spawning of dam removal year 1.

In dam removal year 2 suspended sediment could be high enough for long enough duration to cause moderate physiological stress for returning adults during the fall under a least impacts on fish scenario, impaired homing under a most-likely impacts on fish scenario, and major physiological stress under the worst impacts on fish scenario (Appendix E.3.2.1). For smolts, in dam removal year 2 suspended sediment is anticipated to have sublethal effects on Type I, Type II, and Type III outmigrants (Appendix E.3.2.1) and would not cause substantial reductions in abundance. The Type I smolts affected by increased SSCs during dam removal year 2 would be the progeny of the same cohort[76] of adult spawners potentially affected by dam removal. However, the Type-II and Type-III progeny of that same cohort of adults that successfully spawn in tributaries during dam removal year 2 would produce smolts that would outmigrate to the ocean a year after the spring pulse of suspended sediment in dam removal year 2 and should not be noticeably affected by the Proposed Project.

In the long term (by post-dam removal year 2), SSC in the Middle and Lower Klamath River are predicted to return to similar levels to existing conditions, and no substantial effect on fall-run Chinook salmon is anticipated.

In the short term, a higher proportion of sand in the mainstem channel bed surface may reduce the quality of spawning habitat in the mainstem Klamath River downstream of Iron Gate Dam. As described in detail in Appendix F, the dam removal year 2 fall-run Chinook salmon cohort could be affected by sediment deposits with higher levels of sand than under existing conditions. After a flushing flow of at least 6,000 cfs, the bed is expected to maintain fractions of sand, gravel, and cobble which would be expected under natural conditions, and suitable for fall-run Chinook salmon. Based on the historical record a sufficient flushing flow would likely occur within five years following dam removal. These effects would be most apparent in successive median or dry years following dam removal, but less apparent in successive wet years (Appendix F). Increased proportion of sand in the spawning substrate could

[76] Cohort is a group of fish born during the same year.

reduce embryo survival-to-emergence (Chapman 1988) for fall-run Chinook salmon spawning during fall of dam removal year 1 (affecting fry that would emerge and smolt during dam removal year 2). Changes in bedload would be limited to the reach from Iron Gate Dam to Cottonwood Creek, a length of eight 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 one percent of the channel downstream from Iron Gate Dam), as sediment deposition would lessen downstream from Bogus Creek to Cottonwood Creek. At most, around eight percent of fall-run Chinook salmon in the Klamath Basin are expected to spawn in the mainstem downstream of Iron Gate Dam prior to dam removal, with an even smaller percentage expected to spawn within the 8-mile affected reach (described in Appendix E.3.2.1).

In the long term, the river would eventually exhibit enhanced habitat complexity due to increased sediment supply, a more natural flow regime, greater sediment transport rates, and more frequent bed mobilization that would increase spawning habitat availability and quality and improve early rearing habitat downstream from Iron Gate Dam (see Appendix F). Bedload sediment movement and transport are vital to create and maintain functional aquatic habitat. An increased supply of gravel from upstream sources is predicted to improve spawning gravel quality and increase the amount of fall-run Chinook salmon spawning habitat downstream from Iron Gate Dam by decreasing the median substrate size to 1.5 to 2.4 in (USBR 2012), within the observed range for Chinook salmon spawning (0.6 to 2.8 in [Kondolf and Wolman 1993]). Pools would likely return to their pre-sediment release depth within one year (USBR 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 (less than two months) reductions in dissolved oxygen are anticipated to occur as a result of high organic SSCs following dam removal, as described in detail in Potential Impact 3.2-9. Despite predicted short-term increases in oxygen demand under the Proposed Project, dissolved oxygen concentrations would generally remain above the minimum acceptable level (5 mg/L) for salmonids of all life stages in this reach. Exceptions to this would occur four to eight weeks following drawdown of J.C. Boyle and Iron Gate reservoirs (i.e., in February dam removal year 2), when dissolved oxygen would remain below 5 mg/L for a distance approximately 48–71 miles downstream from Iron Gate Dam (approximately RM 145 to RM 122). Any incubating fall-Chinook salmon eggs in the river during this time are assumed to have already suffered 100 percent 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 no additional effects are expected.

By eliminating peaking flows in the Hydroelectric Reach and removing the Lower Klamath Project reservoirs, the Proposed Project would support a flow regime that more closely mimics natural conditions in the Lower Klamath River. Flows under the Proposed Project 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 in Section 3.2.5.1 *Water Temperature*, 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 Project, 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 3.3-5), which could support higher growth rates and encourage earlier migration 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 the scientific literature relating to increased growth rates and thermal response of outmigrating salmonids, as summarized by Hoar (1988). In addition, fall-run Chinook salmon spawning in the mainstem during fall would no longer be delayed by water temperatures (reducing prespawn mortality) (Figure 3.3-4), and adult migration would occur in lower water temperatures than under existing conditions (Figure 3.3-5). 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.

As described in Section 3.3.5.5 *Fish Disease and Parasites*, the Proposed Project is expected to disrupt many of the existing congruence of factors that lead to high disease parasite concentrations at locations with multiple water quality stressors for fish and resulting high levels of fish disease.

As described in Section 3.3.5.6 *Fish Hatcheries*, operation of the Iron Gate Hatchery and Fall Creek Hatchery, at a combined reduced capacity for eight years following dam removal, would be likely to reduce hatchery Chinook salmon returns available for ocean or in-river harvest compared with existing conditions. However, naturally-spawning adult returns benefiting from dam removal are predicted to occur beginning in post-dam removal year 3 and the larger returns would begin to offset reductions due to lower hatchery capacity during the first eight years following dam removal and, ultimately, to hatchery closure in post-dam removal year 7.

Also, as described in Section 3.3.5.6 *Fish Hatcheries*, the cessation of juvenile fish releases from Iron Gate Hatchery after eight years may also significantly decrease the amount of competition for food resources and habitat space between hatchery-reared and natural origin smolts and yearlings in the Klamath

River. This would result in higher growth rates for natural origin fish (McMichael et al. 1997), and thus larger size at ocean entry beginning in post-dam removal year 8 (first year of no hatchery releases; Table 3.3-11). Smolt size is correlated with increased marine survival for Chinook salmon (Scheuerell et al. 2009, Feldhaus et al. 2016) which, in conjunction with reduced competition with hatchery smolts in the marine environment (Sweeting et al. 2003), is anticipated to result in increased adult returns as soon as post-dam removal year 10 (three-year-old adult returns). In addition, incidences of disease are expected to be reduced by ending hatchery operations after eight years.

Klamath River Estuary and Pacific Ocean Nearshore Environment
Under the Proposed Project, habitat in the Klamath River Estuary and the Pacific Ocean nearshore environment could be affected by sediment releases during dam removal for approximately three months (January through March) under all scenarios. After this time, SSCs would return to levels similar to existing conditions (see Appendix E). SSCs in the Klamath River 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 3.2.5.2 *Suspended Sediments*). However, the increased SSCs predicted to occur in the estuary would not be of sufficient magnitude or duration to result in substantial sublethal or lethal effects on fall-run Chinook salmon individuals (Appendix E.3.2.1). While the magnitude of SSCs released to the Pacific Ocean nearshore environment would be within the range of natural conditions, the duration of elevated SSCs (i.e., weeks) would be greater than would occur under natural (i.e., storm) conditions (i.e., days). Therefore, there also would be elevated SSCs in the Pacific Ocean nearshore environment relative to existing conditions (see Section 3.2.5.2 *Suspended Sediments*). However, no Chinook salmon adults or juveniles are anticipated to occur within the nearshore environment during this period.

Summary
In the short term, reservoir drawdown under the Proposed Project would result in elevated SSCs, low dissolved oxygen, and altered sand and finer bedload sediment transport and deposition, and would adversely impact fall-run Chinook salmon primarily in the Middle Klamath River downstream of Iron Gate Dam. Fall-run Chinook salmon use the mainstem Klamath River for spawning, rearing, and as a migratory corridor. Direct mortality is predicted for a proportion of fall-run Chinook salmon redds. However, the effect of SSCs from the Proposed Project on the fall-run Chinook salmon population, under all scenarios, is not expected to substantially reduce the population because of variable life histories, the timing of SSC pulses to avoid the most vulnerable fall-run Chinook life stages, the comparatively small number of fall-run Chinook salmon that spawn in the mainstem, 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 lower-Basin tributaries (e.g., Salmon and Trinity rivers)

and thus would be subject only to conditions in the Lower Klamath River, where SSCs resulting from the Proposed Project are expected to be lower due to dilution from tributaries (USBR 2012). Based on no predicted substantial short-term decrease in fall-run Chinook salmon abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to fall-run Chinook salmon under the Proposed Project in the short term.

Although this EIR finds no significant impact on fall-run Chinook salmon In the short term, the KRRC proposes aquatic resource measures AR-1 (Mainstem Spawning) and AR-2 (Juvenile Outmigration) which would further reduce the potential for short-term effects of SSCs on salmonid juveniles, smolts, and eggs, including fall-run Chinook salmon. In addition, although CEQA Guidelines Section 15126.4(a)(3) states that mitigation measures are not required for effects which are not found to be significant, mitigation measures AQR-1 and AQR-2, which would be implemented as a result of significant adverse impacts described for Potential Impact 3.3-1 and Potential Impact 3.3-4, would even further reduce the less than significant short-term effects of the Proposed Project on fall-run Chinook salmon by increasing certainty regarding the effectiveness of the KRRC's proposed aquatic resource measures. Aquatic resource measures are summarized in Section 2.7.8.1 *Aquatic Resource Measures* and detailed in Appendix B: *Definite Plan – Appendix I*. Proposed Aquatic Resource Measure AR-1 includes the development and implementation of a monitoring and adaptive management plan to offset the impacts of Lower Klamath Project dam removal on mainstem spawning. Proposed Aquatic Resource Measure AR-1 actions include a 2-year tributary confluence monitoring effort and addressing sediment and debris obstructions that block volitional upstream passage from the Klamath River into tributaries. Monitoring would occur regularly for the two years following dam removal. Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (No. 11516530) within the first two years following reservoir drawdown would trigger a monitoring effort. Mitigation Measure AQR-1 Mainstem Spawning (detailed above), developed for this EIR, further specifies that monitoring shall also be conducted following a significant flow event, even if that flow event occurs more than two years following dam removal. Proposed Aquatic Resource Measure AR-1 also includes a spawning habitat evaluation on the Klamath River and tributaries in the Hydroelectric Reach. The spawning habitat actions of AR-1 are focused on offsetting impacts of the Proposed Project on Chinook salmon and steelhead. If spawning habitat conditions following dam removal do not meet target metrics[77] developed to offset the anticipated loss of Chinook salmon and steelhead redds due to the Proposed Project, spawning gravel augmentation would be completed within the mainstem, with additional spawning habitat actions within tributaries. Tributary spawning habitat restoration actions to be completed in Jenny Creek, Shovel Creek, Fall Creek, and/or Spencer Creek

[77] Spawning gravel in the amount of 44,100 yd^2 for fall Chinook salmon and 4,700 yd^2 for steelhead

could include removal of artificial fish passage barriers, or placement of large woody debris to trap and retain spawning gravels. Mitigation Measure AQR-1 Mainstem Spawning (detailed above) further specifies the range of actions that shall be conducted in tributaries to offset impacts to Chinook salmon spawning. Proposed Aquatic Resource Measure AR-1 and Mitigation Measure AQR-1 would reduce the less than significant short-term impacts of SSCs on fall-run Chinook salmon spawning in dam removal year 1 by improving access to tributary habitat where impacts from SSCs in the mainstem can be avoided, and by augmenting spawning gravel ensuring that suitable spawning habitat in mainstem and tributaries is available following dam removal.

Proposed Aquatic Resource Measure AR-2 includes three primary actions: (1) salvaging mainstem overwintering juvenile salmonids prior to reservoir drawdown; (2) maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River; and (3) developing a water quality monitoring network, trigger thresholds, and plan for salvaging and relocating juvenile fish from tributary confluence areas to cold water tributaries or nearby off-channel ponds. Implementation of proposed Aquatic Resource Measure AR-2 would reduce the short-term effects of SSCs to fall-run Chinook salmon juveniles rearing in the mainstem during dam removal by actively transporting juveniles from vulnerable mainstem areas to off-channel ponds protected from the effects of the Proposed Project, thus offsetting water quality impacts to juvenile Chinook salmon. Seining efforts would be focused on coho salmon, but all captured juvenile Chinook salmon would also be relocated into tributary streams adjacent to the salvage locations. Proposed Aquatic Resource Measure AR-2 would also reduce the potential short-term effects of SSCs to fall-run Chinook salmon smolts by maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River. Monitoring would occur regularly for the two years following dam removal. Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (No. 11516530) within the first two years following reservoir drawdown would trigger a monitoring effort. Mitigation Measure AQR-2 Juvenile Outmigration (detailed below) developed for this EIR, further specifies that monitoring shall also be conducted following a significant flow event, even if that flow event occurs more than two years following dam removal. In addition, proposed Aquatic Resource Measure AR-2 would reduce the less than significant short-term effects of SSCs to migratory Chinook salmon smolts by rescuing and transporting smolts if mainstem SSC are high, and water temperatures within tributaries are too poor to provide safe refuge (a decision to be made in regular consultation with the ATWG).

These actions would effectively reduce the number of fall-run Chinook salmon juveniles and smolts potentially exposed to periods of high SSC in the mainstem following dam removal, and therefore off-set short-term impacts to the proportion of the population experiencing sub-lethal effects or mortality.

In the long term, removal of the Lower Klamath Project dams under the Proposed Project would increase habitat availability, restore a more natural flow regime by eliminating peaking flows in the Hydroelectric Reach and removing the Lower Klamath Project reservoirs, restoring more natural seasonal water temperature variation, improve water quality, and reduce the likelihood of fish disease, all of which would be beneficial for 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. It is anticipated that the Proposed Project would increase the abundance, productivity, population spatial structure, and genetic diversity of fall-run Chinook salmon in the Klamath Basin (Hendrix 2011). In general, free-flowing river conditions created by the Proposed Project would likely increase adult migration rate, decrease outmigrant delay, and increase 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 Project diminished disease conditions and improved water quality in the mainstem Klamath River would likely improve the survival of smolts outmigrating from tributaries downstream from Iron Gate Dam (e.g., Scott and Shasta rivers). Finally, the loss of hatchery production following the closure of Iron Gate Hatchery and Fall Creek Hatchery following eight years of operation is anticipated to be offset by the increase in natural production from habitat upstream of Iron Gate Dam. If fish passage is not provided a Keno Impoundment/Lake Ewuana, restored habitat access to the Hydroelectric Reach and the multiple benefits of the Proposed Project would be beneficial for fall-run Chinook salmon in the long term. If fish passage were provided (per DOI [2007] fish passage prescriptions), an even greater magnitude of restored habitat access to the Upper Klamath River Basin and the multiple benefits of the Proposed Project would be beneficial for fall-run Chinook salmon in the long term.

Significance

No significant impact for fall-run Chinook salmon populations in the short term

Beneficial for fall-run Chinook salmon populations in the long term

Potential Impact 3.3-8 Effects on the spring-run Chinook salmon population due to short-term sediment releases and long-term changes in habitat quality, habitat quantity, and hatchery operations due to dam removal.

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 Project compared with existing conditions (Goodman et al. 2011). While noting uncertainties based on existing data, the panel concluded that the prospects for the Proposed Project to provide a substantial positive effect for spring-run Chinook salmon were less certain than for fall-run Chinook salmon. The primary concern of the panel was that low abundance and productivity (return per spawner) of spring-run Chinook salmon could limit recolonization of habitats upstream of Iron Gate Dam. A secondary concern was that mainstem water temperatures are predicted to be slightly warmer in the spring (2–4 °C from February to mid-July), which could further constrain upstream movements of spring Chinook salmon during the latter portion of the migration (Goodman et al. 2011). Water temperatures in the mainstem upstream of Iron Gate Dam are discussed in more detail below.

There are a few basic mechanisms by which spring-run Chinook salmon could recolonize newly accessible habitat, including (1) straying of adults returning to the Salmon River, (2) adaptation of fall-run Chinook salmon to an early spring-run Chinook salmon life history, or (3) active reintroduction of spring-run Chinook salmon from another population. There are many examples of fall-run Chinook salmon rapidly recolonizing newly accessible habitat discussed in Potential Impact 3.3-7 above, and spring-run Chinook salmon were observed recolonizing habitat in the White Salmon River, Washington, following removal of Condit Dam (Allen et al. 2016). Following the removal of Condit Dam most of the observed spring-run Chinook salmon spawning was upstream of the location of the former Condit Dam. The current spring-run Chinook salmon abundance in the Salmon River is low (Table 3.3-2), and the rate of recolonization could be slow as a result. However, under the Proposed Project water temperatures and instream flows in the Klamath River upstream of the confluence with the Salmon River are predicted to mimic more natural conditions, which could encourage increased straying into upstream habitat.

The potential for adaptation of fall-run Chinook salmon to a spring-run Chinook salmon life history was assessed by Thompson et al. (2018), and they concluded that based on the genetics of the fall-run Chinook salmon currently downstream of Iron Gate Dam, it was unlikely that this would occur. Active reintroduction of Chinook salmon with genetics suited to adapt to an early spring-run Chinook salmon life history may be successful strategy for recolonization (Thompson et al. 2018). The Proposed Project does not include an active reintroduction plan. Although ODFW drafted an Implementation Plan for the Reintroduction of Anadromous Fishes into the Oregon Portions of the Upper Klamath Basin, implementation of the plan remains uncertain (T. Wise, ODFW, pers. comm., 2018). The draft plan includes active reintroduction of spring-run Chinook salmon into tributaries of the Upper Klamath Lake (T. Wise, ODFW, pers. comm., 2019).

Under the Proposed Project, steelhead, coho, and fall-run Chinook salmon yearlings and smolts would no longer be released from hatcheries in the Klamath River following post-dam removal year 7. Currently there are no releases of spring-run Chinook salmon from hatcheries into the Klamath River. Therefore, the closure of hatcheries eight years following dam removal is not anticipated to result in a decline in adult returns for spring-run Chinook. Impacts associated with hatcheries operations in relation to water diversions and minimum bypass flows for fish passage is discussed in Potential Impact 3.3-23 (Iron Gate Hatchery) and Potential Impact 3.3-24 (Fall Creek Hatchery).

The expected influence of the Proposed Project within specific reaches is described below.

Upper Klamath River and Connected Waterbodies
The Proposed Project would not result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins in this reach. Under the Proposed Project, 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. 2011). 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 input to the river would also be conducive to the growth of salmonids (Hamilton et al. 2011).

Poor water quality (e.g., severe hypoxia, temperatures exceeding 77°F, 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 period from October through May (Maule et al. 2009). Currently, adult spring-run Chinook migration takes place in approximately April through June. 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 thermal refuge habitat upstream of Upper Klamath Lake (Snyder 1931, CDFG 1990c, Moyle 2002). One benefit of such early migration (similar to the spring-run Chinook salmon migration timing currently observed in the Klamath Basin) would be the avoidance of periods of poor water quality in the vicinity of Keno Impoundment/Lake Ewuana. The restored water temperature regime under the

Proposed Project may restore the natural 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). Either under the current migration timing or under a shift towards earlier migration, most or all of the spring-run Chinook salmon migrants would be able to pass upstream through the Keno Impoundment/Lake Ewuana area before seasonal water quality reductions would make passage restricted.

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).

Upper Klamath River – Hydroelectric Reach

The Proposed Project would restore spring-run Chinook salmon access to the Hydroelectric Reach, including 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), comprising around 80 miles of potential habitat within the Hydroelectric Reach (DOI 2007, Cunanan 2009). Chinook salmon (both fall- and spring-run) historically spawned and were abundant within this habitat (NMFS 2006a, Hamilton et al. 2016). Adults would be able to access this reach beginning in spring of dam removal year 2 (Table 2.7-1); thus, short-term gains in flow-related habitat or habitat expansion may be limited to later cohorts. Elevated SSCs and bedload movement from dam removal may not have sufficiently dissipated in time for the first potential migrants, but by the second adult migrant season in post-dam removal year 1, would return to background levels similar to those under existing conditions and would not be expected to affect spring-run Chinook salmon using this area. 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.

The Proposed Project would establish flow and water quality conditions that more closely mimics natural conditions by eliminating peaking flows, removing Lower Klamath Project reservoirs, and 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 Section 3.3.5.5 *Fish Disease and Parasites*, it is unlikely that the disease conditions that currently exist downstream of Iron Gate Dam would develop upstream of Iron Gate Dam under the Proposed Project.

Middle and Lower Klamath River

The Proposed Project would release dam-stored sediment downstream to the Lower Klamath River Reach in the short term and would establish a flow and sediment regime that more closely mimics natural conditions in the Middle Klamath River in the long term.

Short-term effects of elevated SSCs on spring-run Chinook salmon under the Proposed Project are described in detail in Appendix E.3.2.2 and summarized here. Spring-run Chinook salmon are primarily distributed in the Salmon River and other tributaries downstream with limits their exposure to temporarily elevated concentrations of suspended sediment that would occur in the mainstem Klamath River under the Proposed Project. Under all scenarios, no impact from suspended sediment is anticipated for all spring-run Chinook salmon spawning and rearing, which occurs primarily within tributaries (Table E-9). Suspended sediment is anticipated to have sublethal effects on adult migration, primarily for those adults returning to the Salmon River (around five percent of all spring-run migrants). All outmigrating spring-run Chinook salmon smolts enter the Klamath River at the confluence with the Salmon River, where SSC are predicted to be much lower than further upstream, and where SSCs under existing conditions can be high from tributary contributions of suspended sediment. Therefore, only sublethal effects on outmigrants are predicted (Appendix E, Table E-9), which is similar to existing conditions (Appendix E, Table E-3).

Short- and long-term changes in channel bed elevations and grain size in response to increased bedload supply would be limited to the reach from Iron Gate Dam to Cottonwood Creek, a length of eight miles, or four percent of the mainstem Klamath River channel downstream from Iron Gate Dam (see Appendix F for details). The most severe effects would also be limited to a small proportion of the total channel length (0.5 miles, or less than one 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 of post-dam removal year 1), SSCs would have returned to existing conditions and the channel would likely have reverted to its previous pool-riffle morphology (Stillwater Sciences 2008).

By eliminating peaking flows in the Hydroelectric Reach and removing the Lower Klamath Project reservoirs, the Proposed Project would support a flow regime that more closely mimics natural conditions in the Lower Klamath River, mostly upstream of the confluence of Scott Creek. Dam removal would cause water temperatures upstream of the Salmon River confluence 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 temperatures that are more favorable for salmonids in the mainstem upstream of the Salmon River confluence (Section 3.3.5.4 *Water Temperature*). Therefore, in the long term it is anticipated that improved mainstem migration conditions may increase migration of spring-run Chinook salmon upstream of the Salmon River towards newly accessible habitat.

Although disease incidence is predicted to decrease (resulting in increased salmonid smolt survival) under the Proposed Project (see Section 3.3.5.5 *Fish Disease*), these benefits would be most noticeable upstream of the confluence with the Salmon River, and thus are anticipated to have less of benefit for spring-run Chinook salmon than other salmonids in comparison with existing conditions.

Klamath River Estuary and Pacific Ocean Nearshore Environment
Under the Proposed Project, habitat in the Klamath River Estuary could be affected by elevated sediment releases during dam removal for about three months (January through March) when spring-run Chinook salmon smolts could be within the estuary (see Section 3.3.5.1 *Suspended Sediment* and Appendix E). 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 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project* and Appendix E). However, the increased SSCs predicted to occur in the Klamath River Estuary would not be of sufficient magnitude or duration to result in substantial sublethal or lethal effects on spring-run Chinook salmon individuals (Appendix E.3.2.2). While the magnitude of SSCs released to the Pacific Ocean nearshore environment would be within the range of natural conditions, the duration of elevated SSCs (i.e., weeks) would be greater than would occur under natural (i.e., storm) conditions (i.e., days). Therefore, there also would be elevated SSCs in the Pacific Ocean nearshore environment relative to existing conditions (see Section 3.2.5.2 *Suspended Sediments*). However, no Chinook salmon adults or juveniles are anticipated to occur within the nearshore environment during this period.

Summary
In the short term, reservoir drawdown associated with dam removal under the Proposed Project would alter SSCs and bedload sediment transport and bedload deposition. The overall effect of suspended sediment from the Proposed Project on the spring-run Chinook salmon population is not anticipated to differ

substantially from existing conditions. Suspended sediment conditions experienced by adult migrants would result in minor and only sublethal impacts. No impacts are anticipated for the spawning, incubation, and fry stages because they do not occur in the mainstem. Type I, II, and III outmigrants are expected to experience similar conditions under the Proposed Project as under existing conditions. Based on no predicted substantial short-term decrease in spring-run Chinook salmon abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to spring-run Chinook salmon under the Proposed Project in the short term.

Although this EIR finds no significant impact on spring-run Chinook salmon In the short term, the KRRC proposes Aquatic Resource Measures AR-2 (Juvenile Outmigration) which would further reduce the potential for short-term effects of SSCs on salmonid juveniles and smolts, including spring-run Chinook salmon. In addition, although CEQA Guidelines Section 15126.4(a)(3) states that mitigation measures are not required for effects which are not found to be significant, Mitigation Measure AQR-2, which would be implemented as a result of significant adverse impacts described for Potential Impact 3.3-1 and Potential Impact 3.3-4, would even further reduce the potential for short-term, less than significant effects of the Proposed Project on spring-run Chinook salmon by increasing certainty regarding the effectiveness of the KRRC's proposed aquatic resource measure.

Aquatic resource measures are summarized in Section 2.7.8.1 and detailed in Appendix B: *Definite Plan – Appendix I*. AR-2 includes three primary actions: (1) salvaging mainstem overwintering juvenile salmonids prior to reservoir drawdown; (2) maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River; and (3) developing a water quality monitoring network, trigger thresholds, and plan for salvaging and relocating juvenile fish from tributary confluence areas to cold water tributaries or nearby off-channel ponds. Implementation of AR-2 would reduce the short-term effects of SSCs to outmigrating juvenile spring-run Chinook salmon smolts by rescuing and transporting smolts if mainstem SSC are high, and water quality conditions within tributaries do not allow safe refuge. This action would effectively reduce the number of spring-run Chinook salmon smolts potentially exposed to periods of high SSC in the mainstem following dam removal, and therefore reduce the proportion of the population experiencing sub-lethal effects.

In the long term, removal of the Lower Klamath Project dams under the Proposed Project would increase habitat availability, restore a more natural temperature regime, improve water quality, and reduce the likelihood of fish disease, all of which would be beneficial for spring-run Chinook salmon. 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 increased expression of life-history variation and the restoration of an additional population of spring-run Chinook salmon to strengthen resiliency in the Klamath Basin, particularly because passage upstream of Iron Gate Dam would provide access to groundwater-fed 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 Project 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 in the mainstem upstream of the confluence with the Salmon River (Hamilton et al. 2011). These changes would result in water temperatures more favorable for spring-run Chinook salmon in the mainstem, supporting any portion of the population that recolonizes Klamath River Basin habitat upstream of the Salmon River. It is anticipated that, as a result of the Proposed Project, the spring-run Chinook salmon population within the Klamath Basin would have an opportunity to increase in abundance, and would have increased productivity, population spatial structure, and genetic diversity. Implementation of the Proposed Project would be beneficial for spring-run Chinook salmon in the long term.

Significance

No significant impact for spring-run Chinook salmon populations in the short term

Beneficial for spring-run Chinook salmon populations in the long term

Potential Impact 3.3-9 Effects on coho salmon populations due to short-term sediment releases and long-term changes in habitat quality, habitat quantity, and hatchery operations due to dam removal.

The Coho Salmon and Steelhead Expert Panel was convened and charged with answering specific questions that had been formulated to assist with assessing the effects of the Proposed Project on coho salmon (Dunne et al. 2011). While noting the constraints of the Coho Salmon and Steelhead Expert Panel to arrive at conclusions within a short time, and without adequate quantitative or synthesized information, the conclusion of the Coho Salmon and Steelhead Expert Panel was that, in the short term, the difference between the Proposed Project and existing conditions is expected to be small. The Coho Salmon and Steelhead Expert Panel stated that larger (moderate) increases in abundance are possible under the Proposed Project if additional restoration actions are implemented, and mortality caused by the pathogen *C. shasta* is reduced. The Coho Salmon and Steelhead Expert Panel predicted a small increase in the population from a modest increase in habitat area usable by coho salmon, small changes in conditions in the mainstem, and positive but un-quantified changes in tributary habitats where most coho spawn and rear. The Coho Salmon and Steelhead Expert Panel also concluded that dam removal would provide greater mitigation to climate change for coho salmon than existing conditions. The Coho

Salmon and Steelhead Expert Panel also noted the potential for increased disease risk and low ocean survival to offset gains in production in the new habitat, although no evidence for either increased disease risk or reduced ocean survival was presented.

Under the Proposed Project, hatchery coho salmon smolts would be released from Fall Creek Hatchery into the Klamath River at current (75,000 smolts annually) production goals for eight years following dam removal. During that eight-year period no change to the coho salmon population resulting from hatchery operations relative to existing conditions is anticipated. Eight years following dam removal, all hatchery coho salmon releases would cease (final releases would occur in dam removal year 7). Based on production goals, ceasing operations after eight years would likely result in a reduction of up to 75,000 coho salmon smolts per year beginning in post-dam removal year 8 (Table 3.3-11). Based on the current low abundance of coho salmon in the upper Klamath River population unit, a conservation focus for the coho salmon hatchery program has been deemed necessary to protect the remaining genetic resources of that population unit (CDFW and PacifiCorp 2014). Assuming smolts are released for the last time in post-dam removal year 7, adults of hatchery progeny would continue to return through post-dam removal year 9 (as age 3 adults). Based on the average coho salmon smolt-to-adult survival ratio of 0.99 percent estimated for current coho salmon Iron Gate Hatchery operations (CDFW and PacifiCorp 2014), a reduction in the release of 75,000 coho salmon smolts following closure of Fall Creek Hatchery could result in a decline of around 743 adult returns on average annually starting in post-dam removal year 10. These adults would return to the Fall Creek Hatchery, but also stray and spawn naturally. Between 2004 and 2011 an average of 46 coho salmon hatchery adults per year strayed into Bogus Creek (CDFW and PacifiCorp 2014). Impacts associated with hatcheries operations in relation to water diversions and minimum bypass flows for fish passage is discussed in Potential Impact 3.3-23 (Iron Gate Hatchery) and Potential Impact 3.3-24 (Fall Creek Hatchery).

As described in Section 3.3.5.6 *Fish Hatcheries* and summarized in CDFW (2014), there are potential adverse hatchery-related effects on the coho salmon population, including straying of hatchery fish into important tributaries such as Bogus Creek (first three years) and Fall Creek (years four through ten) with the potential to reduce the reproductive success of the natural population (Mclean et al. 2003, Chilcote 2003, Araki et al. 2007) and negatively affect the diversity of the Klamath River coho salmon populations via outbreeding depression[78] (Reisenbichler and Rubin 1999). The current Hatchery Genetic Management Plan for Iron Gate Hatchery coho salmon (HGMP, CDFW and PacifiCorp 2014) operates to assist in the basin's coho salmon recovery efforts by conserving a full range of the existing genetic, phenotypic, behavioral, life history, and ecological

[78] Outbreeding depression is progeny that are less adapted to the environment than parents.

diversity of the run. The intent of this program is to use genetic analysis in brood stock selection and rearing and release techniques improve fitness and reduce straying of hatchery fish to natural spawning areas.

Under the Proposed Project, dam removal and the associated habitat improvements are anticipated to result in an increase in coho salmon abundance. The first adults that could potentially access newly available habitat upstream of Iron Gate Dam would be in dam removal year 2 (Table 3.3-11) and produce age 1 smolts benefiting from improved river function (e.g., reduced disease in the Middle Klamath River). Therefore, the first adult returns that could reflect improved conditions would be in post-dam removal year 4 (as age 3 adults). Under existing conditions, CDFW (2014) estimates that greater than 30 percent of the total adult returns to the upper Klamath River are of hatchery origin, including greater than 70 percent of returns to the hatchery, around 34 percent of returns to Bogus Creek, and around 16 percent of returns to tributaries such as the Shasta and Scott rivers. Between post-dam removal years 4 and 10, both hatchery returns and returns from newly accessible habitat, would occur (Table 3.3-11) providing a likelihood of increased abundance and recolonization of the newly accessible habitat.

As described in Section 3.3.5.6 *Fish Hatcheries*, outmigrant smolt mortality from disease would be reduced under the Proposed Project starting in post-dam removal year 8 with the end of Chinook and coho salmon hatchery releases. The cessation of juvenile fish releases may also significantly decrease the amount of competition for food resources and habitat space between hatchery-reared and natural origin smolts in the Klamath River. This would result in higher growth rates for natural origin fish (McMichael et al. 1997), and thus larger size at ocean entry beginning in dam removal year 8. Smolt size is correlated with increased marine survival for coho salmon (Holtby et al. 1990), which in conjunction with reduced competition with hatchery smolts in the marine environment (Sweeting et al. 2003) is anticipated to result in increased adult returns as soon as post-dam removal year 10 (3-year-old adult returns). Although existing data are not available for a quantitative prediction, it is anticipated that benefits from dam removal and cessation of hatchery operations would increase adult returns by more than the loss of hatchery progeny.

Upper Klamath River and Connected Waterbodies

Available data suggests that coho salmon were in both mainstem and tributary reaches of the Klamath River upstream to and including Spencer Creek at RM 232.6 (Figure 3.3-1, NRC 2004, as cited in NMFS 2007a, Hamilton et al. 2005). It is not anticipated that under the Proposed Project coho salmon would begin to occupy habitat within the Upper Klamath River and connected waterbodies, and therefore this reach is not analyzed for effects on coho salmon.

Upper Klamath River – Hydroelectric Reach

The Proposed Project would restore access 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), comprising around 80 miles of potential habitat within the Hydroelectric Reach (DOI 2007, Cunanan 2009). Coho salmon downstream from Iron Gate Dam belonging to the Upper Klamath River Population Unit would migrate upstream of the dam if access was provided (NMFS 2006a). Over time, access to habitat upstream of 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) increasing genetic diversity in the coho stocks; and c) reducing the species' vulnerability to the impacts of degradation. These benefits would cumulatively result in an increase in the abundance of the coho salmon population (NMFS 2006a). The National Research Council (NRC) of the National Academy of Sciences 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). Coho salmon recolonization of newly accessible habitat was observed following fish ladder installation at Landsburg Dam on the Cedar River, Washington (Kiffney et al. 2009), and following removal of Condit Dam on the White Salmon River, Washington (Allen et al. 2016). The Landsburg Dam was laddered in 2003, and coho salmon were observed within areas upstream of the dam within the first year. By 2011 salmon (with coho salmon being most abundant) occurred within nearly all of the accessible habitat upstream of the dam. Pess (et al. 2011) predicted that within the habitat upstream of Landsburg Dam juvenile coho salmon would establish a population that outnumbered resident salmonid species (e.g., rainbow trout, cutthroat trout) by 40 percent within five years of colonization, suggesting a strong ability of coho salmon to successfully occupy newly accessible habitat.

By eliminating peaking flows in the Hydroelectric Reach and removing the Lower Klamath Project reservoirs, the Proposed Project would support a flow regime that more closely mimics natural conditions in the Lower Klamath River. The reservoir drawdowns would also 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 Section 3.3.5.5 *Fish Disease and Parasites*, risk of fish disease and parasites for coho salmon would decrease.

Adults would be able to access the Hydroelectric Reach beginning in fall of dam removal year 2. 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 June of dam removal year 2), returning sections of river currently inundated by the Lower Klamath Project reservoirs and riverine sections between reservoirs to pool-riffle morphology. Within this reach, coho salmon would generally spawn in tributaries and not within the mainstem Klamath River but might rear in 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 individual coho 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). Removal of the Lower Klamath Project reservoirs would result in more favorable water temperature for coho salmon adult migrants, juveniles, and smolts. As described in detail in Section 3.3.5.5 *Fish Disease and Parasites*, it is unlikely that the disease conditions that currently exist downstream of Iron Gate Dam would develop upstream of Iron Gate Dam under the Proposed Project. Access to this reach and the habitat conditions within it would benefit the Upper Klamath River coho salmon population.

Middle and Lower Klamath River

The Proposed Project would release dam-stored sediment downstream to the Lower Klamath River Reach in the short term and would establish a flow and sediment regime that more closely mimics natural conditions in the long term. Suspended sediment effects on coho salmon under the Proposed Project are described in detail in Appendix E.3.2.3, and summarized here.

There are nine coho salmon population units in the Klamath Basin (see the coho salmon subsection of Section 3.3.2.1 *Aquatic Species*). 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. Effects on the Salmon River Population Unit are anticipated to remain similar to existing condition (SEV ranging from 5.4 to 8.4 with sublethal physiological stress) even under a worst impacts on fish scenario (Appendix E.3.2.3, Table E-10), due to dilution of suspended sediment from tributaries in the Middle Klamath River. Effects on the Upper Klamath River, Mid-Klamath River, Shasta River, and Scott River population units under all scenarios are anticipated to be sublethal on most life-stages (Appendix E.3.2.3). Under all scenarios, the small proportion of coho salmon from the Upper Klamath River Population Unit that spawn in the mainstem, as well as their progeny, would suffer 60 to 80 percent mortality due to the effects of suspended sediment on these life stages. This compares to existing conditions high rate of mortality for this small proportion of mainstem spawners predicted to be from 20 to 60 percent depending on severity of conditions (Appendix E.3.1.3). It is believed by experts in the watershed that progeny of mainstem spawning coho salmon experience reduced survival compared to fish produced from tributary spawners (Simondet 2006), since rearing and growth conditions within tributaries are more favorable than in the mainstem. Based on spawning surveys conducted from 2001 through 2017 (Magneson and Gough 2006, Hentz and Wickman 2016, Dennis et al. 2017), from 0 to 13 redds could be affected in dam removal year 1 during the Proposed Project. Many of these redds are thought to be from returning hatchery fish (NMFS 2010a), and thus may be only selecting this habitat after failing to locate the hatchery collection site. Based on the range of escapement estimates of Ackerman et al. (2006), 13 redds (the highest number observed) would be much less than one percent of the natural and hatchery returns to the Klamath River Basin. The Upper Klamath River Population Unit would be expected to recover from these losses in the long term, given the benefits to the population.

Coho salmon smolts from the dam removal year 1 cohort are expected to outmigrate to the ocean beginning in late February, although most natural origin smolts outmigrate to the mainstem Klamath River during April and May (Wallace 2004). Coho smolt releases from Iron Gate Hatchery typically occur in the first three weeks of April (CDFW and PacifiCorp 2014). Numerous field and laboratory studies have shown that juvenile salmonids actively avoid exposure to high (> 150 mg/L) SSCs, including altering migratory patterns to seek lower turbidity (Bisson and Bilby 1982, Berg and Northcote 1985, Redding et al. 1987, Servizi and Martens 1992, Bash et al. 2001, Carlson et al. 2001, Kemp et al. 2011, Kjelland et al. 2015). Therefore, it is assumed that coho salmon outmigration during the spring of dam removal year 2 would occur within the period of typical outmigration with the lowest predicted SSC. Once in the mainstem Klamath River, coho salmon smolts move downstream fairly quickly (Stutzer et al. 2006). Under the Proposed Project, SSCs would be slightly higher during spring than under existing conditions, and coho salmon smolts are likely to suffer moderate to major stress and reduced feeding depending on scenario (Appendix E.3.2.3, Table E-10).

Under existing conditions, coho salmon smolts outmigrating from the Upper Klamath River, Scott River, and Shasta River populations currently have high mortality rates (35 to 70 percent) presumably as a result of poor water quality and disease (Beeman et al. 2007, 2008), which, in conjunction with physiological stress and reduced growth resulting from the Proposed Project, could result in higher mortality than under existing conditions in the spring of dam removal year 2.

Based on the results of coho salmon outmigrant trapping by the USFWS (2001) on the mainstem Klamath River compared with trapping in the Trinity River from 1997 to 2000 (USFWS 2011), most (greater than 80 percent) coho smolts originate from the Trinity River and Lower Klamath River populations. For the majority of coho salmon smolts, produced from tributaries downstream from Orleans, effects of the Proposed Project would be similar to existing conditions by late April.

The Proposed Project would also result in the release of coarse sediment, as described in Section 3.11 *Geology, Soils, and Mineral Resources* and Appendix F of this EIR. Impacts associated with the release of coarse sediment are expected to affect the same individuals described for suspended sediment above. For example, coarse sediment is predicted to bury redds constructed in fall of dam removal year 1, which are the same redds expected to suffer from suspended sediment (potentially from 0 to 13 redds). In addition, sediment deposition could aggrade pools or overwhelm other habitat features that coho salmon use for adult holding or juvenile rearing. However, the sediment impact on habitat is anticipated to be short term, and pools would likely return to their pre-sediment release depth within one year (USBR 2012).

Additionally, as described in Potential Impact 3.2-1 and Potential Impact 3.2-2, water quality improvements are anticipated to reduce stress to smolts, improving fitness and survival. As discussed in detail in Section 3.2.5.1 *Water Temperature*, dam removal would 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 coho salmon and other salmonids in the mainstem. Cooler water temperatures during fall would benefit upstream migrant adults during fall upstream migration and juvenile redistribution to overwintering habitats by providing a broader window of suitable habitat, starting in dam-removal year 2. A predicted earlier outmigration in response to elevated water temperatures in the spring is also supported by of the scientific literature relating to increased growth rates and thermal response of outmigrating salmonids, as summarized by Hoar (1988). Spring outmigrants could therefore begin an earlier outmigration starting in post-dam-removal year 1, potentially reducing their susceptibility to disease. Coincident with increased with SSCs, in the short term, migrating adults and juveniles rearing or migrating in the mainstem would be exposed to reductions in dissolved oxygen due to the Proposed Project. The risk of sublethal physiological stress and avoidance behavior predicted for migrating adults and juveniles rearing or migrating in the mainstem after dam removal resulting from increased suspended sediment is anticipated to be further exacerbated by reductions in dissolved oxygen.

As described in Section 3.3.5.5 *Fish Disease and Parasites*, the Proposed Project is expected to disrupt many of the existing congruence of factors that lead to high disease parasite concentrations at locations with multiple water quality stressors for fish and resulting high levels of fish disease.

Klamath River Estuary and Pacific Ocean Nearshore Environment
Under the Proposed Project, habitat in the Klamath River Estuary could be affected by elevated sediment during dam removal for about three months (January through March) when a low abundance of coho salmon smolts could be within the estuary during their outmigration to the ocean. 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 3.3.5.1 *Suspended Sediment*). However, the increased SSCs predicted to occur in the estuary would not be of sufficient magnitude or duration to result in substantial sublethal or lethal effects on coho salmon individuals (Appendix E.3.2.3). While the magnitude of SSCs released to the Pacific Ocean nearshore environment would be within the range of natural conditions, the duration of elevated SSCs (i.e., weeks) would be greater than would occur under natural (i.e., storm) conditions (i.e., days). Therefore, there also would be elevated SSCs in the Pacific Ocean nearshore environment relative to existing conditions (see Section 3.2.5.2 *Suspended Sediments*). However, no coho salmon adults or juveniles are anticipated to occur within the nearshore environment during this period.

Summary

In the short term, reservoir drawdown associated with dam removal under the Proposed Project could alter SSCs and bedload sediment transport and deposition, causing both lethal and sub-lethal impacts to coho salmon at all life stages. In general, the wide distribution and use of tributaries by both juvenile and adult coho salmon would likely protect the population from the worst short-term impacts of the Proposed Project. A small amount of direct mortality is anticipated for redds from the Upper Klamath Population Unit, and no mortality is anticipated for the other population units under all scenarios. Based on no predicted substantial short-term decrease in coho salmon abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to coho salmon under the Proposed Project in the short term.

Although this EIR finds no significant impact on coho salmon In the short term, the KRRC proposes aquatic resource measures AR-1 (Mainstem Spawning), AR-2 (Juvenile Outmigration), and AR-4 (Iron Gate Hatchery Management) which would further reduce the potential for short-term effects of SSCs on coho salmon eggs, juveniles, and smolts (natural and hatchery production). In addition, although CEQA Guidelines Section 15126.4(a)(3) states that mitigation measures are not required for effects which are not found to be significant, mitigation measures AQR-1 and AQR-2, which would be implemented as a result of significant adverse impacts described for Potential Impact 3.3-1 and Potential Impact 3.3-4, would even further reduce the potential for short-term effects of the Proposed Project on coho salmon by increasing certainty regarding the effectiveness of the KRRC's proposed aquatic resource measures. Aquatic resource measures are summarized in Section 2.7.8.1 *Aquatic Resource Measures* and detailed in Appendix B: *Definite Plan – Appendix I*. Proposed Aquatic Resource Measure AR-1 includes the development and implementation of a monitoring and adaptive management plan to offset the impacts of Lower Klamath Project dam removal on mainstem spawning. Proposed Aquatic

Resource Measure AR-1 actions include a 2-year tributary confluence monitoring effort and addressing sediment and debris obstructions that block volitional upstream passage from the Klamath River into tributaries. Monitoring would occur regularly for the two years following dam removal. Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (No. 11516530) within the first two years following reservoir drawdown would trigger a monitoring effort. Mitigation Measure AQR-1 Mainstem Spawning (detailed in Potential Impact 3.3-1 above) further specifies that monitoring shall also be conducted following a significant flow event, even if that flow event occurs more than two years following dam removal. Proposed Aquatic Resource Measure AR-1 also includes a spawning habitat evaluation on the Klamath River and tributaries in the Hydroelectric Reach. Most coho salmon spawning occurs in tributaries, and very few coho salmon have been observed spawning in the mainstem Klamath River. Therefore, the spawning habitat actions of Proposed Aquatic Resource Measure AR-1 are focused on offsetting impacts of the Proposed Project on Chinook salmon and steelhead. However, due to the similar spawning habitat requirements of coho salmon to both species, these actions would benefit them as well. If mainstem spawning habitat conditions following dam removal do not meet target metrics[79] developed to offset the anticipated loss of Chinook salmon and steelhead redds due to the Proposed Project, spawning gravel augmentation would be completed within the mainstem, with additional spawning habitat actions within tributaries. Tributary spawning habitat restoration actions to be completed in Jenny Creek, Shovel Creek, Fall Creek, and/or Spencer Creek could include removal of artificial fish passage barriers, or placement of large woody debris to trap and retain spawning gravels. Mitigation Measure AQR-1 Mainstem Spawning (detailed in Potential Impact 3.3-1 above) further specifies the range of actions that shall be conducted in tributaries to offset impacts to coho salmon spawners. Implementation of Proposed Aquatic Resource Measure AR-1 and Mitigation Measure AQR-1 would reduce the short-term potential impacts of SSCs on coho salmon spawning in dam removal year 2 by improving access to tributary habitat where impacts from SSC on habitat in the mainstem can be avoided, and by augmenting spawning gravel ensuring that suitable spawning habitat in mainstem and tributaries is available following dam removal.

Proposed Aquatic Resource Measure AR-2 includes three primary actions: (1) salvaging mainstem overwintering juvenile salmonids prior to reservoir drawdown; (2) maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River; and (3) developing a water quality monitoring network, trigger thresholds, and plan for salvaging and relocating juvenile fish from tributary confluence areas to cold water tributaries or nearby off-channel ponds. Implementation of AR-2 would reduce the short-term effects of SSCs to coho salmon juveniles rearing in the mainstem during dam

[79] Spawning gravel in the amount of 44,100 yd^2 for fall Chinook salmon and 4,700 yd^2 for steelhead

removal by actively transporting up to 500 coho salmon juveniles from vulnerable mainstem areas to off-channel ponds protected from the effects of the Proposed Project, thus offsetting water quality impacts to these coho salmon individuals. Proposed Aquatic Resource Measure AR-2 would also reduce the potential short-term effects of SSCs to migrating coho salmon smolts by maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River. Monitoring would occur regularly for the two years following dam removal. Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (No. 11516530) within the first two years following reservoir drawdown would trigger a monitoring effort. Mitigation Measure AQR-2 Juvenile Outmigration (detailed in Potential Impact 3.3-1 above) further specifies that monitoring shall also be conducted following a significant flow event, even if that flow event occurs more than two years following dam removal. In addition, proposed Aquatic Resource Measure AR-2 would reduce the potential short-term effects of SSCs to migrating coho salmon smolts by rescuing and transporting smolts if mainstem SSC are high, and water temperatures within tributaries are too poor to provide safe refuge (a decision to be made in regular consultation with the ATWG). These actions would effectively reduce the number of coho salmon juveniles and smolts potentially exposed to periods of high SSC in the mainstem habitat following dam removal, and therefore reduce the proportion of the population experiencing sub-lethal effects or mortality.

The Proposed Project would shift all production of Iron Gate Hatchery coho salmon (75,000 yearling goal) to Fall Creek Hatchery. In the short term, transfer of coho salmon production from Iron Gate Hatchery to Fall Creek Hatchery would have no impact on adult returns. In addition, proposed Aquatic Resource Measure AR-4 proposes that hatchery-reared yearling coho salmon to be released in the spring of dam removal year 2 be held at Iron Gate Hatchery or Fall Creek Hatchery until water quality conditions in the mainstem Klamath River improve to sublethal levels. This would reduce the short-term effects of SSCs to coho salmon smolt released from the hatchery by decreasing the probability that they would be exposed to peak SSC levels, and would increase survival during downstream migration in dam removal year 2.

In the long term, removal of the Lower Klamath Project dams under the Proposed Project would increase habitat availability, restore a more natural flow regime by eliminating peaking flows in the Hydroelectric Reach and removing the Lower Klamath Project reservoirs, restoring more natural seasonal water temperature variation, improve water quality, and reduce the likelihood of fish disease, all of which would be beneficial for coho salmon populations. Substantial declines in abundance resulting from effects of the Proposed Project are not anticipated for more than one-year class (i.e., one generation). 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. Dam removal would also cause water temperatures to become warmer earlier in the spring and early summer, 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 the long term, increased adult returns resulting from newly accessible habitat upstream of Iron Gate Dam would offset reductions in adult returns due to cessation of hatchery operations eight years following dam removal. It is anticipated that as a result of the Proposed Project, the coho salmon population would experience an increase in abundance, productivity, population spatial structure, and genetic diversity. In general, free flowing river conditions under the Proposed Project would likely increase adult migration efficiency, decrease outmigrant delay, and increase adult escapement (Buchanan et al. 2011b). The Proposed Project would provide multiple benefits to coho salmon from all Klamath River population units in the long term.

Significance
No significant impact for coho salmon populations in the short term

Beneficial for coho salmon populations in the long term

Potential Impact 3.3-10 Effects on the steelhead population due to short-term sediment releases and long-term changes in habitat quality, habitat quantity, and hatchery operations due to dam removal.
The Coho Salmon and Steelhead Expert Panel was convened and charged with answering specific questions that had been formulated to assist with assessing the effects of the Proposed Project on steelhead (Dunne et al. 2011). The conclusion of the Coho Salmon and Steelhead Expert Panel was that the Proposed Project could increase the 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), steelhead 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 currently migrate to habitat directly downstream of Iron Gate Dam (e.g., Bogus Creek), and are not yet rare. The Coho Salmon and Steelhead Expert Panel also concluded that dam removal would provide greater mitigation to climate change for steelhead than existing conditions (Dunne et al. 2011). It is likely that steelhead recolonization would occur rapidly, as was observed for similar steelhead populations following fish ladder installation at Landsburg Dam on the Cedar River, Washington (Kiffney et al. 2009), and following removal of Condit Dam on the White Salmon River, Washington (Allen et al. 2016). Steelhead recolonization of habitat upstream of Condit Dam was notable, with steelhead spawning observed in upper basin tributaries within five years of dam removal.

Under the Proposed Project, steelhead, coho, and fall-run Chinook salmon yearlings and smolts would no longer be released from hatcheries in the Klamath River following post-dam removal year 7. Currently there are no releases of steelhead from hatcheries into the Klamath River. Therefore, the closure of hatcheries eight years following dam removal is not anticipated to result in a decline in adult returns for steelhead. Impacts associated with hatcheries operations in relation to water diversions and minimum bypass flows for fish passage is discussed in Potential Impact 3.3-23 (Iron Gate Hatchery) and Potential Impact 3.3-24 (Fall Creek Hatchery).

The impacts of the Proposed Project on steelhead populations within specific reaches are described below.

Upper Klamath River and Connected Waterbodies

Under the Proposed Project, dam removal would allow steelhead to regain access to the Upper Klamath River upstream of J.C. Boyle Reservoir. Under the Proposed Project, the population's distribution would likely expand to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood rivers (Hamilton et al. 2005). As discussed under Section 3.3.5.3 *Water Quality*, in some years poor water quality in the Keno Impoundment/Lake Ewuana reach may prevent the latest migrants of the summer steelhead run and the earlier migrants from the fall run from accessing upstream spawning habitat in these upper reaches. If no upstream trap and haul is provided at Keno, these fish would be likely to spawn in habitat downstream of Keno Dam in the Hydroelectric Reach (described below), or, in the case of fall-run steelhead, hold below the dam until conditions become passable. However, the majority of the summer steelhead adult migration, much of the fall-run adult steelhead migration, and all of the winter adult steelhead migration is anticipated to occur outside the mid-June to mid-November timeframe in which water quality in the Keno Impoundment/Lake Ewuana reach is typically so poor as to present a migration barrier to adult salmonids. Similarly, juvenile outmigration and run-backs also occur outside this timeframe. Under the Proposed Project, there would be a potential increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising around 360 miles of additional potentially productive habitat (Huntington 2006, DOI 2007, NMFS 2007b).

Upper Klamath River – Hydroelectric Reach

In the long term, the Proposed Project would restore steelhead access to habitat upstream of Iron Gate Dam and below J.C. Boyle, including an estimated 80 miles of habitat within the Hydroelectric Reach (DOI 2007, Cunanan 2009). Reaches currently inundated by reservoirs and reaches between reservoirs would likely return to a pool-riffle morphology, which would benefit steelhead.

In the short term, adults could first access this reach in winter (summer steelhead) or fall (winter steelhead) of dam removal year 2. Because redband/rainbow trout (*Oncorhynchus mykiss sp.*) are already present in all free-flowing portions of the Hydroelectric Reach and resident *O. mykiss* have similar life history requirements for spawning and rearing habitats as steelhead, it is probable that steelhead will readily use these reaches once the habitats become accessible. Further, Hamilton et al. (2005) summarizes historical evidence of steelhead using tributary streams in the Hydroelectric Reach, including Camp Creek, Spencer Creek, Shovel Creek, Scotch Creek, and Fall Creek. Steelhead could use the Hydroelectric Reach as a migration corridor, as most sediment released from the reservoirs would likely be eroded within the first six months after reservoir drawdown (by June of dam removal year 2) and would not impede upstream movement. By late spring of removal year 2, elevated SSCs resulting from dam removal would likely have returned to low levels unlikely to impact steelhead.

By eliminating peaking flows in the Hydroelectric Reach and removing the Lower Klamath Project reservoirs, the Proposed Project would support a flow regime that more closely mimics natural conditions in the Lower Klamath River. The reservoir drawdowns would also 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).

Middle and Lower Klamath River

The Proposed Project 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. Short-term suspended sediment effects on steelhead populations under the Proposed Project are described in detail in Appendix E.3.2.4 and summarized here.

Under all scenarios, sublethal effects from suspended sediment are anticipated for adult migrants, all spawning (which occurs primarily in tributaries), and outmigrating smolts (Appendix E.3.2.4, Table E-11). As detailed in Appendix E.3.2.4, mortality is anticipated for the following steelhead life-stages:

- Half-pounder adult: Mortality ranging from just under 20 percent of those present in the mainstem under a least impacts on fish or most-likely impacts on fish scenario, to just over 20 percent under a worst impacts on fish scenario (data on half pounder adult abundance is lacking). Majority remain in tributaries and would not be affected. Some would enter tributaries if conditions within the mainstem were adverse.
- Juvenile age 0: No mortality under a least impacts on fish or most-likely impacts to fish scenario, up to 20 percent mortality of those present in the mainstem under a worst impacts on fish scenario (up to 843 juveniles or around 3 percent of population basin-wide age 0 production in a worst impacts on fish scenario).

- Juvenile age 1: 0 to 20 percent of those present in the mainstem under a least impacts on fish scenario, or up to 40 percent mortality under the most-likely impacts to fish or worst impacts on fish scenario (up to 6,314 juveniles or around 11 percent of population basin-wide age 1 production).
- Juvenile age 2: 0 to 20 percent of those present in the mainstem under a least impacts on fish scenario, or up to 40 percent mortality under the most-likely impacts to fish or worst impacts on fish scenario (up to 5,303 juveniles or around 10 percent of population basin-wide age 2 production in a worst impacts on fish scenario).

As described in detail in Section 3.11 *Geology, Soils, and Mineral Resources* and Appendix F, dam-released sediment associated with the Proposed Project might aggrade pools or overwhelm other habitat features currently used for adult holding and juvenile rearing upstream of Cottonwood Creek. The effect would be short term (less than one year), as pools would quickly return to their pre-sediment release depth (USBR 2012). Within six months the river would revert to and maintain the pool-riffle morphology that currently exists. In the long term, under the Proposed Project, bedload sediment transport would restore vital aquatic habitat for steelhead.

As discussed in detail above, dam removal would cause water temperatures to warm earlier in the spring and early summer, 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 temperatures that are 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 Project, but these effects would be short term and of limited spatial extent, and not likely to be of sufficient magnitude to exacerbate effects substantially beyond those anticipated for increased suspended sediment. Long-term effects of the Proposed Project would benefit steelhead using the Lower Klamath River.

The Iron Gate Hatchery does not currently produce steelhead smolts, and no steelhead releases are included under the Proposed Project. Therefore, discontinuing hatchery operations under the Proposed Project would not have a direct effect on the steelhead population, although it would eliminate the potential for additional hatchery production were sufficient numbers of steelhead to enter the hatchery again. As described in Section 3.3.5.6 *Fish Hatcheries*, and 3.3.5.5 *Fish Disease and Parasites*, incidences of disease are expected to be reduced under the Proposed Project through changes to a number of factors underlying disease prevalence. Reducing polychaete habitat would likely reduce the prevalence of *P. minibicornis* infection, although the benefit to the steelhead would not be as great as for coho and Chinook salmon because they are resistant to *C. shasta*.

Klamath River Estuary and Pacific Nearshore Environment

Under the Proposed Project, habitat in the estuary could be affected by elevated sediment releases during dam removal for about three months (January through March) when a low abundance of steelhead juveniles and smolts could be within the Klamath River Estuary. 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 3.3.5.1 *Suspended Sediment*). However, the increased SSCs predicted to occur in the estuary would not be of sufficient magnitude or duration to result in substantial sublethal or lethal effects on steelhead salmon individuals (Appendix E.3.2.3). While the magnitude of SSCs released to the Pacific Ocean nearshore environment would be within the range of natural conditions, the duration of elevated SSCs (i.e., weeks) would be greater than would occur under natural (i.e., storm) conditions (i.e., days). Therefore, there also would be elevated SSCs in the Pacific Ocean nearshore environment relative to existing conditions (see Section 3.2.5.2 *Suspended Sediments*). However, no steelhead adults or juveniles are anticipated to occur within the nearshore environment during this period.

Summary

In the short term, reservoir drawdown associated with dam removal under the Proposed Project could alter SSCs and affect steelhead. In general, the short term impacts of suspended sediment resulting from the Proposed Project on steelhead are likely to be substantial for any juveniles rearing in the mainstem. However, there are several aspects of steelhead life history in the Klamath River Watershed that would ameliorate these impacts, and only a limited proportion of the rearing juveniles would be affected. The broad spatial distribution of steelhead in the Klamath Basin and their flexible life history suggests that some juveniles that would otherwise be in the mainstem would avoid the most serious effects of the Proposed Project 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 (e.g., regularly smolting at age 0+, 1+, or 2+) observed in steelhead means that not all individuals in any given year class would smolt during spring of dam removal year 2 and be exposed to the effects of the Proposed Project. Those that do not smolt would remain in tributaries and be unaffected by sediment release. Based on no predicted substantial short-term decrease in steelhead abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to steelhead under the Proposed Project in the short term.

Although this EIR finds no significant impact on steelhead In the short term, the KRRC proposes aquatic resource measures AR-1 (Mainstem Spawning) and AR-2 (Juvenile Outmigration) which would further reduce the potential for short-term effects of SSCs on salmonid juveniles and eggs, including steelhead. In addition, although CEQA Guidelines Section 15126.4(a)(3) states that mitigation measures are not required for effects which are not found to be significant, mitigation measures AQR-1 and AQR-2, which would be implemented as a result of significant adverse impacts described for Potential Impact 3.3-1 and Potential Impact 3.3-4, would even further reduce the potential for short-term effects of the Proposed Project on steelhead by increasing certainty regarding the effectiveness of the KRRC's proposed aquatic resource measures. Aquatic resource measures are summarized in Section 2.7.8.1 *Aquatic Resource Measures* and detailed in Appendix B: *Definite Plan – Appendix I*. Proposed Aquatic Resource Measure AR-1 includes the development and implementation of a monitoring and adaptive management plan to offset the impacts of Lower Klamath Project dam removal on mainstem spawning. Proposed Aquatic Resource Measure AR-1 actions include a 2-year tributary confluence monitoring effort and addressing sediment and debris obstructions that block volitional upstream passage from the Klamath River into tributaries. Monitoring would occur regularly for the two years following dam removal. Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (No. 11516530) within the first two years following reservoir drawdown would trigger a monitoring effort. Mitigation Measure AQR-1 Mainstem Spawning (detailed in Potential Impact 3.3-1) further specifies that monitoring shall also be conducted following a significant flow event, even if that flow event occurs more than two years following dam removal. Proposed Aquatic Resource Measure AR-1 also includes a spawning habitat evaluation on the Klamath River and tributaries in the Hydroelectric Reach. If spawning habitat conditions following dam removal do not meet target metrics[80] developed to offset the anticipated loss of Chinook salmon and steelhead redds due to the Proposed Project, spawning gravel augmentation would be completed within the mainstem, with additional spawning habitat actions within tributaries. Tributary spawning habitat restoration actions to be completed in Jenny Creek, Shovel Creek, Fall Creek, and/or Spencer Creek could include removal of artificial fish passage barriers, or placement of large woody debris to trap and retain spawning gravels. Mitigation Measure AQR-1 Mainstem Spawning (detailed in Potential Impact 3.3-1) further specifies the range of actions that shall be conducted in tributaries to offset impacts to steelhead spawning. Implementation of proposed Aquatic Resource Measure AR-1 and Mitigation Measure AQR-1 would reduce the short-term potential impacts of SSCs on steelhead spawning habitat in dam removal year 2 by improving access to tributary habitat where impacts from SSC on habitat in the mainstem can be avoided, and by augmenting spawning gravel, ensuring that suitable spawning

[80] Spawning gravel in the amount of 44,100 yd^2 for fall Chinook salmon and 4,700 yd^2 for steelhead

habitat in mainstem and tributaries is available following dam removal. Therefore, it is anticipated that steelhead spawning would not be substantially reduced as a result of the Proposed Project.

Proposed Aquatic Resource Measure AR-2 includes three primary actions: (1) salvaging mainstem overwintering juvenile salmonids prior to reservoir drawdown; (2) maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River; and (3) developing a water quality monitoring network, trigger thresholds, and plan for salvaging and relocating juvenile fish from tributary confluence areas to cold water tributaries or nearby off-channel ponds. Implementation of Proposed Aquatic Resource Measure AR-2 would reduce the short-term effects of SSCs on juvenile steelhead rearing in the mainstem during dam removal by actively transporting juveniles from vulnerable mainstem areas to off-channel ponds protected from the effects of the Proposed Project. Seining efforts would be focused on coho salmon juveniles, but other native fish captured during the seining and trapping effort, including juvenile steelhead, would be relocated into tributary streams adjacent to the salvage locations. Proposed Aquatic Resource Measure AR-2 would also reduce the potential short-term effects of SSCs to steelhead smolts by maintaining tributary-mainstem connectivity to ensure volitional fish passage between tributaries and the Klamath River. Monitoring would occur regularly for the two years following dam removal. Additionally, any 5-year flow event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (No. 11516530) within the first two years following reservoir drawdown would trigger a monitoring effort. Mitigation Measure AQR-2 Juvenile Outmigration (detailed in Potential Impact 3.3-1) further specifies that monitoring shall also be conducted following a significant flow event, even if that flow event occurs more than two years following dam removal. In addition, Proposed Aquatic Resource Measure AR-2 would reduce the potential short-term effects of SSCs to steelhead smolts by rescuing and transporting smolts if mainstem SSCs are high, and water temperatures within tributaries are too poor to provide safe refuge (a decision to be made in regular consultation with the ATWG). These actions would effectively reduce the number of steelhead juveniles and smolts potentially exposed to periods of high SSC in the mainstem following dam removal, and therefore reduce the proportion of the population experiencing impacts.

In the long term, removal of the Lower Klamath Project dams under the Proposed Project would increase habitat availability, restore a more natural flow regime by eliminating peaking flows in the Hydroelectric Reach and removing the Lower Klamath Project reservoirs, restoring more natural seasonal water temperature variation, improve water quality, and reduce the likelihood of fish disease, all of which would be beneficial for 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 (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 Basin would benefit steelhead runs. In general, dam removal would likely result in the restoration of more reproducing populations, increased abundance, higher genetic diversity, the opportunity for variable life histories, and use of new habitats (Hamilton et al. 2011). In general, free flowing conditions would likely increase adult migration rate, decrease outmigrant delay, and increase 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, 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. The multiple benefits of the Proposed Project would be beneficial for steelhead populations in the long term.

Significance
No significant impact for steelhead populations in the short term

Beneficial for steelhead populations in the long term

Potential Impact 3.3-11 Effects on the Pacific lamprey population due to short-term sediment releases and long-term changes in habitat quality and quantity due to dam removal.
The Lamprey Expert Panel (Panel) was convened and charged with answering specific questions that had been formulated to assist with assessing the effects of the Proposed Project on lamprey (Close et al. 2010). The conclusion was that the Proposed Project could increase Pacific lamprey habitat by up to 14 percent with access to habitat upstream of Iron Gate Dam, and even more potential habitat if Pacific lamprey gain access to habitat upstream of Keno Dam. However, the Panel concluded that larval lamprey habitat within much of the newly accessible habitat is of less quality that current larval habitat downstream of Iron Gate Dam, and therefore there might be roughly a total increase of production of outmigrant lamprey (and hence harvest potential) in the range of 1 to 10 percent relative to existing conditions, lower than the percent increase in habitat access. The Panel expects that adult Pacific lamprey would recolonize newly accessible habitat after dam removal, as was observed for Pacific lamprey following fish ladder installation at Landsburg Dam on the Cedar River, Washington (Kiffney et al. 2009), and for Pacific lamprey following removal of Condit Dam on the White Salmon River, Washington (Allen et al. 2016). 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 existing conditions because sediment input and transport processes would be restored (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.

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 genetic diversity of the species; and (d) increasing the abundance of the Pacific lamprey population (NMFS 2006a). The FERC EIS (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."

In a 2015 USFWS regional implementation plan for measures to conserve Pacific lamprey in northern California and the Klamath River Basin, Goodman and Reid (2015) conclude that while there remains some uncertainty about the historical extent of Pacific lamprey in the Upper Klamath Watershed, the removal of the dams and restoration of natural hydrologic flow regimes to the Klamath River would have the greatest positive influence on Pacific Lamprey in the Upper Klamath River. The influence of the Proposed Project on Pacific lamprey populations within specific reaches on the Klamath River is described below.

Upper Klamath River and Connected Waterbodies

Pacific lamprey occurred historically at least to Spencer Creek (Hamilton et al. 2005), and there are no predictions that under the Proposed Project Pacific lamprey would occur in the Upper Klamath River and connected waterbodies.

Upper Klamath River – Hydroelectric Reach

Under the Proposed Project, it is anticipated that Pacific lamprey would migrate upstream of the location of Iron Gate Dam (NMFS 2006a). The Proposed Project 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 June of dam removal year 2), 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.

By eliminating peaking flows in the Hydroelectric Reach and removing the Lower Klamath Project reservoirs, the Proposed Project would support a flow regime that more closely mimics natural conditions. Drawing-down the reservoirs would also 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 populations that would occur within the Hydroelectric Reach.

Middle and Lower Klamath River
The Proposed Project would release dam-stored organic sediment and reduce dissolved oxygen downstream to the Lower Klamath River in the short term, and improve water quality and restore a flow regime that more closely mimics natural conditions in the long term. Suspended sediment effects on Pacific lamprey populations under the Proposed Project are described in detail in Appendix E.3.2.5, and summarized here.

Under the most-likely impacts to fish scenario or worst impacts on fish scenario, sub-lethal effects from suspended sediment are anticipated for outmigrants, and for Pacific lamprey migrating to or from the Trinity River or tributaries farther downstream (Appendix E.3.2.5, Table E-13). High rates of mortality are predicted for ammocoetes (lamprey larvae) in the mainstem Klamath River during winter and spring of dam removal year 2. However, there is little information on the effects of suspended sediment on Pacific lamprey. This analysis used the effects of suspended sediment on salmonids to predict effects on Pacific lamprey, with the assumption that effects on Pacific 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 (an overestimate) of potential effects. In addition, Goodman and Hetrick (2017) report that in a 2008 ammocoete survey within the Klamath Basin no Pacific Lamprey were detected in the reach from Iron Gate Dam downstream to the confluence with the Shasta River (RM 179.5), and the densities did not approach levels observed elsewhere in the watershed until the confluence with the Scott River (RM 145.1). Therefore, the proportion of the Pacific lamprey population in the Klamath River potentially exposed to the highest SSCs during dam removal is low. In addition, recent genetic analysis of Pacific lamprey (Goodman and Reid 2012) indicates a high degree of historical gene flow even across expansive distances of the northern Pacific Rim as a result of low fidelity of Pacific lamprey progeny to their natal stream. This suggests that impacts to Pacific lamprey in the Klamath River are unlikely to affect the metapopulation.

As described for salmonid species above, the Proposed Project would affect spawning and incubation in the short term 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. This could reduce the quality of spawning habitat In the short term, but also may increase suitability of habitat for rearing ammocoete (Close et al. 2010). After a flushing flow of at least 6,000 cfs, the bed is expected to maintain fractions of sand, gravel, and cobble which would be expected under natural conditions (suitable for Pacific lamprey spawning). Based on the historical record a sufficient flushing flow would likely occur within five years following dam removal.

The Proposed Project 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 in the Lower Klamath River.

Klamath River Estuary and Pacific Ocean Nearshore Environment
Under the Proposed Project, habitat in the estuary could be affected by sediment releases during dam removal for about three months (January through March) when a low abundance of Pacific lamprey ammocoetes could be within the estuary during outmigration. After this time, SSCs would return to levels similar to existing conditions. SSCs in the Klamath River 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 3.3.5.1 *Suspended Sediment*). However, the increased SSCs predicted to occur in the estuary would not be of sufficient magnitude or duration to result in substantial sublethal or lethal effects on Pacific lamprey individuals (Appendix E.3.2.5). While the magnitude of SSCs released to the Pacific Ocean nearshore environment would be within the range of natural conditions, the duration of elevated SSCs (i.e., weeks) would be greater than would occur under natural (i.e., storm) conditions (i.e., days). Therefore, there also would be elevated SSCs in the Pacific Ocean nearshore environment relative to existing conditions (see Section 3.2.5.2 *Suspended Sediments*). However, few Pacific lamprey adults (and no juveniles) are anticipated to occur within the nearshore environment during this period.

Summary
In the short term, reservoir drawdown associated with dam removal under the Proposed Project would alter SSCs and bedload sediment transport and deposition and could affect Pacific lamprey. The Proposed Project would have short-term effects related to SSCs, bedload sediment transport and deposition, and water quality (particularly dissolved oxygen). As described in detail in Appendix E.3.2.5, Pacific lamprey use the mainstem Klamath River for several aspects of their life history. Because multiple year classes of Pacific lamprey rear in the mainstem Klamath River at any given time, and since adults would migrate upstream over the entire year, including January of dam removal year 2 when effects from the Proposed Project would be most pronounced, effects on Pacific lamprey adults and ammocoetes could be much higher in the mainstem Klamath River than under existing conditions. However, because of their wide spatial distribution and low observed occurrence downstream of Iron Gate Dam, most of the population would likely avoid the most severe suspended sediment pulses resulting from the Proposed Project and a substantial reduction in abundance is not anticipated. In addition, Pacific lamprey are considered to have low fidelity to their natal streams (FERC 2007), and may not enter the mainstem

Klamath River if environmental conditions are unfavorable in dam removal year 2. Migration into the Trinity River and other Lower Klamath River tributaries may also increase during dam removal year 2 because of poor water quality in the mainstem Klamath River. Low fidelity also increases the potential that Pacific lamprey can recolonize mainstem habitat if ammocoetes rearing there suffer high mortality. In addition, the geographic range of the Pacific lamprey population is very large and disperse (Goodman and Reid 2012), and thus the percentage of adult and larval Pacific lamprey that would be affected by the Proposed Project relative to the population as a whole would be minor (although no data are available to estimate percentage of population affected). Based on no predicted substantial short-term decrease in Pacific lamprey abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the Pacific lamprey population under the Proposed Project in the short term.

Although this EIR finds no significant impact on Pacific lamprey In the short term, the KRRC proposes aquatic resource measures AR-1 (Mainstem Spawning) which would further reduce the potential for short-term effects of SSCs on Pacific lamprey spawners. In addition, although CEQA Guidelines Section 15126.4(a)(3) states that mitigation measures are not required for effects which are not found to be significant, Mitigation Measures AQR-1, which would be implemented as a result of significant adverse impacts described for Potential Impact 3.3-1 and Potential Impact 3.3-4, would even further reduce the potential for short-term effects of the Proposed Project on Pacific lamprey by increasing certainty regarding the effectiveness of the KRRC's proposed aquatic resource measure. Aquatic resource measures are summarized in Section 2.7.8.1 and detailed in Appendix B: *Definite Plan – Appendix I*. Proposed Aquatic Resource Measure AR-1 includes the development and implementation of a monitoring and adaptive management plan to offset the impacts of Lower Klamath Project dam removal on mainstem spawning. Proposed Aquatic Resource Measure AR-1 actions include a 2-year tributary confluence monitoring effort and addressing sediment and debris obstructions that block volitional upstream passage from the Klamath River into tributaries. Implementation of AR-1 would reduce the short-term impacts of SSCs on Pacific lamprey spawning in dam removal years 1 and 2 by improving access to tributary habitat where impacts from SSC in the mainstem can be avoided. Therefore, it is anticipated that fewer Pacific lamprey would spawn in the mainstem prior to and following the Proposed Project, further decreasing the proportion of the population exposed to high SSC.

In the long term, the Proposed Project 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 Project the Pacific lamprey population within the Klamath Basin would have an increase in abundance and productivity due to increases in habitat availability, and improved flow regime, water quality, and temperature variation. Based on no predicted substantial long-term decrease in Pacific lamprey abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the Pacific lamprey population under the Proposed Project in the long term. Furthermore, implementation of the Proposed Project would be beneficial for Pacific lamprey in the long term.

Significance
No significant impact for Pacific lamprey populations in the short term

Beneficial for Pacific lamprey populations in the long term

Potential Impact 3.3-12 Effects on the green sturgeon population due to short-term sediment releases and long-term changes in habitat quality due to dam removal.
Southern DPS 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 Project. The remainder of this section focuses on the effects of the Proposed Project on the Northern Green Sturgeon DPS. Northern Green Sturgeon are an anadromous species that enter the Klamath River to spawn from March through July (Table 3.3-9). 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. Since green sturgeon do not occur upstream of Ishi Pishi Falls, they would only be affected by Proposed Project effects that would extend downstream of these falls.

Middle and Lower Klamath River
The Proposed Project would release dam-stored sediment downstream to the Lower Klamath River in the short term. There is not extensive literature on the effects of suspended sediment on green sturgeon. This analysis is based on available information of the effects of SSC on salmonids, with the assumption that effects of suspended sediment on sturgeon are likely less than or equal to those on salmonids. Suspended sediment effects on Northern Green Sturgeon populations under the Proposed Project are described in detail in Appendix E.3.2.6 and summarized here.

As described in Appendix E.3.2.6, green sturgeon in the Klamath River spawn approximately every four years. The result of this life history pattern is that up to 75 percent of the mature adult green sturgeon population (as well as 100 percent of sub-adults) can be assumed to be in the ocean during dam removal year 2 and avoid effects associated with the Proposed Project. For the 25 percent of the adult population that could be in the Klamath River during dam removal year 2, only slightly higher impacts are predicted for adults than under existing conditions under all scenarios (Appendix E.3.2.6, Table E-14), mostly because Northern 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 Project are more diluted from tributary accretion. Green sturgeon females are broadcast spawners that lay thousands of adhesive eggs that settle into the spaces between cobble substrates. Eggs in the mainstream Klamath River are vulnerable to suspended sediment under existing conditions as a result of the contributions of multiple tributaries in the Middle Klamath River (Appendix E 3.1.6). From 40 to 60 percent mortality is predicted for incubating eggs and larval life stages under all scenarios.

Juvenile green sturgeon typically rear for one year in the Klamath River system (M. Belchik, pers. comm., 2008), but may rear for up to three years before they migrate to the estuary and the ocean, usually during summer and fall. Moderate physiological stress is predicted for rearing juveniles under a least impacts on fish scenario. Under a most-likely impacts to fish or worst impacts on fish scenario major physiological stress is predicted (Appendix E.3.2.6). Around 30 percent of green sturgeon juveniles rear in the Trinity River and would not be exposed to SSC from the Proposed Project.

Bedload sediment effects related to dam-released sediment would not extend as far downstream to Ishi Pishi Falls (USBR 2012) and would not affect Northern Green Sturgeon.

The Proposed Project would improve water quality, and reduce instances of algal toxins. These long-term effects would benefit Northern Green Sturgeon in the Lower Klamath River.

Klamath River Estuary and Pacific Ocean Nearshore Environment

Rearing for more than one year is rarely observed in the mid-Klamath River (M. Belchik, pers. comm., 2008), but juvenile green sturgeon may rear for additional months or years in the estuary before migrating to the ocean. Under the Proposed Project, habitat in the Klamath River Estuary could be affected by elevated suspended sediment during dam removal for about three months during winter, when juvenile green sturgeon could be rearing in the estuary. 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 3.3.5.1 *Suspended Sediment*). However, the increased SSCs predicted to occur in the estuary would not be of sufficient magnitude or duration to result in substantial sublethal or lethal effects on green sturgeon juveniles (Appendix E.3.2.6). While the magnitude of SSCs released to the Pacific Ocean nearshore environment would be within the range of natural conditions, the duration of elevated SSCs (i.e., weeks) would be greater than would occur under natural (i.e., storm) conditions (i.e., days). Therefore, there also would be elevated SSCs in the Pacific Ocean nearshore environment relative to existing conditions (see Section 3.2.5.2 *Suspended Sediments*). However, few green sturgeon adults or juveniles are anticipated to occur within the nearshore environment during this period.

Summary
In the short term, reservoir drawdown associated with dam removal under the Proposed Project would alter water quality and SSCs and could affect Northern Green Sturgeon. Overall the effects of the Proposed Project are most likely to include physiological stress, inhibited growth, and high mortality for incubating eggs. Northern Green Sturgeon in the Klamath Basin have the following traits likely to enhance the species' resilience to impacts of the Proposed Project:

- Most of the Northern Green Sturgeon population (sub-adult and adult) would be in the ocean during the year of the Proposed Project (dam removal year 2) and would be unaffected (Appendix E.3.2.6).
- Approximately 30 percent of the Northern Green Sturgeon population that spawn and rear in the Trinity River and would be unaffected.
- Much of the spawning and rearing of Northern Green Sturgeon occurs downstream from the Trinity River, where sediment concentrations would be similar to existing conditions.

Northern Green Sturgeon are long-lived (greater than 40 years) and are able to spawn multiple times (approximately 8 times in their lifetime) (Klimley et al. 2007), so effects on the spawning effort of a proportion of adults for one year are anticipated to have little influence on the population as a whole. Because there would be no predicted substantial short-term decrease in green sturgeon abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the green sturgeon population under the Proposed Project in the short term.

In the long term, suspended sediment levels would return to levels similar to existing conditions, and removal of dams would result in improvements in water quality, temperature variation, and algal toxins which could affect Northern Green Sturgeon. Because there would be no predicted substantial long-term decrease in green sturgeon abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the green sturgeon population under the Proposed Project in the long term.

Significance
No significant impact for green sturgeon populations in the short term

No significant impact for green sturgeon populations in the long term

Potential Impact 3.3-13 Effects on Lost River and shortnose sucker populations due to short- and long-term changes in habitat quality and quantity due to dam removal.
A Resident Fish Expert Panel (Panel) was convened to compare the potential effects of the Proposed Project and existing conditions on resident fish, including sucker populations (Buchanan et al. 2011a). The Panel noted that the populations of Lost River and shortnose sucker in Upper Klamath lake are currently self-sustaining, whereas the populations in the Hydroelectric Reach

(Iron Gate and Copco reservoirs) are not self-sustaining. The Panel concluded that most factors limiting the production of Lost River and shortnose sucker populations occur in Upper Klamath Lake (e.g., poor water quality, nonnative fish predation and competition, lack of emergent vegetation rearing habitat), upstream of the Area of Analysis for aquatic resources.

Upper Klamath River and Connected Waterbodies
The Proposed Project has no elements that would substantially alter habitat conditions for Lost River and shortnose sucker populations in the Upper Klamath River upstream of Keno/Lake Ewuana. Facilitating the movement of anadromous fish presents a relatively low risk of introducing pathogens to sucker species upstream of Iron Gate Dam (NMFS 2006a). Generally, with the exception of *F. columnaris* and Ich, pathogens associated with anadromous fish do not impact non-salmonids (e.g., suckers) (NMFS 2006a). 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 Klamath Project dams is "not likely to adversely affect" listed suckers (Roninger 2012).

Upper Klamath River – Hydroelectric Reach
Lost River and shortnose sucker individuals are found within Lower Klamath Project reservoirs in the Hydroelectric Reach (Desjardins and Markle 2000). The Proposed Project would eliminate reservoir habitat, and as dams within the Hydroelectric Reach were removed, sediment would move downstream. However, the Lost River and shortnose suckers in these reservoirs are considered by the USFWS (2013) as "sink populations", as they are not likely self-sustaining because of low recruitment due to the lack of access to spawning habitats, citing Moyle (2002), and NRC (2004). Buettner et al. (2006) conclude that since little or no reproduction occurs downstream from Keno Dam, and there is no potential for interaction with upstream populations, they are not considered to substantially contribute to the achievement of conservation goals or recovery. This is also consistent with the findings of Hamilton et al. (2011), and NRC (2004).

Middle and Lower Klamath River, Estuary, and Pacific Ocean Nearshore Environment
No Lost River or shortnose suckers have been documented to occur downstream of Iron Gate Dam and therefore these reaches are not considered in the potential impact analysis for this EIR.

Summary
In the short term, reservoir removal associated with dam removal under the Proposed Project could alter habitat availability and affect Lost River and shortnose suckers in Iron Gate and Copco reservoirs. All individual suckers occurring within these reservoirs would likely be lost within dam removal year 2; however, these individuals are not considered to substantially contribute to the

achievement of conservation goals or recovery, since little or no reproduction occurs downstream from Keno Dam (Buettner et al. 2006), and there is no potential for interaction with upstream populations (Hamilton et al. 2011). Although both species are fully protected species under California Fish and Game Code, Assembly Bill Number 2640 (Wood 2018) added Section 2081.11 to the Fish and Game Code to allow the take of both sucker species resulting from impacts attributable to the decommissioning and removal of the Lower Klamath Project facilities, consistent with CDFW take provisions. Based on the best available estimates of Lost River and shortnose sucker abundance in the Lower Klamath Project reservoirs, there are likely fewer than 1,000 adult suckers of both species in all reservoirs combined (USFWS 2012a, Desjardins and Markle 2000), with a combined suitable sucker area of less than 2,500 acres. The populations in Upper Klamath Lake are estimated at 50,000 to 100,000 Lost River sucker (USFWS 2013a), and up to 25,000 shortnose suckers (USFWS 2013b), within around 79,000 acres of suitable habitat in Upper Klamath Lake and connected water bodies. Therefore, a loss of the suckers in Lower Klamath Project reservoirs represents around less than 1.5 percent of the total sucker population, and a loss of less than 3.5 percent of the total suitable sucker habitat. Based on no predicted substantial (< 1.5 percent) short-term decrease in Lost River and shortnose suckers' abundance of a year class, or substantial decrease in habitat quality or quantity (<1.5 percent), the Proposed Project would not cause a significant impact to the Lost River and shortnose sucker populations in the short term.

In the long term, reservoir removal associated with dam removal under the Proposed Project would eliminate habitat availability and affect Lost River and shortnose suckers in Lower Klamath Project reservoirs. All individual suckers occurring within these reservoirs would likely be lost within the short term and would not be replaced in the long term. However, as described above, these individuals are not considered to substantially contribute to the achievement of conservation goals or recovery of the populations (Hamilton et al. 2011). In addition, the return of anadromous species to the Upper Klamath Basin would deliver marine-derived nutrients, potentially bolstering the forage base for Lost River and shortnose suckers. The delivery of marine-derived nutrients by spawning anadromous fish and their resulting decomposing carcasses has been linked with the enrichment of aquatic and terrestrial ecosystems through numerous studies (Cederholm et al. 1999). Marine-derived nutrients are used by stream biota through a variety of pathways and may bolster forage items for native fish species directly, such as through the consumption of eggs, fry, and flesh (Bilby et al. 1996); and indirectly by increasing primary productivity in stream ecosystems, thereby increasing the abundance and biomass of other forage items such as macroinvertebrates (Wipfli et al. 1998). In addition, and as described above, the loss of the sucker population and suitable habitat in the Lower Klamath Project reservoirs is a minor proportion of the total sucker population and suitable habitat area. Based on no predicted substantial long-term decrease in Lost River and shortnose suckers' abundance of a year class, or substantial decrease in habitat quality or quantity, the Proposed Project would not cause a significant impact to the Lost River and shortnose sucker populations in the long term.

Although this EIR finds no significant impact on Lost River and shortnose suckers in the short-or long-term, the Proposed Project includes aquatic resource measure AR-6 (Suckers) to reduce the short- and long-term effects of reservoir removal. Aquatic resource measures are summarized in Section 2.7.8.1 *Aquatic Resource Measures* and detailed in Appendix B: *Definite Plan – Appendix I*. AR-6 includes two primary actions including reservoir and river sampling to estimate the abundance of suckers in the Hydroelectric Reach and conduct genetic testing for hybridization, and sucker salvage and release into waterbodies isolated from the Upper Klamath Lake Populations. As discussed above, Section 2081.11 was added to the Fish and Game Code to authorize take of Lost River and shortnose suckers, subject to certain conditions. CDFW (2018b) has reviewed AR-6 and preliminarily agreed that the Proposed Project with implementation of AR-6 potentially meets the standards for take authorization under Fish and Game Code, section 2081.11. The proposed actions are anticipated to increase the survival of individual Lost River and shortnose suckers currently inhabiting the Hydroelectric Reach, without increasing exposure of the Upper Klamath Lake population to adults with a high degree of hybridization. The number of translocated fish would not exceed 3,000 fish, which is the capacity of the currently identified recipient waterbody (Tule Lake). Tule Lake currently supports both sucker species and has suitable habitat for translocation site. In addition, Tule Lake is isolated from the sucker population in Upper Klamath Lake, and thus this measure would not risk influencing the sucker populations designated as recovery populations in Upper Klamath Lake.

Significance

No significant impact for Lost River and shortnose sucker populations in the short term

No significant impact for Lost River and shortnose sucker populations in the long term

Potential Impact 3.3-14 Effects on the redband trout population due to short-term sediment releases and long-term changes in habitat quality and quantity due to dam removal.

A Resident Fish Expert Panel (Panel) was convened to compare the potential effects of the Proposed Project and existing conditions on resident fish, including redband trout (Buchanan et al. 2011a). The Panel predicted that following the Proposed Project, the abundance of redband trout in the free-flowing reach between Keno Dam and Iron Gate Dam could increase significantly. In addition, the Panel expects the existing trout and colonizing anadromous steelhead to co-exist (or even for the redband to produce anadromous progeny), as they do in other watersheds, although there may be shifts in abundance related to competition for space and food. The effects of implementing the Proposed

Project on redband trout populations within specific reaches of the Klamath River are described below.

Upper Klamath River and Connected Waterbodies

Under the Proposed Project, 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. Redband trout could be affected by increased predation from reintroduced anadromous 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 No. 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 (NMFS 2006a).

Facilitating the movement of anadromous fish presents a relatively low risk of introducing pathogens to resident fish upstream of Iron Gate Dam (NMFS 2006a).

Upper Klamath River – Hydroelectric Reach

Under existing conditions, redband trout are found within the California portion of the Area of Analysis within the Hydroelectric Reach, including within all riverine areas and reservoirs. Spawning primarily occurs within Shovel and Spencer creeks. Redband trout are currently prevented from migrating between some tributaries and the reservoirs to complete their life cycle because of poorly functioning fishways at J.C. Boyle Dam (DOI 2007, NMFS 2007b). Under the Proposed Project, redband trout would be able to migrate more successfully than under existing conditions (Hamilton et al. 2011). Approximately 4 mi (6.4 km) of habitat has been adversely affected by the dewatered 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 (NMFS 2006a). In addition, the NMFS (2006a) finding regarding J.C. Boyle 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 the Proposed Project, the establishment of a flow regime that more closely mimics natural conditions, eliminates hydroelectric peaking and associated negative aquatic impacts, would benefit the redband trout populations in the Hydroelectric Reach. Redband trout throughout this reach of the mainstem would be affected by high SSCs for a period of three to four months during reservoir drawdown associated with the Proposed Project. Redband trout in riverine reaches between the reservoirs in the Hydroelectric Reach would be vulnerable to effects of sediment released during dam removal and bedload deposition (Newcombe and Jensen 1996, Buchanan et al. 2011a). However, SSCs would be the result of sediment stored only in J.C. Boyle and Copco reservoirs, and would not include the additional sediment stored in Iron Gate Reservoir, reducing the potential effect relative to the effects to aquatic species downstream of Iron Gate Dam (USBR 2012). In addition, a large proportion of the adult redband trout 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. Therefore, there will not be a substantial reduction in the abundance of a year-class of redband trout as a result of the Proposed Project.

The Proposed Project would eliminate reservoir habitat, returning sections of river currently inundated by reservoirs and riverine sections between reservoirs to a pool-riffle morphology. Although most redband trout are anticipated to continue to spawn in tributaries, modeling data indicate that after dam removal, spawning gravel in all sections of the Hydroelectric Reach would be within the range usable for redband trout, but the amount of sand within the bed within former reservoir sections might inhibit spawning success in the short term. Riverine sections between reservoirs would be expected to contain gravel with very little sand, suggesting high-quality spawning habitat would become available within a few years following dam removal. 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 Project. The adfluvial individuals within this reach would likely adopt a fluvial[81] life history, which is unlikely to affect the sustainability of the population. Overall migratory opportunities would increase for redband trout, increasing resiliency to disturbance over the short and long-term. The Proposed Project 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 cold-water areas near the mouths of tributaries and the many springs in this reach.

Middle and Lower Klamath River
No redband trout occur downstream of Iron Gate Dam, and therefore these reaches are not considered in the potential impact analysis for this EIR. However, in the long term redband trout would have access to habitat in the Middle Klamath River, and they are anticipated to use cold-water tributaries and portion of the mainstem river. The resident trout currently within the Middle Klamath River (rainbow trout) are genetically very similar to the redband trout currently present upstream of Iron Gate Dam; these two populations that are

[81] Fluvial life history is resident trout spawning in tributaries and maturing within a larger mainstem river.

currently isolated would revert to a connected and sustainable population (Buchanan et al. 2011a).

Summary
In the short term, the Proposed Project would have impacts related to SSCs and bedload movement. However, very little sediment is stored in Copco and J.C. Boyle Reservoirs, and only a small proportion of the redband population is expected to be exposed to short-term effects. Based on no predicted substantial short-term decrease in redband trout abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the redband trout population under the Proposed Project in the short term.

In the long term, dam removal would restore connectivity among the Middle 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. The return of anadromous species to the Upper Klamath Basin would deliver marine-derived nutrients, potentially bolstering the forage base for redband trout. The delivery of marine-derived nutrients by spawning anadromous fish and their resulting decomposing carcasses has been linked with the enrichment of aquatic and terrestrial ecosystems through numerous studies (Cederholm et al. 1999). Marine-derived nutrients are used by stream biota through a variety of pathways and may bolster forage items for native fish species directly, such as through the consumption of eggs, fry, and flesh (Bilby et al. 1996); and indirectly by increasing primary productivity in stream ecosystems, thereby increasing the abundance of biomass of other forage items such as macroinvertebrates (Wipfli et al. 1998). Based on a long-term substantial increase in redband trout habitat quality and quantity, the Proposed Project would be beneficial for redband trout in the long term.

Significance
No significant impact for redband trout population in the short term

Beneficial for redband trout population in the long term

Potential Impact 3.3-15 Effects on the eulachon population due to short-term sediment releases and long-term changes in habitat quality due to dam removal.
The Proposed Project would release dam-stored sediment downstream to the Lower Klamath River and Estuary. 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 (>500 mg/L) and would be higher than the extreme values estimated by the sediment transport model for existing conditions. Predicted increases in SSCs under the most-likely impacts to fish scenario are within the range of existing extreme conditions (Appendix E.4). Under a worst impacts on fish scenario SSCs could be higher than typically occur within the estuary (>1,000 mg/L) for a period of

weeks. Adult eulachon entering the Klamath River in the winter and spring of dam removal year 2 may be exposed to high SSCs for a portion of their migration period. Although no analysis of the effects of SSCs 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 impacts to fish or worst impacts on fish scenario mortality of eulachon adults would occur under the Proposed Project, unless individuals migrate out of the estuary to avoid poor water quality conditions (as has been observed in the Columbia River watershed, NMFS 2010b). Mortality is also predicted for spawning, incubation, and larval life stages under the Proposed Project. However, 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 SSCs (predicted to be over 1,000 mg/L for the month of January under a worst impacts on fish scenario, Appendix E.4). Therefore, no substantial reduction in the abundance of a year class is predicted. Based on no predicted substantial short-term decrease in eulachon abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the eulachon population under the Proposed Project in the short term. Within a short duration (< 6 months) SSCs within the Klamath River Estuary are predicted to return to existing levels (Appendix E.4). There is no predicted substantial long-term decrease in eulachon abundance of a year class, or substantial decrease in habitat quality or quantity, and thus there would not be a significant impact to the eulachon population under the Proposed Project in the long term.

Significance

No significant impact for eulachon population in the short term and long term

Potential Impact 3.3-16 Effects on the longfin smelt population due to short-term sediment releases and long-term changes in habitat quality due to dam removal.

The Proposed Project would release dam-stored sediment downstream to the Klamath River Estuary. Longfin smelt entering the Klamath River in the winter and spring of dam removal year 2 may be exposed to high SSCs for a portion of their migration period. Although no analysis of the effects of SSCs 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 impacts to fish or worst impacts on fish scenario mortality would be higher under the Proposed Project than under existing conditions for a period of weeks. 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 (less than two months), increases the probability that most of the population would migrate and spawn either before or after the largest pulses of SSCs (predicted to be two weeks in duration or less).

Based on no predicted substantial short-term decrease in longfin smelt abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the longfin smelt population under the Proposed Project in the short term. Within a short duration (< 6 months) SSC within the Klamath River Estuary are predicted to return to existing levels (Appendix E.4), and thus there is no predicted substantial long-term decrease in longfin smelt abundance of a year class, or substantial decrease in habitat quality or quantity, and there would not be a significant impact to the longfin smelt population under the Proposed Project in the long term.

Significance

No significant impact for longfin smelt population in the short term and long term

Potential Impact 3.3-17 Effects on species interactions between introduced resident fish species and native aquatic species due to short- and long-term changes in habitat quality and quantity due to dam removal.

Introduced fish species threaten the diversity and abundance of native fish species through competition for resources, predation, interbreeding with native populations, and causing potential physical changes to the invaded habitat (Moyle 2002). Introduced resident species occur in Lake Ewuana and Upper Klamath Lake, but the Proposed Project would not affect populations in this area.

As described in detail in Section 3.20.2.3 *Lower Klamath Project Reservoir-based Recreation*, 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 No. 1 and Iron Gate reservoirs, especially for yellow perch (Hamilton et al. 2011). Adults yellow perch are opportunistic predators that feed on small fish, potentially including native fish species. Juvenile and adult largemouth bass tend to feed on larger invertebrates and fish as well, potentially including native species. The Proposed Project would eliminate reservoir habitat upstream of Iron Gate Dam, and thus the abundance of introduced resident species would decline substantially or be eradicated (Buchanan et al. 2011a), providing a benefit to native aquatic species.

A few introduced resident species occur in the Middle and Lower Klamath River, but water velocities within riverine habitat are too high for the introduced species that in general are adapted to the lotic conditions in the reservoirs in which they were introduced. Under the Proposed Project, conditions would be expected to become even less suitable for introduced resident species. This effect would be beneficial for native aquatic species in the short and long term.

Significance

Beneficial for the effects of introduced resident fish species on aquatic species in the short term and long term

Potential Impact 3.3-18 Effects on aquatic species from interactions among fish species due to short- and long-term changes in habitat quantity due to dam removal.

The Proposed Project 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, with the potential for competition and predation. 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). The return of anadromous species to the Upper Klamath Basin would deliver marine-derived nutrients, potentially bolstering the forage base for bull trout, redband, and other native species. The delivery of marine-derived nutrients by spawning anadromous fish and their resulting decomposing carcasses has been linked with the enrichment of aquatic and terrestrial ecosystems through numerous studies (Cederholm et al. 1999). Marine-derived nutrients are used by stream biota through a variety of pathways and may bolster forage items for native fish species directly, such as through the consumption of eggs, fry, and flesh (Bilby et al. 1996); and indirectly by increasing primary productivity in stream ecosystems, thereby increasing the abundance of biomass of other forage items such as macroinvertebrates (Wipfli et al. 1998).

Anadromous salmonids currently co-exist with resident rainbow trout and resident cutthroat trout downstream from Iron Gate Dam, without any obvious detriment to these native species or the aquatic ecosystem in which they reside. 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 (NMFS 2006a). Conversely, research has shown that hatchery salmon supplementation can negatively impacted resident trout abundance and salmonid biomass in a Washington watershed (Pearsons and Temple 2010). In addition, non-native *O. mykiss* have been widely planted in the Klamath River since the construction of Iron Gate Dam, with an unknown effect on the genetics of the native population (Pearse et al. 2007). However, there is no data or evidence to suggest that increased interactions (breeding) would have any deleterious effect on the genetics for either population. 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 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 (NMFS 2006a). As noted by Buchanan et al. (2011a), existing trout and colonizing anadromous steelhead are expected to co-exist in the Klamath Basin, as they do in other watersheds, although there may be shifts in abundance related to competition for space and food. Overall, there is no predicted substantial short-term or long-term decrease in native aquatic species abundance of a year class, or substantial decrease in habitat quality or quantity, and there would not be a significant impact to the aquatic species populations under the Proposed Project in the short term or long term.

In addition, and as discussed in Potential Impact 3.3-17, conversion of reservoir habitat to riverine habitat is not anticipated to increase interactions among native salmonids and introduced non-native fish species, since water velocities within riverine habitat are too high for the introduced species that in general are adapted to the lotic conditions in the reservoirs in which they were introduced. Under the Proposed Project, conditions would be expected to become even less suitable for introduced resident species such as bass and yellow perch, reducing the potential for interactions among riverine and reservoir species.

Significance

No significant impact for effects to aquatic species from interactions among fish species in the short term and long term

Potential Impact 3.3-19 Effects on freshwater mollusks populations due to short-term sediment releases and long-term changes in habitat quality due to dam removal.

Four species of native freshwater mussels have been observed within the Klamath Basin, including Oregon floater (*A. oregonensis*), California floater (*A. californiensis*), western ridged mussel (*G. angulata*), and western pearlshell mussel (*M. falcata*). Oregon floater and California floater (commonly referred together “floater mussels,” or “*Anodata spp*.”) occur in the mainstem Klamath River in the Hydroelectric Reach, within Lower Klamath Project reservoirs, in a reach (<15 miles) directly downstream of Iron Gate Dam, and within the Upper Shasta River. *M. falcata* are common in the mainstem Klamath River from Iron Gate Dam downstream to the confluence with the Trinity River, and within Middle Klamath tributaries such as Bogus Creek, and Shasta, Scott, and Salmon rivers. *G. angulata* is more widely distributed and more abundant than the other species and has been observed in high densities from Keno Dam downstream to the confluence with the Trinity River, and within the Shasta and Scott rivers (Davis et al. 2013). Mussel abundance also generally declines with increasing distance downstream from Iron Gate Dam, suggesting the effects of the increasing hydrologic variability of the Klamath River with distance from Iron Gate. Davis et al. (2013) concluded that habitats located further downstream had lower probabilities of supporting mussels due to more variable conditions.

Seven to eight species of fingernail clams and peaclams (Family: Sphaeriidae) also occur in the Hydroelectric Reach and from Iron Gate Dam to Shasta River. This evaluation focuses on freshwater mussels because of their similar distribution to other freshwater mollusks, similar habitat requirements, their longer lifespan, and lack of information regarding the effects of sediment on clams and other mollusks.

Suspended Sediment Concentrations

Under the Proposed Project, in the Hydroelectric Reach between J.C. Boyle Dam and Copco No.1 SSCs are predicted to exceed 600 mg/L (the minimum SSC level that would be considered detrimental to freshwater mussels), for short periods of time (1–5 days) during spikes in SSCs. SSCs are expected to be higher than under existing conditions and would likely exceed 600 mg/L for two to four months after removing the dams from Copco No 1. Dam downstream to the Klamath River Estuary; however, the highest levels, well in excess of 1,000 mg/L, would occur between Seiad Valley and Iron Gate Dam. Within six months of dam removal SSCs in the mainstem Klamath River are predicted to return to levels observed under existing conditions. Under existing conditions, SSCs in the mainstem Klamath River often exceed 600 mg/L, although these spikes generally occur for a few days as opposed to several months (see also Potential Impact 3.2-3).

Predicted increases in SSC within the Hydroelectric Reach under the Proposed Project are anticipated to result in major physiological stress to *Anodata spp*., and *G. angulata*, including mortality of at least a proportion of the individuals. 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. For populations occurring downstream of the confluence with the Salmon River (*M. falcata* and *G. angulata*) dilution from tributaries would limit exposure to SSCs likely to be sublethal. Because freshwater mussels found within the Klamath River can be so long lived (from 10 to more than 100 years, depending on the species) and sexual maturity might not be reached until four years of age or more, even relatively short term (e.g., for more than five consecutive days) SSCs in excess of 600 mg/L, would be expected to be detrimental for freshwater mussel populations within the mainstem Klamath River upstream of the Salmon River confluence, in the short term. This would impact all four-mussel species, most notably *Anodata spp*., due to their limited distribution in the proximity of Iron Gate Dam. *M. falcata* and *G. angulata* are less likely to experience a substantial decline in abundance in the short term, due to their broader distribution downstream of Iron Gate Dam in the mainstem, and strong populations in tributaries.

Freshwater clams can live buried in the substrate and are expected to suffer less impact than freshwater mussels. In addition, they are relatively short-lived (one to three years) and bear young several times throughout the spring and summer which would support rapid recovery within the short term to impacts from suspended sediment.

In the long term (i.e., greater than five years), it is anticipated that mainstem Klamath *M. falcata* and *G. angulata* populations would rebound from suspended sediment impacts, 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 Bogus, Shasta, Scott, and Salmon rivers. *Anodata spp*. Are anticipated to recover more slowly from suspended sediment impacts, due to a narrower distribution downstream of Iron Gate Dam, and limited distribution within tributaries (i.e., only found in upper Shasta River).

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 under the Proposed Project. Coarser 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 conditions for approximately eight 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. Therefore, *Anodonta spp*. Populations closest to Iron Gate Dam are likely to be most affected by aggradation of sediments under the Proposed Project, whereas *M. falcata* and *G. angulata* with broad distributions are unlikely to be substantially affected. 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 is reasonable to assume that some percentage of Klamath River freshwater mussels buried under 0.5 to 3.0 feet of new sediment would not survive, especially since these same population would be exposed to the increased SSCs described above. *G. angulata* have a demonstrated ability to withstand burial in sediment and are likely to be the least affected.

As described in Potential Impact 3.11-5, SRH-1D model simulations project up to approximately 1.7 feet of reach-averaged dam-released sediment deposition between Bogus Creek (RM 192.68) and Willow Creek (RM 187.8) in the short term (< 2 years) and up to 0.9 feet between Willow Creek and Cottonwood Creek (RM 185.1). SRH-1D model simulations did not project any significant sediment deposition downstream of Cottonwood Creek. This deposition will occur during and following drawdown, with further remobilization and deposition in association with precipitation-driven flow events following dam removal, typically lasting for several hours and separated by several days or weeks. The results of Vavrinec et al. (2007) suggest that clams may not survive deposition over 0.9 feet in the reach between Bogus Creek (RM 192.68) and Willow Creek (RM 187.8), where *Anodonta spp*. Populations closest to Iron Gate Dam are likely to be most affected (as described above). The results of Vavrinec et al. (2007) further suggest that for clams downstream of Willow Creek there is likely to be high survival following deposition of 0.9 feet or less, especially if there is at least 24 hours between burial events. Therefore, it is predicted that freshwater clams located downstream of Willow Creek (RM 187.8) can survive deposition events such as those predicted to occur following dam removal (Vavrinec et al. 2007) and are expected to avoid impacts from bed deposition.

Changes in Bed Substrate

Removal of the Lower Klamath Project dams under the Proposed Project would result in the erosion of accumulated reservoir sediments and changes in 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 six months (Potential Impact 3.11-5) following removal of the dams. The reformation of river channels between Iron Gate Dam and the upstream reaches of J.C. Boyle Reservoir would benefit *M. falcata* and *G. angulata* and clams in the long term by providing more suitable substrates (i.e., large gravel, cobble, and boulder) than currently exists, especially within the current reservoir reaches. However, conversion of reservoirs to riverine habitat is anticipated to have a short- and long-term impact on *Anodonta spp*., which currently occur within reservoirs, and are adapted to low-flow variability habitat.

Changes in Habitat Accessibility

In addition, the Proposed Project would also open access to river reaches upstream of Iron Gate Dam to migratory fish species, which serve as host fish for parasitic freshwater mussel larvae (glochidia). *M. falcata* in particular may benefit from the increased distribution of anadromous salmonids, which are a primary host species for their larvae. As a result, in the long term suitable habitats upstream of Iron Gate Dam might be colonized or recolonized by all four freshwater mussel species, transported as glochidia from downstream reaches by migratory fish species.

Summary

In the short term, *G. angulata* have a demonstrated ability to withstand burial in sediment and are a widespread and abundant mussel species, including within the Hydroelectric Reach, and within key tributaries upstream and downstream of Iron Gate Dam. Therefore, a relatively small proportion of their population would be directly impacted by sediment released during dam removal. Based on no predicted substantial short-term decrease in *G. angulata* abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the *G. angulata* population under the Proposed Project in the short term.

M. falcata have a broad distribution downstream of Iron Gate Dam in the mainstem, and strong populations in several tributaries in the Middle Klamath River. Therefore, a relatively small proportion of their population would be directly impacted by sediment released during dam removal. Based on no predicted substantial short-term decrease in *M. falcata* abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the *M. falcata* population under the Proposed Project in the short term.

Although this EIR finds no significant impact on *G. angulata* or *M. falcata* in the short term, the KRRC proposes aquatic resource measure AR-7 (Freshwater Mussels) to reduce the short-term effects of sediment transport during dam removal on freshwater mussels. Aquatic resource measures are summarized in Section 2.7.8.1 *Aquatic Resource Measures* and detailed in Appendix B: *Definite Plan – Updated AR-7, October 2018 Update*. Proposed Aquatic Resource Measure AR-7 includes salvage and relocation plan prior to Lower Klamath Project dam removal and completing a reconnaissance of existing freshwater mussels from Iron Gate Dam to Cottonwood Creek and potential relocation habitat between the upstream extent of J.C. Boyle Reservoir and Keno Dam. Freshwater mussels would be salvaged and relocated in dam removal year 1 prior to the reservoir drawdown. Approximately 15,000 to 20,000 mussels (primarily *G. angulata* and *M. falcata)* are planned for translocation. There are currently multiple large-scale mussel relocation projects occurring nationwide (Zimmerman et al. 2017, USDA Forest Service 2016, Illinois Department of Natural Resources 2016). Initial findings from these and previous studies indicate that with planning, mussel relocation can be successful. USDA Forest Service (2016) has found that 71 percent of the translocated mussels were found a year later and that only two mussels (0.22 percent) were confirmed dead. Fernandez (2013) found that Between 55 percent and 95 percent of the transplanted *M. falcata* mussels could be accounted for in individual streams one to three years after relocation. Therefore, it appears likely that these measures could be successful. Sites considered for translocation include areas downstream from the Trinity River confluence (RM 43.4), and between J.C. Boyle Dam (RM 230.6) and Copco No. 1 Reservoir (RM 209.0). These areas would have less impact from increased SSCs but would not be completely protected from short-term effects.

Anodonta spp. Would likely be impacted by the Proposed Project due to their close proximity to Iron Gate Dam, and their preference for the stable that currently exist in Lower Klamath Project reservoirs and downstream of Iron Gate Dam. *Anodonta spp*. Likely only occurs downstream of Iron Gate Dam under existing conditions as a result of the altered hydrograph (Davis et al. 2013). Under natural conditions *Anodonta spp*. Would be unlikely to occur in the Middle and Lower Klamath River. Based on their limited distribution in the mainstem Klamath River, Lower Klamath Project reservoirs, and in the Upper Shasta River, the abundance of the *Anodonta spp*. Year class present during dam removal year 2 would likely decline substantially within the first six months of dam removal as a result of elevated SSCs resulting from reservoir drawdown. In addition, their habitat would likely decline substantially in quality in the short term. Based on the predicted substantial short-term decrease in *Anodonta spp* abundance of a year class, and the substantial decrease in habitat quality, there would be a significant impact to the *Anodonta spp* population under the Proposed Project in the short term.

Aquatic resource measure AR-7 is unlikely to offset the projected impacts to *Anodonta spp*. The areas downstream of the Trinity River confluence identified in aquatic resource measure AR-7 as relocation areas do not currently support *Anodonta spp*. And are unlikely to in the future (Davis et al. 2013). The reach between J.C. Boyle Dam and Copco No. 1 Reservoir does not currently support *Anodonta spp.* Therefore, translocation efforts described in proposed Aquatic Resource Measure AR-7 are anticipated to be potentially successful for *G. angulata* and *M. falcata* (based on suitable habitat in translocation sites), but is unlikely to be successful for *Anodonta spp.* With this aquatic resource measure, there would likely still be a substantial reduction in the abundance of *Anodonta spp.* Species in the short term, and impacts would be significant with for *Anodonta spp.* In the short term. For development of proposed Aquatic Resource Measure AR-7, the KRRC explored several approaches to salvaging and relocating *Anodonta spp*. Prior to dam removal, as described Appendix B: *Definite Plan – Updated AR-7, October 2018 Update*. However, options such as translocating mussels to tributaries, or other reaches upstream of Iron Gate Dam were rejected after surveys suggesting that most locations would not provide suitable habitat, and the concern of risking healthy and abundant mussels populations in tributaries by translocating mussels from the mainstem reach with unknown disease risk. Therefore, the short-term significant impact on *Anodonta spp*. Due to the Proposed Project cannot be avoided or substantially decreased through feasible mitigation.

Freshwater clams can live buried in the substrate and are expected to suffer less impact than freshwater mussels. In addition, they are relatively short-lived (one to three years) and bear young several times throughout the spring and summer which would support rapid recovery within the short term to impacts from suspended sediment. Based on no predicted substantial short-term decrease in freshwater clam abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the freshwater clam populations under the Proposed Project in the short term.

In the long 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 for *M. falcata* and *G. angulata*. Based on no predicted substantial long-term decrease in *M. falcata* and *G. angulata* abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the *M. falcata* and *G. angulata* populations under the Proposed Project in the short term.

Conditions would also improve in the long term in the Hydroelectric Reach for *Anodonta spp.* With reduced flow variability downstream of J.C. Boyle Dam, potentially creating conditions more similar to the reach downstream of Keno Dam, where *Anodonta spp*. Are currently found (Byron and Tupen 2017). This additional habitat is unlikely to offset the long-term habitat lost from increased flow variability within Lower Klamath Project reservoirs and downstream of Iron Gate Dam. The current populations of *Anodonta spp*. In the Lower Klamath Project reservoirs and downstream of Iron Gate Dam are artifacts of an altered hydrology and geomorphology. The reversion of these conditions to more natural river environment (e.g., natural flow regime and increased sediment scour) would no longer support *Anodonta spp*., and the suitable habitat supporting their populations would be revert to natural spring-fed stable flow conditions, such as the Upper Shasta River. Based on predicted substantial long-term decrease in *Anodonta spp.* Abundance of a year class, and substantial decrease in habitat quality and quantity, there would be a significant impact to the *Anodonta spp.* Population under the Proposed Project in the long term. Because reversion of the Klamath River within and downstream of the Lower Klamath Project to more natural river conditions would be an inevitable consequence of the Proposed Project, the long-term significant impact on *Anodonta spp*. Due to the Proposed Project cannot be avoided or substantially decreased through feasible mitigation.

Based on no predicted substantial long-term decrease in freshwater clam abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to the freshwater clam populations under the Proposed Project in the long term.

Significance

No significant impact for *M. falcata* and *G. angulata* in the short or long term

Significant and unavoidable impact for *Anodonta spp.* In the short and long term

No significant impact for freshwater clams in the short or long term

Potential Impact 3.3-20 Effects on fish species from alterations to benthic macroinvertebrates due to short-term sediment releases and long-term changes in habitat quality due to dam removal.

Benthic macroinvertebrates (BMI) are small aquatic animals and the aquatic larval stages of insects. BMI are the primary food source for most freshwater fish species, and therefore, changes in abundance, distribution, or community structure can affect fish populations. A diminished food supply can limit growth of salmonids, and this is especially true at higher temperatures because as water warms, a fish's metabolic rate increases, and it needs more food to sustain growth. Growth is critical to juvenile salmonids because a larger size fish often has a survival advantage during the overwintering period, smolt outmigration, and ocean residence.

In the short term, the Proposed Project could alter SSCs and bedload sediment transport and deposition and thereby negatively affect benthic macroinvertebrates. Increases in suspended sediment and increased bedload deposition following dam removal under the Proposed Project are anticipated to result in a reduction in abundance of BMIs within the first few months of dam removal year 2 in the reach from Iron Gate Dam to confluence with the Salmon River, and SSC increases may decrease growth rates of fish rearing and feeding in the mainstem Klamath River downstream of Iron Gate Dam to around the Salmon River confluence. Short-term reductions in the abundance and diversity of BMIs has been observed following disturbance due to suspended sediment (Reid and Anderson 2000, Orr et al. 2008). During the period of greatest impact (winter of sediment release dam removal years 1 and 2), food availability related to BMI production would likely decrease in the reach downstream of Iron Gate Dam around the confluence with the Salmon River. However, within this reach a reduction in feeding by fish species is already predicted to occur in response to increased SSCs, which is a sub-lethal effect from which fish populations are anticipated to recover. In addition, salmonids typically reduce feeding during winter in response to lower water temperature and decreased metabolic demand (Bustard and Narver 1975).

While a large proportion of the BMI population in the Hydroelectric Reach and in the mainstem Klamath River downstream from Iron Gate Dam would be reduced in the short term, 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. Full recovery of BMI communities is typically observed within a year following disturbance (Tsui and McCart 1981, Anderson et al. 1998). The constant “flushing” action of the Klamath River is anticipated to speed BMI recovery from negative impacts resulting from sediment deposition. Tullos et al. (2014) found that BMI communities downstream of the Brownsville (Calapooia River, Oregon) and Savage Rapids (Rogue River, Oregon) dams resembled upstream control sites within a year after dam removal. Foley et al. (2017) summarizes the effects of multiple dam removal studies and found that researcher reported that following dam removal downstream BMI abundance tends to increase and species assemblages transition to resemble sites upstream of the former dam, noting that some BMI species can double their population size in days to weeks, and quickly (within months) recover once the initial sediment pulse has passed. There, the effects of reduced BMI populations on food availability for fish species is anticipated to be of insufficient magnitude or duration to substantially effect fish species in the short term. Based on no predicted substantial short-term decrease in fish abundance of a year class, or substantial decrease in habitat quality or quantity supporting a fish species, there would not be a significant impact to fish populations under the Proposed Project in the short term from effects to BMIs.

In the long term, the Proposed Project 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. The reformation of river channels in the reservoir reaches upstream of Iron Gate Dam, and the reversion to unimpeded sediment transport downstream of Iron Gate Dam under the Proposed Project, would benefit BMIs by providing more suitable substrates (e.g., gravel) than currently exist. Thus, 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. BMI populations would be expected to recover quickly and provide food availability to fish from short-term impacts because of the many sources for recolonization and their rapid dispersion through drift or aerial movement of adults.

Under the Proposed Project, peaking operations would no longer kill, through stranding, large numbers of aquatic invertebrates that are the primary prey food for resident trout in the reach between J.C. Boyle Powerhouse and Copco No. 1 Reservoir (NMFS 2006a). Based on increased habitat availability and improved habitat quality, the effect of the Proposed Project on BMI as a food source for fish species would be beneficial in the long term. Based on no predicted substantial long-term decrease in fish abundance of a year class, or substantial decrease in habitat quality or quantity supporting a fish species, there would not be a significant impact to fish populations under the Proposed Project in the long term from effects to BMIs.

Significance

No significant impact for effects of alterations to benthic macroinvertebrates on fish species in the short term

Beneficial for effects of alterations to benthic macroinvertebrates on fish species in the long term

Potential Impact 3.3-21 Effects on aquatic resources due to short-term noise disturbance and water quality alterations from construction and deconstruction activities.

This analysis relates to the potential impact to aquatic resources from various construction and deconstruction activities associated with the Proposed Project, outside of the release of reservoir sediments discussed more thoroughly above, and the relocation of the City of Yreka's water supply pipeline, discussed below as Potential Impact 3.3-23.

Disturbance to the river channel during construction related to the Proposed Project could affect aquatic species. The Proposed Project would require demolition of the dams and their associated structures, removal of power generation facilities and transmission lines, installation of cofferdams, road upgrading, hauling, reservoir restoration, recreation site modifications (existing and/or new), and other activities (as described in Section 2.7.1 *Dam and Powerhouse Deconstruction*). These actions would include the use of heavy equipment, and blasting as necessary, and have the potential to disturb aquatic species. Activities at the Lower Klamath Project dams would affect the riverine and introduced resident species in the Hydroelectric Reach. At Iron Gate Dam and Iron Gate Hatchery, anadromous species could also be affected. These potential effects could include shockwaves associated with breaking down the dam structures 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.

Several deconstruction activities are schedule to occur prior to reservoir drawdown, including road improvements (e.g., bridge upgrades), temporary road crossings, Iron Gate modifications, Fall Creek Hatchery modifications, etc. In-water demolition of the dams and their associated structures, power generation facilities, and other activities, are scheduled to occur nearly simultaneously within the first nine months of reservoir drawdown during dam removal year 2 (see Table 2.7-1), and during the peak SSCs associated with reservoir drawdown in dam removal year 2. The aquatic resources impacts of this reservoir drawdown SSC peak are discussed earlier in this section. It is anticipated that this release of sediment during initial drawdown would result in the nearly immediate displacement of most mobile aquatic species from the mainstem into tributaries or farther downstream prior to the prolonged deconstruction or in-water work activities (e.g., cofferdam installation or removal). Native aquatic species (e.g., redband trout) that occur in the Hydroelectric Reach would have less potential refuge in the mainstem from deconstruction impacts, but would have access to key tributaries as refigure, including Jenny, Fall, and Shovel creeks. For non-mobile aquatic resources, like mussels, the impacts are anticipated to be well within the range of what is discussed for reservoir sediment release, as it is assumed that construction and deconstruction-related impacts would be of small magnitude, short duration, and low intensity when compared to those that would occur as a result of release of sediments stored behind the dams.

For aquatic species that occur within reservoirs, the effect of deconstruction is already subsumed by the impact of conversion of reservoir to riverine habitat, as described in multiple potential impacts above. For example, the reservoir habitat that supports Lost River and shortnose suckers (Potential Impact 3.3-13) would be removed, as addressed by the Aquatic Resource Measure AR-6 to salvage and relocate suckers prior to reservoir drawdown, or impacts associated with deconstruction.

To minimize potential construction impacts from crushing, sediment release, toxins, noise, etc., construction areas would be isolated from the river where possible. The Klamath River would be bypassed around the construction area while the isolated portion of the dam is removed. After a work area is isolated, fish rescue and relocation efforts, 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.

In addition, proposed soil erosion and sedimentation control and stormwater pollution prevention (Section 2.7.8.7 *Water Quality Monitoring and Construction BMPs*) measures would minimize effects of construction related toxins, soil erosion, and associated water quality effects on aquatic species downstream from the work area, during and after construction. Further, the State Water Board has issued a draft water quality certification which sets forth multiple conditions to monitor the effects of deconstruction on water quality (e.g., suspended sediment, dissolved oxygen, toxicity, etc.), and to protect aquatic resources through proper disposal of materials. Based on no predicted substantial short- or long-term decrease in aquatic species abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to aquatic resources under the Proposed Project in the short term or long term from deconstruction effects.

Significance
No significant impact for aquatic resources from deconstruction in the short term or long term

Potential Impact 3.3-22 Effects on aquatic species due to short-term noise disturbance and water quality alterations from deconstruction activities and long-term fish screen upgrades or permanent fish passage barrier from the relocation of the City of Yreka Water Supply Pipeline.
The existing water supply pipeline for the City of Yreka passes under the upstream end of Iron Gate Reservoir and would have to be relocated prior to decommissioning the Iron Gate Dam to prevent damage from deconstruction activities or increased water velocities and pipeline exposure once the reservoir has been drawn down. Additionally, the water supply intake screens located in Fall Creek may need to be replaced or upgraded to meet regulatory criteria. Native species currently residing in Iron Gate Reservoir that could be affected from the construction-impacts of removal of the existing pipeline and the installing of a new one in the short term would include redband trout, cutthroat trout, chub species, sucker species, and sculpin species. In the long-term anadromous fish accessing habitat upstream of Iron Gate Dam could also be affected by improved screens at the water supply intakes. If the existing fish screens for the water supply intakes do not meet current regulatory agency screen criteria for anadromous fish, improved screened intakes presumably would meet criteria. The KRRC recently has proposed to include a permanent fish passage barrier at the Fall Creek Hatchery, located approximately 200 to 300 feet downstream of both Dams A and B (KRRC 2019b), such that there would be no need for updates to the City of Yreka's Dam A or B existing diversion intake structures. As described in Section *2.7.8.7 Water Quality Monitoring and Construction BMPs,* standard construction best management practices would reduce the likelihood and extent of aquatic impacts to a less-than-significant level for water quality purposes. These levels are set for protection of aquatic resources. Therefore, based on no predicted substantial short- or long-term decrease in aquatic species abundance of a year class, or substantial decrease

in habitat quality or quantity, there would not be a significant impact to aquatic resources under the Proposed Project in the short term or long term from the relocation of the City of Yreka water supply pipeline and intake screens.

Significance

No significant impact to aquatic resources from the relocation of the City of Yreka water supply pipeline and intake screens in the short or long-term

Potential Impact 3.3-23 Effects on anadromous salmonid populations due to short-term and long-term Bogus Creek flow diversions for the Iron Gate Hatchery.

Under the Proposed Project, up to 8.75 cfs of water would be diverted from Bogus Creek to operate Iron Gate Hatchery for eight years (dam removal year 2 through post-dam removal year 7), as described in Section 2.7.6 *Hatchery Operations*. This diversion would replace the current water supply from Iron Gate Reservoir. Specific diversion rates from Bogus Creek would be as follows:

- 6.50 cfs October through November
- 8.75 cfs in December
- 3.50 cfs January through March
- 8.25 cfs April through May
- 0.00 cfs June through September

To reduce the potential adverse effects of diverting water from Bogus Creek on naturally spawning and rearing salmon, the KRRC proposes to construct the pump station for the hatchery water supply would be constructed as far downstream toward the Klamath River confluence as practicable (within 1,000 feet, Figure 2.7-10). This would result in up to a 1,000-foot reach in lower Bogus Creek that would experience lower fall, winter, and spring flows than under existing conditions (Figure 2.7-11). As further discussed below, CDFW and NMFS have proposed monitoring and adaptation of operations to minimize habitat impacts.

Based on adult migrant monitoring (Knechtle and Chesney 2011, 2016a, 2017), fall-run Chinook salmon are observed to return to Bogus Creek to spawn from mid-September to early November, coho salmon adults return from late October to early January, and steelhead from November through March. Therefore, flow diversions of 6.5 cfs during October and November, and 8.75 cfs in December could affect upstream migration of adult salmonids into Bogus Creek through the lower reach. The volume of flow required for adult salmonids to migrate upstream through lower Bogus Creek has not been directly assessed. Depending on stream gradient, channel width, and other geomorphic conditions, flows below the diversion may continue to be sufficient for upstream passage, or they could result in conditions that restrict passage at times, particularly in early October prior to increased precipitation. The geomorphic conditions that determine passage are subject to change as precipitation events alter the streambed.

Based on two years of recent migration observations in Bogus Creek (Knechtle and Chesney 2016a, 2017) during the low flow years of 2015 and 2016, fall-run Chinook salmon were observed migrating at flows as low as 4.5 cfs in September 2016, and 8 fish were observed migrating at flows between 4.5 and 5 cfs. During the fall-run Chinook salmon migration peak in 2015 and 2016, flows were between 10 and 20 cfs. Based on this data, flows greater than around 4.5 cfs enabled at least some upstream migration in the past. If this flow was sufficient for Chinook salmon, it would also be sufficient for coho salmon and steelhead, which have less restrictive passage requirements. Long-term flow monitoring data are not available for Bogus Creek. However, the available data from 2013–2016 includes severe and extreme drought conditions and are therefore likely appropriate to observe minimum flows to support passage. Based on four years of available data (Figure 2.7-14), proposed water diversions could result in flow reductions during the adult migratory period of around 10 to 40 percent in the affected reach during fall-run Chinook salmon migration, potentially resulting in flows less than 4.5 cfs in at least some years, for at least a few days. By the time coho salmon and steelhead are migrating flows are high enough to provide greater than 4.5 cfs, based on the data available. Based on available data it appears that under the Proposed Project insufficient flows for Chinook salmon passage could result in delays for up five days in some years. Delay of migration for even one day has been observed to increase disease risk by increasing the density of holding adults and increasing mortality of adults prior to spawning (McLaughlin et al. 2012, Connor et al. 2018). Temporary increasing in crowding may be similar to what is observed under existing conditions during periods of low rainfall but could be exacerbated by decreasing flows in lower Bogus Creek. These impacts are anticipated to effect a small proportion of migrants during the 14-week fall-run Chinook salmon migration period (Table 3.3-3). In addition, any redds that are deposited along channel margins (shallow water areas) downstream of the diversion may be susceptible to stranding when diversion rates increase (e.g., primarily December, as well as March), although the affected reach is relatively short (< 1,000 feet). Rearing fish (mobile) are unlikely to be affected by the relatively low magnitude of flow fluctuations.

The proposal for Iron Gate Hatchery operation includes protection for fish passage in Bogus Creek (Appendix B: *Definite Plan – Section 7.8.3*, NMFS and CDFW 2018). To minimize effects of Bogus Creek diversions on fish habitat, NMFS and CDFW would coordinate with KRRC to ensure that at least 50 percent of the flow would remain in Bogus Creek at the point of diversion, conduct an assessment to determine that the habitat below the diversion provides connectivity for fish spawning and rearing habitat, identify appropriate flow levels or percentages of diversion permitted each month, and establish reporting specifications (Appendix B: *Definite Plan – Section 7.8.3*, NMFS and CDFW 2018).

Based on the potential for low flows (i.e., less than 4.5 cfs) in the Bypass Reach during the salmonid migration periods in some years (which could result in delayed migration and increased crowding), the uncertainty in the migration flow levels in Bogus Creek, and the uncertainty in the commitment to ensure flows to protect anadromous salmon volitional migration, the flow diversions from Bogus Creek could decrease the abundance of multiple (up to eight) year classes of anadromous salmonids produced from spawning activity in Bogus Creek. However, it is anticipated that this would only occur infrequently during some dry water years, and only a small portion of the fall-run migration would potentially be affected. Based on the less than substantial decrease in abundance of a year class and habitat quality that could occur under the Proposed Project in the short- and long-term, the effect of reduced instream flows in Bogus Creek under the Proposed Project would not be significant in the short- and long-term.

Although CEQA Guidelines Section 15126.4(a)(3) states that mitigation measures are not required for effects which are not found to be significant, Mitigation Measure AQR-3 would even further reduce the potential for short- and long-term effects of reduced instream flows in lower Bogus Creek under the Proposed Project on anadromous salmon by increasing certainty that fish passage conditions are projected. Mitigation Measure AQR-3 below includes additional components beyond those listed as part of the Proposed Project which would further reduce the potential short-term impacts on migrating anadromous salmonids resulting from hatchery operations. With Mitigation Measure AQR-3, the potential effect of instream flow diversions is further reduced.

Mitigation Measure AQR-3 – Bogus Creek Flow Diversions.
Implementation of Iron Gate Hatchery operations plan (Described in Appendix B: *Definite Plan – Section 7.8.3*) shall include a minimum flow in Bogus Creek of 4.5 cfs, unless a study is conducted that determines an alternative minimum flow is required to provide volitional fish migration for Chinook salmon, coho salmon, and steelhead. If the hatchery diversions cause a flow within Bogus Creek downstream of the bypass that is less than 4.5 cfs (or the minimum flow identified for each species during their migration period), then hatchery operations shall be adjusted, in coordination with NMFS and CDFW, to reduce the percentage of flow diverted from Bogus Creek to be protective of anadromous fish passage.

Significance
No significant impact with mitigation on Chinook salmon, coho salmon, or steelhead in the short term or long term

Potential Impact 3.3-24 Effects on anadromous salmonid populations due to short-term and long-term Fall Creek flow diversions for the Fall Creek Hatchery.
Under the Proposed Project, up to 9.24 cfs of water would be diverted from Fall Creek to operate Fall Creek Hatchery for eight years (through post-dam removal

year 7), as described in Section 2.7.6 *Hatchery Operations*. Specific diversion rates from Fall Creek would be as follows:

- 8.48 cfs in October
- 9.24 cfs in November
- 6.32 cfs in December
- 5.77 cfs in January
- 1.47 cfs in February
- 1.76 cfs in March
- 1.84 cfs in April
- 1.08 cfs in May
- 0.58 cfs in June
- 1.01 cfs in July
- 1.48 cfs in August
- 2.29 cfs in September

In addition, the City of Yreka maintains a water right to divert up to 15 cfs from Fall Creek for municipal purposes (City of Yreka 2012). The primary water intake for this water pipeline is located along the PacifiCorp Fall Creek powerhouse return canal at Dam A (Figure 2.7-17), which is upstream of the proposed Fall Creek Hatchery water diversion. Under the Proposed Project no fish passage would be possible past the existing Dam A or Dam B on Fall Creek (Figure 2.7-8; Appendix B: *Definite Plan – Section 7.8.3*), approximately one mile upstream from the projected confluence of Fall Creek with the Klamath River. The KRRC recently has proposed to include a permanent fish passage barrier at the Fall Creek Hatchery, located approximately 200 to 300 feet downstream of both Dams A and B (KRRC 2019. Depending on final site selection, discharge from the hatchery would re-enter Fall Creek from between 0.08 and 0.36 miles upstream from the confluence with the Klamath River. Therefore, most of the one mile of spawning and rearing habitat for salmonids in Fall Creek, from Dam A and Dam B to the confluence with the Klamath River, would be subject to reduced flows as a result of Fall Creek Hatchery water diversions.

Based on historical records and current assessments of habitat suitability, Fall Creek likely has the potential to provide around one mile of spawning and rearing habitat for fall-run and spring-run Chinook salmon, coho salmon, steelhead, and Pacific lamprey following the removal of the fish passage barrier of Iron Gate Dam (NMFS 2006a, Hamilton et al. 2005, 2011).

The City of Yreka is required to bypass a minimum flow of 15 cfs or the natural flow of Fall Creek, whenever the natural flow is less than 15 cfs. Under existing conditions Yreka uses less than the 15 cfs allocation, but the City has used the full allocation in the past, and for this analysis it is assumed that the City of Yreka would use their full water right of up to 15 cfs. The Fall Creek Hatchery diversion and return flow points would occur between the City of Yreka water supply intake and the City's compliance point for the Fall Creek minimum flow, which is at the Fall Creek USGS gage (USGS No. 11512000). Between the Fall Creek Hatchery diversion and return flow points, the flow remaining in Fall Creek after the diversions for the City of Yreka and the Fall Creek Hatchery would usually be greater than 15.0 cfs, but it could occasionally be slightly less than 15.0 cfs in late summer to early fall (i.e., mid-July to mid-September) when natural Fall Creek flows reach a minimum. Fall Creek Hatchery diversion flows during the late summer would be 1.01 to 2.29 cfs, potentially reducing flows within the hatchery diversion affected reach to less than 15 cfs in dry water years with particularly low flows. However, this slight reduction during late summer is not anticipated to have a substantial effect on habitat availability or fish passage, due to the volume of instream flows remaining in the reach. During periods of the year when hatchery diversions would be higher (e.g., October through January), typically flows greater than 20 cfs would occur in this section of Fall Creek (Figure 2.7-13), which based on the habitat and channel morphology in Fall Creek is anticipated to provide suitable migratory, rearing, and spawning conditions. Any redds that are deposited downstream of the diversion along channel margins (shallower water) during fall may be susceptible to stranding (i.e., reduced egg-to-emergence survival) when diversion rates increase (e.g., primarily October and November). Rearing fish (mobile) are unlikely to be affected by the relatively low magnitude of flow fluctuations.

Under the Proposed Project anadromous salmonids would have increased habitat access upstream of Iron Dam, including within around one mile of habitat within Fall Creek that is currently inaccessible. Overall, a relatively small diversion of water from Fall Creek relative to existing creek flows would occur under the Proposed Project. In addition, the proportion of anadromous salmonids anticipated to use the habitat in Fall Creek is relatively minor in comparison with the totality of newly accessible habitat upstream of Iron Gate Dam under the Proposed Project. Therefore, based on no predicted substantial short- or long-term decrease in anadromous salmonid population abundance of a year class, or substantial decrease in habitat quality or quantity, there would not be a significant impact to anadromous salmonids under the Proposed Project in the short term or long term from Fall Creek Hatchery flow diversions.

Significance

No significant impact on Chinook salmon, coho salmon, or steelhead in the short term or long term

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3.4 Phytoplankton and Periphyton

Volume I Section 3.4.2.1 Phytoplankton and Periphyton – Environmental Setting – Phytoplankton, paragraph 3 on page 3-392 through paragraph 1 on page 3-393:

In addition to dissolved oxygen, pH, and at times ammonia, high concentrations of blue-green algae species, such as *Anabaena flos-aquae* and *Microcystis aeruginosa*, can produce nuisance levels of algal toxins (e.g., anatoxin-a and microcystin) that are harmful to fish, mammals, and humans (see also Section 3.2.2.7 *Chlorophyll-a and Algal Toxins*).

<u>In a lake or reservoir environment, diatoms and green algae typically dominate in spring then decrease due to zooplankton grazing and the onset of water column stratification, which results in the diatoms and green algae settling out of the water column below the lake or reservoir surface layer (epilimnion). Cyanobacteria [blue-green algae] dominance in a lake or reservoir environment increases during late summer and early fall when water temperatures are warm and thermal stratification occurs, because their ability to control their buoyancy provides cyanobacteria [blue-green algae] with a</u>

competitive advantage over diatoms and green algae (Raymond 2008, 2009, 2010; Moisander et al. 2009; Asarian and Kann 2011; McDonald and Lehman 2013; Paerl and Otten 2015; Visser et al. 2016; Paerl et al. 2018). In the late fall, the phytoplankton community composition shifts back to being dominated by diatoms, as thermal stratification breaks down and cyanobacteria abundance declines (Raymond 2008, 2009, 2010).

The stable lacustrine[101] environment created by Copco No. 1 and Iron Gate dams, coupled with high nutrient availability and high water temperatures in summer and fall months, provides ideal conditions for ~~phytoplankton growth, especially~~ the growth of blue-green algae species (Figure 3.4-2 and Figure 3.4-3). While cyanobacteria [blue-green algae] can be found in a variety of lake, reservoir, river, and estuarine environments, the cyanobacteria [blue-green algae] species *Anabaena flos-aquae* and *Microcystis aeruginosa* thrive in warm, high nutrient, and stable water column conditions (Konopka and Brock 1978; Kann 2006; Asarian and Kann 2011) because ~~, where~~ they can outcompete other beneficial algae species such as diatoms and green algae under these environmental conditions (Visser et al. 2016). ~~While they do not thrive in fast-moving water, diatoms~~ and green algae do not regulate their buoyancy, ~~and thus~~ so they rely on mixing in the water column (e.g., from wind, convection, or slow currents) to remain suspended near the water surface where light is available for photosynthesis. During spring conditions, reservoirs are often vertically mixed such that diatoms and green algae generally are able to remain suspended in the water column and dominate the phytoplankton community. During summer and fall, water temperatures are warmer, the water column is more stable, and thermal stratification limits vertical mixing, so ~~In reservoirs with warm water and a stable water column,~~ diatoms and green algae tend to settle out of the water column away from sunlight. Cyanobacteria [blue-green algae] cells contain gas sacs (vesicles[102]), so they can control their buoyancy and remain near the water surface to obtain light for photosynthesis (Walsby et al. 1997). The ability to control their density and position in the water column gives blue-green algae better access to light and they can shade phytoplankton (e.g., diatoms or green algae) lower in the water column. Additionally, cyanobacteria [blue-green algae] can also change their buoyancy to vertically migrate within the reservoir water column to access nutrients below the thermocline when nitrogen or phosphorous are limited in the upper surface layer (i.e., epilimnion) of the reservoir (Moisander et al. 2009; Paerl and Otten 2015; Paerl et al. 2018). Thus, blue-green algae are able to outcompete diatoms and/or green algae under lower mixing conditions in reservoirs. *Microcystis aeruginosa* can dominate the phytoplankton community in calm, stable lacustrine conditions, when their ability to float exceeds the rate of turbulent mixing in the water column (Huisman et al. 2004). However, blue-green algae abundance in the phytoplankton community decreases compared to diatoms and green algae when water column mixing in a water body increases (McDonald and Lehman 2013; Visser et al. 2016). In late fall when thermal stratification breaks down and reservoirs become vertically mixed again, the phytoplankton community shifts from primarily cyanobacteria to diatoms.

Volume I Section 3.4.2.1 Phytoplankton and Periphyton – Environmental Setting – Phytoplankton – Anabaena flos-aquae, paragraph 1, footnote 104 on page 3-397:

Cyanobacteria in the genus *Anabaena* have been recently recategorized, with all planktonic species in the genus *Anabaena* renamed *Dolichospermum* and all benthic species remaining in the genus *Anabaena*. As such, *Anabaena flos-aquae* was recently renamed *Dolichospermum flos-aquae.* However, this EIR continues to use the *Anabaena* name for both planktonic and benthic species since it was more frequently used in the literature cited and it is still commonly used in descriptions of this species.

Volume I Section 3.4.2.2 Phytoplankton and Periphyton – Environmental Setting – Periphyton, paragraph 3 on page 3-403:

Monitoring at multiple locations along the Middle and Lower Klamath River indicates that dissolved oxygen and pH patterns over a 24-hour period are driven primarily by photosynthesis and respiration of periphyton in the absence of a reservoir phytoplankton bloom that is subsequently transported downstream into the river (Ward and Armstrong 2010~~,~~; Asarian et al. 2015; Genzoli and Hall 2016). The repeatable and consistent diel cycling of dissolved oxygen is characteristic of a stream metabolism that is dominated by periphyton photosynthesis and respiration (Odum 1956). However, free-floating algae transported through the system likely exert some influence on the dissolved oxygen signal in the Klamath River, as does the oxygen demand from decaying organic matter (e.g., bacteria, algae, plant litter) exported from upstream Klamath River reservoirs (PacifiCorp 2006; FERC 2007). Estimates of the stream metabolism in the Klamath River at Seiad Valley, Weitchpec, and Turwar during 2012 indicate periphyton and other benthic organisms are responsible for approximately 89 percent of the variations in dissolved oxygen per square meter per day (i.e., stream metabolism) when phytoplankton blooms are not occurring in the reservoirs or being subsequently transported downstream into the river (Genzoli and Hall 2016). Phytoplankton blooms in the reservoirs during September through mid-October 2012 and the transport of suspended phytoplankton into the Middle and Lower Klamath River shifted the stream metabolism from being primarily due to periphyton and other benthic organisms to a mixture of periphyton, other benthic organisms, and phytoplankton. During phytoplankton bloom conditions, the relative contribution of phytoplankton to stream metabolism increased to 55 percent at some river sites (Genzoli and Hall 2016).

Volume I Section 3.4.2.3 Phytoplankton and Periphyton– Environmental Setting – Hydroelectric Reach – Phytoplankton, paragraph 1 on page 3-412:

Additionally, the genetic and toxin analyses show that the *Microcystis aeruginosa* populations in Copco No. 1 and Iron Gate reservoirs are genetically distinct, providing evidence that blooms in Iron Gate Reservoir are internally derived and not due to transport of Microcystis aeruginosa populations from Copco No. 1 Reservoir or further upstream (Otten et al. 2015).

Genetic analyses of *Microcystis aeruginosa* cells from Copco No. 1 Reservoir, Iron Gate Reservoir, and Klamath River sites indicate that while there are five strains of *Microcystis aeruginosa* (i.e., operational taxonomic units [OTUs]) in the Klamath Basin, there is a high abundance of the microcystin-producing gene in only one *Microcystis aeruginosa* I (Otten et al. 2015, Otten and Dreher 2017). Data indicate that microcystin protects cyanobacteria [blue-green algae] cells from high oxidative stress that would occur during periods of high light intensity, so the toxigenic *Microcystis aeruginosa* I in the Klamath Basin may have a competitive growth advantage over the other nontoxic *Microcystis aeruginosa* OTUs during summer and fall periods with high light intensity. In experiments containing both toxic and non-toxic strains of *Microcystis aeruginosa*, warmer temperatures and oxidative stress favor dominance of toxic strains of *Microcystis aeruginosa* (Paerl and Otten 2013). In Copco No. 1 Reservoir between 2007 and 2015, the toxigenic *Microcystis aeruginosa* I dominated throughout 2009 to 2012 and 2015 and comprised the majority for two or more months in 2007, 2008, and 2013, but it had very low prevalence (i.e., less than 10 percent) throughout 2014. In Iron Gate Reservoir between 2008 and 2015, the toxigenic *Microcystis aeruginosa* I dominated during most of the year from 2009 to mid-2013 and 2015, but it did not comprise the majority of the *Microcystis aeruginosa* population in the reservoir during 2008 and 2014. Differences between the timing and type of *Microcystis aeruginosa* OTUs that dominate in Copco No. 1 and Iron Gate reservoirs further indicate that the populations are internally derived in each reservoir. However, the consistent dominance of the toxigenic *Microcystis aeruginosa* I from 2009 to mid-2013, followed by low prevalence in 2014 in Copco No. 1 and Iron Gate reservoirs, also suggests that a regional environmental condition is influencing populations in both reservoirs. While seasonal and inter-annual variations in Klamath River flows and water quality conditions in the reservoirs between 2009 to 2015 did not correlate with changes in toxigenic *Microcystis aeruginosa* I abundance, episodic wildfire smoke in 2008, mid-2013, and part of 2014 did coincide with declines in in toxigenic *Microcystis aeruginosa* I abundance and increases in nontoxic *Microcystis aeruginosa* OTUs. Decreases in light intensity during wildfire smoke periods may have reduced the competitive advantage microcystin provides to the toxigenic *Microcystis aeruginosa* I, resulting in the observed shifts in the reservoir *Microcystis aeruginosa* populations from dominance by toxigenic OTUs to nontoxic OTUs (Otten and Dreher 2017).

The documented presence of algal toxins in water and fish tissue in the Hydroelectric Reach corresponds with spatial and temporal patterns in the distribution of blue-green algae blooms within the reach.

Volume I Section 3.4.2.3 Phytoplankton and Periphyton – Environmental Setting – Hydroelectric Reach – Phytoplankton, paragraph 2 on page 3-412:

The reservoirs create ideal growing conditions for toxigenic blue-green algae (calm, stable lacustrine conditions with bioavailable nutrients), regularly resulting in high microcystin concentrations from approximately July through October (Kann and Corum 2006, 2009; Asarian and Kann 2011; Otten et al. 2015; Watercourse Engineering, Inc. 2016; Otten 2017; Otten and Dreher 2017).

Volume I Section 3.4.2.3 Phytoplankton and Periphyton – Environmental Setting – Hydroelectric Reach – Periphyton, paragraph 2 on page 3-413:

Nuisance blooms of periphyton have not been documented in the riverine portions of the Hydroelectric 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~~ Karuk Tribe 2006), due to turbid water conditions that limit light availability for photosynthesis, high water velocities that limit establishment and growth of periphyton, and the variable flow regime that causes the cycles of drying and rewetting, as described by PacifiCorp (2005).

Volume I Section 3.4.5.1 Phytoplankton and Periphyton – Potential Impacts and Mitigation – Phytoplankton – Potential Impact 3.4-2 – Middle and Lower Klamath River, paragraph 1 on page 3-431:

Long-term increases in annual total nutrient levels would occur in the Middle and Lower Klamath River due to the lack of continued interception of nutrients by the Lower Klamath Project dams (Potential Impact 3.2-8). However, possible summer and fall increases in nutrient concentrations following Lower Klamath Project dam removal (see Section 3.2.5.3 *Nutrients*), particularly directly downstream from Iron Gate Dam, would not substantially contribute to blue-green algae blooms downstream from the dam, due to the lack of the suitable habitat conditions required for extensive phytoplankton growth in the Klamath River (see discussion above under the Hydroelectric Reach). ~~Some phytoplankton growth may still occur after dam removal in calm, slow-moving habitats along shorelines and protected coves and backwaters during low-flow periods in the Middle and Lower Klamath River, but these habitats already support growth of blue-green algae, including *Microcystis aeruginosa*, that results in occasional exceedances of 2016 CCHAB secondary thresholds and WHO guidelines (Falconer et al. 1999; Kann et al. 2010; State Water Board et al. 2010, updated 2016; Genzoli and Kann 2016, 2017).~~ The water velocity and constant mixing in the Middle and Lower Klamath River generally creates an environment that is not supportive of phytoplankton growth (Genzoli and Kann 2017). While higher concentrations of phytoplankton cells and algal toxins have been measured in calm, slow-moving habitats along shorelines, protected coves, and backwaters along the Klamath River than in the faster-moving open channel river habitats (Kann et al. 2010; Genzoli and Kann 2017), growth and/or reproduction of phytoplankton cells within these habitats have not been documented. Measurements of blue-green algae (e.g., *Microcystis aeruginosa*) and algal toxins (e.g., microcystin) along shoreline habitats occasionally exceed 2016 CCHAB secondary thresholds and WHO guidelines under existing conditions, but these high concentrations of blue-green algae cells and associated algal toxins are generally attributed to entrapment and accumulation of cells and toxins transported downstream from the reservoirs rather than growth and/or reproduction within these slow-moving shoreline habitats (Falconer et al. 1999; Kann et al. 2010; State Water Board et al. 2010, updated 2016; Genzoli and Kann 2016, 2017). Furthermore, longitudinal decreases in the measured *Microcystis aeruginosa* cell densities and microcystin downstream of Iron Gate Dam in both slow-moving shoreline and open channel habitats suggest *Microcystis aeruginosa* cells and microcystin are being transported downstream into these shoreline habitats and phytoplankton growth is limited in these slow-moving shoreline habitats (Genzoli and Kann 2017). However, these calm, slow-moving shoreline, protected cove, and backwater habitats during low-flow periods in the Middle and Lower Klamath River would potentially provide suitable slow-moving phytoplankton habitat, so some blue-green algae growth may still occur after dam removal in the Middle and Lower Klamath River. While total nutrient transport into the Middle and Lower Klamath River after dam removal would slightly increase under the Proposed Project, *Microcystis aeruginosa* cell density and microcystin concentrations in Middle and Lower Klamath River after dam removal are expected to decrease because ~~due to~~ the reduced transport of *Microcystis aeruginosa* and microcystin from the Hydroelectric Reach into the Middle and Lower Klamath River under the Proposed Project would be greater than potential growth of phytoplankton, including blue-green algae, within slow-moving habitats in the Middle and Lower Klamath River. Therefore, the slight increase in nutrient availability is not expected to support nuisance phytoplankton growth or blooms that exceed current levels.

Volume I Section 3.4.5.2 Phytoplankton and Periphyton – Potential Impacts and Mitigation – Periphyton – Potential Impact 3.4-4, paragraph 2 on page 3-436:

However, the overall effect of the Proposed Project would likely ~~be to~~ increase periphyton in the ~~margins of low gradient~~ portions of Copco No. 1 and Iron Gate reservoir footprints with suitable habitat for periphyton growth due to the creation of new, previously uncolonized low gradient river channels. Periphyton growth would be most likely to occur along the channel margins with shallower water depths, more light availability, warmer water temperatures, and lower probability of seasonal sediment transport and scour, but periphyton growth could also occur elsewhere in the channel wherever suitable habitat conditions exist. While there is considerable uncertainty, there is the potential under the Proposed Project that nuisance periphyton species could be part of the periphyton assemblages that grow in the ~~margins of these~~ new low gradient river channels. The nuisance periphyton species would potentially provide habitat for the polychaete worm (*Manayunkia speciosa*) that is the intermediate host of the fish parasites *Ceratomyxa shasta* and *Parvicapsula minibicornis*~~, so~~. Thus, if there is a ~~the~~ short-term ~~and~~ or ~~the~~ long-term increase in growth of nuisance periphyton species due to increases in available habitat, especially along channel margin areas ~~of the Hydroelectric Reach~~ within the Copco No. 1 and Iron Gate reservoir footprints of the Hydroelectric Reach, ~~also would~~ it could potentially result in a new or further impairment of designated beneficial uses~~, and~~. It would therefore be a significant impact.

3.4.6 References

Volume I Section 3.4.6 Phytoplankton and Periphyton – References, pages 3-440 through 3-451, includes the following revisions:

Kann, J., L. Bowater, and S. Corum. 2010. Middle Klamath River toxic cyanobacteria trends, 2009. Technical Memorandum. Prepared by Aquatic Ecosystem Sciences, LLC, Ashland, Oregon and the Karuk Tribe Department of Natural Resources for the Karuk Tribe Department of Natural Resources, Orleans, California.

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Other references cited as part of text included in the Section 3.4 list of revisions:

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Huisman, J., J. Sharples, J. M. Stroom, P. M. Visser, W. E. A. Kardinaal, J. M. H. Verspagen, and B. Sommeijer. 2004. Changes in turbulent mixing shift competition for light between phytoplankton species. Ecology 85: 2,960–2,970.

Kann, J. 2006. *Microcystis aeruginosa* occurrence in the Klamath River system of southern Oregon and northern California. Technical Memorandum. Prepared for the Yurok Tribe Environmental and Fisheries Program, Klamath, California.

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Raymond, R. 2009. Phytoplankton species and abundance observed during 2008 in the vicinity of the Klamath Hydroelectric Project. Prepared by E&S Environmental Chemistry, Inc., Corvallis, Oregon, for CH2M Hill, Portland, Oregon and PacifiCorp Energy, Portland, Oregon.

Raymond, R. 2010. Phytoplankton species and abundance observed during 2009 in the vicinity of the Klamath Hydroelectric Project. Prepared by E&S Environmental Chemistry, Inc., Corvallis, Oregon for PacifiCorp Energy, Portland, Oregon.

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Visser, P. M., B.W. Ibelings, M. Bormans, and J. Huisman. 2016. Artificial mixing to control cyanobacterial blooms: a review. Aquat. Ecol. 50: 423–441.

Walsby, A. E., P. K. Hayes, R. Boje, and L. J. Stal. 1997. The selective advantage of buoyancy provided by gas vesicles for planktonic cyanobacteria in the Baltic Sea. New Phytol. 136: 407–417.

Ward, G., and N. Armstrong. 2010. Assessment of primary production and associated kinetic parameters in the Klamath River. Draft Report. Prepared for the USFWS, Arcata Fish and Wildlife Office, Arcata, California.

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3.5 Terrestrial Resources

3.5.2 Environmental Setting

3.5.2.1 Vegetation Communities

Historical Vegetation

Volume I Section 3.5.2.1 Terrestrial Resources – Environmental Setting – Vegetation Communities – Historical Vegetation, paragraph 4 on page 3-467 through page 3-472:

When the reservoirs were built, topography limited the establishment of Montane Riparian habitat. ~~But~~ However, in many places the creation of the reservoir created a flat bench that facilitated Palustrine habitat establishment (PacifiCorp 2004a). Currently, there are ~~11.1~~4.8 acres of Montane Riparian and ~~25.2~~9.4 acres of Palustrine habitat ~~within 300 feet of the reservoir footprint of~~adjacent to Copco No. 1 and Copco No. 2 reservoirs and ~~4.7~~10.2 acres of Montane Riparian and ~~27.1~~19.6 acres of Palustrine habitat ~~within 300 feet of the reservoir footprint of~~adjacent to Iron Gate Reservoir (Table 3.5-2;~~Figures 3.5-4 and 3.5-5;~~ KRRC 2019a~~PacifiCorp 2005~~).

Table 3.5-2. Comparison of Historical (EDAW 2000) and Current (~~PacifiCorp 2005~~KRRC 2019a) Wet Habitat Types at Copco Nos. 1 and 2 and Iron Gate Reservoirs.

CHWR Vegetation Cover Types	Copco Nos. 1 and 2 (ac)	Iron Gate Reservoir (ac)	Total ac
Historical (reservoir footprint) [1]			
Montane Riparian (MRI)	66.2	30.1	**96.3**
Palustrine (PAL)[2]	23.7	2.6	**26.3**
Current ~~(within 300 feet of the reservoir footprint)~~			
Montane Riparian (MRI)	~~11.1~~4.8	~~4.7~~10.2	**~~15.8~~15.0**
Palustrine (PAL)[2]	~~25.2~~9.4	~~27.1~~9.6	**~~52.3~~19.0**

[1] No historical data is available outside of the reservoir footprint.

[2] Not a CWHR type; based on the Cowardin classification for wetlands and deepwater habits (Cowardin et al. 1979).

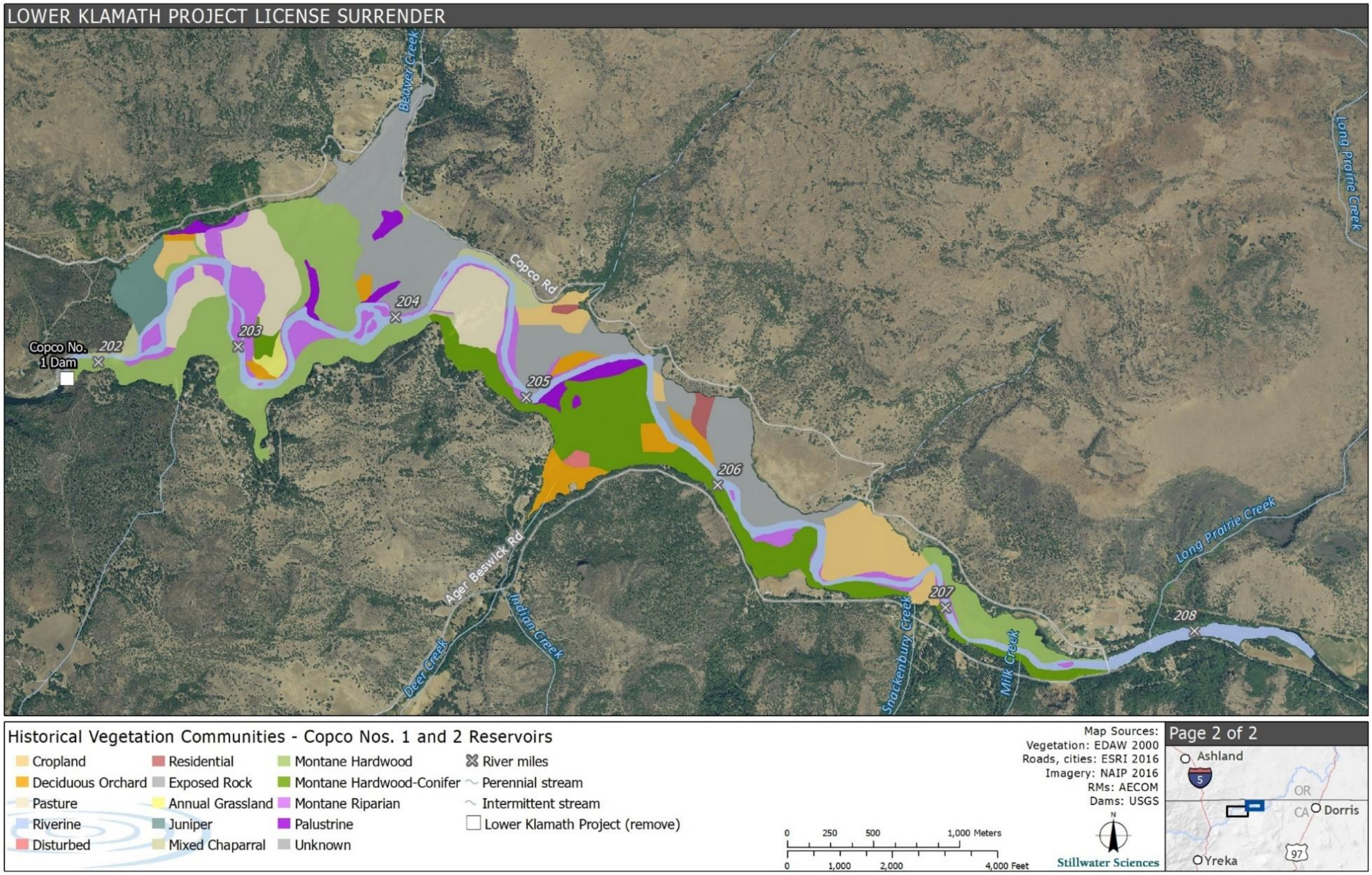


Figure 3.5-2. Historical Vegetation Types in Copco No. 1 and Copco No. 2 Reservoirs.

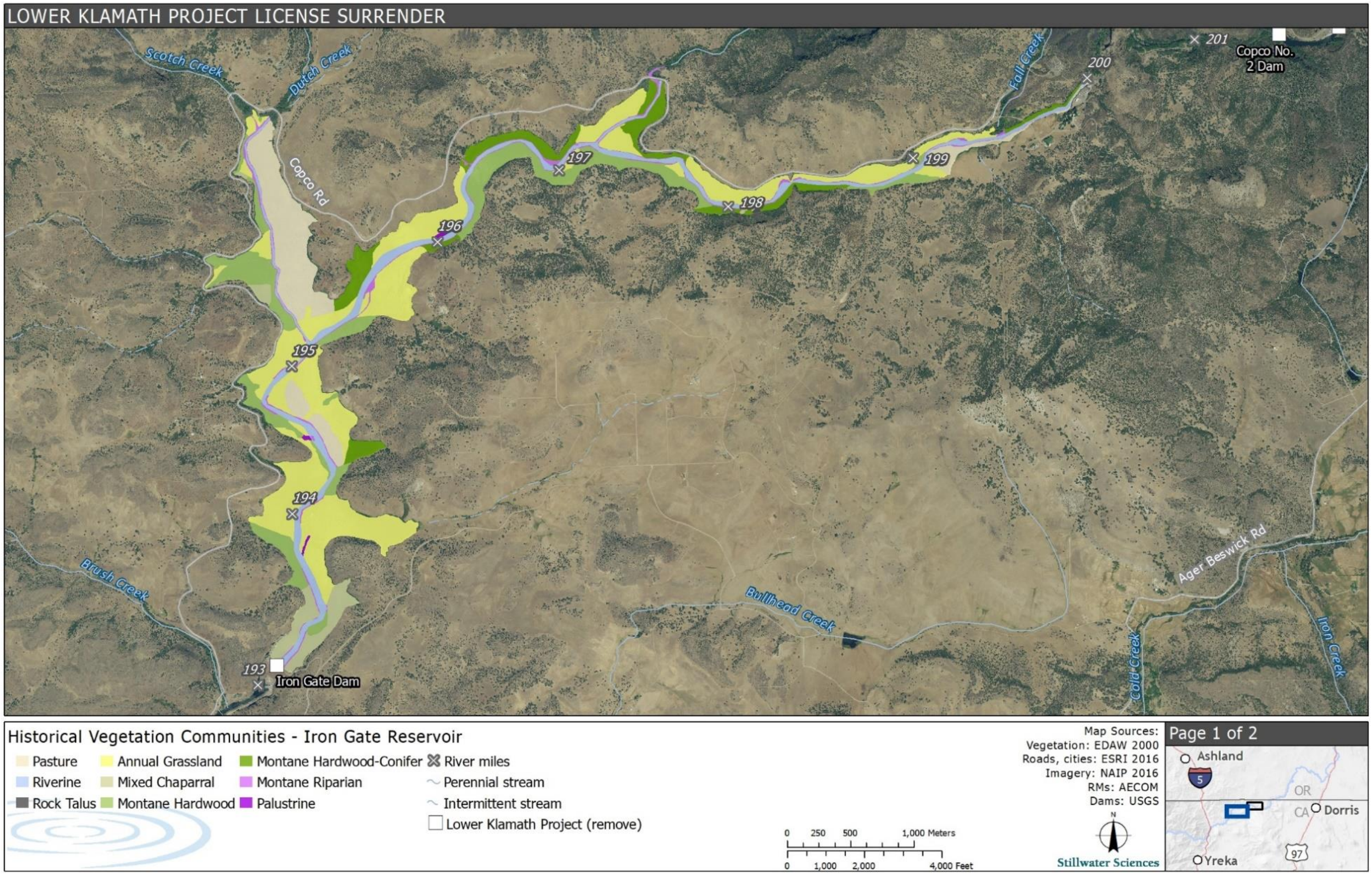
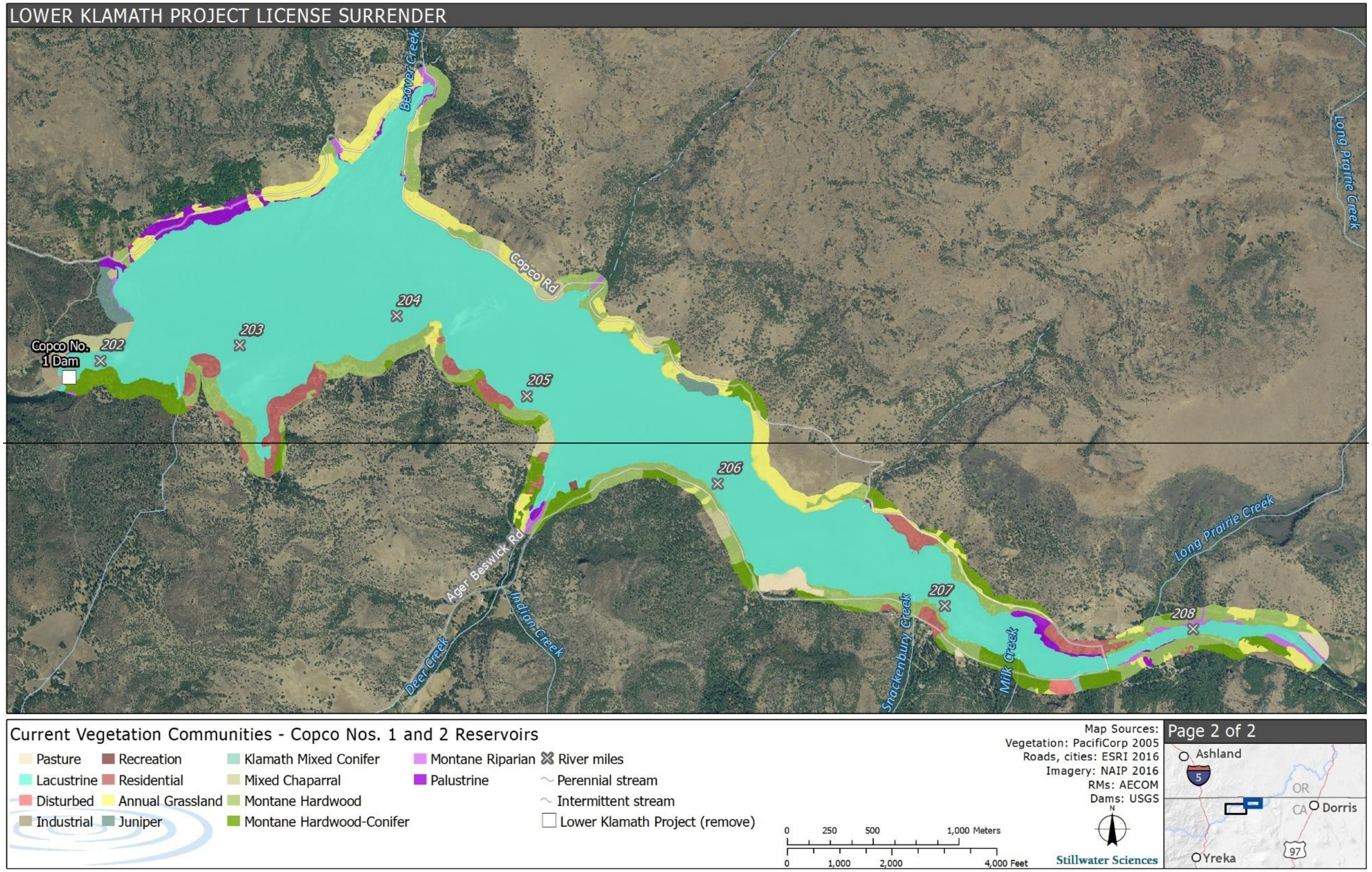
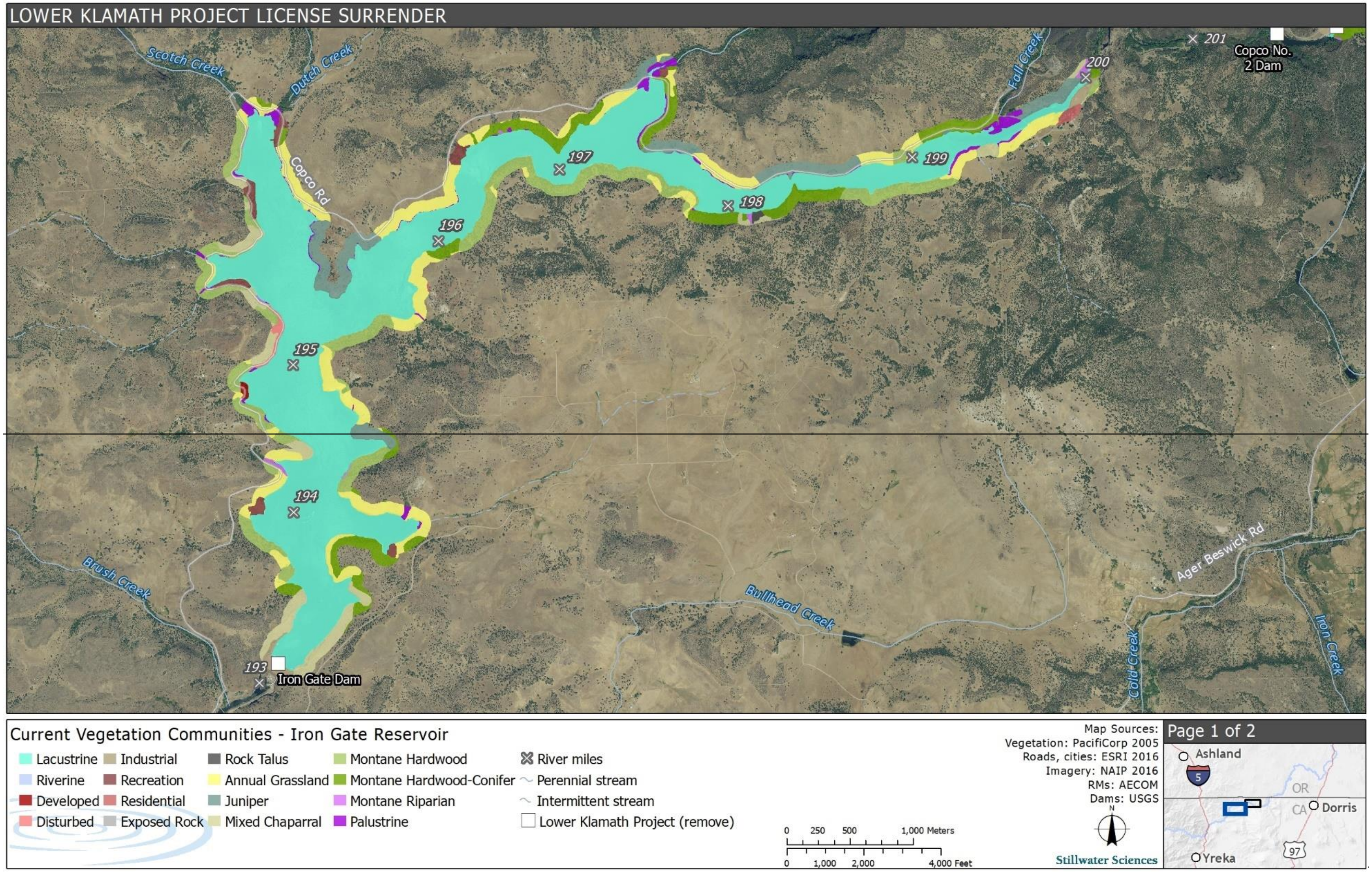


Figure 3.5-3. Historical Vegetation Types in Iron Gate Reservoir.



~~**Figure 3.5-4.** Current Vegetation Types within a 300-foot Buffer of Copco No. 1 and Copco No.2 Reservoirs.~~



~~**Figure 3.5-5.** Current Vegetation Types within a 300-foot Buffer of Iron Gate Reservoir.~~

3.5.2.2 Invasive Plant Species

3.5.2.3 Culturally Significant Plant Species

3.5.2.4 Non-special-status Wildlife

Volume I Section 3.5.2.4 Terrestrial Resources – Environmental Setting – Non-special-status Wildlife, paragraph 1 bullet 3 on page 3-475:

- Non-special-status-birds—mountain quail, double-crested cormorant, herons (great blue, black-crowned night), great egret, bufflehead, osprey, hawks (sharp-shinned, Cooper's), great-horned owl, terns (Forster's, Caspian), woodpeckers (acorn, pileated, Lewis'), black phoebe, black-capped chickadee, pygmy nuthatch, blue-gray gnatcatcher, western bluebird, and Swainson's thrush, (species documented only in J.C. Boyle Peaking Reach include, prairie falcon, flammulated owl, and merlin). Surveys conducted by KRRC in ~~May~~ 2018 also documented several osprey nests on platforms located on top of electrical poles in the Iron Gate Reservoir area~~ (CDM Smith 2018c)~~, <u>Cooper's hawk and great blue heron observed throughout the Iron Gate Reservoir, Copco No. 1, and J.C. Boyle Reservoir areas, with an active great blue heron nesting colony observed near Copco No. 2 penstock,</u> <u>and cliff swallow nests were documented in the Copco Diversion Tunnel (CDM Smith 2018c, KRRC 2019b)</u>; and

Volume I Section 3.5.2.4 Terrestrial Resources – Environmental Setting – Non-special-status Wildlife, new paragraph 2 on page 3-475:

<u>The reservoirs and riparian areas provide foraging habitat for many of these species, such as the non-native bullfrog, egrets, buffleheads, and river otters, by providing habitats that support fish, invertebrates, and reptiles for these species to eat. Migratory birds use these reservoirs seasonally during their migrations and/or for overwintering, by supporting nesting, foraging, and/or loafing (resting on the water) habitat. Surveys conducted by KRRC in 2017 and 2018 documented several osprey nests on platforms located on top of electrical poles in areas surrounding Iron Gate Reservoir, Copco No. 1 Reservoir, Copco No. 2 Reservoir, and along the Klamath River (CDM Smith 2018c, KRRC 2019b), and it is likely that osprey use the reservoirs for foraging on fish. The reservoirs also provide foraging habitat for bat species that primarily prey on aquatic emergent insects, and Project structures have been documented to support habitat for bat species (Yuma myotis) (KRRC 2019b). Project structures may also support roosting for non-special-status bat species that may forage on aquatic emerging insects or terrestrial insects in more upland habitats.</u>

3.5.2.5 Special-status Species

Special-status Wildlife

Volume I Section 3.5.2.5 Terrestrial Resources – Environmental Setting – Special-status Species – Special-status Wildlife new paragraphs 3 and 4 on page 3-500:

Reservoir and surrounding habitats support special-status species (Table 3.5-5). Western pond turtles have been documented at Iron Gate Reservoir and Copco No. 1 Reservoir. The reservoirs and adjacent habitats also support migratory bird species (e.g., American white pelican, Barrow's goldeneye, common loon, black tern, black swift, Vaux's swift, olive-sided flycatcher, willow flycatcher, yellow warbler, and yellow-breasted chat) and year-round species (bald eagle, greater sandhill crane). The reservoirs and riparian areas provide foraging habitat for these species, by providing habitats that support fish, invertebrates, and reptiles for these birds to eat. Migratory birds use these reservoirs seasonally during their migrations and/or for overwintering, by supporting nesting, foraging, and/or loafing (resting on the water) habitat. The reservoirs provide foraging habitat for bat species (e.g., Yuma myotis) that primarily prey on aquatic emergent insects. Project structures have been documented to support habitat for Yuma myotis (KRRC 2019b), and surrounding habitats, including project structures, may also support roosting for other special-status bat species (Western mastiff bat, Townsends's western big-eared bat, spotted bat, pallid bat, fringed myotis, and long-eared myotis) that may forage on terrestrial insects in more upland habitats.

The special-status species discussed above and listed in Table 3.5-5 are not exclusive to the Lower Klamath Project reservoirs, as they have also been documented in adjacent areas. For example, all of the special-status bird species listed above have been either documented in habitats along the Klamath River upstream of Copco No. 1 Reservoir and downstream of Iron Gate Dam, at Lower Klamath National Wildlife and Tule Lake National wildlife refuges, or at other nearby creeks, lakes, and reservoirs including Emigrant Creek, Emigrant Lake, Howard Prairie Lake City Park, and Hyatt Reservoir north of Iron Gate Reservoir (ebird 2019).

Volume I Section 3.5.2.5 Terrestrial Resources – Environmental Setting – Special-status Species – Special-status Wildlife, Table 3.5-5 Suitable Habitat and Occurrence Information for Special-status Wildlife Species, row 2 (Western pond turtle) column 4 (Available Habitat and Occurrence Information within the Primary Area of Analysis) bullet 3 on page 3-504:

2018 surveys documented 42 at Copco No. 1 Reservoir and 8 at Iron Gate Reservoir (KRRC 2019b). ~~Documented basking during May 2018 wildlife surveys in the reservoirs-9 in Iron Gate Reservoir and between 31-36 in Copco No. 1 Reservoir (K. Stenberg, Principal, CDM Smith, pers. comm., July 2018).~~

Volume I Section 3.5.2.5 Terrestrial Resources – Environmental Setting – Special-status Species – Special-status Wildlife, Table 3.5-5 Suitable Habitat and Occurrence Information for Special-status Wildlife Species, row 5 (Common loon) column 4 (Available Habitat and Occurrence Information within the Primary Area of Analysis) new bullet 2 on page 3-505:

Documented during 2018 surveys throughout Copco No. 1 Reservoir and in Keaton Cove (KRRC 2019b).

Volume I Section 3.5.2.5 Terrestrial Resources – Environmental Setting – Special-status Species – Special-status Wildlife, Table 3.5-5 Suitable Habitat and Occurrence Information for Special-status Wildlife Species, row 4 (Golden eagle) column 4 (Available Habitat and Occurrence Information within the Primary Area of Analysis) new bullet 4 on page 3-506:

Documented along the northern Iron Gate Reservoir shoreline and just downstream of the dam (KRRC 2019b).

Volume I Section 3.5.2.5 Terrestrial Resources – Environmental Setting – Special-status Species – Special-status Wildlife, Table 3.5-5 Suitable Habitat and Occurrence Information for Special-status Wildlife Species, row 5 (American peregrine falcon) column 4 (Available Habitat and Occurrence Information within the Primary Area of Analysis) new bullet 3 on page 3-506:

An active nest was observed on the northeastern side of Iron Gate Reservoir in a rocky outcrop above Copco Road (KRRC 2019b).

Volume I Section 3.5.2.5 Terrestrial Resources – Environmental Setting – Special-status Species – Special-status Wildlife, Table 3.5-5 Suitable Habitat and Occurrence Information for Special-status Wildlife Species, row 4 (Yellow warbler) column 4 (Available Habitat and Occurrence Information within the Primary Area of Analysis) bullet 3 on page 3-509:

~~Observed around Copco No. 1. Reservoir and most frequent in riparian woodlands and hillside seep areas and also at Iron Gate Reservoir, including Bogus Creek fish hatchery, Brush Creek, Camp Creek, and Jenny Creek (CDM Smith 2018c).~~ Observed a single willow flycatcher at two locations–(1) along the northern shoreline of Copco No. 1 Reservoir, just south of the confluence with Beaver Creek and (2) at the confluence of Jenny Creek and Iron Gate Reservoir (KRRC 2019b).

Volume I Section 3.5.2.5 Terrestrial Resources – Environmental Setting – Special-status Species – Special-status Wildlife, Table 3.5-5 Suitable Habitat and Occurrence Information for Special-status Wildlife Species, row 4 (Townsend's western big-eared bat) column 4 (Available Habitat and Occurrence Information within the Primary Area of Analysis) new bullet 4 on page 3-510:

Acoustic surveys in the summer of 2018 documented Townsend's western big-eared bat outside the diversion tunnel outlets of Copco No. 1 and Copco No. 2 powerhouses; however, it was noted that it was not confirmed that the bats came from the diversion tunnel outlets (KRRC 2019b).

Volume I Section 3.5.2.5 Terrestrial Resources – Environmental Setting – Special-status Species – Special-status Wildlife, Table 3.5-5 Suitable Habitat and Occurrence Information for Special-status Wildlife Species, row 4 (Yuma myotis) column 4 (Available Habitat and Occurrence Information within the Primary Area of Analysis) new bullet 3 on page 3-512:

Documented during 2017 and 2018 surveys at 5 vacant houses at Copco No. 1 and Copco No. 2, with 200–300 individuals roosting at 'Vacant House #21601' (KRRC 2019b). Also documented at Copco No. 1 Powerhouse, the Diversion Tunnel Outlet, Copco No. 2 Powerhouse, and the Cookhouse (KRRC 2019b). At Iron Gate, species documented at a 'Barn/Garage at Iron Gate Village' and at Residence 2, with several hundred bats observed at the Diversion Tunnel Outlet, Penstock Intake Structure, and Communication Building/Powerhouse (KRRC 2019b).

Volume I Section 3.5.2.5 Terrestrial Resources – Environmental Setting – Special-status Species – Special-status Wildlife, Table 3.5-5 Suitable Habitat and Occurrence Information for Special-status Wildlife Species, row 2 (Western yellow-billed cuckoo) column 4 (Available Habitat and Occurrence Information within the Primary Area of Analysis) bullet 2 on page 3-514:

In coordination with state agencies, it has been noted that breeding habitat is unlikely in the area, and as a result Project impacts are not anticipated.

3.5.3 Significance Criteria

Volume I Section 3.5.3 Terrestrial Resources – Significance Criteria, paragraph 4 on page 3-514:

Criteria for determining significant impacts on terrestrial resources are based upon Appendix G of the CEQA Guidelines (California Code of Regulations title 14, section 15000 et seq.) and professional judgment informed by best available data. Effects on terrestrial resources are considered significant if the Proposed Project would:

- Result in population-level impacts on state species of special concern, USDA Forest Service sensitive wildlife species on USDA Forest Service lands, or BLM sensitive species on BLM lands.
- Result in any of the following to the other types of special-status species112: not listed above: direct mortality or physical harm to individuals; degradation of habitat or a change in habitat conditions that

would result in physiological impairment or that may affect the ability to perform essential behaviors such as migration, feeding, or reproducing; or abandonment of active bird nests or hibernacula or maternity bat roosts due to noise or structure removal (i.e., buildings, vegetation).

- Result in substantial removal or degradation of any riparian habitat ~~or rare natural community~~.
- Result in ~~substantial~~ modifications of federally protected wetlands as defined by Section 404 of the Clean Water Act through direct removal, filling, hydrological interruption, or other means.

3.5.4 Impact Analysis Approach

Volume I Section 3.5.4 Terrestrial Resources – Impact Analysis Approach, paragraph 1 on page 3-516:

Evaluation of the Proposed Project considered both short- and long-term effects on terrestrial resources. Short-term effects were defined as impacts that have the potential to occur within two years of ~~the action~~dam removal and long-term effects were defined as impacts that have the potential to occur two years or more after ~~the activity~~dam removal is completed. The analysis considered the timing of ~~the action~~the proposed activities as identified in Appendix H of the Definite Plan (e.g., pre-dam removal period [one to two years prior to drawdown], reservoir drawdown period [January to March, year of drawdown], dam removal period [spring, summer, and fall immediately after drawdown], post-dam removal period [after dam removal is complete], plant establishment period [Year 1; post-dam removal year 1], and maintenance and monitoring period [Years 2 to 5; post-dam removal years 2-5]). Short-term impacts on nesting birds were evaluated as a result of construction-related noise greater than ambient conditions, and species-specific noise impacts on northern spotted owl were assessed for a 1-mile buffer around all dams to account for the loudest noise disturbance distance associated with blasting, 0.5-mile buffer around all reservoirs to account for the loudest noise disturbance distance associated with helicopter use, and 0.25-mile buffer around all other areas within the Limits of Work to account for noise disturbance associated with heavy equipment. These northern spotted owl noise disturbance distances were developed in coordination with the Arcata USFWS office based on an estimation of auditory and visual disturbance effects (USFWS 2006).

3.5.5 Potential Impacts and Mitigation

3.5.5.1 Vegetation Communities

Volume I Section 3.5.5.1 Terrestrial Resources – Potential Impacts and Mitigation – Vegetation Communities – Potential Impact 3.5-1 Construction-related impacts on wetland and riparian vegetation communities, paragraph 1 on page 3-518 through paragraph 4 on page 3-519:

Potential Impact 3.5-1 Construction-related impacts on wetland and riparian vegetation communities.

Disturbances associated with construction areas, disposal sites, and haul roads where clearing, grading, and staging of equipment would occur could have short-term impacts on sensitive habitats, including wetlands and riparian habitats along reservoirs and river reaches. Additionally, removal of the dams and powerhouses could have short-term impacts on wetlands and riparian habitats. Heavy machinery traversing wetland and riparian areas could change local topography and impact wetland and riparian vegetation and could introduce increased levels of dust and runoff pollution to wetland and riparian areas that could degrade plant community conditions. Several of the bridges required for access to and from the dam sites would be replaced or upgraded prior to reservoir drawdown (see Potential Impact 3.22-2). Adjacent riparian vegetation under or adjacent to the existing or new bridges could be impacted during these activities. Additionally, removal of recreation sites could result in impacts on wetland and riparian vegetation (e.g., the Palustrine Forested Wetland at Iron Gate Reservoir). Wetland and riparian vegetation are likely to be present in the areas where construction activities are planned to occur; without surveys to document these habitats and measures to adequately protect them, these habitats would be likely to be degraded or removed and thus construction-related activities would result in a significant short-term impact.

~~Based on existing data for the Primary Area of Analysis for terrestrial resources (Section 3.5.2.1 *Vegetation Communities*), wetland and riparian habitats (Estuarine, Montane Riparian, Palustrine, and Wet Meadow) account for approximately five percent of the total acreage.~~ The Proposed Project identifies a number of pre-construction measures to reduce impacts on wetland and riparian habitats (Estuarine, Montane Riparian, Palustrine, and Wet Meadow) ~~these habitats. First,~~ including a wetland delineation that ~~would be~~has been conducted within the limits of construction around the dams and facilities, access and haul roads, and disposal sites in accordance with the 1987 USACE Wetland Delineation Manual (USACE 1987) and applicable Regional Supplements (i.e., Western Mountains, Valleys, and Coast Region [USACE 2010] and Arid West [USACE 2008]). The wetland delineation was conducted in 2019. Results indicate that there are approximately 34 acres of wetlands and approximately 73 acres of riparian vegetation within the Primary Area of Analysis for terrestrial resources (KRRC 2019a). Further, the delineation indicates that the following construction areas would be adjacent to wetland and/or riparian vegetation that could be fenced and avoided:

- All staging areas
- Copco No. 2 Powerhouse
- Some portions of the Fall Creek Hatchery retrofit (i.e., riparian vegetation at the upper settling pond location; Figure 2.7-15)
- Iron Gate Hatchery retrofit footprint (Figure 2.7-13)
- Daggett Road Bridge replacement footprint

- Overlook Point Recreation Site
- Mirror Cove Recreation Site
- Juniper Point Recreation Site
- Camp Creek Recreation Site
- Wanaka Springs Recreation Site

For these areas ~~The~~ results of the wetland delineation would be incorporated into the Proposed Project design to avoid and minimize direct impacts on wetlands to the maximum extent feasible, and wetland areas adjacent to the construction Limits of Work would be fenced to prevent inadvertent entry. There could be impacts on wetlands and riparian vegetation at the locations listed above if the fencing does not include an appropriate buffer (i.e., a prescribed distance from the edge of the wetland in which construction activities are prohibited); however, with implementation of Mitigation Measure TER-1, short ~~and long-term~~ impacts on wetlands and riparian vegetation ~~communities~~ would be reduced to less than significant at the locations listed above.

Additionally, the Proposed Project includes construction best management practices (Appendix B: *Definite Plan – Appendix J*) to reduce potential impacts on water quality in wetlands and riparian vegetation at the locations listed above ~~and other survey waters~~ during construction. The combination of these measures and implementation of Mitigation Measure WQ-1, as described in Potential Impact 3.2-4, and HZ-1 as described in Potential Impact 3.21-1, would reduce potential impacts on wetlands and riparian vegetation to less than significant at the locations listed above.

The results of the 2019 wetland delineation indicate that the following construction areas overlap wetland and riparian vegetation and suggest that some fraction (i.e., less than 0.5 acre per site) of the existing wetland and/or riparian vegetation cannot be fenced and avoided:

- Some portions of the Fall Creek Hatchery retrofit (i.e., riparian at the primary location of Fall Creek Hatchery and wetlands at the lower settling pond location)
- City of Yreka water supply line replacement footprint
- Camp Creek, Scotch Creek culvert replacement footprints
- Dry Creek Bridge replacement/strengthening/temporary crossing footprint
- Fall Creek Bridge replacement/strengthening/temporary crossing footprint
- Lakeview Road Bridge replacement/strengthening/temporary crossing footprint
- Culvert replacement at unknown creek northwest of Raymond Gulch footprint
- Culvert replacement at Raymond Gulch footprint
- Jenny Creek Bridge replacement footprint

- Culvert replacement at unknown creek on the north west end of Copco Village footprint
- Flood improvements downstream of Iron Gate Dam

Additionally, the Proposed Project contemplates flood improvements for multiple parcels downstream of Iron Gate Dam (Section 2.7.8.4 *Downstream Flood Control*); the 2019 wetland delineation did not extend to these parcels so the analysis conservatively assumes there may be short-term impacts to wetlands and/or riparian vegetation in these parcels.

The Reservoir Area Management Plan (Appendix B: *Definite Plan – Appendix H*) includes details for the installation of native plants and aerial, barge, or hand seeding 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,~~ Revegetation efforts for the reservoir footprints would begin during the reservoir drawdown period [January to March, year of drawdown; dam removal year 2] and would continue through the post-dam removal period [after dam removal is complete], such that by the end of the plant establishment period [post-dam removal year 1] (i.e., within two years of dam removal) approximately 38 acres of wetlands and 144 acres of riparian vegetation would be created within the reservoir footprints and would achieve at least 70 percent cover by post-dam removal year 1. Demolition and disposal sites, staging, access and haul roads, and turn-arounds would be re-vegetated following construction activities. Under the State Water Board's wetland policy, higher compensation ratios than 1:1 replacement may be required by the permitting agency to compensate for temporal loss (i.e., when there is a time lag between the loss and replacement of aquatic resource functions). The amount of wetland and riparian habitat created through dam removal and revegetation efforts would far exceed the acreage of any existing, fully established wetlands and/or riparian vegetation for which a small portion of wetlands and/or riparian vegetation would not be avoided during construction activities. Thus, under the Proposed Project there would be no substantial removal or degradation of riparian vegetation or substantial modifications of federally protected wetlands, and there would be no significant short-term impact. ~~With a goal of no net loss of wetland or riparian habitat acreage and functions. Wetlands established in restored areas would be monitored for five years or until the performance criteria (as defined in Appendix B: *Definite Plan – Appendix H*, Section 6.1.4) have been met. 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 disposed of in appropriate disposal facilities. The Reservoir Area Management Plan (Appendix B: *Definite Plan – Appendix H*) also includes a five-year monitoring plan with metrics to evaluate success of minimizing invasive exotic vegetation (i.e., percent relative cover by medium and low priority invasive plants [as defined in the Reservoir Area Management Plan] shall be less than the average at designated reference locations as follows: 25~~

~~percent in Year 1; 40 percent in Year 2; 55 percent in Year 3; 70 percent in Year 4; 90 percent in Year 5; and no high-priority invasive plants [as defined in the Reservoir Area Management Plan] shall be present in the Limits of Work at any time during the five-year monitoring).~~

Mitigation Measure TER-1 Establish a 20-foot buffer around delineated wetlands.
The KRRC shall establish a minimum of a 20-foot buffer around all delineated wetlands potentially affected by construction impacts to ensure there will not be any significant environmental impacts to wetlands by deterring heavy machinery from traversing the wetland and preventing runoff pollution from directly entering the wetland where doing so would not result in a significant environmental impact. <u>The buffer may be adjusted (e.g., made larger or smaller) based on site-specific conditions, as determined by a qualified biologist acceptable to USACE, as necessary to ensure adequate protection of the delineated wetlands.</u> The State Water Board has the authority to include this mitigation measure in its water quality certification for the project, and the measure is therefore feasible and used in this analysis to make a significance determination.

With the implementation of these measures, potential short-term impacts on wetlands and riparian areas from construction would be less than significant.

<u>Significance</u>
No significant impact in the short term with mitigation

Volume I Section 3.5.5.1 Terrestrial Resources – Potential Impacts and Mitigation – Vegetation Communities – Potential Impact 3.5-2 Short-term and long-term impacts on wetland and riparian vegetation communities along existing reservoir shorelines due to reservoir drawdown, paragraph 5 on page 3-519 through paragraph 2 on page 3-520:

Potential Impact 3.5-2 Short-term and long-term impacts on wetland and riparian vegetation communities along existing reservoir shorelines due to reservoir drawdown.
Under the Proposed Project, there would be reduction of existing wet habitat at Copco No. 1, Copco No. 2, and Iron Gate reservoirs (currently ~~15.8~~ <u>15.0</u> acres of Montane Riparian and ~~52.3~~ <u>19.0</u> acres of Palustrine habitat, Table 3.5-2) due to reservoir drawdown~~, as detailed below:~~<u>.</u>

- ~~Copco No. 1 Reservoir: The shoreline of Copco No. 1 Reservoir currently supports Palustrine Scrub-shrub Wetland where tributary channels enter the reservoir, and Palustrine Forested Wetland occurs along the northwest shore. Small patches of Palustrine Emergent Wetland also currently exist along the shoreline. These communities would be lost due to reservoir drawdown.~~

- ~~Copco No. 2 Reservoir: The southern slope of Copco No. 2 Dam currently supports a Palustrine Scrub-shrub Wetland and Palustrine Forested Wetland. Reservoir drawdown would reduce the extent of these wet habitats. These features are not anticipated to be entirely lost because Copco No. 2 Reservoir is relatively small and, therefore, the features will be in close in proximity to the newly exposed river channel.~~
- ~~Copco No. 2 penstock: Currently, Copco No. 2 penstock leaks water that supports small, local patches of Palustrine Emergent Wetland. Dam and penstock removal would result in the loss of this vegetation.~~
- ~~Iron Gate Reservoir: Vegetation along the shores of Iron Gate Reservoir includes some Montane Riparian and Palustrine habitat including Palustrine Forested Wetland in the day use and campground areas, and Palustrine Emergent Wetland and Palustrine Scrub-shrub Wetland along Jenny, Scotch, and Camp creeks where tributaries join the reservoir. Reservoir drawdown would reduce the extent of these wet habitats.~~

Degradation or removal of wetland and riparian habitat in these areas ~~listed above~~ would be a significant short-term and long-term impact.

The Proposed Project includes several actions to encourage rapid revegetation with native riparian species in the reservoir footprints as defined in the Reservoir Area Management Plan (Appendix B: *Definite Plan – Appendix H*) that would ensure no net loss of wetland or riparian habitat acreage and functions. Six locations in Copco No. 1 Reservoir and three locations in Iron Gate Reservoir would be targeted for restoration (Figures 2.7-11 and 2.7-12); these areas would undergo barge-mounted pressure washing/sediment jetting during reservoir drawdown and subsequently would be excavated to the historical floodplain elevation to help create wetlands, floodplain areas, and off-channel habitat features. A~~s depicted in Figures 2.7-11 and 2.7-12, a~~pproximately ~~50~~ 144 acres of riparian ~~bank would be targeted for revegetation~~vegetation and approximately ~~100~~38 acres of wetlands~~, floodplain, and off-channel habitat features~~ would be targeted for restoration (KRRC 2019a). The resulting acreage of restored riparian and wetland vegetation will vary depending on field conditions including the presence of cultural resources and human remains, changes in the topography following drawdown that affect the extent of restorable areas, and changes in topography that affect access; however, given that the proposed acreage to be restored (~~150~~ 182 acres) is well above the total acreage that would be potentially impacted (~~68 acres~~approximately 15 acres of riparian vegetation and 19 acres of wetlands), there would be ~~the policy of~~ no net loss of wetlands under the Proposed Project~~is anticipated to be achieved~~.

Volume I Section 3.5.5.1 Terrestrial Resources – Potential Impacts and Mitigation – Vegetation Communities, paragraph 5 on page 3-521 through paragraph 3 on page 3-523:

Potential Impact 3.5-3 Short-term and long-term impacts on wetland habitat downstream of the Lower Klamath Project dams due to erosion or sediment deposition.

In the reach from Iron Gate Dam to Cottonwood Creek, modeling results indicate that dam-released sediment would deposit during and following drawdown (USBR 2010)~~may temporarily deposit in pools and other slack water areas (e.g., eddies), at tributary confluences, and potentially along channel margins~~, where it could have a short-term negative impact on wetland habitat ~~due to temporary burial . However, the wetland habitat impacts would be localized, and~~ Research suggests that post dam removal the median estimate for the initiation of bed mobilization in this reach would be a flow with a return period of approximately two years, and full bed mobilization is predicted to occur approximately every 10 years (USBR 2012; also see Volume I Section 3.11.2.4 *Geology, Soils, and Mineral Resources – Environmental Setting – Sediment Load* and modifications in Volume III Attachment 1, and Potential Impact 3.11-5 in Volume I Section 3.11.5 *Geology, Soils, and Mineral Resources – Potential Impacts and Mitigation* and modifications in Volume III Attachment 1). Farther downstream, from Cottonwood Creek to Indian Creek, no significant sediment deposition is predicted, but transient fine sediment deposition may occur in slack water areas. ~~Because~~ In all of the Klamath River reaches, the post-dam removal ~~transient~~ sediment deposits would be ~~highly~~ erodible during subsequent flow events, thus ~~the impacts~~ would ~~also~~ be ~~short-term~~ transitory.~~(i.e., likely one year or less except during dry years).~~

Wetland habitat impacts would be localized. Between Iron Gate Dam and Bogus Creek, only one small wetland (0.04 ac) was delineated during 2019 surveys (KRRC 2019a). This wetland is positioned upslope of the channel and significant sediment deposition is not expected at this location.

Based on existing data for the Primary Area of Analysis for terrestrial resources (Section 3.5.2.1 *Terrestrial Resources – Existing Conditions – Vegetation Communities*), no wetland habitat (Palustrine or Wet Meadow) is documented adjacent to the riparian corridor between Bogus Creek and Cottonwood Creek, where most of the sedimentation is expected to occur. Therefore, there will be no net loss of wetlands due to sedimentation and ~~Given that the impacts related to dam-released sediment are likely to be temporary (less than a year) and given that there would not be a substantial modification of federally protected wetlands,~~ there would be a less than significant impact on wetland habitat downstream of the Lower Klamath Project dams.

Significance

No significant impact in the short term and long term

Potential Impact 3.5-4 Effects on riparian habitat downstream of the Lower Klamath Project dams due to short-term and long-term erosion or sediment deposition.

Commenters in the Proposed Project public scoping process expressed concerns regarding erosion and sediment deposition immediately downstream of Iron Gate Dam. Downstream of the Lower Klamath Project dams, river flow rates would not increase substantially above median historical rates. Therefore, rates of bank erosion are not expected to increase significantly (see Section 3.11.5 *Geology, Soils, and Mineral Resources – Potential Impacts and Mitigation* Potential Impact 3.11-6).

With respect to ~~short-term~~ sediment deposition downstream of the Lower Klamath Project dams, dam-released sediment deposition and subsequent sediment remobilization~~supply~~ would likely extend from Iron Gate Dam to approximately Cottonwood Creek (RM 185.1) (USBR 2012), where reach-averaged deposition of gravel and sediment is projected to be up to 1.7 feet ~~one foot~~ between ~~Iron Gate Dam and~~ Bogus Creek (RM 192.68) and Willow Creek (RM 187.8) and up to ~~0.8~~ 0.9 feet between ~~Bogus Creek and~~ Willow Creek and Cottonwood Creek (RM 185.1)~~7.8~~, although short-term (< 2-year) deposition may be less (see Potential Impact 3.11-5). ~~If rain and snowmelt levels are high during drawdown, relatively less sedimentation would occur in downstream reaches, as there would be higher flows in the system to flush out sediments (Stillwater Sciences 2008).~~ In the short term, ~~reach-averaged~~ sedimentation, which is significant in the reach from Iron Gate Dam to Cottonwood Creek (see Potential Impact 3.11-5),~~levels of up to one foot are~~ is not expected to substantially negatively impact riparian vegetation~~ downstream of Iron Gate Dam~~, as vegetation growing within or along the river channel margins is generally adapted to this scale of perturbation due to seasonal and inter-annual sedimentation dynamics typical of river systems. Willow and cottonwood species grow rapidly and can bend, break and re-sprout following sediment deposition (Braatne et al. 1996; Shafroth et al. 2002). Similarly, branches and stems broken off and redeposited with sediment can sprout and grow vigorously on newly deposited alluvium, giving these species a relative advantage over non-sprouting upland or non-native species (Braatne et al. 1996, Rood et al. 2003). Thus, there would be a less than significant effect on riparian vegetation downstream of Iron Gate Dam due to short-term sediment deposition caused by dam removal.

Moreover, sedimentation has the potential to create new surfaces for riparian plants to colonize in the long-term. The degree of sedimentation and ability of plants to colonize would depend~~ing~~ on the sequence of water years following dam removal. U~~; u~~nder certain scenarios (e.g., wet water year followed by dry water years whereby a lot of sediment is moved and vegetation has time to colonize), this may result in beneficial effects on riparian habitat especially in areas where there is currently less extensive sediment deposits due to upstream sediment trapping in reservoirs (i.e., from Iron Gate to Cottonwood Creek) (Shafroth et al. 2002). Under such scenarios the riparian vegetation would be able to quickly re-establish through colonization. This colonization occurs following disturbance (i.e., deposition-related to removal of the dam) during peak flows that creates substrate for seedlings, followed by declining spring and summer flows that occur during the seed dispersal period. Under this natural process, it is anticipated that new riparian vegetation would become established within three to five years (Riparian Habitat Joint Venture 2009).

In the long term, no permanent loss of riparian habitat due to erosion or sediment deposition is anticipated to occur in any river reach downstream of the Lower Klamath Project dams, and new surfaces for colonization would be created. This would be a beneficial effect.

Significance
No significant impact in the short term

Beneficial in the long term

3.5.5.2 Culturally Significant Species

Volume I Section 3.5.5.2 Terrestrial Resources – Potential Impacts and Mitigation – Culturally Significant Species – Potential Impact 3.5-6 Short- and long-term impacts on culturally significant species in riparian and wetland habitats, paragraph 1 through 4 on page 3-524:

Potential Impact 3.5-6 Short- and long-term impacts on culturally significant species in riparian and wetland habitats.
Many of the species identified by the Native American Tribes in the Klamath River region as culturally significant ~~occur in~~are associated with riparian and wetland habitats. Those species that are documented to occur within the Primary Area of Analysis (KRRC 2019a) include the following:

- alder (*Alnus* spp.);
- cottonwood (*Populus* spp.);
- blackberries (*Rubus* spp.) including salmonberry (*Rubus spectabilis*);
- willows (Salix spp.);
- hardstem bulrush (*Schoenoplectus acutus* var. *occidentalis*);
- bur reed (*Sparganium* spp.);
- cattails (*Typha* spp.) including broad-leaved cattail (*Typha latifolia*);
- wild grape (*Vitis californica*).

Absent restoration and mitigation measures, Project activities including construction as well as reservoir drawdown could~~would~~ result in population-level impacts to culturally significant plant species or substantial degradation or removal of wetland and riparian habitat~~;~~. Existing data do not confirm whether all of the listed culturally significant species are widely available. ~~t~~Therefore, the EIR conservatively finds there c~~w~~ould be a significant short-term and long-term impact on culturally significant species associated with riparian and wetland habitats.

The Proposed Project includes a number of measures to reduce impacts on ~~several actions to survey for~~ wetland~~s~~ and riparian vegetation, including surveys to document the extent of wetland and riparian vegetation and fencing to avoid impacts where feasible (Appendix B: *Definite Plan – Appendix J*). In addition, Mitigation Measure TER-1 (see Potential Impact 3.5-1) includes wetland buffers to prevent intrusion in wetland habitats, and Mitigation Measure WQ-1 (see Potential Impact 3.2-4), and HZ-1 (see Potential Impact 3.21-1) include measures to prevent runoff pollution from directly entering wetland and riparian areas and avoid substantial degradation~~, deter heavy machinery from traversing the wetland, prevent runoff pollution from directly entering the wetland, and avoid substantial degradation in these areas~~.

The Proposed Project also includes actions to ~~and~~ encourage rapid revegetation with native wetland and riparian species in the reservoir footprints as defined in the Reservoir Area Management Plan (Appendix B: *Definite Plan – Appendix H)* ~~that would ensure no net loss of wetland or riparian habitat acreage and functions~~. The revegetation mixes listed in the Reservoir Area Management Plan (Appendix B: *Definite Plan – Appendix H*) include all of the culturally significant species associated with riparian and wetland habitats that are documented to occur within the Primary Area of Analysis. ~~Will be developed based on updated inventories of existing wetland and riparian vegetation around the reservoir perimeters; therefore, culturally significant species will be documented and incorporated as part of the revegetation effort.~~

~~In addition, Mitigation Measure TER-1 (see Potential Impact 3.5-1) includes wetland buffers to prevent intrusion in wetland habitats, deter heavy machinery from traversing the wetland, prevent runoff pollution from directly entering the wetland, and avoid substantial degradation in these areas.~~ As discussed in Potential Impact 3.5-1, approximately 38 acres of wetlands and 144 acres of riparian vegetation would be created within the reservoir footprints and would achieve at least 70 percent cover by post-dam removal year 1. Therefore, in the long term, there would be no significant impact to culturally significant species.

In combination, avoidance measures, the implementation of Mitigation Measure TER-1, WQ-1 and HAZ-1, and revegetation measures~~.These measures~~ would ensure that impacts on culturally significant species in the short term would be less than significant.

Significance

No significant impact with mitigation in the short term

No significant impact in the long term

3.5.5.3 Special-status Species and Rare Natural Communities

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Potential Impact 3.5-7 Short-term impacts on special-status plants and rare natural communities from construction-related activities, paragraph 5 on page 3-524 through new paragraphs 2 and 3 on page 3-525:

Potential Impact 3.5-7 Short-term impacts on special-status plants and rare natural communities from construction-related activities.
Construction activities including road, bridge, hatchery modifications, ~~and~~ culvert improvements (Section 3.22.2.3 *Road Conditions*), and recreation site modifications, could result in direct mortality or damage to special-status plant species or indirect damage by degrading special-status plant habitat (e.g., introducing invasive plant species) or rare natural communities. Special-status plant species with the potential to occur in the Primary Area of Analysis for terrestrial resources are provided in Table 3.5-4 and rare natural communities with the potential to occur in the Primary Area of Analysis for terrestrial resources are provided in Appendix H. Construction activities would require heavy machinery to move through construction areas, staging areas, and haul roads where these species could occur. Contact with construction vehicles could result in direct mortality or damage to these species or their habitat. Special-status plants and rare natural communities may be present in the areas where construction activities may be performed; without surveys to document these species and habitats and measures to adequately protect them, they would be removed and/or habitat would be degraded; therefore, this would be a significant short-term impact.

As part of the Proposed Project, comprehensive floristic surveys ~~would be~~have been conducted for special status-plants within the construction Limits of Work where ground-disturbing activities would occur plus an established buffer (i.e., a 100-meter buffer around disposal sites and a 10-meter buffer along access and haul roads) following the CDFW guidelines (CDFG 2009; Appendix B: *Definite Plan – Appendix J*). The following species were documented (CDM Smith 2018e, CDM Smith 2018b, KRRC 2019c, and KRRC 2019d):

- Greene's mariposa-lily (*Calochortus greenei*): in the vicinity of the Iron Gate Reservoir; at the Iron Gate disposal site; near both Copco No. 1 and Copco No. 2 Dams; along utility corridors between the Copco No. 1 and Copco No. 2 Dams; along utility corridors in the vicinity of Iron Gate Reservoir; and at the Fall Creek Diversion (near the demolition area).
- bristly sedge (*Carex comosa*): eastern side of the J.C. Boyle Reservoir just south of the Hwy 66 Bridge; and throughout the wetland complex along the eastern shore of the J.C. Boyle Reservoir.
- Egg Lake monkey-flower *(Mimulus pygmaeus):* within the limits of work at the Fall Creek Diversion.

- Bolander's sunflower (*Helianthus bolanderi*): at the Iron Gate disposal site; along utility corridors along the north side of Iron Gate Reservoir; between Iron Gate Reservoir and Copco Lake; and along the east side of the J.C. Boyle Reservoir.
- coast iris (*Iris longipetala*): along the northwestern shoreline of the J.C. Boyle Reservoir.
- purple-flowered Washington lily (*Lilium washingtonianum* ssp. *Purpurascens*): near the Fall Creek diversion; and along Copco Road along the north side of Copco Lake.
- Detling's silverpuffs (*Microseris laciniata* ssp. D*etlingi)*: at Iron Gate disposal site; along utility corridors along the southeast side of the Iron Gate Reservoir; and south of the Copco No. 2 bypass reach.
- Greene's four o'clock (*Mirabilis greenei*): along the northeast side of the Iron Gate Reservoir; along utility corridors along the eastern end of Iron Gate Reservoir; and along the northern side of the Klamath River in several locations downstream of Copco No. 2 Dam including near the intersection of Copco Road and Daggett Road.
- western yampah (*Perideridia erythrorhiza*): north of the J.C. Boyle Dam.
- strapleaf willow (*Salix ligulifolia)*: along the river just below the J.C. Boyle Dam.
- fleshy sage (*Salvia dorrii* var. *incana*): near culvert along southeast side of the Iron Gate Reservoir; along northeast side of Iron Gate Reservoir; and along utility corridor along the north side of Iron Gate Reservoir.

~~And the vegetation maps would be updated to reflect existing conditions including any rare natural communities that may present. The Proposed Project includes avoidance and minimization measures as well as provisions for the establishment of wetland and riparian areas and other sensitive vegetation communities within the project area to result in no net loss of habitat acreage (CDFG 2009; Appendix B: *Definite Plan – Appendix J*); therefore, impacts to rare natural communities would be less than significant.~~

~~If any special-status plants are documented, t~~Where feasible, the Proposed Project ~~design~~ would ~~be modified if possible to avoid~~ preserve any documented special-status plants in place (Appendix B: *Definite Plan – Appendix J*). If ~~Where~~ avoidance is not feasible, a combination of relocation, propagation, and establishment of new populations in designated conservation areas would be implemented, as determined in coordination with the resource agencies and invasive plant species would be controlled by implementing measures such as routine washing of construction vehicles and equipment (Appendix B: *Definite Plan – Appendix J*). There may be significant impacts on special-status plants where avoidance is infeasible and if replanting does not succeed in re-establishment of new populations at a 1:1 ratio such that there is no net loss of individuals. If implemented as part of the Final Restoration Plan, Recommended Terrestrial Measure 1 would reduce impacts to less than significant. KRRC proposes that KRRC and the appropriate state or local agency would work together to develop recommended terms and conditions that should be adopted by FERC as conditions of approval for the Lower Klamath Project. This is consistent with FERC's preference for licensees to be 'good citizens' of the communities in which projects are located and thus to comply, where possible, with state and local requirements. Overseeing development and implementation of terms and conditions relating to protection of terrestrial special-status plants and/or rare natural communities does not fall within the scope of the State Water Board's water quality certification authority. While the State Water Board anticipates that implementation of the entire Final Restoration Plan, including the aforementioned additional details and any modifications developed through the FERC process that provide the same or better level of protection for special-status plants, would reduce impacts to less than significant. However, because the State Water Board cannot ensure implementation of the terrestrial aspects of the Final Restoration Plan, it is analyzing the impact in this Draft EIR as significant and unavoidable.

Additionally, vegetation maps have been updated to reflect existing conditions including any rare natural communities that are present. The following rare natural communities were documented (KRRC 2019b):

- Oregon ash groves: on the western shore of Iron Gate Reservoir; along Copco No. 2 Penstock; on the north and south shore of Copco Lake.
- Bigleaf maple forest: on the north side of Copco Lake.
- Oregon white oak woodland: north of the disposal site at Iron Gate Dam; on the east and west shores of Iron Gate Reservoir; on the north and south shores of Copco No. 2 Bypass; along the north and south shore of Copco Lake; along the east and west shore of Klamath River between Copco Lake and JC Boyle Reservoir; along the northern shore of JC Boyle Reservoir.
- Bitterbrush scrub: at the southern end of Copco Lake; along the east and west shore of Klamath River between Copco Lake and JC Boyle Reservoir; on the east and west shore of JC Boyle Reservoir.
- Chokecherry thicket: at the upstream end of Iron Gate Reservoir along the northern shore and inland; along the north west shore of Klamath River between Copco Lake and JC Boyle Reservoir.
- Shining willow grove: along the western shore of Iron Gate reservoir; on the north and south shore of Iron Gate Reservoir.
- Geyer willow thicket: on the east and west shores of Iron Gate Reservoir; along the north shore of Copco Lake.

The Proposed Project includes avoidance and minimization measures as well as provisions for the establishment of wetland and riparian areas and other sensitive vegetation communities to result in no net loss of habitat acreage. These restored areas will be monitored for up to five years and assessed based on performance criteria that is approved by the regulatory agencies (CDFG 2009;

Appendix B: *Definite Plan – Appendix J*). Therefore, impacts to rare natural communities would be less than significant.

Recommended Terrestrial Measure 1 – Establish Mitigation Ratios for Special-Status Plants.
The Final Restoration Plan shall include a minimum 1:1 mitigation ratio and a Plant Mitigation and Monitoring Plan shall be developed for any special-status species that would be impacted by the Proposed Project. These features of Recommended Terrestrial Measure 1 would be implemented such that any impact to special-status plants would be less than significant.

Significance
No significant impact on rare natural communities in the short term
Significant and unavoidable impacts on special-status plants in the short term

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Potential Impact 3.5-10 Short-term impacts on special-status amphibian, reptiles, and mammals from construction activities, paragraph 1 on page 3-529:

While the Proposed Project avoidance and minimization measures would reduce the potential for short-term construction-related impacts on wildlife species within the Primary Area of Analysis, several of the aforementioned components need more specificity to ensure that short-term construction activities would not result in significant impacts on special-status species amphibians, ~~and~~ reptiles, and mammals or substantially interfere with movement and/or migration of these species, or that any remaining potentially significant impacts are mitigated to the extent feasible.

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Potential Impact 3.5-10 Short-term impacts on special-status amphibian, reptiles, and mammals from construction activities, paragraph 4 on page 3-529:

Overseeing development and implementation of terms and conditions relating to protection of terrestrial wildlife species does not fall within the scope of the State Water Board's water quality certification authority unless the species has a particular nexus with water – for example, it is a wetland or riparian species or primarily eats fish. In this case, there are mitigation measures pertaining to amphibian, ~~and~~ reptiles, and bald eagle that the State Water Board can ensure through the water quality certification. Mitigation measures are also applied for federally listed and federally protected species (gray wolf, bald eagle, and golden eagle). Therefore, these mitigation measures (TER-2, ~~and~~ TER-3, TER-6, and TER-7) are considered as part of the impact analysis and determination of significance.

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation –Special-status Species and Rare Natural Communities – Mitigation Measure TER-2 – Amphibian and Reptile Management, paragraph 2 on page 3-530:

These features of TER-2 will be implemented to reduce the impacts to less than significant ~~such that there is no significant impact~~ on special-status amphibians and reptiles.

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation –Special-status Species and Rare Natural Communities – Mitigation Measure TER-3 – Western Pond Turtle Pre-construction Surveys, paragraph 5 on page 3-530:

These features of TER-3 will be implemented to reduce the impacts to less than significant ~~such that there is no significant impact~~ on western pond turtles.

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Mitigation Measure TER-3 – Western Pond Turtle Pre-construction Surveys, Table 3.5-6 Summary of Proposed Project Components and Recommended Terrestrial Measures on page 3-531:

Table 3.5-6. Summary of Proposed Project Components and Recommended Terrestrial Measures.

Proposed Project Avoidance and Minimization Measure Component	Recommended Terrestrial Measure
Biological monitoring and the development of a detailed Construction Monitoring Plan[114] in coordination with the resource agencies	**Recommended Terrestrial Measure 3** further requires agency approval of on-site biologists and identifies monitoring and reporting requirements to incorporate in the Construction Monitoring Plan.
Mandatory biological resource awareness training for all construction personnel	**Recommended Terrestrial Measure 4** requires additional items, including consideration of exotic and noxious species and appropriate decontamination measures as part of the training, identifies the reoccurrence interval of the training, and stipulates that the training shall be interpreted for non-English speaking workers.

Proposed Project Avoidance and Minimization Measure Component	Recommended Terrestrial Measure
Requirements for construction personnel including disposing of trash, maintain construction related-traffic in construction boundaries, no feeding of wildlife, no pets, no firearms, maintaining equipment in staging areas, reporting on state-listed or federally-listed species	**Recommended Terrestrial Measure 5** includes the additional requirements that (1) all food-related trash items would be disposed of in closed wildlife-proof containers to reduce the potential for special-status wildlife to enter the Limits of Work, and; (2) equipment would be power washed prior to arriving at the site to reduce potential for non-native species to enter the Limits of Work and compete with special-status species or spread to nearby habitats.
Requirements for wildlife exclusion and entrapment	**Recommended Terrestrial Measure 6** in addition to providing a requirement for wildlife exclusion and entrapment, this provides an additional requirement for fencing to be checked daily during active construction to ensure that it remains intact.
Surveys to identify special-status amphibian and reptile habitat and quantity affected, mammal sign, including den sites or burrows, will be noted.	**Recommended Terrestrial Measure 7** includes special-status species identified in Table 3.5-5 to be included for habitat assessments, and if present, for inclusion in pre-construction surveys. **Recommended Terrestrial Measure 7** also requires that an on-site biologist preform daily pre-construction wildlife surveys prior to initiating construction activities.
~~Identifying wolves during general wildlife surveys~~	~~**Recommended Terrestrial Measure 8** includes further means to monitor the CDFW gray wolf activity map, and if wolf activity identified on the map overlaps with the Lower Klamath Project, or if a wolf is observed during any Proposed Project survey or monitoring effort, CDFW would be consulted to further evaluate site-specific measures depending on the time of year and information about the individuals in the area.~~

Footnote 114: No specific details were provided in the Construction Monitoring Plan other than the plan would be developed in coordination with resource agencies (Appendix B: *Appendix J – Terrestrial Resource Measures*).

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Recommended Terrestrial Measure 7 – General Special-status Wildlife Surveys and Pre-construction Surveys, paragraph 1 on page 3-535:

Recommended Terrestrial Measure 7 – General Special-status Wildlife Surveys and Pre-construction Surveys.
A general special-status wildlife survey shall be conducted within 24 months of initial habitat modification associated with construction activities (e.g., grubbing, structure modification) within the Limits of Work to assess the presence of any special-status species and potential for habitat to be present that could support special-status species identified in Table 3.5-5. Surveys shall be conducted by a qualified biologist; such approval shall occur in a timely fashion. If suitable habitat is present, and there is potential for special-status species to be present, a biologist shall further assess if these special-status species are present in the Limits of Work by conducting general visual observation surveys or protocol-level surveys. Surveys for nesting birds are discussed in Recommended Terrestrial Measure 9, willow flycatcher in Recommended Terrestrial Measure 10, bald and golden eagle in Mitigation Measure TER-7 ~~Recommended Terrestrial Measure 11~~, bats in Recommended Terrestrial Measure 12; surveys to be consistent with the Amphibian and Reptile Management Plan discussed in Mitigation Measure TER-2.

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities, paragraph 3 on page 3-535:

Mitigation Measure TER-6 ~~Recommended Terrestrial Measure 8~~ – Gray Wolf.
~~Every~~ Consistent with the direction of the USFWS, every six months, the location of gray wolves shall be assessed using the CDFW gray wolf activity map (CDFW 2018a) and direct communication with the CDFW wolf biologist. If the Lower Klamath Project overlaps with known wolf activity as identified in the CDFW wolf activity map or if a wolf is documented during any Proposed Project surveys or monitoring, CDFW shall be contacted to further determine if activities pose any potential impacts on gray wolves, particularly with respect to potential modification or disruption of key pup-rearing areas such as dens and rendezvous sites. Depending on the time of year and information about the pack or individuals in the area, CDFW may identify additional measures including denning surveys, reduced driving speeds, limited operating periods, disturbance buffers, reduced speed and signage on haul roads, modification of haul roads to avoid key areas, and monitoring. Consistent with USFWS guidance, limiting operating periods (for loud, continuous noise, or smoke) will be implemented within one mile of den or rendezvous sites during the critical breeding and pup-rearing period or within a mile of potential areas that could support denning and rendezvous sites, as based on habitat conditions such as perennial water

availability, dry and wet meadows, and distance to roads). Tracking of gray wolf activities shall be reported every six months to applicable agencies.

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities, paragraphs 4 and 5 on page 3-535:

Significance

No significant impact with mitigation for amphibians and reptiles and gray wolf

Significant and unavoidable for bats and American badger ~~mammals~~

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Recommended Terrestrial Measure 9 – Nesting Birds, bullet 5 on page 3-539:

If an active raptor or special-status bird nest is observed, a restriction buffer shall be established. This shall include consideration of noise effects and line-of-sight considerations. (Bald and golden eagle species-specific recommended measures are discussed below in Potential Impact 3.5-13 and Mitigation Measure TER-7 ~~Recommended Terrestrial Measure 11~~)

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities, paragraph 1 on page 3-545:

Implementation of the ~~recommended~~ bald and golden eagle mitigation measure below, developed in consultation with CDFW and USFWS, would reduce potential short-term construction-related impacts on bald and golden eagles to less than significant.

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Potential Impact 3.5-13 Short-term impacts on bald and golden eagles from construction-related noise and nesting habitat alterations, paragraphs 2 and 3 on page 3-545:

~~It would be appropriate for the recommended terms and conditions relating to protection of bald and golden eagles to include Recommended Terrestrial Measure 11 below, which has been developed in consultation with CDFW and USFWS. This recommended terrestrial measure~~ Mitigation Measure TER-7 includes the following additional components beyond those listed as part of the Proposed Project:

- During the implementation of the 2018 eagle surveys, a two-mile survey area was established surrounding construction and demolition areas and a 0.5-mile survey area surrounding other areas such as reservoirs. Appendix J of the Definite Plan identifies aerial seeding within the reservoir footprint, and as a result the survey area shall reflect the modified noise disturbance areas around the reservoirs by expanding the surveys buffer around the reservoirs from 0.5 mile to one mile. (A minimum of a one-mile survey area is based on the one-mile buffer distance that would be applied if an active nest was present.)

- Consultation with resource agencies shall include both USFWS and CDFW, as the eagles are protected by the federal Bald and Golden Eagle Protection Act and the bald eagle is listed as a state endangered species.
- Nests shall be monitored within buffer zones.

~~Overseeing development and implementation of recommended term and conditions relating to bald and golden eagles does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has initiated a process[82] to reach enforceable good citizen agreements with USFWS and CDFW that will be finalized and implemented, at this time the recommended term and conditions are not finalized, and the State Water Board cannot require their implementation. Accordingly, while the State Water Board anticipates that implementation of the recommended term and conditions, including the Recommended Terrestrial Measures and any modifications developed through the FERC process that provide the same or better level of protection for special-status wildlife, would reduce impacts to less than significant, because the State Water Board cannot ensure implementation of the Recommended Terrestrial Measures, it is analyzing the associated impacts in this Draft EIR as significant and unavoidable.~~

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Recommended Terrestrial Measure 11 – Bald and Golden Eagle, paragraph 1 on pages 3-546 and 3-547:

<u>Mitigation Measure TER-7</u> ~~Recommended Terrestrial Measure 11~~ – Bald and Golden Eagle.

- KRRC shall develop an Eagle Avoidance and Management Plan in coordination with USFWS and CDFW.
- A two-year survey for eagle use patterns shall be conducted prior to construction activities.
  - The first-year survey shall determine bird use patterns at any facilities to be removed or modified during the time of year most likely to detect bird usage (this was completed by KRRC in 2017).
  - The second-year survey shall include focused surveys (see below).
  - Surveys shall be conducted by a qualified avian biologist, approved by resource agencies (CDFW and USFWS).

[82] KRRC submitted the CEQA support document to agencies in September 2017 and requested feedback by November 10, 2017.

- A focused survey (two site visits) shall be conducted in a single nesting season within two years prior to drawdown to document the presence of nests. These focused surveys shall identify bald and golden eagle nests within two miles [123] of disturbance areas within the Limits of Work, including but not limited to demolition areas where there may be any loud noise disturbance (e.g., helicopter or plane). The early nesting season survey shall occur at a time when eagles are most likely found at the nest sites, and the second survey shall occur later in the season and prior to the fledglings leaving the nest to confirm nesting activity. All observations shall be reported to CDFW using the California Bald Eagle Nesting Territory Survey Form (CDFW 2017d).
- Within two weeks prior to commencing construction or ground-disturbing activities, KRRC shall conduct at least one pre-construction survey within the survey area defined above.
- Wherever possible, clearing, cutting, and grubbing activities shall be conducted outside of the eagle nesting season (January 1 through August 31[124]).
- If active eagle nests are documented during the surveys, a ~~one-mile~~[125] restriction buffer shall be identified in coordination with USFWS and CDFW and established around the nest to ensure that nests are not disturbed. This buffer may be reduced in coordination with USFWS and CDFW, while taking into consideration components such as proposed activity, distance to activity, terrain, and line of site. For example, in coordination with agencies, if a nest is not within line-of-site, meaning that trees or topographic features physically block the eagle's view of construction activities, the buffer could be reduced ~~to 0.25 miles~~. Further reduction of buffers or allowance of limited activity inside of buffers could occur in coordination with on-site biologist, CDFW, and the USFWS, while being consistent with the Eagle Avoidance and Minimization Plan, if it is determined that the activities shall not jeopardize nesting success. To reduce the potential for nesting in a previously identified active nest, measures may be implemented prior to the nesting season such as removing the nest or making nest temporarily unavailable (e.g., placing cone or ball in nest).
- Nests within a one-mile buffer shall be monitored by an USFWS- and CDFW-approved biologist when there is a potential for noise disturbance, in order to assess whether eagle activity patterns are normal, as compared with that observed during baseline surveys described above.
- If activities are anticipated to result in take under the Bald and Golden Eagle Protection Act, it would be considered a significant impact and KRRC will coordinate appropriate measures, including procurement of any necessary take permits, with USFWS ~~and CDFW~~. If a take permit is obtained, the need to implement the measures above shall be reevaluated with USFWS. Report on the status of bald and golden eagle surveys within one month of the survey to applicable agencies.

Footnote 123: ~~Eagle breeding season of January 1 through August 31 identified by A. Henderson, CDFW, Environmental Scientist, pers. comm, November 2017.~~ The bald and golden eagle survey distance of two miles identified by Heather Beeler, USFWS, pers. comm, September 2019.

Footnote 124: Eagle breeding season of January 1 through August 31 identified by A. Henderson, CDFW, Environmental Scientist, pers. comm, November 2017.

Footnote 125: ~~Eagle nest restriction buffer of 1.0 mile identified by A. Henderson, CDFW, Environmental Scientist, pers. comm, November 2017~~

Significance

~~*Significant and unavoidable* in the short term~~

No significant impact with mitigation for bald and golden eagles

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Potential Impact 3.5-14 Short- and long-term impacts on bats from construction noise and loss of roosting habitat, Table 3.5-8 Evidence of Bat Use at Structures Based on June 2017 Reconnaissance and Available Information from 2018 surveys (Appendix B: Definite Plan – Appendix J; KRRC 2018a,b) pages 3-547 through 3-549:

Table 3.5-8. Evidence of Bat Use at Structures Based on June 2017 Reconnaissance and Available Information from 2018 Surveys (Appendix B: *Definite Plan – Appendix J;* KRRC 2018a,b; KRRC 2019b)

Building Name	Evidence of Bat Use
All bridges scheduled for removal or modification	No roosting bats
Copco No. 1 and No. 2 Dams and Facilities	
Schoolhouse	No
House 19038 (next to schoolhouse)	Yes – abundant guano in garage ~~crawl space~~.
Vacant House 1 (tan)	Yes – small numbers of bats present under wood panels outside; absent in fall and winter. Use by Yuma myotis confirmed.
Vacant House 2 (blue)	Yes – small numbers of bats present under wood panels outside; absent in fall and winter. Use by Yuma myotis confirmed.
~~Vacant House 3 (yellow)~~	~~Yes – small numbers of bats present under wood panels outside.~~

Building Name	Evidence of Bat Use
Vacant House 3 (yellow-green)	Yes– large colony in garage behind wood window framing~~, whole structure is being heavily used.~~ And under rotting wood panels. Bats present in the summer and absent in fall and winter. Use by Yuma myotis confirmed.
Vacant House 4 (peach)	Yes – maternity colony between flashing & fascia board all around roof edge; pups present. Bats present in the summer and absent in fall and winter. Use by Yuma myotis confirmed.
Cookhouse	Yes – bats present in awning over side door outside, no sign inside. Use by Yuma myotis confirmed.
Bunkhouse	Appendix B: *Definite Plan – Appendix J* noted yes – guano on bed. Night roosting suspected from staining around outside lighting. KRRC 2019b notes no evidence of bat use.
Maintenance Building (next to switchyard)	Yes – guano and staining in the garage.
Copco No. 1 Dam – C12 Gatehouse	Yes – abundant guano/staining on the inside and outside of the building; dead bat (Myotis spp.) found outside on windowsill. Documented a large maternity roost of >2,000 Myotis spp. Inside structure. Use by Yuma myotis confirmed.
Copco No. 1 – C11 Gatehouse	Yes– about 20 Myotis clustered in exposed roof apex (interior) in fall; not present in summer. Not surveyed in winter. Use by Yuma myotis confirmed.
Copco No. 1 Powerhouse	Yes – several dozen bats clustered on wall above Transformer 3781; abundant staining/guano on basement level. Follow-up surveys documented small numbers of roosting bats. Present in summer, but absent in fall and winter. Use by Yuma myotis confirmed. Townsend's big-eared bat detected acoustically during summer emergence surveys, but species not confirmed to be present in the powerhouse.

Building Name	Evidence of Bat Use
Copco No. 1 Diversion Tunnel (also referenced as Tunnel outside of Copco No. 1 Powerhouse)	Yes – several hundred bats observed during emergence. Present in summer, but absent in fall and winter. Use by Yuma myotis confirmed. Townsend's big-eared bat detected acoustically during summer emergence surveys, but species not confirmed to be present in the tunnel.
Copco No. 2 ~~Diversion~~ Dam (concrete dam and associated structures)	No
Vacant House #21601 (light yellow house)	Yes – ~200 bats roosting in attic. Bats present in the summer and absent in fall and winter. Use by Yuma myotis confirmed.
Shed (next to power station)	None found in main portion of shed. Back area of building was inaccessible.
Vacant House (light blue)	Yes – dead bat found in bathroom sink. No guano/staining inside. Attic vents are closed. No points of entry found.
Vacant House (light blue) on Access Road	No
Tin Pumphouse (across from light blue house on Access Road)	No
Groundwater Well House (~~Tin Pumphouse~~ at entrance to Copco Village)	No ~~Yes~~ – small amount of guano on roof indicates bat use of rock crevices above/behind the structure. ~~Outside. Multiple points of entry. Inside inaccessible.~~
Copco No. 2 Powerhouse	Yes – Not found during interior inspections, but confirmed summer use by evening emergence of ~50 bats. 6 (Myotis spp.) adults and pups ~~many dead bats~~ on ground level (on floor, in storage room, control room) and ~~dead pups~~ at bottom of stairs on lower level. More sign/activity found at ground level. Follow-up surveys documented small numbers of roosting bats. Townsend's big-eared bat detected acoustically during summer emergence surveys, but species not confirmed to be present in the powerhouse.
Control Center ~~Room~~ at Copco No. 2 Powerhouse	~~Not inspected during reconnaissance survey.~~No
Maintenance Building ~~Shop~~ next to ~~power station at~~ Copco No. 2 Powerhouse	~~Not inspected during reconnaissance survey.~~No

Building Name	Evidence of Bat Use
Occupied House next to Vacant House 4	~~Not inspected during reconnaissance survey.~~ July 2017 survey of exterior did not document presence of bats; interior survey was not conducted as residence was occupied.
Equipment shed (in front of bunkhouse/cookhouse)	~~Not inspected during reconnaissance survey.~~ No
Haz Waste storage/wood shop ~~by gas pumps (near houses/bunkhouse/cookhouse)~~	~~Not inspected during reconnaissance survey.~~ No
Iron Gate Dam and Facilities	
Diversion Tunnel Gate Structure	No
Gatehouse for low-level outlet (upstream side of dam)	Yes – night roosting evidence outside. No sign found inside.
Iron Gate Diversion Tunnel Outlet (also referenced as Tunnel near Iron Gate Powerhouse and Iron Gate Diversion Tunnel)	Yes – several hundred bats observed during emergence May and June 2018 surveys. Absent in the winter. Use by Yuma myotis confirmed. Townsend's big-eared bat detected acousticaly during summer emergence surveys, but species not confirmed to be present in the tunnel.
Iron Gate Powerhouse Intake Structure (also referenced as Iron Gate Powerhouse Intake)	Yes – from ground level, bats heard through grating below. Entry via open grate on outside. Two dead bats. Observed abundant guano on plastic sheeting on floor inside. Bats observed in summer, while bats absent in the fall. Use by Yuma myotis confirmed.
Iron Gate Emergency Spill Equipment Shed	No
Communication Building/Powerhouse (also referenced as Iron Gate Hydro Resources Office/Powerhouse)	Yes – several hundred bats emerged from concrete shaft in lower portion of powerhouse in the summer. ~~h~~Heavily used night roost by light fixture under stairwell (abundant staining on concrete wall). ~~Sign of significant roost inside concrete shaft (heavy staining/guano).~~ Confined space entry to bottom level of powerhouse, did not inspect due to confined space entry restriction.
Restrooms (near powerhouse) (also referenced as Bathroom/Storage building near powerhouse)	No

Building Name	Evidence of Bat Use
Spawning building	Yes – small amount of guano. Potential night roosting outside.
Fish Holding Facilities	No
2 storage trailers (parked next to each other)	No
Barn/Garage at Iron Gate Village	Yes – bats present in rafters/ceiling; abundant amount of guano. Absent in the fall. Use by Yuma myotis confirmed.
Residence 1 (occupied) blue/gray	No–inspected outside only; inside/attic not accessed due to occupied residence.
Residence 2 (occupied) tan w/green roof	Yes – 15 bats present behind clock on back porch. Attic access likely through loose screen over vent. Outside inspection only; inside/attic not accessed due to occupied residence.

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities, paragraph 7 on page 3-559:

Potential Impact 3.5-17 Effects on benthic macroinvertebrates from short-term dewatering and sedimentation and long-term alterations to habitat.

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Potential Impact 3.5-18 Short-term impacts on amphibian and reptile in riverine habitats from sedimentation, paragraph 1 on page 3-561:

If suspended sediment settles further downstream, and/or foothill yellow-legged frogs are present, the presence of settled fine silt in slow moving portions of the river reaches would not likely affect the adhesion of egg masses based on foothill yellow-legged frogs' ability to loosen algae and sediment that could enhance the adherence ~~ability~~ of egg masses ~~to adhere~~ to the substrate (Rombough and Hayes 2005).

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Potential Impact 3.5-21 Short- and long-term impacts on birds and bats from loss of aquatic reservoir and shoreline vegetative habitat, paragraph 4 on page 3-562:

The loss of aquatic reservoir habitat would also reduce foraging opportunities for fish-eating birds including bald eagle, osprey, merganser, cormorant, egret, and heron ~~(including the great blue heron rookery documented at Copco No. 1 Reservoir~~ (PacifiCorp 2004b).

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Potential Impact 3.5-21 Short- and long-term impacts on birds and bats from loss of aquatic reservoir and shoreline vegetative habitat, paragraphs 3 on page 3-562:

Following dam removal, reservoir aquatic habitat would transition to wet or upland habitat depending on future hydrologic and physical (topographic) conditions. Following drawdown of the reservoirs, existing upland vegetation is expected to remain unchanged and contribute to successional processes on newly exposed areas. Surrounding the reservoirs, upland tree-dominant vegetation types include Montane Hardwood, Montane Hardwood-Conifer, and Juniper (Section 3.5.2.1 *Vegetation Communities*; Appendix G). Trees dominant in these vegetation types are native trees and drought tolerant; although some of the trees immediately adjacent to the reservoir may currently be benefiting from an elevated water table, lowering groundwater following reservoir drawdown it is not expected to result in a large die-off. In contrast, tree-dominated wet habitats surrounding the reservoir (i.e., Montane Riparian and Palustrine Forested Wetland [Section 3.5.2.1 *Vegetation Communities*; Appendix G]) may transition to upland and existing trees including Oregon ash and bigleaf maple may be impacted; they may turn to snags for perching, form cavities for nesting birds and bats, or ultimately fall to the ground to provide habitat for small mammals and insects which birds and bats may forage. <u>Within a few years following dam removal on the Elwha River, wildlife colonization of the exposed reservoir beds was rapid and dominated by early successional and mobile species and included wildlife that facilitated native seed dispersal (McLaughlin et al 2018).</u> The Proposed Project includes several actions to encourage rapid revegetation with native riparian species including trees as defined in the Reservoir Area Management Plan (Appendix B: *Definite Plan – Appendix H*) which will ultimately provide for tall structure habitat adjacent to the water course to support nesting birds and bats, and provide cover for other wildlife species. (Additional information available above under Potential Impact 3.5-2).

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Potential Impact 3.5-21 Short- and long-term impacts on birds and bats from loss of aquatic reservoir and shoreline vegetative habitat, paragraphs 1 and 2 on page 3-563:

Changes in food availability for birds such as dabbling ducks that consume aquatic vegetation and invertebrates would occur. For example, these species would use the river or other aquatic habitat outside the Proposed Project for foraging once the reservoirs are gone. Similarly, foraging over aquatic habitat by swifts ~~and bats~~ that feed on flying insects would be reduced. <u>Numerous other water bodies in the area are present to provide sufficient foraging opportunities</u>, however, <u>and</u> as discussed in Potential Impact 3.5-17, once BMI populations reestablish after drawdown, swifts ~~and bats~~ would be able to feed over new riverine habitat. Although golden eagles will eat fish, they primarily feed on small to medium-sized mammals (e.g., rabbits, squirrels), and therefore, are unlikely to be substantially affected by the change in aquatic habitat.

The special-status bird species listed in Table 3.5-5 are not exclusive to the Lower Klamath Project reservoirs, but rather they have also been documented in adjacent areas. For example, special-status bird species including American white pelican, Barrow's goldeneye, common loon, black tern, black swift, Vaux's swift, olive-sided flycatcher, willow flycatcher, yellow warbler, and yellow-breasted chat and bald eagle, greater sandhill crane have been either documented in habitats along the Klamath River upstream of Copco No. 1 Reservoir and downstream of Iron Gate Dam, at Lower Klamath National Wildlife and Tule Lake National wildlife refuges, or at other nearby creeks, lakes, and reservoirs including Emigrant Creek, Emigrant Lake, Howard Prairie Lake City Park, and Hyatt Reservoir north of Iron Gate Reservoir (ebird 2019), and therefore, are unlikely to be substantially affected by the change in aquatic habitat.

Reservoirs provide foraging habitat for bat species (e.g., Yuma myotis) that primarily prey on aquatic emergent insects. Bats that forage on aquatic emergent insects are most likely to be affected by the reduced aquatic foraging habitat along the reservoirs. Numerous other water bodies in the area are present to provide sufficient foraging opportunities, however, and; as discussed in Potential Impact 3.5-17, once BMI populations reestablish after drawdown, these bats would be able to feed over new riverine habitat. Transitioning aquatic habitat to upland habitat may increase foraging opportunities for special-status bat species that feed mostly on terrestrial invertebrate species (Western mastiff bat, Townsends's western big-eared bat, spotted bat, pallid bat, fringed myotis, and long-eared myotis) (Western Bat Working Group 2017).

It is anticipated that birds (e.g., ducks, eagles, swifts) and bats would continue to use the river for foraging, or would use other aquatic habitat outside of the terrestrial resource Primary Area of Analysis; therefore, impacts in both the short- and long-term would be less than significant.

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Potential Impact 3.5-22 Short-term and long-term impacts on western pond turtle from loss of aquatic habitat, paragraph 3 on page 3-567:

Available information regarding western pond turtle sightings is from 2002 and 2018 (PacifiCorp 2004a; ~~K. Stenberg, Principal, CDM Smith, pers. comm., July 2018~~ KRRC 2019b). Surveys conducted in Copco No. 1 Reservoir in 2002 documented 12 turtles while surveys in 2018 documented 42 ~~31 to 36~~, which ~~are~~ is similar to the anticipated density estimate. Surveys conducted in Iron Gate

Reservoir in 2002 documented 8 turtles, while surveys in 2018 also documented 8 ~~17~~, which is lower than the anticipated density estimates.

Volume I Section 3.5.5.3 Terrestrial Resources – Potential Impacts and Mitigation – Special-status Species and Rare Natural Communities – Potential Impact 3.5-24 Effects on terrestrial species from herbicide use during reservoir activities, new paragraph 7 on page 3-571:

- At typical application rates, none of the acute scenarios studied presented unacceptable risks to wildlife, including predatory birds consuming small mammals (Bautista 2007).

Potential short-term impacts on aquatic biota from herbicide application during restoration of the reservoir areas are discussed in Potential Impact 3.2-16, which requires implementation of Mitigation Measure WQ-4 to reduce potential impacts to a less than significant level.

Volume I Section 3.5.5.4 Terrestrial Resources – Potential Impacts and Mitigation – Wildlife Corridors and Habitat Connectivity – Potential Impact 3.5-29 Long-term effects on wildlife from alteration of wildlife movement corridors, paragraph 4 on page 3-575:

Removal of the Lower Klamath Project reservoirs, penstocks, and restoration of the pre-dam river channel would eliminate areas of wide, deep water crossings that currently represent a hindrance to large and small mammal movements from one side of the river to the other or upland migration for reptiles. Following removal of the reservoirs, relatively narrow and shallow water crossing points would be available for both large and small terrestrial species to move across the river. This would provide long-term benefits to wildlife in the terrestrial resources Primary Area of Analysis by increasing the amount of habitat available to these species, making them less vulnerable to disease, malnutrition, and other environmental stressors as compared with existing conditions. Following dam removal on the Elwha River, wildlife colonization of the exposed reservoir beds was rapid and dominated by early successional and mobile species and included wildlife function that facilitated native seed dispersal to restoration sites, herbivore effects on revegetation, and organic matter dispersal to nutrient nutrient-poor sediments (McLaughlin et al 2018).

3.5.6 References

Volume I Section 3.5.6 Terrestrial Resources – References, pages 3-576 through 3-586, includes the following revisions:

AmphibiaWeb. 2017. *Rana boylii* Foothill Yellow-legged Frog, ~~*Hyalinobatrachium fleischmanni*, Fleischmann's glass frog.~~ Website. https://amphibiaweb.org/cgi/amphib_query?where-genus=Rana&where-

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3.6 Flood Hydrology

3.6.2 Environmental Setting

3.6.2.2 Basin Hydrology

Volume I Section 3.6.2.2 Flood Hydrology – Environmental Setting – Basin Hydrology – Historical Water Management Changes to Klamath River Hydrology, paragraph 1 on page 3-596:

Minimum flow requirements, based on consideration of ESA species, at Iron Gate Dam have gone through multiple iterations (e.g., 2002 Biological Opinion, 2008 Biological Opinion, KBRA/2010 Biological Opinion)~~ and are currently operated under the~~ including the 2013 Joint Biological Opinion (2013 BiOp) that was operational at the time of the Notice of Preparation for the Lower Klamath Project EIR~~,~~ and the 2017~~and~~ court-ordered flushing flows (NMFS and USFWS 2012, U.S. District Court 2017). Minimum flow requirements for the Klamath River are currently~~ operated under~~ set by the NMFS and USFWS 2019 biological opinions for the USBR Klamath Irrigation Project (2019 BiOp Flows) (for more detail see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project,* and the *Iron Gate Reservoir* subsection below) ~~(NMFS and USFWS 2012, U.S. District Court 2017~~ (NMFS 2019; USFWS 2019).

Volume I Section 3.6.2.2 Flood Hydrology – Environmental Setting – Basin Hydrology – Upper Klamath Basin – Upper Klamath Lake and Link River Dam, Table 3.6-4 Klamath River Reservoir Information on page 3-601:

Table 3.6-4. Klamath River Reservoir Information.

Reservoir	**Surface Area (acres)**	**Average Yearly Inflow [a] (cfs)**	**Average Depth [a] (feet ~~amsl~~)**	**Maximum Depth [a] (feet ~~amsl~~)**	**Active Storage (acre-feet)**	**Total Storage (acre-feet)**	**Retention Time (days)**
Upper Klamath Lake	67,000[a]	1,450	9	60	486,830[a, b]	629,780[a, b]	219[a]
Keno	2,475[a]	1,575	7.5	20	495[a, b]	18,500[a, b]	5.9[a]
J.C. Boyle	350[c]	1,575	8.3	40	1,724[a, b]	2,267[c]	1.1[a]
Copco No. 1	972[c]	1,585	47	108	6,235[a, d]	33,724 [c]	10.7[a]
Copco No. 2	N/A[c]	1,585	[e]	[e]	0[a, b]	70[c]	0[a]
Iron Gate	942[c]	1,733	62	167	3,790[a, d]	50,941 [c]	14.8[a]

Notes:

[a] Source: FERC (2007).

[b] Storage volumes are from Table A2.1-1 of PacifiCorp's Exhibit A, as cited in FERC (2007).

[c] Source : AECOM et al. (2017). Data have been adjusted from those reported in FERC 2007 and USBR 2012a based on available data (e.g., as-built drawings, aerial photographs, topographic information).

[d] Storage for Copco No. 1 Reservoir between the normal maximum water level and the invert of the penstock intakes is approximately 20,000 acre-feet. Storage for Iron Gate Reservoir between the normal maximum water level and invert of the penstock intake is approximately 24,000 acre-feet, as reported in FERC (2007).

[e] Very small reservoir, no information on depth provided.

Volume I Section 3.6.2.2 Flood Hydrology – Environmental Setting – Basin Hydrology – Upper Klamath Basin – Iron Gate Reservoir, paragraph 1 on page 3-610:

Table 3.6-7 shows the ramping rate criteria for Iron Gate Dam established in the 1961 FERC license amendment, 2013 BiOp, and ~~the~~ 2019~~3~~ BiOp Flows (NMFS and USFWS 2013, NMFS 2019, and USFWS 2019~~3~~).

Volume I Section 3.6.2.2 Flood Hydrology – Environmental Setting – Basin Hydrology – Upper Klamath Basin – Iron Gate Reservoir, Table 3.6-7 on page 3-610:

Table 3.6-7. Ramping Rate ~~Requirements~~ Targets for Iron Gate Dam.

Flow Range	Maximum Decrease	Source
1961 FERC License Amendment		
General	250 cfs per hour or 3 inches per hour whichever is less	FERC 1961 license amendment
2013 Joint Biological Opinion (2013 BiOp)		
Greater than 3,000 cfs	Follows a 3-day moving average of net inflow into UKL and accretions between Link River Dam and Iron Gate Dam	NMFS & USFW 2013
~~Above~~ Greater than 1,750 cfs ~~and~~ but equal to or less than ~~or equal to~~ 3,000 cfs	N~~n~~ot more than 125 cfs per 4-hour period and not exceeding 300 cfs per 24-hour~~s~~ period	NMFS & USFW 2013
1,750 cfs or less	N~~n~~ot more than 50 cfs per 2-hour period and not exceeding 150 cfs per 24-hour period	NMFS & USFW 2013
2019 Biological Opinions (2019 BiOp Flows)		
Greater than 4,600 cfs	Not more than 500 cfs per 6-hour period and not exceeding 2,000 cfs per 24-hour period	NMFS 2019 & USFWS 2019
Greater than 3,600 cfs but equal to or less than 4,600 cfs	Not more than 250 cfs per 6-hour period and not exceeding 1,000 cfs per 24-hour period	NMFS 2019 & USFWS 2019
Greater than 3,000 cfs but equal to or less than 3,600 cfs	Not more than 150 cfs per 6-hour period and not exceeding 600 cfs per 24-hour period	NMFS 2019 & USFWS 2019
Greater than 1,750 cfs but equal to or less than 3,000 cfs	Not more than 125 cfs per 4-hour period and not exceeding 300 cfs per 24-hour period	NMFS 2019 & USFWS 2019
1,750 cfs or less	Not more than 50 cfs per 2-hour period and not exceeding 150 cfs per 24-hour period	NMFS 2019 & USFWS 2019

Sources: NMFS and USFWS 2013, NMFS 2019, and USFWS 2019

Volume I Section 3.6.2.2 Flood Hydrology – Environmental Setting – Basin Hydrology – Upper Klamath Basin – Iron Gate Reservoir, paragraph 2 on page 3-610:

Flows downstream from Iron Gate Dam are the result of the Link River Dam releases from Upper Klamath Lake, Link River Dam to Iron Gate Dam flow accretions, and management of the Klamath Hydroelectric Project by PacifiCorp. Since approximately 1997, Iron Gate Dam minimum flow releases have been stipulated by various BiOps, which was discussed in detail in the 2007 FEIS as well as the 2008, ~~and~~ 2010, and 2013 BiOps (FERC 2007).

Volume I Section 3.6.2.2 Flood Hydrology – Environmental Setting – Basin Hydrology – Upper Klamath Basin – Iron Gate Reservoir, paragraph 5 on page 3-610:

~~Currently,~~ At the time of the Notice of Preparation (NOP) for the Lower Klamath Project EIR, flow releases at Iron Gate Dam ~~are~~ were dictated by the 2013 BiOp ~~and court-ordered flushing flows~~, which ~~were~~ was designed to protect federally listed coho salmon, Lost River sucker, and shortnose sucker (NMFS and USFWS 2013). Subsequently, ~~U.S. District Court 2017c). The~~ court-ordered flushing flows became effective in February 2017, after the ~~Notice of Preparation (~~NOP~~)~~ was filed by the State Water Board in December 2016, and ~~are~~ were therefore not part of the Existing Conditions for the Proposed Project (U.S. District Court 2017c). However,~~This~~ the Flood Hydrology section of the Draft EIR noted~~s~~, and as appropriate discussed~~s~~, the potential differences to the Existing Conditions and the impact analyse~~i~~s based on the newer flow requirements. Minimum flow requirements for the Klamath River are currently operated under the NMFS and USFWS 2019 biological opinions for the USBR Klamath Irrigation Project (2019 BiOp Flows), which the Final EIR evaluates as a second baseline for the Existing Conditions (for more details see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*) (NMFS 2019; USFWS 2019). Because of the similarity between the 2013 and 2019 BiOp flows and the fact that BiOp flows specify minimum flow targets, and not peak flood flows, ~~The~~ current flow regime does not result in any changes to the findings of significance and does not result in any changes regarding mitigation measures.

Volume I Section 3.6.2.2 Flood Hydrology – Environmental Setting – Basin Hydrology – Upper Klamath Basin – Iron Gate Reservoir, paragraph 6 on page 3-610 through paragraph 1 on page 3-611:

See Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* for a description of USBR's operational details related to implementing the 2013 BiOp and 2019 BiOp Flows.

~~USBR uses the monthly 50 percent exceedance inflow forecasts from the Natural Resources Conservation Service (NRCS) as the basis for Klamath Irrigation Project operations to manage Upper Klamath Lake and the Klamath River during the spring-summer irrigation season (March 1 through September 30). To estimate the water supply available from Upper Klamath Lake and the Klamath River, USBR relies on actual inflows to Upper Klamath Lake and NRCS inflow~~

~~forecasts for Upper Klamath Lake to determine three key operational values: (1) the volume of water to be reserved in Upper Klamath Lake to maintain lake elevations analyzed in the BiOp; (2) the volume of water designated for the Klamath River, referred to as the environmental water account (EWA); and (3) the volume of water available for delivery for irrigation purposes to the Klamath Irrigation Project (USBR 2016).~~

~~USBR makes a preliminary calculation of these three operational values on March 1; however, those estimates are subject to change, based on actual Upper Klamath Lake inflows after March 1 and subsequent NRCS inflow forecasts. USBR recalculates these values on April 1, based on actual Upper Klamath Lake inflows observed in March and NRCS Upper Klamath Lake inflow forecast for April 1 to September 30. This April 1 calculation establishes the initial volume of water available for irrigation from the Upper Klamath Lake and the Klamath River during the spring-summer irrigation season.~~

Volume I Section 3.6.2.2 Flood Hydrology – Environmental Setting – Basin Hydrology – Upper Klamath Basin – Iron Gate Reservoir, paragraphs 2 on page 3-611:

The 2013 and 2019 BiOp's established average daily minimum target flows below Iron Gate Dam. The~~se~~ 2019 BiOp target flows are summarized in Table 3.6-8 and are the same as those specified under the 2013 BiOp. The 2013 BiOp specified ~~M~~average daily maximum target flows ~~are established~~ for July, August, and September, and ~~are~~ were based on the Environmental Water Account (EWA) (water supply from Upper Klamath Lake designated for the Klamath River) volumes. The 2019 BiOp Flows do not specify average daily maximum target flows, although the EWA does vary depending on UKL Supply. ~~These target flows are summarized in Table 3.6-8.~~

Volume I Section 3.6.2.2 Flood Hydrology – Environmental Setting – Basin Hydrology – Upper Klamath Basin – Iron Gate Reservoir, paragraphs 3 on page 3-611:

In addition, increases to the target flows in Table 3.6-8 can occur in late August or early September to support the Yurok Tribal Boat Dance Ceremony. To ensure adequate flow for the Yurok Tribal Boat Dance Ceremony, which occurs during even calendar years, flow releases at Iron Gate Dam can be increased. The volume of water required for the ceremony is estimated to be between 2,000 and 4,000 acre-feet depending on real-time hydrologic conditions, and the EWA is increased by 7,000 acre-feet during even calendar years (NMFW and USFWS 2013, NMFS 2019, USFWS 2019). Deviations to the flow targets in Table 3.6-8 can also occur based on other circumstances, such as large fish disease events or flood hazard risks.

Volume I Section 3.6.2.2 Flood Hydrology – Environmental Setting – Basin Hydrology – Upper Klamath Basin – Iron Gate Reservoir, Table 3.6-8 on page 3-612:

Table 3.6-8. Iron Gate Dam Target Flow Release Criteria According to the 2013 BiOp ~~Biological Opinion~~ and 2019 BiOp Flows.

Month	~~NMFS & USFWS~~ 2013 BiOp~~Biological Opinions~~ Iron Gate Dam Target Flows (cfs)~~2~~		2019 BiOp Flows Iron Gate Dam Target Flows (cfs)
	Average Daily Minimum	Average Daily Maximum1~~3~~	Average Daily Minimum
April	1,325	--	1,325
May	1,175	--	1,175
June	1,025	--	1,025
July	900	1,000 cfs @ EWA = 320,000 acre-feet 1,500 cfs @ EWA ≥ 1,500,000 acre-feet	900
August	900	1,050 cfs @ EWA = 320,000 acre-feet 1,250 cfs @ EWA ≥ 1,500,000 acre-feet	900
September	1,000	1,100 cfs @ EWA = 320,000 acre-feet 1,350 cfs @ EWA ≥ 1,500,000 acre-feet	1,000
October	1,000	--	1,000
November	1,000	--	1,000
December	950	--	950
January	950	--	950
February	950	--	950
March	1,000	--	1,000

Notes:

"–" none specified, but regulated per ramping rates shown in Table 3.6-7.

cfs = cubic feet per second; EWA = Environmental Water Account

~~1 Source: FERC 2007~~

~~2 Source: NMFS and USFWS 2013a~~

1~~3~~ In late August/early September during even calendar years, flow releases at Iron Gate Dam may be increased to support the Yurok Tribal Boat Dance Ceremony. The volume of water required is estimated to be 2,000–4,000 acre-feet depending on real-time hydrologic conditions.

Sources: NMFS and USFWS 2013, NMFS 2019, and USFWS 2019

3.6.2.3 Flood Hydrology

Volume I Section 3.6.2.3 Flood Hydrology – Environmental Setting – Flood Hydrology, paragraph 3 on page 3-623:

During extremely wet years, 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 around and near Upper Klamath Lake due to recent breaching of local dikes and levees, which can help to reduce flooding downstream. In contrast, there is minimal surplus storage in the Lower Klamath Project to help control flooding downstream of Iron Gate Dam. During wet years, decreased irrigation demands in the upper basin may allow for more water to remain in Upper Klamath Lake for use later in the year. The amount of water retained in Upper Klamath Lake is determined under the 2019~~3~~ BiOp~~'s~~ and depends on decisions related to ESA-listed suckers and the magnitude of spring flushing flows and fall migration flows downstream of Iron Gate Dam (NMFS 2019 and USFWS 2019~~3~~) (see also Section 3.1.6.3~~1~~ Klamath River Flows under the Klamath Irrigation Project's 2019~~3~~ BiOp Flows). The 2019~~3~~ BiOp Flows also includes provisions for average and wet years that ~~increase~~ implement opportunistic surface flushing flows ~~minimum flow requirements~~ at Iron Gate Dam and increase surface water elevations in Upper Klamath Lake to more closely mimic natural flow and lake-level conditions and provide storage for surplus water (NMFS 2019; and USFWS 2019~~3~~).

3.6.2.4 Risks of Dam Failure

Volume I Section 3.6.2.4 Flood Hydrology – Environmental Setting – Risks of Dam Failure, paragraph 3 on page 3-624:

Siskiyou County recently developed a Multi-Jurisdictional Hazard Mitigation Plan which addressed, among other issues, flood and dam failure hazards. Maps are currently available that describe dam inundation areas based on potential failure of Lower Klamath Project dams, including ~~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 2011). 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 No. 1 and Iron Gate dams are inspected and evaluated by an independent consultant and reports documenting the evaluation are submitted to FERC for review (FERC 2007).

3.6.4 Impacts Analysis Approach

Volume I Section 3.6.4 Flood Hydrology – Environmental Setting – Impacts Analysis Approach, paragraph 2 on page 3-625:

USBR used KBRA flows as the hydrologic input for modeling floodplain inundation (USBR 2012). The 2013 and 2019 BiOp flows changed the likely flow regime under which dam removal would occur ~~in 2020~~ (i.e., no longer using KBRA flows). However, the differences in hydrology between KBRA and the 2013 and 2019 BiOp flows are minor (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* for further details regarding KBRA and the 2013 and 2019 BiOp flows).

3.6.5 Potential Impacts and Mitigation

3.6.5.1 Flood Hydrology

Volume I Section 3.6.5.1 Flood Hydrology – Potential Impacts and Mitigation – Flood Hydrology – Potential Impact 3.6-1 Reservoir drawdown and dam removal could result in short-term increases in downstream surface water flows and result in exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding, paragraph 3 on page 3-626:

Reservoir drawdown in the Proposed Project includes considerations for minimizing potential flood risks. These considerations include carefully drawing down the LKP reservoirs using controlled flow releases (see Section 2.7.2 *Reservoir Drawdown*) and the increased storage availability in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs once drawdown has begun. If a flood event occurred during drawdown, the KRRC proposes to retain flood flows using the newly available storage capacity and continue drawdown after flood risks have ended. Under ~~E~~existing conditions, PacifiCorp does not currently operate Iron Gate and Copco reservoirs for flood control purposes ~~do not allow these reservoirs to assist in flood prevention~~ in this manner.

Volume I Section 3.6.5.1 Flood Hydrology – Potential Impacts and Mitigation – Flood Hydrology – Potential Impact 3.6-1 Reservoir drawdown and dam removal could result in short-term increases in downstream surface water flows and result in exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding, paragraph 3 on page 3-629:

Dam excavation would proceed at an estimated 7,500 cubic yards (CY) per day in June, 14,250 CY per day in July, and 16,000 CY per day in August and early September, leaving an upstream cofferdam. Minimum reservoir flood release capacities would be approximately ~~7~~4,~~7~~200 cfs in June, ~~7~~3,000 cfs in July, and 3,000 cfs in August and September, to accommodate the passage of at least a 100-year flood during those times of the year. 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. The cofferdam at Iron Gate Dam would be breached prior to breaching the cofferdam at J.C. Boyle Dam to minimize potential downstream impacts. The breach flow from J.C. Boyle Dam would quickly attenuate as it moved downstream due to the very small reservoir volume.

3.6.5.2 River Floodplain

Volume I Section 3.6.5.2 Flood Hydrology – Potential Impacts and Mitigation – River Floodplain – Potential Impact 3.6-3 The long-term FEMA 100-year floodplain inundation extent downstream from Iron Gate Dam could change between river miles 193 and 174, potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding, paragraph 5 on page 3-630:

Modeling of flood flows downstream of Iron Gate Dam indicates that the Lower Klamath Project dams provide a slight attenuation of peak flood flows. USBR (2012) estimated that the discharge of the 100-year peak flood immediately downstream of Iron Gate Dam would increase by up to seven percent following dam removal (Table 3.6-12) and flood peaks would occur about 10 hours earlier. This increased discharge would result in flood elevations that are 1.65 feet higher on average from Iron Gate Dam (RM 193) to Bogus Creek (RM 192.6) and 1.51 feet higher on average from Bogus Creek to Willow Creek (RM 188) (Appendix B: *Definite Plan*). The impact of dam removal on flood peak elevations would decrease with distance downstream of Iron Gate Dam, and USBR (2012) and the KRRC (Appendix B: *Definite Plan*) estimated that there would be no significant effect on flood elevations downstream of Humbug Creek (RM 174) because flow attenuation would occur in the mainstem channel and tributary peak flows would not coincide with the peak flow downstream of RM 193 (i.e., current location of Iron Gate Dam). <u>USBR (2012) and the KRRC have estimated that below Humbug Creek (RM 174) any change to the 100-year floodplain inundation elevation would be less than 0.5 feet, and that changes of less than 0.5 feet would not result in a significant effect. As FEMA does not recognize changes in flood elevations less than 1 foot, the application of a 0.5-foot change in flood elevation to rule out areas that could be significantly affected is a conservative approach to determining the potential effects of the Proposed Project on the Klamath River floodplain.</u>

Volume I Section 3.6.5.2 Flood Hydrology – Potential Impacts and Mitigation – River Floodplain – Potential Impact 3.6-3 The long-term FEMA 100-year floodplain inundation extent downstream from Iron Gate Dam could change between river miles 193 and 174, potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding, paragraph 3 on page 3-631:

Although the original USBR hydrologic and hydraulic modeling was conducted assuming KBRA flows, it is reasonable to conclude that the likely adverse impacts to structures in the <u>altered</u> 100-year floodplain downstream of Iron Gate Dam and the timing of downstream flood peaks would be similar under the 2013 <u>and 2019</u> BiOp flow regime<u>s</u> because: (1) the <u>2019 BiOp Flows,</u> 2013 BiOp flows, and KBRA flows are similar, and (2) there is no change to flood operations under the 2019 and 2013 BiOp flows versus the KBRA flows (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*). Furthermore, BiOps specify minimum flow targets, not peak flood flows, and therefore, do not affect peak flow flood hydrology.

Volume I Section 3.6.5.2 Flood Hydrology – Potential Impacts and Mitigation – River Floodplain – Potential Impact 3.6-4 The FEMA 100-year floodplain inundation extent downstream from J.C. Boyle Dam could change between the California-Oregon state line and Copco No. 1 Reservoir, potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding, paragraph 5 on page 3-633:

Because J.C. Boyle Reservoir provides ~~no~~ limited storage and the dam typically operates in spill mode at flows above ~~plant~~ power canal capacity (i.e., approximately ~~6,000~~ 2,800 cfs; Table 2-1 in USBR 2012), existing conditions peak flows in the Hydroelectric Reach are not substantially attenuated as a result of J.C. Boyle Dam.

Volume I Section 3.6.5.2 Flood Hydrology – Potential Impacts and Mitigation – River Floodplain – Potential Impact 3.6.5 The release of sediment stored behind the Lower Klamath Project dams and resulting downstream sediment deposition under the Proposed Project could result in potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding, paragraph 3 on page 3-634 to paragraph 1 on page 3-635:

Potential Impact 3.6-5 The release of sediment stored behind the Lower Klamath Project dams and resulting downstream sediment deposition under the Proposed Project could result in potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding.

Depending on hydrologic conditions during drawdown and dam removal, approximately 90,000 to 170,000 U.S. tons of sediment behind J.C. Boyle Dam, 950,000 to 1,590,000 U.S. tons of sediment behind Copco No. 1 Dam, and 420,000 to 550,000 U.S. tons of sediment behind Iron Gate Dam would be eroded and flushed down the Klamath River during dam removal activities (USBR 2012) (see also Section 2.7.3 *Reservoir Sediment Deposits and Erosion During Drawdown*). After dam removal, the remaining reservoir sediment would ~~be left in place~~consolidate above the active channel. USBR conducted an analysis of future geomorphology and sediment transport during and after dam removal for dry, average (median), and wet start year scenarios. Most of the erosion would occur during the primary drawdown period from January 1 to March 15 of the drawdown year and afterwards the river bed in the reservoir reaches is expected to stabilize. Significant short term sediment deposition in the Klamath River channel is expected between Iron Gate Dam (RM 193) and the confluence of Cottonwood Creek (RM 185.1) ~~Minor deposition would occur in~~

~~some of the reaches downstream~~ from dam removal activities, however no significant deposition is predicted downstream of Cottonwood Creek ~~none is expected downstream of the Shasta River confluence~~ (USBR 2012). The Geology and Soils analysis considers the effects of sediment deposition in more detail (see Section 3.11.5 *[Soils, Geology, and Mineral Resources] Potential Impacts and Mitigation* of this EIR). Sedimentation would occur downstream from the Lower Klamath Project, but the quantity would vary depending on water year types during and following drawdown. The magnitude of sediment deposition predicted is relatively small compared to sediment loading from other existing sources along the Klamath River. ~~The only measurable sedimentation would occur in the reach from Bogus Creek to Cottonwood Creek.~~ Short-term (2-years) sediment and hydraulic model simulations focused on reservoir sediment erosion and fine sediment load in the Klamath River following drawdown indicate up to about 0.9 feet of reach-averaged sediment deposition between Bogus Creek (RM 192.6) and Willow Creek (RM 188) (Figure 3.11-15), although conservative long-term (50-year) simulations focused on channel bed elevation change indicate that fine and coarse sediment deposition within 2 years of dam removal may be up to 1.7 feet (see Figure 3.11-18) (USBR 2012). Short-term simulations also indicate up to about 0.4 feet of sediment deposition from Willow Creek to Cottonwood Creek (Figure 3.11-15), although conservative long-term (50-year) simulations indicate that fine and coarse sediment deposition within 2 years of dam removal may be up to 0.9 feet (see Figure 3.11-18) (USBR 2012). ~~In the short term (i.e., 2 years following dam removal), there is anticipated to be approximately 1.2 feet of deposition between Bogus Creek (RM 192.6) and Cottonwood Creek (RM 185.1) (Figure 3.11-12). This estimate is based on two successive median water years following dam removal. The predicted bed elevation changes under other modeled scenarios (i.e., two successive wet water year types and two successive dry water year types) are both less than the median water year scenario (USBR 2012). In the long term, average bed elevation is predicted to increase by approximately 1.5 feet in the reach from Bogus to Willow Creek and less than one foot downstream of Willow Creek. Additionally, I~~ sedimentation is anticipated to be localized and occur primarily in slack-water areas, such as pools, and not in the riffle and bedrock sections that tend to control water surface elevations. Because the sediment deposition would be relatively small in comparison with the existing channel bed and bar sediment conditions, it would not affect stream characteristics in a way that would substantively alter flood inundation or flood risks and would therefore be a less than significant impact. Note that even though the effects of sediment deposition would be less than significant with respect to flooding risk, increases in bed elevations due to sedimentation were included in USBR's (2012) hydraulic modeling and mapping of the 100-year floodplain inundation areas downstream of Iron Gate Dam as described above.

Significance

No significant impact

3.6.5.3 Risks of Dam Failure

Volume I Section 3.6.5.3 Flood Hydrology – Potential Impacts and Mitigation – Risks of Dam Failure, Potential Impact 3.6-6 Dam failure could flood areas downstream of the Lower Klamath Project, paragraph 2 to paragraph 7 on page 3-635, which includes new paragraphs:

Potential Impact 3.6-6 Dam failure could flood areas downstream of the Lower Klamath Project.
Removing the Lower Klamath Project dams could reduce the risks of downstream flooding associated with a dam failure. The Lower Klamath Project dams store over ~~169,000~~87,000 acre-feet of water that could inundate a portion of the watershed if the dams failed (Siskiyou County Web Site 2011). The dams are inspected regularly and ~~the probability for failure has been found to be low~~ all three California dams have received a satisfactory rating, meaning that no existing or potential dam safety deficiencies are recognized by the California Department of Water Resources, Division of Safety of Dams (DSOD 2019). Copco No. 1 and Iron Gate dams are classified as having a "high" downstream hazard potential which means that these dams are "expected to cause loss of at least one human life" should the dam fail while operating with a full reservoir (DSOD 2019). Removing the Lower Klamath Project dams would eliminate the potential for dam failure and subsequent flood damages and would therefore be beneficial.

The reservoir drawdown and dam removal processes are specifically designed to reduce the potential for dam failure during dam demolition that could result in downstream flooding, and further details are discussed below. Dam embankment excavation at each site would not take place until after the reservoir was completely drawn down (Appendix B: *Definite Plan*). This approach precludes the possibility of dam demolition activities increasing the risk for failure and subsequent downstream flooding.

As stated in Volume I Section 2.7.2 *Proposed Project – Proposed Project – Reservoir Drawdown* (page 2-57) the maximum drawdown rate of 5 feet per day is proposed by KRRC as a conservative value based upon dam slope stability analyses conducted for each of the Lower Klamath Project reservoirs. According to USBR (2012), the rate of reservoir drawdown is an important factor that affects the stability of the upstream slope of an earthen dam, such as Iron Gate Dam. If the reservoir drawdown occurs at a fast enough rate, pore pressures in the upstream zone and foundations of the dam embankment may not have time to dissipate, which may result in failure of the upstream slope of the dam (USBR 2012).

As discussed in Volume II Appendix B: *Definite Plan – Appendix D Dam Stability Analyses*, Iron Gate Dam is a zoned earth and rock fill embankment dam, with a central impervious clay core, an upstream and a downstream compacted pervious shell with filter zones, and a downstream drain. A 10-foot thick layer of riprap protects the upstream slope of the dam against erosion. A 5-foot thick riprap layer is present on the downstream slope. Additional material characterization, including details of the materials present in the different zones of Iron Gate Dam, is presented in Volume II Appendix B: *Definite Plan – Appendix D*. The dam stability analyses described in the Definite Plan acknowledge that the shear strength parameters of the earthen shell and core of a dam are very important for the rapid drawdown analysis, and because no laboratory shear strength tests are available for the Iron Gate Dam shell and other embankment materials, shear strength parameters for these materials were selected based on available information such as the type of construction, parameters used in previous analyses, and published data. The material properties used for the analyses of Iron Gate Dam stability during drawdown are presented in Table 1 of Volume II Appendix B: *Definite Plan – Appendix D*. The embankment stability analysis for Iron Gate Dam (and J.C. Boyle Dam, which also has earthen embankments) was conducted for the following scenarios:

1. Instantaneous drawdown from steady state condition with full pore pressure dissipation in the shell materials (least conservative bound).
2. Instantaneous drawdown from steady state condition with no pore pressure dissipation in the shell materials (most conservative bound).
3. Slow drawdown rate (3 feet per day for Iron Gate Dam and 2 feet per day for J.C. Boyle Dam).
4. Intermediate drawdown rate (6 feet per day for Iron Gate Dam and 5 feet per day for J.C. Boyle Dam).
5. Rapid drawdown rate (10 feet per day for Iron Gate Dam and 10 feet per day for J.C. Boyle Dam).

As discussed in Volume II Appendix B: *Definite Plan – Appendix D*, the embankment stability analysis results for Iron Gate Dam indicate that the minimum factor of safety of 1.3 for transient seepage analyses would be more than met for all cases analyzed. Note that the minimum factor of safety of 1.3 selected for the KRRC's embankment stability analysis is conservatively at the higher end of the range of minimum acceptable factors of safety of 1.1 to 1.3 established by the Engineering Manual (EM-110-2-1902) of United States Army Corps of Engineers (USACE 2003). Based on the KRRC's analyses, reservoir drawdown could be as high as 10 feet per day without risk of failure of the earthen embankment at Iron Gate Dam. However, the KRRC has proposed that reservoir drawdown be limited to a maximum value of 5 feet per day.

Further, as described in Volume I Section 2.7.2 *Proposed Project – Proposed Project – Reservoir Drawdown* (page 2-57), drawdown of Iron Gate Reservoir (as well as Copco No. 1 Reservoir) would be managed through automated gate control systems with operator oversight, where inputs to determine the amount of gate opening at each reservoir would include continuous measurement of reservoir levels by remote sensor. The gate control system would incrementally open (or close) the gate to increase (or decrease) flow through the diversion tunnels (14-foot by 16-foot each) to maintain the reservoir drawdown of the reservoirs at an approximately constant rate. This would allow the dams to maintain embankment and reservoir rim stability during the drawdown period even as reservoir inflows vary. For example, flows may also vary due to storms and any changes in upstream reservoir releases.

With respect to the potential for Iron Gate Dam to fail during excavation, Iron Gate Dam is the most downstream of the four Lower Klamath Project dams proposed for removal, and excavation of this dam would begin in June of dam removal year 2 after demolition of Copco No. 1 and Copco No. 2 dams are scheduled to begin. J.C. Boyle Dam deconstruction would begin just after Iron Gate Dam deconstruction begins. Following reservoir drawdown and during dam deconstruction, there would be no water stored at the upstream dams or within Iron Gate Reservoir, so there is no possibility of dam failure due to excavation that would result in a substantial flooding risk to downstream areas under these conditions. In the event of large storms or upstream dam failure that could send relatively large amounts of water into Iron Gate Reservoir during the excavation period from early June of dam removal year 2 through mid-October of the same year, this dam would maintain available storage and discharge capacity to pass a 1 percent probable flood without overtopping any embankment that is remaining (Volume I Section 2.7.2 *Proposed Project – Proposed Project – Reservoir Drawdown* [page 2-57]).

Copco No. 1 Dam is a concrete gravity arch structure that would require drilling and blasting during the dam removal phase (Appendix B: *Definite Plan*). Copco No. 1 Dam is thicker and wider at its base, which makes it very strong and less prone to risk of failure as the dam crest is lowered through demolition. With minimal water behind the dam due to reservoir drawdown, there would be little hydrostatic pressure against the remaining sections of the dam that could cause dam failure. Additionally, overtopping flows would not cause dam failure as is evidenced by the lack of deterioration to the stepped face on the downstream side of the dam. High flows have poured over the downstream side of the dam for over 100 years with no scour to the concrete. Seismic loading cannot be controlled by the Proposed Project, but as the dam is lowered, the strength of the remaining gravity structure increases, and therefore, the risk of seismic-induced failure would go down for a given event. Thus, there are no likely failure modes created by the removal process even if water did enter the drained reservoir during a late spring storm, and risk of a failure from the removal process is insignificant (S. Leonard, AECOM as KRRC Technical Representative, pers. comm., November 2018).

FERC requires a potential failure modes analysis, and the KRRC will be revisiting this topic in more detail prior to dam removal. FERC dam safety experts would have to approve the final dam removal analysis before a license surrender order could be issued.

See Potential Impact 3.6-1 for further discussion of reservoir drawdown and dam removal details.

Significance
Beneficial following dam removal

No significant impact during reservoir drawdown and dam removal

3.6.6 References

Volume I Section 3.6.6 Flood Hydrology – References, pages 3-636 through 3-638, includes the following revisions:

DSOD (Division of Safety of Dams). 2019. Dams Within Jurisdiction of the State of California. Dams listed alphabetically by dam name. September 2019. Department of Water Resources, California Natural Resources Agency, Sacramento, California.

NMFS (National Marine Fisheries Service). 2019. Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat response for Klamath Project operations from April 1, 2019 through March 31, 2024. Technical memorandum. Prepared by NMFS, California Coastal Office for U.S. Bureau of Reclamation, Klamath Basin Area Office.

USACE (U. S. Army Corps of Engineers). 2003. Slope Stability Engineer Manual. EM 1110-2-1902. USACE, Washington, D. C.

USFWS (U.S. Fish and Wildlife Service). 2019. Biological Opinion on the Effects of the Proposed Klamath Project Operations from April 1, 2019, through March 31, 2024, on the Lost River Sucker and the Shortnose Sucker. TAILS # 08EKLA00-2019-F-0068. Prepared by U.S. Fish and Wildlife Service, Southwest Region, Klamath Falls Fish and Wildlife Office.

Other references cited as part of text included in the Section 3.6 list of revisions:

AECOM, CDM Smith, and River Design Group. 2017. Klamath River Renewal Project. California Environmental Quality Act (CEQA) and California and Oregon 401 Water Quality Certifications Technical Support Document. Prepared by AECOM, Oakland, California; CDM Smith, Sacramento, California; and River Design Group, Corvallis, Oregon for Klamath River Renewal Corporation, California State Water Resources Control Board, and Oregon Department of Environmental Quality. Available at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/20170929_krrc_tech_report.pdf

FERC (Federal Energy Regulatory Commission). 2007. Final Environmental Impact Statement for Hydropower License, Klamath Hydroelectric Project, FERC Project No. 2082-027, FERC/EIS-0201F. Washington, D.C., Federal Energy Regulatory Commission, Office of Energy Projects, Division of Hydropower Licensing. https://www.ferc.gov/industries/hydropower/enviro/eis/2007/11-16-07.asp

Siskiyou County. 2011. Siskiyou County Multi-Jurisdictional Hazard Mitigation Plan. Website. https://co.siskiyou.ca.us/content/oes-hazard-mitigation-plan. [Accessed December 2018].

USBR. 2012. Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration. Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

3.8 Water Supply/Water Rights

3.8.2 Environmental Setting

3.8.2.1 Upper Klamath Basin

Volume I Section 3.8.2.1 Water Supply/Water Rights – Environmental Setting – Upper Klamath Basin, new paragraph 3 on page 3-670:

At the time of the Notice of Preparation (NOP) for the Lower Klamath Project EIR, operation of USBR's Klamath Irrigation Project (which includes flow releases at Iron Gate Dam) was dictated by the 2013 Joint Biological Opinion (2013 BiOp), which was designed to protect federally listed coho salmon, Lost River sucker, and shortnose sucker (NMFS and USFWS 2013). Minimum flow requirements for the Klamath River are currently operated under the NMFS and USFWS 2019 biological opinions for the USBR Klamath Irrigation Project (2019 BiOp Flows), which the Final EIR evaluates as a second baseline for the Existing Conditions (for more details see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*) (NMFS 2019; USFWS 2019). Because of the similarity between the 2013 and 2019 BiOp flows, the current flow regime does not result in any changes to the findings of significance and does not result in any changes regarding mitigation measures.

Volume I Section 3.8.2.1 Water Supply/Water Rights – Environmental Setting – Upper Klamath Basin, paragraph 3 on page 3-670:

The 2013 ~~Joint Biological Opinion (2013~~ BiOp~~) for operation of USBR's Klamath Irrigation Project~~ set~~s~~ minimum lake and river hydrologic conditions to avoid jeopardizing the continued existence of ESA-listed species and adverse modification of designated critical habitat, while providing for delivery of water for irrigation purposes consistent with historical operations, subject to water availability. The 2013 BiOp included~~s~~ two distinct operational approaches for water management for the fall/winter (October through February) and spring/summer (March through September) time periods. The 2019 BiOp Flows specify comparable hydrologic conditions, irrigation supply objectives, and operational approaches (see sections 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* and 3.6.2.2 *[Flood Hydrology] Basin Hydrology* for further details).

Volume I Section 3.8.2.1 Water Supply/Water Rights – Environmental Setting – Upper Klamath Basin – Fall Creek Water Rights, paragraph 1 on page 3-671:

Four water rights are located on Fall Creek: two non-consumptive rights for hydropower generation at PacifiCorp's Fall Creek powerhouse, which is not part of the Proposed Project, one for the City of Yreka's municipal water supply, and one for fish propagation at the Fall Creek Hatchery (see Appendix M). Additionally, PacifiCorp operates a small diversion dam on neighboring Spring Creek that diverts up to 16.5 cfs into Fall Creek upstream of the diversion facilities that supply the Fall Creek powerhouse and City of Yreka diversion. See Section 3.6.2.2 *Flood Hydrology – Environmental Setting – Basin Hydrology – Spring, Fall and Jenny Creeks* (pages 3-606 to 3-607) for further discussion of the Spring Creek diversion.

Volume I Section 3.8.2.1 Water Supply/Water Rights – Environmental Setting – Mid and Lower Klamath Basin – Federal Reserved Rights for Native American Tribes, paragraph 8 on page 3-673:

Hoopa Valley Tribe, ~~and~~ Yurok Tribe, and Klamath Tribes

Volume I Section 3.8.2.1 Water Supply/Water Rights – Environmental Setting – Mid and Lower Klamath Basin – Federal Reserved Rights for Native American Tribes, new paragraph 1 on page 3-674:

On November 14, 2019 the United States Court of Appeals issued its opinion in the *Baley v. United States* case that the Klamath Basin tribes (i.e., Yurok Tribe, Hoopa Valley Tribe, and Klamath Tribes) have senior, federally reserved water rights that predate the water rights of Klamath Irrigation Project irrigators and that the tribes' water rights require at least enough instream water to ensure the continued existence of tribal trust species listed under the Endangered Species Act (ESA). Additionally, in May 2019 the Yurok tribal council passed a resolution declaring rights of personhood for the Klamath River.

3.8.4 Impacts Analysis Approach

Volume I Section 3.8.4 Water Supply/Water Rights – Impacts Analysis Approach, paragraph 1 on page 3-675:

The 2013 and 2019 BiOps changed the flow regime under which dam removal would occur (i.e., KBRA flows are no longer anticipated). However, the differences in hydrology between KBRA and the 2013 and 2019 BiOp flows are minor (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, for further details regarding KBRA and the 2013 and 2019 BiOp flows) and thus do not affect the analysis of future water supply or water rights under the Proposed Project.

3.8.5 Potential Impacts and Mitigation

Volume I Section 3.8.5 Water Supply/Water Rights – Potential Impacts and Mitigation – Potential Impact 3.8-1 Dam removal could change the amount of surface water flow available for diversion under existing water rights in the mainstem Klamath River within the Hydroelectric Reach and downstream from Iron Gate Dam – Middle and Lower Klamath River, paragraph 3 on page 3-677:

This estimate of peak flow diversion would likely be lower during wetter water years, since not all users would be likely to divert the maximum amount during summer months. Comparing the peak potential diversion flow (138 cfs) to the low-flow condition of a dry water year type immediately downstream of Iron Gate Dam (900 cfs, or a 90 percent exceedance flow per the 2013 and 2019 BiOps), the diversions would represent approximately 15 percent of Klamath River flows in the upstream portion of this reach under the Proposed Project.

Volume I Section 3.8.5 Water Supply/Water Rights – Potential Impacts and Mitigation – Potential Impact 3.8-1 Dam removal could change the amount of surface water flow available for diversion under existing water rights in the mainstem Klamath River within the Hydroelectric Reach and downstream from Iron Gate Dam – Middle and Lower Klamath River, paragraph 3 on page 3-677:

Note that the USBR (2012) modeling effort assumed KBRA flows, rather than the 2013 BiOp flows, or 2019 BiOp F~~f~~lows under which the upstream Klamath Irrigation Project (and hence the Lower Klamath Project) currently operates. Compared to KBRA flows, the 2013 BiOp slightly increased~~s~~ the annual average Environmental W~~w~~ater Account (EWA) (i.e., water available to the Klamath River from Upper Klamath Lake) ~~supply~~ by about 9,000 acre feet (NMFS and USFWS 2013). The 2019 BiOp Flows increase the minimum EWA by 80,000 acre feet (87,000 acre feet in Yurok Boat Dance years) compared to the 2013 BiOp (NMFS and USFWS 2013, NMFS 2019, and USFWS 2019). During summer months when irrigation demand is highest (i.e., July~~ and August~~) in dry water years, the 2013 and 2019 BiOps specify~~requires~~ a higher minimum daily average flow target of 900 cfs at Iron Gate Dam, compared to 83124 cfs under KBRA (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*). Overall, the hydrologic differences between KBRA flows and those implemented under the 2013 and 2019 BiOps are small, decrease the relative effect of other diversion in the river in summer, and do not change the assessment of Proposed Project impacts on surface water flows available for diversion under existing water rights in the Klamath River downstream of the Oregon-California border. Furthermore, under the No Project alternative, flow releases would still be controlled by the 2019~~3~~ BiOp, and therefore, the same quantity of Klamath River flow would be available for downstream water rights.

Volume I Section 3.8.5 Water Supply/Water Rights – Potential Impacts and Mitigation – Potential Impact 3.8-2 Dam removal could change the amount of surface water flow available for diversion from Upper Klamath Lake and/or Keno Reservoir to California water users in the USBR Klamath Irrigation Project, paragraph 5 on page 3-679:

The aforementioned releases did not result in a change to Klamath River flows or water supply downstream of Iron Gate Dam since USBR was~~is~~ obligated under the 2013 BiOp to release the water into the Klamath River. If PacifiCorp had not released the flows from Iron Gate and Copco No. 1 reservoirs in the fall of 2014 and spring of 2018, then USBR would have released the flows at Keno Dam and the water would have traveled downstream through the Lower Klamath Project reservoirs to be discharged at Iron Gate Dam, regardless. The same conditions are true under the current 2019 BiOp Flows.

Volume I Section 3.8.5 Water Supply/Water Rights – Potential Impacts and Mitigation – Potential Impact 3.8-2 Dam removal could change the amount of surface water flow available for diversion from Upper Klamath Lake and/or Keno Reservoir to California water users in the USBR Klamath Irrigation Project, paragraph 6 on page 3-679:

Ultimately, precipitation, irrigation needs, and the 20193 BiOp flow requirements determine the amount of surface water flow available for diversion from Upper Klamath Lake and/or Keno Reservoir to the USBR Klamath Irrigation Project. The same conditions were true under the 2013 BiOp. Under the 2013 BiOp, D~~d~~uring extreme dry years, any reduction in available water for existing water rights would result in additional water being drawn from Upper Klamath Lake until lake levels drop to 4,137.72 feet (1,261.5 meters), at which point USBR would adjust water deliveries to the Klamath Irrigation Project to prevent the lake elevation from dropping below that value (NMFS and USFWS 2013). Similarly, under the 2019 BiOp Flows, water supply deliveries from Upper Klamath Lake to the Klamath Irrigation Project can be curtailed to comply with legal requirements and hydrologic conditions, as necessary (NMFS 2019; USFWS 2019). Decreased water supply caused by such an adjustment would potentially result in reduced deliveries to Klamath Irrigation Project water users (irrigators and wildlife refuges in Oregon and California).

Volume I Section 3.8.5 Water Supply/Water Rights – Potential Impacts and Mitigation – Potential Impact 3.8-2 Dam removal could change the amount of surface water flow available for diversion from Upper Klamath Lake and/or Keno

Reservoir to California water users in the USBR Klamath Irrigation Project, paragraph 1 on page 3-680:

The Lower Klamath Project has no obligation to apply the water stored in its reservoirs to meeting USBR's 2013 and 2019 BiOp requirements, and PacifiCorp has indicated that any future borrowing of water from Lower Klamath Project reservoirs would be predicated upon a definitive, rapid refill schedule, and compensation to PacifiCorp for the value of lost power generation due to reduced Lower Klamath Project reservoir capacity, both of which limit the benefit to USBR of borrowing water from the Lower Klamath Project. This places uncertainty as to whether the water-borrowing operation that ~~has~~ occurred in two years ~~since implementation of~~under the 2013 BiOp ~~will~~ would continue. Additional uncertainty comes from potential necessary changes to water rights to accommodate more than sporadic emergency use of the reservoirs for other than hydroelectric purposes. Despite the stated limitations of borrowing water from the Lower Klamath Project reservoirs, and the uncertainty of what, if any, permissions would be necessary to affect regular implementation of the operations, dam removal under the Proposed Project would preclude the potential option of utilizing the Lower Klamath Project reservoir water supply to help meet 2013 and 2019 BiOp flow requirements and thereby extend the available water supply to the USBR Klamath Irrigation Project.

Volume I Section 3.8.5 Water Supply/Water Rights – Potential Impacts and Mitigation – Potential Impact 3.8-2 Dam removal could change the amount of surface water flow available for diversion from Upper Klamath Lake and/or Keno Reservoir to California water users in the USBR Klamath Irrigation Project, paragraph 2 on page 3-680:

Despite this minor chance of a reduction, there would be no legal injury to the Klamath Irrigation Project users because the Lower Klamath Project operators are not required to temporarily supplement water deliveries, per the 2013 and 2019 BiOp flow requirements. Additionally, there is no indication that water would not be available for public health purposes, absent supplementation of Klamath Irrigation Project available water.

Volume I Section 3.8.5 Water Supply/Water Rights – Potential Impacts and Mitigation – Potential Impact 3.8-2 Dam removal could change the amount of surface water flow available for diversion from Upper Klamath Lake and/or Keno Reservoir to California water users in the USBR Klamath Irrigation Project, paragraph 2 on page 3-680:

The Tulelake Basin is designated a medium priority basin under the Sustainable Groundwater Management Act (SGMA), in part because of declining groundwater levels and high-volume groundwater extractions (DWR 2018~~4~~).

3.8.6 References

Volume I Section 3.8.6 Water Supply/Water Rights – References, pages 3-683 through 3-694, includes the following revisions:

DWR (Department of Water Resources). 2018~~4~~. Groundwater Monitoring Elevation Monitoring Basin Prioritization Process. June 2018~~4~~.

NMFS. 2019. Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat response for Klamath Project operations from April 1, 2019 through March 31, 2024. Technical memorandum. Prepared by NMFS, California Coastal Office for U.S. Bureau of Reclamation, Klamath Basin Area Office.

NMFS and USFWS (U. S. Fish and Wildlife Service). 2013. Biological opinions on the effects of proposed Klamath Project operations from May 31, 2013, through March 31, 2023, on five federally listed threatened and endangered species. Prepared by NMFS, Southwest Region, Northern California Office; and USFWS, Pacific Southwest Region, Klamath Falls Fish and Wildlife Office.

USFWS (U.S. Fish and Wildlife Service). 2019. Biological Opinion on the Effects of the Proposed Klamath Project Operations from April 1, 2019, through March 31, 2024, on the Lost River Sucker and the Shortnose Sucker. TAILS # 08EKLA00-2019-F-0068. Prepared by U.S. Fish and Wildlife Service, Southwest Region, Klamath Falls Fish and Wildlife Office.

Other references cited as part of text included in the Section 3.8 list of revisions

USBR. 2012. Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration. Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

3.9 Air Quality

This section was recirculated on December 21, 2019. Revisions to this section to address public comments can be found in Volume III Attachment 2.

3.10 Greenhouse Gas Emissions and Energy

This section was recirculated on December 21, 2019. Revisions to this section to address public comments can be found in Volume III Attachment 2.

3.11 Geology, Soils, and Mineral Resources

3.11.2 Environmental Setting

3.11.2.1 Regional Geology

Faulting and Seismicity

Volume I Section 3.11.2.1 – Geology, Soils, and Mineral Resources – Environmental Setting – Regional Geology – Faulting and Seismicity, paragraph 4 on page 3-736:

In California, the nearest active fault to the Lower Klamath Project is the Meiss Lake fault~~, which is ~~(part of the Cedar Mountain fault zone), located approximately five miles east of the Klamath River near the California-Oregon State line in Siskiyou County.

Volume I Section 3.11.2.1 – Geology, Soils, and Mineral Resources – Environmental Setting – Regional Geology – Faulting and Seismicity, Table 3.11-1 Earthquake and Fault Information on page 3-737:

Table 3.11-1. Earthquake and Fault Information.

Fault	Zoned by State of California [a]	Magnitude of Maximum Credible Earthquake (moment magnitude) [b]	Approximate Slip Rate (inches/year)	Approximate Recurrence Interval (years)
Meiss Lake fault (Cedar Mountain fault zone)	Yes	6.9	0.04 [c]	3,600[c]
Hat Creek–McArthur faults	Yes	7	0.06 [c]	Unknown, possibly 1,000 to 3,000 [c]
Gillem–Big Crack faults	No	6.6	0.04 [c]	Not available
Pittville fault	No	6.7	less than 0.03 [c]	Not available
Mayfield fault	No	6.5	0.03–0.19 [c]	A few thousand years [c]
Rocky Ledge fault	No	N/A	less than 0.03 [c]	Not available

3.11.2.4 Sediment Load

Volume I Section 3.11.2.4 – Geology, Soils, and Mineral Resources – Environmental Setting – Sediment Load, paragraph 2 on page 3-751:

USBR (2010b) used reach average hydraulic properties and grain size data from previous studies to estimate the flow magnitude and return period at which sediment mobilization occurs downstream of Iron Gate Dam. The representative particle diameters for all data collected downstream of Iron Gate Dam are given in Figure 3.11-5. The estimates did not include the reach from Iron Gate Dam to Bogus Creek, for which there were no grain size data. USBR (2010b) assumed this reach to be fully armored because reservoir trapping has eliminated coarse sediment supply to the reach during the past 50 years. Flows required to initiate mobilization of the median grain size (D_{50}), and for geomorphic reworking of the channel bed, in reaches downstream of Bogus Creek are summarized in Figure 3.11-6.

Volume I Section 3.11.2.4 – Geology, Soils, and Mineral Resources – Environmental Setting – Sediment Load, Figure 3.11-6. Flow and Corresponding Return Period at which Bed Mobilization Begins Under Existing Conditions (USBR 2012) on page 3-753:

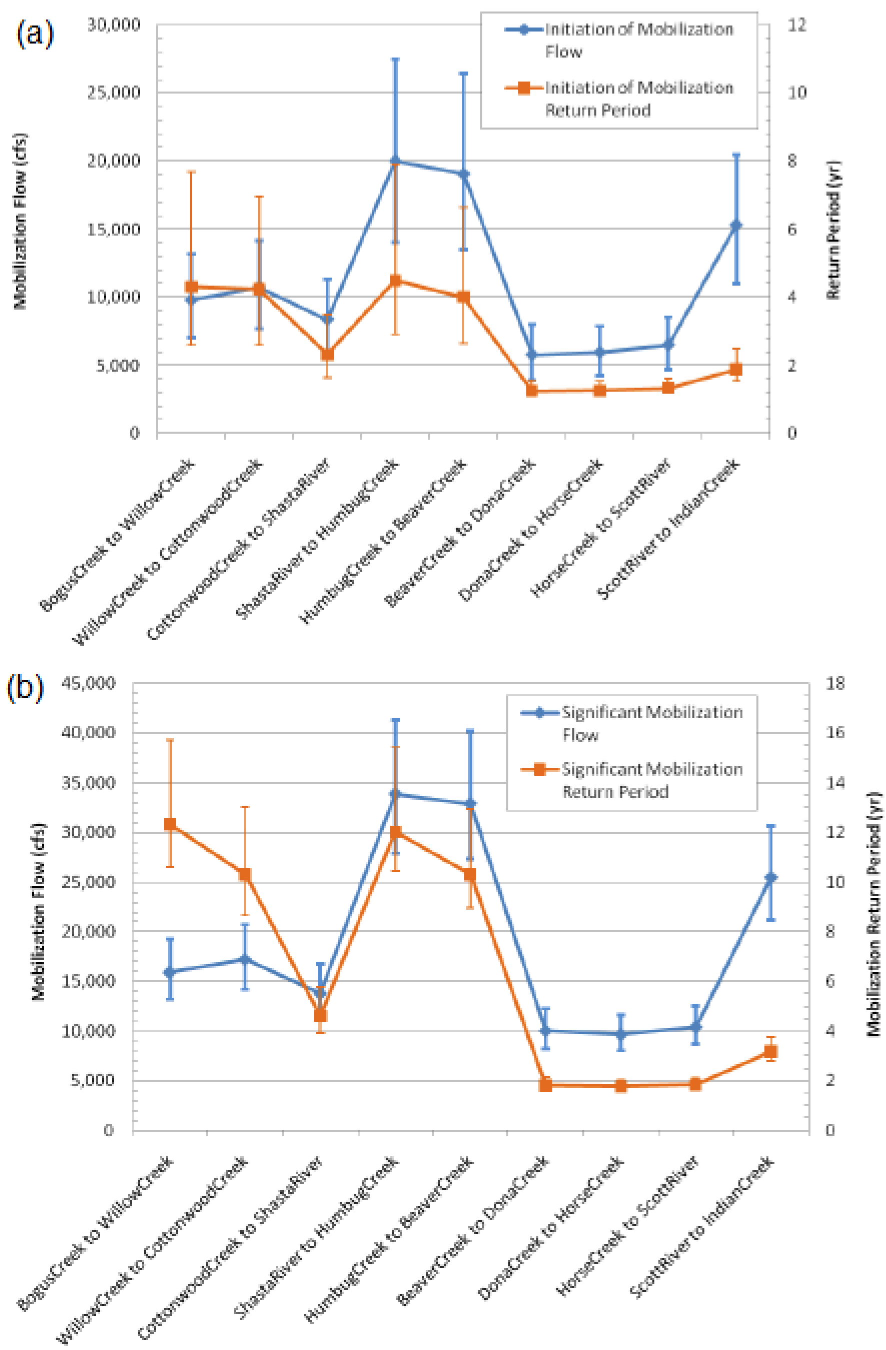

Figure 3.11-6. (a) Flow and Corresponding Return Period at which Bed Mobilization Begins Downstream of Iron Gate Dam Under Existing Conditions (USBR 2012). (b) Flow and Corresponding Return Period at which Significant Bed Material Mobilization Occurs Downstream of Iron Gate Dam Under Existing Conditions (USBR 2012). ~~Flow and Corresponding Return Period at which Bed Mobilization Begins Downstream of Iron Gate Dam Under Existing Conditions (USBR 2012).~~

3.11.3 Significance Criteria

Volume I Section 3.11.3 – Geology, Soils, and Mineral Resources – Significance Criteria, paragraphs 1 and 2 on page 3-759:

For the Lower Klamath Project EIR, impacts to geology and soils would be considered significant if Proposed Project implementation would result in any of the following:

- Substantial soil erosion from upland areas into the reservoirs or the Klamath River due to project construction activities.
- New or exacerbated mass wasting around the rim of the reservoirs during drawdown.
- Substantial deposition of sediment in the Klamath River channel or Klamath estuary due to erosion of reservoir sediment deposits, where substantial is defined as a considerable amount of sediment that would not be redistributed by high flow events that occur in the long-term.
- Long-term removal of access to mineral resources for extraction.
- Exposure of people or structures to adverse effects resulting from rupture of a known earthquake fault, strong seismic ground shaking, volcanic activity, or large-scale slope instability.

Unless otherwise specified, ~~For the purposes of this EIR,~~ substantial is defined as "of considerable importance to public health and safety, water quality, and/or physical conditions supporting aquatic resources as these resources pertain to geology and soils." ~~Additional criteria related to geology and soils associated effect to other resources is addressed in Section 3.2 *Water Quality*, Section 3.3 *Aquatic Resources*, and Section 3.6 *Flood Hydrology* of this EIR.~~

3.11.4 Impacts Analysis Approach

3.11.4.1 Flows

Volume I Section 3.11.4.1 Geology Soils and Mineral Resources – Impacts Analysis Approach – Flows, paragraph 2 on page 3-760:

Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* provides a summary of flow conditions relevant to the Proposed Project. Because the flow modeling used for this EIR dates back to the 2012 KHSA EIS/EIR, the modeling used NMFS 2010 Biological Opinion flows (2010 BiOp Flows) for the analysis of the scenario where dams would remain in place, and modified 2010 BiOp Flows based on KBRA operations criteria for the Klamath Irrigation Project (KBRA Flows) for the analysis of the scenario where dams would be removed (USBR and CDFG 2012). At the time of the 2018 Draft EIR, the KBRA Flows had expired and hydrology was analyzed~~Flows under the Proposed Project were modeled assuming Klamath River hydrology defined by KBRA operations of the Klamath Irrigation Project (USBR 2012). As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed*~~

~~*Project*, the KBRA has expired, and hydrology under the Proposed Project would be~~ pursuant to the 2013 Biological Opinion (2013 BiOp) (NMFS and USFWS 2013). ~~As detailed in Section 3.1.6, I~~ 2013 BiOp Flows were found to provide~~s~~ similar flow releases to KBRA, and did~~oes~~ not alter the key hydrological factors that drive model results.~~, including timing, frequency, and magnitude of flows released during winter and spring.~~ The range of 2013 BiOp Flows was found to be within the range of modeled KBRA Flows approximately 99.9 percent of the time at Keno and Iron Gate dams; therefore, the hydrologic (flow and sediment transport) model (USBR 2012) developed for the 2012 KHSA EIS/EIR was still applicable. In addition to the analyses of 2013 BiOp Flows, at the time of the 2018 Draft EIR, 2017 court-ordered flushing and emergency dilution flow requirements (U.S. District Court 2017) were analyzed as part of the cumulative effects and alternatives analyses, separate from the primary resource area analyses.

After the issuance of the 2018 Draft EIR, the applicable biological opinion and the operational flow requirements for the Klamath River changed again because new biological opinions were issued by NMFS (2019) and USFWS (2019). 2019 Biological Opinion flows (2019 BiOp Flows) are now the current operational flow requirement for the Klamath River, superseding all the flow conditions mentioned above, and provide a second CEQA baseline for the EIR analyses. As summarized in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, the 2019 BiOp Flows were compared to the previously modeled KBRA Flows to determine whether 2019 BiOp Flows would be sufficiently similar such that hydrologic model outputs developed for the 2012 KHSA EIS/EIR would still be applicable. The range of 2019 BiOp Flows is within the range of modeled KBRA Flows approximately 99.0 percent of the time at Keno Dam and approximately 99.9 percent of the time at Iron Gate Dam, and the previously modeled results are sufficiently representative of the range of flow conditions under the 2019 BiOp Flows. The sediment transport model (USBR 2012) developed for the 2012 KHSA EIS/EIR would produce nearly identical results during the main drawdown period between January and May if it was run using 2013 BiOp Flows or 2019 BiOp Flows, because flows are similar for all water year types. Therefore, the sediment transport analysis provided below is not modified from the Draft EIR in relation to anticipated future flow conditions and continues to be applicable to the Proposed Project considering both the original and current water flow baselines. Please refer to Sections 3.1.6.3 *Klamath River Flows under the 2019 BiOp Operations Criteria for the Klamath Irrigation Project* and Section 3.1.6.4 *Comparison of Klamath River Flows under the 2019 BiOp Operational Criteria and the KBRA Operations Criteria* for further details regarding the details of, and similarities between, the applicable flows.

3.11.4.2 Suspended Sediment

Volume I Section 3.11.4.2 – Geology, Soils, and Mineral Resources – Impacts Analysis Approach – Suspended Sediment, paragraph 3 on page 3-760:

USBR (2012) analyzed the potential effects of the Proposed Project on suspended sediment concentration (SSC) using output from the One Dimension Version (2.4) of the Sedimentation and River Hydraulics sediment transport model (SRH-1D). Using the SRH-1D model, 48 two-year simulations (1961-2008) focused on reservoir erosion and suspended sediment load. SRH-1D provided estimates of daily average SSCs at different points in the river under the No Project Alternative and dam removal conditions (Huang and Greimann 2010, as summarized in USBR 2012) (see also Appendix E of this EIR and ~~). Existing conditions were also simulated using the SRH-1D model, to provide a comparison of what SSCs would be under existing conditions or under the Proposed Project in the years 2020 and 2021(see~~ Section 3.2.4.2 *[Water Quality] Suspended Sediments* for more details). ~~Modeling assumed the Proposed Project occurred within the 48-year period beginning in 1961.~~

3.11.4.3 Bedload Sediment

Volume I Section 3.11.4.3 – Geology, Soils, and Mineral Resources – Impacts Analysis Approach – Bedload Sediment, paragraph 4 on page 3-760:

USBR (2012) also analyzed potential changes to ~~river~~channel bed elevation and grain size ~~bedload sediment~~ using output from the ~~the~~SRH-1D model (Huang and Greimann 2010, USBR 2012) (see also Appendix F of this EIR). Information on the data and parameters input to the SRH-1D model ~~is included~~are described in USBR (2012, pages 9-4 to 9-5). The sediment load inputs to the SRH-1D model are also described in USBR (2012, pages 5-4 to 5-11), with additional information on tributary sediment loads provided in Stillwater Sciences (2010). Both the 48 two-year simulations (1961-2008) and three 50-year simulations conducted using the SRH-1D model were used to analyze fine and coarse sediment deposition on the channel ~~river~~bed, although the 50-year simulations were the focus of the analysis of long-term channel evolution (USBR 2012). ~~Short term (2 year) and long term (5, 10, 25, 50 year)~~ C~~c~~hanges in bed elevation ~~load~~ were evaluated for a range of hydrologic conditions using representative 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 short-term bedload sediment conditions (i.e., at the end of 2 ~~-~~years) are representative of long-term bedload sediment conditions (USBR 2012).

3.11.5 Potential Impacts and Mitigation

Volume I Section 3.11.5 Geology, Soils, and Mineral Resources – Potential Impacts and Mitigation – Potential Impact 3.11-3 Reservoir drawdown could result in hillslope instability in reservoir rim areas, pages 3-762 through 3-763:

Potential Impact 3.11-3 Reservoir drawdown could result in hillslope instability in reservoir rim areas.

The KRRC proposes drawdown of J.C. Boyle, Copco No. 1, and Iron Gate reservoirs would take place between November 1 of dam removal year 1 and

March 15 of dam removal year 2 as detailed in the proposed Reservoir Drawdown and Diversion Plan (Appendix B: *Definite Plan*). For all reservoirs, the minimum drawdown rate would be 2 feet per day and the maximum drawdown rate would be 5 feet per day, until drained. Although the new gates at Copco No. 1 and Iron Gate dams would be able to accommodate higher drawdown rates, the maximum drawdown rate of 5 feet per day is recommended by KRRC as a conservative value based upon slope stability analyses conducted for each of the Lower Klamath Project reservoirs.

The area surrounding J.C. Boyle Reservoir is generally low gradient and underlain by competent materials. Review of topographic data and reconnaissance of the reservoir slopes indicate that no landslides occur adjacent to the reservoir. For these reasons, the stability of the J.C. Boyle Reservoir slopes would be unaffected by the reservoir drawdown and there would be no impact due to the Proposed Project.

No large-scale landslides have been identified in the terrestrial or subaqueous slopes around Copco No. 1 Reservoir. Diatomaceous deposits and associated fluvio-lacustrine terrace deposits along the rim and below the reservoir water level present the greatest potential for slope instability during drawdown (Appendix B: *Definite Plan*). Where the toe of the diatomite deposit lies above the current high lake level, slope response to rapid drawdown is determined by the properties and geometry of the underlying volcanic and volcaniclastic strata. Where the toe of the diatomite deposit lies below the current high lake level, slope response to rapid reservoir drawdown is determined by the properties and thickness of the diatomite deposits and the underlying material. Based on the low diatomite permeability, the proposed drawdown rate (2 to 5 feet per day) would have minimal effect on its stability. KRRC is therefore not proposing to limit the drawdown rate of Copco No. 1 Reservoir beyond that proposed.

The geologic assessment and slope stability analysis conducted by KRRC (Appendix B: *Definite Plan – Appendix E*) indicated that certain segments ~~along the~~around Copco No. 1 Reservoir ~~rim~~ have a potential for slope failure that could impact existing roads and/or private property (Figure 3.11-10). These areas include approximately ~~3,700~~1,780 linear feet ~~of slopes along Copco Road and approximately 2,800 linear feet of slope adjacent to private property (Appendix B: *Definite Plan*)~~of shore-parallel length with potential for failures to impact existing structures outside the reservoir rim, including approximately 430 linear feet of slopes along Copco Road (north shore segment N11a) and approximately 1,350 linear feet of slope adjacent to private property (south shore segments S5, S11a, and S12b). ~~Up to eight~~Twelve parcels and four habitable structures in these potentially unstable areas could potentially be impacted by slope failure. An additional five parcels and four habitable structures may experience damage and/or deformation due to nearby slope failure. ~~KRRC has proposed to complete additional field geologic investigation and laboratory testing of material properties to better understand the potential for slope instability in these areas.~~

As part of the Proposed Project, KRRC would consider the following actions to minimize, remediate, or offset potential impacts in reservoir rim areas where there is a high probability of slope failure (Appendix B: *Definite Plan – Appendix E [Amended 2019],* pages 48-49):

1. Additional testing and analyses to provide a satisfactory level of safety, such as permeability testing or deformation analyses.
2. Along the south shore where habitable structures may be impacted, temporary relocation of residents and monitoring until it is safe for residents to return, as well as property purchase or repairs if there is permanent deformation or damage to structures.
3. Stabilization with retaining wall(s) designed to meet the required factor of safety.
4. Stabilization with buttress(es) at the toe or the slope(s).
5. For the north shore segment along Copco Road, rerouting the road to a stable area.

~~1. For segments along Copco Road:~~

   ~~a. Re-align road segment away from rim slope~~

   ~~b. Engineer structural slope improvements (e.g., drilled shafts or other structural elements that could be installed to resist slope movement)~~

~~2. For segments adjacent to property or structure:~~

   ~~a. Move structure or purchase property~~

   ~~b. Engineer structural slope improvements (e.g., drilled shafts or other structural elements that could be installed to resist slope movement)~~

While the KRRC proposed actions in the Definite Plan are ~~the proposed actions is~~ designed to reduce potential impacts ~~the potential for new or exacerbated mass wasting around the rim of the reservoirs~~ associated with slope instability as a result of reservoir drawdown, the proposed actions do not explicitly address potential impacts resulting from hillslope instability outside of those areas currently identified as having a high probability of slope failure or commit KRRC to implementation of their aforementioned proposed actions. Therefore, the impact of the project on properties, structures, and Copco Road from hillslope instability in reservoir rim areas would be significant.

Subsequent to the Definite Plan, the KRRC agreed to implement actions (Mitigation Measure GEO-1, below) to reduce potential impacts to people, structures/public facilities, water quality, and/or volitional fish passage associated with slope instability as a result of reservoir drawdown. Implementation of Mitigation Measure GEO-1 would reduce the impact of slope failure in reservoir areas to less than significant. If instability ~~of these deposits~~ exposes cultural resources, then the impact may be significant and mitigation may be required (see Volume III Attachment 1 Section 3.12.5 *[Historical Resources and Tribal Cultural Resources] Potential Impacts and Mitigation*).

The extent and morphology of bedrock outcrops and general lack of surficial deposits around Iron Gate Reservoir suggest stable reservoir slopes under rapid drawdown conditions (Appendix B: *Definite Plan*). There may be potential for drawdown to induce block sliding where hard, strong volcanic flow rocks are underlain by saturated tuffaceous beds and bedding dips into the valley (PanGEO 2008). Hammond (1983) reports several low to moderate dip angles of volcaniclastic beds into the valley, but there is no evidence of previous slope instability at these locations. Historical aerial photographs indicate that the three possible old landslide-related features that occur on the south rim of Iron Gate Reservoir have been stable and unaffected by historical reservoir drawdowns and have a low risk of instability during future drawdown (Appendix B: *Definite Plan*). Shallower slides are likely to occur in the shallow surficial deposits around the reservoir rim and on the reservoir slopes that are currently below the reservoir surface (Appendix B: *Definite Plan*). Small, shallow soil failures in the more deeply weathered volcaniclastic beds and in colluvial deposits present a minor hazard to Copco Road where the road is immediately adjacent to the shore (Appendix B: *Definite Plan*). These slope failures are likely to be shallow and local and therefore, if they were to occur, would constitute a less than significant impact.

Volume I Section 3.11.5 Geology, Soils, and Mineral Resources – Potential Impacts and Mitigation – Potential Impact 3.11-3 Reservoir drawdown could result in hillslope instability in reservoir rim areas – updated Figure 3.11-10 on page 3-764:

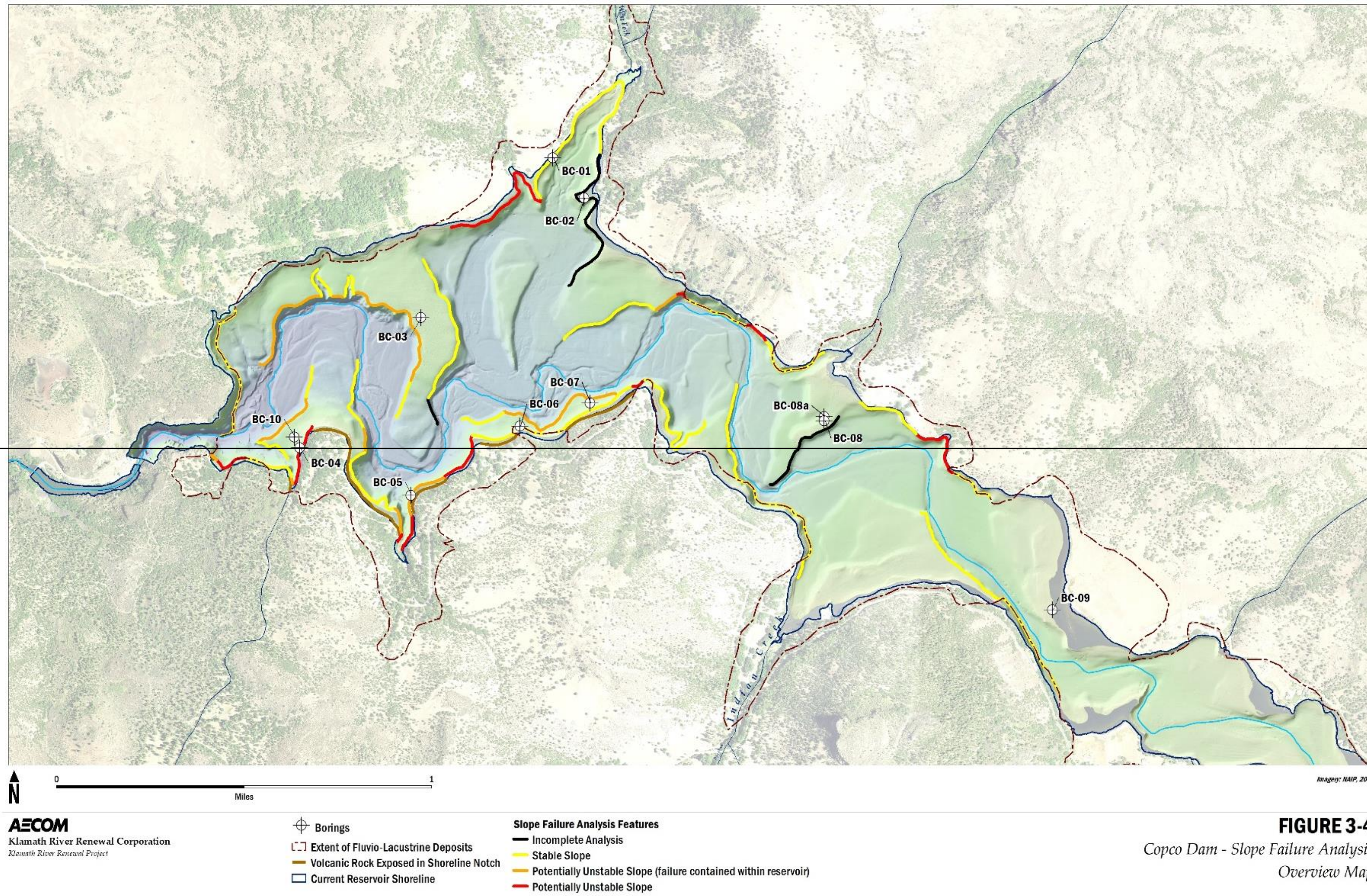

FIGURE 3-4
Copco Dam - Slope Failure Analysis
Overview Map

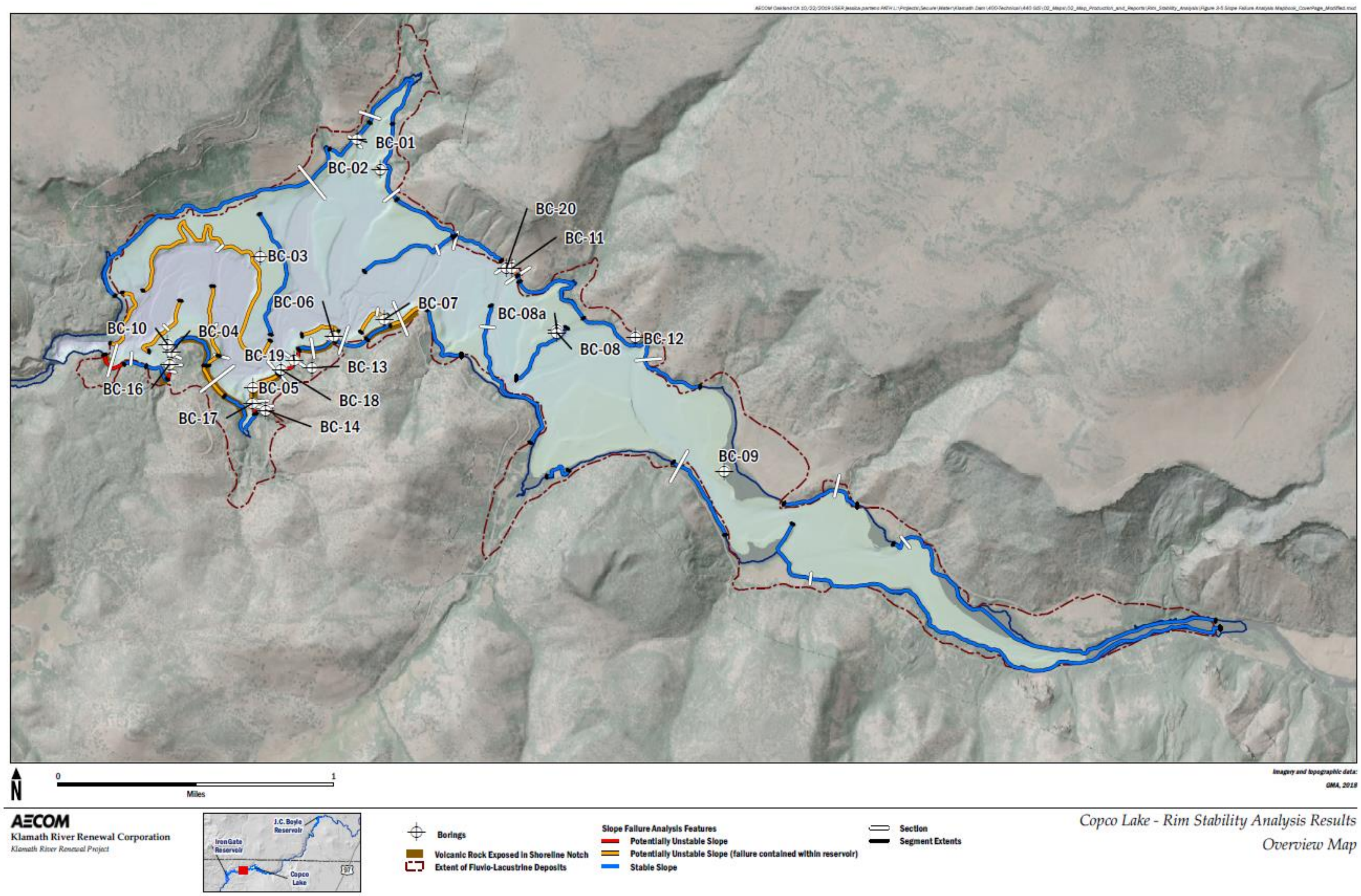

Figure 3.11-10. Results of slope failure analysis at Copco No. 1 Reservoir (Appendix B: *Definite Plan*).

Mitigation Measure GEO-1 – Slope Stabilization.
Prior to the start of reservoir drawdown, KRRC shall offer to temporarily relocate or otherwise assist residents who reside on potentially unstable slopes on the south shore of Copco Lake, and residents on the north shore of Copco Lake whose residences may be affected by slope failures during the drawdown of the reservoir, if testing and analysis undertaken by KRRC indicates that potential slope failures and/or structural impacts related to Project activities could occur in these locations. Potentially unstable slopes currently include those listed in Appendix B: *Definite Plan – Appendix E* (2018). Prior to reservoir drawdown, KRRC shall reroute or take other appropriate action to maintain safe conditions on Copco Road (currently includes the potential areas listed in Appendix B: *Definite Plan – Appendix E* (Amended 2019) if testing and analysis undertaken by KRRC indicates that potential slope failures related to Project activities could affect the road.

KRRC will ~~visually~~ monitor ~~large,~~ potentially unstable areas ~~within~~along the Copco No. 1 Reservoir ~~footprint~~rim for the duration of reservoir drawdown and for two weeks ~~following drawdown~~, or longer if KRRC determines that a longer monitoring period is prudent, after the drawdown is complete. Monitoring may include inclinometers, surveys, vibrating wire piezometers, and visual inspections. Depending on the location, monitoring may involve tribal monitors (see also Mitigation Measures TCR-1, TCR-2, and TCR-3). If slope failure related to Project activities is observed, an exclusion zone will be established around the unstable area and the KRRC will monitor the unstable area.

~~Following~~Throughout drawdown activities, and ~~once~~when the areas are safe to inspect, the KRRC shall inspect any Project-related slope failures that occurred during and following drawdown, and implement slope stabilization measures, as appropriate. For any ~~large~~ slope failure related to Project activities that occurs during drawdown or the year following drawdown and that adversely impacts a structure or public facility or impacts or has a material potential to impact water quality or volitional fish passage, KRRC will ~~offset potential impacts by implementing~~fund or implement the following actions:

1. By agreement with the property owner, repair or ~~M~~move affected structures and/or purchase affected property~~,~~; or
2. Repair and/or ~~R~~re-align affected road segments~~,~~; or
3. Regrade and/or ~~E~~engineer structural slope improvements (e.g., retaining walls, buttresses, drilled shafts or other structural elements that could be installed to resist slope movement)~~,~~; and
4. Revegetate affected areas to the extent revegetation is feasible and appropriate.

Volume I Section 3.11.5 Geology, Soils, and Mineral Resources – Potential Impacts and Mitigation – Potential Impact 3.11-5 Reservoir drawdown could result in substantial short-term sediment deposition in the Klamath River downstream of Iron Gate Dam due to erosion of reservoir sediment deposits and a long-term change in sediment supply and transport due to dam removal, pages 3-765 through 3-775:

Potential Impact 3.11-5 Reservoir drawdown could result in substantial short-term sediment deposition in the Klamath River downstream of Iron Gate Dam due to erosion of reservoir sediment deposits and a long-term change in sediment supply and transport due to dam removal.
Based on average annual sediment deposition rates, approximately 15.1 million yd^3 (4.16 million tons) of sediment would be deposited behind the dams by 2020 (USBR 2012) (Table 3.11-6). Since submitting the original application, KRRC has revised its projection for the year of primary drawdown to be 2022, rather than 2020. Between 2020 and 2022~~1~~ (i.e., ~~revised~~ dam removal year 2 when drawdown would primarily occur), the sediment volume present behind the dams would increase by approximately 162,600~~81,300~~ cubic yards in Copco No. 1 Reservoir (1.97 percent increase) and approximately 2~~1~~00,000 cubic yards in Iron Gate Reservoir (3.51~~%~~ percent increase) based on estimates of annual sedimentation rates for each reservoir (USBR 2012). The percent increase in the total reservoir sediment volume between 2020 and 2022~~, when drawdown is now anticipated,~~ would be less than five percent. The increase in sediment volume between 2020 and 2022~~1~~ would be an order of magnitude less than the total uncertainty of the 2020 total sediment volume estimates and the annual sediment deposition rates (i.e.,~~,which is~~ approximately 2,000,000 ~~1,984,943~~ cubic yards for Copco No. 1 and Iron Gate reservoirs).~~and the percent increase in the total reservoir sediment volume would be less than 5 percentso~~ Therefore, model results using the 2020 sediment volumes would still be representative of, and applicable to, the Proposed Project.

Table 3.11-6. Estimated Amount of Sediment in the Lower Klamath Project Reservoirs in 2020 (Source: USBR 2012).

Reservoir	Estimated 2020 Total			
	Total Volume (yd^3)	Total Sediment (tons)[1]	Fine Sediment[2] (tons)	Sand[3] (tons)
J.C. Boyle	1,190,000	340,000	220,000	120,000
Copco No. 1	8,250,000	2,090,000	1,800,000	290,000
Iron Gate	5,690,000	1,730,000	1,460,000	280,000
Total[4]	**15,130,000**	**4,160,000**	**3,480,000**	**680,000**
Total Copco No. 1 and Iron Gate	**13,940,000**	**3,820,000**	**3,260,000**	**560,000**

[1] Ton is defined as equal to 2,000 pounds (dry weight).
[2] Fine sediment is sediment with a diameter less than 0.063 millimeters.
[3] Sand is sediment with a diameter between 0.063 and 2 millimeters.
[4] Sediment volumes and weights from individual reservoirs from USBR (2012) were rounded to the nearest $10{,}000^{th}$ unit. Copco No. 2 Reservoir does not retain measurable amounts of sediment and therefore is not included in the estimates of total stored sediment.

Reservoir sediment consists primarily of silts and clays that would be easily eroded during drawdown. Approximately 36 to 57 percent of the total sediment stored in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs by dam removal year 2 ~~2021~~ would be eroded and transported downstream during the drawdown period and the year following dam removal (i.e., short-term), or an estimated 5.4 to 8.6 million yd^3 (1.2 to 2.3 million tons) (Table 3.11-7, Figure 3.11-11). Approximately 15 percent of this sediment eroded from reservoir areas during the first year following dam removal would be transported farther downstream as bedload.

The rate of reservoir drawdown would affect the amount of erosion of the sediment deposit. A faster drawdown rate would reduce the time of interaction between the flow and reservoir sediment deposits, thus reducing the overall amount of sediment erosion, whereas a slower drawdown rate would increase the time of interaction between the flow and reservoir sediment deposits, thus increasing the overall amount of sediment erosion. It is expected that increasing the previously modeled maximum drawdown rate of 2.25 to 3 feet per day (USBR 2012~~b~~) to the Proposed Project maximum drawdown rate of 5 feet per day (Appendix B: *Definite Plan – Appendix P*) would slightly decrease the total amount of sediment erosion that occurs during drawdown. The previously modeled maximum drawdown rate would result in erosion of 36 to 57 percent of the reservoir sediment deposits (Table 2.7-11). Increasing the drawdown rate to 5 feet per day would most likely result in less erosion than previously modeled.

Erosion and transport of sediment deposits within Copco No. 1 and Iron Gate reservoirs during drawdown would be assisted by using barge-mounted pressure sprayers to jet water onto newly exposed reservoir sediment deposits as the water level drops (a process referred to as sediment jetting). Sediment jetting would maximize erosion of reservoir sediment deposits in historical floodplain areas (especially the historical two-year floodplain) during drawdown and minimize the potential for future erosion of reservoir sediment deposits after the drawdown period. Additionally, removal of reservoir sediment deposits with sediment jetting would promote riparian bank and floodplain connectivity by increasing river inundation on the historical floodplain during high flow events and minimize manual excavation and grading of sediments from proposed restoration sites after completing drawdown. Sediment jetting would be focused in the six areas where restoration actions are proposed within the Copco No. 1 Reservoir footprint (see enumerated areas for wetlands, floodplains, and off-channel habitat features, and associated yellow triangles depicting areas of tributary connectivity, in Figure 2.7-11~~9~~) and the three areas where restoration actions are proposed within the Iron Gate Reservoir footprint (see enumerated areas for wetlands, floodplains, and off-channel habitat features, and associated yellow triangles depicting areas of tributary connectivity, in Figure 2.7-12~~100~~).

While the anticipated amount of sediment that will be eroded varies by reservoir, approximately 36 to 57 percent (5.4 to 8.6 million yd^3 [1.2 to 2.3 million tons]) of the total dam removal year 2~~2020~~ reservoir sediment volume is expected to erode and be transported downstream during the drawdown period (Table 2.7-1). Large quantities of sediment would remain in place after dam removal in each of the former reservoirs, primarily in areas above the active channel. The remaining sediments would consolidate (dry out and decrease in thickness). Studies of the existing sediments in J.C. Boyle Reservoir show an anticipated change in sediment depth of up to 61 percent of original depth (USBR 2010b; USBR 2012b~~a~~). A higher degree of shrinkage of the sediment layers is expected in Copco No. 1 and Iron Gate reservoirs due to the increased organic matter content in these sediment deposits.

The range in the estimated volume of sediment eroded from each reservoir is primarily dependent upon whether the prevailing hydrology during reservoir drawdown corresponds to a dry hydrologic year or a wet hydrologic year. The majority of the erosion would occur during the reservoir drawdown process and would be a combination of direct erosion of sediment by moving water, slumping of the fine sediment along the reservoir sides toward the river, and sediment jetting of some areas of reservoir-deposited sediments during drawdown. In a dry hydrologic year, reservoir pool levels can be drawn down steadily and relatively quickly, resulting in a shorter period of interaction between the flow and sediment deposits, and thus less overall sediment erosion. In a wet hydrologic year, the reservoir pool may experience cycles of drawdown followed by periods of refilling during high flow events, resulting in longer period of interaction between the flow and the sediment deposits, and thus more overall sediment erosion.

Table 3.11-7. Estimated Amount of Sediment Erodible with Dam Removal (Source: USBR 2012).

Reservoir	Percent Erosion[1]		Fine Sediment Erosion		Sand Erosion	
	Minimum Erosion (percent)	**Maximum Erosion (percent)**	**Minimum (tons)**	**Maximum (tons)**	**Minimum (tons)**	**Maximum (tons)**
J.C. Boyle	27	51	60,000	110,000	30,000	60,000
Copco No. 1	45	76	820,000	1,370,000	130,000	220,000
Iron Gate	24	32	350,000	460,000	70,000	90,000
Total	36	57	1,230,000	1,950,000	230,000	370,000
Total Copco No. 1 and Iron Gate	36	56	1,170,000	1,830,000	200,000	300,000

[1] The erosion rates are based on hydrologic conditions recorded for the March to June flow volume at Keno gage on the Klamath River from water year 2001 (90 percent exceedance) and 1984 (10 percent exceedance). Erosion would primarily occur during the drawdown period. Additional erosion and sediment transport could occur in the following year that would be indistinguishable from the background sediment regime.

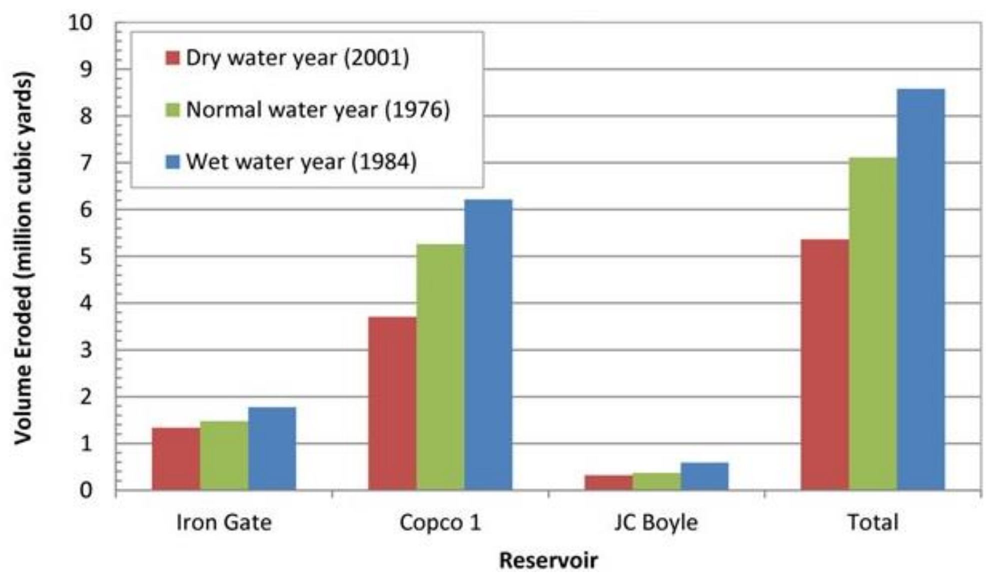

Figure 3.11-11. Volume of Sediment Eroded from Reservoirs in the Hydroelectric Reach During 2020 Drawdown, Beginning in January (USBR 2012, page 9-34).

Model simulations indicate that 43 percent to 64 percent of the sediment stored in the reservoirs would remain in place following the year after dam removal (i.e., long-term), primarily as a relatively thin wedge in areas above the active channel. The remaining sediment would consolidate (i.e., harden, dry, shrink in volume, and decrease in thickness) following reservoir drawdown (USBR 2012). Studies of the existing sediment in Lower Klamath Project reservoirs indicate an anticipated change in sediment thickness in J.C. Boyle Reservoir of up to 61 percent due to consolidation (USBR 2012). A higher degree of shrinkage of the sediment layers is expected for Copco No. 1 and Iron Gate reservoirs due to the increased organic matter content in the sediment deposits contained within these reservoirs. Sediment deposits remaining in the reservoir footprints following reservoir drawdown would erode slowly, or potentially not at all due to consolidation. Secondary erosion of residual reservoir deposits would be affected by increases in shear strength with desiccation, the prevalence of cracks, and disintegration in response to wetting and drying cycles. The prevalence of cracking would encourage gully erosion as lower infiltration rates intensify surface runoff and concentrate flow in cracks. Gullies would incise and widen with time. The availability of coarse sediment (i.e., sand and larger) to abrade fine-grained deposits may be an important factor encouraging gully erosion. Gullies closer to coarse sediment sources (e.g., near the steep hillslopes at Copco No. 1 and Iron Gate reservoirs) may have more effective secondary erosion than areas lacking those sediment sources (e.g., Upstream Reach of J.C. Boyle Reservoir) (Appendix B: *Definite Plan* – Appendix H *Reservoir Area Management Plan*, page 131). As riverine conditions return within the reservoir footprints, any additional erosion and transport of reservoir sediment farther downstream would be indistinguishable from background rates within the watershed. Overall, this degree of long-term erosion would be a less than significant impact. Future construction activities (e.g., access road construction, recreation facilities) would need to consider the potential instability and erodibility of sediment remaining within the reservoir footprints.

~~Anticipated erosion volume due to dam removal into the context of annual basin-wide sediment discharge are estimated to average an annual total sediment supply from the Klamath River to the Pacific Ocean of approximately 5.8 million tons (4 million tons/yr of fine sediment and 1.8 million tons/yr of sand and larger sediment (Stillwater Sciences (2010). Farnsworth and Warrick (2007) estimate that the average annual silt and clay discharge is 1.2 million tons/yr.~~ The total average annual sediment supply to the Klamath River is estimated to be approximately 6.2 million tons (4.2 million tons/yr of fine sediment and 2.0 million tons/yr of sand and larger sediment) (modified from Stillwater Sciences [2010]). Farnsworth and Warrick (2007) estimate that the average annual yield of silt and clay size sediment to the Pacific Ocean is approximately 1.2 million tons/yr. The considerable uncertainty in these average annual ~~average sediment load~~ estimates of supply and yield is related to channel and floodplain sediment storage, the different approaches to estimation, lack of established relationship between flow and SSC, ~~the lack of a unique relationship between flow and SSC,~~

the large variation in ~~the~~ measurement of SSCs, and the large annual variation in sediment loads between different water year types. In dry years the supply of sediment to the ocean could be less than 1 million tons/yr (Figure 3.11-12). Given these estimates, it is expected that the amount of sediment released during the year of drawdown and dam removal would be similar to that transported by the Klamath River to the Pacific Ocean in a year with average flow, much less than that transported by the Klamath River in a wet year, and greater than that transported by the Klamath River in a dry year.

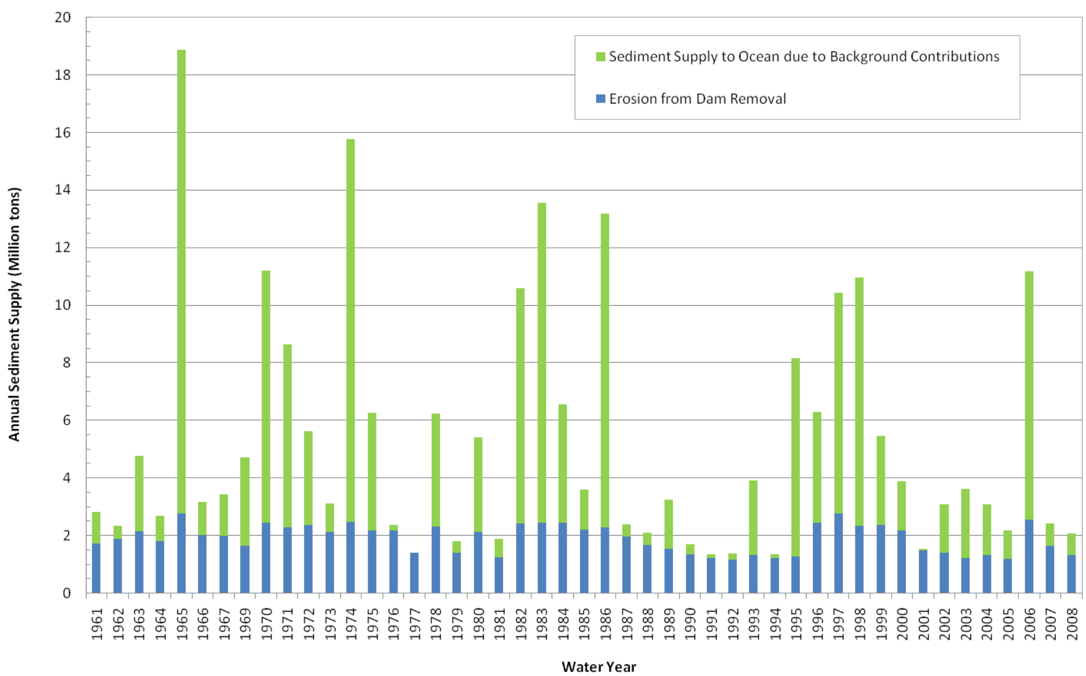

Figure 3.11-12. Annual Predicted Sediment Delivery to the Pacific Ocean under the Proposed Project and Existing Conditions ("Background Contributions") by Water Year. Model results are only valid for the year of dam removal, and no significant increase in sediment loads is predicted in years following dam removal (Source: USBR 2012, page 9-27).

Channel Response in the Hydroelectric Reach

SRH-1D modeling results indicate channel bed elevations would decrease and median channel substrate size would increase within the reservoir reaches during drawdown (January to May of the drawdown year) (Figure 3.11-13, Figure 3.11-14). The proportion of fine sediment would decrease to near zero within two months after drawdown; the proportion of sand would initially increase to 30 to 50 percent then decrease to 10 to 25 percent; the proportion of gravel would change (mostly increase) to 20 to 35 percent; and the proportion of cobble would increase to 50 to 70 percent. The estimated changes depend 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 (USBR 2012). After dam removal, channels currently inundated by reservoirs would likely vary from narrow, single-threaded to wide and sinuous with the potential to form complex features, such as meander cut-offs and vegetated islands (USBR 2012).

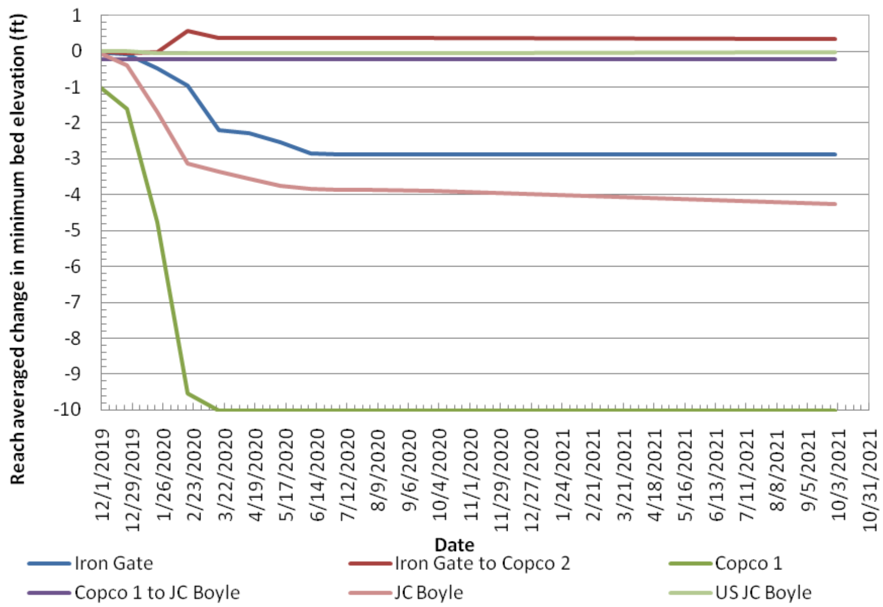

Figure 3.11-13. Reach-Averaged Erosion in the Hydroelectric Reach during a Representative Wet Water Year (USBR 2012, page 9-35).

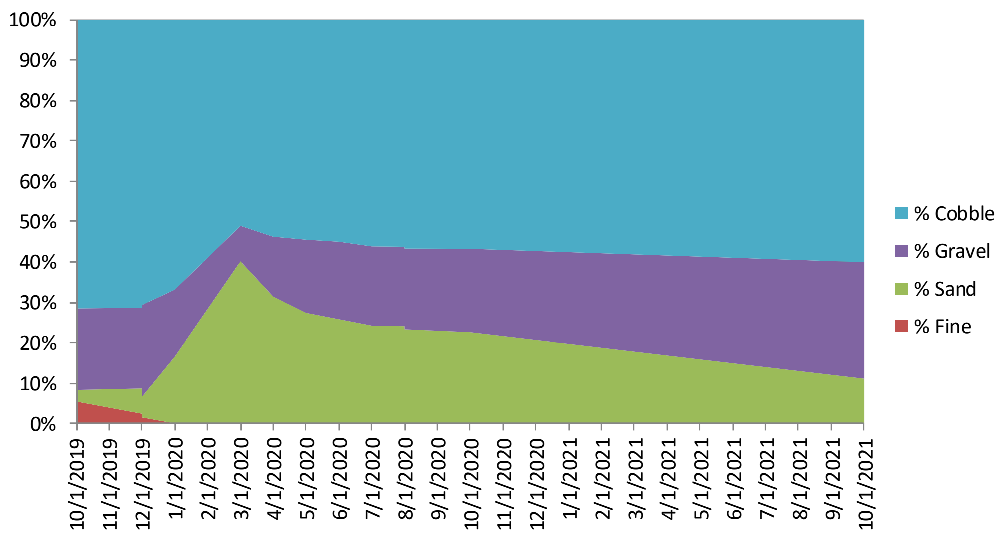

Figure 3.11-14. Simulated Bed Composition from Copco No. 2 to Iron Gate Reservoirs during Two Successive Representative Dry Water Years During and After Drawdown (Based on simulation results provided by USBR ~~, March~~ 2012).

The river reaches upstream of J.C. Boyle Reservoir and from Copco No. 1 Reservoir to J.C. Boyle Dam would experience little change in bed composition or median substrate size during drawdown (USBR 2012). Currently, these reaches are predominantly cobble (90 percent) with small fractions of gravel and sand. Modeling of the Copco No. 2 Dam to Iron Gate Reservoir reach shows decreases in the combined proportion of sand and fines, with the dry simulations showing decreases to approximately 35 percent of sand and fines two years after drawdown.

Channel Response in the Klamath River Downstream of Iron Gate Dam

The short-term (i.e., two years following dam removal) effects of the Proposed Project on dam-released sediment and sediment resupply would likely extend from Iron Gate Dam to approximately Cottonwood Creek (USBR 2012). Because approximately 85 percent of the sediment stored within the reservoirs is fine (silt and clay), most sediment eroded from the reservoirs would be fine. Fine sediment transport rates would increase downstream of Iron Gate Dam during the short-term, but a large portion of this fine sediment would be transported to the ocean as suspended sediment shortly after being eroded (Stillwater Sciences 2008; Stillwater Sciences 2010;~~,~~ USBR 2012). Coarse sediment (i.e., sand and larger) transport would occur more slowly depending on the frequency and magnitude of mobilization flows and attenuation by channel storage.

Short-term (2-year) SRH-1D model simulations –focused on reservoir sediment erosion and fine sediment load in the Klamath River following drawdown -indicate up to about 0.9 feet of reach-averaged sediment deposition between Bogus Creek and Willow Creek (RM 188.0) (Figure 3.11-15), although conservative long-term (50-year) simulations focused on channel bed elevation change indicate that fine and coarse sediment deposition within 2 years of dam removal may be up to 1.7 feet (see Figure 3.11-18 below) (USBR 2012). Short-term simulations also indicate~~and~~ up to about 0.4 feet of sediment deposition from Willow Creek to Cottonwood Creek ~~(USBR 2012)~~ (Figure 3.11-15), although conservative long-term (50-year) simulations indicate that fine and coarse sediment deposition within 2 years of dam removal may be up to 0.9 feet (see Figure 3.11-18 below) (USBR 2012). Model simulations indicate that reaches located farther downstream will change little (< 0.5 feet of erosion or deposition) (Figure 3.11-15; Figure 3.11-18) (USBR 2012). ~~Any f~~Fine sediment that does deposit on the channel bed in the short term would be transient and subject to remobilization. Smaller quantities of coarse sediment would be less transient, as discussed below in relation to long-term sedimentation. Eight miles of the Klamath River mainstem channel from Iron Gate Dam to Cottonwood Creek could potentially be affected by significant short-term sediment deposition released upon dam removal, ~~and resupply~~, representing 4 percent of the total mainstem channel length downstream of Iron Gate Dam (190 miles).

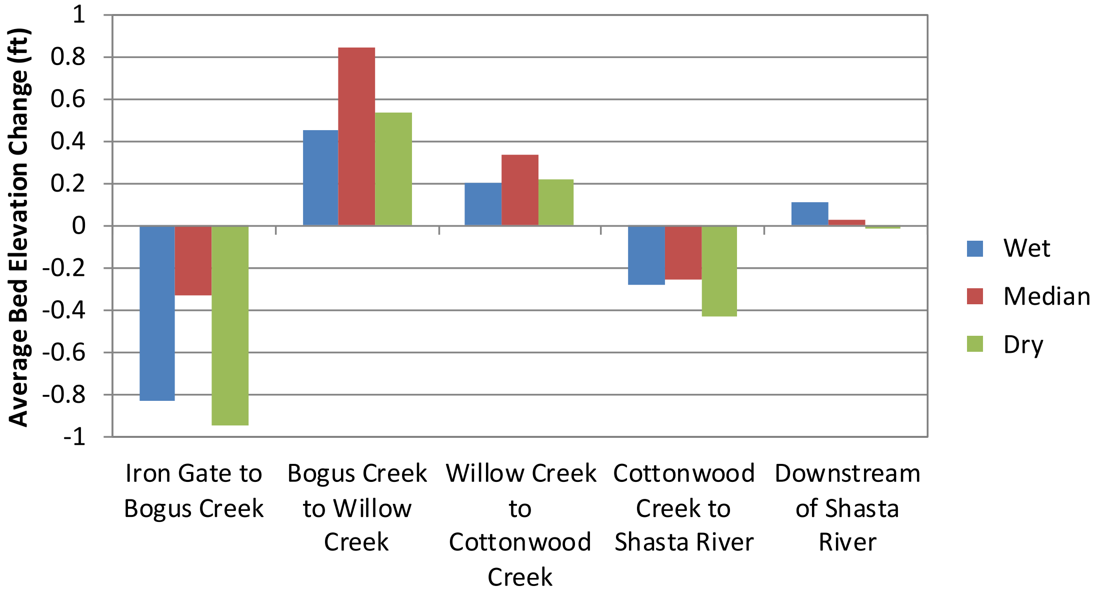

Figure 3.11-15. Reach-~~A~~averaged Bed Elevation Change for Two Successive Wet, Median, or Dry Water Years Following Reservoir Drawdown (Based on SRH-1D 2-year model simulation results provided by USBR ~~, March~~ 2012). Model results contain more uncertainty in the reach from Iron Gate to Bogus Creek due to data gaps.

It is not possible to accurately predict short-term deposition patterns in the mainstem river channel at a fine spatial scale (e.g., individual pools or other slack-water areas) under the Proposed Project using 1D sediment transport models. However, the general short-term sediment transport and depositional patterns can be reasonably surmised based on patterns observed in the Klamath River and other analogous river channels. Dam-released sediment may temporarily deposit in pools and other slack water areas (e.g., eddies) and at tributary confluences, with the greatest deposition predicted in the reach from Iron Gate Dam to Cottonwood Creek. These transient sediment deposits would be highly erodible during subsequent flow events, leading to a short residence time (i.e., the median return period for initiation of sediment remobilization from Iron Gate Dam to Indian Creek is approximately four years considering historic flows [1961-2008] and is predicted to be shorter than this in the reaches from Iron Gate Dam to Cottonwood Creek following dam removal due to fining of the bed [described in more detail below] ~~likely one year or less except during dry years~~). KRRC proposes a channel survey to document pool depths in the Klamath River from Iron Gate Dam to Humbug Creek prior to dam removal, and every year after dam removal for the first 3 years.

In the short term, SRH-1D model simulations indicate that dam-released sediment and sediment resupply under the Proposed Project would increase the proportion of sand in the channel bed and decrease median bed substrate size (Figure 3.11-16 and Figure 3.11-17) (USBR 2012). Under wet, median and dry simulations, sand within the bed in the reach from Iron Gate to Bogus Creek would increase to 30 to 35 percent by March to June of the drawdown year, gradually decreasing to 10 to 20 percent by September two years later. Median substrate size (D_{50}) would fluctuate slightly before stabilizing to approximately existing conditions with a D_{50} of 100 mm (Appendix F). Short-term model simulations also indicate a decrease in median grain size (from an initial value of approximately 80 mm down to 40 to 65 mm) and an increase in the proportion of sand (up to 40 percent) in the reach from Bogus Creek to Willow Creek, and an increase in the proportion of sand (up to 35 percent) and a decrease in median grain size (from an initial value of approximately 65 mm down to 38 to 45 mm) in the reach from Willow Creek to Cottonwood Creek (Appendix F).

<u>Given that the mechanism for short-term sediment deposition in the Klamath River downstream of Iron Gate Dam is erosion of the reservoir sediment deposits that results in elevated SSCs as analyzed in Potential Impact 3.2-3, the reasons that the significant short-term sediment deposition described for the Klamath River from Iron Gate Dam to Cottonwood Creek cannot be avoided or substantially decreased through reasonably feasible mitigation described in Potential Impact 3.2-3 also apply to this significant impact.</u>

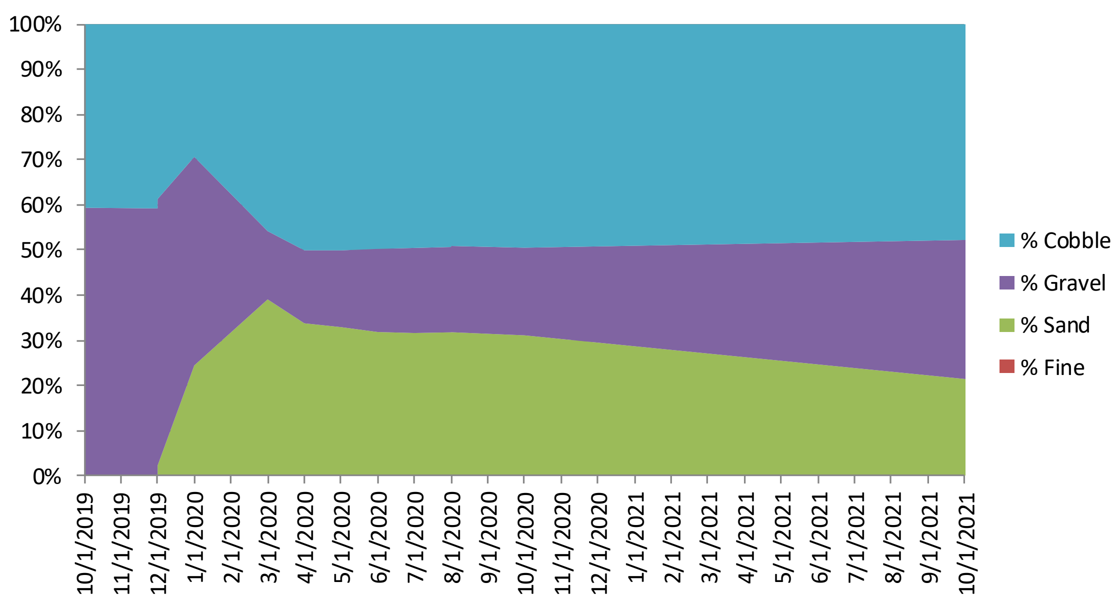

Figure 3.11-16. Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Dry Water Years Following Reservoir Drawdown (Based on simulation results provided by USBR, March 2012).

Figure 3.11-17. 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 USBR~~, March~~ 2012).

In general, the Proposed Project would have the beneficial long-term (i.e., 50 years) effects of increasing sediment supply and transport and creating a more dynamic and mobile bed downstream of Iron Gate Dam. During the 50 years following the initial release of sediment by the Proposed Project, bed elevations would adjust to a new equilibrium in response to sediment supplied by upstream tributaries within the Hydroelectric Reach. While long-term (50-year) SRH-1D model simulations indicate that 0.8 to 1.7 feet of aggradation could result from the Proposed Project between Iron Gate Dam and Cottonwood Creek (i.e., simulations based on a median start year), no significant long-term sediment deposition is expected downstream of Cottonwood Creek (Figure 3.11-18) (USBR 2012). The assumptions in the SRH-1D model regarding bed mixing result in ~~is~~ conservatively thick ~~regarding bed mixing; thus the~~ estimates of long-term bed deposition ~~is conservative~~ (USBR 2012). Long-term (5 to 50 year) simulations indicate that after 5 years, the Proposed Project would increase the proportion of sand in the bed to 5 to 22 percent and decrease the D_{50} to approximately 50 to 55 mm (Appendix F). These changes would stabilize and continue through to Year 50. Fining of the bed surface would reduce the median estimate of flow required to initiate mobilization~~e~~ of the channel bed from approximately 10,000 cfs to 6,000 cfs in the reach from Bogus Creek to Willow Creek (RM 192.6 to RM 188) and from 11,000 cfs to 6,000 cfs in the reach from Willow Creek to Cottonwood Creek (RM 188 to RM 185.1) (USBR 2012). The corresponding return period for the initiation of a bed-mobilizing flow in the reach from Iron Gate Dam to Cottonwood Creek (USGS RM 193.1 to RM 185.1) would decrease from approximately 4 years to approximately 2 years (USBR 2012, pages 9-86 to 9-88) (Figure 3.11-19). Downstream of Cottonwood Creek, the return periods for bed-mobilizing flows would not be significantly altered from historic conditions (Figure 3.11-6).

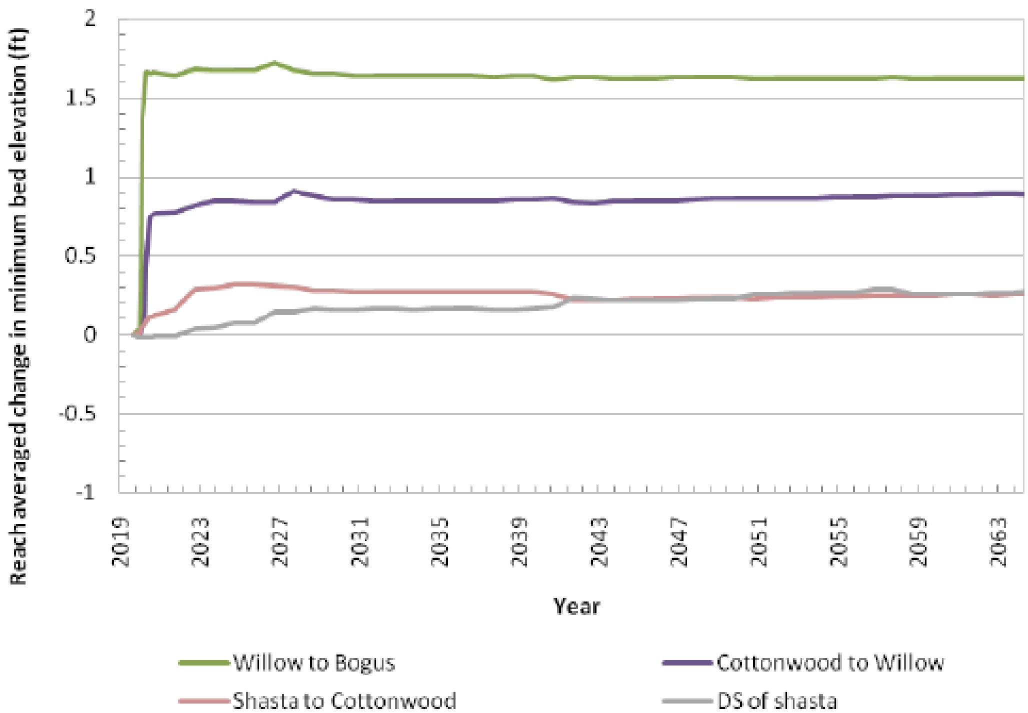

Figure 3.11-18. Reach-averaged Bed Elevation Change from Iron Gate Dam to Shasta River Post Dam Removal, with Dam Removal Occurring in a Median Water Year (Based on SRH-1D 50-year model simulation results provided by USBR 2012, page 9-36).

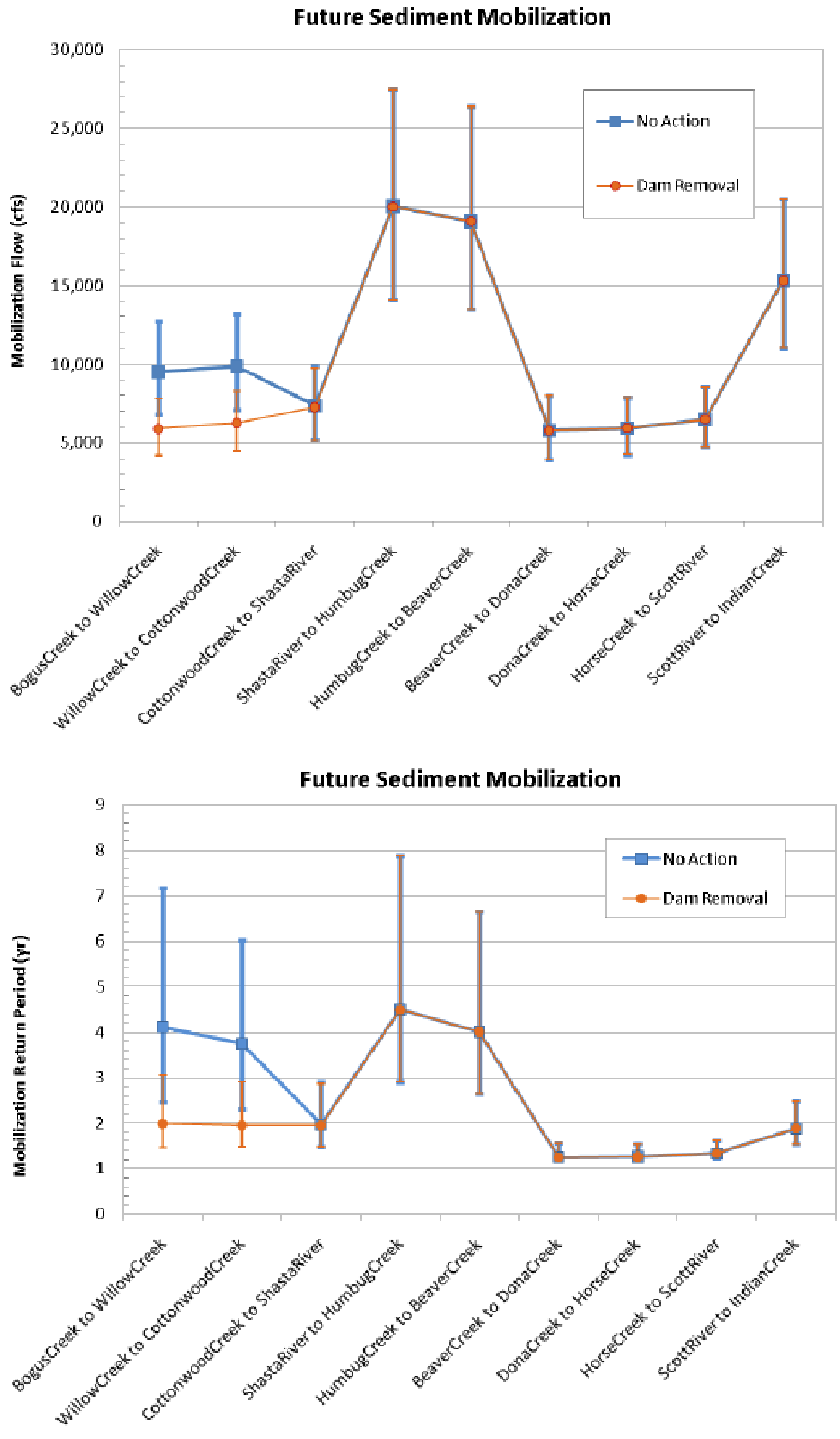

Figure 3.11-19. Flow and Associated Return Period Water Flow for the Initiation of Sediment Mobilization in the Klamath River for the Proposed Project and No Action Alternative (USBR 2012, pages 9-87 to 9-88).

Channel Response in the Klamath River Estuary

The majority of the fine sediment (silts, clays, and organics) released by dam removal would be transported to the ocean (Stillwater Sciences 2010, USBR 2012). The fine material is unlikely to deposit in significant quantities in the estuary, as the mouth only occasionally closes during summer low flow periods (Stillwater Sciences 2008), and it would be open during the drawdown period (November to March)~~evidenced by the lack of a large sandbar within the mouth of the Klamath River under existing conditions~~. There are currently high concentrations of silt and clay transported through the estuary, and sediment sampling by USBR (2010) documented the absence of fine material in the estuary except in the backwater and vegetated areas. If dam removal occurs during a low flow year, there may be relatively small volumes of sediment deposited in these areas.

Pacific Ocean Nearshore Environment

Because of the complexities of the transport processes, the area and depth of fine sediment deposition in the Pacific Ocean nearshore environment resulting from the Proposed Project cannot be precisely predicted. A considerable amount of fine sediment is anticipated to initially deposit on the seafloor shoreward of the 196-feet isobath along the coast, with greater quantities depositing in close proximity to the mouth of the Klamath River. After fine sediment loading onto the continental shelf during river floods, fluid-mud gravity flows typically transport fine sediment offshore. Summer coastal upwelling naturally re-suspends some of the river sediments that are transported to the nearshore environment and deposited on the continental shelf, especially those from the previous winter (Ryan et al. 2005; Chase et al. 2007; see Potential Impact 3.2-7). Along with the background river sediments transported annually by the Klamath River and deposited on the continental shelf, a portion of the sediment deposited on the continental shelf following dam removal would also have the potential to be re-suspended during the summer coastal upwelling. Any sedimentation of the nearshore seafloor resulting from the Proposed Project would likely be transported farther offshore to the mid-shelf and into deeper water depths off-shelf. The short-term (less than two years following dam removal) and long-term (2–50 years following dam removal) effects of the Proposed Project on sediment delivery to the Pacific Ocean would be less-than-significant, given the relatively small amount of total sediment input from reservoir sediment release in comparison to the total annual naturally occurring sediment inputs to the nearshore environment.

Bedload sediment effects related to coarse sediment released by the Proposed Project or sediment re-supply likely would not extend downstream of the Cottonwood Creek confluence (RM 185.1). Therefore, there would be no bedload-related effects in the Klamath River Estuary or Pacific Ocean nearshore environment under the Proposed Project.

Significance

Significant and unavoidable in Middle Klamath River from Iron Gate Dam to Cottonwood Creek in the short term

No significant impact in the Middle Klamath River downstream of Cottonwood Creek, Lower Klamath River, and Klamath River Estuary in the short term

Beneficial for Hydroelectric Reach, Middle and Lower Klamath River, and Klamath River Estuary in the long term

No significant impact in Pacific Ocean nearshore environment in the short term and long term.

3.11.6 References

Volume I Section 3.11.6 Geology, Soils, and Mineral Resources – References, pages 3-776 through 3-780, includes the following revisions:

NMFS (National Marine Fisheries Service). 2019. Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act essential fish habitat response for Klamath Project operations from April 1, 2019 through March 31, 2024. Technical memorandum to J. Nettleton, Area Manager, Klamath Basin Area Office, Bureau of Reclamation from A. Van Atta, Assistant Regional Administrator, California Coastal Office, National Marine Fisheries Service.

USBR and CDFG (California Department of Fish and Game). 2012. Klamath Facilities Removal Final Environmental Impact Statement/Environmental Impact Report. Volume 1. December 2012. http://kbifrm.psmfc.org/wp-content/uploads/2017/05/2012_0246_Klamath-Facilities-Dam-Removal-Final-EIS.pdf.

USBR. 2012b. Detailed Plan for Dam Removal – Klamath River Dams, Klamath Hydroelectric Project, FERC License No. 2082, Oregon – California. July 2012. Available from: https://www.fws.gov/yreka/klamrest.html.

U.S. District Court. 2017. Hoopa Valley Tribe v. U.S. Bureau of Reclamation et al. and Klamath Water Users Association et al. Case No. 3:16-cv-04294-WHO. Order modifying February 8, 2017 injunction. U.S. District Court for the Northern District of California, San Francisco Division.

USFWS (U.S. Fish and Wildlife Service). 2019. Biological Opinion on the Effects of Proposed Klamath Project Operations from April 1, 2019, through March 31, 2024, on the Lost River Sucker and the Shortnose Sucker. Prepared by USFWS, Southwest Region, Klamath Falls, Oregon.

Other references cited as part of text included in the Section 3.11 list of revisions:

Chase, Z., P. G. Strutton, and B. Hales. 2007. Iron links river runoff and shelf width to phytoplankton biomass along the U.S. West Coast. Geophysical Research Letters 34, L04607, doi:10.1029/2006GL028069

Huang, J., and B. Greimann. 2010. User's manual for SRH-1D 2.5, Sedimentation and River Hydraulics – One Dimension Version 2.5. Bureau of Reclamation, Technical Service Center, Denver, Colorado.

NMFS and USFWS (National Marine Fisheries Service and U. S. Fish and Wildlife Service). 2013. Biological opinions on the effects of proposed Klamath Project operations from May 31, 2013, through March 31, 2023, on five federally listed threatened and endangered species. Prepared by NMFS, Southwest Region, Northern California Office; and USFWS, Pacific Southwest Region, Klamath Falls Fish and Wildlife Office.

Ryan J. P., F. P. Chavez, and J. G. Bellingham. 2005. Physical-biological coupling in Monterey Bay, California: topographic influences on phytoplankton ecology. Marine Ecology Progress Series 287: 23 – 32.

Stillwater Sciences. 2008. Technical Report – Klamath River Dam Removal Study: Sediment Transport DREAM-1 Simulation. Prepared for the Coastal Conservancy. October.

Stillwater Sciences. 2010. Anticipated sediment release from Klamath River Dam removal within the context of basin sediment delivery. Final Report. Prepared by Stillwater Sciences, Arcata, California for California Coastal Conservancy, Oakland, California.

USBR (Bureau of Reclamation). 2010a. Klamath River Sediment Sampling Program, Phase I – Geologic Investigations. September.

USBR. 2012. Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration. Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

3.12 Historical Resources and Tribal Cultural Resources

This section focuses on the potential for impacts to historical and tribal cultural resources due to the Proposed Project. For the purposes of this section of the EIR:

Tribal Cultural Resources: Tribal Cultural Resources (TCRs) are defined consistent with Public Resources Code section 21074(a)(which includes sites, features, places, cultural landscapes, sacred places, and objects with cultural value to a California Native American tribe that are either included or determined to be eligible for inclusion in the California Register of Historical Resources, or included in a local register of historical resources, or as determined by the lead agency under the criteria for listing. Tribal Cultural Resources are, by definition, historical resources.

Historical Resources: Historical Resources are defined consistent with Public Resources Code section 21084.1 which includes a resource listed in, or determined to be eligible for listing in, the California Register of Historical Resources (CRHR), included in a local register of historical resources, or determined to be significant by the lead agency (Pub. Resc. Code, section 21084.1, CEQA Guidelines Section 15064.5 (a)). While not all CRHR-eligible resources are also eligible for the National Register of Historic Places (NRHP), resources listed on or evaluated as eligible for the NRHP are considered historical resources under CEQA. The fact that a resource does not meet NRHP listing criteria does not preclude a lead agency from determining that the resource may be an historical resource under the criteria in Public Resources Code Section 5024.1(c). Historical resources may be prehistoric or historic in age and may be archaeological resources, part of the existing built environment, other important historic resources, or a tribal cultural resource such as a sacred place. Additionally, CEQA recognizes the possibility that an archaeological site may not meet the definition of an historical resource but may meet the definition of a “unique archaeological resource” (Pub. Resc. Code, section 21083.2 (g)). Similar to historical resources, unique archaeological resources are afforded protection under CEQA.

Many comments were received during the NOP public scoping process relating to historical and/or tribal cultural resources (Volume II Appendix A). Several commenters expressed a profound personal and tribal connection to the Klamath River, its water quality, and its fishery from a traditional, subsistence, ceremonial, and spiritual viewpoint, and expressed that dam removal would provide an opportunity for river restoration, including the return of a traditional fishery. Other commenters expressed concern regarding low flows and poor water quality that would ensue following dam removal and could preclude certain tribal ceremonies. Several commenters expressed concern regarding dam removal and the potential for impacts to specific known cultural resources associated with ancient Shasta tribal occupation of the landscape and that there may be unknown archaeological resources that could be adversely affected by dam removal. A summary of the historical and/or tribal cultural resources comments received during the NOP public scoping process, as well as the individual comments themselves, are presented in Volume II Appendix A.

After circulation of the Draft EIR, numerous additional comments were received regarding Historical Resources and Tribal Cultural Resources (see Volume III), and changes to the section in response to those comments are flagged in the comment responses and then printed in this Final EIR section. None of the changes result in significant new information in the EIR under the meaning of CEQA Guidelines, section 15088.5, subdivision (a):

> New information added to an EIR is not 'significant' unless the EIR is changed in a way that deprives the public of a meaningful opportunity to comment upon a substantial adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect (including a feasible project alternative) that the project's proponents have declined to implement.

However, the changes were numerous enough that reprinting the section rather than simply including a list of revisions was warranted to improve clarity and readability of the document.

Assembly Bill 52 (AB52) (Gatto 2014) amended Section 5097.94 of the Public Resources Code to require consideration of tribal cultural resources in CEQA review and to require certain consultation requirements with California Native American Tribes. AB52's requirements went into effect on July 1, 2015.

A tribal cultural resource is defined as a site, feature, cultural landscape, sacred place or object with cultural value to a California Native American tribe that is listed or determined to be eligible for listing in the California Register of Historical Resources or under certain local registers, or that the lead agency determines to be significant under the criteria for listing (Public Resources Code, Section 21074, subdivision (a)). For purposes of this analysis, with the exception of isolated occurrences of cultural material, all known and unknown prehistoric archaeological sites within the Project area are considered to be tribal cultural resources, and thus significant resources under CEQA.

The Yurok Tribe, the Shasta Indian Nation, and the Shasta Nation requested consultation under AB52, and met with the State Water Board and the KRRC in a series of confidential consultation meetings within the timeframe of February 2017 through October 2018. The consultations with the Yurok Tribe and the Shasta Indian Nation resulted in identification of potentially-impacted resources, articulation of potential impacts, and development of, and agreement on, specific mitigation measures (see Section 3.12.5.1 *Potential Impacts to Tribal Cultural Resources*, TCR-1 through TCR-8). KRRC has formally committed to implementing the measures as part of concluding AB52 consultation, and has initiated consultation for development of a Tribal Cultural Resources

Management Plan to meet the requirements described in TCR-1 through TCR-4, as well as the requirements of National Historic Preservation Act, Section 106. The TCRMP will be submitted to FERC for implementation.

Consultation with the Shasta Nation has informed the analysis in this EIR, but concluded after the Shasta Nation and the State Water Board acknowledged that it would not be possible to reach agreement on mitigation measures, despite a good faith effort to do so.

In order to support Project development, the KRRC undertook efforts to identify and evaluate historical and tribal cultural resources in the vicinity of the Proposed Project, and these efforts have provided information contributing to the Historical and Tribal Cultural Resources environmental setting, potential impacts and mitigation measures. KRRC has also prepared a Draft Cultural Resources Plan (Appendix B: *Definite Plan – Appendix L*), which provides a framework for understanding the cultural resources studies that KRRC has completed, those that are currently ongoing, and others that KRRC anticipates completing in order to comply with regulatory requirements. The KRRC proposes that the Final Cultural Resources Plan would be available prior to implementation of the Proposed Project. However, this document acknowledges that not all of the required cultural resources inventory and significance analyses will be completed prior to certification of this EIR. Additionally, overseeing development and implementation of the Cultural Resources Plan does not fall within the scope of the State Water Board's water quality certification authority. Therefore, for the purposes of this analysis, all known and unknown cultural resources within the Project area are considered to be significant historical resources under CEQA. This includes the historic built environment; historic-period archaeological resources; and prehistoric archaeological resources, which as stated above are considered TCRs herein.

3.12.1 Area of Analysis

The Area of Analysis for historical and tribal cultural resources is shown in Figure 3.12-1. Within the Area of Analysis, there are four subareas relevant to the analysis of potential historical and tribal cultural resource impacts, as follows:

- *Subarea 1* (Figure 3.12-2)
  - KRRC's Limits of Work for the Proposed Project, which includes the horizontal boundary conforming to the high-water line around the Lower Klamath Project reservoirs, the construction footprint needed for dam and other structure removal, ingress and egress routes, staging and stockpiling areas, disposal areas, and transmissions lines to be removed; and,
  - The inclusive area of known cultural sites that lie partially within and partially outside of the Limits of Work.

- *Subarea 2* (Figure 3.12-3)
  - Post-dam removal altered Federal Emergency Management Agency (FEMA) 100-year floodplain along the 18-river mile stretch of the Middle Klamath River downstream of Iron Gate Dam (RM 193.1) to the confluence with Humbug Creek (RM 174).
- *Subarea 3* (Figure 3.12-4)
  - Parcel B lands immediately surrounding the Lower Klamath Project, which would be transferred from PacifiCorp to the KRRC prior to dam removal and then transferred to the respective states (i.e., California, Oregon), as applicable, or to a designated third-party transferee, following dam removal. The lands would thereafter be managed for public interest purposes (KHSA Section 7.6.4.A).
- *Subarea 4* (Figure 3.12-5)
  - 0.5-mile buffer on either side of the Hydroelectric Reach, Middle Klamath River, and Lower Klamath River encompassing the existing conditions and post-dam removal altered FEMA 100-year floodplain, which, with the exception of the Middle Klamath River reach described in *Subarea 2*, have the same extent.

To allow for individual impact analyses specific to geographic location (e.g., reservoir footprint, riverside location) and Proposed Project activity timing (e.g., pre-dam removal, reservoir drawdown, restoration activities), the subareas include overlap. The subarea overlap has no bearing on the analysis of any impact, since the subareas are considered independently by impact.

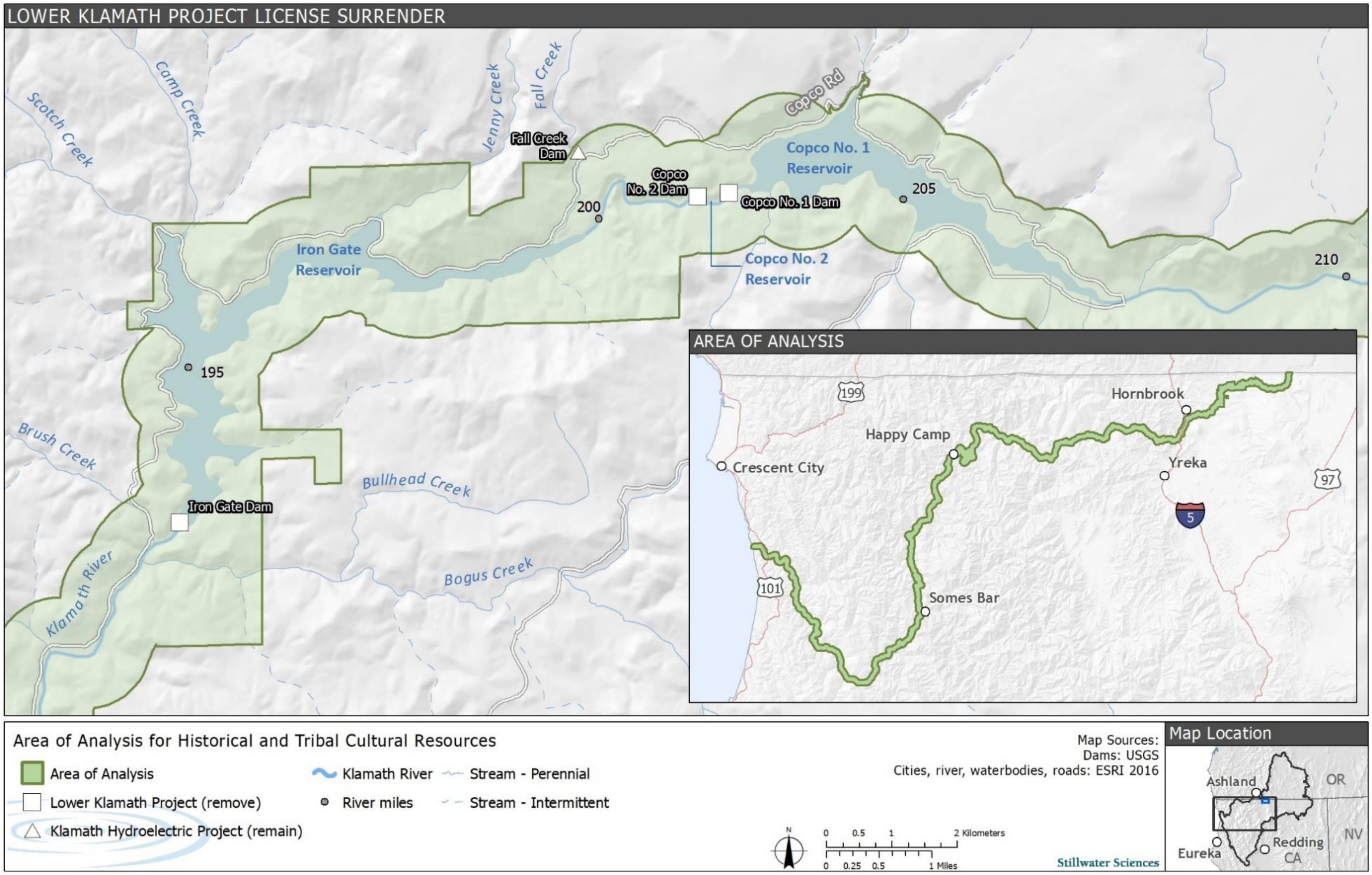

Figure 3.12-1. Area of Analysis for Historical and Tribal Cultural Resources.

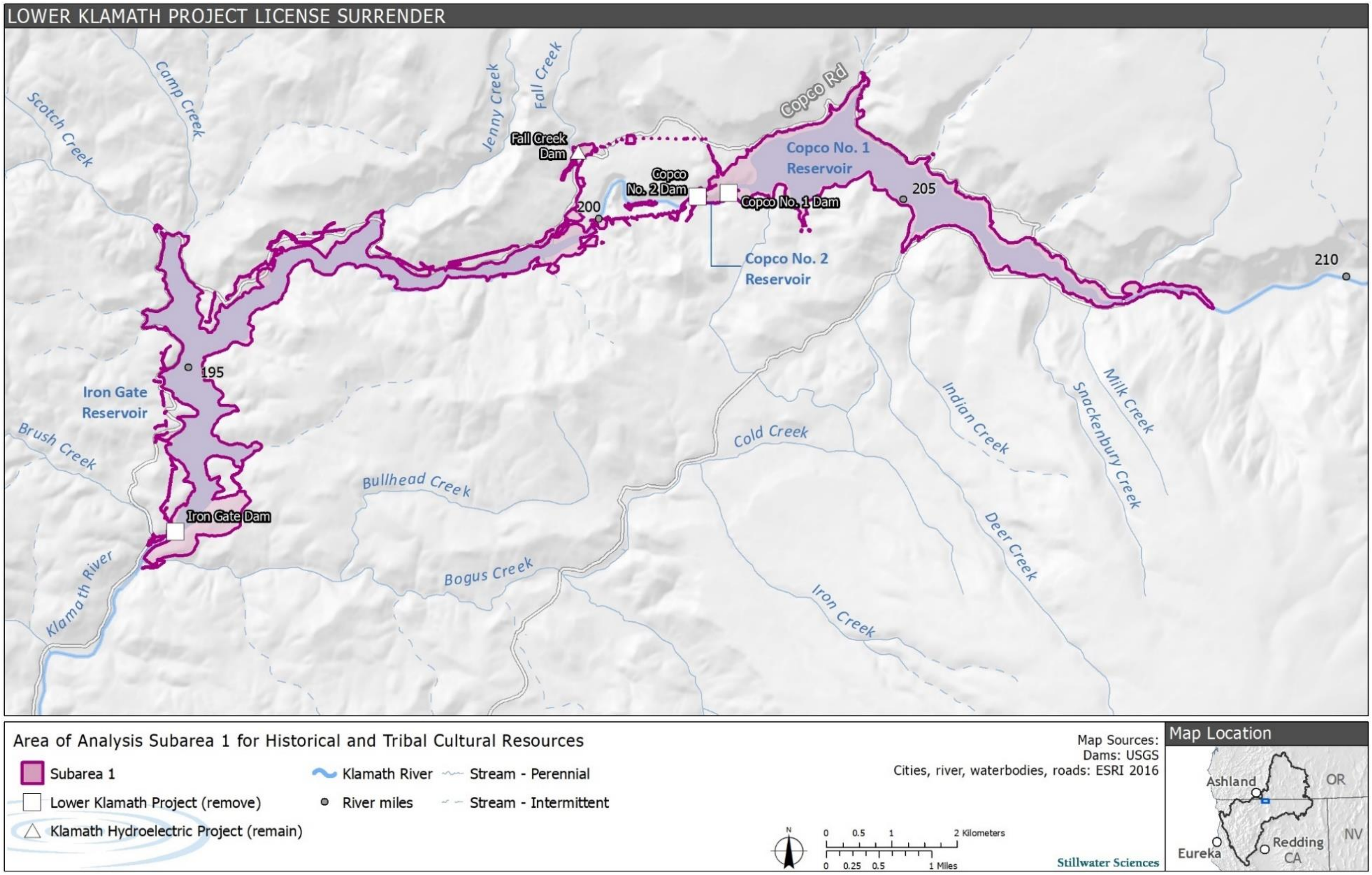

Figure 3.12-2. Area of Analysis *Subarea 1* for Historical and Tribal Cultural Resources.

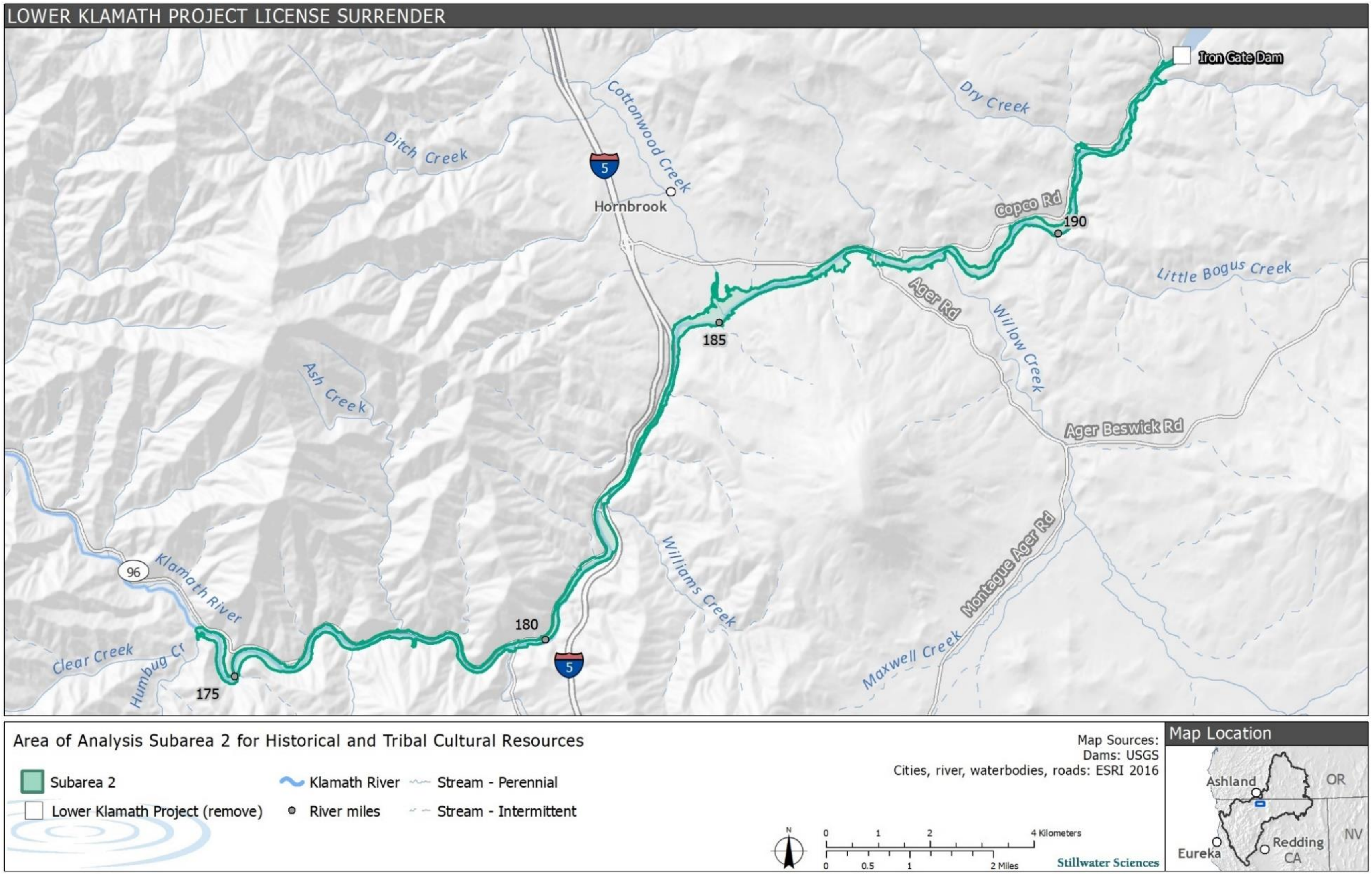

Figure 3.12-3. Area of Analysis *Subarea 2* for Historical and Tribal Cultural Resources.

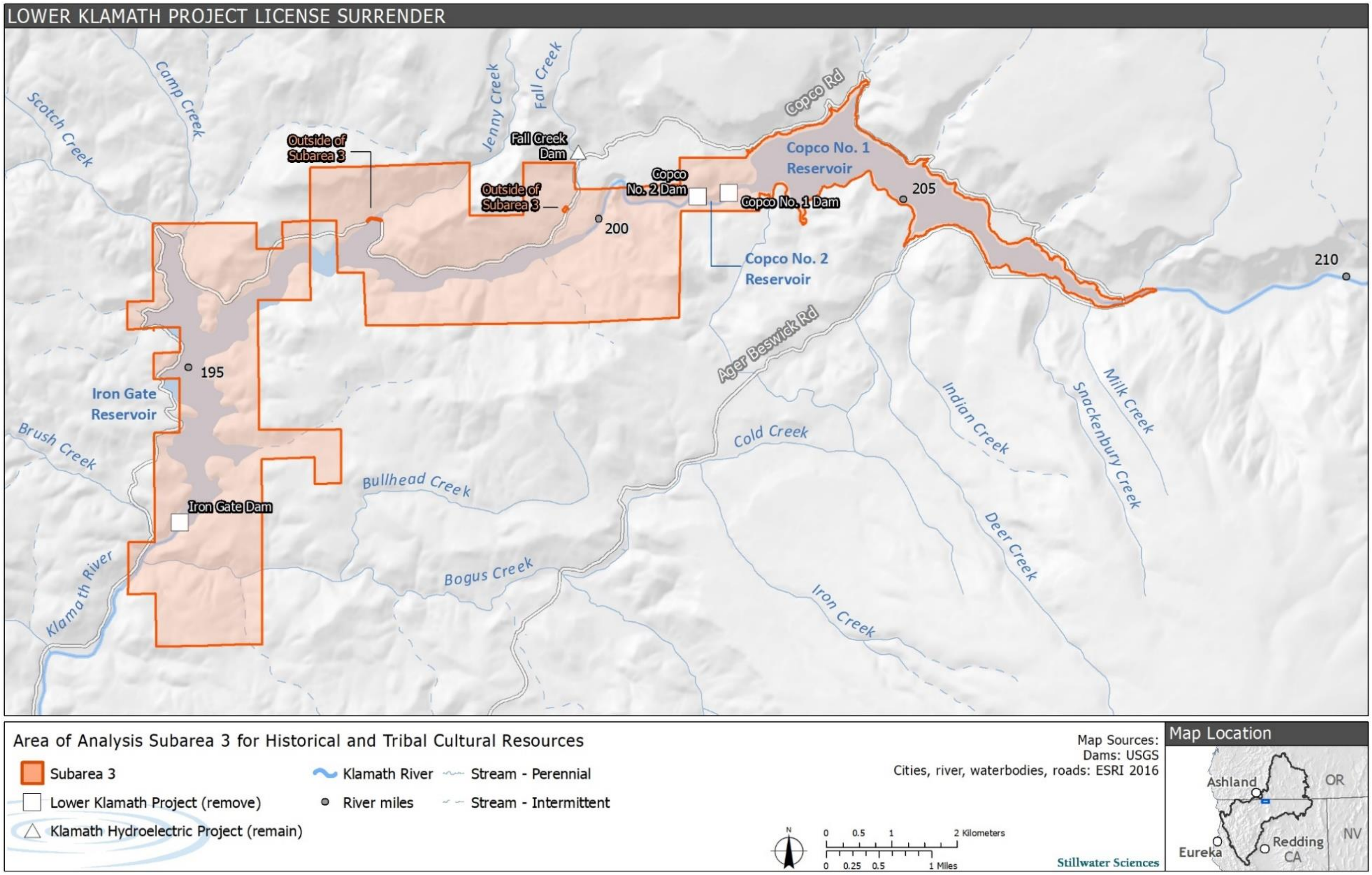

Figure 3.12-4. Area of Analysis *Subarea 3* for Historical and Tribal Cultural Resources.

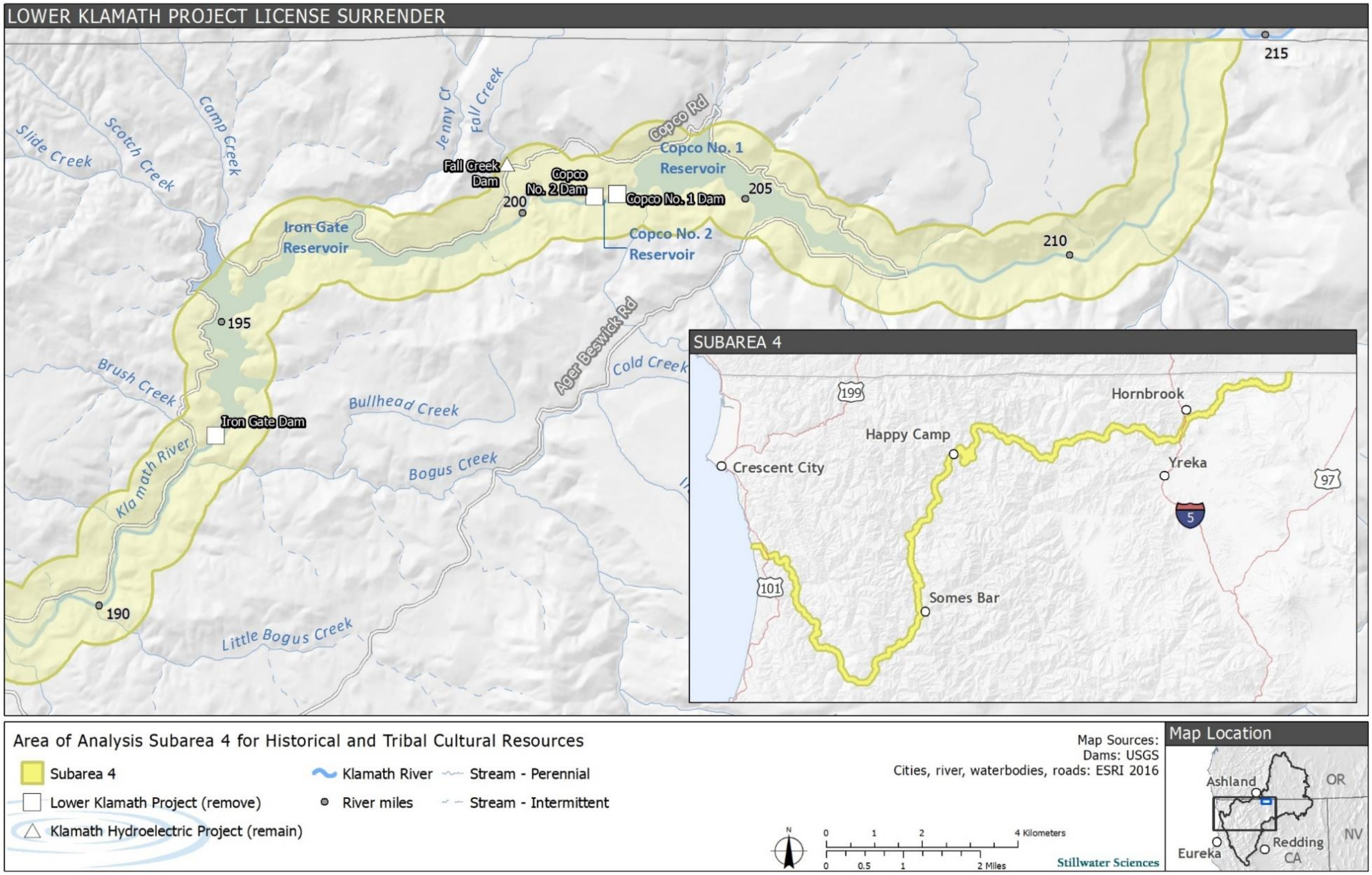

Figure 3.12-5. Area of Analysis *Subarea 4* for Historical and Tribal Cultural Resources.

3.12.2 Environmental Setting

The Klamath River flows through several cultural regions in California's Northwest Coast, the Great Basin, and portions of the Columbia Plateau. These unique cultural regions have been used and occupied by Native American peoples for centuries.

3.12.2.1 Tribal Cultural Chronology and Ethnography (including Historic and Pre-Historic Periods)

The tribal cultural resources analysis focuses on Shasta, Klamath, Karuk, Modoc, Hupa[83], and Yurok peoples that occupy the territory along and adjacent to the Klamath River in the vicinity of the Proposed Project. These tribes have a long history of occupation along the Klamath River as evidenced by the numerous archaeological and ethnographical resources that are present. Traditional beliefs indicate that these groups have occupied the area for time immemorial.

Over the millennia, native peoples occupied the area along the Klamath River in the vicinity of the Proposed Project, especially the corridor along the Klamath River. Ancient stream terraces—composed of gravel and sand and covered in meadows of grass with mixed oak groves—provided ideal conditions for food supply. Additionally, the area of the Upper and Middle Klamath River provided naturally occurring salt deposits, geothermal hot springs, basalt rock caves, and food such as anadromous and resident fish, seeds, roots, birds, and mammals.

Archaeological investigations have confirmed over 10,000 years of human presence in the Middle and Upper Klamath Basins, which extend beyond the extent of the Klamath River (Balter 2008, Ames et. Al 1998, and Aikens and Jenkins 1994). Mammal remains document their use as a food source for native people approximately 7,500 years before the present (BP) (Ames et al., 1998). The presence of milling slabs, mortars, and mullers on the landscape dating back to approximately 6,000 BP, provides evidence for use of bulbs and seeds for subsistence (Mack 1983 and 1991). Use of fish, as a food source, began about 2,600 years BP (Beckham 2006, Daniels 2006, Deur 2011).

Section 3.12 *Tribal Trust* of the 2012 KHSA EIS/EIR is included as Appendix V of this EIR, and includes significant additional context regarding the histories of Native Americans in the basin and the longstanding relationships with various resources. Because this information was developed under auspices of the USBR's trust responsibilities towards federally-recognized Native American tribes, it includes only federally-recognized tribes. Additionally, the subsections of Section 3.12 *Tribal Trust* that address the various potential impacts of the alternatives that were being evaluated in the 2012 KHSA EIS/EIR are not directly

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[83] The term Hupa describes the Hupa People. The term Hoopa is used to reference the Hoopa Valley place or the tribal government.

applicable to the Proposed Project because they involve similar, but not exactly the same, actions.

Columbia Plateau and Great Basin Culture Areas

The Upper Klamath Basin and Klamath Lakes area exhibits a blend of cultural traits from the Columbia Plateau and Great Basin culture areas. The chronology of the area may be organized into the Paleoarchaic (14,000 to 7,000 BP), Early Archaic (7,000 to 4,500 BP), Middle Archaic (4,500 to 2,500 BP), and Late Archaic/Late Prehistoric (2,500 to 200 BP) periods (Ames et al. 1998; Balter 2008; Aikens and Jenkins 1994; Mack 1983, 1991).

Paleoarchaic (14,000 to 7,000 BP)

During the Paleoarchaic period, the Klamath Basin was occupied by hunter-gatherers that tended to focus on hunting large game animals, but also supplemented their diet with fish, birds, and plant resources. These groups were seasonally mobile and generally small in size (Ames et al. 1998). Two of the oldest sites in the region are Paisley Cave, which is dated at 14,200 BP (Balter 2008) and Fort Rock Cave, which is dated between 13,200 and 10,200 BP (Aikens and Jenkins 1994). The oldest site in the upper Klamath River area is the Klamath Shoal midden site, 35KL21, which yielded a date of 7,700 BP.

Early Archaic (7,000 to 4,500 BP)

Most of the archaeological evidence for early human occupation in the Klamath River Canyon dates to the beginning of the Early Archaic period (Mack 1983 and 1991). Semi-subterranean house pits first appear in the Plateau region during this period suggesting that some people were adopting a less mobile lifestyle. Typical artifacts associated with the Early Archaic include large stemmed, lanceolate, or leaf-shaped projectile points, knives, gravers, scrapers, and some cobble and ground stone tools (e.g., abraders or grinding slabs, mortars, mullers, and stone bowls).

Middle Archaic (4,500 to 2,500 BP)

The Middle Archaic period is characterized by an increase in the exploitation of riverine and marsh environments and food resources such as salmon and various plant roots/tubers. There was also an increase in the use of milling stones and pestles at sites during this period. Typical Middle Archaic artifacts include broad-necked, corner-notched, and side-notched projectile points, many types of ground stone tools, bone and antler tools (e.g., chisels and wedges), and specialized fishing gear (e.g., bone harpoon barbs and net sinkers).

Late Archaic/Late Prehistoric (2,500 to 200 BP)

Several major cultural changes occurred during the Late Period, including: the widespread appearance of pit houses; a shift to a heavy reliance on fishing; the use of storage pits for salmon; camas exploitation; the development of seasonal land use patterns (i.e., use of “winter villages”); the appearance of the bow as evidenced by the presence of small corner- and side-notched projectile points at sites; and the appearance of Olivella shell beads. Extensive trade networks became important across the region by as early as 1,500 years ago, as suggested by tools made from obsidian sources 110 to 120 miles away and the presence of beads made from marine shells.

Ethnography

Klamath Tribes

The Klamath Tribes include the Klamath, Modoc, and Yahooskin Band of Snake Indians. Prior to their placement on a shared reservation, these groups utilized overlapping resource areas in the Upper Klamath Basin. The Klamath and Modoc people occupy the entire Upper Klamath Basin and adjacent interior drainages to the east, living in close association with the marsh and riverine resources of this area (Spier 1930 and Barrett 1910). The Klamath and Modoc tribes were occupying the Upper Klamath Basin prior to Euro-American contact, and also participated in salmon fishing and social gatherings along the Klamath River at least as far downstream as Seiad Valley (Deur 2011). The Yahooskin principally occupy lands east of the Klamath Basin, but did participate in resource harvests, including fish harvests, with Klamath and Modoc on the Sprague River and other Klamath River tributaries (Deur 2011).

Deur (2011) also presents a summary of the ethnography of The Klamath Tribes and their relationship to the Klamath River. Klamath ancestral territory stretches from the southern boundary of the Deschutes River watershed in the north to Shovel Creek drainage in the south (Stern 1998). These encompass the Sprague River and Sycan Rivers, Sycan Marsh, Klamath Lake, and Klamath Marsh (Spier 1930, Berreman 1937). Modoc territory extends from Mount Shasta in the south to an area near the current Oregon-California state line in the north and from the eastern slope of the Cascade Range near Mount Shasta to the area around Goose Lake in the east (Ray 1963). This area encompassed Lower Klamath Lake and Tule Lake.

Klamath and Modoc were both organized in villages that collectively owned productive fishing or other resource (e.g., seed or other plants) gathering areas. Influential heads of households, supported by extended families, assumed leadership roles in the villages (Stern 1998). Villages included various types of structures including semi-subterranean winter lodges for families and extended families. The Klamath and Modoc rebuilt their winter lodges in the fall. Spier (1930) identified five geographic subdivisions of winter villages:

- Klamath Marsh-Williamson River group on the southern margin of Klamath Marsh and the Lower Williamson and Sprague rivers (about 34 villages, plus four to five villages on the upper Sprague and Sycan rivers).
- Agency Lake group on Agency Lake and the northern arm of Klamath Lake (one village and one hamlet).
- Lower Williamson River group close to the mouth of Williamson River (about seven villages).

- Pelican Bay group that includes the Pelican Bay district on the west side of Klamath Lake, Four Mile Creek, and the marsh north of the lake (about eight villages).
- Klamath Falls group: along Klamath Lake south of Modoc Point (about 14 villages).

The permanent winter villages were never fully abandoned during the year. Each group of villages maintained one or more places for cremation of the dead. The ashes of cremated individuals were covered with soil and rocks. Individuals dying away from home might be interred under piles of rocks or cremated and returned to the cremation ground. Particular sweat houses, said to have been built by the legendary *Kemu'kumps*, and a hot spring were used to cleanse mourners.

Fish is the primary resource for the Klamath and Modoc; consequently, settlements clustered near rivers and streams. Runs of fish began in the early spring and lasted into the fall (Spier 1930). Men, with some assistance from women, fished throughout the year from the banks of rivers or streams or from canoes using long-handled dip nets, spears, harpoons, and hook-and-line. During parts of the year, fish drives were also used to harvest fish. Members of the tribe would drive fish toward individuals dragging triangular nets on A-frames or purse nets through the water either on foot or from a canoe. Gill nets drawn between canoes and traps were also used to acquire fish. In addition, stone barriers were constructed on some streams to restrict fish passage and facilitate fishing.

Klamath and Modoc typically left their winter villages in early spring to begin a seasonal round of harvest activities. Spring activities began with harvesting fish from the run of large suckers that took place in Upper Klamath Lake in March. Fish were dried on the branches of pine saplings and sometimes pounded into a meal and bagged for storage. As the spring sucker run subsided, Klamath and Modoc women turned their attention to digging ipos (*Carum oregonum*) roots, gathering waterfowl eggs, and scraping the cambium layers of young ponderosa pines for food. By late spring, women dug camas bulbs in wet meadows, baking them in earth ovens and sun-drying them for storage while men hunted waterfowl and other animals.

Summer was the season when women harvested wocas, the nutritious seeds of the yellow pond lily, at Klamath Marsh, Sycan Marsh, Tule Lake, Lower Klamath Lake, and other water bodies. Wocas were an important food resource and shaman conducted a ceremony at the beginning of the harvest. The seeds were processed for soup and flour. Women also collected cattail roots for drying and grinding into meal. During the summer months men hunted waterfowl and a variety of small mammals.

In fall, Klamath and Modoc gathered chokecherries, serviceberries, Klamath plums, pine nuts, blackberries, and gooseberries. Klamath and Modoc eventually moved into the high country of the western Cascades to harvest huckleberries. Women dried the berries before fires, while men hunted deer and elk and trapped furbearing mammals. Deer hunting methods included stalking and driving the animals into the lakes, rivers, or confined spaces where they could be clubbed by women in canoes or shot with bows and arrows. Whitefish were also harvested in the fall primarily by the use of dip-nets.

Klamath and Modoc sought power by visiting places where they believed that sacred beings resided and sought to gain their power through ritualized activities. Klamath and Modoc parents sent boys and girls on a power quest when they reached puberty. Fathers and mourning kinsmen sometimes sought power at the birth of a child or death of a wife or child (Stern 1998). Seekers of power often sought specific competence such as luck in hunting or fishing, war, love-making, gambling, foot-racing, or curing. Seekers of power went alone into the mountains for 5 days to fast, pile rocks, wrestle with trees, run, perhaps take sweat baths, and climb hills. Power might come in the form of a dream or a visit by a spirit, which would be followed by the seeker waking with blood in his mouth or nose and a personalized spirit song in his ears.

Shamans, mourners, and gamblers also sought power by swimming in deep river eddies. During the day, the seeker sweated and fasted, waiting in the brush until nightfall. At that time the power seeker went to the river and dove to the bottom in search of a spirit. The seeker did not appear to be frightened even if he saw something moving under the water. Similar to other power-seeking events, it is reported that sometimes a seeker surfaced from the bottom of the river unconscious, with blood flowing from his mouth and/or nose (Spier 1930).

Shamans performed important ceremonies in midwinter gatherings, first-fruit rites for wocas gathering, and other occasions. They also cured illnesses and provided spiritual and practical support during warfare. Novice shamans received their initiation as a group at midwinter ceremonies. Helpers worked with shamans over a 5-day period during the ceremonies to call spirits, interpret spirit messages, and lead the audience in singing sacred songs.

Euro American expansion into Klamath and Modoc territory had a dramatic effect on their traditional cultural practices. Regardless, The Klamath Tribes exhibited considerable and well-documented persistence in their ceremonial and social traditions, particularly as they related to site-specific and resource-specific traditions. However, in 1954 Congress terminated the reservation and its trust relationship with The Klamath Tribes. The Klamath Tribes retained some rights to resources, but a majority of the tribal members withdrew from the tribe and received a portion of the tribal holdings. The trust account created for the rest of the members was later liquidated. In addition, in 1974 the Federal Government condemned thousands of forest acres that had been part of the Klamath

Reservation so that the forest land could be added to the Winema National Forest (Klamath Tribes 2003).

The Klamath Tribes accomplished restoration of Federal recognition in 1986 and began to rebuild their tribal government, economy, and community. Currently, the tribal Culture and Heritage Department is working to protect, preserve, and enhance traditional cultural values (Klamath Tribes 2003). The Klamath Tribes are also pursuing a variety of economic enterprises through their Economic Self-Sufficiency Plan. (Please refer to 2012 KHSA EIS/EIR Section 3.12 *Tribal Trust* in Appendix V of this EIR for additional information on traditional and current lifeways and the history of Federal recognition.)

Northern Interior California Culture Area

Previous archaeological investigations in the vicinity of the Proposed Project were conducted in response to hydroelectric developments and highway construction projects beginning in the 1940s. These early archaeological investigations contain limited general information on the cultural chronology of lands in the vicinity of the Proposed Project. However, the investigations of Basgall and Hildebrandt (1989) and Cleland (1997a,b) in the northern Sacramento River Canyon do offer information on cultural chronology of lands in the Sacramento River Canyon which can provide additional insights to cultural chronology of lands in the Proposed Project area because it is likely that the subsistence and settlement patterns identify for the Sacramento River Canyon are similar to the patterns along the Klamath River and within the vicinity of the Proposed Project.

Basgall and Hildebrandt (1989) propose a three-phase cultural chronology for the northern Sacramento River Canyon, which is thought to be similar to the prehistory of the Klamath Basin. These are the Pollard Flat Phase (2,700–5,300 BP), the Vollmers Phase (1,700–4,500 BP), and the Mosquito Creek Phase (1,900 BP to contact). The Pollard Flat Phase appears to represent a forager population that occupied residential base camps for extended periods of time, and is characterized by relatively large projectile points, ground stone tools, anvils, mauls, and net weights. The Vollmers Phase represents populations that were more mobile than those of the previous phase, while still maintaining residential camps, and are characterized by medium size projectile points, ground stone tools, anvils, mauls, and net weights. The Mosquito Creek Phase populations consisted of small groups that practiced a pattern of seasonal migration, and have ben archaeologically characterized by small projectile points, ground stone tools, and the absence of hand stones, milling stones, hammer stones, anvils, mauls, and net weights.

Cleland's (1997a,b) chronology for the Lake Britton area is divided into six periods spanning 7,000 years. The six periods include: Paleo-Indian (prior to 7,500 BP; Early Archaic-A (5,000–7,500 BP); Early Archaic-B (3,900–5,000 BP);

Middle Archaic-A (3,000–3,900 BP); Middle Archaic-B (2,000–3,000 BP); Late Archaic (1,000–2,000 BP); and Emergent (150–1,000 BP).

The Paleo-Indian Period is poorly represented at the Area of Analysis and only sporadic use of the area may have been occurring during this time. Early Archaic Period sites along the Pit River and Klamath River, however, may be associated with an intensification of use of the area. Sites associated with this period are usually on mid-slope terraces and tend to be situated some distance from rivers. This period reflects increased occupation of the area and freshwater mussel shell midden deposits appear at sites suggesting the exploitation of riverine resources.

The Middle Archaic Period is highlighted by a continued increase in the intensity of use of the area and a diversification of the overall settlement pattern. Occupation of the higher terraces above the river continues, but habitation sites also occur closer to the river. The diversified settlement pattern of the Middle Archaic-A Period continues during the Middle Archaic-B Period, but there is increased occupation of sites near the river. The Late Archaic-A Period is characterized by an increase of more riverine sites. This pattern continues into the Emergent-A Period during which occupation of riverine sites intensifies.

Ethnography

Shasta People

The Shasta People are currently represented by various Native American entities including but not limited to the Shasta Nation, Shasta Indian Nation, and the Etna Band of Indians. During separate consultations between the State Water Board and the Shasta Indian Nation and Shasta Nation, tribal representatives provided various historic accounts related to locations, individuals, and significant events permanent to the specific tribe's history and culture. These accounts, and specific tribal histories are included in confidential appendixes of this EIR (Confidential Appendix P and Q). Below is the traditional information provided for the Shasta people based on literary research.

Silver (1978) summarizes ethnographic information regarding Shasta collected by Dixon (1907), Voegelin (1942), and Holt (1946). These sources generally agree that traditional Shasta territory extended north to a point about 20 miles north of Ashland, Oregon, and from Clear Creek on the Klamath River east to Mt. Hebron (Silver 1978, Jester 2016) (Figure 3.12-6). Shasta are members of the Hokan language family (Silver 1978).

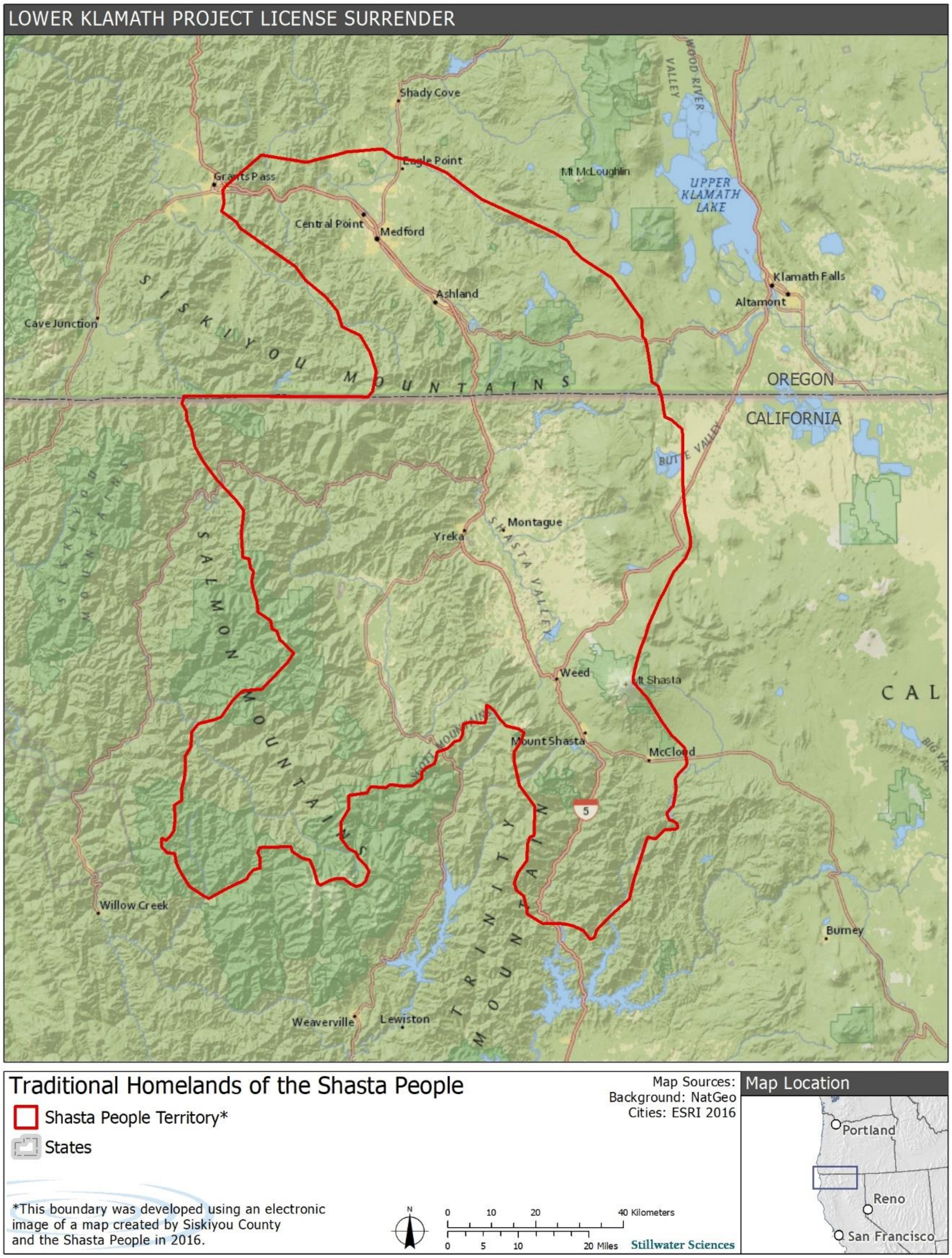

Figure 3.12-6. Traditional Homelands of the Shasta People. Map based on GIS interpretation of traditional Shasta People Homeland map provided by Shasta Nation and Siskiyou County.

There are several groups of Shasta that exhibit different cultural traits. Information presented here focuses on the Klamath River Shasta, called the Wiruhikwaiiruka or Kammatwa (Daniels 2006). Shasta were organized into autonomous tribelets consisting of extended family groups that occupied a group of villages. The family was the basic social unit of the Shasta, with the village being the political and economic unit. Each village had a chief/headman to provide leadership and organize important social, political, and economic events (Silver 1978). Shamans conducted a variety of ceremonies in villages, and the Shasta people considered Mount Shasta to be sacred ground that was used for healing, blessing, and ceremonies. Mount Shasta is a significant part of Shasta traditions and ceremonialism.

Shasta along the Klamath River tended to build their winter villages near the river. Villages had recognized territories with areas for each family, including fishing places with fish weirs along the Klamath. Hunting territories also were held privately over the long term, in contrast to tobacco-growing plots and acorn-gathering trees, which were claimed only for brief periods. Typical villages consisted of brush shelters, bark houses, sweathouses, assembly houses, and winter houses (Silver 1978). The major structures of a Shasta village included the dwelling house (umma), a big house (okwa-umma), the sweat house (wukwu), and the menstrual hut (wapsahumma) (Shasta Indian Nation 2018).

During the spring and summer, Shasta established temporary hunting and gathering camps in the foothills and mountains to make use of seasonally available resources in those ecological zones. Shasta relied on a subsistence pattern emphasizing gathering, hunting, and fishing, and use of a variety of plant and animal resources as they became seasonally available. For example, resources used by the Shasta included deer, brown bear, rabbit, and a variety of small mammals, fish, birds, insects, acorns, buckeye, pine nuts, manzanita berries, and a variety of other plants. Acorns were a staple of the Shasta diet. Regardless of the variety of resources available to the Shasta, the primary components of their diet were deer, Chinook salmon, and acorns (Dixon 1907, Silver 1978).

Individual hunters and communal hunting parties hunted deer using bows and arrows, snares, dogs, and drives (e.g., driving deer over cliffs). Waterfowl and quail were taken using nets, snares, and traps (Moratto 1984). Spring and fall salmon runs were important fishing times for the Shasta. Fishing techniques included a combination of techniques including nets, weirs, spears, and fish drives (Shasta Indian Nation 2018). In the spring, Klamath River Shasta waited to catch salmon until a member of another Shasta Group called the Kammatwa caught the first fish and performed a ritual. Klamath River Shasta could then catch and process the fish for storage but could not eat them until the Karuk performed the White Deerskin Dance ceremony. Salmon and trout were sun dried and stored in baskets for winter consumption (Silver 1978). Women and children also dove for mussels in the Klamath River during the spring.

Shasta traded pine nuts, obsidian blades, and juniper beads with their neighbors for obsidian from the Achumawi; pine nut necklaces from the Wintu; canoes from Karuk and Yurok; acorns, baskets, dentalia shells, haliotis shells, and other shells from the Karuk, Hupa[83], and Yurok; and beads from Wintu (Silver 1978). Shasta also acted as a middleman for the Achumawi, who acquired dentalia shells from groups in the Columbia River area. In addition, Shasta occasionally attended Karuk, Hupa, and Yurok dances.

Euro American settlement into Shasta lands accelerated as a result of the Gold Rush. Conflicts between Indian Tribes and Euro Americans resulted in the Rogue River Indian Wars of 1850–1857 that pushed Shasta from their traditional fishing, hunting, and village sites. A treaty in 1851 established a reservation in Scott Valley for Shasta, but conflict between Euro Americans and Shasta persisted. Consequently, in the 1870s Shasta welcomed cultural revivalist movements such as the Ghost Dance. From the 1870s through the 1940s most Shasta in the vicinity of the Proposed Project lived at the Frain Ranch or Bogus Tom Smith's Rancheria (Daniels 2006) and continued to practice their traditional subsistence activities. Currently, Shasta are represented in the Shasta Nation, Shasta Indian Nation, and the Etna Band of Indians otherwise known as the Ruffey Rancheria. Along with working on federal recognition, through the Ruffey Rancheria Restoration Act (HR 3535, La Malfa 2017), the Shasta people continue to preserve, protect, and maintain traditional cultural practices, including sites associated with those practices.

Northwest California Culture Area

King et al. (2016) identified six patterns or modes of adaptation (i.e., Post, Borax Lake, Berkeley, Mendocino, Tuluwat, and Augustine Patterns) for northwest California and the North Coast Ranges and assigned them to six time periods: Paleo-Indian (10,000–6,000 B.C.); Lower, Middle, and Upper Archaic (6,000 B.C.–A.D. 500); and Upper and Lower Emergent (A.D. 500–1800) periods. The patterns applicable to northwest California are the Post, Borax Lake, Mendocino, and Tuluwat (formerly Gunther).

The Post Pattern (12,000–8,000 BP) represents the earliest occupation of the area and is characterized by fluted, concave-base projectile points and crescents. Regardless, archaeological sites with well-defined assemblage of typical Post Pattern artifacts are not well represented in northwest California.

The Borax Lake Pattern (8,000–2,500 BP) represents a generalized hunting and gathering subsistence pattern. It is characterized by heavy, wide-stemmed points with indented bases, serrated bifaces, ovoid tools, hand stones, and milling slabs (King et al. 2016). The Borax Lake Pattern is identified at sites across a wide variety of environments in Humboldt and Trinity counties along Pilot Ridge and South Fork Mountain and along a river terrace adjacent to the

Trinity River. One archaeological site has a house floor and post holes dated over 7,000 BP (Fitzgerald and Hildebrandt 2001).

The Mendocino Pattern (5,000–1,500 BP) appears to represent a hunting and gathering subsistence pattern that is well adapted to local environments and typically exploits seasonally available resources across different ecological zones. It is characterized by side-notched, corner-notched, and concave base dart points, hand stones, milling slabs, and in some cases small numbers of cobble mortar and pestles. The Mendocino Pattern is not clearly defined in northwestern California, but it has been identified at sites on Point St. George, and along the Smith River, in Humboldt Bay, and in the northern mountains of Humboldt County (King et al. 2016).

The Tuluwat Pattern (beginning about 1,500 years BP) appears to be associated with the exploitation of marine and riverine resources. It is characterized by barbed projectile points, concave based points used for composite harpoons, spears, hooks ground and polished stone artifacts, flanged pestles, notched net sinkers, and steatite bowls. Sites representing this settlement pattern are associated with exploitation of marine mammals and fish and include locations in Del Norte and Humboldt Counties (King et al. 2016). The pattern appears to represent the earliest evidence of subsistence patterns associated with the exploitation of marine mammals and fish that is typical of the Yurok, Hupa, and Karuk that currently inhabit northwest California and the Klamath Basin.

Ethnography

Karuk

Bright (1978) summarizes ethnographic information regarding Karuk primarily from information presented by Gifford (1939a,b; 1940) and Kroeber and Barrett (1960). Karuk occupy territory west of the Shasta, which stretches along the Middle Klamath River near the western boundary of Siskiyou County from Seiad to Bluff Creek just west of Orleans (Bright 1978). Additionally information on Karuk ethnography include the works of John Salter and Craig Tucker (2010) and Thomas King (2004) In 1979, the Karuk Tribe re-established a government to government relationship with the United States (Karuk Tribe 2019). Karuk are members of the Hokan language family (Bright 1978). Karuk share similar cultural traits with the Yurok and Hupa and regularly interact with each other.

Karuk were organized in villages with a relatively loose political structure. The acquisition of wealth is an important part of Karuk culture, and wealthy men assumed leadership roles because of their prestige. Villages varied in size and consisted of rectangular cedar plank houses and sweat houses. Karuk focused on the use of fish and aquatic resources, but other terrestrial resources were also important supplements to their diet. Karuk also harvested acorns and hunted in upland areas around the Klamath River for deer, elk, birds, and fur bearing mammals. The hides of mammals were used for a variety of clothing and bird feathers and pelts were used for ceremonial regalia.

Plentiful fish resources facilitated the occupation of numerous villages along the Klamath and Salmon Rivers (i.e., Salter [2003] reports that 100 villages existed along the two rivers). The villages were in advantageous locations on bends of the Klamath River and bluffs above it, such as near the mouths of Camp Creek (Tishawnik), the Salmon River (Mashuashav), and Clear Creek (Inam).

Archaeologically, Karuk tools reflect their emphasis on the acquisition of fish and other aquatic resources and include harpoons, nets, and hooks. Facilities constructed to harvest fish include weirs, dams, and fishing platforms. Karuk also constructed canoes from hollowed out logs for fishing and transportation along the Klamath River and its tributaries. Transportation along the river and streams was essential to Karuk ceremonial activity. Indeed, Karuk traditions state that the Klamath River was created to facilitate their interaction with Yurok and Hupa and with salmon.

The political and social organization and material cultural of the Karuk are important topics, but their religious and ceremonial practices highlight their relationship to the Klamath River and its associated resources. Of particular importance are world renewal ceremonies and ceremonies for bountiful harvests of fish and other resources (Bright 1978). World renewal ceremonies include the White Deerskin and Jump ceremonies at which the earth and the creator are honored for providing food and facilitating the prosperity of the tribes. These ceremonies were and continue to be conducted at sites along the Klamath River such as Panamnik (Drucker 1936, Verwayen and Hillman 2010). Ceremonies to insure harvests of fish include the First Fish, First Salmon, and Fish Dam ceremonies. Other ceremonies related to world renewal and curing are the Boat Dance and the Brush Dance. Karuk, Hupa, and Yurok regularly attend each other’s ceremonies and the ceremonies are conducted for the benefit of all the groups.

The White Deerskin and Jump ceremonies honor the earth and the creator for providing food resources and maintaining the tribes. The White Deerskin ceremony is held from late August into September, depending on the river and its waters. The Jump ceremony is conducted after the conclusion of the White Deerskin ceremony and is also held for the “good” of the world. Both the White Deerskin and the Jump ceremonies depend on a healthy Klamath River system for fish, basket materials, and bathing. The First Fish ceremony is conducted in spring and the Fish Dam ceremony is conducted to in mid-summer to celebrate the harvesting of fish and to pray for continuing prosperity and access to subsistence resources, primarily fish resources. The Boat ceremony forms part of the White Deerskin ceremony, celebrating the flows and health of the rivers. The Brush Dance is held to cure the sick, particularly children.

Euro American settlement in the Area of Analysis for historical and tribal cultural resources accelerated as a result of the California Gold Rush. Conflicts between Indian Tribes and Euro Americans were commonplace across Karuk territory. Consequently, Karuk welcomed cultural revivalist movements in the 1870s such as the Ghost Dance, but traditional cultural practices and numbers of Karuk continued to decline. Regardless, the Karuk persisted and contemporary Karuk continue to practice their traditional activities and are actively engaged in programs related to improving the health of the Klamath River and its fishery.

Quartz Valley Indian Community

The Quartz Valley Community is a federally recognized tribe mainly representing people of Karuk and Shasta ancestry, with 174 acres of reservation lands in the Scott Valley, near Fort Jones, California. The Quartz Valley Indian Community's reservation lands are located near the community of Fort Jones. The Quartz Valley Indian Community initially filed their constitution and bylaws with the Office of Indian Affairs in 1939 (DOI 1939).

Yurok

Pilling (1978) summarizes ethnographic information regarding Yurok collected by Waterman (1920), Waterman and Kroeber (1934), and others. Sloan (2003, 2011) also presents a summary of the ethnography of the Yurok and the relationship to the tribe to the Klamath River. Yurok are members of the Algonquian language family. Per the Yurok Tribe's constitution (Yurok Tribe 1993), the Ancestral Lands of the Yurok Tribe extend unbroken along the Pacific Ocean coast (including usual and customary off-shore fishing areas) from Damnation Creek, its northern boundary, to the southern boundary of the Little River drainage basin, and unbroken along the Klamath River, including both sides and its bed, from its mouth upstream to and including Bluff Creek drainage basin. Included within these lands are the drainage basin of Wilson Creek, the drainage basins of all streams entering the Klamath River from its mouth upstream to and including the Bluff Creek and Slate Creek drainage basins, including the village site at Big Bar (except for the drainage basin upstream from the junction of Pine Creek and Snow Camp Creek), and the Canyon Creek (also known as Tank Creek) drainage basin of the Trinity River, the drainage basins of streams entering the ocean or lagoons between the Klamath River and Little River (except for the portion of the Redwood Creek drainage basin beyond the McArthur Creek drainage basin and except for the portions of Little River drainage basin which lies six miles up from the ocean) (Yurok Tribe 1993). The Yurok Tribe's reservation currently consists of a strip of land beginning at the Pacific Ocean and extending a mile along each side of the Klamath River approximately 45 miles.

The Yurok life, language, ceremonies, society, and economy are linked with the Klamath River. There are Yurok stories that reinforce the Yurok belief that the River was created in a distinct way in order to provide Yurok people with the best of worlds (Sloan 2003, 2011). Yurok refer to the river as HeL kik a wroi or "watercourse coming from way back in the mountains." Contemporary Yurok often refer to the Klamath River as the "Yurok Highway" emphasizing its comparison to a blood vessel that provides the main flow of sustenance. Karuk, Yurok, and Hupa share similar cultural traits and traditional stories state that the Klamath River was created to facilitate their interaction with each other and with salmon.

The Yurok had permanent settlements with substantial architectural features including houses, smokehouses, and storage facilities (Kroeber and Barrett 1960, Pilling 1978). Pilling (1978) cites 44 villages, 97 fishing spots, 82 significant cultural places (e.g., places used for ceremonies, gathering, and hunting), and 41 places of cultural significance along the Klamath River in Yurok territory. The Yurok Tribe has documented over 70 villages in its ancestral territory

The Yurok represent a socially complex hunter-gatherer population in California (Fredrickson 1973, Kroeber 1925) that used marine and salmon resources. Organizing labor to capture the short-duration salmon runs, preserving fish by smoking, then packing and storing the fish suggests a high degree of sociopolitical differentiation. There is also evidence of a maritime expression to Yurok culture involving marine mammal hunting more than 10 miles offshore. The most telling argument for an open-ocean maritime adaptation comes from the presence of the large amount of northern fur seal fauna in the Stone Lagoon midden. Hildebrandt and Jones (1992) argued that pinnipeds were extirpated early on shore by Native Americans, who then developed watercraft to hunt offshore.

The material culture of the Yurok people includes, to this day, dugout redwood canoes, split-plank houses, storage boxes, sweathouse pillows and stools, many fishing devices, baskets and leather, shell, straw and feather garments and ceremonial regalia.

Transportation along the rivers and streams is essential to Yurok ceremonial activity. One of the most important aspects of Yurok technology was the river- and ocean-going canoe or yoch, which were carved from selected redwood trees (Sloan 2003, 2011). There are historic accounts of expeditions traveling up to 180 miles along the coast (Sloan 2003, 2011). A typical river canoe measured 16 to 20 feet in length and 3 to 4 feet in width. River canoes were customarily paddled and/or pushed with a long pole. Yurok technology and facilities do not only serve utilitarian functions, but also include ceremonial aspects of Yurok culture. For example, facilities, such as fishing weirs, were created specifically to signify the time of sacred ceremonies (e.g., the White Deerskin and Jump ceremonies).

Fishing places along the Klamath River are owned by individuals, families, or groups of individuals. Fishing places can be borrowed, leased, inherited, or bought and sold (Sloan 2003, 2011). Some ownership rights at fishing places depended on species of fish caught at the site, while others depended on the water level (i.e., individuals owned the right to fish at a place if the river was below or above a certain level). Yurok still recognize this traditional form of resource management and use of the river. Families and individuals continue to use and own rights to fishing places on the Klamath River.

Like the Karuk, the religious and ceremonial practices highlight the Yurok relationship to the Klamath River and its associated resources. Of particular importance were the Jump, White Deerskin, Boat, and Brush ceremonies. The Jump and White Deerskin ceremonies were held in late fall to give thanks for food resources abundance collected during the year and to insure a continued abundance of food resources for the next year (Sloan 2003, 2011). Affluent individuals and religious leaders conduct most ceremonies, and wealthy individuals were expected to feed salmon to everyone attending the ceremonies.

The Boat Ceremony is part of the White Deerskin Ceremony. In this ceremony, several boats filled with participants travel down the Klamath River. The participants thank the river for continuing to flow and provide resources. The Brush Ceremony unfolds over a four-day period and highlights the importance of Klamath River resources to Yurok. For example, baskets made of plant materials collected at the water's edge are used to hold food and ceremonial medicine; acorns are cooked in the baskets using cooking stones gathered at specific river bars; ceremonial regalia is made from various plant and animals that live along the river; ceremonial bathing is performed; and participants listen to the sounds made by the Klamath River (King 2004).

The social and ceremonial significance of the Klamath River is evident in and reinforced by Yurok traditions. For example, there are at least 77 Yurok stories that make direct reference to the Klamath River (Sloan 2003, 2011). These Yurok stories reinforce the belief that the Klamath River was created to provide Yurok with a very good place to live.

Spanish explorers and vessels traveling from the Philippines may have interacted with Yurok along the coast in the late 1700s. According to the Yurok Tribe, both the Bodega and Vancouver expeditions visited the village of Tsuri (Yurok Tribe 2019). Other explorers such as Peter Skene Odgen and Jedediah Smith certainly encountered Yurok along the Klamath River in the early 1800s. Regardless, Euro American settlement and use of Yurok territory did not begin until after the discovery of gold in California in early 1850. With strikes along the Klamath and Trinity rivers, gold prospectors inundated the region affecting Yurok traditional culture (Pilling 1978).

In 1851 a "Treaty of Peace and Friendship" was signed between the United States Government and the Klamath River Indians, but the United States Congress did not ratify this treaty. Subsequently, on November 16, 1855, the

Klamath River Reserve, also known as the Klamath Indian Reservation, was established by Executive Order. The Order designated the reservation lands from the mouth of the Klamath River, one mile on each side extending approximately 20 miles upriver to Tectah Creek (Sloan 2003, 2011).

Escalating conflict between Yurok and Euro Americans during the 1860s and 1870s over encroachment onto the Klamath Indian Reservation resulted in the displacement of Lower Klamath Indians further upriver (Sloan 2003, 2011). Euro Americans on the reserve resisted attempts to remove them, including eviction in 1879 by the United States Army (Sloan 2003, 2011). After decades of struggle to regain their traditional homelands, the Yurok Tribe was re-organized and was granted its own reservation in 1988. As a result of the 1988 Hoopa-Yurok Settlement Act (PL-100-580), the Yurok Indian Reservation was established.

The ancestral lands of the Yurok Tribe extend unbroken along the Pacific Ocean coast (including usual and customary off-shore fishing areas) from Damnation Creek, its northern boundary, to the southern boundary of the Little River drainage basin, and unbroken along the Klamath River, including both sides to the associated tributary watershed boundaries from the mouth upstream to the Bluff Creek drainage basin. The Yurok Tribe considers cultural resources sites along and associated with the Klamath River to be part of a larger ethnographic riverscape (King 2004, Yurok Tribe 2012). Sites include fishing areas; a fish dam (weir) site; many different types of resource gathering sites, complex trail systems that connect villages, camps, the river, ceremonial sites, gathering areas, and other Tribes; and 47 villages with graves/cemeteries.

The Yurok Tribe is the largest tribe in California, with over 4,500 enrolled tribal members and over 200 tribal government employees. The Yurok Tribe is actively pursuing economic development and management of fisheries, forestry, and cultural programs, both on the reservation and Yurok ancestral lands.

Resighini Rancheria

The Resighini Rancheria is a federally recognized Tribe of Yurok people. Their reservation is located on the southern banks of the Klamath River Estuary. The tribe shares a cultural history to that of greater Yurok culture, as described above. Land known as the Resighini Rancheria was designated by Secretarial Order and was officially declared a reservation in 1939, within the original Klamath River Reservation. In 1975, a group of Yuroks stood together and formally created a non-traditional form of government with a constitution and bylaws which was approved and ratified by the Department of Interior of the United States. The Tribe asserts that it maintains fishing and water rights in the lower Klamath Basin and strive to protect fishing, wildlife, forestry, surface water, groundwater, and other trust resources. Please note that Volume II, Appendix V *KHSA 2012 EIS/EIR* Section 3.12 *Tribal Trust* does not include all asserted trust resources of the Resighini Rancheria (M. Van Pelt, Resighini Rancheria, pers. comm., March 2019)

Today, the tribal government consists of a General Council comprised of tribal members over age eighteen (18), with an elected Tribal Council to operate the governmental and private tribal affairs, as well as represent the tribal needs. The Tribal Council consists of five tribal members who are elected annually by staggered two-year terms of Chairperson, Vice Chairperson, Secretary, Treasurer and Councilperson. Their General Council serves on boards, committees, commission and corporations to assist the Tribal Council.

Hoopa Valley Tribe

Wallace (1978) summarizes ethnographic information regarding Hupa primarily collected by Goddard (1903). Hupa are members of the Athabascan language family and they call themselves Natinixwe. Hupa ancestral territory is centered in Hoopa Valley and the area surrounding the Trinity River near its confluence with the Klamath River. Hupa, Karuk, and Yurok share similar cultural traits and regularly interact with each other.

Hupa were organized in villages with a relatively loose political structure. Villages typically consisted of family groups (Wallace 1978). Villages varied in size and consisted of rectangular cedar plank houses. For substances, traditional Hupa people primarily used fish and aquatic resources, but also utilized terrestrial resources such as mammals, birds, reptiles, insects, and other fauna (Wallace 1978). Hupa also harvest acorns and hunted in upland areas around the Trinity and Klamath River for deer, elk, birds, and fur-bearing mammals. The hides of mammals were used for a variety of clothing and bird feathers and pelts are used for ceremonial regalia.

Hupa tools reflect their emphasis on the acquisition of fish and other aquatic resources and include harpoons, nets, and hooks. Facilities constructed to harvest fish include weirs and dams. The Hupa used canoes for fishing and transportation along the Trinity and Klamath rivers but obtained their canoes from the Yurok. Transportation along the river and streams was essential to Hupa ceremonial activity.

Like the Karuk and the Yurok, the Hupa’s religious and ceremonial practices highlight their relationship to a river, the Trinity River, and its associated resources. Of particular importance are world renewal ceremonies and ceremonies for bountiful harvests of fish and other resources (Wallace 1978). World renewal ceremonies include the White Deerskin and Jump ceremonies at which the earth and the creator are honored for providing food and facilitating the prosperity of the tribes. Ceremonies to ensure harvests of fish and acorns include the First Salmon ceremony and Acorn Feast (Wallace 1978). Hupa, Karuk, and Yurok regularly attend each other’s ceremonies and the ceremonies are conducted for the benefit of all the groups.

Euro American settlement of the as a result of the Gold Rush, ultimately resulting in the establishment of the original Hoopa Valley Reservation in 1864. President Harrison expanded the Hoopa Valley Indian Reservation in 1891 to include the Klamath River Reserve that extended one mile on either side of the Klamath River from the Pacific Ocean for 22 miles upstream, as well as the lands one mile on either side of the river between the two reservations (Salter 2003). The 1988 Hoopa-Yurok Settlement Act (PL-100-580) divided the reservation again, separating it into the Hoopa Valley Reservation and the Yurok Indian Reservation (Salter 2003).

The culture of Karuk, Hupa, and Yurok is closely tied to the Klamath and Trinity Rivers. These tribes subsist wholly or in large part on the resources acquired from the river, most of their sacred sites are located along it, and their cultural traditions are related to it (Bright 1978, Pilling 1978, Wallace 1978). Contemporary Hupa practice their traditional activities and are actively engaged in programs related to improving the health of the Trinity River and its fishery.

3.12.2.2 Historic Period

Euro American exploration of the Klamath region began in the early 19th century. Jedediah Strong Smith and Peter Skene Ogden explored current Siskiyou and Klamath County in 1826 and 1827 for beaver as part of fur trade, and in 1829 a party of Hudson Bay Company trappers and explorers, led by Alexander Roderick McLeod, also passed through the area (Klamath Hydroelectric Project 2004). The fur trade ended in the mid-1840s. Largely, the area remained sparsely occupied by Euro Americans until the mid-1800s, when mining and logging attracted settlers to the area.

The discovery of gold at Sutter’s Mill in Coloma in 1848 was the catalyst that caused a dramatic alteration of both Native American and Euro American cultural patterns in California. A flood of immigrants entered the California and the Klamath region once news of the discovery of gold spread. Initially, the Euro American population grew slowly, but soon exploded as the presence of large deposits of gold were confirmed. The non-Native American population of California quickly swelled from an estimated 4,000 Euro Americans in 1848 to 500,000 in 1850 (Bancroft 1888). The discovery of gold and the large influx of primarily Euro American immigrants had a positive effect on the growth and economic development of California as a state, but a negative effect on Native American cultures. The discovery of gold in California marked the beginning of a relatively rapid decline of both Native American populations and culture. The influx of primarily European Americans displaced Native Americans from their traditional territory, discouraged the use of traditional languages and the practice of religious ceremonies, and Euro American economic pursuits (e.g., gold mining, logging, ranching, and farming) limited the practice of traditional subsistence activities.

Gold was discovered by Abraham Thompson and his party just north of the present-day location of the City of Yreka in 1851 (Hoover et al. 2002). Known as "Thompson's Dry Diggins", the population quickly exploded to 2,000 miners, and the town of Shasta Plains was established (Hoover et al. 2002). The town primarily included tents and brush shanties, but also included a saloon built out of shakes and canvas by Sam Lockhart. The first permanent house in the town was built by D.H. Lowry and his wife.

Euro American settlement in the Klamath River watershed continued to grow through the 1850s due to the completion of roads such as the Southern Emigrant Road, also known as the Applegate Trail, in 1846 (Klamath Hydroelectric Project 2004). These roads brought prospectors to the region and helped to establish communities such as Henley (Cottonwood), Gottville, Happy Camp, and Somes Bar. Fertile soil and plentiful water sources provided opportunities for homesteading and the private development of agriculture and ranching, particularly in the area around current Upper Klamath Lake, but also extending downriver, occupying the rich alluvial terraces along the river through the canyon. The expansion of Euro Americans in southeastern Oregon resulted in execution of treaties with the various Klamath River tribes and the relocation of these groups in the area (Klamath Hydroelectric Project 2004). Shasta women married into ranching families at this time and are recognized as being instrumental in the tribes' long-term survival today.

Logging began in the Klamath Basin in the 1860s and sustained logging enterprises appeared in the 1880s (Klamath Hydroelectric Project 2004). Early companies were generally small, family-run operations managed by ranching families trying to supplement their income. In 1867, President Ulysses S. Grant signed legislation to create a land-grant subsidy for the construction of the Oregon and California Railroad (Klamath Hydroelectric Project 2004). The grant allowed the Oregon and California Railroad Company to select off-numbered sections from the public domain for the construction of the railroad. In 1887, the Oregon and California Railroad Company claimed "lieu" lands on the Pokegama Plateau as compensation for other lands that had already been claimed by homesteaders or military and wagon road companies. Title to these lieu lands were immediately (and illegally) transferred to the Pokegama Sugar Pine Lumber Company. To move the logs from the Pokegama Plateau, the Pokegama Sugar Pine Lumber Company built a log chute on the rim of the Klamath River Canyon and the first railroad in Klamath County (Gavin 2003). During this period, larger scale logging companies such as Pokegama Sugar Pine Lumber Company and Klamath River Lumber and Improvement Company were established on the north rim of the Klamath River Canyon.

The end of the nineteenth and beginning of the twentieth centuries witnessed an ongoing and growing immigration into the area, which was facilitated by the construction of the railroad through the region. The railroad provided a reliable means of transportation in the area and stimulated regional cultural and economic development. In addition to improving transportation, a railroad grade constructed at the northern end of Lower Klamath Lake functioned as a dike that facilitated drainage of wetlands for agriculture and control of the flow of water from the Klamath River.

The Oregon and California Railroad constructed in 1877 was the first railway through the region (Klamath Hydroelectric Project 2004). It extended from Siskiyou County, California, to Jackson County, Oregon, and facilitated travel and the transport of goods between Sacramento and Portland. Subsequently, the Southern Pacific Railroad Company acquired the Oregon and California Railroad, and by 1909 agricultural and lumber products of the Klamath Basin could be distributed to a nationwide market.

The first hydroelectric development in the Klamath Basin was established in 1891 in the Shasta River Canyon below Yreka Creek to provide electricity to the City of Yreka (Klamath Hydroelectric Project 2004). Four years later, in 1895, the Klamath Falls Light & Water Company built a power plant along the banks of the Link River and soon thereafter began power generation for the town of Klamath Falls (Klamath Hydroelectric Project 2004). The first decade of the 20th century brought a number of mergers and reorganizations of power companies in the specific project reach of Klamath River canyon currently under study. The California-Oregon Power Company (COPCO) was one of the companies that emerged from this period of reorganization (Klamath Hydroelectric Project 2004). The USBR's Klamath Irrigation Project, authorized in 1905, was developed by the DOI to supply farmers with irrigation water and farmland in the Klamath Basin. Link River Dam is the principal source of water for Reclamation's Klamath Project and the irrigation system and serviced areas are situated upriver of the Proposed Project.

COPCO proposed to develop hydroelectric power facilities along the Klamath River. Residents in the Klamath Falls area were divided over COPCO's proposal to dam and generate power on the river. Farmers feared the depletion of precious irrigation water while other businesses saw COPCO operations as an addition to the local economy. Regardless, with the increasing power needs of both irrigation and lumber mills and a huge influx of military personnel stationed at Medford and Klamath Falls, it was only a matter of time before additional power generation facilities were needed in the area. Envisioned in 1911, the Klamath Hydroelectric Project (Klamath Hydroelectric Project) was built in phases through 1962 (Kramer 2003a,b). Klamath Hydroelectric Project facilities were constructed by COPCO beginning with Copco No. 1 Dam (1918), followed by Copco No. 2 Dam (1925), and reconstruction of the old East Side facility in 1924. After World War II, regional population growth prompted a new round of hydroelectric power expansion highlighted by COPCO's Big Bend project (J.C. Boyle Dam and powerhouse) in 1958 and the construction of the Iron Gate facilities in 1962. While the Iron Gate facilities were still under construction, COPCO merged with Pacific Power & Light, currently PacifiCorp. PacifiCorp currently owns and operates the Klamath Hydroelectric Project.

The development of the Klamath Hydroelectric Project played a significant role in the area's economic change, both as part of a regionally significant, locally owned and operated private utility and through the role that increased electrical capacity played in the expansion of the timber, agriculture, and recreation industries during the first six decades of the 20th century. Such, continuing industrial expansion in the region also contributed to the ongoing displacement of Native Americans from their traditional territory and the associated fishing, hunting and gathering economies, as previously noted. The Klamath Hydroelectric Project dams and associated facilities are recommended as eligible for inclusion on the National Register of Historic Places (NRHP) as the Klamath Hydroelectric Historic District (KHHD) under Criterion A for its association with the industrial and economic development of southern Oregon and northern California from 1903–1962 (Kramer 2003a,b; Cardno Entrix 2012). Economic development continues in the region, but it is now driven by tourism and recreation rather than gold mining, agriculture, or logging.

3.12.2.3 Known Tribal and Historical Resources in the Vicinity of the Proposed Project

Summary of California Historical Resources Information System Record Searches

In 2017, the KRRC conducted an updated records search at the California Historical Resources Information System's Northeast center at Chico, State University, for a study area that includes the length of the Klamath River from the Oregon-California state line, 40 miles downstream to Humbug Creek. The section of river below Iron Gate Dam (the most downstream Lower Klamath Project dam) was included in the records search since this 18-mile long area lies within the altered FEMA 100-year floodplain following dam removal, where cultural resources have the potential to be affected. The records search area included a 0.5-mile wide buffer, extending on either side of the shorelines of Copco No. 1 Reservoir and Iron Gate Reservoir, and from the center point of the Klamath River in all other areas.

The KRRC's 2017 record search compliments the cultural resource record searches previously performed as part of the Klamath Hydroelectric Project Relicensing (FERC 2007) and 2012 KHSA EIS/EIR studies (PacifiCorp [2004] and Cardno Entrix [2012]).

The records search included gathering archaeological site forms, survey and excavation reports, maps, and other records. Survey and site locations were hand plotted onto USGS topographic maps at the Northeast Information Center. Research of historic registers included the California Historic Landmarks, National Register of Historic Places (NRHP), California Register of Historical Resources, California Points of Historical Interest, California Inventory of Historic

Resources, and the California State Historic Resources Inventory. In April 2017, the KRRC visited the Klamath National Forest office and the Siskiyou County Museum, both in Yreka, California to collect additional historic information. Klamath National Forest Heritage Program Manager Jeanne Goetz conducted a search of records for Forest Service lands within or near the KRRC records search area and provided appropriate archaeological site record forms (Appendix B: *Definite Plan – Appendix L*).

The KRRC also conducted a background literature search to identify known cultural resources and also to determine the types of cultural resources likely to occur within the area of the Proposed Project. In addition, online newspaper archives were searched, including the National Digital Newspaper Program archives provided by the Library of Congress and National Endowment for the Humanities (https://chroniclingamerica.loc.gov/); Genealogy Bank newspaper archives provided by NewsBank, Inc. (www.geneaologybank.com); the California Digital Newspaper Collection repository provided by University of California, Riverside (https://cdnc.ucr.edu/); and newspaper archives provided by www.Ancestry.com.

In May 2017, the KRRC obtained cultural sources data from PacifiCorp, including GIS shapefiles with previous survey and resource locations, as well as a copy of the final cultural resources technical report prepared for Klamath Hydroelectric Project relicensing (PacifiCorp 2004). In addition, the KRRC contacted Dr. Joanne Mack, Professor Emeritus at Notre Dame University, a primary researcher in the Upper Klamath Basin, to discuss the Proposed Project and to learn of her on-going research in the area that might not be reflected in published or unpublished literature. The KRRC also consulted with Dr. Brian Daniels, Director of Research and Programs for the Penn Cultural Heritage Center at the University of Pennsylvania Museum, regarding ethnographic information, archival documents, and oral histories pertaining to tribal cultural resources within the California records search area.

The KRRC contacted the Native American Heritage Commission in June 2017, to secure a review of the Sacred Lands file for a 0.5-mile wide area on either side of the Klamath River corridor, extending from the California-Oregon state line downstream to the Pacific Ocean. In a June 14, 2017 letter, the Native American Heritage Commission stated that there was a positive result, with the recommendation to contact the Karuk Tribe, Yurok Tribe, and Shasta Nation. The Native American Heritage Commission also provided a consultation list of 29 tribes with traditional lands or cultural places located within the boundaries of Del Norte, Humboldt, and Siskiyou counties.

The KRRC records search and literature review (Appendix B: *Definite Plan – Appendix L*) identified that 58 previous cultural resources investigations have been conducted within the records search study area, with five studies (Kramer 2003a,b; Cardno Entrix 2012; Durio 2003; PacifiCorp 2004) completed specifically for the Proposed Project (Appendix B: *Definite Plan – Appendix L*). Several of these studies are archaeological, ethnographic, or historical overviews, while others describe the findings of specific archaeological excavations.

The majority of the past surveys involve pedestrian field survey and cultural resources monitoring. Overall, an estimated 8,189 acres of federal, state, and/or private land have been previously surveyed within the records search area and except for some proposed disposal sites, encompasses the current boundaries of the Proposed Project.

The KRRC California record searches identified 206 previously recorded cultural resources, consisting of 120 archaeological sites,1 ethnographic property, 9 built environment resources, 68 isolated finds, and 8 resources of an undetermined resources type (Appendix B: *Definite Plan – Appendix L*). By type, these resources include 114 prehistoric, 59 historic-period, 23 multiple-component (prehistoric and historic period), 1 ethnographic property, and 9 resources whose temporal association is unknown.

Section 6.1.6 of Appendix L of Appendix B: *Definite Plan* states that KRRC will examine compiled data and assess them to identify missing information such as gaps in survey coverage within the Limits of Work. Section 6.2.2 of Appendix L of Appendix B: *Definite Plan* indicates that disposal site areas that were not previously surveyed were subject to pedestrian surveys in 2017. More specifically, in July 2017, KRRC conducted a cultural resources pedestrian survey inventory of approximately 27 acres at the Iron Gate Dam disposal site. The inventory identified one historic-period archaeological site (LKP-RB-1) and one historic-period isolated find (LKP-EN1-IF). In addition, the KRRC will identify any other land-based areas within the limits of work that were not previously inventoried for cultural resources and subject them to pedestrian surveys to provide intensive coverage of all direct impact areas associated with the Limits of Work. The CRWG also may identify additional survey areas located outside the limits of work for pedestrian surveys as part of its ongoing efforts to develop the Proposed Project Area of Potential Effects (APE) (Section 106). Conducting pedestrian surveys to encompass the entire area of analysis and updating any pedestrian surveys that were not conducted within the last 5-10 years would be unduly burdensome and is not required by CEQA.

Archaeological Sites

The known archaeological sites on file at the Northeast Information Center represent roughly 60 percent of the previously recorded resources along the Klamath River from the Oregon-California state line to Humbug Creek. The sites consist of 49 prehistoric, 48 historic-period, and 23 multiple-component (both historic and pre-historic at the same location) sites. Identified prehistoric period sites include villages; campsites; lithic scatters; lithic scatters with associated cultural features; toolstone quarries; a possible ceremonial site with multiple features; and a human burial site.

The historic-period archaeological sites consist of late-nineteenth or early-twentieth century properties associated with the development of agriculture, including settlements or features such as homesteads; logging; mining; commercial; public works (hydroelectric); and transportation. Agricultural-related sites include settlements (homesteads), irrigation ditches, rock features, and artifact scatters.

Logging-related sites focus on elements of the former Klamathon townsite, including the town and lumber mill and the associated Pokegama log chute and ditch flume. Mining related sites, located in the Klamath River area below Hornbrook, include two quartz mines and four placer mines with ditches and/or tailings. The Beswick Hotel, ranch, and Klamath Hot Springs area represents the single commercial property. An extensive refuse scatter associated with the Copco No. 1 Village is the sole public works site. Finally, transportation-related sites consist of an abandoned segment of the Klamath Lake Railroad, a collapsed trestle and segment of railroad grade, a segment of Topsy Road, a road leading to Horseshoe Ranch, and a segment of the California-Oregon Stage Road.

The multiple component sites include both prehistoric and historic-period components. Prehistoric components associated with these sites include housepit villages, a housepit village with a documented historic-period cemetery, lithic scatters, a toolstone quarry, and a rockshelter. Historic-period components comprise mining camps and/or tailings features, agricultural related resources such as historic ranches and artifact scatters, and a possible commercial property associated with a former saloon.

Table 3.12-1. Non-confidential Historic–period Cultural Resources within the Area of Analysis.[1]

Primary No.	State Trinomial	Resource Type	Site Type	General Vicinity	NRHP Eligibility
P-47-000522	CA-SIS-522	Site	Empire Quartz Mine	below IGR	7
P-47-000536	CA-SIS-536H, CA-SIS-1315H	Site	Klamathon Townsite and Lumber Mill	below IGR	7
P-47-001671	CA-SIS-1671H	Site	Klamath Lake Railroad Grade	on hillslope	7
P-47-002129	CA-SIS-2129H	Site	Grieve-Miller-DeSoza Ditch	on hill slope	3
P-47-002239	CA-SIS-2239H	Site	COPCO II Ranch Features	on hill slope	4S2
P-47-002266	CA-SIS-2266H	Built Environment	Copco II Powerhouse	Copco Dam	3S
P-47-002267	CA-SIS-2267H	Built Environment	COPCO I Powerhouse and Dam	Copco dam	3S
P-47-002268	CA-SIS-2268H	Built Environment	Fall Creek Powerhouse	Fall Creek	3S
P-47-002823	CA-SIS-2823H	Built Environment	COPCO II Wooden Stave Penstock	In between Copco and IGR	3S
P-47-002824	CA-SIS-2824H	Site	COPCO Guest House	Copco dam	3S
P-47-003917	CA-SIS-3917H	Site	Refuse Scatter	Copco Dam	7
P-47-003922	CA-SIS-3922H	Site	COPCO Village Dump	Copco Dam	7
P-47-003934	CA-SIS-3934H	Site	Historical Cairns	edge of IGR	7
P-47-003937	CA-SIS-3937H	Site	Rock Wall	below IGR	7
P-47-003940	CA-SIS-3940H	Site	Franklin Homestead	edge of IGR	7
P-47-003942	CA-SIS-3942H	Site	Rock wall	edge of IGR	7
P-47-003943	CA-SIS-3943H	Site	Rock Wall	on hill slope	7
P-47-003945	CA-SIS-3945H	Site	Historical Cairns	edge of IGR	7
P-47-004212	N/A	Built Environment	Bridge	below IGR	7
P-47-004427	N/A	Site	Habitation with Artifact Scatter and Features	below IGR	7

Primary No.	State Trinomial	Resource Type	Site Type	General Vicinity	NRHP Eligibility
N/A	N/A	District	Klamath River Hydroelectric Project District	Lower Klamath Project facilities and associated structures	7
LKP-RB-1[2]	--	Site	Historic-period Archeological Site	Iron Gate Dam Disposal Area	
LKP-EN1-IF[2]	--	Isolated Find	Historic-period Isolated Find	Iron Gate Dam Disposal Area	

1 Table 3.12-1 was developed based on Table 3.5-3 3 Previously Recorded Archaeological Sites and Built Environment Resources in the KRRC's September 30 CEQA Technical Submittal. Table 3.5-3 is included as Appendix W of this EIR, and is available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/table3.5_3.pdf

2 Based on KRRC 2017 pedestrian surveys (Appendix B: *Definite Plan*, Section 6.2.2 of Appendix L.

* National Register of Historic Places (NRHP) Eligibility from Cardno ENTRIX (2012) and/or NEIC site records:

- 3: Appears eligible for listing in the National Register of Historic Places;
- 3S: Appears eligible for separate listing;
- 4S2: May become eligible for separate listing in the National Register of Historic Places when more historical or architectural research is performed on the property;
- 7: Not evaluated.
- 8. Eligibility determinations were not made for all historic-period cultural resources listed in this table, but all historic-period cultural resources listed in this table are considered during impact analysis evaluation.

The site recorded solely as an ethnographic property consists of a natural rock landform in the Iron Gate area that features prominently in the cultural history of Shasta tribes. A group of eight sites, termed the Pollock Sites, represents undetermined site components.

Information provided in Table 6-8 in Appendix B: *Definite Plan – Appendix* L regarding the National Register of Historic Places eligibility of the archaeological sites is based on recommendations provided by Cardno Entrix (2012), or by eligibility information noted on site records that were not part of the Cardno Entrix study. Overall, one site is listed in the National Register of Historic Places as a contributor to a district, one site is individually eligible, three sites are contributors to a district, determined eligible, 29 sites appear eligible for listing, 2 sites might become eligible for listing when more historical research is performed; 4 sites have been found ineligible, and the remaining 80 sites have not been evaluated for National Register of Historic Places eligibility.

The information described above addresses resource eligibility for the NRHP. For the purposes of this analysis, with the exception of isolated occurrences of cultural material, all known and unknown prehistoric archaeological resources in the Project area are also considered significant (historical) resources, eligible for the CRHR. This includes known resources that have not been evaluated under CRHR criteria, resources that may be present in areas not yet surveyed, and potentially unique archaeological resources.

During State Water Board AB 52 consultation with the Shasta Indian Nation and Shasta Nation it was agreed that tribal cultural resources reflected in PacifiCorp (2004) and Daniels (2006), qualify as tribal cultural resources. Additionally, the Shasta Indian Nation provided updated tribal cultural resources information which is included in Confidential Appendix Q. There are 47 known Shasta Nation and/or Shasta Indian Nation tribal cultural resources in the Project area. These resources are primarily associated with villages, cairns, and burial sites, as well as fishing, hunting, and other resource extraction sites. A process to evaluate tribal cultural resource eligibility for previously unknown cultural resources or refine understanding of existing tribal cultural resources following Proposed Project activities is discussed in Potential Impact 3.12-1. Please note, known and as of yet unknown tribal cultural resources are covered by mitigation measures TCR-1 through TCR-8, which were developed in consultation with the Shasta Indian Nation, Shasta Nation, and Yurok Tribe.

Historical Built Environment Resources

The KRRC records search (Appendix B: *Definite Plan – Appendix L, Table 6-3*) identified nine historic-period built environment resources associated with the historic themes of commerce, settlement, transportation, and public works, as described below. The single commerce-themed resource includes a former service station converted to residence (Klamath Kamp). Two settlement-related sites have been recorded, consisting of a post-1930s duplex residence with associated structures and the Frank Wood cabin, a late 1890s to 1950s era homesite. Transportation-related sites consist of a one-lane, wooden and steel beam truss bridge over the Klamath River (Ash Creek Bridge) west of Interstate 5, and the concrete State Route 263, T-beam bridge over the Klamath River at the confluence of Shasta River. Public works sites include four recorded elements of the Klamath Hydroelectric Project, including Copco No.1 Hydroelectric Powerhouse and Dam; Copco No. 2 Hydroelectric Powerhouse; Fall Creek Hydroelectric Powerhouse; and the Copco No. 2 Wooden Stave Penstock.

Besides these nine built environment resources, standing historic-period structures have been identified at several archaeological sites, including a ranch house and bunkhouse at the Beswick Hotel site (CA-SIS-513-H) and a shed at Copco II Ranch (CA-SIS-2239-H). The historic Spannaus Barn was noted at prehistoric/ethnographic site CA-SIS-2574, but was not recorded as an element of the site.

National Register of Historic Places eligibility information for these nine sites indicates that the two Klamath River bridges have been determined eligible for listing in the National Register of Historic Places. The four hydroelectric related sites were noted by Cardno Entrix (2012) as appearing eligible for separate listing, but these sites have also been documented as contributing elements to the Klamath Hydroelectric historic district (Kramer 2003b) which has yet to be concurred upon by the California and Oregon State Historic Preservation Officers. Also recommended as National Register of Historic Places eligible is the Frank Wood cabin. The final two resources, composed of a residence and a former service station, have been found ineligible for the National Register of Historic Places.

Isolated Finds

The KRRC records search (Appendix B: *Definite Plan – Appendix L, Table 6-3*) identified 68 individual resources not directly associated with sites (i.e., isolated finds or individual low-density concentrations of artifacts or features that do not appear to be associated with a larger site but could indicate Native American use of the area), including 65 prehistoric resources, 2 historic-period resources, and 1 isolated feature of unknown age. Prehistoric isolates include a rock cairn, bedrock milling feature, possible cupule boulders, an incised cobble, ground/battered stone and flaked stone artifacts. Forty-one isolate locations were found to contain flakestone manufacturing debris (debitage) ranging from 1 flake to as many as 13 flakes in a single location. Debitage includes obsidian, chert, and basalt. Eleven isolates contain both tools and debitage.

The historic-period isolates consist of one rusted horseshoe and the remains of a wagon. The isolate of unknown age is described as a rocky depression measuring 8.2 feet in diameter.

Potential Archaeological Districts

As part of the Klamath Hydroelectric Project relicensing study (FERC 2007), five areas containing multiple prehistoric sites were identified along the same section of the Klamath River which was considered as a potential National Register of Historic Places District (PacifiCorp 2004, FERC 2007). This potential district includes four groups of multiple sites in Oregon located at the head of Link River and the mouth of Upper Klamath Lake, Teeter's Landing, Spencer Creek/mouth of upper Klamath River Canyon, and near Frain Ranch. In California, a cluster of three villages near the headwaters to Iron Gate Reservoir, comprised the fifth potential district group. The National Register of Historic Places eligibility of this district has not been finalized.

A historic-period archaeological district was also considered for the Frain Ranch, in Oregon (PacifiCorp 2004). Due to their association with early homesteading and the beginning of ranching and agriculture within the upper Klamath River, four Frain Ranch area sites were envisioned for this district. The National Register of Historic Places eligibility of this district has not been finalized at this time.

Potential Klamath River Hydroelectric Project District

The Klamath River Hydroelectric Project District comprises seven hydroelectric generation facilities and their related resources located along the Klamath River and its tributaries in Klamath County, Oregon and Siskiyou County, California. Beginning at the Link River Dam, in Klamath Falls, Oregon, the Project boundary continues southwest along the Klamath River to include the Keno Dam Complex and the J.C. Boyle Complex in Oregon. Within California, the Klamath Hydroelectric Project boundary includes the Fall Creek, Copco No. 1 and Copco No. 2 complexes, and terminating at Iron Gate Dam. The Klamath Hydroelectric Project facilities were constructed between 1903 and 1958 by the California Oregon Power Company (COPCO) and its predecessors and are now owned and operated by PacifiCorp under FERC License Nos. 2082 (Kramer 2003a,b) and 14803.

The proposed Klamath River Hydroelectric Project District includes the hydroelectric facilities and various diversion dams; support structures; linear elements such as flumes, canals, and tunnels; and other related buildings and structures. A historic context statement (Kramer 2003a) and Determination of Eligibility (Kramer 2003b) developed for the Klamath Hydroelectric Project notes its eligibility to the National Register of Historic Places as a District under Criterion A for its association with the industrial and economic development of southern Oregon and northern California (Kramer 2003b). The California and Oregon State Historic Preservation Officers have not concurred with this eligibility recommendation. Table 6-11 of Appendix B: *Definite Plan – Appendix L*, identifies key features of the three hydroelectric complexes located in California that are part of the Proposed Project in reference to the National Register of Historic Places eligibility recommendations.

Upper Klamath River Stateline Archaeological District

The newly designated Upper Klamath River Stateline Archaeological District (BLM 2016) is located along the Klamath River, in California, less than 0.5-miles from the Oregon-California state line. The district encompasses three pre-contact village sites that contribute to the district’s significance and one lithic scatter that does not contribute. Archaeological research indicates site use in the district extended from circa 1,000 years ago or earlier to possibly as late as the 1840s (BLM 2016). The district was determined eligible for the National Register of Historic Places at the local level of significance under Criterion D in the areas of Prehistoric Archaeology, Native American Ethnic Heritage, Commerce, Economics, Religion, and Politics/Government. The California State Historic Preservation Officer and the Keeper of the National Register of Historic Places have concurred with the district’s eligibility, and it would therefore qualify as an Historical Resource for the purposes of CEQA.

Ethnographic Information and Tribal Cultural Resources

The ethnographic information presented here for the California portion of the Lower Klamath Project identified tribal cultural resources, and other culturally sensitive areas along the Klamath River in the Proposed Project area are based on ethnographic inventory reports prepared by the Klamath Tribes (Deur 2004), Shasta Nation (Daniels 2003, 2006), Karuk Tribe (Salter 2003), and Yurok Tribe (Sloan 2003) for the FERC Relicensing study, the 2012 KHSA EIS/EIR, and during AB 52 consultation meetings between the State Water Board the Shasta Indian Nation and the Shasta Nation (Confidential Appendices P and Q).

The Klamath Tribes identified several culturally important locations in the Klamath Basin, and noted that tribal fisheries were impacted as a result of impediment of anadromous fish passage due to Klamath River dams (Deur 2004). The Klamath Tribes also identified places along the Klamath River between J.C. Boyle Dam (Oregon) and the Scott River (California) that have tribal cultural value (Theodoratus et al. 1990).

The Shasta Nation reports (Daniels 2003, 2006) present a list of village sites recorded in ethnographic literature, a list of locations that the Shasta consider traditional cultural properties, and another inventory of 11 locations, drawn from the first two listings, that are eligible for the National Register of Historic Places.

The Karuk (Salter 2003) and Yurok (Sloan 2003) ethnographic reports draw upon oral interviews, other writings, ethnographical literature, and a review of natural and cultural resources within the Klamath River to discuss each tribe’s traditional and historical relationships with the river, and its resources, to subsistence, spiritual culture, and identity. These tribes recognized the entire Klamath River as part of an important cultural (ethnographic) riverscape.

Klamath Cultural Riverscape

The Klamath River Inter-Tribal Fish and Water Commission incorporated information from existing ethnographic studies, in addition to information provided by the Hoopa Valley Tribe, into a report that focused on the Klamath River (King 2004). The entire length of the river was then identified as a type of cultural or ethnographic landscape, termed the Klamath Riverscape, due to the relationship between The Klamath Tribes, Shasta, Karuk, Hoopa, and Yurok tribes and the river and its resources (Gates 2003, King 2004). The characteristics that contribute to the riverscape's cultural character include natural and cultural elements such as the river itself; its anadromous and resident fisheries; its biological diversity; and its cultural sites, sacred places, uses, and perceptions of value by the tribes (King 2004). Gates (2003) and King (2004) recommend the Klamath Riverscape as eligible for the National Register of Historic Places based on its association with broad patterns of tribal environmental stewardship, spiritual life, and relationships between humans and the non-human world. The ethnographic reports for the riverscape and its eligibility determination have not been submitted to the Oregon and California State Historic Preservation Officers for national or state register for concurrence (USBR and CDFG 2012). This EIR recognizes the Klamath Cultural Riverscape as a Tribal Cultural Resource under Public Resources Code, section 21074.

The Klamath Riverscape's contributing elements include the resources described in the 2012 KHSA EIS/EIR's discussion of tribal trust resources and resources traditionally used by tribes (see Appendix V – 2012 KHSA EIS/EIR *Section 3.12 Tribal Trust*). It is clear from formal consultation under AB 52 with the Yurok Tribe that the health of the Klamath River as a whole, as well as the fishery in particular, are of critical importance to the Tribe's well-being and identity, forming a core for cultural, spiritual, and economic life, and that the Klamath River as a whole constitutes a vital Tribal Cultural Resource. Formal and informal consultation, and comments from tribal representatives from the Karuk Tribe, Hoopa Valley Tribe, and the Klamath Tribe, also underscore the high degree to which the Klamath River's water quality and fisheries are important cultural resources.

Historical Landscape Analysis

As part of the Project Area records search, a historical landscape analysis was conducted to identify locations where post 1850s era settlement and resource developments occurred within the records search area (AECOM 2018). The sources for this study included the review of the General Land Office records, including California plat maps (1856, 1876, 1880, and 1881) and surveyor's notes; a variety of published and manuscript resources (Beckham 2006, Boyle 1976, Kramer 2003a, PacifiCorp 2004, USDI 1989); and USGS maps available at http://historicalmaps.arcgis.com/usgs. Other map searches included the David Rumsey collection, Northwestern California map collection at Humboldt State University, Library of Congress digital collections, and Online Archive of California. Historical landscape information was digitized into a GIS format and a table prepared with site-specific information annotated by Township/Range/Section (Appendix B: *Definite Plan – Appendix L,* Table 6-12). In summary, this research indicated roads, railroads, bridges, logging features, ditches, fence lines, buildings, homesteads, ranches, sites associated with military encampments, and several townsites.

KRRC also completed the review of the J.C. Boyle Collection (MI 165306) housed at the Southern Oregon Historical Society in Medford, Oregon. This archive contains photo albums, newspaper clippings, maps, manuscripts, financial records, and Copco annual reports belonging to Copco Engineer J.C. Boyle, and pertaining predominately to construction of Copco No. 1 Dam and Reservoir. This archive is a valuable source of information concerning the pre-inundation historical landscape of the Copco No. 1 area and provides important information regarding cultural and historical resources that may be encountered during reservoir drawdown. In addition, archival and historical landscape research was conducted at local County repositories and historical societies to provide information regarding cultural and historical resources that may be anticipated during reservoir drawdown at J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate reservoirs. The Historical Landscape Analysis conducted by KRRC found no Historical Landscape in the Area of Analysis for the Proposed Project.

3.12.3 Significance Criteria

Criteria for determining significance of impacts on historical and tribal cultural resources are based upon consultation, referenced texts, the Appendix G of the CEQA Guidelines (California Code of Regulations title 14, section 15000 et seq.), and professional judgment. <u>As such, these criteria are specific to the Proposed Project</u>.

Impacts to historical and tribal cultural resources are significant if they include the following:

- Physical demolition, destruction, relocation, or other alteration of the historical or tribal cultural resource or its immediate surroundings such that the significance of the historical or tribal cultural resource would be materially impaired.
- Exposure or substantial movement of human remains or associated funerary items[84].
- Exposure of, substantial movement of or increased access to other historic tribal cultural resources leading to increased access and looting[85] of tribal cultural resources above levels occurring under existing conditions.

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[84] Substantial movement is defined as movement that would displace tribal cultural resources completely or predominantly outside of existing cultural context in a manner that would impair its cultural significance.
[85] Refers to the illicit collection of artifacts or other tribal cultural resources.

- Elimination or substantial restriction[86] of access of tribal members to their respective tribal cultural resources above levels occurring under existing conditions.

Tribal cultural resources are defined in Public Resources Code Section 21074(a)(1) as either a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American tribe, and that is:

1. Listed or eligible for listing in the California Register of Historical Resources (which includes all resources eligible for listing on the National Register of Historic Places), or in a local register of historical resources, or
2. A resource that the lead agency determines is a tribal cultural resource, as further described below.

A lead agency has discretion in identifying unlisted resources as tribal cultural resources, but such a determination requires substantial evidence under the criteria used to determine listings in the historical register and considering the significance of the resource to a California Native American tribe (Public Resource Code, Sections 5024.1, 21074). Tribal cultural resources are, by definition, historical resources. California Native American tribes traditionally and culturally affiliated with the geographic area of a project may have expertise concerning their tribal cultural resources (Public Resource Code, Section 21080.3.1(a)).

Historical Resources are defined consistent with Public Resources Code section 21084.1 which includes a resource listed in, or determined to be eligible for listing in, the California Register of Historical Resources (CRHR), included in a local register of historical resources, or determined to be significant by the lead agency (Public Resc. Code section 21084.1, CEQA Guidelines Section 15064.5 (a)). While not all CRHR-eligible resources are also eligible for the National Register of Historic Places (NRHP), resources listed on or evaluated as eligible for the NRHP are considered historical resources under CEQA. The fact that a resource does not meet these criteria does not preclude a lead agency from determining that the resource may be an historical resource under the criteria in Public Resources Code Section 5024.1(c). Historical resources may be prehistoric or historic in age and may be archaeological resources, part of the existing built environment, other important historic resources, or a tribal cultural resource such as a sacred place. Additionally, CEQA recognizes the possibility that an archaeological site may not meet the definition of an historical resource but may meet the definition of a “unique archaeological resource” (Pub. Resc. Code,

[86] Substantial restriction is defined as loss of access during ceremonial windows or periods of hunting and gathering or other traditional activities associated with a particular tribal cultural resource.

section 21083.2 (g)). Similar to historical resources, unique archaeological resources are afforded protection under CEQA.

3.12.4 Impact Analysis Approach

The historical and tribal cultural resources impact analysis is based on a review of existing information, such as the results of the California Historical Resources Information System confidential record searches, KRRCs identification efforts (Appendix B: *Definite Plan – Appendix L*) and the AB 52 process with Native American tribes and representatives. Additionally, information received during public scoping was also used to identify potentially important cultural resources (Appendix A).

Known tribal cultural resources within the Proposed Project Area of Analysis include archaeological sites and districts, ethnographic villages, historic period Shasta communities, cemeteries, and cultural landscapes associated with the historical uses of the environments surrounding Iron Gate and Copco No. 1 reservoirs.

Parts of AB 52 (Gatto 2014) amended Public Resources Code to require consultation with California Native American tribes, when requested, and consideration of tribal cultural resources in the CEQA environmental review process. Following the public scoping meetings, the State Water Board conducted a series of confidential consultation meetings with the Shasta Indian Nation, Yurok Tribe, and Shasta Nation. During consultation, the State Water Board sought information regarding the identification of areas with religious or cultural importance to these tribes, potential impacts of the Proposed Project on such resources, and mitigation measures to avoid, minimize or mitigate adverse effects to identified resources. Information discussed as part of AB52 consultation is incorporated into the impact analyses for historical and tribal cultural resources, as appropriate. AB 52 consultation resulted in development of, and agreement on, mitigation measures with the Shasta Indian Nation and the Yurok Tribe. Consultation with the Shasta Nation informed development of mitigation measures, but the AB 52 process concluded without agreed-upon mitigation measures.

The impact analysis approach for historical and tribal cultural resources also considered existing studies related to reservoir inundation and drawdown with respect to resources located within the Iron Gate and Copco No. 1 reservoir footprints, as described below.

For purposes of this analysis, with the exception of isolated occurrences of cultural material, all known and unknown prehistoric archaeological sites within the Project area are considered to be tribal cultural resources, and thus significant resources under CEQA. Additionally, this document acknowledges that (1) not all of the required cultural resources inventory and significance analyses will be completed prior to certification of this EIR and (2) overseeing development and implementation of the Cultural Resources Plan does not fall within the scope of the State Water Board's water quality certification authority. Therefore, for the purposes of this impact analysis, all known and unknown cultural resources within the Project area are considered to be significant, i.e., historical resources under CEQA. This includes the historic built environment; historic-period archaeological resources; and prehistoric archaeological resources, which as stated above are considered TCRs herein.

3.12.4.1 Studies on Effects of Reservoir Inundation on Cultural Resources

Lenihan et al. (1981), conducted an interagency, interdisciplinary study on the effects of freshwater reservoirs on cultural resources in order to address conservation management of inundated resources. A hierarchical scheme composed of three levels of cultural resources was assessed for inundation effects: artifacts and artifact assemblages; archaeological site or loci; and regional environmental data base, settlement and resource utilization patterns. The use of the hierarchical scheme was intended to include cultural values beyond discrete sites or artifacts that include spatial, temporal, and organizational relationships between the entities within an environmental and cultural context.

This approach is particularly applicable to landscape level resources such as traditional cultural properties and ethnographic landscapes, even though these property type names came into use after the Lenihan et al. (1981) study. When a river with a long history of cultural use is dammed and water is impounded, the cultural landscape is adversely affected through direct impacts to the archaeological or historical sites themselves and to the relationships of these properties to their environment and to each other on local and broader scales. Besides the changes to the environmental setting, processes of inundation that could affect cultural resources are sediment transport and deposition, erosion processes of wave action along shorelines, and saturation and slumping of submerged strata (Lenihan et al. 1981). Note that slumping, or short-term hillslope instabilities, as may occur during reservoir drawdown are discussed in Section 3.11 *Soils, Geology, and Mineral Resources*, Potential Impact 3.11-3, as well as below for tribal cultural resources (Potential Impact 3.12-2) and historical resources (Potential Impact 3.12-13). Erosion of sediment stored within the Lower Klamath Project reservoirs during reservoir drawdown and the potential for downstream sedimentation due to the released sediment is discussed in Section 3.11 *Soils, Geology, and Mineral Resources*, Potential Impact 3.11-5.

Four factors regarding the extent of impacts to archaeological sites by these processes include the characteristics of the reservoirs themselves (size and operation-fill rate and drawdown frequency); location of sites within the impoundment; geological foundation of a site; and characteristics of the site itself (Lenihan et al. 1981). Erosion processes are most damaging along the edges of the reservoirs in wave action zones that vary vertically with reservoir operations.

In general, cultural resource sites located within the wave action zone are most heavily affected, while inundated sites beyond the shore are less affected by erosion and may be capped with sediment. A multitude of other factors, such as, slope, vegetation coverage, substrate, soil and water chemistry, also influences the extent of the impacts to a cultural resource site from inundation. Surface artifact displacement from water movement results in an overrepresentation of heavier weight artifacts (such as, groundstone) and an underrepresentation of lighter weight artifacts (such as, lithic flakes). Damage from vandalism, both intentional and unintentional, increases to sites exposed through erosion and reservoir fluctuations. All of these impacts limit the ability to reconstruct human behavior through artefactual, paleoenvironmental, and site analyses; through direct dating techniques and relative dating of vertical and horizontal placement; and through contextual relationships.

Surveys for previously inundated ancestral Puebloan archaeological sites being exposed due to lowering lake levels as a result of drought at Lake Mead, the reservoir behind Hoover Dam, in Southern Nevada resulted in situations where inundation preserved the sites (Haynes 2008). Sites in shoreline locations were eroded as water regressed, resulting in extensive damage to architectural remains and in the removal of the surface artifact assemblages. In lower energy situations, inundation resulted in capping of the sites with sediment that enhanced preservation. Both architectural and non-architectural features and surface artifacts remained. In other situations, effects of inundation and drawdown resulted in differential artifact removal and secondary re-deposition. Factors contributing to impacts from inundation and later exposure include: energy levels of the reservoir at the site location; terrains upon which the sites sit; weight of artifacts; and artifact collecting once sites were exposed. The results of these surveys on lands exposed from natural drawdown at Lake Mead, a man-made reservoir, are directly applicable to the proposed drawdown of the reservoirs along the Klamath River.

3.12.5 Potential Impacts and Mitigation

3.12.5.1 Potential Impacts to Tribal Cultural Resources

For the purposes of the mitigation measures TCR-1 through TCR-7, the following definitions apply:

Affected Tribes: Tribes on the Native American Heritage Commission list that (1) have expressed interest in participating in further development of the Tribal Cultural Resources (TCRs) measures for the Lower Klamath Project (Project) within 60 days of the Klamath River Renewal Corporation’s (KRRC) January 8, 2018, notice and (2) are traditionally and culturally affiliated with the Area of Potential Effect or otherwise affected by the Project. As of August 13, 2018, the following Native American tribes have expressed interest in participating in further development of such mitigation measures: Cher-Ae heights Indian Community of the Trinidad Rancheria, Karuk Tribe, Klamath Tribes, Modoc Tribe of Oklahoma, Quartz Valley Indian Reservation, Shasta Indian Nation, Shasta Nation, and the Yurok Tribe.

Consultation: Consultation with Affected Tribes in a manner consistent with applicable law. KRRC intends to implement these requirements consistent with California Environmental Protection Agency's "Policy on Consultation with California Native American Tribes," CIT-15-01 (August 20, 2015).

Project Implementation: Project implementation is defined as pre-construction activities, reservoir drawdown, dam removal, restoration activities, and other ground-disturbing activities that comprise the Project, as stated in the Definite Plan.

Potential Impact 3.12-1 Pre-dam-removal activities that involve disturbance of the landscape, including construction or improvement of associated roads, bridges, water supply lines, staging areas, disposal sites, hatchery modifications, recreation site removal and/or development, and culvert construction and improvements could result in potential exposure of or damage to known Tribal Cultural Resources through ground-disturbing construction and disposal activity and increased access to sensitive areas. Pre-dam removal activities involving ground disturbance, construction or improvement of associated roads, bridges, water supply lines, staging areas, disposal sites, hatchery modifications, recreation site removal and/or development, and culvert construction and/or improvements would occur within the Area of Analysis *Subarea 1* (Figure).

Tribal cultural resources are known to be present within Area of Analysis *Subarea 1* (Figure). Cultural resource sites identified at the edges of Copco No. 1 Reservoir include prehistoric archaeological sites with habitation debris and several contributing elements of the ethnographic landscape (Cardno Entrix 2012, Daniels 2006, Heizer and Hester 1970, PacifiCorp 2004). In addition, ethnographic village sites have been identified within Copco No. 1 Reservoir (Heizer and Hester 1970, Daniels 2006). Native American burials and traditional use areas (for ceremonies) within the Copco No. 1 Reservoir footprint have also been identified through ethnographic research and consultations with the Shasta people. At least one ethnographic village site has been identified within Iron Gate Reservoir by PacifiCorp (2004) and Daniels (2006). Specific TCR locations known to the Shasta people, which include TCRs as reflected in PacifiCorp (2004) and Daniels (2006), and as updated by Confidential Appendix Q, Attachment 4, are cataloged in Confidential Appendices P and Q. Resources identified as villages, cairns or burial sites, or other sites eligible for the National Register of Historic Places (NRHP) in a subsequent compilation by Cardno ENTRIX (2012) were also considered as part of this analysis.

Due to the nature of ground-disturbing activities and a general increase in the level of activity (e.g., construction, surveys) within the Area of Analysis *Subarea*

1, pre-dam removal activities that would involve ground disturbance have the potential to result in the following significant impacts to known TCRs identified in Confidential Appendices P and Q, as well as unknown TCRs:

- Physical demolition, destruction, relocation, or alteration of the resource or its immediate surroundings such that the significance of the TCR would be materially impaired; and/or
- Exposure or substantial movement of TCRs leading to increased access and looting above levels occurring under existing conditions.

Note that TCR sites located within the reservoir fluctuation zones (Confidential Appendices P and Q) may be periodically at risk of looting during low water periods under existing conditions and may have suffered significant degradation in the existing condition.

Implementation of mitigation measures TCR-1 (TCRMP), TCR-2 (LVPP), TCR-3 (IDP), TCR-4 (Endowment)[87] would reduce these impacts considerably, and, for many resources is expected to avoid impacts completely, through the design and implementation of construction plans to completely avoid impacts, or on-the-ground modifications to Proposed Project implementation to avoid impacts. For impacts for which it is not feasible to completely avoid impacts, these impacts may be reduced to a less-than-significant level. The measures (listed fully, below) include among other requirements, field worker training, limits to worker and public access, tribal monitors, surveys, and identification of protocols and best practices upon discovery or disturbance of TCRs during implementation of the Proposed Project. With timely discovery and appropriate steps to address exposure or damage, many TCRs can maintain their current level of cultural significance. Additionally, providing a means for the long-term protection or enhancement of affected TCRs can mitigate for some impacts.

However, the impact of exposing, disturbing or otherwise damaging tribal human remains, or associated funerary items, is itself profound. While the mitigation measures are expected to considerably reduce impacts, they cannot reasonably be expected to eliminate such exposure or disturbance, particularly where, as here, the number of potentially affected burials is high. While treating remains and associated funerary objects with the appropriate respect and procedures can reduce and avoid compounding the harm from the initial damage, it cannot do so fully. Additionally, in light of the high density of TCRs within the Limits of Work, and the nature of the construction involved, significant risk remains that other TCRs may sustain damage that results in a material impairment of the resource's significance. In light of the particular harm of exposing human remains even where they are treated appropriately after exposure, and the likelihood of

[87] Mitigation Measures TCR-6, TCR-7, and TCR-8 could also further reduce the potential impact. However, at this point it is not clear whether the measures are feasible (see Potential Impact 3.12-9.) Therefore, this EIR does not rely on implementation of these measures, in reaching its significance determinations.

significantly impairing other types of TCRs in light of the type of construction actions and the density of resources, the impact would remain significant and unavoidable.

Mitigation Measure TCR-1 − Develop and Implement a Tribal Cultural Resources Management Plan.
The KRRC shall develop a Historic Properties Management Plan (HPMP). The HPMP shall include measures to avoid, minimize, or mitigate the Project's adverse impacts to TCRs. The HPMP shall include a Tribal Cultural Resources Management Program (TCRMP), which will state such measures.

KRRC shall develop the TCRMP in consultation with Affected Tribes. The KRRC shall finalize the HPMP during FERC's hearing on the license surrender application for the Project. The KRRC shall propose the HPMP for FERC's approval as a term of the license surrender order.

In developing the TCRMP, KRRC shall engage in good faith consultation with the Affected Tribes that are traditionally and culturally affiliated with a specific portion of the APE or with potentially affected TCRs. Where a particular tribe has identified a specific TCR, the primary consultation about that TCR shall be with the affected tribe. All such consultation shall be subject to the schedule for HPMP development. If consensus cannot be reached during TCRMP development, KRRC shall record the disputed issues, positions on the disputed issues, and KRRC's proposed resolution, in the HPMP that is submitted to FERC.

The TCRMP shall include the following elements consistent with applicable law:

1. The TCRMP shall include an inventory of known and potential TCRs that could be affected by the Project. Appendix B: *Definite Plan – Appendix L* includes a preliminary inventory of such resources. KRRC will continue to develop the inventory through the consultation process for the license surrender application under authority of the National Historic Preservation Act (NHPA) Section 106.

   Based on AB 52 consultation, KRRC acknowledges that the Shasta Indian Nation and Shasta Nation are primarily concerned with TCRs associated with Iron Gate, Copco No. 1, and Copco No. 2 reservoirs, and tributary sub-watersheds such as Fall Creek, Bogus Creek, and Deer Creek. The TCRMP shall include TCRs known to the Shasta Indian Nation, which include TCRs as reflected in PacifiCorp (2004) and Daniels (2006) and as updated by Attachment 4 of the Confidential Appendix Q. The TCRMP shall include TCRs known to the Shasta Nation, which include the TCRs identified in the Confidential Appendix P. The TCRMP shall include TCRs known to other Affected Tribes.

2. The TCRMP shall include provisions to protect the confidentiality of known TCRs. The TCRMP shall also include provisions to share information collected by the KRRC with: Affected Tribes that are traditionally and

culturally affiliated with the known TCR(s); regulatory agencies that have authority over protecting such resources, as necessary; or as necessary with the permission of such tribes in order to implement appropriate protective or enhancement measures. These provisions will be consistent with California Public Resources Code Section 21082.3(c).

3. The TCRMP shall assure that the Project will avoid, minimize, or mitigate adverse impacts to TCRs, consistent with California Public Resources Code section 21084.3(a). In developing the plan, the KRRC will consider measures listed in California Public Resources Code section 21084.3(b) that, if feasible, may be appropriate to avoid, minimize, or mitigate adverse impacts:
   (1) "Avoidance and preservation of the resources in place, including, but not limited to, planning and construction to avoid the resources and protect the cultural and natural context, or planning greenspace, parks, or other open space, to incorporate the resources with culturally appropriate protection and management criteria.
   (2) Treating the resource with culturally appropriate dignity taking into account the tribal cultural values and meaning of the resource, including, but not limited to, the following:
      (A) Protecting the cultural character and integrity of the resource.
      (B) Protecting the traditional use of the resource.
      (C) Protecting the confidentiality of the resource.
   (3) Permanent conservation easements or other interests in real property, with culturally appropriate management criteria for the purposes of preserving or utilizing the resources or places in a manner consistent with the KHSA.
   (4) Protecting the resource."
4. The TCRMP shall require a training program for KRRC's field personnel associated with the Project. The training program will be designed to train KRRC field personnel to work collaboratively with tribal monitors and will focus on field procedures (across the range of field personnel) as necessary for appropriate and respectful treatment of TCRs; and will be intensive and systematic, in light of the scale, complexity, and schedule of the Project undertakings.
5. The TCRMP shall identify TCR areas that will have limited or no public access during Project implementation. During that period, the KRRC shall: install adequate signage to clearly mark areas with limited or no public access areas; install fencing where necessary and feasible to reduce access; and provide appropriate training to field personnel. Upon the recommendation of a tribe that has identified the TCR area, the KRRC may consider, and the TCRMP may include, other equally effective measures to reduce public access in lieu of (or in addition to) those identified immediately above.

6. The TCRMP shall include site-specific mitigation measures for potentially affected TCRs. The TCRMP shall provide for ongoing consultation or site-specific mitigation refinement with the relevant Affected Tribe(s) with a traditional and cultural affiliation to an impacted TCRs, as appropriate and feasible consistent with the schedule for Project implementation.
7. The TCRMP shall identify any areas where the KRRC, before Project implementation, shall conduct any additional cultural resource surveys, consistent with California Public Resources Code section 21074.
8. The TCRMP shall provide that the KRRC, following reservoir drawdown and dam removal, shall undertake intensive surveys of TCRs, archaeological, and other historical resources within the area of analysis, using joint teams of archaeologists and tribal monitors. The TCRMP shall specify the methods for such surveys. It shall also specify the process by which Affected Tribes will nominate, and KRRC will select and compensate tribal monitors. During this process, an Affected Tribe that is traditionally and culturally affiliated with the area may nominate tribal monitor(s) for KRRC's consideration; and KRRC shall make the selection after consultation with Affected Tribes. KRRC shall select and pay tribal monitor(s) for the purpose of Project implementation. In the event that KRRC does not select a tribe's recommended monitor, an Affected Tribe that is traditionally and culturally affiliated with the area may request participation of its recommended tribal monitor in these surveys at its own cost. KRRC's field personnel, in consultation with tribal monitors, shall record these surveys in a manner consistent with applicable law. KRRC shall provide recorded survey data pertaining to a known TCR to the Affected Tribes that are traditionally and culturally affiliated with that TCR.
9. The TCRMP shall state a range of appropriate measures, and a protocol to select from such range, to address the disturbance or exposure of known TCRs during Project implementation. The KRRC shall implement measures necessary to ensure the protection of disturbed or exposed TCRs.
10. The TCRMP shall provide that the KRRC will identify and avoid TCRs during the siting and construction of new recreational sites, to the extent feasible. The KRRC shall address potential conflicts consistent with California Public Resources Code section 21084.3(a) and (b).
11. The TCRMP shall provide for restoration actions associated with any ground disturbances such as grading and manual or machine excavation, so as to protect TCRs. The KRRC shall consider limiting or completely avoiding mechanical weed control activities (e.g., mowing, hand-weeding) or herbicide use to protect TCRs in areas identified by Affected Tribes, as necessary. In revegetation efforts, the KRRC shall incorporate specific plant species that are important to Affected Tribes with a traditional and cultural affiliation to the area at issue, to the extent that doing so is feasible and complies with the requirements of the federal and state

approvals of the Project. The KRRC shall provide training regarding these actions to its field personnel.

12. The TCRMP shall incorporate the results of the KRRC's Bathymetric Survey, and specifically, the refined understanding of sediment thickness in Iron Gate and Copco No. 1 reservoirs, to inform monitoring efforts for potential exposure of TCRs during and following reservoir drawdown. Information from this review shall inform the Inadvertent Discovery Program (described below), which will be part of the TCRMP.
13. The KRRC shall consult with Affected Tribes in the planning process for the redesign and relocation of the water supply line for the City of Yreka to identify, avoid if feasible, or mitigate effects to TCRs during the siting and construction of the water supply line. The KRRC shall address potential conflicts consistent with California Public Resources Code section 21084.3 (a) and (b).
14. Consistent with KHSA Section 7.6.6, the TCRMP shall include recommended measures to identify, avoid, minimize, or mitigate effects to TCRs during modifications of Iron Gate Hatchery, consistent with California Public Resources Code section 21084.3 (a) and (b).
15. Consistent with KHSA Section 7.6.6, the TCRMP shall also include recommended measures to identify, avoid, minimize, or mitigate adverse impacts to TCRs during rehabilitation and expansion of Fall Creek Hatchery, consistent with California Public Resources Code section 21084.3 (a) and (b).
16. The TCRMP shall include a dispute resolution process in the event that, during Project implementation, Affected Tribes dispute which measures to apply to avoid, minimize, or mitigate the Project's adverse impacts to a specific TCR with which the Affected Tribes are traditionally and culturally affiliated. The process shall include neutral mediation to be undertaken consistent with the schedule for Project implementation. In consultation with Affected Tribes, the KRRC shall engage a standing mediator who is available to resolve disputes about which measures to apply.

Mitigation Measure TCR-2 − Develop and Implement a Looting and Vandalism Prevention Program.

In consultation with Affected Tribes and jurisdictional law enforcement, the KRRC shall develop and implement a Looting and Vandalism Prevention Program (LVPP), specifically to deter looting and vandalism to TCRs associated with the Project. The LVPP, which may be part of the TCRMP, shall include the following elements consistent with applicable law:

1. The LVPP shall include appropriate measures to deter looting and vandalism during Project Implementation. The KRRC shall implement these measures for a minimum of 3 years following completion of dam removal, or until KRRC has transferred applicable Parcel B lands to the States or third parties under the terms of the KHSA Section 7.6.4.

2. The LVPP shall specify the frequency of monitoring efforts of known TCR areas and other areas subsequently identified by the KRRC or tribal monitors during Project implementation. Monitoring frequency shall not be less than quarterly, with allowances for additional targeted monitoring that is triggered by natural or opportunistic events, such as a large magnitude flood event. The LVPP shall provide that monitoring need and frequency will vary depending on the level of risk associated with various activities during Project implementation.
3. The LVPP shall include a training program on looting and vandalism prevention and site documentation, for the benefit of KRRC's field personnel as well as tribal monitors.
4. The LVPP shall include protocols for communications and reporting to law enforcement and other relevant state and federal agencies, consistent with applicable law.
5. The LVPP shall include appropriate measures to restrict public access to specific Project areas where known TCRs, or those identified through inadvertent discovery, are located. KRRC shall implement these measures until it has transferred the Parcel B lands to the states or third parties under KHSA Section 7.6.4. Specific measures to be considered shall include: fencing; posting of signs; strategic plantings; strategic routing of access roads, boating access points and trails; specific recommendations for land use or land transfer in the KHSA Section 7.6.4 process or other means determined necessary and feasible to protect TCRs from opportunistic looting and public access (authorized and unauthorized).
6. The LVPP shall include appropriate measures to prevent or restrict public access to reservoir areas during reservoir drawdown and dam removal.
7. The LVPP shall include appropriate measures to prevent or restrict public access to newly exposed reservoir areas following reservoir drawdown. Such measures shall limit use of off-road vehicle paths and informal roads and tracks, and unauthorized use of developed and dispersed recreation sites. KRRC shall implement these measures until it transfers Parcel B lands to the states or third parties pursuant to KHSA Section 7.6.4, subject to an assignment of continuing responsibilities by the transferee.

Mitigation Measure TCR-3 − Develop and Implement Inadvertent Discovery Plan (IDP).

In consultation with Affected Tribes, the KRRC shall develop and implement an Inadvertent Discovery Program (IDP), which shall be a part of the TCRMP. The IDP shall establish protocols for the discovery of unanticipated or previously unknown TCRs, including human burials or human remains discovered during Project implementation. The IDP shall provide for compliance with applicable law regarding cultural resources and human remains; state work site protocols to be followed in the event of an inadvertent discovery; and identify appropriate point of contacts associated with the protocols. The IDP shall include protocols for work in areas known to have a high chance of inadvertent discoveries, including the

Iron Gate, Copco No. 1, Copco No. 2 reservoir areas, as well as the altered FEMA 100-year floodplain area between Iron Gate Dam and Humbug Creek following dam decommissioning.

The IDP shall include the following specific elements:

1. The IDP shall acknowledge that there may be unknown TCRs in association with TCRs known to the Shasta Indian Nation, which include TCRs as reflected in PacifiCorp (2004) and Daniels (2006) and as updated by Confidential Attachment 4 of the Confidential Appendix Q.
2. The IDP shall state protocols that KRRC shall implement for sites that are addressed under California Public Resources Code 5097.993 and/or for sites found to contain TCRs, human burials, or human remains during and after drawdown activities. These protocols shall identify appropriate agency and tribal contacts for such situations. In the case of human remains in California, the KRRC shall also notify the county coroner and follow the procedures stated in California Health and Safety Code section 7050.5(b) to the extent feasible. Upon discovery, the KRRC's environmental monitor shall notify the KRRC's qualified archaeologist of the discovery, and the KRRC's qualified archaeologist shall complete a letter report to assess and document the discovery. The KRRC shall circulate the letter report to Affected Tribes, the Native American Heritage Commission for inadvertent discoveries on private and state lands in California, and other appropriate land management agencies, within 72 hours of the discovery.
3. The IDP shall state protocols that KRRC will implement for reservoir drawdown or restoration activities following an inadvertent discovery. Such protocols shall be consistent with the Definite Plan and shall take into account potential downstream environmental impacts; cultural resource impacts in the Iron Gate, Copco No. 1, Copco No. 2 reservoir areas; mitigation and stabilization for tribal and cultural resources found in the APE outside of the reservoirs; and mitigation in the altered FEMA 100-year floodplain area between Iron Gate Dam and Humbug Creek following dam decommissioning. The IDP shall identify the measures that the KRRC will follow to protect TCRs following an inadvertent discovery.
4. The IDP shall provide for tribal monitors to participate in monitoring during Project implementation. The tribal monitors shall be present as feasible and appropriate pursuant to the schedule for different phases of Project implementation, to address unknown TCRs that are exposed. Pursuant to item (6), the monitoring schedule for tribal monitors shall consider that monitoring frequency and duration may differ by geographic area or Project phase or activity.
5. The IDP shall provide for the development and implementation of a training program regarding the inadvertent discovery of cultural resources and human remains during Project activities. All of KRRC's field personnel and tribal monitors shall be instructed on site discovery, avoidance, and

protection measures, including information on the statutes protecting cultural resources.

6. The IDP shall establish the frequency of specific monitoring efforts during Project implementation in identified areas where the discovery of unidentified TCRs may be likely given currently available information and other known archaeologically or culturally sensitive areas that may be identified by the tribal monitors. Monitoring locations will be specified during the development of the Inadvertent Discovery Program in the HPMP. Monitoring frequency during Project activities that cause ground disturbance shall not be less than quarterly, with allowances for additional targeted monitoring that is triggered by natural or opportunistic events during the reservoir drawdown or a subsequent large magnitude flood event. Such monitoring efforts shall be led by KRRC's archaeologists in consultation with tribal monitors and shall include the field reconnaissance of newly exposed sediments for surface features, to include, but not be limited to intensive, pedestrian survey for areas with relatively low slopes (<30 percent) and that are sufficiently dried to permit for safe access for pedestrian survey and to permit safe access for survey vehicles. In areas where intensive, pedestrian survey is not possible, KRRC in consultation with tribal monitors may use low-elevation aerial survey methods (e.g., unmanned aerial vehicles) or barge surveys to accomplish monitoring.
7. The IDP shall include a timeline, in consultation with Affected Tribes, for completing treatment measures and assessing California Register significance for discovered cultural resources and human burials or remains.
8. The IDP shall include dispute resolution procedures in the event that Affected Tribes disagree on which measures to apply to protect TCRs following inadvertent discovery. When the inadvertent discovery occurs on private or state lands in California, the procedures set forth in California Public Resources Code section 5097.98 will be followed where feasible, including mediation pursuant to California Public Resources Code section 5097.94. To the extent that inadvertent discoveries occur on federal or tribal lands, appropriate procedures under tribal or federal law will apply.

Mitigation Measure TCR-4 − Endowment for Post-Project Implementation. The TCRMP shall include a provision for the KRRC to provide funding for an endowment or other appropriate organization (e.g., a non-profit mutual benefit organization) to protect and enhance TCRs that are exposed due to the Project implementation on state and private lands in California, on a long-term basis following license surrender. This endowment shall include funding for monitoring, including supplementing or enhancing law enforcement resources, and shall also be available to cover measures that will be implemented following license surrender, including measures related to looting and vandalism protections. The endowment shall be governed in a manner that is representative of Affected Tribes that are traditionally and culturally affiliated with the TCRs impacted by Project Implementation. The KRRC shall consult with

Affected Tribes, with the assistance of the standing mediator during development of the TCRMP, to develop the specifications for funding and governance.

Significance
Significant and unavoidable with mitigation

Potential Impact 3.12-2 Drawdown of Iron Gate, Copco No. 1, and Copco No. 2 reservoirs could result in shifting, erosion, and exposure of known or unknown, previously submerged Tribal Cultural Resources.
The Proposed Project would draw down Iron Gate, Copco No.1, Copco No. 2 and J.C. Boyle reservoirs at a rate between 2 and 5 feet per day (i.e., 1 to 2.5 inches per hour). Drawdown of Copco No. 1 would begin November 1 of dam removal year 1 at a maximum rate of 2 feet per day, and drawdown of all reservoirs would occur at a maximum rate of 5 feet per day beginning January 1 of dam removal year 2 and continue until March 15 of the same year. The analysis for Potential Impact 3.12-2 focuses on the California Lower Klamath Project reservoirs, including Copco No.1, Copco No. 2, and Iron Gate, which are contained within Area of Analysis *Subarea 1* (Figure).

Since the Lower Klamath Project reservoirs were constructed, fine sediments composed primarily of organic material (including dead algae), but also including some silts and clays, have accumulated along the reservoir bottoms. The distribution of sediment deposits varies within each reservoir (Figure 2.7-8 and 2.7-9). Because the accumulated sediments are primarily fine material, they would be easily eroded and flushed out of the reservoirs into the Klamath River during reservoir drawdown. The degree of sediment erosion would vary, with the majority of the erosion focused in the historical river channel that is currently submerged in Copco No. 1 and Iron Gate reservoirs (see Figures 2.7-5 and 2.7-6).

Following drawdown, 40 to 60 percent of the existing sediment deposits would remain in place in each of the former reservoir beds, primarily on terraces located above the historical river channel. The sediments that remain in the reservoir footprints would consolidate (dry out and decrease in thickness) (USBR 2012a), making them less subject to erosion. Further, during the drawdown period, aerial seeding of pioneer mixes would occur as the reservoir water level drops before the exposed reservoir sediments dry and form a surface crust. Pioneer seed mixes would contain a variety of riparian and upland common native species, and possibly a small amount of sterile non-native species to enhance initial erosion protection. Aerial seeding during reservoir drawdown would not result in any further disturbance of soil on the exposed reservoir terraces and the establishment of vegetation on the terraces would potentially reduce erosion of fine sediments. Recent laboratory tests of reservoir sediments showed vegetated sediments produced less erodible fine particles and aggregates during cycles of wetting and drying than unvegetated sediments (Appendix B: *Definite Plan – Appendix H*).

Although not currently anticipated by KRRC, the Proposed Project may also include hydroseeding from a barge on exposed reservoir terraces as the water recedes during reservoir drawdown. Hydroseeding from a barge would be accomplished by placing a ground rig on one barge with another boat used to ferry materials from shore. A moveable pier or other engineered method of accessing the supply boat as the water level recedes would also be needed. If it occurs, barge hydroseeding would occur in the higher elevation portion of the reservoir shoreline, until the reservoir levels become too low to operate (i.e., March of dam removal year 2).

The Proposed Project also includes barge-mounted pressure spraying during reservoir drawdown that would target six locations in Copco No. 1 Reservoir and three locations in Iron Gate Reservoir within which to maximize erosion of sediment deposits and subsequently excavate to the historical floodplain elevation to create wetlands, floodplain areas and off-channel habitat features (see Appendix B: *Definite Plan – Appendix H Figures 5-4 and 5-7*).

Tribal cultural resources are known to be present within Area of Analysis *Subarea 1* (Figure). Cultural resource sites identified at the edges of Copco No. 1 Reservoir include prehistoric archaeological sites with habitation debris and several contributing elements of the ethnographic landscape (Cardno Entrix 2012, Daniels 2006, Heizer and Hester 1970, PacifiCorp 2004). In addition, ethnographic village sites have been identified within Copco No. 1 Reservoir (Heizer and Hester 1970, Daniels 2006). Native American burials and traditional use areas (for ceremonies) within the Copco No. 1 Reservoir footprint have also been identified through ethnographic research and consultations with the Shasta Nation and Shasta Indian Nation. At least one ethnographic village site has been identified within Iron Gate Reservoir by PacifiCorp (2004) and Daniels (2006). Specific TCR locations known to the Shasta people, which include TCRs as reflected in PacifiCorp (2004) and Daniels (2006), and as updated by Confidential Appendix Q, Attachment 4, are cataloged in Confidential Appendices P and Q. Resources identified as villages, cairns or burial sites, or sites eligible for the National Register of Historic Places in a subsequent compilation by Cardno ENTRIX (2012) were also considered as part of this analysis.

It is unknown whether adverse effects have already occurred to known or unknown, previously submerged TCR sites due to saturation within reservoir sediments and overlying water currents. However, impacts to these sites would likely result from shifting and exposure of reservoir sediment deposits during and after drawdown. Some TCR sites within the reservoir footprints may remain covered in sediment, or capped, resulting in some degree of preservation and protection.

Tribal cultural resource sites located in areas of steep or perched slopes, such as those along the steeper edges in the reservoir fluctuation zones[88], may experience shifting and slumping as a result of the underlying strata not being able to support the weight of overlying saturated soils. This is of particular concern for diatomaceous deposits located along the rim and below the Copco No. 1 Reservoir water level (see also Section 3.11.2.2 *Geomorphology* and Potential Impact 3.11-3). While the Proposed Project maximum drawdown rates (i.e., between 2 and 5 feet per day) are intended to minimize the potential for shifting and slumping of sediment deposits during reservoir drawdown, some sediment movement could still occur and could displace tribal cultural resources located in areas of steep or perched slopes that have relatively less thick sediment deposits. Note that some of the tribal cultural sites located within the reservoir fluctuation zones may be experiencing macro-scale wave-induced erosion impacts as part of existing conditions. Existing damage to exposed tribal cultural resources at some of these sites may be evident as wave cut terraces (beachlines) and other areas of accelerated erosion or scouring, as well as pedestaled and redeposited artifacts within the reservoir fluctuation zones. Given the proposed drawdown rates (2 to 5 feet per day), the reservoir shoreline would move below the normal fluctuation zone for each reservoir within 1 to 3 days of beginning drawdown. As this is a relatively short time frame compared to the continuous wave action that happens in this zone under existing conditions, reservoir drawdown alone is not expected to result in additional erosion-induced destruction or material alteration of the known tribal cultural resource sites in a way that would undermine their current or historical tribal significance relative to existing conditions. If it occurs, barge hydroseeding within the reservoir fluctuation zone would not result in additional wave-induced shoreline erosion outside of the range of existing conditions because barges tend to generate low wave heights due to their wide, flat bottoms and low operating speeds. Further, any concentrated additional wave-induced erosion from barge hydroseeding would be limited to a shorter duration (i.e., over several hours within a single day) than that of wind-action on the slowly downward-moving reservoir surface. Therefore, barge hydroseeding would be unlikely to exacerbate erosion impacts beyond that of reservoir drawdown itself, which would be within the range of existing conditions.

Additional potential impacts to TCR sites within the reservoir footprints, including short-term erosion, surface/shallow subsurface disturbance (i.e., sediment slumping), artifact displacement, and precipitation-induced runoff disturbance are discussed in Potential Impact 3.12-7. Increased potential for looting of exposed

[88] For Copco No. 1 Reservoir, the normal maximum and minimum reservoir operating levels are between 2,607.5 and 2,601.0 feet mean sea level (MSL), respectively, or a range of 6.5 feet for the reservoir fluctuation zone (PacifiCorp 2004b). For Iron Gate Reservoir, levels are between 2,330.0 and 2,324.0 feet MSL, respectively, or a range of 4 feet for the fluctuation zone (PacifiCorp 2004b).

TCRs at Iron Gate, Copco No. 1, and Copco No. 2 reservoirs during and following reservoir drawdown activities is discussed in Potential Impact 3.12-6.

Overall, the increased likelihood of impacts to known or as-yet unknown previously submerged TCRs due to drawdown of Iron Gate, Copco No. 1, and Copco No. 2 reservoirs would be a significant impact in light of the following:

- Increased potential for shifting, erosion, and/or exposure of TCRs that results in destruction or material alteration of the resources in a way that would undermine current or historical significance, in light of an existing condition in which the TCRs are under water.
- The large number of known TCRs, and the high potential for the presence of as-yet unknown TCRs, that are currently submerged by Copco No.1, Copco No. 2, and/or Iron Gate reservoirs.

Implementation of Mitigation Measures TCR-1 (TCRMP), TCR-2 (LVPP), TCR-3 (IDP), and TCR-4 (Endowment)[89] would reduce these impacts considerably, and, for many resources is expected to avoid impacts completely or to reduce the impact to less than significant. The measures (listed fully, below) include, among other requirements, timely surveys of exposed land, on-side tribal monitors, limits to public access, and identification of protocols and best practices upon discovery or disturbance of TCRs in project implementation. With timely discovery and appropriate steps to address exposure, shifting or erosion impacts, many TCRs can maintain their current level of cultural significance. Additionally, providing a means for the long-term protection or enhancement of affected TCRs can mitigate for certain impacts.

However, the impact of exposing or disturbing tribal human remains, or associated funerary items, is itself profound. While the mitigation measures are expected to considerably reduce impacts, they cannot reasonably be expected to eliminate such exposure or disturbance, particularly in light of evidence that the number of submerged burial sites is high. Thus, while drawdown is not generally anticipated to have large effects on material below the earth's surface at the time of reservoir inundation, where slumping is a risk and where so many sites are involved (including some sites that have been subject to wave action with an erosive effect) material risk remains that some burials may be affected. While treating remains and associated funerary objects with the appropriate respect and procedures can reduce and avoid compounding the harm from the initial exposure or movement, it cannot do so fully. In light of the particular harm of exposing human remains even where they are treated appropriately after exposure, the impacts would remain significant and unavoidable.

[89] Mitigation Measures TCR-6, TCR-7 and TCR-8 could also further reduce the potential impact. However, at this point it is not clear whether the measures are feasible (see Potential Impact 3.12-8). Therefore, this EIR does not rely on implementation of these measures in reaching its significance determinations.

Significance

Significant and unavoidable with mitigation

Potential Impact 3.12-3 Reservoir drawdown could result in short-term erosion or flood disturbance to tribal cultural resources located along the Klamath River.

Hydroelectric Reach

The Hydroelectric Reach from the California-Oregon state line to Copco No. 1 Reservoir includes prehistoric archaeological riverside sites with habitation debris, house pits and rock features and cemeteries; as well as ethnographic places and other features of the cultural landscape (PacifiCorp 2004, Daniels 2006). Historic period refuse scatters, historical hotel ruin sites, historical ranching sites, and historic roads are also present (Cardno Entrix 2012). There are known TCR sites located within the Area of Analysis *Subarea 4* (Figure) along the Klamath River between J.C. Boyle Dam and Copco No.1 Reservoir (Confidential Appendices P and Q). Certain of these sites may be impacted by increased flows during drawdown of J.C. Boyle Reservoir in Oregon because they are situated along the river's edge. It is a profound concern of the Shasta Nation that particular TCR sites along this reach would be flooded, and possibly destroyed, during drawdown (see also Confidential Appendix P as well as Shasta Nation consultation letter [2/1/2017] and public scoping letter [2/1/2017]).

As the Copco No. 1, Copco No. 2, and Iron Gate dams and associated facilities are located below this section of the Klamath River, the TCRs in this area would only be affected by the drawdown of J.C. Boyle. J.C. Boyle Reservoir has a relatively small storage capacity (3,495 acre-feet) and is not operated by PacifiCorp as a flood control reservoir. PacifiCorp operates J.C. Boyle Reservoir to produce hydroelectric power. Under current operations, when the inflow to J.C. Boyle Reservoir is below approximately 2,800 cfs, water is typically stored at night and released for power generation during the day which coincides with peak energy demand. When the inflow to the reservoir is greater than approximately 2,800 cfs, water does not need to be stored to generate power since the maximum capacity of the two turbine units in the J.C. Boyle Powerhouse is 2,850 cfs and any additional inflow to the reservoir spills over the dam. Spillage over the dam and flow through the J.C. Boyle Bypass reach in excess of the typical 100 cfs bypass flows generally occurs during the months of January through May when the Klamath River inflow to J.C. Boyle Reservoir tends to be greater than 2,800 cfs (Appendix B: *Definite Plan*). All flows diverted for power generation are returned to the Klamath River downstream stream of the J.C. Boyle Powerhouse in the J.C. Boyle Peaking Reach. Flows in the Klamath River between J.C. Boyle Reservoir and the upstream end of Copco No. 1 Reservoir vary by season and year, ranging from a daily mean value of less than 1,000 cfs during summer low flow periods to as high as 10,800 cfs in the spring of 1972 (Figure 3.12-7).

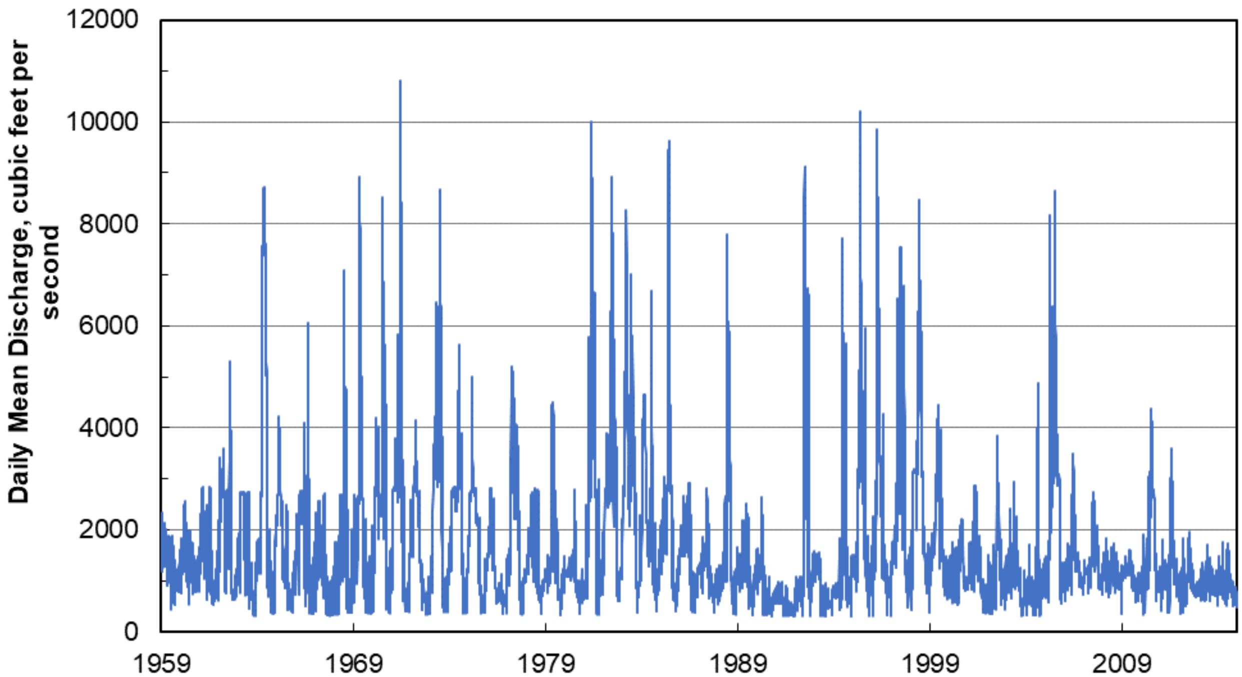

Figure 3.12-7. Discharge (flow) for Klamath River Downstream from J.C. Boyle Powerhouse, 1959–2015. Source: USGS 2016.

The proposed drawdown of the Lower Klamath Project reservoirs is designed to minimize potential flood risks, including carefully drawing down the reservoirs using controlled flow releases and the increased storage availability in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs once drawdown has begun to accommodate for potential winter flow events. Drawdown of J.C. Boyle Reservoir would occur from January 1 to March 15 of dam removal year 2. During drawdown, release flows at J.C. Boyle Dam would range from 1,000 to 3,000 cfs for short durations (1−2 days) (Appendix B: *Definite Plan*). As shown in Figure , flows of this magnitude are typical for the Klamath River upstream of Copco No. 1 Reservoir and downstream from J.C. Boyle Powerhouse and are well below maximum flows (close to 11,000 cfs). Accordingly, the average increase in Klamath River flow due to drawdown of J.C. Boyle Reservoir is expected to be small, from less than 1 percent up to 8 percent during the months of January and February of dam removal year 2 (Appendix B: *Definite Plan*). Thus, the Proposed Project would not result in drawdown flows that are out of the normal range of flows experienced under existing conditions. Since drawdown releases from J.C. Boyle Dam would not cause flooding of the river between the dam and Copco No. 1 Reservoir, the Shasta TCR sites located along this reach of the Klamath River would not be subject to short-term erosion and/or flood disturbance related to the removal of J.C. Boyle Dam.

Many of the Shasta TCR sites located along the river in this reach are located within the current FEMA 100-year floodplain. Because J.C. Boyle Reservoir is not a flood control reservoir, the FEMA 100-year floodplain extent in the Klamath

River between J.C. Boyle Dam and Copco No. 1 Reservoir would not change with dam removal (see Appendix K). Thus, there would be no long-term change in the flooding potential for Shasta TCR sites due to removal of J.C. Boyle Dam. Overall, there would be no significant impact of the Proposed Project on Shasta TCR sites located between J.C. Boyle Dam and Copco No. 1 Reservoir.

Middle Klamath River
Known TCRs within the Area of Analysis *Subarea 2* (Figure) include resources identified in PacifiCorp (2004) and Daniels (2006), as updated by Confidential Appendix Q, Attachment 4, and are cataloged in Confidential Appendices P and Q. Resources identified as villages, cairns or burial sites, or sites eligible for the National Register of Historic Places in a subsequent compilation by Cardno ENTRIX (2012) were also considered as part of this analysis.

Under the Proposed Project, drawdown of the four reservoirs would occur simultaneously beginning in January of dam removal year 2 (Copco No. 1 Reservoir would also experience early drawdown starting November of dam removal year 1 at a lower rate) (see also Section 2.7.2 *Reservoir Drawdown*). Drawdown of Copco No. 2 may occur later, at the start of May of dam removal year 2. The reservoir releases would be controlled and 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 (Appendix B: *Definite Plan*). The proposed drawdown of the Lower Klamath Project reservoirs is designed to minimize potential flood risks, including drawing down the reservoirs using controlled flow releases and the increased storage availability in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs once drawdown has begun to accommodate for winter flow events. If a flood event occurred during drawdown, the flood flows would be retained using the newly available storage capacity in each reservoir and drawdown would continue after flood risks have ended. Current conditions do not allow the Lower Klamath Project reservoirs to assist in flood prevention in this manner as the reservoirs' current operations occur within a narrow reservoir storage rage and do not provide adequate space for storage of winter flows. The Proposed Project drawdown rates are consistent with the historical discharge rates from the reservoirs, where flow rates downstream of the dams would not increase substantially above median historical rates, if at all. Discharges from Copco No. 1 and Iron Gate reservoirs would be similar to, or less than, seasonal 10-year flood flows from the reservoirs (see also Potential Impact 3.6-1).

Thus, drawdown releases from the Lower Klamath Project dams would not cause flooding of the Middle and Lower Klamath River, riverside TCR sites located in Area of Analysis *Subarea 2* (Figure), downstream of Iron Gate Dam either along the reach from Iron Gate Dam (RM 193) to Humbug Creek (RM 174) or further downstream (which is captured in Area of Analysis *Subarea 4* [Figure]). Therefore, these resources would not be subject to increased short-term erosion or flood disturbance as a result of reservoir drawdown that could destroy or materially alter TCRs in a way that would undermine current or historical cultural significance.

However, hydrologic and hydraulic modeling of floodplain inundation shows that removal of the Lower Klamath Project dams could result in minor alterations to the FEMA 100-year floodplain inundation area downstream of Iron Gate Dam, along the 18-river mile stretch of the Middle Klamath River between RM 193 and 174 (i.e., from Iron Gate Dam to Humbug Creek) (USBR 2012b). Changes in the extent of the floodplain inundation area in Area of Analysis *Subarea 2* (Figure) could increase the risk of flood damage to TCRs that are not currently located within the FEMA 100-year floodplain but would be following dam removal, where flood damage could involve physical destruction or relocation of TCRs such that the significance of the TCR would be materially impaired. This would be a significant impact in the short term and long term. Implementation of TCR-1, TCR-2, and TCR-3 would reduce impacts, although for the reasons described in Potential Impact 3.12-1, the impacts would remain significant and unavoidable.

Lower Klamath River and Klamath River Estuary
Because drawdown is not expected to increase flood risk and because dam removal is not expected to alter the floodplain downstream of Humbug Creek, no increased erosion or flooding-related risk of damage to cultural resources in Area of Analysis *Subarea 4* (Figure) is expected over the current conditions along the Klamath River downstream of Humbug Creek and in the Klamath River Estuary in either the short term or the long term.

There is the potential for the morphology of the Klamath River Estuary to change in light of sediment releases from the drawdown of the reservoirs (see Potential Impact 3.2-3). These changes to the estuary have a low-risk potential to affect estuary-based Yurok Tribe TCRs; however, there is some risk of potential impacts that would not occur absent implementation of the Proposed Project. The Yurok Tribe has adopted ordinances and policies to address impacts to cultural resources on the Yurok Reservation, which includes the Klamath River Estuary. In the unlikely event that such Proposed Project-related impacts would occur to resources in the area of the Klamath River Estuary, implementation of Mitigation Measure TCR-5 would reduce the potential impacts to less than significant.

Mitigation Measure TCR-5 − Implementation on Yurok Reservation.
Mitigation Measures TCR-1, TCR-2, and TCR-3 do not apply on the Yurok Reservation. The Yurok Tribe's Cultural Resource Ordinance and Inadvertent Discovery Policy shall apply to such TCRs on the Yurok Reservation.

Significance

No significant impact in the short term or long term for the Hydroelectric Reach between J.C. Boyle Dam and Copco No. 1 Reservoir

Significant and unavoidable with mitigation in the short term and long term for the Middle Klamath River from Iron Gate Dam to Humbug Creek

No significant impact in the short term or long term for Middle Klamath River downstream of Humbug Creek and Lower Klamath River excluding the Yurok Reservation (approximately RM 0 to RM 45)

No significant impact with mitigation on the Yurok Reservation (approximately RM 0 to RM 45) along Lower Klamath River and Klamath River Estuary

Potential Impact 3.12-4 Project activities associated with removal of Iron Gate, Copco No. 1, and Copco No. 2 dams could result in physical disturbance to known or unknown tribal cultural resources from blasting or other removal techniques.

Blasting and other dam removal techniques could cause significant adverse impacts to known or unknown TCRs located in the immediate vicinity[90] of Iron Gate, Copco No.1 and Copco No. 2 dams. While minor ground vibration and sounds from blasting and other dam removal techniques may extend throughout the 0.25-mile distance from each of the dams, the vibration and sounds would not result in significant impacts to TCRs because they would not result in physical demolition, destruction, relocation, or alteration of the resource or its immediate surroundings such that the significance of the TCR would be materially impaired.

However, direct physical disturbance associated with blasting and other removal techniques could significantly impact those TCR sites that directly overlap with the blasting locations. The KRRC proposes complete removal of dam facilities, including, in some instances, excavation of concrete below the existing streambed level, in order to prevent future development of fish barriers as the river morphology changes. Removal of the concrete dam structures would require blasting and drilling which could destroy, relocate, or alter those TCRs sites that directly overlap with the blasting locations or their immediate surroundings such that the significance of these TCRs would be materially impaired.

There is at least one TCR that was present at Copco No. 1 before dam construction that would be potentially impacted. It is unknown the extent to which the resource survives currently as it is no longer accessible. To the extent the site still exists, removal of the dam has a high likelihood of significantly

[90] For the purposes of this analysis, “immediate vicinity” is defined as within 0.25 miles of Copco No. 1, Copco No. 2, and Iron Gate dams.

degrading the site. There is also the potential for as-yet unknown sites to be impacted within the blasting zone, or by other techniques associated with the removal of these features, in light of the density of sites in the Hydroelectric Reach.

Implementation of mitigation measures TCR-1 (TCRMP), TCR-2 (LVPP), TCR-3 (IDP), and TCR-4 (Endowment)[91] would reduce impacts to TCRs associated with dam removal activities, but impacts would remain significant and unavoidable.

Significance

Significant and unavoidable with mitigation

Potential Impact 3.12-5 Ground disturbance associated with reservoir restoration, recreation site removal and/or development, and disposal site restoration could physically disturb known Tribal Cultural Resources. Additionally, ongoing road and recreation site maintenance has the potential to disturb known Tribal Cultural Resources.

The proposed Reservoir Area Management Plan includes restoration activities that would occur both within the reservoir footprint and in upland areas (i.e., disposal, staging, and hydropower infrastructure demolition areas, access roads, former recreational areas) within the Area of Analysis *Subarea 1* (Figure). Known TCR locations include those reflected in PacifiCorp (2004) and Daniels (2006), and as updated by Confidential Appendix Q, Attachment 4, which are cataloged in Confidential Appendices P and Q. Resources identified as villages, cairns or burial sites, or sites eligible for the National Register of Historic Places in a subsequent compilation by Cardno ENTRIX (2012) were also considered as part of this analysis.

After reservoir drawdown, the following ground-disturbing activities would be implemented in the former reservoir areas to stabilize remaining sediments over time and to restore riparian, floodplain, and wetland habitats:

[91] Mitigation Measures TCR-6, TCR-7 and TCR-8 could also further reduce the potential impact. However, at this point it is not clear whether the measures are feasible (see Potential Impact 3.12-9). Therefore, this EIR does not rely on implementation of these measures, in reaching its significance determinations.

- Active seeding[92] via ground equipment to revegetate reservoir areas with native grasses, sedges, rushes and forbes immediately after reservoir drawdown and planting of acorns, shrub seedlings, and pole cuttings as early as feasible;
- Manual removal/treatment of invasive exotic vegetation, which may include manual weed extraction, solarization (covering round areas with black visqueen), tilling, and use of herbicides;
- Planting of woody riparian trees and shrubs along the river banks in the former reservoir areas; and
- Installation of floodplain and off-channel habitat features such as large wood, roughening of the floodplain to enhance establishment of vegetation, and rectifying any non-natural fish passage barriers in mainstems and tributaries.

Within the reservoir footprint portions of the Area of Analysis *Subarea 1*, numerous TCR sites have been identified, including prehistoric archaeological sites with habitation debris, village sites, house pits and rock features and burial sites; as well as ethnographic places and other features of the cultural landscape (Confidential Appendices P and Q). Additionally, there may be many as-yet unknown TCRs located within the footprints of Copco No. 1, Copco No. 2, and Iron Gate reservoirs. Artifacts within the reservoir footprint may be materially impaired through physical demolition, destruction, relocation, or alteration by construction equipment (e.g., tilling) or hand tools (e.g., shovels for planting trees) during the aforementioned reservoir restoration activities. The proposed Reservoir Area Management Plan also includes long-term monitoring of vegetation growth, invasive exotic vegetation, and fish passage to ensure objectives are accomplished; however, these activities are not expected to be ground-disturbing.

Within the upland portions of the Area of Analysis *Subarea 1* (i.e., outside of the Copco No. 1 and Iron Gate reservoir footprints, including the fluctuation zone), known TCRs include those reflected in PacifiCorp (2004) and Daniels (2006), and as updated by Confidential Appendix Q, Attachment 4, and are cataloged in Confidential Appendices P and Q. Resources identified as villages, cairns or burial sites, or sites eligible for the National Register of Historic Places in a

[92] The Reservoir Area Management Plan includes aerial pioneer seeding using helicopters during the winter/early spring during and following reservoir drawdown (Appendix B: *Definite Plan – Appendix H*). Aerial seeding is not a ground-disturbing activity. Fall overseeding, which is potentially ground-disturbing, would be completed with a ground-based broadcast seeder over the mowed or rolled vegetation remaining from the pioneer seeding (Appendix B: *Definite Plan – Appendix H*). Hydroseeding via barge during reservoir drawdown is potentially a ground-disturbing activity, although this activity is not currently anticipated by KRRC. Potential impacts due to barge hydroseeding are discussed in Impact 2.

subsequent compilation by Cardno ENTRIX (2012) were also considered as part of this analysis. Proposed upland restoration activities include active management of invasive exotic vegetation species, which may include ground-disturbing activities such as manual weed extraction, solarization (covering of ground areas with black visqueen), tilling, and planting (Appendix B: *Definite Plan − Appendix H*) (see also Section 2.7.5 *Restoration of Upland Areas Outside of the Reservoir Footprint*). These activities may result in material impairment of TCRs located within upland portions of the Area of Analysis *Subarea 1* from physical demolition, destruction, relocation, or alteration by construction equipment (e.g., tilling) or hand tools (e.g., shovels for planting trees). Non-ground-disturbing, proposed upland restoration activities include the possible use of herbicides for controlling invasive exotic vegetation; collecting seeds for local nurseries to grow trees and shrubs; and implementing a short-term Storm Water Pollution Prevention Plan (SWPPP)/Erosion Control Plan.

Ground-disturbing activities associated with ongoing road and recreation site maintenance within the Area of Analysis *Subarea 1* (Figure) include grading and excavating, which may also result in material impairment due to physical demolition, destruction, relocation, or alteration of TCRs located in both upland and reservoir footprint locations.

In summary, several known and potentially many as-yet unknown TCRs could be significantly adversely impacted due to the aforementioned ground-disturbing activities associated with revegetation and restoration of riparian, floodplain, and wetland habitat within former reservoir areas and upland areas, as well as ongoing road maintenance and potential recreation site construction and maintenance, if any.

Implementation of Mitigation Measures TCR-1 (TCRMP), TCR-2 (LVPP), TCR-3 (IDP), and TCR-4 (Endowment)[93] would reduce these impacts considerably, and, for most resources is expected to avoid impacts completely, through designing restoration plans to completely avoid impacts, or by on-the-ground changes to implementation to avoid impacts. Using hand tools to restores sensitive areas will reduce the risk and severity of potential damage as compared to use of heavy equipment. For impacts that it is not feasible to completely avoid, the impacts may be reduced to a less than significant level. The measures include, among other requirements, field worker training, limits to worker and public access, tribal monitors, surveys, and identification of protocols and best practices upon discovery or disturbance of TCRs in project implementation. With timely discovery and appropriate steps to address exposure or damage, many TCRs can maintain their current level of cultural significance. Additionally, providing a

[93] Mitigation Measures TCR-6, TCR-7, and TCR-8 could also further reduce the potential impact. However, at this point it is not clear whether the measures are feasible (see Potential Impact 3.12-9.) Therefore, this EIR does not rely on implementation of these measures, in reaching its significance determinations.

means for the long-term protection or enhancement of affected TCRs can mitigate for some impacts.

However, the impact of exposing or disturbing tribal human remains, or associated funerary items, is itself profound. The mitigation measures are expected to considerably reduce—but cannot be reasonably be expected to completely avoid—such exposure or disturbance, particularly in light of the density of villages in the reservoir bed areas. While treating remains and associated funerary objects with the appropriate respect and procedures can reduce and avoid compounding the harm from the initial damage, it cannot do so fully.

Additionally, in light of the high density of TCRs in the restoration areas, and because some of the contemplated restoration involves significant earth-moving with heavy equipment, such as potentially regrading areas and enhancing wetlands, significant risk remains that other TCRs may sustain damage that results in a martial impairment of the resource's significance. In light of the particular harm of exposing human remains even where they are treated appropriately after exposure, and the likelihood of significantly impairing other resources in light of the type of construction actions and the density of resources, the impact would remain significant and unavoidable.

Significance

Significant and unavoidable with mitigation

Potential Impact 3.12-6 During and following reservoir drawdown activities at Iron Gate, Copco No. 1, and Copco No. 2 reservoirs there is an increased potential for looting of Tribal Cultural Resources (short-term and long-term).

During and immediately following reservoir drawdown[94], TCRs located within the footprints of Copco No. 1, Copco No. 2, and Iron Gate reservoirs would no longer be partially or completely covered by reservoir waters and thus would be more accessible and at greater risk for looting. For these known TCR sites, plus as-yet unknown sites, some tribal representatives assert that the reservoirs offer the best protection against looting because the reservoir waters currently prevent looter access.

Known TCRs within the Area of Analysis *Subarea 1* (Figure 3.12.2) include resources identified in PacifiCorp (2004a) and Daniels (2006), as updated by Confidential Appendix Q. Resources identified as villages, cairns or burial sites, or sites eligible for the National Register of Historic Places in a subsequent

[94] Consideration of exposure or substantial movement of tribal cultural resources during pre-dam removal ground-disturbing activities that could lead to increased access and looting above levels occurring under existing conditions is discussed in Potential Impact P-1.

compilation by Cardno ENTRIX (2012) were also considered as part of this analysis. Within the footprints of Copco No. 1, Copco No. 2, and Iron Gate reservoirs, which is the focus of this Potential Impact 3.12-5 analysis, numerous TCR sites have been identified. Additionally, there may be many as-yet unknown TCRs located within the footprints of the California reservoirs. Note that many of the known TCR sites are located within the reservoir fluctuation zones and several of these are associated with relatively shallow sediment deposits (approximately 0.2 to 2 feet deep). Tribal cultural resource sites located within the reservoir fluctuation zones may be periodically at risk of looting during low water periods under existing conditions.

Within the reservoir footprints, Proposed Project restoration activities would occur during and immediately following reservoir drawdown (i.e., dam removal years 1 and 2) as well as post-dam removal year 1, including active seeding to revegetate reservoir areas with native grasses, sedges, rushes and forbes, and planting of acorns, shrub seedlings, and pole cuttings, all of which would stabilize sediments remaining in the reservoir footprints (see also Potential Impact 3.12-4). Revegetation activities would reduce erosion of fine sediments (Appendix B: *Definite Plan – Appendix H*) and would physically cover the remaining sediment deposits with a variety of vegetation, thus decreasing the potential for exposure and looting of TCRs located within the reservoir footprints. However, in general, sensitive areas located within the reservoir footprints would be subject to exposure and increased access since they would no longer be partially or completely covered by reservoir waters. This could increase the potential for looting of TCRs above levels occurring under existing conditions. The potential severity of this impact is underscored by significant anecdotal evidence of an extensive looting problem in the area, and by statements made by tribal members regarding the deep impact of past and ongoing looting, particularly in light of a history of repeated dispossession in the area.

Implementation of Mitigation Measure TCR-2 (LVPP) and TCR-4 would significantly reduce the impacts of looting in the short term and long term. However, illegal looting remains a pervasive problem in the vicinity, as related through extensive anecdotal evidence by tribal members and archaeologists with experience in the area. Therefore, although it is likely that the LVPP would be effective in protecting most resources through the intensive monitoring and broad range of tools to address the concern, it would be unlikely to be completely effective. The impact of looting of certain resources is profound, and could result in material impairment of a resources' significant or result in the exposure or disturbance of human remains. Therefore, the increased risk of looting remains significant and unavoidable.

Significance

Significant and unavoidable with mitigation in the short term and long term

Potential Impact 3.12-7 Short-term erosion caused by high-intensity and/or duration precipitation events could cause exposure of or disturbance to known or unknown tribal cultural resources within the reservoir footprints immediately following reservoir drawdown and prior to vegetation establishment/full stabilization of sediment deposits.

Immediately following reservoir drawdown[95], high-intensity and/or long-duration precipitation events could occur that would result in surface erosion of remaining reservoir sediment deposits and cause exposure of or disturbance to TCRs located within the reservoir footprints. Known TCRs to be within the Area of Analysis *Subarea 1* include resources identified in PacifiCorp (2004a) and Daniels (2006), as updated by Confidential Appendix Q. Resources identified as villages, cairns or burial sites, or sites eligible for the National Register of Historic Places in a subsequent compilation by Cardno ENTRIX (2012) were also considered as part of this analysis. Within the footprints of Copco No. 1, Copco No. 2, and Iron Gate reservoirs, which is the focus of this analysis for Potential Impact 3.12-7, numerous TCR sites have been identified (Confidential Appendices P and Q). Additionally, there may be many as-yet unknown TCRs located within the footprints of Copco No. 1, Copco No. 2, and Iron Gate reservoirs.

Since the Lower Klamath Project reservoirs were constructed, fine sediments composed primarily of organic material (including dead algae), but also including some silts and clays, have accumulated along the reservoir bottoms (see Section 2.7.3 *Reservoir Sediment Deposits and Erosion During Drawdown*). The distribution of sediment deposits varies within each reservoir (Figure 2.7-8 and 2.7-9). Because the accumulated sediments are primarily fine material, a percentage of them would be easily eroded and flushed out of the reservoirs into the downstream Klamath River during reservoir drawdown, with the majority of the erosion focused in the original river channel (Figures 2.7-5 and 2.7-6). However, following drawdown, 40−60 percent of the sediment deposits accumulated behind the dams would remain in place in each of the former reservoir beds, primarily on terraces located above the original river channel. The sediments that remain in the reservoir footprints would consolidate (dry out and decrease in thickness) (USBR 2012a), making them less subject to erosion. Further, during the drawdown period, seeding (by helicopter and potentially barge) of pioneer mixes would occur as the reservoir water level drops and before the exposed reservoir sediments dry and form a surface crust. The seeded native grasses are expected to become well established within weeks after application (January to March of dam removal year 2), which would reduce erosion of the remaining reservoir sediment deposits during cycles of wetting (i.e., from precipitation events) and drying (Appendix B: *Definite Plan – Appendix H*). During the first summer and fall following reservoir drawdown (dam removal

[95] Consideration of potential shifting-, erosion-, and exposure-related impacts to tribal cultural resources during reservoir drawdown is discussed in Potential Impact 3.12-2.

year 2), additional seeding application would occur including grasses and ground cover, with monitoring and targeted revegetation for areas that do not meet vegetation cover goals (Appendix B: *Definite Plan – Appendix H*).

During the period of weeks when seeded native grasses have not yet become well established within the reservoir footprints, high intensity and/or long-duration precipitation events could increase erosion of remaining reservoir deposits through sediment cracking and gully erosion, and destroy or materially impair TCRs in a way that would undermine current or historical cultural significance, including through substantial movement of human remains. This could increase disturbance impacts to TCRs that were already affected during drawdown (see Potential Impact 3.12-4), or impact additional TCRs that were not affected by erosion during drawdown. The risk of this occurring would be higher for TCRs located in areas where post-reservoir sediment deposition was relatively thin (i.e., areas where sediment deposits are less than 2 feet deep) and would be limited to TCRs that were located above ground prior to reservoir inundation[96].

However, since 40−60 percent of the reservoir sediment deposits are predicted to remain in place following drawdown, many TCRs that were located above ground at the time of reservoir inundation are expected to remain substantially covered, even those located within reservoir sediment deposits that are less than 2 feet deep (see Confidential Appendices P and Q). For those sites located within deeper reservoir sediment deposits, the overlying sediment layer would offer protection from surface cracking and gully erosion that may result from high intensity and/or duration precipitation events and these deeper sites would not be likely to be destroyed or materially impaired in a way that would undermine current or historical cultural significance.

The risk of continued erosion and subsequent exposure of or disturbance to TCRs located in the reservoir footprints, particularly for those associated with relatively shallow (e.g., less than 2 feet deep) sediment deposits (see Confidential Appendices P and Q), would decrease within weeks to months following reservoir drawdown as revegetation stabilizes the remaining sediments. Monitoring and targeted revegetation activities included in the proposed Reservoir Area Management Plan (Appendix B: *Definite Plan – Appendix H*) would reduce the risk of impacts to TCRs located in areas of large crack or gully formation. As the system returns to riverine conditions within the reservoir footprints, with revegetated terraces along the river and sides of the former

[96] For tribal cultural resources that were located below ground prior to inundation, the Proposed Project is not expected to result in exposure or disturbance impacts because sediment erosion would be limited to the fine materials accumulated since the reservoirs were constructed (see Potential Impact 3.12-2). These tribal cultural resources would remain buried, their significance to the Shasta Nation would not be materially impaired, and there is no anticipated impact.

reservoirs, long-term erosion and sediment transport rates would return to natural rates for this portion of the watershed (USBR 2012b).

Implementation of Mitigation Measures TCR-1 (TCRMP), TCR-2 (LVPP), and TCR-3 (IDP)[97] would reduce these impacts, overall they would remain significant and unavoidable for the reasons described for the erosion related to reservoir drawdown (Potential Impact 3.12-2).

Significance
Significant and unavoidable with mitigation in the short term

Potential Impact 3.12-8 Long-term (post-removal) impacts to Tribal Cultural Resources as a result of dam removal from increased looting opportunities and from surface and subsurface erosion of Tribal Cultural Resources.
Following drawdown of Iron Gate, Copco No.1, and Copco No. 2 reservoirs, 40−60 percent of the reservoir sediment deposits would remain in place, primarily on areas at higher elevation than the active river channel within the reservoir footprints (see also Potential Impacts 3.12-4 and 3.12-8). During tribal consultations, some tribal representatives expressed strong concerns that long-term erosion of remaining sediment deposits within the Lower Klamath Project reservoirs would disturb or destroy TCRs that are located there (see also Confidential Appendix P). In addition, the Proposed Project includes transfer of PacifiCorp lands immediately surrounding the Lower Klamath Project ("Parcel B lands") from PacifiCorp to the KRRC prior to dam removal, where Parcel B lands contain all of the Copco No. 1 Reservoir footprint and the majority of the Iron Gate Reservoir footprint (Figure). The Proposed Project then provides that the KRRC would transfer Parcel B lands to the respective states (i.e., California, Oregon), as applicable, or to a designated third-party transferee, following dam removal. The lands would thereafter be managed for public interest purposes (KHSA Section 7.6.4.A).

The potential for increased looting opportunities and surface erosion to result in long-term impacts to known or unknown TCRs due to the Proposed Project is discussed below for resources located within the reservoir footprints and within Parcel B lands.

Tribal Cultural Resource Sites Within the Reservoir Footprints Prior to Land Transfer
Tribal cultural resources known to the Shasta people to be within the Area of Analysis *Subarea 1* include resources identified in PacifiCorp (2004a) and Daniels (2006), as updated by Confidential Appendix Q, Attachment 4.

[97] Mitigation Measures TCR-6, TCR-7 and TCR-8 could also further reduce the potential impact. However, at this point it is not clear whether the measures are feasible (see Potential Impact 3.12-8). Therefore, this EIR does not rely on implementation of these measures, in reaching its significance determinations.

Resources identified as villages, cairns or burial sites, or sites eligible for the National Register of Historic Places in a subsequent compilation by Cardno ENTRIX (2012) were also considered as part of this analysis. Within the footprints of Copco No. 1, Copco No. 2, and Iron Gate reservoirs, numerous TCR sites have been identified including village and cairn sites (Confidential Appendices P and Q). Additionally, there may be many as-yet unknown TCRs located within the footprints of Copco No. 1, Copco No. 2 and Iron Gate reservoirs.

As described in Potential Impacts 3.12-2 and 3.12-6, following reservoir drawdown, the remaining sediment deposits would consolidate through air drying and would decrease in thickness (USBR 2012a). Revegetation efforts under the Proposed Project would support re-establishment of native species on newly exposed reservoir sediments, including grasses and woody riparian species, where the latter would be planted at densities of several hundred plants per acre. It is expected that former wetland areas within the reservoir footprints would revert to wetland vegetation without long-term active revegetation inputs (Appendix B: *Definite Plan – Appendix H*).

While a portion of the fine sediments that have deposited since the dams were constructed would erode rapidly during reservoir drawdown (see Potential Impacts 3.12-4 and 3.12-8), erosion rates would decrease over weeks to months, as the remaining sediment deposits are stabilized by drying and by active and passive revegetation. As the system returns to riverine conditions within the reservoir footprints, long-term erosion and sediment transport rates would also return to natural rates for this portion of the watershed (USBR 2012b). Previous wave action within the reservoir fluctuation zone would cease as the reservoir shoreline would no longer exist, with a long-term benefit over current conditions to the known and as-yet unknown TCR sites located within the reservoir fluctuation zone (Confidential Appendices P and Q).

Thus, in the long term, drying, consolidation, and stabilization (due to re-vegetation) of the remaining sediment deposits would substantially limit the potential for erosion to result in exposure or substantial movement of TCRs buried within the deposits, or those that were located below the ground surface prior to construction and inundation of Copco No.1, Copco No. 2, and/or Iron Gate dams, such that increased access and looting above levels occurring under existing conditions would be unlikely. Instead, long-term drying, consolidation, and stabilization of the sediment deposits remaining in the reservoir footprints have the potential to preserve and protect known or as-yet unknown TCRs within or beneath the deposits. The potential for long-term erosion-related impacts on TCRs within the reservoir footprints is therefore different from and significantly less than the potential for erosion-related impacts to these resources in the periods during and immediately following reservoir drawdown (Potential Impact 3.12-4). However, despite the protection offered from the remaining sediment deposits, the vulnerability of existing TCRs to long-term exposure due to natural rates of erosion and sediment transport for the watershed would still increase as compared to existing conditions where the reservoir waters offer almost complete protection from access and looting (with the exception of resources located within the reservoir fluctuation zone). The potential impact of this increased potential is underscored by significant anecdotal evidence of an extensive looting problem in the area, and by tribal members' testimony regarding the deep impact of past and ongoing looting, particularly in light of a history of repeated dispossession in the area.

Implementation of Mitigation Measure TCR-1 (TRMP), TCR-2 (LVPP), and TCR-3 (IDP), would reduce long-term impacts to TCRs from increased looting opportunities and surface and subsurface erosion, however, these impacts would remain significant.

Tribal Cultural Resource Sites Within Parcel B Lands After Transfer
Known TCRs within the Area of Analysis *Subarea 3* (Figure) include resources identified in PacifiCorp (2004a) and Daniels (2006), as updated by Confidential Appendix Q, Attachment 4. Resources identified as villages, cairns or burial sites, or sites eligible for the National Register of Historic Places in a subsequent compilation by Cardno ENTRIX (2012) were also considered as part of this analysis. Numerous TCR sites have been identified completely inside or partially inside Parcel B lands (Confidential Appendices P and Q).

It is unknown what public use the lands in Parcel B would ultimately serve. The California Natural Resources Agency (CNRA) and California Department of Fish and Wildlife (CDFW) have begun speaking with interested stakeholders on various recreation, water quality, tribal, resource protection, conservation, and economic uses of the land, including with tribal governments and Siskiyou County representatives. While the lands would be managed for public interest, this could include a range of uses, including open space, active wetland and riverine restoration, river-based recreation, grazing, and potentially other uses. Certain future land uses (e.g., open space) would presumably result in less potential for impacts to TCRs.

However, certain land uses, if undertaken in areas with TCRs, would have the potential to increase public access to TCRs beyond the level of simply removing the reservoirs, and it could therefore result in additional impacts due to construction, looting, illegal excavation, vandalism, and other destruction or damage within the Area of *Subarea 3* (Figure). Existing and potentially new recreation facilities along the river corridor may also direct the public to favorable landforms (e.g., flat topography, close to tributary confluences and other water sources) that coincide with locations chosen by tribal ancestors for habitation and other cultural uses. Increased access to TCRs due to land transfer has the potential to lead to looting above levels occurring under existing conditions or to land uses that result in material alteration of TCRs in a way that would undermine their current or historical tribal significance.

Further, future Parcel B land transfer could result in uses of lands currently not submerged that eliminate or substantially restrict access of tribal members to TCRs during ceremonial windows or periods of hunting and gathering or other traditional activities associated with a TCR. It is unclear what public use of Parcel B lands could result in such an increased barrier over the existing private ownership by PacifiCorp. For currently submerged lands, there is currently no access such that future land use decisions for the reservoir footprint portions of Parcel B would likely result in access-related benefits as compared with existing conditions.

In 2017, the Kikaceki Land Conservancy was formed, which includes representation of Shasta people with ancestry in the area affected by the Proposed Project. In the ongoing consultation process under NHPA section 106, KRRC will address whether this existing land conservancy, or other entities which represent Affected Tribes, could continue to implement measures for TCR protection and enhancement after the KRRC has completed Project implementation. The express mention of the Kikaceki Land Conservancy in this EIR in no way excludes the claims of any other traditionally and culturally affiliated tribes, or harms any other tribes' rights.

The process for determining future land use under the KHSA Section 7.6.4 has the potential to offer TCRs appropriate protection through a variety of land use strategies: that process remains unaltered by this EIR. Implementation of TCR-6 (Land Transfer), TCR-7 (Land Easement and Transfer Stipulations), and TCR-8 (Off-site Land Transfer) have the potential to reduce the impact of future land use decisions to less than significant. These measures are in alignment with the general proposed measures for consideration to mitigate impacts to TCRs described in Public Resources Code section 21084.3, subdivision (b)(3).

However, the ultimate feasibility of these measures is uncertain. The process for determining future land uses under KHSA Section 7.6.4 has not advanced to the point at which competing uses, financial limitations, parcel access requirements, or other constraints have become clear. Additionally, because the KRRC has a set amount of funding with which to implement the Proposed Project, its ability to undertake purchase of lands outside Parcel B as a mitigation measure is also uncertain, and thus the feasibility of Mitigation Measure TCR-8 (Off-site Land Transfer) is also uncertain. Because the ultimate feasibility of these measures is uncertain, and the State Water Board lacks the authority to impose them through its Clean Water Act section 401 certification, this EIR does not rely on implementation of these measures, although it is disclosing them because it is likely that the protections would be viable for at least some portion of the identified lands, and because they represent a potentially feasible path to protect TCRs.

Mitigation Measure TCR-6 − Land Transfer.
The State Water Board has determined, and KRRC has acknowledged, that transfer of some Parcel B lands to an entity representative of Affected Tribes which are traditionally and culturally affiliated with TCRs on such lands, could foster tribal cultural and conservation practices and promote tribal identity; and further, that such transfer could be an appropriate measure to address past disturbance of TCRs caused during construction of Iron Gate Dam, Copco No. 1 Dam, and Copco No. 2 Dam, and to mitigate the impacts to TCRs caused by Project implementation.

Pursuant to KHSA Section 7.6.4, the California Natural Resources Agency (CNRA) and CDFW have begun the process to determine the disposition of Project-related (or "Parcel B") lands, totaling approximately 8,000 acres, for public interest purposes. In California, that process is anticipated to involve the following steps: (1) inspections and preliminary due diligence regarding the condition of the Parcel B lands; (2) consultation with KHSA parties and other stakeholders regarding disposition; (3) for each parcel, a proposal by CNRA and CDFW regarding proposed transferee and other terms; (4) actual transfer of Parcel B lands from PacifiCorp to KRRC, upon KRRC's notice that it has secured all necessary permits for dam removal; and (5) subsequent transfer from KRRC to California or the third-party transferee, by parcel.

Based on AB 52 consultation, the State Water Board has identified the following potential mitigation measure, which is dependent on the outcome of the process required by KHSA Section 7.6.4. The Shasta Indian Nation has proposed the transfer of selected Parcel B lands (as identified in Confidential Appendix Q they have identified as possessing the most significant tribal cultural value to the Shasta Indian Nation and also having central importance to other Shasta peoples. The Shasta Indian Nation has proposed transfer to an entity, such as the Kikaceki Land Conservancy, that includes representation of the several bands of Shasta peoples. While it is too early in the process to determine the feasibility of such transfer, this measure is included for analysis in the Environmental Impact Report. In the process required by KHSA Section 7.6.4, the KRRC shall support consideration of transfers of selected lands to an entity representative of Affected Tribes that are traditionally and culturally affiliated with the TCRs on such lands, in circumstances where the lands have resources of critical tribal importance and such transfer would be a cost-effective approach to protect such resources.

Mitigation Measure TCR-7 − Proposal for Land Easement and Transfer Stipulations.
The CNRA and CDFW have begun initial discussions in a stakeholder process for determining land disposition as described in KHSA Section 7.6.4, including discussions with Shasta people.

1. For TCRs and such sites that are protected under Public Resources Code 5097.993, land easement and transfer stipulations could ensure that protection measures described in the TCRMP encumber the title for all subsequent owners for other lands not returned to the Shasta people. Any such land easement or transfer stipulations shall be consistent with KHSA Section 7.6.4 and other applicable terms.
2. There is also the potential to coincide public wildlife conservation management areas with lands that contain tribal cultural values to restrict public access where feasible and promote protection of cultural sites.
3. These mechanisms can also provide the opportunity for Shasta people to access TCRs through creation of tribal conservation easements.

Mitigation Measure TCR-8 − Off-site Land Transfer.
At any time prior to completing the TCRMP, the KRRC may identify parcels of land not subject to the process under KHSA Section 7.6.4, that may be appropriate for transfer to an entity representative of Affected Tribes (such as the Kikaceki Land Conservancy), as off-site mitigation for Project-related impacts to TCRs. Any such transfer involving the KRRC is subject to funding availability consistent with the terms (including funding authorities) of the KHSA.

Significance
Significant and unavoidable prior to land transfer

No significant impact with mitigation after land transfer

Potential Impact 3.12-9 Klamath Cultural Riverscape Contributing Aspect – Combined effects on the Klamath River fishery of dam removal, changes in hatchery production, and increased habitat for salmonids.
Many California Native American tribes located in the Klamath River Basin historically relied on fish (such as salmon, steelhead, and Pacific lamprey) for food, currently use fish in their diet, including some members at a subsistence level of reliance, and have and continue to consider fish to be an important part of their culture (Section 3.12.2 *[Historical Resources and Tribal Cultural Resources] Environmental Setting* and Appendix V – 2012 KHSA EIS/EIR *Section 3.12 Tribal Trust*). Under existing conditions, these fish may include adult Chinook and coho salmon returns to Iron Gate Hatchery. CDFW operates Iron Gate Hatchery with an annual production goal (CDFW and PacifiCorp 2014) (see also Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project – Fish Hatcheries*) of 75,000 coho salmon smolts, and six million fall-run Chinook salmon yearlings and smolts.

The ability to meet the above production goals varies annually based on adult returns and hatchery performance. Coho salmon production has averaged 75,000 yearlings (achieving production goals). From 1991 through 2017 actual fall-run Chinook salmon yearling production has averaged 973,574 (exceeding production goals), and actual smolt production from 1991 through 2018 has averaged 4,593,220 (around a half-million fewer smolts than the goal on average) (K. Pomeroy, CDFW, pers. comm., 2018). The fall-run Chinook salmon hatchery spawner return goal is 8,000 fish. Total Chinook salmon returns to Iron Gate Hatchery between 1978 and 2016 ranged from 2,558 to 72,474 and averaged 16,206 fish (CDFW 2017). Recent returns of adult Chinook salmon to Iron Gate Hatchery have been similar to the long-term average, with an average of 15,625 adult Chinook salmon returning over the period of 2009–2018 (CDFW 2019).

Adult steelhead (fall- and spring-run) returns to Iron Gate Hatchery averaged 1,064 fish for the period of 1963–2016 (CDFW 2016b). More recent returns have been much lower with an average of 82 adult steelhead returning to Iron Gate Hatchery for the period of 2007–2016 (CDFW 2016b). Returns have been declining, and in 2016 no adult steelhead returned to the hatchery (CDFW 2016b). The low adult returns of steelhead have resulted in no production of steelhead yearlings from Iron Gate Hatchery since 2013.

It appears that progeny from Iron Gate Hatchery releases have contributed appreciably to in-river tribal harvest since the late 1960s (PacifiCorp 2004a). PacifiCorp (2004a) estimates that based on smolt-to-adult survival studies conducted on Iron Gate fall Chinook salmon, the Iron Gate Hatchery production contributes about 50,000 fish annually to the Chinook and coho salmon fisheries (including commercial, tribal and recreational fisheries), in addition to escapement back to the hatchery.

The Proposed Project includes the continued operation of Iron Gate Hatchery and the reopening of Fall Creek Hatchery. The Iron Gate and Fall Creek hatcheries would be operated for eight years following dam removal (Section 2.7.6 *Hatchery Operations* and Section 3.3.5.6 *Fish Hatcheries*). The total production goals for both hatcheries would be reduced from the current production at Iron Gate Hatchery. Under the Proposed Project fall-run Chinook salmon smolt releases will decrease by 8 percent relative to current production (2009 through 2017), and yearling releases will decrease by 88 percent relative to current production (2008 through 2017), coho yearling production would remain the same, and steelhead production would continue to be zero.

As described in Potential Impact 3.3-7, operation of the hatcheries at a combined reduced capacity following dam removal would be likely to reduce average annual hatchery Chinook salmon returns (by around 3,552 fewer fish) compared with existing conditions between post-dam removal years 3 and 10 (Table 3.3-11). There would be no change to the coho salmon population through dam removal year 9 relative to existing conditions as a result of shifting all coho production to Fall Creek Hatchery (Potential Impact 3.3-9) and there would be no change to steelhead production relative to existing conditions since steelhead have not been released since 2012.

No reduction in hatchery adult returns would be evident until post-dam removal year 3 (Section 3.3.5.6 *Fish Hatcheries*), by which time the first adult returns from the progeny of naturally spawning Chinook salmon in newly accessible habitat upstream of the prior location of Iron Gate Dam would occur (Potential Impact 3.3-7). Between post-dam removal years 3 and 10, both hatchery returns and returns from newly accessible habitat would occur, offsetting reductions due to lower hatchery capacity in the early years of the Proposed Project, as total adult returns of Chinook salmon, and the associated tribal fishery resource, increase towards overall higher levels.

The elimination of hatchery production after eight years following dam removal under the Proposed Project would eliminate the congregation of returning hatchery adults to the reach downstream of the prior location of Iron Gate Dam. Combined with the removal of the dams, which would increase the likelihood that adults would disperse further upstream, these factors would be likely to reduce the incidence of fish disease and parasites in the Klamath River (see Section 3.3.5.5 *Fish Disease and Parasites*). Further, since hatchery juveniles would no longer be released after post-dam removal year 7, fish disease would be less likely to affect outmigrating smolts. Higher smolt survival would result in an increase in adult returns available for in-river tribal harvest (PacifiCorp 2004a). Overall, it is anticipated that the Proposed Project would help to reduce the incidence of fish disease and parasites in the Klamath River and thus would be beneficial.

As described in Section 3.3.5.9, Potential Impact 3.3-7, quantitative modeling of fall-run Chinook salmon populations predict that the Proposed Project would increase Chinook salmon abundance. Median escapements to the Klamath Basin are predicted to be higher (median increase greater than 30,000) with the Proposed Project than under existing conditions. The potential for tribal harvest is therefore also predicted to be greater with the Proposed Project due to increased numbers of Chinook salmon adults (affecting the number of fish available annually), and the decrease in the probability of low escapement leading to fishery closures (affecting the number of years in which fishing will be available for more than ceremonial purposes).

While a reduction (around 3,552 fish on average) in total fall-run Chinook salmon returns for up to four years under the Proposed Project would constitute a potential short-term alteration in Chinook salmon as a tribal fishery resource, it is within the existing degree of annual variability in hatchery-origin Chinook salmon returns (2,558 to 72,474 for the period 1980 to 2001 [CDFW 2016b]) and natural Chinook salmon returns (6,957 to 91,757 for the period 1980 to 2001 [CDFW 2016a]). The Proposed Project would be unlikely to represent a material impairment of the Klamath Riverscape as a resource or a substantial restriction of tribal access to the fishery relative to existing conditions, even in the short term. This assessment is bolstered by the lack of reduction in hatchery-origin coho adult returns that would occur under the Proposed Project and the lack of change in hatchery operations from the existing condition for steelhead and spring-run Chinook (neither of which the hatchery produces) under the Proposed Project.

In addition, survival of natural and hatchery smolts is predicted to increase by post-dam removal year 1 from reduced incidence of disease (see Section 3.3.5.5 *Fish Disease and Parasites*) and increased natural production from newly accessible habitat is predicted to increase salmon abundance by post-dam removal year 3 (see Section 3.3.5.6 *Fish Hatcheries*). Thus, reduced hatchery production goals for eight years following dam removal would be a less than significant impact in the short term. In the long term, the loss of hatchery production would be more than replaced by increased natural production (Potential Impact 3.3-7), and the cessation of hatchery operations would be beneficial to the Klamath River fishery TCR by helping to reduce the incidence of fish disease and parasites.

As described in Section 3.3.5.9, the Proposed Project would not have a significant short-term impact and would have a long-term beneficial effect on spring-run Chinook salmon (Potential Impact 3.3-8), coho salmon (Potential Impact 3.3-9), steelhead (Potential Impact 3.3-10), Pacific lamprey (Potential Impact 3.3-11), and redband trout (Potential Impact 3.3-14). The tribal fishery resource is anticipated to benefit from the Proposed Project in the long term as a result of population improvements for these tribal trust species.

As described in Section 3.3.5.9, the Proposed Project would not have a significant short- or long-term impact on green sturgeon (Potential Impact 3.3-12), Lost River and shortnose suckers (Potential Impact 3.3-13), eulachon (Potential Impact 3.3-15), longfin smelt (Potential Impact 3.3-16), and freshwater mussel species *M. falcata* and *G. angulate* (Potential Impact 3.3-16). Freshwater mussel *Anodonta spp*. would experience a significant and unavoidable impact under the Proposed Project (Potential Impact 3.3-16).

As discussed under Section 3.12.2.3 *Known Tribal and Historical Resources in the Vicinity of the Proposed Project [Klamath Cultural Riverscape]*, the influence of the Proposed Project on the riverscape as a whole, and overall ecosystem health, are more important than the individual potential impacts on specific species. Based on the assessment that there would be a short-term, less-than-significant effect on most tribally significant species (with the exception of *Anodonta ssp.*) under the Proposed Project; the relatively short duration of a predicted measurable decline in fall-run Chinook adult returns from reduced hatchery operations that falls within the existing variation of hatchery returns; the lack of predicted impact from the closure of the hatchery after eight years as compared to the existing conditions (i.e., baseline); the predicted increases in fish production and health from dam removal; and the long-term benefits on much of the key tribal trust species (e.g., Chinook salmon, coho salmon, steelhead, and Pacific lamprey) resulting from improved river ecosystem function and increased habitat access, the riverscape is anticipated to benefit under the Proposed Project.

Significance
No significant impact in the short term

Beneficial in the long term

Potential Impact 3.12-10 Klamath Cultural Riverscape Contributing Aspect: Ability of tribes to use the Middle and Lower Klamath River for ceremonial and other purposes due to alterations in riverine water quality and the extent of nuisance and/or noxious blue-green algae blooms.
California Native American tribes, such as Karuk, Yurok, Resighini Rancheria, Hoopa Valley, and Klamath, currently consume considerable amounts of fish and may ingest or contact water during fishing, bathing, collection and washing of basket and plant materials, and during tribal ceremonies such as the Boat Dance (DOI 2011) (see also Section 3.12.2.1 *Tribal Cultural Chronology and Ethnography (including Historic and Pre-Historic Periods – Northwest California Culture Area*). Under current conditions, seasonal blooms of nuisance blue-green algae regularly occur in Lower Klamath Project reservoirs and are released from Iron Gate and Copco No. 1 reservoirs into the Middle and Lower Klamath River. This can result in elevated concentrations of algal toxins in the water commonly exceeds public health advisory postings for water contact and inhibit the use of the Middle and Lower Klamath River for tribal purposes. Released blue-green algae can also clog fishing nets as well as result in elevated concentrations of algal toxins in the water, further interfering with tribal use of the river (see Section 3.2.2.7 *Chlorophyll-a and Algal Toxins*).

Based on available data, measured concentrations of the algal toxin microcystin in fish tissue have varied in the Middle and Lower Klamath River, but instances of microcystin bioaccumulation have been reported at levels that exceed public health guidelines (in addition to the water column exceedances mentioned above) (see Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project – Algal Toxins*). Because of health risks associated with direct ingestion of fish tissue and water, as well secondary health risks due to dermal exposure to water containing elevated levels of algal toxins, tribes have had to adopt precautionary steps to avoid ingestion and water contact (DOI 2011).

Despite the slightly increased total nutrient concentrations anticipated under the Proposed Project in the Hydroelectric Reach (see Potential Impact 3.2-8), elimination of the reservoir environment that currently supports growth conditions for toxin-producing nuisance blue-green algal species such as *Microcystis aeruginosa* would result in decreases in high seasonal concentrations of chlorophyll-*a* (greater than 10 ug/L) and periodically high levels of algal toxins (greater than 8 ug/L microcystin) generated by suspended blue-green algae in the Hydroelectric Reach, the Middle and Lower Klamath River as well as the

Klamath River Estuary (see Potential Impact 3.2-12). The anticipated reductions in blue-green algae concentrations under the Proposed Project would support Cultural Use of Klamath River waters without risk of adverse health effects, which would improve tribal members' access to the river above levels occurring under existing conditions. This would be a beneficial effect. Since drawdown of the reservoirs would begin in winter and would be largely complete by March/April (i.e., the beginning of the algal growth season) of dam removal year 2, reductions in chlorophyll-*a* and algal toxins would be a short-term benefit as well as a long-term benefit since the reduction would begin during dam removal year 2 and it would continue beyond post-dam removal year 1 (Potential Impact 3.2-12).

Significance
Beneficial in the short term and long term

3.12.5.2 Potential Impacts to Built Environment and Historic-Period Archaeological Resources

Potential Impact 3.12-11 Facilities removal would result in significant impacts to Copco No. 1 Dam, Copco No. 2 Dam, and Iron Gate Dam, their associated hydroelectric facilities, and the Klamath River Hydroelectric Project District as a whole.
The Proposed Project would include removal of large-scale contributing elements of the Klamath River Hydroelectric Project District, an historical resource recommended eligible for listing to the California Register of Historical Resources for the role in early development of electricity and the economy of the southern Oregon and northern California regions (Cardno Entrix 2012; Kramer 2003a,b). Please refer to Tables 4.3-1, 4.3-3, and 4.3-5 for National Register eligibility recommendations for each of the features making up the Lower Klamath Project.

Under the Proposed Project, J.C. Boyle Dam, Copco No. 1 Dam, Copco No. 2 Dam, and Iron Gate Dam, and many of the associated hydroelectric facilities would be removed. (see Section 2 *Proposed Project*) Proposed Project activities would directly impact the historical significance of the dam structures and hydroelectric facilities and other associated properties. Removal of the three California dams (the major contributors of significance), would preclude the ability for the district to remain eligible for listing with the California Register of Historical Resources. Thus, facilities removal would be a significant impact on the resource.

As the core of the Proposed Project is removal of the Lower Klamath Project dams and associated facilities, historical restoration and "adaptive re-use" is simply not feasible as mitigation for these facilities. Dams and other hydroelectric facilities are not able to be relocated, making this form of mitigation not feasible. Maintaining some structures in place is considered in Section 4.3 *Partial Removal Alternative*.

Documentation measures that meet the National Park Services Secretary of the Interior standards for documentation of historical architectural and engineering properties are the only feasible form of mitigation because avoidance and minimization measures would not be possible.

The Proposed Project includes a Cultural Resources Plan (Appendix B: *Definite Plan – Appendix L*) that considers potential impacts to historic built environment resources, including the Klamath River Hydroelectric Project District. The Cultural Resources Plan proposes updating the Request for Determination of Eligibility for listing on the NRHP to include Iron Gate Dam (which has reached 50 years of age since the Request was first filed. Additionally, the Cultural Resources Plan sets forth a process for addressing potential impacts through avoidance and preservation in place as a first priority, then minimization, then resource-specific approaches where avoidance and minimization are not feasible. Where documentation is used, the Cultural Resources Plan recommends adopting protocols consistent with the Secretary of the Interior's Standards for Archaeological Documentation, Historical Documentation, and Architectural and Engineering Documentation; the ACHP Section 106 Archaeology Guidance; and other guidance from the appropriate SHPOs and/or THPOs, as applicable.

However, elements of the Cultural Resources Plan are not final. The Cultural Resources Plan would be further developed by KRRC working through the FERC process to comply with Section 106 of the National Historic Preservation Act of 1966, as codified in 36 CFR Part 800. As stated in the Cultural Resources Plan, mitigation measures and other protective measures would be developed and implemented to protect historic built environment resources.

Overseeing development and implementation of the Cultural Resources Plan does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has initiated a process through the Cultural Resources Working Group and FERC to develop a Historic Properties Management Plan and a Programmatic Agreement that will be finalized and implemented, at this time the Historic Properties Management Plan and the Programmatic Agreement are not finalized and the State Water Board cannot require their implementation. While the State Water Board anticipates that implementation of the Historic Properties Management Plan and the Programmatic Agreement would reduce impacts to the historical built environment, the core of the Proposed Project is removal the hydroelectric facilities and much of the context for these historic resources, such that historical restoration, "adaptive re-use," or relocation of the structures and buildings is not feasible. Even with the inclusion of documentation measures in conformance with the Secretary of the Interior's guidance, the impact to the resource and its context would be significant and the historic resource would be materially impaired. Thus, the impact to the Klamath Hydroelectric Historical District under the Proposed Project would be significant and unavoidable even with inclusion of the KRRC's proposed mitigation measure.

Significance
Significant and unavoidable

Potential Impact 3.12-12 Pre-dam-removal activities that involve disturbance of the landscape, including construction or improvement of associated roads, bridges, water supply lines, staging areas, disposal sites, hatchery modifications, recreation site removal and/or development, and culvert construction and improvements could result in potential exposure of or damage to historic-period archaeological resources (identified in Table 3.12-1) through ground-disturbing construction and disposal activity and increased access to sensitive areas.
Historic-period cultural resources are known to be present within Area of Analysis *Subarea 1* (Figure) and are identified in Table 3.12-1. Pre-dam removal activities involving ground disturbance, construction or improvement of associated roads, bridges, water supply lines, staging areas, disposal sites, hatchery modifications, recreation site removal and/or development, and culvert construction and/or improvements would occur within the Area of Analysis *Subarea 1* (Figure).

Due to the nature of ground-disturbing activities and a general increase in the level of activity (e.g., construction, surveys) within the Area of Analysis *Subarea 1*, pre-dam removal activities that would involve ground disturbance have the potential to result in the following impacts to historic-period cultural resources through physical demolition, destruction, relocation, or alteration of the resource or its immediate surroundings; and/or exposure or substantial movement of the resources leading to increased illicit looting resulting in a significant impact.

To reduce impacts to historic-period cultural resources associated with pre-dam removal activities, the KRRC is developing a Historic Properties Management Plan to identify historic properties (including historical resources as defined in Public Resources Code, section 21084.1) and include measures to implement before and during drawdown and dam removal activities to protect significant historic, historical, cultural, and tribal resources during Proposed Project implementation. The Historic Properties Management Plan will be submitted to FERC for approval before the commencement of any ground disturbing activities (including reservoir drawdown).

Additionally, the KRRC has committed to implement a Looting and Vandalism Prevention Program (LVPP) to reduce looting and vandalism to TCRs and historic-period cultural resources (Mitigation Measure TCR-2), and an Inadvertent Discovery Plan (IDP) that would include actions to implement in the event an inadvertent discovery (e.g., human remains) (Mitigation Measure TCR-3), both of which would provide for compliance with applicable laws regarding cultural resources and human burials.

Implementation of the Historic Properties Management Plan, Mitigation Measure TCR-2 (LVPP), and Mitigation Measure TCR-3 (IDP) would reduce these impacts considerably, and, for many resources is expected to avoid impacts completely through the design and implementation of construction plans or on-the-ground modifications to Proposed Project implementation. For impacts for which it is not feasible to completely avoid, these impacts may be reduced to a less than significant level with implementation of the Historic Properties Management Plan, Mitigation Measure TCR-2 (LVPP), and Mitigation Measure TCR-3 (IDP).

Overseeing development and implementation of the Historic Properties Management Plan does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has initiated a process through the Cultural Resources Working Group and FERC to develop the Historic Properties Management Plan and a Programmatic Agreement that will be finalized and implemented, at this time the Historic Properties Management Plan and the Programmatic Agreement are not finalized and the State Water Board cannot require their implementation. While the State Water Board anticipates that implementation of the Historic Properties Management Plan and the Programmatic Agreement, including any modifications developed through the FERC process that provide the same or better level of protection for historic-period cultural resources, would reduce impacts to less than significant, because the State Water Board cannot ensure implementation of the Historic Properties Management Plan and the Programmatic Agreement, it is analyzing the impact in this Draft EIR as significant and unavoidable.

<u>Significance</u>
Significant and unavoidable impact with mitigation

Potential Impact 3.12-13 Drawdown of Iron Gate, Copco No. 1, and Copco No. 2 reservoirs could shift, erode, or exposure historic-period archaeological resources resulting in increased potential for damage and looting.
The Proposed Project would draw down Iron Gate, Copco No.1, Copco No. 2 and J.C. Boyle reservoirs at a rate between 2 and 5 feet per day (i.e., 1 to 2.5 inches per hour). Drawdown of Copco No. 1 would begin November 1 of dam removal year 1 at a maximum rate of 2 feet per day, and drawdown of all reservoirs would occur at a maximum rate of 5 feet per day beginning January 1 of dam removal year 2 and continue until March 15 of the same year. The analysis for this potential impact focuses on the California Lower Klamath Project reservoirs, including Copco No. 1, Copco No. 2, and Iron Gate, which are contained within Area of Analysis *Subarea 1* (Figure).

Since construction of Lower Klamath Project reservoirs, fine sediments composed primarily of organic material (including dead algae), but also including some silts and clays, have accumulated on the reservoir bottoms covering the original topography and potentially historic-period cultural resources that were present prior to reservoir construction. The distribution of sediment deposits associated with sediment deposition following reservoir construction varies within each reservoir (Figures 2.7-8 and 2.7-9). Because the accumulated sediments are primarily fine material, they will be easily eroded and flushed out of the reservoirs into the Klamath River during reservoir drawdown. The degree of sediment erosion will vary, with the majority of the erosion focused in the former river channel that is currently submerged in Copco No. 1, Copco No. 2, and Iron Gate reservoirs (see Figures 2.7-5 and 2.7-6). The Proposed Project also includes barge-mounted pressure spraying during reservoir drawdown that would target six locations in Copco No. 1 Reservoir and three locations in Iron Gate Reservoir within which to maximize erosion of sediment deposits and subsequently excavate to the historical floodplain elevation to create wetlands, floodplain areas and off-channel habitat features (see Appendix B: *Definite Plan – Appendix H Figures 5-4 and 5-7*).

Following drawdown, approximately 40 to 60 percent of the sediment deposited since construction of Lower Klamath Project reservoirs would remain in the former reservoir footprints, primarily on terraces located above the historical river channel. The sediments that remain in the reservoir footprints would consolidate (dry out and decrease in thickness) (USBR 2012a), likely making them less subject to erosion. Further, during reservoir drawdown, aerial seeding of pioneer seed mixes would occur following the receding reservoir waters. Aerial seeding during reservoir drawdown would not result in any further disturbance of soil on the exposed reservoir terraces and the establishment of vegetation on the terraces would potentially reduce erosion of fine sediments. Recent laboratory tests of reservoir sediments showed vegetated sediments produced less erodible fine particles and aggregates during cycles of wetting and drying than unvegetated sediments (Appendix B: *Definite Plan – Appendix H*).

Although not currently anticipated by KRRC, the Proposed Project may also include hydroseeding from a barge on exposed reservoir terraces as the water recedes during reservoir drawdown. Hydroseeding from a barge would be accomplished by placing a ground rig on one barge with another boat used to ferry materials from shore. A moveable pier or other engineered method of accessing the supply boat as the water level recedes would also be needed. If it occurs, barge hydroseeding would occur in the higher elevation portion of the reservoir shoreline, until the reservoir levels become too low to operate (i.e., March of dam removal year 2). If barge hydroseeding occurred, additional disturbances of reservoir sediments would occur as wave action from the barge would increase disturbance of sediment adjacent to the receding reservoir's shoreline, potential increasing the chance for slope instability and exposure of historic-period archaeological resources.

Historic-period cultural resources associated with late-nineteenth and early-twentieth century settlement, agriculture, logging, mining, hydroelectric, and transportation facilities are known to be present within the proposed Limits of Work (Area of Analysis *Subarea 1)* (Figure). Known historic-period archaeological sites along the margin of Copco Reservoir include ruins of buildings (P-47-002824) and refuse dumps (P-47-003917 and P-47-003922). Other known but unrecorded historic period sites at Copco Reservoir included early homesteads[98], such as the lands of Ward, Keeton, Reimundo, and Pecard (Daniels 2017), and Spannaus, Lennox and Kempler. Additionally, there are references to railroads, irrigation ditches, buildings, camps, roads, trails, bridges, and agricultural fields in the historic record that are not attributed to a specific location but could be encountered during Copco Reservoir drawdown (see Appendix B: *Definite Plan – Appendix L, Table 6-12*).

Known historic-period cultural resources along the shoreline of Iron Gate Reservoir include a homestead site (P-47-003940), several stacked rock wall segments (P-47-003943, P-47-003942, and P-47-003937), and a location with dozens of historical rock cairns believed to be the result of field clearing (P-47-003945) (Cardno ENTRIX 2012, PacifiCorp 2004). Additionally, there are references to homesteads of Griever, Madero, and Spearing, rock walls, irrigation ditches, bridges, road trails, railroads, former gauge stations that could be encountered during Iron Reservoir drawdown.

Specific historic-period cultural resources located at the sites identified above include features, such as buildings, foundations, cellars, wood posts, rock stacks, refuse deposits, wells, privies, and orchards. Associated artifacts may include whole of fragmented glass or ceramic containers, table ware, lighting, or electrical artifacts. Metal artifacts may include fencing, wire, containers, fasteners, tools, and roofing. Other structural and personal artifacts may include brick or mortar, wood, rubber, some plastics, and textiles. These archaeological materials can be discovered in concentrations, such as in a refuse dump, or as isolated artifacts.

The condition of historic-period cultural resources inundated under the reservoirs is unknown, however it is anticipated that deposits of artifacts, features and sites are present and could be impacted from shifting and erosion of reservoir sediment deposits during and after drawdown. Some historic-period cultural resources within the reservoir footprints may remain covered in sediment, or capped, resulting in some degree of preservation and disturbance minimization.

Due to the nature of ground-disturbing activities during drawdown within the Area of Analysis *Subarea 1* that have the potential to result in physical demolition,

[98] Some historic-period resources may also be considered Tribal Cultural Resources and are included in Potential Impacts 3.12-1 through 3.12-10.

destruction, relocation, or alteration of the resource or its immediate surroundings; and/or exposure or substantial movement of the resources leading to increased illicit looting, the impact of drawdown to historic-period cultural resources would result in a significant impact. However, as discussed in Potential Impact 3.12-2, the KRRC is developing a Historic Properties Management Plan, LVPP, and IDP to identify historic properties and include measures to implement before and during drawdown and dam removal activities to protect historic, cultural, and tribal resources. Implementation of the Historic Properties Management Plan, Mitigation Measure TCR-2 (LVPP), and Mitigation Measure TCR-3 (IDP) would reduce significant drawdown impacts considerably, and, for many resources is expected to avoid impacts completely through the design and implementation of construction plans or on-the-ground modifications to Proposed Project implementation. For impacts that it is not feasible to completely avoid, the impacts may be reduced to a less than significant level with implementation of the Historic Properties Management Plan, Mitigation Measure TCR-2 (LVPP), and Mitigation Measure TCR-3 (IDP).

Overseeing development and implementation of the Historic Properties Management Plan does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has initiated a process through the Cultural Resources Working Group and FERC to develop the Historic Properties Management Plan and a Programmatic Agreement that will be finalized and implemented, at this time the Historic Properties Management Plan and the Programmatic Agreement are not finalized and the State Water Board cannot require their implementation. While the State Water Board anticipates that implementation of the Historic Properties Management Plan and the Programmatic Agreement, including any modifications developed through the FERC process that provide the same or better level of protection for historic-period cultural resources, would reduce impacts to less than significant, because the State Water Board cannot ensure implementation of the Historic Properties Management Plan and the Programmatic Agreement, it is analyzing the impact in this Draft EIR as significant and unavoidable.

Significance

Significant and unavoidable with mitigation

Potential Impact 3.12-14 Reservoir drawdown could result in short-term erosion or flood disturbance to historic-period cultural resources located along the Klamath River.

As discussed in Potential Impact 3.12-3, the proposed drawdown of the Lower Klamath Project reservoirs is designed to minimize potential flood risks, including carefully drawing down the reservoirs using controlled flow releases and the increased storage availability in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs once drawdown has begun to accommodate for potential winter flow events and drawdown would not result in flows that are out of the normal range of flows experienced under existing conditions.

Hydrologic and hydraulic modeling of floodplain inundation shows that removal of the Lower Klamath Project dams could result in minor alterations to the FEMA 100-year floodplain inundation area downstream of Iron Gate Dam, along the 18-river mile stretch of the Middle Klamath River between RM 193 and 174 (i.e., from Iron Gate Dam to Humbug Creek) (USBR 2012b). Changes in the extent of the floodplain inundation area could affect potential historic-period cultural resources currently located within the FEMA 100-year floodplain (P-47-00522 [Empire Quartz Mine], P-47-00536 [Klamathon Townsite and Limber Mill], P-47-003937 [Rock Wall], P-47-004212 [Bridge], and P-47-004427 [artifact scatters]) which could result in a significant impact to historic-period cultural resources.

As discussed in Potential Impact 3.12-11, the KRRC is developing a Historic Properties Management Plan and an IDP to identify historic properties and include measures to implement before and during drawdown and dam removal activities to protect historic, cultural, and tribal resources. Implementation of the Historic Properties Management Plan and Mitigation Measure TCR-3 (IDP) may reduce impacts to resources identified in the 18-river mile stretch below Iron Gate Dam but given their proximity to Iron Gate Dam and their future inclusion in the altered 100-year floodplain following completion of the Proposed Project, impacts would remain significant and unavoidable.

As implementation of the Proposed Project is not anticipated to result in any other changes to the FEMA 100-year floodplain, or result in drawdown flows above historically recorded flows, potential impacts to historic-period cultural resources along other portions of the Klamath River would result in no significant impact.

Significance

Significant and unavoidable with mitigation for Middle Klamath River from Iron Gate Dam (RM 193) to Humbug Creek (RM 174)

No significant impact for Hydroelectric Reach excluding Iron Gate Dam, Middle Klamath River downstream of Humbug Creek, Lower Klamath River, Klamath River Estuary

Potential Impact 3.12-15 Project activities associated with removal of Iron Gate, Copco No. 1, and Copco No. 2 dams could result in physical disturbance to historic-period cultural resources from blasting or other removal techniques.

As described in Potential Impact 3.12-4, blasting and other dam removal techniques could cause significant adverse impacts to historic-period cultural resources located in the immediate vicinity[99] of Iron Gate, Copco No.1 and

[99] For the purposes of this analysis, “immediate vicinity” is defined as within 0.25 miles of Copco No. 1, Copco No. 2, and Iron Gate dams.

Copco No. 2 dams. The direct physical disturbance associated with blasting and other removal techniques could significantly impact historic-period archaeological resources that directly overlap with the blasting locations.

Though no data has identified historic-period cultural resources in the immediate vicinity of Iron Gate, Copco No. 1, and Copco No. 2 dams, but given the use of lands surrounding Proposed Project dams prior to construction of the Lower Klamath Project, this potential impact analysis assumes that historic-period archeological resources may be present in the immediate vicinity. For historic-period cultural resources that may be present in the immediate vicinity, impacts to these resources associated with dam removal would be significant and unavoidable.

As discussed in Potential Impact 3.12-11, the KRRC is developing a Historic Properties Management Plan and an IDP to identify historic properties and include measures to implement before and during drawdown and dam removal activities to protect historic, cultural, and tribal resources. Implementation of the Historic Properties Management Plan and Mitigation Measure TCR-3 (IDP) may reduce impacts to resources in the immediate vicinity of Iron Gate, Copco No. 1, and Copco No. 2 dams, but given construction activities and their potential for impacts to potential historic-period cultural resources, impacts would remain significant and unavoidable.

Significance
Significant and unavoidable with mitigation

Potential Impact 3.12-16 Ground disturbance associated with reservoir restoration, recreation site removal and/or development, and disposal site restoration could physically disturb historic-period cultural resources. Additionally, ongoing road and recreation site maintenance may have the potential to disturb known historic-period cultural resources.
As discussed in Potential Impact 3.12-5, the Proposed Project includes a Reservoir Area Management Plan that includes restoration activities that would occur both within the reservoir footprint and in upland areas (i.e., disposal, staging, and hydropower infrastructure demolition areas, access roads, former recreational areas) within the Area of Analysis *Subarea 1* (Figure 3.12-2). Historic-period archaeological resources are located within the footprints of Lower Klamath Project reservoirs.

Ground-disturbing activities associated with ongoing road, restoration, and recreation site maintenance within the Area of Analysis *Subarea 1* (Figure 3.12-2) include grading and excavating, which may result in material impairment due to physical demolition, destruction, relocation, or alteration of historic-period cultural resources located in both upland and reservoir footprint locations resulting in a significant impact.

However, as discussed in Potential Impact 3.12-11, the KRRC is developing a Historic Properties Management Plan, LVPP, and IDP to identify historic properties and include measures to implement before and during drawdown and dam removal activities to protect historic, cultural, and tribal resources. Implementation of the Historic Properties Management Plan, Mitigation Measure TCR-2 (LVPP), and Mitigation Measure TCR-3 (IDP) would reduce significant post-dam removal restoration impacts considerably, and, for many resources is expected to avoid impacts completely, through the design and implementation of construction plans or on-the-ground modifications to Proposed Project implementation. For impacts that it is not feasible to completely avoid, the impacts may be reduced to a less than significant level with implementation of the Historic Properties Management Plan, Mitigation Measure TCR-2 (LVPP), and Mitigation Measure TCR-3 (IDP).

Overseeing development and implementation of the Historic Properties Management Plan does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has initiated a process through the Cultural Resources Working Group and FERC to develop the Historic Properties Management Plan and a Programmatic Agreement that will be finalized and implemented, at this time the Historic Properties Management Plan and the Programmatic Agreement are not finalized and the State Water Board cannot require their implementation. While the State Water Board anticipates that implementation of the Historic Properties Management Plan and the Programmatic Agreement, including any modifications developed through the FERC process that provide the same or better level of protection for historic-period cultural resources, would reduce impacts to less than significant, because the State Water Board cannot ensure implementation of the Historic Properties Management Plan and the Programmatic Agreement, it is analyzing the impact in this Draft EIR as significant and unavoidable.

Significance
Significant and unavoidable impact with mitigation

3.12.6 References

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3.15 Agriculture and Forestry Resources

3.15.2 Environmental Setting

3.15.2.1 Important Farmland

Volume I Section 3.15.2.1 Agriculture and Forestry Resources – Environmental Setting – Important Farmland, new Table 3.15-1-A on page 3-890:

Table 3.15-1-A. Summary of Farmland Classification within the Area of Analysis.

Farmland Classification	**Acreage in the Area of Analysis**	**Percentage of the Area of Analysis**
Farmland of local importance	821	7.4
Farmland of statewide importance	22	0.2
Grazing land	7,014	62.9
Other land	1,355	12.2
Urban or built-up	41	0.4
Water	1,892	17.0
Total	11,145	100*

*Total exceeds 100 percent due to rounding.

Volume I Section 3.15.2.1 Agriculture and Forestry Resources – Environmental Setting – Important Farmland, paragraphs 2 and 3 on page 3-890:

Most of the land in the Area of Analysis is classified by the DOC as Grazing Land~~, with a small area of Unique Farmland located approximately two miles south of Copco No. 1 Reservoir~~ (Figure 3.15-~~1~~2).

Parcels zoned by Siskiyou County for Agriculture-Grazing are located within the Area of Analysis to the north and south of Copco No. 1 Reservoir (Figure 3.14-1). There are a number of parcels located immediately upstream of Copco No. 1 Reservoir AOA boundary that are used primarily for grazing and hay production. The DOC (2016c) identified these lands as Prime Farmland or Farmland of Statewide Importance (Figure 3.15-~~1~~2). The pastures/fields on these properties are flood-irrigated via direct diversions from the free-flowing Klamath River upstream of Copco No. 1 Reservoir. There are a few agriculture parcels with grazing land located between 1.2 and 3 miles north of Copco No. 1 Reservoir (Figure 3.15-~~1~~2).

Volume I Section 3.15.2.1 Agriculture and Forestry Resources – Environmental Setting – Important Farmland, Figure 3.15-2 Farmland classification along the Klamath River from Interstate 5 to the Oregon-California state line (Adapted from DOC 2016c) on page 3-893:

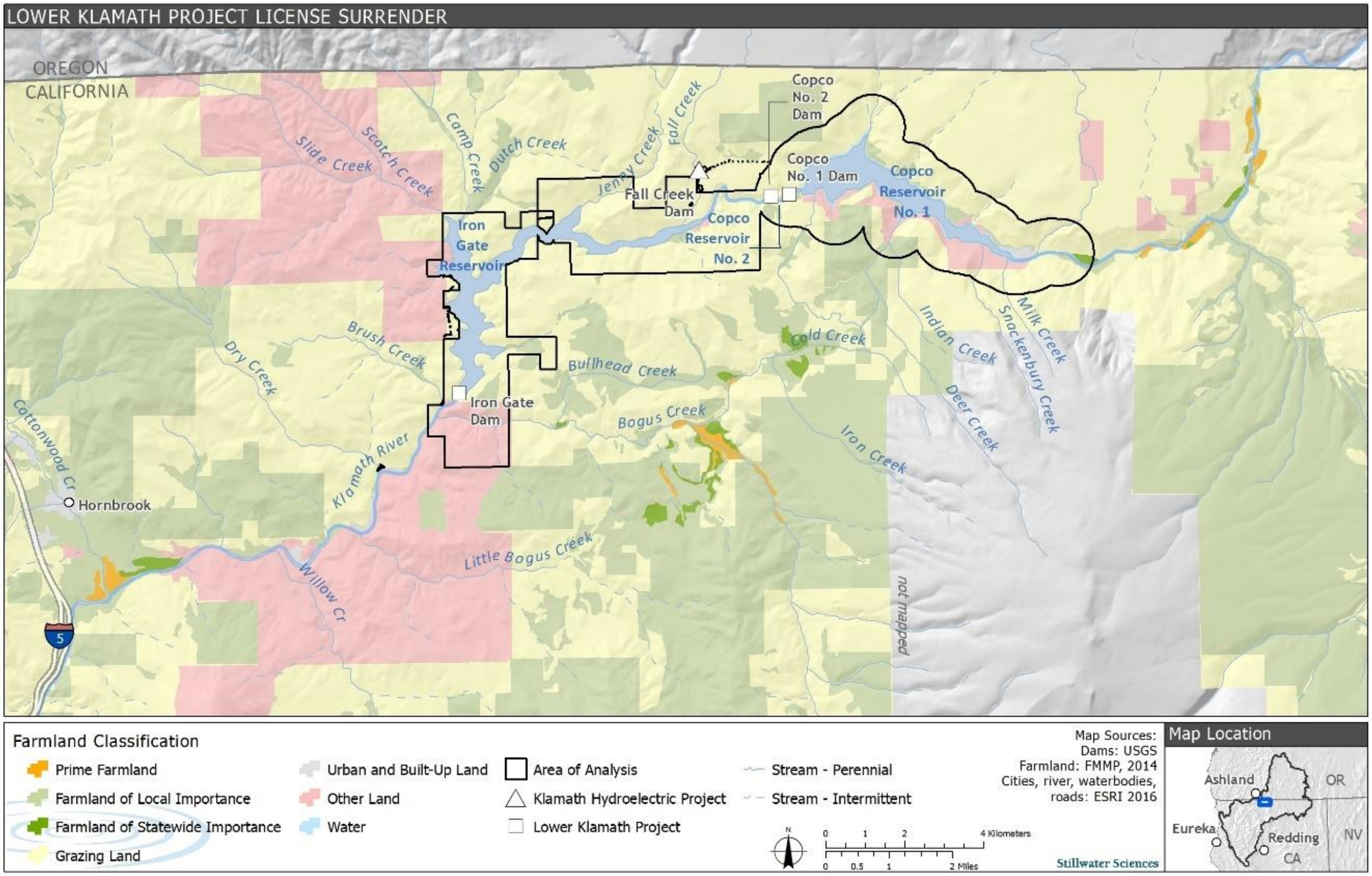


Figure 3.15-2. Farmland Classification along the Klamath River from Interstate 5 to the Oregon-California State Line (Adapted from DOC 2016c).

Volume I Section 3.15.2.4 Agriculture and Forestry Resources – Environmental Setting – Forestry Resources, paragraph 5 and Table 3.15-2 on pages 3-894 through 3-895:

PacifiCorp (2004) identified and mapped a variety of land cover types from the Link River Dam to the Shasta River. In addition, vegetation datasets are available through CALVEG (Classification and Assessment with Landsat of Visible Ecological Groupings) datasets available through the California Land Cover Mapping & Monitoring Program (USDA Forest Service 2017a) and data from USFWS (2017). These datasets were utilized to create the vegetation maps presented in Appendix G: *Vegetation Communities and Habitat Types* and provide summary acreages described in Table 3.5-1. The upland tree acreage within the Area of Analysis ~~between the Oregon-California state line and Iron Gate Dam and extending 0.25 miles on either side of the Klamath River~~ is presented below in Table 3.15-2. See Section 3.5.2.1 *Vegetation Communities* for a description of the vegetation types within the Area of Analysis.

Table 3.15-2. Upland tree habitats within the Area of Analysis ~~and mapped between the Oregon-California state line and Iron Gate Dam~~.

Upland Tree Habitats	Acres	~~Description, Dominant Species, and Location~~
Montane hardwood oak	2,175 ~~813~~	~~Moderately open tree canopy, moderately dense shrub layer, moderately dense herbaceous layer. Yellow starthistle and medusahead occur in about 25 percent of stands in the project vicinity. Most abundant around Copco No. 1 Reservoir.~~
Montane hardwood oak-conifer	2,831 ~~2,656~~	~~Dense tree cover, sparse shrub layer, moderately open herbaceous layer. Most abundant along the J.C. Boyle Peaking and Bypass reaches, at Copco No. 1 Reservoir, at Fall Creek, and along the Copco No. 2 bypassed reach.~~
Ponderosa pine	347 ~~68~~	~~Moderate canopy cover, relatively sparse shrub cover, moderately open herbaceous layer.~~
Juniper	702 ~~457~~	~~Open canopy, shrub layer varies from sparse to dense, herbaceous layer ranges from sparse to dense.~~

Upland Tree Habitats	Acres	~~Description, Dominant Species, and Location~~
Klamath ~~M~~mixed conifer	17 ~~9~~	~~Dense tree cover often is two-layered, open shrub layer, moderately sparse herbaceous layer.~~
Sierran mixed conifer	26	
Lodgepole pine	2	
Eastside pine	17	
Aspen	2	
Total of all upland tree habitats	6,119 ~~5,003~~	

Volume I Section 3.15.3 Agriculture and Forestry Resources – Significance Criteria, new paragraph 1 on page 3-896:

Substantial conversion is defined as the unnecessary and irreversible conversion of farmland to nonagricultural uses. Substantial loss is defined as the unnecessary and irreversible loss of forestland.

3.15.6 References

Volume I Section 3.15.6 Agriculture and Forestry Resources – References, pages 3-901 and 3-902, includes the following revisions:

USDA FOREST Service. 2017a. Vegetation Classification and Mapping. CALVEG Mapping Zones. Website. Available at: https://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192 [Accessed March 2020].

USFWS. 2017b. Klamath EIR Scoping, CA only. IPaC trust resource report. Prepared by USFWS, Sacramento, California.

Other references cited as part of text included in the Section 3.15 list of revisions:

DOC. 2016c. Siskiyou County Important Farmland map. ftp://ftp.consrv.ca.gov/pub/dlrp/FMMP/pdf/2014/sis14.pdf [Accessed 12 May 2017].

PacifiCorp. 2004. Terrestrial Resources Final Technical Report. Klamath Hydroelectric Project (FERC Project No. 2082). Portland, Oregon.

3.16 Population and Housing

3.16.1 Area of Analysis

Volume I Section 3.16.1 Population and Housing – Area of Analysis, paragraph 3 on page 3-903:

The Area of Analysis for population and housing extends beyond the Project Boundary to encompass the following urban and rural communities in California: the community of Hornbrook, the City of Yreka, and the residential rural areas near Copco No.1, Copco No. 2, and Iron Gate reservoirs. The Area of Analysis includes communities with the potential to house workers migrating into the area for Proposed Project construction activities (see also Section 3.16.4 *Significance Criteria*). The Area of Analysis also includes the area where two residences downstream of Iron Gate Dam are noted to be affected by change in flood elevations (FEMA 100-year floodplain) as well as 34 habitable structures that are already affected by these flood elevations. Effects of slope failure along the rim of Copco No. 1 Reservoir from lowering of reservoir water levels that could affect up to eight habitable structures are analyzed in more detail in Section 3.11.5 *Geology, Soils, and Mineral Resources,* where it is determined that Mitigation Measure GEO-1 would reduce the impact to no significant impact with mitigation for Copco 1 No. Reservoir.

3.16.2 Environmental Setting

Volume I Section 3.16.2 Population and Housing – Environmental Setting, paragraph 6 on page 3-903:

As noted above, 36 residences downstream of Iron Gate Dam are affected by change in the FEMA 100-year floodplain elevations. The impacts to these residences are analyzed in Section 3.6 *Flood Hydrology*. An additional eight units could be affected by slope failure adjacent to Copco No. 1 Reservoir. Since these residences represent only ~~0.15~~ 0.18 percent of the total County housing stock, they are not considered a substantial loss and are not further addressed in the Population and Housing section.

3.17 Public Services

Volume I Section 3.17.5 Public Services – Potential Impacts and Mitigation Potential Impact 3.17-1, paragraph 2 on page 3-914 and paragraph 1 on page 3-915:

Mitigation Measure HZ-1 and ~~Recommended~~ Mitigation Measure TR-1 would reduce the potential impacts related to construction activities since these measures require that the KRRC and its contractor(s) for the Proposed Project submit the additional documentation/details included in the final Emergency Response Plan, Fire Management Plan, Traffic Management Plan, and a Hazardous Materials Management Plan, and they work with applicable agencies prior to the start of construction. Implementation of these two measures would reduce the potential for a short-term increase in personal and public health and safety risks due to the Proposed Project as related to emergency response services. There would be no long-term impacts due to the Proposed Project construction-related activities since the construction would be completed in the short term.

Most of the roads within the Area of Analysis are currently owned or managed by PacifiCorp (Section 3.22.2.3 *Road Conditions*). PacifiCorp would continue to own and manage the roads contained within Parcel A and KRRC would own and manage the roads contained in Parcel B (see Figure 3.14-4). Section 3.21 *Hazards and Hazardous Materials* discusses the transport of hazardous materials, emergency, and wildfire potential and includes Mitigation Measure HZ-1 to address potential impacts to emergency response under the Proposed Project. As discussed in Section 3.22 *Traffic and Transportation*, the Proposed Project also includes an Emergency Response Plan. ~~Recommended~~ Mitigation Measure TR-1 includes coordination between the Traffic Management Plan and Emergency Response Plan and additional detail necessary to reduce impacts. ~~Overseeing development and implementation of the final Traffic Management Plan and final Emergency Response Plan does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has stated its intention to reach enforceable good citizen agreements that will be finalized and implemented, at this time the Traffic Management Plan and Emergency Response Plan are not finalized and the State Water Board cannot require their implementation. Accordingly, t~~The State Water Board anticipates that implementation of the final Traffic Management Plan and Emergency Response Plan, including the additional details in ~~Recommended~~ Mitigation Measure TR-1 and any modifications developed through the FERC process that provide the same or better level of protection for transportation and traffic would reduce impacts to a less than significant level. ~~However, because the State Water Board cannot ensure implementation of the final Traffic Management Plan and final Emergency Response Plan, it has determined the impact in this Draft EIR to be significant and unavoidable.~~

Significance

~~Significant and unavoidable~~ No significant impact with mitigation

Volume I Section 3.17.5 Public Services – Potential Impacts and Mitigation Potential Impact 3.17-2, paragraph 4 on page 3-918:

However, where suitable replacement water sources cannot be identified in close proximity to a fire in a location for which the reservoirs would otherwise have been the nearest water source, long-term impacts to the public's risk of loss from wildfires remain significant and unavoidable. This impact is further addressed under Potential Impact 3.21-8, as revised in Volume III Section 3.21.5 *Hazards and Hazardous Materials – Potential Impacts and Mitigation*.

3.18 Utilities and Service Systems

Volume I Section 3.18 Utilities and Service Systems, paragraph 1 on page 3-925:

<u>This section describes the environmental setting for utilities and service systems</u>, including wastewater, stormwater, and solid waste, as well as potential environmental impacts to utilities and service systems due to implementation of the Proposed Project.

3.18.5 Potential Impacts and Mitigation

Volume I Section 3.18.5 Utilities and Service Systems – Potential Impacts and Mitigation – Potential Impact 3.18-1 The Proposed Project could result in the construction of new wastewater treatment facilities, or expansion of existing facilities, due to inadequate capacity to serve the Proposed Project's anticipated demand, and the construction of such facilities could cause significant environmental impacts, page 3-928, paragraph 4:

Potential Impact 3.18-1 The Proposed Project could result in the construction of new wastewater treatment facilities, or expansion of existing facilities, due to inadequate capacity to serve the Proposed Project's anticipated demand, and/or where the construction of such facilities could cause significant environmental impacts.

3.19 Aesthetics

This section identifies and describes potential impacts to scenic resources of the Klamath River and adjacent landscape due to implementation of the Proposed Project.

Several comments were received during the NOP public scoping process relating to potential dam removal impacts on aesthetics, including the likelihood of adverse impacts due to the loss of scenic reservoir views. Several comments expressed concern that the reservoir footprints would be left as bare slopes with only mud and debris for an extended period of time prior to restoration, and that the loss of reservoir views after implementing the Proposed Project would adversely affect the viability of residential communities that currently surround Copco No. 1 and Iron Gate reservoirs. Individual public scoping comments are presented in Volume II Appendix A.

After circulation of the Draft EIR, numerous additional comments were received regarding aesthetics (see Volume III), and changes to the section in response to those comments are flagged in the comment responses and then printed in this Final EIR section. None of the changes result in significant new information in the EIR under the meaning of CEQA Guidelines, section 15088.5, subdivision (a):

> New information added to an EIR is not ‘significant’ unless the EIR is changed in a way that deprives the public of a meaningful opportunity to comment upon a substantial adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect (including a feasible project alternative) that the project’s proponents have declined to implement.

However, the changes were numerous enough that reprinting the section rather than simply including a list of revisions was warranted to improve clarity and readability of the document.

3.19.1 Area of Analysis

Removal of the Lower Klamath Project could affect aspects of scenic quality throughout the Klamath River in California, including water clarity, fish viewing opportunities, and riparian and channel characteristics of the river downstream of the dams. However, potential aesthetic effects would decrease with distance downstream from the Lower Klamath Project as the river is affected more by tributary inputs and less by the dams and associated facilities. Therefore, the primary Area of Analysis for aesthetics is within the viewshed of the Lower Klamath Project reservoirs, which includes the proposed Limits of Work in California (i.e., Copco No. 1, Copco No. 2, and Iron Gate dams, reservoirs, and associated facilities, and the areas identified as construction/demolition areas and staging areas) plus a buffer to the ridgeline surrounding the reservoirs. The secondary Area of Analysis for aesthetics includes those areas within view of the Klamath River downstream from Iron Gate Dam to the confluence with the Shasta River (RM 179.5), as well as the portion of the Klamath River extending upstream from Copco No. 1 Reservoir to the Oregon-California border, because these river reaches may be affected by removal of the upstream dams.

The Primary and Secondary Areas of Analysis were generated in Geographic Information Systems (GIS) to approximate the viewshed visible from the Limits of Work and reaches of the Klamath River from the Oregon-California state line to the confluence with the Shasta River, respectively. Where the Primary and Secondary Areas of Analysis overlapped (e.g., at the upstream end of Copco No. 1 Reservoir, see Figure 3.19-1), precedence was given to the primary Area of Analysis. The viewshed was digitized to follow ridgelines of steep slopes visible using a 10-meter digital elevation model (DEM) hillshade and USGS topographic maps. The area visible from the ground was confirmed using the terrain and ground-level view tools in Google Earth©. The viewshed only includes land that is anticipated to be continuously visible from the Limits of Work or the Klamath River. For example, when ridgelines or peaks appeared to be visible in the distance, but the land between the Limits of Work or Klamath River did not appear to be visible, those areas were not included. The viewshed is meant to be all- encompassing of views from anywhere within the Limits of Work, and viewshed limits are approximate and generalized. The primary Area of Analysis was expanded into Oregon where the viewshed from the Limits of Work in California extended beyond the state line, but it was truncated at the state line along the Klamath River based on the assumption that an on-the-ground viewer would only be looking downstream toward California for the assessment of potential aesthetics impacts in California.

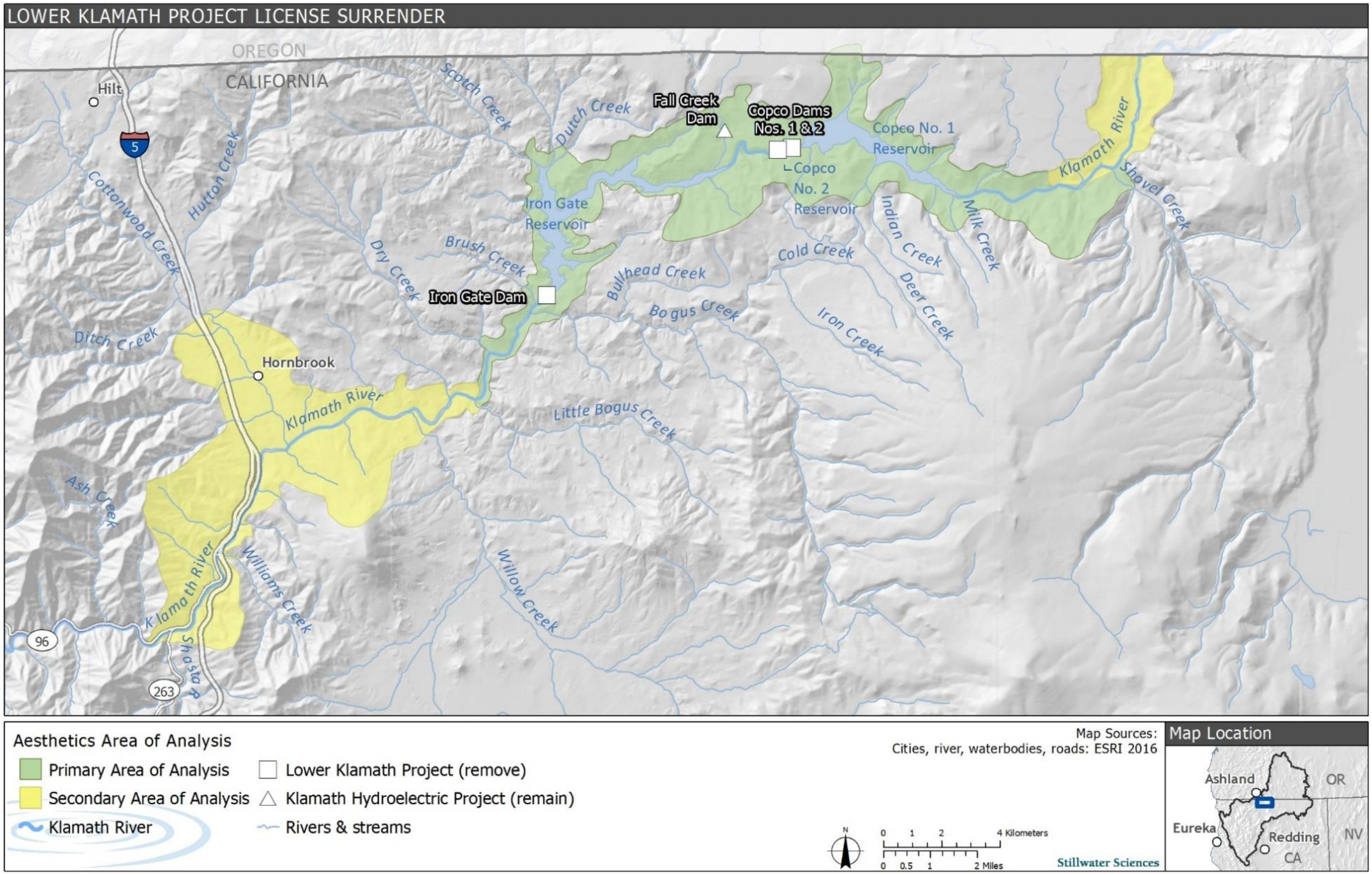


Figure 3.19-1. Aesthetics Primary and Secondary Area of Analysis.

3.19.2 Environmental Setting

The Klamath Basin as a whole contains widely varied scenic resources, including wetlands, uplands, rangelands, National Wildlife Refuges, farmlands, timberlands, and small urbanized areas in Yreka and along the Interstate 5 corridor. The Klamath Basin also supports vegetation communities including, but not limited to, montane hardwood and annual grasslands, as described in Section 3.5.2 *Environmental Setting*. Sightseeing opportunities to enjoy the scenic resources are widely available in the Klamath Basin generally, and more specifically within the primary and secondary Area of Analysis for aesthetics. Section 3.20 *Recreation* lists recreation resources, including Wild and Scenic River (WSR) segments, and locations in the surrounding region that offer wildlife viewing as well as opportunities for sightseeing, leisure drives, photography, and other forms of recreation.

This section describes the environmental setting for scenic resources in the primary and secondary Area of Analysis.

3.19.2.1 PacifiCorp Analysis and Bureau of Land Management Methodology

PacifiCorp conducted a detailed visual evaluation of the project vicinity (FERC 2007) in 2002 and 2003 and documented it in the Land Use, Visual, and Aesthetic Resources Final Technical Report (PacifiCorp 2004a). This evaluation involved identifying and photographing key observation points during different seasons and documenting views of the reservoirs at different water levels. Photographs taken from these viewpoints portray typical scenic/landscape character along the Klamath River, including such features as canyon walls, channel configuration, water clarity, and bank and riparian appearance. Additional photographs were taken from selected locations in October 2010 (CDM 2010) and were compared to the 2003 photographs to verify the continued existence of earlier-documented conditions (Appendix R).

For their visual analysis, PacifiCorp used the Bureau of Land Management's (BLM) Visual Resource Management (VRM) process. Within their visual resource study area, PacifiCorp evaluated the way in which project features and operations fit into the overall visual landscape using the following three-step process: (1) identify the VRM classifications applicable within the study area; (2) define viewpoints from which Lower Klamath Project dams and associated facilities and operations could be seen; and (3) evaluate whether project facilities and operations, when seen from the viewpoints, conform to the objectives of the management classification in which they are found (PacifiCorp 2004a). The VRM process is described in detail below.

The following discussion describes the scenic resources found in the primary and secondary Area of Analysis for aesthetic resources. PacifiCorp (2004a) identified multiple key observation points associated with the Lower Klamath Project. The following points are located within the aesthetics primary and secondary Area of Analysis: two in the Hell's Corner Reach (HC7 and HC-8); seven in the Copco No. 1 Reservoir area (C1 to C7); twelve in the area of Iron Gate Reservoir (IG1 to IG12); five in the Fall Creek area (FC1 to FC5); and, three downstream of Iron Gate Dam (BG1 to BG3) (Figure 3.19-2, Table 3.19-1).

These key observation points are not intended to be comprehensive but were selected to represent typical views (including scenic overlooks) for members of the public from riverside and/or reservoir communities and residences, recreational access sites, campgrounds, as well as scenic byways, and state highways 96, 263, and US Interstate 5.

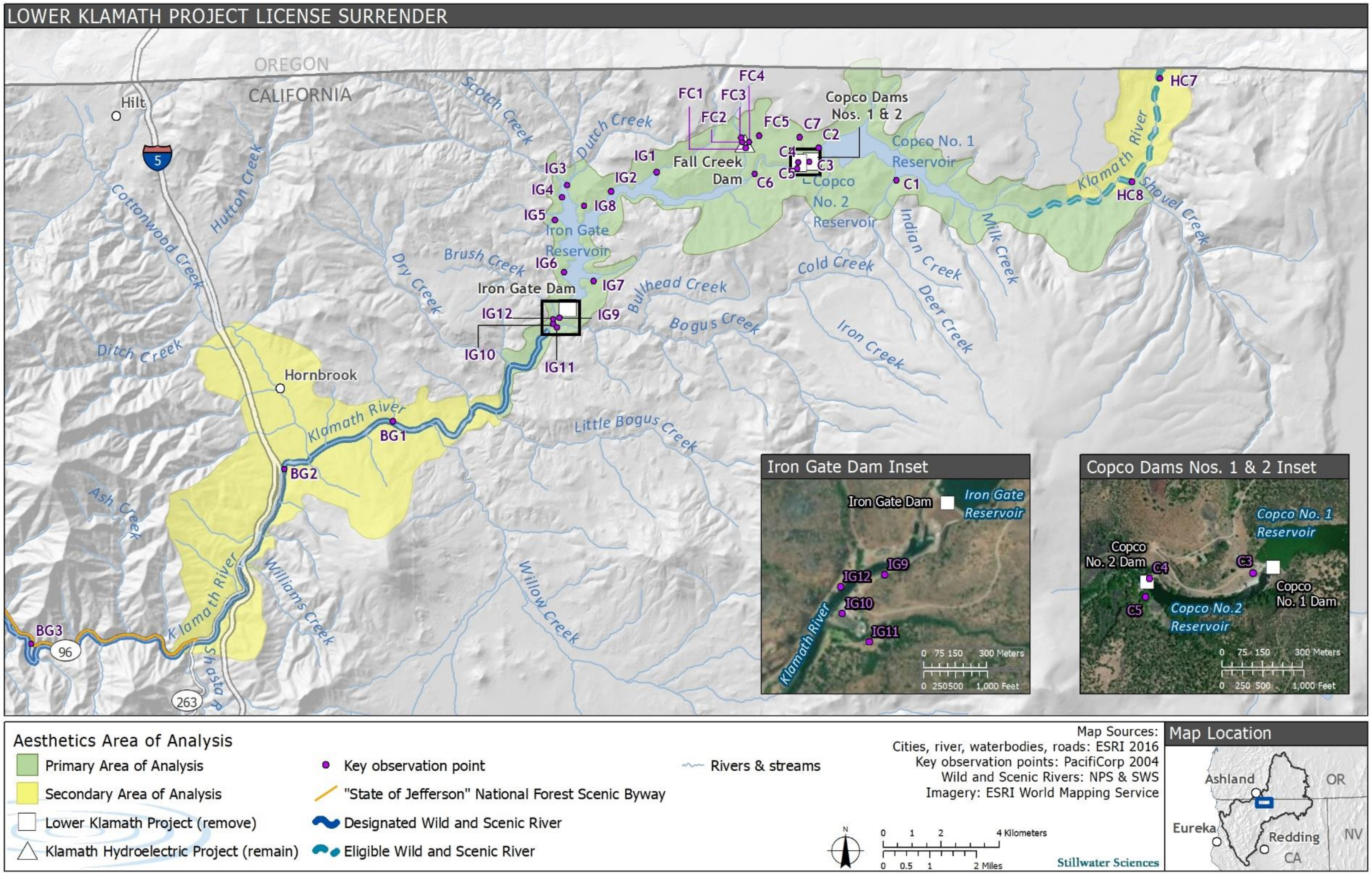


Figure 3.19-2. Locations of Key Observation Points Identified in PacifiCorp (2004a) Within the Aesthetics Primary and Secondary Area of Analysis.

Table 3.19-1. Key Observation Points in the Aesthetics Primary and Secondary Area of Analysis (locations from PacifiCorp 2004a).

Key Observation Point	Description
HC7	Klamath River from Stateline Takeout
HC8	Klamath River from Fishing Access #5 (Ager-Beswick Road)
C1	Copco Reservoir from Mallard Cove Recreation Area
C2	Copco Reservoir from Copco Cove Recreation Area
C3	Copco No. 1 Dam and Powerhouse
C4	Copco No. 2 Dam
C5	Copco No. 2 Forebay from Copco No. 2 Dam
C6	Copco No. 2 Powerhouse
C7	Copco Transmission Line
FC1	Fall Creek Recreation Area
FC2	Fall Creek Fish Hatchery
FC3	Fall Creek from Hatchery Trail
FC4	Fall Creek Powerhouse
FC5	Fall Creek Transmission Line
IG1	Jenny Creek from Jenny Creek Recreation Area
IG2	Iron Gate Reservoir from Wanaka Springs Recreation Area
IG3	Iron Gate Reservoir from Camp Creek Recreation Area
IG4	Iron Gate Reservoir from Juniper Point Recreation Area
IG5	Iron Gate Reservoir from Mirror Cove Recreation Area
IG6	Iron Gate Reservoir from Overlook Point Recreation Area
IG7	Iron Gate Reservoir from Long Gulch
IG8	Iron Gate Transmission Line
IG9	Iron Gate Dam and Powerhouse
IG10	Iron Gate Fish Hatchery and Fish Ladder
IG11	Bogus Creek from Viewpoint at Iron Gate Hatchery
IG12	Klamath River from Iron Gate Hatchery River Access
BG1	Klamath River from Access Below Klamathon Bridge
BG2	Klamath River from Collier Rest Area Overlook/Interpretive Area
BG3	Klamath River from Tree of Heaven River Access Boat Ramp

In response to the Federal Land Policy and Management Act (43 U.S.C. 35, §§ 1701 et seq.) and subsequent agency-specific regulations, federal land management agencies have developed systems specifically designed to inventory, evaluate and manage for scenic (visual) resources on public lands. As a result, the BLM developed the VRM system. The objective of BLM's VRM system is to manage public lands in a manner which will project the quality of the scenic (visual) values of those lands (BLM, 1984).

All BLM lands are assigned to one of four VRM classes, ranging from Class I, which includes the highest value scenery and associated protections, to Class IV, which reflects the lowest value scenery and associated protections. The VRM classes provide a valuation of existing visual resources and protection standards for determining Resource Management Plan conformance during project planning.

The Lower Klamath Project dams and associated facilities fall under the BLM Redding District Resource Management Plan. All of the facilities except three [all associated with J.C. Boyle in Oregon] are located in areas that have been designated as a Class III area by a Resource Management Plan or have been classified as a Class III area because the area has not been given a specific VRM class by BLM (PacifiCorp 2004a). When evaluating project impacts, the objective for Class III visual resources is to “partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape” (BLM 1984).

For the purposes of this document, the site-specific, project level inventory is limited to the primary and secondary aesthetics Area of Analysis and based upon a combination of original data from the 2004a PacifiCorp Technical Report and additional analysis from several key observation points. In addition to the aesthetic resources in the primary and secondary aesthetics Area of Analysis being considered Class III, USBR and CDFW conducted a baseline Visual Resource Inventory within the primary and secondary aesthetics Area of Analysis as part of the 2012 KHSA EIS/EIR, according to three components: scenic quality, visual sensitivity, and distance zones, as described below.

In terms of scenic quality, BLM’s VRM methodology assigns public land a rating of A, B, or C (inherent scenic attractiveness), with A being the most distinctive and C being the most common, in terms of seven key factors including: color, water, vegetation, landform, influence of adjacent scenery, scarcity, and cultural modifications (BLM 1984). Based on review of the visual analysis completed for the 2012 EIS/EIR, all of the Proposed Project area would be contained within rating A landscapes due to the following key factors:

- **Color** – Some intensity or variety in colors and contrast of the soil, rock and vegetation, but not a dominant scenic element
- **Water** – Water flowing or still, dominant in the landscape when viewed from most key observation points, but not always clear and clean appearing
- **Vegetation** – A variety of vegetative types as expressed in interesting forms, textures, and patterns
- **Landform** – Steep canyons, some interesting erosional patterns or variety in size and shape of landforms; or detail features which are interesting though not dominant or exceptional

- **Influence of adjacent scenery** – Adjacent scenery moderately enhances overall visual quality
- **Scarcity** – Distinctive, though somewhat similar to others within the region
- **Cultural modifications** – Some modifications add favorably to visual variety while other add little or no visual variety or may be discordant

In terms of visual sensitivity, BLM's VRM methodology rates landscapes as either High, Moderate, or Low by analyzing the various indicators of public concern, including: type of users, amount of use, public interest, adjacent land uses, specially designated areas, and other factors. Based on review of the visual quality analysis completed for the 2012 EIS/EIR, all of the aesthetics primary and secondary Area of Analysis would be considered High visual sensitivity because: (1) recreational sightseers are highly sensitive to changes in visual quality; (2) public interest and controversy in the area has increased in response to Proposed Project activities; (3) portions of the primary and secondary Area of Analysis are within the viewshed of residential areas; and (4) much of the Klamath River has been designated under the National Wild and Scenic Rivers Act (WSRA).

In terms of distance zones, BLM's VRM methodology classifies public lands as either foreground-middleground, background, or seldom seen. Based on review of the visual quality analysis, all of the primary and secondary Area of Analysis would be located with the foreground-middleground distance zone due to the proximity of views from recreational access sites along the river, campgrounds, key observation points along scenic highways, riverside and/or reservoir communities and residences, rivers, or other viewing locations, which are less than three to five miles away.

Table 3.19-2. Visual Resource Inventory Matrix.

Special Areas		**Visual Sensitivity**						
		High			**Medium**			**Low**
		I	**I**	**I**	**I**	**I**	**I**	**I**
Scenic Quality	**A**	II	II	II	II	II	II	II
	B	II	III	III*	III	IV	IV	IV
				IV*				
	C	III	IV	IV	IV	IV	IV	IV
		f/m	**b**	**s/s**	**f/m**	**B**	**s/s**	**s/s**
		Distance Zones						

Source: BLM 2007, BLM 1984, KHSA 2012 EIS/EIR

Notes:

Highlighted cells indicate visual resource inventory determinations for the affected environment

* If adjacent area is Class III or lower then assign Class III, if higher then assign Class IV, where objectives for each class are listed below.

Class II Objective – to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

Class III Objective – to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.

Class IV Objective – to provide for management activities which require major modifications of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements.

Key:

b: background
f/m: foreground/middleground
s/s: seldom seen

3.19.2.2 Wild and Scenic Rivers and Scenic Highways/Byways

Klamath River components are part of the National (and state) Wild and Scenic Rivers System because of their free-flowing condition and “outstandingly remarkable” values. According to the (Wild and Scenic Rivers Act (WSRA) (16 U.S.C. 1271 et. seq.), these outstandingly remarkable values include scenic, recreational, geologic, fish, wildlife historic, cultural or other similar characteristics. These values along designated wild and scenic reaches are protected by both the federal and state WSRA to various degrees, but all designated river segments must maintain at least a generally natural appearance along their waterways. The natural-appearing scenic quality within the more immediate and prominent portions of these rivers is also protected along these WSR segments by the WSRA.

The Klamath River beginning 3,600 feet downstream from Iron Gate Dam (Figure 3.19-2) and continuing 189 miles downstream to the Pacific Ocean is designated as a WSR. This WSR segment is recognized for its outstandingly remarkable fisheries. It is classified under the California WSRA as recreational (river segments that are readily accessible by road or railroad, and that may have some development along their shorelines, and may have been impounded or diverted in the past (PRC § 5093.53), with portions of the tributaries classified as scenic and wild.

Scenery within the California Klamath WSR is dominated by natural settings. Its water appearance, anadromous fish and riparian vegetation within a forested river canyon are the primary scenic aspects. Since its WSR designation in 1981, flow regimes have varied moderately in response to water resource competition, government mandated flow requirements and weather within the Klamath Basin. During summer months, fluctuations in the flow regime have typically been caused by water diversions (Van de Water et al. 2006). As described in Section 3.20 *Recreation*, reduced water clarity and discoloration resulting from seasonal algae blooms has impaired the scenic character and recreational opportunities of the Middle and Lower Klamath River (see also Section 3.2 *Water Quality* and Section 3.4 *Phytoplankton and Periphyton*).

In addition, in 1990, BLM found the 5.3-mile section of the Klamath River from the Oregon-California state line to Copco No. 1 Reservoir eligible and suitable for WSR designation (Figure 3.19-2). The river segment is free-flowing and possesses outstandingly remarkable scenic, recreational, fish, and wildlife values. This river segment is not a designated WSR and is not protected under the National WSRA and its Section 7(a) requirements. However, agencies are still required within their authorities, to protect this eligible river segment’s free-flowing character, water quality, and outstandingly remarkable river values. This segment of the Klamath River is also listed on the Nationwide Rivers Inventory to ensure protection of its river values (NPS 2009).

There are three Scenic Byways located along the Klamath River and within the Klamath and Six Rivers National Forests. The "State of Jefferson" National Forest Scenic Byway is located primarily on California State Highway 96 (Highway 96) between Shasta River to Happy Camp (Figure 3.19-2), and the "Bigfoot" National Forest Scenic Byway is located on Highway 96 from Happy Camp to California State Highway 299 (Highway 299). There is also an "All American Road" as classified by the U.S. Department of Transportation's Federal Highway Administration—the Volcanic Legacy Scenic Byway—which goes from Lassen National Park in California and through the Proposed Project area via Highways 97, 140, and 62 on its way to Crater Lake National Park in Oregon. These byways provide excellent views for sightseers within the Klamath and Six Rivers National Forests and access to numerous other recreational activities (America's National Scenic Byways 2017). With the exception of a small portion of the "State of Jefferson" National Forest Scenic Byway, these byways are not within the primary or secondary Area of Analysis for aesthetic resources (Figure 3.19-2).

3.19.2.3 Klamath Watershed

Along the northernmost, eastern edge, upstream of the primary and secondary aesthetics Area of Analysis, the Klamath River borders remnants of central Oregon's Modoc Plateau province. The river flows through a broad, flat valley that gradually transitions to a narrow channel as it crosses the low, rolling ridges of the Cascade Mountains.

The Upper Klamath Basin begins at the headwaters of the Klamath River in south-central Oregon and extends downstream into north-central California. This area includes agricultural lands and the Upper Klamath Basin National Wildlife Refuge Complex, which comprises six wildlife refuges and contains the USBR Klamath Irrigation Project. Regionally, a variety of public lands contain notable scenic resources. Table 3.20-1 in Section 3.20.2.1 *Regional Recreation* lists locations within the aesthetics primary and secondary Area of Analysis and surrounding region that offer opportunities for wildlife viewing, sightseeing, leisure driving, photography, and other forms of recreation that benefit from scenic quality.

In the central section of the Upper Klamath Basin, starting upstream of J.C. Boyle Dam, the topography changes dramatically, dropping rapidly into the 1,000-foot-deep upper Klamath River Canyon. The ruggedness of the terrain exemplifies the surrounding landscape, where nearby mountain peaks often reach 5,000 feet in elevation. As the Klamath River passes through the Cascade Mountains, the upper Klamath River Canyon represents a transition from the desert landscape in the east to a mountainous landscape in the west. The steep-walled canyon is the predominant visual element in the region. As it flows through the deep gorge, the river changes from slack, slow-flowing water in the broad, flat valley to a torrent of cascading whitewater. Less than five miles downstream of J.C. Boyle Dam, the canyon and neighboring ridges gradually become flatter and wider as the river flows southwesterly across the state line and into Copco No. 1 Reservoir. Here, along the Proposed Project's western edge, the topography surrounding Copco No. 1 and Iron Gate reservoirs is open and rolling.

3.19.2.4 Klamath River Key Observation Points

PacifiCorp (2004a) identified multiple key observation points associated with the Lower Klamath Project, where the following points are located within the aesthetic primary and secondary Area of Analysis: two in the Hell's Corner Reach (HC7 and HC-8); seven in the Copco No. 1 Reservoir area (C1 to C7); twelve in the area of Iron Gate Reservoir (IG1 to IG12); five in the Fall Creek area (FC1 to FC5); and, three downstream of Iron Gate Dam (BG1 to BG3) (Figure 3.19-2, Table 3.19-1). Many of the reaches have similar characteristics with the aesthetic differences between high flows and low flows varying depending on the individual physical features of each reach (e.g., during low flows, more rocks and vegetation are visible at the river edges than at high flows; in shallower areas, lower flows affect channel depth more greatly).

Figures 3.19-3 and 3.19-4 depict views of the Klamath River from two of the key observation points downstream of Iron Gate Dam (IG12 and BG3, respectively). Under the range of flows observed, river water continues to inundate the entire channel width. Higher flows exhibit deeper water depth and higher flow velocity. Views of the Klamath River, downstream of the Lower Klamath Project dams and associated facilities, show a free-flowing river with broad channel dimensions. As a result, exposed shoreline margins and riverbed deposits are exposed under a wider range of flow conditions than the upstream sections.

Views of the Klamath River, upstream of the Lower Klamath Project dams and associated facilities (Figures 3.19-5 and 3.19-6), show a free-flowing river with similar surface area dimensions over a range of flows due to the narrower channel. Only the shoreline margins are exposed at lower flows of approximately 350 cubic feet per second (cfs). During higher flow conditions ranging up toward 2,800 cfs, water extends into adjacent upland vegetation.

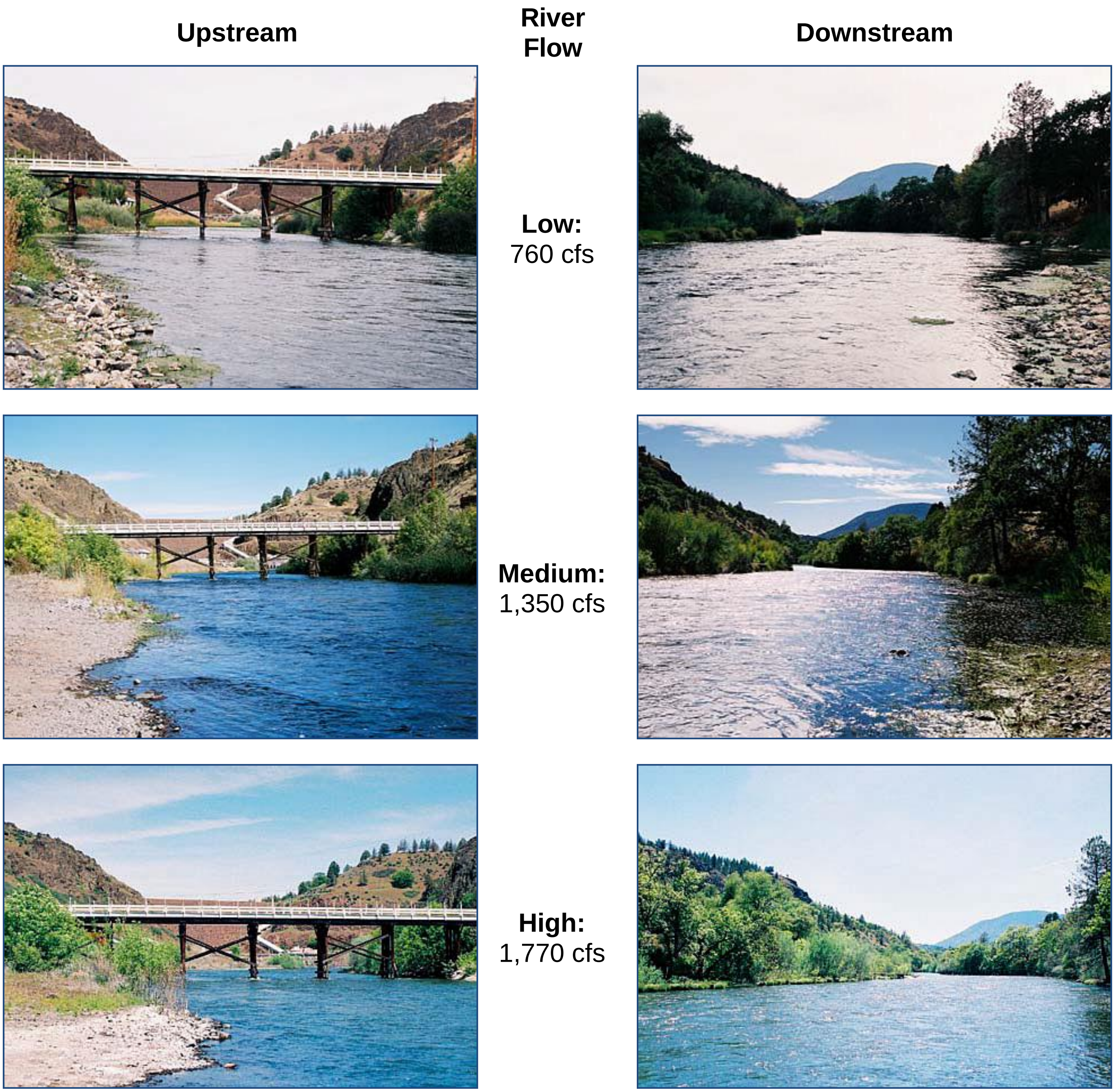


Figure 3.19-3. Views of Klamath River Downstream of Iron Gate Dam (IG12).
Source: PacifiCorp 2004a.

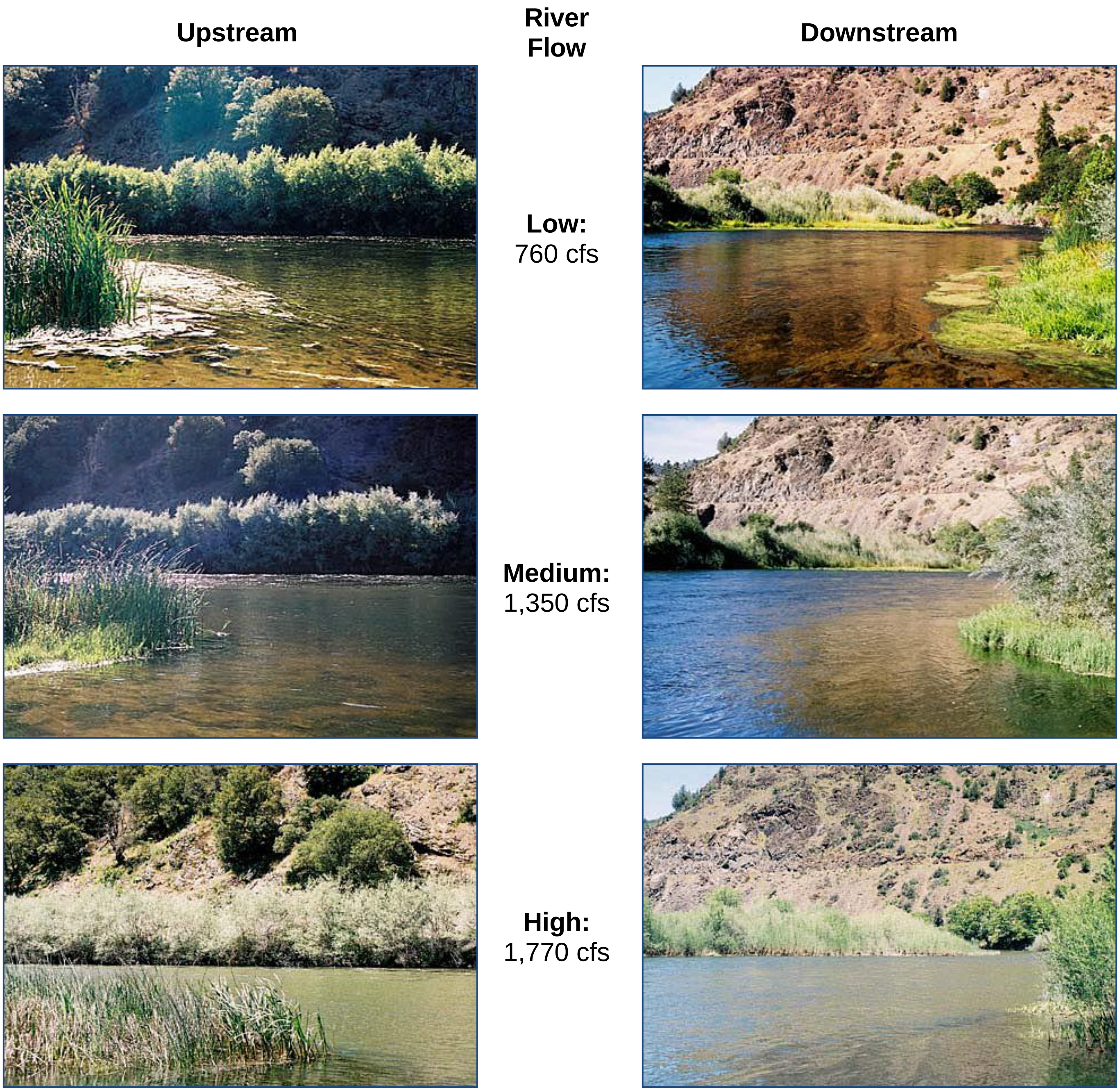


Figure 3.19-4. Views of Klamath River from Tree of Heaven River Access Boat Ramp (1.5 miles downstream of Iron Gate Dam) (BG3). Source: PacifiCorp 2004a.

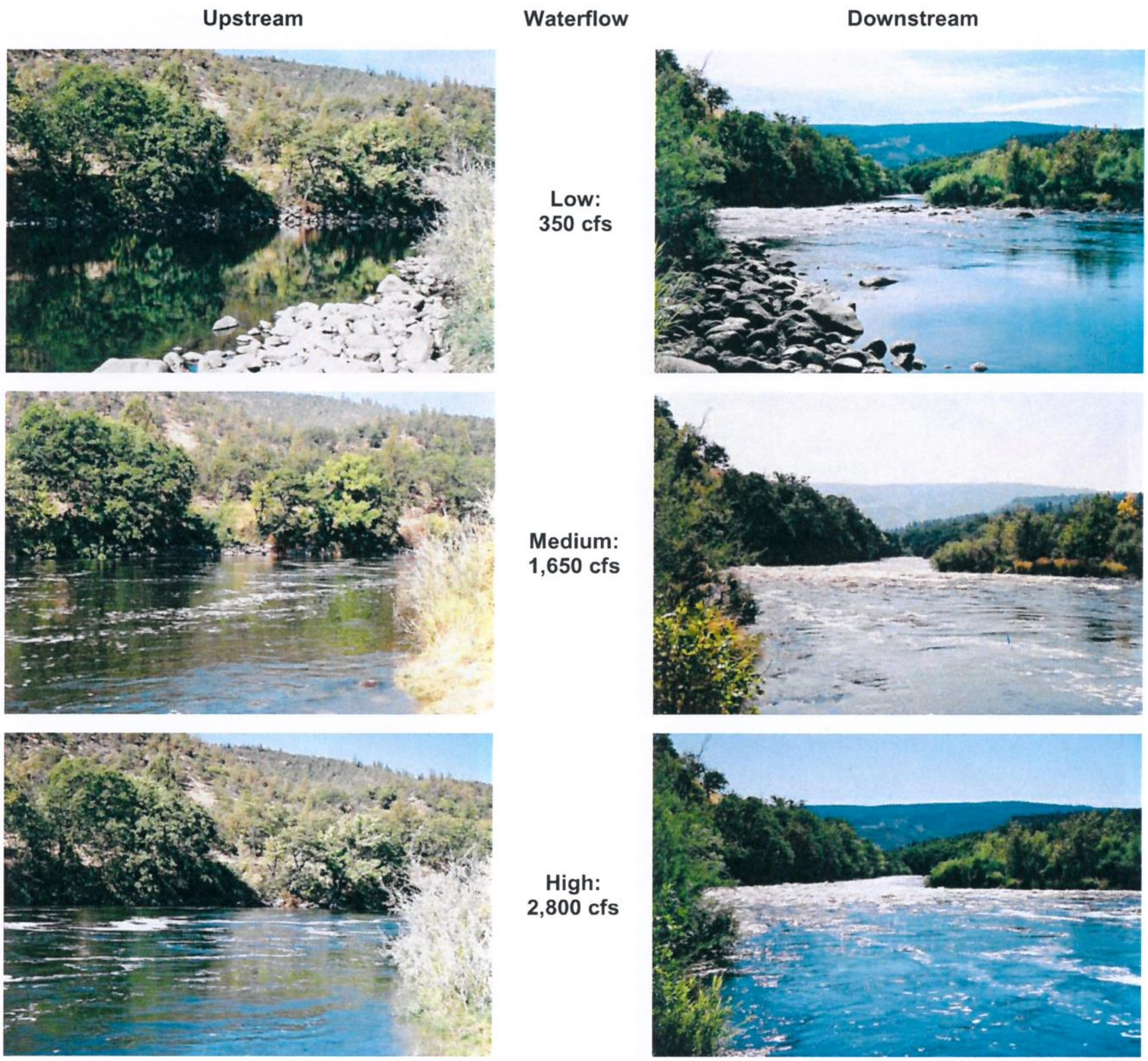


Figure 3.19-5. Views of Klamath River from Stateline Takeout (HC7). Source: PacifiCorp 2004a.

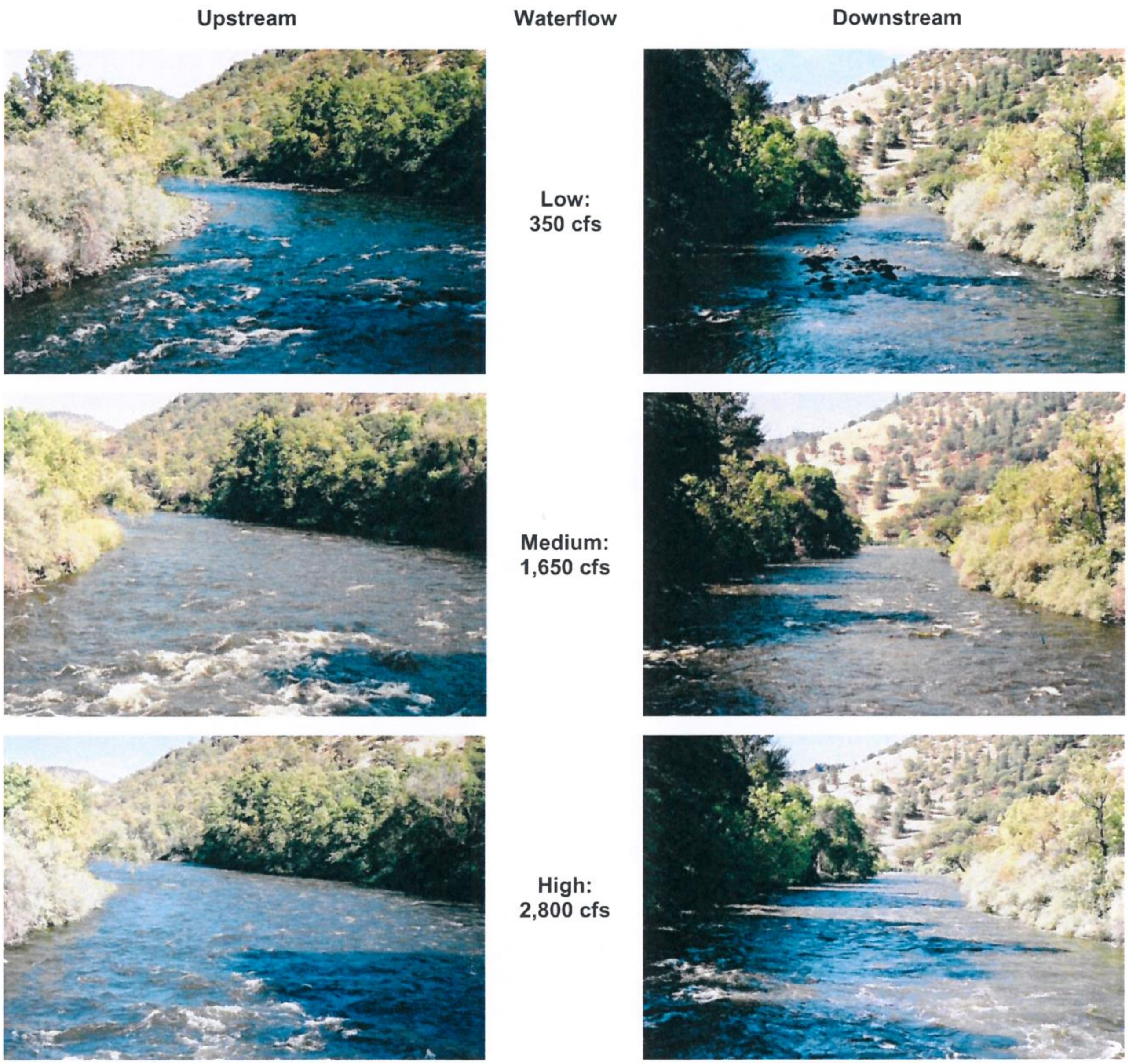


Figure 3.19-6. Views of Klamath River from Fishing Access #5 (Topsy Grade Road). Source: PacifiCorp 2004a.

3.19.2.5 PacifiCorp's Hydroelectric Project Facilities

Reservoirs

PacifiCorp (2004a) described the area landscape from nine key observation points in the vicinity of the reservoirs (C2 to C5, C7, IG9 to IG12). All reservoirs were viewed under high pool and low pool conditions. In general, the reported visual observations of the reservoirs indicated that under normal operating conditions, the three reservoirs share the visual characteristics of open expanses of relatively flat water. Also, as described in sections 3.2 *Water Quality* and 3.4

Phytoplankton and Periphyton, seasonal algae blooms occur in the reservoirs, typically peaking in late summer to early fall. During particularly intense algal blooms, floating algae mats and scums often appear and concentrate in protected areas or along the shoreline where they are not exposed to wind.

Because the water surface elevations of these reservoirs do not fluctuate substantially, the visual appearance of the landscape does not change considerably over the course of the year. When the water surface is drawn down, limited shoreline material is exposed. However, this limited exposure does not detract from the view shown.

Residences along the Copco No. 1 Reservoir shoreline, of which there are approximately 140, have unobstructed views of the reservoir water surface. The waterbody dominates their views and likely enhances the aesthetic quality of this landscape. Views on Iron Gate Reservoir are similar, however, there are no permanent residences located along this reservoir's shoreline. Viewers are limited to recreationists utilizing the local roads and recreational facilities.

Lower Klamath Project Hydroelectric Facilities in California

PacifiCorp documented the scenic characteristics of the Lower Klamath Project facilities within the aesthetics primary and secondary Area of Analysis at the following seven key observation points (alphanumeric designations refer to key observation point designations and accompanying photographs in the PacifiCorp [2004a] report):

- C3: Copco No. 1 Dam and Powerhouse
- C4: Copco No. 2 Dam
- C6: Copco No. 2 Powerhouse
- C7: Copco Transmission Line
- IG8: Iron Gate Transmission Line
- IG9: Iron Gate Dam and Powerhouse from Iron Gate Fish Hatchery
- IG10: Iron Gate Fish Hatchery and Fish Ladder

In the PacifiCorp (2004a) report, the views of the three facilities from these key observation points were characterized using the BLM VRM system. The report describes each of the three facilities in the context of the BLM VRM classification for the surrounding area (Class III). It should be noted that these assessments were done using one single photo from quite close to each facility, which magnifies its influence on the visual landscape. These observations may be summarized by facility as follows:

- **Copco No. 1 Facilities**—Copco No. 1 Dam and Powerhouse (C3) were not considered to be consistent with the VRM Class III objectives of the surrounding area. The size and prominence of these facilities were considered to dominate the view from the key observation point. However, because a view at such close proximity to the powerhouse is not generally available to the average viewer, the impact of dam and powerhouse on the

VRM Class III objectives were considered to be minimized. The Copco No. 1 transmission line was typically distant from the viewing points and would blend into the sky and not obstruct views of other parts of the landscape. Thus, the transmission line was considered to be consistent with VRM Class III objectives.

- **Copco No. 2 Facilities**—Copco No. 2 Powerhouse (C6) was not considered to be consistent with the VRM Class III objectives of the surrounding area because of its size and prominence the powerhouse dominates the view from the key observation point. Although the Copco No. 2 Dam is large, it has been designed with colors and lines that blend with the landscape, and when viewed in isolation, or from a longer distance, could therefore be considered consistent with VRM Class III objectives.
- **Iron Gate Facilities**—The Iron Gate Dam, Powerhouse, and transmission lines (IG8, IG9) were considered to be consistent with the VRM Class III objectives of the surrounding area in a detailed visual evaluation of the project vicinity as summarized in the Final EIS (2007) and documented in the *Land Use, Visual, and Aesthetic Resources Final Technical Report* (PacifiCorp 2004a). Although the dam and powerhouse are large, their colors and lines blend with the landscape. Similarly, the transmission line was typically distant from the viewing points and would blend into the sky and not obstruct views of other parts of the landscape. In instances where the support poles of the transmission lines were prominent, it was only for a short time while a viewer walks or drives by.

Figures 3.19-7 through 3.19-9 depict views of several project features located at Copco No. 1 and Iron Gate dams and associated facilities. The reservoir waterbodies are the dominant visual feature from both distant views and from shoreline locations.

Views of Copco No. 1 and Iron Gate dams are limited by topographic features that obstruct more distant views of these facilities. Views of Copco No. 1 Dam are limited to approximately 0.25 river miles downstream. Views are often blocked by local topography and the meandering course of the river. Views of Copco No. 2 Dam can also be limited because of local topography, the meandering course of the river, and vegetation. Copco No. 2 Dam can only be seen from a distance of approximately 500 feet due to these obstructions. Iron Gate Dam can be seen from a distance of approximately one mile at several residences located downstream of this facility. Views of the dam are partially obstructed by local topographic features.

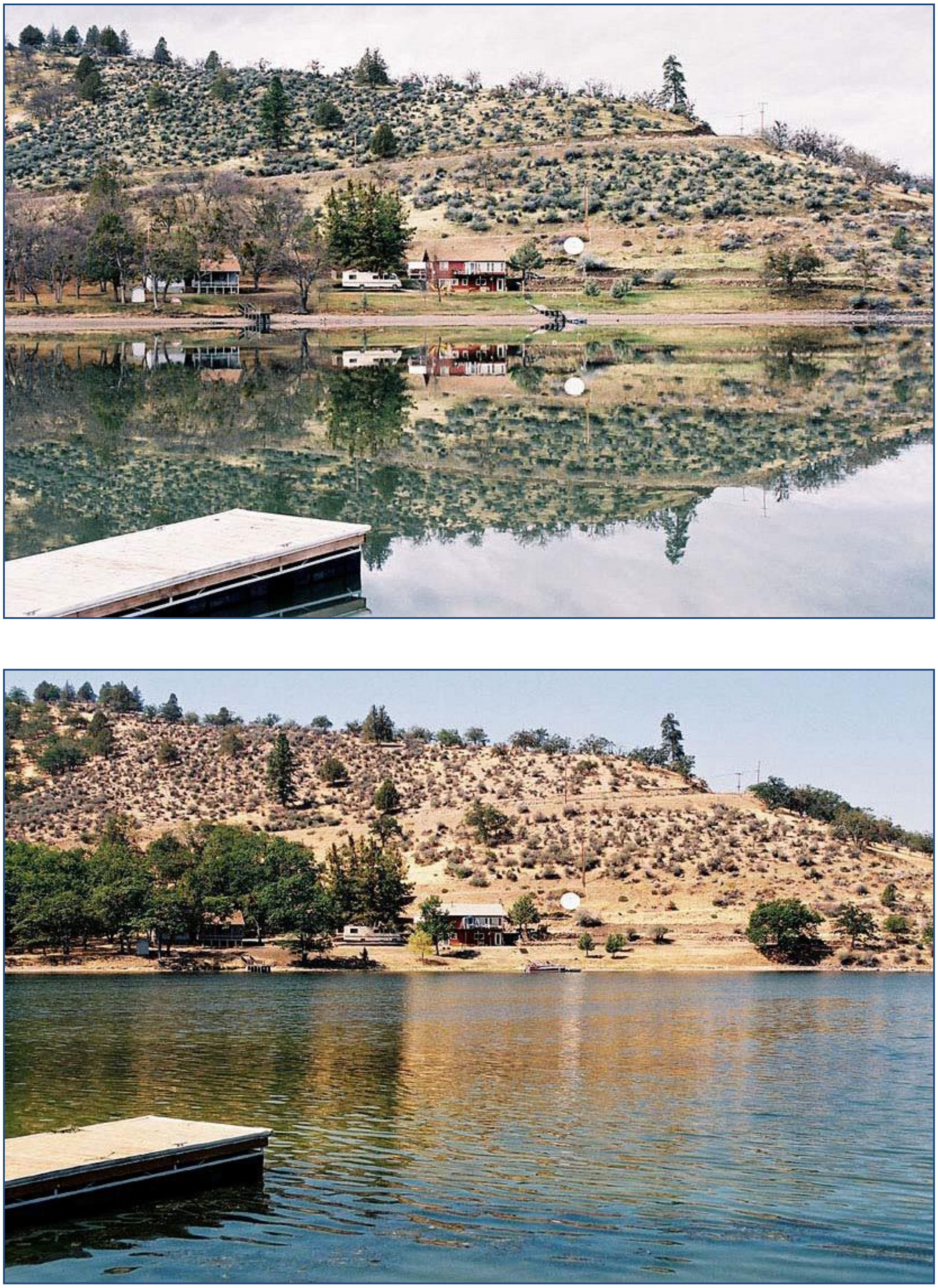
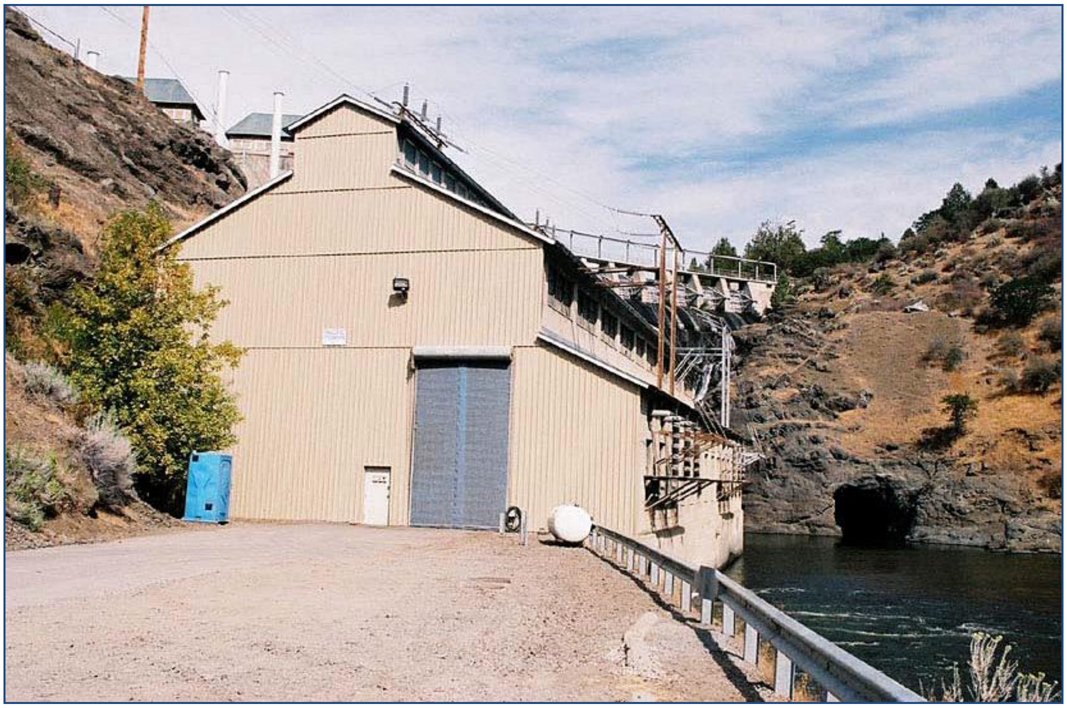


Figure 3.19-7. Copco Lake at Mallard Cove Recreation Area during Low and High Pool Conditions (C1). Source: PacifiCorp 2004a.

Figure 3.19-8. Iron Gate Reservoir at Long Gulch Recreation Area during Low and High Pool Conditions. Note the algal mats in the second photo (IG7). Source: PacifiCorp 2004a.



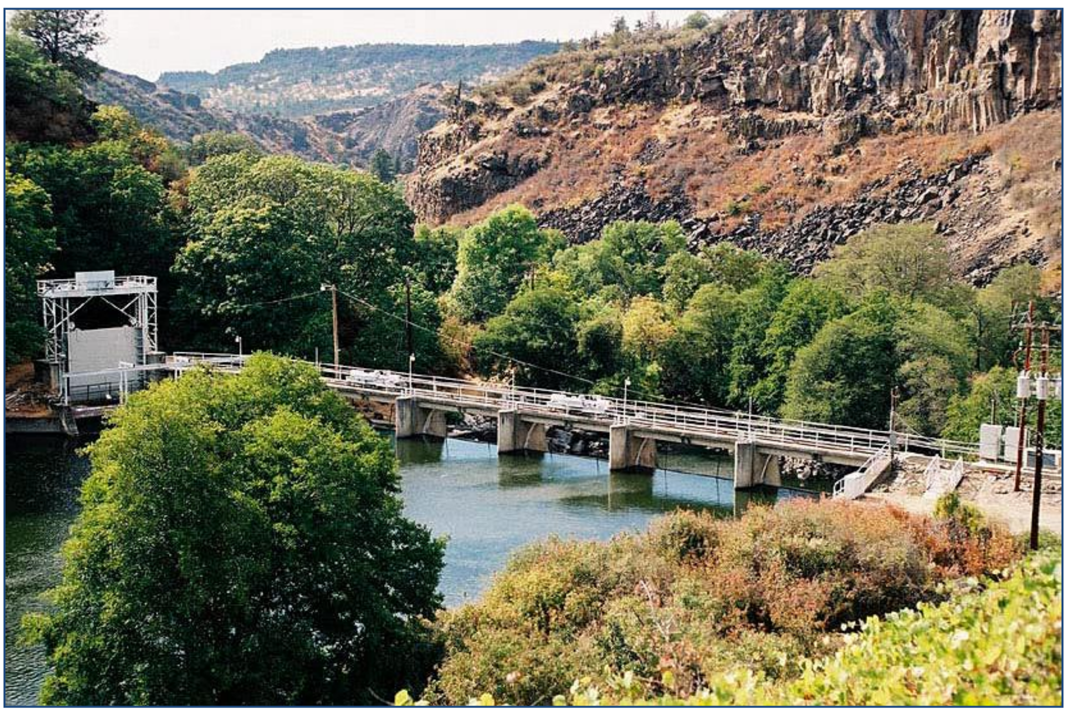


Figure 3.19-9. View of Copco No. 1 Powerhouse and Copco No. 2 Dam (C3, C4). Source: PacifiCorp 2004a.

3.19.3 Significance Criteria

Criteria for determining significant impacts on aesthetics are based upon Appendix G of the CEQA Guidelines (California Code of Regulations, title 14, section 15000 et seq.) and best professional judgement. Impacts are considered significant if the Proposed Project would:

- In areas where the VRM analysis was conducted, cause the VRM class to be degraded (i.e., changed to a higher numerical class) at a key observation point. In areas where the VRM analysis was not conducted, cause a substantial adverse effect on a scenic vista, considering in a qualitative manner the extent of the potential change to the existing landscape, how dominant the change would be in the overall public view, and the consistency of the change in the public view with the existing scenery.
- Result in a loss of or substantial adverse change to scenic elements of a landscape (including, but not limited to, landforms, trees, rock outcroppings, shape of the river channel, or visible aspects of riverbed composition such as boulders, cobble, gravel, and sand bars) as viewed from a vista point, community, recreation site area, trail, scenic highway, or designated wild and scenic river reach, or river reach that is designated as eligible and suitable to be wild and scenic.
- Substantially degrade the existing visual character or quality of the site and its surroundings.
- Create a new source of substantial light or glare that would adversely affect day or nighttime views in the area.

3.19.4 Impact Analysis Approach

The analysis of aesthetic resources in this EIR is primarily qualitative and acknowledges a degree of subjectivity, where one person's idea of what is aesthetically pleasing may not match another person's idea. However, certain guideposts or aesthetic goals can be used to guide an inquiry into what aesthetic changes many, or even most, viewers would find appealing or not. For these cases, the BLM's Visual Resource Management (VRM) methodology was used as guidance, since PacifiCorp previously had used this approach for a visual analysis of Copco No. 1, Copco No. 2, and Iron Gate dams and associated facilities (see also Section 3.19.2.1 *PacifiCorp Analysis and Bureau of Land Management Methodology*).

The primary and secondary Area of Analysis for aesthetics experiences four distinct seasons, across which Klamath River flows, reservoir water levels, and the appearance of vegetation vary. The detailed visual evaluation of the Project vicinity as summarized in the 2007 FERC EIS (FERC 2007) and documented in the *Land Use, Visual, and Aesthetic Resources Final Technical Report* (PacifiCorp 2004a) was used to characterize the primary and secondary Area of Analysis for aesthetics because the PacifiCorp (2004a) report included viewing the key observation points during different seasons and at different water levels over an extended time period.

To evaluate the significance of potential impacts to scenic resources, the key observation points were reviewed to determine which scenic resources would be changed by the Proposed Project, with potential changes identified in terms of degree of contrast, relative size or scale, distance, visibility, and magnitude. Although the contrast rating forms provided in the BLM VRM process were not filled out for this EIR, the same basic steps were used to consider potential impacts of the Proposed Project. These steps include describing the characteristics of the existing landscape, as well as those of the Proposed Project, and assessing the contrast between the two.

Changes in scenic quality were identified and evaluated by establishing a level of contrast (i.e., no effect [visual contrast is imperceptible], weak, moderate, and strong [contrast caused by the action would be substantial]) considering effects on form, line, color, texture. Light pollution effects that could be generated during construction were also considered in relation to the associated significance criterion.

This EIR analysis categorizes potential visual impacts associated with the project into five groups: (1) loss of open water vistas; (2) changes to the river channel, flows and water quality; (3) reservoir drawdown and restoration; (4) removal of the dams and associated facilities; and (5) construction impacts. Short-term (temporary) construction-related impacts would occur during the dam removal period, including reservoir drawdown and short-term restoration activities (zero to five years), while long-term (permanent) impacts would persist beyond the construction and active restoration period.

Because the aesthetics primary and secondary Area of Analysis does not extend downstream of the confluence with the Shasta River (RM 179.5), the review of local plans and policies for aesthetics focuses on Siskiyou County. The following policies and objectives from the Siskiyou General Plan were reviewed and considered relevant to the Proposed Project: Conservation Element (Siskiyou County 1973) Objective F, and Scenic Highways Element (Siskiyou County 1975) Objectives 3 and 4. These objectives generally promote aesthetic characteristics of the land to benefit residents of the county and state, as well as tourists. The issues addressed by the aforementioned Siskiyou General Plan objectives, including revegetation of cut-and-fill slopes, are inherently addressed in the impact analyses presented in Section 3.19.5 *[Aesthetics] Potential Impacts and Mitigation*.

3.19.5 Potential Impacts and Mitigation

The Proposed Project involves removal of three dams in California (Copco No. 1, Copco No. 2, Iron Gate) and essentially all appurtenant features associated with the dams and related facilities, with the exception of buried features (Section 2.7

Proposed Project). Onsite disposal of concrete from Copco No. 1, Copco No. 2, and Iron Gate dams would occur at two disposal sites located adjacent to the reservoirs (see Figures 2.7-2 and 2.7-4). The Proposed Project includes reservoir drawdown prior to removal of the dams (Section 2.7 *Proposed Project*), which would expose the formerly inundated areas to view. The proposed reservoir restoration activities include revegetating the newly exposed reservoir areas with native species through hydroseeding and manual planting. Grading and revegetation of staging areas and onsite disposal areas are also included in the proposed restoration activities (Section 2.7.5 *Restoration of Upland Areas Outside of the Reservoir Footprint*). Monitoring and adaptive management will be used to ensure affected areas are appropriately revegetated. Management of invasive exotic vegetation could include manual weed extraction, soil solarization (covering of ground areas with black plastic sheets), tilling, and use of herbicides (Section 2.7.4 *Restoration Within the Reservoir Footprint* and Appendix B: *Definite Plan*).

Under the Proposed Project, the hard lines of the dams and large expanses of water in the reservoirs would be changed to a more natural setting with river canyon landforms and vegetation framing a continuous river. Due to the surrounding mountainous topography, views of Copco No. 1 Dam are limited to approximately 0.25 river miles downstream, Copco No. 2 Dam can only be seen from a distance of approximately 500 feet, and Iron Gate Dam can be seen from a distance of approximately one mile downstream of this facility (Section 3.19.2.5 *PacifiCorp's Hydroelectric Project Facilities*). While there are three key observation points adjacent to Copco No. 1 and Copco No. 2 dams (C3, C4, C5) at which dam deconstruction activities, concrete disposal sites, and the eventual lack of the dams would be visible (Table 3.19-3), these sites are not generally accessible by the public under existing conditions. There are four key observation points immediately downstream of Iron Gate Dam (IG9 to IG12); which are also not generally accessible by the public, although there are residences approximately one mile downstream of the dam that may be visually affected. The Iron Gate Dam disposal site also would not be visible from the four key observation points or the downstream residences, but it would potentially be visible from key observation point IG7 (Table 3.19-3). The long-term (permanent) scenic change of removing the large expanses of water in the reservoirs would be visible for a very long distance around the prior reservoir locations, at most reservoir key observation points (Table 3.19-3), and for the approximately 140 residences along the Copco No. 1 Reservoir shoreline that have unobstructed views of the reservoir water surface (Section 3.19.2.5 *PacifiCorp's Hydroelectric Project Facilities*). Figures 2.7-5 and 2.7-6 show aerial photos of the existing reservoirs with an overlay of existing reservoir bathymetry, including the historical river channels. The historical river channels represent the projected long-term extent of the Klamath River following implementation of the Proposed Project. Immediately following reservoir drawdown, and until revegetation efforts are complete, areas within the reservoir footprints would appear barren and/or sparsely vegetated (Table 3.19-3). During construction and for one to two years following revegetation of the concrete disposal sites, the disposal site areas would also appear barren and/or sparely vegetated.

Table 3.19-3. Anticipated Visual Effects of the Proposed Project at Key Observation Points in the Aesthetics Primary and Secondary Area of Analysis (key observation point locations from PacifiCorp 2004a and shown in Figure 3.19-2 of this EIR).

Key Observation Point	Short-term (Temporary) Visual Effect[1]	Long-term (Permanent) Visual Effect[1]
HC7	• View of potential recreation site modifications	• View of modified recreation site
HC8	• View of potential recreation site modifications	• View of modified recreation site
C1	• Potential view of road improvements • View of exposed bare sediment and rock in reservoir footprints • View of restoration areas	• Loss of existing scenic reservoir view • Replacement with riverine and canyon scenic views
C2	• Potential view of road improvements • View of exposed bare sediment and rock in reservoir footprints • View of restoration areas	• Loss of existing scenic reservoir view • Replacement with riverine and canyon scenic views
C3	• View of construction areas • View of concrete disposal area for Copco No. 1 and Copco No. 2 dams • View of exposed bare sediment and rock in reservoir footprints • View of restoration areas	• Loss of view of dam and associated facilities • Creation of naturally contoured vegetated mound at concrete disposal area for Copco No. 1 and Copco No. 2 dams
C4	• View of construction areas • View of concrete disposal area for Copco No. 1 and Copco No. 2 dams • View of exposed bare sediment and rock in reservoir footprints • View of restoration areas	• Loss of view of dam and associated facilities • Creation of naturally contoured vegetated mound at concrete disposal area for Copco No. 1 and Copco No. 2 dams

Key Observation Point	Short-term (Temporary) Visual Effect[1]	Long-term (Permanent) Visual Effect[1]
C5	• View of construction areas • View of concrete disposal area for Copco No. 1 and Copco No. 2 dams • View of exposed bare sediment and rock in reservoir footprints • View of restoration areas	• Loss of view of dam and associated facilities • Creation of naturally contoured vegetated mound at concrete disposal area for Copco No. 1 and Copco No. 2 dams
C6	• View of construction areas, including City of Yreka water supply pipeline replacement • View of exposed bare sediment and rock in reservoir footprints • View of restoration areas	• Loss of view of Copco No. 2 powerhouse and associated facilities
C7	• View of construction areas associated with transmission line removal	• Loss of view of transmission lines
FC1	• View of potential recreation site modifications to support additional campsites and improved amenities	• View of modified recreation site
FC2	• View of construction activities, including Fall Creek Hatchery modifications	• Potential view of Fall Creek Hatchery modifications (ultimate fate of hatchery is speculative)
FC3	• View of construction activities, including Fall Creek Hatchery modifications	• View of Fall Creek Hatchery modifications (ultimate fate of hatchery is speculative)
FC4	• Potential view of construction activities, including Fall Creek Hatchery modifications	• View of Fall Creek Hatchery modifications (ultimate fate of hatchery is speculative)
FC5	• View of construction areas related to transmission lines	• Loss of view of transmission lines

Key Observation Point	Short-term (Temporary) Visual Effect[1]	Long-term (Permanent) Visual Effect[1]
IG1	• View of potential recreation site modifications to support additional campsites and improved amenities • View of exposed bare sediment and rock in reservoir footprints	• Loss of existing scenic reservoir view • Replacement with riverine and canyon scenic views
IG2	• View of construction activities to remove this recreation site • View of exposed bare sediment and rock in reservoir footprints	• Loss of existing scenic reservoir view • Replacement with riverine and canyon scenic views • Loss of view of recreation site facilities
IG3	• View of construction activities to remove this recreation site • View of exposed bare sediment and rock in reservoir footprints	• Loss of existing scenic reservoir view • Replacement with riverine and canyon scenic views • Loss of view of recreation site facilities
IG4	• View of construction activities to remove this recreation site • Possible view of construction to the north and across reservoir • View of exposed bare sediment and rock in reservoir footprints	• Loss of existing scenic reservoir view • Replacement with riverine and canyon scenic views • Loss of view of recreation site facilities
IG5	• View of construction activities to remove this recreation site • View of road construction activities • View of exposed bare sediment and rock in reservoir footprints	• Loss of existing scenic reservoir view • Replacement with riverine and canyon scenic views • Loss of view of recreation site facilities
IG6	• View of construction activities to remove this recreation site • View of exposed bare sediment and rock in reservoir footprints	• Loss of existing scenic reservoir view • Replacement with riverine and canyon scenic views • Loss of view of recreation site facilities

Key Observation Point	Short-term (Temporary) Visual Effect[1]	Long-term (Permanent) Visual Effect[1]
IG7	• View of construction activities • Potential view of Iron Gate Dam concrete disposal area • View of exposed bare sediment and rock in reservoir footprints	• Loss of existing scenic reservoir view • Replacement with riverine and canyon scenic views • Creation of naturally contoured vegetated mound at concrete disposal area for Iron Gate Dam
IG8	• View of construction activities to remove this recreation site • Possible view of transmission line construction across reservoir • View of exposed bare sediment and rock in reservoir footprints	• Loss of existing scenic reservoir view • Replacement with riverine and canyon scenic views • Loss of view of recreation site facilities
IG9	• View of construction activities, including Iron Gate Hatchery modifications	• Loss of view of dam and associated facilities (ultimate fate of hatchery is speculative)
IG10	• View of construction activities, including Iron Gate Hatchery modifications	• Loss of view of dam and associated facilities (ultimate fate of hatchery is speculative)
IG11	• View of construction activities, including Iron Gate Hatchery modifications	• Loss of view of dam and associated facilities (ultimate fate of hatchery is speculative)
IG12	• View of construction activities, including Iron Gate Hatchery modifications	• Loss of view of dam and associated facilities (ultimate fate of hatchery is speculative)
BG1	• None	• None
BG2	• None	• None
BG3	• None	• None

[1] Short-term visual changes are generally considered to be temporary, and long-term changes are generally considered to be permanent, unless otherwise indicated.

The Proposed Project includes modifications to the Iron Gate Hatchery and reopening of the Fall Creek Hatchery to support limited operations at these facilities for eight years following dam removal (Section 2.7.6 *Hatchery Operations*). Construction activities related to hatchery modifications would be visible in the short term (temporary) at several key observation points including, but not necessarily limited to FC2, FC3, FC4, IG9, IG10, IG11, and IG12 (Table 3.19-3).

The existing water supply pipeline for the City of Yreka passes under the upstream end of Iron Gate Reservoir (Figure 2.7-17) and would be relocated prior to reservoir drawdown to prevent damage from increased water velocities and scour once the reservoir has been drawn down. Three options for modifying the pipeline are being explored. These include: (1) micro-tunneled crossing, (2) aerial crossing on a new utility bridge, and (3) aerial crossing on a new Daggett Road bridge (see also Section 2.7.7 *City of Yreka Water Supply Pipeline Relocation*). Views of construction activities related to the City of Yreka water supply pipeline relocation would likely occur at only key observation point C6 (Table 3.19-3). Several bridges within the aesthetics primary and secondary Area of Analysis would be replaced to address structural deficiencies and/or to raise them above the new 100-year flood elevation, and roadway improvements (e.g., pavement rehabilitation, culvert replacements) would occur to facilitate construction vehicle access, all of which could be visible from several key observation points (Table 3.19-3).

The Proposed Project includes the complete removal of eight recreation sites (Table 2.7-14), including removal of structures, concrete, pavement, and most other existing recreation facilities, such as campgrounds and boat ramps that are currently located on the reservoir banks, and regrading and revegetating associated parking areas and trails (see also Section 2.7.8.3 *Recreation Facilities Management*). Views of construction activities during recreation site removal would occur at several key observation points (IG2, IG3, IG4, IG5, IG6, IG8; Table 3.19-3). The removed recreation sites would be planted with a native seed mix as described in the Reservoir Area Management Plan (Appendix B: *Definite Plan – Appendix H*). Recreational facilities at Fall Creek and Jenny Creek Day-Use Areas at Iron Gate Reservoir, and the Iron Gate Fish Hatchery Day-Use Area, would remain and may be upgraded or enhanced (Table 2.7-15). Views of construction activities related to Fall Creek and Jenny Creek Day-Use Areas would occur at two key observation points (FC1, IG1; Table 3.19-3). Future enhancements at these locations would depend on the future ownership of Parcel B lands, where these three recreational facilities are located.

Aesthetic changes resulting from the aforementioned actions under the Proposed Project would occur in the short term (up to five years) and/or the long term (more than five years). For the aesthetics analysis, short-term visual changes are generally considered to be temporary, and long-term changes are generally considered to be permanent, unless otherwise indicated. The potential aesthetic changes analyzed under the Proposed Project include the following:

- Long-term (permanent) loss of open water vistas/views and replacement with riverine and canyon vistas/views;
- Short-term (temporary) and long-term (permanent) changes in flows and channel morphology;
- Short-term (temporary) and long-term (permanent) changes in visual water quality, including increased turbidity and reduced algal blooms;
- Short-term (temporary) bare/unvegetated area under former reservoirs after reservoir drawdown;
- Long-term (permanent) visual changes due to removal of Lower Klamath Project dams and associated facilities, and improvements to or construction of new infrastructure (e.g., bridges, recreation facilities);
- Short-term (temporary) visual impacts from stockpiles, lighting, and equipment.

Each of these potential aesthetic changes are analyzed below.

Potential Impact 3.19-1 Loss of open water vistas and replacement with riverine and canyon vistas.
The primary aesthetics Area of Analysis is rural. There are no major highways or towns within the viewshed of the reservoirs. However, there is a substantial amount of public land and public access to the area. While there is only one officially designated scenic overlook or vista point, recreational sites within the aesthetics primary Area of Analysis include the following:

- Nine developed recreation sites along the river corridor between the Oregon-California state line and Copco No. 1 Reservoir (all fishing access sites except for the “Stateline Take-out”);
- Two developed and two dispersed recreation sites at Copco No. 1 Reservoir;
- Eight developed and five dispersed recreation sites at Iron Gate Reservoir;
- Two developed recreation sites just downstream of Iron Gate Dam.

In 2001 and 2002, the California Lower Klamath Project reservoir recreation sites accounted for an average of 61,240 recreation days (defined as one visitor to a recreation area for any reason in a 24-hour period), and the river recreation sites accounted for an average of 12,500 recreation days, (PacifiCorp 2004b), not including estimated angler days. In addition to the public land and recreational sites, there are also approximately 140 residences located around Copco No. 1 Reservoir, the majority of which are vacation homes. Also, several rural and local roads, mostly unpaved, provide access within and around the primary aesthetics Area of Analysis. Most of the nearby residents and the users of the recreational facilities associated with Iron Gate and Copco No. 1 reservoirs are there to enjoy activities on those reservoirs. Part of that experience includes the scenic, open water vistas of the area. (Potential impacts to recreational opportunities are discussed in further detail in Section 3.20 *Recreation*)

Sightseeing is a popular activity within the aesthetics primary Area of Analysis, with 39 percent of all respondents to a recreational survey of the area participating in that activity (PacifiCorp 2004b). However, sightseeing was less popular around the Lower Klamath Project dams and associated facilities, with only 30 percent and 32 percent of visitors participating in that activity at Copco No. 1 Reservoir and Iron Gate Reservoir, respectively (PacifiCorp 2004b). Conversely, 46 percent of respondents participated in sightseeing within the Hell's Corner River reach, between Copco No. 1 and J.C. Boyle reservoirs (which is in the aesthetics secondary Area of Analysis and partly in Oregon), indicating that the river itself provides a more important visual resource for visitors than the reservoirs. Boat fishing, camping and resting/relaxing were the three most popular activities at both Copco No. 1 and Iron Gate reservoirs (PacifiCorp 2004b).

Long-term (permanent) scenic vistas within the primary Area of Analysis would not necessarily be lost as a result of the Proposed Project, but they would be altered. Open water and lake vistas would be lost in favor of more natural river, canyon, and valley vistas. While not all people prefer a more natural, riverine setting, the results of prior surveys (PacifiCorp 2004b) suggest that in general the free-flowing river is preferred to the flatwater reservoir views. The recreation facilities within the aesthetics primary Area of Analysis were the primary destination of 54 percent of the recreation survey respondents (PacifiCorp 2004b), indicating that many users are just passing through and/or are visiting other destinations as well, reducing the severity of the impact of the loss of the Lower Klamath Project reservoirs.

Under the Proposed Project, the existing scenic reservoir view would be replaced with riverine and canyon scenic views, which would be a substantial change. However, since the VRM class would remain Class III (i.e., would not be degraded) at those key observation points associated with the Lower Klamath Project facilities and located within the reservoir viewshed (C1 to C7, FC5, IG1 to IG8; see Figure 3.19-2 and Table 3.19-3) the change is not considered to be adverse.

In areas where the VRM analysis was not conducted, the change in a scenic vista would also be substantial but the changed views would be similar to riverine and canyon scenic views located elsewhere in the general vicinity of the project. Note that owners of residences adjacent to the reservoirs may perceive a degradation in visual quality, while some recreational users and roadway viewers may perceive an improvement in visual quality. The latter is considered possible because under existing conditions, the Copco No. 1 and Iron Gate reservoirs often appear in a visually degraded condition due to summer algal blooms, which negatively impacted a majority of recreational survey respondents (see Potential

Impact 3.19-3). In addition, removal of human-made structures may be perceived as benefiting the visual quality of the aesthetics Area of Analysis. On balance, the long-term (permanent) change from open water reservoir scenic vistas to river, canyon, and valley scenic vistas within the primary Area of Analysis would be less than significant based upon the lack of degradation in VRM Class III relative to existing conditions and a visual change that would be consistent with riverine and canyon scenic views located elsewhere in the general vicinity of the project.

Significance
No significant impact

Potential Impact 3.19-2 Effects of changes in flows and channel morphology on scenic river vistas.
The aesthetics primary Area of Analysis (i.e., within the viewshed of the Lower Klamath Project reservoirs, which includes the proposed Limits of Work in California), is not visible from any of the nearby designated scenic byways, highways, or the WSR sections of the river (Figure 3.19-2). However, the Proposed Project could affect flows and channel morphology within the WSR sections that are associated with the aesthetics secondary Area of Analysis, which could affect scenic elements of the landscape as viewed from a vista point, community, recreation site area, trail, scenic highway, or river vantage point within the designated WSR sections.

Within the aesthetics secondary Area of Analysis, the stretch of the Klamath River from the Oregon-California state line to the upstream end of Copco No. 1 Reservoir has been determined to be eligible for listing under the WSRA. In addition, the mainstem Klamath River from 3,600 feet below Iron Gate Dam downstream to the Klamath River Estuary has been designated as "Recreational" under the WSRA. There are a number of river access sites along the Klamath River from the California-Oregon state line to the upstream end of Copco No. 1 Reservoir, including key observation points HC7 and HC8 (Figure 3.19-2), as well as downstream of Iron Gate Dam, including key observation points BG1 to BG3 (Figure 3.19-2). The river is also visible from several roadways that run parallel to the river channel or that cross the river within the secondary Area of Analysis. These include access roads to riverside and/or reservoir communities, residences, recreational access sites, and campgrounds, as well as state highways 96, 263 and US Interstate 5 (Figure 3.19-2).

In the portion of the Hydroelectric Reach between Copco No. 1 Reservoir and the Oregon-California state line (which is within the aesthetics secondary Area of Analysis), river flows within this reach would be altered by the removal of the J.C. Boyle Dam, located approximately 15 river miles upstream, which could indirectly affect views of the river. Similarly, under the Proposed Project, flows would change in the WSR segment downstream of Iron Gate Dam to the confluence with the Shasta River (RM 179.5), including key observation points BG1, BG2, and BG3 in the aesthetics secondary Area of Analysis (Figure 3.19-2), which could also affect the river's aesthetic character.

Potential changes to flow characteristics include the timing, duration and magnitude of flows. These changes can impact the physical structure (morphology) of the river channel and the riparian vegetation. Much of the channel morphology within the aesthetics secondary Area of Analysis closest to the hydroelectric facilities is bedrock-controlled, which means flows do not have a significant influence on the channel configuration (Philip Williams & Associates, Ltd. [PWA] 2009), though there may be some minor changes to small alluvial floodplains. The hydrologic changes that would occur under the Proposed Project (i.e., smoother hydrograph due to the elimination of relatively rapid changes in flows from dam releases during the dry season, lower flows in the late summer and higher flows in the late fall, and lack of attenuation of large storm events during the wet season) would not be readily noticeable to the casual observer from key vistas along the Klamath River and the aesthetics secondary Area of Analysis downstream of Iron Gate Dam and would not result in a loss of or substantial adverse change to scenic elements of a designated WSR reach.

Further, removal of the dams would not adversely impact visual aspects of the channel aspects of channel morphology (i.e., shape of the river channel and/or presence of boulders, cobble, gravel, sand bars) in the secondary Area of Analysis. The Hydroelectric Reach between Copco No. 1 Reservoir and the Oregon-California state line would experience only small, short-term (temporary) changes in riverbed composition (i.e., proportions of cobble, gravel, sand) due to scouring and deposition of sediments from J.C. Boyle Reservoir during and immediately following drawdown; in the long term, this reach would experience a partial return to natural sediment supply (Keno Dam would remain upstream) (see also Potential Impact 3.11-5). These changes would not result in a loss of or substantial adverse change to scenic elements of a river reach that is designated as eligible and suitable to be wild and scenic. The river channel immediately downstream of Iron Gate Dam would experience the greatest amount of short-term (temporary) changes in riverbed composition, where reservoir-released sediment may temporarily deposit in pools and other slack water areas (e.g., eddies) and at tributary confluences in the reach from Iron Gate Dam to Cottonwood Creek (see also Potential Impact 3.11-5). Although potentially noticeable from scenic vistas, these short-term (temporary) localized sediment deposition areas would not result in a loss of or substantial adverse change to scenic elements of a designated WSR reach (i.e., shape of the river channel and/or presence of boulders, cobble, gravel, sand bars) as compared with existing conditions, and therefore, there would be no impact. In the long term, this reach would experience a partial return to natural sediment supply (Keno Dam would remain upstream), which also would not result in a substantial adverse change river channel aesthetics.

<u>Significance</u>
No significant impact

Potential Impact 3.19-3 Changes in visual water quality.
There would be visible changes in downstream water clarity (as characterized by suspended sediment concentrations and/or turbidity) resulting from the Proposed Project, including short-term (temporary) decreases in clarity due to elevated turbidity in the Hydroelectric Reach, Middle and Lower Klamath River, and Klamath River Estuary during reservoir drawdown, as well as long-term (permanent) seasonal increases in clarity due to decreases in summer algal blooms after dam removal.

Short-term (Temporary) Changes in Visual Water Quality
Due to their general lack of cohesion, the majority of the accumulated sediment deposits currently in the reservoirs would be eroded during reservoir drawdown (Section 2.7.3 *Reservoir Sediment Deposits and Erosion During Drawdown*). The erosion of reservoir sediment deposits would result in short-term (temporary) increases in turbidity and reduced clarity within and downstream of the Lower Klamath Project for several weeks to months during the reservoir drawdown period. Sediment jetting would be used at selected locations within Copco No. 1 and Iron Gate reservoirs to maximize erosion of accumulated sediments during drawdown. Revegetation efforts would occur immediately following drawdown, minimizing the potential for prolonged increases in turbidity due to erosion of sediment deposits remaining in the reservoir footprints (Section 2.7.4 *Restoration Within the Reservoir Footprint*).

Winter and spring water clarity, as characterized by suspended sediment concentrations and turbidity, is expected to return to background conditions by the end of summer during dam removal year 1, with most of the visual impacts of reduced water clarity occurring between January 1 and March 15, regardless of the water year type. The proposed sediment jetting would increase the potential that reservoir sediment deposits would be eroded to the extent possible (see also Section 2.7.3 *Reservoir Sediment Deposits and Erosion During Drawdown*) but the additional turbidity would be within the range of turbidity currently experienced on the river. Because the river reach from Iron Gate Dam (RM 193.1) to the confluence with the Shasta River (RM 179.5) is currently deprived of winter and early spring elevated inorganic suspended sediments due to the presence of the dams, this reach does not exhibit low water clarity (as characterized by relatively high suspended sediments and turbidity) during storm events that are otherwise common to much of the Klamath River downstream of the Hydroelectric Reach, as well as other rivers in the region. The potential impact of short-term (temporary) low water clarity in this reach during reservoir drawdown could result in a moderate to strong visual contrast, as characterized by the difference between high and low water clarity, in this river reach compared with existing conditions. However, because the majority of watercourses within the region experience low water clarity in the winter and early spring, particularly during and just following storm events, this condition is not aesthetically atypical, making it inherently less noticeable by an observer in the viewshed. In addition, this stretch of river is already visually degraded due to existing development, including the Iron Gate Hatchery, recreational facilities, houses, numerous roads and Interstate 5, further limiting the intensity of the visual impact of low water clarity within the context of existing human infrastructure. Overall, there would be no loss of or substantial adverse change to scenic elements of the landscape as viewed from a vista point, community, recreation site area, trail, scenic highway, or designated WSR reach and there would be no significant impact.

The primary drawdown period for the J.C. Boyle Dam, which is upstream of the aesthetics primary and secondary Area of Analysis, would occur between January 1 and January 31 of the drawdown year. Drawdown of Copco No. 1 Reservoir would likely commence on November 1 of the year prior to drawdown, but no significant sediment release is expected until after January 1. Drawdown would be completed by March 15 of the drawdown year. Drawdown of Iron Gate Reservoir would also start January 1, with water levels controlled through the spring (Section 2.7 *Proposed Project*). Copco No. 2 Dam does not impound a significant volume of sediment, and drawdown of this reservoir would occur after Copco No. 1 Reservoir is drained to grade. Due to naturally high levels of turbidity in the river during winter flows, increased turbidity from the Proposed Project would not be noticeable for most of the drawdown period. In addition, impacts would occur for a period of less than six months. Therefore, visual impacts from increased turbidity and reduced clarity related to sediment discharges would be less than significant.

Long-term (Permanent) Changes in Visual Water Quality

Existing summer algal blooms in the Lower Klamath Project reservoirs adversely impact water quality, salmonids, recreation, and aesthetics (Section 3.2 *Water Quality*, Section 3.3 *Aquatic Resources*, Section 3.4 *Phytoplankton and Periphyton*). More than 66 percent of recreational survey respondents indicated that water quality detracted from their experience at least a little at both Copco No. 1 and Iron Gate reservoirs; 91 percent indicated the same concern about the Hell's Corner Reach. Algae was the primary water quality concern cited by respondents (PacifiCorp 2004b). The Proposed Project would reduce the occurrence and severity of algal blooms (Potential Impact 3.4-2). The removal of the dams is expected to reduce the river's summer algae concentrations, which result in changes to both water clarity and coloration. Improvements in water quality, such as water clarity or fish viewing opportunities, could result in some improvement in scenic resources. These improvements would be more noticeable from on-river and riverside viewpoints, and much less noticeable from river canyon roadway and community viewpoints. These improvements to water quality would be beneficial.

Significance

No significant impact from short-term (temporary) changes in water quality including increased turbidity and reduced clarity

Beneficial due to long-term (permanent) changes in visual water quality from reduced algal blooms

Potential Impact 3.19-4 Visual changes resulting from reservoir drawdown and restoration including temporarily bare/unvegetated banks.

Substantial areas of bare sediment and rock would be exposed in previously inundated areas after reservoir drawdown and dam removal. Much of these areas would remain relatively bare, consisting mostly of grass and small forbs, during the summer and first wet season after dam removal, while larger vegetation becomes reestablished. Because much of the sediment would be eroded during reservoir drawdown, and because the river is bedrock-controlled, the river channel would not appear to be to significantly entrenched or flowing through mud, but rather, is expected to appear very similar to conditions before the river was impounded, though lacking in vegetation. Some slumping of the remaining sediment is anticipated, followed by drying, cracking, and hardening of the sediment prior to the establishment of vegetation. Existing wetland vegetation on the reservoir shorelines may also die off, though some of it would be relocated to repopulate the newly formed and exposed banks (Appendix B: *Definite Plan – Appendix H*).

As proposed in the Reservoir Area Management Plan (Appendix B: *Definite Plan – Appendix H*), manual revegetation would occur quickly following reservoir drawdown while the sediment deposits are still wet. In the short term, all exposed areas would be hydroseeded. Woody vegetation would also be planted in the year immediately following drawdown. Planting areas would be divided into zones (e.g., upland, riparian) that would have different species composition. Based on monitoring results, reseeding and replanting would occur again, as needed, for the following five years. Monitoring, revegetation, and invasive species control would occur annually until vegetation is reestablished and reservoir management goals are met (Appendix B: *Definite Plan – Appendix H*).

Until the restoration is complete, some areas of the reservoir footprint could appear barren and/or sparsely vegetated. Some tree-dominated wet areas that are currently near the reservoir edges may experience die-offs, although these areas account for less than 10 percent of the shoreline areas (see Potential Impact 3.5-22 and Figures 3.5-5 and 3.5-6). Revegetation of herbaceous species in barren and/or sparsely vegetated areas is anticipated to be achieved in the short term (from less than one to three years). However, it should be noted that this is not necessarily consistent with restoration of natural-appearing vegetation patterns below and above the reservoir line. Natural-appearing mature vegetation patterns with woody riparian vegetation may require 10 to over 50 years to develop. Although the condition is considered temporary, some adverse scenery impacts would be extensive and long-term, perhaps requiring 30 years for the river corridor habitats to fully recover from dam removal (PWA 2009). However, much of the aesthetics primary Area of Analysis is grassland, which would revegetate rapidly (from less than one to three years). Woody vegetation would begin to grow and add variability to the landscape within a few years, decreasing the contrast with undisturbed areas over time.

Based upon the proposed Reservoir Area Management Plan (Appendix B: *Definite Plan – Appendix H*), the aesthetics primary Area of Analysis would be in a visible state of transition for four to five years, followed by several more years where contrast from adjacent natural woodlands, where they exist, would be evident. The exposure of previously inundated areas could result in a short-term (temporary) change in the VRM class, from VRM Class III to VRM Class IV, for those key observation points associated with the Lower Klamath Project facilities and located within the reservoir viewshed (C1 to C7, FC5, IG1 to IG8; see Figure 3.19-2 and Table 3.19-3) because exposure of the reservoir footprint may dominate the view and be the major focus of viewer attention prior to vegetation reestablishment. This would be a significant and unavoidable impact. In areas where the VRM analysis was not conducted, the exposure of previously inundated areas would cause a substantial short-term (temporary) adverse effect on scenic vistas with views of the reservoir footprint, since the extent of the change to the existing landscape would dominate the overall public view and would be inconsistent with the existing open water reservoir views and the natural vegetation patterns above the reservoir shorelines. This also would be a significant and unavoidable impact.

It is expected that within five years, revegetation within the reservoir footprints would result in scenic views that are generally consistent with the surrounding scenery (e.g., grasslands with herbaceous plants and some woodlands, riparian areas) such that the VRM class at the key observation points associated with the Lower Klamath Project facilities and located within the reservoir viewshed (C1 to C7, FC5, IG1 to IG8; see Figure 3.19-2 and Table 3.19-3) would return to baseline conditions (i.e., Class III) and, in areas where the VRM analysis was not conducted, the extent of the visual change to the existing landscape due to exposure of the reservoir footprints would no longer be inconsistent with the surrounding scenery in a way that would dominate the overall public view. Although natural-appearing mature woodlands and woody riparian vegetation may require several decades to fully develop within the reservoir footprints, the visual variability in the landscape that would occur within a few years and would continue to decrease the contrast with undisturbed areas over time, means that in the long-term (permanent), aesthetic impacts under the Proposed Project due to reservoir drawdown and restoration of bare sediments and rock would be less than significant.

Significance

Significant and unavoidable in the short-term (temporary), until vegetation is re-established, due to reservoir drawdown

No significant impact in the long term (permanent) due to reservoir drawdown

Potential Impact 3.19-5 Long-term (permanent) visual changes resulting from the removal of Lower Klamath Project dam complexes, hatchery modifications, improvements to or construction of new roads, culverts, bridges, water supply infrastructure, and removal and replacement of recreational facilities.

Removal of Dam Complexes and Hatchery Modifications

Many of the facilities associated with the Lower Klamath Project dam complexes (e.g., dams, reservoirs, powerhouses, penstocks, hatcheries) do not blend with the natural landscape and can dominate views due to their form, line, color, size, or locations, particularly those that appear taller from a distance than other natural features, and all of the facilities except three (all associated with J.C. Boyle) are located in areas that have been designated as a Class III area or have been classified as a Class III area because the area has not been given a specific VRM class by BLM (PacifiCorp 2004). Figures 3.19-11 and 3.19-12 show photo-simulations of the post-removal views of Iron Gate Dam and Copco No. 1 Dam, respectively. While the dams themselves are visible from key observation points C3, C4, C5, IG9, IG10, IG11, and IG12 (Figure 3.19-2), they are generally not visible from any scenic highway and the topography of the area makes them generally not visible from most scenic vistas in the primary aesthetics Area of Analysis. Iron Gate Hatchery and Fall Creek Hatchery also are not visible from most scenic vistas, although they are visible from key observation points FC2, FC3, FC4, IG9, IG10, IG11, and IG12 (Table 3.19-3). Accordingly, dam-removal-area landscape disturbances, as well as modifications to the hatcheries, would not have the potential to cause a substantial long-term (permanent) adverse effect on a scenic vista.

Some portions of the Lower Klamath Project dam complexes are considered to be historic structures (FERC 2007), including the Copco No. 1 Powerhouse and Dam; Copco No. 2 Powerhouse; and, the Copco No. 2 wooden stave penstock (see also Table 4.3-1, Table 4.3-3, and Table 4.3-5). However, these particular structures are not visible from any scenic highways or river sections. Potential impacts to historic resources are discussed in more detail in Section 3.12.5 *[Historical Resources and Tribal Cultural Resources] Potential Impacts and Mitigation Measures* but, for purposes of potential impacts to aesthetics, removal of these structures would have no significant impact.

Removal of Copco No. 1 and No. 2 dams involves disposal of 104,000 yd^3 of concrete at a proposed 3.5-acre disposal area immediately adjacent to these dams, at the current location of a maintenance building and the vacant south residence (Figure 2.7-2, tile 1 of 4). The Copco No. 1 and No. 2 concrete disposal site would be visible from key observation points C3, C4, and C5 (Figure and Table). The disposal site would be graded as a hill (maximum fill height of about 55 feet) contoured to blend into the surrounding topography (see Section 2.7.1 *Dam and Powerhouse Deconstruction*). The potential short-term (temporary) impacts of concrete disposal, burial, and grading at this site are discussed in Potential Impact 3.19-6 which focuses on short-term (temporary) construction-related impacts. In the long term, there would not be a permanent visual impact of the concrete disposal site for Copco No. 1 and Copco No. 2 dams because this area is already visually degraded by the presence of the two dam complexes, and the disposal site would be naturally-contoured, covered with soil, and revegetated such that it would visually blend with the surrounding landscape. Therefore, there would not be a further degradation of the VRM classification.

Removal of Iron Gate Dam involves disposal of 1,087,000 yd^3 of earthen materials and 20,700 yd^3 of concrete at the proposed (approximately) 36-acre Iron Gate Dam disposal site, located on PacifiCorp property approximately 1 mile south of the dam (Figure 2.7-4). This disposal site is located on a plateau area above the Iron Gate Dam complex and is not generally visible from existing scenic vistas (i.e., key observation points I7, I9, I10, I11, I12), with the exception of a partially obstructed, distant (i.e., minimum of 1,800 feet away) view from key observation point IG7 (Figure 3.19-2). The disposed material would be placed to a maximum fill height of about 50 feet and graded to blend with the existing topography. Final grading of the disposal site would include relatively flat slopes (8H:1V to 5H:1V) to reduce the potential for erosion (see Section 2.7.1 *Dam and Powerhouse Deconstruction*). The potential short-term (temporary) impacts of concrete disposal, burial, and grading at this site are discussed in Potential Impact 3.19-6, which focuses on short-term (temporary) construction-related impacts. In the long term, there would not be a permanent visual impact of the Iron Gate Dam disposal site because once it is contoured, covered with soil, and revegetated, the form and color of the site would generally conform with adjacent landforms, vegetation, color, and scenery.

Improvements to Roads, Bridges, and Culverts and Water Supply Infrastructure
The Proposed Project includes replacement of the 24-inch diameter water supply pipeline for the City of Yreka, which crosses under the Klamath River near the upstream end of Iron Gate Reservoir. The three potential alignments proposed for the City of Yreka water supply pipeline would be visible from key observation point C6 (Table 3.19-3); however there already are a number of residential, commercial, and industrial developments in the vicinity of the City of Yreka water supply pipeline (see Section 2.7.7 *City of Yreka Water Supply Pipeline Relocation*). In addition, Daggett Road Bridge is located approximately 2,000 feet upstream of the current pipeline. Due to the other development nearby, a new pipeline would be visible as a new landscape feature but would not cause a substantial adverse effect on a scenic vista, or on key observation point C6, because the new pipeline alignment would represent relatively minor changes to the existing, rural, river canyon and mountainous landscape. It also would be

consistent with the existing scenery that includes occasional roads, moderately sized buildings and bridges, and unburied utilities. Therefore the aesthetic impact of these infrastructure improvements would be less than significant.

In addition, at least six bridges would need to be replaced due to structural deficiencies and/or in order to raise them above the new 100-year flood elevation. There are also culverts and roads that would need to be upgraded with new erosion and drainage control improvements (Appendix B: *Definite Plan*). However, these improvements would result in only minor visual changes to existing structures. New bridges would be built in the same general location as the ones being removed and would be sized and oriented similarly. Therefore, they would not degrade the existing visual character of the sites or their surroundings and the impact would be less than significant.

Removal and Replacement of Recreational Facilities
The Proposed Project also includes removal of eight recreational facilities on Copco No. 1 and Iron Gate reservoirs, and modification of three other recreational facilities. In addition, KRRC has developed a Draft Recreation Plan (Appendix B: *Definite Plan – Appendix Q*) that seeks to identify recreation opportunities, in coordination with stakeholders, that would offset the removal of reservoir recreation opportunities and the reduction in whitewater boating days associated with the Proposed Project. New river-based opportunities may include: (a) new routes and roads for river access; (b) two small to medium river recreation facilities that would accommodate 20 campsites, day use amenities, and access to the river for fishing and boating; and (c) a new trail between J.C. Boyle Dam and the Iron Gate Fish Hatchery (see also Section 2.7.8.3 *Recreation Facilities Management*). The areas in which recreation facilities that currently exist but are proposed to be removed (key observation points IG2, IG3, IG4, IG5, IG6, IG8; Table 3.19-3) would be restored through regrading and revegetation, which would minimize aesthetic impacts at these locations.

New roads, trails, and paths for river access could have potentially significant impacts to visual resources if not properly sited and constructed due to tree removal and construction of facilities. Similarly, river recreation facilities (i.e., campgrounds, picnic areas, river access areas with parking, and other day use areas), may distract from more natural views in the river canyon. Because these facilities have not yet been designed or sited, no site- or project-specific assessment is possible. New recreation facilities are anticipated to be modest in size and spread throughout the primary Area of Analysis. Therefore, they would have minimal potential to be inconsistent with the aesthetics significance criteria. In addition, the Final Recreation Plan would be developed by KRRC working with appropriate agencies through the FERC process, and KRRC also proposes that KRRC and the appropriate state and local agencies work together to develop recommended terms and conditions that should be adopted by FERC as conditions of approval for the Lower Klamath Project.

The KRRC's Recreation Plan and this EIR take a programmatic approach to developing recreational facilities and analyzing and mitigating any impacts attributable to these developments. New recreational facilities still are being evaluated by KRRC, including consideration of public input on the potential types and locations of these facilities. Although new recreation facilities are part of the Proposed Project, the final location, size, and design of the facilities are still under development and will be the subject of subsequent approvals. It is thus too soon to conduct a meaningful environmental analysis of the replacement facilities. However, construction and operation of new recreational facilities would undergo any environmental review necessary for the subsequent approvals, and any impacts of the construction and operation of the facilities would be mitigated, if feasible, to levels that comply with all applicable laws, regulations, and environmental standards. A Final Recreation Plan would be submitted to FERC, and this plan would include any new recreation facilities that are proposed by the KRRC. The Final Recreation Plan would be subject to environmental review under NEPA, and any necessary mitigation measures would be determined by FERC. If implementation of the Final Recreation Plan (at FERC's direction) required any further state or local approvals, then written checklists would be prepared pursuant to CEQA Guidelines sections 15162 and 15168(c) to ascertain whether further site-specific environmental review of individual reactional projects would be necessary. Such individual projects shall be subject to applicable best management practices and mitigation measures required by FERC, applicable mitigation measures in this EIR, such as Mitigation Measures WQ-1, TER-1, TER-2, TER-3, TER-5, TCR-1, TCR-2, TCR-3, and HZ-1, and any other measures required by an agency with jurisdiction over those individual recreation projects. The potential aesthetic impacts of these new recreational facilities would be reviewed at a project level in subsequent evaluations prior to their implementation.

Overall Long-Term Visual Impacts of the Proposed Project
Overall, removal of the Lower Klamath Project dam complexes, improvements to or construction of new roads, culverts, bridges, and water supply infrastructure, and removal of recreational facilities would not cause the VRM class to be degraded at a key observation point, would not adversely impact a scenic vista for those areas that were not assigned a VRM class, and there would be no significant long-term (permanent) impact of the Proposed Project.

Significance
No significant impact in the long term (permanent) due to removal of the Lower Klamath Project dam complexes and/or hatchery modifications

No significant impact in the long term (permanent) due to improvements to or construction of new roads, bridges, culverts, and water supply infrastructure

Figure 3.19-10. Iron Gate Dam Before Removal (top) and a Simulation of What the Facility Could Look Like After Dam Removal (bottom) Except for Landform/Vegetation Restoration Details Which Were Not Known at the Time of Simulation. Note that the residence shown in the foreground would also be removed under the Proposed Project Source: 2012 KHSA EIS/EIR.

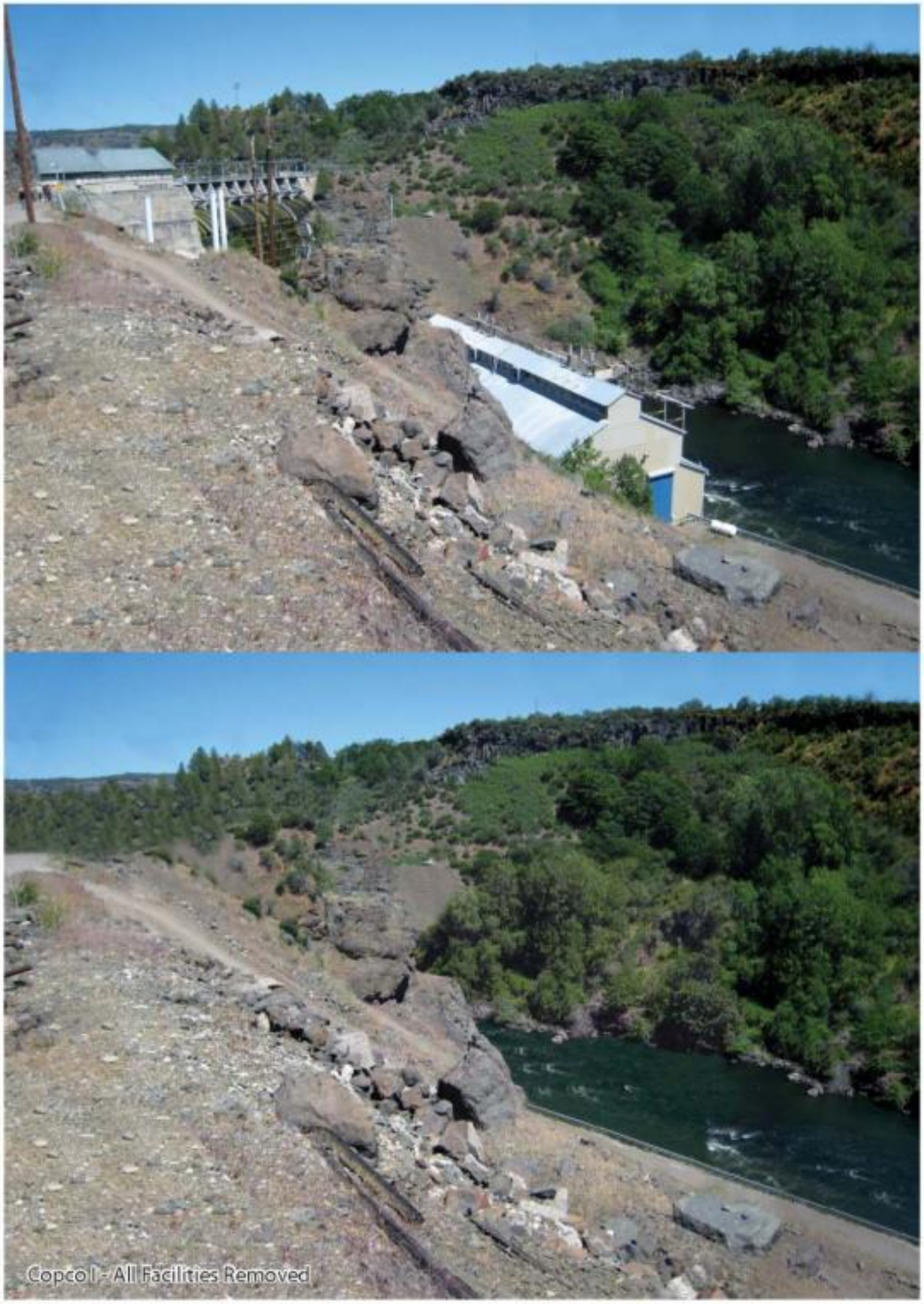


Figure 3.19-11. Copco No. 1 Dam Before Removal (top) and a Simulation of what the Facility Could Look Like After Full Removal (bottom) Except for Landform/Vegetation Restoration Details Were Not Known at the Time of Simulation. Source: 2012 KHSA EIS/EIR.

Potential Impact 3.19-6 Short-term (temporary) visual impacts of construction activities/equipment.

Removal of Dam Complexes and Hatchery Modifications

Removal of the Lower Klamath Project dam complexes (dams, reservoirs, powerhouses, penstocks) and hatchery modifications would be completed in stages over two years, with primary construction activities occurring between May and September of the second year (Table 2.7-1). During construction activities, large construction vehicles and equipment, temporary structures (e.g., trailers, portable toilets, security fencing, temporary power supply, fueling stations), temporary access roads, equipment storage areas, material stockpiles, piles of demolition materials (rock, concrete, steel), and other common construction items that would detract from the natural surroundings would be visible in the aesthetics primary Area of Analysis. Visual impacts of construction equipment and activities would vary depending on the vehicles, equipment, activities, and materials in any given area.

During construction activities, views from several key observation points in the primary Area of Analysis would be affected by dam complex deconstruction (C3, C4, C5, C6, IG9, IG10, IG11, IG12; ; Table 3.19-3) and hatchery modifications (FC2, FC3, FC4, IG9, IG10, IG11, and IG12; Table 3.19-3). Some scenic resources, such as trees, rocks, and vegetation in the immediate vicinity of the dams would need to be removed as part of the dam removal construction activities. The temporary staging of vehicles and construction equipment also would be visible from certain locations within the aesthetics primary Area of Analysis. Staging areas and most equipment would be located just downstream of Copco No. 1 Dam (Figure 2.7-2), at the upstream end of Iron Gate Reservoir (Figure 2.7-2), and just downstream of Iron Gate Dam (Figure 2.7-4), associated with key observation points C3, C4, C5, C6, potentially FC5, IG9, IG10, IG11, and IG12 (Table 3.19-3). The VRM class at these key observation points would not likely be degraded by these activities because the existing dams, powerhouses, and other non-natural facilities already are major features in the landscape. Thus, the short-term (temporary) aesthetic impacts of dam complex deconstruction, including temporary staging of vehicles and construction equipment, would be a less-than-significant impact. The same rationale applies for areas where no VRM analysis was conducted but which would have a view of the areas located just downstream of Copco No. 1 Dam, at the upstream end of Iron Gate Reservoir, and just downstream of Iron Gate Dam.

Removal of Copco No. 1 and No. 2 dams involves disposal of 104,000 yd^3 of concrete at the proposed 3.5-acre disposal area immediately adjacent to these dams, at the current location of a maintenance building and the vacant south residence (Figure 2.7-2, tile 1 of 4). The disposed materials would be placed to a maximum fill height of about 55 feet (see Section 2.7.1 *Dam and Powerhouse Deconstruction*). During construction activities, the Copco No. 1 and No. 2 concrete disposal site would be visible as a large pile of debris from key observation points C3, C4, and C5 (Figure and Table).

Removal of Iron Gate Dam involves disposal of 1,087,000 yd^3 of earthen materials and 20,700 yd^3 of concrete at the proposed (approximately) 36-acre Iron Gate Dam disposal site, located on PacifiCorp property approximately 1 mile south of the dam (Figure 2.7-4). This disposal site is located on a plateau area above the Iron Gate Dam complex and is not generally visible from existing scenic vistas (i.e., key observation points I7, I9, I10, I11, I12), with the exception of a partially obstructed, distant (i.e., minimum of 1,800 feet away) view from key observation point IG7 (Figure 3.19-2). The disposed material would be placed to a maximum fill height of about 50 feet (see Section 2.7.1 *Dam and Powerhouse Deconstruction*).

In the short-term (i.e., during construction and before revegetation occurs), the concrete disposal sites would be visible as constructed features incongruous with a natural landscape. However, at the Copco 1 No. 1 and Copco No. 2 dams' concrete disposal site, the concrete pile, while not aesthetically pleasing, would not be visually incongruent because of the existing substantially disturbed character of that area. As described above, the Iron Gate Dam disposal site would not be visible from any of the identified existing scenic vistas, therefore, even though the concrete disposal would be incongruous with the existing landscape prior to revegetation, it would not create a significant impact.

Dust emissions from deconstruction activities associated with removal of the dam complexes and onsite disposal of concrete and earth may also temporarily impact views of the river. The majority of fugitive dust generally settles out of the atmosphere within 300 feet of the source, with larger particles traveling less distance and smaller particles traveling a longer distance (USEPA 1995). Because the recreational facilities that would be impacted by construction and demolition activities would be closed during the construction period, the VRM class at the key observation points is already impacted by the presence of dams, powerhouses, and other non-natural facilities that represent change from the characteristic landscape, and most dust settles quickly, aesthetic impacts from temporary fugitive dust would not be experienced by a substantial number of people and thus would be less than significant.

Improvements to Roads, Bridges, and Culverts and Water Supply Infrastructure
At least six bridges would need to be replaced under the Proposed Project due to structural deficiencies and/or in order to raise them above the new 100-year flood elevation. Culverts and roads also would need to be upgraded with new erosion and drainage control improvements (Appendix B: *Definite Plan*). The construction activities associated with the bridge replacement, drainage, and roadway improvements (e.g., pavement rehabilitation, culvert replacements) could be visible from several key observation points in the aesthetics primary Area of Analysis (Table 3.19-3).

The Proposed Project also includes replacement of the 24-inch diameter water supply pipeline for the City of Yreka, which crosses under the Klamath River near the upstream end of Iron Gate Reservoir. Construction activities associated with the proposed City of Yreka water supply pipeline realignment would be visible from key observation point C6 (Table 3.19-3); however, views from this observation point already include a number of residential, commercial, and industrial developments in the vicinity of the City of Yreka water supply pipeline (see Section 2.7.7 *City of Yreka Water Supply Pipeline Relocation*).

Construction activities and equipment associated with these portions of the Proposed Project would be relatively small-scale and short term (temporary), consistent with normal road and infrastructure maintenance activities and small construction projects. Construction activities and equipment would be visible during construction but this would be a temporary condition and the VRM class would not be degraded relative to existing conditions since the bridges, roads, culverts, and the City of Yreka water supply pipeline realignment already represent moderate change from the characteristic landscape. Further, because these construction activities would occur over a period of less than a year and during that time most nearby recreational facilities would be closed, the activities would not be visible to a substantial number of people. The proposed construction activities associated with improvements to or construction of new bridges, roads, and culverts, and realignment of the City of Yreka water supply pipeline, would result in less-than-significant visual impacts under the Proposed Project.

Removal and Replacement of Recreational Facilities

The Proposed Project also involves removal of eight recreational facilities on Copco No. 1 and Iron Gate Reservoirs, which would affect views at several key observation points (IG2, IG3, IG4, IG5, IG6, IG8; Table 3.19-3), and potential recreation site enhancements at several key observation points (FC1, IG1; Table 3.19-3). In addition, KRRC has developed a Draft Recreation Plan (Appendix B: *Definite Plan – Appendix Q*) that may result in construction of new recreation facilities. Construction activities associated with the removal and replacement of recreational facilities would be relatively small-scale and short term (temporary). Construction activities and equipment would be visible during construction but this would be a temporary condition and the VRM class would not be degraded relative to existing conditions since the recreation site facilities already represent moderate change from the characteristic landscape. Further, because the construction activities would occur over a period of less than a year and during that time most nearby recreational facilities would be closed, the activities would not be visible to a substantial number of people. The proposed construction activities associated removal and replacement of recreation facilities would result in less-than-significant visual impacts under the Proposed Project.

Significance

No significant impact in the short term (temporary) due to removal of the Lower Klamath Project dam complexes and/or hatchery modifications

No significant impact in the short term (temporary) due to improvements to or construction of new roads, bridges, and culverts and water supply infrastructure

No significant impact in the short term (temporary) due to removal of recreational facilities

Potential Impact 3.19-7 The Project's construction or security lighting could result in new sources of substantial light or glare that would adversely affect nighttime views in the area.

Temporary lighting would be erected for nighttime construction activities during dam demolition, and security lighting might be required during deconstruction. During peak construction periods (April through November of dam removal year 2, Table 2.7-8), nighttime construction activities could occur regularly. Temporary lighting could cause glare that would adversely affect nighttime views in the area, particularly for overnight visitors and residents near the Copco No. 1 Reservoir. Because the area is rural with very little existing night lighting, and because construction lighting would be relatively intense, the impact on nighttime views would be a significant impact that would occur temporarily, until dam deconstruction was complete. No new permanent sources of light or glare would result from the Proposed Project.

The Proposed Project currently does not include measures that would reduce impacts to nighttime views cause by temporary construction lighting. KRRC proposes that KRRC and the appropriate state or local agency would work together to develop recommended terms and conditions that should be adopted by FERC as conditions of approval for the Lower Klamath Project. This is consistent with FERC's preference for licensees to be 'good citizens' of the communities in which projects are located and thus to comply, where possible, with state and local requirements. It would be appropriate for any such terms to include measures to reduce nighttime light and glare on surrounding residences during construction. However, overseeing development and implementation of measures to reduce impacts to nighttime views does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has stated its intention to reach enforceable good citizen agreements that will be finalized and implemented, at this time these agreements are not finalized and the State Water Board cannot require their implementation. Accordingly, while the State Water Board anticipates that implementation of the final FERC terms and conditions for the Proposed Project would reduce potential impacts to nighttime views to less than significant, because the State Water Board cannot ensure implementation of any associated measures, it is analyzing the impact in this EIR as significant and unavoidable.

Significance
Significant and unavoidable

3.19.6 References

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3.20 Recreation

This section describes the environmental setting for recreational resources, as well as potential environmental impacts and associated mitigation measures under the Proposed Project. Water quality, aquatic resources, and phytoplankton and periphyton[100] are discussed in this section only in terms of their relationship to recreation opportunities. For a detailed discussion of these resources, see Section 3.2 *Water Quality*, Section 3.3 *Aquatic Resources*, and Section 3.4 *Phytoplankton and Periphyton* of this EIR. Potential impacts to wild and scenic river segments are discussed in this section, as well as in Section 3.14 *Land Use and Planning*.

As part of the NOP scoping process, the State Water Board received several comments regarding potential recreation impacts due to Lower Klamath Project dam removal. Several commenters noted that reservoir recreational activities, including fishing, would be reduced due to dam removal, particularly at Copco No. 1 Reservoir. Many other comments anticipated an increase in river-related fishing and recreation following dam removal. Several commenters noted that Iron Gate Fish Hatchery is important for enhancing recreational fishing opportunities. Finally, one commenter questioned the future disposition of

[100] *Phytoplankton* are defined as aquatic microscopic organisms, including algae, bacteria, protists, and other single-celled plants, that obtain energy through photosynthesis and float in the water column of still or slowly flowing waters like lakes or reservoirs. *Periphyton* are defined as aquatic organisms including algae and bacteria that live attached to underwater surfaces such as rocks on a riverbed. See Section 3.4 *Phytoplankton and Periphyton* for additional definitions related to algae.

PacifiCorp properties within and adjacent to the former Lower Klamath Project reservoirs. Additional summary of the recreation comments received during the NOP public scoping process, as well as the individual comments themselves, are presented in Volume II Appendix A. Issues raised by the comments have been considered in the discussion below.

After circulation of the Draft EIR, numerous additional comments were received regarding recreation (see Volume III), and changes to the section in response to those comments are flagged in the comment responses and then printed in this Final EIR section. None of the changes result in significant new information in the EIR under the meaning of CEQA Guidelines, section 15088.5, subdivision (a):

> New information added to an EIR is not 'significant' unless the EIR is changed in a way that deprives the public of a meaningful opportunity to comment upon a substantial adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect (including a feasible project alternative) that the project's proponents have declined to implement.

However, the changes were numerous enough that reprinting the section rather than simply including a list of revisions was warranted to improve clarity and readability of the document.

3.20.1 Area of Analysis

The Area of Analysis for recreation includes recreation areas and associated access along the Klamath River corridor from the California-Oregon border to the Klamath Estuary. Outside of the Area of Analysis for recreation, areas within and directly adjacent to the Klamath Basin, including those in Oregon, are also described to provide an overview of regional recreation opportunities and to provide a larger context for the recreational facilities that would be impacted under the Proposed Project. River reach designations are presented in Figures 2.2-2 and 2.2-3.

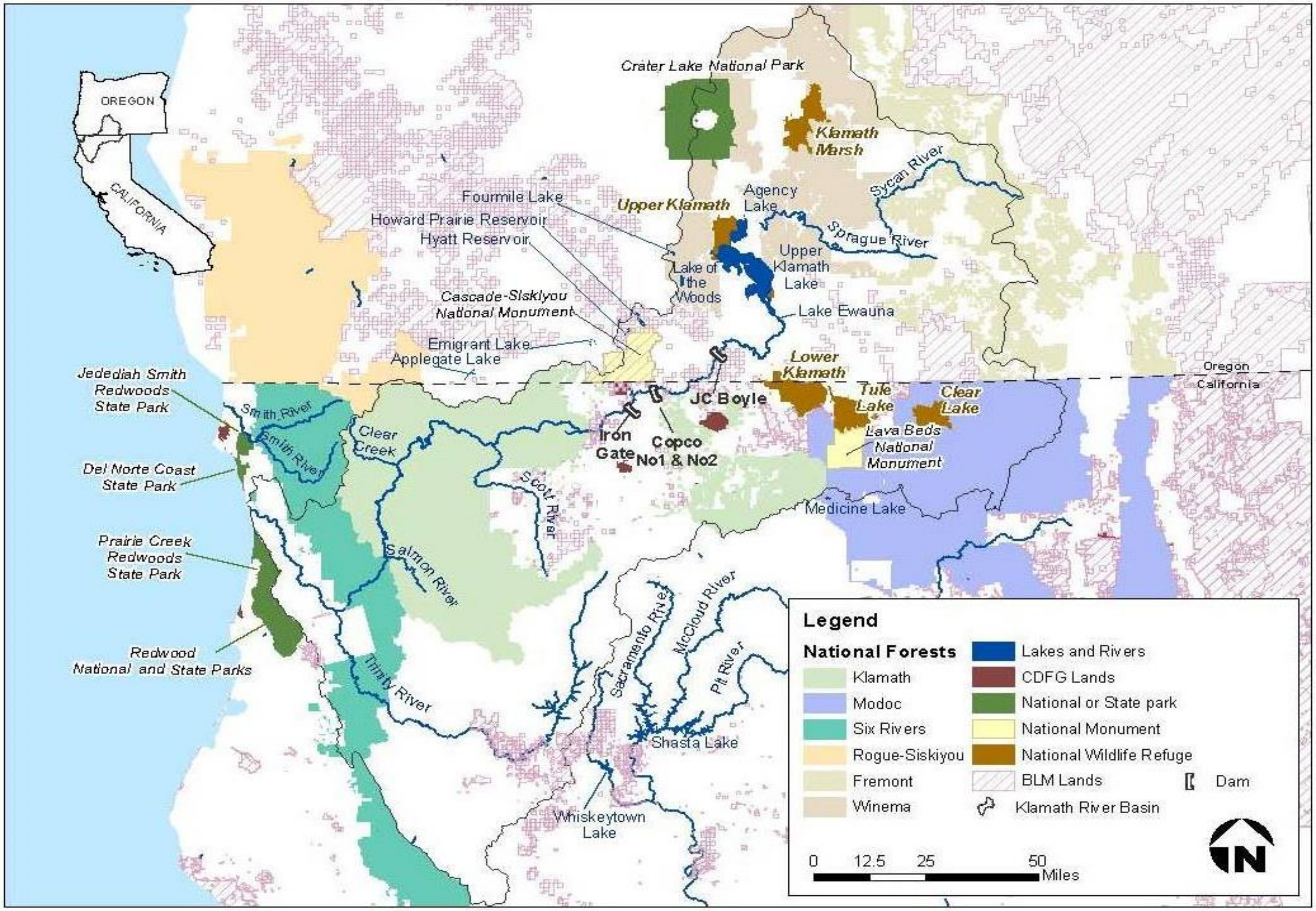

Figure 3.20-1. Area of Analysis for Klamath River Corridor and Regional Recreation Opportunities.

3.20.2 Environmental Setting

3.20.2.1 Regional Recreation

The recreational setting within the Klamath Basin is characterized by an expansive rural landscape that offers a myriad of outdoor recreational opportunities. Rivers, streams, and lakes are common throughout the mountainous landscape of the Klamath Basin, and grasslands exist in the high plateau areas of the region. Within the Klamath Basin, there are four national forests (Klamath, Fremont-Winema, Six Rivers, and Modoc), one joint national and state park (Redwood), one national park (Crater Lake), two national monuments (Lava Beds and Cascade - Siskiyou), and five National Wildlife Refuges (NWRs) (Klamath Marsh, Tule Lake, Clear Lake, Upper Klamath, and Lower Klamath), where the latter make up the Klamath Basin NWR System (Figure 3.20-1). These areas provide sightseeing, camping, hiking, fishing, boating, hunting, wildlife viewing, snow sports, off-highway vehicle uses, and other recreational opportunities. There are 297 miles of wild and scenic (under Section 2(a) (ii) of the Wild and Scenic Rivers Act [WSRA]) rivers in the Klamath Basin, which include segments of the Klamath, Scott, and Salmon rivers and Wooley Creek. There are also extensive public and private recreational opportunities along the Klamath River and within its reservoirs. Federal and state agencies, including the USDA Forest Service, BLM (including the Northern California District, and the Lakeview and Medford districts in Oregon), USFWS, the National Park Service (NPS), and CDFW, are responsible for managing associated lands located in Klamath and Jackson counties in Oregon, and Siskiyou County in California. Table 3.20-1 provides a summary of the opportunities offered on public lands within and adjacent to the Klamath Basin.

Table 3.20-1. Public Lands Offering Recreational Opportunities in the Area of Analysis for Recreation.

Name	**Size**	**No. of Campgrounds**	**Recreational Activities Available**											
			Sightseeing	**Hiking**	**Picnic Areas**	**Fishing**	**Boating**	**OHV**	**Wildlife Viewing**	**Rock Climbing**	**Mountain Biking**	**Snow Play**	**Other**	
Klamath National Forest	1.7 million acres	34	X	X	X	X	X	X	X	X	X	X	X	hunting, equestrian use, spelunking,
Fremont-Winema National Forest	2.3 million acres	40	X	X	X	X	X	X	X	X		X	X	hunting, equestrian use, backpacking, snowmobiling, leisure driving
Six Rivers National Forest	1 million acres	17	X	X	X	X	X	X	X			X	X	hunting, backpacking
Lava Beds National Monument	46,500 acres	1	X	X	X				X				X	spelunking
Crater Lake National Park	183,000 acres	2	X	X	X	X				X		X	X	swimming, snowshoeing, snow camping

Name	**Size**	**No. of Campgrounds**	**Recreational Activities Available**											
			Sightseeing	**Hiking**	**Picnic Areas**	**Fishing**	**Boating**	**OHV**	**Wildlife Viewing**	**Rock Climbing**	**Mountain Biking**	**Snow Play**	**Other**	
Klamath Marsh NWR	40,600 acres	0	X			X	X		X				X	waterfowl hunting, photography
Lower Klamath NWR	50,100 acres	0	X						X				X	waterfowl and pheasant hunting, photography, automobile touring
Upper Klamath NWR	23,100 acres	0	X		X	X	X		X				X	waterfowl hunting, photography
Redwood National and State Parks	132,000 (71,700 federal, 60,300 state) acres	4	X	X	X	X	X		X		X	X	X	Backpacking, tidepooling, bicycling, equestrian trails, scenic drives

Name	**Size**	**No. of Campgrounds**	**Recreational Activities Available**											
			Sightseeing	**Hiking**	**Picnic Areas**	**Fishing**	**Boating**	**OHV**	**Wildlife Viewing**	**Rock Climbing**	**Mountain Biking**	**Snow Play**	**Other**	
BLM - Cascade-Siskiyou National Monument	170,400 total, (113,000 BLM) acres	4	X	X		X	X	X	X		X	X	X	snowmobiling, equestrian use, hunting
BLM - Klamath Falls Resource Area	215,000 acres	8	X	X	X	X	X	X	X			X	X	Hang-gliding, rafting, swimming, snowmobiling

Sources: BLM 1995, 2018; NPS 2018a,b,c; USBR 2012b; USDA Forest Service 2018a,b,c; USFWS 2018a,b.
Key:
- OHV: off-highway vehicle
- NWR: National Wildlife Refuge
- BLM: Bureau of Land Management

River-based Regional Recreation

A number of rivers cross the region, including four rivers designated as wild and scenic under the WSRA (Sprague, Sycan, Smith, and Trinity rivers). Portions of the Klamath River and its tributaries (further described below in Section 3.20.2.4 *Wild and Scenic River Conditions*), are designated as wild and scenic or have been deemed suitable and eligible for listing. Designated tributaries of the Klamath River include the Salmon River, Scott River, and Wooley Creek. These rivers provide a variety of recreational opportunities, including sightseeing, fishing, and whitewater boating. Figure 3.20-1 shows the location of these rivers relative to the Klamath River. Table 3.20-2 provides a summary of the rivers, the fish species caught, and the typical types of fishing methods (e.g., boat, bank, fly). Table 3.20-3 summarizes the whitewater boating opportunities in the region. These three tables show that there are a number of recreational opportunities outside of the Proposed Project area but within the region. The Oregon Wild and Scenic Rivers, in particular, have outstanding recreational and/or scenic values along the length of the designated segments. The California Wild and Scenic Rivers are classified as wild, scenic, and recreational along the length of the designated segments (National Wild and Scenic Rivers 2017).

Table 3.20-2. Rivers Providing Recreational Fishing Opportunities in the Region.

River	Fish Species Caught[1]	Common Types of Fishing
McCloud River	Native trout	Fly fishing, bank fishing
Pit River	Native trout; brown trout; smallmouth bass; rough fish	Fly fishing, bank fishing
Rogue River	Chinook salmon, steelhead	Drift boat, powerboat, fly fishing
Salmon River	Chinook salmon, steelhead, resident trout	Fly fishing, bank fishing
Scott River	Chinook salmon, steelhead, resident trout	Fly fishing, bank fishing
Smith River	Chinook salmon, steelhead	Drift boat, powerboat, fly fishing, bank fishing
Trinity River	Chinook salmon, steelhead, sturgeon, American shad, lamprey	Drift boat, powerboat, fly fishing, bank fishing
Upper Sacramento	Chinook salmon, native and stocked trout, American shad	Fly fishing, bank fishing
Klamath River	Redband trout, salmon	Fly fishing, bank fishing, drift boat

Sources: FERC 2007; Wild Waters Fly Fishing 2019a,b,c,d,e

[1] Wild Water Fly Fishing (2019a–e) for information on the McCloud River, Rogue River, Trinity River, Upper Sacramento River, and Klamath River.

Table 3.20-3. Rivers with Whitewater Boating Opportunities in the Region.

River	Generalized Use Levels	Boating Class Type[1]	Miles of Boatable Whitewater	Factors Affecting Use Levels
Clear Creek	Low	III–V	7	Difficult access
Klamath River (upstream of Oregon-California state line)	Moderate	III–IV+	31	Remote, not suited for beginner or intermediate boaters, unless accompanied by a commercial outfitter
Klamath River (downstream from Iron Gate Dam)	Moderate	II–V	122	Most skill levels, easy access, 186 miles support multi-day floats, shoreline camping, scenery, many outfitters, commercial use
North Umpqua River	Moderate	II–IV	32	Easy access, most skill levels, scenery, boatable year-round, shoreline suitable for camping
McCloud River	Moderate	II–IV	35	Proximity to I-5, most skill levels, low flows in summer
Pit River	Low	IV–V	34	Fragmented/short runs with long stretches of flat water between, remote location
Rogue River	High	II–V	100+	Easy access, most skill levels, scenery, boatable year-round, shoreline suitable for camping, many commercial outfitters
Salmon River	Moderate	II–V	44	Requires advanced/expert boating skills, commercial use
Scott River	Low	III–V	20	Recommended for expert boaters only
Smith River	Low	II–V	100+	Requires advanced/expert boating skills, low summer flows
Upper Sacramento River	Low	III–V	36	Proximity to I-5, average solitude
Trinity River	Moderate	II–V	100+	Most skill levels, easy access, commercial use

Sources: FERC 2007; H. Anderson, U.S. Bureau of Land Management, pers. comm., August 2019 for generalized use level in the Klamath River upstream of the Oregon-California state line.

[1] As rated by the American Whitewater International Scale of Difficulty (American Whitewater 2017).

Reservoir- and Lake-based Regional Recreation

Numerous opportunities for reservoir and lake-based recreation are available in the vicinity of the Proposed Project. Table 3.20-4 provides a summary of some of the comparable lakes and reservoirs in the region, including facilities and use levels. Within Klamath County and Jackson County in Oregon and Siskiyou County in California, there are more than 85 boatable lakes, containing approximately 40 boat ramps (Boat Escape 2017). The region also has more than 180 high-elevation and wilderness lakes in Siskiyou County (FERC 2007). In addition to boat ramps, these lakes provide nearly 2,300 developed campsites within a two-hour drive from the Lower Klamath Project reservoirs. Some reservoirs in the region are also stocked with trout or warm water fish such as perch or bass. Angling occurs at the many lakes and reservoirs in the region and many are known for having excellent fisheries.

Table 3.20-4. Comparison of Lower Klamath Project Reservoirs with Lakes and Reservoirs in the Region.

Lake or Reservoir	Distance from Nearest Subject Reservoir (road miles)	Surface Water (acres)[1]	Number of Developed Campsites	Number of Developed/ Improved Boat Launches	Number of Developed Picnic Areas	Generalized Use Levels[2, 3, 4]
Lower Klamath Project Reservoirs[5]						
J.C. Boyle	N/A	350	13	3	4	Moderate
Copco No. 1	N/A	972	0	2	2	Low
Copco No. 2	N/A	5.2	0	0	0	Low
Iron Gate	N/A	972	75	5	2	Moderate to Low
Other Lakes and Reservoirs in the Region[4, 6]						
Hyatt Reservoir	15	1,250	172	2	1	Moderate
Emigrant Lake	16	806	110	2	2	Moderate
Howard Prairie Reservoir	17	2,000	303	4	1	Moderate
Upper Klamath Lake	20	85,120	269	6	1	Moderate
Lake of the Woods	21	1,113	190	3	1	High
Fourmile Lake	26	740	25	1	0	Low
Agency Lake	28	5,500	43	3	0	Low
Applegate Reservoir	36	988	66	3	1	Low
Medicine Lake	46	408	77	1	3	Low-Heavy[7]
Gerber Reservoir	62	3,830	50	2	1	Moderate
Trinity Lake Unit	73	16,535	500	7	2	Moderate
Whiskeytown Lake	87	3,200	139	3	1	Moderate
Shasta Lake	87	29,500	320	7	7	High
Lost Creek Lake	78	3,430	202	1	2	N/A
Willow Lake	31	927	66	7	8	N/A
Willow Valley Reservoir	69	200	1	1	1	N/A

Lake or Reservoir	Distance from Nearest Subject Reservoir (road miles)	Surface Water (acres)[1]	Number of Developed Campsites	Number of Developed/ Improved Boat Launches	Number of Developed Picnic Areas	Generalized Use Levels[2, 3, 4]
Lake Siskiyou	46	160	1			N/A
Juanita Reservoir	14	55	23	2		N/A
McCloud Reservoir	58	520	6	1	1	N/A

Source: PacifiCorp 2004; Appendix B: *Definite* Plan, PacifiCorp 2015; Jackson County Parks 2017; USDA Forest Service 2017; H. Anderson, U.S. Bureau of Land Management, pers. comm., August 2019; T. Crist, Klamath County, Oregon, pers. comm., August 2019.
mi: miles
N/A: not available

1 The surface water area varies between reports. Dimensions used here are consistent with those presented in Appendix B: *Definite Plan*.

2 Generalized use is defined as the broad recreational use of an area with respect to the area's ability to support that use.

3 SHN Engineers and Geologists communications with H. Anderson are associated with Generalized Use for Other Lakes and Reservoirs (i.e., not with the Lower Klamath Project Reservoirs).

4 Jackson County Parks (2017) and USDA Forest Service (2017) provide information on developed facilities for Other Lakes and Reservoirs (i.e., not the Lower Klamath Project Reservoirs).

5 PacifiCorp (2015) provides information on developed facilities and generalized use for the Lower Klamath Project Reservoirs.

6 Stillwater Sciences communications with T. Crist, Klamath County, Oregon are associated with information on generalized use and developed facilities for Agency Lake and Medicine Lake.

7 General use levels vary widely depending on the time of year:

- Low use generally occurs between late October/early November through June. If not defined by the source then the assumption is that low use is less than 25 percent of capacity.
- Moderate use generally occurs early September through mid-October. If not defined by the source then the assumption is that moderate use is between 26 and 75 percent of capacity.
- High use generally occurs from early July through early September. If not defined by the source then the assumption is that high use is greater than 75 percent of capacity.

A small number of developed recreation facilities exist in the Upper Klamath Basin. The following paragraphs provide brief descriptions of each facility and the recreational opportunities available, to provide further context for the regional recreational setting.

Agency Lake is connected to the northern arm of Upper Klamath Lake. Although Agency Lake has no marina, there are two public boat launches and it has a fishery that features trophy redband trout. Other popular recreational activities at the lake are sightseeing, including wildlife viewing of waterfowl (and waterfowl hunting), otter, mink, deer, and bald eagles (Southern Oregon Directory and Guide 2017). The BLM's Wood River Wetland Management Area is on Agency Lake. As shown in Table 3.20-4, a number of campgrounds surround the lake.

Upper Klamath Lake is the largest freshwater body of water in Oregon. In the northern portion of the lake, Pelican Bay is known for its population of redband trout and is an extremely popular destination for fly-fishing. The bay is also a popular location for canoeing and kayaking, as well as sightseeing and wildlife viewing. Other popular activities in Upper Klamath Lake include sailing and waterfowl hunting. As shown in Table 3.20-4, there are numerous campgrounds and boat launches surrounding the lake.

The Link River segment of the Klamath River, an approximately 1-mile stretch downstream from Link River Dam (Figure 2.4-3), has only one developed recreational facility, the Link River Nature Trail. This 1.4-mile trail is for pedestrian use only and follows a gated access road on the west side of the Link River Bypass Reach. The Link River Nature Trail is popular for sightseeing, hiking, walking, jogging, trout fishing, and bird watching (FERC 2007; PacifiCorp 2019a).

The Keno Impoundment/Lake Ewauna (Figure 2.4-3) provides various recreational opportunities, including fishing, picnicking, boating, camping, sightseeing, and wildlife viewing. In the fall, waterfowl hunting is a popular activity at Keno Impoundment/Lake Ewauna. Although most of the land adjacent to the reservoir is privately owned, Lake Ewauna has several public access areas, including the City of Klamath Falls Veterans' Memorial Park/Boat Launch, Miller Island Boat Launch, the Klamath Wildlife Viewing Area, and the Keno Recreation Area and Campground (PacifiCorp 2004, 2015). Table 3.20-5 provides a summary of the facilities and estimated annual visitation and capacity as assessed by PacifiCorp as part of relicensing studies for the Klamath Hydroelectric Project (PacifiCorp 2004). Note that PacifiCorp (2004) represents the most recent survey data characterizing annual visitation and capacity for most recreational facilities in the Area of Analysis of recreation (exceptions noted, as appropriate).

Table 3.20-5. Keno Impoundment/Lake Ewauna Developed Recreation Facilities.

Site Name	Facilities	2001/2002 Est. Annual Use (User Days[1,2])	Est. Facility Use vs. Capacity
Klamath Falls Veterans' Memorial Park/Boat Launch (OR)	Boat launch, day-use area	42,500	Exceeding capacity
Miller Island Boat Launch and Klamath Wildlife Viewing Area (OR)	Boat launch, wildlife viewing trail, and a portable toilet	7,300	Approaching capacity
Keno Recreation Area and Campground (OR)	Campsites (26), day-use area, restrooms, boat launch and boarding dock	7,200	Below capacity[3]

Source: PacifiCorp 2004, FERC 2007, PacifiCorp 2015

Notes:

[1] User days are defined as one visitor to a recreation area for any reason in a 24-hour period.

[2] Data for PacifiCorp Klamath Hydroelectric Project Facility use was collected by PacifiCorp in 2001 and 2002. No more recently collected data exists or is available.

[3] PacifiCorp (2015) reports data for the Keno Recreation Area and Campground only and generally estimates capacity utilization as follows:

- Boat launch areas at 30 percent
- Picnic areas at 17 percent
- Campsites at 17 percent

The Klamath Falls Veterans' Memorial Park provides a boathouse and boat launch ramp on the northern shoreline of Keno Impoundment/Lake Ewauna and is managed by the City of Klamath Falls, Department of Parks and Recreation. Along the northwestern end of the lake, the Klamath Wingwatchers Lake Ewauna Nature Trail provides opportunities for bird watching and hiking. This 1.8-mile trail connects Veterans' Memorial Park to the Link River trail, along the Link River to the north. Another trail is currently under construction on the northeastern side of the lake (Klamath Birding Trails 2017).

The Miller Island Boat Launch is on the east shore of Keno Impoundment/Lake Ewauna, approximately six miles south of Klamath Falls, and is managed by the Oregon Department of Fish and Wildlife. The facility is accessed by Miller Island Road, which runs three miles through the Klamath Wildlife Area and Miller Unit, and provides an entrance station area, parking area, wildlife viewing trail, and a portable toilet. The Keno Recreation Area and Campground on the southwestern shore of the Keno Impoundment/Lake Ewauna provides a campground, day-use area, and boat launch. The campground has 26 developed campsites, restrooms, and a recreational vehicle (RV) dump station. Recreational opportunities in this area include camping, fishing, picnicking, sightseeing, and boating. The Keno Recreation Area consists of upper and lower use areas, with the upper area adjacent to the campground and the lower area adjacent to the boat launch (FERC 2007).

3.20.2.2 Klamath River-based Recreation

Upper Klamath River and the Hydroelectric Reach

Klamath river-based recreational facilities are only considered upstream to Keno Dam (i.e., inclusive of the Upper Klamath River). Upstream of Keno Dam, due to the flat topography, the influence/slackwater of Keno Reservoir extends almost to Upper Klamath Lake (FERC 2007).

Whitewater Boating Opportunities

In Oregon, the Upper Klamath River provides approximately five miles of river suitable for Class III whitewater boating, including a flatwater paddle upstream of J.C. Boyle Reservoir, however, not much boating use is reported for this reach. The reach is rated Class III difficulty and flows acceptable for whitewater boating opportunities range from 1,000 to 4,000 cfs (FERC 2007). The J.C. Boyle Bypass Reach includes about five miles of the Klamath River downstream from J.C. Boyle Dam and upstream of the J.C. Boyle Powerhouse. This reach provides Class III to IV+ rapids, and acceptable whitewater boating flows range from 1,300 cfs to 1,800 cfs; however, this reach is typically dewatered with only 100 to 300 cfs base flow due to J.C. Boyle bypass operations under existing conditions (FERC 2007). Therefore, the majority of the year there is almost no boating use on this stretch of the river.

The Spring Island boater access is adjacent to (downstream from) the J.C. Boyle Powerhouse and is managed by BLM. This site provides car-top whitewater boat launching and shoreline fishing access. The Klamath River Campground, managed by BLM, is about three miles downstream from the J.C. Boyle Powerhouse. The campground has three developed campsites and the shoreline which can be used for fishing and boater access.

Table 3.20-6 provides a summary of acceptable flow ranges for whitewater boating and other flow-dependent recreational activities in the Klamath River (from the Upper Klamath River to the ocean).

Table 3.20-6. Acceptable Flow Ranges for Various River-Based Activities for Reaches of the Klamath River.

River Reach (Length of Reach)	Activity	Low Value (cfs)[1]	High Value (cfs)[1]
Upper Klamath River (5.0 miles)	Whitewater Boating – Standard	1,000	4,000
	Play Boating	1,100	1,800
	Fishing	200	1,500
J.C. Boyle Bypass Reach (4.3 miles)	Whitewater Boating – Standard	1,300	1,800
	Fishing	200	1,000
Hell's Corner Reach (16.4 miles)	Whitewater Boating/Kayaking[2]	1,000	3,500
	Whitewater Boating/Commercial Rafting[2]	1,300	3,500
	Fishing[3]	200	1,500
Copco No. 2 Bypass Reach (1.3 miles)	Whitewater Boating	600	1,500
	Fishing	50	600
Iron Gate to Scott River (47 miles)	Whitewater Boating/Fishing	800	4,000
Scott River to Salmon River (76 miles)	Boating	800	7,000
	Fishing	800	4,000

River Reach (Length of Reach)	Activity	Low Value (cfs)[1]	High Value (cfs)[1]
Salmon River to Trinity River (23.1 miles)	Whitewater Boating/Fishing	800	10,000
Trinity River to Ocean (43.4 miles)	Whitewater Boating/Fishing	1,800	18,000

Source: Appendix R of USBR 2012b.
Notes:
1. Values were determined by the Secretarial Determination Recreation Sub-team (2010) from relicensing documents (PacifiCorp 2004, FERC 2007) and consultation with USDA Forest Service and BLM representatives.
2. Flows are within the desirable range during the daily peak hydroelectric operations period (between 10:00 AM and 2:00 PM).
3. Flows are within the desirable range for at least 4 hours during the daily non-peak hydroelectric operations period (either between 5:00 AM and 11:00 AM or between 3:00 PM and 9:00 PM).

Key:
cfs: cubic feet per second

Within California, whitewater boating opportunities are provided on the Hell’s Corner Reach of the Klamath River Hydroelectric Reach, and the Copco No. 2 Bypass Reach. The Hell’s Corner Reach from J.C. Boyle Reservoir to Copco No. 1 Reservoir extends about 16.4 river miles. Several public fishing and boat access areas exist along this reach, as summarized in Table 3.20-7. A 2002 recreation survey indicated that whitewater boating is the most common activity among respondents between J.C. Boyle Dam and Copco No. 1 Reservoir (PacifiCorp 2004).

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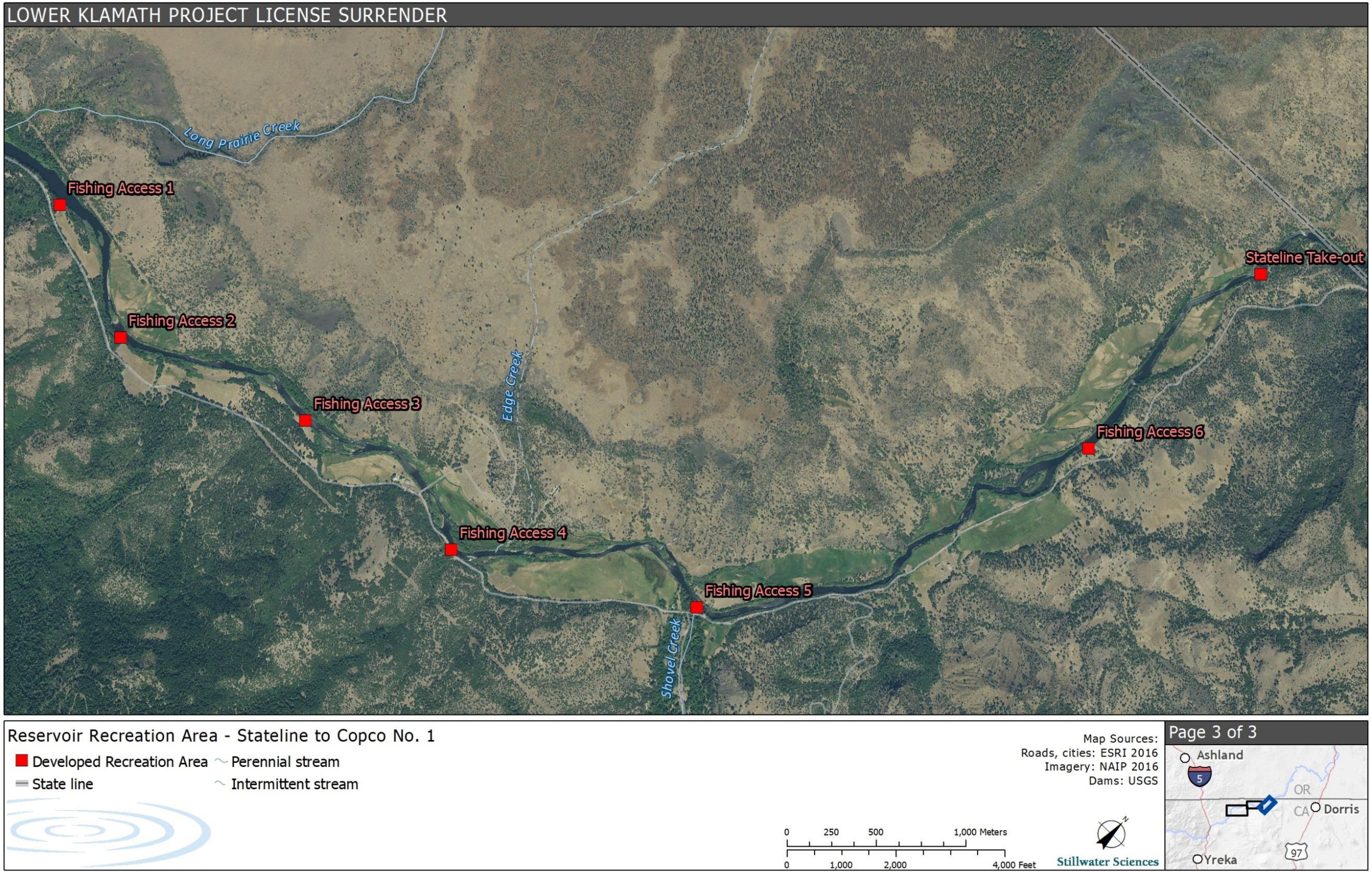

Figure 3.20-2a. California Stateline to Copco No. 1 Reservoir Recreation Area. Data source: PacifiCorp 2004.

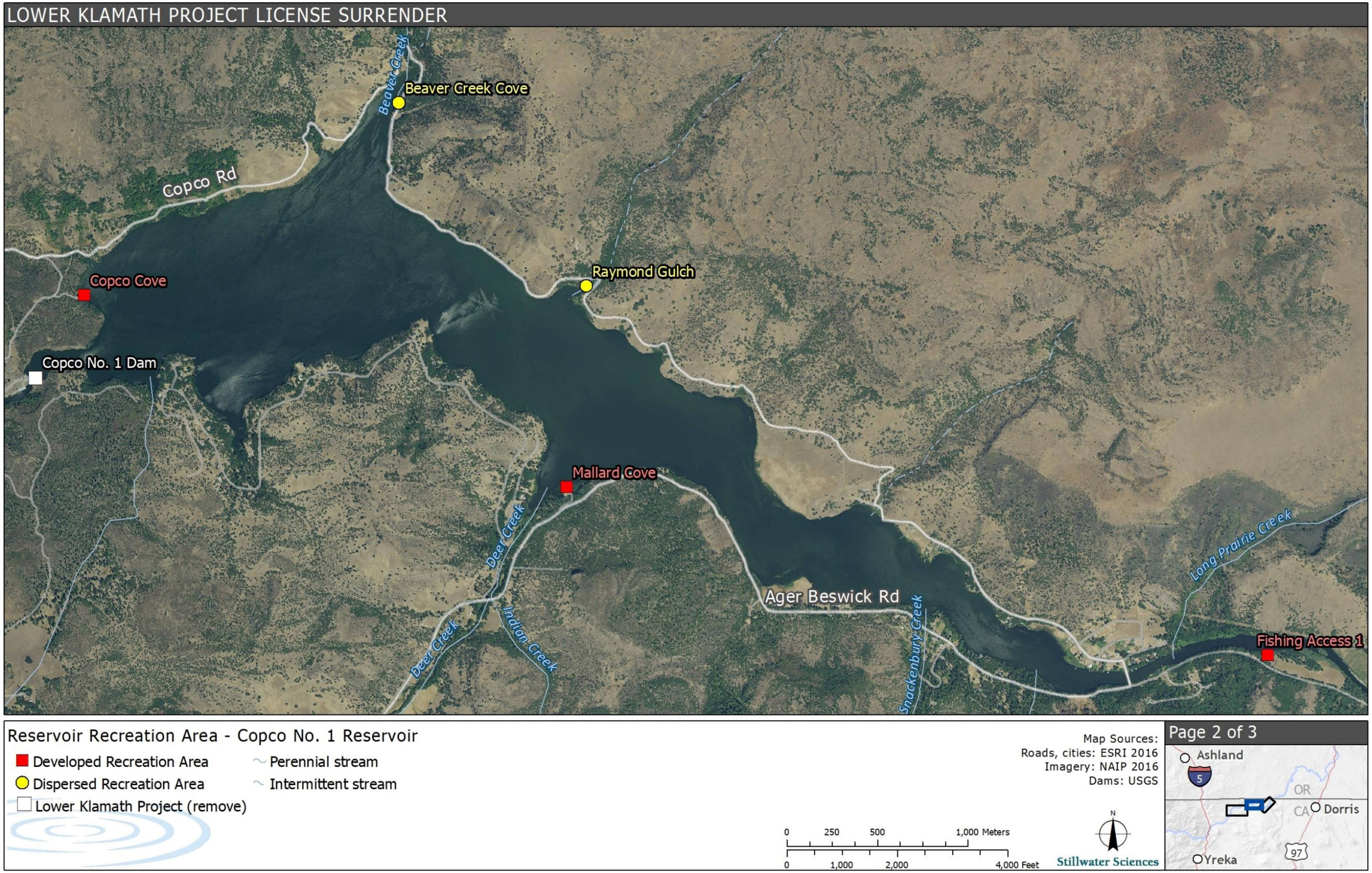

Figure 3.20-2b. Copco No. 1 Reservoir Recreation Area. Data source: PacifiCorp 2004.

Figure 3.20-2c. Iron Gate Recreation Area. Data source: PacifiCorp 2004.

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Table 3.20-7. Hell's Corner Reach Developed Recreation Facilities.

Site Name[1]	Facilities	2001/2002 Est. Annual Use (Recreation days)	Est. Facility Use vs. Capacity
Spring Island Boater Access	Launch area, shoreline fishing access, restrooms	5,200	Moderate to nearly exceeding capacity[2]
Klamath River Campground	Campsites (3), picnic area, shoreline fishing and boating access, restrooms	1,000	Moderate to High[3]
Oregon-California State Line Take-out	Boat put- in/take-out, shoreline fishing access, restrooms	2,700	Approaching capacity
Fishing Access Sites 1–6	Shoreline fishing access, parking	3,600	Below capacity

Source: PacifiCorp 2004, FERC 2007, H. Anderson, U.S. Bureau of Land Management, pers. comm., August 2019.

1 Stillwater Sciences communications with H. Anderson associated with information on facilities and use estimates for all sites except Fishing Access Sites 1–6.

2 Moderate on weekdays and nearly exceeding capacity during weekends and holidays.

3 Moderate on weekdays and high during weekends and holidays.

The State line take-out access area of the Hell's Corner Reach, at the Oregon/California State line, includes upper and lower areas and is co-managed by BLM and PacifiCorp. The facility provides shoreline fishing and boat launching access. The fishing access sites provide access to the Klamath River in six locations between the State line take-out access area and Copco No. 1 Reservoir.

BLM manages whitewater boating use in the Hell's Corner Reach, a 16.4-mile reach from below J.C. Boyle Reservoir to the Fishing Access Site 1 take-out (see Figure 3.20-2a). This reach provides Class III to IV+ rapids during daily peaking flows from the PacifiCorp hydropower operations (between 10:00 AM and 2:00 PM), and acceptable whitewater boating flows range from 1,300 cfs to 3,500 cfs for commercial rafting and heavier loaded boats. Acceptable minimum flows for kayaking and private boaters are 1,000 cfs. Due to J.C. Boyle bypass operations, flow rates within this reach do not meet the acceptable range to create or enhance whitewater boating opportunities outside of the daily peaking flows (i.e., typical base flow ranges from 100 to 300 cfs).

Whitewater boating use occurs typically during April through October, with peak season during June to August. Commercial boating use is allowed by permit only. Currently, there is a set of nine commercial boating permits. There are no limits to the number of clients or trips allowed by commercial permits or restrictions to private boating capacity. In 2018, eight commercial boating permits were issued, which resulted in 2,001 user days. Although there was one additional permit issued for 2019, user days are anticipated to remain within 10 percent of the 2018 total (H. Anderson, U.S. Bureau of Land Management, pers. comm., August 2019). Factors that constrain the carrying capacity of the reach are vehicle congestion at the take-out locations near Copco No. 1 Reservoir and the limited size and number of areas that are available to scout rapids (FERC 2007).

The Copco No. 2 Bypass Reach is approximately 1.3 miles long, extending from Copco No. 2 Dam to the Copco No. 2 Powerhouse and whitewater boating opportunities are limited due to lack of flow. However, the reach could provide Class IV whitewater opportunities at acceptable flows ranging from 600 to 1,400 cfs (Appendix S).

Fishing Opportunities
In Oregon, fishing is allowed from September 30 until June 16 on the Klamath River downstream from Link River Dam. The highest use in this area occurs from late winter through spring; this area is mainly used by Klamath Falls residents. At lower flow times, anglers use the river at a few sites where there is access for bank fishing through thick riparian vegetation. Catch records indicate that although angler success is consistently low, there is a greater percentage of larger fish caught in the upstream reach than between J.C. Boyle Dam and the state line. Table 3.20-6 summarizes flows acceptable for fishing opportunities in the various reaches of the Klamath River.

PacifiCorp conducted a visitor use survey in 2002 to obtain information on existing visitor demand, needs, and recreational activities within the area between J.C. Boyle Reservoir and Iron Gate Dam. The results of the survey indicated that 33 percent of visitors to the area participate in bank fishing, both along the river and reservoirs. Survey respondents also indicated that fishing for trout on river reaches in this area is considered very good, and one of the two most popular reaches for fishing opportunities includes the J.C. Boyle Bypass Reach downstream from J.C. Boyle Dam. Opportunities for trout fishing also exist downstream of J.C. Boyle Powerhouse (Hell's Corner Reach). This reach (between J.C. Boyle Powerhouse and the state line) is popular with anglers, and catch records indicate good angler success, although fish size is typically smaller than fish caught below Keno Dam and rarely exceeds 16 inches (FERC 2007). Note that the prior Klamath Hydroelectric Project relicensing studies represent the most recent survey data characterizing annual visitation and capacity for most recreational facilities in the Area of Analysis of recreation (exceptions noted, as appropriate). River flow and fish habitat conditions have not changed significantly since 2002, such that the level of recreational activities in, and general public use of, this reach are also likely to be generally the same.

Recreational opportunities downstream from Hell's Corner Reach, between the California/Oregon state border and Iron Gate Dam, are quite popular for angling. In 1974, a 6-mile reach of the Klamath River, from the California/Oregon state line to Copco No. 1 Reservoir (not including tributaries), was designated as Wild Trout Waters by the State of California and is managed under the Wild Trout Program (CDFW 2017) (see also Section 3.3 *Aquatic Resources*). Demand for recreational angling is high in this area. However, the Klamath River between the Copco No. 1 and Iron Gate developments has limited public access and no documented fishing activity.

In California, the Lower Klamath Project dams impound three waterbodies on the Klamath River: Copco No. 1, Copco No. 2, and Iron Gate reservoirs. Since Copco No. 2 is small with a surface area of only about 40 acres and contains no recreational facilities, the discussion focuses on Iron Gate and Copco No. 1 reservoirs. In addition to these reservoirs, there is a stretch of un-impounded river between the California-Oregon state line, and Copco No. 1 Reservoir. There is also a small (approximately 1.5-mile) stretch of river in between Copco No. 2 Dam and Iron Gate Reservoir. Figures 3.20-2(a), (b), and (c) show the locations of these waterbodies, and Section 3.20.2.3 *Lower Klamath Project Reservoir-based Recreation* describes recreational opportunities at each of these areas.

Middle and Lower Klamath River

The USDA Forest Service (Klamath and Six Rivers National Forests) manages the majority of the Klamath River corridor from downstream from Iron Gate Dam to the confluence with the Trinity River. Other areas downstream from Iron Gate Dam are also managed by the NPS, BLM, tribes, and private landowners. Table 3.20-8 summarizes the river-based recreational opportunities available on the Klamath River downstream of Iron Gate Dam.

Table 3.20-8. River-Based Recreation Opportunities in the Middle Klamath River, Between Iron Gate Dam and the Confluence with the Trinity River.

Reach	Length (miles)	Current Recreation Opportunities
Iron Gate Dam to Shasta River	13	Sightseeing, fishing (especially from boats), tubing and swimming, whitewater boating (rare), waterplay
Shasta River to Scott River	34	Sightseeing, fishing, canoeing, whitewater boating, locational playboating, waterplay
Scott River to Indian Creek	36	Sightseeing, fishing, canoeing, whitewater boating, waterplay
Indian Creek to Salmon River	40	Sightseeing, fishing, whitewater boating, canoeing, hiking, waterplay
Salmon River to Trinity River	40	Sightseeing, fishing, waterplay

Source: PacifiCorp 2004; PacifiCorp 2019b

There are two privately developed recreation facilities located along the Middle Klamath River a few miles downstream of Iron Gate Dam. The R Ranch Klamath River Campground is located a few miles east of Cottonwood and I-5 and 2.5 miles downstream from Iron Gate Dam along 1.7 miles of the Middle Klamath River. This campground contains 156 campsites with a large lodge/recreation center and provides opportunities to fish, hunt, and view natural scenery and wildlife. And the Klamath Ranch Resort Blue Heron RV Park is located along the Klamath River 1.5 miles downstream of Iron Gate Dam. This campground features 26 campsites, several accessory structures, a fly-fishing school casting pond, historic restaurant, and boat launch.

In addition, there are two National Forest Scenic byways located along the Middle Klamath River and within the Klamath and Six Rivers National Forests. The “State of Jefferson” National Forest Scenic Byway is located primarily on California State Highway 96 (State Highway 96) between Shasta River to Happy Camp, and the “Bigfoot” National Forest Scenic Byway is located on Highway 96 from Happy Camp to California State Highway 299 (State Highway 299). There is also an “All America Road,” the Volcanic Legacy Scenic Byway, which goes from Lassen National Park in California and through the project area via Highways 97, 140, and 62 on its way to Crater Lake National Park in Oregon. These byways provide excellent views for sightseers within the Klamath and Six Rivers National Forests and access to numerous other recreational activities (America’s Scenic Byways 2017).

Downstream of the Trinity River confluence, the Lower Klamath River flows through the Yurok, Hoopa, and Resighini Indian Reservations and Redwood National Park, as well as through public lands managed by the BLM and privately-owned lands. A number of private RV and tent campgrounds are along the river in Redwood National Park, and just outside of the park in the City of Klamath. These campgrounds provide opportunities for bank fishing, camping, and picnicking. Other recreation opportunities in the area are associated with Redwood National and State Parks, which includes Jedediah Smith, Del Norte Coast, and Prairie Creek Redwood state parks and Redwood National Park, which offer hiking, hunting, wildlife viewing, and other recreational opportunities. (See Table 3.20-1 for a summary of the facilities associated with these parks.)

Public Health Issues

As discussed in Section 3.2.2.7 *Chlorophyll-a and Algal Toxins*, concentrations of chlorophyll-*a* and *Microcystis aeruginosa* have exceeded World Health Organization guidelines for protection from adverse effects in recent years, in both Copco No. 1 and Iron Gate reservoirs, as well as reaches of the Klamath River downstream from Iron Gate Dam. In 2005, 2008, 2009, 2010, 2012, 2013, 2014, 2016, and 2017, the North Coast Regional Board, Karuk Tribe, Yurok Tribe, USEPA, and other local, state, and federal agencies issued warnings to residents and recreational users of the reservoirs and river to use caution near these algal blooms due to possible health effects of exposure to *Microcystis aeruginosa* and its microcystin toxin (see also Section 3.4.2.3 *Hydroelectric Reach*) (Kann and Corum 2006, 2009; North Coast Regional Board 2009, 2010, 2012a, 2013, 2014, 2016, 2017a). Effects range from mild, non-life-threatening skin conditions to permanent organ impairment and death, depending upon exposure time and intensity (FERC 2007). As identified in comments received during the scoping period for the 2012 KHSA EIS/EIR, as well as in PacifiCorp's recreation survey in 2002, these water quality issues and public health warnings have resulted in reduced recreational activity in affected river segments in recent years.

Recently, PacifiCorp has been testing the use of an intake barrier/thermal curtain installed in 2015 at Iron Gate Dam to limit the downstream release of high concentrations of blue-green algae [cyanobacteria] and associated algal toxins (e.g., microcystin) from in-reservoir summer and fall algal blooms. The intake barrier/thermal curtain acts as an obstacle that generally restricts the intake zone for Iron Gate Dam, so the intake preferentially withdraws water from the deeper portions of the reservoir with lower blue-green algae [cyanobacteria] concentrations and cooler water. However, the intake barrier/thermal curtain effectiveness is dependent on stratification in the reservoir, so higher water flow or other mixing conditions that reduce reservoir stratification also notably decrease the performance of the intake barrier/thermal curtain. Additionally, the intake barrier/thermal curtain effectiveness is limited when there are low dissolved oxygen concentrations in the deeper reservoir waters that require raising the curtain to meet dissolved oxygen water quality standards downstream of Iron Gate Dam. Blue-green algae [cyanobacteria] and microcystin releases downstream into the Klamath River were reduced when the intake barrier/thermal curtain was in use during 2015 and 2016, but there were still exceedances of posting limits for algal toxins downstream of Iron Gate Dam during 2017 and

2018 (see Section 3.2.2.2 *Water Temperature* and Section 3.2.2.7 *Chlorophyll-a and Algal Toxins* for further discussion) (PacifiCorp 2016, 2017; Watercourse Engineering, Inc. 2016, 2017, 2018, 2019).

Whitewater Boating Opportunities

Extensive whitewater boating opportunities exist downstream from Iron Gate Dam. Depending on the river segment and level of flow, there are opportunities for play, standard, and big water boating on Class II and III waters (American Whitewater 1998). These runs are boatable in rafts, kayaks, inflatable kayaks, and open canoes. Table 3.20-6 summarizes the acceptable flow ranges for all reaches within the area of effect, including downstream from Iron Gate Dam.

Although not as challenging as the Hell's Corner Reach upstream, there are a few rapids that are sometimes rated Class IV, including Hamburg and Upper Savage on the Otter's Playpen run, Rattlesnake on the day-use run below Happy Camp, and Dragon's Tooth between Ferry Point and Coon Creek Access. There is also a well-known kayak playboating wave known as the "School House Wave" between Skehan Bar and Gottville. This wave is typically available during low to moderate summer flows and is popular with local kayakers from the Mount Shasta, Klamath Falls, and Ashland areas (PacifiCorp 2004). There is also a Class V-VI rapid at Ishi Pishi Falls (Somes Bar) that boaters are strongly advised to portage around due to its cultural significance to local tribes (American Whitewater 2017).

The primary whitewater boating season is in summer (June through August), when water temperatures are warm; however, the Klamath River can be boated in most months of the year. There is less whitewater rafting downstream from the Trinity River confluence after the river turns northwest into strong prevailing winds. There are fewer developed river access points along this reach than in the reaches upstream. This reach is located within the boundaries of the Yurok Tribe Indian Reservation. Data collected by the USDA Forest Service and BLM indicate that substantially more whitewater boating occurs on the Klamath River downstream of Iron Gate Dam than in the Klamath River upstream to J.C. Boyle Dam. From 1994 through 2009, the average annual number of user days was 14,392 per year. However, whitewater boating in this portion of the Klamath River has decreased somewhat in recent years. Total user days from 2000 through 2003 ranged from 13,976 to 15,349 per year, whereas from 2005 through 2009, total user days ranged from 11,751 to 15,279 per year (DOI 2011).

Fishing Opportunities

The Klamath River downstream from Iron Gate Dam has high quality angling opportunities extending nearly 200 miles to the Pacific Ocean and is open to fishing year-round. This reach, designated a wild and scenic river (see Section 3.20.2.4 *Wild and Scenic River Conditions* below), attracts and supports several fishing outfitter services that focus on salmon, steelhead, and trout fisheries. A review of outfitters conducted as part of the Secretarial Determination process identified over 50 outfitters providing sport fishing, boat fishing, and/or fly-fishing trips on the Klamath River. Twenty-seven river access sites within the Klamath National Forest provide access for fishing in this section of the river. Use at the sites varies; however, most are rated as light usage (Klamath National Forest 2017). Tables 3.20-9 and 3.20-10 provide available use data for Chinook salmon and steelhead fishing on the Klamath River. As shown in Table 3.20-9, angler success for Chinook salmon has varied annually.

Table 3.20-9. Estimated Number of Recreational Salmon Angler Hours and Chinook Salmon Harvest on the Klamath River (excluding the Trinity River), 2001–2018.

Year[1]	# Angler Hours	Average Hours Per Trip	Chinook Salmon Harvest (# Fish)	Chinook Salmon Harvest (# Fish)	Chinook Salmon Harvest (# Fish)
			Adults	Grilse (Jacks)	Total
2001	88,053	4.4	9,621	1,365	10,986
2002	85,925	4.7	9,769	651	10,420
2003	79,228	4.8	7,322	589	7,911
2004	71,397	4.7	3,463	2,293	5,756
2005	61,000	4.8	1,029	912	1,941
2006	41,792	4.7	57	5,202	5,259
2007	64,101	4.6	4,975	257	5,232
2008	56,005	5.2	1,560	4,039	5,599
2009	67,160	4.6	4,820	2,033	6,853
2010	58,842	5.1	2,610	1,570	4,180
2011	56,759	4.8	3,019	8,738	11,757
2012	87,748	5.0	11,837	3,802	15,639
2013	102,381	4.6	18,628	2,212	20,840
2014	60,376	4.8	4,464	3,190	7,654
2015	77,228	4.6	7,798	1,580	9,315
2016	36,651	4.6	162	1,310	1,472
2017	16,678	4.1	42	71	113
2018	44,204	4.3	2,206	4,075	6,281
01–05Avg	77,121	4.7	6,241	1,162	7,403
06–10Avg	57,580	4.8	2,804	2,620	5,425
11–15Avg	76,898	4.8	9,149	3,904	13,053
16–18Avg	32,511	4.3	803	1,819	2,622

Sources: CDFW 2016, NMFS 2011, CDFW 2018, Troxel and Lindke 2019.
Notes:
[1] CDFW (2018) provides Chinook Salmon Harvest Data for 2016 through 2018.

Table 3.20-10. Estimated Number of Recreational Steelhead Angler Days on the Klamath River (excluding the Trinity River), 2003–2008.

Year	# Angler Days
2003	19,183
2004	14,345
2005	13,216
2006	19,371
2007	15,622
2008	21,192
03-08Avg	17,155

Source: NMFS 2011

Downstream from the Trinity River confluence, angling in the Klamath River is dependent on the annual status of the fall-run Chinook salmon run, so the number of businesses that offer angling guide services varies from year to year with the Chinook salmon population size. The main run of Klamath River Chinook salmon peaks in late fall and is normally over by mid-January each year; the steelhead season generally starts in November and runs through March (see also Section 3.3 *Aquatic Resources*).

Anglers fish from boats and the bank. Most of the boat fishing occurs from drift boats or rafts. Fishing regulations allow anglers to keep up to five trout per day and most of the fishing activity occurs in summer and fall. Quotas and limits on salmon and steelhead have varied over the years, and regulations may depend on whether the fish are wild or from a hatchery.

3.20.2.3 Lower Klamath Project Reservoir-based Recreation

As there are no reservoirs located on the Klamath River downstream of Iron Gate Dam, the following discussion of reservoir-based recreation focuses on the Lower Klamath Project reservoirs located in the Hydroelectric Reach from J.C. Boyle Reservoir to Iron Gate Dam.

Hydroelectric Reach

J.C. Boyle Reservoir

J.C. Boyle Reservoir has a surface area of approximately 420 acres and is about 3.6 miles long. Developed public recreational facilities at the reservoir include Pioneer Park, Sportsman's Park, and Topsy Campground (Table 3.20-11). See Appendix B: *Definite Plan - Appendix C,* Figure 5.1-1, Sheets 2-3, for locations of these recreational facilities.

Table 3.20-11. J.C. Boyle Reservoir Developed Recreation Facilities.

Site Name	Ownership	Facilities[1]	2001/2002 Est. Annual Use	Est. Facility Use vs. Capacity
Pioneer Park	PacifiCorp	Picnic areas, boat launches, interpretive signs, restrooms	16,700	Below capacity
Topsy Campground	BLM	Campsites (13), an RV dump, one day-use areas, a boat launch with boarding dock, an accessible fishing pier, restrooms	5,600	Moderate to nearly exceeding capacity[2]
Sportsman's Park	Klamath County	Shooting ranges, dirt racetracks, archery courses, a model aircraft flying field, off-highway vehicle area, restrooms	12,600	Below capacity

Source: PacifiCorp 2004, FERC 2007, PacifiCorp 2019b, BLM 2019, H. Anderson, U.S. Bureau of Land Management, pers. comm., August 2019.

1 PacifiCorp (2019a) and BLM (2019a) cover facilities information only.

2 Stillwater Sciences communication with H. Anderson provides estimates on facility use versus capacity for Topsy Campground only. This use was estimated as moderate on weekdays and nearly exceeding capacity during weekends and holidays.

Pioneer Park is owned and operated by PacifiCorp and it lies off Oregon State Highway 66 (State Highway 66) east and west of Spencer Bridge. Pioneer Park is a day-use area that provides picnic areas, boat launches, interpretive signs, and two restroom facilities. It has an improved boat ramp on the east shore just off State Highway 66, and a picnic area and unimproved boat launch on the west shore. Popular activities at this location include sightseeing, boating, fishing, swimming, and picnicking (PacifiCorp 2004, 2019b).

Topsy Campground is managed by BLM. The campground is south of State Highway 66 off Topsy Grade Road, a gravel road maintained on an as-needed basis by BLM, private owners, timber companies, and PacifiCorp. This site features a campground with 13 campsites, an RV dump, one day-use area, a boat launch with boarding dock, an accessible fishing pier, and two restroom facilities. The campground is available to the public and BLM charges fees for day-use and camping at this facility (PacifiCorp 2004; BLM 2019).

Sportsman's Park, approximately 0.25-mile east of the reservoir, is a multi-use recreation area owned by Klamath County and leased long term to Klamath Sportsman's Park Association. The park does not provide developed reservoir access, but it does provide river access for fishing. The park contains shooting ranges, dirt racetracks, archery courses, and a model aircraft flying field. The park also has facilities for self-contained RVs and some tent camping. Annual membership passes and single-day passes for use of the park are available to the general public for a fee (PacifiCorp 2004, Sportsman's Park 2017).

In California, the Lower Klamath Project dams impound three waterbodies on the Klamath River: Copco No. 1, Copco No. 2, and Iron Gate reservoirs. In addition to these reservoirs, there is a stretch of un-impounded river between J.C. Boyle Reservoir and Copco No. 1 Reservoir. Figures 3.20-2(a), (b), and (c) show the locations of these reservoirs, and the following sections describe recreational opportunities at each of these areas.

Copco No. 1 Reservoir

Copco No. 1 Reservoir, with a surface area of approximately 1,000 acres and about 4.5 miles long, has two publicly available day-use facilities—Mallard Cove and Copco Cove—that are owned and operated by PacifiCorp. These facilities provide day-use access to the reservoir, and although they are not official campgrounds, camping occasionally occurs at both locations. Copco No. 1 Reservoir currently provides a recreational fishery for non-native fishes including largemouth bass, trout, catfish, crappie, sunfish, and especially yellow perch (Hamilton et al. 2011). Table 3.20-12 summarizes the existing facilities and estimated use during 2001/2002 at both of these areas.

Table 3.20-12. Copco No. 1 Reservoir Developed Recreation Facilities.

Site Name	Facilities[1]	2001/2002 User Days[2,3]	Est. Facility Use vs. Capacity
Mallard Cove	Picnic area, restrooms, boat launch with boarding dock	7,600	Below capacity
Copco Cove	Picnic area, restrooms, boat launch with boarding dock	1,250	Below capacity

Source: PacifiCorp 2004, FERC 2007, PacifiCorp 2019b
Notes:

[1] PacifiCorp (2019b) provides details on the facilities available at each site.

[2] User days are defined as one visitor to a recreation area for any reason in a 24-hour period. Estimated use was during the 2001/2002 study period (PacifiCorp 2004). Note that the prior Klamath Hydroelectric Project relicensing studies represent the most recent survey data characterizing annual visitation and capacity for most recreational facilities in the Area of Analysis of recreation (exceptions noted, as appropriate).

[3] Although annual user data from 2001/2002 represent the most comprehensive information available, these data were collected prior to data characterizing seasonal blue-green algae [cyanobacteria] blooms in Iron Gate Reservoir became available (see also Section 3.4.2.3 *Hydroelectric Reach*) and prior to the freshwater CyanoHABs Program that began posting of public health advisories for California reservoirs that exceed algal toxin thresholds.

Mallard Cove, on the south shore of Copco Reservoir, is accessed off Ager-Beswick Road and includes day-use facilities, two restrooms, and a boat launch with boarding dock. Copco Cove, on the western shoreline of Copco Reservoir, off of Copco Road, has a small picnic area, two restrooms, and a boat launch with boarding dock (PacifiCorp 2004, 2019b).

Additionally, homes on Copco Lake provide private recreational access, including docks for fishing, boating, swimming and birdwatching.

Copco No. 2 Reservoir

Copco No. 2 Reservoir is relatively small (with a surface area of approximately 5.2 acres [PacifiCorp 2015] and about 0.3-mile long) and has a narrow configuration with steep and difficult shoreline access. Copco No. 2 Reservoir has no recreational facilities and no public access (FERC 2007, PacifiCorp 2015).

Iron Gate Reservoir

Iron Gate Reservoir has a surface area of approximately 944 acres and is 6.8 miles long. The reservoir has the highest concentration of recreation sites of all the developments associated with the PacifiCorp facilities. The developed facilities at Iron Gate Reservoir are owned and managed by PacifiCorp and include a trail (Fall Creek Trail), five combination day-use and campground areas (Jenny Creek, Camp Creek, Juniper Point, Mirror Cove, and Long Gulch), three day-use areas (Fall Creek, Overlook Point, and Wanaka Springs), and a fish hatchery and associated day-use area (Iron Gate). Recreational opportunities include sightseeing, swimming, fishing, boating, and day and overnight use. Iron Gate Reservoir currently provides a recreational fishery for non-native fishes including largemouth bass, trout, catfish, crappie, sunfish, and especially yellow perch (Hamilton et al. 2011). Summer and weekend use is high at the reservoir due to the popularity of bass tournaments, waterskiing, and camping. Table 3.20-13 summarizes the developed recreation facilities at the reservoir.

The Fall Creek Day-Use Area is at the upper end of the reservoir and includes a four-site picnic area, unimproved boat launch access, and restroom facilities (PacifiCorp 2019b). This small day-use area is adjacent to the CDFW Fall Creek Fish Hatchery and provides access to Fall Creek Trail. Fall Creek Trail is a short (0.1-mile) trail located adjacent to the Fall Creek Fish Hatchery where visitors can hike up to Fall Creek Falls.

Wanaka Springs Day-Use Area provides six picnic sites, a fishing dock, restroom facilities, hiking trail, and some informal camping occurs in the area (PacifiCorp 2019b).

Table 3.20-13. Iron Gate Reservoir Developed Recreation Facilities.

Site Name	Facilities[1]	2001/2002 Est. Annual Use (User days)[2]	Est. Facility Use vs. Capacity
Fall Creek Day-Use Area and Fall Creek Trail	Picnic sites (4), boat launch access, restrooms, hiking trail	4,150	Below capacity
Overlook Park	Picnic sites (2), restrooms	1,900	Below capacity
Wanaka Springs Day-Use Area	Picnic sites (6), boat dock/fishing pier, restrooms, hiking trail	4,150	Exceeding capacity
Jenny Creek Day-Use Area and Campground	Picnic sites (5), fishing access, restrooms	3,700	Approaching capacity

Site Name	Facilities[1]	2001/2002 Est. Annual Use (User days)[2]	Est. Facility Use vs. Capacity
Camp Creek Day-Use Area and Campground	Campsites (22), large overflow camp area, , boarding and fishing docks, swimming area, a RV dump station, sports field, interpretive display restrooms	15,250	Exceeding capacity
Juniper Point Day-Use Area and Campground	Campsites (9), swimming beach, restrooms	4,700	Exceeding capacity
Mirror Cove Day-Use Area and Campground	Campsites (10), a boat launch, restroom	11,140	Exceeding capacity
Long Gulch Day-Use Area and Campground	Picnic sites (2), boat launch, restrooms	5,200	Below capacity
Iron Gate Fish Hatchery[3]	Picnic area, picnic shelter, visitor center/interpretive kiosk, restrooms, trail to river	450	Below capacity

Sources: PacifiCorp 2004, FERC 2007; PacifiCorp 2019b, H. Anderson, U.S. Bureau of Land Management, pers. comm., August 2019; P. Brock, California Department of Fish and Wildlife, pers. comm., August 2019.

1 PacifiCorp (2019b) provides information on facilities available at each site, excluding Iron Gate Fish Hatchery.

2 Although annual user data from 2001/2002 represent the most comprehensive information available, these data were collected prior to data characterizing seasonal blue-green algae [cyanobacteria] blooms in Iron Gate Reservoir became available (see also Section 3.4.2.3 *Hydroelectric Reach*) and prior to the freshwater CyanoHABs Program that began posting of public health advisories for California reservoirs that exceed algal toxin thresholds.

3 Stillwater Sciences communications with P. Brock , California Department of Fish and Wildlife, covers information for Iron Gate Fish Hatchery.

Overlook Point is on the west side of the reservoir, approximately 0.75-mile upstream of Iron Gate Dam. The facility has picnic sites and restrooms on moderately steep topography, providing a good view of the reservoir and surrounding landscape (PacifiCorp 2019b).

Jenny Creek Day-Use Area includes five picnic sites, fishing access, and a restroom facility. Jenny Creek is on the north side of the reservoir and provides a creekside setting for picnicking and bank fishing (PacifiCorp 2019b).

Camp Creek Day-Use Area and Campground is along a narrow reach on the north side of Iron Gate Reservoir. The surrounding hilly, semi-arid landscape and the reservoir provide pleasant views. Camp Creek Campground has 22 campsites designed primarily for RV campers, with a large overflow RV/tent camping area. The facility also has three boat docks/fishing piers, a double lane boat ramp, and restrooms (PacifiCorp 2019b).

Juniper Point Day-Use Area and Campground has nine campsites, a swimming beach, and restroom facilities (PacifiCorp 2019b).

Mirror Cove is a day-use area and campground centrally located on the west side of the reservoir. The area offers 10 campsites, a boat dock, a double-lane boat ramp, and restroom facilities (PacifiCorp 2019b). This particular location is popular for group camping and is used extensively by local water-ski clubs. This boat launch is the nearest access to a competitive water-ski course placed in the western area of the reservoir.

Long Gulch Day-Use Area and Campground is on the east side of the reservoir directly across from Overlook Point. Facilities at this location include two picnic sites, restroom facilities, and a boat launch. Land along an adjacent ridge is occasionally used for dispersed camping and day-use (PacifiCorp 2004, 2019b).

Immediately downstream of Iron Gate Dam, the Iron Gate Fish Hatchery is operated by CDFW and includes a public day-use area adjacent to the hatchery and an undeveloped boat launch across the river from the hatchery. The day-use area includes a picnic area, a picnic shelter, visitor center/interpretive kiosk, restroom facilities, a trail to the river, and seasonal interpretive tours. Fishing is prohibited in this area as well as within 3,500 feet downstream from the dam.

Visitor Use and Perception

PacifiCorp conducted a visitor survey in 2004 to assess recreational use and visitor perceptions of recreational facilities, including the Lower Klamath Project reservoirs. The majority of visitors surveyed (approximately 60 percent of total) were from Klamath County and Jackson County, Oregon. The remaining visitors were from California (approximately 40 percent of total), approximately half of which came from Siskiyou County (approximately 20 percent of total). When asked to indicate all activities participated in while visiting the Lower Klamath Project reservoirs, more than half of the visitors’ surveys included resting/relaxing as one of the activities. When surveyed on their perception of crowding at the reservoirs, the mean score of respondents was 3.2 (on a 9-point scale from 1—not crowded to 9—extremely crowded), indicating that visitors did not feel overly crowded while participating in recreation activities. Further, approximately 39 percent of respondents had changed their visits to the Lower Klamath Project reservoirs from other lakes in the area to avoid crowding. When surveyed regarding management options of the reservoirs, survey respondents indicated opposition to the collection of user fees at either day-use sites or facility campgrounds (PacifiCorp 2004).

In response to the survey question “Has water quality ever affected your visit to the Klamath River area?” approximately two-thirds of recreational users of the Lower Klamath Project reservoirs had negative perceptions of water quality, commenting on its color, turbidity, and odor. The source of visitor concerns was primarily the brown, foamy water in free-flowing reaches and regular, extensive phytoplankton [algae] blooms that occur throughout the reservoirs. Visitors reported that the phytoplankton [algae] produces bad odors, fouls fishing lines, and reduces the area available for fishing, swimming, and wading (FERC 2007). Note that the prior Klamath Hydroelectric Project relicensing studies represent the most recent survey data characterizing annual visitation and capacity for most recreational facilities in the Area of Analysis of recreation (exceptions noted, as appropriate). Seasonal reservoir algal blooms have not diminished significantly since 2002, such that the level of recreational activities in, and general public use of, the reservoirs are also likely to be generally the same.

3.20.2.4 Wild and Scenic River Conditions

Two segments of the mainstem Klamath River are designated wild and scenic rivers, one in Oregon and one in California (Figure 3.20-3). The reach in Oregon, between the J.C. Boyle Powerhouse and the Oregon-California state line was designated a wild and scenic river in 1994. As this section is not in California, it is not analyzed in this EIR.

In California, the entire river beginning 3,600 feet downstream of Iron Gate Dam to the Klamath Estuary (i.e., Middle and Lower Klamath River) is designated a wild and scenic river segment by both the State of California and the federal government. Wild and scenic river segment boundaries include variable-width linear corridors which typically include not more than 320 acres per linear mile (averaging up to approximately 0.5 mile in width along the river corridor). However, some protections for designated outstanding remarkable values can extend beyond the boundaries. In addition, the 5.3-mile section of the Upper Klamath River from the California-Oregon state line to the slack water of Copco No.1 Reservoir is considered to be eligible and suitable for wild and scenic river designation under Section 5(d)(1) of the WSRA.

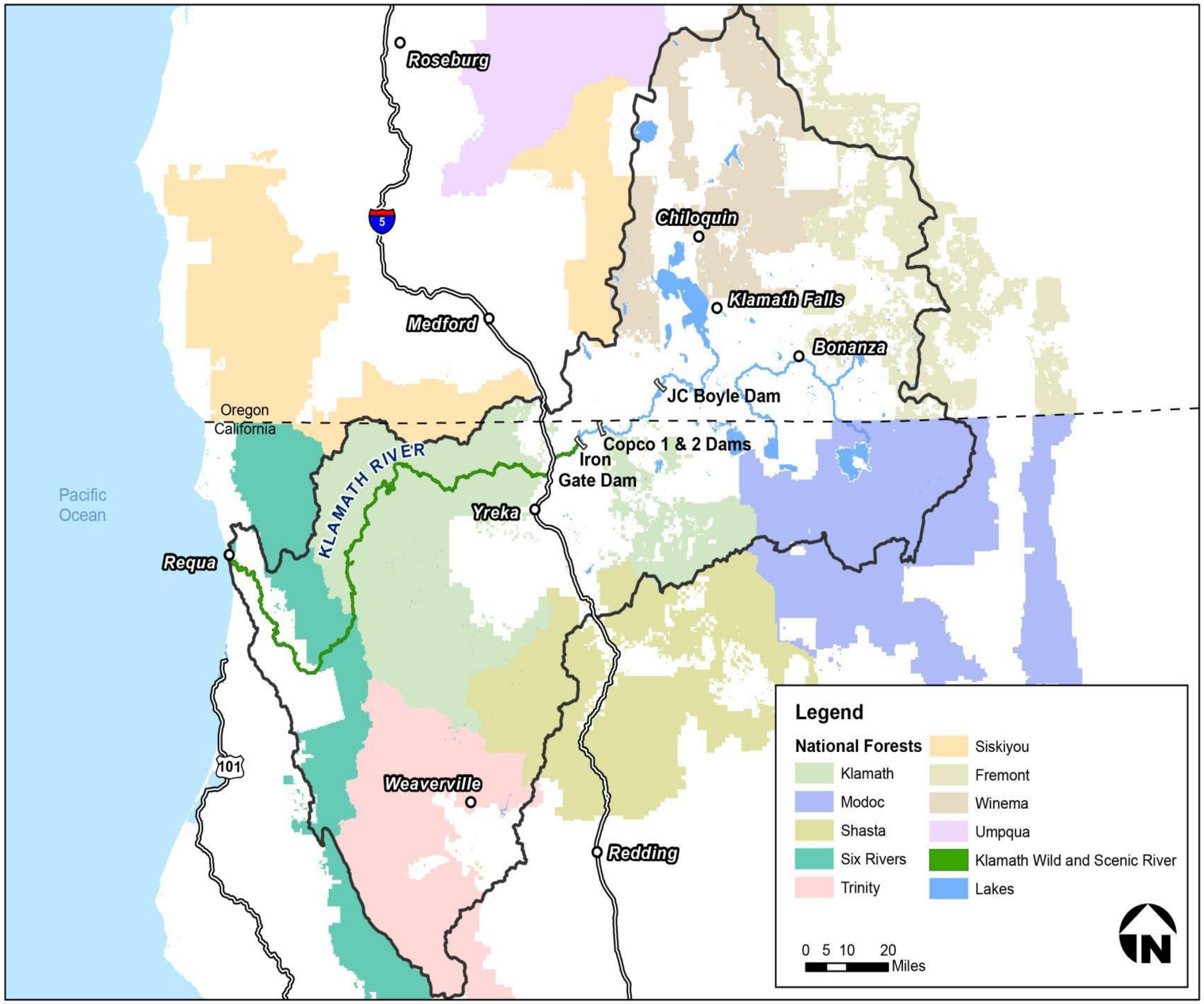

Figure 3.20-3. Klamath Wild and Scenic River Corridor.

California Klamath River Wild and Scenic River Segment
The Klamath River downstream of Iron Gate Dam, as well as portions of three tributaries (Salmon and Scott rivers and Wooley Creek), were added to the National Wild and Scenic River System in 1981 through Section 2(a)(ii) of the WSRA. The wild and scenic river portion of the mainstem Klamath River in California is classified as recreational with portions of the tributaries classified as scenic and wild. At the time of listing, the anadromous fishery, including salmon and steelhead, was considered to have the outstandingly remarkable value for the entire 286 miles of the designated segment, which includes the tributaries. Criteria for designation of this reach as a wild and scenic river include scenery, recreation, fisheries, and wildlife. The environmental setting for each of these topics is described in the corresponding sections of the EIR, as follows:

- Scenery – Section 3.19.1 [*Aesthetics*] Environmental Setting
- Recreation – Section 3.20.1 [*Recreation*] Environmental Setting
- Fishery – Section 3.3.1 [*Aquatic Resources*] Environmental Setting
- Wildlife – Section 3.5.1 [*Terrestrial Resources*] Environmental Setting
- Water Quality – Section 3.2.1 [*Terrestrial Resources*] Environmental Setting
- Algae – Section 3.4.1 [*Phytoplankton and Periphyton*] Environmental Setting

Eligible and Suitable Wild and Scenic River Section on the Klamath River
In 1990, BLM found the 5.3-mile section of the Upper Klamath River from the California-Oregon state line to the slack water of Copco No.1 Reservoir to be eligible and suitable for wild and scenic river designation under Section 5(d)(1) of the WSRA. The river segment is free-flowing and possesses outstandingly remarkable scenic, recreational, fish, and wildlife values. This river segment is not a designated wild and scenic river and is not protected under the WSRA and its Section 7(a) requirements. The BLM is required, within its authorities, to protect this suitable river segment's free-flowing character, water quality, and outstandingly remarkable river values. This segment of the Klamath River is also listed on the Nationwide Rivers Inventory (NPS 2009). If a river is listed in the Nationwide Rivers Inventory, the federal agency involved with the action must consult with the land managing agency in an attempt to avoid or mitigate adverse effects of any proposed water resources projects. This consultation is required pursuant to a directive from the Council on Environmental Quality.

For the purposes of evaluating the potential impacts of the Proposed Project on the eligible and suitable river segment, the environmental setting for each of designation criteria topics are covered in the corresponding sections of the EIR listed above.

3.20.3 Significance Criteria

Criteria for determining significance on recreational opportunities are based on Appendix G of the CEQA Guidelines (California Code of Regulations title 14, section 15000 et seq.) and professional judgement. As the Appendix G checklist questions for recreational impacts are limited, two additional criteria were added for this EIR as there is potential for impacts on a variety of users and uses under the Proposed Project. Impacts from the Proposed Project would be considered significant if any of the following criteria are met:

- Adverse changes to or loss of recreational facilities affecting a large area or substantial number of people.
- Significant increase in the use of existing parks or other recreational facilities such that substantial physical deterioration of the facilities would occur or be accelerated.
- Construction of new or expansion of existing recreational facilities which might have an adverse physical effect on the environment.
- Affect identified resource values in a wild and scenic river segment (i.e., scenic, recreational, fish, and wildlife) such that the long-term wild and scenic river designation or eligibility for listing would be compromised.

3.20.4 Impact Analysis Approach

The impact analysis for recreational resources considers the potential implications of the Proposed Project on changes to river- and reservoir-based recreation opportunities, activities, and settings within the Area of Analysis. Short-term and long-term effects on access, flow-dependent recreational activities, recreational fishing, and other recreational activities associated with the existing Klamath River corridor and reservoir recreational facilities within the Area of Analysis are described. The relocation of the City of Yreka's water supply pipeline is not expected to result in any impacts to recreational resources; therefore, it is not addressed in this section of the EIR.

3.20.4.1 Recreational Setting, Facilities, and Access

Likely changes to recreational use and access were assessed qualitatively, including changes from reservoir-based recreational opportunities to more river-based opportunities in the areas where the Lower Klamath Project dams, recreational facilities, and/or PacifiCorp facilities would be removed. The short-term effects analysis includes a discussion of potential areas where recreational access would be restricted during construction activities. The assessment of long-term effects considers potential changes in the recreational setting and experience, changes in water quality and reservoir area revegetation for Klamath River-based recreational opportunities, as well as potential impacts on regional recreational facilities due to increased use.

The KRRC's Recreation Plan takes a programmatic approach to developing recreational facilities and mitigating any impacts attributable to these developments. Proposed new recreational facilities are being evaluated by KRRC, including consideration of public input on the potential types and locations of these facilities. A Final Recreation Plan would be submitted to FERC, and this plan would include any new recreation facilities that are proposed by the KRRC. The Final Recreation Plan would be subject to environmental review under NEPA, and mitigation measures would be determined by FERC. If implementation of the Final Recreation Plan (at FERC's direction) requires any further state or local approvals, then written checklists would be prepared pursuant to CEQA Guidelines sections 15162 and 15168(c) to ascertain whether further site-specific environmental review of individual reactional projects would be necessary. Such individual projects shall be subject to applicable best management practices and mitigation measures required by FERC, applicable mitigation measures in this EIR, such as Mitigation Measures WQ-1, TER-1, TER-2, TER-3, TER-5, TCR-1, TCR-2, TCR-3, and HZ-1, and any other measures required by an agency with jurisdiction over those individual recreation projects. The potential environmental impacts of these new recreational facilities would be reviewed at a project level in subsequent evaluations prior to their implementation.

Given that this EIR analyzes the potential environmental impacts of adding new recreational sites or expanding existing recreational sites for water quality (Potential Impact 3.2-4), aquatic resources (Potential Impact 3.3-21), terrestrial resources (Potential Impact 3.5-1, Potential Impact 3.5-7, Potential Impact 3.5-10), historical resources and tribal cultural resources (Potential Impact 3.12-1), utilities (Potential Impact 3.18-1), and aesthetics (Potential Impact 3.19-5, Potential Impact 3.19-6), Potential Impact 3.20-4, which was included in the Draft EIR, is unnecessary and has been removed from this Final EIR.

3.20.4.2 Whitewater Boating Opportunities

Optimal and acceptable flows for whitewater boating opportunities along reaches of the Klamath River were assessed as a part of the technical review completed for the Proposed Project. The range of acceptable flows resulted from the Final Technical Report, Klamath Hydroelectric Project (PacifiCorp 2004). Flow values that fall within these ranges are considered acceptable flow levels for the various activities (see Table 3.20-6).

Hydrologic modeling was used to assess changes in the availability of acceptable flows under the various alternatives. The modeling results for each water year type were subjected to a statistical analysis (paired T-tests) to determine whether the difference in number of days meeting the acceptable range of flows following dam removal (both on an annual and monthly basis) would be statistically significant. A qualitative approach was used to assess the effects of the identified alternatives on whitewater boating access and existing whitewater boating opportunities.

3.20.4.3 Recreational Fishing Opportunities

The results of the hydrologic modeling were used to: determine whether changes in flow would affect recreational fishing opportunities (i.e., the number of days with optimal flows for recreational fishing); qualitatively assess potential changes in fisheries populations and abundance; and determine effects of changes from reservoir-based fishing opportunities to river-based opportunities.

3.20.4.4 Other Recreational Opportunities

The analysis also includes an assessment of other recreational activities, such as sightseeing, swimming/wading/tubing, fish and wildlife viewing, and camping that occur within the river corridor and a qualitative discussion of the effects of the various alternatives on these activities. The discussion here covers both anticipated short-term effects, such as construction-related effects, and long-term effects, such as changes in reservoir-based swimming opportunities.

3.20.4.5 Wild and Scenic Rivers

Evaluation criteria for each of the four protected resources specified in the WSRA Section 7 (a) (i.e., scenic, recreational, fish, and wildlife) have been developed to assess the effects of the Proposed Project as compared with conditions at the date of the Klamath River's designation into the National Wild and Scenic Rivers System (see Section 3.20.2.4 *Wild and Scenic River Conditions*). The type (positive or negative) and duration (short term or long term) of the effects are described, and the magnitude of these effects is analyzed. The effects are characterized as unchanged, beneficial, or adverse (or similar conclusion), by value (i.e., scenic, recreational, fisheries, and/or wildlife), for that resource.

Scenery was evaluated using the following criteria:

- Water flow character (river flows and accompanying river width, depth, and channel inundation or exposure)
- Water appearance (clarity, turbidity, depth of view, color, prominence of phytoplankton and periphyton)
- Fish and wildlife viewing
- Riparian vegetation
- Natural appearing landscape character (the visual effects of facilities and structures as viewed from within the designated wild and scenic river corridor)

Recreation was evaluated using the following criteria:

- Whitewater boating
- Recreational fishing
- Other recreational activities (water play, swimming, camping)
- Recreational setting (water quality related aesthetic odors, tastes, contacts, and public health and safety aspects)

Fishery was evaluated using the following criteria:

- Stream flow regime

- Water temperature
- Water quality (physical, biological, and chemical)
- Aquatic habitat (geomorphic condition, sediment transport regime, and substrate quality)
- Fish species population conditions, specifically:
  - Anadromous salmonid fish species
  - Resident fish species
  - Species traditionally used and culturally important to Native Americans

Wildlife was evaluated using the following criterion:

- Changes in habitat for affected species

3.20.5 Potential Impacts and Mitigation

Potential Impact 3.20-1 Effects on existing recreational facilities and opportunities due to access restrictions, noise, dust, and/or sediment release resulting from construction activities.

Construction activities associated with dam removal would result in temporary loss of access to recreational facilities at the Lower Klamath Project reservoirs and associated reservoir-based recreational opportunities. Access could remain restricted for an additional period following completion of dam removal as restoration activities are conducted on the former reservoir area and existing recreational areas are modified to accommodate the new river channel. However, as described above in Section 3.20.2.1 *Regional Recreation*, a number of reservoirs, lakes, and rivers are present within and adjacent to the Klamath Basin and provide similar opportunities for recreational activity. Therefore, temporary impacts on recreational access in the vicinity of Iron Gate and Copco No. 1 reservoirs would be less than significant.

As described in Potential Impact 3.9-1 and Potential Impact 3.23-1, the use of heavy vehicles and equipment during dam removal activities, and to a much lesser degree during restoration, would result in increases in dust and ambient noise in the vicinity of the Proposed Project. These activities will primarily occur over a period of approximately one and a half years; however, in any one location, there will generally be less than six months of nuisance generating activities (see Table 2.7-1). These increases could indirectly result in a decrease in the quality of recreational experiences at nearby facilities that would not have restricted access during construction (e.g., river access, trails, and private parks not directly affected by construction and reservoir drawdown). Specific effects related to dust and noise during construction are discussed in detail in Potential Impact 3.9-1 and Potential Impact 3.23-1, respectively.

With regard to recreational activities, increases in ambient noise and air pollutants could impede visitors' ability to rest and relax, and disrupt bird and wildlife viewing opportunities. These effects would last for the duration of demolition activity and during initial restoration activities. However, as shown in Figures 3.20-2(a-c), the majority of recreation facilities and access points at the Lower Klamath Project reservoirs and along the Hydroelectric Reach are located a fair distance away from the Lower Klamath Project dams and would continue to provide opportunities for recreation until drawdown is completed. Because noise and dust impacts decrease with increasing distance from the source, impacts at these recreational facilities will be minimal. Further, as described in Section 3.20.2.1 *Regional Recreation*, numerous other recreational facilities are available outside the area of affect, but within the vicinity of the Iron Gate and Copco No. 1 reservoirs that provide similar recreational opportunities (Table 3.20-4). Therefore, these temporary noise and dust impacts would be less than significant.

As discussed in Potential Impact 3.2-3, drawdown of the reservoirs would result in short-term increases in turbidity (also expressed as suspended sediment concentration) downstream from the Lower Klamath Project reservoirs. Elevated turbidity would be most pronounced immediately downstream from Iron Gate Dam to Bogus Creek and it would become less noticeable farther downstream due to dilution from tributary flows entering the Klamath River. Modeling of suspended sediment concentrations during drawdown indicates suspended sediment concentrations would decrease to 60 to 70 percent of the initial value by Seiad Valley (RM 132.7) and to 40 percent of the initial value downstream of Orleans (approximately RM 59). Turbidity in the Klamath River is anticipated to flush through the system relatively quickly, but elevated turbidity is conservatively anticipated to occur for six to ten months following drawdown based on modeling of suspended sediment concentrations (USBR 2012a). Sediment jetting would occur during drawdown maximize erosion of accumulated sediments during this period and potentially reduce turbidity after drawdown concludes, and immediate revegetation will occur to further minimize the potential for prolonged increases in turbidity. Turbidity in the Klamath River is expected to resume natural background levels by the end of post-dam removal year 1 regardless of the water year type based on modeling of suspended sediment concentrations (USBR 2012a) (see Potential Impact 3.2-3 for more details).

The increase in turbidity would reduce visibility for boaters, swimmers, and fishermen during the sediment flushing period and could result in reduced public participation for these activities (e.g., swimmers might be less likely to enter the river, and fishermen might be less successful due to the reduced water clarity). Increased turbidity would also affect swimmer safety considerations if swimmers are unable to see the river bottom or navigate around obstacles, such as large boulders or logs beneath the water surface. However, impacts would be temporary; following completion of reservoir drawdown activities, water quality and clarity would be expected to improve as sediments are flushed downstream and into the Pacific Ocean. Due to naturally high levels of turbidity in the river during winter flows, increased turbidity from the Proposed Project would not be noticeable for most of the drawdown period. In addition, turbidity impacts primarily would occur for a period of approximately six to ten months, with turbidity decreasing with distance downstream of Iron Gate Dam due to dilution from tributary flows entering the Klamath River. Turbidity would likely be only slightly above or similar to natural background turbidity in the Klamath River downstream of Seiad Valley (RM 132.7) by mid-May following drawdown based on a comparison of model SSCs during drawdown and natural background SSCs, except during dry water year types when turbidity may remain above natural background turbidity until after September (USBR 2012a). While opportunities for fishing and swimming in the vicinity of the Klamath River, including the area where Copco No. 1 and Iron Gate reservoirs are located, would be reduced during the drawdown period when these recreational activities would typically be low, opportunities for fishing and swimming in the Klamath River downstream of Seiad Valley (RM 132.7) during the deconstruction period would be similar or slightly reduced compared to existing conditions since turbidity would only be slightly above or to similar to natural background turbidity levels during most water year types. Additionally, opportunities for fishing and swimming would remain available in tributaries of the Klamath River during both drawdown and deconstruction. As such, the Proposed Project would not result in adverse changes to or loss of recreational facilities affecting a large area or substantial number of people; therefore, the impacts are less than significant.

Sediment release could also decrease the quality of water-contact-based recreational opportunities if sediment released downstream resulted in longer-term deposition in pools, eddies, slack water, and beaches and decreased the availability of these areas for recreational activity. As discussed in Potential Impact 3.11-5, modeling was conducted to determine the potential for such deposition following dam removal activities. The results of the modeling indicate that following dam removal activities, short-term deposition of fine and coarse sediment would occur primarily between Iron Gate Dam and Cottonwood Creek and average river bed elevation would change (i.e., increase or decrease) by up to 1 foot (see Figure 3.11-15). The Proposed Project was developed to allow reservoir drawdown to occur during winter months when precipitation, river flows, and turbidity are naturally highest. Suspended sediment concentrations would be highest during the period of greatest reservoir drawdown (January through mid-March of dam removal year two), as erodible material behind the dams is mobilized downstream (see also Potential Impacts 3.2-3 and 3.11-6). During normal to dry water years, suspended sediment concentrations would begin to decline in late March and would continue declining through early summer. If it is a wet year, it may take longer to drain the reservoirs and the high concentrations may extend until June. Suspended sediment concentrations would return to near background conditions for all water year types within the first year following removal (see also Potential Impact 3.2-3). Therefore, it is unlikely that sediment release would decrease the availability of pools, eddies, or beaches for recreational activity, even temporarily, and impacts on the quality of water contact-based recreational opportunities would not be- significant.

Overall, the impacts of construction and restoration activities are limited in temporal and geographic scope and so would not result in adverse changes to or loss of recreational facilities affecting a large area or substantial number of people. Nor would they result in a significant temporary increase in the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facilities would occur or be accelerated. Tables 3.20-2, 3.20-3, and 3.20-4 show that there are numerous alternative recreational facilities and access outside the area of affect, but within the vicinity. Most of these facilities experience low to moderate use levels and they can accommodate additional users. Recreational users who are temporarily displaced would be able to use these other areas, but they are unlikely to overload the other areas because those areas have sufficient capacity to accept them. Therefore, impacts will be less than significant.

Significance

No significant impact

Potential Impact 3.20-2 Long-term adverse changes to or loss of reservoir-based recreation activities and facilities due to removal of Iron Gate and Copco No. 1 reservoirs.

The removal of Iron Gate and Copco No. 1 reservoirs under the Proposed Project would eliminate existing opportunities for reservoir-based recreation activities, such as power boating, waterskiing, lake swimming, and flat-water boat angling. Copco No. 2 Reservoir is very small and has no recreational facilities or access. As discussed in Section 3.20.2.3 *Lower Klamath Project Reservoir-based Recreation*, Iron Gate and Copco No. 1 reservoirs are popular recreational areas for sightseeing, fishing, camping, swimming, boating, and wildlife viewing, and they attract visitors primarily from the surrounding communities in Klamath and Jackson counties, Oregon and Siskiyou County, California. The reservoirs are popular recreation areas in part because they are uncrowded relative to other lakes in the area and do not require user fees. Some activities associated with reservoir recreation could still be possible in the restored river channel (e.g., swimming and wading). However, due to increased flows, certain reservoir-based recreation such as swimming opportunities and flat-water boating may be limited in the restored river channel during certain times of year and in wet water years.

Thus, under the Proposed Project there would be a long-term loss of local reservoir-based recreational activities at Iron Gate and Copco No. 1 reservoirs, but there would be no change from existing conditions in reservoir-based recreational activities at Copco No. 2 since it has no recreational facilities or access.

However, a number of other lakes and reservoirs are in the vicinity of the Lower Klamath Project reservoirs and provide similar opportunities for recreation in an uncrowded setting (Table 3.20-4). Specifically, Fourmile Lake, Agency Lake, Applegate Reservoir, and Medicine Lake, located from 26 to 46 miles away from the Lower Klamath Project reservoirs, each have generally low-use levels as well as similar or greater surface area, a greater number of developed campsites, and a similar number of improved boat launches compared with Iron Gate and Copco No.1 reservoirs (see Table 3.20-4). As described in Section 3.20.2.1 *Regional Recreation* (in particular, see Table 3.20-4), there are more than 85 boatable lakes in Klamath and Jackson Counties in Oregon and Siskiyou County in California that are within 100 miles of the Lower Klamath Project reservoirs and provide similar facilities and activities. The Lower Klamath Project reservoirs only account for less than 1.5 percent of the surface area of the regional lakes, 2.2 percent of the developed campsites and 1.1 percent of the boat launches. The percent of picnic areas was not calculated, because Table 3.20-4 only includes day-use only picnic areas and does not include day-use areas that are also associated with overnight facilities. In addition, there are a multitude of other recreational facilities in the region; Table 3.20-1 lists public lands, but there are private facilities as well. Also, as stated by PacifiCorp (2004), approximately two-thirds of recreational visitors to the Lower Klamath Project reservoirs had negative perceptions of water quality, stating concerns of bad odors and phytoplankton (e.g., blue-green algae [cyanobacteria]) blooms, which restrict areas available for fishing, swimming, and wading. Moreover, blue-green algae [cyanobacteria] blooms in the Lower Klamath Project have continued in recent years (see also Section 3.4.2.3 *Hydroelectric Reach*) (E&S Environmental Chemistry, Inc. 2013, 2014, 2015, 2016, 2018a, 2018b; North Coast Regional Board 2008, 2009, 2010, 2012a, 2013, 2014, 2016, 2017; USEPA 2007). Therefore, the loss of Iron Gate and Copco No.1 reservoirs under the Proposed Project would not result in a long-term loss in regional lake-based recreational activities that would affect a large area or a substantial number of people.

With respect to local recreational facilities and access points, the Proposed Project would completely remove most of the existing recreational sites at Iron Gate, Copco No. 1, and J.C. Boyle reservoirs, which primarily provide fishing, boating, and day-use access to the three reservoirs. Several existing recreational sites also provide camping facilities for overnight use. Decommissioning of these facilities would include removal of structures, concrete and pavement, regrading and revegetation of associated parking areas, access roads, and other improvements (Appendix B: *Definite Plan – Appendix Q*). Facilities at Fall Creek and Jenny Creek Day-Use Areas at Iron Gate Reservoir, Topsy Campground at J.C. Boyle Reservoir, and the Iron Gate Fish Hatchery Day-Use Area downstream of Iron Gate Reservoir, would remain, where possible, and be upgraded or enhanced (Appendix B: *Definite Plan – Appendix Q*). In addition, most existing river access facilities would be retained and upgraded.

The Proposed Project includes a Recreation Plan (see Appendix B: *Definite Plan – Appendix Q* for the Draft Recreation Plan) that would be used to identify new recreation opportunities that offset the proposed removal of reservoir recreation sites as well as the reduction in whitewater boating days resulting from the Proposed Project (see Potential Impact 3.20-5 for a discussion of whitewater boating). KRRC has started an ongoing stakeholder outreach process seeking input from potentially impacted recreation users, operators, managers and administrators, including tribes, state and federal agencies, county agencies and chambers of commerce, local residents, recreation businesses, and public interest groups. The stakeholder outreach process would continue through the development of the Final Recreation Plan, which is scheduled for completion by KRRC in June 2019. The Draft Recreation Plan includes potential recreation opportunities identified in the USBR (2012b) Detailed Plan as well as those identified through recent stakeholder outreach efforts. The Draft Recreation Plan also outlines preliminary criteria for screening opportunities, including whether each recreation opportunity would: *"directly address the recreation impacts generated by the KHSA;"* and *"directly address or offset changes in the localized reservoir recreation or Hells Corner boating near where the impacts are occurring."* In addition, the Proposed Project includes the transfer of approximately 8,000 acres of real property (Parcel B lands; see also Section 2.7.10 *Land Disposition and Transfer*) located in Klamath County, Oregon, and Siskiyou County, California, to the respective states (or a designated third party) for public interest purposes, including river-based recreation, open space, active wetland and riverine restoration, and public education.

The Proposed Project would result in the loss of the locally popular fishery for non-native fishes including largemouth bass, trout, catfish, crappie, sunfish, and yellow perch (Hamilton et al. 2011). Fishing is popular in Copco No. 1 and Iron Gate reservoirs, especially for yellow perch, with one fishing guide (Shaffer 2005) considering the reservoirs the best yellow perch fishery in California. Without the Lower Klamath Project dams, fishing for non-native warm water species would be lost at the Lower Klamath Project reservoirs. While the yellow perch fishery in the reservoirs is considered by Shaffer (2005) to be the best in California, it does not constitute a recreational resource that would affect a large area or substantial number of people since there are other yellow perch fishing opportunities near the Copco No. 1 and Iron Gate reservoirs in northern California and southern Oregon, including Emigrant Lake (Ashland Daily Tidings 2009). Additionally, fishing tournaments like the largemouth bass tournaments (e.g., Rogue Valley Bassmasters) in Iron Gate Reservoir would no longer occur under the Proposed Project (Hamilton et al. 2011). However, yellow perch fishing and bass tournaments occur in dozens of lakes in northern California and southern Oregon, including some of those listed in Table 3.20-4, because these non-native fish occur over large areas of the Western United States. Thus, with respect to perch, largemouth bass, and other warm water fishing, Copco No. 1 and Iron Gate reservoirs do not constitute a recreational resource that, if lost or adversely changed under the Proposed Project, would affect a large area or substantial number people. Steelhead, trout, and salmon fisheries would be enhanced by the Proposed Project, since Lower Klamath Project reservoir habitat would be replaced by riverine habitat that supports these cold water species. Lastly, the loss of warm-water fishing in Iron Gate and Copco No. 1 reservoirs does not represent the loss of a recreational resource that would affect a large number of people. Therefore, fishing-related impacts from the Proposed Project would be less than significant.

Given that a number of other lakes and reservoirs in the vicinity of the Lower Klamath Project provide similar opportunities for reservoir-based recreation in an uncrowded setting, KRRC's proposal to retain and enhance most existing river access facilities within the Area of Analysis for recreation, and Parcel B land transfer under the Proposed Project that would potentially allow for additional future river-based recreation opportunities, the Proposed Project would be highly unlikely to result in a loss of recreational facilities affecting a large area or substantial number of people. In addition, the KRRC has prepared a Draft Recreation Plan (Appendix B: *Definite Plan – Appendix Q*) that includes stakeholder outreach, identification of potentially new or modified recreational facilities as well as evaluation and screening criteria, which will further reduce the likelihood of any potential impacts.

Significance

No significant impact

Potential Impact 3.20-3 Significant increase in the use of regional recreational facilities due to loss of Iron Gate and Copco No. 1 reservoirs, such that substantial physical deterioration or acceleration of deterioration of the regional facilities would occur.

The Proposed Project would result in the loss of reservoir-based recreational facilities at Iron Gate and Copco No. 1 reservoirs, but this impact is not significant for the reasons discussed in Potential Impact 3.20-2. While the Proposed Project also includes the creation of additional recreational facilities and opportunities, the types of river-based recreational opportunities available following dam removal activities, including camping in a river setting as opposed to camping in a lake/reservoir setting, may not appeal to the same recreational users who currently visit and recreate at Iron Gate and Copco No. 1 reservoirs. In other words, while new recreation opportunities would exist along the restored river corridor, there could be a change in user type.

A number of other lakes and reservoirs are in the vicinity of the Lower Klamath Project reservoirs and provide similar opportunities for recreation in an uncrowded setting for people specifically seeking lake or reservoir-based recreation (Table 3.20-4). Specifically, Fourmile Lake, Agency Lake, Applegate Reservoir, and Medicine Lake, are located from 26 to 46 miles away from Iron Gate and Copco No.1 reservoirs, and each exhibits generally low use-levels as well as similar or greater surface area, number of developed campsites, and number of improved boat launches. Within Klamath County and Jackson County, Oregon, and Siskiyou County, California, there are more than 85 boatable lakes, containing nearly 40 boat ramps (Boat Escape 2017). There are also more than 180 high-elevation and wilderness lakes in Siskiyou County (FERC 2007). In addition to boat ramps, these lakes provide nearly 2,300 developed campsites within less than a two-hour drive from Iron Gate and Copco No. 1 reservoirs (Table 3.20-4). The Lower Klamath Project reservoirs only account for less than 1.5 percent of the surface area of the regional lakes, 2.2 percent of the developed campsites and 1.1 percent of the boat launches. In addition, there are a multitude of other recreational facilities in the region; Table 3.20-1 lists public lands, but there are private facilities as well. Given the number and proximity of these regional lakes, as well as other lakes and reservoirs summarized in Table 3.20-1, the loss of Iron Gate and Copco No. 1 reservoirs under the Proposed Project would not be a significant impact because it would not result in a substantial increase in the use of regional lake and reservoir recreational facilities such that deterioration of those facilities would occur or be accelerated.

Significance

No significant impact

Potential Impact 3.20-5 Changes to or loss of river conditions that support whitewater boating.

Dam removal activities would not affect whitewater boating access locations, as access areas are at established places along the Klamath River channel, outside of the Lower Klamath Project reservoirs and would not be affected by dam removal activities. As discussed in the impact analysis above and in Potential Impact 3.11-6, drawdown of the reservoirs would not result in substantial changes to the floodplain or river channel. Thus, no impacts to land-based recreational facilities would be expected. Therefore, there would be no adverse impacts on whitewater boating access downstream of Iron Gate Dam. However, in the reaches between the existing dams, particularly in the Hell's Corner Reach, whitewater boating access would likely be temporarily affected due to dam removal activities and sedimentation, as discussed previously. Potential impacts on whitewater boating access locations would be short-term and less than significant.

To assess potential long-term impacts on whitewater boating under the Proposed Project, existing modeling results from the recreation analysis conducted for the 2012 KHSA EIS/EIR were applied to characterize the average number of days that acceptable river flows would occur in specific reaches each month. The existing model uses the KBRA Flows for a "dams out" scenario (i.e., removal of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams and associated facilities) and the 2010 BiOp Flows for a "dams in" scenario (see Appendix S for details). Flow requirements in the Klamath River have changed since the modeling for the 2012 KHSA EIS/EIR was performed, including issuance of new operational flow requirements for USBR's Klamath Irrigation Project (i.e., 2013 BiOp Flows and 2019 BiOp Flows). Accordingly, as detailed in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* and

Appendix S *Recreation Supporting Technical Information*, the Lower Klamath Project EIR analyses consider both the 2013 BiOp Flows and the 2019 BiOp Flows as separate existing conditions CEQA baselines to account for the change in the operational flow requirements for the Klamath Irrigation Project between the issuance of the Notice of Preparation (December 22, 2016) and the issuance of the Draft EIR (December 27, 2018).

In contrast to conditions analyzed for the 2012 KHSA EIS/EIR, Keno Dam flow releases for maintaining the 2013 BiOp Flows or the 2019 BiOp Flows generally would be similar irrespective of dam removal, which would minimize any flow differences between modeled “dams in” and “dams out” scenarios that result from Keno Dam releases, and would minimize any variation in the modeled number of days with acceptable recreational flows between “dams in” and “dams out” scenarios that result from Keno Dam releases (see Appendix S, Section S.3 for additional detail). However, within the Hydroelectric Reach, the primary difference between the “dams in” and “dams out” flow scenarios, namely the lack of hydropower peaking operations under a “dams out” scenario, would still affect recreational flows under the Proposed Project in the same way as was modeled in the 2012 KHSA EIS/EIR. Thus, while the 2013 BiOp Flows and the 2019 BiOp Flows are different from the 2012 KHSA EIS/EIR modeled flows (i.e., KBRA Flows and 2010 BiOp Flows), the previously-modeled number of days with acceptable recreation flows under a “dams out” scenario still generally characterize the number of days of acceptable recreation flows under the Proposed Project for the J.C. Boyle Bypass Reach, the J.C. Boyle Peaking Reach (including Hell’s Corner Reach), and the Copco No. 2 Bypass Reach (see Appendix S, Section S.3 for additional detail).

At Iron Gate Dam, the applicable biological opinion flow requirements also would remain the same regardless of dam removal (i.e., existing conditions flows would not change), which would minimize any flow differences between modeled “dams in” and “dams out” scenarios downstream of Iron Gate Dam, and would minimize any variation in the modeled number of days with acceptable recreational flows between “dams in” and “dams out” scenarios downstream of Iron Gate Dam (see Appendix S, Section S.3 for additional detail). Overall, under the Proposed Project there would be no change in the availability of flows within the acceptable flow ranges for whitewater boating for the reaches downstream from Iron Gate Dam compared to existing conditions and thus there would be no long-term significant impact to whitewater boating in Klamath River reaches downstream from Iron Gate Dam.

The reaches of the Upper Klamath River that are currently inundated by the existing Copco No. 1 and Iron Gate reservoirs would be converted to free-flowing riverine reaches over the long term, and depending on the river channel and access, could provide additional opportunities for whitewater boating in these reaches. However, river flows following dam removal activities were not modeled for areas currently inundated by reservoirs. While it could be expected there would be additional opportunities for whitewater boating in these reaches, no records exist of the condition or suitability of the presently inundated areas for whitewater boating activities. With details of the condition of these areas lacking, it is too speculative to determine the quality and quantity of whitewater boating opportunities that could be realized due to dam removal activities in areas currently inundated by reservoirs. Accordingly, this analysis does not rely on the creation of whitewater boating opportunities in these reaches.

In contrast, for the Copco No. 2 Bypass Reach, previous model results indicate there would be a substantial increase in whitewater boating opportunities during the July through September time period (i.e., 22 to 30 additional days per month on average; Appendix S, Table S-3 and Table S-6). Comparison of the monthly range of KBRA Flows utilized in the modeling with the 2013 BiOp Flows or the 2019 BiOp Flows indicates that the whitewater boating opportunities during the July through September time period would still increase under both the 2013 BiOp Flows and the 2019 BiOp Flows, and the magnitude of the increase may be more than modeled under the KBRA Flows for the 2012 KHSA EIS/EIR (Appendix S, Figure S-5). This is because flows would be more likely to fall within the range of acceptable flows for whitewater boating in the Copco No. 2 Bypass Reach (i.e., 600 cfs to 1,500 cfs) under 2013 BiOp Flows or the 2019 BiOp Flows than the modeled KBRA Flows, especially during July (Appendix S, Figure S-5). Overall, the increase in the number of days with acceptable flows for whitewater boating under the Proposed Project would be a long-term beneficial effect on whitewater boating in the Copco No. 2 Bypass Reach.

In the J.C. Boyle Bypass Reach, modeling done in 2012 under the KBRA Flows show an increase in the average annual number of days with acceptable flows for whitewater boating during the July through September time period after implementation of the Proposed Project (i.e., 2 to 7 additional days per month on average; Appendix S, Table S-3 and Table S-6). However, under either the 2013 BiOp Flows or 2019 BiOp Flows, even though the bypass operations would cease and flows in the J.C. Boyle Bypass Reach would increase under the Proposed Project, the Keno Dam flow exceedance curves indicate that Upper Klamath River flows between July and September would remain below the minimum flow necessary for whitewater boating in this reach (i.e., 1,300 cfs) (Appendix S, Figure S-2). Accretions from groundwater springs in the J.C. Boyle Bypass Reach and tributaries would potentially result in flows greater than 1,300 cfs in July through September during very wet years under the Proposed Project (i.e., exceedance probability less than 5 percent; Appendix S, Figure S-2), but there would be no flow within the acceptable range for whitewater boating in this reach between July and September under most years (i.e., 95 percent of water years; Appendix S, Figure S-2) and the average annual number of days with acceptable flows for whitewater boating under the Proposed Project during July through September would be similar to the original model results for the No Project scenario (i.e., 0 days; Appendix S, Table S-6). However, the difference in the modeled number of days with acceptable flows under the KBRA Flows versus under 2013 BiOp Flows or the 2019 BiOp Flows does not represent an adverse impact for the Proposed Project because the 2013 BiOp Flows and the 2019 BiOp Flows after dam removal do not represent a change from existing conditions (the KBRA Flows represented a change from the existing conditions for the 2012 KHSA EIS/EIR analysis). Thus, there would be no impact on whitewater boating in the J.C. Boyle Bypass Reach during the high demand months of July through September under the Proposed Project.

In other months of the year, modeling done in 2012 under the KBRA Flows shows an increase or decrease in the average annual number of days with acceptable flows for whitewater boating after implementation of the Proposed Project (Appendix S, Table S-3 and Table S-6). Under the Proposed Project with the 2013 BiOp Flows or the 2019 BiOp Flows, there would be flow within the acceptable range for whitewater boating in the J.C. Boyle Bypass Reach in above average to wet water years. For example, in June, 2013 BiOp Flows would be within the acceptable range for whitewater boating between above average to wet water years (i.e., approximately 20 to 35 exceedance probability; Appendix S, Figure S-2) and 2019 BiOp Flows also would be within the acceptable range for whitewater boating between above average to wet water years (i.e., approximately 15 to 25 exceedance probability; Appendix S, Figure S-2). In October, 2013 BiOp Flows would exceed 1,300 cfs during wet water year types (i.e., exceedance probability less than approximately 8 percent; Appendix S, Figure S-2), and 2019 BiOp Flows also would exceed 1,300 cfs during wet water year types (i.e., exceedance probability less than approximately 5 percent; Appendix S, Figure S-2). Thus, there would be a potential increase in the number of days with acceptable flows for whitewater boating in the J.C. Boyle Bypass Reach outside of the current high demand months of July through September during wetter water year types under the Proposed Project compared to existing conditions, which would be potentially beneficial.

The Hell's Corner Reach is located partially in California and partially in Oregon. This stretch of river would be impacted by removal of the J.C. Boyle Dam, which is part of the Proposed Project and is located in Oregon. Since potential impacts to flows in the Hell's Corner Reach were brought up as an issue during the Lower Klamath Project scoping process, and because the impacts would also occur in California, a discussion and analysis is included in this EIR. Currently, the Hell's Corner Reach is the only Class IV+ rapids in the region with late summer flows. Whitewater rafters can boat on the Hell's Corner Reach from April through October due to hydroelectric peaking power and flows historically generated by J.C. Boyle Powerhouse to meet high power demand periods. This typically occurs for four hours, between 10 a.m. and 2 p.m. each day. It also happens approximately 15 to 20 days per month in July, August and September. Additionally, flow peaking occurs on a predictable schedule, which is highly favorable for commercial boating operations. The vast majority of rafting is performed by permitted commercial outfitters, due to the technical difficulty of the run and lack of access to scouting points. There are 10 outfitters, which take up to 200 clients down the river per day, primarily between July and September, and BLM has set an overall carrying capacity of 250 people per day on this stretch of river (DOI 2011).

In the Hell's Corner Reach, there would be loss of acceptable flows for whitewater boating opportunities with the Proposed Project under 2013 BiOp Flows or under the 2019 BiOp Flows as compared to existing conditions due to the loss of hydropower operations. The minimum flow necessary for whitewater boating in this reach is estimated to be between 1,000 cfs and 1,300 cfs. Klamath River flow in the high demand months of July to September are expected to remain below 1,000 cfs under the 2013 BiOp Flows except during very wet water years (i.e., exceedance probability less than 5 percent), and under the 2019 BiOp Flows except during wet and very wet water years (i.e., exceedance probability less than 10 percent), based on an evaluation of flow exceedance curves at Keno Dam (Appendix S, Figure S-4). Accretions from groundwater springs in the J.C. Boyle Bypass Reach and tributaries may cause some increase in the flow between Keno Dam and the Hell's Corner Reach, but the flow exceedance curve at Keno Dam is still expected to be representative of flow conditions within the Hell's Corner Reach under the Proposed Project with 2013 BiOp Flows or with 2019 BiOp Flows. Flow in the Hell's Corner Reach would be below the minimum flow necessary for whitewater boating between July and September during most water year types (i.e., 95 percent of water year types), eliminating most opportunities for whitewater boating during this time under the Proposed Project. During April through June and October, whitewater boating opportunities still would exist during some water year types under the Proposed Project, but there would be a significant reduction compared to existing conditions, especially during October when flows in the Hell's Corner Reach would only be greater than 1,000 cfs (i.e., the minimum for whitewater kayaking) during wetter water years (i.e., exceedance probability less than 30 percent) (Appendix S, Figure S-4).

There are a number of alternative rafting opportunities in the region that are available all summer, including the Klamath River downstream of Iron Gate Dam, Trinity River and Rogue River. However, due to the lower late summer flows, the higher-class rapids are not available, typically from July until the fall rains start. From spring through early summer, there are ample whitewater rafting opportunities for all skill levels in the region (see Table 3.20-3). However, whitewater boating opportunities within the Hell's Corner Reach would be significantly reduced or eliminated during July through October depending on the water year type.

The Proposed Project would result in the loss of a unique opportunity in the region to raft Class IV+ rapids for three months during the late summer and early fall. This would affect recreational rafters during that time, as well as 9 commercial outfitters (see also Section 3.20.2.2 *Klamath River-based Recreation*). However, the resource is not lost completely due to the following:

(1) alternative Class IV+ whitewater boating opportunities during other times of the year; and (2) ample alternative nearby rafting opportunities in the late summer, albeit with lower class ratings. However, the impact to whitewater boating opportunities in the Hell's Corner Reach (within the upper portion of the Hydroelectric Reach) would be significant and unavoidable.

Significance

No significant impact in the Middle and Lower Klamath River

Beneficial impact in the Copco No. 2 Bypass Reach (within the Hydroelectric Reach)

Significant and unavoidable impact in the Hell's Corner Reach (within the upper portion of the Hydroelectric Reach)

Potential Impact 3.20-6 Changes to or loss of other river-based recreation including fishing.

No significant impacts to river-based recreational facilities upstream of the Hydroelectric Reach would occur as a result of the Proposed Project, because any changes to flow and water quality would occur within and downstream of this reach. However, as discussed in Potential Impact 3.3-7 through 3.3-11 in Section 3.3.5.9 *Aquatic Resource Impacts*, removal of the dams would help eliminate barriers to volitional fish passage in the Klamath River upstream of the Lower Klamath Project, which would beneficially affect recreational fishing at these upstream locations.

In general, river-based recreational facilities downstream of the Hydroelectric Reach would not be physically affected by dam removal activities, since there would be little change to the 100-year floodplain extent under the Proposed Project (see also Potential Impacts 3.6-3 and 3.20-1). However, along the Middle Klamath River from Iron Gate Dam (RM 193.1) to the confluence with Humbug Creek (RM 174.0), the 100-year floodplain extent would change slightly due to dam removal and this would potentially impact existing recreational facilities. At the Blue Heron RV Park, the Fish Hook Restaurant (see Site "FS-2" in Appendix B: *Definite Plan – Appendix C, Figure 7.7-1 Sheet 1*) is within the 100-year floodplain extent under current conditions and would remain within the (altered) 100-year floodplain extent following dam removals. The R Ranch office at the Klamath Campground (see Site "FS-3" in Appendix B: *Definite Plan – Appendix C, Figure 7.7-1 Sheet 2*) is also within the 100-year floodplain extent under current conditions and would remain within the (altered) 100-year floodplain extent following dam removals. Thus, there would be no change or loss to these facilities under the Proposed Project. The Blue Heron RV Park office structure (see Site "FS-1" in Appendix B: *Definite Plan – Appendix C, Figure 7.7-1 Sheet 1*) is not within the 100-year floodplain extent under current conditions and would be within the (altered) 100-year floodplain extent following dam removals. While there would be an increased potential for flooding at this office structure, this would not represent an adverse change or loss of a recreational facility affecting a large area or substantial number of people and therefore impacts to recreation would be less than significant. In addition, the Proposed Project includes implementation of the Downstream Flood Control Project Component, as described in Section 2.7.8.4 *Downstream Flood Control* and in Appendix B: *Definite Plan.* Thus, under the Proposed Project, KRRC would move or elevate legally-established structures, where feasible, to reduce the risks of exposing people and/or structures to damage, loss, injury, or death involving flooding, which would further reduce the potential for flooding impacts to this structure.

Downstream of Humbug Creek (RM 174.0), there would be no significant effect on flood elevations (Potential Impact 3.6-3) and therefore there would be no impacts to river-based recreational facilities, including to the Klamath National Forest Tree of Heave Campground near the confluence of Humbug Creek (Figure 7.7-1 in Appendix B: *Definite Plan – Appendix C*).

Over the long term, removal of the Lower Klamath Project dams is also expected to result in water quality improvements within the Hydroelectric Reach and in the Middle and Lower Klamath River downstream of Iron Gate Dam (see Potential Impacts 3.2-1, 3.2-11, 3.2-12, and 3.2-13), which could improve visitor perceptions and attract a greater number of visitors to existing recreational facilities.

Dam removal activities are expected to result in long-term improvements in water quality, notably by decreased prevalence of microcystin toxin during summer phytoplankton blooms in the Lower Klamath Project reservoirs and in the Middle and Lower Klamath River. As discussed in Section 3.2.2.7 *Chlorophyll-a and Algal Toxins* and Section 3.20.2.4 *Wild and Scenic River Conditions*, microcystin toxin has been associated with public health risks for recreational bathing waters. Health warnings issued in 2005, 2007, 2008, 2009, 2010, 2012, 2013, 2014, 2016, and 2017 by the USEPA, the North Coast Regional Board, and other agencies warned recreation visitors to use caution due to the potential health effects of contact with waters containing elevated microcystin concentrations. In addition, 91 percent of recreational survey respondents indicated that water quality detracted from their experience at least a little within the Hell's Corner Reach (PacifiCorp 2004). These adverse effects related to water quality negatively influenced the quality of the recreational experience for visitors and also resulted in safety risks to the recreational visitors. As existing conditions for water-contact-based recreational activities are considered adverse due to water quality, improved water quality conditions would result in long-term beneficial effects.

As discussed in Section 3.3.5.9 *Aquatic Resource Impacts*, dam removal activities are anticipated to result in increased abundance of recreational fish species from increased access to suitable habitat, and improved habitat conditions. The increased fisheries populations and abundance would beneficially affect recreational fishing opportunities. More specifically, the increased abundance and extent would allow for enhanced fishing opportunities and could decrease the number of closures of entire fishing seasons over the long term. These effects on recreation-based fisheries would be long-term and beneficial.

The Proposed Project would improve river access and create new fishing opportunities in the Hydroelectric Reach through implementation of the Recreation Facilities Plan (see Potential Impact 3.20-2), which would benefit fishing opportunities in this area. Given negligible changes in flows and improvements in access, impacts in reaches downstream from Iron Gate Dam would be less than significant. There would be a reduction in length of time available for fishing in the Copco No. 2 Bypass Reach based on analysis of flows in the Klamath River under existing conditions and under the Proposed Project (see Appendix S for additional details), with the decrease in days with suitable flows for fishing primarily occurring during May (Table 3.20-6). In the Hell's Corner Reach there also would be a reduction in the availability of acceptable flows during April (see Appendix S for additional details); however, the potential impacts would be minor overall and outweighed by other beneficial effects (Figure 3.20-4).

Significance

No significant impact for the Middle Klamath River between Iron Gate Dam (RM 193.1) and Humbug Creek (RM 174.3)

Beneficial impact for the Hydroelectric Reach, the Middle Klamath River downstream of Humbug Creek (RM 174.3), and the Lower Klamath River

Potential Impact 3.20-7 Effects on Wild and Scenic River resources, designations, or eligibility for listing.

The following section provides an assessment of the effects of the Proposed Project on each of the four resources specified in the Wild and Scenic River Act Section 7(a) (i.e., scenery, recreation, fish, and wildlife river values). The evaluation criteria presented in Section 3.20.4.5 *Impact Analysis Approach* were used to assess the effects of the Proposed Project as compared with conditions present at the time of wild and scenic river designation or eligibility listing, as well as changes to the condition of the river since the time of the designation or eligibility listing that have affected its wild and scenic character.

California Klamath River Wild and Scenic River Segment

Scenery

The Proposed Project would eliminate the major sources of seasonal phytoplankton blooms to the Klamath River downstream of Iron Gate Dam (see also Section 3.4.2.3 *[Phytoplankton and Periphyton] Hydroelectric Reach,* Section 3.4.2.4 *[Phytoplankton and Periphyton] Middle and Lower Klamath River,* and Potential Impact 3.4-2), enhancing water appearance in the wild and scenic river segment of the Klamath River in California by eliminating or substantially reducing seasonal algal surface scums in the Middle and Lower Klamath River and increasing water clarity during summer low-flow periods.

As discussed in Potential Impact 3.2-3, drawdown of the reservoirs would result in short-term increases in turbidity (also expressed as suspended sediment concentration [SSCs]) downstream from the Lower Klamath Project reservoirs. Elevated turbidity would be most pronounced immediately downstream from Iron Gate Dam to Bogus Creek and it would become less noticeable farther downstream due to dilution from tributary flows entering the Klamath River. Modeling of SSCs during drawdown indicates SSCs would decrease to 60 to 70 percent of the initial value by Seiad Valley (RM 132.7) and to 40 percent of the initial value downstream of Orleans (approximately RM 59). Sediment jetting would occur during drawdown maximize erosion of accumulated sediments during this period and potentially reduce turbidity after drawdown concludes, and immediate revegetation would occur to further minimize the potential for prolonged increases in turbidity. Turbidity in the Klamath River is anticipated to flush through the system relatively quickly, but based on modeling of SSCs elevated turbidity is conservatively anticipated to occur for six to ten months following drawdown, with turbidity completely resuming natural background levels by the end of post-dam removal year 1 regardless of the water year type (USBR 2012a) (see Potential Impact 3.2-3 for more details). Although removal of the dams would result in increases in SSCs (Potential Impact 3.2-3) and decreased water clarity, the SSC increases would be short term and as such would not affect scenic value such that the long-term wild and scenic river designation or eligibility for listing would be compromised. In the long term, improved water appearance from on-river, in-river, and/or riverside viewpoints would improve the wild and scenic character of the Klamath River below the Lower Klamath Project.

With respect to periphyton colonization in the California Klamath wild and scenic river segment, although increased nutrient transport and recycling following dam removal could favor enhanced periphyton growth downstream from Iron Gate Dam, dam removal would also restore more frequent river sediment movement (Potential Impact 3.11-6) and increased flow variability during storm flow downstream of Iron Gate Dam, which could result in increased scouring of periphyton during late spring storm events (Potential Impact 3.4-5). 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 179.5), or the upper portion of the California Klamath River wild and scenic river segment. Although there would be negative water clarity impacts on scenic quality due to elevated SSCs during reservoir drawdown, the increases would be temporary and as such would not affect scenic value in a manner that would compromise the long-term wild and scenic river designation or eligibility for listing. Instead, the long-term effect of the Proposed Project would improve the scenic value of the California Klamath River wild and scenic river segment.

As discussed in Section 3.3.5.9 *Aquatic Resource Impacts*, removal of the Lower Klamath Project dams is expected to increase the long-term abundance, productivity, population spatial structure, and genetic diversity of fall-run Chinook salmon (Potential Impact 3.3-7), spring-run Chinook salmon (Potential Impact 3.3-8), coho salmon (Potential Impact 3.3-9), steelhead (Potential Impact 3.3-10) and Pacific Lamprey (Potential Impact 3.3-11) in the Klamath River. The expected restoration of the anadromous fish populations would largely be the result of the increased access to anadromous fish habitat within the Upper Klamath Basin, along with water quality improvements downstream from the Lower Klamath Project. The increased population of fish species and increased water clarity would improve scenic fish viewing value. Increased fish viewing would be most prominent during fish migration, spawning, or holding periods, when the fish concentrate at particular reaches, pools, riffles, and falls. Fish and wildlife viewing impacts to scenic quality would be long-term and beneficial for the California Klamath River wild and scenic river segment.

Specific effects on river-dependent wildlife populations and scenic viewing opportunities are unknown. As discussed in Section 3.5.5.5 [*Terrestrial Resources] Potential Impacts and Mitigation – Wildlife Corridors and Habitat Connectivity*, riparian habitat in the Iron Gate Dam to Shasta River reach of the California Klamath River wild and scenic river segment would potentially be improved by dam removal activities because proportional increases in wildlife presence related to the increase in abundance of anadromous fish in the river and scenic wildlife viewing are expected. Therefore, effects on river-dependent wildlife populations and scenic viewing opportunities would be long-term and beneficial.

Removal of the Lower Klamath Project may result in an increase in riparian vegetation immediately downstream from Iron Gate Dam due to more regular transport of riverbed sediments (Potential Impact 3.11-5) and sediment deposition that has the potential to create new surfaces for riparian plants to colonize (Potential Impact 3.5-5). Improved riparian vegetation would increase the presence and scenic variety of the vegetation within the Klamath River wild and scenic river segment in California and may result in long-term beneficial effects.

The California Klamath River wild and scenic river segment is downstream from the Lower Klamath Project; therefore, removal of the dams and associated facilities would not result in any changes to the overall landscape character in the designated segment of the river. However, as discussed above, water appearance in the wild and scenic river segment is expected to improve due to elimination or reduction of large seasonal phytoplankton blooms transported into the Middle and Lower Klamath River (Potential Impact 3.4-2), as is the quality of the riparian vegetation (Potential Impact 3.5-4). These improvements would result in a more natural landscape character for the California Klamath River wild and scenic river segment and result in a long-term positive scenic quality effect from both near river and distant viewpoints.

Recreation

During dam removal years 1 and 2, release of sediment deposits stored within the reservoir footprints could decrease the quality of and opportunity for water contact activities. However, initial reservoir drawdown would occur in the coldest high flow months of winter and early spring when recreation use of the Lower Klamath Project reservoirs is at its lowest. Further, the increases in SSCs (Potential Impact 3.2-3) and decreased water clarity during dam removal would be short term so these would not affect the scenic value in a manner that would compromise the long-term wild and scenic river designation or eligibility for listing. In the long term, dam removal activities would improve water quality and also improve water contact-based recreation activities. For the California Klamath River wild and scenic river segment, dam removal activities would not affect recreational activities access downstream from the dams, and dam removal activities would result in improved water quality downstream from the dams in the long term.

As discussed in Potential Impact 3.20-5, following removal of the dams, changes in the availability of flows within the acceptable flow ranges for whitewater boating and fishing opportunities would be negligible for the reaches downstream from Iron Gate Dam following dam removal. Whitewater boating opportunities under the Proposed Project with 2013 BiOp Flows or 2019 BiOp Flows would be similar to results previously modeled under the KBRA Flows downstream of Iron Gate Dam (see also Potential Impact 3.20-5 and Appendix S). Therefore, no adverse impacts to flow-related whitewater boating opportunities would occur for the California Klamath River wild and scenic river segment. Dam removal activities would also result in long-term improvements to water quality conditions over existing conditions. With improved water quality, the whitewater boating recreation experience would also improve. Therefore, long-term water quality-related whitewater boating impacts would be beneficial for the California Klamath River wild and scenic river segment.

As discussed in Potential Impact 3.20-6, removal of the Lower Klamath Project would not result in substantial increases or decreases in the number of days with acceptable flows for recreational fishing. However, as described in Potential Impacts 3.3-7 through 3.3-11, the geographic extent of the Klamath River fish habitat would be substantially expanded compared to existing conditions. Moreover, the long-term improvements to water quality conditions are expected to reduce fish disease and increase the likelihood of fish survival. Increased fish populations could result in expansion of fishing seasons or increases to quotas and bag limits. Thus, recreational fishing effects from implementing the

Proposed Project would be long-term and beneficial for the California Klamath River wild and scenic river segment.

There could be short-term impacts to recreational fishing during Lower Klamath Project reservoir drawdown. While it is not possible to accurately predict short-term deposition patterns in the mainstem Klamath River channel at a fine spatial scale (e.g., individual pools or other slack-water areas that may serve as fishing holes), general sediment transport and depositional patterns observed in the Klamath River and other analogous river channels indicate that dam-released sediment that may temporarily deposit in pools and other slack water areas (e.g., eddies) and at tributary confluences in the reach from Iron Gate Dam to Cottonwood Creek would be highly erodible during subsequent flow events, leading to a short residence time (i.e., likely one year or less except during dry years) (Potential Impact 3.11-5). Thus, the potential for clogged fishing holes or less accessible shorelines that are temporarily blocked by sediment deposits of limited extent would be short-term and as such would not affect recreational value in a manner that would compromise the long-term wild and scenic river designation or eligibility for listing.

Further, in the short term, new beaches and riparian areas may become established, increasing the variety of shoreline settings. Most of these effects would be temporary and many aspects of the wild and scenic river segment's recreation setting would be considerably improved in the long term once the Klamath River stabilizes. The improved water quality conditions following completion of drawdown activities would improve the recreational setting overall. With regard to public health, improved water quality, and in particular a reduction in the potential for seasonal exposure to high levels of algal toxins (greater than 8 μg/L microcystin) generated by nuisance blooms in the Lower Klamath Project reservoirs and transported into the Middle and Lower Klamath River (Potential Impact 3.2-12) would also reduce potential human health risks associated with water-contact-based activities. Therefore, effects on the recreational setting would be long term and beneficial for the California Klamath River wild and scenic river segment.

<u>Fisheries</u>
Following removal of the Lower Klamath Project, the Klamath River would return to a natural flow regime in the Middle Klamath River immediately downstream of Iron Gate Dam. Restoration of the natural flow regime and upstream sediment supply would improve water quality conditions, likely reducing the occurrence of myxozoan parasites (*Ceratomyxa shasta* and *Parvicapsula minibicornis*) that are known to negatively affect salmonids (see Potential Impact 3.3-10). Increased spawning gravel from upstream sources could enhance spawning habitat following dam removal. Restoring natural sediment mobility processes could also help scour periphyton (e.g., *Cladophora* spp.) (Potential Impact 3.4-5), and deposited sand and gravel would be a less favorable substrate for the periphyton because of greater particle mobility during high-flow events than the existing

armored substrate. A reduction in periphyton would reduce the habitat for the fish pathogen's alternate host (Section 3.3.5.5 *Fish Disease and Parasites*). Further, as discussed above, removal of the reservoirs would eliminate habitat for populations of blue-green algae that produce toxins that can result in acute and chronic effects on fish, including increased mortality, reduced fecundity, reduced feeding, and habitat avoidance (see Potential Impact 3.3-12). Thus, stream flow regime effects would be long term and beneficial for the California Klamath River wild and scenic river segment.

Removal of the Lower Klamath Project would improve water quality conditions over existing conditions. Following dam removal, the seasonal temperature regime downstream from Iron Gate Dam would be more suitable for salmon (see Potential Impact 3.2-2, Potential Impact 3.3-1, Potential Impact 3.3-6, Potential Impact 3.3-7, Potential Impact 3.3-8, Potential Impact 3.3-9, Potential Impact 3.3-10, and Potential Impact 3.3-11). Water temperature effects of dam removal would therefore be long-term and beneficial for the California Klamath River wild and scenic river segment.

As described in Potential Impact 3.11-5, the Proposed Project would restore natural sediment transport processes. Following the initial drawdown period and flushing of reservoir sediment downstream, aquatic habitat conditions would be expected to improve compared to existing conditions, in the long term. Therefore, effects on aquatic habitat conditions would be long-term and beneficial for the California Klamath River wild and scenic river segment.

As discussed in as described in Potential Impacts 3.3-7 through 3.3-11, dam removal would result in beneficial long-term effects on anadromous salmonids. Dam removal 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. While sediment released during dam removal could be sufficient to cause substantial smothering of spawning gravels, pool infilling, gill abrasion, and changes to holding and migration patterns in the Klamath River reaches immediately downstream of Iron Gate Dam, these impacts would be temporary, as sediment is expected to be flushed through the river system relatively quickly, and would not affect survivability of fish species in a manner that would compromise the long-term wild and scenic river designation or eligibility for listing. Removal of the Lower Klamath Project would also eliminate fish barriers and expand fish access to upstream spawning areas.

Removal of the Lower Klamath Project would improve conditions for native resident fish species, including culturally important fish species (e.g., Chinook salmon, coho salmon, steelhead, and lamprey), by restoring connectivity between the Lower and Upper Klamath River, and by returning a natural flow regime to the reaches where the reservoirs currently exist, thereby improving water quality (see Potential Impact 3.3-1, Potential Impact 3.3-4, Potential Impact

3.3-7, Potential Impact 3.3-8, Potential Impact 3.3-9, Potential Impact 3.3-10, Potential Impact 3.3-11, Potential Impact 3.3-12, and Potential Impact 3.3-21). Dam removal would also likely result in diminished non-native fish habitat and populations, reducing competition for space and resources with native resident fish (see Potential Impact 3.3-17). Therefore, effects on the conditions for native resident fish species, including species traditionally used and culturally important to Indian Tribes, would be beneficial and long term in the California Klamath River wild and scenic river segment.

<u>Wildlife</u>
Riparian vegetation in the California Klamath River wild and scenic river segment downstream from the Iron Gate Dam would benefit from dam removal activities In the long term, especially in the reach between the Iron Gate Dam and the Shasta River confluence (Potential Impact 3.5-4). Special status species that utilize riparian habitat, such as the willow flycatcher (Potential Impact 3.5-12) and Western pond turtle (Potential Impact 3.5-16) would benefit in the long term from successful riparian habitat recovery from Iron Gate Dam downstream to the Klamath River's confluence with the Shasta River.

In addition to improving riparian habitat, the Proposed Project would result in improvements in fish resources in the long term following dam removal, thus providing increased forage for wildlife species that depend upon fish as a food source. The area currently blocked by dams would provide additional available habitat for anadromous fish (see above discussion). Increased fish abundance would also create greater foraging opportunities for riparian and riverine species such as bald eagle, river otter, osprey and black bear (see also Potential Impact 3.5-24). Therefore, there would be a long-term, beneficial effect on habitat for special status species in the California Klamath River wild and scenic river segment. Because wildlife viewing is an important component of recreational opportunities within the Area of Analysis, impacts to recreation would also be long-term and beneficial.

<u>Summary</u>
Overall, dam removal activities under the Proposed Project that return the Middle and Lower Klamath River (i.e., downstream of Iron Gate Dam) to a more natural condition would result in long-term beneficial effects to this candidate wild and scenic river reach's free-flowing condition, water quality, scenic, wildlife, fishery, and recreation river values and the long-term wild and scenic river designation or eligibility for listing would be not be compromised.

Eligible and Suitable Wild and Scenic River Section on the Klamath River
In addition to the designated wild and scenic river segment, the Klamath River reach from the California-Oregon state line to the upstream end of Copco No. 1 Reservoir was found to be "eligible and suitable" for wild and scenic river designation, though it has not yet been designated into either the National or the State Wild and Scenic River System. The potential outstandingly remarkable

values include scenery, fisheries, wildlife, and recreation (whitewater boating and fishing). This candidate wild and scenic river reach is included in the Area of Analysis for recreation.

Short-term negative impacts on water quality, scenic, recreation, fishery, and wildlife river values would be likely to occur due to high SSCs anticipated during drawdown of the upstream J.C. Boyle Reservoir (see Potential Impact 3.2-3). Short-term impacts would also occur as a result of restricted access and use of river-based recreation facilities and opportunities within the Limits of Work during dam removal years 1 and 2. However, these temporary impacts would not affect river values in a manner that would compromise the long-term wild and scenic river eligibility for listing. In the long term, dam removal under the Proposed Project would eliminate hydropower peaking and return this section of the Hydroelectric Reach to a more natural condition than under existing conditions.

Overall, dam removal activities under the Proposed Project that return this section of the Hydroelectric Reach to a more natural condition would result in long-term beneficial effects to this candidate wild and scenic river reach's free-flowing condition, water quality, scenic, wildlife, fishery, and recreation river values and the long-term wild and scenic river designation or eligibility for listing would be not be compromised.

Significance

No significant impact in the short term for the designated California Klamath River wild and scenic river segment

No significant impact in the short term for the eligible and suitable California Klamath River wild and scenic river section

Beneficial in the long term for the designated California Klamath River wild and scenic river segment

Beneficial in the long term for the eligible and suitable California Klamath River wild and scenic river section

3.20.6 References

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3.21 Hazards and Hazardous Materials

Volume I Section 3.21 Hazards and Hazardous Materials, paragraph 1 on page 3-1029:

This section describes the environmental setting for hazards and hazardous materials, as well as potential environmental impacts and associated mitigation measures for the Proposed Project. The discussions in the following subsections focus primarily on the transport, use, and disposal of hazardous materials, school proximity to hazardous materials, contaminants and contaminated sites, nearby airports, emergency response plans, and wildfires. For information on chemicals and aquaculture drugs used in hatchery operations, please see Section 3.2.5 Water Quality – Potential Impacts and Mitigation Potential Impact 3.2-17.

Volume 1 Section 3.21.2.3 Hazards and Hazardous Materials – Environmental Setting – Contaminants/Contaminated Sites, paragraph 4 on page 3-1034:

The dams and hydroelectric facilities within the Proposed Project area may also include items such as transformers, batteries, bushings, oil storage tanks, bearing and hydraulic control system oils, lead bearings, soils or other material contaminated with lead from the use of lead-based paints or plumbing and 700 tons of creosote-treated wood in the wooden stave penstock at Copco No. 2 Dam, as well as wood utility poles (see also Appendix B: Definite Plan – Appendix O3).

Volume I Section 3.21.2.3 Hazards and Hazardous Materials – Environmental Setting – Contaminants/Contaminated Sites, paragraph 4 on page 3-1034:

Certain closed systems, such as transformer bushings, cannot be tested until time of disposal. Thus, small quantities of polychlorinated biphenyls (PCBs) may be present in hydraulic fluids, soils, and in transformers and other electrical equipment, including older fluorescent light fixtures. Old light switches may contain mercury. The dams and hydroelectric facilities within the Proposed Project area may also include items such as transformers, batteries, bushings, oil storage tanks, bearing and hydraulic control system oils, lead bearings, soils or other material contaminated with lead from the use of lead-based paints or plumbing and 700 tons of creosote-treated wood in the wooden stave penstock at Copco No. 2 Dam (see also Appendix B: *Definite Plan – Appendix O3*). ~~Phase 1 and Phase 2 Environmental Site Assessments are currently underway (Appendix B: *Definite Plan*).~~

Volume I Section 3.21.5 Hazards and Hazardous Materials – Potential Impacts and Mitigation – Potential Impact 3.21-1 Proposed construction-related activities *could result in substantial exposure to hazardous materials through the routine transport, use, or disposal of hazardous materials, paragraph 1 on page 3-1042 to paragraph 5 on 3-1045:*

Potential Impact 3.21-1 Proposed construction-related activities could result in substantial exposure to hazardous materials through the routine transport, use, or disposal of hazardous materials.

The Proposed Project would not result in the long term routine transport, use, or disposal of hazardous materials since the Proposed Project is the removal of existing dams and their associated hydroelectric facilities, and, once completed, the Proposed Project would not involve the continued use, transport or disposal of hazardous materials. However, in the short term, construction-related dam removal would involve routine transport, use, and disposal of general construction waste materials (e.g., concrete, rebar, building waste, power lines; see also Appendix B: *Definite Plan – Sections 5.3–5.5*) and some hazardous materials (e.g., treated lumber, asbestos, lead, PCBs, fuels, gases, etc.) would be encountered, used, transported and disposed of during those construction activities.

~~The Proposed Project Phase 1 Environmental Site Assessment for hazardous materials is underway but has not yet been completed. A Phase 2 Environmental Site Assessment for hazardous materials would be undertaken, as needed.~~ Existing information regarding hazardous waste associated with the Lower Klamath Project dams and its facilities indicates that creosote or other treated wood is present, including 700 tons of treated wood waste from the wooden-stave penstock at Copco No. 2 Dam, wood utility poles, as well as batteries, possible PCBs from transformers and other electrical equipment, asbestos-containing materials in building materials, fuels and oils, flammable and combustible liquids, flammable and nonflammable gases, corrosives, concrete dust (if it generates high pH waste), and soils or other material contaminated with lead from the use of lead-based paints or plumbing (see additional detail in Appendix B: *Definite Plan – Appendix O3*). On December 30, 2019, the State Water Board received a submittal from PacifiCorp (PacifiCorp 2019a), which included redacted versions of Phase I and Phase II reports (KRRC 2019f, g, h, i, j, k, l, m, n, and o). As noted in the submittal, these reports included the following.

Phase I Environmental Site Assessments (ESA) documents

- Phase I ESA for the Lower Klamath Hydroelectric Project, Dated August 23, 2019
- Phase I ESA for the City of Yreka Diversion Dam, Dated July 10,2019
- Phase I ESA for the Fall Creek Hatchery, Dated July 10,2019

Phase II documents consisting of a series of Hazardous Building Materials Survey (HMBS) reports and a single Phase 2 ESA

- J.C. Boyle Development, HBMS Revision I , Dated August 27, 2019

- Copco No. I Development, HBMS Revision I , Dated August 22, 2019
- Copco No. 2 Development, HBMS Revision 1, Dated August 22, 2019 Iron Gate Development, HBMS Revision 1, Dated August 22, 2019
- Iron Gate Hatchery and Fall Creek Hatchery, HBMS Revision I , Dated August 22, 2019
- City of Yreka Diversion Dam, HBMS Revision l, Dated August 27, 2019
- Iron Gate Hatchery Burn Pit, Phase II ESA, Dated September 13,2019

These redacted reports disclosed the potential for certain types of hazardous materials (e.g., asbestos, heavy metals, polychlorinated biphenyls (PCBs), creosote-treated wood) at the various facilities, consistent with information in the Definite Plan, Appendix O-3 Hazardous Materials Management Plan.

Demolition and disposal of structures containing the aforementioned hazardous materials, ~~or~~ as well as others determined as part of Phase ~~1~~I and Phase II investigations ~~(and Phase 2, as needed)~~, under the Proposed Project could result in exposure to quantities of hazardous, or acutely hazardous, materials that would be harmful to the public or the environment due to accidental releases and thus could result in a significant impact. Operation of construction equipment in close proximity to aquatic environments could involve equipment failures that would also result in the public or the environment being exposed to hazardous materials due to petroleum spills. Because the Proposed Project is located in a sensitive environment (i.e., along the Klamath River) and consists of substantial demolition activities, the increased amount of construction-related activity relative to existing conditions would increase the risk of exposing the public or the environment to quantities of hazardous, or acutely hazardous, materials that would be harmful. This would be a significant impact.

The Proposed Project includes an assessment of roads, intersections, bridges and culverts (Appendix B: *Definite Plan – Appendix K*) within the Area of Analysis for hazards and hazardous materials and proposes a number of improvements to help reduce the potential for accidental release of hazardous materials during transport of these materials to and from the dam sites. The proposed replacements and upgrades to transportation structures, as well as proposed construction-related traffic management, including signage, flaggers, and traffic coordination (Appendix B: *Definite Plan – Appendix O2*), would reduce the risk of traffic accidents that could result in exposure to quantities of hazardous, or acutely hazardous, materials that would be harmful to the public or the environment.

Further, existing federal and state regulations require the KRRC and its construction contractors to undertake a number of measures related to hazardous materials. KRRC is developing a dam safety program that would ensure that removal of the Proposed Project would be undertaken in a manner that minimizes risk to people, structures, infrastructure, and the natural resources of the Klamath River Basin (Appendix B: *Definite Plan – Section 3*). Such removal would fully comply with FERC's dam safety requirements, and it would be consistent with FERC Engineering Guidelines (FERC 2017). In addition, the below list of state and federal regulations include requiring, for example, that the KRRC and its contractors keep an inventory of hazardous materials at each dam facility and the intention for final disposition of these materials. The KRRC and its contractors are required to describe the storage, spill prevention, and cleanup measures, including the deployment and maintenance of spill cleanup materials and equipment at each facility/site to contain any spill from Proposed Project activities. Onsite containment for storage of chemicals classified as hazardous is required to be away from watercourses and include secondary containment and appropriate management as specified in California Code of Regulations, Title 27, Section 20320.

The KRRC and its contractors are also required to comply with the terms and conditions in the State Water Board's *National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities* (Construction General Permit; State Water Board Order 2009-0009-DWQ, as amended by State Water Board Orders 2010-0014-DWQ and 2012-0006-DWQ), and ongoing amendments during the life of the Proposed Project.), Hazardous materials, substances, and waste within the Area of Analysis for hazards and hazardous substances are regulated by several other federal and state laws and policies, some of which are listed below. Compliance with required regulations would substantially minimize the potential impact of hazardous materials on the public and the environment during the routine transport, use, or disposal of hazardous materials. <u>The following represent some of the many regulations for which activities would be subject.</u>

Federal Regulations

- Resource Conservation and Recovery Act (42 USC 6901 et seq.)
- Hazardous Materials Transportation Act (49 USC Section 1801 et seq.)
- Clean Water Act (33 USC 1251 et seq.)
- Comprehensive Environmental Response Compensation and Liability Act and
- Superfund Amendment Reauthorization Act (SARA) (43 USC 9601 et seq.)
- 0 CFR 260-279 Federal Regulations on hazardous waste management
- 40 CFR 301 et seq. Emergency Planning and Community Right to Know Act
- Toxic Substances Control Act (15 USC 2601 et seq.)
- <u>National Emissions Standards for Hazardous Air pollutants (NESHAP) 40 CFR Part 61</u>
- <u>Occupational Safety and Health Standards (29 CFR 1910)</u>
- <u>Environmental Protection Agency Protection of the Environment (40 CFR Part 761-PCBs)</u>

State Regulations

- California Hazardous Waste Control Law (California Health and Safety Code [HSC] Section 25500 et seq.)
- Carpenter-Presley-Tanner Hazardous Substances Account Act (HSC Section 25300 et seq.)
- Unified Hazardous Waste and Hazardous Materials Management Regulatory Program (HSC Section 25404 et seq.)
- Cal/OSHA Regulations (CCR Title 8)
- Environmental Health Standards for the Management of Hazardous Waste (CCR Title 22 Division 4.5)

The Proposed Project also includes Appendix B: *Definite Plan – Appendix O3 Hazardous Materials Management Plan*. The Hazardous Materials Management Plan states that all hazardous materials removed within the Project Boundary would be either returned to the vendor, recycled, or managed and disposed of as hazardous waste at an approved hazardous waste facility in accordance with applicable regulations. Transformer oils would be tested for PCBs if no data exist. Any tanks that contain hazardous materials would be decontaminated prior to disposal. Universal hazardous waste (e.g., lighting ballasts, mercury switches, and batteries) would be handled per applicable federal and state universal waste regulations. The Hazardous Materials Management Plan notes that any additional hazardous materials noted during the Phase ~~1~~I site visits and Phase ~~2~~II investigations would be included in an updated Hazardous Materials Management Plan and the contractor would sample and test for asbestos, lead and PCB's at all structures to be removed. The Hazardous Materials Management Plan is required to comply with, among other regulations, California Health and Safety Code, title 27, division 20, chapter 6.95, sections 25500 through 25545, and California Code of Regulations title 19, division 2, chapter 4.

Overseeing development and implementation of the Final Hazardous Materials Management Plan falls within the scope of the State Water Board's water quality certification authority. While the KRRC has stated its intention to be consistent with the water quality certification from California, at this time the Hazardous Materials Management Plan is not finalized. Therefore, implementation of Mitigation Measure HZ-1 is required to reduce the short-term, construction-related risk of exposing the public and/or the environment to harmful quantities of hazardous, or acutely hazardous, materials during their transport, use, and disposal under the Proposed Project to less than significant.

Mitigation Measure HZ-1 − Hazardous Materials Management.
No later than six months following issuance of the FERC license surrender order, and prior to the start of pre-dam removal activities and any construction activities, the KRRC shall submit a Final Hazardous Materials Management Plan ~~(Final Hazardous Materials Management Plan)~~ to the State Water Board Deputy

Director for review and approval. The State Water Board has authority to review and approve any final Hazardous Materials Management Plan through its water quality certification under Clean Water Act Section 401. The State Water Board has issued a draft water quality certification[171] which sets forth monitoring and adaptive management requirements for any Hazardous Materials Management Plan to meet~~, as Condition 11~~. Additionally, the Oregon Department of Environmental Quality has issued a water quality certification[172] that sets forth water quality monitoring and adaptive management conditions for points upstream of California.

Footnotes:
[171] The State Water Board's draft water quality certification is available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_dwqc.pdf (Accessed December 19, 2018).
[172] The Oregon Department of Environmental Quality's final water quality certification is available online at: https://www.oregon.gov/deq/FilterDocs/ferc14803final.pdf (Accessed December 21, 2018).

Consistent with the above, the Final Hazardous Materials Management Plan shall include any modifications to the proposed Hazardous Materials Management Plan developed in coordination with State Water Board staff that provide the same or better level of protection regarding procedures for proper disposal or abatement of hazardous materials encountered during Proposed Project activities; proper storage, containment, and response to spills caused by the Proposed Project; and proper removal and disposal of septic tanks as part of the Proposed Project.

The Final Hazardous Materials Management Plan shall also describe how the elements of the KRRC's proposed Health and Safety Plan (Appendix B: *Definite Plan – Appendix O4*), the Spill Prevention, Control, and Countermeasure Plan (Appendix B: *Definite Plan – Appendix O4*), the Emergency Response Plan (Appendix B: *Definite Plan – Appendix O4*), and the Traffic Management Plan (Appendix B: *Definite Plan – Appendix O2*) are coordinated together, and as such, adequately protect water quality with respect to hazardous materials management. <u>The Final Hazardous Materials Management Plan shall meet the monitoring and adaptive management requirements described in the final water quality certification.</u>

The KRRC shall implement the Final Hazardous Materials Management Plan upon receipt of State Water Board Deputy Director approval and any changes to the Hazardous Materials Management Plan must be approved by the State Water Board Deputy Director prior to implementation.

The KRRC shall provide monthly reporting to the State Water Board detailing the volumes of hazardous materials and wastes that were cleaned up and disposed of from site construction activities and any other modifications to the proposed Hazardous Materials Management Plan developed in coordination with State Water Board staff.

Significance
No significant impact with mitigation

Volume I Section 3.21.5 Hazards and Hazardous Materials – Potential Impacts and Mitigation – Potential Impact 3.21-4 The Proposed Project could be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, could result in substantial exposure to hazardous materials, paragraph 6 on page 3-1046:

Potential Impact 3.21-4 The Proposed Project could be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, could result in substantial exposure to hazardous materials.
The Proposed Project is not located on a site which is currently included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5. However, ~~no Phase 1 or 2 reports have been submitted to make the determination of whether portions of the Proposed Project Area should be included on the lists.~~ ~~T~~the type of use and activities and the length of time these activities have been occurring within the Proposed Project Area suggest the possibility that contaminated sites/soils exist on site. On December 30, 2019, the State Water Board received a submittal from PacifiCorp (PacifiCorp 2019a), which included redacted versions of Phase I and Phase II reports (KRRC 2019f, g, h, i, j, k, l, m, n, and o). As noted in the submittal, these reports included the following.

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- Iron Gate Hatchery and Fall Creek Hatchery, HBMS Revision I , Dated August 22, 2019
- City of Yreka Diversion Dam, HBMS Revision I, Dated August 27, 2019
- Iron Gate Hatchery Burn Pit, Phase II ESA, Dated September 13,2019

These redacted reports disclosed the potential for certain types of hazardous materials (e.g., asbestos, heavy metals, polychlorinated biphenyls (PCBs), creosote-treated wood) at the various facilities, consistent with information in the Definite Plan, Appendix O-3 Hazardous Materials Management Plan. ~~Therefore, the risk remains that contaminants exist on the site that could result in a substantial exposure that would be harmful to the public or the environment. The Proposed Project could also result in a significant impact if the project involved activity in areas that contained contaminated substances that would result in substantial exposure to the public or the environment. Crucial to this analysis would be the analysis of what contaminants exist on the site. This is typically ascertained by completion of a Phase 1 Environmental Analysis and, when necessary, a follow up with a Phase 2 Environmental Analysis.~~

Volume I Section 3.21.5 Hazards and Hazardous Materials – Potential Impacts and Mitigation – Potential Impact 3.21-4 The Proposed Project could be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, could result in substantial exposure to hazardous materials, paragraph 3 on page 3-1047:

In addition to the measures included in the Proposed Project, Mitigation Measure HZ-1 would be necessary to ensure that adherence to existing regulations are included in contractor bid documents. ~~This includes that the findings of the Phase 1 and Phase 2 Environmental Site Assessment reports would need to be added to the Hazardous Materials Management Plan and Health and Safety Plan.~~ With implementation of Mitigation Measure HZ-1, potential impacts due to exposure to hazardous materials during the proposed construction-related activities would be less than significant.

Volume I Section 3.21.5 Hazards and Hazardous Materials – Potential Impacts and Mitigation – Potential Impact 3.21-7 Proposed construction-related activities could impair implementation of, or physically interfere with, an adopted emergency response plan or emergency evacuation plan, paragraph 3 on page 3-1049.

The draft Traffic Management Plan (Appendix B: *Definite Plan − Appendix O2)* further notes that the KRRC's contractor would perform a risk assessment of all intersections and roadways as part of the final Traffic Management Plan. Implementation of ~~Recommended~~ Mitigation Measure TR-1 would require additional components beyond those listed as part of the Proposed Project (i.e., the final versions of the Traffic Management Plan and Emergency Response Plan) and these components would be necessary to adequately implement an

Emergency Response Plan that addresses short-term construction-related impacts, consisting of an increase in traffic on narrow rural roads from commuting workers, hauling of large equipment and disposal of wastes, to the point that the potential impact would be less than significant.

~~Overseeing development and implementation of the final Traffic Management Plan and Emergency Response Plan, including measures described in Recommended Measure TR-1, does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has stated its intention to reach enforceable good citizen agreements that will be finalized and implemented, at this time the Traffic Management Plan and Emergency Response Plan are not finalized and the State Water Board cannot require their implementation. Accordingly, t~~The State Water Board anticipates that implementation of the final Traffic Management Plan and Emergency Response Plan, including the aforementioned additional details in ~~Recommended~~ Mitigation Measure TR-1 and any modifications developed through the FERC process that provide the same or better level of protection for transportation and traffic would reduce impacts to a less than significant level. ~~However, because the State Water Board cannot ensure implementation of the final Traffic Management Plan and Emergency Response Plan, it has determined the impact in this Draft EIR to be significant and unavoidable.~~

Significance

~~Significant and unavoidable impact~~ No significant impact with mitigation

Volume I Section 3.21.5 Hazards and Hazardous Materials – Potential Impacts and Mitigation – Potential Impact 3.21-8 Proposed construction-related activities and/or removal of the Lower Klamath Project reservoirs could substantially increase the public's risk of loss, injury, or death associated with wildland fires, new paragraph 4 on page 3-1050:

KRRC's application for water quality certification of the Proposed Project, as submitted to the State Water Board in December 2019 (KRRC 2019a), includes the following additional information about the Fire Management Plan:

- "KRRC intends to avoid a material net increase of fire risk as compared to baseline conditions in the Project area as defined in the Definite Plan."
- "KRRC is developing an updated Fire Management Plan that will include effective and feasible strategies and concepts to enhance both short-term and long-term fire prevention, detection, and suppression in the Klamath River Basin, and will submit the updated Fire Management Plan with FERC in support of the pending surrender application."
- "The updated Fire Management Plan is being developed in consultation with federal, California, Oregon, and local fire agencies. During construction, these measures include, but are not limited to meeting or exceeding federal, Oregon, and California requirements for fire prevention and suppression during construction activities, implementation of best

management practices following National Fire Protection Association standards, and the designation of a safety officer on site that is responsible for overseeing fire responsibilities for construction operations 24 hours a day, seven days a week. The Fire Management Plan will also address long-term fire management to ensure that the Klamath River Basin's fire-fighting resources are not diminished due to the implementation of the Project, including the potential deployment of technology that will rapidly detect wildfire ignitions in the Basin allowing fire agencies to respond quickly to fire ignitions. KRRC is also consulting with fire agencies on identifying replacement water sources and access, including identification of aerial river access points."

- "In addition, KRRC has also contracted with Reax, a leading fire engineering firm that has assisted utilities throughout California (including PacifiCorp) to reduce operational fire risk. Reax will assist KRRC with the development of the updated Fire Management Plan to ensure that the measures set forth in the updated Fire Management Plan will effectively reduce short- and long-term fire risk as a result of the implementation of the Project".

Volume I Section 3.21.5 Hazards and Hazardous Materials – Potential Impacts and Mitigation Potential Impact 3.21-8, new paragraphs 2 and 3 on page 3-1051:

In their comment letter on the Draft EIR dated February 25, 2019 (please refer to comment SA4-1), CALFIRE notes *"…It is fair to say the possible impacts of the dam removal on firefighting would depend on a variety of factors including: Location of fire, type of fire, fire behavior, firefighting resources assigned to the fire, time of year when the fire occurs, the water flow of the Klamath River on the day of the fire, etc…. Ultimately the impact of the dam removals will have to be evaluated on a case by case basis. CAL FIRE is used to fighting wildland fires in a large variety of circumstances and will adapt to whatever conditions we encounter at each fire. Also CAL FIRE understands that the …(KRRC) will be working with CAL FIRE on KRRC's Fire Management Plan to address the analyzed issues."*

In its comment letter on the Draft EIR, dated February 26, 2019 (please refer to comment ORG 47-3), KRRC states *"As a condition of license surrender, KRRC will address any potential increased response time and associated wildland fire risk due to implementation of the Proposed Project."* KRRC further states *"KRRC continues to work with CAL FIRE to identify not only replacement sources of water, but ways in which KRRC can facilitate the reduction of overall emergency response times through communications and roadway improvements."* KRRC goes on to describe specific steps that it would take to implement replacement sources and reduce overall emergency response times under the Proposed Project.

3.21.6 References

Volume I Section 3.21.6 Hazards and Hazardous Materials – References, pages 3-1054 through 3-1055, includes the following revisions:

KRRC. 2019a. Request for section 401 water quality certification; application for surrender of license for major project and removal of project works; FERC Project No. 2082-063 and 14803-001 (Lower Klamath Project). Prepared by KRRC, Berkeley, California for State Water Resource Control Board, Sacramento, California.

KRRC. 2019f. Klamath River Renewal Project: Phase I Environmental Site Assessment for the Lower Klamath Hydroelectric Project. Dated August 23, 2019. Prepared by AECOM Technical Services, INC., Oakland, California and CDM Smith, Portland, Oregon for Klamath River Renewal Corporation.

KRRC. 2019g. 2019. Klamath River Renewal Project: Phase I Environmental Site Assessment for the City of Yreka Diversion Dam. Dated July 10,2019. Prepared by AECOM Technical Services, INC., Oakland, California and CDM Smith, Portland, Oregon for Klamath River Renewal Corporation.

KRRC. 2019h. Klamath River Renewal Project: Phase I Environmental Site Assessment for the Fall Creek Hatchery. Dated July 10, 2019. Prepared by AECOM Technical Services, INC., Oakland, California and CDM Smith, Portland, Oregon for Klamath River Renewal Corporation.

KRRC. 2019i. Klamath River Renewal Project: J.C. Boyle Development, Hazardous Building Materials Survey Revision I. Dated August 27, 2019. Prepared by AECOM Technical Services, INC., Oakland, California and CDM Smith, Portland, Oregon for Klamath River Renewal Corporation.

KRRC. 2019j. Klamath River Renewal Project: Copco No.1 Development, Hazardous Building Materials Survey Revision I. Dated August 22, 2019. Prepared by AECOM Technical Services, INC., Oakland, California and CDM Smith, Portland, Oregon for Klamath River Renewal Corporation.

KRRC. 2019k. Klamath River Renewal Project: Copco No.2 Development, Hazardous Building Materials Survey Revision 1. Dated August 22, 2019. Prepared by AECOM Technical Services, INC., Oakland, California and CDM Smith, Portland, Oregon for Klamath River Renewal Corporation.

KRRC. 2019l. Klamath River Renewal Project: Iron Gate Development, Hazardous Building Materials Survey Revision 1. Dated August 22, 2019. Prepared by AECOM Technical Services, INC., Oakland, California and CDM Smith, Portland, Oregon for Klamath River Renewal Corporation.

KRRC. 2019m. Klamath River Renewal Project: Iron Gate and Fall Creek Hatchery, Hazardous Building Materials Survey Revision I. Dated August 22, 2019. Prepared by AECOM Technical Services, INC., Oakland, California and CDM Smith, Portland, Oregon for Klamath River Renewal Corporation.

KRRC. 2019n. Klamath River Renewal Project: City of Yreka Diversion Dam, Hazardous Building Materials Survey Revision I. Dated August 27, 2019. Prepared by AECOM Technical Services, INC., Oakland, California and CDM Smith, Portland, Oregon for Klamath River Renewal Corporation.

KRRC. 2019o. Klamath River Renewal Project: Burn Pit at Iron Gate Hatchery, Phase II Soil Investigation. Dated September 13, 2019. Prepared by AECOM Technical Services, INC., Oakland, California and CDM Smith, Portland, Oregon for Klamath River Renewal Corporation.

PacifiCorp, 2019a. December 30, 2019 Letter to State Water Resources Control Board, RE: Response to the State Water Resources Control Board's November 15, 2019 Letter Requesting the Phase 1 and 2 Environmental Site Assessment Reports.

Other references cited as part of text included in the Section 3.21 list of revisions:

FERC (Federal Energy Regulatory Commission). 2017. Engineering Guidelines for the Evaluation of Hydropower Projects. Available at: https://www.ferc.gov/industries/hydropower/safety/guidelines/eng-guide.asp. [Accessed December 2018].

3.22 Transportation and Traffic

Volume I Section 3.22.2.1 Transportation and Traffic – Environmental Setting – Traffic Flow – Roadways – Copco Road, paragraph 4 on page 3-1060:

Copco Road is a paved, two-lane road in generally good pavement condition between I-5 and Ager Road with few pavement cracks or ruts and is approximately 32 ~~27~~ feet wide.

Volume I Section 3.22.2.3 Transportation and Traffic – Environmental Setting – Road Conditions – Road and Bridge Improvement/Replacements, paragraph 5 on page 3-1063:

- Access Road from Long Gulch Recreational Facility to Lakeview Road - some road surface rehabilitation during construction.
- ~~Access Road from Overlook Point Recreational Facility to Copco Road - some road surface rehabilitation during construction.~~

Volume I Section 3.22.4 Transportation and Traffic – Impact Analysis Approach, paragraph 3 on page 3-1068:

In addition, the major goal and objective of the Land Use and Circulation element of the County's general plan is "to protect the county's critical natural resources and still allow room for adequate growth and development. The Proposed Project would not conflict with the measures set forth in the Regional Transportation Plan or with the goal and objective of the Land Use and Circulation element of the County's general plan. ~~The Regional Transportation Plan does not contain measures or programs that would conflict with the Proposed Project in a manner that would adversely affect the environment.~~

Volume I Section 3.22.5 Transportation and Traffic – Potential Impacts and Mitigation Potential Impact 3.22-1 and Potential Impact 3.22-2, paragraph 2 on page 3-1070:

Recreational use trips associated with recreation at areas within the Area of Analysis other than Copco No. 1 and Iron Gate reservoirs may still occur during construction periods, but because Copco No. 1 and Iron Gate facilities would be closed, it is expected that continued recreational use traffic would be dispersed away from the immediate vicinity of Copco No. 1 and Iron Gate and would not overlap with construction traffic. Additional discussion of alternative recreational opportunities is described in Section 3.20 *Recreation*. However non-reservoir-related traffic could still occur within the Area of Analysis and, while numbers of such traffic are unknown, when coinciding with peak construction activity, could result in potential conflicts on Copco Road, especially when considering large RV's and oversized construction equipment.

Volume I Section 3.22.5 Transportation and Traffic – Potential Impacts and Mitigation Potential Impact 3.22-1 and Potential Impact 3.22-2, Table 3.22-6 Vehicle Trips (VT) for the Import/Export of Materials for the Proposed Project on page 3-1071:

Table 3.22-6. Vehicle Trips (VT) for the Import/Export of Materials for the Proposed Project.*

Dam	Estimated VT Imported	Estimated VT Exported	Total VT	Peak Duration	VT per Day
Copco No. 1	1,720	706	2,426	7 months	~~15~~ 12
Copco No. 2	Included in Copco No. 1 VT estimates	1,928	1,928+	6 months	~~14~~ 11
Iron Gate	380	746	1,126	4 months	~~12~~ 9
J.C. Boyle	200	1,024	1,224	4 months	~~13~~ 10

* VT numbers consider both full and empty returns. VT per Day is calculated by dividing Total VT by peak duration divided by an average 30-day month. Numbers rounded.

Source: Appendix B: *Definite Plan – Section 5, revised (S. Leonard, AECOM as KRRC Technical Representative, pers. comm., November 2018).*

Volume I Section 3.22.5 Transportation and Traffic – Potential Impacts and Mitigation Potential Impact 3.22-1 and Potential Impact 3.22-2, paragraph 1 on page 3-1071:

As noted in Section 3.22.2.1 *Traffic Flow*, the two major roads used for access would be Interstate 5 and Copco Road. Copco Road has an ADT of 485 and a LOS A capacity of 1300 ADT. Adding ~~391~~ 392 ADT from both worker trips (350 ADT) and waste movement (~~41~~ 42 ADT), Copco Road would remain at a LOS A. Likewise for Interstate 5, with an AADT of 20,900 and LOS A capacity of 25,400 AADT, there is sufficient capacity for added traffic (~~391~~ 392 ADT) to keep the LOS level at LOS A. These short-term additional trips would cease after the Proposed Project is completed.

Volume I Section 3.22.5 Transportation and Traffic – Potential Impacts and Mitigation Potential Impact 3.22-1 and Potential Impact 3.22-2, paragraph 1 on page 3-1072:

Finally, as noted above, the Proposed Project ~~would~~ is not in conflict with the measures or programs set forth in the Regional Transportation Plan or with the goals and objectives of the Land Use and Circulation elements of the County's general plan. ~~does not contain measures or programs that would conflict with the Proposed Project in a manner that would adversely affect the environment.~~

Volume I Section 3.22.5 Transportation and Traffic – Potential Impacts and Mitigation Potential Impact 3.22-1 and Potential Impact 3.22-2, paragraph 5 on page 3-1072 through paragraph 1 on page 3-1074:

~~It would be appropriate for the recommended~~ In its comments on the Draft EIR (ORG46) and in its application for water quality certification filed on December 3, 2019, the KRRC provided additional standards and commitments regarding the Traffic Management Plan. The terms and conditions relating to traffic and transportation in the final Traffic Management Plan and Emergency Response Plan ~~to~~ will provide implementation details consistent with all applicable regulatory permit requirements including the latest version of the Caltrans California Manual on Uniform Traffic Control Devices (Caltrans 2018b) and will be coordinated with the noted agencies (Caltrans, Siskiyou County, California Highway Patrol, CALFIRE, and other emergency response agencies) as part of the detailed design phase and prior to start of construction. ~~Recommended~~ Mitigation Measure TR-1 includes additional and feasible components beyond those listed as part of the Proposed Project that would reduce potential short-term construction-related impacts on performance of the circulation system and congestion. ~~However, overseeing development and implementation of the final Traffic Management Plan and Emergency Response Plan does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has stated its intention to reach enforceable "good citizen" agreements that will be finalized and implemented, at this time the Traffic Management Plan and Emergency Response Plan are not finalized and the State Water Board cannot require their implementation. Accordingly, t~~The State Water Board anticipates that implementation of the final Traffic Management Plan and Emergency Response Plan, including the aforementioned additional details and any modifications developed through the FERC process that provide the same or better level of protection for transportation and traffic, would be expected to ensure that impacts are lowered to less than significant. ~~Because the State Water Board cannot ensure the Traffic Management Plan's and Emergency Response Plan's implementation, it has determined the impact in this Draft EIR to be significant and unavoidable.~~

~~Recommended~~ Mitigation Measure TR-1 – Transportation and Traffic.

A. The KRRC and/or its contractor(s) shall develop a final Traffic Management Plan that provides:

1. Implementation details consistent with all applicable regulatory requirements including the latest version of the Caltrans California Manual on Uniform Traffic Control Devices (MUTCD, Caltrans 2018b), Caltrans Traffic Management Plan (TMP) Guidelines, Oregon Department of Transportation (ODOT) Oregon Supplement to the MUTCD, Federal Highway Administration MUTCD, ODOT Traffic Control Plans Design Manual, and ODOT TMP Project Level Guidance Manual. ~~and coordination~~KRRC will coordinate with the noted agencies (Caltrans, ODOT, Siskiyou and Klamath County Public Works and Sheriff's Departments, California Highway Patrol and Oregon State Police, CALFIRE, Oregon Department of Forestry [ODF] Fire Division, and other emergency response agencies) as part of the detailed design phase and prior to start of construction. Potential

conflicts with bicycle and pedestrian use, as well as transit and school bus service, need to be addressed in the Traffic Management Plan. The final version of the Traffic Management Plan, after coordination with the above referenced agencies, shall be received by the State Water Board prior to the start of construction.

2. Each road, bridge, and culvert improvement project included in the Proposed Project, or any other road, bridge, or culvert improvement project that is identified as necessary for the Proposed Project, shall be constructed consistent with the latest version of the Caltrans Highway Design Manual (Caltrans 2018c<u>), Caltrans Standard Plans, Caltrans Standard Specifications, or ODOT Highway Design Manual, ODOT, Standard Drawings and Standard Details, and ODOT Standard Specifications,</u> or equivalent, and shall not conflict with any applicable plan, ordinance, or policy regarding performance of the transportation system, traffic safety and/or congestion management within the Area of Analysis. Construction shall not begin until all final designs for road, bridge, and culvert improvement projects included in the Proposed Project have been received and approved, as necessary, by the county and other responsible agencies.
3. The KRRC shall be responsible for repairing and/or rehabilitating any Siskiyou County roadways within the traffic and transportation Area of Analysis that are damaged or otherwise adversely impacted by Proposed Project activities, such that they are in a condition equal to or better than they were before dam removal activities.

B. The KRRC and/or its construction contractor(s) shall develop an Emergency Response Plan with details and procedures to be put in place to help prevent incidents, to ensure preparedness in the event incidents occur, and to provide a systematic and orderly response to emergencies through coordination with emergency response agencies, as described in Appendix B: *Definite Plan − Appendix O4*.

<u>Significance</u>

~~Significant and unavoidable impact~~ *<u>No significant impact with mitigation</u>*

Volume I Section 3.22.5 Transportation and Traffic – Potential Impacts and Mitigation Potential Impact 3.22-3, paragraph 2 on page 3-1074:

Roads, bridges, and culverts in the transportation and traffic Area of Analysis currently serve rural residential and extensive recreational uses (Section 3.22.2.3 *Road Conditions*). Some of the roadways originally may have been built for the construction of the Lower Klamath Project dams and appear to have served adequately for that purpose. However, the existing conditions of the roadways and other infrastructure are not adequate for all of the construction activities included in the Proposed Project, as described in Appendix B: *Definite Plan − Appendix K*. As described in Impacts 3.22-1 and 3.22.-2, the improvements may include five bridges (two of them over the Klamath River) that need to be replaced: four bridges for construction purposes, and one bridge post-construction because it is built on reservoir sediment. There are 13 or more culverts that need replacement. As described in Appendix B: *Definite Plan − Appendix K,* there are portions of 20.3 miles of road that would need partial road improvements. Some descriptions note that sections of roads are in poor condition but no improvements are proposed. These sections of roads may not be up to a standard for the transportation of construction equipment, adequate for emergency response, or in a condition adequate for future use after dam removal activities have been completed; however, as described in Appendix B: *Definite Plan − Appendix K*, there will be pavement rehabilitation as part of the proposed Project, which will address the deficiencies in the existing road conditions to the extent necessary.

Volume I Section 3.22.5 Transportation and Traffic – Potential Impacts and Mitigation Potential Impact 3.22-3, paragraph 4 on page 3-1074:

Implementation of ~~Recommended~~ Mitigation Measure TR-1 ~~would~~ requires additional components beyond those listed as part of the Proposed Project ~~(i.e., the final versions of the Traffic Management Plan and Emergency Response Plan)~~ and these components ~~would be~~ are necessary to reduce potential traffic and transportation hazards due to a design feature or incompatible uses to a less than significant level. ~~Overseeing development and implementation of the final Traffic Management Plan and Emergency Response Plan, including measures described in Recommended Measure TR-1, does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has stated its intention to reach enforceable "good citizen" agreements that will be finalized and implemented, at this time the Traffic Management Plan and Emergency Response Plan are not finalized and the State Water Board cannot require their implementation. Accordingly, t~~The State Water Board anticipates that implementation of the final Traffic Management Plan and Emergency Response Plan, including the aforementioned additional details in ~~Recommended~~ Mitigation Measure TR-1 and any modifications developed through the FERC process that provide the same or better level of protection for transportation and traffic, would be expected to ensure that impacts to less than significant. ~~However, because the State Water Board cannot ensure implementation of the final Traffic Management Plan and Emergency Response Plan, it has determined the impact in this Draft EIR to be significant and unavoidable.~~

Significance

~~Significant and unavoidable impact~~ *No significant impact with mitigation*

Volume I Section 3.22.5 Transportation and Traffic – Potential Impacts and Mitigation Potential Impact 3.22-4, paragraph 3 on page 3-1075:

The Proposed Project includes an Emergency Response Plan that addresses transportation-related emergency concerns (e.g., emergency access and response), while a final Emergency Response Plan, with additional details, would be required from the construction contractor (Appendix B: *Definite Plan − Appendix O4*). The Proposed Project considers how emergency access and response would be provided during the time of construction activity and how it would be coordinated with the contractor's Health and Safety Plan, Spill Prevention and Response Plan and Fire Management Plan. (Appendix B: *Definite Plan − Appendices O1 through O4*.) Emergency response is also discussed in Section 3.17 *Public Services* and Section 3.21 *Hazards and Hazardous Materials*, which address impacts related to emergency response providers as well as the risk of increased hazards such as wildfires and adequate access for abating wildland fires. Implementation of ~~Recommended~~ <u>Mitigation</u> Measure TR-1 ~~would~~ require<u>s</u> additional details and procedures to be put in place to help prevent incidents, to ensure preparedness in the event incidents occur, and to provide a systematic and orderly response to emergencies through coordination with emergency response agencies, as described in Appendix B: *Definite Plan − Appendix O4*, which would render potential traffic and transportation impacts of the Proposed Project to levels similar to baseline conditions. However, because wildfires can spread at a rapid speed and involve high risks, any amount of additional response time compared with existing conditions could result in a substantial increased risk of loss, injury, or death involving wildland fires and this would be a significant impact.

~~Overseeing development and implementation of the final Emergency Response Plan, including the aforementioned additional details in Recommended Measure TR-1, does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has stated its intention to reach enforceable "good citizen" agreements that will be finalized and implemented, at this time the Emergency Response Plan is not finalized and the State Water Board cannot require its implementation. Accordingly, t~~<u>T</u>he State Water Board anticipates that implementation of the final Emergency Response Plan, including the aforementioned additional details in ~~Recommended~~ <u>Mitigation</u> Measure TR-1 and any modifications developed through the FERC process that provide the same or better level of protection for transportation and traffic, would reduce impacts to <u>a</u> less than significant <u>level.</u> ~~Since the State Water Board cannot ensure the Emergency Response Plan's implementation, it has determined the impact in this Draft EIR to be significant and unavoidable.~~

<u>Significance</u>

~~Significant and unavoidable impact~~ *<u>No significant impact with mitigation</u>*

Volume I Section 3.22.5 Transportation and Traffic – Potential Impacts and Mitigation Potential Impact 3.22-5, paragraph 1 on page 3-1077:

If an unacceptable level of risk to non-motorized users is deemed to persist, KRRC's contractor will arrange appropriate detours to allow safe and adequate continued movement for such users ~~to allow continued movement for such users~~ (Appendix B: *Definite Plan – Appendix O2*).

Volume I Section 3.22.5 Transportation and Traffic – Potential Impacts and Mitigation Potential Impact 3.22-5, paragraphs 2 and 3 on page 3-1077:

~~It would be appropriate for the recommended~~ The terms and conditions relating to traffic and transportation ~~to~~ will include ~~Recommended~~ Mitigation Measure TR-1 as part of the detailed design phase and prior to start of construction. ~~Recommended~~ Mitigation Measure TR-1 includes additional components beyond those listed as part of the Proposed Project and would ensure that potential short-term construction-related impacts on the safety of all users of the roadways within the Area of Analysis would be less than significant.

~~Overseeing development and implementation of the final Traffic Management Plan does not fall within the scope of the State Water Board's water quality certification authority. While the KRRC has stated its intention to reach enforceable "good citizen" agreements that will be finalized and implemented, at this time the Traffic Management Plan is not finalized and the State Water Board cannot require its implementation. Accordingly, t~~The State Water Board anticipates that implementation of the final Traffic Management Plan, including any modifications developed through the FERC process that provide the same or better level of protection for Transportation and Traffic resource, would reduce impacts to a less than significant level. ~~However, because the State Water Board cannot ensure the Traffic Management Plan's implementation, it has determined the impact in this Draft EIR to be significant and unavoidable.~~

Significance

~~Significant and unavoidable impact~~ *No significant impact with mitigation*

3.22.6 References

Volume I Section 3.22.6 Transportation and Traffic – References, page 3-1078, includes the following revisions:

Caltrans. 2019. California Manual on Uniform Traffic Control Devices (CA MUTCD, 2014, Revision 4 (2019). Available at: http://www.dot.ca.gov/trafficops/camutcd/. [Accessed January 2020]

Other references cited as part of text included in the Section 3.22 list of revisions:

Caltrans. 2018b. California Manual on Uniform Traffic Control Devices (CA MUTCD, 2014, Revision 3 (2018). Available at: http://www.dot.ca.gov/trafficops/camutcd/. [Accessed January 2020]

Caltrans. 2018c. Highway Design Manual, Sixth Edition. Available at: http://www.dot.ca.gov/design/manuals/hdm.html. [Accessed January 2020].

3.23 Noise

3.23.4 Impact Analysis Approach

Volume I Section 3.23.4 Noise – Impact Analysis Approach, paragraph 6 on page 3-1091:

Minor changes in proposed construction activities between the 2012 EIS/EIR analysis and the Proposed Project are primarily due to the timing associated with removing Iron Gate Dam, Copco No. 1 Dam, and Copco No. 2 Dam, and incorporation of road, bridge, and culvert improvement activities into the Proposed Project, some of which could occur outside of the peak construction period for dam removal (see Section 2.7 Proposed Project).

3.23.5 Potential Impacts and Mitigation

Volume I Section 3.23.5 Noise – Potential Impacts and Mitigation, paragraph 3 on page 3-1093:

While sporadic activities would occur throughout these periods and are analyzed herein, the ~~following analysis is~~ noise and vibration impact modeling results are focused on the six-month period during the peak of the construction-related activity, when the three California dams would be removed.

Volume I Section 3.23.5 Noise – Potential Impacts and Mitigation – Potential Impact 3.23-1 Use of standard construction equipment could exceed Siskiyou County General Plan criteria for maximum allowable noise levels from construction equipment, paragraph 5 on page 3-1093:

Given the maximum allowable noise levels identified in the Siskiyou County General Plan Noise Element (Siskiyou County 1978), any use of dozers, jackhammers, and/or tractors during the Proposed Project, whether during the six-month peak of construction activities (i.e., dam and powerhouse removal), and/or during pre- or post-dam removal construction activities (i.e., hatchery modifications; road, bridge, and culvert improvement activities; recreation area facilities removal; City of Yreka water supply pipeline replacement), would constitute an exceedance of County maximum allowable noise levels and this would be a significant impact.

Volume I Section 3.23.5 Noise – Potential Impacts and Mitigation – Potential Impact 3.23-1 Use of standard construction equipment could exceed Siskiyou County General Plan criteria for maximum allowable noise levels from construction equipment, paragraph 1 on page 3-1094:

Therefore, this impact would be significant and unavoidable for construction-related activities that would use dozers, jackhammers, and/or tractors.

3.23.6 References

References cited as part of text included in the Section 3.23 list of revisions:

Siskiyou County. 1978. Siskiyou County General Plan Noise Element.

3.24 Cumulative Effects

3.24.1 Introduction

3.24.1.1 Analysis Approach

Volume I Section 3.24.1.1 Cumulative Effects – Introduction – Analysis Approach, paragraph 5 on page 3-1103:

We note that the existing conditions analyses include~~d~~ consideration of the NMFS and USFWS 2013 Joint Biological Opinion (2013 BiOp) flow requirements for the USBR Klamath Irrigation Project (NMFS and USFWS 2013), which served as the operational flow requirement for the Klamath River at the time of the Notice of Preparation for the Lower Klamath Project EIR (i.e., December 22, 2016), as well as the flows specified in the NMFS and USFWS 2019 biological opinions (2019 BiOp) for the USBR Klamath Irrigation Project (NMFS 2019; USFWS 2019), which are the current operational flow requirement for the Klamath River (see 3.1.6 *Introduction – Summary of Available Hydrology Information for the Proposed Project*). ~~but t~~The cumulative effects analysis considers the ~~additional~~ court-ordered winter-spring surface flushing flows and deep flushing flows, as well as emergency dilution flows, that ~~became~~ were a requirement ~~in~~ between February 2017 and March 2019 (U.S. District Court 2017). Additionally, measures PacifiCorp has committed to undertake as part of the KHSA upon certain triggers related to implementation of the Proposed Project are considered in this cumulative effects' analysis.

Volume I Section 3.24.1.1 Cumulative Effects – Introduction – Analysis Approach, Table 3.24-1. List of Planned, Approved, or Reasonably Foreseeable Projects (Plus Wildfires) that Would Potentially Result in Related or Cumulative Effects When Combined with the Proposed Project (prepared September 2018), on pages 3-1106 to 3-1146 [note that only rows with modifications and their headers have been included below]:

Table 3.24-1. List of Planned, Approved, or Reasonably Foreseeable Projects (Plus Wildfires) that Would Potentially Result in Related or Cumulative Effects When Combined with the Proposed Project (prepared September 2018, with minor modifications made in October 2019).

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
Riverine Restoration Projects					
National Fish and Wildlife Foundation	Klamath Basin Restoration Program~~—current applicants include Combined PacifiCorp, Klamath River Coho Enhancement Fund and USBR, Klamath River Coho Habitat Restoration Program~~2018 grants issued to: Lower Scott Valley Stream Habitat Restoration: Phase 2; Water Dedication Development in the Scott River Basin; Reducing Road Sourced Sediment Loading for Scott River Tributaries on EcoTrust Lands; Lower Bear Creek Stream and Floodplain Habitat Enhancement to Benefit Native Salmonids; South Fork Scott River Floodplain Restoration and Increased Habitat Complexity for Coho Salmon;	Klamath Basin	Grants have been~~advertised in 2018, soon to be~~ announced	NFWF 2018	https://www.nfwf.org/klamathbasin/Documents/2018grantslate.pdf~~https://www.nfwf.org/klamathbasin/Pages/2018rfp.aspx~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
	Reduce Entrainment of Native Fishes through Installation of Fish Screens on the Wood River; Channel Reconnection and Water Transfer to Restore Threemile and Crane Creek Critical Habitat; Scott River Beaver Dam Analogues: Implementation, Monitoring and Passage Assessment; Water Quality and Fisheries Habitat Restoration for Anadromous Fish in Blue Creek; Enhancing and Protecting Water for Salmon through Voluntary Dedications in the Shasta River Basin; Upper Sycan Bull Trout Critical Habitat Preservation; Water Transactions to Benefit Chinook Salmon and Support the Shasta River Water Transaction Program; Creating and Restoring Off-Channel and Side Channel Habitat along Humbug and Seiad Creeks; Upper Sprague Riparian Protection and Enhancement to Improve Water Quality for Native Fish; and Increase Habitat Complexity in the Wood River and Sprague River to Benefit Native Fish				

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
PacifiCorp	Coho Enhancement Fund: PacifiCorp has agreed to make annual payments of $510,000 into the Coho Enhancement Fund for each year that the permit (authorizing the potential incidental take of SONCC coho salmon) is in effect even though PacifiCorp has already made payments of $510,000 per year into the Coho Enhancement Fund for 2009, 2010, 2011 and 2012	Klamath Basin	2009–2020	PacifiCorp 2012 (pp. 141–142)	https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/hydro/klamath-river/habitat-conservation-plans/KR_Coho_HCP_Feb162012Final.pdf~~http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Hydro/Hydro_Licensing/Klamath_River/KR_Coho_HCP_Feb162012Final.pdf~~
California Department of Transportation, District 2–Northeastern California	Fort Goff Creek Fish Passage Improvement—prevent entrainment of fish into an existing water diversion ditch where they could be injured or killed over a two-acre project area; conserve water for the benefit of salmon and steelhead trout in Fort Goff Creek and the Klamath River	Fort Goff Creek, Siskiyou County, CA; water diversion/fish exclusion structure will be constructed at same site as current water diversion, which is at RM	Funded in 2012; on hold 2018	USDA Forest Service 2018a	https://www.fs.fed.us/sopa/components/reports/sopa-110505-2018-04.pdf ~~https://www.fs.fed.us/sopa/components/reports/sopa-110505-2018-04.pdf~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
		0.6 on Fort Goff Creek			
Karuk Tribe, Fisheries Department	Lower Seiad Creek Channel Restoration—restoration of 4,000 lineal feet of stream; also known as part of the Klamath River Riparian Habitat Restoration—part of the Klamath River Coho Enhancement Fund (2010-0500-015)	Seiad Creek intersection with the Klamath River, CA	2015–2018	NFWF 2016b	https://www.nfwf.org/klamathriver/Documents/krcef_2015_totalprojects.pdf
Yurok Tribe	Restoring Off-Estuary Habitat in Hoppaw Creek, Klamath River—rearing habitat for natal and non-natal juvenile Coho salmon in an off-estuary tributary of the Klamath River; restoration effectiveness will be assessed; part of the Klamath River Coho Enhancement Fund (2010-0500-020)	Hoppaw Creek is a 3rd order stream that enters the Klamath River 2.6 miles upstream of the Pacific Ocean, Del Norte County, CA	Funded in 2013; ongoing in 2016	NFWF 2016b~~NFWF 2016~~	https://www.nfwf.org/klamathriver/Documents/krcef_2015_totalprojects.pdf
PacifiCorp	Gravel Enhancement below Iron Gate Dam for Coho Salmon–gravel augmentation program is to be implemented in the Klamath River downstream of Iron Gate dam to improve coho spawning and rearing habitat	Iron Gate Dam	Funded in 2014; gravel placed in 2014, 2016, and 2017	NFWF 2016b~~NFWF 2016~~	https://www.nfwf.org/klamathriver/Documents/krcef_2015_totalprojects.pdf

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
Terrestrial Resource Management, Conservation and Restoration					
California Wildlife Conservation Board	Climate Adaptation and Resiliency Program—created by AB109; program funds are to be used for climate adaptation and resiliency projects that will result in enduring benefits to wildlife, including: grants for the acquisition of perpetual conservation easements and long-term conservation agreements; natural and working lands adaptation and resiliency planning	CA	Applications closed August 2018	CAWCB 2018a~~b~~	https://www.wcb.ca.gov/Programs/Climate-Adaptation
Water Flow and Water Quality Resource Management Projects					
U.S. Bureau of Reclamation, National Marine Fisheries Service (NMFS), and U.S. Fish and Wildlife Service	Re-consultation of the 2013 Joint Biological Opinion Flows (2013 BiOp Flows) for the Klamath Irrigation Project, including the 2017 court-ordered flushing and emergency dilution flows	Klamath River dams and downstream reaches	From the Court Order on February 8, 2017 until March 31, 2019, after which the 2019 BiOp Flows became the new	U.S. District Court 2017	https://www.govinfo.gov/content/pkg/USCOURTS-cand-3_16-cv-04294/pdf/USCOURTS-cand-3_16-cv-04294-7.pdf

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
			operational standard for the Klamath River		
California Natural Resources Agency	The Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1) authorizes $7.545 billion in general obligation bonds to fund ecosystems and watershed protection and restoration, water supply infrastructure projects, including surface and groundwater storage, and drinking water protection	CA wide	In progress since 2014	California Natural Resources Agency ~~2015~~2018	http://bondaccountability.resources.ca.gov/p1.aspx
California Wildlife Conservation Board	Proposition 1 Stream Flow Enhancement Program—Proposition 1 authorized the Legislature to appropriate $200 million to the Wildlife Conservation Board (WCB) to administer the California Stream Flow Enhancement Program (Program). The Program awards grant funding on a competitive basis to projects representing the mission of the WCB, and address the three goals of the California Water Action Plan: reliability, restoration, and resilience	CA	Applications for the 2018 Proposal Solicitation Notice and Application closed September 2018; projects must be complete by 2023	CAWCB 2018b~~a~~	https://www.wcb.ca.gov/Programs/Stream-Flow-Enhancement

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
California Wildlife Conservation Board (California Stream Flow Enhancement Program FY 2016/17)	Hart Ranch Instream Flow Enhancement—proposal is to consider the allocation for an implementation grant to California Trout (CalTrout) for a cooperative project with United States Fish and Wildlife Service (USFWS), Natural Resources Conservation Service (NRCS), The Nature Conservancy (TNC), and UC Davis Center for Watershed Sciences to dedicate instream, through a California Water Code section 1707 transfer, 1.5 cfs of cold water to the Little Shasta River through a combination of on-farm efficiency savings and voluntary flow contributions, located on privately-owned land six miles east of Montague in Siskiyou County	Little Shasta River, six miles east of Montague, Siskiyou County	In planning phase, 2017	CalTrout ~~2017~~2018	https://caltrout.org/2017/03/caltrout-receives-grants-fish-passage-improvement-projects/
California Department of Water Resources	Sustainable Groundwater Management Act (SGMA)—high and medium priority basins are required to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge	CA	Signed in 2014, currently in progress	DWR 2019~~8~~	https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management
Siskiyou County	In Siskiyou County, Butte Valley, Shasta Valley, and Scott River Valley, as well as the Tulelake sub-	Butte Valley, Shasta Valley, Scott River Valley, and	Signed in 2014, currently in progress	Siskiyou County 2015a,b	https://www.co.siskiyou.ca.us/sites/default/files/fileattachments/board_of_supervisors/meeting/1

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
	basin, are designated as medium priority basins under SGMA	Tulelake sub-basin, Siskiyou County, CA			2671/bos_20151013_minutes.pdf~~https://www.co.siskiyou.ca.us/sites/default/files/public_docs/PLN-20151013_BOS-MEMO_ReSGMA-Update_v1002_WithAttachments.pdf~~
Scott River Water Trust	Emergency Stream Augmentation for the Scott River—to benefit salmon	French Creek, Miners Creek, and the mainstem Scott River	Funded in 2014	NFWF 2016b	https://www.nfwf.org/klamathriver/Documents/krcef_2015_totalprojects.pdf
Scott River Water Trust	Improving Streamflow for Coho Salmon in the Scott River	Scott River sub-basin, CA	Funded in 2010	NFWF 2016b	https://www.nfwf.org/klamathriver/Documents/krcef_2015_totalprojects.pdf
Montague Water Conservation District	MWCD-Shasta River Flow Enhancement Project	The southern portion of the Shasta River watershed, centered near Dwinnell Reservoir in Siskiyou County, CA	Funded in 2013	NFWF 2016b	https://www.nfwf.org/klamathriver/Documents/krcef_2015_totalprojects.pdf
City of Yreka (partly funded by a Flood Hazard Reduction grant	City of Yreka 2016 Greenway Master Plan and Flood Hazard Reduction Project—includes:	Yreka Creek and other	~~In planning phase,~~	City of Yreka 2016	http://www.ci.yreka.ca.us/DocumentCenter/View/693/2016-Greenway-

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
from the California Department of Water Resources)	enhancing fish habitat, recreational opportunities, educational opportunities, improved law enforcement and public security, Coho recovery, flood hazard reduction, water quality improvement, stormwater management in small tributaries, trail system expansion and linkages, widening of Yreka Creek, excavations adjacent to Yreka Creek, overflow floodwater channels, removing soils from the floodway, expanding greenway corridors	streams, Yreka, CA	~~2016~~Final EIR, 2017		Master-Plan-Environmental-Impact-Report-PDF ~~https://ci.yreka.ca.us/sites/ci.yreka.ca.us/assets/files/_Yreka_2016_Greenway_Master_Plan_DEIR.pdf~~
IM1 – Interim Measures Implementation Committee (IMIC)	The IMIC is comprised of representatives from PacifiCorp, other parties to the KHSA (as amended on November 30, 2016), and non-signatory representatives from the State Water Board and Regional Water Board (see KHSA Appendix B, Section 3.2). The purpose of the IMIC is to advise on implementation of the Non-Interim Conservation Plan Interim Measures set forth in Appendix D of the Amended KHSA.	CA and OR	~~Ongoing~~ Would not continue and cease to exist when KHSA is fully implemented	KHSA 2016	https://www.doi.gov/sites/doi.gov/files/uploads/FINAL%20KHSA%20PDF.pdf

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, Klamath Water Users Association, irrigation districts, Oregon Department of Environmental Quality, North Coast Regional Water Quality Control Board	Klamath Watershed ~~Stewardship~~ Partnership works with landowners, agencies, and other partners to conserve, enhance, and restore natural resources of the Klamath Basin through education, consultation, ~~and~~ restoration, and planning. ~~Various water quality improvement projects and practices are generally implemented in the Upper Klamath River, Lower Klamath Lake, Lost River, Klamath Irrigation Project~~	OR	Ongoing	KWP 2018	https://www.klamathpartnership.org/~~http://www.klamathpartnership.org/programs.html~~
Wildfire					
CAL_FIRE	2016 Fires in CA—Old, Moffett, Gap, Grade, Tully, Summit, Stafford, Table, Bailey, Pony, and Mill Fires; Acres burned: Del Norte (105 acres), Humboldt (768 acres), Siskiyou (844 acres), Trinity (4 acres)	CA	2016	CAL_FIRE 2016	https://www.fire.ca.gov/incidents/2016/ ~~http://cdfdata.fire.ca.gov/incidents/incidents_archived?archive_year=2016&pc=20&cp=1~~
ODF	2016 Fires in OR—5,661-acre Withers Fire northeast of Klamath Falls	OR	2016	ODF 2016	https://www.oregon.gov/ODF/Documents/Fire/2016_Protection_Division_Fire_Season_Report.pdf ~~https://www.OR.gov/ODF/Documents/Fire/2016~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
					~~_Protection_Division_Fire_Season_Report.pdf~~
~~CALFire~~CAL FIRE	2017 Fires in CA—Miller Complex, Eclipse, Young, and Orleans Fires	CA	2017	~~CALFIRE~~CAL FIRE 2017	https://www.fire.ca.gov/incidents/2017/ ~~http://cdfdata.fire.ca.gov/incidents/incidents_archived?archive_year=2017~~
~~CALFire~~CAL FIRE	2018 Fires in CA—Mill Creek 1, Natchez, Klamathon, Watson Creek, Iron Gate, Cherry, Steamboat, Lott, Johnson, Petersburg, Meamber, Martin, Grape, Ager, and Shastina Fires	CA	2018	CAL_FIRE 2018	http://www.fire.ca.gov/current_incidents
ODF	2018 Fires in OR—Watson Creek Fire in OR	OR	2018	ODF 2018	https://www.oregon.gov/ODF/Documents/AboutODF/KlamathLakeDistrictAnnualReport.pdf ~~http://wildfireORdeptofforestry.blogspot.com/2018/08/watch-out-for-watson-creek-fire.html~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
Forest and Wildfire Management Projects					
USDA Forest Service—Klamath National Forest (Federal Lands)	Crawford Vegetation Management Project—thinning in stands for forest health and fuels reduction, with fuel treatments, including under-burning and pile burning on about 1,600 acres; Water Board Waiver Category B	Happy Camp Ranger District, Klamath National Forest	In progress; implementation expected in 2019	USDA Forest Service 2018a; Elberlien 2018	https://www.fs.fed.us/sopa/components/reports/sopa-110505-2018-04.pdf
USDA Forest Service—Klamath National Forest (Federal Lands)	Steamboat Oak Habitat Improvement—fuels reduction and oak woodland habitat improvement and retention for improved defensible space adjacent to the CAL_FIRE Deadwood Camp, improved wildlife habitat, increased fire resiliency, and overall forest health over an area of 45.5 acres	Scott River Ranger District, Klamath National Forest; 5 miles north of Fort Jones, CA, Siskiyou County; located on the ridge between Soares and Steamboat Gulch adjacent to the ~~CALFIRE~~CAL FIRE Deadwood Camp in the	In planning phase, 2018; expected implementation 2018	USDA Forest Service 2018a	https://www.fs.fed.us/sopa/components/reports/sopa-110505-2018-04.pdf

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
		McAdams Creek Drainage			
USDA Forest Service—Klamath National Forest (Federal Lands)	Somes Bar Integrated Fire Management—remove fuels prior to prescribed burning in plantations 40 years and older, and mature natural stands while enhancing cultural and ecological plant species; shaded fuel breaks are proposed, and temporary roads are considered on a case by case basis over a project area of 5,570 acres	Scott River Ranger District, Klamath National Forest	In planning phase, 2018	USDA Forest Service 2018a; USDA Forest Service 2018c	https://www.fs.fed.us/sopa/components/reports/sopa-110505-2018-04.pdf
TCRCD	California Fire Safe Council CWPP Implementation Phase I: OR Mountain area of Weaverville—mechanical chipping and thinning over 1.2 miles of roadside shaded break; 50 acres completed to date	OR Mountain area of Weaverville, including OR St and Dutch Ln	Work initiated in 2017	TCRCD 2019~~8b~~	http://www.tcrcd.net/index.php/2014-02-05-08-30-03/forest-health
Cannabis Cultivation Projects					
City of Yreka	A City Council-initiated Ordinance entitled "Non-Medical Marijuana Cultivation Regulation and the Prohibition of Commercial Cannabis Activity, Manufacture, Testing, Dispensing, Sales, Distribution and Delivery within all Zoning Districts in the City of Yreka" (note that indoor	City of Yreka limits	Adopted, 2017	Yreka Planning Commission 2017	http://www.ci.yreka.ca.us/AgendaCenter/ViewFile/Agenda/_07192017-43 ~~http://ci.yreka.ca.us/sites/ci.yreka.ca.us/assets/files/P_C_Mintues_7_19_17.pdf~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
	cultivation is regulated, not prohibited)				
Other Agricultural and Rural Residential Projects					
Siskiyou County, Agritourism Technical Advisory Committee, Planning	AG1, AG2, and RR Zoning Modifications for Agritourism	Siskiyou County, CA	In planning phase, 2018	Siskiyou County 2018a	https://www.co.siskiyou.ca.us/sites/default/files/fileattachments/planning_commission/page/1881/tac_20180606_agritourismtacresolution_signed20180517.pdf ~~https://www.co.siskiyou.ca.us/sites/default/files/public_docs/TAC_20180606_AgritourismTACResolution_Signed20180517.pdf~~
Siskiyou County, Multispecies Livestock Technical Advisory Group, Planning	AG1, AG2, and RR Zoning Modifications to allow certain pastured hog and poultry operations	Siskiyou County, CA	In planning phase, 2018	Siskiyou County 2018b	https://www.co.siskiyou.ca.us/sites/default/files/fileattachments/planning_commission/page/1881/tac_20180606_multispeciestacresolution_signed20180517.pdf ~~https://www.co.siskiyou.ca.us/sites/default/files/public_docs/TAC_20180606_MultispeciesTAC~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
					~~Resolution_Signed20180517.pdf~~
JH Ranch; planning processing by Siskiyou County	Planned Development (PD) Plan Amendment for JH Ranch—increase the amount of land in the existing PD District from 79 acres to 201 acres, and modify the PD to accommodate existing operations; retain existing maximum capacity of 482 persons; retain and renovate guest cabins, tent-like cabins, staff cabins, homes, and bunk cabins	French Creek Road, Siskiyou County	In planning phase, 2016	Siskiyou County 2018c	https://www.co.siskiyou.ca.us/community-development/page/jh-ranch-project ~~https://www.co.siskiyou.ca.us/content/planning-division-jh-ranch-documentation~~
Kidder Creek Orchard; planning processing by Siskiyou County	Kidder Creek Orchard Camp Zone Change and Use Permit—rezoning 170 acres from Timberland Production District to Rural Residential Agricultural (40-acre minimum parcel size); increase of allowable camp occupancy from 165 to 844; increase of physical camp size from 333 acres to 580 acres; structures, recreation features, a pond, and ancillary activities	South Kidder Creek Road, 2 miles west of SH 3, south of Greenview in the Scott Valley, Siskiyou County	In planning phase, 2018	Siskiyou County2018d	https://www.co.siskiyou.ca.us/community-development/page/kidder-creek-orchard-camp ~~https://www.co.siskiyou.ca.us/content/planning-kidder-creek-orchard-camp~~
Grady Padgett	Cannaworx Zone Change—rezone 44 acres from Open Space to Non-Prime Agricultural, Initial Study / Mitigated Negative Declaration	21635 Walker Road, 11 miles southwest of Yreka, Klamath River,	Adopted, 2018	Siskiyou County 2018e; CEQAnet 2019	https://ceqanet.opr.ca.gov/2018052063~~https://www.co.siskiyou.ca.us/sites/default/files/public_docs/PLN-~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
		Siskiyou County, CA			~~20180525_Z1505_CannaworxNOA_NOI.pdf~~
Gary Black	Grenada Irrigation District, Huseman Relocation Instream Phase	Shasta River, CA	Funded in 2010	NFWF 2016b	https://www.nfwf.org/klamathriver/Documents/krcef_2015_totalprojects.pdf
Mining and Mining Withdrawal Projects					
USDA Forest Service—Klamath National Forest (Federal Lands)	Brooks Mine—existing Brooks mining claim with a new plan of operations over an area of 20 acres; mining using backhoe, 2.5-cubic-yard dump truck, grizzly, and trammel; opening existing road to new extraction site; Water Board Waiver Category A	Happy Camp Ranger District, Klamath National Forest; near Humbug Creek	~~On hold, 2018~~Cancelled, 2019	USDA Forest Service 2018a; USDA Forest Service 2019	https://www.fs.fed.us/sopa/components/reports/sopa-110505-2018-04.pdf https://www.fs.usda.gov/projects/klamath/landmanagement/projects
Infrastructure and Energy Projects					
Siskiyou County Public Works	Guys Gulch Road Realignment—Guys Gulch Bridge and Approaches; Schulmeyer Gulch Bridge Approaches	Intersection of Guys Gulch and Old Highway 99 Intersection of Schulmeyer Gulch and Old Highway 99	In Progress, 2017–2018	Siskiyou County 2017a	https://www.co.siskiyou.ca.us/publicworks/project/guysschulmeyer-gulch-bridges ~~https://www.co.siskiyou.ca.us/content/public-works-contract-16-07-guysschulmeyer-gulch-bridges~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
Siskiyou County Public Works	Salmon River Road Flood Damage Repair—Federal Emergency Aid Relief Project	Salmon River Road, M.P. 5.76	In Progress, 2018	Siskiyou County 2018f; 2018g	https://www.co.siskiyou.ca.us/sites/default/files/fileattachments/board_of_supervisors/meeting/11181/bos_20171017_minutes.pdf ~~https://www.co.siskiyou.ca.us/content/public-works-contract-17-02-salmon-rv-rd-flood-damage-repair-at-mp-576~~
Siskiyou County Public Works	Wooley Creek Bridge Rehabilitation and Pier Repair	Wooley Creek Bridge (Bridge 2C-016)	Pending, 2018	Siskiyou County 2018h~~g~~; Siskiyou County 2018i	https://www.co.siskiyou.ca.us/sites/default/files/fileattachments/board_of_supervisors/meeting/10261/bos_20181002_minutes.pdf ~~https://www.co.siskiyou.ca.us/content/public-works-fap-no-brlo-5902080-wooley-creek-bridge-rehabilitation-and-pier-repair~~
Siskiyou County, Planning	Denny Point Tower—80-foot lattice communications tower, cellular equipment shelters, electrical backup generators, cellular equipment cabinets, a foot access	Near 3801 McConaughy Gulch Road, Etna, Siskiyou County, CA	In planning phase, 2018	Siskiyou County 2018j~~h~~	[link no longer available] ~~https://www.co.siskiyou.ca.us/sites/default/files/~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
	road, and trench for lines over a 7,000-sqare-foot project area				~~public_docs/PC_20180615_DraftISMND_UP1804_Topsites-Plank.pdf~~
Del Norte County Community Development Department, Engineering Division	Hunter Creek Bridge Replacement Project	Requa Road at Hunter Creek, Klamath, CA	In planning phase, 2018; construction anticipated in 2020	Del Norte County ~~2017a~~2019	http://www.co.del-norte.ca.us/departments/community-development-department/engineering-division/projects
City of Yreka	Ringe Pool Facility Condition Assessment—options include: (1) short- and long-term repairs, (2) replacing the existing facility with new pools, (3) demolishing the facility and returning it to lawn; 0.88-acre site	Ringe Memorial Swim Center, Knapp St, Yreka	In planning phase, 2018	McCelland Architecture + Planning 2018	https://ci.yreka.ca.us/DocumentCenter/View/675/Ringe-Pool-Feasibility-Study-PDF ~~https://ci.yreka.ca.us/sites/ci.yreka.ca.us/assets/files/Ringe_FCA_Full_Report.09.17.18.pdf~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
City of Yreka	Proposed Mitigated Negative Declaration and Initial Study: Yreka Water Supply and Storage Improvements—includes public water system improvements, water tank replacements, installation of water mains, and installation of a new well	City of Yreka, unincorporated area of Siskiyou County, with improvements at: Lower Humbug Water Tank Site, Shasta Belle Water Tank Site, and Davis Well Site	In initial planning phase, 2017	City of Yreka 2017	https://ci.yreka.ca.us/DocumentCenter/View/668/Proposed-Mitigated-Negative-Declaration---Yreka-Water-Supply-and-Storage-Improvements-Project-PDF ~~http://ci.yreka.ca.us/sites/ci.yreka.ca.us/assets/files/P_C_Mintues_12_20_17.pdf~~
Yurok Tribe	Coastal Grading Permit—waterline and storage tank replacement	Requa Area, Klamath, Del Norte County, CA	In planning phase, 2017	Del Norte County 2017~~b~~a	http://countyofdelnorte.us/agendas/agenda_management/agendas/PLN1216.pdf
Resighini Rancheria	Extension of Time for a Coastal Grading Permit for Road Improvements and Culvert Replacement	Klamath Beach Road, and Waukell and Juniors Creek, Klamath, Del Norte County, CA	In planning phase, 2018	Del Norte County 2017b~~8~~	http://countyofdelnorte.us/agendas/agenda_management/agendas/PLN1256.pdf

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
Other Rezoning and Development Projects					
Siskiyou County (Siskiyou County Planning/Board of Supervisors)	Siskiyou County Jail Project—39,000 square feet on an 84-acre parcel	269 Sharps Road, Yreka, Siskiyou County	In initial planning phase, 2018	Siskiyou County 2018k~~i~~	https://www.co.siskiyou.ca.us/sites/default/files/fileattachments/board_of_supervisors/meeting/10521/bos_20180619_minutes.pdf ~~https://www.co.siskiyou.ca.us/sites/default/files/public_docs/PLN-20180521_NOI_MND.pdf~~
Karuk Tribe	Karuk Tribe Casino Project / Rain Rock Casino—36,497 sq-ft	City of Yreka, CA—Tribal Trust land and land held in fee title by the Tribe	Under construction, 2017	Siskiyou County 2018~~j~~l; Karuk Tribe 2019	http://www.karuk.us/index.php/88-info/342-karuk-casino ~~https://www.co.siskiyou.ca.us/content/planning-division-karuk-tribe-casino-project~~
Cross Development, with City of Yreka as lead agency	Yreka Dollar General Retail Store Project—includes a parking lot, landscaping / tree planting, a retaining wall, and stormwater retention areas on a 3.43-acre parcel	North side of Montague Road / State Route 3 between N. Main St and Deer Creek Way	In planning phase, 2018	City of Yreka 2018	http://www.ci.yreka.ca.us/AgendaCenter ~~http://ci.yreka.ca.us/planning-commission/minutes~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
Sousa Ready Mix, LLC; with City of Yreka as lead agency	Sousa Ready Mix Concrete Batch Plant Project—Conditional Use Permit to allow the construction of a 4.26-acre concrete batch plant, complete with a small portable office trailer, aggregate storage area, truck and auto parking, precast concrete area, and concrete truck washout basin	319 South Phillipe Lane, Yreka, CA	In planning phase, 2016	City of Yreka 2018	http://www.ci.yreka.ca.us/AgendaCenter ~~http://ci.yreka.ca.us/planning-commission/minutes~~
Fruit Growers Supply Company, with City of Yreka as lead agency	Fruit Growers Supply Company Sawmill Project: Initial Study / Mitigated Negative Declaration	Industrial area at the eastern edge of Yreka, CA; accessed via South Phillipe Lane 229 South Phillipe Lane, Yreka, CA	In planning phase, 2018	City of Yreka 2018	http://www.ci.yreka.ca.us/AgendaCenter ~~http://ci.yreka.ca.us/planning-commission/minutes~~
SK Yreka Inc.	Consideration of proposed categorical exemption and Conditional Use Permit to construct, establish, and operate a new gas station and convenience store in the Commercial Tourist Zone	1801 Fort Jones Road, Yreka, CA	In planning phase, 2017	City of Yreka 2018	http://www.ci.yreka.ca.us/AgendaCenter ~~http://ci.yreka.ca.us/planning-commission/minutes~~

Applicant or Implementing Agency	Project/Program Name	Location	Timeframe	Reference	Website
Campora Propane (Contractor Rick Bettis)	Consideration of proposed Categorical Exemption and Conditional Use Permit for construction establishment and operation of a fuel storage yard facility with two 30,000-gallon bulk propane storage tanks in the Light Industrial Zone	1420 Mill Road, Yreka, CA	In planning phase, 2016	City of Yreka 2018	http://www.ci.yreka.ca.us/AgendaCenter ~~http://ci.yreka.ca.us/planning-commission/minutes~~
Debora Behm	Consideration of proposed Categorical Exemption and Conditional Use Permit for the establishment and operation of a Microbrewery	204 W. Miner St, CA	In planning phase, 2016	City of Yreka 2018	http://www.ci.yreka.ca.us/AgendaCenter ~~http://ci.yreka.ca.us/planning-commission/minutes~~
Del Norte County	Off-Highway Motor Vehicle Recreation (OHV) Grants Program, Plan, and actions	Del Norte County	Plan completed, 2018	Del Norte County 2018b	http://www.co.del-norte.ca.us/departments/community-development-department/planning-division/documents ~~http://www.co.del-norte.ca.us/departments/community-development-department/planning-division/del-norte-county-ohv-planning-project~~

3.24.2 Water Quality

Volume I Section 3.24.2 Cumulative Effects – Water Quality, paragraph 2 on page 3-1148:

The non-project activity types are included in Table 3.24-1~~)~~.

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-1 Long-term water quality effects of the Proposed Project in combination with restoration, flow enhancement, and water quality improvement projects, paragraph 1 on page 3-1149:

In combination with restoration, flow enhancement, and water quality improvement projects, the Proposed Project would help to offset the effects of climate change on late summer/fall water temperatures, where climate change is expected to increase these temperatures in the Klamath Basin on the order of 1.8–5.4°F between 2012 and 2061 (Bartholow 2005; Perry et al. 2011).

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-2 Short-term increases in suspended sediments under the Proposed Project in combination with the 2017 court-ordered flushing and emergency dilution flows, paragraph 3 on page 3-1150 through paragraph 1 on page 3-1151:

Potential Cumulative Impact 3.24-2 ~~-~~Short-term increases in suspended sediments under the Proposed Project in combination with the 2017 court-ordered flushing and emergency dilution flows.
Formal consultation of the NMFS and USFWS 2013 Joint Biological Opinion (2013 BiOp) (NMFS and USFWS 2013) for the USBR Klamath Irrigation Project was reinitiated in 2017 to improve management of *Ceratanova Shasta (C. Shasta)* infection among coho salmon in the Klamath River. During the interim period February 2017 to March 2019~~ Until formal consultation is completed and a new biological opinion (BiOp) is issued~~, USBR ~~is~~ was required to manage *C. Shasta* by releasing additional winter-spring surface flushing flows and deep flushing flows, as well as emergency dilution flows (U.S. District Court 2017). The Lower Klamath Project Draft EIR acknowledged the re-initiation of consultation on the 2013 BiOp Flows by considering the 2017 court-ordered flushing and emergency dilution flow requirements downstream of Iron Gate Dam as interim flow requirements until completion of formal consultation (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*). The flushing and emergency dilution flow requirements ~~are~~ were analyzed in addition to 2013 BiOp flow requirements~~, which remain in effect until formal consultation is completed~~ for this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur. ~~, the 2017 flow requirements (i.e., 2013 BiOp Flows plus the 2017 court-ordered flushing and emergency dilution flows) or the to-be-determined new BiOp flow requirements may be in~~

~~effect since USBR's consultation with NMFS and USFWS on the 2013 BiOp Flows for the Klamath Irrigation Project is currently underway and is expected to be completed by August of 2019 (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*). At this time, estimates of flows that will be required under the future Klamath Irrigation Project biological opinion are speculative, so they are not included in hydrologic modeling. Potential new BiOp flow requirements under the Proposed Project are speculative in part because the fish disease conditions that prompted the flushing and emergency dilution flow requirements would be reduced due to increased dispersal of spawners and carcasses, transport of bedload, and establishment of variable flows, even if infection is not eliminated (see Section 3.3.5.5 *Fish Disease and Parasites*). Thus, it is not clear whether flushing and emergency dilution flow requirements would continue under a new BiOp after dam removal. It is also not clear if the prior location of Iron Gate Dam would remain as the compliance point if the flushing and emergency dilution flows continued. However, the 2017 flow requirements are the most reasonable assumption for conditions until formal consultation is completed and a new BiOp is issued. This is different from the existing conditions flow requirements, since the flushing flow requirements were imposed after issuance of the Notice of Preparation.~~

The 2017 flow requirements for the USBR Klamath Irrigation Project ~~are~~ were generally the same as the 2013 BiOp Flows analyzed as existing conditions under the individual resource sections for the Proposed Project, but they also included new flushing and emergency dilution flows based on the management guidance from *Measures to Reduce Ceratanova Shasta Infection of Klamath River Salmonids: A Guidance Document* (Hillemeier et al. 2017; U.S. District Court 2017). The management guidance specifieds~~s~~ surface and deep flushing flows downstream of Iron Gate Dam to dislodge and flush out polychaete worms attached to the streambed that host *C. Shasta*, and emergency dilution flows downstream of Iron Gate Dam to reduce disease conditions in the Klamath River, if specific disease criteria ~~are~~ were exceeded. In the 2013 BiOp, Iron Gate Dam ~~is~~ was the compliance point for flow requirements. Iron Gate Dam ~~is~~ was assumed to be the compliance point for the 2017 court-ordered flushing and emergency dilution flows for this cumulative effects analysis since the injunction specifie~~s~~d the flushing and emergency flows be modeled on the management guidance and the management guidance specified the flows occur downstream of Iron Gate Dam. Surface flushing flows of at least 6,030 cfs for a 72-hour period ~~are~~ were required to be met by USBR every year between November 1 and April 30 to scour riverbed sediments (i.e., scour fine sediment from approximately 20 to 30 percent of the surface of the streambed). USBR ~~is~~ was also required to release deep flushing flows averaging at least 11,250 cfs over a single 24-hour period between February 15 and May 31 every other year to scour fine sediment from between gravels and cobbles (i.e., armor layer) on the streambed and potentially move individual armor layer particles, if such a flow ~~does~~ did not occur naturally. Deep flushing flows were first required in 2017, so according to the court order they would have been required again in 2019 and

2021. The timing of surface and deep flushing flows within the specified period ~~is~~ was left to the discretion of USBR, but the USBR was required to coordinate with the parties[101] specified in the U.S. District Court case regarding the timing and magnitude of the flushing flows. Emergency dilution flows of 3,000 cfs (potentially increasing to 4,000 cfs) up to a maximum volume of 50,000 acre-feet ~~may~~ were also ~~be~~ potentially required to be released by USBR from Iron Gate Dam between April 1 to June 15, if fish disease thresholds in the Klamath River downstream of Iron Gate Dam ~~are~~ were exceeded. USBR, as part of their management of the Klamath Irrigation Project, ~~is~~ was required to reserve the 50,000 acre-feet in case the emergency dilution flow release ~~is~~ was needed.

This ~~P~~potential ~~C~~cumulative ~~I~~impact analysis examines whether the Proposed Project in combination with the 2017 flow requirements (i.e., 2013 BiOp Flows plus the 2017 court-ordered flushing and emergency dilution flows) potentially would have a short-term significant cumulative effect on suspended sediments, with the incremental contribution of the Proposed Project being cumulatively considerable. Although the 2013 BiOp Flows are no longer the operational standard for the Klamath River, and the 2017 court-ordered flushing and emergency dilution flows are no longer required (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*), the analysis of the 2017 court-ordered flushing and emergency dilution flow requirements remains in this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur and retaining the analysis does not change any significance determinations. The 2019 Biological Opinion flows (2019 BiOp Flows) are now the current operational flow requirement for the Klamath River and the 2019 BiOp Flows are assessed as a second CEQA baseline in the Lower Klamath River Final EIR analyses for water quality and other resource areas (see Section 3.1.6 *Introduction – Summary of Available Hydrology Information for the Proposed Project*). As discussed in Potential Impact 3.2-3, the Proposed Project would result in a significant and unavoidable short-term impact on suspended sediment by causing suspended sediment to be greater than 100 mg/L over a continuous two-week period (i.e., the suspended sediment significance criteria), especially during the reservoir drawdown period from November to March. This impact evaluates the potential change in significance to that impact in light of the 2017 flow requirements.

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-2 Short-term increases in suspended sediments under

[101] Parties refer to Yurok Tribe, Pacific Coast Federation of Fishermen's Associations, Institute for Fisheries Resources, Klamath Riverkeeper, Hoopa Valley Tribe, National Marine Fisheries Service, Klamath Water Users Association, Sunnyside Irrigation District, Ben DuVal, Klamath Drainage District, Klamath Irrigation District, and Pine Grove Irrigation District.

the Proposed Project in combination with the 2017 court-ordered flushing and emergency dilution flows, paragraph 1 on page 3-1152:

In years where reservoir drawdown flows would not meet the magnitude or duration of flushing flow requirements (Figures 3.24-1 and ~~3.25-2~~ 3.24-2), surface and/or deep flushing flow releases may still be required.

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-2 Short-term increases in suspended sediments under the Proposed Project in combination with the 2017 court-ordered flushing and emergency dilution flows, Figure 3.24-1 Proposed Project Modeled Drawdown Flow Downstream of Iron Gate Dam and Iron Gate Reservoir Elevation for Representative Wet and Above Normal Water Year Types caption on page 3-1153:

Surface annual flushing flows of at least 6,030 cfs for 72 hours would occur between November 1 and April 30, while deep flushing flows of at least ~~11, 250~~ 11,250 cfs for 24 hours would occur every other year starting in 2017 (i.e., odd numbered years) between February 15 and May 31.

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-2 Short-term increases in suspended sediments under the Proposed Project in combination with the 2017 court-ordered flushing and emergency dilution flows, Figure 3.24-2 Proposed Project Modeled Drawdown Flow Downstream of Iron Gate Dam and Iron Gate Reservoir Elevation for Representative Median and Dry Water Year Types caption on page 3-1154:

Surface annual flushing flows of at least 6,030 cfs for 72 hours would occur between November 1 and April 30, while deep flushing flows of at least ~~11, 250~~ 11,250 cfs for 24 hours would occur every other year starting in 2017 (i.e., odd numbered years) between February 15 and May 31.

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-2 Short-term increases in suspended sediments under the Proposed Project in combination with the 2017 court-ordered flushing and emergency dilution flows, paragraph 1 on page 3-1155:

If required, emergency dilution flows (3,000 to 4,000 cfs) are unlikely to increase SSCs and/or durations due to re-wetting and mobilization of remaining floodplain and reservoir sediment deposits, because ~~they~~ these flows are below the thresholds recognized for coarse and fine particle entrainment (see ~~USBR 2012~~ USBR [2012]).

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-2 Short-term increases in suspended sediments under *the Proposed Project in combination with the 2017 court-ordered flushing and emergency dilution flows, paragraph 1 on page 3-1155:*

Overall, exceedances of disease thresholds that would trigger emergency dilution flows would be unlikely ~~In~~ in the short term, particularly in dam removal year 2, and thus there would be no cumulative impact due to an increase in SSCs from emergency dilution flows associated with the 2017 court-ordered flows.

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-2 Short-term increases in suspended sediments under the Proposed Project in combination with the 2017 court-ordered flushing and emergency dilution flows, paragraph 2 on page 3-1155:

Overall, the short-term combined impact of the Proposed Project and the 2017 flow requirements (i.e., 2013 BiOp plus 2017 court-ordered flushing and emergency dilutions flows) would result in a cumulative increase in the SSCs during water years when reservoir drawdown flows are less than the surface and/or deep flushing flows.

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-2 Short-term increases in suspended sediments under the Proposed Project in combination with the 2017 court-ordered flushing and emergency dilution flows, paragraph 2 on page 3-1155:

Thus, the Proposed Project under the 2013 BiOp combined with the 2017 court-ordered flow requirements would potentially have a short-term cumulatively considerable impact in the in the Hydroelectric Reach, the Middle and Lower Klamath River, and the Klamath River Estuary.

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-2 Short-term increases in suspended sediments under the Proposed Project in combination with the 2017 court-ordered flushing and emergency dilution flows, paragraph 3 on page 3-1155:

As such, the combined impact of the Proposed Project and the 2017 flow requirements would not be cumulatively considerable in the long term.

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-3 Long-term water quality effects of the Proposed Project in combination with forest and wildfire management activities, paragraph 1 on page 3-1156:

The main water quality parameters potentially adversely impacted by these activities would be water temperature~~, since~~ due to vegetation removal allow~~s~~ing more solar radiation to reach streams and the surrounding floodplain surfaces, and suspended sediment due to vegetation removal, prescribed burns, fuel treatments, and road construction and usage increasing erosion. The North Coast Regional Water Quality Control Board's Forest Activities Program issues waste discharge requirements and general waivers with terms and conditions to address the potential water quality problems potentially associated with a range of forest management activities on private and on US Forest Service lands (North Coast Regional Board 201~~8c~~9a). Reasonably foreseeable forest and wildfire management projects within or near the water quality Area of Analysis are included in Table 3.24-1.

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-4 Short-term and long-term water quality effects of the Proposed Project in combination with wildfires, paragraph 1 on page 3-1158:

While wildfires potentially would increase SSCs occasionally in the long term if eroded sediments from a burn area during heavy rain entered the Klamath River, there would be no cumulative effect on water temperature or SSCs from the Proposed Project and wildfires since the SSCs would have resumed natural background levels.

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-6 Long-term water quality effects of the Proposed Project in combination with grazing and other agricultural projects, paragraph 5 on page 3-1159:

These require compliance with best management practices designed to meet state water quality requirements~~.~~ (North Coast Regional Board ~~2018a~~2019b).

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-6 Long-term water quality effects of the Proposed Project in combination with grazing and other agricultural projects, paragraph 5 on page 3-1159:

Grazing (and other agricultural projects) are required to meet the requirements of the non-point source discharge policy, the prohibition against unpermitted discharges, and the North Coast Regional Water Quality Control Board's Agricultural Lands Discharge Program (North Coast Regional Board 2019c). These require compliance with best management practices designed to meet state water quality requirements~~.~~ (North Coast Regional Board 2018~~a~~).

Volume I Section 3.24.2 Cumulative Effects – Water Quality – Potential Cumulative Impact 3.24-7 Long-term water quality effects of the Proposed Project in combination with mining projects, paragraph 2 on page 3-1160:

Potential Cumulative Impact 3.24-7 Long-term water quality effects of the Proposed Project in combination with mining projects.
Mining projects within the water quality Area of Analysis and the Klamath Basin were evaluated to determine if there would be a cumulative effect with the Proposed Project. Mining projects may impact multiple water quality parameters, including increasing suspended sediment and inorganic or organic contaminants. ~~Most of the anticipated mining projects are not within the water quality Area of Analysis or the vicinity of the mainstem Klamath River (Table 3.24-1) and they would be unlikely to impact water quality conditions within the Area of Analysis. Projects in the vicinity of the water quality Area of Analysis include the Brooks Mine, an existing mine located approximately five miles south of the Klamath River, near Humbug Creek, California.~~ The only planned mining project within the water quality Area of Analysis at the time of the Draft EIR was the Brooks Mine, but this project has now been cancelled (Table 3.24-1) (USDA 2019). Any existing mining operations impacts on water quality within the Area of Analysis are accounted for in the analysis of the existing conditions. While there are potential water quality impacts from mining, these projects would be required to adhere to local, state, and/or federal mining regulations to protect water quality and implement project-specific measures to manage and reduce potential water quality impacts. Storm water management, waste discharge permits, and monitoring would all likely be necessary for any mining projects adjacent to water ways. As mining projects are required to implement such measures to reduce water quality impacts and there are currently no known planned mining projects within the water quality Area of Analysis in addition to those occurring under existing conditions, the combined effect of the Proposed Project and mining would not result in further impacts to water quality. As such, there would be no significant cumulative water quality impact due the Proposed Project and mining projects.

3.24.3 Aquatic Resources

Volume I Section 3.24.3 Cumulative Effects – Aquatic Resources – Potential Cumulative Impact 3.24-11 Effects of short-term increases in suspended sediments on aquatic resources under the Proposed Project in combination with 2017 court-ordered flushing and emergency dilution flows, paragraphs 2 and 3 on page 3-1163:

Potential Cumulative Impact 3.24-11 Effects of s~~S~~hort-term increases in suspended sediments on aquatic resources under the Proposed Project in combination with 2017 court-ordered flushing and emergency dilution flows.
As discussed in Potential Cumulative Impact 3.24-2, the short-term combined impact of the Proposed Project and the 2017 court-ordered flow requirements (i.e., 2013 BiOp plus the court ordered flushing and emergency dilutions flows) would result in a cumulative increase in the suspended sediment concentrations during water years when reservoir drawdown flows are less than the surface and/or deep flushing flows. The 2017 court-ordered flushing flows ~~are released~~

were required to be released from Iron Gate Dam for the purpose of disrupting the nidus downstream of Iron Gate Dam and reducing disease risk. Although the 2013 BiOp Flows are no longer the operational standard for the Klamath River, and the 2017 court-ordered flushing and emergency dilution flows are no longer required (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*), the analysis of the court-ordered flushing and emergency dilution flow requirements remains in this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur and retaining the analysis does not change any significance determinations.

High concentrations of suspended sediment and bedload sediment released during dam removal year 2 is anticipated to effectively scour and disrupt the periphyton intermediate host of the key fish diseases, and thus it is not likely that the flushing flows and emergency dilution flows ~~are highly unlikely to~~ would have been required during the same period of impacts from the Proposed Project. In addition, the incremental effect of the increased suspended sediment on aquatic resources under the 2017 court-ordered flushing flows would be dwarfed by the substantial sediment volumes of sediment predicted to occur under the Proposed Project (described in detail in Appendix E). Therefore, the impacts predicted for aquatic resources under the Proposed Project (described in Section 3.3.5.9 *Aquatic Resource Impacts*) are no lesser, nor higher, when considered cumulatively with the 2017 court-ordered flushing and emergency dilution flows.

Significance

No significant cumulative impact in the short term

Volume I Section 3.24.3 Cumulative Effects – Aquatic Resources – Potential Cumulative Impact 3.24-12 Long-term effects on aquatic resources from the Proposed Project in combination with forest and wildfire management activities, paragraph 4 on pages 3-1163 to 3-1164:

The North Coast Regional Water Quality Control Board's Forest Activities Program issues waste discharge requirements and general waivers with terms and conditions to address the potential water quality problems potentially associated with a range of forest management activities on private and on USDA Forest Service lands (North Coast Regional Board 2019a).

Volume I Section 3.24.3 Cumulative Effects – Aquatic Resources – Potential Cumulative Impact 3.24-15 Long-term effects on aquatic resources from the Proposed Project in combination with grazing projects and agriculture projects, paragraph 1 on page 3-1166:

Grazing (and other agricultural projects) are required to meet the requirements of the non-point source discharge policy, the prohibition against unpermitted discharges, and the North Coast Regional Water Quality Control Board's Agricultural Lands Discharge Program (North Coast Regional Board 2019c).

3.24.4 Phytoplankton and Periphyton

Volume I Section 3.24.4 Cumulative Effects – Phytoplankton and Periphyton – Potential Cumulative Impact 3.24-16 Long-term phytoplankton and periphyton effects from the Proposed Project in combination with habitat restoration, flow enhancement, and water quality improvement projects, paragraph 1 on page 3-1168:

However, the conversion of reservoir areas to free-flowing river reaches would result in a significant and unavoidable impact on periphyton conditions because the newly created free-flowing river reaches would provide additional low-gradient habitat suitable for periphyton growth (Potential Impact 3.4-4). The extent, duration, or biomass of nuisance periphyton may increase within these newly created free-flowing river reaches. Short-term and long-term nutrient increases from the release of sediment-associated nutrients or the lack of interception of nutrients behind the Lower Klamath Project dams due to the Proposed Project would be less than significant for phytoplankton and periphyton growth and habitat conditions, so they would have no significant impact on phytoplankton or periphyton (~~and~~ Potential Impacts 3.4-1, 3.4-3, and 3.4-5).

Volume I Section 3.24.4 Cumulative Effects – Phytoplankton and Periphyton – Potential Cumulative Impact 3.24-17 Short-term and long-term phytoplankton and periphyton effects from the Proposed Project in combination with 2017 court-ordered flushing and emergency dilution flows, paragraph 5 on page 3-1168 through paragraph 2 on page 3-1169:

Potential Cumulative Impact 3.24-17 Short-term and long-term phytoplankton and periphyton effects from the Proposed Project in combination with 2017 court-ordered flushing and emergency dilution flows.

Formal consultation was reinitiated in 2017 on the NMFS and USFWS 2013 Joint Biological Opinion. During the interim period February 2017 to March 2019 ~~Until formal consultation is completed and a new biological opinion (BiOp) issued~~, USBR ~~is~~ was required to continue adhering to the 2013 BiOp Flow requirements while also releasing additional winter-spring surface and deep flushing flows and potentially emergency dilution flows (U.S. District Court 2017). ~~New BiOp Flows would alter the hydrodynamic (i.e., flow) conditions in the Klamath River within the phytoplankton and periphyton Area of Analysis. The potential new BiOp flow requirements under the Proposed Project are speculative since the fish disease conditions that prompted the flushing and emergency dilution flow requirements would be reduced due to increased dispersal of spawners and carcasses, transport of bedload, and establishment of variable flows, even if infection itself is not eliminated (see Section 3.3.5.5 *Fish Disease and Parasites*). Further, if flushing and emergency dilution flow requirements were to continue under a new~~

~~BiOp, it is not clear if the prior location of Iron Gate Dam would remain as the compliance point. Thus, this cumulative effects analysis analyzes only the 2017 flow requirements (i.e., 2013 BiOp Flows plus the 2017 court-ordered flushing and emergency dilution flows), which although not part of the existing conditions (2016), are considered to be a reasonably foreseeable flow condition until formal consultation is completed and a new BiOp is issued (see Potential Cumulative Impact 3.24-2 for more details).~~ Although the 2013 BiOp Flows are no longer the operational standard for the Klamath River, and the 2017 court-ordered flushing and emergency dilution flows are no longer required (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*), the analysis of the court-ordered flushing and emergency dilution flow requirements remains in this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur and retaining the analysis does not change any significance determinations. The 2019 Biological Opinion flows (2019 BiOp Flows) are now the current operational flow requirement for the Klamath River and the 2019 BiOp Flows are assessed as a second CEQA baseline in the Lower Klamath River Final EIR analyses for water quality and other resource areas (see Section 3.1.6 *Introduction – Summary of Available Hydrology Information for the Proposed Project*).

The Proposed Project and 2017 court-ordered flow requirements would decrease favorable growth conditions and optimum habitat availability for phytoplankton or periphyton since ~~they are~~ the 2017 court-ordered flow requirements were designed to limit periphyton establishment along the streambed, which also limits favorable habitat for the polychaete worm that hosts fish parasites (e.g., *C. shasta*) (see Section 3.3.5.5 *Fish Disease and Parasites*). Additionally, an increase in the frequency of higher flushing flows and emergency dilution flows between November and June would have increased turbulent flows in the Klamath River, reducing the extent of slow-water habitat that favors phytoplankton growth. The Proposed Project would eliminate slow-water habitat in the reservoir areas and convert those areas into more turbulent free-flowing reaches that would not support extensive phytoplankton blooms, including blue-green algae blooms (Potential Impact 3.4-2). As such, the cumulative effect of the Proposed Project combined with an increase in the frequency of flushing flows and emergency dilution flows would result in a beneficial effect by further reducing the availability of slow-water habitat that supports nuisance and/or noxious phytoplankton blooms.

The increase in the frequency of higher flushing flows and emergency dilution flows between November and June under the 2017 flow requirements would have also increased sediment movement and streambed scour in the Klamath River, reducing conditions where periphyton could establish along the streambed when flushing flows or emergency dilution flows are occurring. As discussed in Section 3.4.5.2 *Periphyton*, the Proposed Project drawdown flows would mobilize streambed sediments and scour periphyton attached to the streambed, especially at higher flows that move larger sediments like cobbles (Potential Impact 3.4-3). Although the Proposed Project would result in an increase in periphyton and a potentially significant and unavoidable short-term and long-term increase in nuisance periphyton along the Hydroelectric Reach due to the conversion of the reservoir areas to a free-flowing river and elimination of hydropower peaking operations, the cumulative effect of an increase in the frequency of higher flushing flows and emergency dilution flows would be beneficial and reduce the extent, duration, and biomass of nuisance periphyton.

Volume I Section 3.24.4 Cumulative Effects – Phytoplankton and Periphyton – Potential Cumulative Impact 3.24-18 Short-term and long-term phytoplankton and periphyton effects from the Proposed Project in combination with forest and wildfire management projects, paragraph 4 on page 3-1170:

While phytoplankton and periphyton are not directly addressed by the North Coast Regional Water Quality Control Board's Forest Activities Program, the program issues waste discharge requirements and general waivers with terms and conditions to address the potential water quality problems (e.g., water temperature or suspended sediment increases) potentially associated with a range of forest management activities on private and on USDA Forest Service lands (North Coast Regional Board 2019a~~8c~~).

Volume I Section 3.24.4 Cumulative Effects – Phytoplankton and Periphyton – Potential Cumulative Impact 3.24-18 Short-term and long-term phytoplankton and periphyton effects from the Proposed Project in combination with forest and wildfire management projects, paragraph 5 on page 3-1170:

Vegetation removal and temporary or permanent road construction and usage for tree removal (i.e., logging) would potentially increase phytoplankton and periphyton growth in the local vicinity of the project due to increases in solar radiation and water temperature ~~or reductions in suspended sediment~~, but these activities also would potentially decrease local phytoplankton and periphyton growth by increasing suspended sediment and reducing the solar radiation available for photosynthesis. ~~revegetating~~ Revegetating areas, enhancing riparian cover along meadow streams, and decommissioning or downgrading roads ~~to reduce suspended sediment delivery to streams activities~~ also would have potentially opposing effects on ~~decrease~~ phytoplankton and periphyton growth since revegetation and enhanced riparian cover would potentially decrease local phytoplankton and periphyton growth by reducing solar radiation and water temperature ~~or increasing suspended sediment~~, but decommissioning or downgrading roads would potentially increase local phytoplankton and periphyton growth by reducing suspended sediments and increasing the solar radiation available for photosynthesis.

Volume I Section 3.24.4 Cumulative Effects – Phytoplankton and Periphyton – Potential Cumulative Impact 3.24-21 Short-term and long-term phytoplankton *and periphyton effects from the Proposed Project in combination with grazing and agricultural projects, paragraph 3 on page 3-1173:*

Grazing and agricultural projects are required to meet the requirements of the North Coast Regional Water Quality Control Board's Agricultural Lands Discharge Program, including a series of waivers of waste discharge requirements when applicants comply with best management practices designed to meet state water quality requirements, the State Nonpoint Source Policy, and the TMDLs in specific watersheds (North Coast Regional Board 2018~~a~~, North Coast Regional Board 2019a).

Volume I Section 3.24.4 Cumulative Effects – Phytoplankton and Periphyton – Potential Cumulative Impact 3.24-22 – Potential Cumulative Impact 3.24-22 Short-term and long-term phytoplankton and periphyton effects from the Proposed Project in combination with mining, paragraph 2 on page 3-1174:

Potential Cumulative Impact 3.24-22 Short-term and long-term phytoplankton and periphyton effects from the Proposed Project in combination with mining.
~~Most of the anticipated mining projects are not within the phytoplankton and periphyton Area of Analysis or the vicinity of the mainstem Klamath River (Table 3.24-1), so they would not impact phytoplankton and periphyton conditions within the Area of Analysis. Projects in the vicinity of the phytoplankton and periphyton Area of Analysis include the Brooks Mine, an existing mine located approximately five miles south of the Klamath River, near Humbug Creek, California.~~ The only planned mining project within the phytoplankton and periphyton Area of Analysis at the time of the Draft EIR was the Brooks Mine near Humbug Creek, California, but this project has now been cancelled (Table 3.24-1) (USDA 2019). Any existing mining operations impacts on the phytoplankton and periphyton Area of Analysis are accounted for in the analysis of the existing conditions. Mining could potentially alter light availability for phytoplankton and periphyton in the Klamath River by increasing suspended sediment conditions, but since mining projects would be required to adhere to local, state, and/or federal mining regulations to protect water quality and implement project-specific measures to manage and reduce potential water quality impacts, there would be no cumulative impact. Stormwater management, waste discharge permits, and monitoring would all likely be necessary for any mining projects adjacent or draining to waterways. Mining projects implementing such project-specific measures would reduce their impacts on phytoplankton and periphyton growth. There are no significant adverse phytoplankton or periphyton impacts due to suspended sediment concentrations under the Proposed Project (Potential Impact 3.4-4 and Potential Impacts 3.4-1, 3.4-2, 3.4-3, and 3.4-5). As the Proposed Project would not have a significant adverse impact on phytoplankton and periphyton related to mining ~~cultivation~~ and there are no closely related mining projects that would, in combination with the Proposed Project, have a significant and adverse impact, there would be no significant cumulative

phytoplankton or periphyton impacts in the short term or long-term due to the Proposed Project and mining projects.

3.24.5 Terrestrial Resources

Volume I Section 3.24.5 Cumulative Effects – Terrestrial Resources – Potential Cumulative Impact 3.24-24 Short-term effects on terrestrial resources from the Proposed Project in combination with 2017 court-ordered flushing and emergency dilution flows, paragraph 6 on page 3-1175 through paragraph 4 on page 3-1176:

Potential Cumulative Impact 3.24-24 Short-term effects on terrestrial resources from the Proposed Project in combination with 2017 court-ordered flushing and emergency dilution flows.
The 2013 BiOp Flows ~~have been~~ are analyzed under the individual resource sections for the Proposed Project as the operational flow requirement for the Klamath River at the time of the Notice of Preparation for the Lower Klamath Project EIR (i.e., December 22, 2016). ~~Potential Impact 3.24-1 in Section 3.24.2 *Cumulative Water Quality Effects* provides background and context regarding agency re-consultation on the 2013 Joint Biological Opinion.~~ Although the 2013 BiOp Flows are no longer the operational standard for the Klamath River, and the 2017 court-ordered flushing and emergency dilution flows are no longer required (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*), the analysis of the court-ordered flushing and emergency dilution flow requirements remains in this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur and retaining the analysis does not change any significance determinations.

~~For the reasons set out in Potential Impact 3.24-1, this analysis only considers the 2017 court-ordered flow requirements, which are not part of the existing conditions, and are a reasonably foreseeable flow condition; this analysis does not consider the potential new BiOp. The court-ordered flushing and emergency dilution flows are required primarily to reduce *C. Shasta* infection of Klamath River salmonids.~~ Potential Impact 3.24-1 determines that it is unlikely that there would be exceedances of disease thresholds that would have triggered 2017-mandated emergency dilution flows ~~In~~ in the short term, particularly in dam removal year 2; therefore, emergency dilution flows are not expected to temporally overlap with the Proposed Project. 2017 court-ordered flushing flows may have overlapped in space and time with the Proposed Project, and thus they are the focus of ~~this~~ the below analysis.

Sediment discharge, sedimentation, and impacts to channel morphology from the Proposed Project are not expected to substantially adversely impact in-channel and riparian vegetation downstream of Iron Gate Dam (Potential Impact 3.5-4). This is because vegetation growing within, or along, the river channel margins can likely withstand, or revegetate following, this scale of perturbation, which is not dissimilar to seasonal and inter-annual river system dynamics over the past century. Conversely, sediment discharge, sedimentation, and changes to channel morphology would result in potentially significant impacts to the foothill yellow-legged frog (Potential Impact 3.5-16).

In years where reservoir drawdown flows alone would not have me~~e~~t the magnitude or duration of the 2017 court-ordered flushing flow requirements, ~~surface and/or deep flushing flows may be implemented to meet the 2017 court-ordered flow requirements, which would be additional to flows from the Proposed Project. Although the magnitude of flows would not be greater than assessed in Section 3.5.5 *[Terrestrial Resources] Impacts and Mitigation*,~~ there are one to two months when flushing flows may have occurred outside of the Proposed Project reservoir drawdown period (November 1 to March 15) since surface flushing flows potentially would have occurred until April 30 and deep flushing flows potentially would have occurred until May 31. Given that the 2017 court-ordered surface and/or deep flushing flows ~~are~~ were within the range of flows modeled for the Proposed Project, it is unlikely that sediment discharge, sedimentation, and impacts to channel morphology, would exceed what in-channel riparian vegetation can withstand, or that vegetation would not revegetate in a few years, due to the combination of flushing flows and reservoir drawdown.

With regard to wildlife, the combination of the Proposed Project and the 2017 court-ordered surface and/or deep flushing flows would extend the period of high flows that could scour foothill yellow-legged frog eggs or displace tadpoles (Potential Impact 3.5-16); however, since reservoir drawdown flows would be expected to remain below the 10-year flood event under the Proposed Project, the incremental impact of the Proposed Project to potential scour of foothill yellow-legged frog eggs would not be cumulatively considerable.

Significance

No significant cumulative impact on riparian vegetation or wildlife

Volume I Section 3.24.5 Cumulative Effects – Terrestrial Resources – Potential Cumulative Impact 3.24-25 Short-term effects on terrestrial resources from forest and wildfire management, paragraph 1 on page 3-1177:

The Proposed Project would also result in noise and habitat modifications that would have significant short-term impacts on terrestrial wildlife species before mitigation (Potential Impact 3.5-10 for amphibians, ~~and~~ reptiles, and gray wolf and Potential Impact 3.5-13 for bald and golden eagles), and a significant and unavoidable impacts on some other terrestrial wildlife species (Potential Impacts 3.5-10 for other special-status wildlife species, 3.5-11, 3.5-12, ~~3.5-13,~~ and 3.5-14).

Volume I Section 3.24.5 Cumulative Effects – Terrestrial Resources – Potential Cumulative Impact 3.24-26 Short-term effects on terrestrial resources from the Proposed Project in combination with wildfire, paragraph 3 on page 3-1177:

The Proposed Project would also result in noise and habitat modifications that would have significant short-term impacts on terrestrial wildlife species before mitigation (Potential Impact 3.5-10 for amphibians, ~~and~~ reptiles, and gray wolf and Potential Impact 3.5-13 for bald and golden eagles), and a significant and unavoidable impacts on some other terrestrial wildlife species (Potential Impacts 3.5-10 for other special-status wildlife species, 3.5-11, 3.5-12, ~~3.5-13,~~ and 3.5-14).

Volume I Section 3.24.5 Cumulative Effects – Terrestrial Resources – Potential Cumulative Impact 3.24-27 Short-term and long-term effects on terrestrial resources from the Proposed Project in combination with agriculture, including cannabis cultivation, paragraph 3 on page 3-1178:

The Proposed Project would also result in noise and habitat modifications that would have significant short-term impacts on terrestrial wildlife species before mitigation (Potential Impact 3.5-10 for amphibians, ~~and~~ reptiles, and gray wolf and Potential Impact 3.5-13 for bald and golden eagles), and a significant and unavoidable impacts on some other terrestrial wildlife species (Potential Impacts 3.5-10 for other special-status wildlife species, 3.5-11, 3.5-12, ~~3.5-13,~~ and 3.5-14).

Volume I Section 3.24.5 Cumulative Effects – Terrestrial Resources – Potential Cumulative Impact 3.24-28 Short-term effects on terrestrial resources from the combination of the Proposed Project and mining, paragraph 4 on page 1179 and paragraph 1 on page 3-1180:

The Proposed Project includes ground-disturbing activities (i.e., construction) that would have significant short-term impacts on wetlands and riparian habitats before mitigation (Potential Impact 3.5-1), and ground-disturbing activities (i.e., construction and dam removal) that would have significant and unavoidable impacts on special-status plant species and rare natural communities (Potential Impacts 3.5-7 and 2.5-8). The Proposed Project would also result in noise and habitat modifications that would have significant short-term impacts on terrestrial wildlife species before mitigation (Potential Impact 3.5-10 for amphibians, ~~and~~ reptiles, and gray wolf and Potential Impact 3.5-13 for bald and golden eagles), and a significant and unavoidable impacts on some other terrestrial wildlife species (Potential Impacts 3.5-10 for other special-status wildlife species, 3.5-11, 3.5-12, ~~3.5-13,~~ and 3.5-14). Mining projects within the Primary Area of Analysis for terrestrial resources (Table 3.24-1) could also result in ground disturbance. Most other mining projects are withdrawal or remediation projects, renewals of existing permits in Del Norte County, or are situated in the Salmon River sub-basin (far from the Hydroelectric Reach), with the exception of the new Plan of

Operations for the existing Brooks Mine, which has been cancelled since the Draft EIR (Table 3.24-1) (USDA 2019). ~~The new plan of operations for the Brooks Mine is near the expected hydrological and sedimentation footprint from dam removal, which extends downstream to Humbug Creek.~~ Although details of implementation methods for mining projects are currently speculative, these projects would be required to adhere to state and/or federal guidelines, which would ensure that sensitive habitats (e.g., wetlands), rare natural communities, and special-status plant species are inventoried prior to project implementation and avoided, or that mitigation is applied where necessary. Given that there are no expected ~~onlyexpected~~ mining projects within the Primary Area of Analysis for terrestrial resources, ~~is a new plan of operations~~ there would be no significant ground-disturbing impact to terrestrial resources from the combination of the Proposed Project and other closely related mining projects.

Mining projects (Table 3.24-1) within or near the Primary Area of Analysis for terrestrial resources may result in reduced water quality affecting special-status terrestrial species such as amphibians and reptiles. ~~The majority of mining projects are located outside of the terrestrial Primary Area of Analysis. A new (20-acre) Plan of Operations for the existing Brooks Mine (Table 3.24-1) is near the expected hydrological and sedimentation footprint from dam removal, which extends downstream to Humbug Creek.~~ Impacts from mining projects on water quality, and terrestrial wildlife that use waterways, would be anticipated to be less than significant, since there are no known planned mining projects within the Primary Area of Analysis for terrestrial resources and mining projects would be required to adhere to existing water quality regulations and implement project-specific measures (e.g., storm water management). Although the Proposed Project would result in significant and unavoidable adverse impacts due to short-term water quality impacts (as described in Cannabis Cultivation above), there are no closely related mining~~grazing~~ projects that would, in combination with the Proposed Project, result in further significant and adverse impacts to water quality that would cumulatively affect terrestrial wildlife. Thus, there would be no cumulative water quality impacts on terrestrial wildlife due to the Proposed Project in combination with closely related mining projects.

Volume I Section 3.24.5 Cumulative Effects – Terrestrial Resources – Potential Cumulative Impact 3.24-29 Short-term effects on terrestrial resources from the Proposed Project in combination with development and infrastructure projects, paragraph 3 on page 3-1180:

The Proposed Project would also result in noise and habitat modifications that would have significant short-term impacts on terrestrial wildlife species before mitigation (Potential Impact 3.5-10 for amphibians, ~~and~~ reptiles, and gray wolf and Potential Impact 3.5-13 for bald and golden eagles), and a significant and unavoidable impacts on some other terrestrial wildlife species (Potential Impacts 3.5-10 for other special-status wildlife species, 3.5-11, 3.5-12, ~~3.5-13,~~ and 3.5-14).

3.24.6 Flood Hydrology

Volume I Section 3.24.6 Cumulative Effects – Flood Hydrology, paragraphs 3 through 5 on page 3-1181:

Existing conditions for flood hydrology are detailed in Section 3.6.2 *[Flood Hydrology] Environmental Setting*, which provides a description of basin hydrology including precipitation; reservoirs; major rivers and tributaries; lakes; springs and seeps providing measurable flow; historical stream flows; and flood hydrology. Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* also provides relevant information related to recent management decisions that dictate Klamath River flows downstream of Iron Gate Dam. These include the 2013 BiOp Flows, ~~and~~ the 2017 court-ordered flushing and emergency dilution flows, and the 2019 BiOp Flows. Section 3.6.2 *[Flood Hydrology] Environmental Setting* includes consideration of major past or ongoing projects that have impacted, or currently impact, flood hydrology resources.

This cumulative impact analysis focuses on the potential impacts of the Proposed Project combined with other closely related projects that are not already considered in the analysis of flood hydrology resource area effects (Section 3.6 *Flood Hydrology*). Non-project activity types within the flood hydrology Area of Analysis with the potential for significant cumulative flood hydrology effects are included in Table 3.24-1.

Significance criteria for cumulative flood hydrology effects are the same as defined in Section 3.6.3 *[Flood Hydrology] Significance Criteria* for the flood hydrology resource.

Volume I Section 3.24.6 Cumulative Effects – Flood Hydrology – Potential Cumulative Impact 3.24-30 Short-term and long-term flood hydrology effects from the Proposed Project in combination with other non-project activities, paragraph 1 on page 3-1182:

Formal consultation of the 2013 BiOp ~~f~~Flows was reinitiated in 2017 to improve management of *Ceratanova shasta (C. shasta)* infection among coho salmon in the Klamath River. In 2017, a court order required USBR to implement three specific flows in the Klamath River, as measured immediately downstream of Iron Gate Dam: annual winter-spring surface flushing flows, biennial winter-spring deep flushing flows, and spring-summer emergency dilution flows (U.S. District Court 2017a–c). Although the 2013 BiOp Flows are no longer the operational standard for the Klamath River, and the 2017 court-ordered flushing and emergency dilution flows are no longer required (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*), the analysis of the 2017 court-ordered flushing and emergency dilution flow requirements remains in this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur and retaining the analysis does not change any significance determinations. After the issuance of the Lower Klamath Project Draft EIR on December 27, 2018, the applicable biological opinion and the operational flow requirements for the Klamath River changed in March 2019, when the new biological opinions were issued by NMFS (2019) and USFWS (2019). The 2019 BiOp Flows are now the current operational flow requirement for the Klamath River (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*). ~~Although specific flow details for a new BiOp resulting from re-consultation are speculative at this time, f~~Flow changes in the Klamath River due to the ~~a new BiOp (or the~~ 2017 court-ordered flushing and emergency dilution flows ~~[~~(U.S. District Court 2017~~]~~), as originally analyzed in the Draft EIR, ~~are not~~ would not ~~expected to~~ alter flood hydrology or the FEMA 100-year floodplain in the flood hydrology Area of Analysis. This is because ~~BiOp'~~biological opinions specify minimum flow releases and do not impact peak flows during flood events.

Volume I Section 3.24.6 Cumulative Effects – Flood Hydrology – Potential Cumulative Impact 3.24-30 Short-term and long-term flood hydrology effects from the Proposed Project in combination with other non-project activities, paragraph 3 on page 3-1182:

Although the Proposed Project would result in significant and unavoidable adverse impacts due to exposing structures to a substantial risk of damage due to flooding (Potential Impact 3.6-3), there are no closely related projects that would, in combination with the Proposed Project, result in further significant and adverse flood hydrology impacts. Thus, there would be no significant cumulative flood hydrology impacts due to the Proposed Project and flow release and floodplain development projects. Additionally, there would be beneficial cumulative effects due to the Proposed Project and habitat restoration projects.

3.24.7 Groundwater

Please refer to Volume I Section 3.24.7 *Cumulative Effects – Groundwater*.

3.24.8 Water Supply/Water Rights

Volume I Section 3.24.8 Cumulative Effects – Water Supply/Water Rights – Potential Cumulative Impact 3.24-32 Cumulative water supply and water rights impacts from the combination of the Proposed Project and other potential non-project activities, page 3-1184, paragraph 5:

The 2017 flow requirements (i.e., 2013 BiOp Flows plus the 2017 court-ordered flushing and emergency dilution flows) included winter-spring (November 1–April 30) surface flushing flows every year to scour surface riverbed sediments, deep flushing flows between February 15 and May 31 every other year to scour and disturb larger riverbed sediments, and emergency dilution flows between April 1 to June 15, if disease thresholds ~~are~~ were exceeded (see Cumulative Potential Impact 3.24-2 for further discussion). As there is sufficient water released from the Lower Klamath Project under existing conditions, ~~and from~~ under the 2017 flow requirements, and under the 2019 BiOp to satisfy downstream water rights, ~~and a new BiOp would be more likely to increase than decrease flows,~~ there would be no significant cumulative impact to water supply/water rights in the hydroelectric reach or downstream of Iron Gate Dam from the combination of the Proposed Project and the re-consultation of the 2013 BiOp. In a parallel process, USBR has initiated renegotiation for a new Upper Klamath Basin agreement, which would be informed by the final 2019 BiOp flow requirements, ~~under the 2013 BiOp re-consultation~~ regarding water rights among agricultural irrigators, Native American tribes, and environmental uses (Herald and News 2017; Herald and News 2018). However, at this time the outcome of the renegotiation for Upper Klamath Basin water rights is speculative and is not analyzed as part of the cumulative effects.

3.24.9 Air Quality

Please refer to Section 3.24.9 *Cumulative Effects – Air Quality* that was recirculated on December 21, 2019.

3.24.10 Greenhouse Gas Emissions

Please refer to Section 3.24.10 *Cumulative Effects – Greenhouse Gas Emissions and Energy* that was recirculated on December 21, 2019.

3.24.11 Geology, Soils, and Mineral Resources

Volume I Section 3.24.11 – Cumulative Effects – Geology, Soils, and Mineral Resources – Potential Cumulative Impact 3.24-40 Short-term soil disturbance, erosion, and sedimentation effects from the Proposed Project in combination with other construction projects, paragraph 7 on page 3-1191:

The Proposed Project would also not have a significant sedimentation impact downstream of Cottonwood Creek~~the Lower Klamath Project reservoirs~~, or the sedimentation would be beneficial, although there would be a significant and unavoidable impact in the Middle Klamath River from Iron Gate Dam to Cottonwood Creek (Potential Impact 3.11-5).

Volume I Section 3.24.11 Cumulative Effects – Geology, Soils, and Mineral Resources – Potential Cumulative Impact 3.24-41 Short-term soil disturbance, erosion, and sedimentation effects from the Proposed Project in combination with wildfire, mining, forest and wildfire management, and agriculture, paragraphs 2 and 3 on page 3-1192:

Potential Cumulative Impact 3.24-41 Short-term soil disturbance, erosion, and sedimentation effects from the Proposed Project in combination with wildfire, mining, forest and wildfire management, and agriculture.
Non-construction sediment-generating activities, such as wildfire, forest and wildfire management, mining and agriculture, would be subject to separate planning standards and requirements than for construction activities assessed in Potential Cumulative Impact 3.24-40~~2~~ above. Wildfires are a naturally recurring event in the Klamath Basin, and have the potential to result in substantial erosion and sediment delivery if rainfall events occur before vegetation reestablishes. Increased sediment delivery would be most likely if a wildfire occurred late in the fire season (fall), and a combination of the Proposed Project and rain storms occurred shortly following the fire. As discussed in Potential Cumulative Impact 3.24-4, this could increase suspended sediment and sedimentation additional to the Proposed Project, and the water quality impact could be significant. The combination of geology and soils impacts under the Proposed Project and wildfires would also be significant, if temporal and spatial overlap occurs. However, given that most geology and soil impacts, including soil disturbance, erosion, and sedimentation impacts, associated with the Proposed Project in isolation would not be significant (see Potential Impacts 3.11-2, 3.11-3, 3.11-5, and 3.11-6), significant short-term sedimentation impacts are only expected in one reach of the Middle Klamath River – from Iron Gate Dam to Cottonwood Creek, and these impacts would likely be small or spatially restricted compared with flooding on large areas of bare ground exposed by wildfire, the incremental impact of the Proposed Project would not be cumulatively considerable.

Most known forest and wildfire management projects are not close to the mainstem Klamath River, except the Somes Bar Integrated Fire Management Project (approximately 90 miles downstream of Humbug), and Crawford Vegetation Management Project (approximately 70 miles downstream of Humbug), as well as the Oak Fire Roadside Hazard Tree Proposal downstream of Happy Camp, although this project is buffered from the Klamath River by Highway CA-96. Most mining projects described in the assessment of existing conditions for the Proposed Project are withdrawal or remediation projects, or are situated in tributaries far from the Hydroelectric Reach, apart from the new Plan of Operations for the existing Brooks Mine, which has been cancelled since the Draft EIR (Table 3.24-1) (USDA 2019). ~~The new plan of operations for the Brooks Mine (Table 3.24-1) is near the expected hydrologic and sedimentation footprint from Lower Klamath Project dam removal, which extends through the Hydrologic Reach and the Middle Klamath River from Iron Gate Dam to Humbug Creek.~~ Most agricultural projects, including cannabis cultivation projects, are also captured by existing conditions, or are situated far from the Hydroelectric Reach, except for the adopted Cannaworx Zone Change near Humbug. The Cannaworx Zone Change would convert Open Space to Non-Prime Agricultural zoned land, thus supporting agricultural activities on previously agriculture-free land. Based on the above information, the soil disturbance, erosion, and sedimentation impact of the Proposed Project, in combination with forest and wildfire management, mining-related activities, and agricultural activities, would not be cumulatively significant.

Volume I Section 3.24.11 – Cumulative Effects – Geology, Soils, and Mineral Resources – Potential Cumulative Impact 3.24-42 Short-term hillslope instability, effects to earthen dam embankments, and/or bank erosion from the Proposed Project in combination with other potential non-project activities, paragraphs 3 through 5 on page 3-1193:

Potential Cumulative Impact 3.24-42 Short-term hillslope instability, effects to earthen dam embankments, and/or bank erosion from the Proposed Project in combination with other potential non-project activities.
Slope stability analyses conducted for the Proposed Project indicate that segments of the Copco No. 1 Reservoir rim and adjacent slopes have a potential for slope failure that could impact existing roads and/or private property. These areas include approximately 1,780 linear feet of shore-parallel length with potential impacts outside of the reservoir rim, including 430 linear feet along Copco Road on the north shore, and approximately 1,350 linear feet adjacent to private property on the south shore~~3,700 linear feet of slopes along Copco Road and approximately 2,800 linear feet of slope adjacent to private property~~ (Appendix B: *Definite Plan* – Appendix E – Section 3.4.4 *Slope Stability Analysis Results,* and Figure 3.5, slope segments S5, S11, S12, and N11). Up to eight parcels in these areas have existing habitable structures that could potentially be impacted. The impact of the Proposed Project on hillslope instability in reservoir rim areas would be significant. Implementation of Mitigation Measure GEO-1 would reduce the cumulative impact to less than significant. No other projects have been identified that would cause hillslope instability along the rim or slopes adjacent to the rim of Copco No. 1 Reservoir (or the rims of Iron Gate or Copco No. 2 reservoirs) (Table 3.24-1); therefore, there would be no cumulative impact.

Analyses of embankment stability during drawdown at the earthen dams (i.e., Iron Gate Dam and J.C. Boyle Dam) indicate that the proposed reservoir drawdown rates would not result in substantial embankment instability (Appendix B: *Definite Plan*). Small, shallow slumping along the upstream embankment slopes due to the potential strength loss of surficial materials during drawdown would not threaten the structural integrity of the embankments or deliver a substantial amount of sediment. No other projects have been identified that would cause embankment instability at Iron Gate Dam and J.C. Boyle Dam (Table 3.24-1); therefore, there would be no cumulative impact related to embankment stability.

Drawdown flow rates for the Proposed Project are similar to existing and historical flow rates, and would be adjusted according to the water year type, thus substantial bank erosion is not expected (Potential Impact 3.11-4). As discussed in Potential Impact 3.24-2 *[Water Quality]*, 2017 flow requirements (i.e., 2013 BiOp Flows plus the 2017 court-ordered flushing and emergency dilution flows) are within the range of flows modeled under the Proposed Project; therefore, there would not be any cumulative impact related to bank erosion. Note that although the 2013 BiOp Flows are no longer the operational standard for the Klamath River, and the court-ordered flushing and emergency dilution flows are no longer required (see Volume I Section 3.1.6 *Introduction – Summary of Available Hydrology Information for the Proposed Project*), the analysis of the court-ordered flushing and emergency dilution flow requirements remains in this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur and retaining the analysis does not change any significance determinations.

3.24.12 Historical Resources and Tribal Cultural Resources

Volume I Section 3.24.12 Cumulative Effects – Historical Resources and Tribal Cultural Resources – Potential Cumulative Impact 3.24-46 Short-term historical and trial cultural resources effects of the Proposed Project in combination with 2017 court-ordered flushing and emergency dilution flows, paragraph 3 on page 3-1196 through paragraph 3 on page 3-1197:

Potential Cumulative Impact 3.24-46 Short-term historical and tribal cultural resources effects of the Proposed Project in combination with 2017 court-ordered flushing and emergency dilution flows.
The 2013 BiOp Flows are ~~have been~~ analyzed under the individual resource sections for the Proposed Project as the operational flow requirement for the Klamath River at the time of the Notice of Preparation for the Lower Klamath Project EIR (i.e., December 22, 2016). Potential Impact 3.24-2 in Section 3.24.2 *Cumulative Water Quality Effects* provides background and context regarding agency re-consultation on the 2013 BiOp, which was completed following the issuance of the Draft EIR in December 2018, and the cumulative effects analysis. ~~For the reasons set out in Potential Impact 3.24-2, this analysis only considers the 2017 court-ordered flow requirements, which were imposed after issuance of the Notice of Preparation (i.e., are not part of the existing conditions), and are a reasonably foreseeable flow condition; this analysis does not consider the potential new BiOp.~~ Although the 2013 BiOp Flows are no longer the operational standard for the Klamath River, and the 2017 court-ordered flushing and emergency dilution flows are no longer required (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*), the analysis of the court-ordered flushing and emergency dilution flow requirements remains in this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur and retaining the analysis does not change any significance determinations.

The existing 100-yr floodplain in the Middle Klamath River downstream of Iron Gate Dam between RM 190 and 171, defined as *Subarea 2*, would increase slightly under the Proposed Project, and associated flooding and erosion may have a significant and unavoidable impact on historical and tribal cultural resources along this reach of the Klamath River, (Potential Impacts 3.12-3 and 3.12-14). In other reaches of the Klamath River, the floodplain is not expected to change (Potential Impacts 3.12-3 and 3.12-14). There are no closely related development projects that would, in combination with the Proposed Project, have a significant and adverse impact on flooding in *Subarea 2* (Table 3.24-1), where the floodplain is expected to increase under the Proposed Project. During the period when the Proposed Project would occur, the 2017 flow requirements (i.e., 2013 BiOp Flows plus the 2017 court-ordered flushing and emergency dilution flows) ~~would be in effect (see Cumulative Impact 3.24-1 for additional detail). However, these flow requirements are~~ would not have been ~~not~~ sufficiently high as to increase flooding risk, thus there would be no cumulative flooding and/or erosion impacts to historical and tribal cultural resources located within the 100-year floodplain.

As mentioned in Impact 3.24-45 above, the Proposed Project would benefit the cultural riverscape and ecosystem health, including tribal fisheries resources, by dam removal and elimination of hatchery production (Potential Impact 3.12-9). The 2017 flow requirements would have improved Klamath River fishery tribal cultural resource by reducing the incidence of fish disease (see Section 3.3.5.5 *Fish Disease and Parasites*), and in combination with the removal of upstream migration barriers (i.e., the Lower Klamath Project dams) and improvements to the quality of riverine habitat in the Middle Klamath River and the Hydroelectric Reach (see Section 3.3.5.8 *Aquatic Habitat*), there would be a cumulative beneficial effect on the fishery tribal cultural resource.

Volume I Section 3.24.12 Cumulative Effects – Historical Resources and Tribal Cultural Resources – Potential Cumulative Impact 3.24-47 Historical and tribal cultural resources effects from the Proposed Project in combination with development projects, paragraph 4 on page 3-1197:

Potential Cumulative Impact 3.24-47 ~~Short-term and/or long-term h~~ Historical and tribal cultural resources effects from the Proposed Project in combination with development projects.

Tribal Cultural Resources

Significant and unavoidable ~~short-term~~ ground-disturbing construction-related impacts on archaeological and non-archaeological tribal cultural resources (TCRs) would occur even with mitigation for the 4 to 8-year period of dam removal and restoration activities under the Proposed Project (Potential Impacts 3.12-1, 3.12-4, 3.12-5).

Volume I Section 3.24.12 Cumulative Effects – Historical Resources and Tribal Cultural Resources – Potential Cumulative Impact 3.24-47 Historical and tribal cultural resources effects from the Proposed Project in combination with development projects, paragraph 3 on page 3-1198:

Significant and unavoidable ~~short-term~~ ground-disturbing construction-related impacts on historic-period archaeological resources would occur with mitigation for the 4 to 8-year period of dam removal and restoration activities under the Proposed Project (Potential Impacts 3.12-12, 3.12-15, 3.12-16).

3.24.13 Paleontologic Resources

Volume I Section 3.24.13 Cumulative Effects – Paleontologic Resources, paragraph 6 on page 3-1198:

Existing conditions for paleontologic resources are as described in Section 3.13.2~~3.14.2~~ [Paleontologic Resources] *Environmental Setting*. The majority of bedrock deposits within the Area of Analysis for paleontologic resources are not fossil-bearing units. Two mapped geologic units that contain paleontologic resources are present within the Area of Analysis: (1) the unnamed diatomite deposit at Copco No. 1 Reservoir; and (2) the Hornbrook Formation. The diatomite deposit is determined to be of Low Paleontologic Potential. The fossils in the Hornbrook Formation are documented to include megafossils and microfossils, but it is not known if the fossil abundance varies spatially within this geologic unit. The Klamath River cuts across the Hornbrook Formation in the region of Hornbrook, California, along approximately three river miles (Figure 3.13-2). Sub-units within the Hornbrook formation are described in Section 3.13.2~~3.14.2~~ [Paleontologic Resources] Environmental Setting. Section 3.13.2~~3.14.2~~ also includes consideration of major past or ongoing projects that have impacted, or currently impact, paleontologic resources.

Volume I Section 3.24.13 Cumulative Effects – Paleontologic Resources – Potential Cumulative Impact 3.24-48 Long-term paleontologic resources effects from the Proposed Project in combination with other non-project activities, paragraph 3 on page 3-1199:

As there are no closely related projects that would, in combination with the Proposed Project, result in cumulative flood hydrology impacts (see Section 3.24.6 *Cumulative Effects – Flood Hydrology* ~~*Effects*~~) there would be no cumulative downcutting and erosion impacts related to altered flood flows within the Klamath River.

3.24.14 Land Use and Planning

Volume I Section 3.24.14 *Cumulative Effects – Land Use and Planning*, *paragraph 2 on page 3-1200*:

Significance criteria for cumulative land use and planning~~aquatic resources~~ impacts are the same as defined in Section 3.14.3 *[Land Use and Planning] Significance Criteria*.

3.24.15 Agriculture and Forestry

Volume I Section 3.24.15 Cumulative Effects – Agriculture and Forestry – Potential Cumulative Impact 3.24-53 Short-term and long-term effects to forestry resources from the combination of the Proposed Project and wildfire, paragraph 3 on page 3-1202:

Potential Cumulative Impact 3.24-53 Short-term and long-term effects to forestry resources from the combination of the Proposed Project <u>and</u> wildfire.

3.24.16 Population and Housing

Volume I Section 3.24.16 Cumulative Effects – Population and Housing, paragraphs 4 and 5 on page 3-1203:

The nature of the ~~above listed~~ <u>relevant</u> projects is that they could increase population growth and create housing demand, especially during construction periods when additional workers would be present.

Significance criteria for cumulative <u>population and housing</u>~~aquatic resources~~ impacts are the same as defined in Section 3.16.3 *[Population and Housing] Significance Criteria*.

Volume I Section 3.24.16 Cumulative Effects – Population and Housing – Potential Cumulative Impact 3.24-54 Short-term and long-term population and housing effects from the Proposed Project in combination with residential and industrial development projects, paragraph 6 on pages 3-1203 to 3-1204:

However, given that the temporary population increase due to the Proposed Project would be small (0.4 percent) (Potential Impact 3.16-2), and m<u>any</u>~~ost~~ workers for the Proposed Project are anticipated to be sourced from Yreka and smaller nearby communities, the Proposed Project's use of vacant units would be minimal, and the incremental impact on population and housing would not be cumulatively considerable.

3.24.17 Public Services

Volume I Section 3.24.17 Cumulative Effects – Public Services, paragraph 4 on page 3-1204:

Existing conditions for public services are described in Section 3.17.2 [Public Services] Environmental Setting, which describes fire protection, police, medical services, schools, parks, and other public facilities within the Area of Analysis. Fire protection in the Area of Analysis is provided via cooperative fire protection agreement with ~~CALFIRE~~<u>CAL FIRE</u>.

Volume I Section 3.24.17 Cumulative Effects – Public Services, new paragraph 1 on page 3-1205:

Significance criteria for cumulative public services impacts are the same as defined in Section 3.17.3 *[Public Services] Significance Criteria* for the resource.

Volume I Section 3.24.22 Cumulative Effects – Public Services – Potential Cumulative Impact 3.24-55, paragraph 1 on page 3-1205:

The Proposed Project could result in a significant short-term impact if it resulted in substantial increased emergency response times within the Area of Analysis. Other projects and activities that could potentially impact emergency response times include multiple thinning and forest fuel reduction projects in the Happy Camp, Oak Knoll, Salmon River, Scott River, and Goosenest Ranger Districts of the Klamath National Forest, the Brooks Mine (cancelled since the Draft EIR), fiber optic cable installation along Highway 96, PacifiCorp powerline replacement in the Happy Camp Ranger District, Guys Gulch Road Realignment, Wooley Creek Bridge Rehabilitation, KHSA (IM)-16 Water Diversion Projects, and construction of the Yreka Nanocellulose Facility, Siskiyou County Jail, Rain Rock Casino, Sousa Ready Mix Concrete Batch Plant, and the Fruit Growers Supply Company Sawmill (Table 3.24-1). These projects are unlikely to overlap in space and time with the Proposed Project's potential impacts to public services response times or emergency service routes, with the exception of KHSA (IM)-16 Water Diversion Projects and the Yreka Nanocellulose Facility, Siskiyou County Jail, Rain Rock Casino, Sousa Ready Mix Concrete Batch Plant, and Fruit Growers Supply Company Sawmill projects. If these projects occur at the same time as the Proposed Project, they could add to the increased emergency response times from the Proposed Project described as Potential Impact 3.17-1. ~~Although t~~The Emergency Response Plan, Fire Management Plan, Traffic Management Plan (TMP), and Hazardous Materials Management Plan to be prepared per Mitigation Measure~~s~~ HZ-1 and ~~Recommended~~ Mitigation Measure TR-1 would take into account any other construction projects occurring at the same time that could potentially slow emergency services access in the affected area~~, the State Water Board cannot ensure the TMP's and Emergency Response Plan's implementation~~. As with Potential Cumulative Impact 3.24-65, the combination of the Proposed Project, mitigation measures HZ-1 and TR-1, and one or more other construction projects within the Area of Analysis would be unlikely to result in significant impacts to traffic and transportation. ~~However, because the State Water Board has determined that short-term construction-related impacts of the Proposed Project would be significant and unavoidable with respect to traffic flow, road safety, road conditions, emergency access, public transit, and non-motorized transportation, unless and until KRRC reaches enforceable 'good citizen' agreements through the FERC process, it has determined the incremental contribution of the Proposed Project in this Draft EIR to be cumulatively considerable.~~ In its comments on the Draft EIR (ORG46) and in its application for water quality certification filed on December 3, 2019, the

KRRC provided additional standards and commitments regarding the Traffic Management Plan. The State Water Board anticipates that implementation of Mitigation Measure TR-1 would reduce short-term construction-related impacts of the Proposed Project to less than significant with respect to traffic flow, road safety, road conditions, emergency access, public transit, and non-motorized transportation, and the analysis above finds no significant overlapping transportation and traffic impacts from other projects; therefore, there would be no significant cumulative impact.

Significance

~~*Cumulatively considerable*~~ *No significant cumulative impact*

Volume I Section 3.24.17 Cumulative Effects – Public Services – Potential Cumulative Impact 3.24-55, paragraph 1 on page 3-1206:

The Proposed Project could expose people or structures to a risk of loss, injury, or death involving wildland fires by reducing reservoir storage (Potential Impact 3.17-2, and Potential Cumulative Impact 3.21-8). The 2017 court-ordered flushing and emergency dilution flows could have changed flows from upstream of the Proposed Project and affected the volume of water available for firefighting in the Area of Analysis; however, ~~and~~ the timing of the 2017 flows ~~is~~ was likely to have had a beneficial effect during wildfire season should they have been required during Proposed Project reservoir drawdown. Note that although the 2013 BiOp Flows are no longer the operational standard for the Klamath River, and the 2017 court-ordered flushing and emergency dilution flows are no longer required (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*), the analysis of the court-ordered flushing and emergency dilution flow requirements remains in this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur and retaining the analysis does not change any significance determinations.

3.24.18 Utilities and Service Systems

Volume I Section 3.24.18 Cumulative Effects – Utilities and Service Systems, paragraph 5 on page 3-1206:

Potential cumulative impacts to water supply, including consideration of the City of Yreka’s water supply infrastructure, are addressed in Section 3.24.8 *Cumulative Effects [Water Supply/Water Rights].*

Volume I Section 3.24.18 Cumulative Effects – Utilities and Service Systems, paragraph 1 on page 3-1207:

The Anderson Landfill had an estimated remaining capacity of 11,914,025 cubic yards (72 percent of capacity remaining) in 2008, with an anticipated closure date of 2055 (CalRecycle 2017~~a~~).

Volume I Section 3.24.18 Cumulative Effects – Utilities and Service Systems – Potential Cumulative Impact 3.24-56 Short-term and long-term utilities and service system effects from the Proposed Project in combination with non-project activities, new paragraph 3 on page 3-1207:

Significance criteria for cumulative utilities and service systems impacts are the same as defined in Section 3.18.3 *[Utilities and Service Systems] Significance Criteria* for the resource.

3.24.19 Aesthetics

Volume I Section 3.24.19 Cumulative Effects – Aesthetics, paragraph 4 on page 3-1208 to paragraph 5 on page 3-1211:

~~The Area of Analysis for aesthetics is the Klamath River from the Oregon-California state line to the Klamath River Estuary.~~ The Primary Area of Analysis for aesthetics is within the viewshed of the Lower Klamath Project reservoirs, which includes the proposed Limits of Work in California (i.e., Copco No. 1, Copco No. 2, and Iron Gate dams, reservoirs, ~~and~~ associated facilities, and the areas identified as construction/demolition areas and staging areas), plus a buffer to the ridgeline of surrounding the reservoirs (Figure 3.19-1). The secondary Area of Analysis for aesthetics includes those areas within view of the Klamath River downstream from Iron Gate Dam to the confluence with the Shasta River (RM 179.5), as well as the portion of the Klamath River extending upstream from Copco No. 1 Reservoir to the Oregon-California border, because these river reaches may be affected by removal of the upstream dams.

Existing conditions for aesthetics are defined in Section 3.19.2 *[Aesthetics] Environmental Setting*. ~~The~~ Within the Primary Area of Analysis ~~for aesthetic resources contains~~ , the Lower Klamath Project dams and associated facilities except three [all associated with J.C. Boyle in Oregon] are located in areas that have been designated as a as a Bureau of Land Management (BLM) Visual Resource Management (VRM) Class III ~~visual resources, for which the~~ area by a Resource Management Plan or have been classified as a Class III area because the area has not been given a specific VRM class by BLM (PacifiCorp 2004) (see Section 3.19.2.1 *PacifiCorp Analysis and Bureau of Land Management Methodology*). The objective of Class III areas is to partially retain the existing character of the landscape~~, with only moderate change from a project such as~~ . Using BLM's VRM methodology, all of the Proposed Project~~. The variety of color, vegetation, landforms, adjacent scenery, scarcity, cultural modifications, and the presence of water within the Area of Analysis leads to a BLM Class A (distinctive~~ area has high scenic quality, rating A for inherent scenic attractiveness~~) classification for scenic quality. The~~ of the landscape. Both the Primary and Secondary Area of Analysis for aesthetics also ha~~s~~ve a High BLM visual sensitivity classification, meaning the public seeks a high level of visual quality in the landscape, and a foreground-middleground distance zone classification. ~~Additionally~~In addition to the BLM classifications, Klamath River components are part of the National (and state) Wild and Scenic Rivers (WSR) System, because of their free-flowing condition and "outstandingly remarkable" values. ~~The~~There are three Scenic Byways located along the Klamath River and within the Klamath and Six Rivers National Forests, although only a small portion of the "State of Jefferson" National Forest Scenic Byway~~, and "Bigfoot" National Forest Scenic Byway are also situated~~ is within the Area of Analysis. Section 3.19.2 *[Aesthetics] Environmental Setting* includes consideration of major past or ongoing projects that have impacted, or currently impact, aesthetics resources.

~~This cumulative impact analysis focuses on the potential impacts of the Proposed Project combined with other closely related projects that are not already considered in the analysis of utilities and service systems resource area effects (Section 3.18).~~

This cumulative impact analysis focuses on the impact of the Proposed Project and other projects that are not already considered in the analysis of aesthetics resource area effects (Section 3.19) due to actions and elements included in the Proposed Project (Section 2). Non-project activity types within the aesthetics Area of Analysis with the potential for significant cumulative land use and planning impacts include (Table 3.24-1):

- Large-scale construction projects;
- 2017 court-ordered flushing and emergency dilution flows, or other hydrological impacts that change flow characteristics, open water conditions, channel morphology, or turbidity;
- Water discharges that visually affect water quality;
- Riverine restoration projects;
- Changes or removal of historic structures;
- Near-channel infrastructure projects (i.e., bridges, culverts); and
- Large-scale infrastructure projects~~.~~;
- Mining projects; and
- Forest management;

Significance criteria for cumulative aquatic resources impacts are the same as defined in Section 3.19.3 *[Aesthetics] Significance Criteria*.

Potential Cumulative Impact 3.24-57 Short-term and long-term scenic vista effects from the loss of open water from the Proposed Project in combination with other non-project activities.

~~The~~Under the Proposed Project~~ would have no significant impact from the loss of open water vistas, because open water and lake vistas~~, the existing scenic reservoir view would be ~~altered in favor of more natural river, ~~replaced with riverine and canyon~~, and valley vistas, there are numerous open-water lakes in the region, and visual quality for ~~ scenic views, which would be a substantial change. However, since the ~~public~~VRM class would remain Class III (i.e., would not be ~~substantially~~ degraded) at the associated scenic vistas, the long-term change is not considered to be adverse (Potential Impact 3.19-1). ~~No other~~ The USDA Forest Service Lucky Penny project, which is a local timber harvest project that involves thinning of existing stands (no clear-cut silviculture) to improve forest resiliency and reduce catastrophic wildfires, is among the set of planned and reasonably foreseeable projects listed in Table 3.24-1. However, treatments for this project would take place in the headwaters of Cold Creek and Deer Creek, which are well outside of the Primary and Secondary Area of Analysis for aesthetics, and these treatments are projected to be completed prior to dam removal. No other non-project activities that would result in ~~loss of open water~~significant adverse impacts to scenic vistas in the reservoir or riverine viewsheds within the Area of Analysis have been identified (Table 3.24-1), thus there would be no significant cumulative impacts to scenic vistas ~~due to the Proposed Project and other closely related projects~~in the reservoir viewsheds affected by the loss of open water.

Significance
No significant cumulative impact

Potential Cumulative Impact 3.24-58 Short-term and long-term scenic resources effects from the Proposed Project in combination with restoration, flow enhancement, and water quality improvement projects, and other non-project activities.
~~The Proposed Project could affect~~Potential Impact 3.19-2 considered the visual effect of changes to flow characteristics within sections of Klamath River classified as WSR~~. Potential changes to flow characteristics include the timing, duration, and magnitude of~~ or WSR eligible. The hydrologic changes that would occur under the Proposed Project (i.e., smoother hydrograph due to the elimination of relatively rapid changes in flows~~, which can affect channel morphology; however~~ from dam releases during the dry season, lower flows in the late summer and higher flows in the late fall, and lack of attenuation of large storm events during the wet season) would not be readily noticeable to the casual observer from key vistas along the Klamath River in the aesthetics secondary Area of Analysis downstream of Iron Gate Dam, and they would not result in a loss of, or substantial adverse change to, scenic elements of a designated WSR reach. Further, although some short-term changes in sediment composition and temporary sediment deposition are expected, the Proposed Project would not have ~~flow characteristics that are visually similar to existing conditions and~~significant adverse impacts on visual ~~impacts related to changes~~aspects of channel morphology (i.e., shape of the river channel ~~morphology would not be significant~~and/or presence of boulders, cobble, gravel, sand bars) (Potential Impact 3.19-2). ~~Other~~Restoration, flow enhancement, and water quality improvement projects (Table 3.24-1) have the potential to alter ~~river~~hydrology and visual aspects of channel morphology and result in a cumulative impact~~. Potential Impact 3.24-1 in Section 3.24.2 *Cumulative Water Quality Effects* provides background and context regarding agency re-~~

~~consultation on the 2013 BiOp, and Potential Impact 3.24-24 provides a summation of the approach taken in this document. As for Potential Impact 3.24-24, the~~ , thus are considered here.

The 2017 court-ordered flushing flows are ~~the focus of this analysis. Surface and deep flushing flows would reflect a more natural regime, thus could have either no impact or beneficial effects to river channel morphology in combination with the Proposed Project.~~within the range of flows modeled under the Proposed Project, thus potential changes to hydrology and river channel morphology would be similar to the Proposed Project (i.e., less than significant). The combination of the Proposed Project and the 2017 court-ordered flushing flows would have no more than a moderate change to visual aspects of key vistas along the Klamath River and would reflect a more natural flow regime. There would be no significant cumulative aesthetic impact in the short term, and either no significant cumulative aesthetic impact or a beneficial enhancement of visual aspects of hydrology and channel morphology in the long term. Note that although the 2013 BiOp Flows are no longer the operational standard for the Klamath River, and the court-ordered flushing and emergency dilution flows are no longer required (see Volume I Section 3.1.6 *Introduction – Summary of Available Hydrology Information for the Proposed Project*), the analysis of the court-ordered flushing and emergency dilution flow requirements remains in this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur and retaining the analysis does not change any significance determinations.

~~The Proposed Project~~ Potential Impact 3.19-3 found that there would ~~result in significant and unavoidable short-term~~ be no loss of, or substantial adverse change to, scenic elements of the landscape as viewed from a vista point, community, recreation site area, trail, scenic highway, or designated WSR reach due to visual changes in water quality ~~due to elevated suspended sediment concentrations during~~. In the short term, there would be no significant impact due to reduced water clarity associated with reservoir drawdown ~~(Potential Impact 3.2-3); however, the visual quality (water clarity) impact from this would~~ , which is not ~~be a significant impact as the contrast is expected to be weak to moderate (i.e., not a visually noticeable change from~~atypical in winter and early spring under existing conditions ~~for most of the drawdown period) and spatially limited (decreasing downstream)~~ (Potential Impact 3.19-3). The only other closely related project that might result in an adverse cumulative visual water clarity impact is the 2017 court-ordered flushing flows. While there may be ~~an increase in the duration of elevated suspended sediment concentrations~~a decrease in water clarity in years when the Proposed Project reservoir drawdown flows do not meet the surface and/or deep flushing flow requirements and the 2017 court-ordered flushing flows are still required to occur until either April 30 (surface flushing flows) or May 31 (deep flushing flows) (see Potential Cumulative Impact 3.25-1 for more details); reduced clarity conditions would be of short duration (i.e., 24 to 72 hours) and spatially limited. Overall, there would ~~not~~ be ~~a~~no significant short-term cumulative visual quality impact due to the Proposed Project and the 2017 court-ordered flushing flows.

In the long term, ~~the~~ there would be a beneficial ~~reductions of~~aesthetic impact from the Proposed Project due to reduced seasonal ~~nuisance algae~~algal blooms ~~would have no impact on aesthetics~~originating from the Lower Klamath Project reservoirs (Potential Impact 3.~~18~~19-3). The 2017 court-ordered flushing flows would improve management of *C. Shasta,* which could have adverse visual water quality outcomes if left uncontrolled. Similarly, other restoration projects occurring within the Klamath Watershed, such as the Long-Term Plan to Protect Adult Salmon in the Lower Klamath River, would reduce nutrients and thus the prevalence of seasonal alga~~e~~l blooms (Table 3.24-1). The Proposed Project, in combination with riverine restoration projects, would have beneficial cumulative effects on visual water quality in the long term.

Significance

No significant cumulative impact from short-term changes in water quality including increased turbidity and reduced clarity

Beneficial cumulative impact due to long-term changes in visual water quality from reduced algal blooms

Potential Cumulative Impact 3.24-59 Short-term and long-term visual character and quality effects from the Proposed Project in combination with other ground disturbing and construction activities.

Exposure of Bare Sediment and Rock

The Proposed Project would ~~potentially~~ impact the visual character and quality of the site and its surroundings. Substantial areas of bare sediment and rock would be exposed in previously inundated areas after reservoir drawdown and dam removal, and would remain exposed until vegetation establishes, which would result in a significant impact in the short term for the primary aesthetics Area of Analysis (Potential Impact 3.19-4). Existing wetland vegetation on the reservoir shorelines may also die. Other closely related activities that could cause a similar change in visual character within the ~~Lower Klamath Project reservoir footprints~~primary aesthetics Area of Analysis include mining ~~and~~, near-channel infrastructure~~. However, no reasonably foreseeable~~, large-scale construction projects ~~involving such activities within the reservoir footprints have been~~, and forestry and wildfire management projects. Only one of the anticipated mining, construction, infrastructure, and forest and wildfire management projects identified ~~(~~in Table 3.24-1~~);~~ overlaps with the aesthetics Primary or Secondary Area of Analysis. This is the Lucky Penny forest and wildfire management project, and as stated in Impact 3.24-57, no treatment would occur within the aesthetics Area of Analysis; therefore, ~~there would be no~~other projects would not expose bare ground within the viewsheds or result in a significant cumulative visual impact.

~~Replacement of the Yreka water supply pipeline, bridges, culverts, roads, and recreational facilities would result in minor visual changes compared to existing conditions, which would not constitute a significant short-term or long-term impact (Potential Impacts 3.19-5 and 3.19-6). Although there are other projects of this nature within the Klamath Basin, none of them are within the aesthetics Area of Analysis; therefore, the combination of the Proposed Project and other construction-related projects would not result in a significant cumulative visual impact.~~

Removal of Lower Klamath Project Dams and Historic Structures
In general, the aesthetic effects of removing the Lower Klamath Project dam complexes would be beneficial, because the resulting view would be better aligned with the predominant natural features of the characteristic landscape (Potential Impact 3.11-5). The Proposed Project involves the removal of historic structures (Copco No. 1 Hydroelectric Powerhouse and Dam; Copco No. 2 Hydroelectric Powerhouse; and Copco No. 2 Wooden Stave Penstock) (Potential Impact 3.19-5~~).~~); however, these particular structures are not visible from any scenic highways or river sections and there would be no aesthetic impact associated with their removal. Separate from the Proposed Project, no other historic structures have recently been removed, or are known to be planned for removal, in the aesthetics Area of Analysis (Table 3.24-1). Thus, there would be no significant cumulative ~~scenic historic resource~~aesthetic impact resulting from the ~~Proposed Project~~removal of the Lower Klamath Dams and historic structures and other closely related projects.

~~Additionally, there would be potential~~

Yreka Water Supply Pipeline, Bridges, Roads, Culverts, and Recreational Facilities
Replacement of the Yreka Water Supply Pipeline, and replacement and upgrades of bridges, roads, and culverts would result in minor visual changes compared to existing conditions, which would not constitute a significant short-term or long-term impact in the context of the existing landscape (Potential Impact 3.19-5). Potential new recreational facilities have not yet been designed and sited. They would be subject to a restoration plan and are unlikely to be inconsistent with the aesthetics significance criteria, but because the State Water Board cannot ensure implementation of measures in the Final Restoration Plan that would minimize potential aesthetic impacts, the visual impacts of new recreation facilities is significant and unavoidable. Although there are other projects of this nature (e.g., infrastructure and development projects) within the Klamath Basin, none of them are within the aesthetics Area of Analysis; therefore, the combination of the replaced, upgraded, or new infrastructure of the Proposed Project and other projects would not result in a significant cumulative visual impact.

Visual Construction Impacts

Potential short-term impacts to visual character and quality due to Proposed Project construction activities, including the presence of vehicles and equipment, temporary structures, temporary access roads, upgrades of existing bridges, roads, and culverts, equipment storage, stockpiles, ~~and~~ demolition~~.~~, onsite disposal of concrete, removal of recreational facilities, and fugitive dust are considered. The Proposed Project would have temporary weak (the element can be seen, but does not attract attention) to strong (the element demands attention, would not be overlooked, and dominates the landscape) visual contrasts associated with construction activities and would generate dust, but ~~most nearby recreational facilities with views of the~~ any change to the characteristic landscape from stockpiles and equipment would be moderated by existing alterations from the Lower Klamath Project, and there would be no degradation of the VRM classification or a substantial adverse effect on scenic vistas. Additionally, construction ~~site~~ would ~~be closed~~occur for ~~the duration of the~~ a period less than one year, most dust would settle out within approximately 300 ft of the source, and recreational facilities affected by demolition and construction ~~period~~would be closed, thus ~~the impact would not be significant~~a substantial number of people would not be affected by the temporary change in views from demolition and construction (Potential Impact 3.19-6). Although it is possible that there would be small-scale construction activities within the Area of Analysis at the same time as the Proposed Project, no overlapping large-scale construction projects are anticipated that would, in combination with the Proposed Project, result in reasonably foreseeable significant and adverse aesthetics impacts~~.~~ (see Table 3-24-1). Thus, there would be no short-term cumulative aesthetics impacts due to the construction activities associated with the Proposed Project~~.~~ and other construction projects. Since the concrete disposal areas at Iron Gate Dam and Copco No. 1 and Copco No. 2 dams would be graded and revegetated to conform with landform, vegetation, color, and adjacent scenery in the area, there would be no long-term cumulative aesthetics impact due to onsite disposal of concrete from the dam structures under the Proposed Project.

Significance

No significant cumulative impact

Potential Cumulative Impact 3.24-60 Short-term light and glare effects from the Proposed Project in combination with other construction projects.

Temporary lighting would be erected for nighttime construction activities under the Proposed Project, and security lighting may be required during deconstruction (Potential Impact 3.19-7). Although the Proposed Project would result in significant and unavoidable adverse impacts due to construction-related lighting, there are no closely related, spatially and temporally overlapping projects that would, in combination with the Proposed Project, result in further ~~significant and adverse~~substantial light or glare impacts that would adversely affect day or nighttime views in the area (Table 3.24-1). Thus, there would be no significant cumulative aesthetics impacts due to short-term light~~ing~~ and glare under the Proposed Project.

Significance
No significant cumulative impact

3.24.20 Recreation

Volume I Section 3.24.20 Cumulative Effects – Recreation, paragraph 7 on page 3-1211:

~~Within the Klamath Basin, t~~The Klamath, Scott, Salmon, Sprague, Sycan, Smith, and Trinity rivers, and Wooley Creek have segments classified as having Wild and Scenic values under ~~the WSRA.~~ Section 2(a)ii of the Wild and Scenic Rivers Act [WSRA]). Additionally, there are extensive public and private recreational opportunities along the Klamath River and within several lakes/reservoirs. Developed recreational facilities, including: Agency Lake, Upper Klamath Lake, the Link River Trail, and the Keno Impoundment/Lake Ewauna, and activity specific recreational resources, including whitewater boating, fishing, camping, and other opportunities on the Klamath River, are described in Section 3.30.2 *[Recreation] Environmental Setting*.

Volume I Section 3.24.20 Cumulative Effects – Recreation, paragraph 1 on page 3-1212:

- Water flow changes~~ and whitewater boating~~.

Volume I Section 3.24.20 Cumulative Effects – Recreation – Potential Cumulative Impact 3.24-61 Short-term and long-term recreation effects from the Proposed Project in combination with development projects, paragraph 3 on page 3-1212 through paragraph 1 on page 3-1213:

Proposed Project short-term construction-related impacts on existing recreational opportunities would not be significant (Potential Impact 3.20-1) for the following reasons: a number of reservoirs, lakes, and rivers are present within and adjacent to the Klamath Basin that provide similar recreational opportunities as areas where access would be restricted during Proposed Project construction; several existing recreational sites are located away from where dust and noise would be generated during Proposed Project construction; turbidity impacts would be short-term and primarily during the winter when turbidity is naturally high and recreational use for non-contact (e.g., boating) and contact recreation (e.g., swimming and fishing) is relatively low; and water quality and clarity would improve with distance downstream of Iron Gate Dam, as sediments are flushed downstream and into the Pacific Ocean. Additionally, effects on the environment due to the construction of new or expansion of existing recreational facilities associated with the Proposed Project would not have a significant impact

(Potential Impact 3.20-4). Although there is potential for other large-scale construction projects in the Klamath Basin to temporally overlap with the Proposed Project, such as the Sousa Ready Mix Concrete Plant and the potential nanocellulose facility, these projects would be located in Yreka (Table 3.24-1). Such projects in Yreka are not close enough to the Proposed Project reservoir footprints and/or the Middle Klamath River immediately downstream of Iron Gate Dam (where turbidity impacts would be greatest) to result in a significant cumulative impact to recreation or the environment. There may be some overlapping, small-scale construction projects in more proximal locations (Table 3.24-1), but there are no other reasonably foreseeable construction projects that would contribute to a short-term adverse cumulative impact on recreation in the area where the Copco No. 1, Copco No. 2, and Iron Gate dams are proposed for removal (Table 3.24-1). Thus, the Proposed Project, in combination with other construction projects, would not have a significant adverse cumulative impact on recreational opportunities, or on the environment from the development of recreational facilities, in the Area of Analysis.

The Proposed Project would not have significant long-term impacts on reservoir-based recreation activities and facilities (Potential Impact 3.20-2), or substantial or accelerated physical deterioration of other regional facilities (Potential Impact 3.20-3).

Volume I Section 3.24.20 Cumulative Effects – Recreation – Potential Cumulative Impact 3.24-62 Short-term and long-term recreation effects from the Proposed Project in combination with other restoration, flow enhancement, and water quality improvement projects, paragraphs 3 and 4 on page 3-1213:

The Proposed Project would improve scenery, recreation, fisheries, and wildlife values in the long term (which are values specified in the Wild and Scenic River Act Section 7(a)) on the California Klamath Wild and Scenic River segments that are ~~(both~~ designated or~~and~~ eligible for listing) and scenic river designations or eligibility for listing would not be compromised (Potential Impact 3.20-7). Other aquatic habitat restoration, flow enhancement, and water quality improvement projects along the Klamath River and its tributaries (see Table 3.24-1) would include placement of off-channel habitat features, floodplain restoration, incorporation of large wood into tributaries to the Klamath River, increases in stream flow, and reduction in water quality pollutants. These types of projects would have a beneficial cumulative effect on recreation associated with wild and scenic values in the long term.

The Proposed Project would be beneficial with respect to ~~the~~ river-based recreational fishing in the Hydroelectric Reach, Middle Klamath River downstream of Humbug Creek, and the Lower Klamath River because it would: restore volitional fish passage, improve long-term water quality, likely increase recreational fish species, and implement the Recreation Facilities Plan for the Hydroelectric Reach (Potential Impact 3.20-6). There would be no significant impact to, or loss of, other river-based recreation, for the Middle Klamath River between Iron Gate Dam and Humbug Creek under the Proposed Project, because there is only one structure that is expected to be within the post-dam removal 100-year floodplain that is not in the floodplain under existing conditions and downstream flood control would be implemented (Potential Impact 3.20-6). Other restoration projects (Table 3.24-1) would also improve fisheries by restoring habitat; therefore, the Proposed Project in combination with other restoration projects would be beneficial for recreational fishing.

Volume I Section 3.24.20 Cumulative Effects – Recreation – Potential Cumulative Impact 3.24-63 Short-term and long-term whitewater boating effects from the combination of the Proposed Project and water flow changes, paragraph 6 on page 3-1213:

The 2017 court-ordered flushing flows (interim flows until re-consultation of the 2013 BiOp ~~is~~was completed, see also Potential Cumulative Impact 3.24-1) would increase water flows during relatively short (i.e., 24 to 72 hours) controlled periods (see Potential Cumulative Impact 3.24-1), which could provide periodic benefits to whitewater boaters. Note that although the 2013 BiOp Flows are no longer the operational standard for the Klamath River, and the court-ordered flushing and emergency dilution flows are no longer required (see Volume I Section 3.1.6 *Introduction – Summary of Available Hydrology Information for the Proposed Project*), the analysis of the court-ordered flushing and emergency dilution flow requirements remains in this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur and retaining the analysis does not change any significance determinations. No projects have been identified that would substantially reduce flows and result in a significant cumulative impact on whitewater boating opportunities in combination with the Proposed Project (Table 3.24-1).

3.24.21 Hazards and Hazardous Materials

Volume I Section 3.24.21 Cumulative Effects – Hazards and Hazardous Materials, new paragraph 5 on page 3-1214:

Significance criteria for cumulative hazards and hazardous materials impacts are the same as defined in Section 3.21.3 *[Hazards and Hazardous Materials] Significance Criteria* for the resource.

Volume I Section 3.24.21 Cumulative Effects – Hazards and Hazardous Materials – Potential Cumulative Impact 3.24-64 Short-term and long-term hazards and hazardous materials effects from the Proposed Project in combination with non-project activities, paragraphs 1 through 3, on page 3-1215:

~~No non-project activity types within the hazards and hazardous materials Area of Analysis that could be located on a hazardous materials site, projects that could~~

~~result in a safety hazard within two miles of airports, or that could impair implementation emergency response or emergency evacuation plans (Potential Impacts 3.21-5, 3.21-6, and 3.21-7), would have the potential for significant incremental short- or long-term cumulative impacts related to hazards and hazardous substances because none of these activities would overlap in type, location, or time with anticipated impacts under the Proposed Project.~~

The Proposed Project could result in substantial exposure for the public or environment to hazards or hazardous materials due to routine transport, use, or disposal of hazardous materials, potential accidental release of hazardous materials, or be located on a hazardous site (Potential Impacts 3.21-1, 3.21-2, and 3.21-4~~3~~), and would require implementation of Mitigation Measure HZ-1 to reduce potential impacts to less than significant. The Proposed Project would not require handling of hazardous substances within one-quarter mile of a school, nor activities within two miles of an airport (Potential Impacts 3.21-3, 3.21-5, and 3.21-6). Although the Campora Propane and Pacific Connector Gas Pipeline projects are in development and may present additional hazards or hazardous materials ~~similar~~ risks, both projects are too distant from the Lower Klamath Project dam complexes in California to cause significant impacts in the Area of Analysis. Thus, there would be no cumulative impact.

The Proposed Project could have a significant and unavoidable impact on emergency response and evacuation (Potential Impact 3.21-7), and the associated cumulative impacts are discussed in Potential Cumulative Impact 3.24-55.

The Proposed Project would result in a significant and unavoidable long-term impact due to reduction in reservoir storage for fighting wildland fires (Potential Impact 3.21-8) because the State Water Board cannot ensure the implementation of Recommended Measure PS-1, which would require a Fire Management Plan after reaching agreement with ~~CALFIRE~~CAL FIRE on a long-term water source replacement for helicopter and ground crews (including construction and utilization of proposed dry hydrants, dip ponds or other alternatives). ~~While the effects of new BiOp flow requirements for the Klamath Irrigation Project are speculative, t~~The 2017 flow requirements (i.e., 2013 BiOp Flows plus the 2017 court-ordered flushing and emergency dilution flows) would periodically increase the volume of water entering the Hydroelectric Reach and the Middle Klamath River immediately downstream of Iron Gate Dam by requiring 24-hr to 72-hr periods of higher flows into May and June. While this short period of inflow and limited periodicity is not sufficient to be beneficial with respect to fighting wildland fires, the 2017 flow requirements would not reduce the volume of water available for firefighting during the spring and early summer months (see also Potential Cumulative Impact 3.24-1) and there would be no cumulative impact to water supply. Note that although the 2013 BiOp Flows are no longer the operational standard for the Klamath River, and the 2017 court-ordered flushing and emergency dilution flows are no longer required (see Section 3.1.6

Summary of Available Hydrology Information for the Proposed Project), the analysis of the court-ordered flushing and emergency dilution flow requirements remains in this cumulative effects analysis because at the time of the Draft EIR it was acknowledged that these flows may have occurred during the period when the Proposed Project would occur and retaining the analysis does not change any significance determinations.

3.24.22 Transportation and Traffic

Volume I Section 3.24.22 Cumulative Effects – Transportation and Traffic, new paragraph 6 on page 3-1216:

Significance criteria for cumulative transportation and traffic impacts are the same as defined in Section 3.22.3 *[Transportation and Traffic] Significance Criteria* for the resource.

Volume I Section 3.24.22 Cumulative Effects – Transportation and Traffic – Potential Cumulative Impact 3.24-65, paragraphs 1-4 on page 3-1217 and paragraph 1 on page 3-1218:

Potential Cumulative Impact 3.24-65 Short-term and long-term traffic and transportation effects from the Proposed Project in combination with non-project activities.
As described in Section 3.22.5 *[Transportation and Traffic] Potential Impacts and Mitigation*, ~~the Proposed Project would result in significant and unavoidable~~ short-term impacts of the Proposed Project on~~to~~ traffic flow, road safety, road conditions, emergency access, public transit, and non-motorized transportation would be less than significant with mitigation ~~, unless and until KRRC reaches enforceable 'good citizen' agreements that are finalized and implemented through the FERC process and that include proposed items for the final TMP and Emergency Response Plan (Appendix B: *Definite Plan − Appendices O1 through O4*), as well as the additional components included in Recommended Measure TR-1~~ (see Potential Impacts 3.22-1 through 3.22-5). Mitigation shall include a Traffic Management Plan and Emergency Response Plan.

The Proposed Project is not located within two miles of an airport nor would it result in a change in air traffic patterns that would result in a substantial safety risks (Potential Impact 3.22-6). Therefore, there would be no cumulative impacts related to air traffic due to the Proposed Project in combination with non-project activities within the traffic and transportation Area of Analysis.

It is possible that some riverine restoration projects, such as projects under the Klamath Basin Restoration Program, forest and wildfire management projects, and road repair projects, could overlap temporally, but they are unlikely to occur close enough to Proposed Project construction areas to contribute to a cumulative impact. The closest known forest and wildfire management projects are not within the Area of Analysis for transportation and traffic (i.e., Somes Bar

Integrated Fire Management Project; approximately 90 miles downstream of Humbug, and Crawford Vegetation Management Project; approximately 70 miles downstream of Humbug) and so would not overlap spatially with the Proposed Project. The Proposed Project includes road, bridge, and improvement projects associated with the primary access roads (Copco Road, Ager-Beswick Road, Lakeview Road), so other road repair projects occurring at the same time as the Proposed Project would necessarily be located elsewhere.

Other potential construction projects identified in Table 3.24-1 (e.g., Sousa Ready Mix Concrete Batch Plant Project, Siskiyou County jail development, and a potential nanocellulose facility development) are all located in Yreka, and as such, would not be likely to require use of the primary access roads associated with the Proposed Project (Copco Road, Ager-Beswick Road, Lakeview Road) for which short-term impacts to traffic flow, road safety, road conditions, emergency access, public transit, and non-motorized transportation could occur. California segments of Interstate 5, which would be used by workers and for hauling equipment and supplies to and from the Proposed Project, could be used by one or more of the potential other construction projects for the same reasons and during the same time period, although the smaller scale of the other projects would be unlikely to result in a high number of vehicle trips relative to the Proposed Project. Since Interstate 5 has sufficient capacity for added traffic (391 ADT) associated with the Proposed Project to keep the LOS level at LOS A (see Potential Impact 3.22-1), the combination of the Proposed Project and one or more other construction projects within the Area of Analysis would be unlikely to result in significant impacts to traffic and transportation. In its comments on the Draft EIR (ORG46) and in its application for water quality certification filed on December 3, 2019, the KRRC provided additional standards and commitments regarding the Traffic Management Plan. The State Water Board anticipates that implementation of Mitigation Measure TR-1 would reduce short-term construction-related impacts of the Proposed Project to less than significant with respect to traffic flow, road safety, road conditions, emergency access, public transit, and non-motorized transportation, and the analysis above finds no significant overlapping transportation and traffic impacts from other projects; therefore, there would be no significant cumulative impact. ~~However, because the State Water Board has determined that short-term construction-related impacts of the Proposed Project would be significant and unavoidable with respect to traffic flow, road safety, road conditions, emergency access, public transit, and non-motorized transportation, unless and until KRRC reaches enforceable ‘good citizen’ agreements through the FERC process (as described above), it has determined the incremental contribution of the Proposed Project in this Draft EIR to be cumulatively considerable.~~

Significance

~~Cumulatively considerable~~ No significant cumulative impact

3.24.23 Noise

Volume I Section 3.24.23 Cumulative Effects – Noise, paragraph 6 on page 3-1218:

Significance criteria for cumulative noise and vibration impacts are the same as defined in Section 3.23.3 *[Noise] Significance Criteria*.

3.24.24 References

Volume I Section 3.24.24 Cumulative Effects – References, pages 3-1219 through 3-1225, includes the following revisions:

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4 ALTERNATIVES

4.1 Alternatives Section/Overview

4.1.1 Alternatives Section

4.1.1.1 Alternatives Carried Forward for More Detailed Analysis

No Project Alternative
Volume I Section 4.1.1.1 [Alternatives Selection/Overview] Alternatives Selection – Alternatives Carried Forward for More Detailed Analysis – No Project Alternative, paragraph 1 on page 4-3:

No Project Alternative
CEQA Guidelines section 15126.6(e)(2) states that the No Project analysis shall discuss the existing conditions at the time the Notice of Preparation is published, or if no Notice of Preparation is published, at the time environmental analysis is commenced, as well as what would be reasonably expected to occur in the foreseeable future if the project were not approved, based on current plans and consistent with available infrastructure and community services. In this instance, the No Project Alternative would be no change from the current management conditions, other than as noted below, with the dams remaining in place. However, while it is relatively certain that the current management conditions – continued operation of the Klamath Hydroelectric Project under the current terms of annual licenses issued by FERC – would continue for the short term, that condition is not feasible in the long term. Federal agencies have imposed fish passage requirements, ramping requirements, and other significant changes to the Lower Klamath Project dam complexes and operations in the context of the PacifiCorp Klamath Hydroelectric Project relicensing (FERC Project No. 2082). These requirements were challenged and upheld under a trial-type administrative hearing (Section 241 of the Energy Policy Act of 2005). Additionally, any relicensing procedure would have to comply with conditions to meet water quality standards in California and in Oregon, and it is not clear that this would be possible with all (or perhaps any) of the Lower Klamath Project dams and reservoirs in place. ~~There is significant uncertainty about the long-term results if the KRRC's Proposed Project does not proceed. It is recognized that future consultations with the NMFS and the USFWS on the USBR's operation of the Klamath Irrigation Project, adaptive management of existing projects, and planned restoration activities can significantly alter conditions in the Klamath Basin, but the extent that these and other future basin activities would modify conditions is speculative. In light of this uncertainty,~~ As it would be misleading to analyze a long-term scenario for a temporary condition that would not persist, the No Project Alternative analysis focuses on the reasonably foreseeable period of 1–5 years), as described in Section 4.2.1.1 *[No Project Alternative] Alternative Description*.

4.2 No Project Alternative

4.2.1 Introduction

Volume I Section 4.2.1.1 Alternatives – No Project Alternative – Introduction – Alternative Description, paragraph 2 on page 4-15

In this instance, in the short term, the No Project Alternative would be no change from the current management conditions, other than as noted below with regard to ~~2017~~ flow requirements and cessation of certain KHSA measures related to water quality and habitat.

Volume I Section 4.2.1.1 Alternatives – No Project Alternative – Introduction – Alternative Description – Foreseeable Short-term Operations, paragraph 2 on page 4-16:

In the No Project Alternative analysis, the ~~existing~~ environmental conditions associated with the Lower Klamath Project and its operations under 2013 BiOp Flows would ~~continue except as~~ be modified by:

- Court-ordered flushing and emergency dilution flows downstream of Iron Gate Dam, which ~~became~~ were required ~~after~~ between February 2017 (U.S. District Court 2017) and March 2019 (NMFS 2019, USFWS 2019).

Additionally, because the 2019 BiOp Flows are now the current operational flow requirement for the Klamath River (USFWS 2019, NMFS 2019), this analysis also considers the newly defined environmental conditions associated with the Lower Klamath Project and its existing operations under 2019 BiOp Flows, as these flows would continue under the No Project Alternative.

Volume I Section 4.2.1.1 Alternatives – No Project Alternative – Introduction – Alternative Description – Foreseeable Short-term Operations, paragraph 3 on page 4-16:

Please see Section 4.2.1.1 *[Alternative Description] Summary of Available Hydrology Information for the No Project Alternative* for a discussion of the effects of ~~this~~ these additions on the analysis of the No Project Alternative).

Volume I Section 4.2.1.1 Alternatives – No Project Alternative – Introduction – Alternative Description – Foreseeable Short-term Operations, paragraph 4 on page 4-16:

There are various restoration efforts underway in the Klamath Basin to improve water quality, as discussed in Section 3.24 *Cumulative Effects*. However, the effects of these efforts, including efforts aimed at meeting Klamath River total maximum daily loads (TMDLs) are not analyzed for the reasonably foreseeable period under the No Project Alternative because the basin response to the restoration ~~measures~~ efforts to meet the ~~total maximum daily loads (~~TMDLs~~)~~ during the short-term is too speculative

Volume I Section 4.2.1.1 Alternatives – No Project Alternative – Introduction – Alternative Description – Summary of Available Hydrology Information for the No Project Alternative, paragraph 1 on page 4-17:

Summary of Available Hydrology Information for the No Project Alternative

Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* describes information regarding the EIR's analysis of the 2013 Biological Opinion (BiOp) flow requirements and the 2019 BiOp flow requirements. In addition, the 2010 BiOp Flows are briefly summarized below. The relevancy of the 2010 BiOp Flows to the Lower Klamath Project EIR is narrowly focused on the analysis of potential suspended sediment effects on fish under the existing condition/No Project Alternative (see also Appendix E), since no other analysis in this EIR uses USBR (2012) model output for the existing condition/No Project Alternative.

2010 BiOp Flows

The 2010 BiOp operations criteria were designed, in order of priority, to (1) meet or exceed minimum flows downstream of Iron Gate Dam; (2) meet or exceed the minimum Upper Klamath Lake elevations; (3) sustain water diversions to meet contractual agreements between USBR and water users, including the National Wildlife Refuges; and (4) meet the Upper Klamath Lake refill targets. A set of operational rules and an Interactive Management process was established to manage the distribution of stored water and the flows. Target flows at Iron Gate Dam were comprised of a base flow based on the 95 percent exceedance probability described in the 2010 BiOp and an augmentation flow based on water supply conditions in the basin. During fall and winter months, the water supply conditions were based only on the storage in Upper Klamath Lake, while the water supply conditions during spring and summer months were calculated from a combination of the storage volume, forecasted April through September inflow, and the target end-of-September Upper Klamath Lake carryover storage. Equations were developed for each month of half-month timestep to determine the augmentation flow that would best achieve the target flows at Iron Gate Dam that match the flow exceedance probability detailed in the 2010 BiOp. In addition to the target flows at Iron Gate Dam, the 2010 BiOp Flows incorporated a fall and winter flow variability program to enhance flow variability between September 1 and March 1 to mimic the natural hydrologic response downstream of Iron Gate Dam due to precipitation. The fall and winter flow variability program included:

- Developing a flow variability team comprised of technical staff from USBR, NMFS, NOAA Weather Surface (NWS), USFWS, USGS, CDFG, the Karuk, Hoopa Valley, and Yurok Tribes, and PacifiCorp.
- Releasing flow from Iron Gate Dam between September 1 and March 1 based on the recommendations of the flow variability team, unless USBR, in coordination with PacifiCorp, determined (1) operation constraints

prohibit implementation; or (2) the implementation of the recommendation will result in a risk to human safety or property. The maximum volume of releases to enhance flow variability downstream of Iron Gate Dam is 18,600 acre-feet.

2013 BiOp Flows and 2017 Court-ordered Flushing and Emergency Dilution Flows

In addition to the 2013 BiOp Flows, ~~and until the reinitiated formal consultation is complete,~~ the USBR ~~is~~ was also required by a 2017 court order to manage Ceratanova Shasta (C. Shasta) infection among coho salmon in the Klamath River with additional winter-spring surface flushing flows and deep flushing flows, as well as emergency dilution flows (U.S. District Court 2017 a–c). The ~~F~~flushing flows ~~are~~ were designed to dislodge and flush out polychaete worms that host C. Shasta in the Klamath River. Emergency dilution flows were developed to reduce C. Shasta infections in coho salmon if certain disease thresholds in the Klamath River ~~are~~ were exceeded. The details of the flushing flow and emergency dilution flow requirements are outlined in Measures to Reduce Ceratanova Shasta Infection of Klamath River Salmonids: A Guidance Document and US District Court Filing 111 (U.S. District Court 2017). The flushing flow and emergency dilution flow requirements included:

- Releasing surface flushing flows every year from Iron Gate Dam of at least 6,030 cfs for a 72-hour period during the winter period (November 1–April 30) sufficient to move surface sediments.
- Releasing deep flushing flows at least every other year (beginning in 2017) with the Klamath River flow measured at Iron Gate Dam averaging at least 11,250 cubic feet per second (cfs) over a single 24-hour period between February 15 and May 31, unless USBR determines that such flows are limited and/or precluded by inherent hydrologic, infrastructure, and/or public safety constraints.
- Releasing emergency dilution flows of downstream of Iron Gate Dam between April 1 to June 15 or when 80% of juvenile Chinook Salmon outmigration has occurred if either: (1) spore concentrations exceed five spores (non-specified genotype) per liter for the preceding sample based on quantitative polymerase chain reaction (qPCR) from water filtration samples at any sampling station, or (2) the prevalence of inflection (POI) of all captured juvenile Chinook salmon (both wild and hatchery) exceeds 20 percent in aggregate for the preceding week at the Kinsman Rotary Screw Trap. Emergency dilution flows are 3,000 cfs measured at Iron Gate Dam until spore or POI at Kinsman Trap decreases if flows at Iron Gate Dam are below 3,000 cfs when disease thresholds are met or exceeded. Emergency flows at Iron Gate Dam are maintained at 3,000 cfs or increased from 3,000 cfs to 4,000 cfs if disease levels remain above disease thresholds after flows at Iron Gate Dam have been 3,000 cfs for at least seven days. The volume of emergency dilution releases is capped at 50,000 acre-feet (AF).

The requirements of the flushing and emergency dilution releases ~~are~~ were in addition to the 2013 BiOp flow requirements during the period February 2017 – March 2019~~, which must still be met by USBR~~. Water released during flushing and emergency dilution flows ~~are~~ was not part of the Environmental Water Account detailed in the 2013 BiOp. The exact timing of the releases of flushing flows ~~is~~ was left to the discretion of USBR, provided they occurred within the specified timeframes for the releases. Provisions for adaptive management of the flushing and emergency dilution flows existed, provided consensus for an amended flow plan ~~is~~ was reached among the applicable agencies and submitted to the U.S. District Court for the Northern District of California San Francisco Division.

The additional surface and deep flushing flows, along with the emergency dilution flows to manage C. Shasta, ~~are~~were within the range of historical Klamath River flows evaluated in the 2013 BiOp studies. For example, while infrequent (i.e., less than 1 percent of the time at Iron Gate Dam), daily average flows in the Klamath River exceeded the deep flushing flow requirement of 11,250 cfs during some storm events in the period of analysis. Additionally, the duration of a deep flushing flow event ~~is~~ was short (i.e., 24 hours plus the time to ramp down the flushing flow) and ~~is~~ was designed to occur every other year (beginning in 2017), such that the overall period that deep flushing flows influenced Klamath River hydrology ~~is~~ was limited.

The flow-related analyses for the No Project Alternative in this EIR acknowledge the re-initiation of consultation on the 2013 BiOp Flows by considering the 2017 court-ordered flushing and emergency dilution flow requirements downstream of Iron Gate Dam as interim flow requirements until completion of formal consultation.

2019 BiOp Flows

After the issuance of the Lower Klamath Project Draft EIR on December 27, 2018, the applicable biological opinion and the operational flow requirements for the Klamath River changed in March 2019, when the new biological opinions were issued by NMFS (2019) and USFWS (2019). The 2019 BiOp Flows are now the current operational flow requirement for the Klamath River and thus they represent hydrology moving forward under the No Project Alternative. The 2019 BiOp flow requirements include:

- Releasing approximately 50,000 acre-feet from Iron Gate Dam in a manner that best meets coho salmon needs (e.g., disease mitigation, habitat) in below average to dry years.
- Releasing an “opportunistic” surface flushing flow from Iron Gate Dam of at least 6,030 cfs for a 72-hour period during the spring period (March 1–April 15) in average to wet years, if hydrologic conditions allow.
- Releasing an additional volume of 20,000 acre-feet for enhanced May/June flows in years in which the April 1 Environmental Water Account (EWA) is

greater than 400,000 acre-feet (407,000 acre-feet in years 2020, 2022, and 2024) and less than 576,000 acre-feet.

Comparison of Klamath River Flows under the 2010 BiOp Operational Criteria and the 2013 BiOp and 2019 BiOp Operational Criteria

Modeled Klamath River flows under the 2010 BiOp, 2013 BiOp, and 2019 BiOp operations criteria are similar (i.e., less than 90 cfs different) when examined on an average annual basis, with flows downstream of Iron Gate Dam averaging approximately 1,984 cfs, 1,896 cfs, and 1,898 cfs, respectively, during the 1980 to 2011 comparison period when modeled 2010 BiOp, 2013 BiOp, and 2019 BiOp Flows are available. The average annual 2010 BiOp, 2013 BiOp, and 2019 BiOp Flows downstream of Keno Dam from 1980 to 2011 are also similar (i.e., less than 60 cfs different), averaging approximately 1,456 cfs, 1,401 cfs, and 1,403 cfs, respectively. Average monthly 2013 BiOp and 2019 BiOp Flows range from approximately 35 percent less than 2010 BiOp Flows to approximately 12 percent greater than 2010 BiOp Flows over the entire 1980 to 2011 comparison period (Table 3.1- and 4.2-1-B). The 2010 BiOp Flows incorporated higher spring flows during average and wetter water years than the 2019 BiOp Flows, so the difference between average monthly 2019 BiOp Flows and average monthly 2010 BiOp Flows during mid to late spring (i.e., May and June) is greater than 10 percent.

Table 4.2-1-A. Average Monthly 2010 BiOp, 2013 BiOp, and 2019 BiOp Flows at Keno Dam From 1980 to 2011.

Month	**Average Monthly Flow Downstream of Keno Dam**			**Differences (2013 BiOp vs. 2010 BiOp Flows)**		**Differences (2019 BiOp vs. 2010 BiOp Flows)**	
	2010 BiOp Operations Criteria	**2013 BiOp Operations Criteria**	**2019 BiOp Operations Criteria**				
	(cfs)	**(cfs)**	**(cfs)**	**(cfs)**	**(percent)**	**(cfs)**	**(percent)**
Oct	938	885	828	-54	-6.1	-111	-13.4
Nov	1154	966	960	-189	-19.5	-195	-20.3
Dec	1530	1204	1133	-326	-27.1	-397	-35.1
Jan	1712	1409	1573	-303	-21.5	-139	-8.8
Feb	2167	1768	2011	-399	-22.6	-156	-7.8
Mar	2690	2548	2847	-142	-5.6	157	5.5
Apr	2297	2394	2386	97	4.1	89	3.7
May	1952	1952	1779	0	0.0	-172	-9.7
Jun	1440	1374	1139	-66	-4.8	-301	-26.5
Jul	730	772	716	42	5.4	-14	-2.0
Aug	692	749	733	57	7.6	41	5.6
Sep	725	825	776	100	12.1	51	6.6

Data source: USBR 2010, 2019a, 2019b.

Table 4.2-1-B. Average Monthly 2010 BiOp, 2013 BiOp, and 2019 BiOp Flows at Iron Gate Dam From 1980 to 2011.

Month	Average Monthly Flow Downstream of Iron Gate Dam			Differences	(2013 BiOp vs. 2010 BiOp Flows)	Differences	(2019 BiOp vs. 2010 BiOp Flows)
	2010 BiOp Operations Criteria	2013 BiOp Operations Criteria	2019 BiOp Operations Criteria				
	(cfs)	(cfs)	(cfs)	(cfs)	(percent)	(cfs)	(percent)
Oct	1302	1260	1179	-42	-3.4	-123	-10.5
Nov	1561	1367	1348	-194	-14.2	-214	-15.9
Dec	2105	1699	1655	-405	-23.9	-450	-27.2
Jan	2380	2021	2168	-359	-17.8	-212	-9.8
Feb	2907	2446	2698	-461	-18.9	-209	-7.7
Mar	3490	3290	3599	-199	-6.1	109	3.0
Apr	3072	3072	3086	0	0.0	14	0.4
May	2591	2524	2348	-67	-2.7	-242	-10.3
Jun	1918	1804	1557	-114	-6.3	-361	-23.2
Jul	1133	1095	1050	-38	-3.5	-83	-7.9
Aug	1045	1054	1042	9	0.8	-3	-0.3
Sep	1076	1163	1102	86	7.4	25	2.3

Data source: USBR 2010, 2019a, 2019b.

To maintain consistency with comparative analyses conducted for KBRA Flows and 2013 and 2019 BiOp Flows in Section 3.1.6 Summary of Available Hydrology Information for the Proposed Project, variations in the average monthly flows between years are also shown using paired heteroscedastic t-tests of the average monthly 2013 BiOp versus 2010 BiOp Flows and the average monthly 2019 BiOp versus 2010 BiOp Flows for the 31-year comparison period between 1980 and 2011 (Table 4.2-1-C). Probability values (p-values) less than 0.05 indicating a significant difference and p-values and less than 0.01 indicating a highly significant difference (Table 4.2-1-C). 2010 BiOp Flows are significantly or highly significantly different from either 2013 BiOp Flows or 2019 BiOp Flows (or both) in nine of twelve months. While Tables 4.2-1-A through 4.2-1-C summarize modeled average monthly flows and the significance of the differences between 2010 BiOp Flows and the flows under the 2013 BiOp and 2019 BiOp operations criteria, the monthly flow exceedance plots in Figure and Figure present a more in-depth comparison of the range of possible flows by month and their probability of occurring under the three operations scenarios.

Table 4.2-1-C. Comparison of Average Monthly 2010 BiOp, 2013 BiOp, and 2019 BiOp Flows From 1980 to 2011 Using Paired Heteroscedastic T-tests.

Month	**Keno Dam**		**Iron Gate Dam**	
	p-value 2010 BiOp vs. 2013 BiOp Flows	**p-value 2010 BiOp vs. 2019 BiOp Flows**	**p-value 2010 BiOp vs. 2013 BiOp Flows**	**p-value 2010 BiOp vs. 2019 BiOp Flows**
Oct	0.340	0.024 a	0.420	0.010 a
Nov	0.044a	0.039 a	0.036 a	0.021 a
Dec	0.170	0.035 a	0.081	0.022 a
Jan	0.470	0.730	0.510	0.770
Feb	0.110	0.640	0.047 a	0.940
Mar	0.580	0.150	0.440	0.260
Apr	0.870	0.960	0.620	0.780
May	0.890	0.051	0.690	0.024 a
Jun	0.320	8.9E-04 b	0.170	1.5E-04 b
Jul	0.340	0.120	0.021 a	5.9E-05 b
Aug	4.4E-04b	0.140	0.680	0.360
Sep	3.6E-10 b	2.5E-06 b	1.7E-06 b	0.093

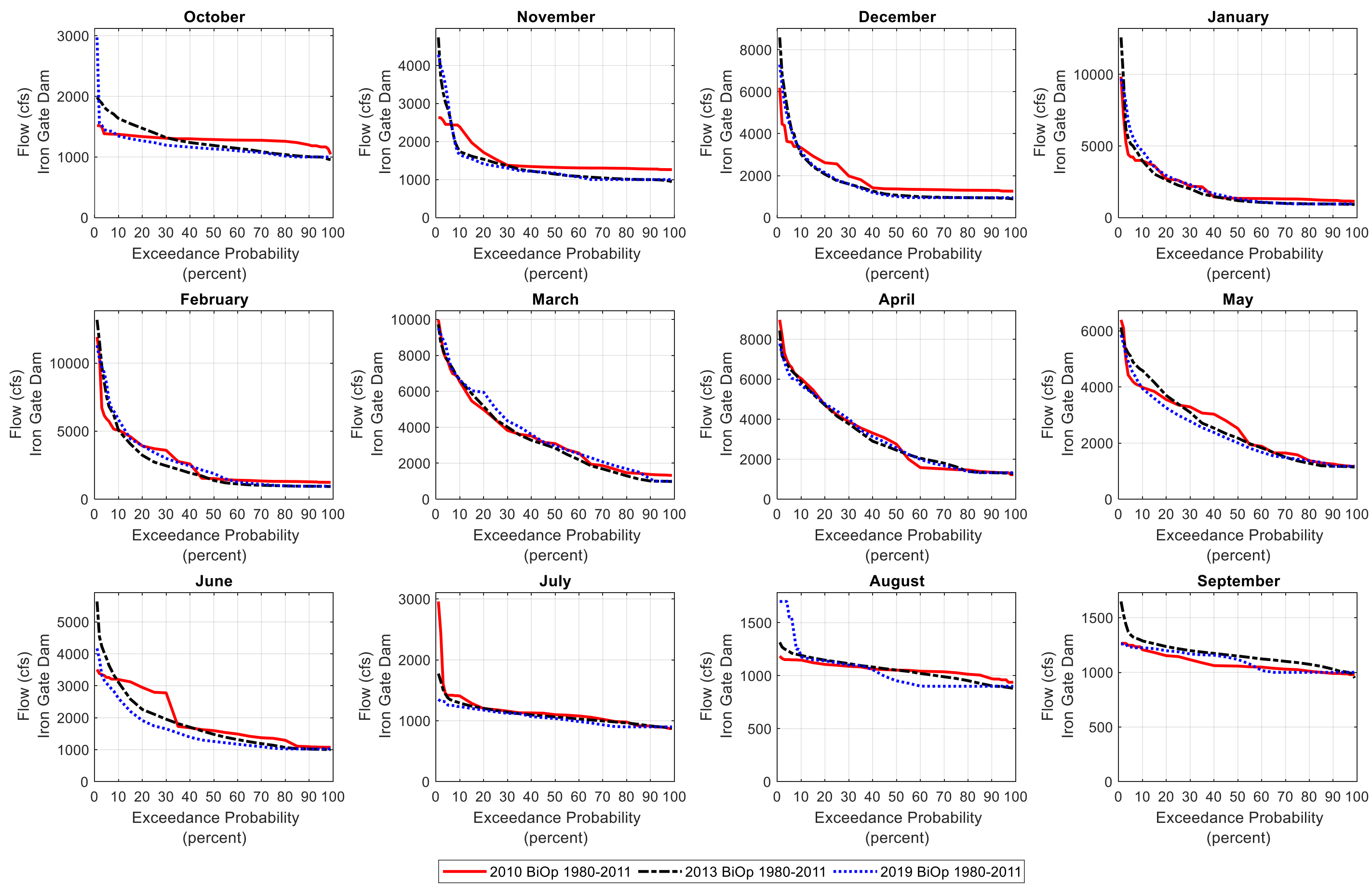
Data source: USBR 2010, 2019a, 2019b.
[a] significant difference ($p<0.05$)
[b] highly significant difference ($p<0.01$)

Figure and Figure present monthly flow exceedance probabilities for modeled 2010 BiOp, 2013 BiOp, and 2019 BiOp Flows downstream of Keno and Iron Gate dams, respectively, for the 31-year period of overlapping flow projections from 1980 to 2011, where this period encompasses water year types ranging from very dry to very wet. Flows with a 1 to 99 percent probability of occurring at Keno or Iron Gate dam are shown in the monthly flow exceedance curves; these curves do not display the upper maximum flows (i.e., exceedance probability less than 1 percent) or lower minimum flows (i.e., exceedance probability greater than 99 percent) that may occur under 2010 BiOp, 2013 BiOp, or 2019 BiOp operations criteria. The monthly flow exceedance plots show the range of flows expected in different water year types, with wet years characterized by flows with a 10 percent exceedance probability, median years characterized by flows with a 50 percent exceedance probability, and dry years characterized by flows with a 90 percent exceedance probability.

Monthly exceedance probability curves are often similar for 2010 BiOp, 2013 BiOp, and 2019 BiOp Flows at Keno and Iron Gate dams and the overall range of 2010 BiOp and 2019 BiOp Flows are similar. Monthly exceedance probability curves for 2010 BiOp and 2013 BiOp Flows are most similar during winter to mid-spring (i.e., January through May) with relatively small flow variations between the curves, except during the wettest water years (i.e., exceedance probability of one percent) in January and February when 2010 BiOp Flows are less than 2013 BiOp Flows. The similarity in the monthly exceedance probability curves indicate that modeled 2010 BiOp Flows would generally characterize the frequency, timing, and magnitude of 2013 BiOp Flows during winter to mid-spring, except during the wettest water years for 2013 BiOp Flows. Maximum 2010 BiOp Flows during the wettest water year types (i.e., exceedance probability of one percent) are less than maximum 2013 BiOp Flows during this time, so modeled 2010 BiOp Flows would not characterize peak 2013 BiOp Flows during the wettest water year types. Monthly exceedance probability curves for 2010 BiOp and 2019 BiOp Flows also are most similar during winter to mid-spring (i.e., January through May) with relatively small flow variations between the curves. Modeled 2010 BiOp Flows would generally characterize the frequency, timing, and magnitude of 2019 BiOp Flows during winter to mid-spring across all water year types though because 2010 BiOp Flows represent the range of 2019 BiOp Flows greater than 99.9 percent of the time. Extremely infrequent peak 2019 BiOp Flows (i.e., occurring less than 0.1 percent of the time between 1980 to 2011) would not be represented by 2010 BiOp Flows, so outputs of hydrologic models using the 2010 BiOp Flows may underrepresent the outputs of hydrologic models using the 2019 BiOp Flows during extremely wet water years. As elevated suspended sediment transport is associated with peak flows, which tend to occur in winter to mid-spring months, the aforementioned differences are discussed in the analysis of potential suspended sediment effects on fish under the existing conditions/No Project Alternative in Appendix E.

While the overall trends in 2010 BiOp, 2013 BiOp, and 2019 BiOp Flows are similar during late spring through fall months, 2010 BiOp Flows frequently have a smaller range than 2013 BiOp or 2019 BiOp Flows, especially during later summer and early winter (i.e., August through December). The magnitude of the difference between the range of 2010 BiOp and 2013 BiOp or 2019 BiOp Flows varies between months and water year types, but it tends to be the greatest during wet (exceedance probability less than 10 percent) or dry (exceedance probability greater than 90 percent) water years. As such, modeled 2010 BiOp Flows may under or overpredict the flow conditions occurring under 2013 BiOp or 2019 BiOp Flows during late spring through early winter (i.e., June through December), depending on the water year type. As elevated suspended sediment transport is associated with peak flows, which do not tend to occur in late summer through early winter, the aforementioned differences are not relevant to the analysis of potential suspended sediment effects on fish under the existing conditions/No Project Alternative and are not discussed further.

As tributary flows enter the Klamath River in the Middle and Lower Klamath River, the proportion of the total flow in the river from Iron Gate Dam releases generally declines with distance downstream of Iron Gate Dam and the influence of 2010 BiOp, 2013 BiOp, and 2019 BiOp Flows on Klamath River flows diminishes. While differences between Klamath River flows under 2010 BiOp, 2013 BiOp, and 2019 BiOp ~~F~~flows would continue to exist downstream of Iron Gate Dam even as tributary inflows make up a larger proportion of the total Klamath River flow, the outputs of hydrologic models using 2010 BiOp Flows would better characterize Klamath River conditions under 2013 BiOp or 2019 BiOp Flows with distance downstream of Iron Gate Dam as the relative magnitude of differences between 2010 BiOp, 2013 BiOp, and 2019 BiOp Flows decreases compared to the total magnitude of the Klamath River flow.



<u>**Figure 4.2-1.** Monthly Flow Exceedance Curves at Iron Gate Dam for the 2010 Biological Opinion Flows (2010 BiOp), 2013 Biological Opinion Flows (2013 BiOp), and 2019 Biological Opinion Flows (2019 BiOp) Based on the Modeled Flows from 1980 to 2011. Data Source: USBR 2010, 2019a, 2019b. Note: The Scale of the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Year Types Are Characterized by Flows at the 10, 50, 90 Percent Exceedance, Respectively.</u>

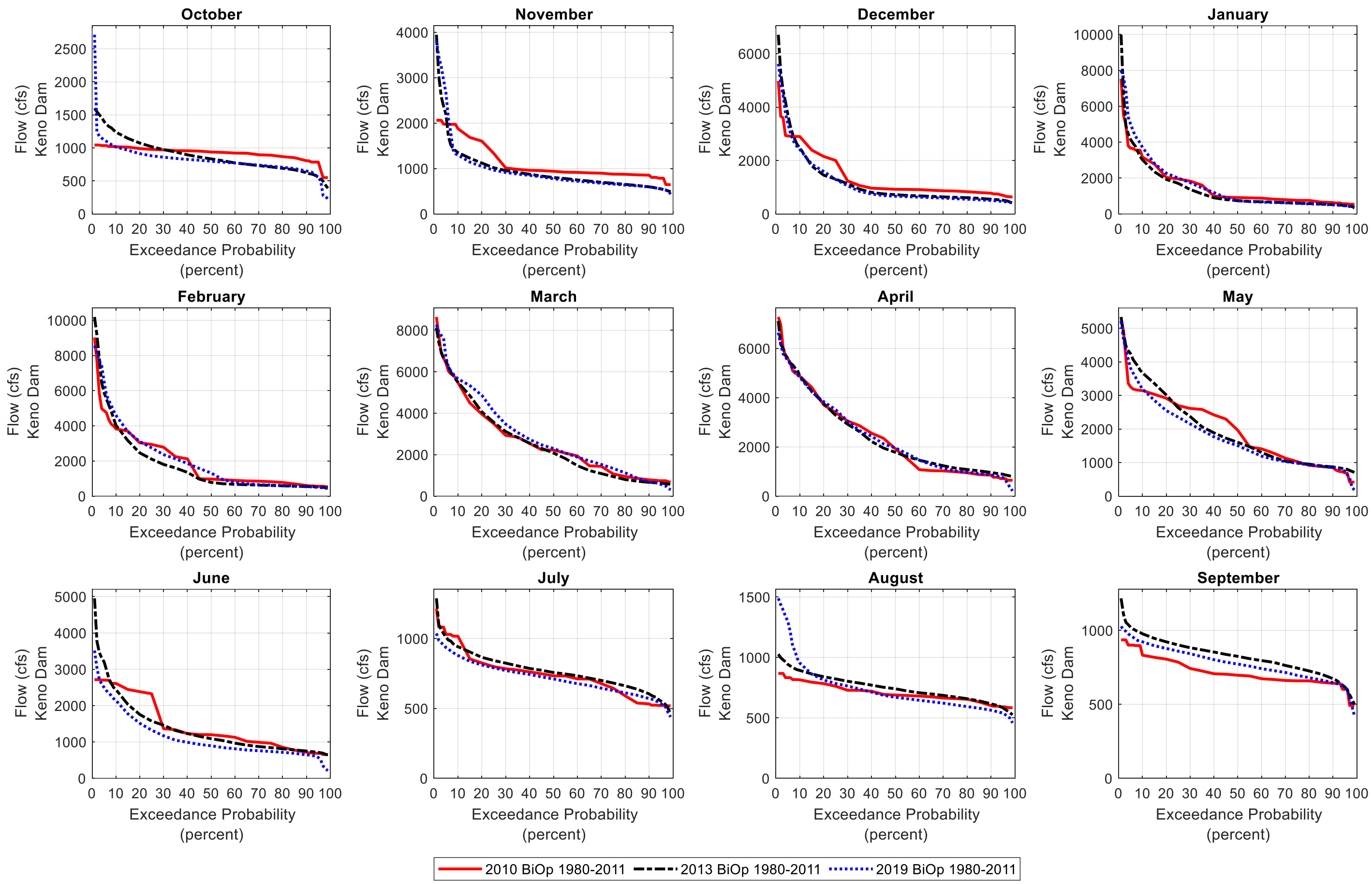


Figure 4.2-2. Monthly Flow Exceedance Curves at Keno Dam for the 2010 Biological Opinion Flows (2010 BiOp), 2013 Biological Opinion Flows (2013 BiOp), and 2019 Biological Opinion Flows (2019 BiOp) Based on the Modeled Flows from 1980 to 2011. Data Source: USBR 2010, 2019a, 2019b. Note: The Scale of the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Year Types Are Characterized by Flows at the 10, 50, 90 Percent Exceedance, Respectively.

Summary

In summary, river flow-related environmental impacts under the EIR No Project Alternative are evaluated by synthesizing the ~~existing 2013 BiOp hydrology including the winter-spring surface and deep flushing flows as well as emergency dilution flow requirements,~~ existing conditions hydrology, the No Project Alternative hydrology analysis presented in the 2012 KHSA EIS/EIR (which is modeled using 2010 BiOp Flows), and the technical studies that supported the 2012 KHSA EIS/EIR. Both the 2013 BiOp hydrology (including the winter-spring surface and deep flushing flows as well as emergency dilution flow requirements) and the newly defined existing 2019 BiOp hydrology (including the surface flushing flows and potential for release of 20,000 to 50,000 acre-feet depending on the water year type) are considered. Additional analysis is undertaken when necessary to evaluate how variations between 2010 BiOp Flows and 2013 BiOp or 2019 BiOp Flows would alter the outputs of hydrologic modeling using the 2010 BiOp Flows, including evaluating how ~~the~~ flushing and dilution flows under 2013 BiOp or 2019 BiOp Flows would impact conditions in the Klamath Basin.

Volume I Section 4.2.1.1 Alternatives – No Project Alternative – Introduction – Alternative Description – KHSA Interim Measures, Table 4.2-1 KHSA Interim Measures Relevant to California Under the No Project Alternative Compared with Existing Conditions and the Proposed Project row 1 (Interim Measure) column 6 (Proposed Project) on page 4-19:

~~Would continue separate from the Proposed Project~~[2] Would not continue and cease to exist when the KHSA is fully implemented.

4.2.2 Water Quality

Volume I Section 4.2.2 Alternatives – No Project Alternative – Water Quality – Water Temperature – Potential Impact 4.2.2-1 Seasonal alterations in water temperature due to continued impoundment of water in the reservoirs, paragraph 2 on page 4-25 through paragraph 1 on page 4-26:

Water temperature existing conditions would continue to occur under the No Project Alternative in the Hydroelectric Reach from J.C. Boyle Reservoir to Copco No. 1 Reservoir (see Section 3.2.2.2 *Water Temperature*) since the bypass operations at the J.C. Boyle Dam (RM 229.8) and peaking power generation at the J.C. Boyle Powerhouse (RM 225.2) would continue. In the J.C. Boyle Bypass Reach from J.C. Boyle Dam (RM 229.8) to the J.C. Boyle Powerhouse (RM 225.2), reservoir discharges would continue to be diverted around this reach (see also Section 2.3.1 *J.C. Boyle Dam Development*) and cold groundwater springs that enter the river in this reach would continue to dominate the remaining flows. Thus, water temperature in the J.C. Boyle Bypass Reach would continue to be primarily influenced by the temperature of the groundwater springs (approximately 11 to 12°C [51.8 to 53.6°F]), with less daily water temperature variations and cooler water temperatures during summer and warmer water temperatures during winter than would occur without bypass operations. Downstream of the J.C. Boyle Bypass Reach, water temperature existing conditions in the J.C. Boyle Peaking Reach would also continue to occur under the No Project Alternative since hydropower peaking operations from the J.C. Boyle Powerhouse would continue and flow diverted around the J.C. Boyle Bypass Reach would rejoin the Klamath River through the J.C. Boyle Powerhouse (see Figure 2.3-1). 2004/2005 KRWQM results indicate the range of daily water temperature variations and the daily maximum water temperature in the J.C. Boyle Peaking Reach would continue to be greater than natural daily water temperature conditions similar to existing conditions as cold groundwater dominated flows from the J.C. Boyle Bypass Reach combine with bypassed warmer reservoir flows for hydropower operations downstream of the J.C. Boyle Powerhouse (PacifiCorp 2004a). In the ~~Hydroelectric Reach~~ J.C. Boyle Peaking Reach from the Oregon-California state line to the upstream end of Copco No. 1 Reservoir, TMDL model and 2004/2005 KRWQM results indicate that daily hydropower peaking operations would continue to potentially cause artificially high daily maximum water temperatures during late spring to mid-summer (i.e., June through August according to the TMDL model and May through July according to the 2004/2005 KRWQM) and late fall (i.e., October to November according to the TMDL model and November to December according to the 2004/2005 KRWQM) and daily variability in water temperatures that occur under existing conditions (North Coast Regional Board 2010; PacifiCorp 2004a, 2008, 2014). In the remainder of the Hydroelectric Reach (i.e., Copco No. 1 and Iron Gate reservoirs) water temperatures would be the same as those described under the existing condition (see Section 3.2.2.2 *Water Temperature*), where spring, summer, and fall water temperatures would continue to be influenced by the thermal mass of Copco No. 1 and Iron Gate reservoirs, and the seasonal stratification patterns of the two reservoirs. It is unclear what, if any, steps could reduce the impact of the reservoirs on the thermal regime within the Hydroelectric Reach between Copco No. 1 Reservoir and Iron Gate Dam and comply with the Thermal Plan's ban on elevated temperature discharges into COLD interstate waters (Table 3.2-4). Improvements from existing conditions under the Proposed Project described in Potential Impact 3.2-1 would not occur under the No Project Alternative.

Middle and Lower Klamath River and Klamath River Estuary
The continued impoundment of water in Copco No. 1 and Iron Gate reservoirs under the No Project Alternative would maintain existing ~~adverse~~ conditions. Releases from Iron Gate Reservoir under the No Project Alternative would continue to maintain cooler water temperatures in the Klamath River downstream of Iron Gate Dam from mid-January to April and to maintain variably cooler or warmer water from April through early August than would occur under the Proposed Project (see Potential Impact 3.2-1). Additionally, continued impoundment would continue to maintain adverse late summer/fall water temperatures in the Hydroelectric Reach downstream of Copco No. 1 Reservoir and in the Middle Klamath River downstream of Iron Gate Dam (see Section 3.2.2.2 *Water Temperature*) that result in the exceedance of the water quality

standards set forth in the Thermal Plan. Existing water temperature conditions are adverse because water temperature discharges from Copco No. 1 and Iron Gate reservoirs in late summer/fall regularly exceed the Thermal Plan water quality standard prohibiting the discharge of elevated water temperature into COLD interstate waters. A powerhouse intake barrier/thermal curtain installed by PacifiCorp under IM 11 in Iron Gate Reservoir during 2015 to isolate surface waters that have high concentrations of blue-green algae (cyanobacteria) and limit downstream release of the blue-green algae has also been reported by PacifiCorp to provide a secondary benefit of isolating surface waters and drawing deeper cooler water for release to the Klamath River downstream of Iron Gate Dam (PacifiCorp 2018). Results from the intake barrier/thermal curtain indicate that modest 1 to 2°C (1.8 to 3.6°F) water temperature improvement is possible (PacifiCorp 2017), although data do not indicate that this measure could achieve compliance with the Thermal Plan or to meet the Klamath River TMDLs temperature requirement in the Middle Klamath River (North Coast Regional Board 2010). Additionally, water temperature improvements downstream of Iron Gate Dam from operation of the intake barrier/thermal curtain would be potentially limited by the need to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards, with the curtain completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018). Temperature effects of the dams do not extend downstream of the Salmon River confluence (see Section 3.2.2.2 *Water Temperature*).

Implementation of the 2017 court-ordered flushing and emergency dilution flows downstream of Iron Gate Dam would not significantly alter the existing conditions for water temperature downstream of Iron Gate Dam in the Middle and Lower Klamath River, the Klamath River Estuary, and the Pacific Ocean nearshore environment, but the additional flushing and emergency dilution releases would potentially result in a temporarily more prominent seasonal shift in water temperature downstream of Iron Gate Dam during the releases. Water temperature existing conditions downstream of Copco No. 1 and Iron Gate dams are generally warmer than expected under natural conditions during late-summer and fall and cooler than expected under natural conditions during spring and early summer (see Section 3.2.2.2 *Water Temperature*). These existing conditions could be accentuated by the additional flushing and emergency dilution releases since these flows would potentially occur from November 1 to June 15 (see Section 4.2.1.1 *Alternative Description – Summary of Available Hydrology Information for the No Project Alternative*). However, these conditions would be accentuated only if releases occurred outside of winter and only for a brief time with surface flushing flows occurring for only 72-hours once every year, deep flushing flows occurring for only 24 hours once every other year, and emergency dilutions only occurring in some years if specific disease conditions are met in the Klamath River.

Similarly, the 2019 BiOp Flows downstream of Iron Gate Dam would not significantly alter the existing conditions for water temperature downstream of Iron Gate Dam in the Middle and Lower Klamath River, the Klamath River Estuary, and the Pacific Ocean nearshore environment, but the flow regime would potentially result in a temporarily more prominent seasonal shift in spring to early summer water temperature downstream of Iron Gate Dam during the surface flushing releases. In the 2019 BiOp, "opportunistic" surface flushing flows are specified during wetter water years, but during drier water years, when conditions in the Klamath River Basin may prevent the release of surface flushing flows, approximately 50,000 acre-feet of water is available for a surface flushing flow or for use in a manner that best meets coho salmon needs. In wet to average water years, the 2019 BiOp "opportunistic" surface flushing flows would be release as 6,030 cfs for a 72-hour period between March 1 and April 15. In below average to dry water years, NMFS may request alternative distributions (i.e., releases) of the 50,000 acre-feet of water between March 1 and April 15, but the 2019 BiOp specifies that a surface flushing flow would be attempted between March 1 and April 15 if the necessary Klamath River and Upper Klamath Lake conditions are met. In the event that by April 15 a surface flushing flow (or other use of the 50,000 acre-feet) has not been released, the 50,000 acre-feet would be released as a required surface flushing flow event that approximates, to the maximum extent practicable, a surface flushing flow of 6,030 cfs for 72 hours (NMFS 2019; USFWS 2019). As such, it is possible that the 50,000 acre-feet would be used and the flow in the Klamath River would be elevated after April 15 during below average to wet water years. There is also potential for release of 20,000 acre-feet in May/June depending on the water year type. Implementation of the 2019 BiOp surface flushing flows downstream of Iron Gate Dam according to the above requirements would not significantly alter the existing conditions for water temperature downstream of Iron Gate Dam in the Middle and Lower Klamath River, the Klamath River Estuary, and the Pacific Ocean nearshore environment, but the additional flushing releases would potentially result in a temporarily more prominent seasonal shift in water temperature downstream of Iron Gate Dam during the releases. Water temperature existing conditions downstream of Copco No. 1 and Iron Gate dams are generally cooler than expected under natural conditions during spring and early summer (see Section 3.2.2.2 *Water Temperature*). These existing conditions could be accentuated by the additional surface flushing releases since these flows would occur between March and June depending on water year type, (see Section 4.2.1.1 *Alternative Description – Summary of Available Hydrology Information for the No Project Alternative*). However, these conditions would occur only for a brief time (i.e., 72-hours) each year.

As such, the temporary accentuation of the existing fall or spring shifts in water temperature in the Middle Klamath River downstream of Iron Gate Dam during 2017 court-ordered flushing and emergency dilution releases or 2019 BiOp flushing flow releases would result in a less than significant change to existing water temperature conditions. Therefore, there would be no change in water temperature existing conditions in the Middle and Lower Klamath River reaches downstream from the confluence with the Salmon River, including the Klamath River Estuary and the Pacific Ocean nearshore environment under the No Project Alternative.

Overall, there would be no change from existing conditions for water temperature in the Hydroelectric Reach, the Middle and Lower Klamath River, the Klamath River Estuary, or the Pacific Ocean nearshore environment in the reasonably foreseeable short-term (0−5 years) under the No Project Alternative and the existing, adverse water temperature conditions would continue to occur due to increases in late summer/fall water temperatures downstream of Copco No. 1 and Iron Gate dams that cause an exceedance of water quality standards as set forth in the Thermal Plan.

Significance
No significant impact

Volume I Section 4.2.2 Alternatives – No Project Alternative – Water Quality – Water Temperature – Potential Impact 4.2.2-3 Increases in suspended material due to implementation of 2017 court-ordered flushing and emergency dilution flows downstream of Iron Gate Dam, paragraph 3 on page 4-27:

Potential Impact 4.2.2-3 Increases in suspended material due to implementation of 2017 court-ordered flushing and emergency dilution flows or 2019 BiOp surface flushing flows downstream of Iron Gate Dam. Implementation of the 2017 court-ordered flushing and emergency dilution flows and the 2019 BiOp surface flushing flows downstream of Iron Gate Dam would mobilize more sand, silt, and clay sized sediment downstream of Iron Gate Dam than under the existing conditions when the releases occur since the flushing releases are designed to mobilize such sediments. There would be an increase in suspended sediment concentrations (SSCs) under flushing flows compared to existing conditions, but the increase in SSCs downstream of Iron Gate Dam would have a limited duration much less the two-weeks that would result in a significant impact. Flushing flows under the 2017 court-ordered flushing and emergency dilution flows would only occur for 72-hours (surface flushing) or 24-hours (deep flushing), so increases in SSCs due to flushing flows are unlikely to increase SSCs above 100 milligrams per liter (mg/L) for an entire two-week period (i.e., the suspended sediment threshold of significance; see Section 3.2.3.1 *Thresholds of Significance – Suspended Sediments*). While emergency dilution releases would potentially occur for a longer period, emergency dilution flows (3,000 to 4,000 cfs) are unlikely to increase SSCs since they are below the thresholds recognized to cause transport of suspended sediment in the Klamath River downstream of Iron Gate Dam (see USBR 2012). Similarly, surface flushing flows under the 2019 BiOp would only occur for 72-hours, so increases in SSCs due to flushing flows are unlikely to increase SSCs above the suspended sediment threshold of significance. Thus, increases in SSCs due to implementation of the flushing and emergency dilution releases would have a less than significant impact on suspended sediment concentrations under the No Project Alternative.

Significance
No significant impact

Volume I Section 4.2.2 Alternatives – No Project Alternative – Water Quality – Nutrients – Potential Impact 4.2.2-4 Annual interception and retention of nutrients and seasonal release of nutrients due to continued impoundment of waters in the reservoirs – Hydroelectric Reach, paragraph 6 on page 4-28:

The No Project Alternative would continue to result in the same relatively small annual decreases in total phosphorus (TP) and total nitrogen (TN) through the Hydroelectric Reach as occurs under existing conditions, due to settling of particulate matter and retention of associated nutrients originating from upstream reaches, including Upper Klamath Lake (in Oregon), in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs, and dilution by the coldwater springs located downstream of J.C. Boyle Reservoir. On an annual basis, the combined total phosphorus retention in Copco No. 1 and Iron Gate reservoirs is approximately 9 to 13 percent of the total phosphorus inflow and the combined total nitrogen retention in Copco No. 1 and Iron Gate reservoirs is approximately 12 to 13 percent of the total nitrogen inflow based on data from May 2005 to May 2007 (see Section 3.2.2.4 *Nutrients* for additional details).

On a seasonal basis, nutrient concentrations typically decrease in the downstream direction from Copco No. 1 Reservoir to downstream of Iron Gate Dam during spring/summer. Nutrients generally increase in the downstream direction from Copco No. 1 Reservoir to downstream of Iron Gate Dam during mid-summer/fall due to a combination of anoxic conditions in the reservoirs releasing nutrients from reservoir sediments (i.e., internal nutrient loading), the hydraulic residence time of the reservoirs resulting in a temporal shift in the transport of upstream nutrients through the reservoirs, and reservoir turnover during fall (Asarian et al. 2009). Internal loading of nutrients on a seasonal basis is common in reservoirs that thermally stratify and become anoxic for several weeks to months during summer and fall. In Copco No. 1 and Iron Gate reservoirs, the total combined TP retention under existing conditions was approximately negative 8 percent during May through September (i.e., the main reservoir phytoplankton growing season), with the negative combined TP retention during this period indicating a net export of TP. While the reservoirs retain TP during the earlier part of the May through September time period, TP exports associated with internal nutrient loading during the later part of the time period are greater than the earlier TP retention and result in a net export of TP over the entire May through September period (Asarian et al. 2009). The total combined TN retention in Copco No. 1 and Iron Gate reservoirs under existing conditions was approximately 23 percent during May to September (i.e., the main reservoir phytoplankton growing season). The higher TN retention during summer months was attributed to settling of organic matter and algal material, denitrification, and/or ammonia volatilization (Asarian et al. 2009, 2010). While TN retention was seasonally higher in Copco No. 1 and Iron Gate reservoirs during the main phytoplankton growing season, the ammonia concentration downstream of Iron Gate Reservoir increased beginning in September from approximately 0.01 to 0.05 mg/L until peaking in October and November at approximately 0.1 to 0.2 mg/L due to the anoxic conditions in the lower section Iron Gate Reservoir (Asarian et al. 2009, 2010) (see Appendix C for more detail). Copco No. 1 and Iron Gate reservoirs would remain in place under the No Project Alternative, so seasonal ~~Seasonal~~ increases in TP, and to a lesser degree TN, in the Hydroelectric Reach would continue to occur under this alternative due to the release (export) of dissolved forms of phosphorus (ortho-phosphorus) and nitrogen (ammonium) from reservoir sediments during summer and fall, when reservoir bottom waters are anoxic (i.e., through the process of internal nutrient loading, see Figure 3.2-2).

Volume I Section 4.2.2 Alternatives – No Project Alternative – Water Quality – Nutrients – Potential Impact 4.2.2-4 Annual interception and retention of nutrients and seasonal release of nutrients due to continued impoundment of waters in the reservoirs – Middle and Lower Klamath River and Klamath River Estuary, paragraph 2 on page 4-29:

There would be no change from existing conditions for nutrients due to implementation of the 2017 court-ordered flushing and emergency dilution flows or the 2019 BiOp surface flushing flows downstream of Iron Gate Dam under the No Project Alternative since suspended sediments transported by these releases would be primarily mineral (inorganic) sediments occurring in the Klamath River under existing conditions.

Volume I Section 4.2.2 Alternatives – No Project Alternative – Water Quality – Dissolved oxygen – Potential Impact 4.2.2-5 Seasonal low dissolved oxygen concentrations due to continued impoundment of water in the reservoirs, paragraph 3 on page 4-30 through paragraph 1 on page 4-31:

Dissolved oxygen concentrations due to implementation of the 2017 court-ordered flushing and emergency dilution flows and the 2019 BiOp surface flushing flows downstream of Iron Gate Dam would be similar to existing conditions, but dissolved oxygen would likely increase immediately downstream of Iron Gate Dam in the Middle Klamath River during releases due to increased turbulent mixing and aeration under the higher flushing flows. However, the 2017 court-ordered flushing and emergency dilution flows these conditions would be present for only a brief time between November 1 to May 31 since surface flushing flows occur for only 72-hours once every year and deep flushing flows occur for only 24-hours once every other year. Under the 2019 BiOp surface flushing flows these conditions would be present for only a brief time between

March 1 to April 15 since surface flushing flows occur for only 72-hours once every year. The temporary, brief increases in dissolved oxygen due to flushing flows also generally would occur before reservoirs stratify, so flushing releases would not alter the low dissolved oxygen downstream of Iron Gate Dam that occur under existing conditions during summer/late fall months. Dissolved oxygen concentrations in the Middle Klamath River under emergency dilution releases (3,000 to 4,000 cfs) would be similar to existing conditions since the increase in flow and associated mixing and aeration would be relatively small compared to existing conditions.

Increases in sediment transport due to flushing flows under this alternative would dislodge periphyton from the riverbed and decrease periphyton abundance downstream of Iron Gate Dam in the Middle Klamath River immediately after releases (see also Potential Impact 4.2.4-1). The relationship between flushing and emergency dilution releases, streambed scour and changes in periphyton abundance from the releases, and daily variations in summertime dissolved oxygen due to photosynthesis by periphyton is not fully understood, but seasonal periphyton abundance variations due to seasonal flow changes are a natural process in river systems and occur under existing conditions in the Klamath River. Periphyton naturally re-grow following high winter flows under existing conditions, so periphyton are anticipated to re-grow similarly after flushing flows. While the frequency of flushing flows (i.e., annually for surface flushing and every other year for deep flushing) and the rate of periphyton re-growth may result in a reduction in periphyton abundance downstream of Iron Gate Dam, these reductions in periphyton abundance are expected to have a less than significant impact on daily variations in summertime dissolved oxygen in the Klamath River and dissolved oxygen would be similar to existing conditions. Thus, there would be no significant impact on dissolved oxygen concentrations in the Middle and Lower Klamath River, the Klamath River Estuary, and the Pacific Ocean nearshore environment under the No Project Alternative due to 2017 court-ordered flushing and emergency dilution flows or 2019 BiOp surface flushing flows.

Significance

No significant impact

Volume I Section 4.2.2 Alternatives – No Project Alternative – Water Quality – pH – Potential Impact 4.2.2-6 Seasonal high pH and daily pH fluctuations due to continued impoundment of water in the reservoirs – Hydroelectric Reach, paragraph 1 through paragraph 3 on page 4-32:

The Klamath River is a naturally weakly buffered system (i.e., has typically low alkalinity less than 100 mg/L as calcium carbonate [$CaCO_3$]; PacifiCorp [2004a], Karuk Tribe of California [2010]), so it is susceptible to photosynthesis-driven daily and seasonal swings in pH. The No Project Alternative would result in no change from the existing, adverse condition with respect to pH values that exceed the Basin Plan instantaneous maximum pH objective of 8.5 standard units (s.u.) and large daily fluctuations in the Hydroelectric Reach in Copco No. 1 and Iron Gate reservoirs during summertime periods of intense algal blooms that produce photosynthesis-driven variations in pH (see Section 3.2.2.6 *pH*).

As discussed above, the No Project Alternative would continue to result in the same pH values that exceed the Basin Plan instantaneous maximum pH objective of 8.5 s.u and large daily fluctuations in the Hydroelectric Reach in Copco No. 1 and Iron Gate reservoirs during summertime periods of intense algal blooms (see Section 3.2.2.6 pH). The Middle and Lower Klamath River and Klamath River Estuary are also a weakly buffered system, so daily and seasonal swings in pH would potentially occur due to photosynthesis and respiration by phytoplankton, periphyton, and macrophytes. In the Middle and Lower Klamath River and Klamath River Estuary, pH exhibits large (0.5–1.5 pH units) daily fluctuations under existing conditions during periods of high photosynthesis and pH values also regularly exceed Basin Plan instantaneous maximum pH objective of 8.5 s.u. during late-summer and early-fall months (August–September), with the most extreme pH exceedances typically occurring from Iron Gate Dam to approximately Seiad Valley (see Section 3.2.2.6 pH).

The pH in the Middle Klamath River likely would be similar to existing, adverse conditions with the 2017 court-ordered flushing and emergency dilution flows and the 2019 BiOp surface flushing flows under the No Project Alternative since periphyton along the riverbed contributing to pH conditions would re-grow after reductions following releases and continue to alter pH in the river during summertime periods of high photosynthesis.

Volume I Section 4.2.2 Alternatives – No Project Alternative – Water Quality – Chlorophyll-a and Algal Toxins – Potential Impact 4.2.2-7 Seasonal increases in chlorophyll-a and algal toxins due to continued impoundment of water in the reservoirs – Hydroelectric Reach, paragraph 5 on page 4-33:

Further downstream in the Hydroelectric Reach, adverse, large, seasonal phytoplankton blooms, including blue-green algae, would continue to occur in Copco No. 1 and Iron Gate reservoirs under the No Project Alternative similar to existing conditions, resulting in chlorophyll-*a* concentrations exceeding the TMDL target of 10 ug/L during the May to October growth season, and periodically high levels of algal toxins (concentrations greater than 0.8 and/or 4 ug/L microcystin[181]) (see also Section 3.2.2.7 *Chlorophyll-a and Algal Toxins*). In 2015, PacifiCorp installed a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11 to isolate surface waters that have high concentrations of blue-green algae (cyanobacteria) and potentially limit the release of Iron Gate Reservoir water containing extensive summer and fall blue-green algae blooms downstream to the Middle and Lower Klamath River. Available data (PacifiCorp 2016, 2017) do not indicate that the curtain could improve algal-derived (organic) suspended material in the reservoirs such that they would no longer cause an exceedance of water quality standards (Table 3.2-4) or achieve the Klamath TMDLs phytoplankton chlorophyll-*a* target of 10 ug/L for Copco No. 1 and Iron Gate reservoirs during the May to October growth season (North Coast Regional Board 2010). The influence of the intake barrier/thermal curtain on chlorophyll-*a* and algal toxin conditions in the Middle and Lower Klamath River downstream of Iron Gate Dam are discussed below. Overall, the No Project Alternative would result in no change from existing, adverse conditions and would continue to cause exceedances of water quality standards in the Hydroelectric Reach.

Volume I Section 4.2.2 Alternatives – No Project Alternative – Water Quality – Chlorophyll-a and Algal Toxins – Potential Impact 4.2.2-7 Seasonal increases in chlorophyll-a and algal toxins due to continued impoundment of water in the reservoirs – Middle and Lower Klamath River and Klamath River Estuary, paragraphs 1 and 2 on page 4-34:

Downstream of Iron Gate Dam, chlorophyll-*a* and algal toxin trends generally would be similar to existing conditions under the No Project Alternative, with releases of chlorophyll-*a* and algal toxins (i.e., microcystin) in the Lower Klamath Project reservoirs to the Middle and Lower Klamath River, and eventually the Klamath River Estuary. Longitudinal and temporal variations in microcystin concentrations from upstream of Copco No. 1 Reservoir to Turwar indicate that Iron Gate Reservoir is the principal source of *Microcystis aeruginosa* cells to the Middle and Lower Klamath River (Otten et al. 2015) (see also Section 3.2.2.7 *Chlorophyll-a and Algal Toxins*). As discussed above, PacifiCorp installed a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11 during 2015. The primary purpose of the curtain is to isolate surface waters that have high concentrations of blue-green algae (cyanobacteria) such that extensive summer and fall blooms are not readily released downstream to the Middle and Lower Klamath River. The curtain also provides a potential secondary benefit of isolating warmer, less dense near-surface waters while withdrawing cooler, denser, and deeper waters from the reservoir for release to the Klamath River downstream (see further discussion in Section 4.4.2 *Water Quality*, Potential Impact 4.2.2-1) (PacifiCorp 2018). Water quality measurements during 2015 and 2016 when the intake barrier/thermal curtain was in use indicate that the curtain reduces entrainment of blue-green algae into the Iron Gate Powerhouse intake and subsequent release downstream into the Klamath River (PacifiCorp 2016, 2017). However, water quality monitoring data from 2017 and 2018 downstream of Iron Gate Dam show multiple exceedances of the Klamath TMDLs phytoplankton chlorophyll-a target (i.e., 10 ug/L) and the microcystin thresholds of significance (i.e., 4 ug/L) and multiple microcystin posting limits (e.g., 6 ug/L for CCHAB Warning TEIR I; Table 3.2-10) (Watercourse Engineering, Inc. 2018, 2019). An analysis of the intake barrier/thermal curtain performance during 2017 or 2018 has not been published and PacifiCorp continues to test and refine the intake barrier/thermal curtain design and operations, but available data do not indicate that this measure would prevent releases from Iron Gate Dam that would exceed water quality standards (Table 3.2-4) or consistently achieve the Klamath TMDLs phytoplankton chlorophyll-*a* target of 10 ug/L for Copco No. 1 and Iron Gate reservoirs during the May to October growth season (North Coast Regional Board 2010). Additionally, potential reductions in the entrainment of blue-green algae, chlorophyll-a concentrations, and microcystin concentrations downstream of Iron Gate Dam from operation of the intake barrier/thermal curtain would be potentially limited by the need to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards, with the curtain completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018). Since t~~T~~here would be no change to the habitat conditions that promote growth of *Microcystis aeruginosa* in Iron Gate Reservoir under existing conditions (see also Section 3.4.2.3 *Hydroelectric Reach*) and water quality monitoring data downstream of Iron Gate Dam still show exceedances of chlorophyll-*a* and microcystin water quality standards after installation of the curtain in 2015, the export of *Microcystis aeruginosa* cells and associated increases in chlorophyll-*a* and microcystin in the Middle Klamath River from Iron Gate Reservoir would continue to occur under the No Project Alternative similar to existing conditions.

The 2017 court-ordered flushing and emergency dilution flows and the 2019 BiOp flushing flows would result in no change from existing conditions for chlorophyll-*a* or algal toxins downstream of Iron Gate Dam, since releases would not alter conditions in Copco No. 1 or Iron Gate reservoirs that produce high chlorophyll-*a* concentrations and periodically high levels of algal toxins under existing conditions, and the court-ordered flushing and emergency dilution flows would primarily occur during winter and spring when chlorophyll-*a* and algal toxin concentrations in Iron Gate Reservoir would be low (see also Section 3.2.2.7 *Chlorophyll-a and Algal Toxins*). The 2017 court-ordered flushing and emergency dilution flows downstream of Iron Gate Dam would end by June 15, and the 2019 BiOp surface flushing flows would end by April 15, while monitoring data from the past five years (i.e., 2013 to 2018) indicates the abundance of blue-green algae and algal toxin concentrations (i.e., microcystin) in Iron Gate Reservoir increases above 0.8 ug/L or 4 ug/L after late June to early July (E&S Environmental Chemistry, Inc. 2013, 2014, 2015, 2016, 2018a, 2018b). Assuming blue-green algae cell counts and algal toxin concentrations from the past five years are representative of likely conditions in the reasonably foreseeable short-term (0−5 years), releases would end before elevated levels of chlorophyll-*a* or algal toxin concentrations occur in Iron Gate Reservoir, and there would be no changes from existing conditions for chlorophyll-a or algal toxin concentrations in the Middle and Lower Klamath River or the Klamath River Estuary. Overall, the No Project Alternative would result in no change from existing, adverse conditions and would continue to cause an exceedance of water quality standards in the Middle and Lower Klamath River and Klamath River Estuary. Thus, there would be no significant impact to chlorophyll-*a* and algal toxins due to 2017 court-ordered flushing and emergency dilution releases and the 2019 BiOp surface flow releases in the reasonably foreseeable short-term (0−5 years) under the No Project Alternative in the Middle and Lower Klamath River and the Klamath River Estuary.

Significance

No significant impact

Volume I Section 4.2.2 Alternatives – No Project Alternative – Water Quality – Inorganic and Organic Contaminants – Potential Impact 4.2.2-8 Human and freshwater aquatic species' exposure to inorganic and organic contaminants due to continued impoundment of water in the reservoirs, paragraph 6 on page 4-35:

Implementation of the 2017 court-ordered flushing and emergency dilution flows and the 2019 BiOp surface flushing flows downstream of Iron Gate Dam would have no effect on exposure pathways for inorganic and organic contaminants because the flow changes would not alter the Lower Klamath Project reservoir sediment deposits nor would they alter physical, chemical, or biological conditions within the river or reservoir reaches that would change the potential for exposure to inorganic or organic contaminants compared with existing conditions.

4.2.3 Aquatic Resources

Volume I Section 4.2.3.1 Alternatives – No Project Alternative – Aquatic Resources – Key Ecological Attributes – Water Quality, paragraphs 1 through 4 on page 4-38:

Ongoing efforts to improve water quality conditions in this reach are underway through the TMDL process and considerable efforts to improve habitat are also underway (Hamilton et al. 2011). Once fully implemented, these efforts could reduce existing water quality degradation 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 (Section 4.2.1 *Introduction*). In the interim, water quality conditions that may reduce survival of fish and other aquatic resources, including seasonally low dissolved oxygen concentrations and elevated pH with high diurnal variability that may be deleterious to aquatic resources (see also Section 3.2.2.5 *Water Quality – Environmental Setting – Dissolved Oxygen* and Section 3.2.2.6 *Water Quality – Environmental Setting –* pH), would persist downstream from Iron Gate Dam.

~~Modeling conducted for development of the California Klamath River TMDL indicates that under the No Project Alternative, dissolved oxygen concentrations immediately downstream from Iron Gate Dam would not meet the North Coast Basin Plan water quality objective of 85 percent saturation during August–September and the 90 percent saturation objective from October–November (Section 3.2.2.5 Dissolved Oxygen, Figure 3.2-20). Further downstream, near the confluence with the Shasta River, dissolved oxygen concentrations under the No~~

~~Project Alternative would not meet the 90 percent saturation objective from October–November (Section 3.2.2.5 Dissolved Oxygen, Figure 3.2-21). In the Klamath River at Seiad Valley, concentrations would be mostly in compliance, with the exception of modeled values in November that would not meet the 90 percent saturation objective (Section 3.2.2.5 Dissolved Oxygen, Figure 3.2-21). By the Salmon River (RM 66) 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 Water Quality Control Plan for the North Coast Region (California Basin Plan) requirements.~~

~~Under the 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. Under the 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 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. The seasonally low dissolved oxygen levels in this reach would not consistently meet California Basin Plan and Hoopa Valley Tribe water quality objectives. The 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 adverse effects would be similar to or less than under existing conditions.~~

Volume I Section 4.2.3.1 Alternatives – No Project Alternative – Aquatic Resources – Key Ecological Attributes – Water Temperature, paragraph 5 on page 4-38:

~~Under the No Project Alternative, the effects of ongoing and future upstream water quality improvements under the TMDLs would improve water temperatures downstream of Keno Dam, as described in Section 3.2.2.2 Water Temperature.~~ In general, the No Project Alternative would not affect the current ongoing changes to water temperature caused by the reservoirs and by dam operations, as described in Section 3.2.2.2 *Water Temperature*. 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).

Volume I Section 4.2.3.1 Alternatives – No Project Alternative – Aquatic Resources – Key Ecological Attributes – Water Temperature – Middle and Lower Klamath River, paragraph 1 on page 4-39:

Bartholow et al. (2005) and PacifiCorp (2004a~~b~~) showed that the reservoirs delay seasonal thermal signatures by an average of 18 days on an annual basis downstream of Iron Gate Dam (RM 193.1), with longer durations during the fall low-flow period (3 to 4 weeks) and shorter in the high-flow spring and early summer (2 to 3 weeks). The delay in the seasonal thermal signature is still evident upstream of the Shasta River (RM 179.5), greatly diminished by Seiad Valley (RM 132.7), and generally absent by the Salmon River (RM 66.3).

Volume I Section 4.2.3.1 Alternatives – No Project Alternative – Aquatic Resources – Key Ecological Attributes – Fish Disease and Parasites, paragraph 2 on page 4-40:

As described in Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project [Fish Disease and Parasites]*, ~~T~~ the ongoing presence of the dams under the No Project Alternative would continue to contribute to the static flows, immobile substrate, seasonally warm water temperatures, and planktonic food sources in the mainstem Klamath River 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. Under the No Project Alternative, mortality associated with *C. shasta* and *P. minibicornis* would be expected to worsen or remain similar to existing conditions. These conditions would continue to adversely affect salmon outmigrating from tributaries downstream from Iron Gate Dam, including those from the Shasta and Scott rivers. The highest rates of infection would likely continue to occur in the reach from Shasta River to Seiad Valley (Stocking and Bartholomew 2007, Bartholomew and Foott 2010). However, additional winter-spring surface flushing flows and ~~deep flushing~~ emergency dilution flow requirements outlined in Measures to Reduce Ceratanova Shasta Infection of Klamath River Salmonids: A Guidance Document and U.S. District Court Filing 111 (U.S. District Court 2017a–c; described in Section 4.2.3) and the newly defined existing 2019 BiOp Flows (including the surface flushing flows and potential for enhancement releases of 20,000 to 50,000 acre-feet depending on the water year type) is predicted to help reduce juvenile salmon disease below Iron Gate Dam. As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, ~~2017~~ court-ordered flushing flows were required ~~in~~ between February 2017 and ~~2018~~ March 2019, with the intent of reducing disease in the Lower Klamath River by mobilizing bedload sediments. In addition, 2017 court ordered emergency dilution flows were required in 2018. As described in Section 3.1.6, the 2017 court-ordered flows include a requirement to ensure that certain high flows are reached each winter, and also include an emergency dilution requirement if juvenile fish disease reaches high levels in the infection nidus. The emergency dilution flows were used in 2018. While the flushing flows have not been occurring over a long enough time to allow collection of enough data on the efficacy of the flushing flows, the necessity to use the emergency dilution flows in 2018 and 2019 suggests that the ~~addition~~

~~of the~~ flushing flows ~~is~~ are insufficient on ~~its~~ their own to resolve the issue of fish disease downstream of Iron Gate Dam. Therefore, the No Project Alternative would result in continued substantial deleterious effects on salmon because of fish disease and parasites.

Volume I Section 4.2.3.1 Alternatives – No Project Alternative – Aquatic Resources – Key Ecological Attributes – Fish Disease and Parasites – Potential Impact 4.2.3-4 Effects on Chinook and coho salmon Essential Fish Habitat (EFH) quality due to continued operations of the Lower Klamath Project, paragraph 6 on page 4-42:

Potential Impact 4.2.3-4 Effects on Chinook and coho salmon Essential Fish Habitat (EFH) quality due to continued operations of the Lower Klamath Project.

EFH in the Klamath River for Chinook and coho salmon 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. Under the No Project Alternative, EFH for Chinook and coho salmon would be expected to remain similar to current conditions. Access to habitat would be limited to current levels and there would be no change from existing adverse conditions for water temperature in the Middle and Lower Klamath River, the Klamath River Estuary. ~~Conditions under the 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).~~ Under the No Project Alternative, there would be no change from existing adverse conditions for Chinook and coho salmon EFH in the reasonably foreseeable short-term (0−5 years).

Volume I Section 4.2.3.2 Alternatives – No Project Alternative – Aquatic Resources – Aquatic Resource Potential Impacts, Impacts, and Mitigation – Potential Impact 4.2.3-7 Effects on the fall-run Chinook salmon population due to continued operations of the Lower Klamath Project, paragraph 1 on page 4-44:

This includes around 76 miles of potential habitat within the Lower Klamath Project, based on approximately 54 miles of potential anadromous fish (steelhead) habitat in the Project Reach (NMFS 2006~~a~~, DOI 2007)[102], reduced in consideration of 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).

[102] This also takes into consideration slight differences in the NMFS (2006) definition of the Project Reach from what is used in this report.

Volume I Section 4.2.3.2 Alternatives – No Project Alternative – Aquatic Resources – Aquatic Resource Potential Impacts, Impacts, and Mitigation – Potential Impact 4.2.3-7 Effects on the fall-run Chinook salmon population due to continued operations of the Lower Klamath Project, paragraph 1 on page 4-44:

Additional factors related to the Lower Klamath Project would continue to exacerbate the risk of disease downstream from Iron Gate Dam, including increased water temperatures and ~~dampened~~ reduced natural 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 (as discussed above in Section 4.2.3.1 *[No Project Alternative] Key Ecological Attributes – Aquatic Resources- Fish Disease and Parasites*).

Volume I Section 4.2.3.2 Alternatives – No Project Alternative – Aquatic Resources – Aquatic Resource Potential Impacts, Impacts, and Mitigation – Potential Impact 4.2.3-8 Effects on the spring-run Chinook salmon population due to continued operations of the Lower Klamath Project, paragraph 2 on page 4-47:

This includes around 76 miles of potential habitat within the Lower Klamath Project, based on approximately 54 miles of potential anadromous fish (steelhead) habitat in the Project Reach (NMFS 2006~~a~~, DOI 2007)[103], reduced in consideration of 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).

Volume I Section 4.2.3.2 Alternatives – No Project Alternative – Aquatic Resources – Aquatic Resource Potential Impacts, Impacts, and Mitigation – Potential Impact 4.2.3-9 Effects on the coho salmon populations due to continued operations of the Lower Klamath Project, paragraph 4 on page 4-48:

Under the No Project Alternative, Iron Gate Dam would continue to block access by 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 Lower Klamath Project, based on approximately 54 miles of potential anadromous fish (steelhead) habitat in the Project Reach (NMFS 2006~~a~~, DOI 2007),[104] reduced in consideration of 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.

[103] This also takes into consideration slight differences in the NMFS (2006) definition of the Project Reach from what is used in this report.
[104] This also takes into consideration slight differences in the NMFS (2006) definition of the Project Reach from what is used in this report.

Volume I Section 4.2.3.2 Alternatives – No Project Alternative – Aquatic Resources – Aquatic Resource Potential Impacts, Impacts, and Mitigation – Potential Impact 4.2.3-10 Effects on the steelhead population due to continued operations of the Lower Klamath Project, paragraph 1 on page 4-51:

In addition, there are around 80 miles of potential habitat for steelhead within the Klamath Hydroelectric Project that are currently inaccessible, comprising approximately 58 miles of anadromous habitat with the Project reach (NMFS 2006~~a~~, DOI 2007), that includes over 22 miles inundated by Klamath Hydroelectric Project reservoirs (Cunanan 2009) and habitat within the bypass reaches.

Volume I Section 4.2.3.2 Alternatives – No Project Alternative – Aquatic Resources – Aquatic Resource Potential Impacts, Impacts, and Mitigation – Potential Impact 4.2.3-11 Effects on the Pacific lamprey population due to continued operations of the Lower Klamath Project, paragraph 1 on page 4-53:

Although the exact upstream extent of suitable habitat for Pacific lamprey prior to the completion of the Lower Klamath Project dams and associated facilities is unknown, it is believed that Pacific lamprey would have migrated at least as far as Spencer Creek (Hamilton et al. 2005), including an estimated 80 miles of potential habitat within the Lower Klamath Project, based on approximately 58 miles of potential anadromous fish (steelhead) habitat in the Project Reach (NMFS 2006~~a~~, DOI 2007),[105] and including over 22 miles inundated by Klamath Hydroelectric Project reservoirs (Cunanan 2009), and habitat within the bypass reaches.

Volume I Section 4.2.3.2 Alternatives – No Project Alternative – Aquatic Resources – Aquatic Resource Potential Impacts, Impacts, and Mitigation – Potential Impact 4.2.3-14 Effects on the redband trout population due to continued operations of the Lower Klamath Project, paragraphs 5 and 6 on page 4-55:

Resident trout upstream of Iron Gate Dam are considered to be redband trout. Before construction of the Lower Klamath Project dams and associated facilities, redband trout in the area belonged to one population, with no migration barriers isolating populations from one another (NMFS 2006~~a~~). Under the No Project Alternative, genetic exchange and movement by redband trout between reaches would continue to be limited by the partially functional J.C. Boyle fish ladder (NMFS 2006~~ a~~) and lack of fish ladders at the Copco No. 1 and 2 Dams, as would access to productive spawning habitat in Spencer Creek in the J.C. Boyle Bypass and Peaking Reaches (NMFS 2006~~ a~~). The fragmentation of this

[105] This also takes into consideration slight differences in the NMFS (2006) definition of the Project Reach from what is used in this report.

population into several smaller, isolated subpopulations renders each more vulnerable to extinction due to stochastic events (wildfire, landslides, disease outbreaks, etc.) and limits genetic exchange among subpopulations.

Under the No Project Alternative, habitat connectivity for redband trout in the Klamath River would continue to be compromised by structural features of the Lower Klamath Project dams and associated facilities developments as well as by 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 the ineffective fish ladder at J.C. Boyle Dam, which poses a partial passage barrier (Hamilton et al. 2011). Spencer Creek is a highly productive spawning and rearing habitat for rainbow/redband trout (Hamilton et al. 2011). 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 (NMFS 2006~~a~~). Migration over the Copco No. 1 and 2 dams is in the downstream direction only, as there is no fishway. These conditions would remain unchanged under the No Project Alternative and the redband trout population would continue to suffer the effects of restricted habitat connectivity.

Volume I Section 4.2.3.2 Alternatives – No Project Alternative – Aquatic Resources – Aquatic Resource Potential Impacts, Impacts, and Mitigation – Potential Impact 4.2.3-14 Effects on the redband trout population due to continued operations of the Lower Klamath Project, paragraph 7 on page 4-55:

Under existing conditions, the lack of fully functioning fish screens at Iron Gate, Copco No. 1, and Copco No. 2 dams results in potential entrainment and ~~loss~~ mortality of juvenile redband trout ~~and reduces recruitment of redband trout to downstream reaches~~ (DOI 2007). All Lower Klamath Project hydropower facilities use Francis turbines. A 1987 report prepared by the Electric Power Research Institute (EPRI 1987) concluded that fish mortality from entrainment at hydroelectric projects using Francis turbines averaged 24 percent. ~~It is estimated that "several tens of thousands of resident fish" are annually entrained at "each of the Projects" facilities (NMFS 2006a), and it is likely that these~~ Risk of entrainment and mortality ~~rates~~ for redband trout would continue under the No Project Alternative.

Volume I Section 4.2.3.2 Alternatives – No Project Alternative – Aquatic Resources – Aquatic Resource Potential Impacts, Impacts, and Mitigation – Potential Impact 4.2.3-14 Effects on the redband trout population due to continued operations of the Lower Klamath Project, paragraphs 1 and 2 on page 4-56:

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 Project Alternative. Obstruction of sediment transport at J.C. Boyle Dam has altered substrates and channel features in the peaking and bypass reaches (FERC

2007). High flows have mobilized and removed sediment from storage sites and transported it downstream, reducing habitat quality for redband trout as well as for the macroinvertebrates they feed on (NMFS 2006~~a~~). These effects would continue under the No Project Alternative. In the J.C. Boyle Peaking Reach, redband trout numbers would continue to be subject to large fluctuations in flows that would: (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 are expected to continue to limit redband trout health and productivity ~~could result in substantial declines in redband trout abundance~~ in ~~this~~ these reaches.

Under the No Project Alternative, diversion of water ~~at Copco No. 2~~ for hydropower generation would continue to alter flows downstream, as occurs under existing conditions. Reduced flows in the 1.4-mile-long Copco No. 2 Bypass Reach would continue to prevent redband trout from using what would otherwise be habitat suitable for spawning and rearing. Productivity of redband trout in the bypass and peaking reaches downstream of J.C. Boyle Dam would continue to be suppressed by Lower Klamath Project effects that limit spawning and rearing habitat in these reaches (Hamilton et al. 2011). Under existing conditions, spawning of redband trout downstream of J.C. Boyle Dam 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 (NMFS 2006~~ a~~, Hamilton et al. 2011). These conditions would continue under the No Project Alternative.

Volume I Section 4.2.3.2 Alternatives – No Project Alternative – Aquatic Resources – Aquatic Resource Potential Impacts, Impacts, and Mitigation – Potential Impact 4.2.3-14 Effects on the redband trout population due to continued operations of the Lower Klamath Project, paragraph 3 on page 4-56:

Although redband trout in the Upper Klamath Basin support a robust sport fishery, Lower Klamath Project features and operations currently limit habitat connectivity and genetic exchange, reduce habitat quality, and reduce productivity. ~~Reduced redband trout abundance and distribution upstream of Iron Gate Dam attributable to Lower Klamath Project features and operations would continue under the No Project Alternative.~~ Habitat connectivity and suitability are substantially reduced in the Hydroelectric Reach due in part to Lower Klamath Project facilities isolating population units by limiting migration and reducing habitat suitability. Apparent phenotypic changes in redband trout in these reaches would likely be maintained or continue under the No Project Alternative, such as declines in size (Jacobs et al. 2007, as cited in Hamilton et al. 2011). ~~and condition factor (ODFW 2003, as cited in Hamilton et al. 2011).~~ The effect of the No Project Alternative would be no change from existing conditions for redband trout in the reasonably foreseeable short-term (0−5 years).

Volume I Section 4.2.3.2 Alternatives – No Project Alternative – Aquatic Resources – Aquatic Resource Potential Impacts, Impacts, and Mitigation – Potential Impact 4.2.3-20 Effects on fish species from alterations to benthic macroinvertebrates due to continued operations of the Lower Klamath Project, paragraph 2 on page 4-58:

Under existing conditions, J.C. Boyle peaking operations kill, through stranding, large numbers of young fish and aquatic invertebrates that are the primary prey food for resident trout (NMFS 2006~~a~~). Current peaking operations reduce the production of sessile organisms, like macroinvertebrates, by 10 to 25 percent (Administrative Law Judge (2006). Fluctuations in the peaking reach are considered to be a contributing factor to the lower macroinvertebrate drift rates (NMFS 2006~~a~~).

4.2.5 Terrestrial Resources

Volume I Section 4.2.5.3 Alternatives – No Project Alternative – Terrestrial Resources – Special-status Species – Potential Impact 4.2.5-1 Effects of 2017 court-ordered flushing and emergency dilution flows released from Iron Gate Dam on foothill yellow-legged frog and western pond turtle breeding, paragraph 4 on page 4-64 through paragraph 2 on page 4-66:

Potential Impact 4.2.5-1 Effects of 2017 court-ordered flushing and emergency dilution flows and 2019 BiOp flows released from Iron Gate Dam on foothill yellow-legged frog and western pond turtle breeding.
To manage the fish parasite *C. shasta*, mandatory surface flushing flows in the winter-spring, deep flushing flows, and emergency dilution flows would occur in the short-term (0−5 years) in the Middle Klamath River downstream of Iron Gate Dam under the No Project Alternative (see Section 4.2.1.1 *[No Project Alternative] Alternative Description – Summary of Available Hydrology Information for the No Project Alternative*).

As part of the 2017 court-ordered modification to the 2013 BiOp Flows, the 2017 court-ordered ~~The~~ winter-spring surface flushing flow of 6,030 cfs is designed to occur for a 72-hour period between November 1 and April 30 (U.S. District Court 2017). This flow would be sufficient to move surface sediments (i.e., sand and potentially pea-sized gravel). The beginning of the foothill yellow-legged frog breeding season (typically April 22 through early July) overlaps with ~~this~~ the 2017 court-ordered flushing flow for about one week (April 22 through April 30). Mean daily flows in April are generally 2,000–3,000 cfs (Figure 3.6-4, Section 3.6.2.2 *Basin Hydrology*). Foothill yellow-legged frogs are known to time their egg-laying with the flow pattern of a given year, initiating egg-laying on the descending limb of the spring hydrograph (i.e., when flows are trending down) (Seltenrich and Pool 2002). If the 2017 court-ordered winter-spring surface flushing flows were to occur early in the foothill yellow-legged frog breeding season, individuals may delay breeding (Gonsolin 2010 and GANDA 2008); otherwise there is a potential for eggs to be scoured, if present, during the 2017 court-ordered winter-spring surface flushing flows.

The 2017 court-ordered deep flushing flows are designed to occur in one 24-hour period at least every other year (i.e., biennially) (U.S. District Court 2017). This one-day flow would ~~will~~ consist of an average flow of 11,250 cfs and occur any time between February 15 and May 31. Mean daily flows observed between April and May at Iron Gate Dam are typically between about ~~2,500~~ 1,500–3,500 (Figure 3.6-4 Section 3.6.2.2 *Basin Hydrology*). This deep flushing flow may scour or damage eggs attached to submerged rocks and pebbles during the one-month period that egg-laying overlaps with the 2017 court-ordered deep flushing flows (April 22–May 31). Tadpoles, which hatch between 5–37 days following egg-laying, could be present in May and could be displaced by the deep flushing flows, which would likely result in injury or mortality because the species is not adapted to high flows.

Both the 2017 court-ordered annual surface flushing and biennial deep flushing flows are implemented through flow augmentation when the required flows are not met naturally (i.e., in the case of a dry water year). The flows are timed, where possible, to occur during high precipitation events, in order to reduce the impact on water supplies. This means that any foothill yellow-legged frogs in the area would already be exposed to high flows, though supplementation would make these flows higher. Because the flows are designed to cause bed mobilization, the supplementation would be more likely to cause an impact than the precipitation event alone.

The 2017 court-ordered emergency dilution flows of 3,000–4,000 cfs are designed to occur between April 1 and June 15 if certain disease thresholds are present in the river (U.S. District Court 2017). Existing flows are typically at or above 3,000 cfs for approximately 40~~50~~ percent of April, 30~~25~~ percent of May, and 10~~5~~ percent of June (Figure 3.1-1; Section 3.1.6.2 *Comparison of Klamath River Flows under 2013 Biological Opinion and KBRA*). The 2017 court-ordered emergency dilution flows may scour or damage any eggs that are present between April 22 and June 15, when the flows overlap with the typical foothill yellow-legged frog breeding season. Additionally, direct impacts may result from stranding of eggs if breeding occurs along the river edge during the emergency dilution flows, and the subsequent receding flows reduce the wetted channel and dewatered egg masses. Tadpoles, which hatch between 5 and 37 days following egg-laying, could also be displaced by the emergency dilution flows.

In the 2019 BiOp, "opportunistic" surface flushing flows are specified during wetter water years, but approximately 50,000 acre-feet of water is available for a "forced" surface flushing flow or use in a manner that best meets coho salmon needs during drier water years since conditions in the Klamath River Basin may prevent the release of surface flushing flows. In wet to average water years, the 2019 BiOp specifies "opportunistic" surface flushing flows of 6,030 cfs for a 72-hour period between March 1 and April 15 would be released. In below average to dry water years, the 2019 BiOp specifies that 50,000 acre-feet of water would be available to be released in a manner that best meets coho salmon needs between March 1 and April 15 since conditions during these water year types may not be sufficient to "force" a surface flushing flow in the Klamath River between March 1 and April 15 (e.g., insufficient hydraulic head at Link River Dam to produce 6,030 cfs for 72 hours at Iron Gate Dam). In these water year types, NMFS may request alternative distributions (i.e., releases) of the 50,000 acre-feet of water between March 1 and April 15, but the 2019 BiOp specifies that a "forced" surface flushing flow would be attempted between March 1 and April 15 if the necessary Klamath River and Upper Klamath Lake conditions are met, in the absence a request by NMFS for an alternative distribution. In the event that by April 15 a surface flushing flow (or other use of the 50,000 acre-feet) has not been released, the 50,000 acre-feet would be released as a "forced" surface flushing flow event that approximates, to the maximum extent practicable, a surface flushing flow of 6,030 cfs for 72 hours (NMFS 2019; USFWS 2019). As such, it is possible that the 50,000 acre-feet would be used and the flow in the Klamath River would be elevated after April 15 during below average to wet water years. Effects from the 2019 BiOp "opportunistic" surface flushing flows on foothill yellow-legged frogs would be similar to or less than that identified above for the 2017 court-ordered surface flushing flows since the 2019 BiOp surface flushing flows would tend to end earlier in the year (i.e., April 15), further reducing the potential of overlap with foothill yellow-legged frog breeding season (typically begins April 22). The 2019 BiOp "opportunistic" surface flushing flows during wet to average water years would end by April 15, while the 2019 BiOp "forced" surface flushing flows during below normal to dry water years would only occur after April 15 if the 50,000 acre-feet of water is not used before April 15. However, if the "forced" flows are released into the foothill yellow-legged frog breeding season (typically beginning April 22), there is a potential for egg scour and tadpole displacement.

The 2019 BiOp specifies that deep flushing flows (i.e., 11,250 cfs for 24 hours) would be attempted during late winter or early spring when hydrologic conditions and public safety allow, but they would be unlikely to occur. Modeling of 2019 BiOp Flows indicates the hydrologic and public safety conditions for deep flushing flows would only occur in 4 out of 36 years (approximately 11 percent of years) (NMFS 2019; USFWS 2019). While the specific time periods when deep flushing flows would occur are not specified in the 2019 BiOp, it is assumed deep flushing flows would occur within of the time period specified by the 2017 court-ordered deep flushing flows (i.e., February 15 and May 31) since the purpose of deep flushing flows remains the same in the 2017 court order and the 2019 BiOp (i.e., increase streambed mobility to reduce risks to coho salmon associated with *C. shasta* infections) and deep flushing flows would only be able to occur in conjunction with a natural high flow event. The 2019 BiOp deep flushing flows have the potential to occur through May, so impacts from the 2019 BiOp deep flushing flows on foothill yellow-legged frogs would be similar to that identified above for the 2017 court-ordered flows.

The 2019 BiOp also specifies that an additional 20,000 acre-feet may be released in May and June during some water year types when specific conditions listed in the 2019 BiOp are met. While the 20,000 acre-feet may be used in different ways to enhance flows downstream of Iron Gate Dam in May and June based on NMFS recommendations to benefit coho salmon, the default approach for using the 20,000 acre-feet would increase flows downstream of Iron Gate Dam by 195 cfs (i.e., 12,000 acre-feet) in May and 134 cfs (i.e., 8,000 acre-feet) in June (NMFS 2019). Mean daily flows observed between May and June at Iron Gate Dam are typically between about 800 to 2,500 cfs (see Section 3.6.2.2 *Flood Hydrology – Environmental Setting – Basin Hydrology*, Figure 3.6-4). In the event Klamath River flow at Iron Gate Dam increases 134 to 195 cfs, it is possible that tadpoles, if present, may be displaced and impacts similar to those identified for the 2017 court-ordered emergency dilution flows would occur.

Although survey data are limiting for characterizing the presence of foothill yellow-legged frog in the Klamath River (i.e., this species has not been documented since 1976), occurrences are known in tributaries and presumably individuals have the potential to be present in the mainstem river as well. Due to the listing status of the foothill yellow-legged frog (i.e., State Candidate Threatened), direct mortality or harm to an individual would result in a significant impact. Thus, if eggs, juvenile and/or adult foothill yellow-legged frogs are present in the Middle Klamath River immediately downstream of Iron Gate Dam, direct impacts from scouring and displacement due to the court-ordered flushing and dilution flows may occur. The likelihood of this occurring is not high, because of the lack of certainty that individuals are present in the upper Middle Klamath River and the timing of flow supplementation to occur with natural high flows. However, if present and affected, this would be a significant impact.

Due to the low likelihood of locating eggs during high flow events, mitigation typically employed to reduce impacts to this species (i.e., rescuing and relocating eggs) would be ineffective. Modification of the flows to avoid the potential presence of foothill yellow-legged frog is not feasible. The USBR, which is responsible for the court-ordered flow releases, is a federal agency with a mandate to maximize agricultural deliveries as possible. Therefore, it is not feasible for the agency to adjust its decision-making to accommodate a candidate state-listed and state species of special concern that it does not have a particular obligation to protect. Thus, this would be a significant and unavoidable impact.

Since western pond turtles' nest on land and usually above the floodplain, up to several hundred meters from water (Ashton et al. 1997), there would be no significant impacts to their nests due to the 2017 court-ordered flushing and emergency dilution flows and 2019 BiOp flows. While the flushing and dilution flows may disperse juvenile and adult western pond turtles, this would be a less than significant impact because although this species is considered an aquatic species, they are known to spend a considerable portion of their lives in upland habitats and may move to upland habitats during high winter flows.

Significance

Significant and unavoidable for foothill yellow-legged frog breeding populations, if present, in the Middle Klamath River immediately downstream of Iron Gate Dam in the short term (0−5 years)

No significant impact for western pond turtle in the Middle Klamath River immediately downstream of Iron Gate Dam in the short term (0−5 years)

4.2.6 Flood Hydrology

Volume I Section 4.2.6 Alternatives – No Project Alternative – Flood Hydrology – Potential Impact 4.2.6.1 The FEMA100-year floodplain inundation extent downstream from Iron Gate Dam could change due to 2017 flow requirements, potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding, paragraph 4 on page 4-66:

Under the No Project Alternative, the dams would remain in place and the Lower Klamath Project would continue to operate in the short term (0−5 years) under annual licenses issued by FERC. Between February 2017 and March 2019, the ~~The~~ 2013 BiOp requirements for the upstream USBR Klamath Irrigation Project and the 2017 court-ordered flushing and emergency dilution flows ~~would~~ determined how instream flows through the Lower Klamath Project and releases from Iron Gate Dam ~~are~~ were managed (NMFS and USFWS 2013, U.S. District Court 2017). The 2019 BiOp Flows are now the current operational flow requirement for the Klamath River (USFWS 2019, NMFS 2019).

The 100-year floodplain inundation extent in the Klamath River between RMs 193 and 174 (i.e., from Iron Gate Dam to Humbug Creek) was modeled by USBR (2012), including a "WithDams_100yr" scenario that assumes 2010 BiOp flows and Lower Klamath Project dams remain in place. Floodplain inundation maps illustrating the USBR (2012) model results are presented in Appendix K of this EIR. Because the overall magnitude of the 2010 BiOp flows is consistent with that of the 2013 BiOp Flows ~~flows~~ and the 2019 BiOp Flows, and the 2017 court-ordered flushing and emergency dilution flows and the 2019 BiOp flushing flows are within the range of historical Klamath River flows evaluated in 2013 BiOp studies (see also Section 4.2.1.1 *[No Project Alternative] Alternative Description – Summary of Available Hydrology Information for the No Project Alternative*), the 100-year floodplain inundation extent previously modeled by USBR (2012) also serves as the Lower Klamath Project EIR No Project Alternative 100-year floodplain inundation extent.

Volume I Section 4.2.6 Alternatives – No Project Alternative – Flood Hydrology – Potential Impact 4.2.6.2 The FEMA 100-year floodplain inundation extent downstream from J.C. Boyle Dam could change due to 2017 flow requirements between the California-Oregon state line and Copco No. 1 Reservoir, potentially exposing people and/or structures to a substantial risk of damage, loss, injury, or death involving flooding, paragraph 1 on page 4-68:

As described for the Proposed Project analysis of Potential Impact 3.6-4 (see Section 3.6.5.2), J.C. Boyle Reservoir provides ~~no~~ limited storage (i.e., 1,724 acre-feet of active storage capacity; see Table 3.6-4) and the dam typically operates in spill mode at flows above power canal ~~plant~~ capacity (i.e., approximately ~~6,000~~ 2,800 cfs; Table 2-1 in USBR 2012). Existing-conditions peak flows in the Hydroelectric Reach are not substantially attenuated as a result of J.C. Boyle Dam.

Volume I Section 4.2.6 Alternatives – No Project Alternative – Flood Hydrology – Potential Impact 3.6-6 Dam failure could flood areas downstream of the Lower Klamath Project, paragraph 3 on page 4-68:

The Lower Klamath Project dams collectively store over ~~169,000~~ 87,000 acre-feet of water when they are full (Table 2.3-1).

4.2.8 Water Supply/Water Rights

Volume I Section 4.2.8 Alternatives – No Project Alternative – Water Supply/Water Rights – Potential Impact 4.2.8-1 Water availability changes from coordinated operations under 2017 flow requirements, paragraph 1 on page 4-69

With Iron Gate Dam continuing to block fish passage, it is assumed that ~~the 2017~~ flushing and emergency dilution flow requirements will continue under the No Project Alternative in the short term. The 2017 flow requirements determined how instream flows through the Lower Klamath Project and releases from Iron Gate Dam ~~are~~ were managed between February 2017 and March 2019 (NMFS and USFWS 2013, U.S. District Court 2017; see Section *[No Project] Alternative Description – Summary of Available Hydrology Information for the No Project Alternative*). The 2017 flow requirements require use of more water than the 2013 flow requirements, in that the USBR must guarantee at Iron Gate Dam, annual flushing flows and bi-annual deep flushing flows. Additionally, USBR must maintain an additional 50,000 acre feet of water until approximately June 15 annually, as a reserve in case emergency dilution flows are needed. The amount of water required to maintain the flow requirements is not fixed, because the requirements work in tandem with available high flows. Thus, the amount of water that USBR must withhold from deliveries in order to ensure the flow minimums are met will vary each year. Additionally, in some years, the 50,000 acre-feet of water held in reserve for dilution flows will be available for delivery to the Klamath Irrigation Project later in the year, while in other years it will not.

While it is not possible to quantify the reduction in water available for Klamath Irrigation Project deliveries, it is reasonable to assume that there will be some level of reduced deliveries in most, if not all, years. In 2018, the amount of Klamath Irrigation Project Supply water required to meet 2017 flow requirements was 76,713 acre-feet. As noted in Potential Impact 3.8-2, the potential for the Lower Klamath Project dams to somewhat ameliorate reductions in water deliveries would be uncertain in light of stated operational changes. Despite this uncertainty, there would remain some potential for coordinated operations to reduce the amount of supply by up to 20,000 acre-feet in drought situations. Similarly, the 2019 BiOp requires releasing an “opportunistic” surface flushing flow from Iron Gate Dam during the spring period (March 1 to April 15) if hydrologic conditions allow in average to wet years, although deep flushing flows are only required when hydrologic conditions and public safety allow, including, but not limited to, Upper Klamath Lake storage to allow for sufficient Link River Dam release capacity, Upper Klamath Lake storage sufficient to protect sucker needs, substantial accretions, and Klamath River tributary discharge that does not result in public safety or property concerns. An additional volume of 20,000 acre-feet for enhanced May/June flows would occur in years in which the April 1 EWA is greater than 400,000 acre-feet (407,000 acre-feet in years 2020, 2022, and 2024) and less than 576,000 acre-feet. As discussed in Section 3.8 *Water Supply/Water Rights*, coordinated efforts for any of the above flow releases do not affect releases downstream of Iron Gate Dam, and therefore do not impact water rights downstream. The Lower Klamath Project is not required to operate in such a manner as to extend USBR deliveries.

The potential for coordinated operations under either the 2017 flushing and emergency dilution flow requirements or the 2019 BiOp flushing flow requirements ~~has~~ would have no significant impact as compared to the ~~exiting~~ existing condition.

Significance

No significant impact in the short term (0−5 years)

4.2.11 Geology, Soils, and Mineral Resources

Volume I Section 4.2.11 Alternatives – No Project Alternative – Geology, Soils, and Mineral Resources, paragraph 4 on page 4-70.

The continued interception of sand, gravel and coarser sediment supplied by sources upstream of Iron Gate Dam would continue to coarsen the channel bed and reduce the size and frequency of mobile coarse sediment deposits in the Hydroelectric Reach and in the Middle Klamath River from Iron Gate Dam to approximately the Scott River, limiting the amount and quality of spawning gravel deposits in these reaches (see also Appendix F). From February 2017 to March 2019 (i.e., at the time of the Draft EIR), 2017 court-ordered flushing and emergency dilution flow requirements (U.S. District Court 2017) were in effect. With operation of the 2017 court-ordered ~~While the~~ winter-spring surface flushing flows and deep flushing flow requirements at Iron Gate Dam (Section 4.2.1.1 *[No Project Alternative] Alternative Description – Summary of Available Hydrology Information for the No Project Alternative)* ~~would increase~~ the mobility of existing surficial fine sediment deposits and infilled fine sediment from the armor layer would be increased, with potential for continued infrequent (i.e., decadal scale)~~slight~~ mobilization of the armor layer in some locations, while new sediment supply would not occur. ~~However, all p~~Previous flow requirements have now been superseded by the ~~Biological Opinion flows (~~2019 BiOp Flows~~)~~, which require surface flushing flows (6,030 cfs), without deep flushing or emergency dilution flow requirements (see Section 3.1.6.3 *Klamath River Flows under the 2019 BiOp Operations Criteria for the Klamath Irrigation Project*); therefore, the potential for sediment mobilization would be similar to historical conditions and there would be no new sediment supply. Overall, with implementation of either of the flow conditions, ~~maintenance~~ the condition of ~~static~~ channel features would ~~represent no~~not change substantially from existing adverse conditions for the Middle Klamath River between Iron Gate Dam and the confluence with the Scott River.

4.2.12 Historical Resources and Tribal Cultural Resources

Volume I Section 4.2.12 No Project Alternative – Historical Resources and Tribal Cultural Resource, paragraph 1 on page 4-71:

Additionally, there would be no impacts to Copco No. 1 Dam, Copco No. 2 Dam, and Iron Gate Dam, their associated hydroelectric facilities, and the Klamath River Hydroelectric Project District (Potential Impact 3.12-11), because the Lower Klamath Project would remain in place. Please refer to Tables 4.3-1, 4.3-3, and 4.3-5 for National Register eligibility recommendations for each of the features making up the Lower Klamath Project. Potential impacts to submerged historic-period archaeological resources (Potential Impacts 3.12-12 through 3.12-16) within the reservoir footprints and along the Klamath River would not occur. Overall, conditions for historical resources and tribal cultural resources would remain consistent with existing conditions, and there would be no significant impacts in the short-term period (0−5 years).

4.3 Partial Removal Alternative

4.3.5 Terrestrial Resources

4.3.5.3 Special-status Species

Volume I Section 4.3.5.3 Alternatives – Partial Removal Alternative – Terrestrial Resources – Special-status Species, paragraph 4 on page 4-86 through paragraph 1 on page 4-87:

Under the Partial Removal Alternative there would be less construction activity as compared to the Proposed Project as some structures would remain in place (see Table 4.3-1 through Table 4.3-6); however, short-term construction-related noise would still be generated due to the removal of the large majority of the dam complexes, including the entirety of each dam, and sealing of remaining structures and installation of security fencing. Thus, retaining some structures under the Partial Removal Alternative would not reduce noise-related impacts on special-status bats or non-federally listed birds to a less than significant level. Although bats are known to use some of the structures that would be retained (i.e., Copco No. 1, Copco No. 2, and Iron Gate powerhouses, see Section 3.5.5.3 *Special-status Species and Rare Natural Communities*), the Partial Removal Alternative would seal openings in the structures that remain, which would prevent bats from accessing the inside of the structures.

The structures that currently support the largest of the known bat roosts (e.g., Copco No. 1 and Iron Gate diversion tunnels) would be removed under this alternative. Birds may be nesting on the exterior of the structures that would be retained and potentially affected by facility preservation. As such, short- and long-term construction-related potential impacts (Potential Impacts 3.5-9, 3.5-10, 3.5-11, 3.5-12, 3.5-13, 3.5-14, 3.5-15, and 3.5-28) on terrestrial resources would be the same as those described for the Proposed Project. The mitigation measures and recommended terrestrial measures also would be the same as those identified for the Proposed Project. Implementation of Mitigation Measures TER-2, TER-3, TER-6, and TER-7 would reduce construction-related impacts, including in-water work, on all special-status amphibian species, gray wolf, and bald and golden eagles to less than significant.

4.3.12 Historical and Tribal Cultural Resources

Volume I Section 4.3.12 Alternatives – Partial Removal Alternative – Historical and Tribal Cultural Resources, paragraph 1 on page 4-92:

The retention of the aforementioned structures under the Partial Removal Alternative would potentially avoid disturbance-related impacts to three known TCR's, and potentially additional unknown TCR's, that are located in the immediate vicinity of structures that would remain in place under this alternative. While avoidance of potential impacts to these three TCR's would mean fewer overall impacts to TCR's under this alternative as compared with the Proposed Project, relative to existing conditions this alternative generally would not result in different effects related to either historic-period archaeological resources or tribal cultural resources compared with those described for the Proposed Project. Therefore, potential impacts and beneficial effects on these resources and any associated mitigation measures under the Partial Removal Alternative would be the same as those described for the Proposed Project (Potential Impacts 3.12-1 through 3.12-10 and 3.12-12 through 3.12-16).

4.3.17 Public Services

Volume I Section 4.3.17 Alternatives – Partial Removal Alternative – Public Services, paragraph 2 on page 4-93:

Implementation of Mitigation Measure HZ-1 (Section 3.21 *Hazards and Hazardous Materials*) and Mitigation Measure TR-1 (Section 3.22 *Traffic and Transportation*) would reduce impacts for reasons described under the Proposed Project. ~~However, the KRRC is developing a Traffic Management Plan to identify mitigation and other protective measures that would be implemented to reduce impacts to public services. Overseeing development and implementation of a Traffic Management Plan does not fall within the scope of the State Water Board's water quality certification authority. While the State Water Board expects that the Traffic Management Plan will be finalized and implemented, at this time the plan is not finalized, and the State Water Board cannot require its implementation. Accordingly, while the State Water Board anticipates that implementation of HZ-1 and Recommended Measure TR-1 would reduce impacts to public services, because it cannot require implementation of Recommended Measure TR-1, it is analyzing the impacts under this alternative as significant and unavoidable.~~

4.3.19 Aesthetics

Volume I Section 4.3.19 Alternatives – Partial Removal Alternative – Aesthetics, paragraph 1 on page 4-95:

The retention of some structures under the Partial Removal Alternative (e.g., powerhouse elements, penstocks, some buildings, see Table 4.3-1 through Table 4.3-6) would mean that the long-term (permanent) visual character of the Lower Klamath Project area would continue to be affected by the remaining man-made features, including for key observation points C3, C4, C5, IG9, IG10, IG11, and IG12; Table 3.19-3 and Figure 3.19-2 in Volume III Attachment 1 Section 3.19.5 *Aesthetics – Potential Impacts and Mitigation*) (Potential Impact 3.19-5). The retention of some structures under the Partial Removal Alternative would not cause the VRM class to be degraded at a key observation point, would not adversely impact a scenic vista for those areas that were not assigned a VRM class, and would not result in a significant long-term (permanent) impact. ~~However, as the remaining features are already part of the existing conditions (i.e., environmental baseline), the aesthetic effect of removing the other large existing structures (e.g., dams, some buildings) the would be beneficial as compared with existing conditions, even though the benefits would be of a slightly lesser degree than those described for the Proposed Project (Potential Impact 3.19-5).~~ Long-term (permanent) ~~V~~visual impacts due to construction of new infrastructure and improvements to existing infrastructure would be less than significant for the reasons described for the Proposed Project (Potential Impact 3.19-5). In general, short-term construction-related impacts to visual resources under the Partial Removal Alternative would be slightly less than those described for the Proposed Project and as such would be less than significant (Potential Impact 3.19-6).

4.4 Continued Operations with Fish Passage Alternative

4.4.1 Introduction

Volume I Section 4.4.1.1 Alternatives – Continued Operations with Fish Passage Alternative – Introduction – Alternative Description, paragraph 2, bullets 1 and 2, on page 4-99:

The following conditions under the Continued Operations with Fish Passage Alternative are modifications to the 2012 KHSA EIS/EIR *Fish Passage at Four Dams Alternative*:

- Flows specified in the NMFS and USFWS 2013 BiOp for the USBR Klamath Irrigation Project, which served as the operational flow requirement for the Klamath River at the time of the Notice of Preparation for the Lower Klamath Project EIR (i.e., December 22, 2016), combined ~~are currently being considered under reinitiated consultation (see also 3.1.6.1~~ ~~*Klamath River Flows under the Klamath Irrigation Project's 2013 BiOp*~~); ~~C~~court-ordered flushing and emergency dilution flows downstream of Iron Gate Dam, which ~~became~~ were required ~~after~~ between February 2017 and March 2019 (U.S. District Court 2017) (3.1.6 *Summary of Available Hydrology Information for the Proposed Project* ~~see also Section 4.2.1.3~~ ~~*Summary of Available Hydrology Information for the No Project Alternative*~~);
- Flows specified in the NMFS and USFWS 2019 biological opinions for the USBR Klamath Irrigation Project (2019 BiOp), which are the current operational flow requirement for the Klamath River (see also 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*); and
- Design and implementation of a Reservoir Management Plan, as described in the 2014 water quality certification application for Klamath Hydroelectric Project operations.

Volume I Section 4.4.1.2 Alternatives – Continued Operations with Fish Passage Alternative – Introduction – Alternative Analysis Approach, paragraph 5 on page 4-101:

As for the Proposed Project, the potential impacts of the Continued Operations with Fish Passage Alternative are analyzed in comparison to existing conditions. Unless otherwise indicated, the significance criteria, area of analysis, environmental setting, and impact analysis approach, including consideration of existing local policies, for all environmental resource areas under the Continued Operations with Fish Passage Alternative are the same as those described for the Proposed Project (see Section 3.1 Introduction and individual resource area subsections in Section 3 *Environmental Setting, Potential Impacts, and Mitigation Measures*). The potential impacts for each environmental resource area are analyzed both in the short term and the long term, and unless otherwise indicated, use the same definitions of short term and long term as described for each resource area analyzed for the Proposed Project.

There are various restoration efforts underway in the Klamath Basin to improve water quality, as discussed in Section 3.24 *Cumulative Effects*. However, the effects of these efforts, including efforts aimed at meeting Klamath River TMDLs, are not analyzed in the short term under the Continued Operations With Fish Passage Alternative because the basin response to the restoration efforts to meet the total maximum daily loads (TMDLs) during the short term is too speculative.

4.4.2 Water Quality

Volume I Section 4.4.2.1 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Water Temperature, paragraph 1 on page 4-102:

Short-term and long-term potential impacts to water temperature due to implementation of the 2017 court-ordered flushing and emergency dilution flows or the 2019 BiOp surface flushing flows under this alternative would be similar to the potential short-term impacts to water temperature described for the No Project Alternative (Section 4.2.2, Potential Impact 4.2.2-1).

Volume I Section 4.4.2.1 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Water Temperature, paragraph 3 on page 4-102:

The 2007 FERC EIS found that PacifiCorp's proposal for relicensing of the Klamath Hydroelectric Project failed to address the project's water quality impairments within and downstream of the Hydroelectric Reach (FERC 2007). Studies indicated that water released from Iron Gate Dam is 1.8 to 4.5°F (approximately 1 to 2.5°C) cooler in the spring and approximately 4 to 18°F (approximately 2 to 10°C) warmer in the summer and fall as compared to modeled conditions without J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams (PacifiCorp 2004a, 2005, 2008, 2014; Dunsmoor and Huntington 2006; North Coast Regional Board 2010). In 2010, the Klamath River TMDLs ~~later~~ assigned water temperature and dissolved oxygen dual (i.e., co-occurring) load allocations to Copco No. 1 and Iron Gate reservoirs for the stratification period (May through October) to ensure compliance with the dissolved oxygen and water temperature targets (i.e., dissolved oxygen consistent with 85 percent saturation or better through September, and 90 percent or better in October [see also Table 3.2-5], and a zero water temperature increase above natural water temperatures~~, where natural baseline summer mean water temperature is approximately 18.7ºC~~) within the reservoirs and to ensure support of cold freshwater habitat (COLD), which is a designated beneficial use.

Volume I Section 4.4.2.1 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Water Temperature, paragraph 3 on page 4-102:

The 2007 FERC EIS found that PacifiCorp's proposal for relicensing of the Klamath Hydroelectric Project failed to address the project's water quality impairments within and downstream of the Hydroelectric Reach (FERC 2007). Studies indicated that water released from Iron Gate Dam is 1.8 to 4.5°F (approximately 1 to 2.5°C) cooler in the spring and approximately 4 to 18°F (approximately 2 to 10°C) warmer in the summer and fall as compared to modeled conditions without J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams (PacifiCorp 2004a, 2005, 2008, 2014; Dunsmoor and Huntington 2006; North Coast Regional Board 2010). In 2010, the Klamath River TMDLs ~~later~~ assigned water temperature and dissolved oxygen dual (i.e., co-occurring) load allocations to Copco No. 1 and Iron Gate reservoirs for the stratification period (May through October) to ensure compliance with the dissolved oxygen and water temperature targets (i.e., dissolved oxygen consistent with 85 percent saturation or better through September, and 90 percent or better in October [see also Table 3.2-5], and a zero water temperature increase above natural water temperatures~~, where natural baseline summer mean water temperature is approximately 18.7ºC~~) within the reservoirs and to ensure support of cold freshwater habitat (COLD), which is a designated beneficial use.

Volume I Section 4.4.2.1 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Water Temperature, paragraph 3 on page 4-102:

Results from testing of a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11 indicate that a ~~modest~~ 1 to 2°C (1.8 to 3.6°F) water temperature improvement is possible using this technique, considered to be a modest improvement since data indicate that this improvement would still not achieve compliance with the Thermal Plan or meet the Klamath River TMDLs temperature requirement in the Middle Klamath River (North Coast Regional Board 2010); Section 4.4.2 *Water Quality*, Potential Impact 4.2.2-1 below discusses these results.

Volume I Section 4.4.2.1 Continued Operations with Fish Passage Alternative – Water Quality – Water Temperature Potential Impact 4.2.2-1, paragraphs 3 and 4 on page 4-103:

Under the Continued Operations with Fish Passage Alternative, J.C. Boyle Reservoir would remain in place, but ~~increased~~ changes in minimum flows in the J.C. Boyle Bypass Reach and ~~limitation of~~ limits on peaking operations ~~at J.C. Boyle Powerhouse~~ within the J.C. Boyle Peaking Reach would ~~decrease the large daily water temperature range that occurs under existing conditions when warmer reservoir water is diverted around the Bypass Reach to produce power (Section 3.2.2.2 Water Temperature)~~ alter water temperature conditions in the Hydroelectric Reach from J.C. Boyle Dam to Copco No. 1 Reservoir. Minimum flows in the J.C. Boyle Bypass Reach in Oregon would increase to meet the requirement that at least 40 percent of the J.C. Boyle Reservoir inflow be released through the J.C. Boyle Bypass Reach, so flow from the cold groundwater springs (a relatively constant approximately 11 to 12°C [51.8 to 53.6°F]) entering the Klamath River in this reach would comprise relatively less of the total flow. The range of daily water temperatures and the maximum daily water temperature in the J.C. Boyle Bypass Reach in Oregon would increase compared to existing conditions under the Continued Operations with Fish Passage Alternative due to more warmer reservoir water being released through the J.C. Boyle Bypass Reach and reducing the relative influence of the groundwater springs on water temperatures in this reach. Warmer water temperatures would occur during summer and early fall, while cooler water temperatures would occur in late fall and winter (i.e., November to April) in the J.C. Boyle Bypass Reach under this alternative compared to existing conditions. Areas adjacent to the cold groundwater springs in the J.C. Boyle Bypass Reach would continue to ~~serve as~~ potentially provide thermal refugia for aquatic species because the flow from the springs themselves would not be affected by the Continued Operations with Fish Passage Alternative, but the total thermal refugia area for aquatic species in the J.C. Boyle Bypass Reach would likely decrease as the percentage of flow in the river from the cold groundwater springs decreases and the percentage of flow from the warmer reservoir increases. Data and/or models results are not currently available to quantify the potential changes in the thermal refugia area under the Continued Operations with Fish Passage Alternative compared to existing conditions. See Section 4.4.3.3 *[Aquatic Resources] Water Quality* for more details about changes in thermal refugia for aquatic resources.

Under the Continued Operations with Fish Passage Alternative, downstream of the J.C. Boyle Bypass Reach, ~~The primary decrease in daily and seasonal flow fluctuations relative to existing conditions would occur in the J.C. Boyle Bypass Reach in Oregon because flow fluctuations in the downstream J.C. Boyle Peaking Reach in California (i.e., from the Oregon-California state line to Copco No. 1 Reservoir) are attenuated with distance downstream due to tributary inputs and accretion flows. With the limitation of peaking operations under this alternative,~~ the temperature effects ~~downstream from~~ in the J.C. Boyle Peaking Reach are generally similar to those described by removal of the facility, as described in Proposed Project (Potential Impact 3.2-1 *Hydroelectric Reach*). There would be a decrease in the range of daily water temperatures and the maximum daily water temperature compared to existing conditions under the Continued Operations with Fish Passage Alternative primarily due to reductions in hydropower peaking flows that discharge warmer reservoir water diverted around the J.C. Boyle Bypass Reach and into the J.C. Boyle Peaking Reach (see Section 3.2.2.2 *Water Temperature*). Decreases in peaking flow fluctuations relative to existing conditions would primarily occur in the upper portion of the J.C. Boyle Peaking Reach in Oregon and diminish in the downstream direction since peaking flow fluctuations attenuate with distance downstream due to tributary inputs and accretion flows.

In the lower portion of the J.C. Boyle Peaking Reach (i.e., near Shovel Creek upstream of Copco No. 1 Reservoir) from the Oregon-California state line to Copco No. 1 Reservoir, decreases in the peaking flow fluctuations under the Continued Operations with Fish Passage Alternative and associated water temperature changes from this decrease would be relatively less than would occur at the beginning of the J.C. Boyle Peaking Reach immediately downstream of the J.C. Boyle Powerhouse. Maximum water temperatures at the Oregon-California state line during summer and early fall would be slightly lower and temperatures would be less artificially variable relative to existing conditions due to higher overall flows and lower frequency of peaking operations at the J.C. Boyle Powerhouse (i.e., ~~weekly~~ one day per week peaking under this alternative as compared to daily peaking under existing conditions). According to the KRWQM (PacifiCorp 2004a), annual and summer peak maximum water temperatures in the lower portion of the J.C. Boyle Peaking Reach would be reduced under this alterative compared to existing conditions, but daily Klamath River water temperatures in this reach would potentially increase or decrease by approximately 2^{o}C or less due to the influence of local meteorological conditions in the absence of peaking flows. Overall, the ~~The~~ decrease in maximum daily water temperatures and temperature variability in the J.C. Boyle Peaking Reach would be less than described under the Proposed Project, because there would still be peaking operations occurring one day per week in conjunction with recreational flows (see Section 4.4.1 *[Continued Operations with Fish Passage Alternative] Introduction*). Relative to existing conditions, the slight decreases in long-term maximum summer/fall water temperatures and less artificial diel temperature variation in the J.C. Boyle Peaking Reach would return the river to a more natural thermal regime, although the degree of benefit would be slightly lower than under the Proposed Project (Potential Impact 3.2-1). ~~Elimination of~~ Reductions in the artificial temperature signal caused by peaking operations under existing conditions would better conform with the California Thermal Plan's prohibition on elevated temperature discharges (Table 3.2-4) and would be beneficial.

Volume I Section 4.4.2.1 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Water Temperature – Potential Impact 4.2.2-1 Seasonal alterations in water temperature due to continued impoundment of water in the reservoirs, paragraph 3 on page 4-103 through paragraph 1 on page 4-104:

Under the Continued Operations with Fish Passage Alternative, J.C. Boyle Reservoir would remain in place, but changes in minimum flows in the J.C. Boyle Bypass Reach and limits on peaking operations within the J.C. Boyle Peaking Reach would alter water temperature conditions in the Hydroelectric Reach from J.C. Boyle Dam to Copco No. 1 Reservoir. Minimum flows in the J.C. Boyle Bypass Reach in Oregon would increase to meet the requirement that at least 40 percent of the J.C. Boyle Reservoir inflow be released through the J.C. Boyle Bypass Reach, so flow from the cold groundwater springs (a relatively constant approximately 11 to 12ºC [51.8 to 53.6ºF]) entering the Klamath River in this reach would comprise relatively less of the total flow. The range of daily water temperatures and the maximum daily water temperature in the J.C. Boyle Bypass Reach in Oregon would increase compared to existing conditions under the Continued Operations with Fish Passage Alternative due to more warmer reservoir water being released through the J.C. Boyle Bypass Reach and reducing the relative influence of the groundwater springs on water temperatures in this reach. Warmer water temperatures would occur during summer and early fall, while cooler water temperatures would occur in late fall and winter (i.e., November to April) in the J.C. Boyle Bypass Reach under this alternative compared to existing conditions. Areas adjacent to the cold groundwater springs in the J.C. Boyle Bypass Reach would continue to potentially provide thermal refugia for aquatic species because the flow from the springs themselves would not be affected by the Continued Operations with Fish Passage Alternative, but the total thermal refugia area for aquatic species in the J.C. Boyle Bypass Reach would likely decrease as the percentage of flow in the river from the cold groundwater springs decreases and the percentage of flow from the warmer reservoir increases. Data and/or models results are not currently available to quantify the potential changes in the thermal refugia area under the Continued Operations with Fish Passage Alternative compared to existing conditions. See Section 4.4.3.3 *[Aquatic Resources] Water Quality* for more details about changes in thermal refugia for aquatic resources.

Under the Continued Operations with Fish Passage Alternative, downstream of the J.C. Boyle Bypass Reach, the temperature effects in the J.C. Boyle Peaking Reach are generally similar to those described by removal of the facility, as described in Proposed Project (Potential Impact 3.2-1 *Hydroelectric Reach*). There would be a decrease in the range of daily water temperatures and the maximum daily water temperature compared to existing conditions under the Continued Operations with Fish Passage Alternative primarily due to reductions in hydropower peaking flows that discharge warmer reservoir water diverted around the J.C. Boyle Bypass Reach and into the J.C. Boyle Peaking Reach (see Section 3.2.2.2 *Water Temperature*). Decreases in peaking flow fluctuations relative to existing conditions would primarily occur in the upper portion of the J.C. Boyle Peaking Reach in Oregon and diminish in the downstream direction since peaking flow fluctuations attenuate with distance downstream due to tributary inputs and accretion flows.

In the lower portion of the J.C. Boyle Peaking Reach (i.e., near Shovel Creek upstream of Copco No. 1 Reservoir) from the Oregon-California state line to Copco No. 1 Reservoir, decreases in the peaking flow fluctuations under the Continued Operations with Fish Passage Alternative and associated water temperature changes from this decrease would be relatively less than would occur at the beginning of the J.C. Boyle Peaking Reach immediately downstream of the J.C. Boyle Powerhouse. Maximum water temperatures at the Oregon-California state line during summer and early fall would be slightly lower and temperatures would be less artificially variable relative to existing conditions due to higher overall flows and lower frequency of peaking operations at the J.C. Boyle Powerhouse (i.e., one day per week peaking under this alternative as compared to daily peaking under existing conditions). According to the KRWQM (PacifiCorp 2004a), annual and summer peak maximum water temperatures in the lower portion of the J.C. Boyle Peaking Reach would be reduced under this alterative compared to existing conditions, but daily Klamath River water temperatures in this reach would potentially increase or decrease by approximately 2ºC or less due to the influence of local meteorological conditions in the absence of peaking flows.

Overall, the decrease in maximum daily water temperatures and temperature variability in the J.C. Boyle Peaking Reach would be less than described under the Proposed Project, because there would still be peaking operations occurring one day per week in conjunction with recreational flows (see Section 4.4.1 *[Continued Operations with Fish Passage Alternative] Introduction*). Relative to existing conditions, the slight decreases in long-term maximum summer/fall water temperatures and less artificial diel temperature variation in the J.C. Boyle Peaking Reach would return the river to a more natural thermal regime, although the degree of benefit would be slightly lower than under the Proposed Project (Potential Impact 3.2-1). Reductions in the artificial temperature signal caused by peaking operations under existing conditions would better conform with the California Thermal Plan's prohibition on elevated temperature discharges (Table 3.2-4) and would be beneficial.

In the remainder of the Hydroelectric Reach (i.e., Copco No. 1 and Iron Gate reservoirs) water temperatures would be ~~the same as~~ similar to those described under the existing condition (see Section 3.2.2.2 *Water Temperature*), where spring, summer, and fall water temperatures would continue to be influenced by the thermal mass of Copco No. 1 and Iron Gate reservoirs, and the seasonal stratification patterns of the two reservoirs. While the specific flow conditions of the Continued Operations With Fish Passage Alterative were not modeled, a comparison between Steady Flow conditions (i.e., no peaking flows and no additional flow through the J.C. Boyle Bypass Reach) and existing conditions results from the 2004 version of the KRWQM would characterize the general variations and trends in water temperature under this alternative by highlighting how the elimination of peaking operations would alter water temperature in the Hydroelectric Reach. During the periods when flow is not steady under the Continued Operations With Fish Passage Alternative (e.g., peaking operations one day per week, as water supplies allow), water temperature conditions would be more similar to existing conditions than those modeled under Steady Flow conditions. Overall, the water temperature upstream, within, and downstream of Copco No. 1 Reservoir would be generally similar or the same under both modeled Steady Flow conditions and existing conditions, but there potentially would be approximately 2ºC or less differences in the water temperature during some periods (PacifiCorp 2004a). Increased flow in the J.C. Boyle Bypass

Reach under the Continued Operations With Fish Passage Alternative compared to modeled Steady Flow conditions would likely result in water temperature differences between this alternative and existing conditions more frequently approaching 2°C, but periods of water temperature cooler than existing conditions still would frequently occur during summer. In general, water temperature trends under the Continued Operations With Fish Passage Alternative would be similar to those calculated between Steady Flow and existing conditions. The thermal structure of Copco No. 1 and Iron Gate reservoirs (i.e., onset of stratification date, fall turnover date, duration of stratification, maximum stratification date, maximum water temperature difference, and minimum reservoir bottom water temperature) were similar for modeled Steady Flow and existing conditions using the 2004 version of the KRWQM, with only small (10 days or less) changes in the fall turnover date, duration of stratification, or maximum stratification date in one of the two years modeled.

It is unclear what, if any, steps could reduce the impact of the reservoirs on the thermal regime within the Hydroelectric Reach between Copco No. 1 Reservoir and Iron Gate Dam and comply with the Thermal Plan's ban on elevated temperature discharges into COLD interstate waters (Table 3.2-4). Of the seven water quality improvement actions described in the Reservoir Management Plan[192], selective withdrawal and intake control is most focused on water temperature improvements. ~~With respect to this approach,~~ PacifiCorp has estimated that the maximum useable cool water volume in Copco No. 1 Reservoir in summer under existing conditions (approximately 3,100 acre-feet at less than 14°C and 4,800 acre-feet at less than 16°C) (PacifiCorp 2014b), which if selectively withdrawn from the reservoirs, would decrease water temperatures immediately downstream of Copco No. 1 Reservoir. However, the limited cool water volume in Copco No. 1 Reservoir under existing conditions would result in selective withdrawal exhausting the cool water volume in less than 2 days at 1,000 cfs (or slightly longer at a lower flow) and producing only a relatively brief decrease in water temperature downstream of Copco No. 1 Dam (PacifiCorp 2005; FERC 2007; PacifiCorp 2014b). Water temperature differences upstream of Copco No. 1 or Iron Gate reservoirs between modeled Steady Flow and existing conditions were analyzed for the potential to alter the usable cool water volume in the reservoirs. A comparison of Steady Flow and existing conditions results from the 2004 version of the KRWQM shows either minimum water temperatures ranging from approximately 1°C colder to approximately 1°C warmer or consistently cooler minimum water temperatures under Steady Flow conditions depending on the time period being considered (PacifiCorp 2004a) and this suggests the total usable cool water volume would likely remain similar or slightly increase compared to existing conditions if peaking flows are eliminated and Steady Flow conditions occur. However, the increased flow in the J.C. Boyle Bypass Reach under the Continued Operations With Fish Passage Alternative compared to modeled Steady Flow conditions would increase the water temperature in the J.C. Boyle Bypass Reach during the portion of the year when the J.C. Boyle Reservoir water temperature is greater than the groundwater spring temperatures (i.e., approximately mid-spring through mid-fall) due to the relative proportion of flow from J.C. Boyle Reservoir releases increasing relative to the cooler groundwater spring flows. As a result of this, the cooling effect of flows from the J.C. Boyle Bypass Reach on the flows in the J.C. Boyle Peaking Reach would be diminished under Continued Operations With Fish Passage Alternative compared to modeled Steady Flow conditions. Additionally, the increased surface area of the river compared to the bypass canal would allow more solar radiation to be absorbed by flow through the river than the bypass canal, so the overall water temperature in the J.C. Boyle Peaking Reach would potentially be greater under the Continued Operations With Fish Passage Alternative with J.C. Boyle Reservoir releases of at least 40 percent of inflow to the reservoir through the J.C. Boyle Bypass Reach, groundwater springs flows into the J.C. Boyle Bypass Reach, and flow through the J.C. Boyle Powerhouse than under modeled Steady Flow conditions with minimum J.C. Boyle Reservoir releases to J.C. Boyle Bypass Reach (i.e., 100 cfs; consistently less than 40 percent of inflow to J.C. Boyle Reservoir), groundwater springs flows into the J.C. Boyle Bypass Reach, and steady flow through the J.C. Boyle Powerhouse. Due to the reduced cooling from J.C. Boyle Bypass Reach flows on water temperature in the J.C. Boyle Peaking Reach, the water temperature entering the Copco No. 1 Reservoir would potentially be slightly higher during mid-spring to mid-fall under this alternative compared to the modeled Steady Flow conditions, resulting in the total usable cool water volume being similar or potentially slightly less than existing conditions. Overall, modeling of the water temperature changes in the J.C. Boyle Bypass and Peaking reaches when hydropower peaking flows are eliminated (i.e., Steady Flow conditions) indicates there is potential for the useable cool water volume in Copco No. 1 Reservoir to slightly increase or remain the same, but the useable cool water volume in Copco No. 1 may be similar or slightly decrease under the flow conditions in the Continued Operations With Fish Passage Alternative. The magnitude of potential increases or decreases in useable cool water volume in Copco No. 1 was not quantified by previous modeling (PacifiCorp 2004a), so potential changes in useable cool water volume and the duration cool water would be available for selective withdrawal from Copco No. 1 Reservoir are unknown under the Continued Operations With Fish Passage Alternative. Thus, ~~It~~ it is currently unclear whether selective withdrawal from Copco No. 1 Reservoir alone would be sufficient to allow compliance with the Thermal Plan or to meet the Klamath TMDLs temperature requirement in the Hydroelectric Reach (see also below discussion in Middle and Lower Klamath River and Klamath River Estuary).

Volume I Section 4.4.2.1 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Water Temperature – Potential Impact 4.2.2-1 Seasonal alterations in water temperature due to continued impoundment of water in the reservoirs – Hydroelectric Reach, paragraph 2 on page 4-105:

The anticipated increases in water temperatures due to climate change would occur over a timescale of decades and would act in opposition to improvements in water temperature in the Hydroelectric Reach at the Oregon-California state line expected from actions taken in furtherance of TMDL implementation throughout the Upper Klamath Basin, such as flow augmentation or storage, increased riparian shading, erosion control, and restoration of natural channel morphology ~~and decreased diversion from cold springs~~ (~~ODEQ 2010~~ ODEQ 2019). While full implementation of the Klamath TMDLs would alleviate the reservoir-induced thermal lag modeled by PacifiCorp (2004a, 2005, 2008, 2014), Dunsmoor and Huntington (2006), and North Coast Regional Board (2010), ~~is anticipated to~~ resulting in late summer/fall reductions in water temperature in the range of 2~~–~~ to 10ºC immediately downstream from Iron Gate Dam ~~(North Coast Regional Board 2010)~~, there is currently no reasonable proposal to achieve the temperature allocations in the Klamath TMDLs with the Lower Klamath Project dams remaining in place ~~despite~~ since the modest improvements exhibited through implementation of the KHSA IMs ~~Reservoir Management Plan~~ during the past several years were not able to achieve Klamath River TMDL temperature allocations (PacifiCorp 2017, 2018), it has not been demonstrated that the current Reservoir Management Plan measures could achieve Klamath River TMDL temperature allocations, and there are no additional proposed operations and/or technologies to incorporate into a final Reservoir Management Plan that have been shown could achieve the Klamath River TMDL temperature allocations.

In summary, continued impoundment of water in Copco No. 1 and Iron Gate reservoirs under the Continued Operations with Fish Passage Alternative would maintain existing adverse late summer/fall water temperatures in the Hydroelectric Reach downstream of Copco No. 1 Reservoir (Section 3.2.2.2 *Water Temperature*). There is currently no reasonable proposal to achieve the temperature allocations in the Klamath TMDLs with the Lower Klamath Project dams remaining in place, despite the modest improvements achieved to date through implementation of ~~the~~ KHSA IMs that could be incorporated into a final Reservoir Management Plan.

Volume I Section 4.4.2.1 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Water Temperature – Potential Impact 4.2.2-1 Seasonal alterations in water temperature due to continued impoundment of water in the reservoirs – Middle and Lower Klamath River and Klamath River Estuary, paragraph 1 on page 4-106:

As discussed above, short-term and long-term potential impacts on water temperature due to implementation of the 2017 court-ordered flushing and emergency dilution flows or the 2019 BiOp surface flushing flows under this alternative would be similar to the potential short-term impacts on water temperature under the No Project Alternative (Section 4.2.2, Potential Impact 4.2.2-1).

Volume I Section 4.4.2.1 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Water Temperature – Potential Impact 4.2.2-1 Seasonal alterations in water temperature due to continued impoundment of water in the reservoirs – Middle and Lower Klamath River and Klamath River Estuary, paragraph 2 on page 4-106:

~~One of the purposes of the curtain is to isolate warmer, less dense near-surface waters while withdrawing cooler, denser, and deeper waters from the reservoir for release to the Klamath River downstream (PacifiCorp 2018). The other~~ While the primary purpose of the curtain is to isolate surface waters that have high concentrations of blue-green algae (cyanobacteria) such that extensive summer and fall blooms are not readily released downstream to the Middle and Lower Klamath River (see further discussion in Potential Impact 4.2.2-4), PacifiCorp reports that the curtain also provides a secondary benefit of isolating warmer, less dense near-surface waters while withdrawing cooler, denser, and deeper waters from the reservoir for release to the Klamath River downstream of the Iron Gate Dam (PacifiCorp 2018). Results from the intake barrier/thermal curtain indicate that a modest 1~~–~~ to 2°C (1.8~~–~~ to 3.6°F) water temperature improvement is possible (PacifiCorp 2017), although data do not indicate that this measure could achieve compliance with the Thermal Plan or to meet the Klamath River TMDLs temperature requirement in the Middle Klamath River (North Coast Regional Board 2010). Additionally, water temperature improvements from operation of the intake barrier/thermal curtain would be potentially limited by the need to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards, with the curtain completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018).

Volume I Section 4.4.2.1 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Water Temperature – Potential Impact 4.2.2-1 Seasonal alterations in water temperature due to continued impoundment of water in the reservoirs – Middle and Lower Klamath River and Klamath River Estuary, paragraph 2 on page 4-108:

There is currently no reasonable proposal to achieve the temperature allocations in the Klamath TMDLs with the Lower Klamath Project dams remaining in place, despite the modest improvements achieved to date through implementation of ~~the~~ KHSA IMs that could be incorporated into a final Reservoir Management Plan (see discussion in Section 4.4.2 *Water Quality*, Potential Impact 4.2.2-1 *Hydroelectric Reach*).

Volume I Section 4.4.2.2 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Suspended Sediments, paragraph 4 on page 4-109:

The Continued Operations with Fish Passage Alternative also includes 2017 court-ordered flushing and emergency dilution flows or the 2019 BiOp surface flushing flows downstream of Iron Gate Dam that would increase SSCs compared to existing conditions during these releases.

Volume I Section 4.4.2.2 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Suspended Sediments – Potential Impact 4.2.2-2 Seasonal increases in algal-derived (organic) suspended material due to continued impoundment of water in the reservoirs, paragraph 2 on page 4-110:

In 2015, PacifiCorp installed a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11. ~~One of the purposes~~ The primary purpose of the curtain is to isolate ~~warmer, less dense near-surface waters while withdrawing cooler, denser, and deeper waters from the reservoir for release to the Klamath River downstream (PacifiCorp 2018). The other purpose is to isolate~~ surface waters that have high concentrations of blue-green algae (cyanobacteria) such that extensive summer and fall blooms are not readily released downstream to the Middle and Lower Klamath River (see further discussion in Section 4.4.2 *Water Quality*, Potential Impact 4.2.2-1 and Potential Impact 4.2.2-7), but PacifiCorp reports that the curtain also provides a secondary benefit of isolating warmer, less dense near-surface waters and drawing deeper cooler, denser water for release to the Klamath River downstream of Iron Gate Dam (PacifiCorp 2018). ~~Results from the intake barrier/thermal curtain~~ Water quality measurements during 2015 and 2016 when the intake barrier/thermal curtain was in use indicate that the curtain reduces entrainment of blue-green algae into the Iron Gate Powerhouse intake and subsequent release downstream into the Klamath River (PacifiCorp 2016, 2017), but water quality monitoring data from 2017 and 2018 downstream of Iron Gate Dam show multiple exceedances of the Klamath TMDLs phytoplankton chlorophyll-a target (i.e., 10 ug/L) and multiple microcystin posting limits (e.g., 6 ug/L for CCHAB Warning TEIR I; Table 3.2-10) (Watercourse Engineering, Inc. 2018, 2019). An analysis of the intake barrier/thermal curtain performance during 2017 or 2018 has not been published and PacifiCorp continues to test and refine the intake barrier/thermal curtain design and operations, but the available data do not indicate that this measure could improve algal-derived (organic) suspended material in the reservoirs such that they would no longer cause an exceedance of water quality standards (Table 3.2-4) or achieve the Klamath TMDLs phytoplankton chlorophyll-a target of 10 ug/L for Copco No.1 and Iron Gate reservoirs during the May to October growth season (North Coast Regional Board 2010). Additionally, potential reductions in the entrainment of blue-green algae downstream of Iron Gate Dam from operation of the intake barrier/thermal curtain would be potentially limited by the need to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards, with the curtain completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018).

Volume I Section 4.4.2.2 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Suspended Sediments – Potential Impact 4.2.2-2 Seasonal increases in algal-derived (organic) suspended material due to continued impoundment of water in the reservoirs, paragraph 1 on page 4-111:

While episodic large fluxes of algal-derived (organic) suspended material from phytoplankton growth in the Upper Klamath Lake would still likely enter the Hydroelectric Reach from upstream during some years even with nutrient measures in Oregon's Upper Klamath River and Lost River TMDLs (ODEQ 2019), these ~~Nutrient~~ nutrient reduction measures ~~in Oregon's Upper Klamath River and Lost River TMDLs~~ could, over time, decrease algal-derived (organic) suspended material in Copco No.1 and Iron Gate reservoirs ~~and could, in the long term, be beneficial to water quality~~ due to decreased nutrient availability reducing phytoplankton growth in the reservoirs.

Volume I Section 4.4.2.2 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Nutrients, Potential Impact 4.2.2-4 Annual interception and retention of nutrients and seasonal release of nutrients due to continued impoundment of waters in the reservoirs. paragraph 2 on page 4-114:

With respect to the potential impact of 2017 court-ordered flushing and emergency dilution flows or the 2019 BiOp surface flushing flows on nutrients downstream of Iron Gate Dam under the Continued Operations with Fish Passage Alternative, since suspended sediments transported by these releases would be primarily mineral (inorganic) sediments there would be no change from existing conditions for nutrients due to implementation of these flows.

Volume I Section 4.4.2.4 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Dissolved Oxygen – Potential Impact 4.2.2-5 Seasonal low dissolved oxygen concentrations due to continued impoundment of water in the reservoirs – Hydroelectric Reach, paragraph 5 on page 4-115:

Since 2007, PacifiCorp has developed several iterations of a proposed Reservoir Management Plan that put forward solutions to addressing water quality impairments associated with J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams, including dissolved oxygen. Study results, including those under IM 11 (see Table 4.2-1), have indicated that ~~while~~ proposed reservoir management techniques can improve some of the project impacts to water quality (e.g., transport of nuisance and/or noxious blue-green algae downstream of Iron Gate Dam [Austin et al. 2016, PacifiCorp 2018]), but the various techniques have not resulted in water quality improvements at Copco No. 1 or Iron Gate reservoirs that create the TMDL compliance lens nor have they otherwise sufficiently improved Lower Klamath Project impacts to dissolved oxygen (see Section 3.2.2.5 *Dissolved Oxygen*). Results from operation of a turbine venting system at Iron Gate Dam indicate that dissolved oxygen improvement is possible using this technique, however, turbine venting alone is insufficient to prevent dissolved oxygen percent saturation values below the Basin Plan minimum dissolved oxygen criteria. The current Reservoir Management Plan (PacifiCorp 2014) lists operations and technologies that feasibility studies have indicated would improve dissolved oxygen concentrations to meet Basin Plan minimum dissolved oxygen criteria, but PacifiCorp has stated that it is not prepared to proceed with oxygen diffuser systems in the reservoirs and that further studies are necessary to determine whether other cost-effective technologies would sufficiently improve dissolved oxygen conditions (PacifiCorp 2014). Similarly, it is possible that further iterations of a Reservoir Management Plan would potentially include a combination of operations and technologies that would meet Basin Plan minimum dissolved oxygen criteria in the reservoirs and in the Klamath River downstream of the reservoirs. However, neither multiple iterations of the Reservoir Management Plans, nor additional testing under KHSA IM11, have indicated that this is feasible, and there currently is no proposed, feasible set of operations and technologies to sufficiently improve dissolved oxygen concentrations to meet Basin Plan minimum dissolved oxygen criteria. Therefore, an assumption that a future iteration of the current Reservoir Management Plan would adequately address the issue would be speculative at this point. Potential Impact 4.2.2-5 below discusses the potential for operations and technologies to improve dissolved oxygen conditions in the Hydroelectric Reach and the Middle and Lower Klamath River ~~these results~~, along with consideration of flow changes under this alternative.

Volume I Section 4.4.2.4 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Dissolved Oxygen – Potential Impact 4.2.2-5 Seasonal low dissolved oxygen concentrations due to continued impoundment of water in the reservoirs – Hydroelectric Reach, paragraph 2 on page 4-116:

In 2015, PacifiCorp installed a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11 with the primary purpose of isolating~~. One of the purposes of the curtain is to isolate warmer, less dense near-surface waters while withdrawing cooler, denser, and deeper waters from the reservoir for release to the Klamath River downstream (PacifiCorp 2018). The other purpose is to isolate~~ surface waters that have high concentrations of blue-green algae (cyanobacteria) such that extensive summer and fall blooms are not readily released downstream from upstream or within Iron Gate Reservoir to the Middle and Lower Klamath River (see further discussion in Section 4.4.2.2 *[Continued Operations with Fish Passage]* *Water Quality – Suspended Sediments*, Potential Impact 4.2.2-2). The curtain also provides a potential secondary benefit of isolating warmer, less dense near-surface waters while withdrawing cooler, denser, and deeper waters from the reservoir for release to the Klamath River downstream (see further discussion in Section 4.4.2.1 *[Continued Operations with Fish Passage] Water Quality – Water Temperature*, Potential Impact 4.2.2-1) (PacifiCorp 2018). Results from deployment of the intake barrier/thermal curtain in 2016 indicate that the presence of the curtain can reduce mixing of reservoir surface waters near the curtain such that moderate (5 to 6 mg/L) to low (approximately 2 to 5 mg/L) dissolved oxygen concentrations occur at depths from 2 to 12 meters due to respiration of dense phytoplankton blooms (PacifiCorp 2017). The curtain was completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018), so operation of the intake barrier/thermal curtain under this alternative would be limited when it is necessary to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards in the Klamath River. Overall, while results from the Reservoir Management Plan feasibility investigations of in-reservoir oxygenation and deployment of an intake barrier/thermal curtain suggest that improvement in dissolved oxygen is possible in the reservoirs (PacifiCorp 2017, 2018), these studies have not resulted in water quality improvements at Copco No. 1 or Iron Gate reservoirs that meet TMDL requirements for dissolved oxygen in the reservoirs, nor have they otherwise sufficiently improved Lower Klamath Project impacts to dissolved oxygen in the Middle Klamath River immediately downstream of Iron Gate Dam (see below discussion under Middle and Lower Klamath River and Klamath River Estuary).

Volume I Section 4.4.2.4 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Dissolved Oxygen – Potential Impact 4.2.2-5 Seasonal low dissolved oxygen concentrations due to continued impoundment of water in the reservoirs – Middle and Lower Klamath River and Klamath River Estuary, paragraph 1 on page 4-118:

There is currently no reasonable proposal to achieve the Klamath TMDLs compliance lens for dissolved oxygen in Copco No. 1 and Iron Gate reservoirs or Basin Plan minimum dissolved oxygen criteria (minimum dissolved oxygen criteria of 85 percent saturation for the period April 1 through September 30, and below the minimum criterion of 90 percent saturation for the period October 1 to March 31, for the Klamath River from Oregon-California state line [RM 214.1] to the Scott River [RM 145.1]; Table 3.2-4) with the dams remaining in place, despite the modest improvements achieved to date through implementation of ~~the~~ KHSA IMs that could be incorporated into a final Reservoir Management Plan.

Volume I Section 4.4.2.4 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Dissolved Oxygen – Potential Impact 4.2.2-5 Seasonal low dissolved oxygen concentrations due to continued impoundment of water in the reservoirs – Middle and Lower Klamath River and Klamath River Estuary, paragraph 2 on page 4-118:

Alterations in dissolved oxygen concentrations due to implementation of the 2017 court-ordered flushing and emergency dilution flows or the 2019 BiOp surface flushing flows downstream of Iron Gate Dam would result in no significant impacts for the reasons described under the No Project Alternative (Section 4.2.2, Potential Impact 4.2.2-5).

Volume I Section 4.4.2.4 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Dissolved Oxygen – Potential Impact 4.2.2-5 Seasonal low dissolved oxygen concentrations due to continued impoundment of water in the reservoirs – Middle and Lower Klamath River and Klamath River Estuary, paragraph 1 on page 4-119:

In 2015, PacifiCorp installed a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11with the primary purpose of isolating~~. One of the purposes of the curtain is to isolate warmer, less dense near-surface waters while withdrawing cooler, denser, and deeper waters from the reservoir for release to the Klamath River downstream (PacifiCorp 2018). The other purpose is to isolate~~ surface waters that have high concentrations of blue-green algae (cyanobacteria) such that extensive summer and fall blooms are not readily released from upstream or within Iron Gate Reservoir downstream to the Middle and Lower Klamath River (see further discussion in Section 4.4.2.2 *[Continued Operations with Fish Passage] Water Quality – Suspended Sediments*, Potential Impact 4.2.2-2). The curtain also provides a potential secondary benefit of isolating warmer, less dense near-surface waters while withdrawing cooler, denser, and deeper waters from the reservoir for release to the Klamath River downstream (see further discussion in Section 4.4.2.1 *[Continued Operations with Fish Passage] Water Quality – Water Temperature*, Potential Impact 4.2.2-1) (PacifiCorp 2018). Results from deployment of the intake barrier/thermal curtain in 2016 indicate that the presence of the curtain can reduce mixing of reservoir surface waters near the curtain such that low dissolved oxygen concentrations are entrained in the powerhouse intake, and to date turbine venting does not sufficiently improve dissolved oxygen concentrations in the Middle Klamath River immediately downstream of Iron Gate Dam (PacifiCorp 2018). The curtain was completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018), so operation of the intake barrier/thermal curtain under this alternative would be limited when it is necessary to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards in the Klamath River.

Volume I Section 4.4.2.4 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Dissolved Oxygen – Potential Impact 4.2.2-5 Seasonal low dissolved oxygen concentrations due to continued impoundment of water in the reservoirs – Middle and Lower Klamath River and Klamath River Estuary, paragraph 1 on page 4-120:

There is currently no reasonable proposal to achieve the Klamath TMDLs compliance lens for dissolved oxygen in Copco No. 1 and Iron Gate reservoirs or Basin Plan minimum dissolved oxygen criteria (minimum dissolved oxygen criteria of 85 percent saturation for the period April 1 through September 30, and below the minimum criterion of 90 percent saturation for the period October 1 to March 31, for the Klamath River from Oregon-California state line [RM 214.1] to the Scott River [RM 145.1]; Table 3.2-4) with the dams remaining in place, despite the modest improvements achieved to date through implementation of ~~the~~ KHSA IMs that could be incorporated into a final Reservoir Management Plan.

Volume I Section 4.4.2.5 [Continued Operations with Fish Passage] Water Quality – pH, paragraph 3 on page 4-120:

The Klamath River is a naturally weakly buffered system with alkalinity typically less than 100 mg/L as calcium carbonate [CaCO3] (PacifiCorp 2004a; Karuk Tribe of California 2010), so it is susceptible to daily and seasonal swings in pH due photosynthesis by phytoplankton, periphyton, and macrophytes. The Continued Operations with Fish Passage Alternative would result in no change from the existing adverse condition with respect to pH values that exceed the Basin Plan instantaneous maximum pH objective of 8.5 s.u and large daily fluctuations in the Hydroelectric Reach in Copco No. 1 and Iron Gate reservoirs during summertime periods of intense algal blooms (see Section 3.2.2.6 *pH*).

Volume I Section 4.4.2.5 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – pH – Potential Impact 4.22-6 Seasonal high pH and daily pH fluctuations due to continued impoundment of water in the reservoirs – Hydroelectric Reach, paragraph 2 on page 4-121:

Also as described in Section 4.4.2 *[Continued Operations with Fish Passage] Water Quality* Potential Impacts 4.2.2-2, 4.2.2-4, and 4.2.2-5, nutrient reduction measures in Oregon and California's TMDLs would, over time, be beneficial to pH. However, the measures necessary to achieve significant reductions are, at this point, unknown and reductions are likely to require decades to achieve. As there is currently no reasonable proposal to achieve TMDL targets and meet applicable water quality standards for water temperature, nutrients, and dissolved oxygen, elevated pH in the surface waters of Copco No. 1 and Iron Gate reservoirs during summer and fall months would continue to occur. Warmer water temperatures under climate change also would further exacerbate seasonal phytoplankton blooms in the Hydroelectric Reach, increasing pH variations and potentially resulting in more frequent exceedances of pH water quality standards in the Hydroelectric Reach in the long term compared to existing conditions. ~~and overall there is currently no reasonable proposal to achieve TMDL targets and meet applicable water quality standards for water temperature, nutrients and dissolved oxygen, which would also continue to result in elevated pH in the surface waters of Copco No. 1 and Iron Gate reservoirs during summer and fall months.~~ Overall, the Continued Operations with Fish Passage Alternative would result in no change from existing adverse conditions and would continue to cause an exceedance of pH water quality standards in the Hydroelectric Reach.

Volume I Section 4.4.2.5 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – pH – Potential Impact 4.22-6 Seasonal high pH and daily pH fluctuations due to continued impoundment of water in the reservoirs – Middle and Lower Klamath River and Klamath River Estuary, paragraph 3 on page 4-121:

Alterations in pH due to implementation of the 2017 court-ordered flushing and emergency dilution flows or the 2019 BiOp flushing flows downstream of Iron Gate Dam would result in no significant impacts for the reasons described under the No Project Alternative (Section 4.2.2, Potential Impact 4.2.2-6).

Volume I Section 4.4.2.6 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Chlorophyll-a and Algal Toxins – Potential Impact 4.2.2-7 Seasonal increases in chlorophyll-a and algal toxins due to continued impoundment of water in the reservoirs – Hydroelectric Reach, paragraph 1 on page 4-123:

While seasonal phytoplankton (including blue-green algae) blooms originating from Upper Klamath Lake (in Oregon) can enter J.C. Boyle Reservoir, the short residence time of this reservoir generally does not support substantial additional growth of algae (Section 3.2.2.3 Suspended Sediments and Appendix C.2.1.1). Microcystin concentrations greater than California water quality objectives have been infrequently measured to increase in J.C. Boyle Reservoir adjacent to the shore (e.g., Topsy Campground) compared to microcystin concentrations in the Klamath River upstream of the reservoir (Watercourse Engineering, Inc, 2016, 2017, E&S Environmental Chemistry 2018a), so there is potentially some localized *Microcystis aeruginosa* growth and microcystin production within J.C. Boyle Reservoir. However, measurements of *Microcystis aeruginosa* cell density and microcystin concentrations in the downstream J.C. Boyle Bypass and Peaking reaches suggest there is limited downstream transport of *Microcystis aeruginosa* microcystin from J.C. Boyle Reservoir (see Section 3.2.2.7 *[Water Quality] Chlorophyll-a and Algal Toxins*, Section 3.4.2.3 *[Phytoplankton and Periphyton] Hydroelectric Reach*, and Appendix C, Section 3.2.2.6 *Algal toxins and Chlorophyll-a* for further discussion). Increased minimum flows in the J.C. Boyle Bypass Reach and limitations on ~~of~~ peaking operations at J.C. Boyle Powerhouse under this alternative would not be expected to significantly affect ~~this~~ conditions in J.C. Boyle Reservoir and there would be no significant impact of the Continued Operations with Fish Passage Alternative on chlorophyll-*a* and algal toxin concentrations in the Hydroelectric Reach from J.C. Boyle Reservoir to the upstream end of Copco No. 1 Reservoir.

Volume I Section 4.4.2.6 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Chlorophyll-a and Algal Toxins – Potential Impact 4.2.2-7 Seasonal increases in chlorophyll-a and algal toxins due to continued impoundment of water in the reservoirs – Hydroelectric Reach, paragraph 2 on page 4-123:

Warmer water temperatures under climate change would further exacerbate seasonal phytoplankton blooms in the Hydroelectric Reach, which would then be transported downstream. Further, ~~, and overall~~ there is currently no reasonable proposal to achieve TMDL targets and meet applicable water quality standards for water temperature, nutrients and dissolved oxygen, which would also continue to result in elevated chlorophyll-*a* concentrations and periodically high algal toxin concentrations in the surface waters of Copco No. 1 and Iron Gate reservoirs during summer and fall months.

Volume I Section 4.4.2.6 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Chlorophyll-a and Algal Toxins – Potential Impact 4.2.2-7 Seasonal increases in chlorophyll-a – Middle and Lower Klamath River and Klamath River Estuary, paragraph 1 on page 4-124:

Downstream of Iron Gate Dam, this alternative would continue to result in similar chlorophyll-a and algal toxin trends when large phytoplankton blooms are transported from Iron Gate Reservoir into the Middle and Lower Klamath River and Klamath River Estuary. In 2015, PacifiCorp installed a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11 with the primary purpose of isolating surface waters that have high concentrations of blue-green algae (cyanobacteria) and potentially limiting the release of Iron Gate Reservoir water containing extensive summer and fall blue-green algae blooms downstream to the Middle and Lower Klamath River. The curtain also provides a potential secondary benefit of isolating warmer, less dense near-surface waters while withdrawing cooler, denser, and deeper waters from the reservoir for release to the Klamath River downstream (see further discussion in Section 4.4.2.1 *[Continued Operations with Fish Passage] Water Quality – Water Temperature*, Potential Impact 4.2.2-1) (PacifiCorp 2018). Water quality measurements during 2015 and 2016 when the intake barrier/thermal curtain was in use indicate that the curtain reduces entrainment of blue-green algae into the Iron Gate Powerhouse intake and subsequent release downstream into the Klamath River (PacifiCorp 2016, 2017). However, water quality monitoring data from 2017 and 2018 downstream of Iron Gate Dam show multiple exceedances of the Klamath TMDLs phytoplankton chlorophyll-a target (i.e., 10 ug/L) and the microcystin thresholds of significance (i.e., 4 ug/L) and multiple microcystin posting limits (e.g., 6 ug/L for CCHAB Warning TEIR I; Table 3.2-10) (Watercourse Engineering, Inc. 2018, 2019). An analysis of the intake barrier/thermal curtain performance during 2017 or 2018 has not been published and PacifiCorp continues to test and refine the intake barrier/thermal curtain design and operations, but available data do not indicate that this measure would prevent releases from Iron Gate Dam that would exceed water quality standards (Table 3.2-4) or consistently achieve the Klamath TMDLs phytoplankton chlorophyll-*a* target of 10 ug/L for Copco No. 1 and Iron Gate reservoirs during the May to October growth season (North Coast Regional Board 2010). Additionally, potential reductions in the entrainment of blue-green algae, chlorophyll-a concentrations, and microcystin concentrations downstream of Iron Gate Dam from operation of the intake barrier/thermal curtain would be potentially limited by the need to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards, with the curtain completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018).

Volume I Section 4.4.2.6 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Chlorophyll-a and Algal Toxins – Potential Impact 4.2.2-7 Seasonal increases in chlorophyll-a and algal toxins due to continued impoundment of water in the reservoirs – Middle and Lower Klamath River and Klamath River Estuary, paragraph 2 on page 4-124:

The improvement actions described in Section 4.4.2 *[Continued Operations with Fish Passage] Water Quality* Potential Impacts 4.2.2-2, 4.2.2-4, 4.2.2-5, and 4.2.2-6 do not indicate that this measure could reduce the extent of phytoplankton blooms in the upstream Lower Klamath Project reservoirs such that they would no longer cause exceedances of chlorophyll-*a* or algal toxin standards in the Middle and Lower Klamath River. A powerhouse intake barrier/thermal curtain was installed in Iron Gate Reservoir during 2015 under IM 11 to isolate surface waters that have high concentrations of blue-green algae (cyanobacteria) such that extensive summer and fall blooms are not readily released downstream to the Middle and Lower Klamath River (see further discussion in Section 4.4.2 *Water Quality* Potential Impact 4.2.2-1 and Potential Impact 4.2.2-2), with PacifiCorp reporting that the curtain also provides a secondary benefit of isolating warmer, less dense near-surface waters and drawing deeper cooler, denser water for release to the Klamath River downstream of Iron Gate Dam (PacifiCorp 2018). Water quality measurements during 2015 and 2016 when the intake barrier/thermal curtain was in use indicate that the curtain reduces entrainment of blue-green algae into the Iron Gate Powerhouse intake and subsequent release downstream into the Klamath River (PacifiCorp 2016, 2017), but water quality monitoring data from 2017 and 2018 downstream of Iron Gate Dam show multiple exceedances of the Klamath TMDLs phytoplankton chlorophyll-a target (i.e., 10 ug/L) and multiple microcystin posting limits (e.g., 6 ug/L for CCHAB Warning TEIR I; Table 3.2-10) (Watercourse Engineering, Inc. 2018, 2019). An analysis of the intake barrier/thermal curtain performance during 2017 or 2018 has not been published and PacifiCorp continues to test and refine the intake barrier/thermal curtain design and operations, but the available data do not indicate that this measure could reduce transport of chlorophyll-a or algal toxins (e.g., microcystin) from the reservoirs into the Klamath River downstream of Iron Gate Dam such that releases from Iron Gate Dam would not cause exceedances of water quality standards (Table 3.2-4) or achieve the Klamath TMDLs phytoplankton chlorophyll-a target of 10 ug/L for Copco No.1 and Iron Gate reservoirs during the May to October growth season (North Coast Regional Board 2010). Furthermore, potential reductions in the entrainment of blue-green algae, chlorophyll-a, and algal toxins (e.g., microcystin) downstream of Iron Gate Dam from operation of the intake barrier/thermal curtain would be potentially limited by the need to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards, with the curtain completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018). Alterations in chlorophyll-a and algal toxins due to implementation of the 2017 court-ordered flushing and emergency dilution flows or the 2019 BiOp flushing flows downstream of Iron Gate Dam would result in no significant impacts for the reasons described under the No Project Alternative (see Section 4.2.2, Potential Impact 4.2.2-7).

Volume I Section 4.4.2.7 Alternatives – Continued Operations with Fish Passage Alternative – Water Quality – Inorganic and Organic Contaminants, paragraph 34 on page 4-125:

Alterations in human and freshwater aquatic species' exposure to inorganic and organic contaminants due to implementation of the 2017 court-ordered flushing and emergency dilution flows or the 2019 BiOp flushing flows downstream of Iron Gate Dam would result in no significant impacts for the reasons described under the No Project Alternative (Section 4.2.2, Potential Impact 4.2.2-8).

4.4.3 Aquatic Resources

Volume I Section 4.4.3.2 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Bed Elevation and Grain Size Distribution, paragraph 2 on page 4-126:

Additionally, as described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, in 2017, the United States District Court ordered USBR to change operations to meet court-ordered flushing flows below Iron Gate Dam. These flows are not modeled as part of existing conditions hydrology because they went into effect in February 2017 after the December 2016 Notice of Preparation was filed. These flows were intended to increase bedload mobilization during the years in which they occurred (2017, 2018). In March 2019, the court-required re-initiation of USBR consultation with NMFS and USFWS was completed and new biological opinions (BiOps) were issued by NMFS (2019) and USFWS (2019a). The 2019 BiOp flow requirements include annual surface flushing flows and the potential for dilution flows and/or enhanced spring flows should water be available and disease conditions support their use (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project)*. The flushing ~~These~~ flows increase bedload mobilization during the years in which they ~~are ordered by the court~~ occur.

Volume I Section 4.4.3.3 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Water Quality, paragraph 1 on page 4-127:

The combination of warm water temperatures in surface waters and low dissolved oxygen below approximately 10 meters would potentially limit upstream migration of a proportion of fall-run Chinook salmon through the Hydroelectric Reach, unless migrating fish are able to remain within a water depth shallow enough to provide suitable dissolved oxygen and deep enough to avoid unsuitable water temperatures. Migrating at night and use of thermal refugia from Fall Creek and other cool water tributaries, would increase the ability of fall-run Chinook salmon to migrate through reservoirs under this alternative. If the trap and haul fish passage option was implemented consistent with FERC (2007), these water quality migration impediments would be further avoided (as described in Section 4.4.3.7 *Fish Passage*).

Volume I Section 4.4.3.4 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Fish Disease and Parasites, paragraph 1 on page 4-129:

Additionally, as described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*, in 2017, the United States District Court ordered USBR to change operations to meet court-ordered flushing and dilution flows below Iron Gate Dam. These flows are not modeled as part of existing conditions hydrology because they went into effect in February 2017 after the December 2016 Notice of Preparation was filed. These flows ~~are aimed at~~ were intended to reduce~~ing~~ fish disease downstream of Iron Gate Dam in the years in which they occurred (2017, 2018). ~~This alternative assumes that these flows would continue to be required, because the addition of habitat alone is unlikely to eliminatethe current nidus downstream of Iron Gate Dam under the Continued Operations with Fish Passage Alternative.~~ In March 2019, the court-required re-initiation of USBR consultation with NMFS and USFWS was completed and new biological opinions (BiOps) were issued by NMFS (2019) and USFWS (2019a). The 2019 BiOp flow requirements include annual surface flushing flows and the potential for dilution flows and/or enhanced spring flows should water be available and disease conditions support their use (see Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project)*.

Therefore, under this alternative, fish disease would potentially be reduced by the addition of habitat and associated reduction in crowding below Iron Gate Dam, and the ~~continued operation of 2017~~ flushing flow requirements. While there has not been sufficient time to collect data characterizing the efficacy of the flushing flows since they were initiated in 2017, the necessity to use dilution flows in 2018 and 2019 suggests that flushing flows are insufficient on their own to resolve the fish disease nidus downstream of Iron Gate Dam. ~~The flushing flow and dilution requirements alone have not been successful in eliminating the disease nidus to date.~~ Thus, although the conditions leading to nidus downstream of Iron Gate Dam ~~will~~ would be ameliorated by reduced crowding, and by ~~flushing and dilution enhancement~~ flushing flows and the potential for dilution flows~~as required by the~~

~~2017 court order~~, the nidus is anticipated to continue to occur to some degree under the Continued Operations with Fish Passage Alternative.

Volume I Section 4.4.3.6 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Aquatic Habitat and Instream Flows, paragraph 3 on page 4-131:

These actions are also beneficial for coho salmon (particularly from the Upper Klamath River Population Unit). Implementation of the Coho Enhancement Fund under the ~~No Project Alternative~~ Continued Operations with Fish Passage Alternative would have no significant impact (no change from existing conditions) on redband trout, shortnose and Lost River suckers, green sturgeon, eulachon, and Southern Resident Killer Whales, since these species are not found in or near the river reaches associated with IM2 projects or actions.

Volume I Section 4.4.3.7 [Continued Operations with Fish Passage] Aquatic Resources – Fish Passage, paragraph 3 on page 4-131:

Therefore, trap and haul was predicted to have lower cumulative mortality than volitional ladders, since this option would avoid mortality associated with passage through the Lower Klamath Project reservoirs and riverine habitat that would be bypassed. ~~FERC (2007)~~Oosterhout (2005), as subsequently cited by FERC (2007), predicted that average cumulative mortality for adult Chinook salmon migrating upstream from Iron Gate Dam to upstream of J.C. Boyle Dam would be 21 percent for trap and haul (including delayed mortality of adults transported in trucks). The Oosterhout (2005) mortality prediction for juveniles migrating downstream from ~~Upper Klamath Lake~~J.C. Boyle Reservoir to downstream of Iron Gate Dam averaged 19 percent (Option 1C in Oosterhout 2005)~~to downstream of Iron Gate was 46 percent for trap and haul. However, the FERC analysis did not consider the impacts of the trap and haul operation itself, such as handling and trucking stress and mortality.~~ The recent review of Lusardi and Moyle (2017) note that adults trapped and hauled upstream can experience high ~~(> 20 percent)~~ pre-spawn mortality rates (which are incorporated into the predictions used here), and juvenile salmonids transported downstream are observed to experience delayed mortality, reduced growth rates, and increased predation. ~~Therefore, for purposes of comparing the impacts of the Continued Operations with Fish Passage alternative with the impacts of trap and haul, this analysis does not assume that mortality would be different from that estimated for volitional fishways reported by FERC (2007). In addition,~~

For this analysis, it is assumed that mortality ~~effects~~ from ~~of~~ passage through trap and haul facilities would be equivalent for other migratory species, which is a reasonable assumption for modern fishways designed to accommodate all species (including Pacific lamprey).

Volume I Section 4.4.3.7 [Continued Operations with Fish Passage] Aquatic Resources – Fish Passage – Potential Impact 4.2.3-1 Effects on coho salmon critical habitat quality and quantity due to continued operations of the Lower Klamath Project, paragraph 1 on page 4-134:

As under existing conditions, this thermal stress may continue to contribute to coho salmon being more susceptible to disease downstream of Iron Gate Dam to the confluence of the Salmon River.

Volume I Section 4.4.3.7 [Continued Operations with Fish Passage] Aquatic Resources – Fish Passage – Potential Impact 4.2.3-1 Effects on coho salmon critical habitat quality and quantity due to continued operations of the Lower Klamath Project, paragraph 3 on page 4-134:

Delay, injury, and mortality could occur for upstream migrating adults, and downstream migrating juveniles, as described in Section 4.4.3.7 *Fish Passage*~~, upstream migrating adult mortality within fishways is predicted to be approximately 28 percent, and 58 percent for downstream migrating juveniles (FERC 2007)~~. Increased production resulting from increased habitat access is anticipated to off-set losses from fish passage injury and mortality (FERC 2007). Since mortality estimates are cumulative assuming migration through all facilities past all dams and through all reservoirs, any upstream migrating adults that migrated past fewer facilities and reservoirs and spawned in Fall or Jenny creeks for example, would have much lower morality (e.g., 10 percent for adults, FERC 2007). The same is true for downstream migrating juveniles; the fewer facilities and reservoirs required during downstream migration, the lower the cumulative mortality. Trap and haul operations are also predicted to have lower cumulative mortality during passage than volitional fishways.

Volume I Section 4.4.3.7 [Continued Operations with Fish Passage] Aquatic Resources – Fish Passage – Potential Impact 4.2.3-7 Effects on the fall-run Chinook salmon population due to continued operations of the Lower Klamath Project – Upper Klamath River and Connected Waterbodies, paragraph 6 on page 4-136:

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).

Oosterhout (2005) estimated that fall-run Chinook salmon spawner abundance for the Continued Operations with Fish Passage Alternative with volitional fish passage would be around 29,754, or around 28,539 with trap and haul facilities (under a no harvest assumption). Either fish passage option produced about 12,000 fewer adults than modeling dam removal similar to the Proposed Project. However, under this alternative, Iron Gate Hatchery would continue to target current annual production goals as described in Section 3.3.2.3 *Habitat Attributes Expected to be Affected by the Proposed Project – Fish Hatcheries*, resulting in a greater abundance of fall-run Chinook salmon production than predicted under the Proposed Project.

Volume I Section 4.4.3.7 [Continued Operations with Fish Passage] Aquatic Resources – Fish Passage – Potential Impact 4.2.3-7 Effects on the fall-run Chinook salmon population due to continued operations of the Lower Klamath Project – Upper Klamath River and Connected Waterbodies, paragraph 2 on page 4-137:

It is anticipated juveniles would migrate downstream with mortality from predation and poor water quality considered in the estimates of passage survival discussed in Section 4.4.3.7 *Fish Passage*. ~~As described in Section 4.4.3.7 *Fish Passage*, upstream migrating adult mortality within fishways is predicted to be approximately 28 percent, and 58 percent for downstream migrating juveniles (FERC 2007).~~ Increased production resulting from increased habitat access is anticipated to off-set losses from fish passage injury and mortality (FERC 2007). Since mortality estimates are cumulative assuming migration through all facilities past all dams and through all reservoirs, the fewer facilities and reservoirs required during downstream migration, the lower the cumulative mortality in the reach. Trap and haul operations are also predicted to have lower cumulative mortality during passage than volitional fishways.

Volume I Section 4.4.3.7 [Continued Operations with Fish Passage] Aquatic Resources – Fish Passage – Potential Impact 4.2.3-7 Effects on the fall-run Chinook salmon population due to continued operations on the Lower Klamath Project – Middle and Lower Klamath River, paragraph 3 on page 4-139:

Despite modest improvements in dissolved oxygen concentrations from implementation of actions contained within the current Reservoir Management Plan (i.e., turbine venting system at Iron Gate Dam; see discussion in Section 4.4.2.1 *[Continued Operations with Fish Passage] Water Temperature*, Potential Impact 4.2.2-1 and Appendix C – *Section C.4.2*), dissolved oxygen concentrations during August through October immediately downstream from Iron Gate Dam would continue to be low (less than 7 mg/l ~~85 percent saturation~~ during August through September and ~~90~~ less than 8 mg/l~~percent saturation~~ from October and November (see Figure 3.2-20 in Section 3.2.2.5 *Dissolved Oxygen*). Dissolved oxygen concentration in this range during typical fall water temperatures would mostly be a risk for incubating eggs and could cause moderate production impairment (Carter 2008).

Volume I Section 4.4.3.7 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Fish Passage – Potential Impact 4.2.3-8 Effects on the spring-run Chinook salmon population due to continued operations *of the Lower Klamath Project – Upper Klamath River — Hydroelectric Reach, paragraph 3 on page 4-141:*

It is anticipated that adults will migrate upstream through inundated reservoir habitat, and that juveniles will migrate downstream with mortality from predation and poor water quality considered in the estimates of passage survival discussed in Section 4.4.3.7 *Fish Passage*. ~~As described in Section 4.4.3.7 *Fish Passage*, upstream migrating adult mortality within fishways is predicted to be approximately 28 percent, and 58 percent for downstream migrating juveniles (FERC 2007).~~

Volume I Section 4.4.3.7 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Fish Passage – Potential Impact 4.2.3-9 Effects on coho salmon populations due to continued operations of the Lower Klamath Project – Upper Klamath River — Hydroelectric Reach, paragraph 6 on page 4-145:

It is anticipated that adults will migrate upstream through inundated reservoir habitat, and that juveniles will migrate downstream with mortality from predation and poor water quality considered in the estimates of passage survival discussed in Section 4.4.3.7 *Fish Passage*. ~~As described in Section 4.4.3.7 *Fish Passage*, upstream migrating adult mortality within fishways is predicted to be around 28 percent, and 58 percent for downstream migrating juveniles (FERC 2007).~~ Since mortality estimates are cumulative assuming migration through all facilities past all dams and through all reservoirs, any upstream migrating adults that migrated past fewer facilities and reservoirs and spawned in Fall or Jenny creeks for example, would have much lower morality (e.g., 10 percent for adults, FERC 2007). The same is true for downstream migrating juveniles; the fewer facilities and reservoirs required during downstream migration, the lower the cumulative mortality (FERC 2007). <u>Trap and haul operations are also predicted to have lower cumulative mortality during passage than volitional fishways.</u>

Volume I Section 4.4.3.7 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Fish Passage – Potential Impact 4.2.3-10 Effects on the steelhead population due to continued operations of the Lower Klamath Project, paragraph 2 on page 4-150:

It is anticipated that adults will migrate upstream through inundated reservoir habitat, and that juveniles will migrate downstream with mortality from predation and poor water quality considered in the estimates of passage survival discussed in Section 4.4.3.7 *Fish Passage*. ~~As described in Section 4.4.3.7 *Fish Passage*, upstream migrating adult mortality within fishways is predicted to be around 28 percent, and 58 percent for downstream migrating juveniles (FERC 2007).~~ Increased production resulting from increased habitat access is anticipated to off-set losses from fish passage injury and mortality (FERC 2007). Since mortality estimates are cumulative assuming migration through all facilities past all dams and through all reservoirs, any upstream migrating adults that migrated past fewer facilities and reservoirs and spawned in Fall or Jenny creeks for example, would have much lower morality (e.g., 10 percent for adults, FERC 2007). The same is true for downstream migrating juveniles; the fewer facilities and reservoirs required during downstream migration, the lower the cumulative mortality. Trap and haul operations are also predicted to have lower cumulative mortality during passage than volitional fishways.

Volume I Section 4.4.3.7 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Fish Passage – Potential Impact 4.2.3-11 Effects on the Pacific lamprey population due to continued operations of the Lower Klamath Project – Upper Klamath River — Hydroelectric Reach, paragraph 1 on page 4-153:

It is anticipated that adults will migrate upstream through inundated reservoir habitat, and that juveniles will migrate downstream with mortality from predation and poor water quality considered in the estimates of passage survival discussed in Section 4.4.3.7 *Fish Passage*. ~~As described in Section 4.4.3.7 *Fish Passage*, upstream migrating adult mortality within fishways is predicted to be around 28 percent, and 58 percent for downstream migrating juveniles (FERC 2007).~~ Since mortality estimates are cumulative assuming migration through all facilities past all dams and through all reservoirs, any upstream migrating adults that migrated past fewer facilities and reservoirs and spawned in Fall or Jenny creeks for example, would have much lower morality (e.g., 10 percent for adults, FERC 2007). The same is true for downstream migrants; the fewer facilities and reservoirs required during downstream migration, the lower the cumulative mortality. Trap and haul operations are also predicted to have lower cumulative mortality during passage than volitional fishways. Increased production resulting from increased habitat access is anticipated to off-set losses from fish passage injury and mortality (FERC 2007).

Volume I Section 4.4.3.7 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Fish Passage – Potential Impact 4.2.3-13 Effects on Lost River and shortnose sucker populations due to continued operations of the Lower Klamath Project, paragraph 8 on page 4-155:

~~Overall, i~~There are no available data to ~~t is speculative to~~ determine whether increased access to spawning habitat outweigh the ~~increased risk~~impacts to the population of hybridization, or vice-versa. Increased risk of hybridization negates any potential long-term benefits of habitat connectivity, but increased risk of hybridization is unlikely to pose a long-term significant impact, since hybridization is already occurring in the Upper Klamath Lake population even in the absence of upstream passage from Lower Klamath Project reservoirs.

Volume I Section 4.4.3.7 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Fish Passage – Potential Impact 4.2.3-14

Effects on the redband trout population due to continued operations of the Lower Klamath Project – Upper Klamath River and Connected Waterbodies, paragraph 3 on page 4-156:

New fish passage facilities would improve access to Spencer Creek, which provides important spawning habitat and temperature refugia for redband trout (DOI 2007, Buchanan et al. 2011b). New upstream fish passage would also improve connectivity of resident redband populations in the mainstem Klamath River to those in Lake Ewauna, the Link River, and Upper Klamath Lake (DOI 2007). If trap and haul as described by FERC (2007) were implemented, redband trout would not have access to expanded habitat because the upstream entrance to the trapping facility would be located downstream of Iron Gate Dam, downstream of the range for redband trout.

Volume I Section 4.4.3.7 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Fish Passage – Potential Impact 4.2.3-14 Effects on the redband trout population due to continued operations of the Lower Klamath Project – Summary, paragraph 3 on page 4-157:

The habitat improvements and increased connectivity would confer greater population-level benefits than the expected mortality within the fishways, resulting in overall benefits to redband trout in the long term. If passage were provided through trap and haul as described by FERC (2007), there would not be an increase in accessible habitat for redband trout since the upstream entrance to the trapping facility would be located downstream of Iron Gate Dam, downstream of the range for redband trout.

Volume I Section 4.4.3.7 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Fish Passage – Potential Impact 4.2.3-8 Effects on the spring-run Chinook salmon population due to continued operations of the Lower Klamath Project – Upper Klamath River — Hydroelectric Reach, paragraph 3 on page 4-141:

It is anticipated that adults will migrate upstream through inundated reservoir habitat, and that juveniles will migrate downstream with mortality from predation and poor water quality considered in the estimates of passage survival discussed in Section 4.4.3.7 *Fish Passage*. ~~As described in Section 4.4.3.7 *Fish Passage*, upstream migrating adult mortality within fishways is predicted to be approximately 28 percent, and 58 percent for downstream migrating juveniles (FERC 2007).~~ As mortality estimates are cumulative assuming migration through all facilities past all dams and through all reservoirs, any upstream migrating adults that migrated past fewer facilities and reservoirs and spawned in Fall or Jenny creeks for example, would have much lower morality (e.g., 10 percent for adults, FERC 2007). The same is true for downstream migrating juveniles; the fewer facilities and reservoirs required during downstream migration, the lower the cumulative mortality. Trap and haul operations are also predicted to have lower cumulative mortality during passage than volitional fishways.

*Volume I Section 4.4.3.7 Alternatives – Continued Operations with Fish Passage Alternative – Aquatic Resources – Fish Passage – Potential Impact 4.2.3-9 Effects on coho salmon populations due to continued operations of the Lower Klamath Project – Upper Klamath River — Hydroelectric Reach**,** paragraph 6 on page 4-145:*

It is anticipated that adults will migrate upstream through inundated reservoir habitat, and that juveniles will migrate downstream with mortality from predation and poor water quality considered in the estimates of passage survival discussed in Section 4.4.3.7 *Fish Passage*. ~~As described in Section 4.4.3.7 *Fish Passage*, upstream migrating adult mortality within fishways is predicted to be around 28 percent, and 58 percent for downstream migrating juveniles (FERC 2007).~~ Since mortality estimates are cumulative assuming migration through all facilities past all dams and through all reservoirs, any upstream migrating adults that migrated past fewer facilities and reservoirs and spawned in Fall or Jenny creeks for example, would have much lower morality (e.g., 10 percent for adults, FERC 2007). The same is true for downstream migrating juveniles; the fewer facilities and reservoirs required during downstream migration, the lower the cumulative mortality. Trap and haul operations are also predicted to have lower cumulative mortality during passage than volitional fishways.

4.4.5 Terrestrial Resources

Volume I Section 4.4.5.1 Alternatives – Continued Operations with Fish Passage Alternative – Terrestrial Resources – Vegetation Communities – Mitigation Measure TER-5 – Identification, protection, and restoration of wetland and riparian habitats, paragraph 1 on page 4-166:

Mitigation Measure TER-5 − Identification, protection, and restoration of wetland and riparian habitats.
The KRRC shall conduct a wetland delineation within the limits of construction in accordance with the 1987 U.S. Army Corps of Engineers (USACE) Wetland Delineation Manual (USACE 1987) and applicable Regional Supplements (i.e., Western Mountains, Valleys, and Coast Region [USACE 2010] and Arid West [USACE 2008]). The results of the wetland delineation shall be incorporated into the Continued Operations with a Continued Operations with Fish Passage Alternative, the Two Dam and Three Dam designs to avoid and minimize direct impacts on wetlands to the maximum extent feasible, and wetland areas adjacent to the construction Limits of Work shall be fenced to prevent inadvertent entry. Where avoidance is not feasible the KRRC shall develop a restoration plan to re-vegetate all areas disturbed during construction with a ~~goal~~ requirement of no net loss of wetland or riparian habitat acreage or no net loss of overall ~~and~~ functions and values. The restoration plan shall include details on revegetation native seed mixes based on existing species that will be impacted and installation

techniques for container plants and seeds. Wetlands established in restored areas would be monitored for five years or until the performance criteria, as defined in the restoration plant that shall be developed, have been met.

Volume I Section 4.4.5.3 Alternatives – Continued Operations with Fish Passage Alternative – Terrestrial Resources – Special-status Species, paragraph 1 on page 4-168:

Compared to the existing condition, the substantial construction involved with constructing fish passage facilities would have the potential to significantly impact special-status wildlife species for the reasons described above and in Section 3.5.5 (Potential Impacts 3.5-10, 3.5-11, 3.5-12, 3.5-13, 3.5-14, and 3.5-28). Implementation of Mitigation Measures TER-2, ~~and~~ TER-3, TER-6, and TER-7 would reduce construction-related impacts, including in-water work, on all special-status amphibian species, gray wolf, and bald and golden eagles to less than significant. Implementation of Recommended Terrestrial Measures 3–~~12~~10 and 12 would reduce impacts on special-status birds and mammals to less than significant. Implementation of the TER-2 and TER-3 measures would be enforceable through inclusion in a water quality certification. Therefore, the TER-2 and TER-3 measures are feasible and Potential Impact 3.5-10 would result in no significant impacts on amphibian and reptile with mitigation from construction-related impacts and Potential Impact 3.5-28 impacts would be reduced for the reasons described in Section 3.5.5.3 *Terrestrial Resources Potential Impacts and Mitigation*. Implementation of Mitigation Measures TER-6 and TER-7 would be covered under the United States Fish and Wildlife Service (USFWS) Endangered Species Act permit authority and impacts on the gray wolf and bald and golden eagles from construction-related impacts (Potential Impacts 3.5-10 and 3.5-13). It is not clear, however, whether the hydroelectric project owner or operator would implement the Recommended Terrestrial Measures 3–10 and 12 (Potential Impacts 3.5-10, 3.5-11, 3.5-12, ~~3.5-13,~~ 3.5-14, and 3.5-28) through 'good citizen' agreements, as described in the Definite Plan, and it is unclear how these recommended terrestrial measures would be enforced in light of Federal Power Act preemption. Without an enforcement mechanism, these restoration activities cannot be deemed feasible for the purposes of CEQA. Therefore, this impact on special-status birds~~,~~ and mammals would be significant and unavoidable.

4.4.8 Water Supply/Water Rights

Volume I Section 4.4.8 Alternatives – Continued Operations with Fish Passage Alternative – Water Supply/Water Rights, paragraph 1 on page 4-170.

Flow increases in the J.C. Boyle and Copco No. 2 bypass reaches are related to minimum instream flows in the Hydroelectric Reach and would not impact water supply or water rights downstream of Iron Gate Dam. Similarly, there would be no changes to water supply/water rights related to the 2017 court-ordered flushing and emergency dilution flow requirements, or the 2019 BiOp flushing flow requirements, which is discussed in detail in Potential Impact 4.2.8-1. Overall, the Continued Operations with Fish Passage Alternative would not affect water supply/water rights as compared with the existing condition.

4.4.11 Geology, Soils, and Mineral Resources

Volume I Section 4.4.11 Alternatives – Continued Operations with Fish Passage Alternative – Geology, Soils, and Mineral Resources, paragraph 2 on page 4-172.

Increases in minimum flows and decreases in peaking flows due to changes in J.C. Boyle Dam and Copco No. 2 Dam operations, plus the 2013 BiOp Flows with the 2017 court-ordered winter-spring surface flushing flows and deep flushing flow requirements at Iron Gate Dam (and emergency dilution flows, if needed), which ~~that~~ were in effect from February 2017 to March 2019 (i.e., at the time of the Draft EIR) (see also Section 4.2.1.1 *[No Project] Alternative Description – Summary of Available Hydrology Information for the No Project Alternative)*, would result in an overall increase in flows under this alternative compared to existing conditions. The 2019 BiOp Flows that are currently in effect require surface flushing flows (6,030 cfs), without deep flushing or emergency dilution flow requirements; therefore, although minimum flows would be increased with changes in dam operations under this alternative, peaking flows would be similar to historical conditions under the 2019 BiOp Flows. New sediment supply would not occur under this alternative, regardless of the flow regime. With the 2013 BiOp Flows and 2017 court-ordered flushing and emergency dilution flows, ~~While~~ the additional flows would increase the mobility of existing surficial fine sediment deposits and infilled fine sediment from the armor layer, with potential for ~~slight~~continued mobilization of the armor layer on an approximately decadal scale (i.e., with 10- to 12-year return period probability flows) in some locations. With the 2019 BiOp Flows, sediment mobilization would be similar to historical conditions. However, given that there would be no new sediment supply under either of the flow conditions, ~~maintenance of static~~the conditions of channel features under the Continued Operations with Fish Passage Alternative would ~~represent no~~not change substantially from~~s~~ existing adverse conditions for the Middle Klamath River between Iron Gate Dam and the confluence with the Scott River.

4.4.12 Historical and Tribal Cultural Resources

Volume I Section 4.4.12 Alternatives – Continued Operations with Fish Passage Alternative – Historical Resources and Tribal Cultural Resources, paragraph 2 on page 4-173.

Under the Continued Operations with Fish Passage Alternative, construction activities to install fish ladders would occur at all four Lower Klamath Project dam complexes. Construction activities would result from the development of structures to support these fish passage options; however, the overall area of ground disturbance would be reduced as less structures would be removed. While construction-related impacts under this alternative would be less than those described for the Proposed Project, there would still be potential for construction-related impacts due to ground-disturbance, heavy equipment, and blasting such that Potential Impacts 3.12-1, 3.12-4, and 3.12-5 for tribal cultural resources and Potential Impacts 3.12-~~12~~11, 3.12-15, and 3.12-16 for historic-period archaeological resources, would occur in the manner described for the Proposed Project.

4.4.17 Public Services

Volume I Section 4.4.17 Alternatives – Continued Operations with Fish Passage Alternative – Public Services, paragraph 4 on page 4-174:

Implementation of Mitigation Measure HZ-1 (Section 3.21 *Hazards and Hazardous Materials*) and Mitigation Measure TR-1 (Section 3.22 *Traffic and Transportation*) would reduce this impact to less than significant for reasons described under the Proposed Project. Overseeing development and implementation of a Hazardous Materials Management Plan, as required under Mitigation Measure HZ-1 falls within the scope of the State Water Board's water quality certification authority. It is not clear, however, whether the hydroelectric project owner or operator would implement measures relating to traffic management (such as ~~Recommended~~ Mitigation Measure TR-1), emergency response, and construction-related fire management through 'good citizen' agreements, as described in the Definite Plan, and it is unclear how these measures would be enforced. Because the State Water Board cannot ensure implementation of these additional measures, it has determined that the construction-related impact on increased response times for emergency, fire, police, and medical services to be significant and unavoidable under this alternative.

4.4.19 Aesthetics

Volume I Section 4.4.19 Alternatives – Continued Operations with Fish Passage Alternative – Aesthetics, paragraph 1 on page 4-176:

Under the Continued Operations with Fish Passage Alternative, construction activities to install upstream and downstream fish ladders would occur at all four Lower Klamath Project dam complexes. This activity would take place within the Limits of Work for the Proposed Project. and would involve construction equipment, as well as use of staging areas and demolition areas. ~~However, since c~~Construction of new infrastructure to support fish passage would occur near and potentially directly adjacent to the existing infrastructure ~~(Potential Impact 3.19-5), the construction activities and the facilities themselves would not distract from a natural view relative to existing conditions in the short term or the long term and this alternative would result in a less than significant impact.~~ such that there would be no long-term (permanent) visual changes for key observation points C3, C4, C5, IG9, IG10, IG11, and IG12; Table 3.19-3 and Figure 3.19-2 in Volume III Attachment 1 Section 3.19.5 *Aesthetics – Potential Impacts and Mitigation*) (Potential Impact 3.19-5). The construction of new infrastructure to support fish passage under the Continued Operations with Fish Passage Alternative would not cause the VRM class to be degraded at a key observation point, would not adversely impact a scenic vista for those areas that were not assigned a VRM class, and would not result in a significant long-term (permanent) impact.

4.4.22 Transportation and Traffic

Volume I Section 4.4.22 Alternatives – Continued Operations with Fish Passage Alternative – Transportation and Traffic, paragraph 1 on page 4-179:

Under the Continued Operations with Fish Passage Alternative, construction activities would occur to install upstream and downstream fish ladders at all four Lower Klamath Project dam complexes. These construction activities would include the type of short-term construction-related transportation and traffic impacts described for the Proposed Project (Potential Impacts 3.22.5-1 through 3.22.5-5~~6~~). Although the level of construction under this alternative would be less than the level of construction necessary for removal of the Lower Klamath Project dam complexes under the Proposed Project, this alternative could still result in an increase in traffic on narrow rural roads from commuting workers, hauling of large equipment, and disposal of wastes, particularly for fishway construction at Iron Gate Dam and Copco No. 1 dams, which would last for 12 months and 9 months, respectively (Table 4.4-1). For reasons described for the Proposed Project (Section 3.22 *[Traffic and Transportation] Potential Impacts and Mitigation*), this would result in~~be a~~ significant short-term impacts compared with existing conditions for Potential Impacts 3.22.5-1 through 3.22.5-5. Implementation of measures such as those contained in the Traffic Management Plan and Emergency Management Plan proposed by the KRRC, as well as ~~Recommended~~ Mitigation Measure TR-1, would be expected to reduce short-term construction-related impacts to less than significant under this alternative. It is not clear, however, whether the hydroelectric project owner or operator would implement these measures through ‘good citizen’ agreements, as described in the Definite Plan, and it is unclear how these measures would be enforced. Without an enforcement mechanism, these measures cannot be deemed feasible for the purposes of CEQA. Therefore, this alternative would result in significant and unavoidable short-term construction-related traffic and transportation impacts.

4.5 Two Dam Removal Alternative

4.5.1 Introduction

Volume I Section 4.5.1.1 Alternatives – Two Dam Removal Alternative – Introduction – Alternative Description, bullet 1, and paragraph 2, on page 4-182:

The following conditions under the Two Dam Removal Alternative are a modification to the 2012 KHSA EIS/EIR *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*:

- Flows specified in the NMFS and USFWS 2013 BiOp for the USBR Klamath Irrigation Project~~, which are currently being considered under reinitiated consultation~~ (see also 3.1.6.1 *Klamath River Flows under the Klamath Irrigation Project's 2013 BiOp* [as revised in Volume III Attachment 1 Section 3.1.6]).

As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* (as revised in Volume III Attachment 1 Section 3.1.6), 2017 court-ordered flushing and emergency dilution flows ~~are~~ were required to be released from Iron Gate Dam during the period February 2017 – March 2019 as part of re-initiation of consultation on the 2013 BiOp Flows, but they ~~are~~ were not modeled as part of existing conditions hydrology. The 2019 BiOp Flows are now the current operational flow requirement for the Klamath River (USFWS 2019, NMFS 2019) thus they would represent hydrology moving forward under the Two Dam Removal Alternative. ~~Potential new BiOp flow requirements under this alternative are speculative at this time, and it is not clear whether flushing and emergency dilution flow requirements would continue under the new BiOp during or after dam removal. However, the 2017 flow requirements are considered to be the most reasonable assumption for conditions until agency formal consultation is completed and a new BiOp is issued.~~ For analysis of potential impacts related to fish disease, the Two Dam Removal Alternative considers conditions with and without 2017 court-ordered flushing and emergency dilution flows and with the 2019 BiOp flushing flows (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* [(as revised in Volume III Attachment 1 Section 3.1.6]).

4.5.2 Water Quality

Volume I Section 4.5.2.1 Alternatives – Two Dam Removal Alternative – Water Quality – Water Temperature, paragraph 2 on page 4-187:

The Two Dam Removal Alternative would ~~not include~~ increase flow in the J.C. Boyle Bypass to meet the requirement that at least 40 percent of the J.C. Boyle Reservoir inflow be released through this reach and peaking power generation or whitewater recreation flows ~~from the J.C. Boyle Dam~~ in the J.C. Boyle Peaking Reach would be eliminated as the downstream dams would not be available to regulate the peaking flows. The increase in the J.C. Boyle Reservoir water being released through the J.C. Boyle Bypass Reach in Oregon would reduce the relative influence of the cold groundwater springs (a relatively constant approximately 11 to 12°C [51.8 to 53.6°F]) on water temperatures in this reach, such that the range of daily water temperatures and the maximum daily water temperature in the J.C. Boyle Bypass Reach in Oregon would increase under the

Two Dam Removal compared to existing conditions. Warmer water temperatures would occur during summer and early fall, while cooler water temperatures would occur in late fall and winter (i.e., November to April) in the J.C. Boyle Bypass Reach under this alternative compared to existing conditions. Areas adjacent to the cold groundwater springs in the J.C. Boyle Bypass Reach would continue to potentially provide thermal refugia for aquatic species because the flow from the springs themselves would not be affected by the Two Dam Removal Alternative, but the total thermal refugia area for aquatic species in the J.C. Boyle Bypass Reach would likely decrease as the percentage of flow in the river from the cold groundwater springs decreases and the percentage of flow from the warmer reservoir increases (see also Section 4.5.3.3 *[Two Dam Removal Alternative] Aquatic Resources – Water Temperature*). Data and/or models results are not currently available to quantify the potential changes in the thermal refugia area under the Two Dam Removal compared to existing conditions.

Elimination of the peaking and recreation flows from J.C. Boyle Dam would likely result in J.C. Boyle Reservoir operating in a run of the river manner ~~and increases~~(i.e., steady flow conditions). While the Two Dam Removal Alterative was not specifically modeled, a comparison between KRWQM steady flow conditions (i.e., no peaking flows) and existing conditions results (PacifiCorp 2004a) would characterize the general water temperature variations and trends in the J.C. Boyle Peaking Reach under the Two Dam Removal. Increases in the water temperature range associated with J.C. Boyle peaking operations under existing conditions would no longer occur under ~~both~~ the Two Dam Removal Alternative ~~and the Proposed Project~~ (see also Section 3.2.2.2 *Water Temperature*), resulting in a more natural daily water temperature variations within the J.C. Boyle Peaking Reach. The upper portion of the J.C. Boyle Peaking Reach (i.e., downstream of the J.C. Boyle Powerhouse) would typically have lower maximum water temperatures and higher minimum water temperatures under the Two Dam Removal Alternative than under existing conditions, but the potential impact of eliminating peaking operations would diminish in the downstream direction. The annual and summer peak maximum water temperatures in the lower portion of the J.C. Boyle Peaking Reach (i.e., near Shovel Creek upstream of Copco No. 1 Reservoir) would be reduced under this alterative compared to existing conditions, but the daily Klamath River water temperatures in this reach would occasionally increase or decrease by approximately 2°C or less compared to existing conditions due to the influence of local meteorological conditions in the absence of peaking flows (PacifiCorp 2004a). However, the maximum water temperature and daily water temperature range would be similar or slightly less under the Two Dam Removal Alternative compared to the Proposed Project based on 2004/2005 KRWQM modeling of steady flow conditions in the lower portion of the J.C. Boyle Peaking Reach. Overall, elimination of peaking flows would move the J.C. Boyle Peaking Reach towards a more natural thermal regime under the Two Dam Removal Alternative compared to existing conditions.

Volume I Section 4.5.2.1 Alternatives – Two Dam Removal Alternative – Water Quality – Water Temperature, paragraph 1 on page 4-189:

~~J.C. Boyle Reservoir would not alter water temperature in the J.C. Boyle Peaking Reach from the Oregon-California state line to Copco No. 1 Reservoir and J.C. Boyle Dam operations for peaking and recreation releases that cause increases in the water temperature range would be eliminated under both the Two Dam Removal Alternative and the Proposed Project.~~ Elimination of J.C. Boyle Dam peaking and recreation releases and more steady flow in this section of the Klamath River would result in water temperature in the J.C. Boyle Peaking Reach moving towards a more natural thermal regime under the Two Dam Removal Alternative compared to existing conditions. At the upper end of the J.C. Boyle Peaking Reach near the Oregon-California state line, the daily range of water temperatures would decrease, with lower maximum water temperatures and higher minimum water temperatures (PacifiCorp 2004a). In the lower portion of the J.C. Boyle Peaking Reach downstream of the Oregon-California state line, available modeling data indicates that annual and summer maximum water temperatures would decrease, but daily water temperatures would vary by approximately +/- 2^{o}C or less compared to existing conditions in the lower end of the J.C. Boyle Peaking Reach near Copco No. 1 Reservoir (PacifiCorp 2004a). Short-term and long-term alterations in water temperatures in the J.C. Boyle Peaking Reach from the Oregon-California state line to Copco No. 1 Reservoir under the Two Dam Removal Alternative would result in water temperature effects similar to those of the Proposed Project (i.e., slightly lower maximum water temperatures and less artificial diel temperature variation during summer and early fall, see also Potential Impact 3.2-1)~~ and ~~, but the magnitude of these water temperature changes potentially would be slightly less under the Two Dam Removal Alternative than under the Proposed Project. Overall, the short-term and long-term alterations would move the water temperature in the J.C. Boyle Peaking Reach towards a more natural thermal regime and this would be beneficial.

Volume I Section 4.5.2.2 Alternatives – Two Dam Removal Alternative – Water Quality – Suspended Sediments, paragraph 1 on page 4-191:

Sediments and suspended materials (inorganic and organic) would continue to be intercepted and retained behind J.C. Boyle Dam in the long term under the Two Dam Removal Alternative, albeit to a lesser degree compared with existing conditions because~~, since~~ while ~~that~~ J.C. Boyle dam would remain in place it would be operated in a run of the river manner albeit with a similarly short hydraulic residence time (i.e., on the order of one to three days) compared with existing conditions (1.1 days [FERC 2007]). ~~While t~~The amount of sediment supplied to the Klamath River on an annual basis from the watershed upstream of J.C. Boyle Dam is a relatively small fraction of the total sediment (Stillwater Sciences 2010a) (see also Section 3.11.2.4 *Sediment Load*).~~,~~ While there would be a long-term increase in mineral (inorganic) suspended material downstream of J.C. Boyle Dam under this alternative compared with existing conditions, it would be less than under the Proposed Project since J.C. Boyle Dam would continue to intercept sediment in calm areas along the channel margins and areas nearest the dam face. The majority of algal-derived (organic) suspended material from upstream sources (Upper Klamath Lake, Klamath Straights Drain, Lost River) is intercepted and retained by the Keno Impoundment/Lake Ewauna, but J.C. Boyle Dam does retain some algal-derived (organic) suspended material under existing conditions (see Appendix C, Section C.2.1 *Upper Klamath Basin* for more detail). ~~Thus, t~~The long-term increases in algal-derived (organic) suspended material downstream of J.C. Boyle Dam under this alternative would be less than under the Proposed Project since the dam would continue to intercept and retain some degree of upstream algal-derived suspended material in calm areas along the channel margins and areas nearest the dam face.

Volume I Section 4.5.2.1 Alternatives – Two Dam Removal Alternative – Water Quality – Suspended Sediments, paragraph 3 on page 4-191:

However, under the Two Dam Removal Alternative, the overall long-term impact from changes in the interception of sediments due to retention of J.C. Boyle and Copco No. 2 dams and removal of Copco No. 1 and Iron Gate dams would be similar ~~under both the Two Dam Removal Alternative and~~ to the Proposed Project and thus would be a less than significant impact. ~~The long-term increases in mineral (inorganic) and algal-derived (organic) suspended material due to the lack of interception by the dams would be a less than significant impact under the Proposed Project as only a small amount of sediment and suspended material is delivered from upstream of J.C. Boyle Dam. Thus, a decrease in the amount of sediment transported downstream under the Two Dam Alternative due to the retention of J.C. Boyle and Copco No. 2 dams and removal of Copco No. 1 and Iron Gate dams would still be a less than significant impact.~~ The long-term increases in mineral (inorganic) and algal-derived (organic) suspended material due to the lack of interception by the dams would be a less than significant impact under the Proposed Project as ~~only~~ a relatively small amount of sediment and suspended material is delivered from upstream of J.C. Boyle Dam.

Volume I Section 4.5.2.4 Alternatives – Two Dam Removal Alternative – Water Quality – Dissolved Oxygen, paragraphs 3 and 4 on pages 4-197-198:

In the long term, since J.C. Boyle Dam would remain in place, continuing summertime interception and retention of sediments and suspended materials from upstream sources containing high biological oxygen demand (see also Section 3.2.2.5 *Dissolved Oxygen*) would still occur in J.C. Boyle Reservoir under the Two Dam Removal Alternative. J.C. Boyle Reservoir would be operated in a run-of-the-river manner (i.e., steady flow conditions) due to elimination of the peaking and recreation flows from J.C. Boyle Dam under this alternative, which would increase mixing within J.C. Boyle Reservoir under this alternative compared to under existing conditions. ~~Accordingly,~~ While existing large summertime variations in dissolved oxygen in J.C. Boyle Reservoir, especially at depth, would still occur and could continue to influence dissolved oxygen concentrations in the California portion of the Hydroelectric Reach similar to ~~in the same manner as under~~ existing conditions (see also Section 3.2.2.5 *Dissolved Oxygen*), the magnitude of dissolved oxygen variations with depth in J.C. Boyle Reservoir and its downstream influence on dissolved oxygen would be less under the Two Dam Removal Alternative than under existing conditions. This assessment is based on 2004/2005 KRWQM modeling of dissolved oxygen conditions in the J.C. Boyle Reservoir, Bypass Reach, and Peaking Reach under steady flow conditions (i.e., no peaking flows and no additional flow through the J.C. Boyle Bypass Reach), which although not exactly the same as the specific flow conditions included in the Two Dam Removal Alternative (i.e., no peaking or recreation flows and at least 40 percent of reservoir inflow released downstream into the J.C. Boyle Bypass), are similar and would characterize the general dissolved oxygen trends expected under the Two Dam Removal Alternative. In J.C. Boyle Reservoir, dissolved oxygen concentrations would generally increase under steady flow conditions and result in fewer periods with dissolved oxygen concentrations less than 6 mg/L compared to existing conditions, but dissolved oxygen concentrations would still reach approximately 2 mg/L during portions of some years (PacifiCorp 2004a). In the J.C. Boyle Bypass Reach downstream of the J.C. Boyle Dam, dissolved oxygen would decrease below 85 percent saturation and 6.5 mg/L immediately downstream of the dam during summertime periods when dissolved oxygen is low in J.C. Boyle Reservoir under steady flow conditions, which is similar to existing conditions. However, the minimum dissolved oxygen concentrations immediately downstream of the dam typically would be higher under steady flow conditions than under existing conditions, due to generally higher dissolved oxygen concentrations in J.C. Boyle Reservoir (PacifiCorp 2004a). Under both steady flow and existing conditions, aeration and fast-moving water velocities in the J.C. Boyle Bypass Reach would increase dissolved oxygen to near or slightly greater than saturation levels by the J.C. Boyle Powerhouse. Higher flow releases under the Two Dam Removal Alternative (i.e., at least 40 percent inflow to J.C. Boyle Reservoir released into the J.C. Boyle Bypass Reach) compared to modeled steady flow conditions (i.e., no additional flow releases into the J.C. Boyle Bypass Reach) would potentially result in more rapid aeration, with dissolved oxygen increasing to near or slightly greater than saturation levels within a shorter distance downstream of J.C. Boyle Dam than under modeled steady flow or existing conditions.

In the J.C. Boyle Peaking Reach downstream of the J.C. Boyle Powerhouse, measurements and modeling of existing conditions indicate~~s these~~ summertime dissolved oxygen variations in J.C. Boyle Reservoir and peaking flow releases of diverted reservoir water increase the range of dissolved oxygen concentrations between the Oregon-California state line and the upstream end of Copco No. 1 Reservoir (North Coast Regional Board 2011), but aeration and fast water velocities within the free-flowing reach result in dissolved oxygen concentrations near or slightly greater than saturation upstream of Copco No. 1 Reservoir (PacifiCorp 2004a; FERC 2007; Raymond 2008; Raymond 2009a). The Two Dam Removal Alternative would not include peaking power generation and release of flow for recreation within the J.C. Boyle Peaking Reach, but run-of-the-river operations and release of steady flow from the J.C. Boyle Powerhouse would likely result in the dissolved oxygen at the Oregon-California state line ~~would~~ ~~still likely have~~ having slightly greater daily variability than natural conditions during summertime periods of low dissolved oxygen in J.C. Boyle Reservoir (see also Potential Impact 3.2-10). 2004/2005 KRWQM results indicate that daily variability of dissolved oxygen would increase downstream of the J.C. Boyle Powerhouse under steady flow conditions compared to natural conditions, and dissolved oxygen would potentially fall below 85 percent saturation and 6.5 mg/L during summer, similar to existing conditions. However, the magnitude of the daily dissolved oxygen variability would be less under steady flow conditions than under existing conditions (PacifiCorp 2004a). Higher summertime dissolved oxygen in J.C. Boyle Reservoir under steady flow conditions compared to existing conditions reduces the daily dissolved oxygen variability by reducing the decrease in dissolved oxygen in the J.C. Boyle Peaking Reach, when diverted reservoir flow is released downstream of the powerhouse. As such, the daily variability of dissolved oxygen at the Oregon-California state line also would be reduced under the Two Dam Removal Alternative compared to existing conditions, but there may still be more daily variability of dissolved oxygen at the Oregon-California state line than would occur under natural conditions. While the degree of influence of peaking flows on daily variability in dissolved oxygen concentrations at the Oregon-California state line is not clearly defined by existing information, the daily variability is not currently adversely affecting beneficial uses. ~~However, dissolved oxygen concentrations immediately downstream of J.C. Boyle would potentially fall below 85 percent saturation and 6.5 mg/L during summer similar to existing conditions.~~ Thus, retaining J.C. Boyle Dam with no peaking or recreation flows under the Two Dam Removal Alternative would have only a small influence on dissolved oxygen concentrations downstream of the Oregon-California state line compared to existing conditions and there would be no significant impact.

4.5.3 Aquatic Resources

Volume I Section 4.5.3.3 Alternatives – Two Dam Removal Alternative – Aquatic Resources – Water Quality, paragraph 4 on page 4-205:

In the Hydroelectric Reach from the upstream end of Copco No. 1 Reservoir to Iron Gate Dam, removing Iron Gate~~,~~ and Copco No. 1~~, and Copco No. 2~~ reservoirs and converting the reservoir areas to a free-flowing river under this alternative would result in the same effects on water temperatures in the Middle Klamath River immediately downstream from Iron Gate Dam as described for the Proposed Project (i.e., long-term increases in spring water temperatures and decreases in late summer/fall water temperatures) (see Section 3.3.5.3 *Water Quality*).

Volume I Section 4.5.3.4 Alternatives – Two Dam Removal Alternative – Aquatic Resources – Fish Disease and Parasites, paragraph 2 on page 4-206:

As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* (as revised in Volume III Attachment 1 Section 3.1.6), 2017 court-ordered flushing and emergency dilution flows ~~are~~ were required to be released from Iron Gate Dam during the period February 2017 – March 2019 as part of re-initiation of consultation on the 2013 BiOp Flows, but they ~~are~~ were not modeled as part of existing conditions hydrology. The 2019 BiOp Flows are now the current operational flow requirement for the Klamath River (USFWS 2019, NMFS 2019) thus they would represent hydrology moving forward under the Two Dam Removal Alternative. Under the Two Dam Removal Alternative, it is anticipated that the nidus would no longer form downstream of Iron Gate Dam, and the risk of a new nidus forming upstream is low, even in the absence of the 2017 flushing flow and emergency dilution requirements or the 2019 BiOp surface flushing flows (see also Section 3.3.5.5 *Fish Disease and Parasites*). Although the conditions leading to a reach that would exhibit the highest infectivity (nidus) for *C. shasta* and *P. minibicornis* downstream of Iron Gate Dam would be ameliorated once Copco No. 1 and Iron Gate dams are removed, some disease factors would continue under the Two Dam Removal Alternative, including eight years of additional Iron Gate Hatchery operations potentially resulting in continued (through post-dam removal year 10) congregations of mostly adult fall-run Chinook salmon in the reach from Iron Gate Dam to Seiad Valley (see also Section 3.3.5.6 *Fish Hatcheries*). Under the Two Dam Removal Alternative, if a nidus were to remain in the vicinity of Iron Gate Hatchery, or theoretically were to form within newly accessible upstream habitat such as the reach immediately downstream of Copco No. 2 or J.C. Boyle dam where future fish passage facility entrances would be located, flushing and emergency dilution flows as required by the 2017 court order, or the 2019 BiOp, may be required from a new upstream location to achieve the same ecological benefits (i.e., disruption of nidus).

Volume I Section 4.5.3.8 Alternatives – Two Dam Removal Alternative – Aquatic Resources – Fish Passage – Potential Impact 3.3-14 Effects on the redband trout population due to short-term sediment releases and long-term changes in habitat quality and quantity due to dam removal, paragraph 1 on page 4-221:

Under the Two Dam Removal Alternative, ~~Suspended~~ suspended and bedload sediment effects would differ from those described for the Proposed Project. Since redband trout are restricted to locations ~~distributed~~ upstream of Iron Gate Dam, ~~and therefore under the Proposed Project~~ the only impacts these individuals would experience from sediment releases under the Two Dam Removal Alternative would be limited to the Hydroelectric Reach between Iron

Gate Dam and Copco No. 2. ~~downstream of J.C. Boyle or downstream of Copco No.2). Therefore, despite the relatively small volume of sediment stored in J.C. Boyle Reservoir (and even less in Copco No. 2), impacts of sediment release on redband trout that would occur under the Proposed Project would be substantially less under the Two Dam Removal Alternative.~~ Release of sediment currently trapped behind Copco No. 1 Dam would remain a short-term impact on redband trout within the 1.4-mile riverine reach downstream of Copco No. 1 and upstream of Iron Gate Reservoir under the Two Dam Removal Alternative. A productive population of redband trout exists upstream of Copco No.1 Dam; however, downstream of Copco No. 1 Dam, redband trout are less abundant with relatively few and sporadic observations in the 1.4-mile riverine section between Copco No. 2 Dam and the upstream end of Iron Gate Reservoir (PacifiCorp 2004a). Redband trout observed in this section of the Klamath River likely migrate upstream from Iron Gate Reservoir during the fall when water conditions are more favorable. Therefore, only a small proportion of the population is expected to be exposed to short-term effects.

Volume I Section 4.5.3.8 Alternatives – Two Dam Removal Alternative – Aquatic Resources – Fish Passage – Potential Impact 3.3-14 Effects on the redband trout population due to short-term sediment releases and long-term changes in habitat quality and quantity due to dam removal, paragraph 3 on page 4-221:

Based on a long-term substantial increase in redband trout habitat quality and quantity compared to existing conditions, the Two Dam Removal Alternative would be beneficial for redband trout in the long term

Volume I Section 4.5.3.8 Alternatives – Two Dam Removal Alternative – Aquatic Resources – Fish Passage – Potential Impact 3.3-19, paragraph 2 on page 4-222:

~~Potential impacts on freshwater mollusks in California would be similar under the Two Dam Removal Alternative as those described for the Proposed Project (Section 3.3.5.9, Potential Impact 3.3-19), with a few subtle differences. As described in Section 4.5.3.1 *Suspended Sediment*, impacts on freshwater mollusks from sediment releases would be similar to the Proposed Project.~~ Based on the distribution of freshwater mollusks primarily downstream of Iron Gate Dam (summarized in Section 3.3.5.9, Potential Impact 3.3-19~~3.3-14~~), the potential impacts of the Two Dam Removal Alternative ~~would~~ are expected to be similar to ~~the same as~~ those described for the Proposed Project (Section 3.3.5.9, Potential Impact 3.3-19~~3.3-14~~) with one exception. Under the Two Dam Removal Alternative, suitable habitat for floater mussels (*Anodonta spp.*) would remain within J.C. Boyle Reservoir and within a section of the Hydroelectric Reach downstream of J.C. Boyle Reservoir. ~~The Proposed Project would have the most substantial impact on the floater mussels (*Anodonta spp.*) which occur in the mainstem Klamath River in the Hydroelectric Reach, within Lower Klamath Project reservoirs, in a reach (<15 miles) directly downstream of Iron Gate Dam,~~

~~and within the Upper Shasta River.~~ *Anodonta spp.* have been found in high abundance within J.C. Boyle Reservoir as recently as summer 2018 (Troy Brandt, River Design Group, pers. comm., November 2018). Therefore, under the Two Dam Removal Alternative the *Anodonta spp.* would remain unaffected within a portion of their range in J.C. Boyle Reservoir and the Upper Shasta River. Therefore, while the impacts to other species of freshwater mollusks would be the same under the Proposed Project (not significant), impacts to the *Anodonta spp.* would be less substantial under the Two Dam Removal Alternative than under the Proposed Project. However, impacts on ~~the~~ *Anodonta spp.* would still occur under the Two Dam Removal Alternative in the mainstem Klamath River (primarily downstream of Iron Gate Dam) as described for the Proposed Project (Section 3.3.5.9, Potential Impact 3.3-19~~3.3-14~~), and without any protective measures, ~~based on~~ it is predicted that there would be a substantial short-term decrease in *Anodonta spp.* abundance of a year class, ~~there would be a significant impact to the *Anodonta spp.* population~~ under the Two Dam Removal Alternative in the short term.

~~However,~~ To reduce the potential short-term impacts of sediment transport during dam removal on freshwater mussels, as described for the Proposed Project (Section 3.3.5.9, Potential Impact 3.3-19), the Two Dam Removal Alternative includes Aquatic Resource Measure AR-7 (Freshwater Mussels)~~to reduce the short-term effects of sediment transport during dam removal on *Anodonta spp.*, as described for the Proposed Project (Section 3.3.5.9, Potential Impact 3.3-14).~~ This measure includes ~~Under the Proposed Project this~~ salvage ~~and relocation plan~~ of freshwater mussels from the reach downstream of Iron Gate Dam and relocation at potential sites ~~would consider sites for translocation~~ located downstream from the Trinity River confluence (RM 43.4), and between J.C. Boyle Dam (RM 230.6) and Copco No. 1 Reservoir (RM 209.0). These areas would have less impact from increased SSCs but would not be completely protected from short-term effects. Under the Proposed Project, these ~~The~~ areas ~~downstream of the Trinity River confluence do not currently support *Anodonta spp.* and~~are unlikely to provide suitable habitat to support *Anodonta spp.* due to increased hydraulic variability from the loss of regulating reservoirs.~~in the future (Davis et al. 2013).~~ However, under the Two Dam Removal Alternative *Anodonta spp.* could be salvaged from the reach downstream of Iron Gate Dam and relocated to J.C. Boyle Reservoir and directly downstream of J.C. Boyle Reservoir, which does support suitable *Anodonta spp.* habitat. Therefore, with aquatic resource measure AR-7, there would likely not be a substantial reduction in the abundance of *Anodonta spp.* species in the short term, and impacts would be not significant ~~with~~ for *Anodonta spp.* in the short term. No significant short-term impacts are expected for other freshwater mollusks under the Two Dam Removal Alternative. The re-formation of river channel that would occur following the removal of Iron Gate Dam is expected to have long term benefits for *Anodonta spp., M. falcata, G. angulate,* and freshwater clams by providing more suitable substrates (i.e., large gravel, cobble, and boulder) than currently exists, especially within the current reservoir reaches.

4.5.5 Terrestrial Resources

Volume I, Section 4.5.5 Alternatives – Two Dam Removal Alternative – Terrestrial Resources, paragraph 2 on page 4-228:

Although short-term dam deconstruction activities would not occur for Copco No. 2 Dam under the Two Dam Removal Alternative, deconstruction of Copco No. 1 and Iron Gate dams and associated facilities, and construction of upstream and downstream fish passage facilities and a new day use area near Copco No. 2 Dam would occur, and thus the level of overall construction activities in the Hydroelectric Reach in California would be only slightly less than those described under the Proposed Project. Therefore, in general the Two Dam Removal Alternative would have slightly less short-term potential impacts on vegetation communities, culturally significant species, special status species, wildlife corridors and habitat connectivity, as those described for the Proposed Project (see Section 3.5.5 *[Terrestrial Resources] Potential Impacts and Mitigation*). The mitigation measures and recommended terrestrial measures would be the same as those identified for the Proposed Project. Implementation of Mitigation Measures TER-2, TER-3, TER-6, and TER-7 would reduce construction-related impacts, including in-water work, on all special-status amphibian species, gray wolf, and bald and golden eagles to less than significant. There could be impacts on wetlands during activities associated with fish ladder construction in the absence of a wetland delineation; implementation of Mitigation Measure TER-5 described in Section 4.4.5 short and long-term impacts on wetland communities would be reduced to less than significant. Long-term potential impacts and any short-term potential impacts that would be different under the Two Dam Removal Alternative than the Proposed Project are discussed below.

In the long term, since Copco No. 2 Dam and Reservoir would remain under the Two Dam Removal Alternative, the reduction of ~~existing wet habitat that currently supports the following~~ wetland vegetation communities would not occur ~~and there would be no significant impact compared with existing conditions:~~

- ~~Palustrine Scrub-shrub Wetland and Palustrine Forested Wetland on the southern slope of Copco No. 2 Dam.~~
- ~~• Small, local patches of Palustrine Emergent Wetland supported by water leaks from the Copco No. 2 penstock.~~

While retaining the existing wetland habitat at Copco No. 2 Reservoir would reduce potential long-term impacts to these wetland and riparian vegetation communities described under the Proposed Project and thus may be relatively beneficial, the proposed acreage (~~150~~182 acres) for restored riparian and wetland vegetation under the Proposed Project is well above the total acreage that would potentially be impacted (~~68 acres~~ approximately 10.2 acres of riparian vegetation and 9.6 acres of wetlands due to the removal of Iron Gate Reservoir), such that ~~the~~ there would be ~~policy of~~ no net loss of wetlands compared with existing conditions ~~would be achieved~~ under the Proposed Project, regardless of whether the Copco No. 2 Dam remains under the Two Dam Removal Alternative.

In summary, relative to existing conditions, the potential long-term impacts of the Two Dam Removal Alternative on terrestrial resources would be different from those described for the Proposed Project, as follows:

- Long-term reduction of existing wet habitat that supports the ~~aforementioned~~ wetland vegetation communities associated with ~~on the southern slope of~~ Copco No. 2 Dam ~~and associated with the Copco No. 2 penstock (Potential Impact 3.5-2)~~ would not occur and there would be no significant impact.
- Long-term disturbance of potentially suitable rock talus habitat for the terrestrial invertebrates Oregon shoulderband, Trinity shoulderband, Siskiyou shoulderband, and Tehama chaparral located just downstream of Copco No. 2 Dam (Potential Impact 3.5-9) would not occur and there would be no significant impact.
- Long-term impacts to small day roosts and large maternity colonies in or near the Copco No. 2 Powerhouse and other Copco No. 2 facility structures (Potential Impact 3.5-15) would not occur and there would be no significant impact.

4.5.12 Historical and Tribal Cultural Resources

Volume I Section 4.5.12 Alternatives – Two Dam Removal Alternative – Historical Resources and Tribal Cultural Resources, paragraph 2 on page 4-235:

Copco No. 1 and Iron Gate dams would be removed under this alternative and potential impacts to the built environment and historic-period archaeological resources (Potential Impacts 3.12-11 through 3.12-16) and tribal cultural resources (Potential Impacts 3.12-1 through 3.12-8) would be the same as those described for the Proposed Project and would be significant and unavoidable. However, under the Two Dam Removal Alternative, the Copco No. 2 facility, which contributes to the Klamath Hydroelectric Historic District 214, would not be removed and direct impacts to the historical significance of its structures and hydroelectric facilities (e.g., wooden-stave penstock) would not occur (Potential Impact 3.12-11). Installation of upstream and downstream fish passage at Copco No. 2 dam, including all associated construction activities, may impact Copco No. 2 Dam and its associated facilities, and combined with the removal of Copco No. 1 and Iron Gate facilities, the Two Dam Alternative could possibly affect the overall integrity of the Klamath Hydroelectric Historic District. This would be a significant and unavoidable impact for the reasons described under the Proposed Project (Potential Impact 3.12-11). Direct impacts to historic-period archaeological resources due to the construction of upstream and downstream fish passage at Copco No. 2 dam and a new day use area near Copco No. 2 Dam would also result in significant and unavoidable impacts for the reasons described under the Proposed Project (Potential Impact 3.12-12 through 3.12-16).

Section 4.5.12 Alternatives – Two Dam Removal Alternative – Historical and Tribal Cultural Resources, paragraph 1 on page 4-236:

Leaving Copco No. 2 Dam, Copco No. 2 Powerhouse, and the powerhouse penstocks in place under the Two Dam Removal would potentially avoid disturbance-related impacts to two known tribal cultural resources, and potentially additional unknown tribal cultural resources, ~~reduce impacts to known, or as yet unknown, tribal cultural resources~~ located within the footprint of Copco No. 2 reservoir and its associated hydroelectric facilities. However, installation of upstream and downstream fish passage at Copco No. 2 dam and a new day use area near Copco No. 2 Dam, including all associated construction activities, may impact known, or as yet unknown, tribal cultural resources to a similar degree as that described for the Proposed Project. For this reason, and because Copco No. 1 and Iron Gate dams would be removed under this alternative as described for the Proposed Project, potential impacts to tribal cultural resources (Potential Impacts 3.12-1 through 3.12-8) would be the same as those described for the Proposed Project. Implementation of Mitigation Measures TCR-1 through TCR-8 would reduce impacts to tribal cultural resources, but for the reasons described under the Proposed Project, the impacts would remain significant and unavoidable.

4.5.17 Public Services

Volume I Section 4.5.17 Alternatives – Two Dam Removal Alternative – Public Services, paragraph 1 on page 4-237:

For reasons described for the Proposed Project, removal of the two largest California dams under this alternative would still result in significant impacts due to short-term increased response times for emergency fire, police, and medical services (Potential Impact 3.17-1)~~.~~, and implementation of Mitigation Measure HZ-1 and Mitigation Measure TR-1 would reduce impacts to a less than significant level. ~~In addition, the KRRC is developing a Traffic Management Plan to identify mitigation and other protective measures that would be implemented to reduce impacts to public services. It would also be appropriate for the final Traffic Management Plan to include Recommended Measure TR-1. Overseeing development and implementation of the Traffic Management Plan does not fall within the scope of the State Water Board's water quality certification authority. While the State Water Board expects that this plan will be finalized and implemented, at this time the plan is not finalized, and the State Water Board cannot require its implementation. Accordingly, while the State Water Board anticipates that implementation of Mitigation Measure HZ-1 would reduce impacts to public services, because it cannot require implementation of Recommended Measure TR-1, it is analyzing the impacts under this alternative as significant and unavoidable.~~

4.5.19 Aesthetics

Volume I Section 4.5.19 Alternatives – Two Dam Removal Alternative – Aesthetics, paragraphs 1 and 2 on page 4-240:

Under the Two Dam Removal Alternative, the Copco No. 2 facilities would not be removed and installation of new upstream and downstream fish passage at Copco No. 2 Dam, including all associated construction activities, would occur. ~~However, due to the small size of the Copco No. 2 facilities, their inaccessibility to the public, and the fact that they are already inconsistent with the area VRM classification, this would not change the significance determination.~~ Construction of the new infrastructure to support fish passage would occur near and potentially directly adjacent to the existing infrastructure such that there would be no long-term (permanent) visual changes for key observation points C3, C4, and C5; Table 3.19-3 and Figure 3.19-2 in Volume III Attachment 1 Section 3.19.5 *Aesthetics – Potential Impacts and Mitigation*) (Potential Impact 3.19-5). The construction of new infrastructure to support fish passage under the Continued Operations with Fish Passage Alternative would not cause the VRM class to be degraded at a key observation point, would not adversely impact a scenic vista for those areas that were not assigned a VRM class, and would not result in a significant long-term (permanent) impact.

Visual changes due to removal of Copco No. 1 and Iron Gate dams and facilities (Potential Impact 3.19-5), construction activities (Potential Impact 3.19-6) including fishway construction at Copco No. 2 Dam, would be the same as those of the Proposed Project since the manner of dam deconstruction for these two relatively large facilities would be the same under the Two Dam Removal Alternative; impacts would be less than significant. Similarly, impacts to nighttime views from construction lighting would be significant and unavoidable as under the Proposed Project (Potential Impact 3.19-7).

4.5.22 Transportation and Traffic

Volume I Section 4.5.22 Alternatives – Two Dam Removal Alternative – Transportation and Traffic, paragraph 1 on page 4-244:

As described in Section 3.22.5 *[Transportation and Traffic] Potential Impacts and Mitigation*, the Proposed Project would result in significant ~~and unavoidable~~ short-term impacts to traffic flow, road safety, road conditions, emergency access, public transit, and non-motorized transportation. Implementation of Mitigation Measure TR-1 would reduce these impacts to a less than significant level (Potential Impacts 3.22-1 through 3.22-5). ~~, unless and until KRRC reaches enforceable 'good citizen' agreements that are finalized and implemented through the FERC process and that include proposed items for the final Traffic Management Plan and Emergency Response Plan (Appendix B: *Definite Plan – Appendices O1 through O4*), as well as the additional components included in~~

~~Recommended Measure TR-1 (Potential Impacts 3.22-1 through 3.22-5). Because the level of overall construction activities and impacts to transportation and traffic in California would be only slightly less than those described under the Proposed Project, the Two Dam Removal would also result in significant and unavoidable short-term impacts to the aforementioned traffic- and transportation-related activities and would require similarly enforceable 'good citizen' agreements to reduce impacts to less than significant, as described for the Proposed Project.~~

Volume I Section 4.5.22 Alternatives – Two Dam Removal Alternative – Transportation and Traffic, paragraph 3 on page 4-244 through paragraph 1 on page 4-245:

As described previously, fish passage under the Two Dam Removal Alternative would either be provided by volitional fishways, or trap and haul, or some combination. Facility construction, and thus any related potential transportation and traffic impacts (Potential Impacts 3.22.5-1 through 3.22.5-5) for trap and haul would be less than that described above for fish ladders.

Potential Impact 4.4.22-1 Trap and haul operational traffic could potentially result in a substantial increase in traffic in excess of the capacity or design of the road improvements or impairs the safety or performance of the circulation system, including transit, roadways, bicycle lanes and pedestrian paths, or otherwise result in an increased risk of harm to the public due to an increase in traffic.

Long-term (ongoing) trap and haul operations would consist of trapping adult upstream migrants downstream of Copco No. 2 Dam and releasing them in J.C. Boyle Reservoir as an ongoing activity. Similarly, downstream migrating smolts would be trapped at J.C. Boyle Reservoir, and released downstream of Copco No. 2 Dam. Roads within the traffic and transportation Area of Analysis currently carry substantially fewer vehicles than the planning capacity (Table 3.22-2 and Section 3.22.2.1*Traffic Flow*), such that additional truck trips, assuming both upstream and downstream trap and haul operations, would not substantially change traffic conditions. Although the exact extent and timing of these ongoing hauling activities is not known, it is unlikely that more than ten truck trips per day would be necessary, including a conservative assumption of round trip (i.e., upstream and downstream) hauling for 30 to 40 miles each way between Copco No. 2 Dam and J.C. Boyle Reservoir. Therefore, long-term (ongoing) trap and haul traffic would be a less than significant impact.

Significance

No significant impact in the long term

4.5.23 Noise

Volume I Section 4.5.23 Alternatives – Two Dam Removal Alternative – Noise – Potential Impact 4.5-1 Trap and haul-related noise, Section header on page 4-245:

Potential Impact 4.5-~~1~~23-1 Trap and haul-related noise.

4.6 Three Dam Removal Alternative

4.6.1 Introduction

Volume I Section 4.6.1.1 Alternatives – Three Dam Removal Alternative – Introduction – Alternative Description, paragraph 1, bullet 1, and paragraph 2, on page 4-248:

The following conditions under the Three Dam Removal Alternative are a modification to the 2012 KHSA EIS/EIR *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*:

- Flows specified in the NMFS and USFWS 2013 BiOp for the USBR Klamath Irrigation Project~~, which are currently being considered under reinitiated consultation~~ (see also 3.1.6.1 *Klamath River Flows under the Klamath Irrigation Project's 2013 BiOp* [as revised in Volume III Attachment 1 Section 3.1.6]).

As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* (as revised in Volume III Attachment 1 Section 3.1.6), 2017 court-ordered flushing and emergency dilution flows ~~are~~ were required to be released from Iron Gate Dam during the period February 2017 – March 2019 as part of re-initiation of consultation on the 2013 BiOp Flows, but they ~~are~~ were not modeled as part of existing conditions hydrology. The 2019 BiOp Flows are now the current operational flow requirement for the Klamath River (USFWS 2019, NMFS 2019) thus they would represent hydrology moving forward under the Three Dam Removal Alternative. ~~Potential new BiOp flow requirements under this alternative are speculative at this time, and it is not clear whether flushing and emergency dilution flow requirements would continue under the new BiOp during or after dam removal. However, the 2017 flow requirements are considered to be the most reasonable assumption for conditions until agency formal consultation is completed and a new BiOp is issued.~~ For analysis of potential impacts related to fish disease, the Three Dam Removal Alternative considers conditions with and without 2017 court-ordered flushing and emergency dilution flows and with the 2019 BiOp flushing flows (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* [(as revised in Volume III Attachment 1 Section 3.1.6]).

4.6.3 Aquatic Resources

Volume I Section 4.6.3.3 Alternatives – Three Dam Removal Alternative – Aquatic Resources – Water Quality, paragraph 4 on page 4-267:

~~California~~ For the reasons discussed below, potential impacts of water quality on aquatic resources in California would be the same under the Three Dam Removal Alternative as those described for the Proposed Project (see also Section 3.3.5.3 *Water Quality*).

Volume I Section 4.6.3.4 Alternatives – Three Dam Removal Alternative – Aquatic Resources – Fish Disease and Parasites, paragraph 4 on page 4-268:

As described in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* (as revised in Volume III Attachment 1 Section 3.1.6), 2017 court-ordered flushing and emergency dilution flows ~~are~~ were required to be released from Iron Gate Dam during the period February 2017 – March 2019 as part of re-initiation of consultation on the 2013 BiOp Flows, but they ~~are~~ were not modeled as part of existing conditions hydrology. The 2019 BiOp Flows are now the current operational flow requirement for the Klamath River (USFWS 2019, NMFS 2019) thus they would represent hydrology moving forward under the Three Dam Removal Alternative. Under the Three Dam Removal Alternative, it is anticipated that the nidus would no longer form downstream of Iron Gate Dam, and the risk of a new nidus forming upstream is low, even in the absence of the 2017 flushing flow and emergency dilution requirements or the 2019 BiOp surface flushing flows (see also Section 3.3.5.5 *Fish Disease and Parasites*). Although the conditions leading to a reach that would exhibit the highest infectivity (nidus) for *C. shasta* and *P. minibicornis* downstream of Iron Gate Dam would be ameliorated once Copco No. 1 and Iron Gate dams are removed, some disease factors would continue under the Three Dam Removal Alternative, including eight years of additional Iron Gate Hatchery operations potentially resulting in continued (through post-dam removal year 10) congregations of mostly adult fall-run Chinook salmon in the reach from Iron Gate Dam to Seiad Valley (see also Section 3.3.5.6 *Fish Hatcheries*). Under the Three Dam Removal Alternative, if a nidus were to remain in the vicinity of Iron Gate Hatchery, or theoretically were to form within newly accessible upstream habitat such as the reach immediately downstream of Copco No. 2 or J.C. Boyle dam where future fish passage facility entrances would be located, flushing and emergency dilution flows as required by the 2017 court order, or the 2019 BiOp, may be required from a new upstream location to achieve the same ecological benefits (i.e., disruption of nidus).

Volume I Section 4.6.3.8 Alternatives – Three Dam Removal Alternative – Aquatic Resources – Fish Passage – Potential Impact 3.3-14, paragraph 1 on page 4-283:

Therefore, for those individuals upstream of Copco No. 1, despite the relatively small volume of sediment stored in J.C. Boyle Reservoir, impacts of sediment release on redband trout ~~that would occur~~ would be less under the Three Dam Removal Alternative ~~would be substantially less under~~ compared to the Proposed Project.

Volume I Section 4.6.3.8 Alternatives – Three Dam Removal Alternative – Aquatic Resources – Fish Passage – Potential Impact 3.3-14, paragraph 3 on page 4-283:

Based on a long-term substantial increase in redband trout habitat quality and quantity compared to existing conditions, the Three Dam Removal Alternative would be beneficial for redband trout in the long term.

Volume I Section 4.6.3.8 Alternatives – Three Dam Removal Alternative – Aquatic Resources – Fish Passage – Potential Impact 3.3-19, paragraph 2 on page 4-284:

~~Potential impacts on freshwater mollusks in California would be similar under the Two Dam Removal Alternative as those described for the Proposed Project (Section 3.3.5.9, Potential Impact 3.3-19), with a few subtle differences. As described in Section 4.5.3.1 *Suspended Sediment*, impacts on freshwater mollusks from sediment releases would be similar to the Proposed Project.~~ Based on the distribution of freshwater mollusks primarily downstream of Iron Gate dam (summarized in Section 3.3.5.9, Potential Impact 3.3-19~~3.3-14~~), the potential impacts of the Three Dam Removal Alternative ~~would~~ are expected to be similar to ~~the same as~~ those described for the Proposed Project (Section 3.3.5.9, Potential Impact 3.3-19~~3.3-14~~) with one exception. Under the Three Dam Removal Alternative, suitable habitat for floater mussels (*Anodonta spp.*) would remain within J.C. Boyle Reservoir and within a section of the Hydroelectric Reach downstream of J.C. Boyle Reservoir. ~~The Proposed Project would have the most substantial impact on the floater mussels (*Anodonta spp.*) which occur in the mainstem Klamath River in the Hydroelectric Reach, within Lower Klamath Project reservoirs, in a reach (<15 miles) directly downstream of Iron Gate Dam, and within the Upper Shasta River.~~ *Anodonta spp.* have been found in high abundance within J.C. Boyle Reservoir as recently as summer 2018 (Troy Brandt, River Design Group, pers. comm., November 2018). Therefore, under the Three Dam Removal Alternative the *Anodonta spp.* would remain unaffected within a portion of their range in J.C. Boyle Reservoir and Upper Shasta River. Therefore, while the impacts to other species of freshwater mollusks would be the same under the Proposed Project (not significant), impacts to the *Anodonta spp.* would be less substantial under the Three Dam Removal Alternative than under the Proposed Project. However, impacts to ~~the~~ *Anodonta spp.* would still occur under the Three Dam Removal Alternative in the mainstem Klamath River (primarily downstream of Iron Gate Dam) as described for the Proposed Project (Section 3.3.5.9, Potential Impact 3.3-19~~3.3-14~~), and without any protective measures, ~~based on~~ it is predicted that there would be a substantial short-term decrease in *Anodonta spp.* abundance of a year class, ~~there would be a significant impact to the *Anodonta spp.* population~~ under the ~~Proposed Project~~ Three Dam Removal Alternative. ~~in the short term.~~

~~However,~~ To reduce the potential short-term effects of sediment transport during dam removal on freshwater mussels, as described for the Proposed Project (Section 3.3.5.9, Potential Impact 3.3-19), the Three Dam Removal Alternative includes Aquatic Resource Measure AR-7 (Freshwater Mussels)~~to reduce the short-term effects of sediment transport during dam removal on *Anodonta spp.*, as described for the Proposed Project (Section 3.3.5.9, Potential Impact 3.3-14).~~ This measure includes ~~Under the Proposed Project this~~ salvage ~~and relocation plan~~ of freshwater mussels from the reach downstream of Iron Gate Dam and relocation at potential sites ~~would consider sites for translocation~~ located downstream from the Trinity River confluence (RM 43.4), and between J.C. Boyle Dam (RM 230.6) and Copco No. 1 Reservoir (RM 209.0). These areas would have less impact from increased SSCs but would not be completely protected from short-term effects. Under the Proposed Project, these ~~The~~ areas ~~downstream of the Trinity River confluence do not currently support *Anodonta spp.* and~~are unlikely to provide suitable habitat to support *Anodonta spp.* due to increased hydraulic variability from the loss of regulating reservoirs.~~in the future (Davis et al. 2013).~~ However, under the Three Dam Removal Alternative *Anodonta spp.* could be salvaged from the reach downstream of Iron Gate Dam and relocated to J.C. Boyle Reservoir and directly downstream of J.C. Boyle Reservoir, which does support suitable *Anodonta spp.* habitat. Therefore, with Aquatic Resource Measure AR-7, there would likely not be a substantial reduction in the abundance of *Anodonta spp.* species in the short term, and impacts would be not significant ~~with~~ for *Anodonta spp.* in the short term. No significant short-term impacts are expected for other freshwater mollusks under the Three Dam Removal Alternative. Deposition of sediment following dam removal resulting in short-term impacts to freshwater mollusks described above are predicted to be short in duration (< 1year). The re-formation of river channel that would occur following the removal of Iron Gate Dam is expected to have long term benefits for *Anodonta spp., M. falcata, G. angulate,* and freshwater clams by providing more suitable substrates (i.e., large gravel, cobble, and boulder) than currently exists, especially within the current reservoir reaches."

Volume I Section 4.6.3.8 Alternatives – Three Dam Removal Alternative – Aquatic Resources – Fish Passage – Potential Impact 3.3-19, paragraph 3 on page 4-284:

Therefore, with aquatic resource measure AR-7, there would likely not be a substantial reduction in the abundance of *Anodonta spp.* species in the short term, and impacts would be not significant ~~with for *Anodonta spp.*~~ in the short term~~.~~ No significant short-term impacts are expected for other freshwater mollusks under the Three Dam Removal Alternative. The reformation of river channel that would occur following the removal of Iron Gate Dam is expected to have long term benefits for *Anodonta spp., M. falcata, G. angulate,* and freshwater clams by providing more suitable substrates (i.e., large gravel, cobble, and boulder) than currently exists, especially within the current reservoir reaches.

4.6.5 Terrestrial Resources

Volume I Section 4.6.5 Alternatives – Three Dam Removal Alternative – Terrestrial Resources, paragraph 1 on page 4-290:

Relative to the Proposed Project, leaving the J.C. Boyle Dam and associated facilities in place would reduce overall construction activities related to dam removal. However, the Three Dam Removal Alternative also includes construction of a new fish ladder at J.C. Boyle Dam (and removal of the existing one within a similar footprint to the existing ladder). While there would potentially be less construction activities resulting in noise or habitat removal under this alternative than under the Proposed Project, the relative decrease in construction activities under the Three Dam Removal Alternative would not change the level of impacts to terrestrial resources in California since J.C. Boyle is located in Oregon. Thus, potential impacts on sensitive habitats (wetlands and riparian habitat), rare natural communities, culturally significant species, special-status species, wildlife corridors and habitat connectivity within the Primary Area of Analysis for terrestrial resources would be the same under the Three Dam Removal Alternative as those described for the Proposed Project (Potential Impacts 3.5-1 through 3.5-31) with the exception that there could be impacts on wetlands during activities associated with fish ladder construction in the absence of a wetland delineation; implementation of Mitigation Measure TER-5 described in Section 4.4.5 short and long-term impacts on wetland communities would be reduced to less than significant. Implementation of Mitigation Measures TER-2, TER-3, TER-6, and TER-7 would reduce construction-related impacts, including in-water work, on all special-status amphibian species, gray wolf, and bald and golden eagles to less than significant.

4.6.12 Historical and Tribal Cultural Resources

Volume I Section 4.6.12 Alternatives – Three Dam Removal Alternative – Historical Resources and Tribal Cultural Resources, paragraph 1 on page 4-294:

The potential for flood disturbance of known or unknown historical and/or tribal cultural resources located further downstream along the Klamath River would not be different under this alternative from that described for the Proposed Project (Potential Impact 3.12-3) since Copco No. 1, Copco No. 2, and Iron Gate dams would still be removed.

4.6.17 Public Services

Volume I Section 4.6.17 Alternatives – Three Dam Removal Alternative – Public Services, paragraph 1 on page 4-296:

Thus, for reasons described in Section 3.17.5 [Public Services] Potential Impacts and Mitigation, impacts and associated mitigation measures from increased public service response times for emergency fire, police, and medical services due to construction and demolition activities, elimination of a long-term water source for wildfire services substantially increasing the response time for suppressing wildfires, and potential effects on schools services and facilities would be the same under the Three Dam Removal Alternative as those described for the Proposed Project (Potential Impacts 3.17-1 through 3.17-3) ~~(Potential Impacts 3.5-1 through 3.5-3)~~.

4.6.21 Hazards and Hazardous Materials

Volume I Section 4.6.22 Alternatives – Three Dam Removal Alternative – Transportation and Traffic, paragraph 1 on page 4-299:

As described in Section 3.22.5 *[Transportation and Traffic] Potential Impacts and Mitigation*, the Proposed Project would result in significant ~~and unavoidable~~ short-term impacts to traffic flow, road safety, road conditions, emergency access, public transit, and non-motorized transportation. Implementation of Mitigation Measure TR-1 would reduce these impacts to a less than significant level (Potential Impacts 3.22-1 through 3.22-5).~~, unless and until KRRC reaches enforceable 'good citizen' agreements that are finalized and implemented through the FERC process and that include proposed items for the final TMP and Emergency Response Plan (Appendix B: *Definite Plan – Appendices O1 through O4*), as well as the additional components included in Recommended Measure TR-1 (Potential Impacts 3.22-1 through 3.22-5)~~. As described for the Proposed Project, the Lower Klamath Project dams are not located within two miles of an airport nor would their removal result in a change in air traffic patterns that would result in a substantial safety risks, regardless of whether J.C. Boyle Dam remains place, and there would be no significant impact (Potential Impact 3.22-6).

4.7 No Hatchery Alternative

4.7.1 Introduction

Volume I Section 4.7.1.1 Alternatives – No Hatchery Alternative – Introduction – Alternative Description, paragraph 2 on page 4-303:

Under the No Hatchery Alternative, the Fall Creek Hatchery would not reopen with upgraded facilities (e.g., renovated raceways, upgraded plumbing) for raising coho salmon and Chinook salmon. Construction of the settling pond would not be needed on Parcel B lands downstream of the Fall Creek Hatchery.

Water diversion from the PacifiCorp Fall Creek powerhouse return canal downstream of the City of Yreka's diversion facility at Fall Creek Dam ~~A~~ would not be needed. ~~As Fall Creek Hatchery is part of PacifiCorp's Klamath Hydroelectric Project No. 2082, the existing Fall Creek Hatchery facilities are subject to the terms of any new FERC action for Project No. 2082.~~ Accordingly, this alternative analysis assumes the status quo, i.e., that the Fall Creek Hatchery facilities would not be demolished or re-purposed.

4.7.3 Aquatic Resources

Volume I Section 4.7.3 Alternatives – No Hatchery Alternative – Aquatic Resources, paragraph 3 on page 4-305:

While the Proposed Project includes continued operation of Iron Gate Hatchery for eight years using flows diverted from Bogus Creek (Section 3.3.5.9, Potential Impact 3.3-23) and the reopening of Fall Creek Hatchery for eight years using flows diverted from Fall Creek (Section 3.3.5.9, Potential Impact 3.3-24), the No Hatchery Alternative does not include continued hatchery operations, and thus there would be no flow diversions from Bogus Creek or Fall Creek and no change relative to existing conditions. <u>Therefore, potential impacts 3.3-23 and 3.3-24 discussed for the Proposed Project do not pertain to the No Hatchery Alternative.</u>

4.7.4 Phytoplankton and Periphyton

Volume I Section 4.7.4 Alternatives – No Hatchery Alternative – Phytoplankton and Periphyton, paragraph 2 on page 4-313:

While Iron Gate Hatchery nutrient releases would decrease under the No Hatchery Alternative, the hatchery nutrient discharges are less-than-significant based on an analysis of the water quality impacts of California Department of Fish and Wildlife hatcheries, including Iron Gate Hatchery (ICF 2010) <u>(for more detail see Potential Impact 3.2-17),</u> and decreases in hatchery nutrient releases would not necessarily result in a beneficial effect on phytoplankton or periphyton conditions downstream of the hatchery discharge.

4.7.5 Terrestrial Resources

Volume I Section 4.7.5 Alternatives – No Hatchery Alternative – Terrestrial Resources, paragraph 2 on page 4-314:

Full removal of Iron Gate Hatchery under the No Hatchery Alternative would result in a similar degree of construction activities and associated impacts to terrestrial resources as the Iron Gate Hatchery modifications (i.e., relocation of fish trapping and holding facilities, relocation of the cold-water supply) and Fall Creek Hatchery upgrades are included under the Proposed Project. Further, not operating the hatcheries under this alternative would have no bearing on the anticipated long-term changes in terrestrial habitat that would result from removal of the Lower Klamath Project dams, reservoirs, and associated facilities. Therefore, the No Hatchery Alternative would have the same short-term and long-term potential impacts on vegetation communities, culturally significant species, special-status species, wildlife corridors, and habitat connectivity as those described for the Proposed Project (Potential Impacts 3.5-1 through 3.5-24 and 3.5-28 through 3.5-30). Implementation of Mitigation Measures TER-2, TER-3, TER-6, and TER-7 would reduce construction-related impacts, including in-water work, on all special-status amphibian species, gray wolf, and bald and golden eagles to less than significant.

4.7.7 Groundwater

Volume I Section 4.7.7 Alternatives – No Hatchery Alternative – Groundwater, paragraph 2 on page 4-316:

Removing Iron Gate Hatchery and not reopening Fall Creek Hatchery under the No Hatchery Alternative would have the same potential ~~not affect~~ effects on groundwater levels or wells immediately adjacent (potentially extending up to a mile from the reservoirs under certain conditions) to Copco No. 1 and Iron Gate reservoirs ~~relative to~~ as described for the Proposed Project. This is because the proposed diversions for both Iron Gate Hatchery (from Bogus Creek) and Fall Creek Hatchery (from Fall Creek) under the Proposed Project are non-consumptive and the proposed points of diversion and points of return are within several hundred feet of one another, with no groundwater wells located between these points (see location of “Fall Creek Dam” along Fall Creek in Figure 3.7-9 and hatchery area just downstream of Iron Gate Dam along Bogus Creek in Figure 3.7-10). ~~Therefore, t~~The groundwater impacts of the No Hatchery Alternative would be the same as those described for the Proposed Project (Potential Impacts 3.7-1 and 3.7-2) and there would be no significant impacts relative to existing conditions.

4.7.12 Historical and Tribal Cultural Resources

Section 4.7.12 Alternatives – No Hatchery Alternative – Historical and Tribal Cultural Resources, paragraph 4 on page 4-318:

Since the Iron Gate Hatchery would not be operated for eight years following dam removal, construction activities to convert two of the existing raceways to adult holding tanks, and construction of a new spawning facility within the portion of the Limits of Work containing the Iron Gate Hatchery footprint (Figure 2.7-4), would not occur. This level of construction would potentially avoid disturbance-related impacts to one known tribal cultural resource, and potentially additional unknown tribal cultural resources, that are located within the Iron Gate Hatchery footprint, which would mean fewer overall impacts to tribal cultural resources (Potential Impact 3.12-1) and historic-period archaeological resources (Potential Impact 3.12-12) under this alternative as compared with the Proposed Project

~~would be returned to more natural conditions In the short term, which would be beneficial relative to existing conditions and the Proposed Project~~. Further, since construction/upgrading activities would not occur at Fall Creek Hatchery, there would be no pre-dam removal construction activities (Potential Impact 3.12-1) at the Fall Creek site and thus no significant impacts to <u>one</u> known ~~or as yet~~ <u>and other potentially</u> unknown tribal cultural resources (Potential Impact 3.12-1) or historic-period archaeological resources (Potential Impact 3.12-12) relative to existing conditions, and fewer impacts relative to the Proposed Project.

4.7.16 Population and Housing

Volume I Section 4.7.16 Alternatives – No Hatchery Alternative – Population and Housing, paragraph 4 on page 4-320:

Full removal of Iron Gate Hatchery under the No Hatchery Alternative would result in a similar degree of construction activities and associated impacts related to population and housing as the Iron Gate Hatchery modifications (i.e., relocation of fish trapping and holding facilities, relocation of the cold-water supply) and Fall Creek Hatchery upgrades are included under the Proposed Project. Construction activities are the only part of the Proposed Project and this alternative that merit analysis for potential impacts on population and housing. This is <u>because the number of operational staff at the Iron Gate Hatchery under existing conditions, and the number of operational staff at the reopened Fall Creek Hatchery under the Proposed Project, are expected to be far less than the number of construction workers required during the majority of the two-year construction activity period (35-105) under the Proposed Project and this alternative. As noted in Potential Impact 3.16-1, there would be no significant impact of the relatively large number of construction workers under the Proposed Project due to the general availability of vacant units in the City of Yreka and the County, as a whole. Thus, eliminating the need for hatchery operational staff under this alternative would be inconsequential with respect to population and housing.</u> The number of construction workers in California would be the same as those described for the Proposed Project and would not result in a substantial influx of population (Potential Impact 3.16-1), nor would there be a need to displace existing residents or build replacement housing elsewhere (Potential Impact 3.16-2), and there would be no significant impacts relative to existing conditions.

4.7.17 Public Services

Volume I Section 4.7.17 Alternatives – No Hatchery Alternative – Public Services, paragraph 4 on page 4-320:

Thus, for reasons described in Section 3.17.5 *[Public Services] Potential Impacts and Mitigation*, impacts and associated mitigation measures from increased public service response times for emergency fire, police, and medical services due to construction and demolition activities, elimination of a long-term water source for wildfire services substantially increasing the response time for suppressing wildfires, and potential effects on schools services and facilities would be the same under the No Hatchery Alternative as those described for the Proposed Project (Potential Impacts 3.17-1 through 3.17-3) ~~(Potential Impacts 3.5-1 through 3.5-3)~~.

4.7.19 Aesthetics

Volume I Section 4.7.19 Alternatives – No Hatchery Alternative – Aesthetics, paragraphs 2 and 3 on page 4-321:

Under the No Hatchery Alternative, long-term (permanent) potential visual ~~changes~~ impacts resulting from the removal of the Lower Klamath Project dams and associated facilities would be the same as described for the Proposed Project (Potential Impact 3.19-5). This remains the case in spite of minor aesthetic differences from the Proposed Project ~~with the exception of~~ for the portions of the Limits of Work that contain the Iron Gate Hatchery (i.e., key observation points IG9, IG10, IG11, IG12; Table 3.19-3 and Figure 3.19-2 in Volume III Attachment 1 Section 3.19.5 *Aesthetics – Potential Impacts and Mitigation*) and Fall Creek Hatchery (i.e., key observation points FC2, FC3, FC4; Table 3.19-3 and Figure 3.19-2 in Volume III Attachment 1 Section 3.19.5 *Aesthetics – Potential Impacts and Mitigation*) footprints. The removal of Iron Gate Hatchery would not cause the VRM class to be degraded at a key observation point, would not adversely impact a scenic vista for those areas that were not assigned a VRM class, and would not result in a significant long-term (permanent) impact. The aesthetics of the Fall Creek Hatchery itself would remain unchanged from the baseline. ~~Since Iron Gate Hatchery would not be operated for eight years following dam removal, the portion of the Limits of Work containing the Iron Gate Hatchery footprint (Figure 2.7-13) would be returned to more natural conditions in the short term. This would be beneficial relative to existing conditions and the Proposed Project. Since construction/upgrading activities would not occur at the Fall Creek Hatchery, there would be no impact (no change from existing conditions) and a small reduction in short-term impacts on aesthetic resources for the portion of the Limits of Work containing the Fall Creek Hatchery footprint (Figure 2.7-15) relative to the Proposed Project.~~

Construction-related activities at Fall Creek Hatchery under this alternative would not occur, and would result in no change from existing conditions and would not be a significant impact. Other short-term (temporary) visual impacts of construction activities (Potential Impact 3.19-6) and nighttime views during short-term construction activities (Potential Impact 3.19-7) would be the same as those described for the Proposed Project.

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Volume I Section 4.8 [Alternatives References], pages 4-325 through 4-338, includes the following revisions:

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5 OTHER REQUIRED CEQA DISCUSSION AND CONSIDERATION OF SOCIAL AND ECONOMIC FACTORS

5.4 Social and Economic Factors Under CEQA

5.4.1 Consideration of Economic Information for Resources Potentially Affected by Dam Removal

Volume I Section 5.4.1.1 Other Required CEQA Discussion and Consideration of Social and Economic Factors – Social and Economic Factors Under CEQA – Consideration of Economic Information for Resources Potentially Affected by Dam Removal – Commercial Fishing, paragraph 2 on page 5:

Primarily using the EDRRA model, and dependent on the management area, dam and facilities removal was estimated by USBR (2012) to provide an additional 11 to 218 commercial fishing industry jobs within the five management areas (San Francisco Management Area Area—218; Fort Bragg Management Area—69; KMZ-CA—19; KMZ-OR—11; Central Oregon Management Area—136), an increase of labor income between $0.06 million to $2.56 million, and an economic output of $0.13 million to $6.6 million (all 42 to 43 percent increases) for commercial fishing compared with the status quo (see Table V-4 in NMFS 2012). The average annual increase in net revenue for all areas modeled with removal of the dams and associated facilities would be $7.296 million (43 percent increase), and ocean commercial fishery benefits for 2012 to 2061 were estimated to be $134.5 million (discounted to 2012 value). The KMZ-CA portion of this annual net revenue benefit was estimated to be $381,396 ~~$267,131~~ (2012 dollars).

Volume I Section 5.4.1.3 Other Required CEQA Discussion and Consideration of Social and Economic Factors – Social and Economic Factors Under CEQA – Consideration of Economic Information for Resources Potentially Affected by Dam Removal – Real Estate and Property Taxes, paragraph 3 on page 5-7:

USBR (2012) qualitatively assessed dam removal based on net economic benefits associated with various resources, and found that removal of the four dams and facilities could result in short-term declines in real estate values of parcels surrounding Copco 1 and Iron Gate reservoirs, which would be partially offset as the barren landscape is revegetated.

Volume I Section 5.4.1.3 Other Required CEQA Discussion and Consideration of Social and Economic Factors – Social and Economic Factors Under CEQA – Consideration of Economic Information for Resources Potentially Affected by Dam Removal – Real Estate and Property Taxes, paragraph 3 on page 5-7:

For other riverine parcels downstream of Iron Gate Dam, USBR (2012) indicated that detectable improvements of water quality could lead to increased real estate values in the long term.

5.5 References

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APPENDIX C. WATER QUALITY SUPPORTING TECHNICAL INFORMATION

After circulation of the Draft EIR, numerous additional comments were received regarding water quality (see Volume III), and changes to this appendix in response to those comments are flagged in the comment responses and then printed in this Final EIR Appendix C. None of the changes result in significant new information in the EIR under the meaning of CEQA Guidelines, section 15088.5, subdivision (a):

> New information added to an EIR is not 'significant' unless the EIR is changed in a way that deprives the public of a meaningful opportunity to comment upon a substantial adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect (including a feasible project alternative) that the project's proponents have declined to implement.

However, the changes were numerous enough that reprinting this appendix rather than simply including a list of revisions was warranted to improve clarity and readability of the document.

C.1 Water Temperature

C.1.1 Upper Klamath Basin

C.1.1.1 Keno Impoundment/Lake Ewauna

Water temperatures in much of the Upper Klamath River, including the reach from Link River Dam through the Keno Impoundment/Lake Ewauna, exceed 20°C (68°F) in June through August. The Keno Impoundment/Lake Ewauna experiences periods of intermittent, weak summertime stratification, however water temperatures are generally similar throughout the water column and are among the warmest in the Klamath Basin with peak values greater than 25°C (77°F). Weekly measurements in 2007 in the Link River and upper portion of the Keno Impoundment indicate maximum temperatures of 25°C (77°F) in mid-to-late summer (Deas and Vaughn 2006; Sullivan et al. 2008). Recorded average monthly temperatures for the period 2001 to 2004 in Keno Impoundment were 22.4°C (72.3°F) in July, 20.8°C (69.4°F) in August and 18.0°C (64.4°F) in September (FERC 2007). Average monthly temperatures reported by PacifiCorp downstream from Keno Dam for the same period were 23.2ºC (73.8ºF), 21.1ºC (70.0°F), and 16.9°C (62.4°F) during July, August, and September, respectively (FERC 2007). Similarly, during 2009, summer water temperatures downstream from Keno Dam were generally greater than 16°C (60.8°F) from June through September, with peak temperatures exceeding 26°C (78.8°F) in late-July (Watercourse Engineering, Inc. 2011a).

C.1.1.2 Hydroelectric Reach

The Hydroelectric Reach spans the Oregon–California state line from J.C. Boyle to Iron Gate Dam. During summer months, maximum weekly maximum temperatures (MWMTs) in the Hydroelectric Reach regularly exceed the range of chronic effects temperature thresholds (13 to 20ºC [55.4 to 68ºF]) for full salmonid support (North Coast Regional Board 2010; Kirk et al. 2010; Asarian and Kann 2011).

In general, water temperatures in this reach follow a seasonal pattern, with average monthly water temperatures from March through November ranging from just over 5°C (41°F) in November to more than 22°C (71.6°F) during June through August (FERC 2007). Winter water temperatures throughout the reach are largely driven by the temperature of river inflows (Deas and Orlob 1999). In the summer, the relatively shallow J.C. Boyle Reservoir does not exhibit long-term thermal stratification, with a typical vertical temperature difference of less than 2°C (3.6°F) in the water column (FERC 2007; Raymond 2008a, 2009a, 2010a), so the reservoir does not directly alter summertime water temperatures in reaches farther downstream (NRC 2004). However, current bypass operations at the J.C. Boyle Dam affect water temperatures in the river immediately downstream from the dam. While natural diel (24-hour) water temperature variations occur in the river, bypass operations between J.C. Boyle Dam (river mile [RM] 229.8) and the J.C. Boyle Powerhouse (RM 225.2) result in water temperatures that are typically cooler from May to September and warmer from November to March than ambient river temperatures upstream or downstream (PacifiCorp 2004b). In the J.C. Boyle Bypass Reach downstream from J.C. Boyle Dam, at approximately RM 225.8, water from cold groundwater springs enters the river at a relatively constant 11 to 12°C (51.8 to 53.6°F). Decreases in the daily water temperature (i.e., cooler water temperature than upstream of J.C. Boyle Reservoir) and the range of daily water temperature variations occur in the J.C. Boyle Bypass Reach during the summer/fall when daily peaking operations at J.C. Boyle Powerhouse (RM 225.2) divert warmer reservoir discharges around the J.C. Boyle Bypass Reach (see also Section 2.3.1 *J.C. Boyle Dam Development*) and leave the cold groundwater springs to dominate the river flow. Water temperatures in the J.C. Boyle Bypass Reach can decrease by 9 to 27°F when bypass operations are underway due to the influence of the springs (Kirk et al. 2010). In the J.C. Boyle Peaking Reach, downstream of the J.C. Boyle Bypass Reach, the flow diverted around the J.C. Boyle Bypass Reach rejoins the Klamath River at the J.C. Boyle Powerhouse (see Figure 2.3-1). The cooler, spring-influenced river exiting the J.C. Boyle Bypass Reach mixes rapidly with the warmer water discharged from the J.C. Boyle Powerhouse that can exceed 25°C (77°F) in July and August (Kirk et al. 2010). At the upstream end of the J.C. Boyle Peaking Reach, the natural, cold groundwater input from the J.C. Boyle Bypass Reach, combined with fluctuations in river flow due to hydroelectric power operations in the J.C. Boyle Peaking Reach also produces an observed increase in daily water temperature range above the natural diel water temperature fluctuations (Kirk et al. 2010). For example, in 2002 daily water temperature in the J.C. Boyle Peaking Reach varied by approximately 3 to 13°F during hydroelectric power operations, while daily water temperature varied by approximately 1 to 2°F during non-peaking flows. Based on available data, the influence of the springs dominates water temperatures in this reach; for example, while daily variations in water temperature increased during peaking operations, water temperatures in the J.C. Boyle Peaking Reach still decreased by 9 to 16°F compared to upstream of J.C. Boyle Reservoir (PacifiCorp 2004b; FERC 2007).

Further downstream in the J.C. Boyle Peaking Reach, near the confluence of the Klamath River and Shovel Creek (Figure 2.2-3), there are natural hot springs that contribute flows to the mainstem river. The natural hot springs were not found to result in warming of the Klamath River based on two measurements made in November and December 2017. Water temperature data collected upstream and downstream of the confluence of the Klamath River and Shovel Creek showed a 1.4°F increase in the downstream direction during the November 2017 measurement, but a 0.2°F decrease during the December 2017 measurement (KRRC Recreation Technical Team 2018).

Within and downstream from Copco No. 1 Reservoir, spring, summer and fall temperatures in the Hydroelectric Reach are heavily influenced by the large thermal mass of the two deepest reservoirs, Copco No. 1 and Iron Gate reservoirs, and their seasonal stratification patterns. Spring temperatures are generally cooler than would be expected under natural conditions, and summer and fall temperatures are generally warmer (PacifiCorp 2004b; North Coast Regional Board 2010). Both Iron Gate and Copco No. 1 reservoirs thermally stratify beginning in April/May and do not mix again until October to December (Figure C-1, Table C-1) (Raymond 2008a, 2009a, 2010a; Asarian and Kann 2011). Water temperature data indicate thermal stratification in Copco No. 1 Reservoir begins about a month later and ends about a month earlier than stratification in Iron Gate Reservoir (Asarian and Kann 2011). The onset of spring/summer stratification and the timing of fall turnover in Iron Gate and Copco No. 1 Reservoirs are driven by meteorological conditions (Deas and Orlob 1999; Asarian and Kann 2011).

In 2015, PacifiCorp installed a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11. While the primary purpose of the curtain is to isolate surface waters that have high concentrations of blue-green algae (cyanobacteria) such that extensive summer and fall blooms are not readily released downstream to the Middle and Lower Klamath River, PacifiCorp reports that the curtain also provides a secondary benefit of isolating warmer surface waters and draws deeper cooler water for release to the Klamath River downstream of Iron Gate Dam (PacifiCorp 2016a, 2017a, 2018). Results from the intake barrier/thermal curtain studies indicate that modest 1 to 2°C (1.8 to 3.6°F) water temperature improvement is possible (PacifiCorp 2016a, 2017a), although data do not indicate that this measure could achieve compliance with the Thermal Plan or to meet the Klamath River TMDLs temperature requirement in the Middle Klamath River (North Coast Regional Board 2010). Additionally, water temperature improvements from operation of the intake barrier/thermal curtain would be potentially limited by the need to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards, with the curtain completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018).

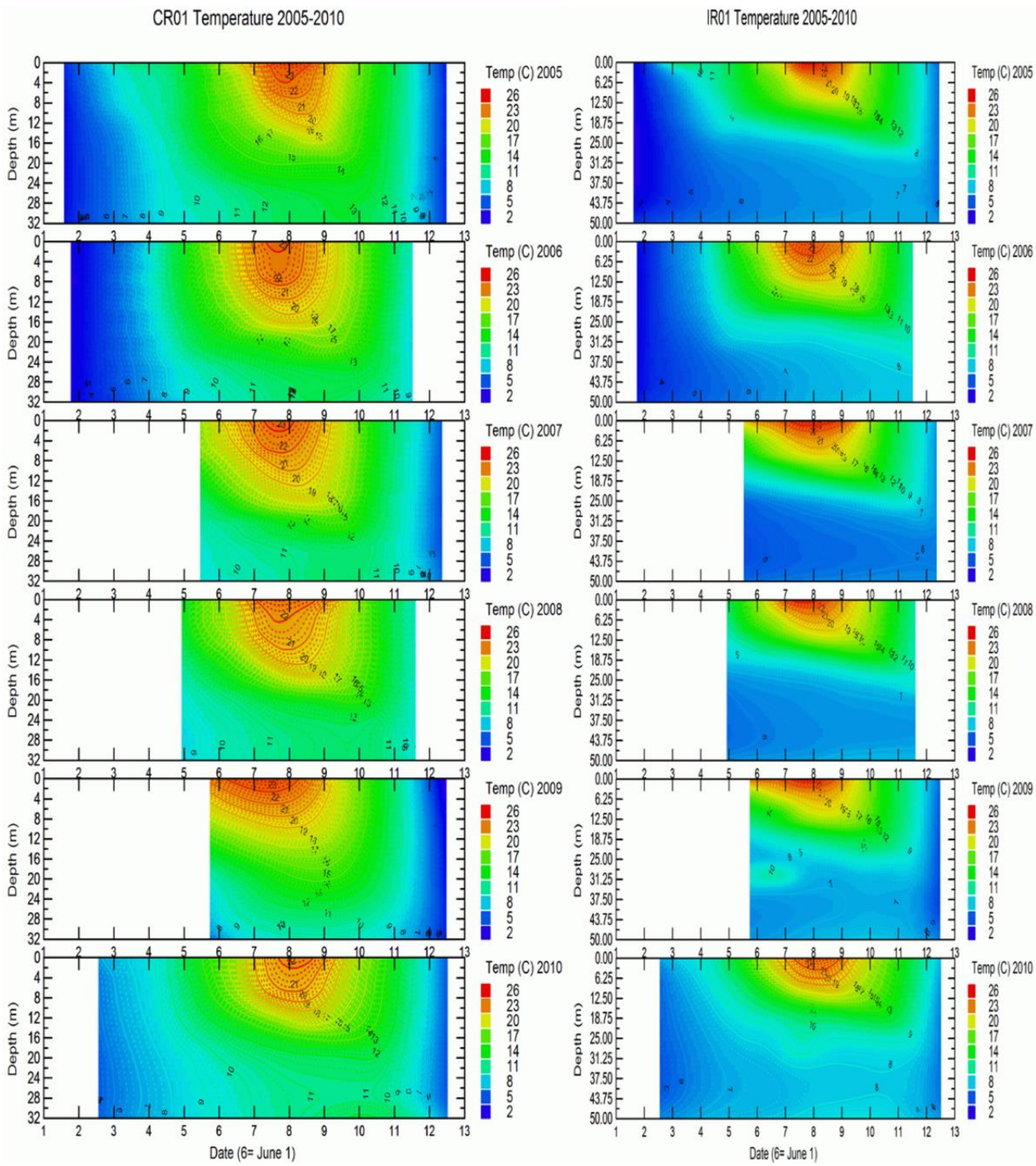

Figure C-1. Depth-time Distribution of Isopleths of Water Temperature at Station CR01 in Copco No. 1 Reservoir and IR01 in Iron Gate Reservoir from January 2005 to December 2010. Source: Asarian and Kann 2011.

Table C-1. General Reservoir Turnover Dates for Copco No. 1 and Iron Gate Reservoirs (2007 to 2009).

Year	Thermally Stable Hypolimnion Establishment Date		Approximate Reservoir Turnover Date		Source
	Copco	Iron Gate	Copco	Iron Gate	
2007	By June 6	By June 6	Before October 23	Before November 28	Raymond 2008a
2008	By April 30	By April 30	Before October 22	Before November 19	Raymond 2009a
2009	By May 24	By May 24	Before October 13	Before November 17	Raymond 2010a

Powerhouse withdrawals for Copco No. 1 and Iron Gate dams are primarily from the epilimnion (surface water). The depth of the epilimnion changes over time based on the season and characteristics of each reservoir. The depth of the thermocline (metalimnion) separating the epilimnion (surface waters) from the hypolimnion (bottom waters) is approximately 50 feet below the water surface in both Copco No. 1 and Iron Gate reservoirs by mid-summer when thermal stratification is present in the reservoirs (FERC 2007). In Copco No. 1 Reservoir, powerhouse withdrawal is from approximately 9.8 m (32 ft) below the water surface when the reservoir is full (full pool). The design and operation of the Iron Gate Dam intake structure results in the water temperature in the Klamath River immediately downstream of Iron Gate Dam being similar (i.e., within a few degrees or less) to the water temperature measured approximately 10 to 30 feet below the surface of Iron Gate Reservoir near the dam (PacifiCorp 2004b; FERC 2007). Occasionally, withdrawals extend into the hypolimnion; for example, in Iron Gate Reservoir, the withdrawal envelope has been estimated to extend down to approximately 18 m (60 ft) in depth (Deas and Orlob 1999). After deployment of PacifiCorp's intake barrier/thermal curtain in Iron Gate Reservoir, the water temperature in the Klamath River immediately downstream of Iron Gate Dam was most similar to the water temperature measured approximately 16 feet below the surface of Iron Gate Reservoir (PacifiCorp 2017a).

Additionally, a small withdrawal (about 50 cfs) for the Iron Gate Hatchery occurs from the hypolimnion at Iron Gate Reservoir. In general, however, temperature in waters discharged from Copco No. 1 and Iron Gate reservoirs reflect the warmer temperatures of surface water (NRC 2004). Seasonal stratification of these two reservoirs also prevents mixing of waters within the water column and adversely affects dissolved oxygen concentrations, nutrient concentration (and speciation), and pH in bottom waters, limiting the potential for hypolimnetic cool water releases to the Mid- and Lower Klamath River (FERC 2007). The small relative volumes of the hypolimnions in Copco No. 1 and Iron Gate reservoirs also limit the potential for seasonal releases to decrease water temperatures in downstream river reaches. Since J.C. Boyle Reservoir does not exhibit long-term thermal stratification (i.e., it lacks a seasonal hypolimnion), there are no controllable actions that can be taken to cool water released from this waterbody (FERC 2007).

C.1.2 Mid- and Lower Klamath Basin

C.1.2.1 Iron Gate Dam to Salmon River

Water temperature in the Lower Klamath Basin varies seasonally, with mean monthly temperatures in the river downstream from Iron Gate Dam ranging from 3 to 6°C (37 to 43°F) in January to 20 to 22.5°C (68 to 72.5°F) in July and August (Bartholow 2005; Karuk Tribe of California 2009, 2010a, 2010b, 2011, 2012, 2013; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; Asarian and Kann 2013). Water temperature increases with distance downstream from Iron Gate Dam due to meteorological controls (Basdekas and Deas 2007; Asarian and Kann 2013). The presence of the Lower Klamath Project exerts less influence on water temperatures farther downstream of Iron Gate Dam, so the Klamath River water temperature is more influenced by solar energy, the natural heating and cooling regime of ambient air temperatures, and tributary inputs of surface water. Based upon annual water temperature monitoring conducted by the Karuk Tribe, water temperatures peak during the summer when air temperatures increase and flows decrease in the Klamath Basin (Figure C-2; Karuk Tribe of California 2002, 2003, 2007, 2009, 2010a, 2010b, 2011, 2012, 2013). Figures C-2, C-3, C-4, C-5, and C-6 show the range of annual variability in daily average water temperature at several Klamath River locations downstream of Iron Gate Dam from 2006 to 2013. Daily average summer water temperatures regularly exceed 20°C during summer months near Seiad Valley, while daily average values documented immediately downstream from Iron Gate Dam are generally cooler and less variable. Daily average temperatures between June and September are between 1 to 6°C (1.8 to 10.8°F) higher near Seiad Valley than those just downstream from Iron Gate Dam (Figure C-2 to C-6; Karuk Tribe of California 2009, 2010a, 2010b, 2011, 2012, 2013). Water temperature modeling in the Klamath River indicates releases from Iron Gate Dam do not affect mainstem water temperature by the Salmon River (RM 66.3) (PacifiCorp 2005a, 2005b; Dunsmoor and Huntington 2006; North Coast Regional Board 2010; Perry et al. 2011; Risley et al. 2012).

Water temperature trends under the 2013 BiOp flows are consistent with measured water temperature between 2001 and 2012 (Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019; Asarian and Kann 2013). Water temperature trends under the 2019 BiOp Flows cannot be compared with those under the pre-2013 BiOp Flows and the 2013 BiOp Flows since water temperature data from the Klamath River, including KHSA IM 15 data, after the 2019 BiOp Flows became the applicable flow criteria (i.e., April 1, 2019) has not been reviewed and approved for distribution. Water temperature trends under the 2019 BiOp Flows are expected to be similar to those under 2013 BiOp Flows due to the similarities in 2019 BiOp Flows and 2013 BiOp Flows. An average of water temperature data from 2001 to 2011 at locations along the Klamath River shows that daily mean and daily maximum water temperature peaked between July and August with a maximum temperature of approximately 24°C (Figure C-7; Asarian and Kann 2013). A comparison of water temperature and flow measured in 2009 (Figure C-8) and 2015 (Figure C-9) demonstrates that water temperature downstream of Iron Gate Dam in 2015 peaked in July under 2013 BiOp minimum flows of 900 cfs (NMFS and USFWS 2013, Watercourse Engineering, Inc. 2016), similar to the water temperature downstream of Iron Gate Dam in 2009 which peaked between July and August under 2002 Biological Opinion minimum flows of 1,000 cfs (NMFS 2002; Watercourse Engineering, Inc. 2010). Similar water temperature trends are also observed in the Klamath River at Seiad Valley (Figures C-8 and C-9).

With respect to the longer term water temperature record (i.e., prior to 2000), Bartholow (2005) presents evidence that water temperatures in the lower Klamath River have been increasing since before 1950. Bartholow (2005) indicates that the observed multi-decade trend of increasing water temperatures in the lower river is related to the cyclic Pacific Decadal Oscillation and is consistent with a measured average basin wide air temperature increase of 0.33°C/decade (0.59°F/decade). Bartholow (2005) estimates that the season of high temperatures that are potentially stressful to salmonids has lengthened by about 1 month in the Klamath River since the early 1960s, and the average length of the lower river exhibiting summer water temperatures less than 15°C (59°F) has declined by about 8.2 km/decade (5.1 mi/decade). Potential climate change effects on water temperature are discussed in more detail as part of the effects determination for the No Project Alternative (see Section 3.2.4.3).

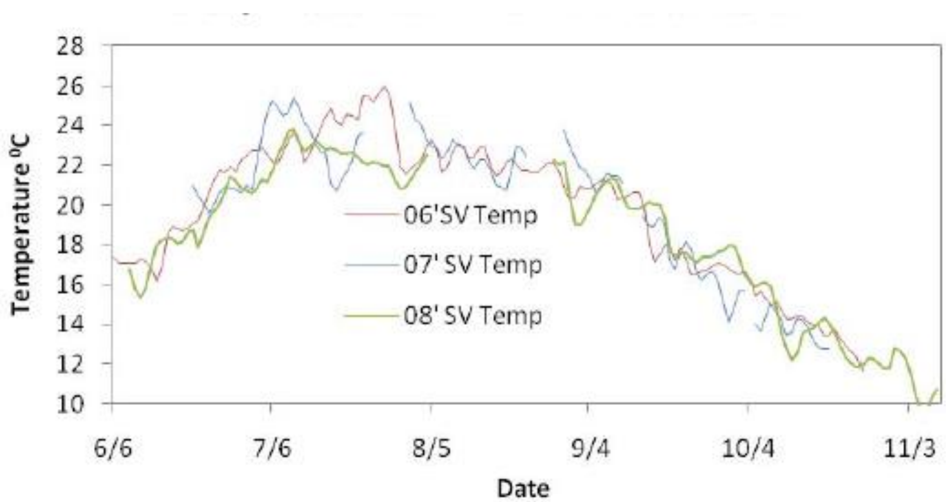

Figure C-2. Daily Average Water Temperature in the Klamath River near Seiad Valley (RM 132.7) June through November 2006, 2007, and 2008. Source: Karuk Tribe of California 2009.

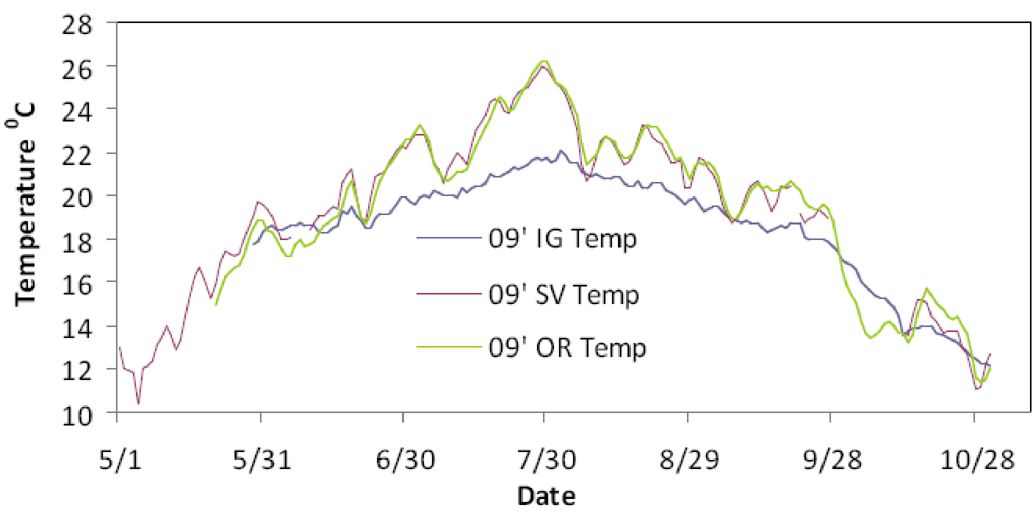

Figure C-3. Daily Average Water Temperature in the Klamath River Downstream from Iron Gate Dam (≈RM 193.1), near Seiad Valley (RM 132.7) and at Orleans (RM 58.9) During May through October 2009. Source: Karuk Tribe of California 2010a.

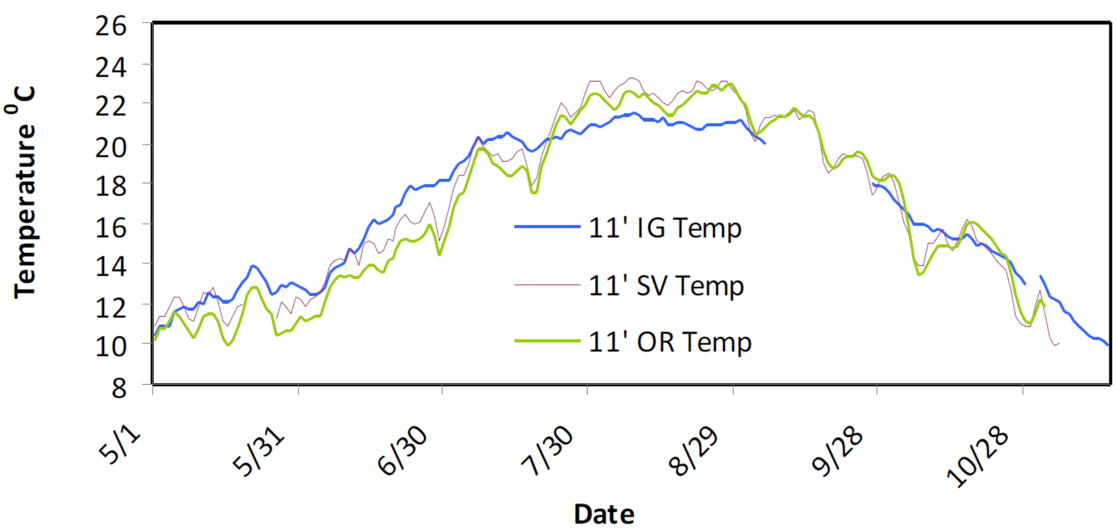

Figure C-4. Daily Average Water Temperature in the Klamath River Downstream from Iron Gate Dam (≈RM 193.1), near Seiad Valley (RM 132.7) and at Orleans (RM 58.9) During May through November 2011. Source: Karuk Tribe of California 2011.

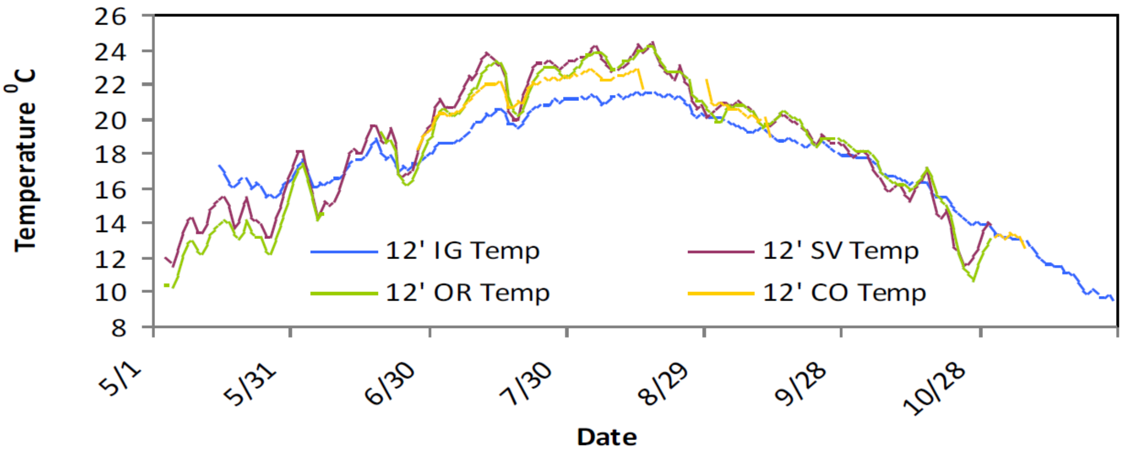

Figure C-5. Daily Average Water Temperature in the Klamath River Downstream from Iron Gate Dam (≈RM 193.1), near Colliers Rest Area/I-5 Bridge upstream of the Shasta River confluence (≈RM 179.5), near Seiad Valley (RM 132.7) and at Orleans (RM 58.9) During May through November 2012. Source: Karuk Tribe of California 2012.

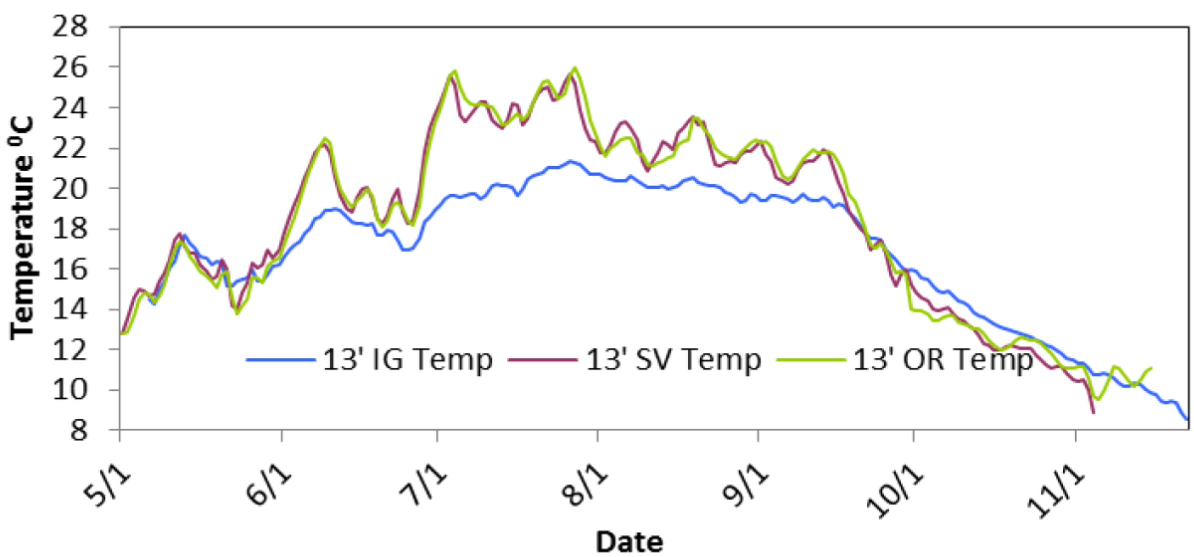

Figure C-6. Daily Average Water Temperature in the Klamath River Downstream from Iron Gate Dam (≈RM 193.1), near Seiad Valley (RM 132.7) and at Orleans (RM 58.9) During May through November 2013. Source: Karuk Tribe of California 2013.

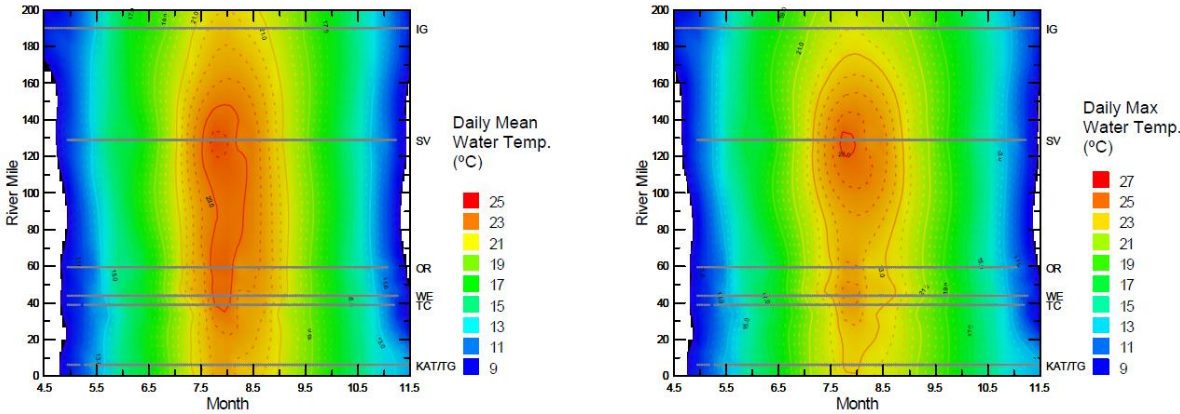

Figure C-7. Daily Mean and Daily Maximum Water Temperature in the Klamath River Downstream from Iron Gate Dam (≈RM 193.1) to the Klamath River at Turwar (≈RM 5.6) Averaged from 2001 to 2011 Data. Horizontal Grey Lines Indicate the Location and Time Period of Measurement in the Klamath River at Iron Gate (IG), Seiad Valley (SV), Orleans (OR), Weitchpec Upstream of the Trinity River (WE), Upstream of Tully Creek (TC), and Turwar (KAT/TG). Source: Asarian and Kann 2013.

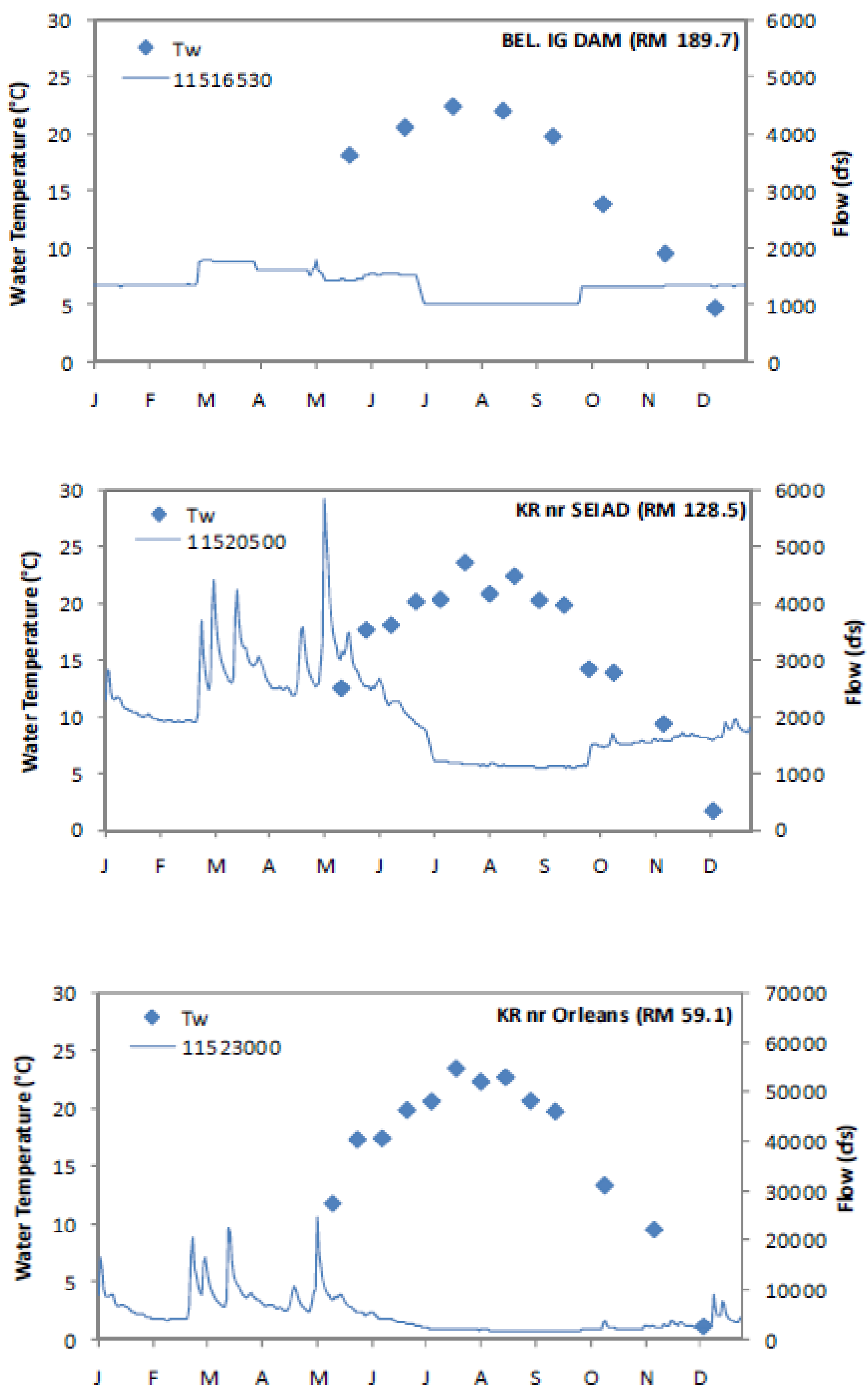

Figure C-8. Klamath River Water Temperature in 2009 During Monthly Water Quality Grab Samples and Flow at USGS Gage Stations (Station Number Listed in the Legend). Source: Watercourse Engineering, Inc. 2011a.

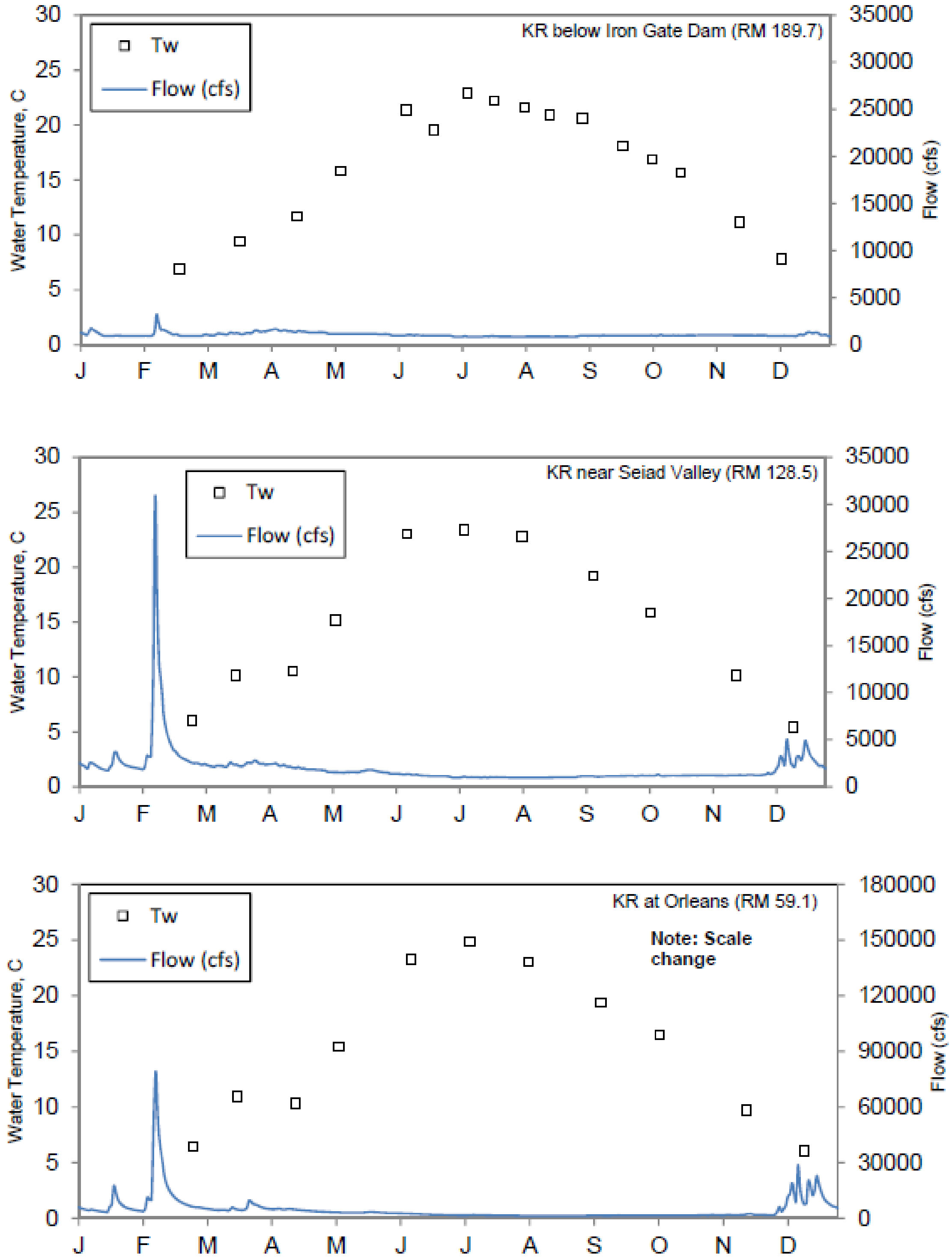

Figure C-9. Klamath River Water Temperature in 2015 During Monthly Water Quality Grab Samples and Flow at USGS Gage Stations. Source: Watercourse Engineering, Inc. 2016.

C.1.2.2 Salmon River to Estuary

Water temperature monitoring by the Karuk Tribe includes data from Orleans (RM 58.9), which is just downstream from the Salmon River confluence with the mainstem Klamath River. Daily average water temperature at Orleans was 10.5 to 26°C (50.9 to 78.8°F) from June through November 2006 to 2008, with the warmest temperatures generally occurring during July (Figure C-10; Karuk Tribe of California 2009). More contemporary data from 2009 to 2015 (Figures C-3 to C-9) further support these water temperature trends at Orleans (Karuk Tribe of California 2009, 2010a, 2010b, 2011, 2012, 2013; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; Asarian and Kann 2013). Asarian and Kann (2013) reports that average daily maximum water temperature between 2001 and 2011 is approximately 23°C to 24°C between July and August from the Salmon River (RM 66.3) to Turwar Creek (RM 5.6) (Figure C-7).

In the mainstem river between the Klamath River's confluence with the Trinity River and the Klamath River Estuary, the Yurok Tribe, through the Yurok Tribe Environmental Program (YTEP), has conducted annual water temperature monitoring since 2002 (YTEP 2004; Sinnott 2010a, 2011a, 2012a; Hanington 2013; Hanington and Ellien 2014). Between 2009 and 2013, peak temperatures generally occur in mid-July to mid-August with the highest daily maximum temperatures recorded at the most upstream locations (Sinnott 2010a, 2011a, 2012a; Hanington 2013; Hanington and Ellien 2014). The effect of the Trinity River on the mainstem Klamath River water temperature varied within individual years and between years. A small (0.5°C [0.9°F] or less) cooling effect was usually observed from the contribution of the Trinity River to the mainstem Klamath River between 2009 and 2011, but inflows from the Trinity River caused a 0.5°C (0.9°F) or less warming effect between mid-May and late June during 2010 and 2011 (Sinnott 2010a, 2011a, 2012a). During 2012 and 2013, inflows from the Trinity River usually altered water temperature in the Klamath River by 0.5°C (0.9°F) or less, but from mid-August to late September inflow from the Trinity River cooled Klamath River water temperature on average by approximately 1°C (Hanington 2013, Hanington and Ellien 2014). During May through November 2009, water temperatures ranged from approximately 11.1°C (52.0°F) in October to 26.8°C (80.2°F) in July (Sinnott 2010a). Similar trends were measured during 2013 with the lowest water temperature of 12.4°C (54.2°F) occurring in October while the highest water temperature of 26.4°C (79.4°F) occurred in July (Hanington and Ellien 2014). Between 2009 and 2013, the daily maximum summer water temperatures ranged from approximately 23.8 to 26.9°C (74.8 to 80.4°F) just upstream of the confluence with the Trinity River (Weitchpec [RM 43.3]), decreasing to approximately 23.4 to 24.9°C (74.1 to 76.8°F) near Turwar Creek (RM 5.6) (YTEP 2005; Sinnott 2010a, 2011a, 2012a; Hanington 2013; Hanington and Ellien 2014). Figure C-11 shows the upper range of the daily maximum water temperature which occurred in 2009, while Figure C-12 shows the lower range of the daily maximum water temperature which occurred in 2011 (Sinnott 2010a, 2012a). These summer temperatures exceed optimal growth thresholds as well as critical thermal maxima for coho, Chinook salmon, and steelhead (Brett 1952, Armour 1991, Stein et al. 1972, McGeer et al. 1991). Historically, summer water temperature maxima in the lower Klamath River have been greater than in other coastal rivers to the north and south. For example, Blakey (1966, as cited in Bartholow 2005), reports water temperatures in the Klamath River downstream from the Trinity River confluence (RM 43.3) reaching 26.6°C (79.9°F) for up to 10 days per year, in contrast to proximal coastal rivers that never reach this temperature.

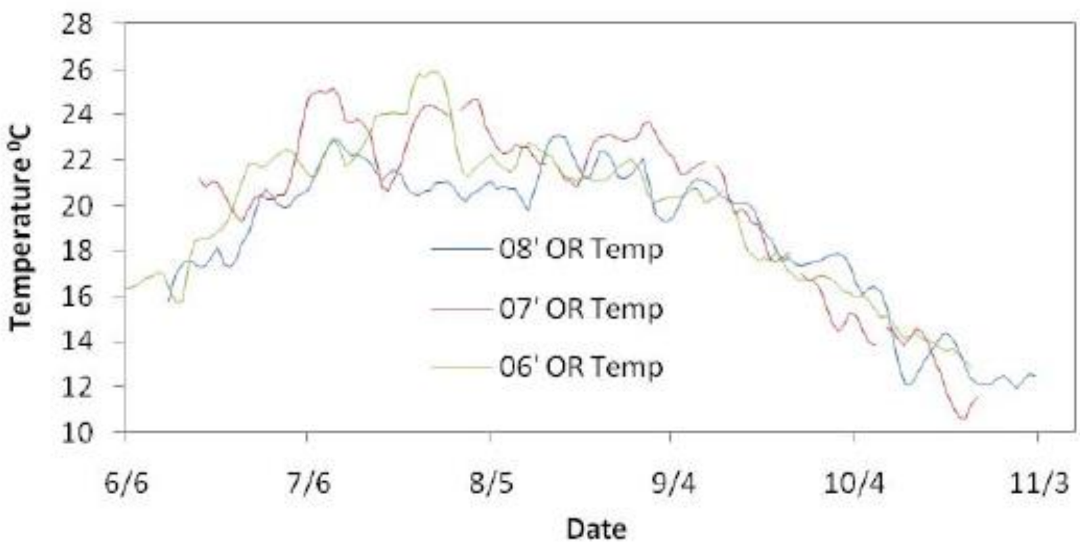

Figure C-10. Daily Average Water Temperature in the Klamath River at Orleans (RM 58.9) June through November 2006, 2007, and 2008. Source: Karuk Tribe of California 2009.

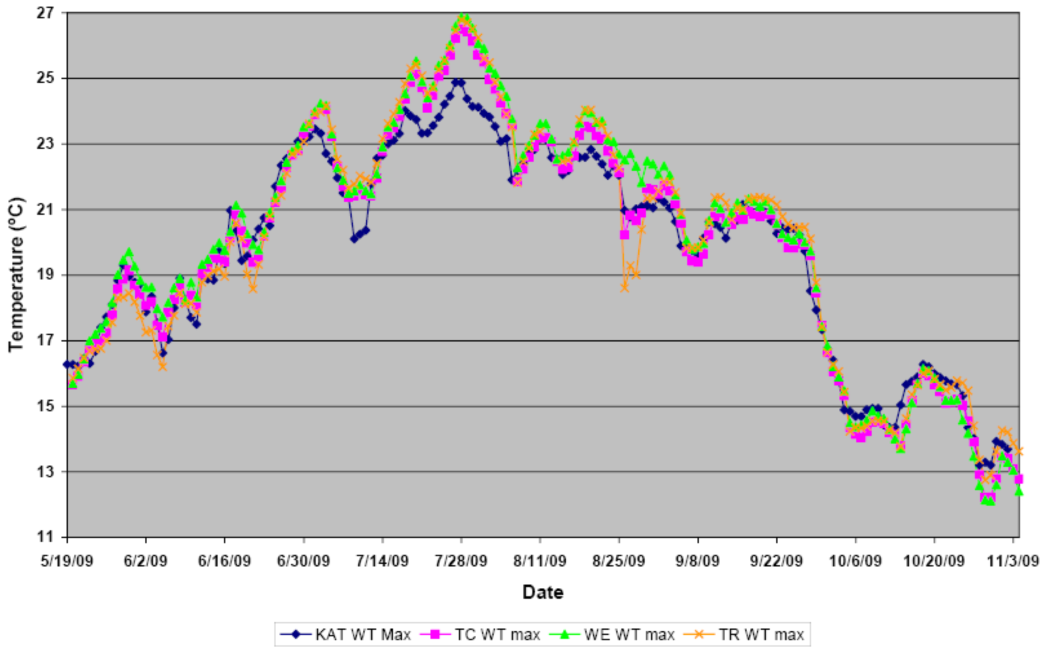

Figure C-11. Daily Maximum Water Temperatures in the Klamath River at Weitchpec (RM 43.6 [WE]), Upstream of Tully Creek (RM 40.1 [TC]), and Upstream of Turwar Boat Ramp (RM 6 [KAT]), as well as in the Trinity River (RM 43.3) near the Confluence with the Klamath River (RM 0.5 [TR]) May through November 2009. Source: Sinnott 2010a.

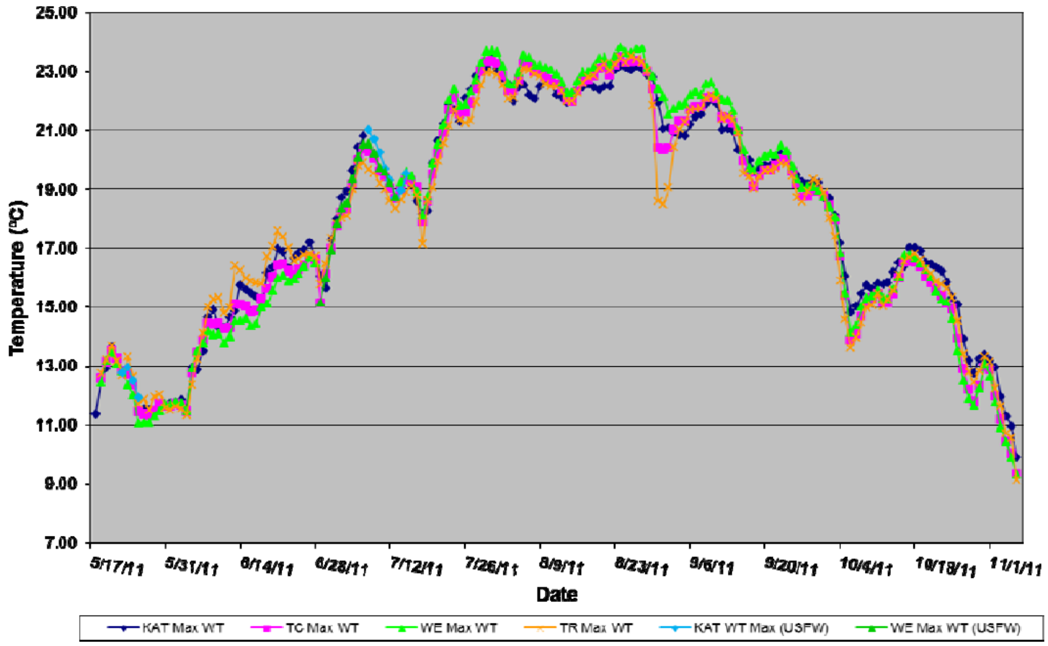

Figure C-12. Daily Maximum Water Temperatures in the Klamath River at Weitchpec (RM 43.6 [WE]), Upstream of Tully Creek (RM 40.1 [TC]), and Upstream of Turwar Boat Ramp (RM 6 [KAT]), well as in the Trinity River (RM 43.3) near the Confluence with the Klamath River (RM 0.5 [TR]), at Upstream of Turwar Boat Ramp from the U.S. Fish and Wildlife (RM 6 [KAT (USFW)]), and at Weitchpec from U.S. Fish and Wildlife (RM 43.6 [WE (USFW)]) May through November 2011. Source: Sinnott 2012a.

C.1.2.3 Klamath River Estuary

Hydrodynamics and water quality within the Klamath River Estuary are highly variable spatially and temporally and are greatly influenced by season, river flow, vertical water column stratification (thermal and/or chemical), and location of the estuary mouth, the latter changing due to periodic sand bar movement. Input of cool ocean water and meteorological conditions (e.g., solar radiation and coastal fog) along the coast minimizes extreme water temperatures much of the time (Scheiff and Zedonis 2011). Water temperature has been monitored in the Klamath River Estuary by California Department of Fish and Game (Wallace 1998) and most recently by the Yurok Tribe Fisheries Program (Hiner 2006) and the YTEP (2005), with support from the North Coast Regional Board. Water temperatures in the Klamath River Estuary from December through April are roughly 5 to 12°C (41 to 54°F) (Hiner 2006). In summer and fall months, warmer air temperatures and lower flows result in increased water temperatures. Under low-flow summertime conditions, water temperatures in the Klamath River Estuary have been observed at 20 to 24°C (68 to 75.2°F) (Wallace 1998) or greater than 24°C (75.2°F) (Hiner 2006). During June to September from 2009 to 2015, water temperatures during water quality grab samples ranged from approximately 13.1 to 21.9°C (55.6 to 71.4°F) (Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). These levels exceed optimal growth thresholds for salmonids, as cited in the previous section.

Estuarine water temperature is linked to upstream hydrology and periods of mouth closure because when the estuary mouth is open, denser salt water from the ocean sinks below the less dense fresh river water, resulting in chemical stratification and a "salt wedge" that moves up and down the estuary with the daily tides (Horne and Goldman 1994, Wallace 1998, Hiner 2006). The salt wedge is also thermally stratified with cooler, higher salinity ocean waters remaining near the estuary bottom, and warmer, lower salinity river water near the surface. Upstream hydrology can affect the location of the salt water wedge and thus, affect thermal structure in the Klamath River Estuary. For example, during pulse flows released from the Lewiston Dam on the Trinity River in August 2004, the upstream extent of the salt wedge moved downstream approximately one mile (YTEP 2005). In the Klamath River Estuary, mouth closure has been reported to reduce the size of the salt water wedge, decrease overall salinity, and subsequently increase water temperatures in the Klamath River Estuary (Hiner 2006). Mouth closure, caused by formation of a sand berm across the mouth of the Klamath River Estuary, is a function of off-shore and alongshore wave power and sediment supply, freshwater inflows, the tidal prism, and morphological characteristics of the inlet (Escoffier 1940; Brunn 1966; O'Brien 1971; Barnes 1980). The historical frequency and duration of mouth closure in the Klamath River Estuary has not been documented, although it is expected to occur during low-flow periods (June to October).

C.2 Suspended Sediments

For the purposes of the Lower Klamath Project EIR, "suspended sediments" refer to settleable suspended material in the water column. Bed materials, such as gravels and larger substrates, are discussed in Section 3.11.2.4 *Sediment Load*. Two types of suspended sediments are considered for the analysis in the Lower Klamath Project EIR: 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, Mid-, and Lower Klamath Basins.

Suspended sediments in the water column are quantified using different methods, depending on the study. Two standard methods widely used for determining the amount of suspended sediments in water are Method D 3977-97, which reports suspended sediments as suspended sediment concentrations (SSCs), and Method 2450 D, which reports the suspended sediments as total suspended solids (TSS) (Gray et al. 2000). While data produced by the SSC method are more representative of natural suspended sediments, SCC is considered equivalent to TSS for this report. SSC and TSS are generally similar (i.e., follow a 1:1 line of equal value), but TSS measurements tend to underestimate actual suspended material when the suspended material contains larger particles (i.e., sand-sized particles or greater) due to the TSS measurement methodology potentially underestimating larger particles that rapidly settle or clog measurement tools. SSC and TSS are more or less evenly distributed around the 1:1 line of equal value when particle sizes are smaller than 0.062 mm (i.e., silts or clays) and TSS is greater than approximately 5 mg/L. As needed, data from multiple sources, reported as either TSS or SSC, are used interchangeably for the Lower Klamath Project EIR, but TSS measurements may underestimate actual suspended material when sand-sized or larger particles comprise more than 25 percent of a sample mass (Gray et al. 2000).

Turbidity, an optical property referring to the amount of light scattered or absorbed by a fluid, is another common way to quantify suspended sediments and is measured in nephelometric turbidity units (NTUs). The exact relationship between turbidity and suspended sediment is dependent on the parent geology and must be determined for each watershed (Montgomery 1985; MacDonald et al. 1991). High suspended sediments in the water column affect organisms directly (e.g., interfering with vision) or indirectly by changing water temperature (e.g., suspended sediment particles absorb heat from sunlight) and reducing dissolved oxygen (DO) concentrations by scattering light and reducing photosynthetic activity. Suspended sediments are also a water quality concern because they are often associated with storing contaminants from the water column (e.g., polar organics and cationic metal forms). Municipal and domestic water supply beneficial uses can also be adversely affected by changes in suspended sediment concentrations and turbidity in streams.

For the Klamath River, coincident turbidity data is occasionally presented along with TSS data. However, as the dataset is not consistent in space or time, turbidity levels are not used to support significance determinations (see Section 3.2.4 *Impact Analysis Approach*) and are not analyzed in detail in the Lower Klamath Project EIR.

C.2.1 Upper Klamath Basin

C.2.1.1 Hydroelectric Reach

Suspended sediment generally decreases through the Hydroelectric Reach as suspended sediment from upstream is intercepted, decomposed, retained, or diluted between the J.C. Boyle and Copco No. 1 reservoirs. J.C. Boyle, Copco No.1, and Iron Gate reservoirs trap sediment and suspended material, reducing suspended sediment concentrations immediately downstream of their respective dams. Copco No. 2 Reservoir does not trap appreciable amounts of sediment or suspended material (USBR 2011) or reduce suspended sediment concentrations downstream of its dam, since the immediately upstream Copco No. 1 Dam traps upstream sediment and the relatively small volume of Copco No. 2 Reservoir (i.e., 70 acre-feet) prevents suspended material from settling out inside the reservoir. Organic suspended sediment originating from Upper Klamath Lake is the predominant form of suspended sediment entering the Hydroelectric Reach from upstream and affecting water quality (PacifiCorp 2004a, 2004b; Deas and Vaughn 2006; Watercourse Engineering, Inc. 2011). During the winter and spring (November through April), the reservoirs at the Lower Klamath Project intercept and retain inorganic suspended sediment delivered from tributaries (e.g., Shovel Creek, Fall Creek, Jenny Creek) to the reservoirs, where peak concentrations occur in association with high-flow events. While this may be somewhat beneficial for downstream reaches by decreasing suspended sediment concentrations and turbidity, the interception of inorganic sediments by the reservoirs does not appear to be an important mechanism related to sediment delivery in the mainstem Klamath River. This is because a relatively small (3.4 percent) fraction of total inorganic 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) (Stillwater Sciences 2010) and beneficial uses in the upper Klamath River are currently not impaired due to inorganic suspended material (see Section 3.2, Table 3.2-8).

During the phytoplankton[106] growth season (May through October), organic suspended sediments exhibit a general decreasing trend from upstream to downstream in the Hydroelectric Reach, although the relative decrease through this reach is less than that occurring further upstream where phytoplankton blooms (also called algal blooms) originating in Upper Klamath Lake largely settle out of the water column (Figure C-13; PacifiCorp 2004a; Raymond 2008a, 2009a, 2010a). The most significant decrease (approximately 50 percent) in organic suspended sediments (as TSS) typically occurs between the mouth of Link River and Keno Dam. Further decreases in concentrations of organic suspended sediments can occur in the upstream end of the Hydroelectric Reach, which may be due to the mechanical breakdown of phytoplankton remains and sorting of progressively smaller sizes of natural organic matter (NOM) in the turbulent river reaches between J.C. Boyle Dam and Copco No. 1 Reservoir, as well as by dilution from the springs immediately downstream from J.C. Boyle Dam. By the upstream end of Copco No. 1 Reservoir, average TSS concentrations are approximately 70 percent lower than those measured at the mouth of Link River (Figure C-13; PacifiCorp 2004a, 2004b; Raymond 2008a, 2009a, 2010a).

[106] Microscopic organisms, including algae, bacteria, protists, and other single-celled plants, that float in the water column of fresh and salt waters and obtain energy from photosynthesis.

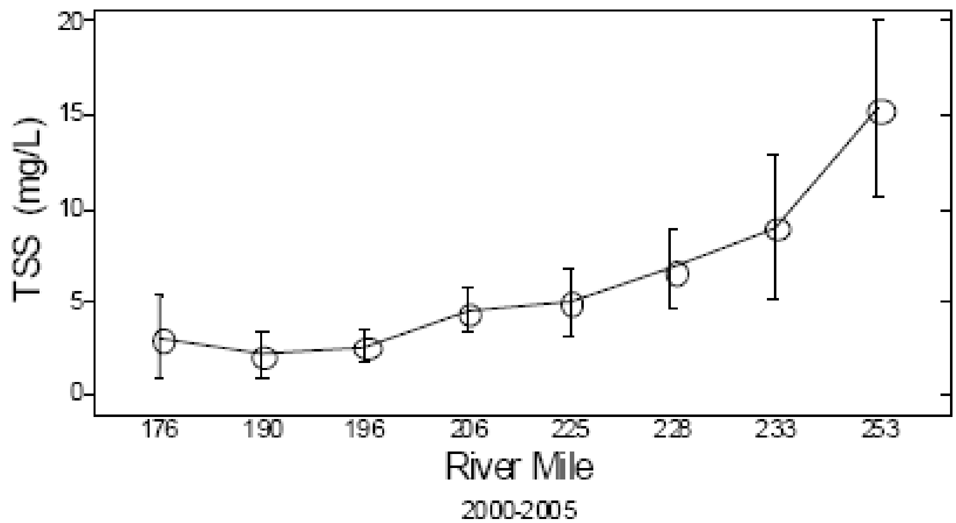

Figure C-13. Mean May to October Total Suspended Solids (TSS) Values for Data Collected from Various Sites in the Klamath River Between 2000 and 2005. Error bars depict 90 percent confidence interval of the mean. The location of features in the graph are specified using 2008 river mile designations, which are slightly different from updated 2018 river miles (see Table 3.2-1). The location of key landmarks in 2008 river mile designations: RM 176 = Klamath River at I-5 crossing; RM 190 = Klamath River downstream of Iron Gate Dam; RM 196 = Klamath River downstream of Copco No. 2 Powerhouse; RM 206 = Klamath River upstream of Copco No. 1 Reservoir; RM 220 = Klamath River downstream of J.C. Boyle Powerhouse; RM 225 = Klamath River downstream of J.C. Boyle Dam; RM 228 = Klamath River upstream of J.C. Boyle Reservoir; RM 233 = Klamath River downstream of Keno Dam; RM 253 = mouth of Link River. Source: Raymond 2008a.

Despite the mechanisms supporting decreased longitudinal concentrations of organic suspended sediments in the riverine portions of the Hydroelectric Reach, concentrations in this reach can also increase due to large seasonal phytoplankton blooms occurring in Copco No. 1 and Iron Gate reservoirs. TSS values in Copco No. 1 Reservoir during the phytoplankton growth season (May through October) typically range less than 2 to 20 mg/L and those in Iron Gate Reservoir range less than 2 to 14 mg/L, although intense phytoplankton blooms can result in TSS levels greater than 20 mg/L (Raymond 2008a, 2009a, 2010a). During 2003 sampling by PacifiCorp, a particularly high TSS measurement of 280 mg/L was recorded in the epilimnion of Copco No. 1 Reservoir during May. Simultaneous measurements of suspended sediments measured in the outflow to the reservoir indicated only 4.8 mg/L TSS (FERC 2007), suggesting that the suspended sediment source (phytoplankton cells) had largely settled out of the water column within the reservoir. Since powerhouse withdrawals for Copco No.

1 and Iron Gate dams are from depths of approximately 9.8 m (32 ft) to 10.7 m (35 ft) below the water surface when the reservoirs are full (see Section C.1.1.1), only portions of the extensive phytoplankton blooms positioned closer to the water surface may be transported to the downstream Klamath River. During 2009 water quality monitoring, TSS measured in J.C. Boyle Reservoir ranged less than 2 to 6.8 mg/L from May through November. Levels in Copco No. 1 and Iron Gate reservoirs levels were somewhat greater, with TSS ranging less than 2 to 9.6 mg/L in Copco No. 1 Reservoir (peak in August) and less than 2 to 7.2 mg/L in Iron Gate Reservoir (peak in May) (Watercourse Engineering, Inc. 2011a). Additional water quality monitoring has been conducted from 2010 to 2015 with TSS data from May through October that generally supports previous findings that TSS in Copco No. 1 Reservoir was higher than TSS in Iron Gate Reservoir. TSS in Copco No. 1 Reservoir from 2010 to 2015 usually ranged from the lower reporting limit (0.5 to 5 mg/L) to 17.6 mg/L, with peak TSS measured at 140 mg/L in 2013 and 72.4 mg/L in 2015. TSS in Iron Gate Reservoir from 2010 to 2015 usually ranged from the lower reporting limit (0.5 to 5 mg/L) to 9.2 mg/L, with a peak TSS of 37.6 mg/L measured in 2014 (Watercourse Engineering, Inc. 2011b, 2012, 2013, 2014, 2015, 2016).

There are currently 13.1 million cubic yards of sediment deposits stored within J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate reservoirs (USBR 2012) (see also Table 2.8). Prior estimates of the sediment deposits were 14.5 million cubic yards (Eilers and Gubala 2003) and 20.4 million cubic yards (GEC 2006). Sediment texture analysis results of the current reservoir deposits indicate that the deposits are composed of predominantly fine material (i.e., silt and clay less than 0.0625 mm [GEC 2006]; see also Section 3.11) with 3 to 5 percent of the accumulated material as organic carbon, corroborating interpretation of longitudinal suspended sediment patterns and indicating that in-reservoir and upstream phytoplankton growth is largely intercepted and retained in reservoir sediments in the Hydroelectric Reach.

C.2.2 Mid- and Lower Klamath Basin

C.2.2.1 Iron Gate Dam to Salmon River

Trapping of fine sediments and suspended materials by the Lower Klamath Project reservoirs reduces suspended sediment concentrations immediately downstream of Iron Gate Dam (RM 193.1), thus inorganic suspended material concentrations are generally low in the reach immediately downstream of Iron Gate Dam. Inorganic suspended sediment tend to increase with distance downstream from Iron Gate Dam during winter months. Two of the three tributaries that contribute the largest amount of sediment to the Klamath River on an annual basis are in this reach. The Scott River, which enters the mainstem Klamath River at RM 145.1, contributes 607,300 tons per year of suspended sediment or 10 percent of the cumulative average annual delivery from the basin. The Salmon River (RM 66.3) contributes 320,600 tons per year or 5.5 percent of the cumulative average annual delivery from the basin (Stillwater Sciences 2010).

During the phytoplankton growth season (May to October), suspended sediments immediately downstream from Iron Gate Dam are relatively lower than upstream locations, with generally low (less than 5 to 8 mg/L) concentrations for 2000 to 2005 (PacifiCorp 2004a, 2004b; Raymond 2008a, 2009a, 2010a) (Figure C-13). However, in the summer months, organic suspended materials can increase in the Klamath River between Iron Gate Dam and Seiad Valley (RM 132.7) due to the transport of in-reservoir algal blooms to downstream reaches of Klamath River, resuspension of previously settled organic materials, and degradation (i.e., senescence) of periphyton communities along the stream (YTEP 2005; Sinnott 2008; Armstrong and Ward 2008; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017). The relative magnitude of the contribution from the different sources of organic (algal-derived) suspended material in the Klamath River has not been and cannot be quantified from the available data since the measurements did not attempt to distinguish between the potential sources. TSS concentrations near the Shasta River confluence (RM 179.5) for the period 2000 to 2005 were roughly 1 mg/L greater than those measured further upstream at Iron Gate Dam (Figure C-13), and during 2009 monitoring, TSS ranged 0.87 to 4.4 mg/L downstream from Iron Gate Dam (RM 193.1), increasing to 2.5 to 11.5 mg/L downstream from Seiad Valley (RM 132.7) (Watercourse Engineering, Inc. 2011a)[107]. Additional TSS monitoring in the Klamath River was conducted from 2010 to 2015 with TSS in 2015 ranging from 0.8 to 3.8 mg/L downstream of Iron Gate Dam to 4.2 to 155.0 mg/L downstream of Seiad Valley (Watercourse Engineering, Inc. 2011b, 2012, 2013, 2014, 2015, 2016). In 2015, TSS in the Klamath River downstream of Seiad Valley peaked at 155.0 mg/L in July, but otherwise did not exceed 13.0 mg/L between May and October (Watercourse Engineering, Inc. 2016). The pattern of suspended sediments increasing in the Klamath River downstream from Seiad Valley compared to downstream of Iron Gate Dam may be related to the transport of some portion of the in-reservoir phytoplankton blooms to downstream reaches of Klamath River. River bed scour may also cause resuspension of previously settled materials and increases in summer and fall TSS from 0 to 20 miles downstream from Iron Gate Dam (Figure C-14). Farther downstream, near the confluence with the Scott River (RM 145.1 or approximately 47 miles downstream from Iron Gate Dam) concentration of suspended sediments tend to decrease with distance as suspended sediment gradually settle out of the water column or are diluted by tributary inputs (Armstrong and Ward 2008). Chlorophyll-*a* data show a similar trend (see Section C.6.2.1).

[107] This data set includes measurements in November and December 2009 as well.

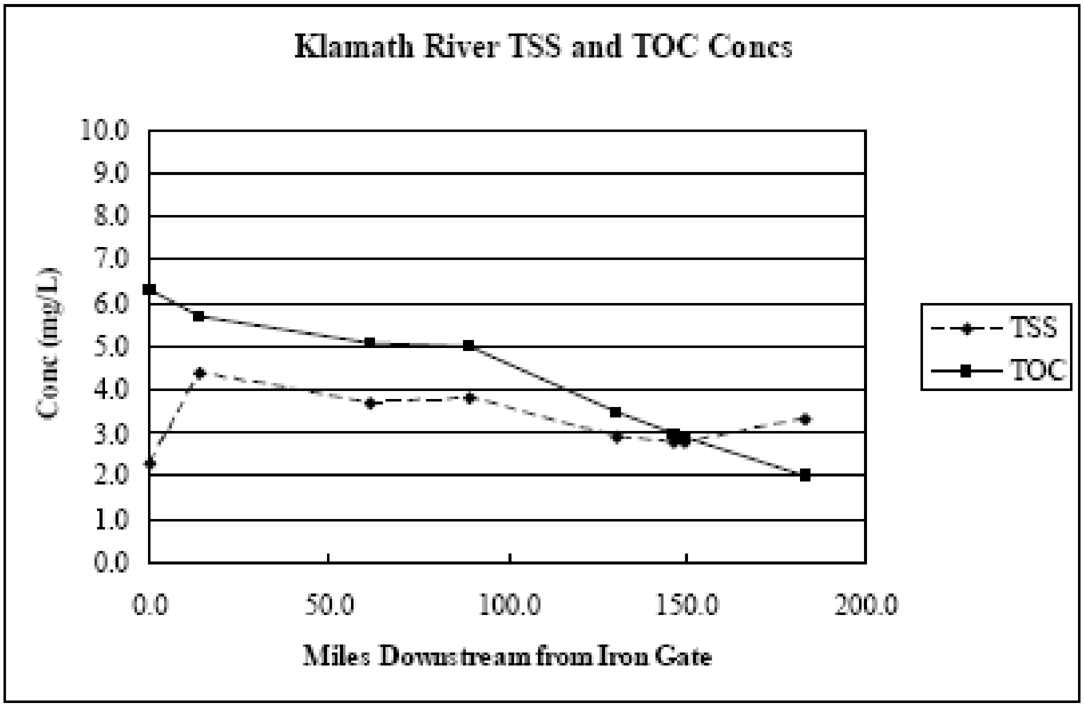

Figure C-14. Average TSS and Total Organic Carbon in the Klamath River Downstream from Iron Gate Dam during June to October 2001 to 2005. River Miles Specified Are Based on the River Miles Designations Used in 2008 and Differ Slightly from 2018 River Mile Designations. Source: Armstrong and Ward 2008.

C.2.2.2 Salmon River to Klamath River Estuary

As in other reaches of the Klamath River, seasonal variation in turbidity and suspended sediments is evident in the Klamath River from the Salmon River (RM 66.3) to the Klamath River Estuary (RM 0 to 3.9), with peak summer turbidity values associated with organic matter (i.e., algal blooms) and peak spring and winter turbidity values associated with inorganic sediments that are mobilized during high flow events (Stillwater Sciences 2009).

Historical (1950 to 1979) suspended sediment data (in SCC) for the Klamath River at Orleans (RM 58.9) (USGS gage no.11523000) range from less than 5 mg/L during summer (low-flow) periods to greater than 5,000 mg/L during winter (high-flow) periods, although some high (greater than 1,000 mg/L) suspended sediment events have occurred during summer months (e.g., 1974, see Figure C-15). During the winter periods, elevated suspended sediment levels are typically associated with storm events and high flows, lasting on the order of days to weeks. More recent data indicate that suspended material levels in the lower Klamath River from the Salmon River confluence (RM 66.3) to the Estuary (RM 0 to 3.9) can be similar to those measured in the upstream reach from Iron Gate

Dam to the Salmon River (RM 66.3). During 2009 monitoring, TSS values measured at Orleans were generally 1.1 to 13.3 mg/L between May and December, with peak values (approximately 56 mg/L) occurring during October (Watercourse Engineering, Inc. 2011a). TSS measured at Orleans from 2010 to 2015 had similar trends with TSS usually between 1.2 to 17 mg/L, but TSS occasionally peaking anywhere from 71 mg/L in August 2014 up to 437 mg/L in June 2010 (Watercourse Engineering, Inc. 2011b, 2012, 2013, 2014, 2015, 2016).

Results from grab samples collected by the Yurok Tribe Environmental Program during the period 2003 to 2004 indicate that TSS ranged less than 1.0 to 3.2 mg/L upstream of the Trinity River (RM 43.3) and less than 1.0 to 14.0 farther downstream at Turwar (RM 5.6), with the peak value (14.0 mg/L) occurring in December 2003 (YTEP 2005). However, the majority of the grab samples were collected from June to September and only two grab samples were collected in December and January. The data exhibit similar values for 2007, with the highest TSS (up to 16.0 mg/L) observed at Turwar in September of that year (Fetcho 2008). Additional water quality monitoring has been conducted by the Hoopa Valley Tribal Environmental Protection Agency (HVTEPA) from 2008 to 2012 and the Yurok Tribe Environmental Program from 2006 to 2014 with TSS at sites from upstream of the confluence with the Trinity River to the Klamath River Estuary (Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; HVTEPA 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). Between 2008 and 2012, TSS in the Klamath River at Saints Rest Bar (RM 44.9) ranged from 1.0 to 15 mg/L, with TSS reaching a peak of 33.0 mg/L in October 2009. In 2014, TSS in the Klamath River at Weitchpec, upstream from the Trinity River (RM 43.6), ranged from 1 to 12 mg/L while TSS in the Klamath River at the Turwar Boat Ramp (RM 6) ranged 1 to 20 mg/L with the peak values occurring in February at Weitchpec and December at the Turwar Boat Ramp (Figure C-16; Hanington and Cooper-Carouseli 2014).

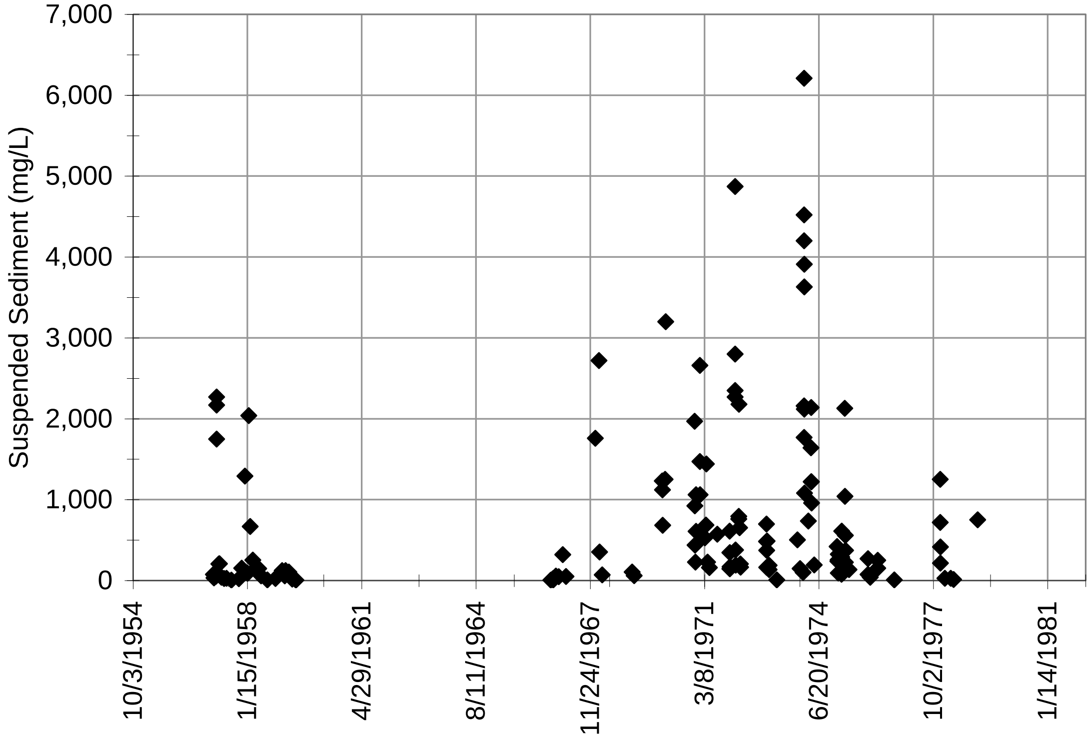

Figure C-15. Suspended Sediment (mg/L in SCC) Grab Samples for USGS Klamath River at Orleans (USGS Gage No. 11523000) (RM 58.9) 1950 to 1979. Source: USGS 2011 (http://waterdata.usgs.gov/nwis).

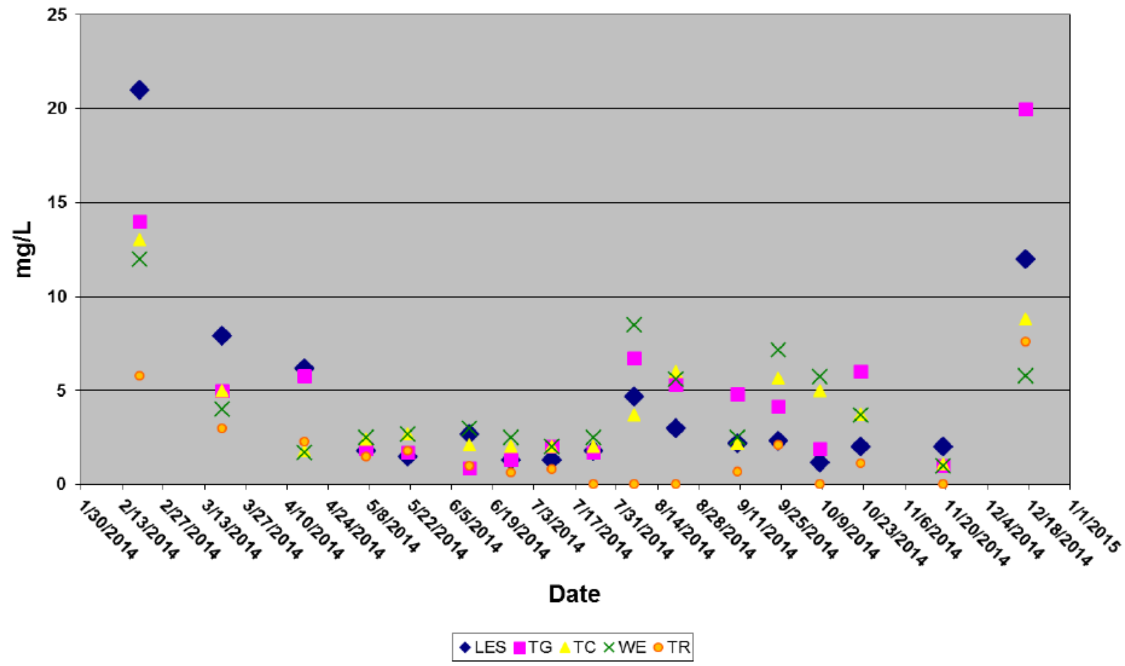

Figure C-16. Suspended Sediment (mg/L TSS) Grab Samples at the Lower Estuary Surface (LES [RM 0]), the Klamath River at Turwar Boat Ramp (TG [RM 6]), the Klamath River Upstream of Tully Creek (TC [RM 40.1]), the Klamath River at Weitchpec (Upstream of the Trinity River) (WE [RM 43.6]), and the Trinity River Upstream of the Confluence with the Klamath River (TR). Source: Hanington and Cooper-Carouseli 2014.

The Trinity River contributes 3,317,300 tons of sediment per year to the lower Klamath River or 57 percent of the cumulative average annual delivery from the basin (Stillwater Sciences 2010). Mass wasting, bank erosion, and other natural erosion processes contribute a large but currently unknown portion of the total fine sediment supply to the lower Klamath River, along with management activities such as timber harvest and road construction along tributaries (USDA Forest Service 2004; Stillwater Sciences 2010). When combined with the steep terrain, granular soil matrix, and high precipitation, these sources may be a primary contributor to fine sediment deposits found in deep pools near cultural sites in the lower Klamath River (FERC 2007).

Available historical (1958 to 1996) suspended sediment data for the Klamath River at Klamath Glen (RM 5.9) (USGS gage no. 11530500) indicates values of less than 5 mg/L (in SCC) during summer (low-flow) periods to greater than 500 mg/L during winter (high-flow) periods, although one high (greater than 750 mg/L) suspended sediment event appears to have occurred during the early fall (i.e., October 1977, see Figure C-17).

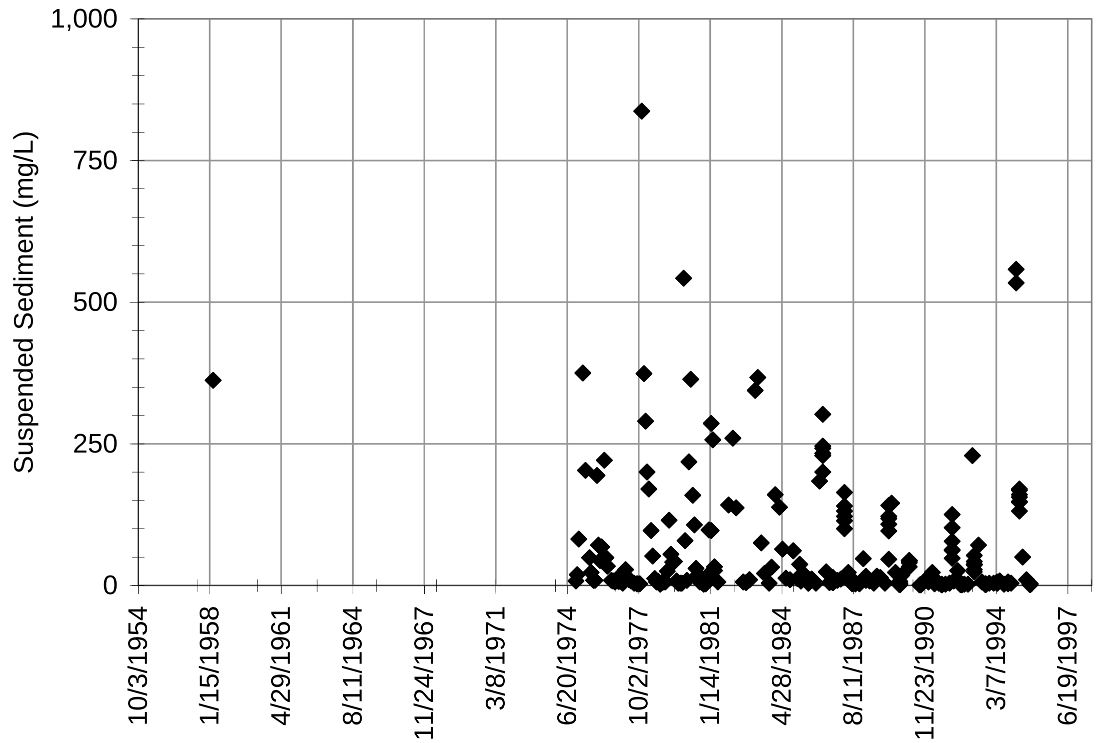

Figure C-17. Suspended Sediment (mg/L) Grab Samples for USGS Klamath River near Klamath (USGS Gage No. 11530500) (RM 7) 1958 to 1995. Source: USGS 2011 (http://waterdata.usgs.gov/nwis).

C.2.2.3 Klamath River Estuary

An analysis of collected TSS data in the Klamath River Estuary indicates that TSS are variable but generally similar to those measured at upstream sites in the lower Klamath River (YTEP 2004, 2005; Sinnott 2008). For 2003 to 2004, TSS levels were less than 1.0 to 3.2 mg/L for surface waters in the mid- and lower-estuary, and slightly greater (1.8 to 10.0 mg/L) at depth (YTEP 2004, 2005). During May to December 2009, measured TSS levels were generally 2.1 to 12.7 mg/L, with the peak value (17.9 mg/L) occurring in May (Watercourse Engineering, Inc. 2011a). More contemporary data measured between 2006 to 2014 show a larger range in the TSS in the lower Klamath River Estuary, with TSS ranging from 1.3 to 21 mg/L in 2014[108] (Figure C-16; Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). Turbidity measurements in small tributaries (e.g., McGarvey, Den, Blue, and Turwar creeks) immediately

[108] The various reports cited for available TSS information provide data for each individual year. There is currently no synthesis report for TSS monitoring data for the Klamath River. The most recent data range that highlights the intent of the discussion is presented, along with multiple citations to available reports.

upstream or within a few river miles upstream of the Klamath River Estuary exhibit peak values during winter high flow periods (i.e., storm events), with measured values exceeding 500 NTU during December through February 2004 (YTEP 2005). Additional turbidity measurements at sites from upstream of the confluence with the Trinity River to the Klamath River Estuary have been collected by the Yurok Tribe Environmental Program from 2010 to 2014 with peak turbidity typically occurring between December and April and a secondary smaller peak in turbidity occurring in the summer or fall (Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). In 2014, turbidity in the Klamath River Estuary ranged from 0.49 to 9.4 NTU with the peak occurring in February (Figure C-18; Hanington and Cooper-Carouseli 2014). During late spring through early fall, when average rates of precipitation in the Klamath Basin are relatively lower, inorganic suspended sediments and turbidity in the Klamath River Estuary are generally lower as well.

Blooms of phytoplankton within and upstream of the Klamath River Estuary have the potential to cause large spikes in turbidity and organic suspended sediments in the estuary. This occurred during the extensive phytoplankton bloom detected throughout at least 40 river miles of the lower Klamath River in September 2007 (Kann 2007a, b, c, d). In the lower estuary, increases in nutrient levels and phytoplankton concentrations were correlated with an increase in TSS from 2.2 mg/L on August 21, 2007 to 9.0 mg/L on September 18, 2007, and increases in nutrients, phytoplankton levels, and TSS during that period were measured as far upstream as Iron Gate and Copco No. 1 reservoirs (Asarian et al. 2009). Thus, the observed 2007 increase in estuarine TSS may have been influenced by phytoplankton growth originating in Iron Gate and Copco No. 1 reservoirs. The downstream transport of phytoplankton from Iron Gate and Copco No. 1 reservoirs into the Middle and Lower Klamath River and the Klamath River Estuary is discussed more in Section C.6 and Section 3.4 *Phytoplankton and Periphyton*.

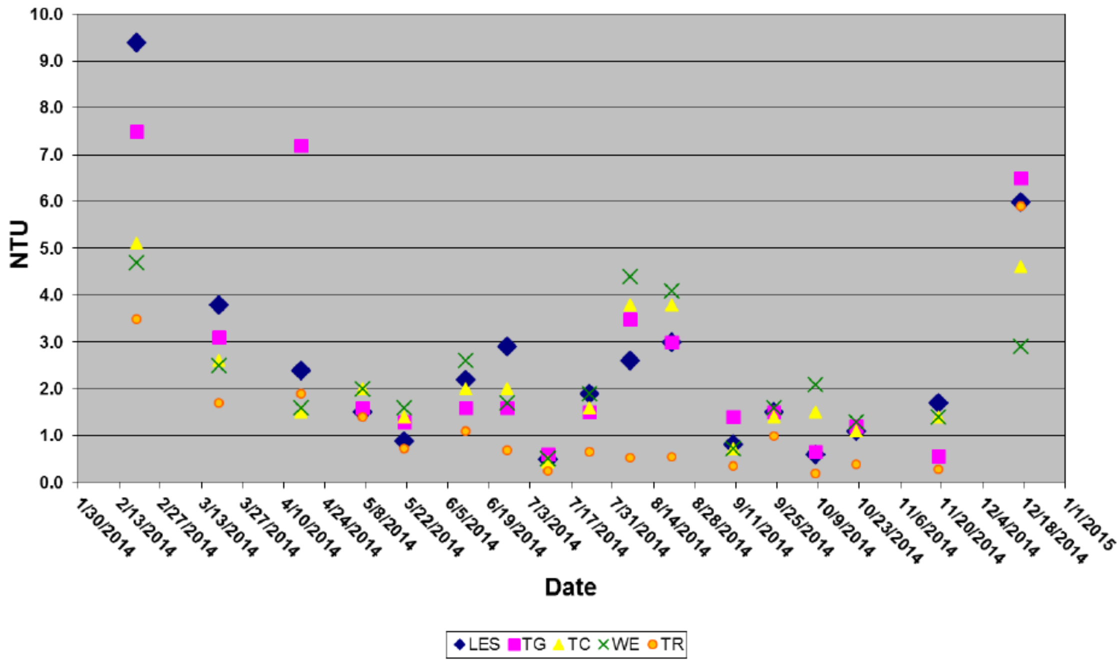

Figure C-18. Turbidity (NTU) Grab Samples at the Lower Estuary Surface (LES [RM 0]), the Klamath River at Turwar Boat Ramp (TG [RM 6]), the Klamath River Upstream of Tully Creek (TC [RM 40.1]), the Klamath River at Weitchpec (Upstream of Trinity River)(WE [RM 43.6]), and the Trinity River Upstream the Confluence with the Klamath River (TR). Source: Hanington and Cooper-Carouseli 2014.

C.3 Nutrients

Nutrients are critical for the support of primary productivity (i.e., plant growth) in both terrestrial and aquatic ecosystems. High levels of nutrients (nitrogen and phosphorus) in lakes and rivers have the potential to impact overall water quality by increasing rates of phytoplankton growth and decay, which can lead to increased levels of turbidity, large fluctuations in dissolved oxygen concentrations and pH levels, as well as potential increases of toxic substances such as ammonia (NH_4^+/NH_3), hydrogen sulfide (H_2S), and release of heavy metals from low oxidation-reduction potential at the sediment water interface (see Section 3.2.3.1 for additional background information on water quality processes in the Klamath Basin). Dissolved nutrients (e.g., ortho-phosphorus, nitrate, and ammonium) can be used directly by phytoplankton, whereas particulate nutrients (e.g., organic phosphorus, organic nitrogen) are not readily bioavailable for most phytoplankton species.

C.3.1 Upper Klamath Basin

C.3.1.1 Hydroelectric Reach

Nutrients are introduced into the mainstem Klamath River Area of Analysis primarily by the Upper Klamath Lake which inputs nitrogen and phosphorus (Kann and Walker 1999; ODEQ 2002; PacifiCorp 2004b; Deas and Vaughn 2006; FERC 2007; Sullivan et al. 2008; Asarian et al. 2010) and the Lost River Basin via the Klamath Straits Drain and the Lost River Diversion channel which inputs nutrients and organic matter (Lytle 2000; Mayer 2005; Sullivan et al. 2009; Sullivan et al. 2011; Kirk et al. 2010). Historical and contemporary nutrient data indicate that, on an annual basis, nutrients in the Hydroelectric Reach tend to be lower than upstream due in part to dilution from springs downstream of J.C. Boyle Reservoir. According to Asarian et al. (2010), who cited analysis by IFR and PCFFA (2009), Gard (2006), and TetraTech (2009), the long-term average nutrient concentrations of the springs downstream of J.C. Boyle Dam was estimated to be on the order of 0.2 mg/L for total nitrogen (TN) and on the order of 0.07 mg/L for total phosphorus (TP) using mixing equations and PacifiCorp's 2001 to 2007 nutrient sampling data. The Klamath TMDL model TN and TP concentrations, derived from model calibration through 2000, are consistent with these values.

Total Nitrogen and Total Phosphorus Patterns

The settling of particulate matter and associated nutrients in the larger Lower Klamath Project reservoirs contributes significantly to annual decreases in nutrient concentrations in the Klamath River from the Oregon-California state line to Iron Gate Dam (PacifiCorp 2004b; FERC 2007; Butcher 2008; Asarian et al. 2009; Asarian and Kann 2011; Oliver et al. 2014). In J.C. Boyle Reservoir (RM 229.8), the furthest upstream reservoir in the Hydroelectric Reach, concentrations of TN and TP measured between the inflow and outflow are typically similar, likely due to the shallow depth and short residence time characteristic of this impoundment (PacifiCorp 2006), indicating that relatively little nutrient retention occurs in this reservoir.

Annual data from 2000 through 2004 and early modeling studies by PacifiCorp conducted for the FERC relicensing process indicate that Copco No. 1 and Iron Gate reservoirs act primarily as TN and TP sinks due to trapping of phytoplankton detritus (PacifiCorp 2004b; FERC 2007). However, subsequent analyses found that while overall annual retention is likely occurring, the Lower Klamath Project reservoirs can also serve as seasonal sources of TN and TP (though far less for TN than for TP) through the following processes: release of nutrients from reservoir sediments into the water column during periods of phytoplankton decomposition and seasonal hypolimnetic anoxia; the hydraulic residence time of the reservoirs resulting in a temporal shift in the transport of upstream nutrients through the reservoirs; reservoir turnover during fall; and possibly direct nitrogen fixation from the atmosphere by cyanobacteria [blue-green algae] (Kann and Asarian 2005, 2006; Asarian and Kann 2006a, 2006b, 2011; Butcher 2008; Asarian et al. 2009, 2010; Oliver et al. 2014). On an annual basis, a decreasing longitudinal trend in TN and TP from downstream of J.C. Boyle to Iron Gate Dam is generally consistent in analyses of datasets from 2005 to 2015, but the annual range and seasonal variations of TN and TP concentrations occasionally results in TN and TP plateauing or slightly increasing in the Copco No. 1 to Iron Gate portion. Analysis of nutrient data from 2005 to 2008 found the flow-weighted mean longitudinal TN and TP concentrations generally decrease with distance downstream from J.C. Boyle Dam with a strongly downward trend through Copco No. 1 and Iron Gate reservoirs, particularly for TN, due to nutrient retention in Copco No. 1 and Iron Gate reservoirs and dilution by the coldwater springs located downstream of J.C. Boyle Reservoir (see Figure C-19 and C-20; Asarian et al. 2009; Asarian et al. 2010; North Coast Regional Board 2010; Oliver et al. 2014). Annual total nitrogen (TN) inputs to Copco No. 1 and Iron Gate reservoirs ranged from approximately 2,026 to 3,443 metric tons TN between May 2005 and May 2007, with an annual TN retention of approximately 259 to 419 total metric tons TN. Thus, the annual TN retention in Copco No. 1 and Iron Gate reservoirs was approximately 12 percent (419 of 3,443 metric tons TN) from May 2005 to May 2006 and 13 percent (259 of 2,026 metric tons TN) from May 2006 to May 2007 (Asarian et al. 2009). The annual total phosphorus (TP) inputs to Copco No. 1 and Iron Gate ranged from approximately 210 to 335 metric tons TP between May 2005 and May 2007, with an annual TP retention of approximately 28 to 30 total metric tons TP. Thus, annual TP retention in Copco No. 1 and Iron Gate reservoirs was approximately 9 percent (30 of 335 metric tons TP) from May 2005 to May 2006 and 13 percent (28 of 210 metric tons TP) from May 2006 to May 2007 (Asarian et al. 2009). Overall, on an annual basis, external loading of nutrients from the Upper Klamath River appears to be the dominant source of total nutrients to the Hydroelectric Reach and the Lower Klamath Project reservoirs and is also responsible for the majority of total nutrients being transported downstream of the reservoirs.

Nutrient data from 2007 to 2015 support the overall annual longitudinal trend of TN and TP, but also reveal annual and seasonal longitudinal variability in both the range and median TN and TP concentrations through the Hydroelectric Reach (Raymond 2008a, 2009a, 2010a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). Asarian and Kann (2011) observe an overall annual longitudinal decrease in TN between 2005 and 2010 through the Hydroelectric Reach of the Upper Klamath River with concentrations usually highest upstream of Copco No. 1, intermediate upstream of Iron Gate, and lowest downstream of Iron Gate Dam. Data from 2012 to 2015 further highlight the annual range of TN variations from upstream of J.C. Boyle Reservoir to downstream of Iron Gate Dam and support the generally decreasing annual TN trend through the Hydroelectric Reach (Figures C-21; Watercourse Engineering, Inc. 2013, 2014, 2015, 2016). TP data from 2012 to 2015 further demonstrate that TP measured at river locations is generally decreasing in the downstream direction through the Hydroelectric Reach, but the annual mean TP concentration occasionally is similar or increases in the downstream direction through the

Hydroelectric Reach during some years due to seasonal variations in TP (Figures C-22; Watercourse Engineering, Inc. 2013, 2014, 2015, 2016). For example, in 2012 the annual mean TP concentration in the Klamath River downstream of Iron Gate Dam (RM 189.7 in Figure C-22) is slightly greater than the annual mean TP concentration in the Klamath River upstream of Copco No. 1 Reservoir (RM 206.4 in Figure C-22).

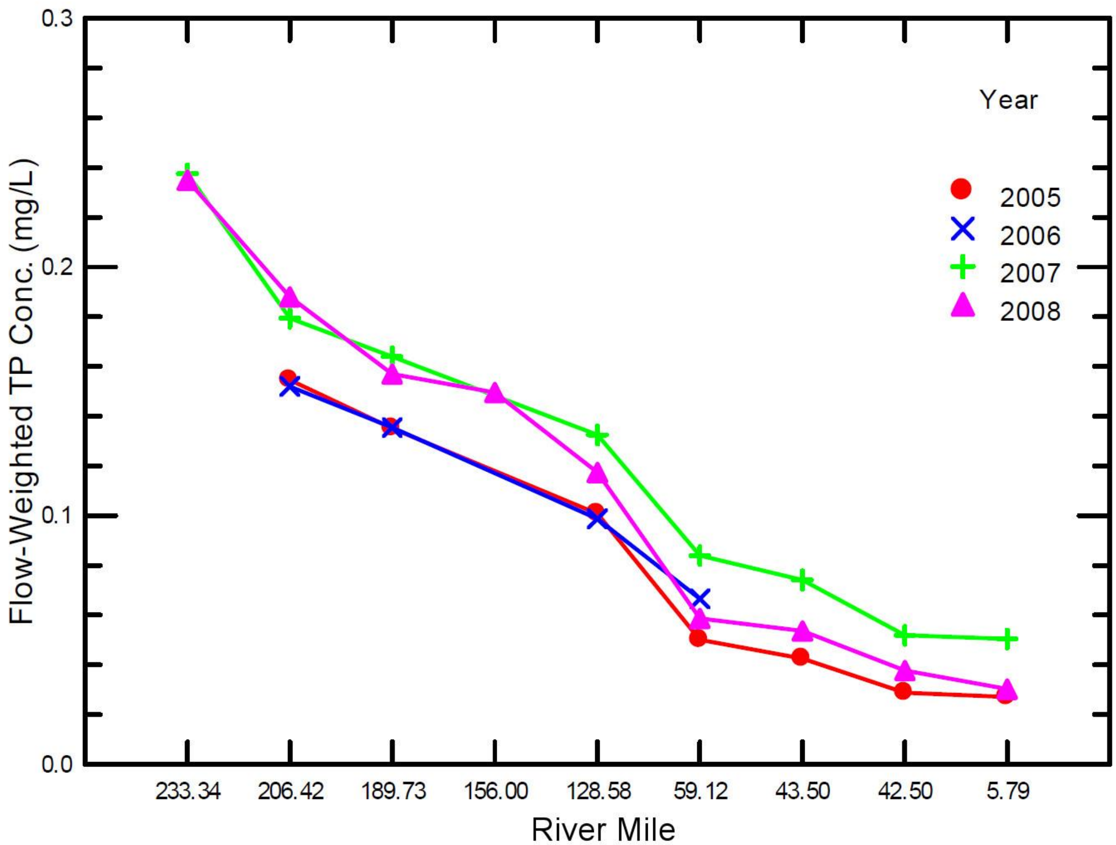

Figure C-19. Summary of Flow-Weighted Mean Concentration (mg/L) for TP at Mainstem Klamath River Sites for the Months of June to October (2005 to 2008). River Miles Specified Are Based on the River Miles Designations Used in 2010 and Differ Slightly from 2018 River Mile Designations (Table 3.2-1). Location of Mainstem Klamath River Measurements in 2010 River Mile Designations: Downstream Keno Dam (RM 233.34), Upstream Copco No. 1 Reservoir (RM 206.42), Downstream Iron Gate Dam (RM 189.73), Walker Bridge (RM 156.00), Seiad Valley (RM 128.58), Orleans (RM 59.12), Upstream Trinity River Confluence (RM 43.50), Downstream Trinity River Confluence (RM 42.50), Turwar (RM 5.79). Source: Asarian et al. 2010.

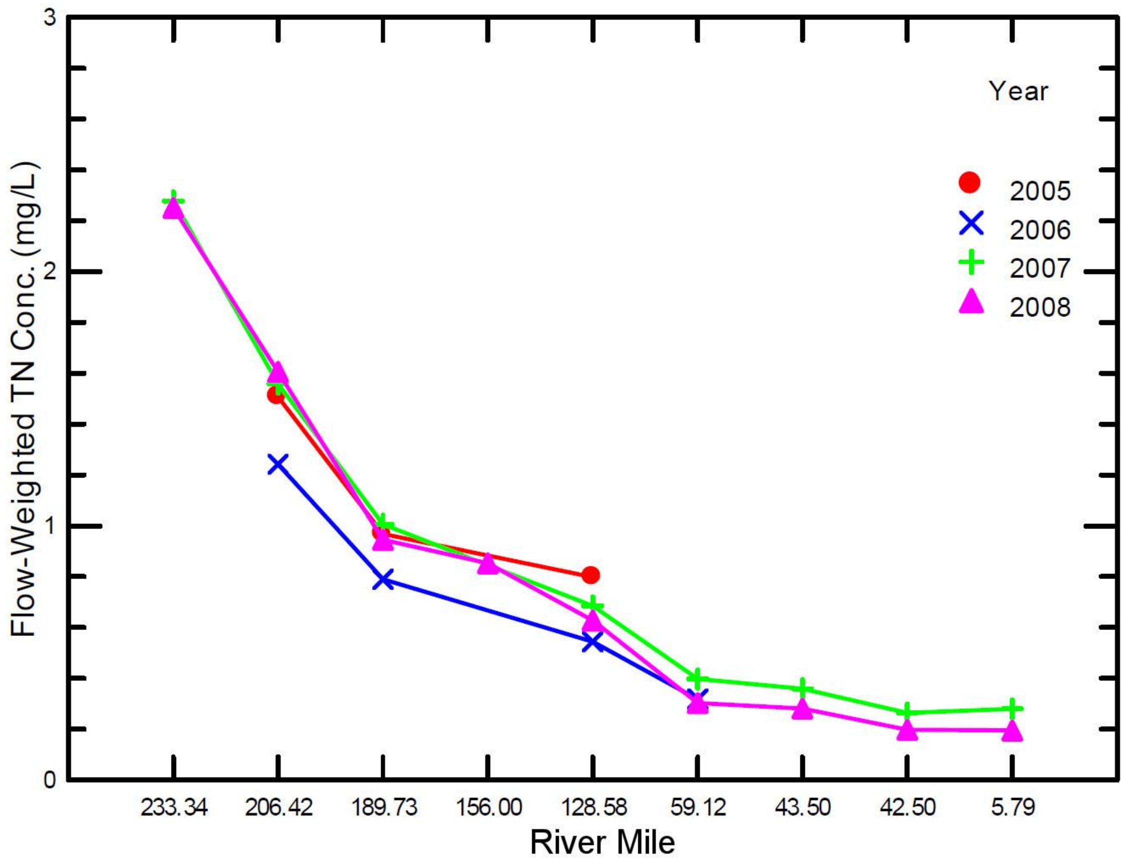

Figure C-20. Summary of Flow-Weighted Mean Concentration (mg/L) for TN at Mainstem Klamath River Sites for the Months of June to October (2005 to 2008). River Miles Specified Are Based on the River Miles Designations Used in 2010 and Differ Slightly from 2018 River Mile Designations (Table 3.2-1). Location of Mainstem Klamath River Measurements in 2010 River Mile Designations: Downstream Keno Dam (RM 233.34), Upstream Copco No. 1 Reservoir (RM 206.42), Downstream Iron Gate Dam (RM 189.73), Walker Bridge (RM 156.00), Seiad Valley (RM 128.58), Orleans (RM 59.12), Upstream Trinity River Confluence (RM 43.50), Downstream Trinity River Confluence (RM 42.50), Turwar (RM 5.79). Source: Asarian et al. 2010.

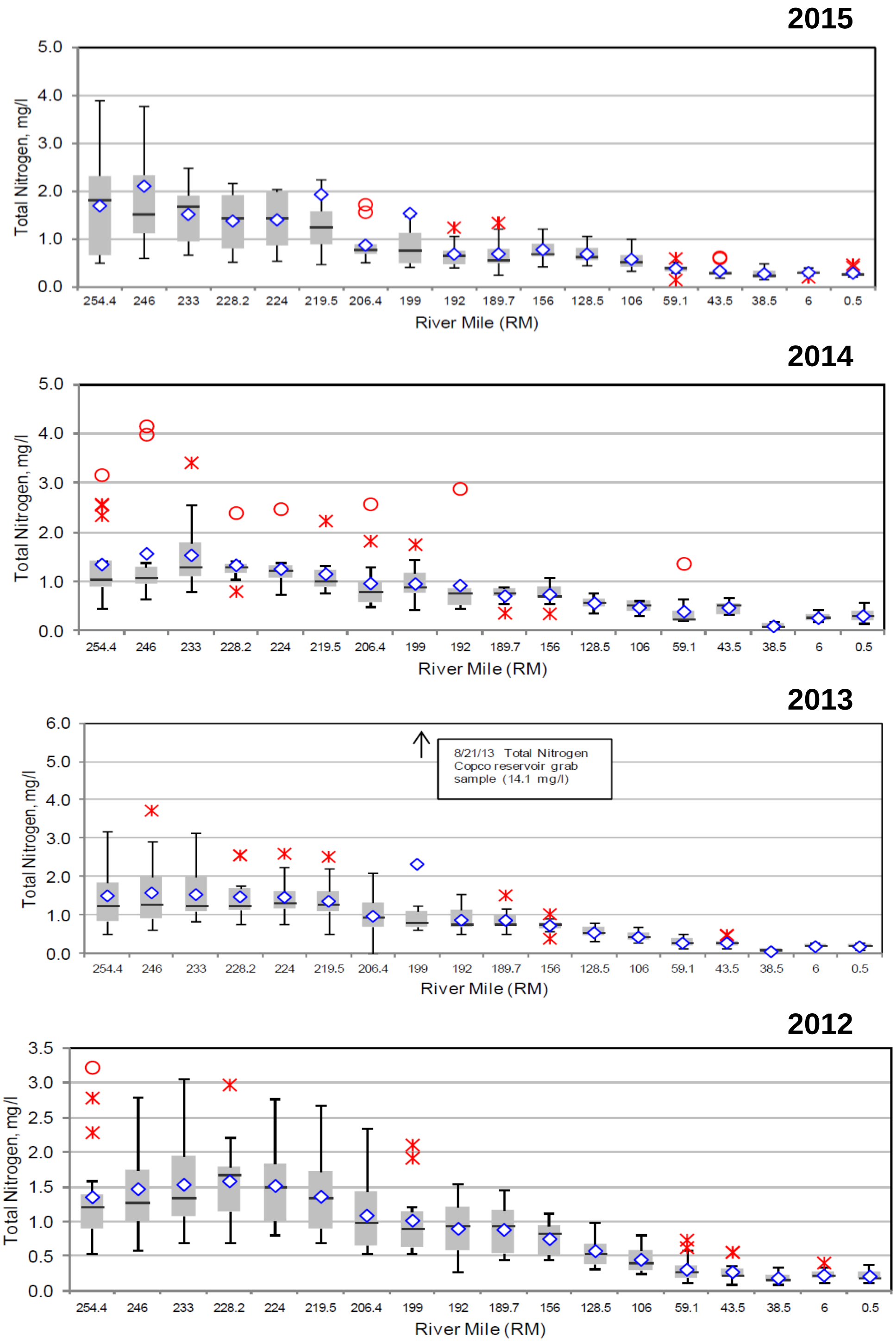

Figure C-21. Klamath River total nitrogen trends including Copco Reservoir (RM 198.7) and Iron Gate Reservoir (RM 189.7) with median (-), mean (◊), outlier (*), and extreme outliers (○) identified (Watercourse Engineering, Inc. 2013, 2014, 2015, 2016). River miles specified are based on those accurate at time of reports and differ slightly from 2018 river mile designations (Table 3.2-1).

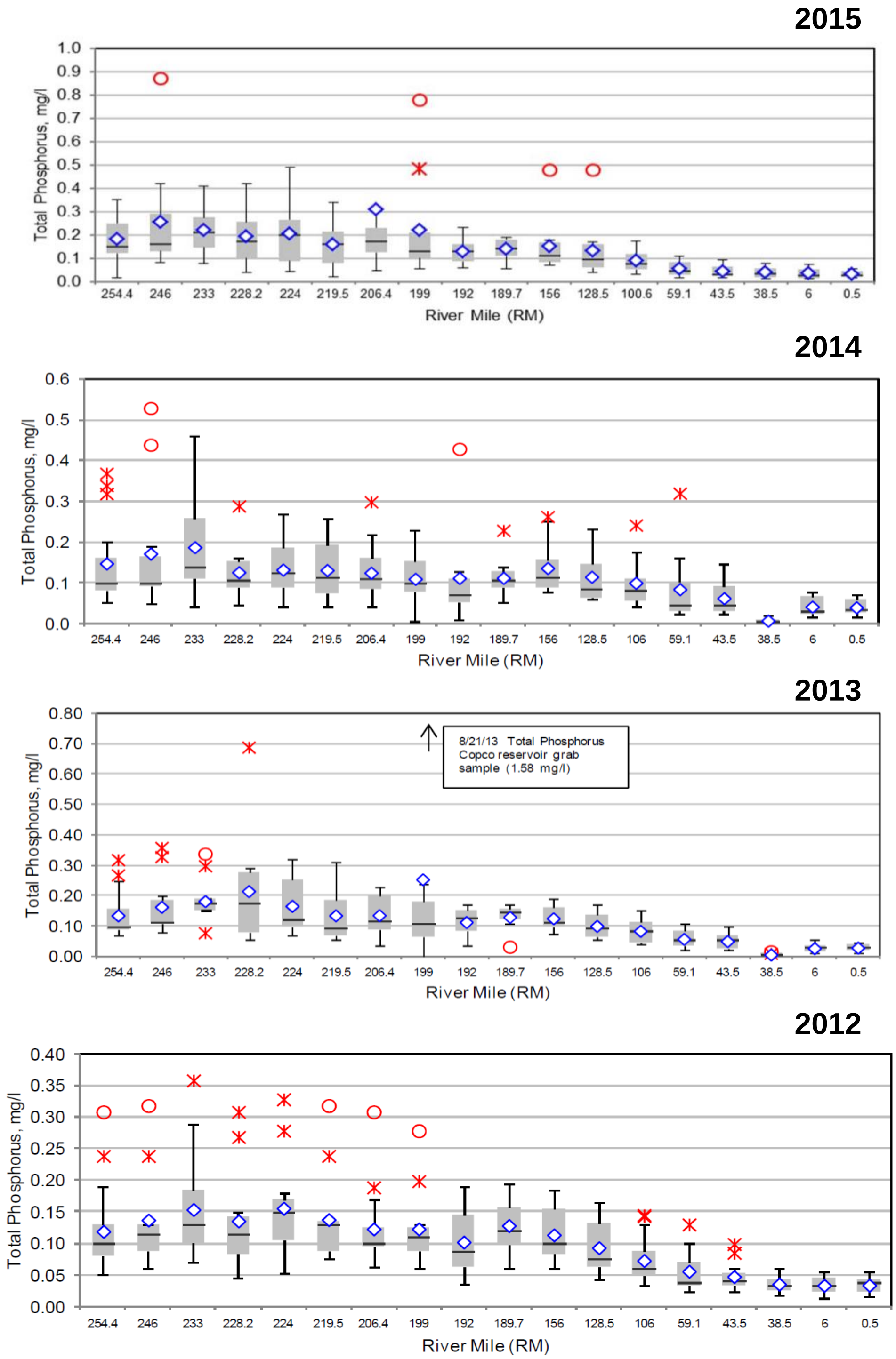

Figure C-22. Klamath River total phosphorus trends including Copco Reservoir (RM 198.7) and Iron Gate Reservoir (RM 189.7) with median (-), mean (◊), outlier (*), and extreme outliers (○) identified (Watercourse Engineering, Inc. 2013, 2014, 2015, 2016). River miles specified are based on those accurate at the time of the reports and differ slightly from 2018 river mile designations (Table 3.2-1).

Seasonal TN and TP variations in the Hydroelectric Reach result in longitudinal increases in TP, and to a limited degree the ammonia contribution to TN, during mid-summer/fall due to a combination of the release (export) of dissolved forms of phosphorus (ortho-phosphorus) and nitrogen (ammonium) from reservoir sediments during summer and fall when reservoir bottom waters are anoxic (i.e., internal nutrient loading), the hydraulic residence time of the reservoirs resulting in a temporal shift in the transport of upstream nutrients through Copco No. 1 and Iron Gate reservoirs, and reservoir turnover during fall (Kier Associates 2006; Kann and Asarian 2007; Stillwater Sciences 2009; Asarian et al. 2009, 2010; Oliver et al. 2014). Data from 2005 to 2008 show seasonal variations in TN and TP occurring from spring to fall as seasonal hypolimnetic anoxia resulted in nutrients being released into the water column (Figures C-23 and C-24; Asarian et al. 2010). Internal loading of nutrients on a seasonal basis is common in reservoirs that thermally stratify and become anoxic for several weeks to months during summer and fall. Asarian and Kann (2011) detail the 2005 to 2010 average monthly TN and TP variations at various depths in Copco No. 1 and Iron Gate reservoirs. TN concentrations generally are highest at the deepest depths in both reservoirs except in July to September when organic N was very high during phytoplankton blooms (also called algal blooms). Asarian and Kann (2011) report TP concentrations are approximately uniform with depth when the reservoirs are not stratified, but the TP increases significantly with depth, especially in the bottom layer, during the period the reservoirs stratify (June to October in Copco No. 1 and June through November in Iron Gate). Data presented in Asarian et al. (2009), Asarian et al. (2010), and Asarian and Kann (2011) suggest that much of the TP released from sediments in Copco No. 1 and Iron Gate reservoirs during summertime anoxia remains in the hypolimnion until the reservoirs begin to turn over in the fall, rather than being released to downstream river reaches during the summer period of peak periphyton growth. A frequent and notable exception occurs during August to November, when TP concentrations are often higher in Iron Gate Reservoir than upstream of Copco No. 1 Reservoir. This is likely due to the combination of internally-driven nutrient dynamics related to algal bloom crashes in Copco No. 1 and Iron Gate reservoirs and an approximately 1- to 2-month temporal lag due to the longer hydraulic retention time of the reservoirs as compared to free-flowing river reaches (Kann and Asarian 2007; Asarian et al. 2009, 2010; Asarian and Kann 2011; Watercourse Engineering, Inc. 2011a). Oliver et al. (2014) further explore the seasonality of TP dynamics with algal bloom variations highlighting measurements that show TP concentrations are lowest during May to July (“bloom period”), highest during August to October (“post-bloom period”), and then decrease during the winter periods. These results indicate that some release of TP may occur at times which could stimulate downstream periphyton growth.

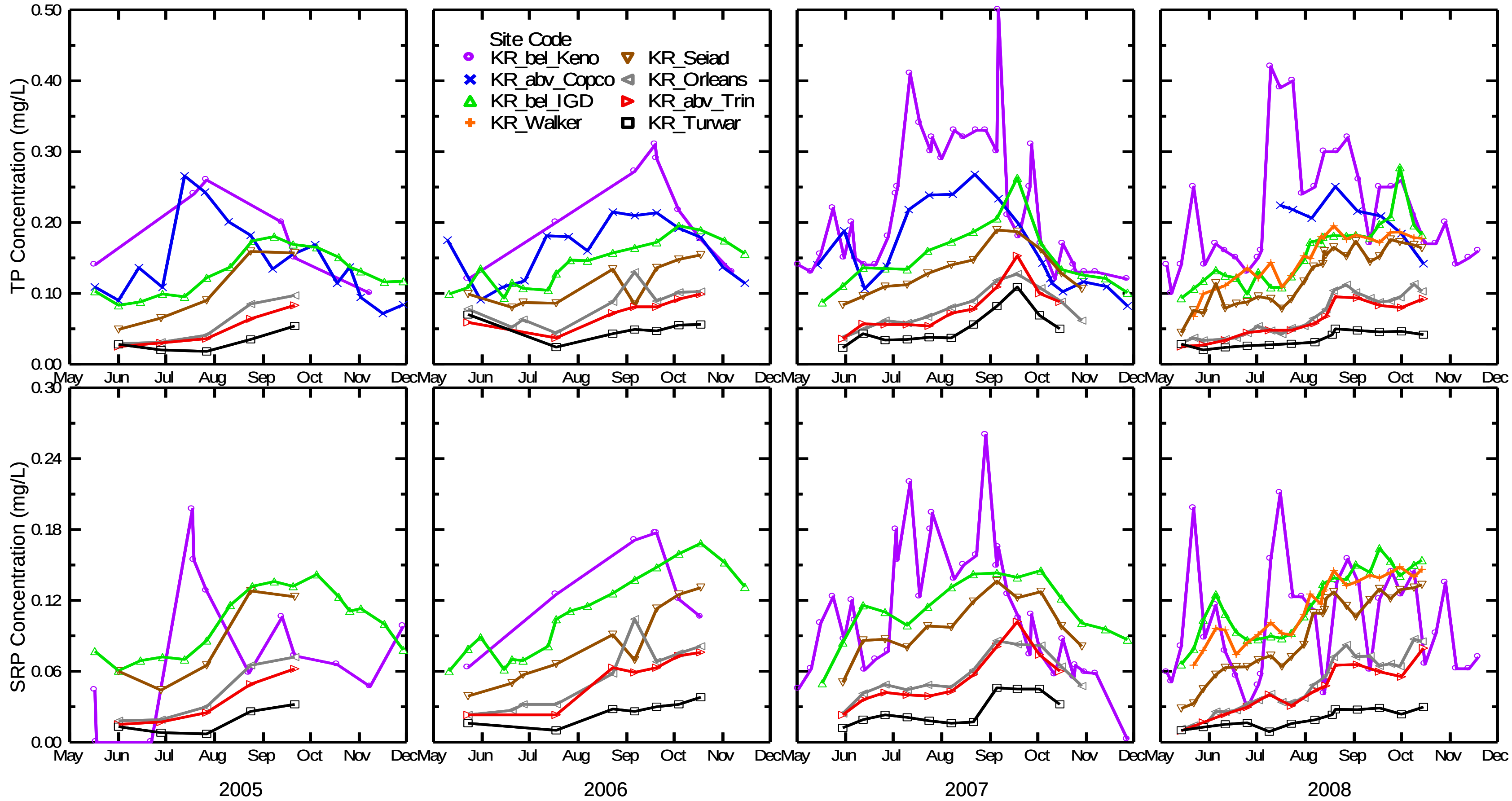

Figure C-23. Time Series of Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP) Concentrations for Selected Mainstem Klamath River Sites from Downstream Including the J.C. Boyle Dam (RM 229.8) to Turwar (RM 5.6) Reach, May 2005 to November 2008. Source: Asarian et al. 2010.

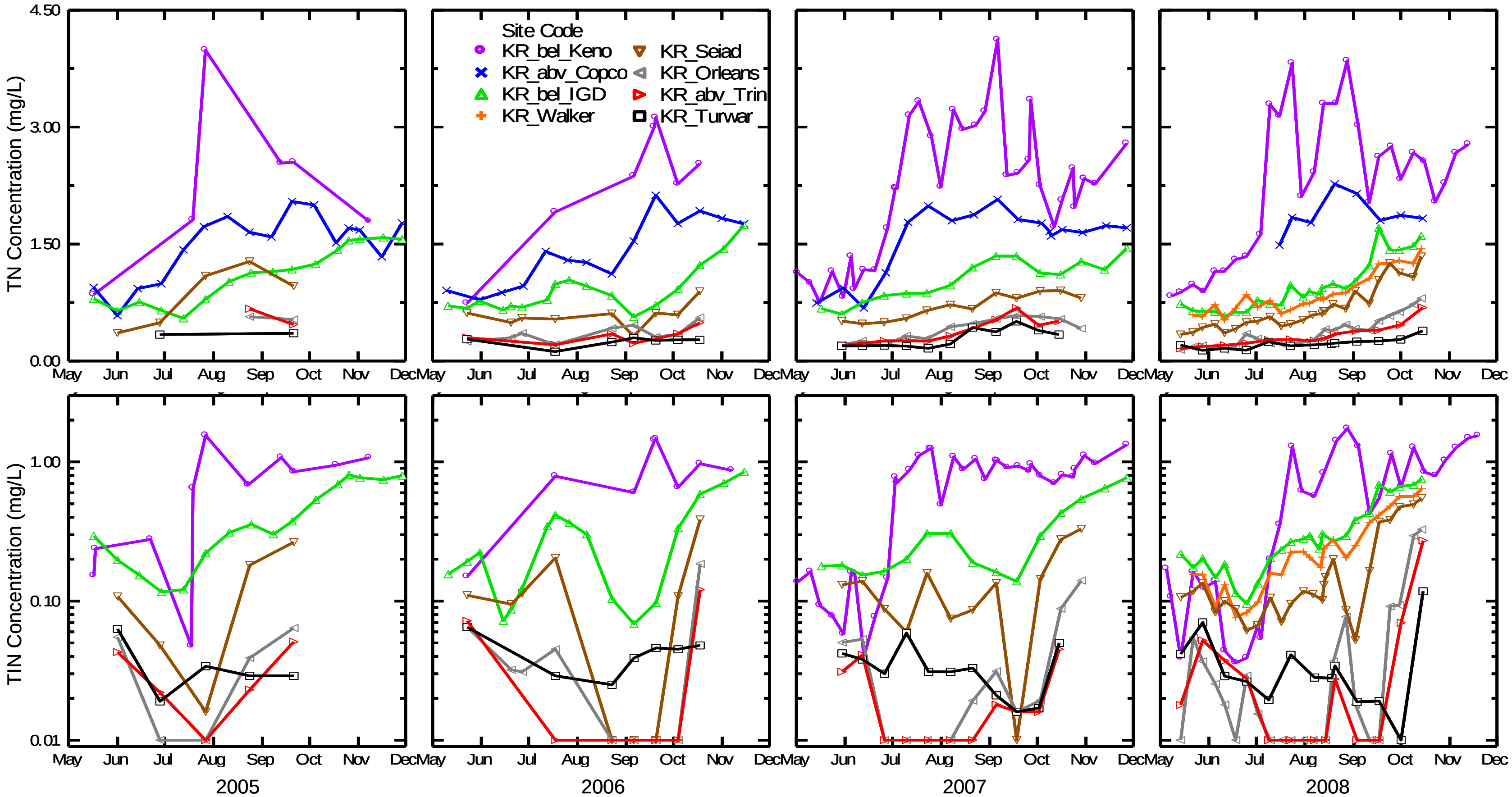

Figure C-24. Time Series of Total Nitrogen (TN) and Total Inorganic Nitrogen (TIN) Concentrations for Selected Mainstem Klamath Sites from Downstream Including the J.C. Boyle Dam (RM 229.8) to Turwar (RM 5.6) Reach, May 2005 to November 2008. Source: Asarian et al. 2010.

During the May 2005 to December 2007 period, TN and TP retention and release for Copco No. 1 and Iron Gate reservoirs are estimated based on a multiple regression modeling method, bi-weekly nutrient concentration measurements, and a daily reservoir water balance (Figures C-24-A, C-24-B, C-24-C, and C-24-D; Asarian et al. 2009). Three seasonal May through September periods spanning the main phytoplankton growing season in the reservoirs occur during May 2005 to December 2007, so the seasonal May through September nutrient retention is calculated for each individual reservoir along with the total combined nutrient retention for both reservoirs to evaluate seasonal TN and TP variations in the Hydroelectric Reach due to the reservoirs.

The May through September (i.e., seasonal) TN retention in Copco No. 1 Reservoir ranges from approximately 38 to 102 metric tons TN during 2005 through 2007, while the May through September TN retention in Iron Gate Reservoir ranges from approximately 44 to 80 metric tons TN during this same period. As a percent of the total inflow, the May through September TN retention in Copco No. 1 Reservoir ranges from approximately 7 to 16 percent, while the May through September TN retention in Iron Gate Reservoir ranges from approximately 9 to 17 percent. The total combined May through September (i.e., seasonal) TN retention in Copco No. 1 and Iron Gate reservoirs ranges from approximately 22 to 25 percent of the inflow, with an average of 23 percent over the three May through September periods in 2005, 2006, and 2007 (Asarian et al. 2009). The combined TN retention in Copco No. 1 and Iron Gate reservoirs during May through September is higher than the annual combined TN retention in Copco No. 1 and Iron Gate reservoirs (i.e., approximately 12 to 13 percent of inflow) due to settling of organic matter and algal material, denitrification, and/or ammonia volatilization (Asarian et al. 2009, 2010). While TN retention is seasonally higher in Copco No. 1 and Iron Gate reservoirs during May through September, the ammonia concentration downstream of Iron Gate Reservoir increases beginning in September from approximately 0.01 to 0.05 mg/L until peaking in October and November at approximately 0.1 to 0.2 mg/L due to the anoxic conditions in the lower section Iron Gate Reservoir (Asarian et al. 2009, 2010) (see discussion of Ammonium/Ammonia below).

In Copco No. 1 Reservoir, the May through September (i.e., seasonal) TP retention ranges from approximately negative 6.3 to negative 1.7 metric tons TP during 2005 through 2007, with the negative TP retention indicating a net export of TP from the reservoirs. The May through September TP retention in Iron Gate Reservoir ranges from approximately negative 4.7 to 3.5 metric tons TP during 2005 through 2007, indicating there may be a net export (e.g., negative 4.7 metric tons TP in 2006) or a net retention (e.g., 3.5 metric tons TP in 2007) from Iron Gate Reservoir between May and September depending on the year. As a percent of the total inflow, the May through September TP retention in Copco No. 1 Reservoir ranges from approximately negative 2 to negative 11 percent of inflow (i.e., export of TP), while the May through September TP retention in Iron Gate Reservoir ranges from approximately negative 6 to 5 percent of inflow (i.e., export or retention of TP) (Asarian et al. 2009). Data indicate much of the TP released from reservoir sediments in Copco No. 1 and Iron Gate reservoirs during summertime anoxia remains in the hypolimnion until the reservoirs begin to turn over in the fall (Asarian et al. 2009, 2010; Asarian and Kann 2011), but there is still an overall net export of TP from the two reservoirs during the main reservoir phytoplankton growth season as evidenced by the total combined TP retention in Copco No. 1 and Iron Gate reservoirs ranging from approximately negative 12 to negative 4 percent of inflow during May through September in 2005, 2006, and 2007 and the average combined TP retention in the reservoirs being equal to approximately negative 8 percent over these three years (Asarian et al. 2009). While the combined influence of the reservoirs is a net export of TP into the Hydroelectric Reach over the May through September period, Copco No. 1 and Iron Gate reservoirs typically retain TP during the earlier part of the May through September time period and export TP during the later part of the summer as internal nutrient loading associated with anoxic conditions increases (Asarian et al. 2009). Asarian and Kann (2011) observe TP measured at river locations generally decreasing through the Hydroelectric Reach from January to May and from July to August/September (varies by year), but TP exhibiting an increasing trend from August/September until approximately December. Oliver et al. (2014) also note TN and TP usually decrease with distance downstream from J.C. Boyle, but TP is found to occasionally slightly increase from J.C. Boyle Reservoir to Iron Gate Dam primarily between July and November.

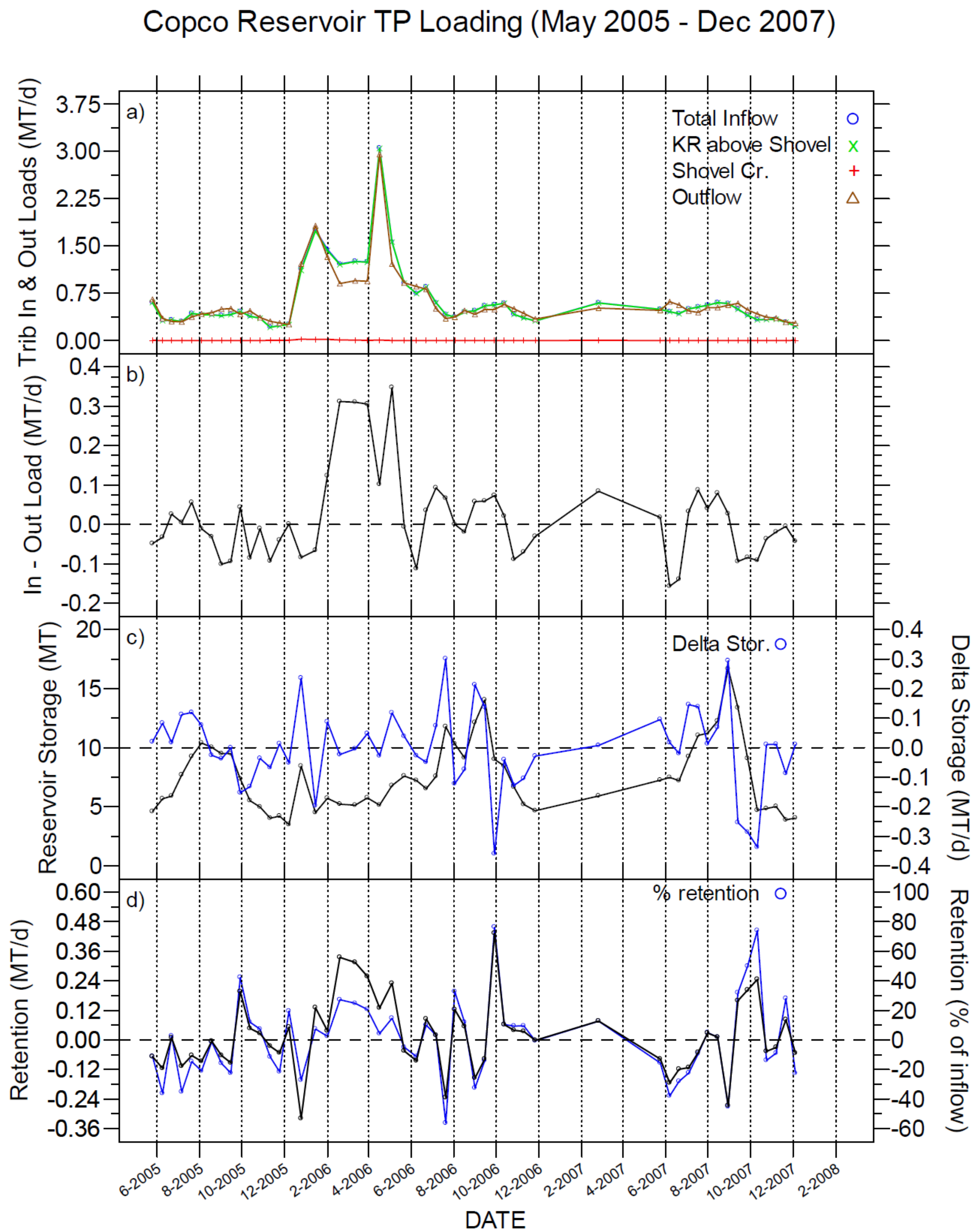

Figure C-24-A. Copco No. 1 Reservoir Total Phosphorus Loading, May 2005 to December 2007. Each Point Represents Data from an Entire Sampling Interval (Approximately Biweekly) and is Placed at the Midpoint of the Two Adjacent Sampling Dates. Horizontal Dashed Lines are Placed at Zero for Delta Storage and Retention. Source: Asarian et al. 2009.

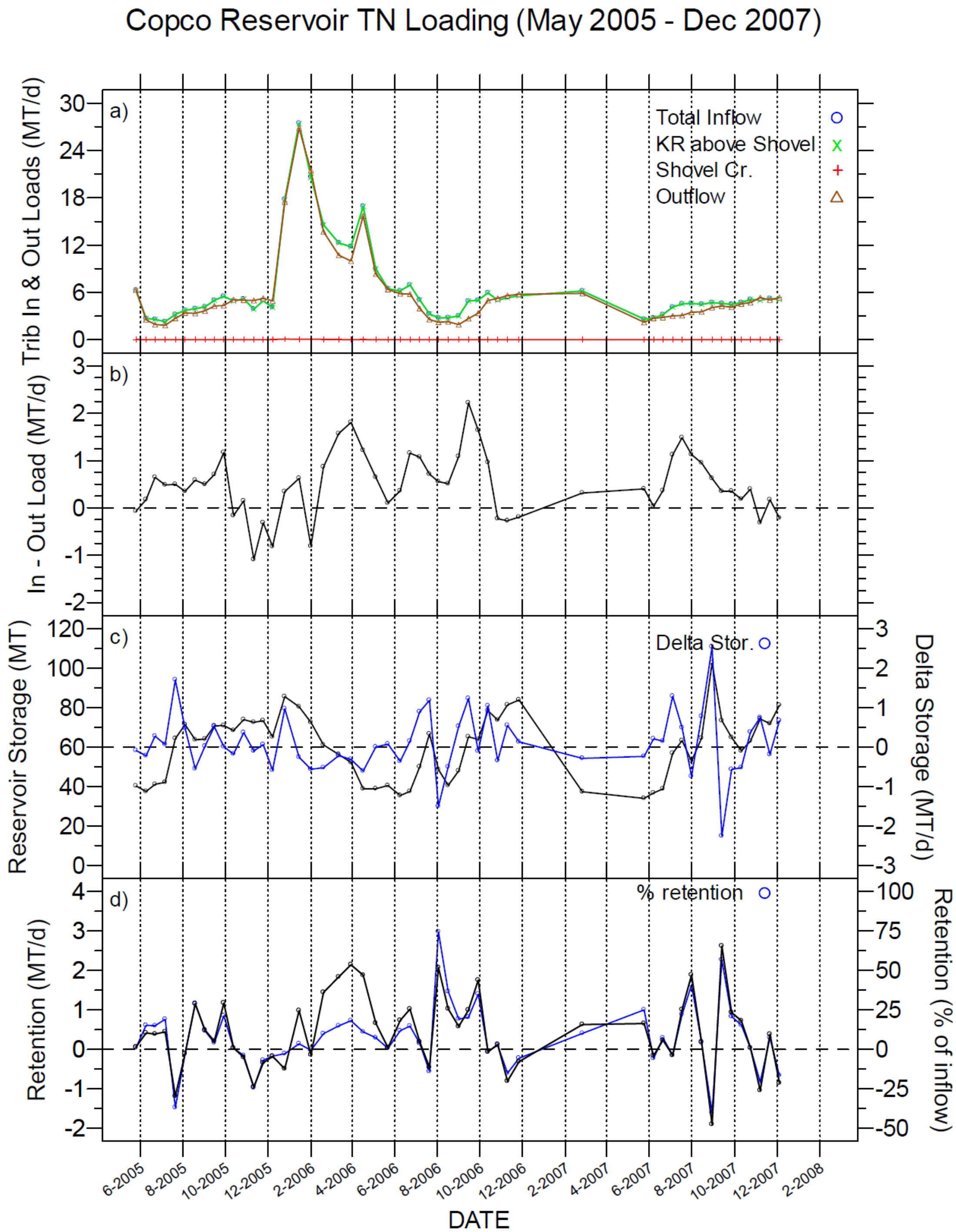

Figure C-24-B. Copco No. 1 Reservoir Total Nitrogen Loading, May 2005 to December 2007. Each Point Represents Data from an Entire Sampling Interval (Approximately Biweekly) and is Placed at the Midpoint of the Two Adjacent Sampling Dates. Horizontal Dashed Lines are Placed at Zero for Delta Storage and Retention. Source: Asarian et al. 2009.

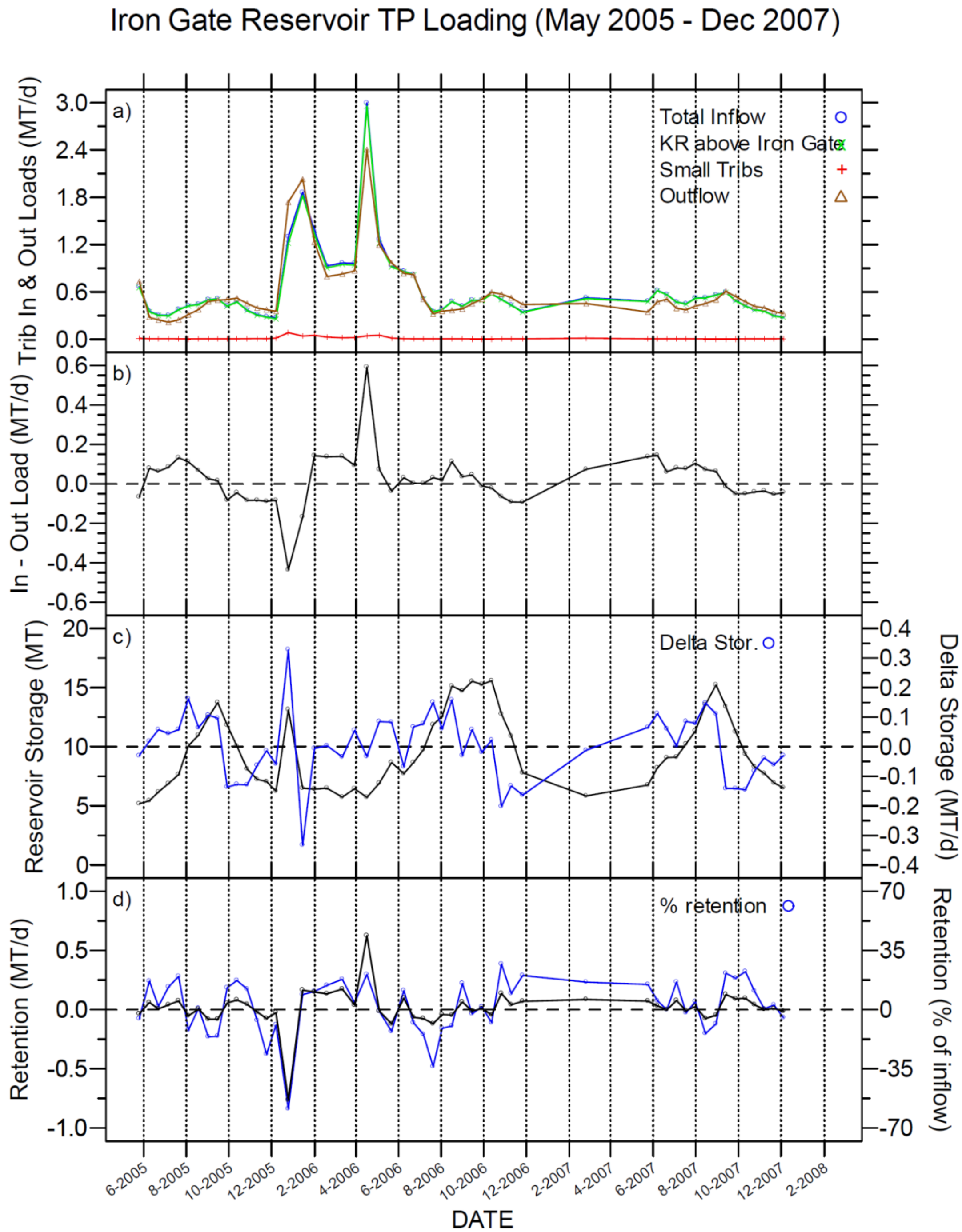

Figure C-24-C. Iron Gate Reservoir Total Phosphorus Loading, May 2005 to Dec 2007. Each Point Represents Data from an Entire Sampling Interval (Approximately Biweekly) and is Placed at the Midpoint of the Two Adjacent Sampling Dates. Horizontal Dashed Lines are Placed at Zero for Delta Storage and Retention. Source: Asarian et al. 2009.

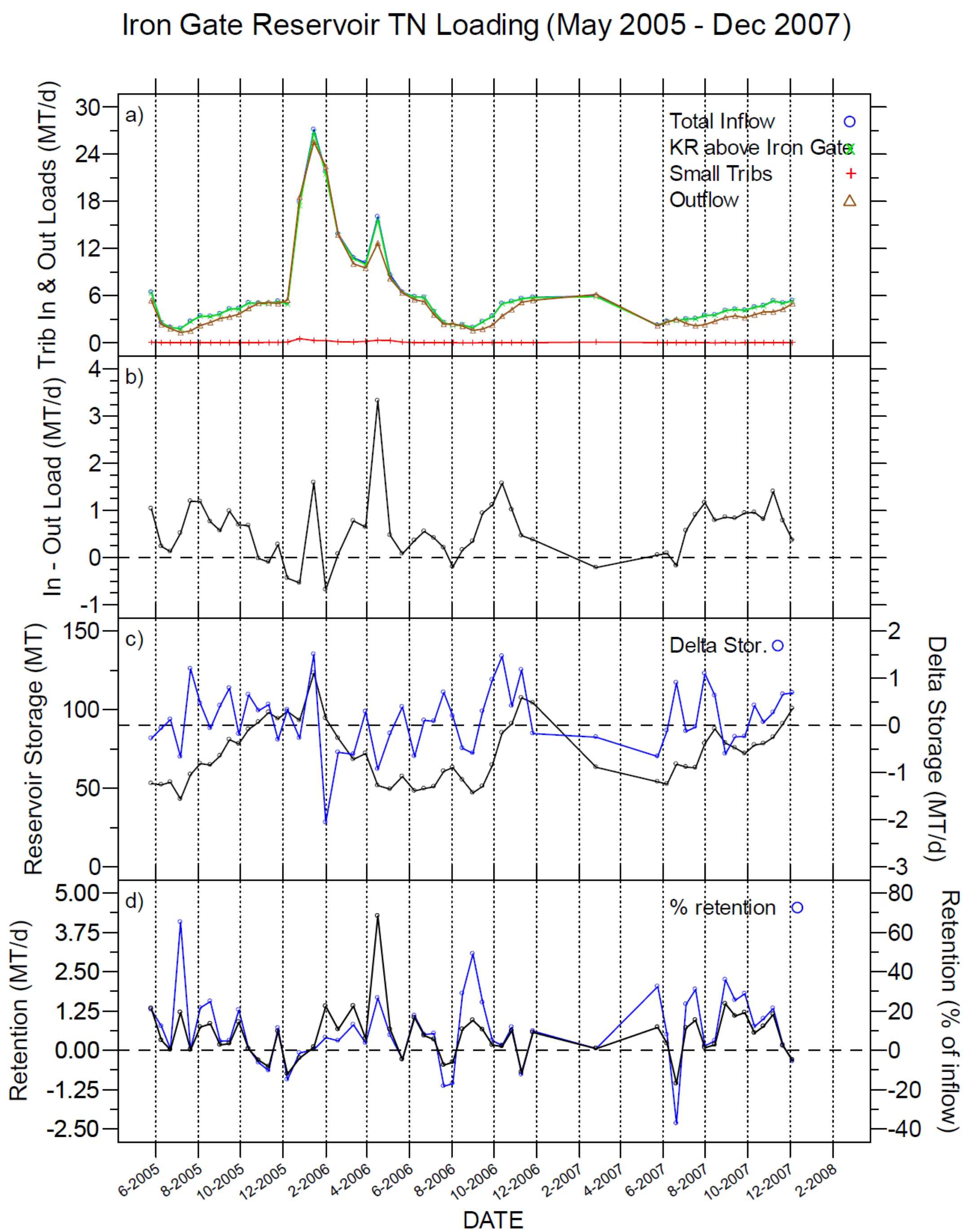

Figure C-24-D. Iron Gate Reservoir Total Nitrogen Loading, May 2005 to Dec 2007. Each Point Represents Data from an Entire Sampling Interval (Approximately Biweekly) and is Placed at the Midpoint of the Two Adjacent Sampling Dates. Horizontal Dashed Lines are Placed at Zero for Delta Storage and Retention. Source: Asarian et al. 2009.

With respect to nutrient speciation, internally driven reservoir nutrient dynamics due to stratification patterns and hydraulic residence time in Iron Gate and Copco No. 1 reservoirs appear to influence ortho-phosphorus and, to a lesser degree, ammonium concentrations within the Hydroelectric Reach.

Orthophosphate

Orthophosphate is a bioavailable and dissolved form of phosphorus that is frequently measured in addition to total phosphorus to assess the nutrients available for uptake by aquatic organisms. Orthophosphate is the most commonly measured form of dissolved phosphorus, but soluble reactive phosphorus (SRP) is also measured and can be used as a surrogate for orthophosphate. SRP concentrations in the riverine portions of the Hydroelectric Reach generally follow a decreasing longitudinal trend through this reach for summer and fall months (i.e., May through November; see Figure C-23). However, concentrations in Iron Gate Reservoir can exceed those of upstream sites (i.e., Klamath River downstream from J.C. Boyle and Copco No. 1 reservoirs) particularly between September and December (Asarian et al. 2009; Asarian et al. 2010; Raymond 2009a, 2010a; Asarian and Kann 2011; Oliver et al. 2014). Although there are limited data during winter months when the reservoirs are mixed, a synthesis of SRP data from 2005 to 2010 shows concentrations of orthophosphate appear to be more constant throughout the water column, while in stratified periods (i.e., May to October/November) concentrations near the bottom of the reservoirs can reach relatively high levels (Asarian and Kann 2011). For example, orthophosphate concentrations in the bottom waters of Copco No. 1 Reservoir reached 1.4 mg/L in September and October of 2008 and 2009, while surface water concentrations were approximately 0.2 to 0.3 mg/L (see Figure 26 in Raymond [2009a] and Figure 22 in Raymond [2010a]). Orthophosphorus concentrations in Iron Gate Reservoir during this same period ranged from approximately 0.1 mg/L to 0.3 mg/L (Raymond 2009a, 2010a). Vertical differences in orthophosphorus concentrations in Iron Gate Reservoir were less than 0.1 mg/L, but the highest concentrations often occurred near the bottom sediments (see Figure 26 in Raymond [2009a] and Figure 25 in Raymond [2010a]).

Nitrate

Data from 2001 to 2008 indicate that nitrate concentrations often peak in the vicinity of J.C. Boyle Reservoir and decrease through the remainder of the Hydroelectric Reach (Raymond 2009a). More recent analyses of nitrate concentrations from 2005 to 2011 in the Hydroelectric Reach support this conclusion and detail seasonal nitrate variations with nitrate substantially higher upstream of Copco No. 1 Reservoir than downstream of Copco No. 1 Reservoir or Iron Gate Reservoir (Asarian and Kann 2011, Oliver et al. 2014). On a seasonal basis, coupled nutrient and phytoplankton data indicate that nitrate levels decrease during algal blooms in the Hydroelectric Reach. Cyanobacteria [blue-green algae] blooms were recorded in Iron Gate and Copco No. 1 reservoirs in summer and fall 2005 coincident with a nitrate decrease of up to 0.8

mg/L between the inflow to Copco No. 1 and the outflow of Iron Gate reservoirs (Kann and Asarian 2007). In 2010 to 2011, Oliver et al. (2014) also observed low nitrate concentrations corresponding to algal blooms measuring nitrate concentrations from 0.01 to 0.08 mg/L NO_3^--N in May-July during the onset and initial peak of the algal bloom, 0.08 to 0.94 mg/L NO_3^--N in August to October following the bloom peak and during the initial bloom decline , 0.39 to 1.01 mg/L NO_3^--N in November to January, and 0.21 to 0.73 mg/L NO_3^--N in February to April. Dilution from the springs downstream from J.C. Boyle Dam also reduces nitrate concentrations in this reach even though the springs are also a relatively constant source of nitrate (Oliver et al. 2014).

Ammonium/Ammonia (NH_4^+/NH_3)

Ammonium (NH_4^+) and ammonia (NH_3) are two related forms of nitrogen that influence water quality, with the ratio of ammonium and ammonia dependent on the water temperature and pH (North Coast Regional Board 2010). Ammonium is converted to ammonia at higher water temperatures and higher pH. Ammonium and ammonia are naturally formed in the environment by microbes and some forms of blue-green algae that combine nitrogen from the air with hydrogen (nitrogen fixation), microbes that convert nitrogen in decaying organic matter into ammonia and ammonium, and fish excreting ammonia (USEPA 2013). Ammonium is a nutrient that is directly usable by phytoplankton and as such it can promote phytoplankton growth. At high concentrations, ammonium and ammonia are toxic to aquatic species, with toxicity levels varying by species. Ammonia is more toxic than ammonium (North Coast Regional Board 2010), so it is the form typically measured and reported.

Nutrient data from 2005 to 2010 show ammonia concentrations from May to September are often lowest upstream of Copco No. 1 Reservoir or downstream of Iron Gate Dam with the highest concentrations in Copco No. 1 Reservoir, but ammonia concentrations from October to December are higher upstream of Iron Gate Reservoir and downstream of Iron Gate Dam (Asarian and Kann 2011). Low ammonia concentrations between May and September are attributed to nitrification in the turbulent oxygen-rich Klamath River upstream of Copco Reservoir (Deas 2008). Asarian and Kann (2011) identify deterioration and decay of algal blooms along with reservoir turnover as the likely causes of higher ammonia concentrations from October to December. Seasonal longitudinal trends in the ammonium concentrations in the Hydroelectric Reach show minimums occur during May to July algal bloom periods and maximums occur during November to January (Oliver et al. 2014).

Relatively high levels of ammonium have been recorded in reservoirs in the Hydroelectric Reach especially in the lower reservoir depths. While available data collected to date suggests no actual ammonia toxicity events associated with the operation of the Lower Klamath Project (North Coast Regional Board 2010), elevated ammonia levels in the deeper portions of the hypolimnion of both Copco No. 1 and Iron Gate reservoirs in summer of 2005 exceeded 0.6 mg/L

(Figures 12 and 14 in Kann and Asarian 2007), indicating that anoxic conditions are likely causing conversion of organic nitrogen in reservoir deposits to ammonia. From 2001 to 2004, June and November mean ammonia concentrations in Iron Gate Reservoir were 0.1 to 0.3 mg/L to a depth of 45 meters, whereas Copco No. 1 Reservoir concentrations were consistently higher for the 20- to 32-meter depth and were 0.9 to 1.0 mg/L in September and October (FERC 2007). Only minor increases in ammonia (0.05 to 0.1 mg/L) have been observed to occur in the Hydroelectric Reach between upstream of Copco No. 1 Reservoir and downstream from Iron Gate Reservoir, most often during October and November (Kann and Asarian 2005, 2007). Data from 2005 to 2008 show ammonia concentrations downstream of Iron Gate Reservoir ranging from approximately 0.01 to 0.05 mg/L in September, increasing through September until becoming greater than ammonia concentrations upstream of Iron Gate Reservoir during October, and peaking between October and November at approximately 0.1 to 0.2 mg/L due to the anoxic conditions in the lower section Iron Gate Reservoir (Asarian et al. 2009, 2010). The 2005 to 2010 average monthly ammonia concentrations support previous findings showing ammonia concentrations increase substantially (often over an order of magnitude) with depth in Copco No. 1 Reservoir between May and October peaking at over 1.0 mg/L in September/October, while ammonia concentrations in Iron Gate Reservoir increase with depth between May and November usually peaking around 0.4 to 0.8 mg/L in October/November (Asarian and Kann 2011).

C.3.2 Mid- and Lower Klamath Basin

C.3.2.1 Iron Gate Dam to Salmon River

Historical (1950 to 2001) TP data indicate median values of 0.11 to 0.19 mg/L in the Lower Klamath Basin between Iron Gate Dam and Seiad Valley, with the highest values occurring just downstream from the dam (Figure C-25). Variability over the long-term record in this reach is lower than upstream reaches, with concentrations varying from near zero to over 0.3 mg/L for the period of record (Figure C-25). The historical record indicates relatively low variability in orthophosphate concentrations in the reach (as compared with variability in the Upper Klamath Basin), with median values of 0.03 to 0.1 mg/L (PacifiCorp 2004b).

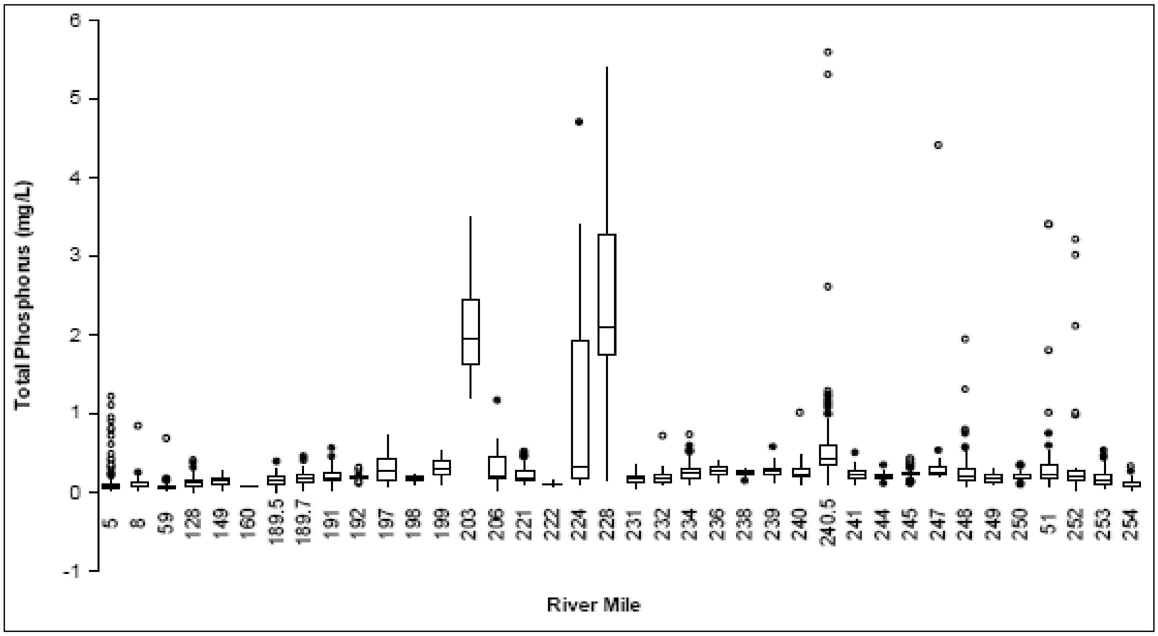

Figure C-25. Box and Whisker Plot of Historical TP Data Collected from Various Sites in the Klamath River from Klamath River at Klamath Glen (RM 5.9) to Klamath River at Link River Dam (RM 259.7) Between 1950 and 2001. Source: PacifiCorp 2004b.

More recent data from 2001 to 2015 also show TP concentrations generally decreasing with distance downstream from Iron Gate Dam and indicate that phosphorus dynamics in the Klamath River immediately downstream from Iron Gate Dam are affected by conditions within the Lower Klamath Project reservoirs (Section C.3.1.1) (Figures C-22 and C-26; Asarian et al. 2010; Asarian and Kann 2013; Oliver et al. 2014; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). Analysis of data from 2001 to 2011 shows the highest TP concentrations occurring during the low flow years of 2001 to 2004 when TP exceeded 0.4 mg/L downstream from Iron Gate Dam and the lowest TP concentrations occurring during the high flow years of 2006, 2010, and 2011 and the moderate flow year of 2005 (Asarian and Kann 2013). TP concentrations vary seasonally with TP peaking after the algal bloom peak and then decreasing during late fall and early winter (Oliver et al. 2014). During May 2005 to November 2008, peak TP concentrations at locations downstream from Iron Gate Dam occurred between mid-August and early October, which is roughly one to two months later than peak timing in upstream reaches and may be due to the hydraulic residence time in Iron Gate and Copco No. 1 reservoirs, or release of TP from anoxic sediments during summer stratification or following algal bloom and death (Figure C-23). After peaking, the TP concentrations declined steeply in late-fall in some years, but they exhibited a more gradual decline in others (Figure C-23). Orthophosphate or SRP tends to decrease in the mainstem Klamath River with distance downstream from Iron Gate Dam (FERC 2007; Asarian et al. 2010; Asarian and Kann 2013). Seasonal trends in orthophosphate closely follow observed TP concentrations and for the period 2005 to 2008 this phosphorus species regularly accounts for 60 to 90 percent of TP sampled (Asarian et al. 2010; Asarian and Kann 2013; Oliver et al. 2014).

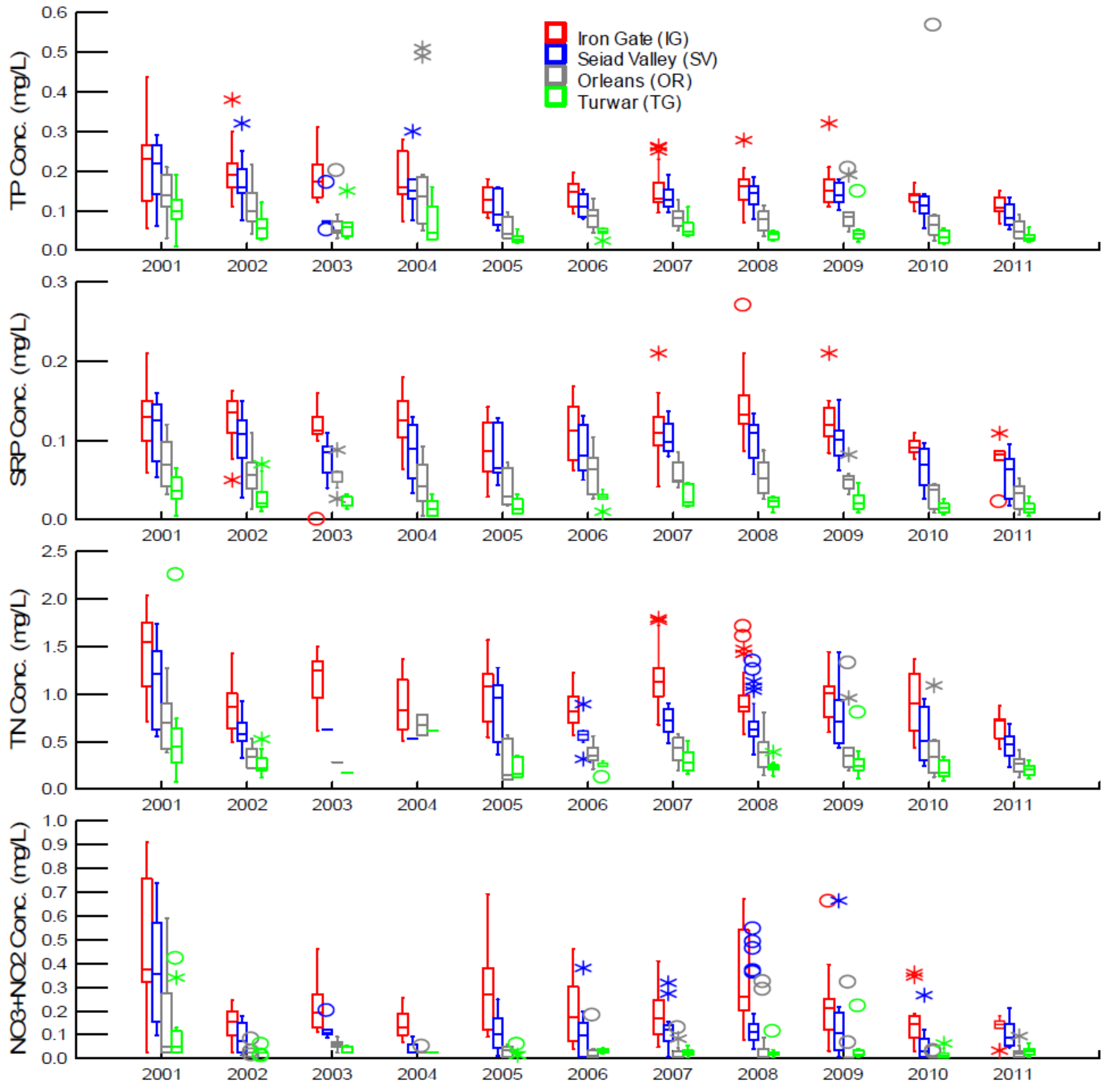

Figure C-26. Box and Whisker Plot of Total Phosphorus (TP), Soluble Reactive Phosphorus (SRP), Total Nitrogen (TN), and Nitrate plus Nitrite Nitrogen (NO3+NO2) for the June-October Period from 2001-2011 at Four Mainstem Klamath River Sites. Source: Asarian and Kann 2013.

For the period 1996 to 2007, average TN concentrations downstream from Iron Gate Dam (RM 193.1), vary by year, with mean concentrations of 1.2 mg/L (FERC 2007) and a range of measured concentrations from less than 0.1 to over 2.0 mg/L (North Coast Regional Board 2010). Additional historical (1951 to 2001) nitrogen data is available as Total Kjeldahl Nitrogen or TKN, a measure of organic nitrogen plus ammonia. TKN median values for this period were 0.6 to 0.9 mg/L in the Lower Klamath Basin between Iron Gate Dam and Seiad Valley, with the highest median values occurring just downstream from the dam (PacifiCorp 2004b). Variability over the long-term record in this reach is relatively low compared with that of upstream reaches. For 1951 to 2001, high variability in nitrate concentrations is apparent in the reach between Iron Gate Dam and the Salmon River confluence, with some relatively high concentrations (greater than 5 mg/L) occurring at the Seiad Valley location (RM 132.7) (PacifiCorp 2004b).

More recent data from 2001 to 2015 show TN concentrations tend to decrease with distance downstream from Iron Gate Dam (Figures C-21, C-24, and C-26) and the nitrogen dynamics immediately downstream of Iron Gate Dam are affected by conditions within the Lower Klamath Project reservoirs (Asarian et al. 2010; Asarian and Kann 2013; Oliver et al. 2014; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). Based on data collected from 2001-2011, TN concentrations in the river downstream from Iron Gate Dam are generally lower than those in upstream reaches (Figures C-24 and C-26) due to dilution from the springs downstream from J.C. Boyle Dam and reservoir retention in the Hydroelectric Reach (Asarian et al. 2009; Asarian and Kann 2013). Further decreases in TN occur in the mainstem river downstream from Iron Gate Dam due to a combination of tributary dilution and in-river nitrogen removal processes such as denitrification and/or storage related to biomass uptake (Asarian et al. 2010). TN concentrations between 2001 and 2011 are highest in the low flow year 2001 and lowest in the high flow year 2011 (Asarian and Kann 2013). On a seasonal basis, TN increases from May through November, with peak concentrations (1−1.5 mg/L) typically observed during September and October (Figure C-24). Analysis of the 2001−2004 dataset also indicates that median TN concentrations in the Klamath River from Iron Gate Dam to (RM 193.1) to Seiad Valley (RM 132.7) exceed 0.2 mg/L (Asarian and Kann 2006b). A review of median TN concentrations from 2012 to 2015 (Figure C-21) also shows TN consistently exceeding 0.2 mg/L downstream of Iron Gate Dam (RM 193.1), Seiad Valley (RM 132.7), and Happy Camp (RM 108.4) (Watercourse Engineering, Inc. 2013, 2014, 2015, 2016).

Ratios of TN to TP (TN:TP) measured in the Klamath River suggest the potential for the system to be nitrogen-limited with some periods of co-limitation by N and P; however, concentrations of both nutrients are high enough in the river from Iron Gate Dam (RM 193.1) to approximately Seiad Valley (RM 132.7) (and potentially farther downstream) that nutrients are not likely to be limiting primary productivity (e.g., periphyton growth) in this portion of the Klamath River (FERC 2007, HVTEPA 2008, Asarian et al. 2010). In addition, nitrogen-fixing species dominate the periphyton communities in the lower reaches of the Klamath River where inorganic nitrogen concentrations are low (Asarian et al. 2010, Asarian et al. 2015). Since these species can fix their own nitrogen from the atmosphere, nitrogen would not limit their growth (Asarian et al. 2015).

Data collected during 2001 to 2015 indicate nitrate concentrations also tend to decrease longitudinally in the Klamath River downstream from Iron Gate Dam (Asarian et al. 2010; Asarian and Kann 2013; Oliver et al. 2014; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). Although patterns in nutrient concentrations vary between years, nitrate typically increases between July and September, with measured concentrations downstream from Iron Gate Dam frequently greater than 0.25 mg/L (Asarian et al. 2010; Asarian and Kann 2013). In the fall, nitrate concentrations tend to increase again, occasionally reaching values of over 0.6 mg/L (Asarian et al. 2010, Asarian and Kann 2013). Mean 2000 to 2004 nitrate concentrations downstream from Iron Gate Dam were 0.15 to 0.44 mg/L between March and November, with the highest concentrations observed in early September (FERC 2007). Over the same time period, mean nitrate concentrations farther downstream near the confluence of the Shasta River (RM 179.5) had decreased to 0.02 to 0.36 mg/L, with peaks observed in early November (FERC 2007). Nitrate generally comprises less than 40 percent of the TN concentration throughout the lower Klamath River (Asarian et al. 2010). Nitrate concentrations at Seiad Valley (RM 132.7) from 2001 to 2011 consistently increase in the fall between August and November frequently exceeding 0.2 mg/L (Asarian and Kann 2013, Oliver et al. 2014).

As a result of the seasonal production of ammonia in anoxic hypolimnetic waters of the Lower Klamath Project reservoirs (Section C.3.1.1) and the high pH levels (greater than 7.5 pH units) measured seasonally downstream from Iron Gate Dam (YTEP 2005, North Coast Regional Board 2011), the North Coast Regional Board evaluated all available sampling data records as part of Klamath River TMDL development. The North Coast Regional Board analysis showed that for sampling events in which all three parameters (pH, ammonia, and water temperature) were collected simultaneously, no acute or chronic toxicity exceedances of the *Water Quality Control Plan for the North Coast Region* (Basin Plan) criteria for ammonia were indicated (North Coast Regional Board 2010). For the May to November sampling period in 2005 to 2008, ammonia concentrations in the Klamath River downstream from Iron Gate Dam were generally less than 0.3 mg/L and constituted less than 10 percent of the TN concentration (Asarian et al. 2010). Highest concentrations were measured during fall months downstream from Iron Gate Dam (RM 193.1), with late-fall ammonia concentrations generally increasing at this location and values increasing to above 0.2 mg/L during November 2006. For the period 2000 to 2004, mean ammonia levels of 0.13 mg/L were reported in Iron Gate Dam outflow (FERC 2007).

Although tributary dilution generally has a proportionally greater effect on nutrient concentration reductions in the Klamath River downstream from Iron Gate Dam, nutrient retention is an important component of overall nutrient dynamics in this reach (Asarian et al. 2010, Oliver et al. 2014). In a study of the June to October and July to September periods during 2005 to 2008, nutrient retention in the reach from Iron Gate Dam to the Klamath River Estuary was calculated after accounting for tributary dilution (Asarian et al. 2010). For the study, positive retention values represented seasonal removal of nutrients from the water column through storage in phytoplankton/plant biomass or denitrification, and negative retention represented an internal source of nutrients from sediment release or phytoplankton regeneration and nitrogen fixation. Retention rates downstream from Iron Gate Dam were variable but generally positive for TP, although negative retention was observed during some years in the reach between Seiad Valley (RM 132.7) and the Salmon River (RM 66.3), as well as further downstream to Turwar (RM 5.6) (Asarian et al. 2010). In general, TP and orthophosphate retention increased with distance downstream from Iron Gate Dam while particulate phosphorus retention decreased (i.e., negative retention). Nutrient retention for TN was similarly positive, with instances of negative retention observed during 2005 between Iron Gate Dam (RM 193.1) and Seiad Valley (RM 132.7) (see Section C.3.2.2 for discussion of retention in lower reaches). Additionally, during 2005 to 2008, total inorganic nitrogen (TIN = nitrite + nitrate + ammonia) retention was consistently positive between Iron Gate Dam and as far downstream as the Trinity River confluence (RM 43.3). The Asarian et al. (2010) analysis indicates that large quantities of nitrogen and phosphorus were retained in the river across the roughly 130 miles from Iron Gate Dam to just downstream from the Salmon River at Orleans (RM 58.9). During July to September of 2007 to 2008, the incoming nutrient load at Iron Gate Dam was reduced by 24 percent for TP, 25 percent for orthophosphate, 21 percent for particulate phosphorus, 41 percent for TN, 93 percent for TIN, and 21 percent for organic nitrogen (Asarian et al. 2010). Oliver et al. (2014) report a pattern of decreasing TN loads downstream of Iron Gate Dam due to algal sedimentation or denitrification during August to November, increasing TN loading during December through April once discharge increased in the winter/spring period, and relatively similar TN loads across sites from downstream of Iron Gate Dam to Seiad Valley between May and July. Trends in TP loads indicate TP is less influenced by algal blooms than seasonal changes in discharge with TP loads generally increasing with distance downstream of Iron Gate Dam at higher winter/spring discharge rates (Oliver et al. 2014).

C.3.2.2 Salmon River to Estuary

Downstream from the confluence with the Salmon River (RM 66.3), nutrient concentrations continue to decrease in the Klamath River as compared with those measured farther upstream. Historical (1950 to 2001) TP data indicate median values of 0.06 to 0.07 mg/L in river between the Salmon River confluence and near the Klamath River Estuary, with generally low variability (Figure C-25). Orthophosphate levels and variability over the long-term record in the reach downstream from the Salmon River are similar to those in the reach downstream from Iron Gate Dam (see previous section). Data from 2001 to 2015 indicate that TP concentrations in this reach are generally 0.05 to 0.1 mg/L with TP concentrations approaching 0.2 mg/L or greater in some years at the furthest upstream site Orleans (RM 58.9) (Figures C-22, C-23, and C-14; Asarian et al.

2010; Asarian and Kann 2013; Oliver et al. 2014; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). Data from 2005-2008 shows peak values occurring in September and October (Figure C-23). Water quality monitoring by the HVTEPA from 2008 to 2012 at Saints Rest Bar (RM 44.9) in the Klamath River shows TP ranging from 0.026-0.127 mg/L while SRP ranges from approximately 0.005 to 0.07 mg/L. Both TP and SRP (i.e., orthophosphate) at Saints Rest Bar generally increase from June through October reaching the annual peak between August and October (HVTEPA 2013). Data from 2007 to 2014 collected by the Yurok Tribe Environmental Program provide more recent seasonal patterns in the TP and SRP concentrations from Weitchpec (RM 43.6) upstream of the confluence with the Trinity River to the Klamath River Estuary (Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b, Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). In 2014, both TP and SRP at sites downstream of the Trinity River are at a minimum around mid-May, increase until peaking in September/October, and decrease until December (Hanington and Cooper-Carouseli 2014). Downstream from the Trinity River, orthophosphate often accounts for less than 50 percent of TP, possibly due to dilution from the Trinity River (Asarian et al. 2010).

As with upstream reaches, historical (1951 to 2001) nitrogen data is available as TKN, nitrate, and ammonia. TKN median values downstream from the Salmon River for this period were 0.25 to 0.3 mg/L (PacifiCorp 2004b). Variability over the 1951 to 2001 record in this reach is dependent on sampling location, with the greatest variability for the most downstream site at Klamath Glen (RM 5.9). In the 1951 to 2001 dataset, high variability in nitrate concentrations is apparent throughout this reach, with some relatively high concentrations (greater than 3 mg/L) occurring at Orleans (RM 58.9) and Klamath Glen (RM 5.9) (PacifiCorp 2004b). Data from 2001 to 2015 indicate that TN concentrations in this reach are generally between 0.1 to 0.5 mg/L with TN concentrations frequently peaking above 0.5 mg/L between August and October at sites upstream of the Trinity River (Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Asarian and Kann 2013; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014; Watercourse Engineering, Inc 2012, 2013, 2014, 2015, 2016). However, TN concentrations substantially exceeded the typical range in some years like 2001. Data from 2005 to 2008 show the seasonal variations with TN increasing from May through November and peak concentrations (approximately 0.5 mg/L) typically observed during September and October (Figure C-24), which are at or above the Hoopa Valley Tribe numeric criterion of 0.2 mg/L TN. TN concentrations from 2008 to 2012 at Saints Rest Bar (RM 44.9) range from less than 0.1 mg/L to approximately 1.0 mg/L while nitrate plus nitrite ranges from less than 0.05 mg/L to approximately 0.28 mg/L. TN at Saints Rest Bar generally increases from June through October reaching the annual peak between September and October, but nitrate plus nitrite varies less until September when it increases and peaks between September and October (HVTEPA 2013). Downstream from the Trinity River confluence (RM 43.3), TN concentrations are typically less than 0.5 mg/L (YTEP 2005; Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Asarian and Kann 2013; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014), with general increases from spring to fall months. For the 2005 to 2008 dataset, TN increases were observed between September and October at Orleans (RM 58.9), upstream of the confluence with the Trinity River (approximately RM 43.3), and at Turwar (RM 5.6) (Figure C-24; Asarian et al. 2010). Similar patterns in TN concentrations were measured between 2009 and 2014 at sites between Orleans and Turwar (Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Asarian and Kann 2013; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014).

Nutrient retention rates in the Klamath River, from approximately the Salmon River confluence to the Trinity River, are variable for the period 2005 to 2008, but generally positive for TN and TP. However, from the Trinity River to the Klamath River Estuary, TN and TP nutrient retention rates are generally negative (Asarian et al. 2010). For example, during 2005 to 2008, total inorganic nitrogen (TIN = nitrite + nitrate + ammonia) retention was consistently negative between the Trinity River confluence and Turwar (RM 5.6) (Asarian et al. 2010). The Asarian et al. (2010) analysis suggests that while nitrogen and phosphorus are largely being removed from the river upstream of the Trinity River confluence (RM 43.3) during the June to October and July to September study periods, downstream from the confluence, nutrients are being added. Since retention is a load-based estimate and is inherently tied to flows, it is possible for nutrient loads to increase even while nutrient concentrations in the water decrease (in this case, only slightly).

C.3.2.3 Klamath River Estuary

Nutrient concentrations in the Klamath River Estuary are highly variable spatially and temporally and are greatly influenced by season, river flow, tidal prism, and location of the estuary mouth. In general, nutrient concentrations in the Klamath River Estuary are lower than in the Klamath River just upstream of the Trinity River confluence (RM 43.6) and comparable to the nearest river sampling station (RM 5.6) near Turwar (YTEP 2004, 2005; Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). One exception to that trend is ammonia which is consistently higher in the Klamath River Estuary than upstream locations with peaks occurring between August and December (YTEP 2004, 2005; Sinnott 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). Inter-annual and seasonal variability are apparent in the contemporary data collected by the Yurok Tribe during 2006 to 2014 (Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). For example, measured concentrations of TP in the Klamath River Estuary are below 0.12 mg/L during the period June to October 2006 to 2014. Contemporary data (2006 to 2014) indicate that TP concentrations in the Klamath River Estuary generally range from approximately

0.02 to 0.08 mg/L with peak values generally occurring in September and October, although 2009 and 2010 data indicated that concentrations of TP can continue to increase into November and December, especially during elevated river flows (Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). During peak concentrations, values often exceed the Hoopa Valley Tribe's standard of 0.035 mg/L TP (HVTEPA 2008). During the same period, orthophosphate is consistently reported at less than 0.06 mg/L. Orthophosphate often accounts for more than 50 percent of TP from June through October.

Contemporary data (2006 to 2014) indicate that TN concentrations in the Klamath River Estuary were consistently below 0.7 mg/L, generally ranging from approximately 0.1 to 0.6 mg/L (Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). Concentrations increase from June to October with peak values occurring in September and October, although 2009, 2010, and 2011 data indicate that concentrations can continue to increase into November and December, especially during high river flows (Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). During peak concentrations, values often exceed the Hoopa Valley Tribe's standard of 0.2 mg/L TN (HVTEPA 2008). During June to October 2006 to 2014, measured values of nitrate plus nitrite in the Klamath River Estuary are near or below the reporting limit (0.01 mg/L) with concentrations ranging from 0.01 mg/L to 0.2 mg/L though nitrate plus nitrite concentrations are typically between 0.01 mg/L and 0.04 mg/L. Concentrations of nitrate plus nitrite in the Klamath River Estuary increase from June to October, with peak values during this period occurring in September and October. As with TN, recent data indicates that nitrate plus nitrite concentrations can continue to increase into November and December, especially during elevated river flows (Sinnott 2010b, 2011b). Measured values of ammonia in the Klamath River Estuary were low, with measurements consistently below 0.1 mg/L during the period June to October 2006 to 2014, generally ranging from 0.01 mg/L to approximately 0.04 mg/L, with peak values generally occurring in September. Many ammonia samples from the Klamath River Estuary return values near or below the reporting limit of 0.01 mg/L (YTEP 2004, 2005; Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper-Carouseli 2014). However, the Klamath River Estuary sampling site has more detectable concentrations of ammonia than any other sampling site within the Yurok Reservation. Nutrient retention has not been explicitly measured in the Klamath River Estuary, although measurements have been made just upstream of the Klamath River Estuary in the reach from the Trinity River confluence (RM 43.3) to Turwar (RM 5.6).

C.4 Dissolved Oxygen

C.4.1 Upper Klamath Basin

C.4.1.1 Keno Impoundment/Lake Ewauna

In the downstream Keno Impoundment/Lake Ewauna, dissolved oxygen reaches very low levels (less than 1 to 2 mg/L) during July through October as algae transported from Upper Klamath Lake settle out of the water and decay (see Figure 3.4-9). Decomposition of algae transported from Upper Klamath Lake appears to be the primary driver of low oxygen in the Keno Impoundment/Lake Ewauna. Dissolved oxygen concentrations measured in 2005 from the downstream end of Lake Ewauna to Keno Dam ranged from 7 to 8 mg/L in the early spring, and by late July concentrations were less than 2 mg/L throughout the water column (Deas and Vaughn 2006). During this same period, dissolved oxygen concentrations in Link River inflow were 7 to 8 mg/L, but apparently had little effect on the dissolved oxygen concentrations in the Keno Impoundment. Continuous dissolved oxygen data collected by Reclamation at Klamath River upstream of Keno Dam (USGS gage no. 11509370) for the period January 2006 through December 2018 exhibit seasonally low dissolved oxygen concentrations (less than 1 mg/L to 5 mg/L) from July through October.

C.4.1.2 Hydroelectric Reach

Dissolved oxygen concentrations in the Hydroelectric Reach vary on a seasonal and daily basis (e.g., FISHPRO 2000; PacifiCorp 2004b, 2008a; FERC 2007; Raymond 2008a, 2009a, 2010a; USFWS 2008; Kirk et al. 2010; Zedonis and Turner 2010; Asarian and Kann 2011; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015). Historical (1950 to 2001) data collected during daytime at various times in the year show median dissolved oxygen concentrations of approximately 5 to 8 mg/L in the Upper Klamath River between J.C. Boyle Reservoir and Iron Gate Dam, with the lowest median values occurring at RM 201.8 and RM 193.1 corresponding to Copco No. 1 Reservoir and Iron Gate Reservoir, respectively (Figure C-27). The highest historical median dissolved oxygen concentrations in the Hydroelectric Reach occur from RM 229.8 to RM 201.8 downstream of J.C. Boyle and upstream of Copco No. 1 Reservoir. Historical water column oxygen demand data is also available for the Hydroelectric Reach from J.C. Boyle to Iron Gate reservoirs. The historical record indicates relatively low biological oxygen demand (BOD) in the Lower Klamath Project reservoirs (Figure C-28).

During summer months, the Lower Klamath Project reservoirs exhibit varying degrees of dissolved oxygen supersaturation in surface waters due to high rates of phytoplankton photosynthesis, especially large blue-green algae blooms, and hypolimnetic anoxia as dissolved oxygen is depleted in bottom waters during seasonal thermal stratification and microbial decomposition of dead phytoplankton. During daylight hours, phytoplankton produce dissolved oxygen (through photosynthesis), resulting in super-saturation of dissolved oxygen.

During nighttime hours, phytoplankton consume dissolved oxygen (through respiration) contributing to lower dissolved oxygen levels.

While reaeration in the reach between Keno Dam and J.C. Boyle Reservoir can increase dissolved oxygen concentrations in the river to near saturation levels, the high oxygen demand in water entering J.C. Boyle Reservoir and a vertical water temperature gradient driven by diurnal fluctuations in river water temperature that limit vertical mixing from July to mid-September can still reduce dissolved oxygen concentrations in the reservoir itself (Figure C-29; Raymond 2008a, 2009a, 2010a). Peaking operations from J.C. Boyle Dam seem to have a negligible effect on dissolved oxygen concentrations between J.C. Boyle and Copco No. 1 because the free-flowing river upstream of J.C. Boyle Reservoir and the high velocity of peaking flows provides sufficient aeration (PacifiCorp 2004b).

Dissolved oxygen concentrations in Copco No. 1 and Iron Gate reservoirs vary seasonally with thermal stratification that limits mixing of surface and bottom waters and results in decreasing dissolved oxygen concentrations with depth. Copco No. 1 and Iron Gate reservoirs thermally stratify beginning in April or May and do not mix again until October to December with Iron Gate achieving complete mixing approximately a month later than Copco No. 1 (FERC 2007; Asarian and Kann 2011). During the stratification time period, dissolved oxygen concentrations in Iron Gate and Copco No. 1 surface waters generally are at or above saturation likely due to photosynthesis by aquatic plants and phytoplankton growth, especially large blue-green algae blooms, concentrating near the reservoirs' surface (Asarian and Kann 2011). Dissolved oxygen concentrations in the hypolimnetic waters near the bottom of the reservoirs are much lower reaching minimum values near 0 mg/L by July (for example, see 2008 data shown in Figures C-30 and C-31). Low dissolved oxygen concentrations (less than 3 mg/L) extend further up in the water column and longer in the season in Iron Gate Reservoir than in Copco No. 1 Reservoir (Figure C-32; Asarian and Kann 2011).

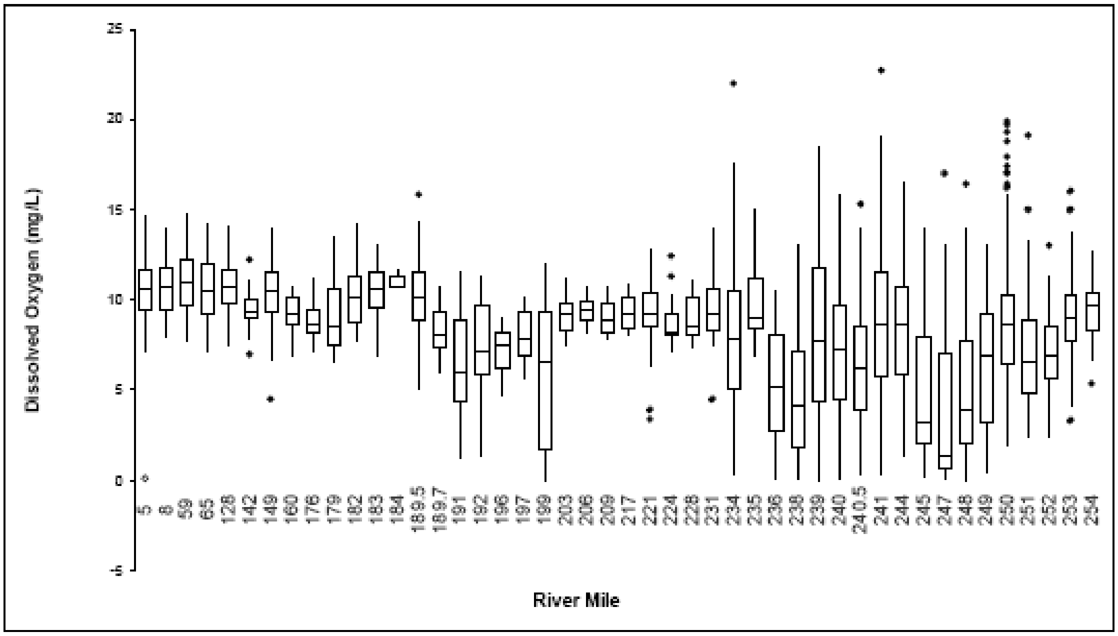

Figure C-27. Box and Whisker Plot of Historical Dissolved Oxygen Concentration Data Collected as Daytime Grab Samples from Various Sites in the Klamath River from Klamath River at Klamath Glen (RM 5.9) to Klamath River at Link River Dam (RM 259.7) between 1950 and 2001. Source: PacifiCorp 2004b.

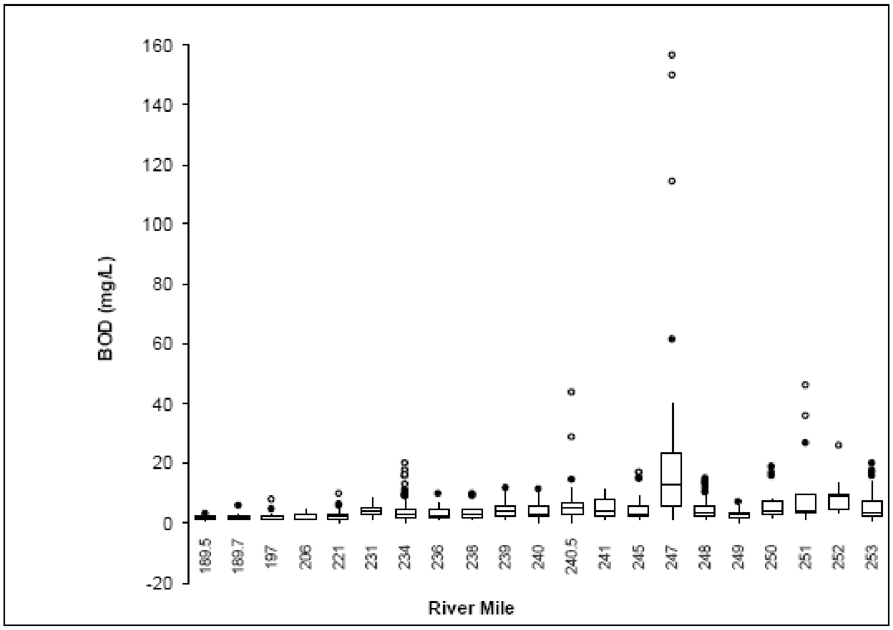

Figure C-28. Box and Whisker Plot of Historical BOD Data Collected from Riverine Sites in the Klamath River Between 1950 and 2001. J.C. Boyle Reservoir (RM 229.8 to RM 233.3), Copco No. 1 Reservoir (RM 201.8 to RM 208.3), Copco No. 2 Reservoir (RM 201.5 to RM 201.8), Iron Gate Reservoir (RM 193.1 to RM 200.0). Source: PacifiCorp 2004b.

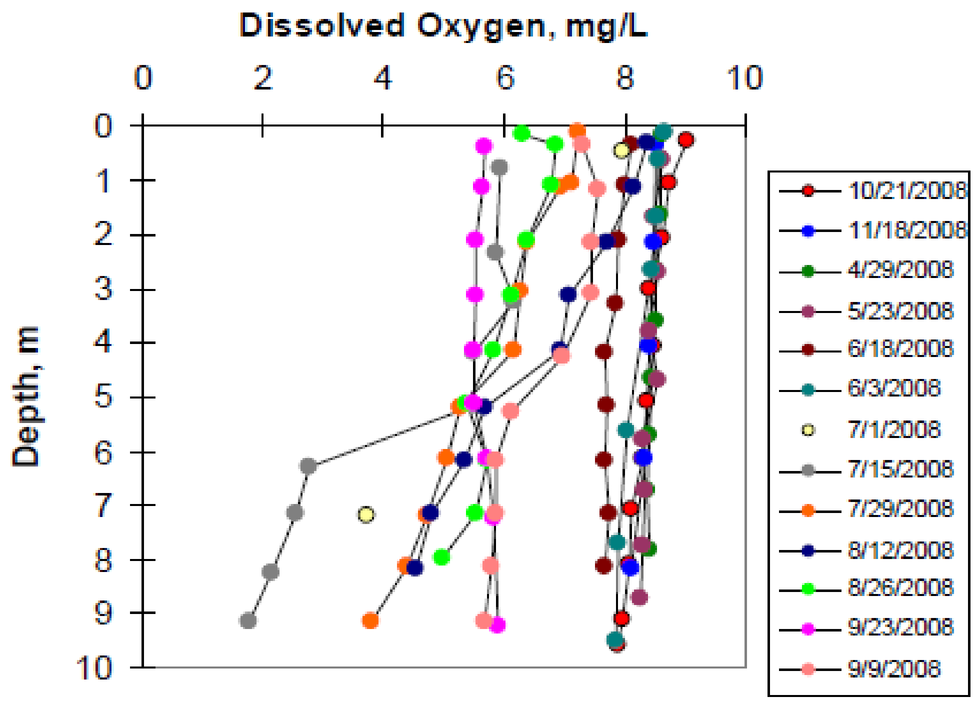

Figure C-29. Vertical Profiles of Dissolved Oxygen Concentration Measured in J.C. Boyle Reservoir Near the Dam in 2008. Source: Raymond 2009a.

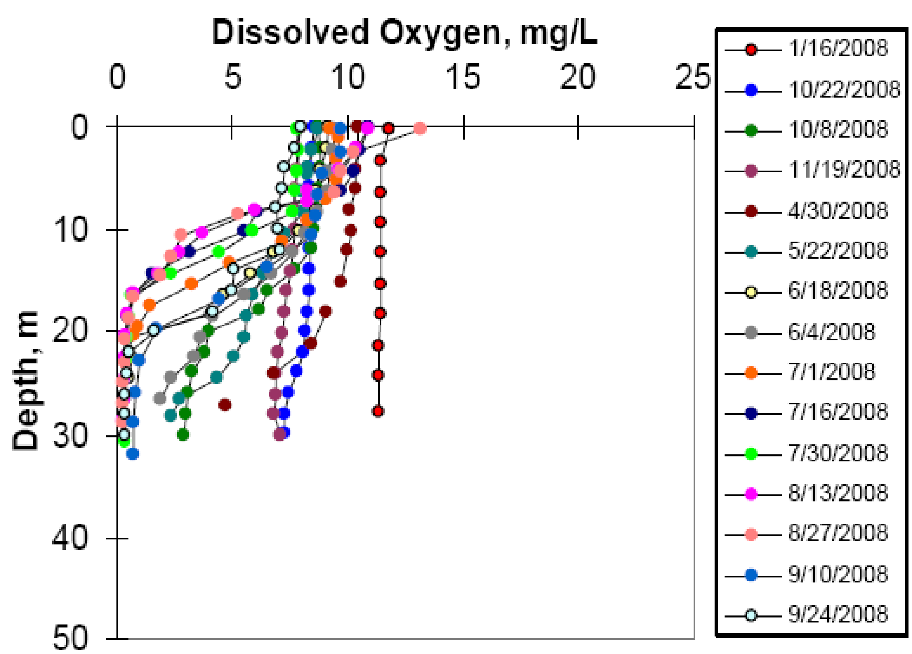

Figure C-30. Vertical Profiles of Dissolved Oxygen Concentration Measured in Copco No. 1 Reservoir Near the Dam in 2008. Source: Raymond 2009a.

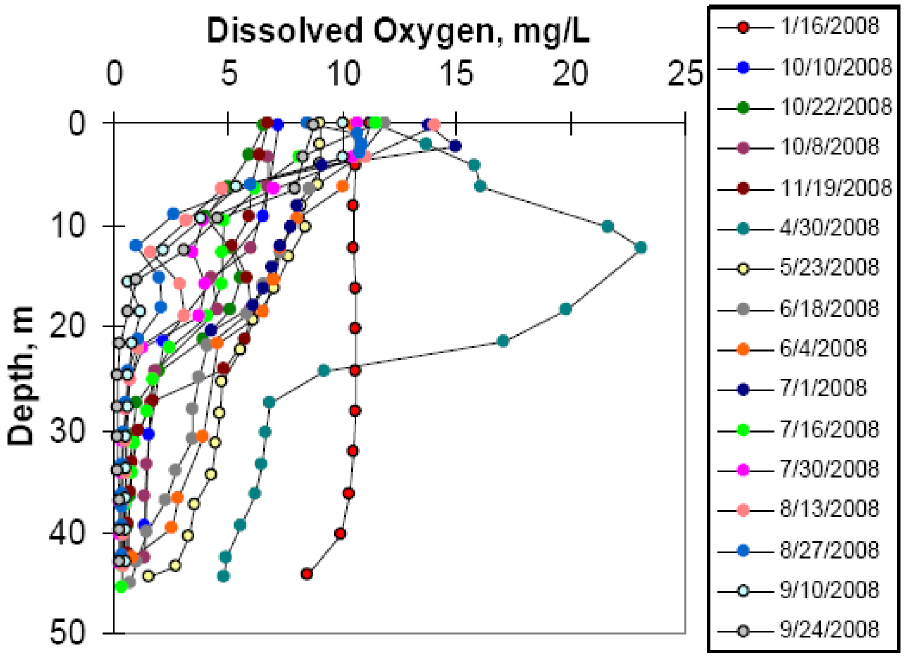

Figure C-31. Vertical Profiles of Dissolved Oxygen Concentration Measured in Iron Gate Reservoir Near the Dam (Bottom Plot) in 2008. Source: Raymond 2009a.

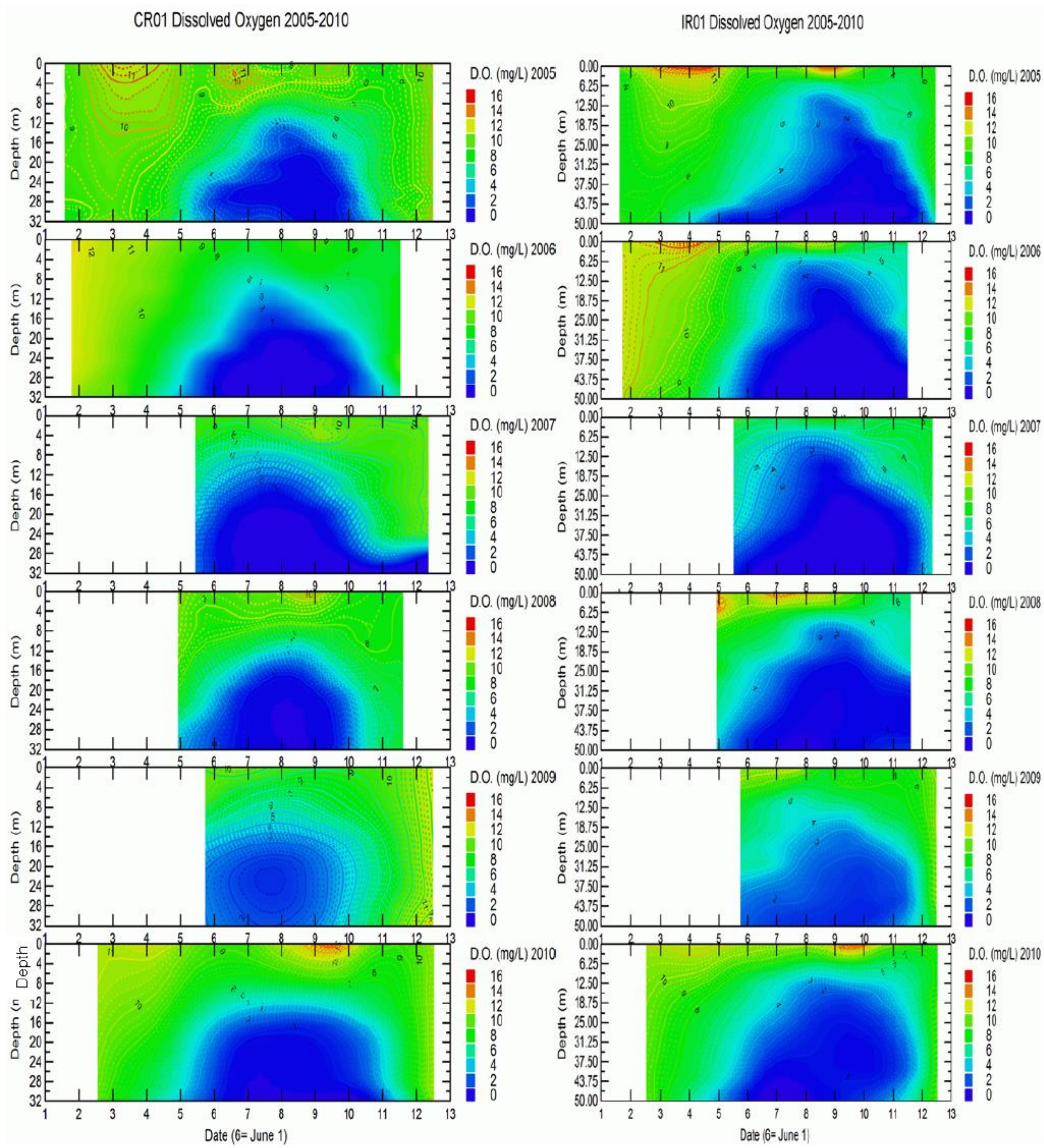

Figure C-32. Depth-time Distribution of Isopleths of Dissolved Oxygen Concentrations in Copco No. 1 Reservoir (CR01) and in Iron Gate Reservoir (IR01) from January 2005-December 2010. Source: Asarian and Kann 2011.

Substantial depression of dissolved oxygen concentrations with depth are reported in Iron Gate Reservoir as early as 1975 as part of the United States Environmental Protection Agency (USEPA) National Eutrophication Study (USEPA 1978). While the lowest dissolved oxygen concentrations in Copco No. 1 generally occur coincident with maximum water temperatures in July and August, the lowest dissolved oxygen concentrations (62 percent less than 8.0 mg/L and 11 percent less than 6.0 mg/L) and the lowest dissolved oxygen percent saturation (74 percent less than 90 percent saturation, 61 percent less than 85 percent saturation) occur in October at Iron Gate Reservoir. The lower dissolved oxygen concentrations and their occurrence later in the season at Iron Gate Reservoir may be associated with respiration of ongoing seasonal algae blooms in surface waters in this reservoir, as well as the decomposition of organic matter from upstream sources and the decomposition of cyanobacteria [blue-green algae] biomass as seasonal blooms decline and the breakdown of thermal stratification in the reservoir (Raymond 2009a, 2010a; Asarian and Kann 2013). Low dissolved oxygen concentrations in bottom waters generally persist longer in Iron Gate Reservoir than Copco No. 1 Reservoir since Copco No. 1 Reservoir experiences complete water-column mixing during approximately mid-October to early November, but Iron Gate Reservoir tends to mix approximately a month later, in late November to early December (see Figure C-32) (Raymond 2009a, 2010a; Asarian and Kann 2011).

Daily patterns in dissolved oxygen concentrations follow a 24-hour cycle with photosynthesis by aquatic plants and phytoplankton elevating dissolved oxygen concentrations during the day and respiration by those same organisms decreasing dissolved oxygen concentrations at night. The daily dissolved oxygen concentration range has a seasonal trend typically peaking between late July and early September. The magnitude of the 24-hour variations in dissolved oxygen concentration is muted in Iron Gate Reservoir compared to other sections of the river due to the reservoir thermal mass and the depth water is withdrawn from the reservoir (Asarian and Kann 2013).

In addition to the biological oxygen demand from aerobic organisms in the water column itself, there is also a sediment oxygen demand that also that influences dissolved oxygen concentrations in the water column. Sediment oxygen demand is the rate at which dissolved oxygen is removed from the water column by the decomposition of organic matter in streambed or lakebed sediments. In lakes, reservoirs, and rivers, sediment oxygen demand can affect the level of dissolved oxygen concentrations in the water column (Doyle and Lynch 2005). Sediment oxygen demand ranges from approximately 1.75 to 3.25 grams of oxygen per square meter per day (g O_2/m^2/day) in sediment cores from three locations in J.C. Boyle sampled in 2002. The sediment oxygen demand from Copco No. 1 and Iron Gate reservoirs ranges from approximately 1.0 to 2.0 g O_2/m^2/day (FERC 2007). A comparison of the total oxygen required to meet the sediment oxygen demand and the water column biological oxygen demand in the reservoirs indicates that the sediment oxygen demand in J.C. Boyle was much less than water column biological oxygen demand and thus the sediments are not the largest influence on dissolved oxygen concentrations in J.C. Boyle Reservoir. Conversely, the sediment oxygen demand was greater than the water column biological oxygen demand in Copco No. 1 and Iron Gate reservoirs, indicating that sediment oxygen demand has a greater influence on water column dissolved oxygen concentrations in the two larger reservoirs (PacifiCorp 2004b).

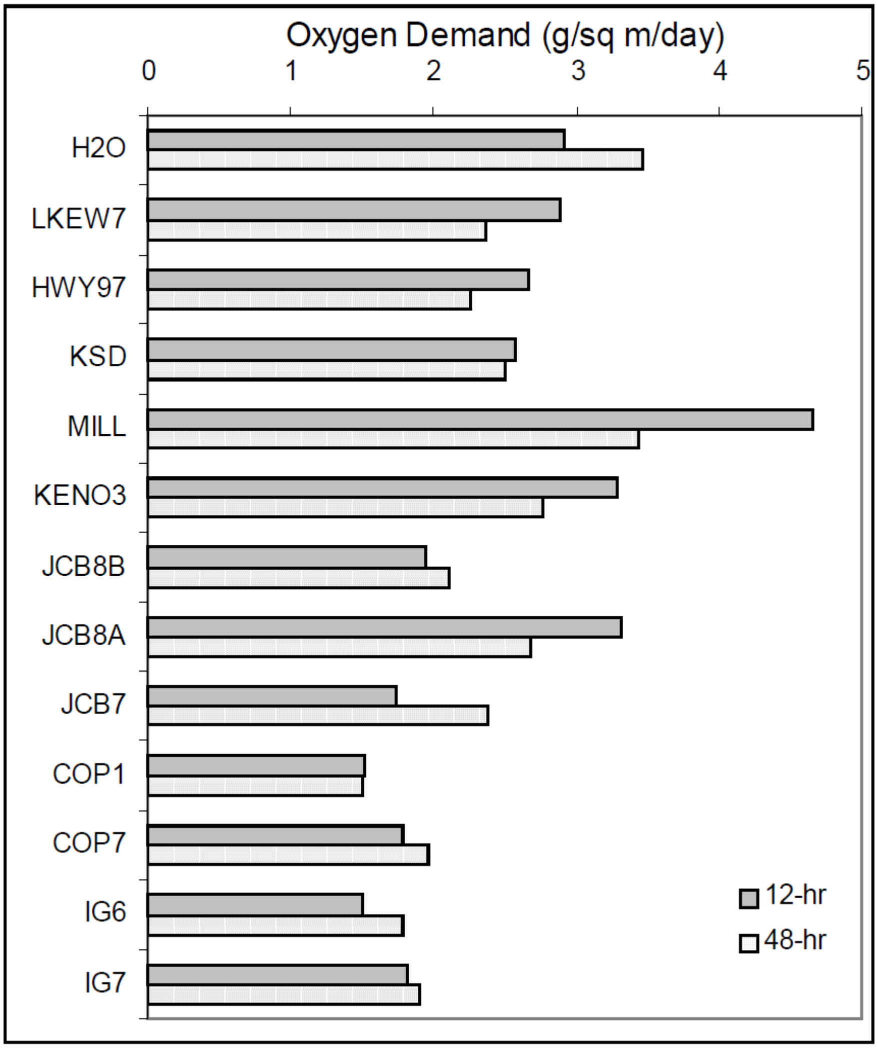

Figure C-33. Sediment Oxygen Demand from Sediment Cores at Multiple Locations within J.C. Boyle (JCB8B, JCB8A, JCB7), Copco No. 1 (COP1 and COP7), and Iron Gate (IG6 and IG7) Reservoirs. Source: PacifiCorp 2004b.

C.4.2 Mid- and Lower Klamath Basin

C.4.2.1 Iron Gate Dam to Salmon River

Historical (1950 to 2001) dissolved oxygen concentrations (reflecting day time grab sampling) in the Klamath River downstream of Iron Gate Dam are variable with dissolved oxygen concentrations approaching saturation values in Klamath River reaches that are free-flowing (PacifiCorp 2004b). Discharges occur from depths of approximately 12 meters in Iron Gate Reservoir, so downstream dissolved oxygen concentrations tend to reflect oxygen conditions of the reservoir's lower epilimnion (Section C.4.1.1) when the reservoir is stratified, with some increases in dissolved oxygen concentrations as the water is re-aerated upon discharge. In the fall, before and after reservoir turnover, low dissolved oxygen concentrations from the hypolimnion can be translated downstream. Dissolved oxygen concentration median values between 1950 and 2001 were 8.1 to 10.8 mg/L in the Klamath River between Iron Gate Dam and the confluence with the Salmon River, with the lowest median values and the greatest general variability in the first mile downstream from the dam (Figure C-27, PacifiCorp 2004b).

More recent data indicates dissolved oxygen concentrations approximately 1,000 feet downstream from Iron Gate Dam regularly fall below 8.0 mg/L and the current Basin Plan minimum dissolved oxygen criteria based on percent saturation (Figure C-34) (Karuk Tribe of California 2001, 2002, 2003, 2007, 2009, 2010a, 2010b, 2011, 2012, 2013; North Coast Regional Board 2010; Asarian and Kann 2011, 2013; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019). Measured dissolved oxygen concentrations at the monitoring site approximately 1,000 feet downstream of Iron Gate Dam are the net result of daily dissolved oxygen variations in the water being discharged from Iron Gate Dam along with mechanical aeration in the Klamath River and photosynthesis and respiration by organisms between the location water is discharged from Iron Gate Dam and the monitoring site, but the magnitude of dissolved oxygen contributions from processes in the Klamath River between the reservoir discharge location and the monitoring site compared to the magnitude of contributions from the upstream reservoirs have not been quantified. Based on continuous Sonde data collected at multiple locations in the lower Klamath River during summer 2004 to 2006, roughly 45 to 65 percent of measurements approximately 1,000 feet downstream from Iron Gate Dam did not achieve the (previous) Basin Plan water quality objective of 8.0 mg/L (instantaneous minimum concentration). The Basin Plan water quality objective is now based on percent saturation. The percent of dissolved oxygen concentration measurements below 8.0 mg/L decreases with distance downstream, particularly in 2005 and 2006. Table C-2 summarizes the percent of dissolved oxygen concentrations in the Lower Klamath River below 8.0 mg/L during Summer 2004 to 2006.

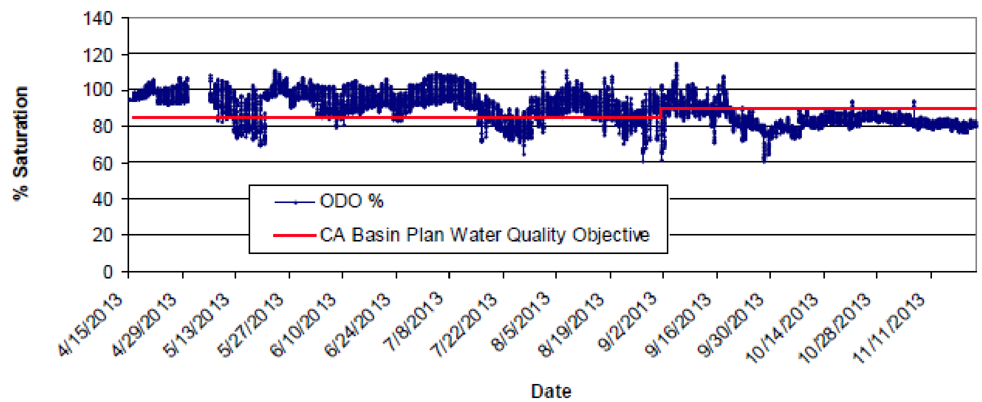

Figure C-34. Percent saturation dissolved oxygen readings recorded every 30-minutes for Klamath River below Iron Gate Dam (IG) in 2013. The red line indicates the Basin Plan Klamath River site-specific dissolved oxygen water quality objective from the Oregon-California state line to the mouth of the Scott River (greater than 90 percent saturation from October 1 to March 30 and greater than 85 percent saturation from April 1 to September 30. Source: Karuk Tribe of California (2013).

Continuous Sonde data collected between 2001 and 2017 show the range of daily average dissolved oxygen concentrations downstream from Iron Gate Dam (RM 193.1) between September through October and in November (Table C-3). Analysis of the longer dataset from 2001 to 2017 agrees with the 2004 to 2006 analysis results showing dissolved oxygen concentrations are less than 8.0 mg/L for June to October immediately downstream of Iron Gate Dam approximately 48 percent of the time. Asarian and Kann (2013) note that dissolved oxygen concentrations immediately downstream of Iron Gate Dam exceed water quality thresholds later in the year than other sites downstream of Iron Gate Dam. *In situ* continuous data collected during 2008 to 2017 by PacifiCorp in the Klamath River downstream from Iron Gate Dam also demonstrate the seasonal decreases in dissolved oxygen (measured as percent saturation and concentration) originating from the reservoirs, with the lowest average monthly values occurring in August (warmer water temperatures) through November (cooler water temperatures), depending on the year (Table C-4).

In 2008, PacifiCorp began implementation of turbine venting at Iron Gate Dam as KHSA Interim Measure 3, with the goal of improving dissolved oxygen concentrations immediately downstream from the dam during periods of reservoir stratification. Early testing results in 2008 indicated that dissolved oxygen concentrations immediately downstream from Iron Gate Dam could be increased by approximately 0.5 to 2 mg/L (approximately 7 to 20 percent dissolved oxygen saturation) through the mechanical introduction of oxygen as water passed through the turbines (Carlson and Foster 2008, PacifiCorp 2008a). In 2009, PacifiCorp installed a forced air blower to enhance aeration, which became fully operational in 2010. The combination of turbine venting and the blower during the 2010 testing period increased dissolved oxygen immediately downstream of the dam from approximately 50 percent saturation to approximately 70 percent saturation. Further downstream, 2.5 river miles from the dam, the combination of turbine venting and the blower increased dissolved oxygen from approximately 65 percent saturation to approximately 80 percent saturation. By approximately six river miles downstream from the dam, natural river aeration increased dissolved oxygen concentrations sufficiently that there was no difference between periods with turbine venting plus blower operation and periods without (PacifiCorp 2011a). Currently, and on a year-round basis, PacifiCorp automatically operates the blower when dissolved oxygen levels drop below 87 percent saturation and the blower is automatically turned off when dissolved oxygen levels exceed 87 percent saturation.

Despite the improvements reported during 2008 and 2011, and as discussed in the previous paragraphs, dissolved oxygen immediately downstream of Iron Gate Dam has continued to exhibit percent saturation values below the Basin Plan Basin Plan minimum dissolved oxygen criteria of 85 percent saturation for the period April 1 through September 30, and below the minimum criterion of 90 percent saturation for the period October 1 to March 31, with the majority of measured low dissolved oxygen saturation values occurring from August through November (PacifiCorp 2013a, 2014a, 2015a, 2016b, 2017b; Karuk Tribe of California 2012, 2013). Data from 2017 indicate that when dissolved oxygen decreased to 70 percent saturation in September at the monitoring site approximately 1,000 feet downstream of Iron Gate Dam, reaeration to greater than the applicable Basin Plan minimum dissolved oxygen saturation criterion (i.e., 85 percent saturation) occurred within approximately 2 to 3 miles downstream of Iron Gate Dam (PacifiCorp 2018).

Table C-2. Percent of Dissolved Oxygen Concentrations below 8.0 mg/L in the Lower Klamath River during Summer 2004 to 2006.

Location	**2004**		**2005**		**2006**	
	n (1)	**%**	**n (1)**	**%**	**n (1)**	**%**
At Iron Gate Dam (RM 193.1)	2,706	64	4,498	45	5,391	61
Upstream of Shasta River (RM 179.5)	5,478	50	5,533	49	-	-
Upstream of Scott River (RM 145.1)	2,966	58	4,457	47	-	-
Seiad Valley (RM 132.7)	3,381	57	4,713	45	5,526	40
Orleans (RM 58.9)	57	37	4,533	23	5,349	15
Weitchpec (RM 43.6)	4,142	48	5,400	7	5,332	6
Downstream from Weitchpec (≈ RM 43.4)	5,500	16	3,529	11	5,293	4
Upstream of Trinity (RM 43.3)	-	-	5,535	5	5,739	3
Turwar (RM 5.6)	5,066	30	5,543	6	-	-

Source: Ward and Armstrong 2006; North Coast Regional Board 2010.

[1] Dissolved oxygen measurements were collected at 30-minute increments for a total of forty-eight daily measurements.

Key:

n=number of measurements

%=percent of measurements not achieving the Basin Plan previous water quality objective of 8.0 mg/L

Table C-3. Range of Observed Dissolved Oxygen Concentrations Downstream from Iron Gate Reservoir.

Year	General Range of Daily Average Dissolved Oxygen (mg/L) downstream from Iron Gate Dam (RM 193.1, near USGS Gage No. 11516530)		Source
	September–October	**November**	
2001	4–6[(1)]	7–8	Karuk Tribe of California 2003
2002	4–9[(2)]	-	Karuk Tribe of California 2003
2004	6–9.5	8–9	Zedonis and Turner 2010
2006	6.5–8	7–8	Karuk Tribe of California 2009
2007	7–9[(2)]	-	Karuk Tribe of California 2009
2008	6.5–8.5	-	Karuk Tribe of California 2009
2009	7.5–10	-	Karuk Tribe of California 2010a
2010	7–9.5	-	Karuk Tribe of California 2010b
2011	7–9.5	8–9.5	Karuk Tribe of California 2011
2012	6–9.5	7.5–8.5	Karuk Tribe of California 2012
2013	7–9	8.5–9.5	Karuk Tribe of California 2013
2014	6–13	8.5–11	PacifiCorp 2014a
2015	7–9	7–9	PacifiCorp 2015a
2016	6–9.5	8–9	PacifiCorp 2016b
2017	5–10	8–9.5	PacifiCorp 2017b

[1] No September data reported
[2] No October data reported

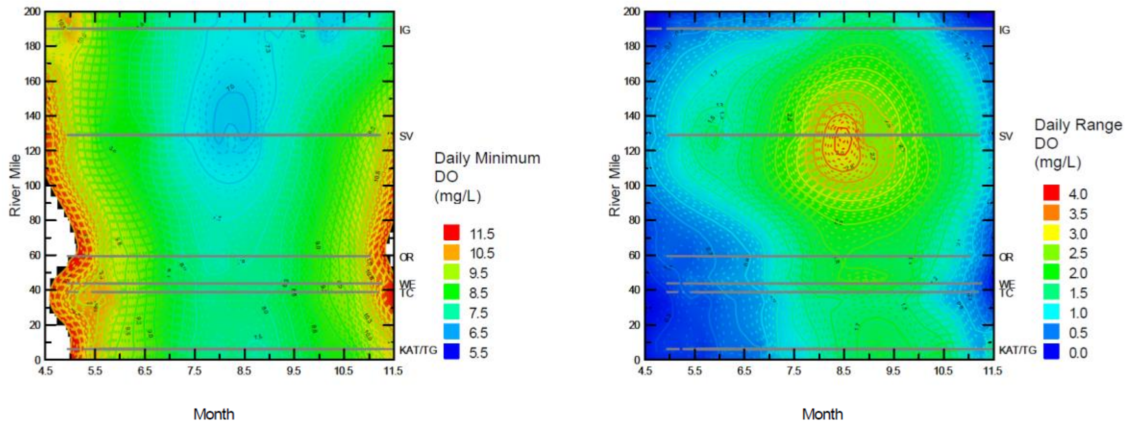

Figure C-35. Distribution of Isopleths Showing the 2001-2011 Average Daily Minimum Dissolved Oxygen (DO) Concentrations and Daily Range of Dissolved Oxygen (DO) Concentrations at Klamath River Sites Downstream of Iron Gate Dam from Around Mid-April (4.5) to Mid-November (11.5). Grey Lines Represent the Times Dissolved Oxygen Was Measured in the Klamath River Downstream of Iron Gate Dam (IG at RM 193.1), at Seiad Valley (SV at RM 132.7), at Orleans (OR at RM 58.9), at Weitchpec Upstream of the Trinity River (WE at RM 43.6), Upstream of Tully Creek (TC at RM 40.1), and at Turwar (KAT/TG at RM 5.6). Source: Asarian and Kann 2013.

It has been suggested that daily fluctuations of up to 3 mg/L measured in the Klamath River approximately 1,000 feet downstream from Iron Gate Dam (RM 193.1) (Karuk Tribe of California 2002, 2003; YTEP 2005; North Coast Regional Board 2010; Asarian and Kann 2011, 2013) are caused by daytime photosynthesis by phytoplankton, periphyton, and aquatic plants and nighttime algal and bacterial respiration. Low dissolved oxygen concentrations can also be often caused by bacterial aerobic decomposition of phytoplankton in the reservoir (Ward and Armstrong 2010). As previously discussed, the magnitude of dissolved oxygen contributions from these processes and mechanical aeration in the Klamath River between the reservoir discharge location and the monitoring site compared to the magnitude of contributions from the upstream reservoirs have not been quantified.

Table C-4. Average Monthly Water Temperature, Dissolved Oxygen Percent Saturation, and Dissolved Oxygen Concentration in the Klamath River Downstream from Iron Gate Dam (RM 193.1).

Month	Average Monthly Water Temperature (ºC)	Average Monthly Dissolved Oxygen (% Saturation)	Average Monthly Dissolved Oxygen (mg/L)
2008			
June	18.4	92.2	8.7
July	22.3	90.0	7.8
August	21.8	91.8	8.0
September	18.6	84.5	7.9
October	14.8	66.2	6.7
November	10.3	67.4	7.5
December	7.0	70.0	8.5
2009			
January	3.7	79.4	10.5
February	4.4	83.0	10.8
March	6.7	83.2	10.2
April	8.4	82.2	9.6
May	17.4	94.4	9.0
June	19.3	87.9	8.1
July	21.2	86.8	7.7
August	21.7	99.9	8.8
September	19.4	95.7	8.8
October	14.6	77.7	7.9
November	9.9	71.2	8.1
December	5.0	81.2	10.4
2010			
January	3.9	94.2	11.4
February	5.4	100.2	11.1
March	7.2	96.6	10.5
April	9.5	108.9	11.4
May	12.7	104.8	10.2
June	16.8	94.9	8.5
July	21.3	98.8	8.1
August	21.9	95.9	7.7
September	18.4	105.2	9.1
October	15.5	92.5	8.5
November	11.8	62.5	6.2

Month	**Average Monthly Water Temperature (ºC)**	**Average Monthly Dissolved Oxygen (% Saturation)**	**Average Monthly Dissolved Oxygen (mg/L)**
2011			
January	4.0	90.2	10.9
February	4.6	95.0	11.3
March	5.8	96.3	11.1
April	9.2	101.4	10.7
May	12.9	107.1	10.4
June	16.1	100.9	9.2
July	20.6	94.0	7.8
August	22.2	97.9	7.8
September	20.2	93.4	7.8
October	16.0	92.1	8.4
November	10.1	74.6	7.8
December	5.6	90.2	10.5
2012			
January	3.8	12.0	90.8
February	4.3	12.6	96.2
March	5.8	12.0	95.7
April	9.4	10.6	92.2
May	15.5	9.5	94.9
June	17.8	8.8	92.2
July	20.9	8.2	91.7
August	21.9	7.5	85.0
September	19.5	7.7	83.1
October	16.1	7.2	72.9
November	11.3	8.0	72.3
December	7.2	9.7	79.8
2013			
January	15.2	97.8	9.1
February	8.5	96.6	10.4
March	11.4	102.4	10.3
April	16.0	107.8	9.8
May	18.9	105.6	9.0
June	21.7	101.6	8.2
July	21.4	100.3	8.2
August	19.9	92.5	7.8
September	14.2	89.5	8.5
October	10.0	89.6	9.4
November	5.3	91.2	10.7
December	15.2	97.8	9.1

Month	Average Monthly Water Temperature (ºC)	Average Monthly Dissolved Oxygen (% Saturation)	Average Monthly Dissolved Oxygen (mg/L)
2014			
January	3.8	94.0	11.5
February	4.7	99.3	11.9
March	8.4	98.6	10.9
April	12.0	97.1	9.9
May	16.7	101.4	9.3
June	19.3	101.0	8.7
July	22.3	103.6	8.6
August	22.0	111.1	9.8
September	19.3	104.7	9.7
October	15.8	80.3	8.0
November	11.0	87.1	9.7
December	7.6	91.0	10.9
2015			
January	5.7	93.5	11.7
February	-	-	-
March	10.3	103.5	11.6
April	12.0	93.4	10.1
May	15.9	96.9	9.6
June	20.0	94.4	8.6
July	22.4	91.9	8.0
August	20.9	83.3	7.4
September	18.7	80.0	7.5
October	15.8	79.5	7.9
November	11.6	78.2	8.5
December	6.8	85.3	10.4
2016			
January	4.3	103.8	12.5
February	5.2	101.3	11.9
March	7.7	103.6	11.4
April	12.4	101.7	10.1
May	15.7	105.9	9.7
June	19.0	103.3	8.9
July	20.2	93.7	7.9
August	21.4	81.9	6.7
September	18.7	77.8	7.2
October	15.0	84.1	8.1
November	11.3	87.1	8.9
December	7.0	91.3	10.3

Month	Average Monthly Water Temperature (°C)	Average Monthly Dissolved Oxygen (% Saturation)	Average Monthly Dissolved Oxygen (mg/L)
2017			
January	2.9	90.3	12.2
February	4.3	97.8	12.7
March	7.2	102.7	12.4
April	10.2	106.1	11.2
May	14.7	94.2	9.6
June	19.4	97.5	8.5
July	21.9	89.3	7.8
August	22.3	79.2	6.9
September	19.9	74.0	6.7
October	14.3	73.4	7.5
November	10.5	78.8	8.8
December	6.6	84.6	10.4

Raw daily data from https://www.pacificorp.com/energy/hydro/klamath-river/water-quality.html (PacifiCorp 2008b, 2009a, 2010b, 2011b, 2012a, 2013a, 2014a, 2015a, 2016b, 2017b). Data obtained with YSI 6600 V2 or 6900 Multiprobe Datasondes (30-minute intervals).

Farther downstream in the mainstem Klamath River, near Seiad Valley (RM 132.7), dissolved oxygen concentrations tend to increase; however, values below 8.0 mg/L do still occur (i.e., 2001, 2002, 2006, 2007, 2010, 2011, 2012, 2013, 2014, and 2015 as reported in Karuk Tribe of California [2001, 2002, 2009, 2010b, 2011, 2012, 2013] and Watercourse Engineering, Inc. [2011a, 2011b, 2012, 2013, 2014, 2015, 2016]). Dissolved oxygen concentrations near Seiad Valley continue to exhibit variability, with mean daily values ranging from approximately 6.5 mg/L to supersaturated concentrations of approximately 11.5 mg/L from June through November 2001 to 2002 and 2006 to 2013 (Karuk Tribe of California 2001, 2002, 2003, 2007, 2009, 2010a, 2010b, 2011, 2012, 2013). Longitudinal variations in dissolved oxygen concentrations from Iron Gate Dam (RM 193.1) to Seiad Valley (RM 132.7) are most pronounced between mid-September and November when dissolved oxygen concentrations decrease immediately downstream of Iron Gate but increase at Seiad Valley (Karuk Tribe of California 2013). Dissolved oxygen concentrations at Seiad Valley between 2001 and 2011 are less than the 8.0 mg/L, 90 percent saturation, and 85 percent saturation water quality thresholds less frequently than immediately downstream of Iron Gate Dam, but still are less than these water quality thresholds more frequently than further downstream sites (Asarian and Kann 2013). Between July and September, dissolved oxygen concentrations at Seiad Valley are less than 8.0 mg/L for 29 to 51 percent of measurements, less than 90 percent saturation for 28 to 34 percent of measurements, and less than 85 percent saturation for 10 to 18 percent of measurements (Asarian and Kann 2013). More contemporary data from 2012 to 2016 have dissolved oxygen concentration patterns similar to previous measurements with concentrations ranging from approximately 6.0 mg/L to (supersaturated concentrations of) approximately 12 mg/L from June through November and dissolved oxygen concentrations regularly less than 8.0 mg/L during that time period (Watercourse Engineering, Inc. 2013, 2014, 2015, 2016).

C.4.2.2 Salmon River to Estuary

Measured dissolved oxygen concentrations in the mainstem Klamath River downstream from the confluence with the Salmon River (RM 66.3) continue to increase relative to concentrations at upstream sites (Figure C-36). Despite this, values sometimes fall below 8.0 mg/L in this reach (e.g., at the Orleans gage [RM 58.9] during 2001, 2002, 2006, 2012, 2013 as reported in Karuk Tribe of California [2001, 2002, 2007, 2009, 2010a, 2010b, 2011, 2012, 2013], Ward and Armstrong 2006, North Coast Regional Board 2010). Dissolved oxygen concentrations near Orleans also exhibit variability, with mean daily values ranging from approximately 6.5 mg/L to supersaturated concentrations of 11.5 mg/L from June through November in 2001, 2002, and 2006 to 2013. Asarian and Kann (2013) report dissolved oxygen concentrations at Orleans are less than 8.0 mg/L for 16 percent of measurements, less than 90 percent saturation for 10 percent of measurements, and less than 85 percent saturation for only 1 percent of measurements between June and October from 2001 to 2011. Dissolved oxygen concentrations were most frequently less than the 8.0 mg/L, 90 percent saturation, and 85 percent saturation water quality thresholds during July and August when water temperature peaked (Asarian and Kann 2013). Extremely high mean daily dissolved oxygen concentrations (11 to 15.5 mg/L) (Sonde data) were reported for October 2006 at the Orleans gage (Karuk Tribe of California 2007, 2009). More contemporary grab sample data from 2012 to 2015 agree with previous measurements showing dissolved oxygen concentrations generally increase from Seiad Valley (RM 132.7) to Orleans (RM 58.9) with dissolved oxygen concentrations ranging from approximately 7.5 mg/L to supersaturated concentrations of approximately 11.5 mg/L between June and November with the minimum concentrations occurring in July or August (Figure C-36; Watercourse Engineering, Inc. 2013, 2014, 2015, 2016).

Dissolved oxygen concentrations in the mainstem Klamath River upstream of the confluence with the Trinity River (RM 43.3) ranged from approximately 5.5 to 10.3 mg/L in 2004, with the lowest concentration of dissolved oxygen occurring in September and the highest dissolved oxygen concentration occurring in October. Dissolved oxygen concentrations below 8.0 mg/L (the Basin Plan minimum dissolved oxygen criterion prior to 2010) occurred for extended periods of time in mid-August (8/13 to 8/22) and early September (8/30 to 9/8) (YTEP 2005). In 2009 at this location, dissolved oxygen concentrations ranged from approximately 7.1 to 11.8 mg/L, with minimum dissolved oxygen concentrations dropping below 8.0 mg/L (the Basin Plan minimum dissolved oxygen criterion prior to 2010) for an extended period of time from mid-July to early August, and again from late August to early September (Sinnott 2010a). In 2010, dissolved oxygen concentrations ranged from 7.9 to 12.1 mg/L (Sinnott 2011a), with minimum dissolved oxygen concentrations remaining above the 2010 amended Basin Plan minimum dissolved oxygen concentration criteria based on percent saturation (e.g., 7.0, 6.9, and 7.8 mg/L for July, August, and September, respectively, see Section 3.2, Table 3.2-5). A synthesis of dissolved oxygen concentration data from 2001 to 2011 at Weitchpec (RM 43.6) on the mainstem Klamath River upstream of the confluence with the Trinity River indicates dissolved oxygen concentrations are below 8.0 mg/L most frequently between July and August, but the dissolved oxygen percent saturation is most frequently below 90 percent or 85 percent in August and September (Asarian and Kann 2013). On average, between June and October from 2001 to 2011, dissolved oxygen concentrations at Weitchpec (RM 43.6) are less than 8.0 mg/L for 16 percent of measurements, less than 90 percent saturation for 12 percent of measurements, and less than 85 percent saturation for only 5 percent of measurements. While only based on discrete dissolved oxygen concentration measurements during water quality grab samples, dissolved oxygen concentrations at Weitchpec (RM 43.6) from 2011 to 2015 are similar to previous measurements with concentrations ranging from approximately 8.0 mg/L to supersaturated concentrations of approximately 11.5 mg/L between June and November (Figure C-36; Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015; Hanington 2013; Hanington and Ellien 2014).

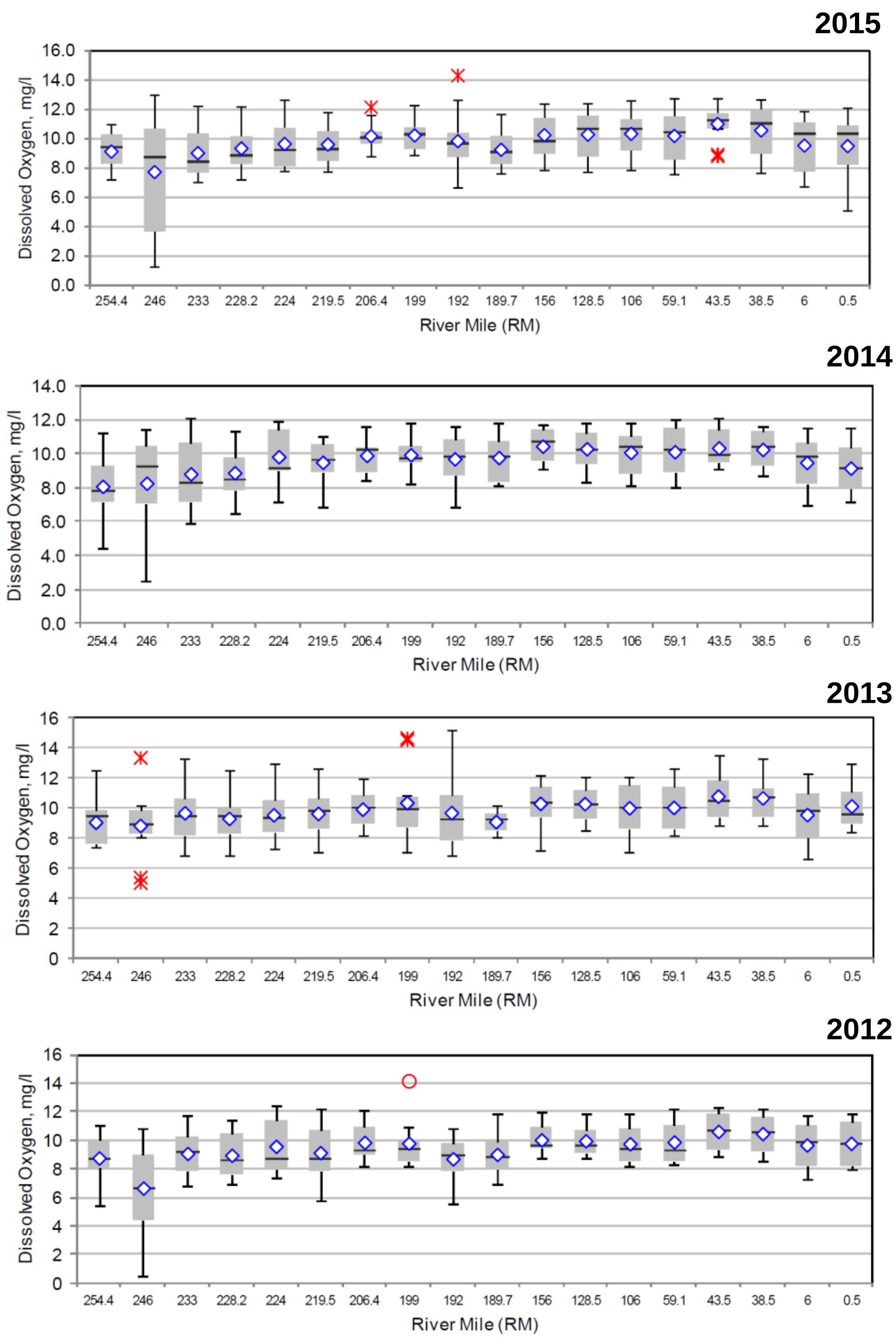

Figure C-36. Klamath River dissolved oxygen concentration trends from measurements made between February and December with median (-), mean (◊), outlier (*), and extreme outliers (○) identified. River miles specified are based on those accurate at the time of the reports and differ slightly from 2018 river mile designations (Table 3.2-1). Source: Watercourse Engineering, Inc. 2013, 2014, 2015, 2016.

Dissolved oxygen concentrations tend to decrease downstream from the confluence of the Trinity River with the Klamath River (Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015; Asarian and Kann 2013; Hanington 2013; Hanington and Ellien 2014). At the confluence with the Trinity River (RM 43.3) and at the Turwar gage (RM 5.6), daily minimum dissolved oxygen concentrations at the Trinity River and Turwar sites during May through November are consistently observed to occur late-night or early in the morning, likely due to respiration by aquatic vegetation (YTEP 2004, 2005; Sinnott 2010a, 2011a). At Turwar (RM 5.6) in 2004, minimum dissolved oxygen concentrations dropped below 8.0 mg/L (the Basin Plan minimum dissolved oxygen criterion prior to 2010) between late July and late August (YTEP 2005); dissolved oxygen concentrations ranging 5.9 to 10.1 mg/L were observed in August and September. In 2009, dissolved oxygen concentrations at Turwar ranged from 7.3 to 11.7 mg/L, with minimum dissolved oxygen concentrations dropping below 8.0 mg/L for an extended period of time from mid-July to early August (Sinnott 2010a). In 2010, dissolved oxygen concentrations ranged from 7.8 to 11.8 mg/L, with minimum values remaining above 2010 amended Basin Plan minimum dissolved oxygen concentration criteria based on percent saturation (e.g., 7.0, 6.9, and 7.8 mg/L for July, August, and September, respectively, see Section 3.2, Table 3.2-5). Dissolved oxygen concentration data from 2001 to 2011 downstream of the Trinity River (RM 43.3) and at Turwar (RM 5.6) show dissolved oxygen concentrations are the lowest and most frequently below the 8.0 mg/L, 90 percent saturation, and 85 percent saturation water quality thresholds during July and August (Asarian and Kann 2013). Turwar (RM 5.6) consistently has lower dissolved oxygen concentrations and is more frequently below the 90 percent or the 85 percent saturation levels than the site immediately downstream of the confluence with the Trinity River (RM 43.3) (Asarian and Kann 2013). Dissolved oxygen concentrations downstream of the confluence with the Trinity River (RM 43.3) to Turwar (RM 5.6) from 2011 to 2015 are similar to previous measurements in that reach. During that period, dissolved oxygen concentrations range from approximately 6.5 mg/L to supersaturated concentrations of approximately 11.5 mg/L between June and November with lower dissolved oxygen concentrations occurring more frequently at Turwar and higher dissolved oxygen concentrations occurring more frequently immediately downstream of the confluence with the Trinity River (Figure C-36; Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015; Hanington 2013; Hanington and Ellien 2014; Hanington and Cooper Carouseli 2014).

C.4.2.3 Klamath River Estuary

Dissolved oxygen concentrations within the Klamath River Estuary are highly variable spatially and temporally and are greatly influenced by season, river flow, vertical water column stratification (thermal and/or chemical), and location of the estuary mouth, the latter changing due to periodic sand bar movement. Dissolved oxygen concentrations have been monitored in the Klamath River Estuary by CDFG (Wallace 1998) and most recently by the Yurok Tribe Fisheries

(Hiner 2006) and Environmental Programs (YTEP 2005) with support from the North Coast Regional Water Quality Control Board. Concentrations in the deeper, main channel of the estuary are generally greater than approximately 6.0 to 7.0 mg/L throughout the year (Hiner 2006; YTEP 2004, 2005).

Lower dissolved oxygen concentrations (ranging 2.5 to 5.5 mg/L) have been measured near the bottom of deep pools or in heavily vegetated side channels (Wallace 1998). Low dissolved oxygen concentrations (less than 1.0 mg/L to approximately 5.0 mg/L) have been observed during summer months in the relatively shallow, heavily vegetated south slough (Wallace 1998; Hiner 2006). The low levels of dissolved oxygen observed in the slough are likely due to high rates of growth and subsequent decomposition of phytoplankton and aquatic plants, which are not abundant elsewhere in the Klamath River Estuary.

Dissolved oxygen concentrations become progressively more variable and generally lower nearer the estuary bottom and the estuary mouth, with concentrations frequently below 6.0 mg/L during summer months (YTEP 2004, 2005; Hiner 2006). Low dissolved oxygen has also been observed during late summer months when a sand berm forms across the river mouth, forcing the river to flow south diagonally between two sand spits. This berm prevents ocean water from entering the Klamath River Estuary, creating 'lagoon-like' conditions until higher flows breech the berm (Wallace 1998; Hiner 2006). These conditions were documented in 1994 and 2001; in 2001, a decrease in dissolved oxygen concentrations was measured related to sand berm formation, with especially marked decreases in dissolved oxygen concentrations in the south slough (Hiner 2006).

Additional monitoring by the Yurok Tribe Environmental Program from 2009 to 2015 detail more recent dissolved oxygen concentration trends near the surface in the lower Klamath River Estuary (RM 0.5). During that time period, dissolved oxygen concentrations usually range from approximately 7 mg/L to (supersaturated concentrations of) approximately 11 mg/L between June and November, with a particularly low value of 5.08 mg/L recorded on June 10, 2015 (Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; Hanington 2013; Hanington and Ellien 2014; Hanington and Cooper Carouseli 2014). The dissolved oxygen percent saturation between 2009 and 2014 ranges from approximately 83 percent to 106 percent, with the percent saturation in 2014 exhibiting almost that entire range and broad seasonal variability (Figure C-37; Sinnott 2010a, 2011a, 2012a; Hanington 2013; Hanington and Ellien 2014; Hanington and Cooper Carouseli 2014).

Eilers and Raymond (2005) report sediment oxygen demand from a sediment core taken in the Klamath River Estuary in 2004. The raw sediment oxygen demand in the first 24-hours is 3.21 g O_2/m^2/day while the corrected sediment oxygen demand is 2.06 g O_2/m^2/day. The long-term rate of sediment oxygen demand is approximately 0.5 g O_2/m^2/day after 600 hours of incubation which is attributed to the high proportion of sand in the estuary sediment core (Eilers and Raymond 2005).

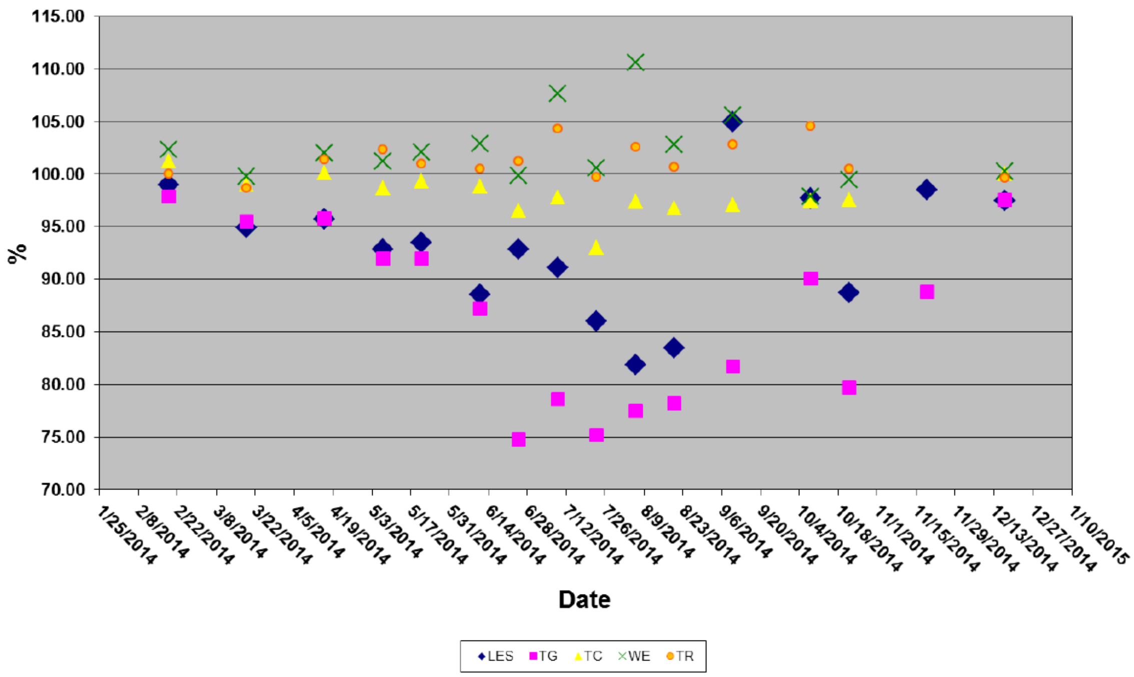

Figure C-37. Percent Saturation of Dissolved Oxygen During Grab Samples at the Lower Estuary Surface (LES [RM 0]), the Klamath River at Turwar Boat Ramp (TG [RM 6]), the Klamath River Upstream of Tully Creek (TC [RM 40.1]), the Klamath River at Weitchpec (Upstream of Trinity River) (WE [RM 43.6]), and the Trinity River Upstream the Confluence with the Klamath River (TR). Source: Hanington and Cooper-Carouseli 2014.

C.5 pH

C.5.1 Upper Klamath Basin

C.5.1.1 Hydroelectric Reach

Based upon monitoring conducted by PacifiCorp, pH in the Hydroelectric Reach is seasonally variable, with levels near neutral (7.5 to 8.0 standard units [s.u.]) during the winter and increasing in the spring and summer (7.7 to 8.1 s.u.). Peak values (8.0 to 9.2 s.u.) are recorded during May and September (Raymond 2010a). Longitudinally, pH ranges from 7.3 to 9.2 s.u. in this reach, with the lowest values recorded downstream from J.C. Boyle Reservoir and the highest values in Copco and Iron Gate reservoirs (Raymond 2008a, 2009a, 2010a). In 2009, springtime pH levels at J.C. Boyle Reservoir were typically 8.5 s.u., decreasing during the summer and fall to 7.6 to 7.9 s.u. (Watercourse

Engineering, Inc. 2011). As part of monthly sampling events between March and November from 2000 to 2005 and June through November 2007, pH was measured at Klamath River sites along within Iron Gate and Copco reservoirs (Figure C-38; PacifiCorp 2008c). Summer pH values tend to fluctuate the most at all sites with the largest variations and highest pH values occurring primarily between September and November upstream of Copco No. 1 Reservoir and between August and October downstream of Copco No. 1 Reservoir (PacifiCorp 2008c).

Depth profiles of pH in the Copco and Iron Gate reservoirs show pH generally decreasing with depth in both reservoirs (Table C-5; PacifiCorp 2008c). At depths less than 8 meters (the epilimnion), pH is greater than 8.5 s.u. in approximately 30 percent of samples (144 of 494) collected in Copco Reservoir and 20 percent of samples (25 of 485[109]) collected in Iron Gate Reservoir, while pH less than 7.0 s.u. occurred in less than 2 percent (6 of 494) of the samples. At depth greater than 20 meters (the hypolimnion), pH is greater than 8.5 s.u. in less than 1 percent of samples (1 of 391 in Copco No. 1 and 0 of 613 in Iron Gate) collected in both reservoirs, but approximately 17 percent of samples (68 of 391) collected in Copco Reservoir and 22 percent of samples (135 of 613) collected in Iron Gate Reservoir record pH values less than 7.0 s.u. (PacifiCorp 2008c). The distribution of pH values in both reservoirs is attributed to a phytoplankton response to nutrient inputs from upstream sources with photosynthesis in the upper reservoir waters (the epilimnion) resulting in higher pH levels (PacifiCorp 2008c; Raymond 2008a). Subsequent analysis of pH data from 2005 to 2010 concurs with previous results that high pH near the surface during summer stratification is likely due to higher phytoplankton biomass and productivity from buoyant cyanobacteria [blue-green algae] near reservoir surfaces (Asarian and Kann 2011). Monthly water quality grab samples collected in Copco and Iron Gate reservoirs at three depths (near the surface [epilimnion], thermocline [metalimnion], and near the bottom [hypolimnion]) show similar pH trends in both reservoirs between 2011 and 2015 with pH usually between approximately 7.0 and 9.0 s.u., but ranging from 5.3 to 9.9 s.u. in Copco No. 1 Reservoir and 5.4 to 10.0 s.u. in Iron Gate Reservoir during 2013 (Watercourse Engineering, Inc. 2012, 2013, 2014, 2015, 2016).

[109] In PacifiCorp (2008c) Table 5.2-11, reproduced here as Table C-5, the number of samples with pH greater than 8.5 is listed as 25 of 485 total samples, but the percent of samples with pH greater than 8.5 is listed as 19.6 percent. The inconsistency between the number of samples with pH greater than 8.5 and the percent of samples with pH greater than 8.5 cannot be resolved with the available information in PacifiCorp (2008), so both are presented here for completeness and transparency

Table C-5. Frequency of pH values in the Klamath River above or below threshold values from 2000 to 2007.

Location	Summary of pH values				
	N	N > 8.5	% > 8.5	N < 7.0	% < 7.0
Klamath River above Shovel Creek	72	7	9.7	1	1.4
Copco Reservoir	1202	148	12.3	84	7.0
Copco Reservoir < 8 m	494	144	29.1	6	1.2
Copco Reservoir > 18 m	391	1	0.3	68	17.4
Iron Gate Reservoir	1470	116	7.9	189	41.9
Iron Gate Reservoir < 8 m	485	25	19.6	8	1.6
Iron Gate Reservoir > 20 m	613	0	0.0	135	22.0
Below Iron Gate Dam	71	3	4.2	4	5.6
Klamath River at I-5	30	7	23.3	2	6.7
Klamath River near Shasta River	7	6	85.7	0	0.0

Source: PacifiCorp 2008c.

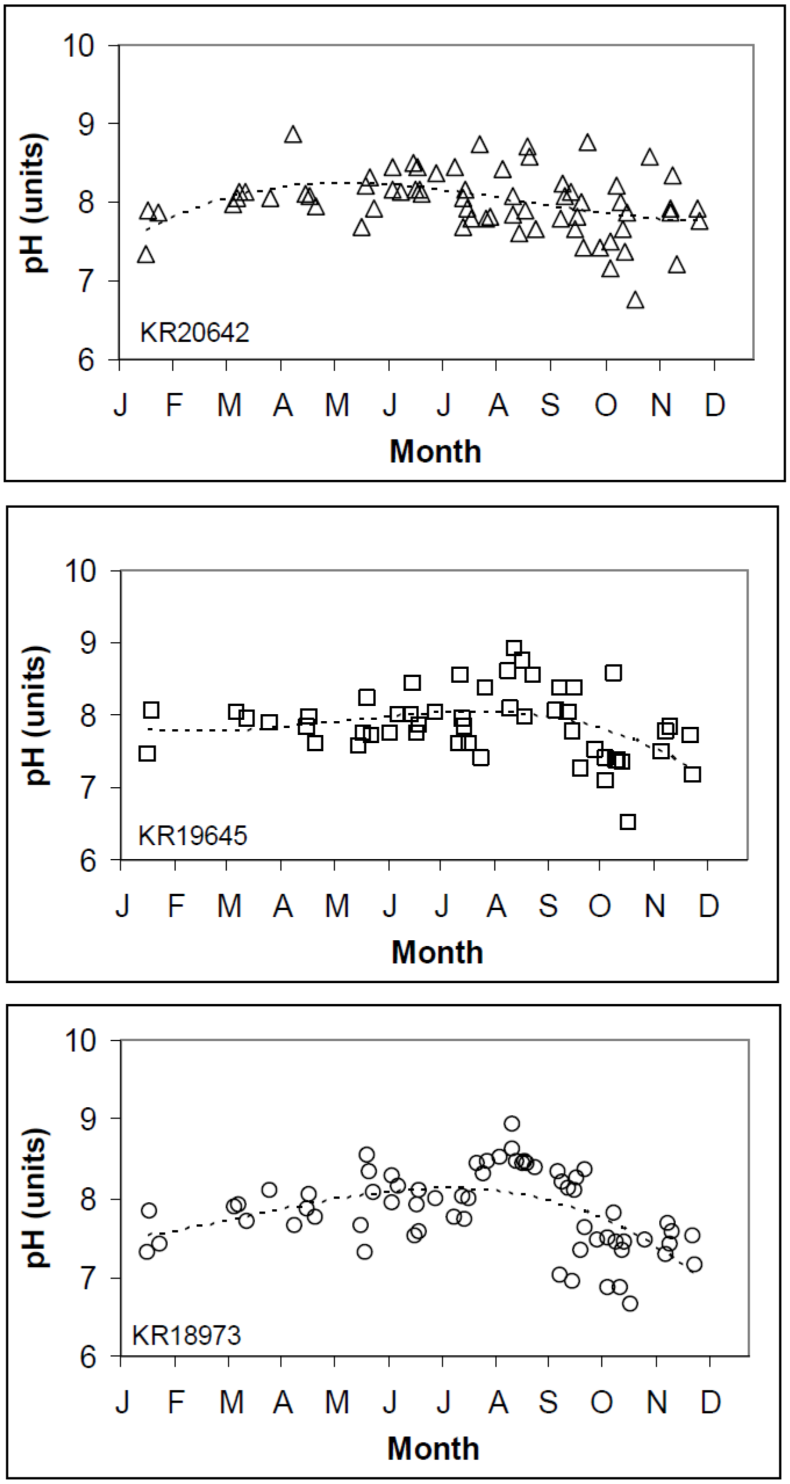

Figure C-38. Seasonal variations in pH values measured in the Klamath River upstream of Copco Reservoir near Shovel Creek (KR20642), downstream of Copco No. 2 powerhouse (KR19645), and downstream of Iron Gate Dam (KR18973). Source: PacifiCorp 2008c.

C.5.2 Mid- and Lower Klamath Basin

C.5.2.1 Iron Gate Dam to Salmon River

Downstream of Iron Gate Dam (RM 193.1) to Salmon River (RM 66.3) pH varies both longitudinally and temporally with the highest seasonal values generally occurring during late-summer and early fall months (August to September) depending on the location in the Klamath River (Figure C-39; Asarian and Kann 2013). The Basin Plan pH maximum of 8.5 s.u. is regularly exceeded in the Klamath River downstream from Iron Gate Dam (FISHPRO 2000; Karuk Tribe of California 2002, 2003, 2007, 2009, 2010a, 2010b, 2011, 2012, 2013; YTEP 2004, 2005; FERC 2007; USFWS 2008; North Coast Regional Board 2010, 2011; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; Asarian and Kann 2013). During April through October 2000 to 2009, incidences of pH *below* the minimum Basin Plan limit of 7.0 s.u. were also observed immediately downstream from Iron Gate Dam (RM 193.1), but pH below 7.0 s.u. was not recorded after 2009 (Karuk Tribe of California 2002, 2003, 2009, 2010a, 2010b, 2011, 2012, 2013; PacifiCorp 2004b; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). The Klamath River is a weakly buffered system (i.e., has typically low alkalinity below 100 mg/L as calcium carbonate [$CaCO_3$]), so it is susceptible to photosynthesis-driven daily swings in pH. Observed exceedances of pH water quality objectives usually occur during later afternoon or early evening, following the period of maximum photosynthesis (North Coast Regional Board 2010; Asarian and Kann 2013). Hourly pH variations measured in the Klamath River downstream of its confluence with the Shasta River during a 48-hour period between July 28 to 30, 1997 show the daily change in pH ranging from approximately 0.8 to 1.5 s.u. (Deas and Orlob 1999). A synthesis of pH measurements from 2001 to 2011 shows the daily range (i.e., daily maximum minus daily minimum) of pH generally peaks between late July and early September corresponding to daily cycles of photosynthesis and respiration (Figure C-38; Asarian and Kann 2013).

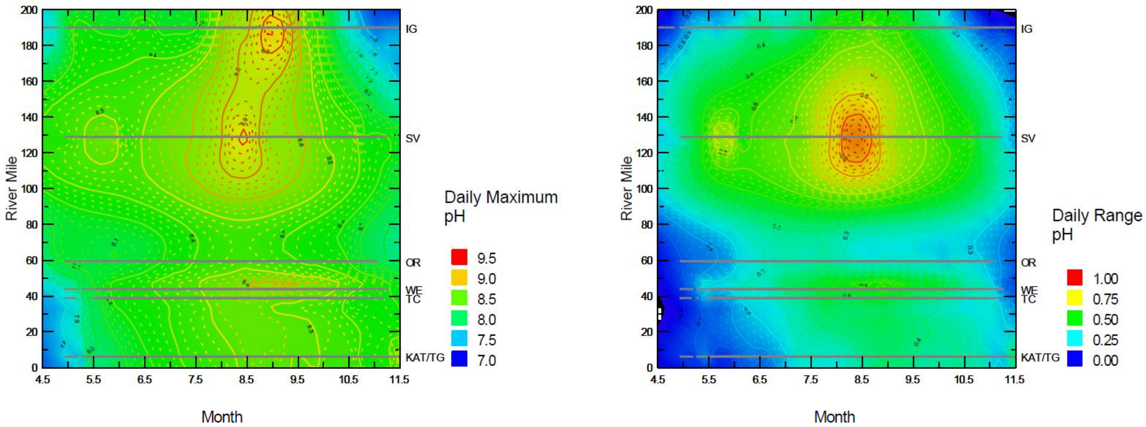

Figure C-39. Distribution of Isopleths Showing the 2001-2011 Average Daily Maximum pH and Daily Range of pH at Klamath River Sites Downstream of Iron Gate Dam from Around Mid-April (4.5) to Mid-November (11.5). Grey Lines Represent the Times the Dissolved Oxygen Concentration Was Measured in the Klamath River Downstream of Iron Gate Dam (IG at RM 193.1), at Seiad Valley (SV at RM 132.7), at Orleans (OR at RM 58.9), at Weitchpec Upstream of the Trinity River (WE at RM 43.6), Upstream of Tully Creek (TC at RM 40.1), and at Turwar (KAT/TG at RM 5.6). Source: Asarian and Kann 2013.

The most extreme pH exceedances typically occur from Iron Gate Dam (RM 193.1) to approximately Seiad Valley (RM 132.7) with pH values generally increasing from Iron Gate Dam to the Klamath River upstream of Shasta River (RM 179.5) then decreasing with distance downstream (Figure C-40; FERC 2007; Karuk Tribe of California 2007, 2009, 2010a, 2010b, 2011, 2012, 2013; Asarian and Kann 2013). During May to October 2005, the greatest number of pH exceedances in this reach occur just upstream of the mainstem confluence with the Shasta River (RM 179.5) (Figure C-41). In 2007, daily maximum pH values downstream from Iron Gate Dam (RM 193.1) were 8.2 to 9.6 s.u. with the highest documented pH occurring in September (Figure C-42); near Seiad Valley (RM 132.7), maximum pH values were slightly lower, at 8.1 to 9.4 s.u. with the highest documented pH occurring in mid-August (Figure C-43; Karuk Tribe of California 2007). A synthesis of all the data from June through October 2001 to 2011 shows these trends are consistent over time with pH greater than 8.5 s.u. in 23 percent of measurements downstream of Iron Gate Dam, 35 percent of measurements upstream from the Shasta River, and 26 percent of measurements at Seiad Valley. Measurements of pH greater than 8.5 s.u. are most frequent in August and September for most mainstem locations, but they are most frequent in July and August in the Klamath River upstream of Shasta River. Measurements of pH greater than 9.0 s.u. are most frequent at Iron Gate Dam (9 percent for September), upstream from Shasta River (8 percent for August), and Seiad Valley (6 percent for August), but measurements of pH greater than 9.0 s.u. are rare (less than 0.1 percent) at mainstem locations downstream of Seiad Valley. High daily maximum pH values at Iron Gate Dam are correlated with high chlorophyll-*a* concentrations from upstream algal blooms rather than large 24-hour cycles (Asarian and Kann 2013).

Trends in pH from 2011 to 2015 are generally similar to previous findings with pH initially increasing with distance downstream of Iron Gate Dam before then decreasing with distance downstream to Salmon River, but there is substantial variability in the pH both seasonally and during individual days (Watercourse Engineering, Inc. 2012, 2013, 2014, 2015, 2016). Measurements of pH in 2015 demonstrate typical patterns with the seasonal range in pH being greater immediately downstream of Iron Gate Dam, but the daily range in pH being greater at Seiad Valley (Figure C-44; Watercourse Engineering, Inc. 2016). Downstream of Iron Gate Dam, pH ranges from approximately 7.5 to 9.5 s.u., while pH ranges from approximately 7.5 to 9.0 s.u. at Seiad Valley.

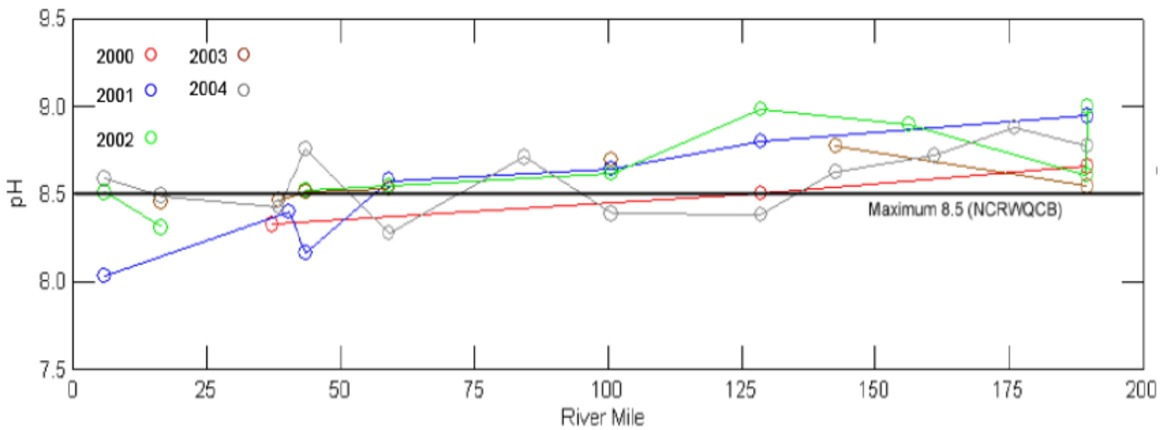

Figure C-40. Average August Daily Maximum pH Values for Locations along the Mainstem Klamath River Downstream from Iron Gate Dam for the Years 2000 to 2004 using Data Collected by USFWS, USGS, and the Karuk Tribe of California and Yurok Tribe. Source: Kier Associates 2006 as cited in FERC 2007.

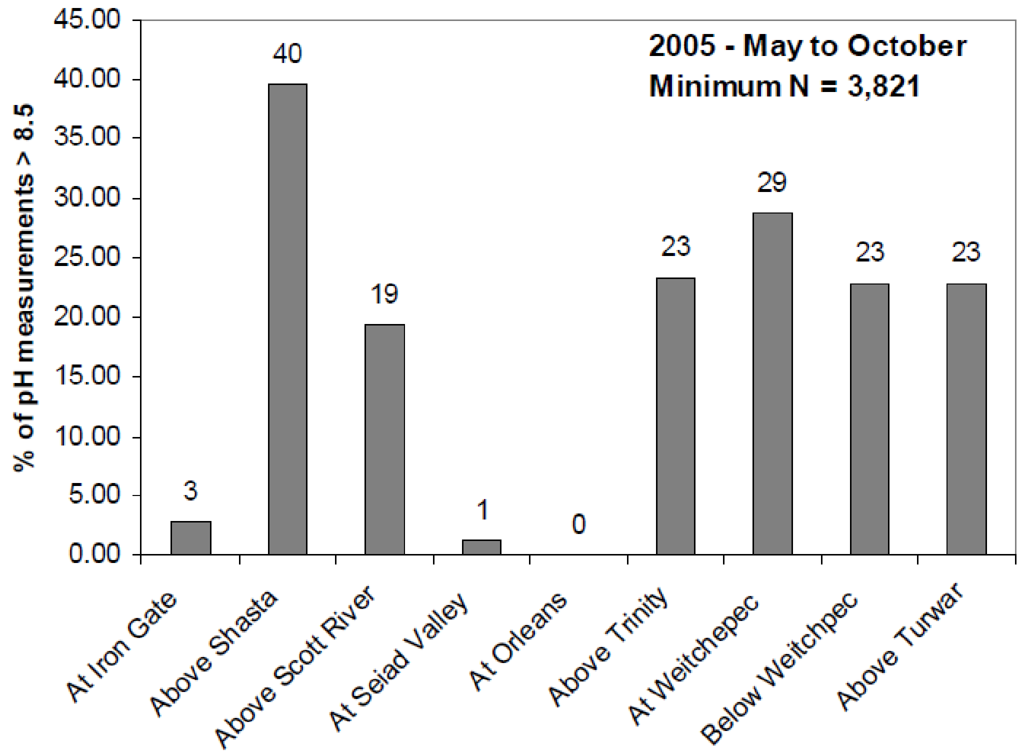

Figure C-41. Percent of pH Measurements in the Lower Klamath River Exceeding the Basin Plan Water Quality Objective of 8.5 s.u. during 2005. Source: North Coast Regional Board 2010.

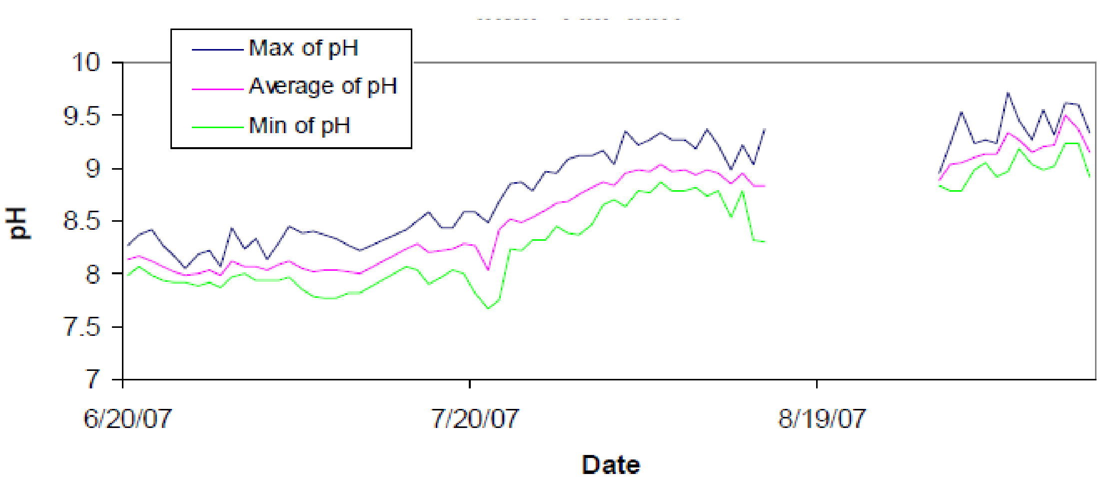

Figure C-42. Daily Maximum, Mean, and Minimum pH in the Klamath River Downstream from Iron Gate Dam (RM 193.1) from June to October 2007. Source: Karuk Tribe of California 2007.

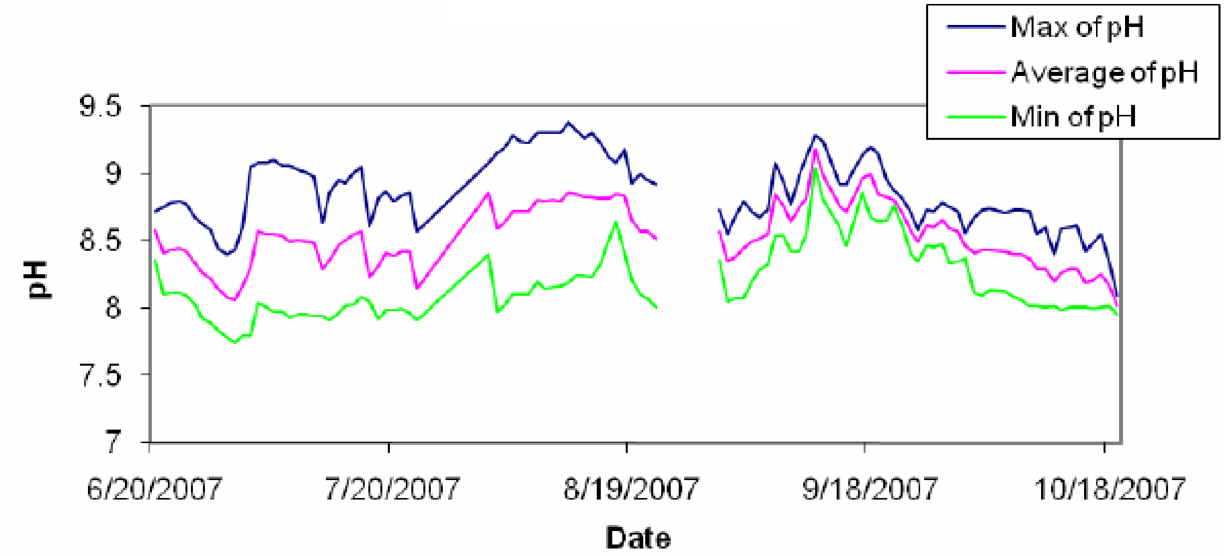

Figure C-43. Daily Maximum, Mean, and Minimum pH in the Klamath River near Seiad (≈RM 132.7) from June to October 2007. Source: Karuk Tribe of California 2007**.**

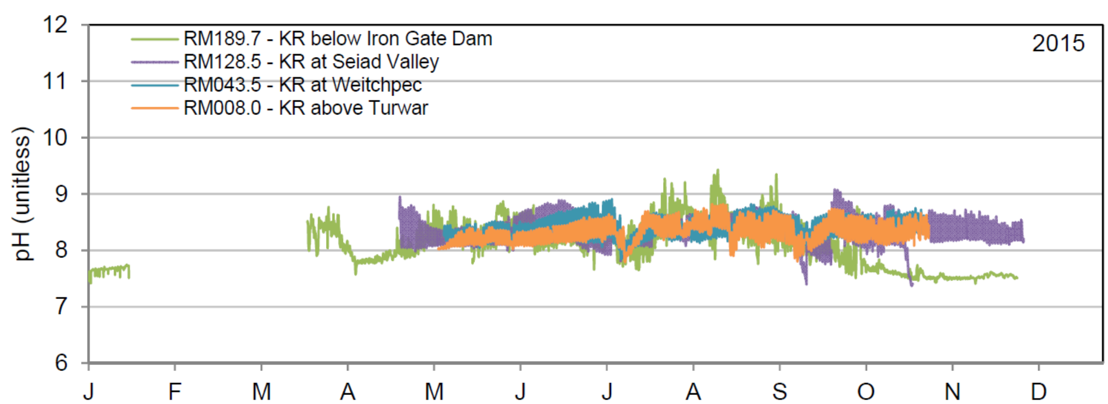

Figure C-44. Continuous pH Data from 2015 in the Klamath River Downstream of Iron Gate Dam (RM 193.1), at of Seiad Valley (RM 132.7), at Weitchpec (RM 43.6), and Upstream of Turwar (RM 5.6). Source: Watercourse Engineering, Inc. 2016.

C.5.2.2 Salmon River to Estuary

The Basin Plan pH maximum of 8.5 s.u. is also regularly exceeded in the lower Klamath River between the Salmon River (RM 66.3) and Turwar Creek (RM 5.6) during summer months with most of the exceedances occurring downstream of the Trinity River (Figures C-39 and C-41; FISHPRO 2000; Karuk Tribe of

California 2002, 2003, 2009, 2010a, 2010b, 2011, 2012, 2013; YTEP 2004, 2005; USFWS 2008; North Coast Regional Board 2010, 2011; Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; Asarian and Kann 2013 Hanington 2013; Hanington and Ellien 2014; Hanington and Cooper Carouseli 2014). Water quality monitoring by the Karuk Tribe includes pH data from Orleans (RM 58.9), which is just downstream from the mainstem confluence with the Salmon River (see also Section C.5.2.1). Daily maximum pH values at Orleans were 7.9 to 8.9 s.u. from June through October 2007, with the highest pH occurring in mid-September (Figure C-45; Karuk Tribe of California 2007). Analysis of data from 2001 to 2011 by Asarian and Kann (2013) shows similar trends, yet pH at Orleans most frequently exceeds 8.5 s.u. during August (19 percent) rather than September (12 percent). More contemporary data from 2012 and 2013 further indicate that the maximum pH and frequency of exceeding 8.5 s.u. varies between August and September, depending on the year, with pH peaking in August in 2012 and peaking in September in 2013 (Karuk Tribe of California 2012, 2013).

In the mainstem river between the confluence with the Trinity River and the Klamath River Estuary, annual water pH monitoring has been conducted by the YTEP since 2002 (YTEP 2004, 2005; Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; Asarian and Kann 2013; Hanington 2013; Hanington and Ellien 2014; Hanington and Cooper Carouseli 2014). The pH trends downstream of Weitchpec (RM 43.6) to Turwar (RM 5.6) vary seasonally with a general decreasing trend during the earlier part of the year then during September through October the pH decreases from the Klamath River at Weitchpec (RM 43.6) to the Klamath River upstream of Tully Creek (RM 40.1) then increases from upstream of Tully Creek downstream to Turwar (Figure C-39; Asarian and Kann 2013). The timing of peak pH and highest frequency of exceeding 8.5 s.u. varies between July and September depending on the year. Between 2001 and 2011, the pH most frequently exceeds 8.5 s.u. in September at Weitchpec (36 percent) and at Turwar (24 percent), while it most frequently exceeds 8.5 s.u. in the Klamath River upstream of Tully Creek (RM 40.1) in August (23 percent) (Asarian and Kann 2013). However, during 2009 monitoring, peak pH values were documented from July through September with the highest daily maximums recorded in early July. The highest pH values were documented at the most upstream location (i.e., just over 9.0 s.u. at Klamath River at Weitchpec [RM 43.6]), while both sample locations farther downstream were approximately 8.8 s.u. (Klamath River upstream of Tully Creek [RM 40.1] and upstream of Turwar Boat Ramp [RM 6]) (Figure C-46; Sinnott 2010a). More recent pH monitoring from 2012 and 2013 also show the variability in timing of pH peaks with pH at Weitchpec (RM 43.6) peaking at 8.7 s.u. in October in 2012 and 8.8 s.u. in July in 2013. The pH recorded upstream of the Turwar Boat Ramp (RM 6) is more consistent with pH peaking at approximately 8.7 s.u. during August in both 2012 and 2013 (Hanington 2013; Hanington and Ellien 2014).

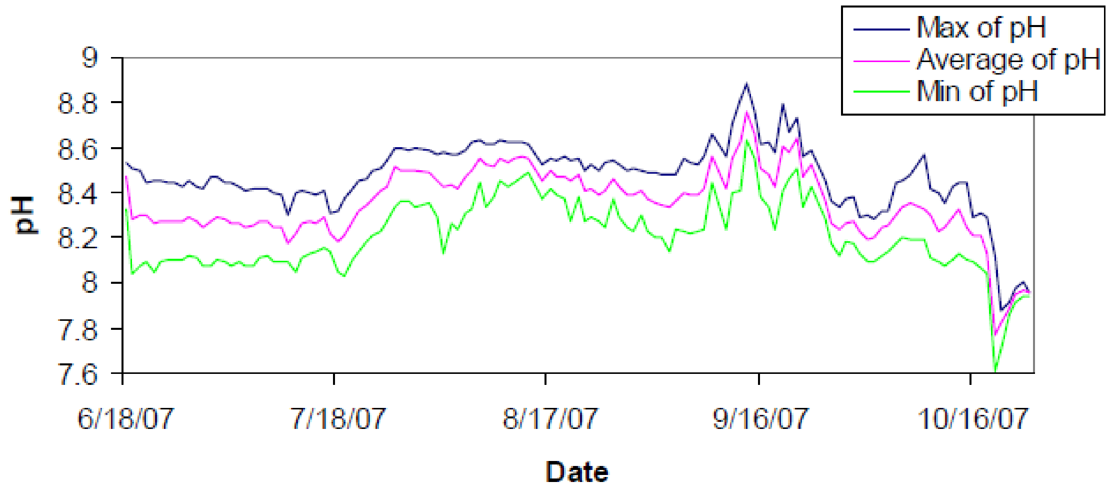

Figure C-45. Daily Maximum, Mean, and Minimum pH on the Klamath River near Orleans (RM 58.9) from June to October 2007. Source: Karuk Tribe of California 2007.

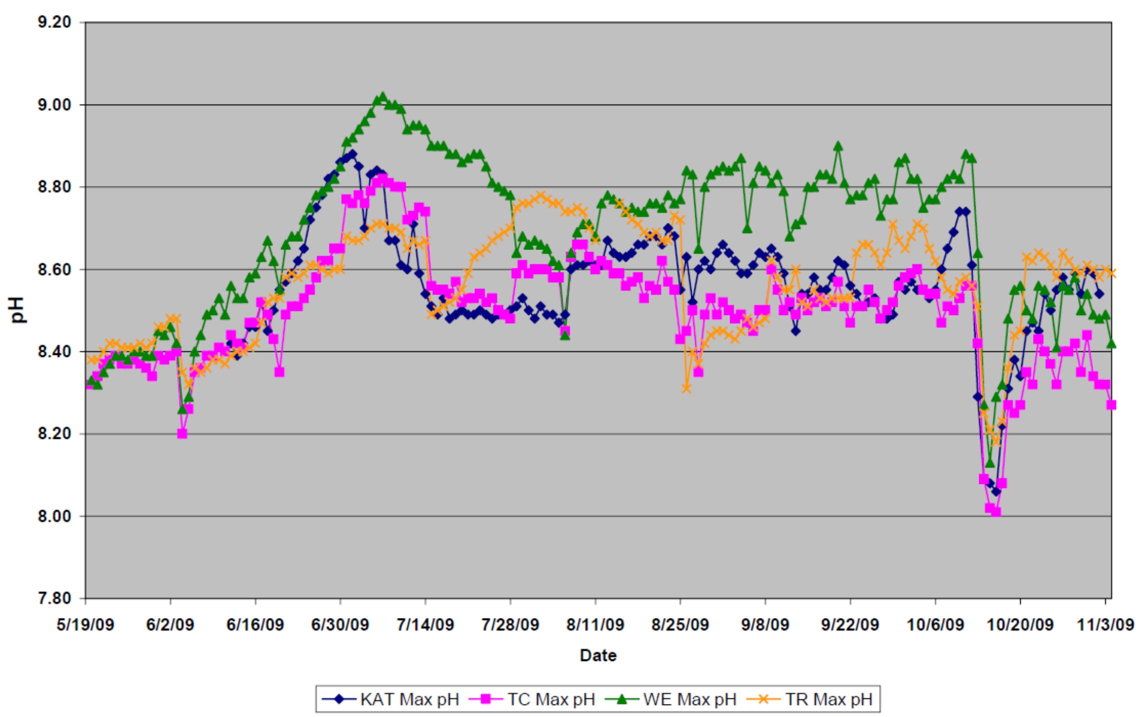

Figure C-46. Daily Maximum pH in the Klamath River at Weitchpec (RM 43.6 [WE]), Upstream of Tully Creek (RM 40.1 [TC]), and Upstream of Turwar Boat Ramp (RM 6 [KAT]), as well as in the Trinity River (RM 43.3 [TR]) near the Confluence with the Klamath River (RM 0.5 [TR]). Source**:** Sinnott 2010a.

C.5.2.3 Klamath River Estuary

pH within the Klamath River Estuary is variable spatially and temporally and is influenced by season, river flow, vertical stratification (thermal and/or salinity), and location of the estuary mouth, the latter changing due to periodic sand bar movement. The Basin Plan pH maximum of 8.5 s.u. is regularly exceeded in the Klamath River Estuary though pH measured during monthly grab samples near the surface of the lower estuary from 2009 to 2015 only show pH exceeding 8.5 s.u. in February 2011 and August 2013 (YTEP 2005; Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper Carouseli 2014). Based on Yurok Tribe water quality data, pH in the Klamath Estuary typically ranges from approximately 6.9 to 9.0 s.u. though values below 7.0 s.u. are occasionally measured, with peak values generally occurring during the summer months (YTEP 2005; Sinnott 2010a, 2011a, 2012a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper Carouseli 2014). Daily variations in pH are typically on the order of 0.5 s.u., and fluctuations tend to be somewhat larger in the late summer and early fall. The Environmental Fluid Dynamics Code estuary model component used in the California Klamath River TMDL development as well as observed data show very low phytoplankton and chlorophyll-*a* concentrations in the Klamath River Estuary (YTEP 2005), suggesting that local photosynthesis and biological respiration are not significant enough to cause large daily fluctuations of pH, as seen in upstream reaches. When large daily fluctuations are observed, they are likely caused by an upstream daily signal that is subsequently transported into the Klamath River Estuary.

C.6 Algal Toxins and Chlorophyll-*a*

C.6.1 Upper Klamath Basin

C.6.1.1 Hydroelectric Reach

Seasonal phytoplankton blooms (also called algal blooms) in the Hydroelectric Reach have been recorded historically, with chlorophyll-*a* concentrations in Iron Gate Reservoir ranging from 0.3 micrograms per liter (ug/L) to 21.6 ug/L during March, July, and October 1975 (USEPA 1978). The blue-green algae species *Aphanizomenon sp.* and *Oscillatoria sp.* were identified in the July and/or October 1975 Iron Gate Reservoir survey, with the potentially microcystin and anatoxin-a producing *Oscillatoria sp*. as the most abundant of the five phytoplankton species identified in the October algal bloom. However, no *Microcystis aeruginosa* or *Anabaena flos-aquae* were identified during the three sampling dates in 1975 (USEPA 1978). Over the past decade, algal toxins and chlorophyll-*a* have become routinely monitored water quality parameters in the Hydroelectric Reach. PacifiCorp's chlorophyll-*a* monitoring data for the river upstream of J.C. Boyle Reservoir to immediately downstream from Iron Gate Dam from 2002 through 2009 (May to October) indicates that annual mean values above 10.0 ug/L are typical of the dataset and there is generally greater apparent variability upstream of J.C. Boyle Reservoir as compared with just downstream from Iron Gate Reservoir (PacifiCorp 2004a, 2004b; Raymond 2008a, 2009a, 2010a). Chlorophyll-*a* concentrations have a wider range with higher peak values in reservoirs compared to the free-flowing portion of the Klamath River (Raymond 2008a; Asarian and Kann 2011).

A broader longitudinal analysis of measured chlorophyll-*a* concentrations was conducted using monitoring data compiled during 2005 to 2007 (May to September) from the Yurok Tribe, Karuk Tribe of California, North Coast Regional Board, and PacifiCorp (North Coast Regional Board 2010). Results at numerous locations from the lower Klamath River Estuary (RM 0 to 3.9) to J.C. Boyle Dam (RM 229.8) demonstrate that median chlorophyll-*a* concentrations within Copco No. 1 and Iron Gate reservoirs are 2 to 10 times greater (note the logarithmic scale in Figure C-47) than those documented in free-flowing locations in the mainstem river, with median concentrations greater than 10.0 ug/L exhibited in the reservoirs and median concentrations less than 10.0 ug/L exhibited at river locations (North Coast Regional Board 2010). Analysis of chlorophyll-*a* measurements from June to October 2005 to 2010 show similar trends with chlorophyll-*a* higher in Copco No. 1 and Iron Gate reservoirs than in river locations upstream, between, and downstream of the reservoirs (Figure C-48; Asarian and Kann 2011). Chlorophyll-*a* concentrations upstream of Copco No. 1 Reservoir ("Abv Shovel" location in Figure C-47; "KRACorig" location in Figure C-48) are lower than those measured downstream within the reservoir suggesting chlorophyll-*a* concentrations in the reservoirs are due to algal blooms originating in the reservoirs. Chlorophyll-*a* concentrations are generally higher in Copco No. 1 Reservoir than Iron Gate Reservoir though annual variability does result in Iron Gate Reservoir having higher median chlorophyll-*a* concentrations during some years (Asarian and Kann 2011). In the Copco No. 1 and Iron Gate reservoirs, median chlorophyll-*a* concentrations are highest near the surface than decrease with depth (Figure C-48). Chlorophyll-*a* data indicates concentrations at a 5 m depth are elevated compared to inflow values from upstream with chlorophyll-*a* in Copco No. 1 (and Iron Gate to a lesser extent) exceeding 10.0 ug/L for much of August to September in 2005 to 2007 (Asarian and Kann 2011). Peak chlorophyll-*a* concentrations indicating periods of algal blooms are generally larger in Copco No. 1 than Iron Gate with some exceptions (Asarian and Kann 2011).

Longitudinal KHSA Interim Measure 15 chlorophyll-*a* data from May through October over a longer period from 2000 to 2017 also show relatively similar chlorophyll-*a* trends as the May to September 2005 to 2007 and June to October 2005 to 2010 datasets, but the 2000 to 2017 data show a larger range of chlorophyll-a concentrations in J.C. Boyle Reservoir than the previous datasets (Figure C-48-A). In the May to September 2005 to 2007 dataset, chlorophyll-a in J.C. Boyle Reservoir is generally lower than chlorophyll-a measured in Klamath River monitoring sites upstream of Copco No. 1 (Figure C-47). However, in the

May to October 2000 to 2017 dataset, chlorophyll-a in J.C. Boyle Reservoir would occasionally exceed chlorophyll-a measured at some monitoring sites between Copco No. 1 Reservoir and J.C. Boyle Dam and chlorophyll-a in the Klamath River upstream of the J.C. Boyle Powerhouse is typically lower. Additionally, the average chlorophyll-a concentrations at several Klamath River monitoring sites (e.g., Klamath River downstream of Iron Gate Dam) in the May to October 2000 to 2017 dataset are similar or slightly higher than those measured in the upper 10 meters of Copco No. 1 and Iron Gate reservoirs.

Seasonal chlorophyll-*a* patterns in the Hydroelectric Reach indicate that relatively high concentrations can occur during spring diatom blooms (e.g., approximately 30.0 to 40.0 ug/L for Copco No. 1 and Iron Gate reservoirs in March 2000 to 2003), followed by a period of relatively low concentrations after the blooms die (e.g., less than 10 mg/L for Copco No. 1 and Iron Gate reservoirs in April to July 2000 to 2003). In some years (e.g., 2009 and 2010), the intense spring blooms have included the blue-green algae *Anabaena* spp. with sufficient density to require health advisory posting of the reservoirs. A second increase occurs during August and September when dense blooms dominated by both *Aphanizomenon flos-aquae* and *Microcystis aeruginosa* are typical (e.g., approximately 30.0 to 58.0 ug/L for Copco No. 1 and Iron Gate reservoirs 2000 to 2003) (FERC 2007). Asarian and Kann (2011) found similar seasonal chlorophyll-*a* trends in 2005 to 2010 data with peak values occurring from March to April and August to September. Chlorophyll-*a* concentrations from November to April were lower downstream of Iron Gate Dam than upstream of Copco due to settling of diatoms from upstream (Asarian and Kann 2011).

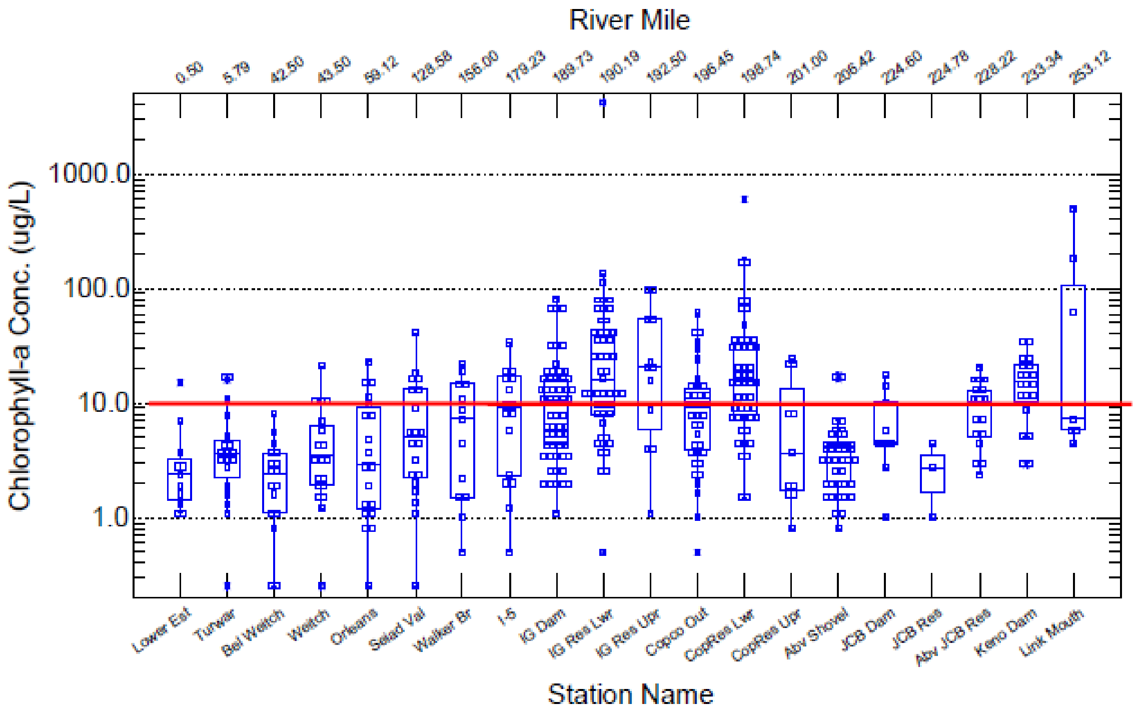

Figure C-47. Longitudinal Analysis of Summer (May through September) Chlorophyll-*a* Concentrations from 2005 to 2007 Along the Klamath River. Note the Logarithmic Scale. River miles specified for Klamath River features are based on those accurate at the time of the report and differ slightly from 2018 river mile designations (Table 3.2-1). Data from the Yurok Tribe, Karuk Tribe of California, North Coast Regional Water Quality Control Board, and PacifiCorp. Source: North Coast Regional Board 2010.

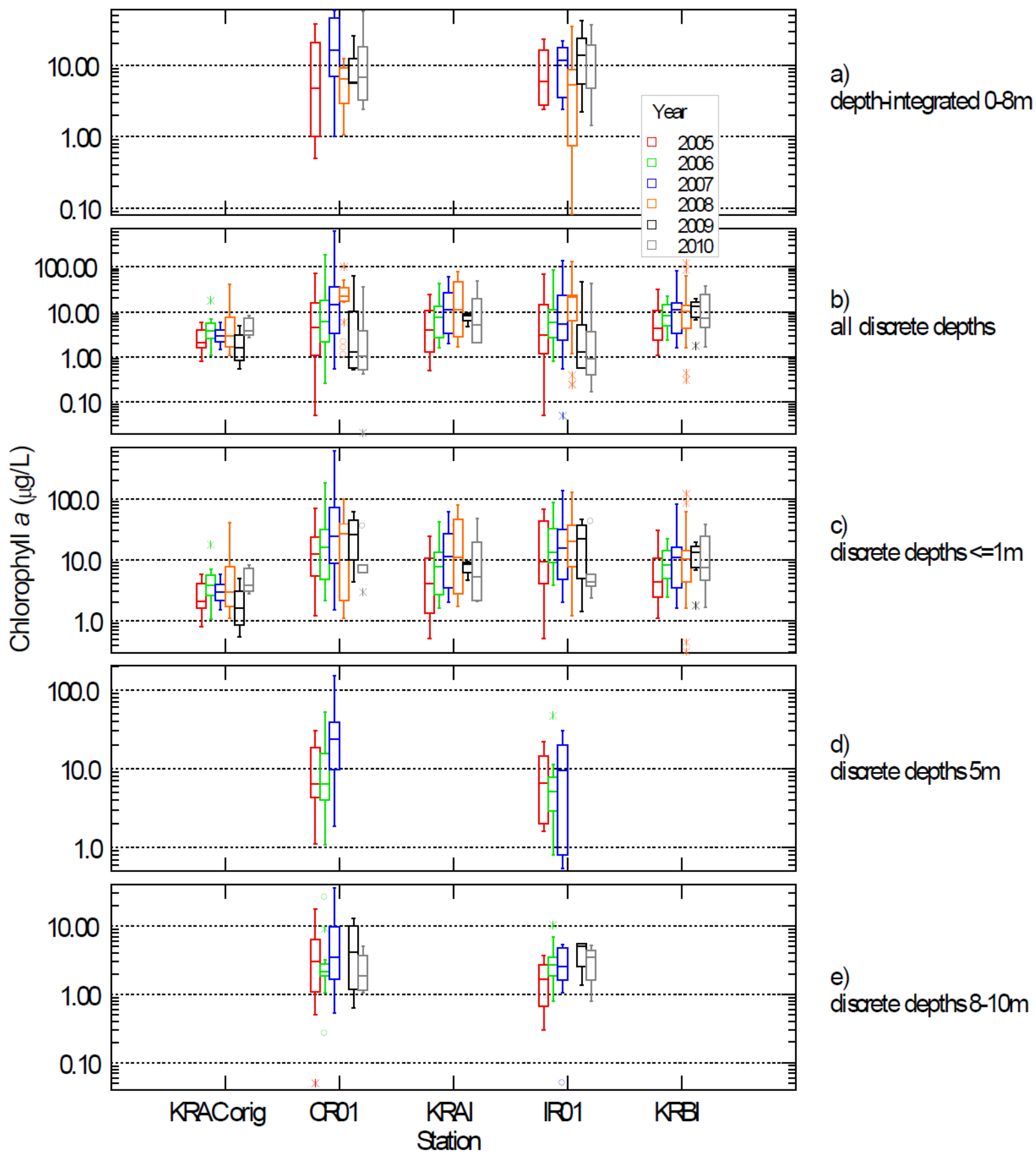

Figure C-48. Longitudinal and Vertical Chlorophyll-*a* Concentrations June to October 2005 to 2010 at the Klamath River Upstream of Copco (KRACorig), Copco Reservoir Before the Dam (CR01), Klamath River Upstream of Iron Gate (KRAI), Iron Gate Reservoir Before the Dam (IR01), and Klamath River Downstream of Iron Gate Dam (KRBI). Source: Asarian and Kann 2011.

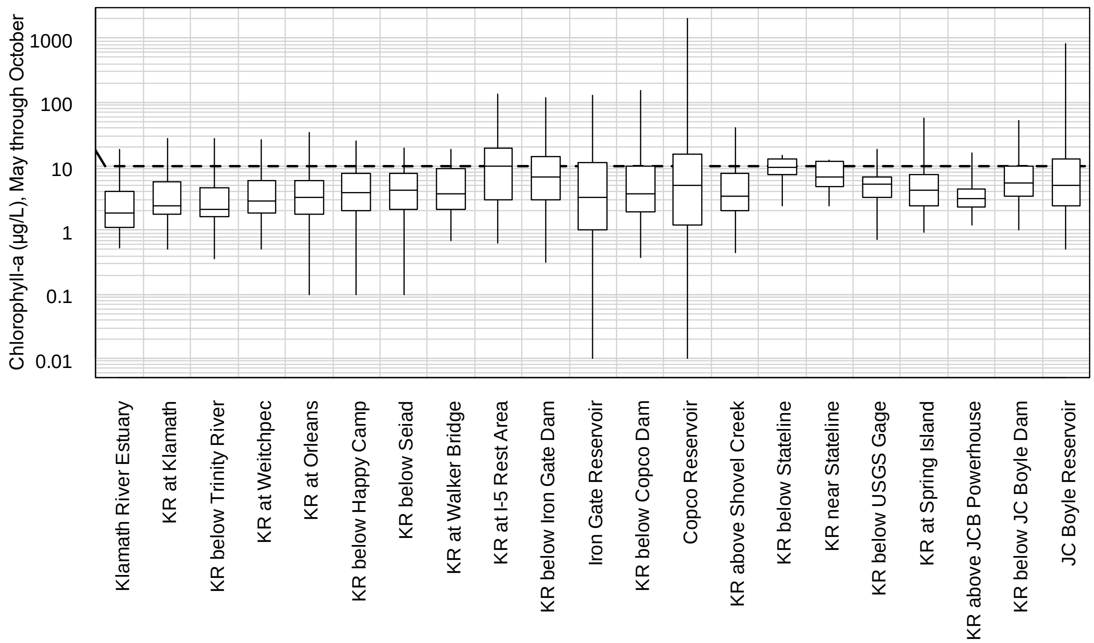

Figure C-48-A. Longitudinal Analysis of Summer Through Fall (May to October) KHSA Interim Measure 15 (IM15) Chlorophyll-*a* Concentrations from 2000 to 2017 Along the Klamath River and in the Upper 10 Meters of the Lower Klamath Project Reservoirs. Whiskers Extend From Minimum to Maximum Value, Boxes Extend From the First to the Third Quartile, and the Horizontal Line Indicates the Median of the Dataset at Each Site. Note the Logarithmic Scale. The Dashed Horizontal Line is the Chlorophyll-a Klamath River TMDL Target (i.e., 10 ug/L). Chlorophyll-*a* Data From Stations That Shifted Locations Between Years Are Plotted Together (e.g., KR at Walker Bridge). Source: PacifiCorp 2003, 2004d, 2005c, 2007, 2008d, 2009b, 2010c, 2011c, 2012b, 2013b, 2014b, 2015b, 2016c, 2017c.

Algal toxins, also referred to as cyanotoxins, can be produced by some species of blue-green algae, which are also called cyanobacteria, especially during large seasonal blooms in reservoir or lake environments. 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) can cause irritation, sickness, or in extreme cases, death to exposed organisms, including humans (Chorus and Bartram 1999). Species capable of producing microcystin include *Microcystis aeruginosa*, while species in the genus *Anabaena* can produce anatoxin-a and saxitoxin. More complete listings of specific toxins produced by genera of blue-green algae worldwide are provided in Lopez et al. (2008) and ODEQ (2011). The California Cyanobacteria and Harmful Algal Bloom (CCHAB) Network, a multi-agency workgroup formerly called the Statewide Blue-Green

Algae Working Group, has developed guidance for responding to harmful algal blooms (HABs), cyanotoxin [algal toxin] threshold levels for protection of human health, and posting and de-posting cyanotoxin [algal toxin] triggers in recreational waters (State Water Board et al. 2010, updated 2016). The State Water Resources Control Board (State Water Board), the California Department of Public Health (CDPH), and the California Environmental Protection Agency (CalEPA) Office of Environmental Health and Hazard Assessment (OEHHA) Caution Action trigger threshold for the protection of human health in recreational waters was previously 8 ug/L of microcystin, but it is 0.8 ug/L of microcystin in the 2016 update (State Water Board et al. 2010, updated 2016).

Species present in the Klamath River capable of producing microcystin include *Microcystis aeruginosa* and *Anabaena flos-aquae*[110], while species present in the Klamath River in the genus *Anabaena* can produce anatoxin-a and saxitoxin. The potentially microcystin and anatoxin-*a* producing *Oscillatoria sp.* was identified in the October 1975 survey of an algal bloom in Iron Gate Reservoir (USEPA 1978), but based on more recent data this algal species exhibits generally low abundance in the reservoirs and the Klamath River (Raymond 2008b, 2009b, 2010b; Asarian et al. 2014, 2015; Genzoli and Kann 2017). Microcystin-producing species in the genera *Gloeotrichia* and *Planktothrix* along with other algal toxin-producing species in the genera *Limnothrix* and *Pseudanabaena* also have been detected in the Klamath River, but these species have never been found to dominate the algal community (Kann and Asarian 2006; Genzoli and Kann 2017; E&S Environmental Chemistry, Inc. 2018a, 2018b). More complete listings of specific toxins produced by genera of blue-green algae worldwide are provided in Lopez et al. (2008) and ODEQ (2011).

Microcystin concentrations are generally low from J.C. Boyle to Copco No. 1 reservoirs, higher between Copco No. 1 and Iron Gate reservoirs, then decrease with distance downstream from Iron Gate Dam (Kann 2006; Jacoby and Kann 2007; Kann 2007a, b, c, d; Kann and Corum 2007, 2009; CH2M Hill 2008; Kann et al. 2010a; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; Otten et al. 2015; Genzoli and Kann 2017). High chlorophyll-*a* concentrations have been shown to correlate with the toxigenic blue-green algae blooms dominated by *Anabaena* spp. and *Microcystis aeruginosa* and sharp increases in microcystin levels above WHO numeric targets (Kann and Corum 2009) and the State Water Board, the CDPH, and CalEPA OEHHA public health thresholds (State Water Board et al. 2010, updated 2016). Data collected from

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[110] While *Anabaena flos-aquae* are capable of producing microcystin (Lopez et al. 2008), it is widely assumed that detected concentrations of microcystin are due to *Microcystis aeruginosa* rather than *Anabaena flos-aquae* due to the lower abundance of *Anabaena flos-aquae* compared to *Microcystis aeruginosa*. The relative proportion of microcystin contributions from *Anabaena flos-aquae* versus *Microcystis aeruginosa* has not been documented for the Klamath Basin.

2005 through 2009 indicate high levels of microcystin in Copco No. 1 and Iron Gate reservoirs, with measured concentrations exceeding the current State Water Board, CDPH, and CalEPA OEHHA public health threshold of 0.8 ug/L for microcystin by over 10,000 times in Copco No. 1 Reservoir in 2006, 2007, 2008, and 2009 and by over 1,000 times in Iron Gate Reservoir in 2006 and 2009 (Figure C-49; Jacoby and Kann 2007; Kann 2007a, b, c, d; Kann and Corum 2007, 2009; Kann et al. 2010a).

Microcystin measured during May to December 2009 exhibited extremely high concentrations (1,000 to 73,000 ug/L) during algal blooms occurring in July, August, and September in Copco No. 1 Reservoir in Mallard Cove and Copco Cove, and in Iron Gate Reservoir at Jay Williams. The highest microcystin concentration (73,000 ug/L) was measured on September 28, 2009 at Mallard Cove in Copco No. 1 Reservoir. Microcystin concentrations in Iron Gate Reservoir at Jay Williams peaked in October at 3,200 ug/L (Watercourse Engineering, Inc. 2011a). More contemporary measurements of microcystin in the Copco No. 1 and Iron Gate reservoirs during May to December 2015 exhibit very high concentrations consistent with previous findings (Watercourse Engineering, Inc. 2016). In Copco No. 1 Reservoir at Mallard Cove and Copco Cove, microcystin increases in June to July 2015 until peaking at 12,000 to 16,000 ug/L during algal blooms while microcystin concentrations also increase to between 200 to 370 ug/L in August, September, and October. In Iron Gate Reservoir at Jay Williams, microcystin concentrations in 2015 peaked at 770 ug/L in September, while microcystin in Iron Gate Reservoir at Camp Creek reached a maximum of 64 ug/L (Watercourse Engineering, Inc. 2016).

In 2015, PacifiCorp installed a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11 with the primary purpose of isolating surface waters that have high concentrations of blue-green algae (cyanobacteria) and potentially limiting the release of Iron Gate Reservoir water containing extensive summer and fall blue-green algae blooms downstream to the Middle and Lower Klamath River. The curtain also provides a potential secondary benefit of isolating warmer, less dense near-surface waters while withdrawing cooler, denser, and deeper waters from the reservoir for release to the Klamath River downstream (PacifiCorp 2016a, 2017a, 2018). Water quality measurements during 2015 and 2016 when the intake barrier/thermal curtain was in use indicate that the curtain reduces entrainment of blue-green algae into the Iron Gate Powerhouse intake and subsequent release downstream into the Klamath River (PacifiCorp 2016a, 2017a). Chlorophyll-*a* concentrations downstream of Iron Gate Dam during 2015 and 2016 when the intake barrier/thermal curtain was in use also showed a decrease compared to chlorophyll-a concentrations in Iron Gate Reservoir, with chlorophyll-a concentrations consistently below 10 ug/L (i.e., Klamath TMDLs phytoplankton chlorophyll-a target) even when chlorophyll-a concentrations in the reservoir were greater than 10 ug/L (PacifiCorp 2016a, 2017a). Microcystin concentrations downstream of Iron Gate Dam during 2015 and 2016 when the intake barrier/thermal curtain was in use typically showed a decrease compared to microcystin concentrations in Iron Gate Reservoir, but microcystin concentrations in the Klamath River downstream of Iron Gate Dam still occasionally exceeded microcystin posting limits during 2015 (e.g., 6 ug/L for CCHAB Warning TEIR I; Table 3.2-10) even when the intake barrier/thermal curtain deployed (PacifiCorp 2016a, 2017a). However, water quality monitoring data from 2017 and 2018 downstream of Iron Gate Dam show multiple exceedances of the Klamath TMDLs phytoplankton chlorophyll-a target (i.e., 10 ug/L) and multiple microcystin posting limits (e.g., 6 ug/L for CCHAB Warning TEIR I; Table 3.2-10) (Watercourse Engineering, Inc. 2018, 2019). An analysis of the intake barrier/thermal curtain performance during 2017 or 2018 has not been published and PacifiCorp continues to test and refine the intake barrier/thermal curtain design and operations, but available data do not indicate that this measure would prevent releases from Iron Gate Dam that would exceed water quality standards (Table 3.2-4) or consistently achieve the Klamath TMDLs phytoplankton chlorophyll-*a* target of 10 ug/L for Copco No. 1 and Iron Gate reservoirs during the May to October growth season (North Coast Regional Board 2010). Additionally, potential reductions in the entrainment of blue-green algae, chlorophyll-a concentrations, and microcystin concentrations downstream of Iron Gate Dam from operation of the intake barrier/thermal curtain would be potentially limited by the need to access water with higher dissolved oxygen concentrations to comply with dissolved oxygen standards, with the curtain completely rolled up during portions of 2017 to maximize dissolved oxygen concentrations for aquatic life (PacifiCorp 2018).

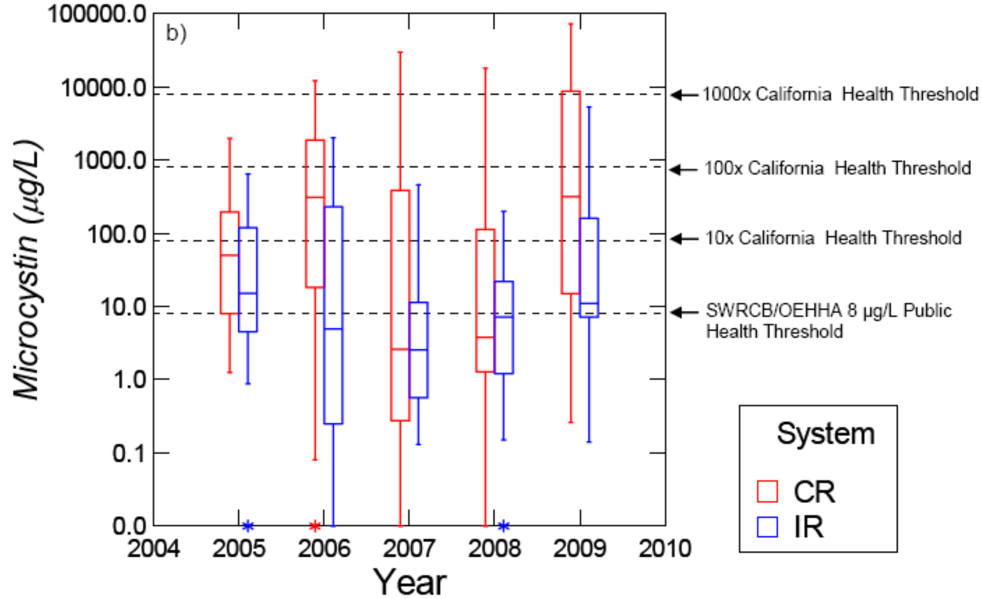


Figure C-49. Inter-annual Comparison of Microcystin Concentration for Copco No. 1 Reservoir (Red Square) and Iron Gate Reservoir (Blue Square) during July through October 2005 to 2009. Note: the SWRCB [State Water Board]/[CalEPA] OEHHA Public Health Threshold for microcystin was 8 ug/L in 2010, but it was revised to 0.8 ug/L in 2016. Source: Kann et al. 2010a.

Otten et al. (2015) report the longitudinal and temporal variations in microcystin levels from upstream of Copco No. 1 to Turwar along with genetic analysis of *Microcystis aeruginosa* in Copco No. 1 Reservoir, Iron Gate Reservoir, and multiple Klamath River sites downstream of Iron Gate Dam indicate Iron Gate Reservoir is the principal source of *Microcystis aeruginosa* cells contributing to microcystin concentrations downstream of Iron Gate Dam. Overall, microcystin concentrations are generally low from J.C. Boyle Reservoir to Copco No. 1 Reservoir, higher between Copco No. 1 Reservoir and Iron Gate Reservoir, and then generally decrease with distance downstream from Iron Gate Reservoir (Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016, 2017; Genzoli and Kann 2017; Otten 2017). The consistently low microcystin levels above Copco No. 1 along with phycological (conditions associated with algae), genetic, and toxin analyses that identify different population dynamics in Copco No. 1 and Iron Gate reservoirs indicate microcystin in the Copco No. 1 and Iron Gate reservoirs is due to local *Microcystis aeruginosa* populations (Otten et al. 2015). In 2012, Copco No. 1 microcystin concentrations peak in August then decline while Iron Gate Reservoir microcystin concentrations peak in September with the temporal differences in peak microcystin occurring because depth differences between the reservoirs cause thermal stratification in Iron Gate Reservoir approximately two weeks later than Copco No. 1 Reservoir. The timing of peak microcystin levels in Iron Gate Reservoir corresponds to the highest microcystin concentrations in the Klamath River downstream of Iron Gate Dam consistent with Iron Gate Reservoir being the source of downstream *Microcystis aeruginosa* cells. This evidence indicates that *Microcystis aeruginosa* populations from Iron Gate Reservoir contribute to *Microcystis aeruginosa* public health exceedances in the Klamath River downstream of Iron Gate Reservoir (see Section 3.4.2.3 *[Phytoplankton and Periphyton] Hydroelectric Reach*). Genetic analysis of the *Microcystis aeruginosa* populations showed Copco No. 1 Reservoir populations were dominated by one genetic type the entire year, but the populations in Iron Gate Reservoir and immediately downstream of Iron Gate Dam had a simultaneous switch in the dominant genetic type in late August that was also detected in the further downstream populations. The simultaneous timing of the genetic change in Iron Gate Reservoir and downstream *Microcystis aeruginosa* populations, but no corresponding genetic change in Copco No. 1 Reservoir provides direct evidence that downstream populations are originating in Iron Gate Reservoir rather than Copco No. 1 (Otten et al. 2015).

In 2007, a *Microcystis aeruginosa* bloom prompted a Yurok Tribe health advisory along multiple affected reaches in the Klamath River (Kann 2007a, b, c, d); data from July through September 2007 also indicate microcystin bioaccumulation in fish and mussel tissue samples collected in the Klamath River and Iron Gate and Copco No. 1 reservoirs (Kann 2008a; see Section 3.3.3.3 for more information on algal toxins in fish and mussel tissue). Additional public health advisories were issued in 2009 and 2010 in Copco No. 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 (Fetcho 2010, Kann et al. 2010a, Kann et al. 2010b). Data from 2008 and 2009 did not show microcystin bioaccumulation in the tissue and liver samples from fish collected from Copco No. 1 and Iron Gate reservoirs (CH2M Hill 2009b, PacifiCorp 2010a). In 2010, the Lower Klamath Project reservoirs were posted to protect public health due to elevated blue-green algae cell counts and algal toxin (i.e., microcystin) concentrations. In 2013, 2014, and 2016, public health advisories were posted for both Copco No. 1 and Iron Gate reservoirs when algal toxin levels or blue-green algae cell concentrations exceeded one or more public health advisory threshold (North Coast Regional Board 2013, 2014, 2016). Copco No. 1 Reservoir also had a public health advisory posted in July 2017 when microcystin concentrations exceeded both the “caution action trigger” threshold (0.8 ug/L) and the “warning, Tier 1” threshold (6 ug/L) (North Coast Regional Board 2017) with microcystin concentrations reaching 380,000 ug/L in Copco No. 1 Reservoir in August 2017 (E&S Environmental Chemistry, Inc. 2017).

As part of an evaluation of the relationship between *Microcystis aeruginosa* cell density and microcystin concentration, Kann et al. (2010a) compared the 2009 measured values to the 2010 WHO guidelines for a low probability of adverse health effect (20,000 cells/mL *Microcystis aeruginosa*, or 4 ug/L microcystin) and the 2010 State Water Board/ [CalEPA] OEHHA guidelines for protection against a moderate probability of adverse effects (40,000 cells/mL *Microcystis aeruginosa*, or 8 ug/L microcystin). These results showed that the more conservative guideline of 20,000 cells/mL *Microcystis aeruginosa* decreases the frequency of exceeding the 8 ug/L 2010 State Water Board/ [CalEPA] OEHHA guideline value for microcystin, and it is more protective of public health (Kann and Corum 2009; Kann 2014). Overall, the 2005 to 2012 results clearly illustrate that the majority of exceedances to all guidelines and thresholds occurred in the reservoirs in the Hydroelectric Reach (as compared with downstream riverine sites), with the highest overall levels measured in Copco No. 1 Reservoir (Figure C-50; Kann and Corum 2009; Kann and Bowman 2012; Kann 2014; Watercourse Engineering, Inc. 2016). Concentrations of microcystin toxin in Iron Gate and Copco No. 1 reservoirs are typically 1 to 3 orders of magnitude greater relative to the Klamath River downstream of Iron Gate Dam (Raymond 2008a; Kann et al. 2010a; Kann and Bowman 2012; Kann 2014; Watercourse Engineering, Inc. 2016). Overall, the available data indicate that while river exceedances to the 2010 microcystin water quality guidelines do occur, they are far less in number than exceedances in Copco No. 1 and Iron Gate reservoirs (Figure C-50; see also Raymond 2008a; Kann et al. 2010a; Kann and Bowman 2012; Kann 2014; Watercourse Engineering, Inc. 2016).

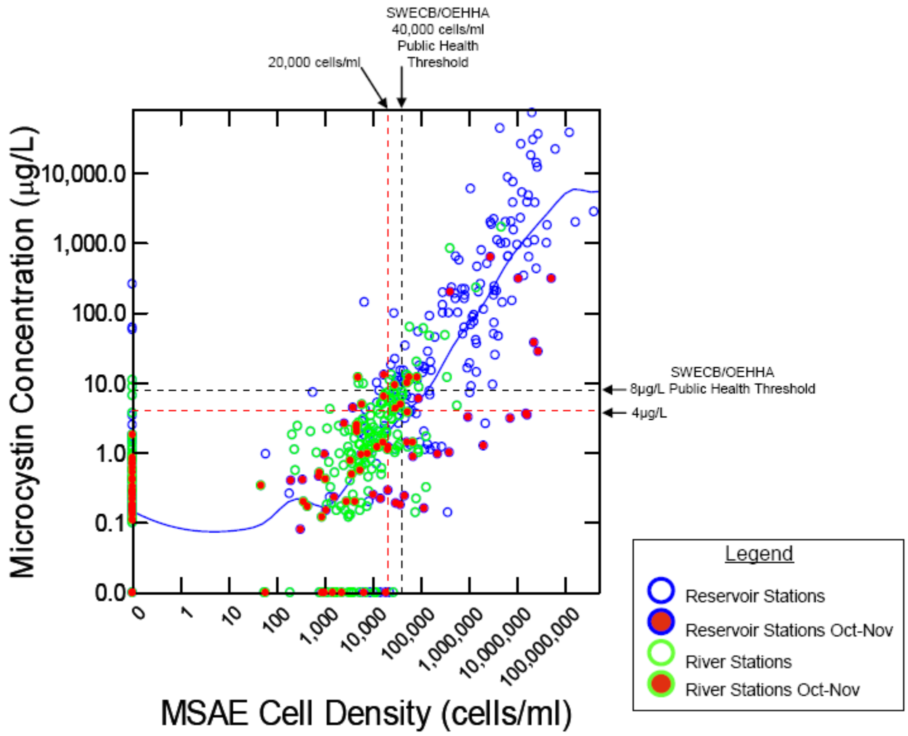


Figure C-50. Relationship between *Microcystis aeruginosa* Cell Density and Microcystin Toxin Concentration for Copco No. 1 and Iron Gate Reservoirs and Klamath River Stations 2005 to 2009. Note: the SWRCB [State Water Board]/[CalEPA] OEHHA Public Health Threshold for microcystin was 8 ug/L in 2010, but it was revised to 0.8 ug/L in 2016. Similarly, the SWRCB [State Water Board]/[CalEPA] OEHHA Public Health Threshold for Microcystis aeruginosa Cell Density was 40,000 cells/mL in 2010, but it was revised to 4,000 cells/mL of any toxin producing blue-green algae in 2016. Source: Kann et al. 2010a.

Anatoxin-a has been detected in the Klamath River system, although the timing, distribution, and sources of anatoxin-a production in the Klamath River are not well understood. Anatoxin-a can be produced by number of blue-green algae [cyanobacteria] genera, including *Anabaena*[111], *Aphanizomenon, Cylindrospermopsis, Planktothrix, Oscillatoria*, and *Phormidium* (Chorus and Bartram 1999; Quiblier et al. 2013; USEPA 2014; Bouma-Gregson et al. 2018).

[111] Cyanobacteria in the genus *Anabaena* have been recently recategorized, with all planktonic species in the genus *Anabaena* renamed *Dolichospermum* and all benthic species remaining in the genus *Anabaena*. For example, the phytoplankton *Anabaena flos-aquae* was recently renamed *Dolichospermum flos-aquae.* However, this EIR continues to use the *Anabaena* name for both planktonic and benthic species since it was more frequently used in the literature cited and it is still commonly used in descriptions of this species.

In the Klamath River, anatoxin-a production is generally assumed to be due to *Anabaena flos-aquae*, but toxin production by some strains of *Anabaena flos-aquae* appears to be sporadic, and the circumstances which prompt toxin production are unknown. While toxin-producing phytoplankton are more well-studied, periphyton can also produce toxins, including anatoxin-a (Heath et al. 2011; Quiblier et al. 2013). In many California rivers and streams not impounded by dams, periphyton are assumed to be the primary sources of anatoxin-a (Fetscher et al. 2015), including species in the genera *Anabaena* and *Phormidium* in tributaries of the Eel River located south of the Klamath River (Asarian and Higgins 2018; Bouma-Gregson et al. 2018). The relative proportion of anatoxin-a contributions from phytoplankton versus periphyton in the Klamath Basin has not been documented.

In the Klamath River system, anatoxin-a was detected in Iron Gate Reservoir on September 3, 2005 in testing by the California Department of Health Services (Kann 2007b; Kann 2008b), while monitoring conducted for the Karuk Tribe during 2005, 2006, 2007, and 2008 in Copco No. 1 or Iron Gate reservoirs did not detect anatoxin-a (Kann and Corum 2006, 2007, 2009; Kann 2007d). While concentrations of *Anabaena flos-aquae* cells have continued to be monitored, anatoxin-a concentrations are not available for Lower Klamath Project reservoir sites in recent years.

C.6.2 Mid- and Lower Klamath Basin

C.6.2.1 Iron Gate Dam to Salmon River

As noted above (Section C.6.1.1), 2005 to 2007 data indicate that during May through September median chlorophyll-*a* concentrations decrease longitudinally with distance downstream from Iron Gate Dam (Figure C-47) to the Klamath River confluence with the Salmon River (RM 66.3), but concentrations remain greater than those measured just upstream of Copco No. 1 Reservoir. This suggests that algal blooms occurring in the reservoirs were being transported to the downstream river reaches. Ward and Armstrong (2010) report the 2001 to 2005 mean chlorophyll-*a* concentrations ranged from approximately 0.5 to 3.5 ug/L, with concentrations generally decreasing with distance downstream from Iron Gate Dam though variability is observed (Figure C-41). During 2001 to 2005, the highest annual mean value (approximately 5.0 ug/L) occurs in 2005 at the confluence with the Shasta River (RM 179.5). In 2009, the Karuk Tribe collected chlorophyll-*a* and pheophytin-*a* (an additional photosynthetic pigment) data from the Klamath River downstream from Iron Gate Dam; chlorophyll-*a* values were approximately 1.0 to 35.0 ug/L and were variable depending on location. Generally speaking, relatively greater values were observed at upstream locations near Iron Gate Dam (RM 193.1) and Walker Bridge sites, but the peak value was observed farther downstream of the confluence with the Salmon River (RM 66.3) at Orleans (RM 58.9) (Karuk Tribe of California 2010a). Analysis of the chlorophyll-*a* data from 2001 to 2011 by Asarian and Kann (2013) summarizes the June to October annual variability and range of chlorophyll-*a* concentrations downstream of Iron Gate Dam (Figure C-52). The highest values occur in 2007 and 2008 with chlorophyll-*a* concentrations greater than 100 ug/L downstream of Iron Gate Dam, yet most measurements were less than 50 ug/L. Chlorophyll-*a* concentrations have a seasonal variation with concentrations in Seiad Valley (RM 132.7) decreasing in May/June, then increasing from July until peaking in late August/early September, and finally declining from September to October (Asarian and Kann 2013). Monthly/bi-weekly monitoring data from 2012 to 2015 show similar trends with chlorophyll-*a* concentrations generally decreasing from downstream of Iron Gate Dam (RM 193.1) to the Klamath River downstream of Seiad Valley (RM 132.7), but chlorophyll-*a* concentrations occasionally remained approximately the same or increased between Iron Gate Dam and Seiad Valley (Watercourse Engineering, Inc. 2013, 2014, 2015, 2016). In June to October 2015, chlorophyll-*a* concentrations range from approximately 1.3 to 9.5 ug/L downstream of Iron Gate Dam (RM 193.1), while chlorophyll-*a* concentrations range from approximately 1.3 to 9.6 ug/L downstream of Seiad Valley (RM 132.7) (Watercourse Engineering, Inc. 2016).

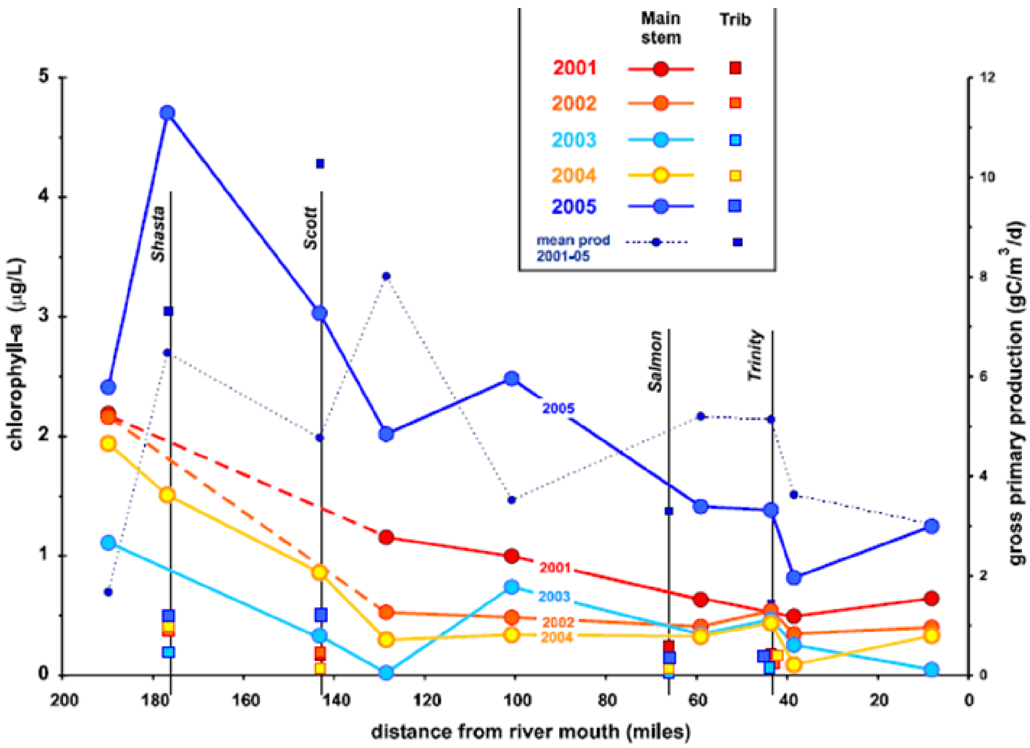


Figure C-51. Annual Mean Values of Chlorophyll-*a* in the Klamath River Downstream from Iron Gate Dam during June to September 2001 to 2005. River miles specified for Klamath River features are based on those accurate in 2010 and differ slightly from 2018 river mile designations (Table 3.2-1). Source: Ward and Armstrong 2010.

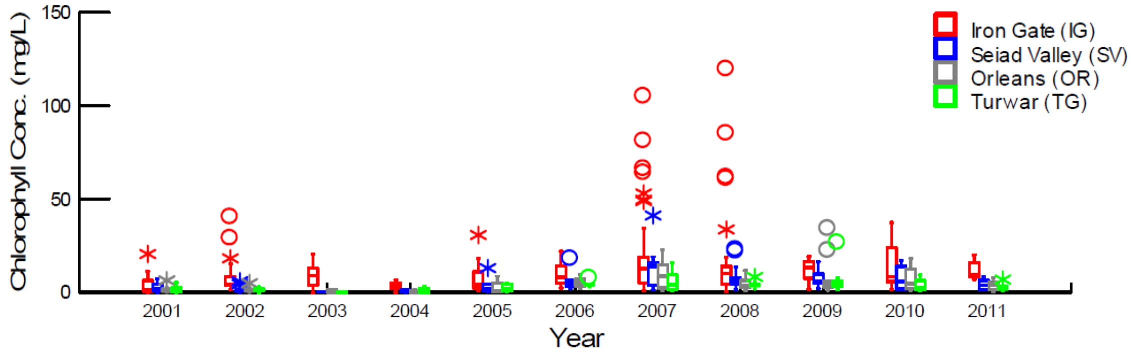


Figure C-52. Chlorophyll-*a* in the Klamath River Downstream from Iron Gate Dam during June to October 2001 to 2011. Source: Asarian and Kann 2013.

In 2008, the Karuk Tribe collected blue-green algae concentrations (cells/mL) using optical phycocyanin probes to allow more timely assessment of public health threats from toxigenic blue-green algae species. Data from downstream from Iron Gate Dam measured during June to October indicated peak values (greater than 25,000 cells/mL) in July and early-to-mid September (Karuk Tribe of California 2009). At the Klamath River monitoring sites Iron Gate (RM 193.1) and Seiad Valley (RM 132.7), phycocyanin data from 2007 to 2014 is typically low from May through early July, increases to a peak in early to mid-September, and decreases until reaching low levels again by the end of October to early November (Asarian and Kann 2013). Phycocyanin concentrations generally coincide with chlorophyll-*a* concentrations for the portion of the Klamath River at Seiad Valley. Blue-green algae concentrations (cells/mL) were also collected by the Karuk Tribe in 2016 at sites downstream of Iron Gate Dam to the confluence with the Salmon River with peak values (greater than 30,000 cells/mL) occurring in July (Watercourse Engineering, Inc. 2016).

Although concentrations of both *Microcystis aeruginosa* and microcystin in the Klamath River downstream from the Hydroelectric Reach are lower relative to the reservoirs (Figures C-53 and C-54), WHO guidelines for exposure to microcystin (i.e., less than 4.0 ug/L) have been exceeded downstream from Iron Gate Dam on numerous occasions (Kann 2004; Kann and Corum 2009; Kann et al. 2010a; Fetcho 2010; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; KTWQC 2016), including late-summer/early-fall *Microcystis aeruginosa* blooms in September 2007, 2009, 2010, 2011, 2012, 2013, and 2016 from Iron Gate Dam (RM 193.1) to the mouth of the Klamath River (RM 0.0). Health Advisories were posted along the Iron Gate Dam to Shasta River reach of the Klamath River in 2009 and 2010, due to elevated *Microcystis aeruginosa* cell counts and/or microcystin concentrations in river water. During 2009, mean microcystin concentrations immediately downstream from Iron Gate Dam (RM

193.1) were approximately 2.0 ug/L, with mean values decreasing to less than 1.0 ug/L at sites further downstream to approximately Orleans (RM 58.9) (Watercourse Engineering, Inc. 2011a). However, two measurements exceeded 7.0 ug/L at stations located at RM 156 and 128.5 (Watercourse Engineering, Inc. 2011a). Baseline grab sample water quality monitoring between 2012 and 2015 demonstrate the range of annual variability in longitudinal microcystin concentration trends (Figure C-54). Additional public health sampling, separate from the baseline monitoring, in 2015 show microcystin concentrations peaking in late July to early August between 2.9 and 5.6 ug/L (Watercourse Engineering, Inc. 2016). Microcystin concentrations collected in 2012 and 2013 document how microcystin concentrations vary over a 24-hour period and the potential influence of grab sampling time on microcystin measurements. On September 17 to 18, 2013, microcystin downstream of Iron Gate Dam ranges from approximately 8.0 to 16.0 ug/L with minimum values occurring around noon and the peak occurring at midnight (Kann 2014).

Available data indicate that algal blooms, especially those involving *Microcystis aeruginosa,* in Iron Gate and Copco No. 1 reservoirs have been responsible for the public health exceedances in the lower river (Kann 2006; Kann and Corum 2009). The highest microcystin concentrations in the Klamath River downstream of Iron Gate Dam coincide with peak microcystin levels in Iron Gate Reservoir. This is consistent with the reservoir being the source of downstream *Microcystis* cells causing elevated microcystin concentrations. A simultaneous genetic change in Iron Gate Reservoir and downstream *Microcystis aeruginosa* populations, but no corresponding genetic change in Copco No. 1 Reservoir provides further evidence that downstream populations are originating in Iron Gate Reservoir rather than Copco No. 1 (Otten et al. 2015). While cyanobacteria [blue-green algae] that potentially produce algal toxins have been observed in calm, slow-moving habitats along shorelines and protected coves and backwaters during low-flow periods in the Middle and Lower Klamath River under existing conditions (Fetcho 2008; Raymond 2008b; Kann and Corum 2009; Kann et al. 2010a; Genzoli and Kann 2016, 2017), Otten et al. (2015) found no evidence of endemic *Microcystis aeruginosa* populations that would produce algal toxins (i.e., microcystin) in the flowing regions of the Klamath River upstream or downstream of Copco No. 1 and Iron Gate reservoirs. Longitudinal decreases in *Microcystis aeruginosa* cell density and microcystin concentrations in open-channel and shoreline samples from the Klamath River downstream of Iron Gate Dam (RM 193.1) to upstream of the Klamath River Estuary suggest that water velocity and constant mixing in the river are not supportive of blue-green algae reproduction and algal toxin production, although microcystin concentrations between downstream of Iron Gate Dam and Orleans (RM 58.9) in July through October can exceed established public health thresholds (e.g., 0.8 ug/L) (Otten et al. 2015; Genzoli and Kann 2017). For example, microcystin concentrations in the Klamath River during the period 2010 to 2015 from Orleans (RM 58.9) to Klamath (RM 5.9) range from less than 1.0 ug/L to approximately 12.0 ug/L, with the highest concentrations usually occurring at Weitchpec (RM

43.6) and decreasing with distance downstream (Gibson 2016), although microcystin is occasionally higher at Orleans (RM 58.9) than Weitchpec (RM 43.6).

Additionally, microcystin can also bioaccumulate in aquatic biota. During July through September 2007, 85 percent of fish and mussel tissue samples collected from yearling fall-run Chinook salmon in Iron Gate Hatchery, yellow perch in Copco No. 1 and Iron Gate reservoirs, and mussels at Klamath River locations downstream of Iron Gate Dam exhibited microcystin bioaccumulation, with the total microcystin congeners ranging from less than detection levels to 2,803 ng/g, reported as wet weight (Kann 2008a). Microcystin congeners were detected in yellow perch fillet and liver samples, but microcystin congeners were only detected in Chinook liver samples (Kann 2008a). Microcystin bioaccumulation was not detected in muscle tissue or liver samples collected during October 2007 from eleven adult Chinook salmon and eight adult steelhead captured at eight locations in the Klamath River downstream of Iron Gate Dam (CH2M Hill 2009a). While microcystin bioaccumulation was detected in mussel samples between July and September 2007, microcystin bioaccumulation was not detected in mussel tissue samples collected in November 2007, suggesting that depuration (i.e., biological purging of algal toxins from living tissue) occurred after *Microcystis aeruginosa* cell densities and microcystin concentrations declined in late October (Kann 2008a). In contrast to the 2007 fish data, microcystin bioaccumulation was not detected in any samples collected during 2008 from resident fish or mussels in the vicinity of Copco No. 1 and Iron Gate reservoirs (CH2M Hill 2009b). Microcystin was not detected in any of the 272 muscle tissue samples (i.e., 166 yellow perch samples, 30 crappie samples, and 76 rainbow trout samples) collected during four seasonal sampling events in 2008 (i.e., May to June, July, September, and November) from 257 resident fish (duplicate tissue samples were obtained from 15 fish) captured in Copco No. 1 and Iron Gate reservoirs and in the river upstream of Copco No. 1 Reservoir or downstream of Iron Gate Dam or in any of the 14 mussel tissue samples from upstream of Copco No. 1 Reservoir and downstream of Iron Gate Reservoir (CH2M Hill 2009b). Fish livers were not tested for microcystin during 2008. Microcystin was not detected in muscle tissue or liver samples collected during two sample events in 2009 (i.e., August and September) from 43 yellow perch captured in Copco No. 1 and Iron Gate reservoirs (PacifiCorp 2010a). However, microcystin was detected in tissue samples of freshwater mussels in the Klamath River from monthly sampling events in 2009 from July to October and December (Kann et al. 2010b). Microcystin bioaccumulation also was measured during 2010 in muscle tissue and liver samples from 20 Chinook salmon, 25 steelhead, and 3 coho salmon collected at five locations downstream of Iron Gate Dam from September through November. Microcystin was detected in 3 of 7 Chinook livers collected in September 2010 near Happy Camp, in 1 of 7 Chinook livers collected in October near Happy Camp, and in 1 of 15 steelhead livers collected in October near Weitchpec, with no microcystin detected in any other fish tissue sample. Other measured algal toxins (i.e., anatoxin-a, domoic acid, or okadaic acid) were not detected in any Klamath River fish samples (Kann et al. 2013). Estuarine and marine nearshore effects (e.g., sea otter deaths) from blue-green algae exposure have been reported in other California waters; however, none have been documented to date for the Klamath River Estuary or marine nearshore (Miller et al. 2010).

The levels of microcystin bioaccumulation measured in fish and mussel tissue samples collected during July through September 2007 (i.e., less than detection levels to 2,803 ng/g, reported as wet weight) exceeded the public health guidelines defined by Ibelings and Chorus (2007) (i.e., Acute Tolerable Intake: 1,900 ng/g for an adult, 250 ng/g for a child; Seasonal Tolerable Daily Intake: 300 ng/g for an adult, 40 ng/g for a child; Lifetime Tolerable Daily Intake: 30 ng/g for an adult, 4 ng/g for a child, all as wet weight), indicating ingestion of the fish or mussels would potentially pose a health hazard to humans (Kann 2008a). While microcystin levels were less than the method detection limit for all salmonid muscle tissue and liver samples in October 2007, the method detection limit for these microcystin bioaccumulation tests on salmonids (i.e., 100 to 240 ng/g, reported as dry weight) overlapped with or was greater than the Lifetime Tolerable Daily Intake public health guideline (i.e., 120 ng/g dry weight for an adult and 16 ng/g dry weight for a child) defined by Ibelings and Chorus (2007). Thus, there was a potential chronic (i.e., long-term) health hazard to humans for the October 2007 salmonid samples if microcystin concentrations in the salmonid muscle tissue were between the method detection limit and the Tolerable Daily Intake (CH2M Hill 2009a). Public health advisories were issued in 2009 and 2010 in the Klamath River from the Salmon River confluence to the Klamath River Estuary (including locations on the Yurok Reservation) for elevated microcystin levels in ambient and/or freshwater mussel tissue samples (Fetcho 2010; Kann et al. 2010a; Kann et al. 2010b). During 2010, there was no detectable risk to human health from microcystin bioaccumulation in salmonid fillets because the microcystin concentration in salmonid fillets was less than acute, seasonal, and Lifetime Tolerable Daily Intake public health guidelines. During September 2010, microcystin concentrations measured in salmonid livers were less than the public health guideline values. However, during October 2010, microcystin concentrations measured in salmonid livers were greater than multiple public health guideline values (e.g., Klasing and Brodberg 2008; Butler et al. 2012; Mulvenna et al. 2012; Ibelings and Chorus 2007). Although fish livers are not typically consumed, these fish potentially posed a human health hazard due to the high microcystin concentrations (i.e., 121.20 to 152.40 ng/g) measured in the livers (Kann et al. 2013).

Overall, there was no acute or seasonal public health concern identified with eating salmonid fillets based upon the 2007 and 2010 data since microcystin was only detected in salmonid liver samples and salmonid liver is not typically eaten. However, there is potential for a chronic health hazard to humans from microcystin bioaccumulation in salmonids since the method detection limit during 2007 was greater than the Lifetime Tolerable Daily Intake, precluding the assessment of the lifetime public health risk. The method detection limit during 2010 was less than the Lifetime Tolerable Daily Intake and no microcystin was detected in 2010 salmonid fillet samples, so there was not a detectable chronic health hazard to humans in 2010 from microcystin bioaccumulation in salmonid fillets. (see also Section 3.3.3.3).

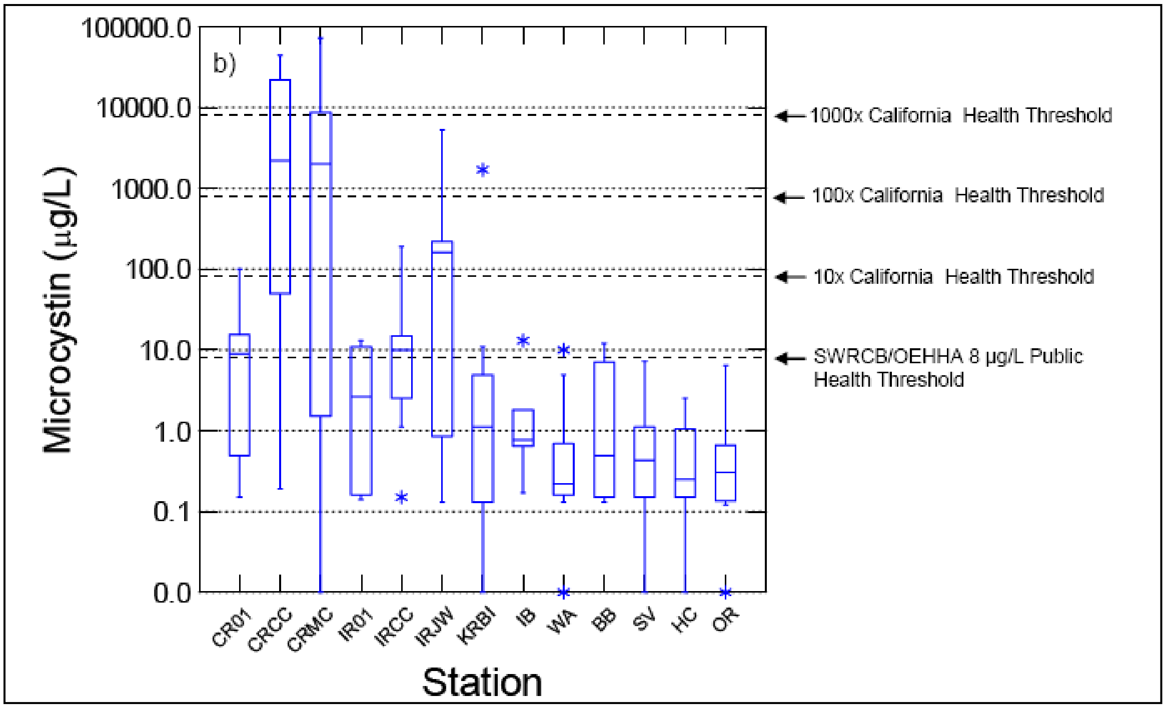
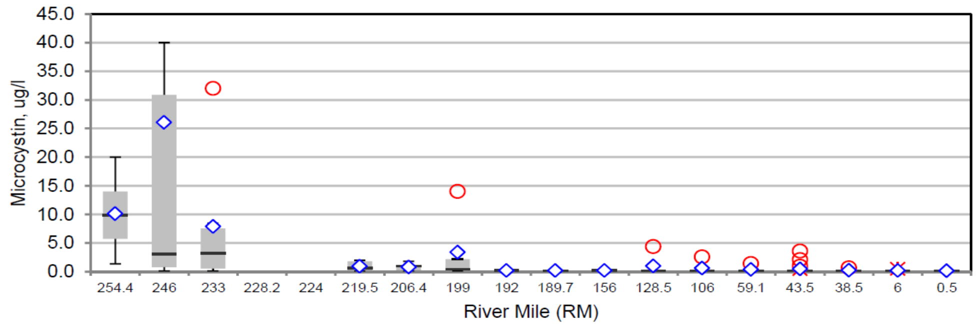
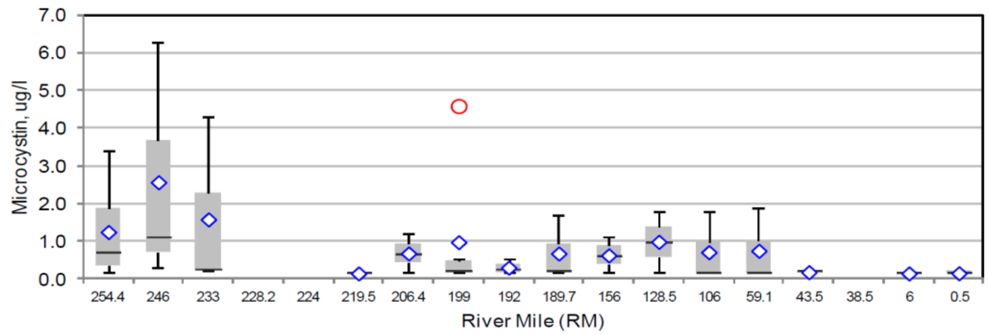


Figure C-53. Microcystin Concentration in Klamath River from Copco No. 1 (CR01) to Orleans (RM 58.9) during June to November 2009. WA=Walker Bridge, SV=Seiad Valley (RM 132.7), OR=Orleans (RM 58.9). Note: the SWRCB [State Water Board]/[CalEPA] OEHHA Public Health Threshold for microcystin was 8 ug/L in 2010, but it was revised to 0.8 ug/L in 2016. Source: Kann et al. 2010a.

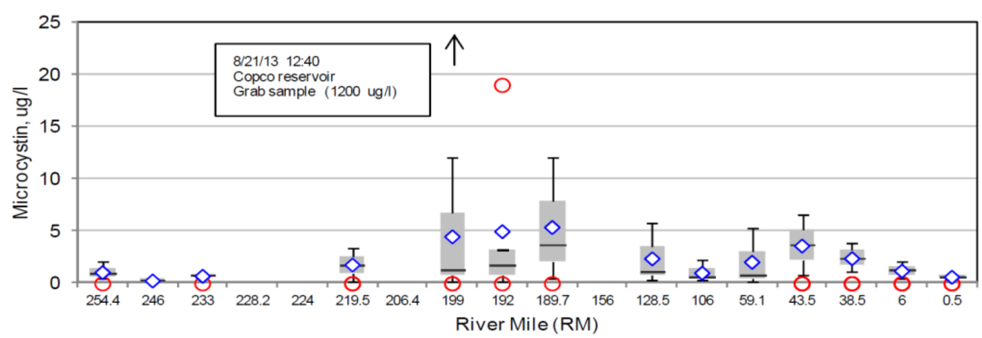
2015



2014



2013



2012

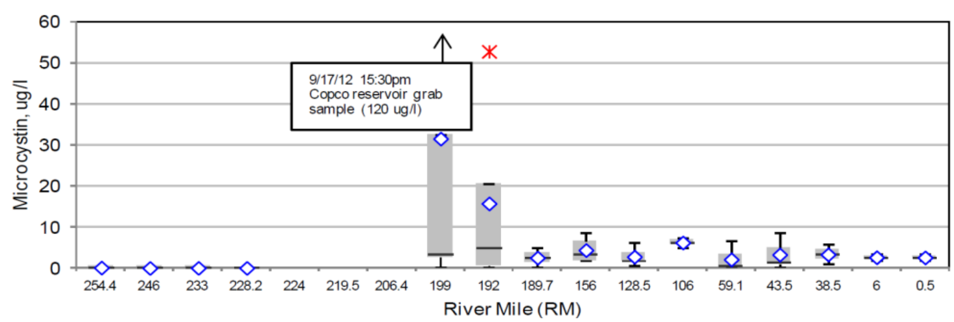


Figure C-54. Klamath River Microcystin Concentration trends from measurements made between February and December with median (-), mean (◊), outlier (*), and extreme outliers (○) identified. River miles specified are based on those accurate at the time of the reports and differ slightly from 2018 river mile designations (Table 3.2-1). Source: Watercourse Engineering, Inc. 2013, 2014, 2015, 2016.

C.6.2.2 Salmon River to Estuary

Downstream from the confluence with the Salmon River (RM 66.3), chlorophyll-*a* and algal toxin concentrations exhibit variability and are generally lower than those measured farther upstream. Water quality monitoring from 2008 to 2012 at Saints Rest Bar (RM 44.9) in the Klamath River shows chlorophyll-*a* usually ranging from approximately 1.0 to 15.0 ug/L, but occasional higher peaks with one peak reaching 44.9 ug/L in August 2011 (HVTEPA 2013). The Yurok Tribe monitors chlorophyll-*a*, pheophytin-*a*, and blue-green algae concentrations (cells/mL) annually, and use optical phycocyanin probes to allow more timely assessment of public health threats from toxigenic blue-green algae species on the Yurok Reservation (YTEP 2005; Fetcho 2006, 2007, 2008, 2009, 2011; Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper Carouseli 2014; Gibson 2016). Chlorophyll-*a* 2001 to 2005 data from Ward and Armstrong (2010) show small relative increases in chlorophyll-*a* with distance downstream, from near the Trinity River confluence (RM 43.3) to Turwar (RM 5.6), (Figure C-51), suggesting that phytoplankton productivity may increase slightly as water moves toward the Klamath River Estuary. Chlorophyll-*a* data measured from Weitchpec (RM 43.6) to the Klamath River Estuary during 2003 to 2004 did not show that trend though with concentrations, where detectable, generally decreasing in the downstream direction and below 5.0 ug/L (YTEP 2004, 2005). During 2006 to 2010 from May to October, chlorophyll-*a* concentrations frequently show an increase in chlorophyll-*a* with distance downstream from the confluence with the Trinity River (RM 43.3) to the Turwar Boat Ramp (RM 6) consistent with the findings of Ward and Armstrong (2010) (Sinnott 2008, 2009a, 2009b, 2010b, 2011b). Between May and July chlorophyll-*a* is typically less than 5.0 ug/L, but it increases during August to October with peak concentrations of 24.0 to 27.0 ug/L in 2009 (Sinnott 2008, 2009a, 2009b, 2010b, 2011b). Longitudinal chlorophyll-*a* concentrations from 2011 to 2014 are variable from the confluence with the Trinity River (RM 43.3) to the Turwar Boat Ramp (RM 6) with concentrations seasonally increasing or decreasing with distance downstream (Sinnott 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper Carouseli 2014). In 2011 to 2014, chlorophyll-*a* is less than 6.0 ug/L from May to July then increases to approximately 10.0 to 15.0 ug/L during August to October before decreasing to below 3.0 ug/L in December (Sinnott 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper Carouseli 2014). The peak values between 2006 and 2014 usually occur at Weitchpec (RM 43.6) from late August to mid-October and varying by year (6.7 ug/L in 2008 and 26.0 ug/L in 2009), but there is one exception in November 2013 when chlorophyll-*a* at Weitchpec reaches 27.0 ug/L.

During 2009, mean microcystin concentrations from Orleans (RM 58.9) to Klamath River at Klamath (RM 5.9) were less than 1.0 ug/L, well below the 2010 State Water Board/ [CalEPA] OEHHA guideline value for microcystin (8 ug/L), but greater than the 2016 State Water Board/ [CalEPA] OEHHA guideline for microcystin (0.8 ug/L) (Watercourse Engineering, Inc. 2011a). Individual microcystin measurements generally remained less than 1.0 ug/L as well, with the exception of a sample collected in late-September at Orleans (RM 58.9) for which the microcystin concentration was 6.4 ug/L (Watercourse Engineering, Inc. 2011a). Microcystin at Saints Rest Bar (RM 44.9) in 2010 to 2012 usually ranges from below 0.15 ug/L (the detection limit) to 5.6 ug/L, but microcystin in September 2012 reaches a peak of 19.0 ug/L (HVTEPA 2013). Microcystin concentrations from 2010 to 2015 range from less than 1.0 ug/L to approximately 12.0 ug/L with concentrations usually highest at Weitchpec (RM 43.6) then decreasing with distance downstream (Gibson 2016) though microcystin was occasionally higher at Orleans (RM 58.9) than Weitchpec (RM 43.6) in some years (Figure C-54). Microcystin concentrations peak between July and September around the same time the maximum concentration of *Microcystis aeruginosa* are measured, but Gibson (2016) notes microcystin is present at high levels in some samples even when *Microcystis aeruginosa* are not. While peak microcystin in the Klamath River at Weitchpec exceeds 8.0 ug/L in 2010, 2012, and 2013, microcystin concentrations downstream of Weitchpec, are less than 8.0 ug/L for all years between 2010 and 2015 (Gibson 2016). Microcystin exceeded 0.8 ug/L at Weitchpec at least once every year between 2010 to 2015, but microcystin exceeded 0.8 ug/L only once every year in 2010 through 2013 in the Klamath River at the Turwar Boat Ramp (RM 6). While microcystin levels in fish tissue samples are usually below detection level or trace (0.17 micrograms per gram [ug/g]), 0.54 ug/g microcystin was measured in a half pounder steelhead liver collected in the Klamath River at Weitchpec in 2005 (Kann 2006).

In the Klamath River upstream of Tully Creek (RM 38.8) and at Turwar (RM 5.8), phycocyanin, a pigment produced by blue-green algae, is typically low from May through early July, but it increases more gradually and peaks in late-September before decreasing to low levels again at the end of October. Phycocyanin generally decreases in the downstream direction from Iron Gate Dam to Orleans, but there is an increase in phycocyanin at Weitchpec before again decreasing in the downstream direction to Turwar. The longitudinal decrease in phycocyanin was most pronounced between Iron Gate Dam and Seiad Valley and Seiad Valley and Orleans (Genzoli and Kann 2016).

As described for the Klamath River from Iron Gate Dam to the Salmon River (Section C.6.2.1), there have been numerous exceedances of public health guidelines in the Klamath River from the Salmon River confluence to the Klamath River Estuary, particularly in 2010. Public health advisories were issued in 2009 and 2010 in this reach (including locations on the Yurok Reservation) for elevated microcystin levels in ambient and/or freshwater mussel tissue samples (Fetcho 2010; Kann et al. 2010a; Kann et al. 2010b). In addition, substantial bioaccumulation (exceeding public health guidelines) of microcystin in freshwater mussels has been shown in this reach (Kann 2008a, Kann et al. 2010b). In 2014 and 2015, public health advisories were posted when microcystin concentrations exceeded the 0.8 ug/L Recommended Threshold for Recreational Waters and blue-green algae cell concentrations were elevated (YTEP 2014, 2015).

Anatoxin-a was not detected above the reporting limit in water samples collected during 2008 and 2009 at Lower Klamath River monitoring sites (Fetcho 2009, 2011). In recent years, anatoxin-a has been measured in the Klamath River downstream of Iron Gate Reservoir on several occasions, typically in the lower reaches including at monitoring sites near Weitchpec and Orleans (Otten 2017). Concentrations of *Anabaena flos-aquae* cells have continued to be monitored in recent years, but anatoxin-a concentrations are not available for Klamath River monitoring sites.

C.6.2.3 Klamath River Estuary

Chlorophyll-*a* and algal toxin levels in the Klamath River Estuary are generally similar to those measured at stations just upstream. During 2006 to 2014, chlorophyll-*a* concentrations in the Klamath River Estuary were less than 5.0 ug/L from May to July (except for one measurement of 9.9 ug/L in July 2012), then ranged from 0.5 to 15.0 ug/L from August to October (Sinnott 2008, 2009a, 2009b, 2010b, 2011b, 2012b; Hanington and Torso 2013; Hanington and Stawasz 2014; Hanington and Cooper Carouseli 2014). Peak concentrations of chlorophyll-*a* during 2006 to 2014 occurred during late-July to mid-October and varied by year (2.4 ug/L in 2006, 15.0 ug/L in 2007).

Algal toxin concentrations in the Klamath River Estuary are generally below 4.0 ug/L, corresponding to relatively low concentrations of *Microcystis aeruginosa* with several exceptions (Fetcho 2006, 2007, 2008, 2009, 2011; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016; Gibson 2016). In September 2007 and 2010 the Yurok Tribe issued advisories because *Microcystis aeruginosa* concentrations exceeded 40,000 cells/mL. In 2010 and 2011 measured microcystin concentrations exceeded 4.0 ug/L between September and October (Gibson 2016). Microcystin in the Klamath River Estuary (RM 0.5) exceeded 0.8 ug/L at least once every year in 2010 through 2012, but it did not exceed 0.8 ug/L in 2013 through 2015 (Gibson 2016). In one additional instance, in September 2005, concentrations exceeded the WHO guideline for low risk recreational use (20,000 cells/mL). These elevated levels of *Microcystis aeruginosa* corresponded with elevated levels measured farther upstream in Copco No. 1 and Iron Gate reservoirs (Kann and Corum 2006). Lastly, there is emerging evidence that algal toxins 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 when large blooms are transported through the Klamath River Estuary and into the Pacific Ocean.

C.7 Inorganic and Organic Contaminants

C.7.1 Upper Klamath Basin

C.7.1.1 Hydroelectric Reach

Water Column Contaminants

Existing water quality data are available from the California Surface Water Ambient Monitoring Program (SWAMP), which collected water quality data, including inorganic and organic contaminant data, from 2001 through 2005 at eight monitoring sites from the Oregon-California state line (RM 214.1) to Klamath River at Klamath Glen (RM 5.9) (North Coast Regional Board 2008). Results from the state line site indicated that for the majority of inorganic constituents, excluding nutrients (i.e., arsenic, cadmium, chloride, chromium, copper, lead, mercury, nickel, selenium, silver, sulfate, and zinc), concentrations were in compliance with water quality objectives at the time of sampling. Nutrients are discussed above in Section C.3.1. Aluminum concentrations (50.7 to 99.2 ug/L) exceeded the USEPA continuous concentration for freshwater aquatic life protection (87 ug/L) on two of four site visits (50 percent exceedance rate), and exceeded the USEPA secondary Maximum Contaminant Level (MCL) for drinking water (50 ug/L) on all four site visits (100 percent exceedance rate) (North Coast Regional Board 2008). 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 detections, but one detection of dichlorodiphenyldichloroethylene (1,1-bis-(4-chlorophenyl)-2,2-dichloroethene or DDE) (25 percent of samples) and one detection of trans-nonachlor (25 percent of samples) were found (North Coast Regional Board 2008).

Sediment Contaminants

To investigate the potential for toxicity of the sediments trapped behind the Lower Klamath Project reservoirs, Shannon & Wilson, Inc. (2006) collected 25 cores from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs during 2006 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. The locations of the sediment cores were distributed throughout each reservoir, including locations on the historical Klamath River channel (on-thalweg) and the surrounding submerged terraces or near tributary mouths (off-thalweg) along the edge of the historical Klamath River. Four locations on-thalweg were sampled in J.C. Boyle Reservoir, with maximum core depths ranging from 0.3 feet at the upstream end of the reservoir to 13.2 feet near the dam. Twelve locations (7 on-thalweg, 5 off-thalweg) were sampled in Copco No. 1 Reservoir, with maximum core depths ranging from 1.5 feet at the upstream end of the reservoir to 12.1 feet near the middle of the reservoir. Nine locations (5 on-thalweg, 4 off-thalweg) were sampled in Iron Gate Reservoir, with maximum core depths ranging from 0.7 feet at the upstream end of the reservoir to 7.8 feet within the Slide Creek/Camp Creek arm of the reservoir. During sediment core drilling, the sediments were evaluated to distinguish recent reservoir-deposited sediment from pre-reservoir sediment with drilling logs noting the depth of different sediment horizons. Interval composite/depth interval sediment samples were generated from the sediment cores, including both the reservoir-deposited and pre-reservoir sediments, with the number of interval samples depending on the total depth of the sediment core. No herbicides or PCBs were found above U.S. Army Corps of Engineers (USACE) Puget Sound Dredged Disposal Analysis Program (PSDDA) screening levels and only one sample exceeded applicable PSDDA screening levels for VOCs ethyl benzenes and total xylenes (Shannon & Wilson, Inc. 2006). While cyanide was detected in two of three sediment cores, it was not found in toxic free cyanide form (HCN or CN^-), and it is not likely to be bioavailable or result in adverse effects on fish and other aquatic biota.

Dioxin, a known carcinogen, was measured in three samples from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs. Dioxin is a collective term for a group of seventeen chemically-related dioxin and furan compounds: 2,3,7,8-TCDD, 1,2,3,7,8-PeCDD, 1,2,3,4,7,8-HxCDD, 1,2,3,6,7,8-HxCDD, 1,2,3,7,8,9-HxCDD, 1,2,3,4,6,7,8-HpCDD, OCDD, 2,3,7,8-TCDF, 1,2,3,7,8-PeCDF, 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, 1,2,3,6,7,8-HxCDF, 2,3,4,6,7,8-HxCDF, 1,2,3,7,8,9-HxCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, OCDF._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. The various dioxin and furan compounds have different relative toxicities, so a Toxic Equivalent Quotient (TEQ) is calculated by multiplying the measured concentrations of the individual compounds by its toxicity relative to 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD) (i.e., its Toxicity Equivalent Factor) and summing the Toxicity Equivalent Factor weighted concentrations for each compound into one number that can be used to assess overall dioxin toxicity. A Toxic Equivalent Quotient (TEQ) is equal to a Toxic Equivalent Concentration and the two terms are used interchangeably in the literature, so they are both abbreviated as TEQ in this report. In the 2006 reservoir samples, measured levels were 2.48 to 4.83 pg/g TEQ (picograms per gram or parts per trillion [ppt] expressed as Toxic Equivalent Concentrations [TEQ] relative to 2,3,7,8 tetrachlorodibenzodioxin toxicity) and did not exceed USACE (1,000 pg/g TEQ), proposed freshwater sediment Apparent Effects Threshold for benthic fauna (8.8 pg/g TEQ), International Joint Commission for Great Lakes Science Advisory Board (10 pg/g TEQ), PSDDA bioaccumulation (15 pg/g TEQ), or U.S. Environmental Protection Agency fish and wildlife guidelines (2.5 to 210 pg/g TEQ) screening levels (Shannon & Wilson, Inc. 2006). More comprehensive reviews of dioxin guidelines and sediment studies from watersheds outside of the Klamath basin were conducted by Dillon (2008) and USEPA (2010), the latter presenting an estimate of background dioxin concentrations (2 to 5 ppt TEQ) for non-source-impacted sediments throughout the U.S. and specifically in the western U.S. (USEPA 2010). Based on the information presented in (USEPA 2010), in addition to being within the range of natural background, Klamath dioxin sediment levels reported by Shannon & Wilson, Inc. (2006) are one to three orders of magnitude below risk-based USEPA (1,000 pg/g dry weight [DW], TEQ) preliminary remediation goals in residential soils, and Washington Department of Ecology (11 pg/g DW TEQ) for residential soil clean-up levels (USEPA 2010). They are also generally an order of magnitude below USEPA effects-based ecological receptors thresholds (60 to 100 pg/g DW TEQ for fish; 2.5 to 25 pg/g DW TEQ for mammals; 21 to 210 pg/g DW TEQ for birds).

While the existing sediment data (Shannon & Wilson, Inc. 2006) did not indicate a high risk of sediment toxicity, it was not sufficient to evaluate all analytes of interest. Thus, as part of the Secretarial Determination studies, a sediment evaluation was undertaken during 2009 to 2011 to provide a more comprehensive data set to further guide decisionmakers in an evaluation of potential impacts from dam removal. The United States Bureau of Reclamation (USBR) and USFWS plan expanded the number of sediment cores and the analyte suite examined, including chemicals likely to bioaccumulate, and included biological and elutriate tests (USBR 2010). In 2009 to 2011 evaluation, establishment of toxicity and/or bioaccumulative potential for sediment contaminants relied upon thresholds developed through regional and state efforts such as the 2009 Sediment Evaluation Framework (SEF) for the Pacific Northwest Oregon and ODEQ bioaccumulation screening level values (SLVs). Sediment cores were collected during 2009 to 2010 at 37 sites on the historical Klamath River channel (on-thalweg) and the surrounding submerged terraces or near tributary mouths along the edge of the historical Klamath River (off-thalweg), distributed throughout J.C. Boyle Reservoir (Figure 2.6-4), Copco No. 1 Reservoir (Figure 2.6-5), Iron Gate Reservoir (Figure 2.6-6), and the Klamath River Estuary (**Figure**) (USBR 2010, 2011). Twelve sites (7 on-thalweg, 5 off-thalweg) were sampled in J.C. Boyle Reservoir, with maximum core depths ranging from 0.3 feet near the middle of the reservoir to 18.7 feet near the dam. Twelve sites (7 on-thalweg, 5 off-thalweg) were sampled in Copco No. 1 Reservoir, with maximum core depths ranging from 1.2 feet on an off-thalweg site downstream of the Beaver Creek arm of the reservoir to 9.7 feet on an off-thalweg location upstream of the Beaver Creek arm of the reservoir. Thirteen sites (8 on-thalweg, 5 off-thalweg) were sampled in Iron Gate Reservoir, with maximum core depths ranging from 0.5 feet at the upstream end of the reservoir to 7.7 feet within the Jenny Creek arm of the reservoir. At each site, cores were inspected by on-site geologists to verify that the reservoir-deposited/pre-reservoir sediment contact had been reached for each core. Sediment cores were used to either create whole core composite sediment samples or interval composite/depth interval composite sediment samples for laboratory analysis of potential contaminants with samples representing both the reservoir-deposited and pre-reservoir sediments. Area composite samples were also generated from sediment cores for the Klamath River Estuary. A total of 77 sediment samples were created to analyze sediment conditions in J.C. Boyle Reservoir (26 sediment samples), Copco No. 1 Reservoir (25 sediment samples), Iron Gate Reservoir (24 sediment samples), and the Klamath River Estuary (2 sediment samples) from the 37 sediment cores (USBR 2011).

A total of 501 analytes were quantified across the samples, including metals, poly-aromatic hydrocarbons (PAHs), PCBs, pesticides/herbicides, phthalates, VOCs, SVOCs, dioxins, furans, and polybrominated diphenyl ethers (PBDEs) (i.e., flame retardants). The chemical composition of sediment and elutriate[112] sediment samples were analyzed, and bioassays were conducted on the sediment and elutriate sediment samples using fish and invertebrate national benchmark toxicity species. Using results of these analyses, the following five exposure pathways were evaluated under Level 2A and 2B of the SEF using multiple lines of evidence: (CDM 2011):

- Pathway 1 – Proposed Project - Short-term water column exposure for aquatic biota from sediments flushed downstream (suspended sediments, not a bioaccumulation issue).
- Pathway 2 – Proposed Project - Long-term sediment exposure for riparian biota and humans from reservoir terrace deposits and river bank deposits (terrestrial exposures).
- Pathway 3 – Proposed Project - Long-term sediment exposure for aquatic biota and humans from river bed deposits (aquatic exposures).
- Pathway 4 – Proposed Project - Long-term sediment exposure for aquatic biota from estuary and marine near shore deposits.
- Pathway 5 – No Project Alternative - Long-term sediment exposure for aquatic biota and humans (via fish consumption) to reservoir sediments.

Results indicate that sediment in all three reservoirs exceeded freshwater ecological screening levels (SLs) for nickel, iron, and 2,3,4,7,8-Pentachlorodibenzofuran (PECDF) (Table C-6). Sediment in J.C. Boyle Reservoir also exceeded freshwater ecological SLs for 4,4’-Dichlorodiphenyltrichloroethane (DDT), 4,4’-Dichlorodiphenyldichloroethane (DDD), 4,4’-dichlorodiphenyldichloroethylene (DDE), dieldrin, and 2,3,7,8-Tetrachlorodibenzodioxin (TCDD) (Table C-6). Several pesticides and semi-volatile organic compounds (SVOCs) were not detected in the reservoir sediments, but the reporting limits were above the freshwater SLs. Human health SLs were only exceeded for arsenic and nickel, pentachlorophenol (in the case of J.C. Boyle Reservoir), and some legacy pesticides (e.g., 4,4’-DDT, 4,4’-DDD, 4,4’-DDE, dieldrin, see Table C-7). Several dioxin-like compounds were detected and exceeded the ODEQ Bioaccumulation SLVs (Table C-7). Several pesticides and SVOCs were not detected, but the reporting limits were above the

[112] Elutriate sediment samples are created from reservoir composite sediment samples mixed with reservoir water (e.g., one part sediment to four parts water). In general, elutriate tests are a standard approach that analyze the chemical composition of the overlying water of the elutriate sediment samples to estimate potential chemical concentrations that may be released into the water from reservoir sediments during suspension. Standard elutriate tests do not reflect the full dilution of re-suspended sediments that would occur during dam removal.

human health SLs (Table C-7). Marine ecological SLs were only exceeded for dieldrin and 2,3,4,7,8-PECDF in J.C. Boyle Reservoir (see Table C-8). Several organic compounds were not detected, but the reporting limits were above the available marine SLs (Table C-8). Analytes that were not detected but had reporting limits above freshwater or marine SLs were listed as chemicals of potential concern (COPCs) and analyzed in macroinvertebrate and/or fish tissue bioaccumulation tests to evaluate any effects from those chemicals potentially being in the sediment. No consistent pattern of elevated chemical composition was observed across discrete sampling locations within a reservoir, but sediment in J.C. Boyle Reservoir does have marginally higher iron concentrations and more detected COPCs as compared to Copco No. 1 and Iron Gate Reservoir and Klamath River Estuary sediments (CDM 2011). Also, J.C. Boyle reservoir has more COPCs based on comparison to CalEPA, National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (USFWS), USEPA, and ODEQ freshwater ecological and human health SLs.

Analysis of the 2009 to 2010 USBR collected sediment core results (USBR 2010, 2011) from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs and the Klamath River Estuary indicate that total chromium and total nickel concentrations are higher in estuary sediments than in Lower Klamath Project reservoir sediments, but total arsenic, total copper, and total lead concentrations are higher in reservoir sediments than estuary sediments (Eagles-Smith and Johnson 2012). Total arsenic concentrations in the reservoir sediments samples range from 4.3 to 15 milligrams per kilogram, dry weight (mg/kg) in J.C. Boyle Reservoir, 6.3 to 13 mg/kg in Copco No. 1 Reservoir, and 7.4 to 10 mg/kg in Iron Gate Reservoir. Peak total copper concentrations in Lower Klamath Project reservoir sediments (9.8 to 38 mg/kg) are greater than total copper concentrations in Klamath River Estuary sediments (19 to 26 mg/kg) (Eagles-Smith and Johnson 2012). Total lead concentrations in reservoir sediments range from 2.8 to 25 mg/kg in J.C. Boyle Reservoir, 6.4 to 10 mg/kg in Copco No. 1 Reservoir, and 5.1 to 11 mg/kg in Iron Gate Reservoir (USBR 2011).

Comparison of the measured total arsenic, total copper, and total lead concentrations with the relevant human-health screening levels show that only total arsenic concentrations exceed USEPA total carcinogenic residential screening levels (0.39 mg/kg), USEPA total non-carcinogenic residential screening levels (22 mg/kg), and CalEPA California Human Health residential (0.07 mg/kg) and commercial (0.24 mg/kg) screening levels. Peak total copper concentrations are approximately two to three orders of magnitude less than USEPA total non-carcinogenic residential screening levels (3,100 mg/kg) and CalEPA California Human Health residential (3,000 mg/kg) and commercial (38,000 mg/kg) screening levels. Total lead concentrations are consistently less than USEPA total non-carcinogen residential screening levels (400 mg/kg) and CalEPA California Human Health residential (80 mg/kg) and commercial (320 mg/kg) screening levels (CDM 2011). There are no USEPA total carcinogenic residential screening levels for copper or lead.

Comparison of the measured total arsenic, total copper, and total lead concentrations with the relevant ecological screening levels shows that total arsenic and total copper concentrations exceeded some ecological screening levels, but total lead concentrations remained below the most stringent freshwater and marine ecological screening level (**freshwater**: Lowest Effect Level [31 mg/kg]; **marine**: T20 [chemical concentration corresponding to 20 percent probability of observing toxicity] [30 mg/kg]). Total arsenic concentrations in Lower Klamath Project reservoir and Klamath River Estuary sediments only exceeded lower NOAA Screen Quick References Table (SQuiRT) freshwater and marine screening levels for arsenic in sediment (**freshwater**: Threshold Effect Concentrations [9.79 mg/kg], Threshold Effects Level [5.9 mg/kg], Lowest Effect Level [6 mg/kg]; **marine**: T20 [chemical concentration corresponding to 20 percent probability of observing toxicity] [7.4 mg/kg], Threshold Effects Level [7.24 mg/kg], Effects Range-Low [8.2 mg/kg]) with no measured total arsenic concentrations in reservoir or estuary sediments above freshwater or marine probable effects concentrations (**freshwater**: Probable Effect Concentrations [33mg/kg], Severe Effect Level [33 mg/kg], Probable Effect Level [17 mg/kg]; **marine**: T50 [chemical concentration corresponding to 50 percent probability of observing toxicity] [20 mg/kg], Probable Effect Level [41.6 mg/kg], Effects Range-Medium [70 mg/kg]). Total copper concentrations in Lower Klamath Project reservoir and Klamath River Estuary sediments also only exceeded lower NOAA Screen Quick References Table (SQuiRT) freshwater and marine screening levels for copper in sediment (**freshwater**: Threshold Effect Concentrations [31.6 mg/kg], Threshold Effects Level [37.3 mg/kg], Lowest Effect Level [16 mg/kg]; **marine**: T20 [chemical concentration corresponding to 20 percent probability of observing toxicity] [32 mg/kg], Threshold Effects Level [18.7 mg/kg], Effects Range-Low [34 mg/kg]) with no measured total copper concentrations in reservoir or estuary sediments above freshwater or marine probable effects concentrations (**freshwater**: Probable Effect Concentrations [149 mg/kg], Probable Effect Level [197 mg/kg]; **marine**: T50 [chemical concentration corresponding to 50 percent probability of observing toxicity] [94 mg/kg], Probable Effect Level [108 mg/kg]).

Note that while total metal concentrations were measured in the existing sediment cores, metals are typically bound to fine sediments and exhibit limited bioavailability or aquatic toxicity. The amount of bioavailable metals released by sediments may vary significantly depending on the sediment (surface area, availability of sorption sites, organic material, and clay content) and water properties (temperature, dissolved organic compounds, suspended particles, pH, various inorganic cations and anions like those composing hardness and alkalinity) (USEPA 2007).

Several chemicals identified as COPCs may occur in reservoir sediments at concentrations similar to background levels, however, background concentrations of most chemicals associated with Lower Klamath Project reservoir sediments are generally unavailable for the Klamath Basin. Arsenic concentrations in measured reservoir sediments (4.3 to 15 mg/kg) were within the range of arsenic concentrations measured in soil samples from the Mid- and Lower Klamath Basin (0.8 to 23 mg/kg with typical arsenic concentrations between approximately 2.0 and 7.0 mg/kg) (USGS NGS 2008) and arsenic may be naturally elevated in the Upper Klamath Basin, with average regional background arsenic concentrations of 3.99 mg/kg ± 5.03 mg/kg in the vicinity of the Upper Klamath Lake (Sturdevant 2010; ODEQ 2013; Sullivan and Round 2016). Suitable background sites characterized by similar sediment compositions as the Lower Klamath Project reservoirs, but without the same potential chemical sources (e.g., urban areas, irrigated agriculture, industry, and hydroelectric development), could not be identified (CDM 2011).

Overall, there were relatively few chemicals in sediment from the three reservoirs (and the Klamath River Estuary) identified as COPCs, with several COPCs being listed for the reservoirs only because the reporting limits were greater than freshwater or marine SLs. Analytical testing methods for chemicals were selected to achieve a reporting limit 3 to 5 times lower than the lowest applicable sediment screening level or water quality criteria. Despite this, due to limitations of the standard methods, several reporting limits were greater than the associated SLs and other reporting limits were not achieved due to background effects of the sample matrix or required sample dilutions (USBR 2011). However, as part of multiple lines of evidence (see *Contaminants in Aquatic Biota* below), CDM (2011) concluded that the sediment quality of reservoirs does not appear to be notably contaminated based on the detected COPCs in reservoir sediments and comparisons to ecological freshwater and marine SEF, USACE Dredge Material Management Program (DMMP), NOAA Screening Quick Reference Tables (SQuiRT), and ODEQ bioaccumulative SLs along with comparisons to human health SLs, including USEPA residential (total carcinogenic and total non-carcinogenic) regional screening levels (RSLs), CalEPA OEHHA California Human Health Screening Levels (CHHSLs), or ODEQ bioaccumulation (human subsistence and human general) SLs.

Updates to SEF Screening Levels

In 2015, new SEF SLs were implemented by the RSET to replace the 2009 SEF SLs. RSET undertook a range of updates to the various SEF SLs, including increasing SLs, decreasing SLs, adding SLs for new chemicals, and removing SLs for chemicals listed in the 2009 SEF SLs (RSET 2009, 2018). The majority of the changes to the SLs were updates to the freshwater SEF SLs with only a few updates to the marine SEF SLs (e.g., the marine SL for DDT was revised from 34 ug/kg in 2009 to 12 ug/kg in 2018). The 2009 Pacific Northwest SEF freshwater SLs and the updated freshwater SLs detailed in the 2018 Pacific Northwest SEF are presented in Table C-9. While the value of SLs for some analytes changed between the 2009 and 2018 SEF, the changes in SLs did not alter the detected COPC list determined by CDM (2011) or the resulting analysis, since the detected COPCs were not listed only in reference to the SEF SLs. More specifically, a decrease in the lower SEF SL (SL1) for nickel between the

2009 and 2018 SEF did not change its classification in the COPC list, because nickel had already been identified as a COPC in the CDM (2011) analysis for exceedances of the FWS TEL, FWS LEL, and FWS TEC screening values. Nickel concentrations measured in reservoir sediments (18 to 33 mg/kg) were occasionally above the nickel 2018 SEF lower SL (26 mg/kg), so exceedances of the 2018 SEF lower SL would be added to the list of reasons why nickel is listed as a COPC for the reservoir sediment. While the chromium SEF SLs decreased, chromium concentrations in reservoir sediments were still below chromium 2018 SEF SLs, so it is still not a COPC for reservoir sediments. Selenium was added to the list of 2018 SEF SLs, but selenium concentrations measured in reservoir sediments were less than the 2018 SEF SLs and it would not be a COPC.

As some SEF SLs are less than the laboratory reporting limit, the COPCs listed in CDM (2011) would change with application of the 2018 SEF SLs for the following reasons:

1. an SL no longer applied for a chemical in the 2018 SEF SL;
2. an SL was added for a new chemical and the USBR (2011) reporting limit for that chemical was less than the 2018 SEF SL; or
3. an SL was added for a new chemical and the chemical had not been tested in the USBR (2011) analysis of reservoir sediments.

Analyte-specific details are provided below.

The 2009 SEF SLs for PAHs no longer appear in the 2018 SEF SLs, so they would be removed from the COPC list. Total PAHs would be added to the COPC list, because it is a new analyte in the 2018 SEF SLs and the total PAHs were not measured as part of the USBR (2011) tests. While individual PAHs were measured in reservoir sediment testing and the range of the reporting limits for individual PAHs (6.7 to 1,200 ug/kg) were below the total PAHs 2018 SEF lower SL (17,000 ug/kg), total PAHs were not measured and would need added to the COPC list. Similarly, individual aroclors (e.g., aroclor 1221) would be removed from the COPC list and total aroclors would be added to the COPC list since it was not measured as part of the USBR (2011) testing.

The 2018 SEF added SLs for several organochlorine pesticides (i.e., 4-4'-DDD, 4-4'-DDE, 4-4'-DDT, dieldrin, beta-hexachlorocyclohexane, and endrin ketone). UBSR (2011) testing did not detect any of these chemicals in reservoir sediments and the reporting limits for these chemicals were above the 2018 SEF SL, so 4-4'-DDD, 4-4'-DDE, 4-4'-DDT, dieldrin, beta-hexachlorocyclohexane, and endrin ketone would not need to be added to the COPC list based on 2018 SEF SLs.

The 2018 SEF revised the SLs for phthalates (Bis(2-ethylhexyl) phthalate and Di-N-octyl phthalate), removed SLs for phthalates (Butyl benzyl phthalate and Dimethyl phthalate), and added SLs for phthalates (Di-n-butyl-phthalate). None of the phthalates were detected in reservoir sediments above the reporting limit, but all the phthalates with 2018 SEF SLs would be retained or added to the

COPC list since their reporting limit was below the 2018 SEF SLs. The phthalates without 2018 SEF SLs (Butyl benzyl phthalate and Dimethyl phthalate) would be removed from the COPC list.

The 2018 SEF added SLs for several SVOC phenols (Phenol, 4-Methylphenol, and Pentachlorophenol). Pentachlorophenol was not detected in USBR (2011) reservoir sediments and the reporting limit was below the 2018 SEF SLs, so it would not need to be added to the COPC list. Phenol and 4-Methylphenol were not detected in reservoir sediments, but the reporting limit was greater than the 2018 SEF SLs, so it would be added to the COPC list.

SLs were also added in the 2018 SEF for the extractable compounds benzoic acid, carbazole, and dibenzofuran. These three chemicals were not detected in USBR (2011) sediment tests, but the range of reporting limits was greater than the 2018 SEF SLs. As such, they would be added to the COPCs list.

Several new chemicals were added to the list of chemicals with 2018 SEF SLs that had not been previously considered or measured in USBR (2011) reservoir sediments tests. Butyltins are a group of organotin compounds used as stabilizers for polyvinyl chloride (PVC), biocides, fungicides, and anti-biofouling agents, especially used in coatings and paints applied to the bottom hull of ships to minimize biofouling (USEPA 2003; RSET 2018). Tributyltin is the primarily form of butyltin of concern in the environment due to its use as an anti-biofouling agent in paints for large ships with other forms (mono-, di-, and tetra-butyltin) occurring as byproducts as tributyltin breaks down. Elevated concentrations of butyltins in fresh and salt waters, sediments, and biota are primarily associated with harbors, marinas, boat yards, and dry docks with frequent ship traffic, but use of butyltin as an anti-biofouling agent on nets, crab pots, docks, and water cooling towers also contributes to its presence in aquatic environments (WHO 1999; USEPA 2003). According to RSET (2018), the need for analysis of butyltins (and other organotins) is limited to areas and sites affected by vessel maintenance and construction activities, marine shipping, and frequent vessel traffic (e.g., shipyards, boatyards, marinas, and marine terminals). Conditions in the Hydroelectric Reach of the Klamath River and upstream reaches did not support these activities historically and currently the reservoirs do not experience frequent large vessel traffic, therefore the site-specific SEF butyltin SLs would not apply to the Lower Klamath Project.

Total Petroleum Hydrocarbons (TPHs) represent gasoline, diesel, and other petroleum hydrocarbon compounds (e.g., motor oil or grease). While many other individual hydrocarbons that are present in gasoline, diesel, and petroleum products (e.g., PAHs, VOCs, SVOCs) were measured by USBR (2011), the overarching TPH test was not performed, thus TPHs would need to be added to the COPC list.

While the COPCs list would change due to the changes in SLs between the 2009 SEF and 2018 SEF, the previous CDM (2011) analysis of the five exposure pathways still sufficiently analyzes the potential effects of chemicals in Lower Klamath Project reservoir sediments through sediment toxicity and bioaccumulation tests for macroinvertebrates and/or fish. Since the sediment toxicity and bioaccumulation tests were performed using sediment samples from the Lower Klamath Project reservoirs, the results quantify the integrative (cumulative) effects of all COPCs in the reservoir sediments, even if the full updated list of COPCs was not included in the CDM (2011) analysis. Additionally, SEF SLs were only one of three ecological freshwater sediment SLs used in the original analysis, so the other SLs (USACE DMMP, NOAA SQuiRT, and ODEQ bioaccumulation) ensure that the CDM (2011) analysis sufficiently assessed the inorganic and organic contaminants in reservoir sediment that may impact freshwater aquatic species. Finally, SEF SLs were not used as human health screening levels, so the changes in the SEF SLs would not alter the CDM (2011) analysis with respect to reservoir sediments on human health.

Updates to U.S. EPA National Recommended Water Quality Criteria
In 2015, the USEPA published an update to its National Recommended Water Quality Criteria (NRWQC) for human health, with the 2015 NRWQC updating the criteria of 94 chemicals from the previous 2002 NRWQC (USEPA 2002, 2015a, 2015b). While analysis of sediment screening levels and the COPC list directly evaluated inorganic and organic contaminants in the reservoirs sediments and the overall sediment quality of reservoirs, the NRWQC was one of six sets of human health water quality criteria used to assess human exposure to chemicals from consumption of water and organisms or the consumption of organisms only. In other words, sediment screening levels were used to assess measurements of contaminants in the reservoir sediments, while NRWQC were used to assess potential chemical concentrations released into the water column from reservoir sediments during suspension. The changes in the human health NRWQC between 2015 and the previous criteria reflected updates to exposure inputs, bioaccumulation factors, health toxicity values, and relative source contributions. The 2015 update to the NRWQC typically decreased the water quality criteria for chemicals with previously established water quality criteria, but it also added water quality criteria for several chemicals (USEPA 2015b). A comparison of the 2015 NRWQC and the previous NRWQC for human health is shown below in Table C-9-A.

Variations in the NRWQC for human health between the 2015 update and the previous water quality criteria would not alter the CDM (2011) analysis or conclusions on the potential toxicity associated with water column exposure under a dam removal scenario. As previously mentioned, NRWQC were one of six sets of human health water quality criteria (i.e., California Department of Public Health California Code of Regulations, California Basin Plan, NRWQC, California Ocean Plan, ODEQ Human Health, and ODEQ Water Quality) evaluated by CDM (2011). Multiple NRWQC used in CDM (2011) were less stringent than the other water quality criteria used and the updated 2015 NRWQC are still less stringent than some of the other water quality criteria. In these instances, variations in the NRWQC between 2015 and the previous criteria would not alter the assessment of reservoir sediments since a more stringent water quality criterion was the basis of the analysis and conclusions by CDM (2011). Additionally, the majority of the chemicals in the updated 2015 NRWQC were part of the previous NRWQC, so the 2009 – 2010 USBR Sediment Chemistry Investigation (USBR 2011) included the relevant chemicals in reservoir sediment testing; the chemicals were not detected during measurements of elutriate chemical concentrations; and the CDM (2011) analysis included these results in its assessment of the potential human exposure to inorganic and organic contaminants under a dam removal scenario. Three chemicals in the 2015 NRWQC did not exist in the previous NRWQC (i.e., 1,1,2,2-tetrachloroethane, pentachlorobenzene, pentachlorophenol). However, pentachlorophenol was part of the California Basin Plan water quality criteria, so it was tested as part of the 2009 – 2010 USBR Sediment Chemistry Investigation. Pentachlorophenol was not detected in elutriate measurements (i.e., less than the reporting limit) (USBR 2011). The two chemicals 1,1,2,2-tetrachloroethane, pentachlorobenzene were not measured by elutriate testing in the 2009 – 2010 USBR Sediment Chemistry Investigation. However, 1,1,2,2-tetrachloroethane was included in the reservoir sediment testing and it was not detected (i.e., less than the reporting limit) (USBR 2011).

It is not possible to directly confirm that chemicals are above or below 2015 NRWQC for human health for the two chemicals that were not measured in elutriate testing (i.e., 1,1,2,2-tetrachloroethane and pentachlorobenzene) or the chemicals with applicable 2015 NRWQC less than the laboratory analytical reporting limits (i.e., the standard laboratory tests used could not measure whether the analytes were present above NRWQC because the smallest amount the laboratory tests could detect [i.e., the reporting limit] for those analytes was greater than the NRWQC itself). Under a dam removal scenario, the potential human exposure to chemicals in the new 2015 NRWQC that were not measured in 2009 and 2010 elutriate testing or to chemicals with NRWQC less than reporting limits would be limited to the duration SSCs in the Klamath River are above background conditions. Additionally, the NRWQC are based on human exposure by consuming water and organisms (e.g., drinking water and eating fish or mussels exposed to the chemicals) or consuming organisms only (e.g., eating fish exposed to the chemicals), so potential human exposure would be further limited by the likelihood of individuals drinking water or consuming organisms during the period when SSCs in the Klamath River are above background concentrations. Furthermore, potential human exposure to chemicals in the water column under a dam removal scenario were assessed in CDM (2011) using five other sets of human health water quality criteria along with toxicity bioassays, so the 2015 update to the NRWQC for human health would not be expected to alter the overall CDM (2011) analysis or conclusions.

Sediment toxicity and bioaccumulation tests
Toxicity equivalent quotients (TEQs) were calculated for dioxin, furan, and dioxin-like PCBs in reservoir sediment samples to evaluate potential adverse effects from exposure to dioxin, furan, and dioxin-like PCBs. TEQs ranged from approximately 4 to 9 pg/g for J.C. Boyle Reservoir, 5 to 10 pg/g for Copco No. 1 Reservoir, and 2 to 4 pg/g for Iron Gate Reservoir. In some cases, these values are slightly higher than background values reported by USEPA for Region 9 (i.e., 2 to 5 pg/g), Region 10 (i.e., 4 pg/g), and for non-impacted lakes of the United States (i.e., 5.3 pg/g) (USEPA 2010, CDM 2011). The calculated TEQs may also be within the range of local background values. Since the TEQs are only slightly above regional background concentrations and the nationwide background for non-impacted lakes, they have limited potential for adverse effects for fish exposed to reservoir sediments (CDM 2011).

Toxicity tests generally indicated low potential for sediment toxicity to benchmark benthic indicator species since the 10-day survival of these species in reservoir sediments was similar compared to laboratory controls, except in a single sample from J.C. Boyle Reservoir, where a decrease in survival of the benthic midge *Chironomus dilutus* in the reservoir sediment sample (64 percent) (compared to the laboratory control at 95 percent) indicated a moderate potential for sediment toxicity (CDM 2011). Additional bioaccumulation tests of reservoir sediment samples using two benthic organisms (i.e., *Corbicula fluminea* [Asian clams] and *Lumbricula variegates* [blackworms]) showed 100 percent survival with minimal weight changes in J.C. Boyle Reservoir sediments over the 28-day bioaccumulation test period, further supporting the conclusion that there was generally low potential for sediment toxicity to benthic species from reservoir sediments. Results of elutriate chemistry and elutriate toxicity tests on rainbow trout (*Oncorhynchus mykiss*) are discussed as part of the Proposed Project potential impact analysis (Section 3.2.5.7 *Inorganic and Organic Contaminants*). Collectively, the elutriate chemistry and elutriate toxicity test results do not identify a consistent pattern of toxicity by location, representative organism, or conditions.

Overall, twenty lines of evidence were used with various lines of evidence integrated to evaluate the five exposure pathways and to draw conclusions regarding potential adverse effects from the chemicals present in the reservoir sediments (Table C-10). Lines of evidence related to contaminants in aquatic biota are detailed and discussed together below. Based on these twenty lines of evidence from the 2009 to 2010 Secretarial Determination study, reservoir sediments do not appear to be highly contaminated (CDM 2011). No consistent pattern of elevated chemical composition is observed across discrete sampling locations within a reservoir. No single reservoir was observed to be consistently more or less contaminated based on these 20 lines of evidence. Where elevated concentrations of chemicals in sediment are found, the degree of exceedance based on comparisons of measured (i.e., detected) chemical concentrations to

SLs is small, and in several cases, may reflect regional background conditions (CDM 2011).

Table C-6. Chemicals in Sediment that Exceed One or More Freshwater Sediment Screening Levels. Source: CDM (2011).

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
J.C. Boyle Reservoir							
Nickel	D	mg/kg	19–32	---	2 [c]	FWS TEL, **FWS LEL** [c], FWS TEC	2d [c]
4,4-DDD	D	ug/kg	3.7	---	9.5	ODEQ Bioacc SLV	2c
4,4-DDE	D	ug/kg	3.4	---	8.7	ODEQ Bioacc SLV	2c
4,4-DDT	D	ug/kg	4.1	---	11	ODEQ Bioacc SLV	2c
Dieldrin	D	ug/kg	3.4	---	1.5–9.2	FWS TEL, FWS LEL, FWS TEC, **ODEQ F-FW, ODEQ B-I**, ODEQ B-P, ODEQ M-I, ODEQ M-P	2c
2,3,4,7,8-PECDF	D	pg/g	1.5–1.5	---	1.4–8.8	**ODEQ F-FW**, ODEQ B-I, **ODEQ M-I**	2c
2,3,7,8-TCDD	D	pg/g	0.19	---	3.7	ODEQ M-I	2c
Iron	D	mg/kg	21,000–37,000	---	1.85	FWS LEL	2d
Cadmium	RL	mg/kg	---	0.16–0.84	---	SEF-SL1	2a
Aroclor 1221	RL	ug/kg	---	0.24–0.49	---	SEF-SL1 (total PCBs)	2a
Aroclor 1232	RL	ug/kg	---	0.16–0.24	---	SEF-SL1 (total PCBs)	2a
Aroclor 1242	RL	ug/kg	---	0.045–0.24	---	SEF-SL1 (total PCBs)	2a

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
Aroclor 1248	RL	ug/kg	---	0.045–0.24	---	SEF-SL1 (total PCBs)	2a
Aroclor 1254	RL	ug/kg	---	0.045–0.24	---	SEF-SL1 (total PCBs)	2a
Aroclor 1260	RL	ug/kg	---	0.045–0.24	---	SEF-SL1 (total PCBs)	2a
Bis(2-ethylhexyl)phthalate	RL	ug/kg	---	230–1200	---	SEF-SL1	2a
Butyl benzyl phthalate	RL	ug/kg	---	230–1200	---	SEF-SL1	2a
Dimethyl phthalate	RL	ug/kg	---	230–1200	---	SEF-SL1	2a
Di-n-octyl phthalate	RL	ug/kg	---	230–1200	---	SEF-SL1	2a
2-METHYLNAPHTHALENE	RL	ug/kg	---	230–1200	---	SEF-SL1	2a
ACENAPHTHENE	RL	ug/kg	---	230–1200	---	SEF-SL1	2a
ACENAPHTHYLENE	RL	ug/kg	---	230–1200	---	SEF-SL1	2a
BENZO(K)FLUORANTHENE	RL	ug/kg	---	230–1200	---	SEF-SL1	2a
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	230–1200	---	SEF-SL1	2a
DIBENZOFURAN	RL	ug/kg	---	230–1200	---	SEF-SL1	2a
FLUORENE	RL	ug/kg	---	230–1200	---	SEF-SL1	2a
Chlordane (Technical)	RL	ug/kg	---	4.5–24	---	ODEQ Bioacc SLV	2c
Chlordane-Alpha	RL	ug/kg	---	0.9–4.9	---	ODEQ Bioacc SLV	2c
Chlordane-Gamma	RL	ug/kg	---	0.9–4.9	---	ODEQ Bioacc SLV	2c
Dieldrin	RL	ug/kg	---	0.9–4.9	---	ODEQ Bioacc SLV	2c
BHC-Gamma (HCH-gamma, Lindane)	RL	ug/kg	---	0.9–4.9	---	SQuiRTs (TEL, LEL, PEL, TEC)	2d

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
Endrin	RL	ug/kg	---	0.9–4.9	---	SQuiRTs (TEL, LEL, TEC)	2d
Heptachlor	RL	ug/kg	---	0.9–4.9	---	SQuiRTs (TEL, LEL, TEC)	2d
Heptachlor Epoxide	RL	ug/kg	---	0.9–4.9	---	SQuiRTs (TEL, PEL, TEC)	2d
Toxaphene	RL	ug/kg	---	45–240	---	SQuiRTs (TEL)	2d
Copco No. 1 Reservoir							
Nickel	D	mg/kg	22–32	---	2 [c]	FWS TEL, **FWS LEL** [c], FWS TEC	2d [c]
2,3,4,7,8-PECDF	D	pg/g	1.8–1.9	---	1.7–11.2	**ODEQ F-FW, ODEQ B-I, ODEQ M-I**	2c
Iron	D	mg/kg	21,000–24,000	---	1.2	FWS LEL	2d
SILVER	RL	mg/kg	---	1.8–2.4	---	SEF-SL1	2a
AROCLOR 1221	RL	ug/kg	---	0.24–0.3	---	SEF-SL1 (total PCBs)	2a
AROCLOR 1232	RL	ug/kg	---	0.12–0.15	---	SEF-SL1 (total PCBs)	2a
BIS(2-ETHYLHEXYL) PHTHALATE	RL	ug/kg	---	580–730	---	SEF-SL1	2a
BUTYL BENZYL PHTHALATE	RL	ug/kg	---	580–730	---	SEF-SL1	2a
DIMETHYL PHTHALATE	RL	ug/kg	---	580–730	---	SEF-SL1	2a

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
DI-N-OCTYL PHTHALATE	RL	ug/kg	---	580–730	---	SEF-SL1	2a
2-METHYLNAPHTHALENE	RL	ug/kg	---	580–730	---	SEF-SL1	2a
ACENAPHTHYLENE	RL	ug/kg	---	580–730	---	SEF-SL1	2a
BENZO(K)FLUORANTHENE	RL	ug/kg	---	580–730	---	SEF-SL1	2a
DIBENZOFURAN	RL	ug/kg	---	580–730	---	SEF-SL1	2a
4,4'-DDE	RL	ug/kg	---	2.4–3	---	SQuiRTs (TEL)	2d
4,4'-DDT	RL	ug/kg	---	2.4–3	---	SQuiRTs (TEL)	2d
BHC-gamma (HCH-gamma, Lindane)	RL	ug/kg	---	2.4–3	---	SQuiRTs (TEL, PEL, TEC)	2d
CHLORDANE (TECHNICAL)	RL	ug/kg	---	12–15	---	SQuiRTs (TEL, LEL, PEL, TEC)	2d
DIELDRIN	RL	ug/kg	---	2.4–3	---	SQuiRTs (TEL, LEL, TEC)	2d
ENDRIN	RL	ug/kg	---	2.4–3	---	SQuiRTs (TEC)	2d
HEPTACHLOR	RL	ug/kg	---	2.4–3	---	SQuiRTs (TEL, TEC)	2d
HEPTACHLOR EPOXIDE	RL	ug/kg	---	2.4–3	---	SQuiRTs (TEL, PEL, TEC)	2d
TOXAPHENE	RL	ug/kg	---	120–150	---	SQuiRTs (TEL)	2d

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
Iron Gate Reservoir							
Nickel	D	mg/kg	18–33	---	2.1 [c]	FWS TEL, **FWS LEL** [c], FWS TEC	2d [c]
2,3,4,7,8-PECDF	D	pg/g	0.74	---	1.1–4.4	ODEQ B-I, ODEQ M-I	2c
Iron	D	mg/kg	26,000–32,000	---	1.6	FWS LEL	2d
SILVER	RL	mg/kg	---	0.94–2.2	---	SEF-SL1	2a
AROCLOR 1221	RL	ug/kg	---	0.067–0.3	---	SEF-SL1 (total PCBs)	2a
AROCLOR 1232	RL	ug/kg	---	0.033–0.15	---	SEF-SL1 (total PCBs)	2a
BIS(2-ETHYLHEXYL) PHTHALATE	RL	ug/kg	---	170–730	---	SEF-SL1	2a
BUTYL BENZYL PHTHALATE	RL	ug/kg	---	170–730	---	SEF-SL1	2a
DI-N-OCTYL PHTHALATE	RL	ug/kg	---	170–730	---	SEF-SL1	2a
2-METHYLNAPHTHALENE	RL	ug/kg	---	170–730	---	SEF-SL1	2a
ACENAPHTHYLENE	RL	ug/kg	---	170–730	---	SEF-SL1	2a
BENZO(K)FLUORANTHENE	RL	ug/kg	---	170–730	---	SEF-SL1	2a
DIBENZOFURAN	RL	ug/kg	---	170–730	---	SEF-SL1	2a
NAPHTHALENE	RL	ug/kg	---	5–520	---	SEF-SL1	2a

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[a]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[b]
4,4'-DDE	RL	ug/kg	---	0.67–3	---	SQuiRTs (TEL, TEC)	2d
4,4'-DDT	RL	ug/kg	---	0.67–3	---	SQuiRTs (TEL)	2d
BHC-gamma (HCH-gamma, Lindane)	RL	ug/kg	---	0.67–3	---	SQuiRTs (TEL, PEL, TEC)	2d
CHLORDANE (TECHNICAL)	RL	ug/kg	---	3.3–15	---	SQuiRTs (TEL, PEL, LEL, TEC)	2d
DIELDRIN	RL	ug/kg	---	0.67–3	---	SQuiRTs (TEL, LEL, TEC)	2d
ENDRIN	RL	ug/kg	---	0.67–3	---	SQuiRTs (TEL, TEC)	2d
HEPTACHLOR	RL	ug/kg	---	0.67–3	---	SQuiRTs (TEL, TEC)	2d
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.67–3	---	SQuiRTs (TEL, PEL, TEC)	2d
TOXAPHENE	RL	ug/kg	---	33–150	---	SQuiRTs (TEL)	2d

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
Klamath River Estuary							
Lower Klamath							
Chromium	D	mg/kg	96	--	1.0	**SL1-FWS**, SL2-FWS, FWS TEL, FWS LEL, FWS PEL, FWS TEC	2b
Nickel	D	mg/kg	110	--	1.8 [c]	**SL1-FWS,** SL2-FWS, FWS TEL, FWS LEL, FWS PEL, FWS TEC	2b
Iron	D	mg/kg	24,000–24,000	--	1.2	**FWS LEL**	2d
BIS(2-ETHYLHEXYL) PHTHALATE	RL	ug/kg	---	230	---	**SEF-SL1**	2a
DIMETHYL PHTHALATE	RL	ug/kg	---	230	---	**SEF-SL1**	2a
DI-N-OCTYL PHTHALATE	RL	ug/kg	---	230	---	**SEF-SL1**	2a
CHLORDANE (TECHNICAL)	RL	ug/kg	---	4.6	---	**SQuiRTs (TEL, TEC)**	2d
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.91	---	**SQuiRTs (TEL)**	2d
TOXAPHENE	RL	ug/kg	---	46	---	**SQuiRTs (TEL)**	2d

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[a]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[b]
Upper Klamath							
Chromium	D	mg/kg	96–97	---	1.0	**SL1-FWS,** FWS TEL, FWS LEL, FWS PEL, FWS TEC	2a
Bis(2-ethylhexyl)phthalate	D	ug/kg	250	---	1.1	**SL1-FWS**	2a
DIMETHYL PHTHALATE	RL	ug/kg	---	230	---	**SEF-SL1**	2a
DI-N-OCTYL PHTHALATE	RL	ug/kg	---	230	---	**SEF-SL1**	2a
CHLORDANE (TECHNICAL)	RL	ug/kg	---	4.6	---	**SQuiRTs (TEL, TEC)**	2d
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.93	---	**SQuiRTs (TEL)**	2d
TOXAPHENE	RL	ug/kg	---	46	---	**SQuiRTs (TEL)**	2d

Notes:

Screening Level Hierarchy --
Retain if above:
1) DMMP-MLs
2a) SEF-SL1
2b) SEF-SL1 AND SEF-SL2
2c) Chemicals with no SEF and one or more ODEQ bioaccumulative SLVs exceeded
2d) Chemicals with no SEF or ODEQ but one or more SQuiRT exceeded

Units:

Metals:	mg/kg
Pesticides:	ug/kg
dioxins and furans:	pg/g
SVOCs:	ug/kg
phthalates:	ug/kg

Key:

FWS = U.S. Fish and Wildlife Service
DMMP = Dredged Material Management Program
TEL = Threshold Effect Level
LEL = Lowest Effect level
SL1 = Sediment Screening Level 1
TEC = Threshold Effect Concentration
SEF = Sediment Evaluation Framework
PEL = Probable Effect Level
SLV = Screening Level Value
ODEQ: = Oregon Department of Environmental Quality
B-P: Bird population
B-I: Bird individual
M-I: Mammal individual
M-P: Mammal population
F-FW: Fish-freshwater

[a] Ratio of maximum detected concentration to the SL is typically expressed as a Hazard Quotient (HQ). This ratio is presented above for each detected chemical and is calculated using the maximum detected concentration; the highest and lowest of screening values when multiple screening values are exceeded of same level in screening hierarchy. When more than two screening values are exceeded, the screening level used for calculation of the ratio (HQ) are in bold.

[b] Screening level hierarchy depicted in CDM (2011) Figure 2.

[c] Updated from CDM (2011) Table 2 based on review of screening values listed in CDM (2011) Table A-2 and range of detections for detected analytes in CDM (2011) and USBR (2011).

Based on the information provided in Table A-6 in CDM (2011) and database query for ambiguous and positive exceedances.

Table C-7. Chemicals in Sediment that Exceed One or More Human Health Sediment Screening Levels. Source: CDM (2011).

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes(1)	Screening Values Exceeded	Notes
J.C. Boyle Reservoir							
Arsenic	D	mg/kg	4.3–15	---	38–214	**EPA RSL TOT CAR**, **CHHSL Res**, CHHSL Comm	a
Nickel	D	mg/kg	19–32	---	84	**EPA RSL TOT CAR**	a
4,4-DDD	D	ug/kg	3.7	---	11–93	ODEQ BSLV H-S, ODEQ BSLV H-G	---
4,4-DDE	D	ug/kg	3.4	---	10–85	ODEQ BSLV H-S, ODEQ BSLV H-G	---
4,4-DDT	D	ug/kg	4.1	---	12–103	ODEQ BSLV H-S, ODEQ BSLV H-G	---
Dieldrin	D	ug/kg	3.4	---	420–3,400	ODEQ BSLV H-S, ODEQ BSLV H-G	---

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes(1)	Screening Values Exceeded	Notes
1,2,3,4,6,7,8-HPCDD	D	pg/g	170–180	---	2.1	ODEQ BSLV H-S	---
1,2,3,4,7,8-HXCDD	D	pg/g	1.5–1.6	---	4.4	ODEQ BSLV H-S	---
1,2,3,6,7,8-HXCDD	D	pg/g	6.6–7.3	---	2.7–21	ODEQ BSLV H-S, ODEQ BSLV H-G	---
1,2,3,7,8,9-HXCDD	D	pg/g	3.7	---	1.4–11	ODEQ BSLV H-S, ODEQ BSLV H-G	---
1,2,3,4,7,8-HXCDF	D	pg/g	1.7–2.1	---	6.2	ODEQ BSLV H-S	
1,2,3,6,7,8-HXCDF	D	pg/g	4.4–5.3	---	2.0–16	ODEQ BSLV H-S, ODEQ BSLV H-G	---
1,2,3,7,8,9-HXCDF	D	pg/g	0.66–0.67	---	0.5–1.9	ODEQ BSLV H-S	---
1,2,3,7,8-PECDD	D	pg/g	1.1	---	4.1–37	ODEQ BSLV H-S, ODEQ BSLV H-G	---
1,2,3,7,8-PECDF	D	pg/g	0.88–1.1	---	3.5	ODEQ BSLV H-S	---
2,3,4,6,7,8-HXCDF	D	pg/g	3–3.2	---	1.2–9.4	ODEQ BSLV H-S, ODEQ BSLV H-G	---
2,3,4,7,8-PECDF	D	pg/g	1.5	---	50–405	ODEQ BSLV H-S, ODEQ BSLV H-G	---
2,3,7,8-TCDD	D	pg/g	0.19	---	19–173	ODEQ BSLV H-S, ODEQ BSLV H-G	b
2,3,7,8-TCDF	D	pg/g	0.88–0.9	---	1.2–9.6	ODEQ BSLV H-S, ODEQ BSLV H-G	---

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes(1)	Screening Values Exceeded	Notes
Pentachlorophenol	D	ug/kg	34	---	1.1	ODEQ BSLV H-S	b
4,4,'-DDD	RL	ug/kg	---	0.9–4.9	---	ODEQ	---
4,4,'-DDE	RL	ug/kg	---	0.9–4.9	---	ODEQ	---
4,4,'-DDT	RL	ug/kg	---	0.9–4.9	---	ODEQ	---
Aroclor 1221	RL	ug/kg	---	0.24–0.49	---	EPA RSL	---
Aroclor 1232	RL	ug/kg	---	0.16–0.24	---	EPA RSL	---
Aroclor 1242	RL	ug/kg	---	0.045–0.24	---	EPA RSL	---
Aroclor 1248	RL	ug/kg	---	0.045–0.24	---	EPA RSL	---
Aroclor 1254	RL	ug/kg	---	0.045–0.24	---	EPA RSL	---
Aroclor 1260	RL	ug/kg	---	0.045–0.24	---	EPA RSL	---
BHC-Gamma (HCH-gamma, Lindane)	RL	ug/kg	---	0.9–4.9	---	CHHSLs	---

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes(1)	Screening Values Exceeded	Notes
Chlordane (Technical)	RL	ug/kg	---	4.5–24	---	ODEQ	---
Chlordane-Alpha	RL	ug/kg	---	0.9–4.9	---	ODEQ	---
Chlordane-Gamma	RL	ug/kg	---	0.9–4.9	---	ODEQ	---
1,2,3-TRICHLOROPROPANE	RL	ug/kg	---	6.7–36	---	EPA RSL	---
1,2-DIBROMO-3-CHLOROPROPANE	RL	ug/kg	---	6.7–36	---	EPA RSL	---
3,3'-DICHLOROBENZIDINE	RL	ug/kg	---	230–1200	---	EPA RSL	---
BENZ(A)ANTHRACENE	RL	ug/kg	---	230–1200	---	EPA RSL	---
BENZO(A)PYRENE	RL	ug/kg	---	230–1200	---	EPA RSL, CHHSLs	---
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230–1200	---	EPA RSL	---

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes(1)	Screening Values Exceeded	Notes
BIS(2-CHLOROETHYL) ETHER	RL	ug/kg	---	230–1200	---	EPA RSL	---
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	230–1200	---	EPA RSL	---
FLUORENE	RL	ug/kg	---	230–1200	---	EPA RSL	---
HEXACHLOROBENZENE	RL	ug/kg	---	230–1200	---	ODEQ, USEPA RSL	---
INDENO(1,2,3-CD)PYRENE	RL	ug/kg	---	230–1200	---	EPA RSL	---
N-NITROSODI-N-PROPYLAMINE	RL	ug/kg	---	230–1200	---	EPA RSL	---
TRANS-1,4-DICHLORO-2-BUTENE	RL	ug/kg	---	6.7–36	---	EPA RSL	---
1,2-DIBROMOETHANE	RL	ug/kg	---	6.7–36	---	EPA RSL	---
Copco No. 1 Reservoir							
Arsenic	D	mg/kg	6.3–13	---	33–186	**EPA RSL TOT CAR, CHHSL Res,** CHHSL Comm	---
Nickel	D	mg/kg	22–32	---	84	EPA RSL TOT CAR	---

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes(1)	Screening Values Exceeded	Notes
1,2,3,4,6,7,8-HPCDD	D	pg/g	180–190	---	---	----	c
1,2,3,4,6,7,8-HPCDF	D	pg/g	89–96	---	---	----	c
1,2,3,4,7,8-HXCDD	D	pg/g	1.7–1.9	---	---	----	c
1,2,3,6,7,8-HXCDD	D	pg/g	8.8–9.8	---	---	----	c
1,2,3,7,8,9-HXCDD	D	pg/g	4.2–4.3	---	---	----	c
1,2,3,4,7,8-HXCDF	D	pg/g	2.3–2.8	---	---	----	c
1,2,3,6,7,8-HXCDF	D	pg/g	3.5–5.5	---	---	----	c
1,2,3,7,8,9-HXCDF	D	pg/g	1.0	---	---	----	c
2,3,4,6,7,8-HXCDF	D	pg/g	3.2–3.7	---	---	----	c
1,2,3,7,8-PECDD	D	pg/g	1.2–1.4	---	---	----	c
1,2,3,7,8-PECDF	D	pg/g	0.84	---	---	----	c
2,3,4,7,8-PECDF	D	pg/g	1.8–1.9	---	---	----	c
2,3,7,8-TCDF	D	pg/g	0.99–1.2	---	---	---	c
AROCLOR 1221	RL	ug/kg	---	0.24–0.3	---	EPA RSL	---
AROCLOR 1232	RL	ug/kg	---	0.12–0.15	---	EPA RSL	---
BHC-gamma (HCH-gamma, Lindane)	RL	ug/kg	---	2.4–3	---	CHHSLs	---

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes(1)	Screening Values Exceeded	Notes
1,2,3-TRICHLOROPROPANE	RL	ug/kg	---	18–22	---	EPA RSL	---
1,2-DIBROMO-3-CHLOROPROPANE	RL	ug/kg	---	18–22	---	EPA RSL	---
BENZ(A)ANTHRACENE	RL	ug/kg	---	580–730	---	EPA RSL	---
BENZO(A)PYRENE	RL	ug/kg	---	580–730	---	EPA RSL, CHHSLs	---
BENZO(B)FLUORANTHENE	RL	ug/kg	---	580–730	---	EPA RSL	---
BIS(2-CHLOROETHYL) ETHER	RL	ug/kg	---	580–730	---	EPA RSL	---
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	580–730	---	EPA RSL	---
HEXACHLOROBENZENE	RL	ug/kg	---	580–730	---	EPA RSL	---
INDENO(1,2,3-CD)PYRENE	RL	ug/kg	---	580–730	---	EPA RSL	---
N-NITROSODI-N-PROPYLAMINE	RL	ug/kg	---	580–730	---	EPA RSL	---
TRANS-1,4-DICHLORO-2-BUTENE	RL	ug/kg	---	18–22	---	EPA RSL	---

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[1]	Screening Values Exceeded	Notes
Iron Gate Reservoir							
Arsenic	D	mg/kg	7.4–10	---	26–143	**EPA RSL TOT CAR, CHHSL Res,** CHHSL Comm	---
Nickel	D	mg/kg	18–33	---	87	EPA RSL TOT CAR	---
1,2,3,4,7,8-HXCDD	D	pg/g	1.1	---	---	----	c
1,2,3,6,7,8-HXCDD	D	pg/g	3.4–3.5	---	---	----	c
1,2,3,7,8,9-HXCDD	D	pg/g	2–2.5	---	---	----	c
1,2,3,4,7,8-HXCDF	D	pg/g	1.2	---	---	----	c
1,2,3,6,7,8-HXCDF	D	pg/g	1.2–1.4	---	---	----	c
2,3,4,6,7,8-HXCDF	D	pg/g	1.2–1.4	---	---	----	c
1,2,3,7,8-PECDD	D	pg/g	0.62–0.82	---	---	----	c
1,2,3,7,8-PECDF	D	pg/g	0.44–0.52	---	---	----	c
2,3,4,7,8-PECDF	D	pg/g	0.74	---	---	----	c
2,3,7,8-TCDF	D	pg/g	0.68	---	---	---	c

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes(1)	Screening Values Exceeded	Notes
AROCLOR 1221	RL	ug/kg	---	0.067–0.3	---	EPA RSL	---
AROCLOR 1232	RL	ug/kg	---	0.033–0.15	---	EPA RSL	---
1,2,3-TRICHLOROPROPANE	RL	ug/kg	---	5–22	---	EPA RSL	---
1,2-DIBROMO-3-CHLOROPROPANE	RL	ug/kg	---	5–22	---	EPA RSL	---
BENZ(A)ANTHRACENE	RL	ug/kg	---	170–730	---	EPA RSL	---
BENZO(A)PYRENE	RL	ug/kg	---	170–730	---	EPA RSL, CHHSLs	---
BENZO(B)FLUORANTHENE	RL	ug/kg	---	170–730	---	EPA RSL	---
BIS(2-CHLOROETHYL) ETHER	RL	ug/kg	---	170–730	---	EPA RSL	---
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	170–730	---	EPA RSL	---
HEXACHLOROBENZENE	RL	ug/kg	---	170–730	---	EPA RSL	---
INDENO(1,2,3-CD)PYRENE	RL	ug/kg	---	170–730	---	EPA RSL	---
N-NITROSODI-N-PROPYLAMINE	RL	ug/kg	---	170–730	---	EPA RSL	---
TRANS-1,4-DICHLORO-2-BUTENE	RL	ug/kg	---	5–22	---	EPA RSL	---

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(1)]	Screening Values Exceeded	Notes
Klamath River Estuary							
Lower Klamath River Estuary							
Arsenic	D	mg/kg	3.2	---	8.2–46	**EPA RSL TOT CAR, CHHSL Res,** CHHSL Comm	---
Nickel	D	mg/kg	110	---	289	EPA RSL TOT CAR	---
BHC-gamma (HCH-gamma, Lindane)	RL	ug/kg	---	0.91	---	CHHSLs	---
1,2,3-TRICHLOROPROPANE	RL	ug/kg	---	6.8	---	EPA RSL	---
1,2-DIBROMO-3-CHLOROPROPANE	RL	ug/kg	---	6.8	---	EPA RSL	---
BENZ(A)ANTHRACENE	RL	ug/kg	---	230	---	EPA RSL	---
BENZO(A)PYRENE	RL	ug/kg	---	230	---	EPA RSL, CHHSLs	---
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230	---	EPA RSL	---
BIS(2-CHLOROETHYL) ETHER	RL	ug/kg	---	230	---	EPA RSL	---
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	230	---	EPA RSL	---
INDENO(1,2,3-CD)PYRENE	RL	ug/kg	---	230	---	EPA RSL	---
N-NITROSODI-N-PROPYLAMINE	RL	ug/kg	---	230	---	EPA RSL	---

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[1]	Screening Values Exceeded	Notes
Upper Klamath River Estuary							
Arsenic	D	mg/kg	2.2	---	5.6–31	**EPA RSL TOT CAR, CHHSL Res,** CHHSL Comm	---
Nickel	D	mg/kg	110	---	289	EPA RSL TOT CAR	---
BHC-gamma (HCH-gamma, Lindane)	RL	ug/kg	---	0.93	---	CHHSLs	---
1,2,3-TRICHLOROPROPANE	RL	ug/kg	---	7	---	EPA RSL	---
1,2-DIBROMO-3-CHLOROPROPANE	RL	ug/kg	---	7	---	EPA RSL	---
BENZ(A)ANTHRACENE	RL	ug/kg	---	230	---	EPA RSL	---
BENZO(A)PYRENE	RL	ug/kg	---	230	---	EPA RSL, CHHSLs	---
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230	---	EPA RSL	---
BIS(2-CHLOROETHYL) ETHER	RL	ug/kg	---	230	---	EPA RSL	---
DIBENZ(A,H)ANTHRACENE	RL	ug/kg	---	230	---	EPA RSL	---
INDENO(1,2,3-CD)PYRENE	RL	ug/kg	---	230	---	EPA RSL	---
N-NITROSODI-N-PROPYLAMINE	RL	ug/kg	---	230	---	EPA RSL	---
TRANS-1,4-DICHLORO-2-BUTENE	RL	ug/kg	---	7	---	EPA RSL	---

Notes:

[1] Ratio of maximum detected concentration to the SL is typically expressed as a Hazard Quotient (HQ). This ratio is presented above for each detected chemical and is calculated using the maximum detected concentration; the highest and lowest of screening values when multiple screening values are exceeded of same level in screening hierarchy. When more than two screening values are exceeded, the screening level used for calculation of the ratio (HQ) are in bold.

Screening Level Hierarchy for Human Health:

USEPA Residential RSLs (total carcinogenic and total non-carcinogenic), CHHSLs, and ODEQ bioaccumulation SLVs (Human Subsistence and Human General)

a no ODEQ values

b below USEPA RSLs, CHHSLs

c ODEQ values not applicable per text of Appendix A (only applicable for J.C. Boyle Reservoir); USEPA RSL and CHHSLs not available

Key:

EPA =	U.S. Environmental Protection Agency
RSL =	Residential Screening Level
TOT CAR =	Total carcinogen
TOT NON CAR =	Total non-carcinogen
CHHSL =	California Human Health Screening Levels
BSLV =	Land Quality Division Sediment Bioaccumulation Screening Level Values
Comm =	commercial/industrial
Res =	residential

Units:

metals:	mg/kg
pesticides:	ug/kg
dioxins and furans:	pg/g
SVOCs:	ug/kg

Table C-8. Chemicals in Sediment that Exceed One or More Marine Sediment Screening Levels. Source: CDM (2011).

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[a]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[b]
J.C. Boyle Reservoir							
Dieldrin	D	ug/kg	3.4	---	1.8	**SEF-SL1**, SEF-SL2, MS ERL, MS T20, MS TEL, MS T50, F-M	2a
2,3,4,7,8-PECDF	D	pg/g	1.5–1.5	---	1.4	ODEQ BSLV	2c
Butyl benzyl phthalate	RL	ug/kg	---	230–1,200	---	DMMP-ML	1
2,4-DIMETHYLPHENOL	RL	ug/kg	---	230–1,200	---	DMMP-ML	1
2-METHYLPHENOL	RL	ug/kg	---	230–1,200	---	DMMP-ML	1
4-METHYLPHENOL	RL	ug/kg	---	230–1,200	---	DMMP-ML	1
BENZOIC ACID	RL	ug/kg	---	930–4,800	---	DMMP-ML	1
BENZYL ALCOHOL	RL	ug/kg	---	230–1,200	---	DMMP-ML	1
HEXACHLOROBENZENE	RL	ug/kg	---	230–1,200	---	DMMP-ML	1
N-NITROSODIPHENYLAMINE	RL	ug/kg	---	230–1,200	---	DMMP-ML	1
Aroclor 1232	RL	ug/kg	---	0.16–0.24	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
Aroclor 1242	RL	ug/kg	---	0.045–0.24	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
Aroclor 1248	RL	ug/kg	---	0.045–0.24	---	DMMP-SL, SEF-SL1 (total PCBs)	2a

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[a]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[b]
Aroclor 1254	RL	ug/kg	---	0.045–0.24	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
Aroclor 1260	RL	ug/kg	---	0.045–0.24	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
Chlordane (Technical)	RL	ug/kg	---	4.5–24	---	DMMP-SL, SEF-SL1	2a
Chlordane-Alpha	RL	ug/kg	---	0.9–4.9	---	DMMP-SL, SEF-SL1	2a
Chlordane-Gamma	RL	ug/kg	---	0.9–4.9	---	DMMP-SL, SEF-SL1	2a
Heptachlor	RL	ug/kg	---	0.9–4.9	---	SEF-SL1	2a
Endrin	RL	ug/kg	---	0.9–4.9	---	no value	2c
Heptachlor Epoxide	RL	ug/kg	---	0.9–4.9	---	SQuiRTs (T20, PEL)	2c
Toxaphene	RL	ug/kg	---	45–240	---	SQuiRTs (TEL)	2c
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230–1200	---	SQuiRTs (T20, T50)	2c
Butyl benzyl phthalate	RL	ug/kg		230–1,200		DMMP-ML	
Copco No. 1 Reservoir							
2,4-DIMETHYLPHENOL	RL	ug/kg	---	580–730	---	DMMP-ML	1
2-METHYLPHENOL	RL	ug/kg	---	580–730	---	DMMP-ML	1
BENZOIC ACID	RL	ug/kg	---	2,300–2,900	---	DMMP-ML	1
HEXACHLOROBENZENE	RL	ug/kg	---	580–730	---	DMMP-ML	1
N-NITROSODIPHENYLAMINE	RL	ug/kg	---	580–730	---	DMMP-ML	1

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
AROCLOR 1221	RL	ug/kg	---	0.24–0.3	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
AROCLOR 1232	RL	ug/kg	---	0.12–0.15	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
CHLORDANE (TECHNICAL)	RL	ug/kg	---	12–15	---	DMMP-SL, SEF-SL1	2a
CHLORDANE-ALPHA	RL	ug/kg	---	2.4–3	---	SEF-SL1	2a
CHLORDANE-GAMMA	RL	ug/kg	---	2.4–3	---	SEF-SL1	2a
DIELDRIN	RL	ug/kg	---	2.4–3	---	SEF-SL1	2a
HEPTACHLOR	RL	ug/kg	---	2.4–3	---	SEF-SL1	2a
HEPTACHLOR EPOXIDE	RL	ug/kg	---	2.4–3	---	SQuiRTs (T20, PEL)	2c
BENZO(B)FLUORANTHENE	RL	ug/kg	---	580–730	---	SQuiRTs (T20)	2c
BENZO(G,H,I)PERYLENE	RL	ug/kg	---	580–730	---	no value	2c
Iron Gate Reservoir							
1,4-DICHLOROBENZENE	RL	ug/kg	---	5–520	**---**	DMMP-ML	1
2,4-DIMETHYLPHENOL	RL	ug/kg	---	170–730	**---**	DMMP-ML	1
2-METHYLPHENOL	RL	ug/kg	---	170–730	**---**	DMMP-ML	1
BENZOIC ACID	RL	ug/kg	---	670–2900	**---**	DMMP-ML	1
HEXACHLOROBENZENE	RL	ug/kg	---	170–730	**---**	DMMP-ML	1
HEXACHLOROBUTADIENE	RL	ug/kg	---	5–520	**---**	DMMP-ML	1
N-NITROSODIPHENYLAMINE	RL	ug/kg	---	170–730	**---**	DMMP-ML	1

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[a]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[b]
AROCLOR 1221	RL	ug/kg	---	0.067–0.3	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
AROCLOR 1232	RL	ug/kg	---	0.033–0.15	---	DMMP-SL, SEF-SL1 (total PCBs)	2a
CHLORDANE (TECHNICAL)	RL	ug/kg	---	3.3–15	---	DMMP-SL, SEF-SL1	2a
CHLORDANE-ALPHA	RL	ug/kg	---	0.67–3	---	SEF-SL1	2a
CHLORDANE-GAMMA	RL	ug/kg	---	0.67–3	---	SEF-SL1	2a
DIELDRIN	RL	ug/kg	---	0.67–3	---	SEF-SL1	2a
HEPTACHLOR	RL	ug/kg	---	0.67–3	---	SEF-SL1	2a
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.67–3	---	SEF-SL1	2a
1,2,4-TRICHLOROBENZENE	RL	ug/kg	---	5–520	---	DMMP-SL, SEF-SL1	2a
1,3-DICHLOROBENZENE	RL	ug/kg	---	5–520	---	DMMP-SL	2a
BENZO(B)FLUORANTHENE	RL	ug/kg	---	170–730	---	SQuiRTs (T20)	2c
Klamath River Estuary							
Lower Klamath							
2,4-DIMETHYLPHENOL	RL	ug/kg	---	230	---	DMMP-ML	1
2-METHYLPHENOL	RL	ug/kg	---	230	---	DMMP-ML	1
BENZOIC ACID	RL	ug/kg	---	910	---	DMMP-ML	1
N-NITROSODIPHENYLAMINE	RL	ug/kg	---	230	---	DMMP-ML	1
CHLORDANE (TECHNICAL)	RL	ug/kg	---	4.6	---	SEF-SL1	2a
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.91	---	SQuiRTs (T20)	2c

Chemical	COC Based on Detect (D) or Elevated Reporting Limit (RL)	Units	Range of Detections for Detected Analytes that Exceed One or More Screening Levels	Range of Reporting Limits (RL) for Non-Detects	Ratio of Maximum Chemical Concentration to SL for Detected Analytes[(a)]	Screening Values Exceeded	Highest of Screening Value Hierarchy Level[(b)]
TOXAPHENE	RL	ug/kg	---	46	---	SQuiRTs (TEL)	2c
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230	---	SQuiRTs (T20)	2c
Upper Klamath							
2,4-DIMETHYLPHENOL	RL	ug/kg	---	230	---	DMMP-ML	1
2-METHYLPHENOL	RL	ug/kg	---	230	---	DMMP-ML	1
BENZOIC ACID	RL	ug/kg	---	930	---	DMMP-ML	1
N-NITROSODIPHENYLAMINE	RL	ug/kg	---	230	---	DMMP-ML	1
CHLORDANE (TECHNICAL)	RL	ug/kg	---	4.6	---	SEF-SL1	2a
HEPTACHLOR EPOXIDE	RL	ug/kg	---	0.93	---	SQuiRTs (T20)	2c
TOXAPHENE	RL	ug/kg	---	46	---	SQuiRTs (TEL)	2c
BENZO(B)FLUORANTHENE	RL	ug/kg	---	230	---	SQuiRTs (T20)	2c

Notes:

Screening Level Hierarchies for Marine Waters--
Retain if above:
1) DMMP-MLs
2a) SEF-SL1 or DMMP-SL
2b) SEF-SL1 or DMMP-SL AND SEF-SL2 or DMMP-BT
2c) Chemicals with no SEF or DMMP and one or more SQuiRTs exceeded

Units:

metals:	mg/kg
pesticides:	ug/kg
dioxins and furans:	pg/g
SVOCs:	ug/kg
phthalates:	ug/kg

Key:

MS = marine sediment
DMMP = Dredged Material Management Program
ERL = Effects Range Low
ERM = Effects Range Median
TEL = Threshold Effect Level
F-M = Fish-marine
SL1 = Sediment Screening Level 1
PEL = Probable Effect Level
SEF = Sediment Evaluation Framework
ODEQ = Oregon Department of Environmental Quality
T20 = concentration representing 20 percent probability of observing effect
RL = Reporting Limit
T50 = concentration representing 50 percent probability of observing effect
D = Detect
BSLV = Land Quality Division Sediment Bioaccumulation Screening Level Values
ML = Maximum Level

[a] Ratio of maximum detected concentration to the SL is typically expressed as a Hazard Quotient (HQ). This ratio is presented above for each detected chemical and is calculated using the maximum detected concentration; the highest and lowest of screening values when multiple screening values are exceeded of same level in screening hierarchy. When more than two screening values are exceeded, the screening level used for calculation of the ratio (HQ) are in bold.

[b] Screening level hierarchy depicted on Figure 2 in CDM (2011).

Based on the information provided in Table A-5 in CDM (2011) and database query for ambiguous and positive exceedances.

Table C-9. 2009 and 2018 Pacific Northwest Sediment Evaluation Framework Freshwater Screening Levels. Adapted from RSET (2009) and RSET (2018).

Analyte	Units	Pacific Northwest SEF [a]				Add (+), Remove (-), or No Change (o) to COPC[d] list
		SL1[b] 2009	SL1[b] 2018	SL2[c] 2009	SL2[c] 2018	
Metals						
Arsenic	mg/kg	20	14	51	120	o
Cadmium	mg/kg	1.1	2.1	1.5	5.4	-
Chromium	mg/kg	95	72	100	88	o
Copper	mg/kg	80	400	830	1,200	o
Lead	mg/kg	340	360	430	>1,300	o
Mercury	mg/kg	0.28	0.66	0.75	0.8	o
Nickel	mg/kg	60	26	70	110	+
Selenium	mg/kg	n/a[e]	11	n/a	>20	o
Silver	mg/kg	2	0.57	2.5	1.7	o
Zinc	mg/kg	130	3,200	400	>4,200	o
Organics						
Polycyclic Aromatic Hydrocarbons (PAHs)						
Total PAHs	ug/kg	n/a	17,000	n/a	30,000	+
2-Methylnaphthalene	ug/kg	470	n/a	560	n/a	-
Acenaphthene	ug/kg	1,100	n/a	1,300	n/a	-
Acenaphthylene	ug/kg	470	n/a	640	n/a	-
Anthracene	ug/kg	1,200	n/a	1,600	n/a	-
Benz(a)anthracene	ug/kg	4,300	n/a	5,800	n/a	-
Benzo(a)pyrene	ug/kg	3,300	n/a	4,800	n/a	-
Benzo(g,h,i)perylene	ug/kg	4,000	n/a	5,200	n/a	-
Benzo(k)fluoranthene	ug/kg	600	n/a	4,000	n/a	-
Chrysene	ug/kg	5,900	n/a	6,400	n/a	-
Dibenz(a,h)anthracene	ug/kg	800	n/a	840	n/a	-
Dibenzofuran	ug/kg	400	n/a	440	n/a	-
Fluoranthene	ug/kg	11,000	n/a	15,000	n/a	-
Fluorene	ug/kg	1,000	n/a	3,000	n/a	-
Indeno(1,2,3-cd)pyrene	ug/kg	4,100	n/a	5,300	n/a	-
Naphthalene	ug/kg	500	n/a	1,300	n/a	-
Phenanthrene	ug/kg	6,100	n/a	7,600	n/a	-
Pyrene	ug/kg	8,800	n/a	16,000	n/a	-

Analyte	Units	Pacific Northwest SEF [a]				Add (+), Remove (-), or No Change (o) to COPC[d] list
		SL1[b] 2009	SL1[b] 2018	SL2[c] 2009	SL2[c] 2018	
Organics						
Polychlorinated biphenyl (PCBs)						
Total PCBs	pg/g	60,000	n/a	120,000	n/a	+
Total Aroclors	ug/kg	n/a	110	n/a	2,500	-
Organics						
Pesticides/Herbicides/Insecticides: Organochlorine Pesticides						
4,4'-DDD	ug/kg	n/a	310	n/a	860	o
4,4'-DDE	ug/kg	n/a	21	n/a	33	o
4,4'-DDT	ug/kg	n/a	100	n/a	8,100	o
BHC-alpha (HCH-alpha)	ug/kg	n/a	n/a	n/a	n/a	o
BHC-beta(HCH-beta)	ug/kg	n/a	n/a	n/a	n/a	o
BHC-gamma (HCH-gamma, Lindane)	ug/kg	n/a	n/a	n/a	n/a	o
Chlordane	ug/kg	n/a	n/a	n/a	n/a	o
Chlordane (technical)	ug/kg	n/a	n/a	n/a	n/a	o
Chlordane-alpha	ug/kg	n/a	n/a	n/a	n/a	o
Chlordane-gamma	ug/kg	n/a	n/a	n/a	n/a	o
Dieldrin	ug/kg	n/a	4.9	n/a	9.3	o
Heptachlor	ug/kg	n/a	n/a	n/a	n/a	o
Heptachlor epoxide	ug/kg	n/a	n/a	n/a	n/a	o
beta-Hexachlorocyclohexane	ug/kg	n/a	7.2	n/a	11	o
Endrin ketone	ug/kg	n/a	8.5	n/a	n/a	o
Organics						
Phthalates						
Bis(2-ethylhexyl) phthalate	ug/kg	220	500	320	22,000	o
Butyl benzyl phthalate	ug/kg	260	n/a	370	n/a	-
Dimethyl phthalate	ug/kg	46	n/a	440	n/a	-
Di-n-butyl-phthalate	ug/kg	n/a	380	n/a	1,000	+
Di-N-octyl phthalate	ug/kg	26	39	45	1,100	o

Analyte	Units	Pacific Northwest SEF [a]				Add (+), Remove (-), or No Change (o) to COPC[d] list
		SL1[b] 2009	SL1[b] 2018	SL2[c] 2009	SL2[c] 2018	
Organics						
Semi-Volatile Organic Compounds (SVOCs): Phenols						
Phenol	ug/kg	n/a	120	n/a	210	+
4-Methylphenol	ug/kg	n/a	260	n/a	2,000	+
Pentachlorophenol	ug/kg	n/a	1,200	n/a	<1,200	o
Organics						
SVOCs: Chlorinated hydrocarbons						
Hexachlorobenzene	ug/kg	n/a	n/a	n/a	n/a	o
Organics						
Polychlorinated Dioxins and Furans						
1,2,3,4,6,7,8-HPCDD	pg/g	n/a	n/a	n/a	n/a	o
1,2,3,4,6,7,8-HPCDF	pg/g	n/a	n/a	n/a	n/a	o
1,2,3,4,7,8,9-HPCDF	pg/g	n/a	n/a	n/a	n/a	o
1,2,3,4,7,8-HXCDD	pg/g	n/a	n/a	n/a	n/a	o
1,2,3,4,7,8-HXCDF	pg/g	n/a	n/a	n/a	n/a	o
1,2,3,6,7,8-HXCDD	pg/g	n/a	n/a	n/a	n/a	o
1,2,3,6,7,8-HXCDF	pg/g	n/a	n/a	n/a	n/a	o
1,2,3,7,8,9-HXCDD	pg/g	n/a	n/a	n/a	n/a	o
1,2,3,7,8,9-HXCDF	pg/g	n/a	n/a	n/a	n/a	o
1,2,3,7,8-PECDD	pg/g	n/a	n/a	n/a	n/a	o
1,2,3,7,8-PECDF	pg/g	n/a	n/a	n/a	n/a	o
2,3,4,6,7,8-HXCDF	pg/g	n/a	n/a	n/a	n/a	o
2,3,4,7,8-PECDF	pg/g	n/a	n/a	n/a	n/a	o
2,3,7,8-TCDD	pg/g	n/a	n/a	n/a	n/a	o
2,3,7,8-TCDF	pg/g	n/a	n/a	n/a	n/a	o
OCDD	pg/g	n/a	n/a	n/a	n/a	o
OCDF	pg/g	n/a	n/a	n/a	n/a	o

Analyte	Units	Pacific Northwest SEF [a]				Add (+), Remove (-), or No Change (o) to COPC[d] list
		SL1[b] 2009	SL1[b] 2018	SL2[c] 2009	SL2[c] 2018	
Site Specific Chemicals of Concern						
Butyltins						
Monobutyltin (µg/kg)	ug/kg	n/a	540	n/a	>4,800	o
Dibutyltin (µg/kg)	ug/kg	n/a	910	n/a	130,000	o
Tributyltin (µg/kg)	ug/kg	n/a	47	n/a	320	o
Tetrabutyltin (µg/kg)	ug/kg	n/a	97	n/a	>97	o
Total [Bulk] Petroleum Hydrocarbons (TPHs)						
TPH-diesel	mg/kg	n/a	340	n/a	510	+
TPH-residual	mg/kg	n/a	3,600	n/a	4,400	+
Miscellaneous Extractables Compounds						
Benzoic acid	ug/kg	n/a	2,900	n/a	3,800	+
Carbazole	ug/kg	n/a	900	n/a	1,100	+
Dibenzofuran	ug/kg	n/a	200	n/a	680	+

[a] Sediment Evaluation Framework
[b] Screening Level 1
[c] Screening Level 2
[d] Chemicals of Potential Concern
[e] not applicable

Units Key:

- g gram
- kg kilogram (1,000 grams)
- mg milligram (10^{-3} grams)
- ug microgram (10^{-6} grams)
- pg picogram (10^{-12} grams)

Table C-9-A. 2015 and Previous USEPA National Recommended Water Quality Criteria (NRWQC) for Human Health. Adapted from USEPA (2015b).

Analyte	CAS No.	2015 Human Health NRWQC		Previous Human Health NRWQC	
		Consumption of Water + Organism (ug/L)	Consumption of Organism Only (ug/L)	Consumption of Water + Organism (ug/L)	Consumption of Organism Only (ug/L)
1,1,1-Trichloroethane	71-55-6	10,000	200,000	*	---
1,1,2,2-Tetrachloroethane	79-34-5	0.2	3	0.17	4
1,1,2-Trichloroethane	79-00-5	0.55	8.9	0.59	16
1,1-Dichloroethylene	75-35-4	300	20,000	330	7,100
1,2,4,5-Tetrachlorobenzene	95-94-3	0.03	0.03	0.97	1.1
1,2,4-Trichlorobenzene	120-82-1	0.071	0.076	35	70
1,2-Dichlorobenzene	95-50-1	1,000	3,000	420	1,300
1,2-Dichloroethane	107-06-2	9.9	650	0.38	37
1,2-Dichloropropane	78-87-5	0.90	31	0.5	15
1,2-Diphenylhydrazine	122-66-7	0.03	0.2	0.036	0.2
1,3-Dichlorobenzene	541-73-1	7	10	320	960
1,3-Dichloropropene	542-75-6	0.27	12	0.34	21
1,4-Dichlorobenzene	106-46-7	300	900	63	190
2,4,5-Trichlorophenol	95-95-4	300	600	1,800	3,600
2,4,6-Trichlorophenol	88-06-2	1.5	2.8	1.4	2.4
2,4-Dichlorophenol	120-83-2	10	60	77	290
2,4-Dimethylphenol	105-67-9	100	3,000	380	850
2,4-Dinitrophenol	51-28-5	10	300	69	5,300
2,4-Dinitrotoluene	121-14-2	0.049	1.7	0.11	3.4
2-Chloronaphthalene	91-58-7	800	1,000	1,000	1,600
2-Chlorophenol	95-57-8	30	800	81	150

Analyte	CAS No.	2015 Human Health NRWQC		Previous Human Health NRWQC	
		Consumption of Water + Organism (ug/L)	Consumption of Organism Only (ug/L)	Consumption of Water + Organism (ug/L)	Consumption of Organism Only (ug/L)
2-Methyl-4,6-Dinitrophenol	534-52-1	2	30	13	280
3,3'-Dichlorobenzidine	91-94-1	0.049	0.15	0.021	0.028
3-Methyl-4-Chlorophenol	59-50-7	500	2,000	*	*
Acenaphthene	83-32-9	70	90	670	990
Acrolein	107-02-8	3	400	6	9
Acrylonitrile	107-13-1	0.061	7.0	0.051	0.25
Aldrin	309-00-2	0.00000077	0.00000077	0.000049	0.00005
alpha-Hexachlorocyclohexane (HCH)	319-84-6	0.00036	0.00039	0.0026	0.0049
alpha-Endosulfan	959-98-8	20	30	62	89
Anthracene	120-12-7	300	400	8,300	40,000
Benzene	71-43-2	0.58 - 2.1	16 - 58	0.61 - 2.2	14 - 51
Benzidine	92-87-5	0.00014	0.011	0.000086	0.0002
Benzo(a)anthracene	56-55-3	0.0012	0.0013	0.0038	0.018
Benzo(a)pyrene	50-32-8	0.00012	0.00013	0.0038	0.018
Benzo(b)fluoranthene	205-99-2	0.0012	0.0013	0.0038	0.018
Benzo(k)fluoranthene	207-08-9	0.012	0.013	0.0038	0.018
beta-Hexachlorocyclohexane (HCH)	319-85-7	0.0080	0.014	0.0091	0.017
beta-Endosulfan	33213-65-9	20	40	62	89
Bis(2-Chloro-1-Methylethyl) Ether	108-60-1	200	4,000	1,400	65,000
Bis(2-Chloroethyl) Ether	111-44-4	0.030	2.2	0.03	0.53
Bis(2-Ethylhexyl) Phthalate	117-81-7	0.32	0.37	1.2	2.2
Bis(Chloromethyl) Ether	542-88-1	0.00015	0.017	0.0001	0.00029
Bromoform	75-25-2	7.0	120	4.3	140

Analyte	CAS No.	2015 Human Health NRWQC		Previous Human Health NRWQC	
		Consumption of Water + Organism (ug/L)	Consumption of Organism Only (ug/L)	Consumption of Water + Organism (ug/L)	Consumption of Organism Only (ug/L)
Butylbenzyl Phthalate	85-68-7	0.10	0.10	1,500	1,900
Carbon Tetrachloride	56-23-5	0.4	5	0.223	1.6
Chlordane	57-74-9	0.00031	0.00032	0.0008	0.00081
Chlorobenzene	108-90-7	100	800	130	1,600
Chlorodibromomethane	124-48-1	0.80	21	0.4	13
Chloroform	67-66-3	60	2,000	5.7	470
Chlorophenoxy Herbicide (2,4-D)	94-75-7	1,300	12,000	100	---
Chlorophenoxy Herbicide (2,4,5-TP) [Silvex]	93-72-1	100	400	10	---
Chrysene	218-01-9	0.12	0.13	0.0038	0.018
Cyanide	57-12-5	4	400	140	140
Dibenzo(a,h)anthracene	53-70-3	0.00012	0.00013	0.0038	0.018
Dichlorobromomethane	75-27-4	0.95	27	0.55	17
Dieldrin	60-57-1	0.0000012	0.0000012	0.000052	0.000054
Diethyl Phthalate	84-66-2	600	600	17,000	44,000
Dimethyl Phthalate	131-11-3	2,000	2,000	270,000	1,100,000
Di-n-Butyl Phthalate	84-74-2	20	30	2,000	4,500
Dinitrophenols	25550-58-7	10	1,000	69	5,300
Endosulfan Sulfate	1031-07-8	20	40	62	89
Endrin	72-20-8	0.03	0.03	0.059	0.06
Endrin Aldehyde	7421-93-4	1	1	0.29	0.3
Ethylbenzene	100-41-4	68	130	530	2,100
Fluoranthene	206-44-0	20	20	130	140

Analyte	CAS No.	2015 Human Health NRWQC		Previous Human Health NRWQC	
		Consumption of Water + Organism (ug/L)	Consumption of Organism Only (ug/L)	Consumption of Water + Organism (ug/L)	Consumption of Organism Only (ug/L)
Fluorene	86-73-7	50	70	1,100	5,300
gamma-Hexachlorocyclohexane (HCH)	58-89-9	4.2	4.4	0.98	1.8
Heptachlor	76-44-8	0.0000059	0.0000059	0.000079	0.000079
Heptachlor Epoxide	1024-57-3	0.000032	0.000032	0.000039	0.000039
Hexachlorobenzene	118-74-1	0.000079	0.000079	0.00028	0.00029
Hexachlorobutadiene	87-68-3	0.01	0.01	0.44	18
Hexachlorocyclohexane (HCH)-Technical	608-73-1	0.0066	0.010	0.0123	0.0414
Hexachlorocyclopentadiene	77-47-4	4	4	40	1,100
Hexachloroethane	67-72-1	0.1	0.1	1.4	3.3
Indeno(1,2,3-cd)pyrene	193-39-5	0.0012	0.0013	0.0038	0.018
Isophorone	78-59-1	34	1,800	35	960
Methoxychlor	72-43-5	0.02	0.02	100	---
Methyl Bromide	74-83-9	100	10,000	47	1,500
Methylene Chloride	75-09-2	20	1,000	4.6	590
Nitrobenzene	98-95-3	10	600	17	690
Pentachlorobenzene	608-93-5	0.1	0.1	1.4	1.5
Pentachlorophenol	87-86-5	0.03	0.04	0.27	3
Phenol	108-95-2	4,000	300,000	10,000	860,000
p,p'-Dichlorodiphenyldichloroethane (DDD)	72-54-8	0.00012	0.00012	0.00031	0.00031

Analyte	CAS No.	2015 Human Health NRWQC		Previous Human Health NRWQC	
		Consumption of Water + Organism (ug/L)	Consumption of Organism Only (ug/L)	Consumption of Water + Organism (ug/L)	Consumption of Organism Only (ug/L)
p,p'-Dichlorodiphenyldichloroethylene (DDE)	72-55-9	0.000018	0.000018	0.00022	0.00022
p,p'-Dichlorodiphenyltrichloroethane (DDT)	50-29-3	0.000030	0.000030	0.00022	0.00022
Pyrene	129-00-0	20	30	830	4,000
Tetrachloroethylene (Perchloroethylene)	127-18-4	10	29	0.69	3.3
Toluene	108-88-3	57	520	1,300	15,000
Toxaphene	8001-35-2	0.00070	0.00071	0.00028	0.00028
trans-1,2-Dichloroethylene (DCE)	156-60-5	100	4,000	140	10,000
Trichloroethylene (TCE)	79-01-6	0.6	7	2.5	30
Vinyl Chloride	75-01-4	0.022	1.6	0.025	2.4

* NRWQC for this analyte were not provided in USEPA’s previous update.

--- No NRWQC for the analyte in USEPA’s previous update.

Units Key:

ug/L microgram per liter

Table C-10. Summary of the Lines of Evidence Used to Evaluate Each Exposure Pathway. Source: CDM (2011).

Line of Evidence	**Exposure Pathways**				
	1	**2**	**3**	**4**	**5**
Sediment Evaluation Framework Level 2A Step 1 – Sediment Screening Levels					
1. DMMP Marine MLs				+	
Sediment Evaluation Framework Level 2A Steps 2a, 2b, 2c, 2d – Sediment Screening Levels					
2. Ecological SLs (freshwater and marine)			+	+	+
3. Ecological TEQ SLVs (sediment)			+	+	+
Sediment Evaluation Framework Level 2B – Results of Water Quality Criteria Evaluations and Bioassays					
4. Elutriate WQC (ecological)	+			+	
5. Benthic midge *(Chironomus dilutens)* Bioassay			+	+	+
6. Benthic amphipod *(Hyalella azteca)* Bioassay			+	+	+
7. Rainbow trout *(Oncorhynchus mykiss)* Bioassay	+			+	
8. Asian clam *(Corbicula fluminea)*[1] Bioaccumulation Study/BSAF			+		+
9. Blackworm *(Lumbriculus variegatus)*[2] Bioaccumulation Study/BSAF			+		+
10. Asian clam *(Corbicula fluminea)*[1] Tissue TRV			+	+	+
11. Blackworm *(Lumbriculus variegatus)*[2] Tissue TRV			+	+	+

Line of Evidence	Exposure Pathways				
Special Evaluations – Human Health in Sediment and Fish Tissue					
12. Yellow perch (*Perca flavescens*) Tissue TRV (ecological)			+	+	+
13. Bullhead (*Ameirus sp.*) Tissue TRV (ecological)			+	+	+
14. Fish Tissue TEQ (ecological)			+	+	+
15. HHSLs		+	+		+
16. HH TEQ SLVs (sediment)		+	+		+
17. Elutriate WQC (human health)					
18. Perch Tissue TRV (human health)			+		+
19. Bullhead Tissue TRV (human health)			+		+
20. Fish Tissue TEQ (human health)			+		+

+: Applicable line of evidence for exposure pathway
[1] Representative bivalve
[2] Representative oligochaete
Key:
DMMP = Dredged Material Management Program
ML = Maximum Level
SL = Screening Level
TEQ = Toxic Equivalency
SLV = Screening Level Value
WQC = Water Quality Criteria
TRV = Toxicity Reference Value
BSAF = Biota-Sediment Accumulation Factor
HHSL = Human Health Screening Level
HH = Human Health

Contaminants in Aquatic Biota

Separate assessments of 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 No. 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 No. 1 reservoirs (Table C-11) indicate mercury tissue concentrations above the USEPA criterion of 300 nanograms per gram (ng/g) methylmercury in fish tissue to protect the health of consumers of noncommercial freshwater fish; and greater than the OEHHA public health guideline levels advisory tissue level (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 to 4 orders of magnitude lower than OEHHA thresholds of concern (2,500 to 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).

Table C-11. Total Mercury, Selenium, and PCBs in (ng/g wet weight) in Largemouth Bass taken from Iron Gate and Copco No. 1 Reservoirs During 2007 to 2008 (Davis et al. 2010).

Contaminant	Species	Iron Gate Reservoir	Copco No. 1 Reservoir
Methylmercury	Largemouth Bass (LMB)	330	310
Selenium	LMB	80	80
PCBs	LMB	1.31	*Not reported*

In a screening-level study of potential chemical contaminants in fish tissue in J.C. Boyle, Copco No. 1, and Iron Gate reservoirs, PacifiCorp analyzed metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc), organochlorine (pesticide) compounds, and PCBs in largemouth bass (*Micropterus salmoides*) (PacifiCorp 2004c). PacifiCorp reported that, in general, contaminant levels in fish tissue are below both 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 measured fish tissue levels of total mercury in samples from Copco No. 1 and Iron Gate reservoirs as compared to the wildlife screening level of 0.00227 ug/g and measured fish tissue levels of arsenic (less than 0.3 ug/g) that PacifiCorp indicated may equal or exceed the toxicity screening level for subsistence fishers (0.147 ug/g) in samples of largemouth bass from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs. Subsequent reanalysis of the PacifiCorp mercury tissue data indicates that all tissue samples exceed the most protective wildlife screening level of 0.00227 ug/g, samples from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs exceed the screening level for subsistence fishers (0.049 ug/g), and samples from Copco No. 1 and Iron Gate reservoirs exceed the screening level for recreational fishers (0.4 ug/g) (Table C-12).

Table C-12. Total Mercury Concentrations (ug/g wet weight) in Largemouth Bass (LMB) Composite Tissue Samples taken from Lower Klamath Project Reservoirs in 2003 (PacifiCorp 2004c).

Sample	Composite	Site	Species	Total Mercury (ug/g wet weight)[1]
L-262-03	2F	J.C. Boyle Reservoir	LMB	0.153
L-262-03	3F	J.C. Boyle Reservoir	LMB	0.190
L-273-03	1F	Iron Gate Reservoir	LMB	0.564
L-273-03	2F	Iron Gate Reservoir	LMB	0.508
L-273-03	3F	Copco No. 1 Reservoir	LMB	0.563
L-273-03	4F	Copco No. 1 Reservoir	LMB	0.389
		Method Detection Limit		0.003[2]
		Method Reporting Limit		0.007[2]
		Screening Levels[3]:		
		Recreational fishers		0.4
		Subsistence fishers		0.049
		Wildlife		0.00227

[1] PacifiCorp (2004c) total mercury data was provided in ng/g dry weight. Data was converted to ug/g wet weight using percent moisture data provided for each sample by Moss Landing Marine Laboratory (A. Bonnema, pers. comm., 17 February 2011).

[2] The Method Detection Limit and Reporting Limit were converted from dry weight to wet weight using an average of the percent moisture data for all samples.

[3] Screening Levels (SLs) are numeric chemical guidelines that are used to assess and characterize the potential toxicity or bioaccumulative nature of environmental samples (i.e., sediments, water, organism tissue).

Additionally, PacifiCorp indicated that some of the fish tissue samples from J. C. Boyle and Copco No. 1 reservoirs exceeded the suggested wildlife screening value for total DDTs (Table C-13) (DDE,p,p' was detected; however DDT and DDD were not detected in the study), and total PCB values exceeded the screening level for subsistence fishers in largemouth bass from J.C. Boyle, Copco No. 1, and Iron Gate Reservoirs (Table C-14). Dioxins were not tested.

Table C-13. Total DDE Concentration (ng/g) in Large Mouth Bass (LMB) Composite Tissue Samples taken from Lower Klamath Project Reservoirs in 2003 (PacifiCorp 2004c).

Sample	Composite	Site	Species	DDE,p,p' (ng/g wet weight)
L-262-03	2F	J.C. Boyle Reservoir	LMB	<2.00
L-262-03	2F Duplicate	J.C. Boyle Reservoir	LMB	<2.00
L-262-03	3F	J.C. Boyle Reservoir	LMB	2.91
L-273-03	1F	Iron Gate Reservoir	LMB	<2.00
L-273-03	2F	Iron Gate Reservoir	LMB	<2.00
L-273-03	3F	Copco Reservoir	LMB	2.16
L-273-03	4F	Copco Reservoir	LMB	<2.00
		Method Detection Limit		0.56
		Method Reporting Limit		2
		Screening Levels[1] (for Total DDTs):		
		Recreational fishers		117
		Subsistence fishers		14.4
		Wildlife		0.2–1.07

[1] Screening Levels (SLs) are numeric chemical guidelines that are used to assess and characterize the potential toxicity or bioaccumulative nature of environmental samples (i.e., sediments, water, organism tissue).

Table C-14. Total PCB Concentrations (ng/g) in Large Mouth Bass (LMB) Composite Tissue Samples taken from Lower Klamath Project Reservoirs in 2003 (PacifiCorp 2004c).

Sample	Composite	Site	Species	Total PCB (ng/g wet weight)
L-262-03	2F	J.C. Boyle Reservoir	LMB	0.885
L-262-03	2F Duplicate	J.C. Boyle Reservoir	LMB	1.397
L-262-03	3F	J.C. Boyle Reservoir	LMB	3.521
L-273-03	1F	Iron Gate Reservoir	LMB	6.574
L-273-03	2F	Iron Gate Reservoir	LMB	4.909
L-273-03	3F	Copco Reservoir	LMB	2.822
L-273-03	4F	Copco Reservoir	LMB	2.158
		Method Detection Limit		Varies
		Method Reporting Limit		0.2
		Screening Levels[1]:		
		Recreational fishers		20
		Subsistence fishers		2.45
		Wildlife		100

[1] Screening Levels (SLs) are numeric chemical guidelines that are used to assess and characterize the potential toxicity or bioaccumulative nature of environmental samples (i.e., sediments, water, organism tissue).

To provide additional lines of evidence in the Klamath Dam Removal Secretarial Determination sediment evaluation, the potential for chemicals in sediment samples to bioaccumulate in aquatic species was investigated using laboratory invertebrates (Asian clams, *Corbicula fluminea*; and Black worms, *Lumbriculus variegates*) exposed to reservoir-derived sediments. Results indicated that multiple chemicals were found in invertebrate tissue (acenaphthene, arsenic, benzo(a)pyrene, DDD/DDE, endosulfan I, endosulfan II, endosulfan sulfate, fluoranthene, hexachlorobenzene, lead, mercury, phenanthrene, pyrene, total PBDEs, total PCBs). Of these detected chemicals, only fluoranthene possessed a toxicity reference value (TRV) for the species tested; exceedances of the fluoranthene TRV were only identified above the No Effect TRV and were below the Low Effect TRV. Tissue-based TRVs were unavailable for the remaining invertebrate chemicals detected, and hexachlorobenzene has no tissue-based TRVs (for any species) (CDM 2011).

Lastly, two species of field-caught fish (yellow perch and bullhead) were collected during late September 2010 from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs and analyzed for contaminant concentrations (CDM 2011). Table C-

15 lists all the chemicals detected in the fish tissue along with a list of chemicals tested for, but not detected in any sample of fish tissue. Chemicals found in the fish tissue samples included 2,3,7,8-TCDD, arsenic, DDE/DDT, dieldrin, endrin, mercury, mirex, selenium, and total PCBs (CDM 2011). Mercury exceeded tissue-based TRVs for perch in Iron Gate Reservoir and bullhead samples in all three reservoirs (CDM 2011). TRVs were not available the remaining several chemicals detected in yellow perch and bullhead samples (CDM 2011). Results of chemical analyses of field collected fish revealed that no consistent pattern of contaminant distribution was identified among chemicals, media type, or location. Data revealed that fish can accumulate a fairly large number of sediment-associated chemicals; however, regional background conditions may be elevated for more than one of the measured chemicals (e.g., arsenic, mercury) (CDM 2011).

Table C-15. Chemicals Detected and Not Detected in Fish Tissue Field Caught in 2010 from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs (CDM 2011).

Bullhead (*Ameiurus sp.*)		**Yellow Perch (*Perca flavescens*)**	
Detected[1]	**Not Detected[2]**	**Detected[1]**	**Not Detected[2]**
2,4'-DDD	2,4'-DDT	2,4'-DDD	Acenaphthene
2,4'-DDE	Acenaphthene	2,4'-DDE	Acenaphthylene
2-Fluorobiphenyl	Acenaphthylene	2,4'-DDT	Aldrin
4,4'-DDD	Aldrin	2-Fluorobiphenyl	Anthracene
4,4'-DDE	Anthracene	4,4'-DDD	BDE (4)
4,4'-DDT	BDE (3)	4,4'-DDE	Benzo(a)anthracene
alpha-BHC	Benzo(a)anthracene	4,4'-DDT	Benzo(a)pyrene
Arsenic	Benzo(a)pyrene	alpha-BHC	Benzo(b)fluoranthene
BDE (8)	Benzo(b)fluoranthene	Arsenic	Benzo(ghi)perylene
beta-BHC	Benzo(ghi)perylene	BDE (7)	Benzo(k)fluoranthene
cis-Chlordane	Benzo(k)fluoranthene	beta-BHC	Chrysene
cis-Nonachlor	Chrysene	cis-Chlordane	D/F (14)
D/F (1)	D/F (14)	cis-Nonachlor	Dibenz(a,h)anthracene
delta-BHC	Dibenz(a,h)anthracene	D/F (1)	Endosulfan I
Dieldrin	Endosulfan I	delta-BHC	Endosulfan II
Endosulfan sulfate	Endosulfan II	Dieldrin	Endrin aldehyde
Fluorene	Endrin	Endosulfan sulfate	Endrin ketone
gamma-BHC (Lindane)	Endrin aldehyde	Endrin	Fluoranthene
Heptachlor epoxide	Endrin ketone	gamma-BHC (Lindane)	Fluorene
Hexachlorobenzene	Fluoranthene	Heptachlor	Indeno(1,2,3-cd)pyrene
Lead	Heptachlor	Heptachlor epoxide	Lead

Bullhead (*Ameiurus sp.*)		Yellow Perch (*Perca flavescens*)	
Detected[1]	**Not Detected[2]**	**Detected[1]**	**Not Detected[2]**
Mercury	Indeno(1,2,3-cd)pyrene	Hexachlorobenzene	OCDF
Methoxychlor	OCDF	Mercury	PCB congeners (24)
Mirex	PCB congeners (28)	Methoxychlor	Phenanthrene
Naphthalene	Phenanthrene	Mirex	Pyrene
Nitrobenzene-d5	Pyrene	Naphthalene	Total HpCDF
OCDD	Total HpCDF	Nitrobenzene-d5	Total HxCDD
oxy-Chlordane	Total HxCDD	OCDD	Total HxCDF
PCB congeners (181)	Total HxCDF	oxy-Chlordane	Total PeCDD
Selenium	Total PeCDD	PCB congeners (185)	Total PeCDF
Total HpCDD	Total PeCDF	Selenium	Total TCDD
trans-Chlordane	Total TCDD	Total HpCDD	Total TCDF
trans-Nonachlor	Total TCDF	trans-Chlordane	
		trans-Nonachlor	

[1] Detected in one or more samples
[2] Not detected in any sample

In 2017, the State Water Board established water quality objectives for mercury to protect people and wildlife from consuming fish that contain high levels of mercury (State Water Board 2017). Five mercury fish tissue water quality objectives were developed depending on consumption patterns by individuals and wildlife. The Copco No. 1 and Iron Gate reservoirs were 303(d) listed as impaired for mercury by the State Water Board based on four or more lines of evidence showing mercury concentrations in fish fillets exceeding USEPA 304(a) concentrations of methylmercury in fish tissue of trophic level 4 fish (USEPA 2000; PacifiCorp 2004c; Davis et al. 2010; CDM 2011). No TMDL has been determined for Copco No. 1 or Iron Gate reservoirs, with an expected TMDL completion date of 2025.

C.7.2 Mid- to Lower Klamath Basin

C.7.2.1 Iron Gate Dam to Salmon River

Water Column Contaminants

SWAMP collected water quality data for inorganic and organic contaminants from 2000 through 2005 at eight monitoring sites from the Oregon-California state line (RM 214.1) to Klamath River at Klamath Glen (RM 5.9) (North Coast Regional Board 2008). As was the case for the SWAMP state line site (Section C.7.1.1), results for the four sites in the reach from Iron Gate Dam to the Salmon River indicated that with the exception of aluminum, all other measured concentrations of inorganic constituents (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver and zinc) were in compliance with all water quality objectives at the time of sampling. Aluminum concentrations (26.3 to 280.0 ug/L) exceeded the USEPA continuous concentration for freshwater aquatic life protection (87 ug/L) on 23 of 59 site visits (39 percent exceedance rate), exceeded the USEPA secondary MCL for drinking water (50 ug/L) on 37 site visits (63 percent exceedance rate), and exceeded the California Department of Health Services secondary MCL for drinking water (200 ug/L) on five site visits (8 percent exceedances rate) (North Coast Regional Board 2008). The Klamath River from Iron Gate Dam to its confluence with the Scott River is 303(d) listed for aluminum. Water quality measurements in 2002 and 2003 at two USGS gage stations downstream of Iron Gate Dam to the Salmon River indicate that, with the exception of barium, nickel, magnesium, and calcium, the concentration of trace elements either remained the same or decreased as water flowed downstream, most likely because of binding to other particles and settling out of the water column (Tables C-16 and C-17; Flint et al. 2005). Additional data from two more USGS gage stations downstream of the confluence of the Klamath River and the Salmon River further support these trends, except for magnesium which does not continue to increase downstream of the Salmon River. Asarian and Kann (2014) note that the mean dissolved copper concentrations at three Klamath River sites between 2001 to 2013 are approximately 0.75 ug/L or less and the maximum is always less than 1.5 ug/L.

Sediment Contaminants

Sediment data for inorganic and organic contaminants in the Klamath River from Iron Gate Dam to the Salmon River are not readily available, nor are fish tissue analyses for contaminants in the lower Klamath River.

Table C-16. Water Quality Data Collected at 4 Sites in the Klamath River in 2002 (Flint et al. 2005).

Trace Element	Walker[1]	Seiad[2]	Orleans[3]	Klamath[4]
Aluminum	2	2	1	<1
Antimony	E0.04	E0.04	E0.05	<0.05
Arsenic	5	4	3	3
Barium	8.0	10.0	14.0	14.0
Beryllium	<0.06	<0.06	<0.06	<0.06
Cadmium	<0.04	<0.04	<0.04	<0.04
Chromium	<0.8	2.4	<0.8	<0.8
Cobalt	0.13	0.13	0.1	0.08
Copper	0.6	1.2	0.8	0.7
Manganese	6.1	7.2	2.5	3
Mercury	E0.01	0.01	<0.01	E0.01

Trace Element	Walker[1]	Seiad[2]	Orleans[3]	Klamath[4]
Mercury (total recoverable)	E0.01	0.02	<0.01	<0.01
Molybdenum	1.0	1.0	0.8	0.6
Nickel	1.00	1.36	2.28	2.43
Selenium	<2	<2	<2	E1
Silver	<1	<1	<1	<1
Zinc	ND	ND	ND	1
Uranium	0.13	0.12	0.11	0.07

Notes:
[1] Klamath River at Walker Bridge (USGS 11517818)
[2] Klamath River at Seiad Valley (USGS 11520500)
[3] Klamath River at Orleans (USGS 11523000)
[4] Klamath River near Klamath (USGS 11530500)
All data shown in micrograms per liter.

Table C-17. Water Quality Data Collected at 4 Sites in the Klamath River in 2003 (Flint et al. 2005).

Trace Element	Walker[1]		Seiad[2]		Orleans[3]		Klamath[4]	
	July	Sept	July	Sept	July	Sept	July	Sept
Calcium	15.3	12.7	16.9	14.4	16.0	15.6	15.5	15.9
Magnesium	9.63	8.21	10.6	9.22	8.19	8.69	7.59	8.77
Potassium	2.85	2.55	2.25	2.47	1.47	1.99	0.91	1.34
Sodium	16.6	14.1	13.4	13.9	8.18	11.3	5.25	7.59
Chloride	5.37	5.21	5.48	5.65	3.78	5.23	2.87	3.87
Fluoride	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Silica	27.2	36.1	23.9	34.4	19.8	29.2	16.2	21.4
Sulfate	11.9	6.4	10.5	6.5	7.0	5.9	5.7	5.4

Notes:
[1] Klamath River at Walker Bridge (USGS 11517818)
[2] Klamath River at Seiad Valley (USGS 11520500)
[3] Klamath River at Orleans (USGS 11523000)
[4] Klamath River near Klamath (USGS 11530500)
All data shown in micrograms per liter.

C.7.2.2 Salmon River to Klamath River Estuary

Water Column Contaminants

SWAMP collected water quality data for inorganic and organic contaminants from 2001 through 2005 at three monitoring sites in this reach of the Klamath River to Klamath Glen (RM 5.9) (North Coast Regional Board 2008). With the exception of aluminum, all other measured concentrations of inorganic constituents (i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc) were in compliance with all water quality objectives at the time of sampling. Aluminum concentrations (8.8 to 565.0 ug/L) exceeded the USEPA continuous concentration for freshwater aquatic life protection (87 ug/L) on 12 of 28 site visits (43 percent exceedance rate), exceeded the USEPA secondary MCL for drinking water (50 ug/L) on 15 site visits (54 percent exceedance rate), and exceeded the California Department of Health Services secondary MCL for drinking water (200 ug/L) on four site visits (14 percent exceedances rate). At one station (Klamath River at Klamath Glen [RM 5.9]), grab samples were analyzed for 100 pesticides, pesticide constituents, or pesticide metabolites; 50 PCB congeners; and 6 phenolic compounds. There were no PCB detections, but the pesticide disulfoton was detected in one sample. Disulfoton is a systemic organophosphate insecticide for which there is no numeric water quality objective. Similar to the Klamath River from downstream of Iron Gate to the confluence with the Salmon River, the water quality measurements in 2002 and 2003 at two USGS gage stations in the Lower Klamath River from the confluence with the Salmon River to the Klamath River Estuary indicate that, with the exception of barium, nickel, and calcium, the concentration of trace elements either remained the same or decreased as water flowed downstream, most likely because of binding to other particles and settling out of the water column (Tables C-16 and C-17; Flint et al. 2005). While barium concentrations remain the same at the two USGS gage stations between the Salmon River and the Klamath River Estuary (Orleans and Klamath), a comparison of barium concentrations at those gages with the two upstream gages (Walker Bridge and Seiad Valley) shows an increasing trend in barium with distance downstream from Iron Gate Dam. Nickel concentrations consistently increase with distance downstream.

Sediment Contaminants

Sediment data characterizing inorganic and organic contaminants in the Lower Klamath River from the Salmon River to the Klamath River Estuary are not readily available, nor are fish tissue analyses for contaminants in this reach of the Klamath River. Sediment data from the Klamath River Estuary are described below.

C.7.2.3 Klamath River Estuary

Sediment and water column data for inorganic and organic contaminants in the Klamath River Estuary are not readily available. However, contaminant conditions in the Klamath River Estuary (RM 0 to 3.9) are likely to be similar to those a few miles upstream at the site for which SWAMP data have been recently collected (see previous section).

As part of the Secretarial Determination studies, a sediment evaluation evaluated the potential environmental and human health impacts of the downstream release of sediment deposits currently stored behind the dams under the Proposed Project. Sediment cores were collected during 2009 to 2010 at multiple sites and at various sediment depths per site, including two locations in the Klamath River Estuary (see Section C.7.1.1). Overall, using thirteen lines of evidence from the 2009 to 2010 Secretarial Determination study (Lines of Evidence 1 to 11, 15, and 16 in Table C-10), sediment quality in the Klamath River Estuary does not appear to be highly contaminated (CDM 2011). The other lines of evidence were not used in the evaluation of conditions in the Klamath River Estuary, because no fish tissue was collected from the Klamath River Estuary. Where elevated concentrations of chemicals in sediment were found (i.e., arsenic, chromium, iron, nickel, bis[2-ethylhexyl]phthalate), the degree of exceedance based on comparisons of measured (i.e., detected) chemical concentrations to SLs was small and in several cases (i.e., arsenic, nickel) may reflect regional background conditions (CDM 2011). The results of the acute toxicity bioassays for midge and amphipod identified no statistically significant difference in survival of either test organism exposed to estuary sediments compared to control sediments. As with the reservoir sediments (Section C.7.1.1), the lone chemical identified in tissue from invertebrates exposed to estuary sediments above TRVs was fluoranthene. Further, it was only identified above the No Effect TRV, and was below the Low Effect TRV. TEQs for dioxin, furan, and dioxin-like PCBs were all below 0.2 pg/g for the Klamath River Estuary, thus adverse effects from exposure to TEQs are not expected following exposure to sediment in the Klamath River Estuary (CDM 2011).

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APPENDIX D. WATER QUALITY ENVIRONMENTAL EFFECTS DETERMIMATION METHODOLOGY SUPPLEMENTAL INFORMATION

Volume II Appendix D Section D.1.1 Available Numeric Models for Analysis of the Proposed Project and Alternatives – Klamath River Water Quality Model (KRWQM), paragraph 1 on page D-1:

Numeric models[113] used to assess potential water quality impacts for the Proposed Project and Alternatives are presented in Table D-1. For the FERC relicensing process, PacifiCorp developed the Klamath River Water Quality Model (KRWQM) (Watercourse Engineering, Inc. 2003, PacifiCorp 2004, 2005), consisting of linked Resource Management Associates (RMA) RMA-2 and RMA-11 dimensional models for riverine segments, where RMA-2 simulates riverine hydrodynamics and RMA-11 simulates water quality processes, and a 2-dimensional CE-QUAL-W2 model used for water quality in reservoir segments. The 2004/2005 KRWQM does not include an analysis for the Klamath River Estuary. The ~~KRWQM~~2004/2005 KRWQM possesses the following attributes (Tetra Tech 2009a):

Volume II Appendix D Section D.1.1 Available Numeric Models for Analysis of the Proposed Project and Alternatives – Klamath River Water Quality Model (KRWQM), paragraph 2 on page D-1:

~~KRWQM~~2004/2005 KRWQM results for water temperature and dissolved oxygen compare the existing condition (all Project dams in place) to four without-dams scenarios (i.e., without Iron Gate Dam ["WIG"]; without Copco No. 1, Copco No. 2, and Iron Gate dams ["WIGC"]; without J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams ["WIGCJCB"]; and without Keno, J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams ["WOP" and "WOP2"]). Model runs were calibrated using data from calendar years 2001□2004 (PacifiCorp 2004). General modeling assumptions in comparison to conditions considered for this EIR water quality effects analyses are presented in Table D-2. Limitations and sources of uncertainty for the ~~KRWQM~~2004/2005 KRWQM are presented in Watercourse Engineering, Inc. (2003).

Volume II Appendix D Section D.1.1 Available Numeric Models for Analysis of the Proposed Project and Alternatives – Klamath River Water Quality Model (KRWQM), new paragraph 3 on page D-1:

[113] Here numeric models refers to mathematical models that are developed to represent the physical, chemical, and biological conditions in waterbodies such as rivers, lakes, reservoirs, wetlands, estuaries, and the ocean.

More recent 2019 KRWQM documentation (PacifiCorp 2019) indicates that PacifiCorp has developed an updated version of the KRWQM model, where the updates were primarily focused on Keno Reservoir. However, PacifiCorp (2019) does not present comparisons of dam removal scenarios, so the previous 2004/2005 KRWQM results cannot be replaced with the newer 2019 KRWQM results in the EIR analyses.

Volume II Appendix D Section D.1.1 Available Numeric Models for Analysis of the Proposed Project and Alternatives – Klamath River TMDL Model, paragraph 3 on page D-1:

For development of Klamath River Total Maximum Daily Loads (TMDLs) in Oregon and California, Oregon DEQ, North Coast Regional Board, and the United States Environmental Protection Agency (USEPA) Regions 9 and 10 collaborated to enhance the existing ~~KRWQM~~2004/2005 KRWQM by revisiting assumptions for several model algorithms, including the three-dimensional Environmental Fluid Dynamics Code model, to represent water quality in the Klamath River Estuary. Algorithm enhancements are described in Tetra Tech (2009a). The Klamath River TMDL model was calibrated for water temperature, dissolved oxygen, nutrients (TP, TN, ortho-phosphorus, nitrate, ammonia), and pH using year 2000 data, with the exception of the Klamath River Estuary which was calibrated using year 2004 data. Additional model corroboration was conducted for Klamath River reaches in Oregon using data from year 2002, indicating that the Klamath River TMDL model scenarios reproduce general temporal and spatial trends in the observed data (Tetra Tech 2009a). Four simulated scenarios were run for the Klamath River TMDL model including the following (Tetra Tech 2009b):

Volume II Appendix D Section D.1.1 Available Numeric Models for Analysis of the Proposed Project and Alternatives – Klamath River TMDL Model, Table D-1 Numeric Models Used to Assess Potential Water Quality Impacts for the Proposed Project and Alternatives on page D-3:

Table D-1. Numeric Models Used to Assess Potential Water Quality Impacts for the Proposed Project and Alternatives.

Reach	**Water Quality Parameter**					
	Water Temperature	**Sediment and Turbidity**	**Dissolved Oxygen**		**Nutrients**	**pH**
	Long-term[1]	**Short-term[2]**	**Short-term[2]**	**Long-term[1]**	**Long-term[1]**	**Long-term[1]**
No Project Alternative, Continued Operations with Fish Passage Alternative						
Downstream from J.C. Boyle Reservoir (RM 229.8)	Klamath TMDL T4BSRN Klamath TMDL T1BSR RBM10			Klamath TMDL T4BSRN Klamath TMDL T1BSR	Klamath TMDL T4BSRN	Klamath TMDL T4BSRN
Oregon-California State line (RM 214.1)						
Downstream from Iron Gate Dam (RM 193.1)						
Shasta River (RM 179.5)						
Scott River (RM 145.1)						
Seiad Valley (RM 132.7)						
Salmon River (RM 66.3)						
Trinity River (RM 43.3)						

Reach	**Water Quality Parameter**					
	Water Temperature	**Sediment and Turbidity**	**Dissolved Oxygen**		**Nutrients**	**pH**
	Long-term[1]	**Short-term[2]**	**Short-term[2]**	**Long-term[1]**	**Long-term[1]**	**Long-term[1]**
Turwar (RM 5.6)						
Klamath River Estuary (RM 0-3.9)						
Proposed Project, Partial Removal Alternative, No Hatchery Alternative						
Downstream from J.C. Boyle Reservoir (RM 229.8)	Klamath TMDL TOD2RN			Klamath TMDL TOD2RN	Klamath TMDL TOD2RN	Klamath TMDL TOD2RN
Oregon-California State line (RM 214.1)						
Downstream from Iron Gate Dam (RM 193.1)	Klamath TMDL TCD2RN ~~KRWQM~~2004/2005 KRWQM WIGCJCB[3] RBM10	Reclamation SRH-1	Reclamation, USFWS, USGS, Stillwater Sciences BOD/IOD	Klamath TMDL TCD2RN ~~KRWQM~~2004/2005 KRWQM WIGCJCB[3]	Klamath TMDL TCD2RN	Klamath TMDL TCD2RN
Shasta River (RM 179.5)						
Scott River (RM 145.1)						
Seiad Valley (RM 132.7)						
Salmon River (RM 66.3)						
Trinity River (RM 43.3)						
Turwar (RM 5.6)						
Klamath River Estuary (RM 0-3.9)						

Reach	Water Quality Parameter					
	Water Temperature	Sediment and Turbidity	Dissolved Oxygen		Nutrients	pH
	Long-term[1]	Short-term[2]	Short-term[2]	Long-term[1]	Long-term[1]	Long-term[1]
Three Dam Removal Alternative, Two Dam Removal Alternative						
Downstream from J.C. Boyle Reservoir (RM 229.8)						
Oregon-California State line (RM 214.1)						
Downstream from Iron Gate Dam (RM 193.1)	~~KRWQM~~2004/2005 KRWQM WIGC[3] RBM10			~~KRWQM~~2004/2005 KRWQM WIGC[3]		
Shasta River (RM 179.5)						
Scott River (RM 145.1)						
Seiad Valley (RM 132.7)						
Salmon River (RM 66.3)						
Trinity River (RM 43.3)						
Turwar (RM 5.6)						
Klamath River Estuary (RM 0-3.9)						

1 Long-term—greater than 2 years following dam removal/construction of fish passage facilities or greater than 5 years for the No Project Alternative

2 Short-term—less than 2 years following dam removal/construction of fish passage facilities or 1–5 years for the No Project Alternative.

3 ~~KRWQM~~2004/2005 KRWQM results for the scenarios shown are available for the mainstem Klamath River immediately downstream from Iron Gate Dam, at the Scott River confluence, and at the Salmon River confluence (PacifiCorp 2004, 2005). While the KRWQM was run for the Hydroelectric Reach, results for that reach were not presented in PacifiCorp (2004, 2005).

Key:

Klamath TMDL T4BSRN—with-dams Oregon and California TMDLs allocation scenario (Tetra Tech 2009b).

Klamath TMDL T1BSR—natural conditions baseline scenario for California TMDLs (Tetra Tech 2009b). The T1BSR natural conditions scenario is useful for analyzing those water quality parameters that rely on a comparison to background or natural levels for regulatory water quality standards, such as water temperature and dissolved oxygen.

Klamath TMDL TOD2RN—Oregon TMDLs allocation scenario (Tetra Tech 2009b).

Klamath TMDL TCD2RN—California TMDLs allocation scenario (Tetra Tech 2009b).

~~KRWQM~~2004/2005 KRWQM WIGCJCB—Klamath River Water Quality Model Without Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle dams scenario (Watercourse Engineering, Inc. 2003, PacifiCorp 2004)

Volume II Appendix D Section D.1.1 Available Numeric Models for Analysis of the Proposed Project and Alternatives – Klamath River TMDL Model, Table D-2 Comparison of Assumptions and Parameters for Available Numeric Models to Conditions Used for the Assessment of Potential Water Quality Impacts on page D-5:

Table D-2. Comparison of Assumptions and Parameters for Available Numeric Models to Conditions Used for the Assessment of Potential Water Quality Impacts.

Assumptions/Model Parameters	**Available Numeric Models for Long-term Conditions**			**Conditions Considered for Lower Klamath Project EIR**			
	~~KRWQM~~2004/2005 KRWQM	**Klamath TMDL**	**RBM10**	**Proposed Project, Partial Removal Alternative, No Hatchery Alternative**	**No Project and Continued Operations with Fish Passage Alternative**	**Three Dam Removal**	**Two Dam Removal**
Water quality constituents considered	• Water temperature [1] • Dissolved oxygen[1] • Nutrients • Chlorophyll-a	• Water temperature • Dissolved oxygen • Nutrients • pH • Chlorophyll-a	• Water temperature	• Water temperature • Suspended material • Dissolved oxygen • Nutrients • pH • Chlorophyll-a			

Assumptions/Model Parameters	Available Numeric Models for Long-term Conditions			Conditions Considered for Lower Klamath Project EIR			
	~~KRWQM~~2004/2005 KRWQM	Klamath TMDL	RBM10	Proposed Project, Partial Removal Alternative, No Hatchery Alternative	No Project and Continued Operations with Fish Passage Alternative	Three Dam Removal	Two Dam Removal
Dams remaining in-place (different modeling scenario names are shown in quotations for ~~KRWQM~~2004/2005 KRWQM and the Klamath TMDL model)	• “WOP” and “WOP2” = Link River • “WIGCJCB” = Link River and Keno • “WIGC” = Link River, Keno, J.C. Boyle • “WIG” = Link River, Keno, J.C. Boyle, Copco No. 1 and 2 • “EC” = Link River, Keno, J.C. Boyle, Copco No. 1 and 2, Iron Gate	• “T4BSRN” = Link River, Keno, J.C. Boyle, Copco No. 1 and 2, Iron Gate • “TOD2RN” and “TCD2RN” = Link River and Keno Reef [2] • “T1BSR” = Link River and Keno Reef [2]	“No Action Alternative” = J.C. Boyle, Copco No. 1, Copco No. 2, Iron Gate	None	J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate	J.C. Boyle	J.C. Boyle and Copco No. 2

Assumptions/Model Parameters	**Available Numeric Models for Long-term Conditions**			**Conditions Considered for Lower Klamath Project EIR**			
	~~KRWQM~~2004/2005 KRWQM	**Klamath TMDL**	**RBM10**	**Proposed Project, Partial Removal Alternative, No Hatchery Alternative**	**No Project and Continued Operations with Fish Passage Alternative**	**Three Dam Removal**	**Two Dam Removal**
Flows	• Existing conditions for 2000–2004 [3] • NMFS 2002 Biological Opinion Mandatory Flows for the Klamath Project	Existing conditions for 2000 [4]	2010 Biological Opinion Mandatory (NMFS) and KBRA Flows[5]	See Section 3.1.6	See Sections 4.2.1.2 and 4.4.1.1	See Section 4.6.1.1	See Section 4.5.1.1
Reaches	Link River Dam (RM 259.7) to Turwar (RM 5.6)	Link River Dam (RM 259.7) to the Klamath River Estuary (RM 0–3.9)	Link River Dam (RM 259.7) to the Pacific Ocean	J.C. Boyle Reservoir (RM 233.3) to the Klamath River Estuary (RM 0–3.9)			
Analysis year(s)	2000–2004	2000	2012–2061	As detailed in EIR Sections 3 and 4			
Climate change	Not included	Not included	Included				

Assumptions/Model Parameters	Available Numeric Models for Long-term Conditions			Conditions Considered for Lower Klamath Project EIR			
	~~KRWQM~~2004/2005 KRWQM	Klamath TMDL	RBM10	Proposed Project, Partial Removal Alternative, No Hatchery Alternative	No Project and Continued Operations with Fish Passage Alternative	Three Dam Removal	Two Dam Removal
Nutrients							
Upper Klamath Lake and inputs to Keno Impoundment[6]	Current conditions at the time of the model development[7]	OR and CA full TMDL compliance [8]	Not applicable	• Eventual OR and CA full TMDL compliance[8] • Timescale assumed to be decades			
Small tributaries to the lower Klamath River (i.e., Iron Gate Dam to Klamath River Estuary)	• TN: 0.275 mg/L • TP: 0.075 mg/L	• TN: 0.077 mg/L [10] • TP: 0.014 mg/L [10]	Not applicable	See assumptions for Klamath TMDL			

Assumptions/Model Parameters	**Available Numeric Models for Long-term Conditions**			**Conditions Considered for Lower Klamath Project EIR**			
	~~KRWQM~~2004/2005 KRWQM	**Klamath TMDL**	**RBM10**	**Proposed Project, Partial Removal Alternative, No Hatchery Alternative**	**No Project and Continued Operations with Fish Passage Alternative**	**Three Dam Removal**	**Two Dam Removal**
Algae and particulate organic matter (POM)							
Upper Klamath Lake and inputs to Keno Impoundment[6]	Current conditions at the time of the model development[7]	OR and CA full TMDL compliance[8]	Not applicable	• OR and CA full TMDL compliance[8] • Timescale unknown			
Settling rates in all reservoirs	• Algal settling rate = 1.0 m/day • POM = 0.5 m/day [9]	• Algal settling rate = 0.3 m/day [11] • POM = 0.8 m/day [11]	Not applicable	See assumptions for Klamath TMDL			

[1] Published results available for water temperature and dissolved oxygen in PacifiCorp (2005). Additional results available in the FERC record and as an electronic appendix to http://www.riverbendsci.com/reports-and-publications-1/klam_wq_model_eval.pdf

[2] The historically natural Keno Reef was included in place of Keno Dam, such that the Keno Reach is not characterized as a free-flowing river.

[3] The WOP2 scenario has “smoothed flows” from Klamath Irrigation Project, to account for the fact that if Keno Dam were removed, Link releases would have to be smoothed due to instream flow requirements downstream.

[4] Exceptions to current conditions include the TIBSR model (natural conditions) where dramatically increased summer flows (i.e., no diversions) were assumed for tributaries to the mainstem Klamath River. USBR 2005 "un-depleted natural flows" were used for flows at Link River Dam and Keno Impoundment. For T4BSRN, TOD2RN, and TCD2RN, Shasta River flows are increased by 45 cfs. Hydropower peaking in the J.C. Boyle Peaking Reach was not included in the no-dam scenarios (TOD2RN, TCD2RN, T1BSR) (Tetra Tech 2009a).

[5] While analysis for the Lower Klamath Project EIR considered the 2013 Joint Biological Opinion and the court-ordered flushing and emergency dilution flows, the KBRA and 2013 Joint Biological Opinion flows were determined to be sufficiently similar (see Section 3.1.6) that modeling using KBRA flows was used if modeling using 2013 Joint Biological Opinion flows was not available.

[6] Upper Klamath Lake and inputs to Keno impoundment are model boundary inputs for the available numeric models only. The area of analysis for water quality constituents in the Lower Klamath Project License Surrender only considers the Klamath River in Oregon from J.C. Boyle Reservoir to the Oregon-California State line to the extent that conditions in that reach influence water quality in California. See Section 3.2.1 for further details.

[7] Current conditions at the time of the model development based on combination of individual samples and long-term monthly averages (used when individual samples not available) from Freemont Bridge (near outlet of Upper Klamath Lake, Link Dam, and Eastside/Westside powerhouses. Current conditions at the time of the model development for other inputs to Keno Impoundment are based on combination of individual samples and averages.

[8] Full implementation assumes the decrease in nutrient loads at the Oregon-California State line is 87% for TP and 62% for TN and BOD (calculated from information in Table 2-8, Kirk et al. [2010]). Analysis for the Lower Klamath Project EIR only considered OR TMDL compliance with regard to what crosses the Oregon-California State line into California and how it may influence water quality in the Upper, Mid-, and Lower Klamath Basin in California.

[9] PacifiCorp (2005).

[10] North Coast Regional Board (2010).

[11] Tetra Tech (2009a).

Volume II Appendix D Section D.1.1 Available Numeric Models for Analysis of the Proposed Project and Alternatives – Considerations for the Lower Klamath Project, paragraph 2 on page D-8:

As presented in Table D-2, major differences between the existing numeric models and the conditions considered for water quality analyses in this EIR include the following:

- The Klamath River TMDL TOD2RN and TCD2RN ("dams out") model runs remove PacifiCorp dams and represent Keno Dam as the historical natural Keno Reef, such that the Keno Reach is not characterized as a free-flowing river. The ~~KRWQM~~2004/2005 KRWQM includes a model run retaining Keno. The analysis in this EIR retains Keno Dam for the Proposed Project and all alternatives.
- River flows for the Lower Klamath Project EIR analysis are based on the NMFS and USFWS 2013 Joint Biological Opinion flows (NMFS and USFWS 2013) and the court-ordered flushing and emergency dilutions flows (U.S. District Court 2017), but modeling using KBRA flows are used if modeling using the 2013 Joint Biological Opinion flows are not available. The KBRA and 2013 Joint Biological Opinion flows are sufficiently similar (see Section 3.1.6) that modeling using KBRA flows still captures the range of conditions under 2013 Joint Biological Opinion flows. The river flows used in the Lower Klamath Project EIR analysis tend to be greater than those modeled in either the Klamath River TMDL model (with the exception of T1BSR) or the ~~KRWQM~~2004/2005 KRWQM.
- Climate change was not considered in either the ~~KRWQM~~2004/2005 KRWQM or the Klamath River TMDL model.
- The RBM10 water temperature model includes climate change projections, but uses NMFS 2010 Biological Opinion (NMFS 2010) flows "BO" alternative for the "No Action Alternative" analyzed in the Secretarial Determination studies and KBRA flows for the "Action Alternative" analyzed in the Secretarial Determination studies.

References

Volume II Appendix D Section D.4 References, pages D-16 through D-18, includes the following revisions:

PacifiCorp. 2019. Response to the State Water Resources Control Board request for additional information related to PacifiCorp's February 2019 comments on the draft environmental impact report for the Lower Klamath Project License Surrender. Prepared by PacifiCorp, Portland, Oregon for California State Water Resources Control Board, Sacramento, California.

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APPENDIX E. AN ANALYSIS OF POTENTIAL SUSPENDED SEDIMENT EFFECTS ON ANADROMOUS FISH IN THE KLAMATH BASIN

E.2 Methods

Volume II Appendix E Section E.2 Methods, paragraph 1 on page E-2:

Daily durations of SSC concentrations were modeled assuming the Proposed Project occurred within each of the 48 years in the available hydrology from 1961 through 2009. As described in Chapter 6 of USBR (2012), the 2010 NMFS BiOp (NMFS 2010a) flows were used for modeling suspended sediment, but flow requirements in the Klamath River have changed since the modeling was performed. The NMFS and USFWS 2013 Joint BiOp flows (NMFS and USFWS 2013) along with 2017 court-ordered flushing and emergency dilution flows were required during the period February 2017 – March 2019 ~~are the current key flow requirements to which the LKP must operate~~. The 2019 Biological Opinion flows (2019 BiOp Flows) are now the current operational flow requirement for the Klamath River (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*). The 2013 Joint BiOp and the 2019 BiOp retained the overall magnitude of 2010 BiOp flows, but altered flow conditions by shifting the monthly timing and water year type distribution of flows. As described in Section 4.2.1.1 *[No Project Alternative] Alternative Description* ~~3.1.6 Summary of Available Hydrology Information for the Proposed Project~~, during January through May the 2013 Joint BiOp (NMFS and USFWS 2013) flows~~, that replaced the 2010 BiOp flows,~~ are ~~sufficiently similar~~ within the range of 2010 BiOp Flows ~~to the 2010 BiOp flow releases~~ used in the modeling approximately 99 percent of the time, such that the model results are still representative of the key hydrological factors including timing, frequency, and magnitude of flows released during winter and spring. Peak 2013 BiOp Flows during extremely wet years (1 percent of the time) would not be captured by the 2010 BiOp Flows. Similarly, under the 2019 BiOp Flows, January through May flows are within the range of 2010 BiOp Flows used in the modeling 99.9 percent of the time, and peak 2019 BiOp Flows would not be captured by the 2010 BiOp Flows 0.1 percent of the time (see also Section 4.2.1.1 *[No Project Alternative] Alternative Description*).

E.2.2 Using the Model to Predict Suspended Sediment Concentrations

E.2.2.1 Range of Conditions Assessed

Volume II Appendix E Section E.2.2.1 Methods – Using the Model to Predict Suspended Sediment Concentrations – Range of Conditions Assessed, paragraph 3 on page E-6:

Similarly, by definition, the “extreme conditions for fish” and “worst impacts on fish” described above use a 10 percent threshold of analysis, which means that for any given species and life-stage there are only a few corresponding water years in the modeled hydrologic record during which the predicted high SSCs and associated exposure durations would occur. There are few instances in which the high SSCs condition would occur in the same water year for multiple life-stages of a given species (e.g., two years [4 percent] for coho salmon smolts and adults), and few instances (< 0.5 percent) in which the high SSCs condition would occur in the same water year for multiple species and life-stages. Because the peak 2010 BiOp Flows would not capture the extreme January and February maximum 2013 or 2019 BiOp flows, the modeled SSC peaks using the 2010 BiOp Flows may be slightly underpredicting (0.1 to 1 percent of the time) for extreme conditions for fish under existing conditions.

E.3 Results

E.3.1 Existing Conditions

E.3.1.3 Coho Salmon

Volume II Appendix E Section E.3.1.3 Results – Existing Conditions – Coho Salmon, Table E-4 Predicted Newcombe and Jensen Severity Index and Anticipated Effects on Coho Salmon for Klamath River at Seiad Valley (RM 132.7) on page E-13:

Table E-4. Predicted Newcombe and Jensen Severity Index and Anticipated Effects on Coho Salmon for Klamath River at Seiad Valley (RM 132.7).

Life-history Stage (period)	SEV at Condition s			Effects on Production
	Mild[1]	Median[2]	Extreme[3]	
Adult upstream migrants (Sept 1–Jan 1) 30 days of exposure to median SSC for the period	6.6	7.2	8.5	Moderate to major stress and impaired homing for adults migrating upstream (~4 percent of all populations exposed).

Life-history Stage (period)	SEV at Conditions			Effects on Production
	Mild[1]	**Median**[2]	**Extreme**[3]	
Spawning, incubation, and fry emergence (Nov 1–Mar 14) 60 days of exposure to highest SSC for the period	11.6	12.2	12.9	No modeling of suspended sediment infiltration into gravel was conducted. Available information suggests 20 to 60 percent mortality of spawning adults, incubating eggs, and emergent fry in the mainstem; typically, a small percentage of the percent of the Upper Klamath River Population spawns in the mainstem as opposed to tributaries.
Age-1 juveniles during winter (Nov 15–Feb 14) Exposure to highest SSC for the period	7.4	8.7	9.9	Moderate to major stress and reduced growth rates depending on conditions for age 1 juveniles rearing the mainstem. An unknown but assumed small number of all juveniles (<1 percent) rear in mainstem during winter.
Age-0 juveniles during summer (Mar 15–Nov 14) Exposure to highest SSC for the period	8.8	9.5	10.2	Major stress to some mortality depending on conditions for age 0 juveniles rearing in mainstem.
Age 1 juvenile outmigration (Feb 15–May 31) 20 days of exposure to ~~median~~ lowest SSC for the period	~~8.3~~6.8	~~8.7~~7.3	~~8.9~~8.1	Moderate to major stress and reduced growth rates depending on conditions for smolts.

[1] Mild conditions for fish = 90 percent exceedance probability
[2] Median conditions for fish = 50 percent exceedance probability
[3] Extreme conditions for Fish (10 percent exceedance probability

Volume II Appendix E Section E.3.1.3 Results – Existing Conditions – Coho Salmon, paragraph 1 on page E-20:

Additional age 0 juveniles depart from tributaries in the Mid-Klamath and Salmon River population units (and possibly others) during fall (Soto et al. 2008, Hillemeier et al. 2009). Some of these have been observed to overwinter in tributaries and off-channel habitats in the lower mainstem Klamath River near or within the estuary (Soto et al. 2008, Hillemeier et al. 2009, Soto et al. 2016). T. Soto (Senior Biologist, Karuk Tribe, pers. comm., 2019) and others have observed that juvenile coho salmon using off-channel habitats during the winter appear to be seeking refuge from high water velocities, as well as refuge from high suspended sediment loads. Very often off-channel areas are disconnected from the main channel, and thus have lower suspended sediment loads (Sullivan et al. 2009). Therefore, coho salmon juveniles rearing in off-channel habitats would be less affected by suspended sediments than fish rearing within the mainstem, ~~which may reduce the amount of time they are exposed to suspended sediment in the mainstem.~~

E.3.2 Proposed Project

Volume II Appendix E Section E.3.2 Results – Proposed Project, paragraph 2 on page E-29:

Model results (USBR 2012) indicate that the ~~significant~~ short-term impact of increased SSCs is limited to one year following the initiation of dam removal regardless of the type of hydrology (i.e., dry, normal, or wet conditions) present during the drawdown period. The SSCs in the Klamath River from the erosion of reservoir sediment deposits would not exceed a two-week duration of increased concentrations greater than 100 mg/L ~~be less than the SSC threshold of significance (i.e., 100 mg/L for two or more consecutive weeks)~~ by the end of post-dam removal year 1 and there would be no substantial~~ignificant~~ increase~~impact~~ due to the release of reservoir sediment deposits currently trapped behind the Lower Klamath Project dams. In the long-term, any SSCs generated by remobilized sediment from dam removal, which is anticipated in the reach from Iron Gate Dam to Cottonwood Creek where sediment deposition is predicted to occur during and following drawdown, would occur during flood events (i.e., flows > 10,250 cfs). During flood events of this magnitude, substantial sediment and debris mobilization would occur with or without dam removal; therefore, no significant difference in the long-term hydrological conditions due to sediment remobilization are anticipated. ~~As a result, the hydrologic conditions beyond the first year following dam removal will have minimal effect toward the impact of increased SSC. After the first year following dam removal, the flow will be confined within the historical main channel and no longer be able to access the remaining fine sediment left on the floodplain, unless an extremely high flood event is to occur. As a result, the suspended sediment condition in the Klamath River after the first year will be similar to~~

~~existing conditions with minimal impact from dam removal under most hydrological conditions. The riverine flows will have the potential to access the reservoir deposits left on the floodplain only during high flood events, during which the additional suspended sediment from erosion of the reservoir deposits is expected to be minor (high flow events carry high concentrations of suspended solids and any increase in SSCs from reservoir sediments would be insignificant).~~ In the following sections, the predicted SSCs and upper error estimates of the predicted SSCs (USBR 2012) are used to assess ~~predicted for~~ the most-likely and worst impacts ~~on fish scenarios are used to evaluate the potential effects of the Proposed Project on~~ anadromous fish species from the Proposed Project.

E.3.2.3 Coho Salmon

Volume II Appendix E Section E.3.2.3 Results – Proposed Project – Coho Salmon, paragraph 4 on page E-35:

Adult coho salmon enter the Klamath River between late September and mid-December, with peak upstream migration occurring between late October and mid-November. Based on adult coho salmon migration observations in the Scott River (2007–2009), Shasta River (2007–2009), and Bogus Creek (2003–2009), on average only approximately 4 percent of adults remain in the mainstem Klamath River after December 15 ~~(initiation of reservoir drawdown under the Proposed Project)~~ (California Department of Fish and Game, unpubl. data).

Volume II Appendix E Section E.3.2.3 Results – Proposed Project – Coho Salmon, paragraph 2 on page E-37:

Under existing conditions, SSCs are typically high during the winter in the mainstem Klamath River and predicted to cause major stress under all scenarios (least impacts on fish, most-likely impacts on fish, or worst impacts on fish). Under the Proposed Project, age-1 juveniles (progeny of the dam removal year 1 cohort) that have either successfully over-summered or moved from tributaries into the mainstem Klamath River during the fall, could be exposed to much higher SSCs in the mainstem during the winter of dam removal than under existing conditions, and may suffer mortality rates of up to 40 percent under a worst impacts on fish scenario (Table E-10). However, many juvenile coho salmon in the mainstem Klamath River appear to migrate downstream to rear and may avoid adverse conditions in the mainstem by using tributary or off-channel habitats during winter, thus reducing high SSC exposure and potential mortality (Soto et al. 2008, Hillemeier et al. 2009, Soto et al. 2016).

References

Volume II Appendix E Section E.6 References, pages E-48 through E-58, includes the following revisions:

Soto, T., D. Hillemeier, S. Silloway, A. Corum, A. Antonetti, M. Kleeman, L. Lestelle. 2016. The role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon (*Oncorhynchus kisutch*): May 2007–August 2011. August 2013 (updated April 2016). Submitted to USBR Mid-Pacific Region, Klamath Area Office, Klamath Falls, Oregon.

Sullivan, S. M. P., and M. C. Watzin. 2009. Stream-floodplain connectivity and fish assemblage diversity in the Champlain Valley, Vermont, U.S.A. Journal of Fish Biology 74: 1,394-1,418.

References cited as part of text included in the Appendix E list of revisions:

Hillemeier, D., T. Soto, S. Silloway, A. Corum, M. Kleeman, and L. Lestelle. 2009. The role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon (*Oncorhynchus kisutch*): May 2007–May 2008. Prepared by Yurok Fisheries Program, Klamath, California; Karuk Tribe Department of Natural Resources, Orleans, California; and Biostream Environmental, Poulsbo, Washington for Bureau of Reclamation, Klamath Falls, Oregon.

NMFS (National Marine Fisheries Service). 2010. Biological opinion on the operation of the Klamath Project between 2010 and 2018. Prepared for Bureau of Reclamation by NOAA Fisheries Service, Southwest Region. https://www.fisheries.noaa.gov/resource/document/2010-klamath-project-biological-opinion.

NMFS and USFWS (U. S. Fish and Wildlife Service). 2013. Biological opinions on the effects of proposed Klamath Project operations from May 31, 2013, through March 31, 2023, on five federally listed threatened and endangered species. Prepared by NMFS, Southwest Region, Northern California Office; and USFWS, Pacific Southwest Region, Klamath Falls Fish and Wildlife Office.

Soto, T., A. Corum, H. Voight, D. Hillemeier, and L. Lestelle. 2008. The role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon (*Oncorhynchus kisutch*). Phase 1 Report: 2006-07 winter. Prepared for Bureau of Reclamation, Mid-Pacific Region, Klamath Area Office, Klamath Falls, Oregon.

USBR (U.S. Bureau of Reclamation). 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration. Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

APPENDIX F. POTENTIAL EFFECTS OF DAM REMOVAL ON CHANNEL BED ELEVATIONS, GRAIN SIZE, AND RELATED ANADROMOUS FISH HABITAT IN THE KLAMATH RIVER

Volume II Appendix F Section F.5.1.2 Proposed Project – Changes in Bed Substrate – Summer Steelhead, paragraph 4 on page F-13:

With the removal of the dams, summer steelhead would be able to re-establish throughout much of their historical range, including the mainstem and tributaries within the Hydroelectric Reach and the upper basin (Hamilton et al. 2005). Under the Proposed Project, improved pool habitat would also benefit rearing summer steelhead. ~~Under the Proposed Project, increased coarse sediment supply and finer channel substrate in the mainstem Klamath River downstream of Iron Gate Dam would improve spawning habitat, and improved pool habitat would benefit rearing summer steelhead.~~

Volume II Appendix F Section F.5.2.2 Proposed Project – Lower Klamath River: Downstream from Iron Gate Dam – Changes in Bed Elevation, paragraph 1 on page F-16:

Short-term (2-year) model simulations—~~-~~focused on reservoir sediment erosion and fine sediment load in the Klamath River following drawdown—~~-~~indicate ~~no significant deposition between Iron Gate Dam and Bogus Creek (RM 192.6),~~ up to about 0.9 feet of reach-averaged deposition between Bogus Creek and Willow Creek (RM 188.0), and up to about 0.4 feet of deposition from Willow Creek to Cottonwood Creek (USBR 2012) (Figure F-11, Figure F-12, Figure F-13). Conservative long-term (50-year) simulations focused on bed elevation change indicate that fine and coarse sediment deposition within 2 years of dam removal may be up to 1.7 feet between Bogus Creek and Willow Creek and up to 0.9 feet between Willow Creek and Cottonwood Creek (see Figure 9-31 in USBR 2012). Model simulations indicate that reaches located farther downstream will change little (< 0.5 feet of erosion or deposition). Eight miles of the Klamath River mainstem channel could potentially be affected by sediment release and resupply, representing 4 percent of the total mainstem channel length downstream of Iron Gate Dam (190 miles). Bed elevations over the long-term (from 5 to 50 years) would adjust to a new equilibrium in response to the restored sediment supply from upstream areas. Model simulations predict up to approximately 1.7 ~~2 to 3~~ feet of aggradation between Iron Gate Dam and Cottonwood Creek over the next 50 years (USBR 2012).

Volume II Appendix F Section F.5.2.2 Proposed Project – Lower Klamath River: Downstream from Iron Gate Dam – Changes in Bed Elevation, Figure F-11

Reach-Averaged Bed Elevation Change for Two Successive Wet, Median, or Dry Water Years Following Dam Removal (based on simulation results provided by USBR, March 2012) on page F-17:

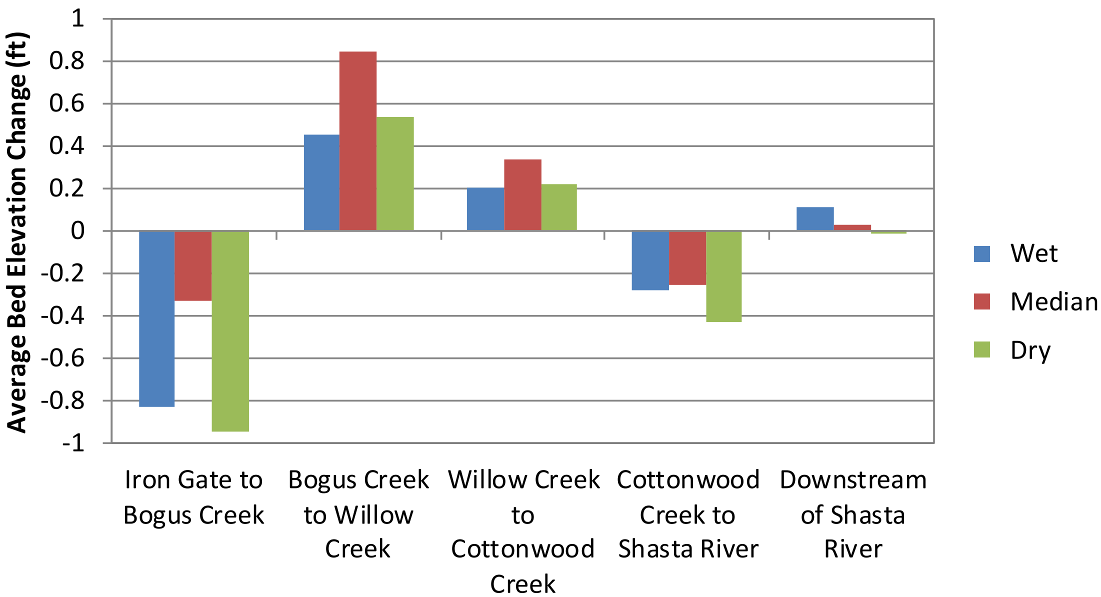

Figure F-11. Reach-Averaged Bed Elevation Change for Two Successive Wet, Median, or Dry Water Years Following Dam Removal (based on simulation results provided by USBR, March 2012). Model results contain more uncertainty in the reach from Iron Gate to Bogus Creek due to data gaps.

Volume II Appendix F Section F.5.2.3 Proposed Project – Lower Klamath River: Downstream from Iron Gate Dam – Changes in Bed Substrate, paragraph 2 on page F-18:

The probability of transporting fine sediment out of the reach ~~from Iron Gate Dam to Bogus Creek~~ depends on flow magnitude and duration. USBR (2012) estimated that a flow of 6,000 cfs in the reach from Bogus Creek to Willow Creek would be the median estimate necessary to initiate flushing of sands and fine material from the bed following dam removal. This flow is approximately equal to the 2-year recurrence interval flood (50 percent probability of occurring in a given year) at Iron Gate.~~ If the dams are removed during a median or dry year, the probability that sand and finer sediment would be flushed from the bed is 50 percent by the end of the first year following removal, 75 percent by the end of second year following removal, and over 95 percent by end of the fifth year following removal.~~

Volume II Appendix F Section F.5.2.3 Proposed Project – Lower Klamath River: Downstream from Iron Gate Dam – Changes in Bed Substrate, paragraph 1 on page F-21:

Under the Proposed Project, the channel bed elevations would increase in response to increased sediment supply. Flows required to mobilize the channel bed would decrease in the reach between Bogus Creek and Cottonwood Creek due to fining of the riverbed. USBR (2012) estimated the magnitude and return period of flows required to mobilize sediment downstream from Iron Gate Dam, 10 years after dam removal, using reach-averaged predicted grain sizes from long-term SRH-1D simulations. The estimates indicate that under the Proposed Project, the threshold for initiation of bed mobilization from Bogus Creek to Willow Creek and from Willow Creek to Cottonwood Creek would range from ~~3~~4,000 to 8,000~~7,000~~ cfs (1.5- to 3.25~~2.5~~-year return period) and ~~5,000~~4,500 to ~~9,000~~8,500 cfs (1.5- to 3~~.2~~-year return period), respectively (the ranges of estimates are based on the variation in the reference shear stress for mobilization [0.025 to 0.035]) (USBR 2012, pages 9-86 to 9-88). These mobility thresholds are lower than under current conditions and the No Project Alternative. Downstream from the Shasta River, there would be no difference in flow magnitudes required for bed mobilization between the Proposed Project and current conditions or the No Project Alternative.

Volume II Appendix F Section F.5.2.3 Proposed Project – Lower Klamath River: Downstream from Iron Gate Dam – Changes in Bed Substrate – Bedload sediment effects on aquatic species – Fall-run Chinook Salmon, paragraph 2 on page F-21:

Bedload sediment effects on aquatic species

Fall-run Chinook Salmon

The Proposed Project Could Have Short-term Effects on Spawning Habitat

The proportion of sand in the channel bed will likely be higher during the first four months following dam removal than under existing conditions. More interstitial sand in the Klamath River channel upstream of the Cottonwood Creek confluence could reduce embryo survival-to-emergence in these reaches (Chapman 1988). ~~The approximately 8-mile affected channel length encompasses only four percent of the current total Klamath River channel length.~~Based on redd surveys indicating an average of 2,100 redds in the mainstem Klamath River (Magneson and Wright 2010), and escapement estimates (CDFG 2010, unpublished data), on average eight percent of all anticipated fall-run Chinook salmon redds occur in the Klamath Basin during fall-run spawning. Less than half of the fall-run Chinook salmon redds (< 1,050 on average, or < 4 percent of Klamath Basin spawners) are constructed within the reach from Iron Gate Dam to Cottonwood Creek (Magneson and Wright 2010) that would be most susceptible to the interstitial sand resulting from dam removal. ~~These e~~Effects would be most apparent in successive median or dry years following dam removal, but less apparent in successive wet years.

References

Volume II Appendix F Section F-11 References, pages F25 through F-27, includes the following revisions:

CDFG. 2010. Klamath River Mainstem Spawner Escapement Estimates, 1978–2009. Unpublished data received from M. Knechtle, Biologist, California Department of Fish and Game, Yreka, California.

Magneson, M. D., and K. Wright. 2010. Mainstem Klamath River fall Chinook salmon redd survey 2009. Arcata Fisheries Data Series Report DS 2010-19. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California.

Other references cited as part of text included in the Appendix F list of revisions:

Chapman, D. W. 1988. Critical Review of Variables Used to Define Effects of Fines in Redds of Large Salmonids. Transactions of the American Fisheries Society 117: 1–21.

USBR (U.S. Bureau of Reclamation). 2012. Hydrology, hydraulics and sediment transport studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration. Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

APPENDIX H. RARE NATURAL COMMUNITES DOCUMENTED IN THE PROJECT VICINITY

Volume II Appendix H, Table H-1 Rare Natural Communities Documented in the Project Vicinity[1] on page H-1:

Table H-1. Rare Natural Communities Documented in the Project Vicinity[1,2].

Natural Community (Holland 1986)	**~~Rank~~[2]Status[3] (Global/State)**	**Habitat Description [3][4]**	**Included in or Excluded from the EIR, and Rationale**	**Corresponding MCV Alliances that are Considered Rare Natural Communities[5]**
Coastal and Valley Freshwater Marsh	G3/S2.1	Dominated by perennial, emergent monocots including tules (*Schoenoplectus* spp.) and cattails (*Typha* spp.). Often forms completely closed canopies.	Included; likely occurs in areas typed as Palustrine within the Primary Area of Analysis.	Slough Sedge Swards, Sand Dune Sedge Swaths, Mats of Floating Pennywort, Quillwort Beds, Yellow Pond-Lily Mats, Water-Parsley Marsh, Hardstem and California Bulrush Marshes, American Bulrush Marsh, Small-Fruited Bulrush Marsh
Darlingtonia Seep	G4/S3.2	Typically on peridotite but also on other parent materials in wet boggy meadows and other habitats saturated with running water that may or may not have peat.[5]	Included; may be habitat in the Primary Area of Analysis.	California Pitcher Plant Fens
Northern Interior Cypress Forest	G2/S2.2	An open forest dominated by cypress (*Cupressus* spp.) that is low in stature, usually less than 49.5 feet. On dry, rocky, sterile, often ultramafic soils.	Included; may be inclusions in forested areas within the Primary Area of Analysis.	Baker Cypress Stands, McNab Cypress Woodland, Sargent Cypress Woodland

Natural Community (Holland 1986)	**~~Rank[2]~~Status[3] (Global/State)**	**Habitat Description ~~[3]~~[4]**	**Included in or Excluded from the EIR, and Rationale**	**Corresponding MCV Alliances that are Considered Rare Natural Communities[5]**
Northern Basalt Flow Vernal Pool[6]	G2/S2.1	A low, amphibious, herbaceous community dominated by annual herbs and grasses. Germination and growth begin with fall rains, often continuing even when inundated. Pools are typically less than 540 square feet. Rising spring temperatures evaporate the pools.	Included; may be habitat in the Primary Area of Analysis.	Needle Spike Rush Stands, Water Blinks – Annual Checkerbloom Vernal Pools
Sitka Spruce Forest	G1/S1.1	Dense forest dominated by Sitka spruce with a dense understory of broadleaved trees, shrubs and perennial herbs, including several species of ferns.	Included; may be inclusions in forested areas immediately adjacent to the coast within the Primary Area of Analysis.	Sitka Spruce Forest
Upland Douglas-fir Forest	G4/S3.1	A mixed-age climax forest dominated by Douglas-fir (*Pseudotsuga menziesii*). Stands are typically even-aged and dense with canopy closure greater than 70 percent. Sites typically occur on moderately deep, well-drained soils.	Included; may be inclusions in areas typed as Douglas Fir within the Primary Area of Analysis.	Douglas Fir – Tanoak Forest

[1] Source: CDFW. 2017. California Natural Diversity Database. RareFind5. Electronic database. Natural Heritage Division, California Department of Fish and Game, Sacramento, California. https://map.dfg.ca.gov/rarefind/view/RareFind.aspx [Accessed May 2017].

[2] Details regarding what rare natural communities are documented and may have potential habitat in the Secondary Area of Analysis are not included since this area was analyzed at a programmatic level.

[~~2~~3] Status:

Global Rank

- G1 Critically Imperiled—At very high risk of extinction due to extreme rarity (often five or fewer populations), very steep declines, or other factors.
- G2 Imperiled: At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
- G3 Vulnerable: At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
- G4 Apparently Secure: Uncommon but not rare; some cause for long-term concern due to declines or other factors.

State Rank

- S1 Critically Imperiled—Critically imperiled in the state because of extreme rarity (often five or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state/province.
- S2 Imperiled: Imperiled in the nation or state/province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the nation or state/province.
- S3 Vulnerable: Vulnerable in the nation or state/province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.

Additional Threat Ranks

- 0.1 Very Threatened
- 0.2 Threatened

[~~3~~4] Holland, R. F. 1986. Preliminary descriptions of the terrestrial natural communities of California. California Department of Fish and Game, Nongame-Heritage Program, Sacramento, California. unless otherwise noted.

~~[4] Details regarding what rare natural communities are documented and may have potential habitat in the Secondary Area of Analysis are not included since this area was analyzed at a programmatic level.~~

[5] ~~Sawyer, J. O., T. Keeler-Wolf, and J. M. Evens. 2009. A manual of California vegetation. Second edition. California Native Plant Society Press, in collaboration with California Department of Fish and Game. Sacramento. CNPS (California Native~~

~~Plant Society).~~ CNPS (California Native Plant Society). 2019. A manual of California vegetation. Online edition. California Native Plant Society, Sacramento, California. Available at: http://www.cnps.org/cnps/vegetation/

6 Listed as “Northern Vernal Pool” in CNDDB; assumed based on distribution to be Northern Basalt Flow Vernal pool Holland Type.

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APPENDIX J. SPECIAL-STATUS PLANT, FISH, AND WILDLIFE SCOPING LIST

Volume II Appendix J, Table J-3 Special-status Terrestrial Wildlife Documented in the Project Vicinity, new row 2 on page J-75:

Common Name Scientific Name	Status[a] Federal/ State/USDA Forest Service, US Bureau of Land Management	Query Sources	Distribution in California	Habitat Association	Included in or Excluded from EIR, and Rationale
Canada Lynx *Lynx canadensis*	FT/--/--	USFWS	The range of the species in Oregon does not extend into California	Boreal forests	Excluded from further analysis. The species range includes Oregon, but does not include California (USFWS 2019[b]).

[a] Status codes:

Federal:

FE = Listed as endangered under the federal Endangered Species Act
FT = Listed as threatened under the federal Endangered Species Act
FPT = Federally proposed as threatened
BGEPA = Federally protected under the Bald and Golden Eagle Protection Act
FSS = Forest Service Sensitive species
BLMS = Bureau of Land Management Sensitive Species

State:

SE = Listed as Endangered under the California Endangered Species Act
ST = Listed as Threatened under the California Endangered Species Act
SCE = State Candidate Endangered
SCT = State Candidate Threatened
SSC = CDFW Species of Special Concern
SFP = CDFW Fully Protected species

[b] USFWS (U.S. Fish and Wildlife Service). 2019. ECOS species profile for Canada Lynx (Lynx canadensis). Website. Available at: https://ecos.fws.gov/ecp0/profile/speciesProfile?sId=3652#crithab [Accessed March 2020].

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APPENDIX S. RECREATION SUPPORTING TECHNICAL INFORMATION

After circulation of the Draft EIR, the applicable biological opinion and the operational flow requirements for the Klamath River changed and changes to this appendix to address those changes are printed in this Final EIR Appendix S. None of the changes result in significant new information in the EIR under the meaning of CEQA Guidelines, section 15088.5, subdivision (a):

> New information added to an EIR is not 'significant' unless the EIR is changed in a way that deprives the public of a meaningful opportunity to comment upon a substantial adverse environmental effect of the project or a feasible way to mitigate or avoid such an effect (including a feasible project alternative) that the project's proponents have declined to implement.

However, the changes were numerous enough that reprinting the section rather than simply including a list of revisions was warranted to improve clarity and readability of the document.

As part of the 2012 KHSA EIS/EIR, potential changes in recreation opportunities were modeled by evaluating flow variations between the No Project ("dams in" scenario using the 2010 BiOp Flows) and the Proposed Project ("dams out" scenario using the KBRA Flows), since river flows influence when certain recreational activities could occur. The 2012 KHSA EIS/EIR modeling estimated the flows in multiple reaches of the Klamath River and the analysis compared those modeled flows with the acceptable range of flows for whitewater boating and fishing by reach to estimate the average number of days when those recreational activities could occur under each scenario. The analysis of potential changes in recreation opportunities from the 2012 KHSA EIS/EIR is reproduced in this appendix in Sections S.1 and S.2.

Flow requirements in the Klamath River have changed since the modeling for the 2012 KHSA EIS/EIR was performed. Separate and independent of the Proposed Project, the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) issued a Joint Biological Opinion for the Klamath Irrigation Project in 2013 specifying the hydrology requirements for the Klamath River (2013 BiOp Flows) and the standard to which the USBR Klamath Irrigation Project operated at that time (NMFS and USFWS 2013). Accordingly, the 2013 BiOp Flows served as the operational flow requirement for the Klamath River at the time of the Notice of Preparation for the Lower Klamath Project EIR (i.e., December 22, 2016), as detailed in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*. For the Lower Klamath Project EIR, the 2013 BiOp Flows serve as an existing conditions CEQA baseline and they replace both the KBRA Flows ("dams out" scenario [i.e., Proposed Project]) and the 2010 BiOp Flows ("dams in" scenario [i.e., No Project Alternative]) in the previous 2012 KHSA EIS/EIR recreational flow analysis.

After the issuance of the Lower Klamath Project Draft EIR on December 27, 2018, the applicable biological opinion and the operational flow requirements for the Klamath River changed again in March 2019, when the new biological opinions were issued by NMFS (2019) and USFWS (2019). The 2019 BiOp Flows are now the current operational flow requirement for the Klamath River and as such they are analyzed in the Lower Klamath Project Final EIR as a second CEQA baseline, representing flows under newly defined existing conditions (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*). The potential change in the average number of days of acceptable river flows for whitewater boating and fishing under "dams out" and "dams in" conditions are analyzed in the Lower Klamath Project Final EIR using both the 2013 BiOp Flows, which were the applicable flows when the Lower Klamath Project Notice of Preparation was issued, and the 2019 BiOp Flows, which became the applicable flows after March 2019. Section S.3 presents an analysis of the changes in the 2012 KHSA EIS/EIR flow-dependent recreational opportunities due to differences between the previously modeled flows and the 2013 BiOp and the 2019 BiOp Flows.

The Proposed Project, the data modeled as part of the 2012 KHSA EIS/EIR, and the recreational opportunities under the 2013 BiOp Flows and the 2019 BiOp Flows are further discussed in Section 3.20.5 *[Recreation] Potential Impacts, Impacts, and Mitigation*.

S.1 Potential Flow Changes That May Alter Flow-Dependent Recreation

Flow-dependent recreational activities on the Klamath River include whitewater boating and fishing. River flows may change based on the various future management scenarios (i.e., "dams in" versus "dams out") and could subsequently affect the availability and the quality of the recreation experience. Optimal and acceptable flows for various recreation opportunities along reaches of the Klamath River were developed as a part of technical studies completed during the relicensing process (FERC 2007). Optimal and acceptable flow levels can be compared with existing or proposed levels to assess the effect on various recreation activities. River flows under both No Project and Proposed Project alternatives have been modeled by U.S. Bureau of Reclamation (USBR); results of the models are used to project the effects on recreation activities within the various river reaches.

The following tables summarize flows acceptable for fishing and whitewater boating opportunities in the various reaches of the Klamath River. Table S-1 provides a summary for each of the major river reaches where whitewater boating and fishing currently take place. Table S-2 summarizes monthly changes in flows for the Hells Corner Reach specifically for two sets of flow conditions (1,000 to 3,500 cfs and 1,300 to 3,500 cfs) that may be deemed acceptable for different types of whitewater boating. Tables S-3 through S-8 include the number of days per month with acceptable flows for each activity under the No Project Alternative (“dams in”) and the Proposed Project (“dams out”). This data is also presented graphically in Section 3.20 *Recreation*. In Tables S-3 through S-8, it is assumed that flows less than 1,300 cfs are not acceptable for whitewater boating in order not to understate the potential impact of the Proposed Project on whitewater boating. However, the impact of dam removal on whitewater boating could be smaller if acceptable flows for some types of whitewater boating occur between 1,000 and 1,300 cfs.

Table S-1. Summary of Acceptable Flow Data for Whitewater Boating and Fishing. (Table reproduced from Table R-1 in 2012 KHSA EIS/EIR Volume II.)

River Reach	Activity	Acceptable Flows		Total Avg. Annual No Days with Acceptable Flows		Percent Difference
		Low Value (cfs)	High Value (cfs)	Dams In	Dams Out	
Keno Reach	Whitewater Boating	1,000	4,000	151.29	139.30	-7.93%
	Fishing	200	1,500	246.10	237.53	-3.48%
J.C. Boyle Bypass Reach	Whitewater Boating	1,300	1,800	4.63	41.35	793.56%
	Fishing	200	1,000	106.96	141.86	32.63%
Hells Corner Reach	Whitewater Boating/Kayaking	1,000	3,500	331.61	187.67	- 43%
	Whitewater Boating/Rafting	1,300	3,500	277.98	119.33	-57.07%
	Fishing	200	1,500	234.37	228.07	-2.69%
Copco No. 2 Bypass Reach	Whitewater Boating	600	1,500	10.22	223.09	2083.83%
	Fishing	50	600	13.75	2.84	-79.36%
Iron Gate to Scott River	Whitewater Boating/Fishing	800	4,000	278.04	280.86	1.01%
Scott River to Salmon River	Boating	800	7,000	242.96	246.26	1.36%
	Fishing	800	4,000	174.92	182.23	4.18%
Salmon River to Trinity River	Whitewater Boating/Fishing	800	10,000	207.00	210.67	1.78%
Trinity River to Ocean	Whitewater Boating/Fishing	1,800	18,000	238.86	238.33	-0.22%

Source: USBR 2012b,c; PacifiCorp 2004; FERC 2007; Greimann 2012.

Table S-2. Hells Corner – Whitewater Boating Recreation Days from two Different Criteria for "Acceptable Flows." (Table reproduced from Table R-2 in 2012 KHSA EIS/EIR Volume II.)

Month	1,000–3,500 cfs			1,300–3,500 cfs		
	Dams In	Dams Out Days	% Change Days	Dams In Days	Dams Out Days	% Change Days
January	26.27	16.00	39%	20.88	13.4	36%
February	21.94	11.65	47%	17.80	10.3	42%
March	22.59	18.23	19%	21.78	15.7	28%
April	21.80	18.81	14%	20.27	15.4	24%
May	26.88	22.37	17%	25.90	19.5	25%
June	29.96	25.14	16%	28.78	20.3	29%
July	30.41	15.40	49%	17.27	11.0	36%
August	31.00	13.09	58%	19.45	2.3	88%
September	30.00	19.47	35%	17.04	4.1	76%
October	31.00	10.48	66%	31.00	0	100%
November	30.00	6.79	77%	29.43	1	97%
December	29.76	10.24	66%	28.35	4.3	85%
Total	331.61	187.67	43%	277.95	117.3	58%

Source: Greimann 2012.

S.2 Recreational Flow Analysis

The recreation analysis evaluated and estimated the effect of potential future river flows on different recreation activities along various reaches of the Klamath River. High and low flow values for the recreation activities along the various reaches are provided in the following tables. Flow values that fall within these ranges are considered necessary for the various activities to occur. The Klamath Project Simulation Model (KPSIM) coupled to a daily operations model of the Klamath River below Link Dam for the No Project and the Proposed Project alternatives estimated the duration of recreational flows by reach. For additional information on the KPSIM model please refer to the USBR (2012a) report, "Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration, Technical Report No. SRH-2011-02."

The average, the maximum, and minimum number of days by month that the river is expected to be within the high and low value are listed on each row of Tables S-3 through S-8. The results are provided for wet, average, and dry start years under both the No Project ("dams in") and Proposed Project ("dams out") alternatives. The data provided for the Proposed Project are only for the years following dam removal (post-2019).

The Hells Corner Reach is a peaking reach and daily averages do not adequately capture conditions. Therefore, the following conditions must be met in order to be considered within range:

Whitewater Boating: Flows are within the desirable range between 10 a.m. and 2 p.m.

Fishing: Flows are within the desirable range for at least 4 hours either between 5 a.m. and 11 a.m., or between 3 p.m. and 9 p.m.

Table S-3. Analysis for Proposed Project, All Years, Average Number of Days.
(Table reproduced from Table R-3 in 2012 KHSA EIS/EIR Volume II.)

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Average Number of Days within Flow Range												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WY Total
Keno Reach	Whitewater Boating—Standard	1,000	4,000	15.7	12.0	20.5	19.3	23.2	20.9	12.3	2.9	4.2	0.0	2.0	6.5	139.3
	Play Boating	1,100	1,800	6.4	1.9	4.5	5.4	5.7	5.6	6.4	1.4	2.8	0.0	0.8	3.3	44.1
	Fishing	200	1,500	14.9	13.2	6.9	6.3	10.0	14.0	24.4	31.0	30.0	31.0	28.6	27.1	237.5
J.C. Boyle Bypass Reach	Whitewater Boating—Standard	1,300	1,800	3.8	1.9	4.4	3.7	5.8	5.7	7.2	2.3	4.1	0.0	0.0	2.4	41.3
	Fishing	200	1,000	11.6	11.1	3.0	1.4	4.9	4.8	15.6	17.9	10.5	20.5	22.8	19.1	141.9
Hells Corner Reach	Whitewater Boating	1,200	3,500	13.8	10.3	16.1	16.0	21.5	21.6	13.8	3.7	5.5	0.1	1.0	5.2	130.9
	Fishing	200	1,500	14.2	13.1	6.1	5.6	8.6	12.5	22.1	30.2	30.0	31.0	28.6	26.0	228.1
Copco No. 2 Bypass Reach	Whitewater Boating	600	1,500	13.5	12.4	6.1	5.6	8.6	12.5	22.1	30.2	30.0	31.0	28.6	24.5	223.1
	Fishing	50	600	0.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	2.8

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Average Number of Days within Flow Range												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WY Total
Iron Gate to Scott River	Whitewater Boating	800	4,000	21.1	16.6	12.7	13.8	19.2	24.3	29.6	31.0	30.0	29.7	26.9	25.8	280.9
	Fishing	800	2,500	12.7	9.9	5.1	5.5	6.4	14.3	24.8	31.0	30.0	29.7	24.7	20.7	215.1
Scott River to Salmon River	Boating	800	7,000	14.6	9.5	7.5	8.8	14.2	23.7	30.2	31.0	30.0	31.0	26.3	19.3	246.3
	Fishing	800	4,000	5.5	3.9	2.0	2.6	4.7	12.7	26.7	31.0	30.0	30.9	21.8	10.9	182.2
Salmon River to Trinity River	Whitewater Boating/ Fishing	800	10,000	8.7	5.0	3.4	4.7	9.6	20.4	30.5	31.0	30.0	30.9	23.8	13.0	210.7
Trinity River to Ocean	Whitewater Boating/ Fishing	1,800	18,000	11.8	6.9	5.6	10.1	16.0	25.0	30.5	30.3	30.0	30.8	25.3	16.2	238.3

Source: USBR 2012b,c; PacifiCorp 2004; FERC 2007; Greimann 2012.

Table S-4. Analysis for Proposed Project, All Years, Maximum Number of Days.
(Table reproduced from Table R-4 in 2012 KHSA EIS/EIR Volume II.)

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Maximum Number of Days within Flow Range												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WY Total
Keno Reach	Whitewater Boating—Standard	1,000	4,000	31	29	31	30	31	30	31	31	30	0	30	31	271
	Play Boating	1,100	1,800	31	28	31	30	31	30	31	31	30	0	30	31	180
	Fishing	200	1,500	31	29	31	30	31	30	31	31	30	31	30	31	366
J.C. Boyle Bypass Reach	Whitewater Boating—Standard	1,300	1,800	31	28	31	30	31	30	31	31	30	0	1	24	117
	Fishing	200	1,000	31	29	31	30	31	30	31	31	30	31	30	31	365
Hells Corner Reach	Whitewater Boating	1,200	3,500	31	29	31	30	31	30	31	31	30	1	30	31	242
	Fishing	200	1,500	31	29	31	30	31	30	31	31	30	31	30	31	366
Copco No. 2 Bypass Reach	Whitewater Boating	600	1,500	31	29	31	30	31	30	31	31	30	31	30	31	366
	Fishing	50	600	29	29	0	0	0	0	0	0	0	0	0	31	89

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Maximum Number of Days within Flow Range												
				Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**WY Total**
Iron Gate to Scott River	Whitewater Boating	800	4,000	31	29	31	30	31	30	31	31	30	31	30	31	366
	Fishing	800	2,500	31	29	31	30	31	30	31	31	30	31	30	31	366
Scott River to Salmon River	Boating	800	7,000	31	29	31	30	31	30	31	31	30	31	30	31	366
	Fishing	800	4,000	31	29	31	30	31	30	31	31	30	31	30	31	366
Salmon River to Trinity River	Whitewater Boating/ Fishing	800	10,000	31	29	31	30	31	30	31	31	30	31	30	31	366
Trinity River to Ocean	Whitewater Boating/ Fishing	1,800	18,000	31	29	31	30	31	30	31	31	30	31	30	31	366

Source: USBR 2012b,c; PacifiCorp 2004; FERC 2007; Greimann 2012.

Table S-5. Analysis for Proposed Project, All Years, Minimum Number of Days.
(Table reproduced from Table R-5 in 2012 KHSA EIS/EIR Volume II.)

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Minimum Number of Days within Flow Range												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WY Total
Keno Reach	Whitewater Boating—Standard	1,000	4,000	0	0	0	0	0	0	0	0	0	0	0	0	0
	Play Boating	1,100	1,800	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fishing	200	1,500	0	0	0	0	0	0	0	30	30	31	0	0	92
J.C. Boyle Bypass Reach	Whitewater Boating—Standard	1,300	1,800	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fishing	200	1,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Hells Corner Reach	Whitewater Boating	1,200	3,500	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fishing	200	1,500	0	0	0	0	0	0	0	0	30	31	0	0	91
Copco No. 2 Bypass Reach	Whitewater Boating	600	1,500	0	0	0	0	0	0	0	0	30	31	0	0	91
	Fishing	50	600	0	0	0	0	0	0	0	0	0	0	0	0	0

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Minimum Number of Days within Flow Range												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WY Total
Iron Gate to Scott River	Whitewater Boating	800	4,000	0	0	0	0	0	0	1	30	30	3	2	0	152
	Fishing	800	2,500	0	0	0	0	0	0	0	30	30	3	0	0	99
Scott River to Salmon River	Boating	800	7,000	0	0	0	0	0	0	4	31	30	31	0	0	137
	Fishing	800	4,000	0	0	0	0	0	0	0	30	30	28	0	0	104
Salmon River to Trinity River	Whitewater Boating/ Fishing	800	10,000	0	0	0	0	0	0	16	30	30	29	0	0	124
Trinity River to Ocean	Whitewater Boating/ Fishing	1,800	18,000	0	0	0	0	0	0	17	1	30	24	0	0	136

Source: USBR 2012b,c; PacifiCorp 2004; FERC 2007; Greimann 2012.

Table S-6. Analysis for No Project, All Years, Average Number of Days.
(Table reproduced from Table R-6 in 2012 KHSA EIS/EIR Volume II.)

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Average Number of Days within Flow Range												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WY Total
Keno Reach	Whitewater Boating—Standard	1,000	4,000	16.1	13.7	19.6	18.0	24.5	22.9	1.8	0.0	0.0	7.9	11.8	14.9	151.3
	Play Boating	1,100	1,800	2.7	0.0	3.6	3.6	7.3	11.2	0.0	0.0	0.0	0.6	5.3	2.5	36.8
	Fishing	200	1,500	16.4	12.2	7.9	13.5	11.6	21.0	30.9	31.0	30.0	31.0	22.9	17.7	246.1
J.C. Boyle Bypass Reach	Whitewater Boating—Standard	1,300	1,800	0.1	1.3	1.7	0.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.4	4.6
	Fishing	200	1,000	12.5	6.7	10.5	12.1	12.8	9.5	1.2	0.0	6.5	18.9	7.6	8.6	107.0
Hells Corner Reach	Whitewater Boating	1,200	3,500	23.4	18.7	22.6	21.6	26.3	29.9	24.4	26.7	27.1	31.0	30.0	29.2	310.9
	Fishing	200	1,500	15.0	12.2	7.3	13.4	9.7	15.2	30.8	31.0	30.0	31.0	21.2	17.5	234.4
Copco No. 2 Bypass Reach	Whitewater Boating	600	1,500	0.9	2.5	3.2	2.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.7	10.2
	Fishing	50	600	2.1	2.5	2.8	2.7	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7
Iron Gate to	Whitewater Boating	800	4,000	20.3	13.8	12.2	15.0	17.3	24.4	30.9	31.0	30.0	31.0	29.1	23.0	278.0

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Average Number of Days within Flow Range												
				Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**WY Total**
Scott River																
	Fishing	800	2,500	10.8	7.0	5.4	7.4	6.4	17.5	30.1	31.0	30.0	30.5	23.5	14.3	214.0
Scott River to Salmon River	Boating	800	7,000	13.7	8.3	7.1	10.2	13.2	24.0	30.9	31.0	30.0	30.8	26.0	17.8	243.0
	Fishing	800	4,000	4.1	2.5	1.2	2.2	3.9	13.0	29.4	31.0	30.0	30.3	19.6	7.6	174.9
Salmon River to Trinity River	Whitewater Boating/ Fishing	800	10,000	8.7	4.1	2.8	4.5	9.0	21.0	30.7	31.0	30.0	30.5	23.2	11.6	207.0
Trinity River to Ocean	Whitewater Boating/ Fishing	1,800	18,000	11.7	6.2	6.1	10.1	16.2	25.5	30.7	30.4	30.0	30.7	25.3	15.9	238.9

Source: USBR 2012b,c; PacifiCorp 2004; FERC 2007; Greimann 2012.

Table S-7. Analysis for No Project, All Years, Maximum Number of Days.
(Table reproduced from Table R-7 in 2012 KHSA EIS/EIR Volume II.)

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Maximum Number of Days within Flow Range												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WY Total
Keno Reach	Whitewater Boating—Standard	1,000	4,000	31	29	31	30	31	30	31	0	0	31	30	31	245
	Play Boating	1,100	1,800	31	0	31	30	31	30	0	0	0	31	30	31	142
	Fishing	200	1,500	31	29	31	30	31	30	31	31	30	31	30	31	366
J.C. Boyle Bypass Reach	Whitewater Boating—Standard	1,300	1,800	2	20	29	8	11	0	0	0	0	0	0	19	48
	Fishing	200	1,000	31	29	31	30	31	30	31	0	30	31	30	31	245
Hells Corner Reach	Whitewater Boating	1,200	3,500	31	29	31	30	31	30	31	31	30	31	30	31	366
	Fishing	200	1,500	31	29	31	30	31	30	31	31	30	31	30	31	366
Copco No. 2 Bypass Reach	Whitewater Boating	600	1,500	31	28	31	20	18	1	0	0	0	0	0	20	83
	Fishing	50	600	29	25	31	29	30	1	0	0	0	0	0	1	59

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Maximum Number of Days within Flow Range												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WY Total
Iron Gate to Scott River	Whitewater Boating	800	4,000	31	29	31	30	31	30	31	31	30	31	30	31	366
	Fishing	800	2,500	31	29	31	30	31	30	31	31	30	31	30	31	366
Scott River to Salmon River	Boating	800	7,000	31	29	31	30	31	30	31	31	30	31	30	31	366
	Fishing	800	4,000	31	29	31	30	31	30	31	31	30	31	30	31	366
Salmon River to Trinity River	Whitewater Boating/ Fishing	800	10,000	31	29	31	30	31	30	31	31	30	31	30	31	366
Trinity River to Ocean	Whitewater Boating/ Fishing	1,800	18,000	31	29	31	30	31	30	31	31	30	31	30	31	366

Source: USBR 2012b,c; PacifiCorp 2004; FERC 2007; Greimann 2012.

Table S-8. Analysis for No Project, All Years, Minimum Number of Days.
(Table reproduced from Table R-8 in 2012 KHSA EIS/EIR Volume II.)

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Minimum Number of Days within Flow Range												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	WY Total
Keno Reach	Whitewater Boating—Standard	1,000	4,000	0	0	0	0	0	0	0	0	0	0	0	0	0
	Play Boating	1,100	1,800	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fishing	200	1,500	0	0	0	0	0	0	30	31	30	31	0	0	122
J.C. Boyle Bypass Reach	Whitewater Boating—Standard	1,300	1,800	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fishing	200	1,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Hells Corner Reach	Whitewater Boating	1,200	3,500	0	0	0	0	0	29	0	0	0	31	30	0	183
	Fishing	200	1,500	0	0	0	0	0	0	30	31	30	30	0	0	122
Copco No. 2 Bypass Reach	Whitewater Boating	600	1,500	0	0	0	0	0	0	0	0	0	0	0	0	0
	Fishing	50	600	0	0	0	0	0	0	0	0	0	0	0	0	0

River Reach	Activity	Low Value (cfs)	High Value (cfs)	Minimum Number of Days within Flow Range												
				Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**WY Total**
Iron Gate to Scott River	Whitewater Boating	800	4,000	0	0	0	0	0	0	29	31	30	31	20	0	144
	Fishing	800	2,500	0	0	0	0	0	0	15	31	30	3	0	0	121
Scott River to Salmon River	Boating	800	7,000	0	0	0	0	0	0	28	31	30	19	0	0	133
	Fishing	800	4,000	0	0	0	0	0	0	12	31	30	1	0	0	101
Salmon River to Trinity River	Whitewater Boating/ Fishing	800	10,000	0	0	0	0	0	0	22	30	30	9	0	0	128
Trinity River to Ocean	Whitewater Boating/ Fishing	1,800	18,000	0	0	0	0	0	0	22	1	30	18	0	0	138

Source: USBR 2012b,c; PacifiCorp 2004; FERC 2007; Greimann 2012.

S.3 Changes in 2012 KHSA EIS/EIR Model Results Due to Variations Between KBRA Flows and 2013 BiOp Flows or KBRA Flows and 2019 BiOp Flows

As previously introduced, the 2013 BiOp Flows were the hydrology requirement to which the USBR Klamath Irrigation Project operated at the time that the Lower Klamath Project EIR Notice of Preparation was issued (December 22, 2016). For the Lower Klamath Project EIR, the 2013 BiOp Flows serve as an existing conditions CEQA baseline, and they replace both the KBRA Flows ("dams out" scenario [i.e., Proposed Project]) and the 2010 BiOp Flows ("dams in" scenario [i.e., No Project Alternative]) originally modeled for the 2012 KHSA EIS/EIR since the KRRC's Proposed Project does not include a change in the flow requirements for the Klamath River as part of dam removal (i.e., the same flow requirements downstream of the location of Iron Gate Dam would occur regardless of dam removal). After the issuance of the Lower Klamath Project Draft EIR on December 27, 2018, the applicable biological opinion and the operational flow requirements for the Klamath River changed again in March 2019, when the new biological opinions were issued by NMFS (2019) and USFWS (2019). The 2019 BiOp Flows are now the current operational flow requirement for the Klamath River and as such they are analyzed in the Lower Klamath Project Final EIR as a second CEQA baseline, representing flows under newly defined existing conditions (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*).

The Lower Klamath Project EIR recreational flow analysis considers that, if the dams were to be removed, Keno Dam flow releases would be managed to maintain biological opinion required flows downstream of the location of Iron Gate Dam. While the specific Keno Dam flow releases under a dam removal scenario with the 2013 BiOp Flows or the 2019 BiOp Flows are unknown, if dam removal occurs, USBR, NMFS, and USFWS would coordinate to identify a methodology to back calculate the Keno Dam releases and flow requirements necessary to provide flows downstream of Iron Gate Dam consistent with the expectations under the applicable biological opinion (NMFS 2019). Overall, this means that Keno Dam flow releases for maintaining the 2013 BiOp Flows or the 2019 BiOp Flows at the location of Iron Gate Dam generally would be similar irrespective of dam removal, which would minimize flow differences between "dams in" and "dams out" scenarios for the Lower Klamath Project analysis as compared with the analysis conducted for the 2012 KHSA EIS/EIR. In the 2012 KHSA EIS/EIR analysis, (Tables S-1 to S-8) KBRA Flows ("dams out" scenario [i.e., Proposed Project]) and the 2010 BiOp Flows ("dams in" scenario [i.e., No Project Alternative]) were purposefully different because KBRA Flows were a connected action to dam removal. For the Lower Klamath Project analysis, having the same biological opinion flow requirements in the Klamath River regardless of dam removal also means that during certain months there would be less variation in the number of days with acceptable flows for flow-dependent recreational opportunities (i.e., whitewater boating and fishing) between the "dams in" and "dams out" scenarios, as compared with the 2012 KHSA EIS/EIR analysis (Tables S-1 to S-8).

However, the primary difference between the "dams in" and "dams out" flow scenarios, namely the lack of hydropower peaking operations under a "dams out" scenario, would still affect recreational flows under the Proposed Project in a similar way as was modeled in the 2012 KHSA EIS/EIR. Although the 2013 BiOp Flows and the 2019 BiOp Flows underlying the recreational flow analysis in this EIR are different from the KBRA Flows and the 2010 BiOp Flows modeled in the 2012 KHSA EIS/EIR, the flows due to hydropower operations in the J.C. Boyle Bypass Reach, the J.C. Boyle Peaking Reach (including Hell's Corner Reach), and the Copco No. 2 Bypass Reach would still change in the following generally predictable ways should the dams be removed: flows within the J.C. Boyle Bypass Reach and the Copco No. 2 Bypass Reach would increase due to the absence of hydropower bypass operations; flows within the J.C. Boyle Peaking Reach would generally become more constant due to the elimination of hydropower peaking operations; and peak flows within the J.C. Boyle Peaking Reach would decrease due to the elimination of hydropower peaking operations.

As explained in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project,* monthly flow exceedance curve plots are useful for comparing the flow differences by month under 2013 BiOp and KBRA Flows, since they show the entire potential range of flows that would occur during different water year types (i.e., wet, median, and dry year types). Variations between exceedance flow curves for the 2013 BiOp Flows and the KBRA Flows, as well as for the 2019 BiOp Flows and the KBRA Flows, were evaluated to qualitatively determine how monthly variations between the flow regimes would alter the estimated number of days within the acceptable flow range for flow-dependent recreational activities. The acceptable flow ranges for various reaches (Table S-1) are plotted along with the calculated monthly flow exceedance curves for the modeled 2013 BiOp Flows and the 2019 BiOp Flows for the period 1980−2011, as well as the modeled KBRA Flows for the same period, at Keno Dam (Figure S-1 to Figure S-) and at Iron Gate Dam (Figure). Figures S-1 to Figure S- also display p-values for paired heteroscedastic t-tests of the KBRA Flows and 2019 BiOp Flows for the period 1980−2011, where the p-values indicate whether there is a statistical difference between the flow distributions. Months with a white background have a p-value greater than 0.05, indicating that there is no statistical difference between the KBRA and the 2019 BiOp flow distributions, while months with a light yellow background (p-value less than 0.05) or a bright yellow background (p-values less than 0.01) indicate a corresponding statistical difference between the two flow distributions. Klamath River reaches between Keno Dam and Iron Gate Dam are assessed using the exceedance curves at Keno Dam and the applicable acceptable flow range for flow-dependent recreation activities (Table S-1), and the reaches downstream of Iron Gate Dam are assessed using the exceedance curves at Iron Gate Dam and the applicable acceptable flow range for flow-dependent recreation activities

(Table S-1) in these reaches. This evaluation focuses on exceedance flow curves during July, August, and September, because those are the highest demand months for recreational activities on the Klamath River, but it also considers the exceedance flow curves for the entire year.

Note that Klamath River flows from Keno Dam to Iron Gate Dam would be the sum of the Keno Dam flow releases and accretions from tributaries along this entire section of the Klamath River and groundwater springs in the J.C. Boyle Bypass Reach, so the Keno Dam flow exceedance curves under the 2013 BiOp Flows or 2019 BiOp Flows with "dams in" also are still expected to be generally representative of flow conditions within the Klamath River from Keno Dam to Iron Gate Dam under the Proposed Project ("dams out").

S.3.1 Changes in 2012 KHSA EIS/EIR Model Results Due to Variations Between KBRA Flows and 2013 BiOp Flows

In the Keno, J.C. Boyle Bypass, and Hell's Corner reaches of the Upper Klamath River, differences between the average number of days with acceptable flows for whitewater boating under the 2013 BiOp Flows and those under the KBRA Flows, as shown by the monthly flow exceedance curves at Keno Dam (Figure S-1 to Figure S-), would likely result in a net decrease in the number of days suitable for whitewater boating under the Proposed Project. Whitewater boating requires a minimum flow of 1,000 cfs to 1,300 cfs in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches, and whitewater boating cannot occur when the maximum flows exceed 4,000 cfs in the Keno Reach, 1,800 cfs in the J.C. Boyle Bypass Reach, or 3,500 cfs in the Hell's Corner Reach of the Klamath River (Table S-1). Much of the variation between the 2013 BiOp Flows and the KBRA Flows during winter and spring occurs within the acceptable range of flows for whitewater boating and these variations would not alter the number of days that whitewater boating could occur during this time period. However, during summer and fall months, variations between the 2013 BiOp Flows and the KBRA Flows would alter the number of days available for whitewater boating under the Proposed Project, since they would change the frequency that flows would be within the acceptable range. In July through September, KBRA Flows would exceed 1,000 cfs during wet water years, with KBRA Flows exceeding 1,300 cfs during wet water years in July. Under the KBRA Flows, the projected average number of days of whitewater boating for all water year types between July and September would range from 2.3 days in August in the J.C. Boyle Bypass Reach to 13.8 days in July in the Hell's Corner Reach (Table S-3). However, the 2013 BiOp Flows would remain below 1,000 cfs in July and September except during very wet water year types (i.e., exceedance probability less than 5 percent) and 2013 BiOp Flows would remain below 1,000 cfs during all water year types in August. Additionally, the 2013 BiOp Flows would remain below 1,300 cfs during all water year types between July through September. As such, the number of days that whitewater boating could occur between July and September in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches of the Klamath River would decrease under the 2013 BiOp Flows compared to the KBRA Flows since the

2013 BiOp Flows would be within the acceptable range for whitewater boating less frequently than the KBRA Flows.

p < 0.01
p < 0.05

P-values based on the results of paired heteroscedastic t-tests of the KBRA Flows and 2019 BiOp Flows for the period 1980−2011 for each time-step (i.e., month)

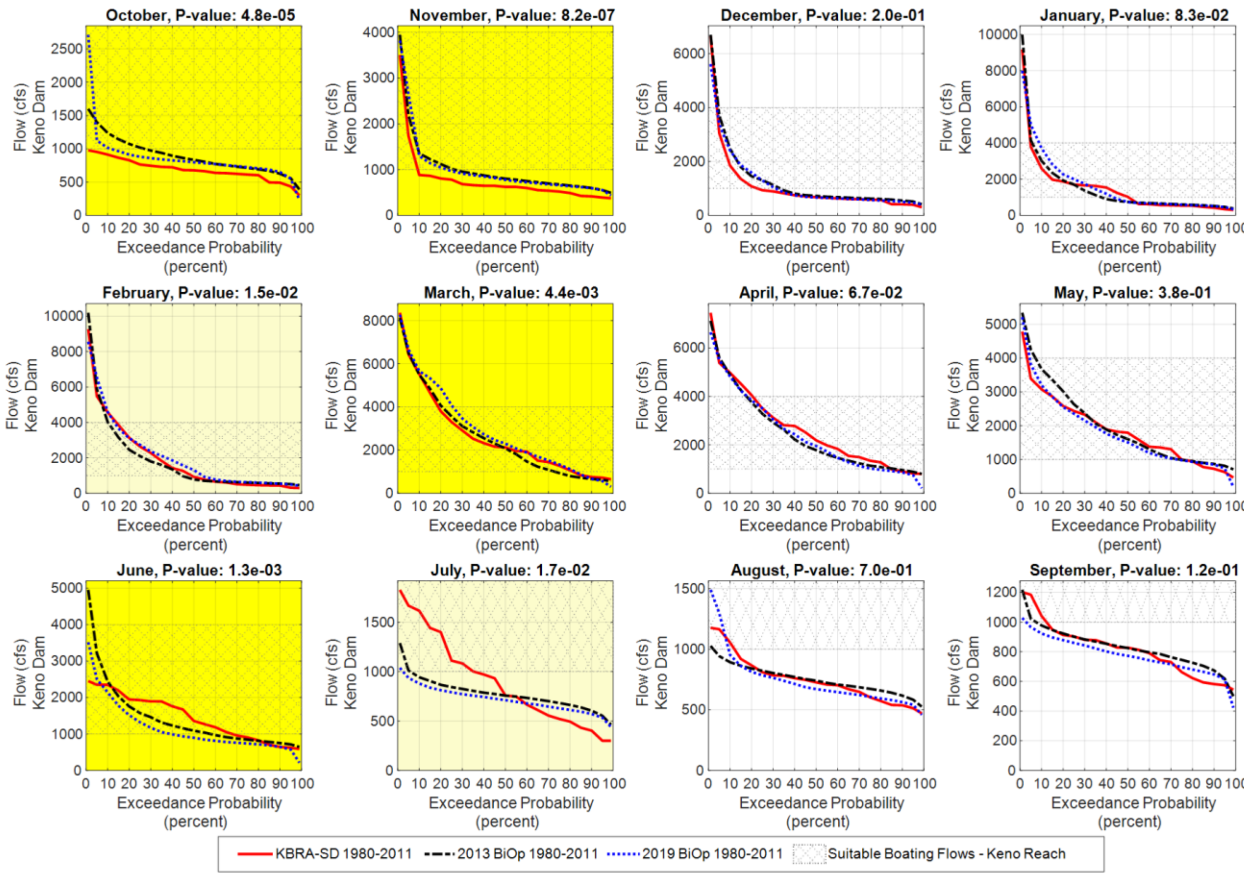

Figure S-1. Consideration of Whitewater Boating Flows in the Keno Reach: Monthly Flow Exceedance Curves at Keno Dam for the KBRA Flows (KBRA-SD 1980−2011), 2013 Joint Biological Opinion Flows (2013 BiOp 1980−2011), and 2019 Biological Opinion Flows (2019 BiOp 1980−2011) Along With The Range of Suitable Whitewater Boating Flows in the Keno Reach in Grey Cross-Hatching. Source: USBR 2019. Note: The Scale on the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Years Correspond to the 10 Percent, 50 Percent, and 90 Percent Flow Exceedance Probabilities, Respectively.

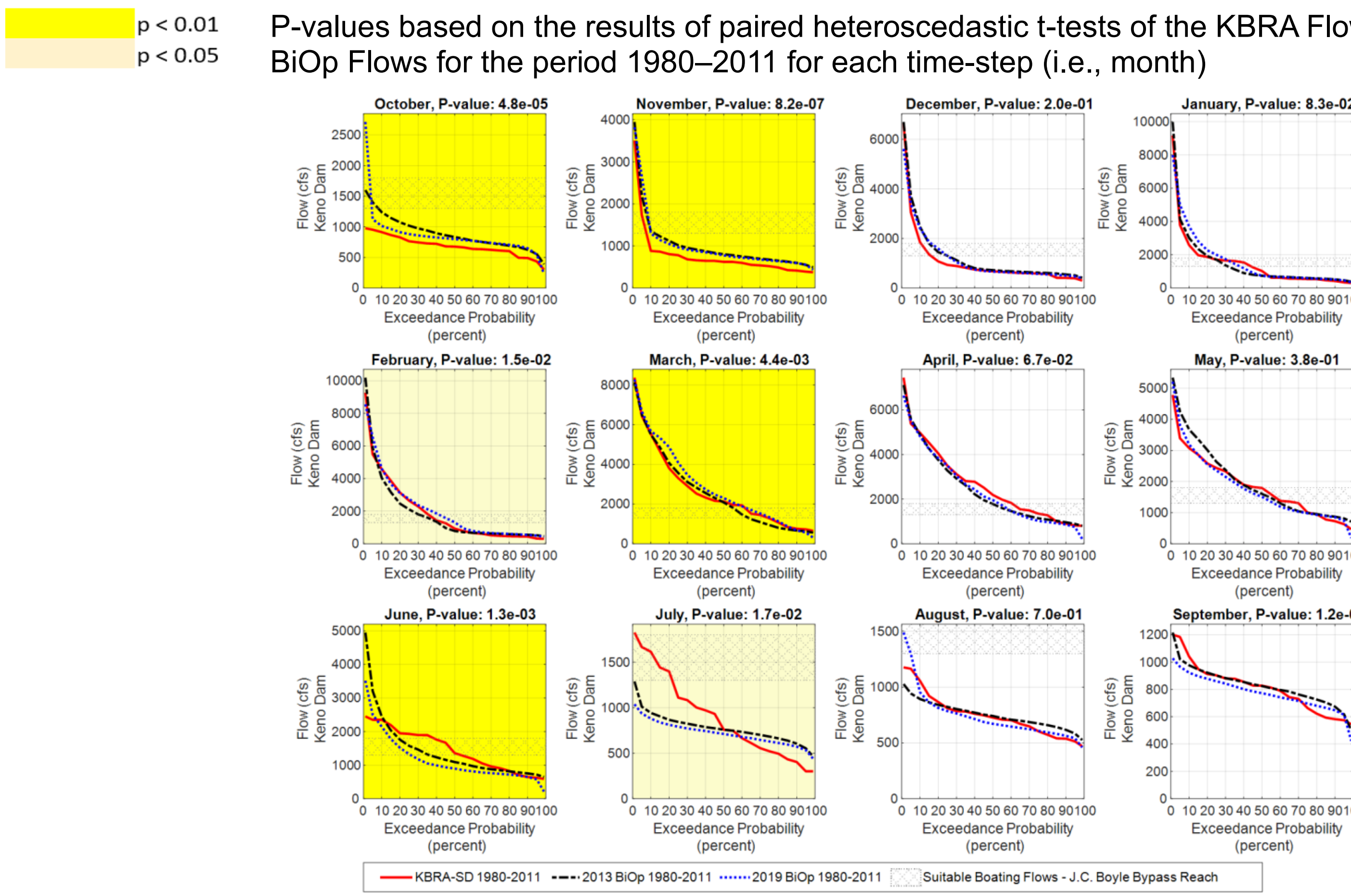

Figure S-2. Consideration of Whitewater Boating Flows in the J.C. Boyle Reach: Monthly Flow Exceedance Curves at Keno Dam for the KBRA Flows (KBRA-SD 1980−2011), 2013 Joint Biological Opinion Flows (2013 BiOp 1980−2011), and 2019 Biological Opinion Flows (2019 BiOp 1980−2011) Along With The Range of Suitable Whitewater Boating Flows in the J.C. Boyle Bypass Reach in Grey Cross-Hatching. Source: USBR 2019. Note: The Scale on the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Years Correspond to the 10 Percent, 50 Percent, and 90 Percent Flow Exceedance Probabilities, Respectively.

p < 0.01
p < 0.05

P-values based on the results of paired heteroscedastic t-tests of the KBRA Flows and 2019 BiOp Flows for the period 1980−2011 for each time-step (i.e., month)

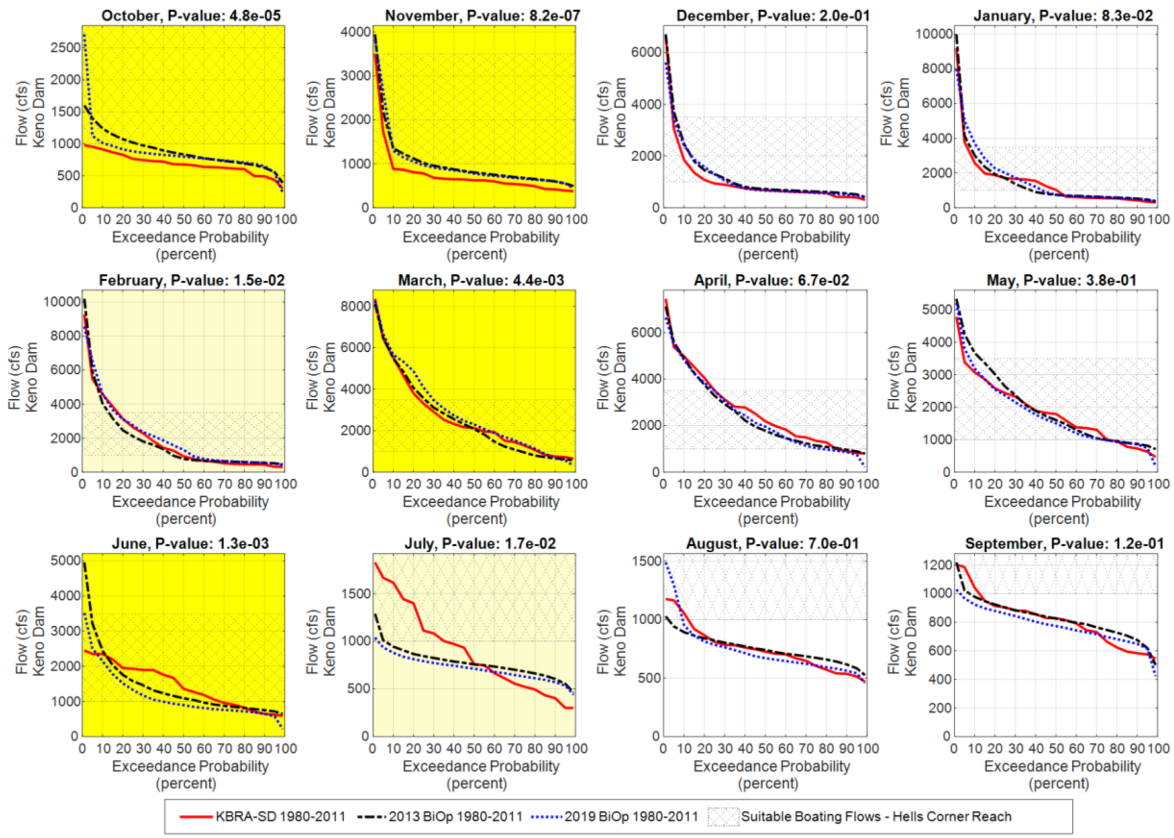

Figure S-3. Consideration of Whitewater Boating Flows (Kayaking) in the Hell's Corner Reach: Monthly Flow Exceedance Curves at Keno Dam for the KBRA Flows (KBRA-SD 1980−2011), 2013 Joint Biological Opinion Flows (2013 BiOp 1980−2011), and 2019 Biological Opinion Flows (2019 BiOp 1980−2011) Along With The Range of Suitable Whitewater Boating Flows (Kayaking) in the Hell's Corner Reach in Grey Cross-Hatching. Source: USBR 2019. Note: The Scale on the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Years Correspond to the 10 Percent, 50 Percent, and 90 Percent Flow Exceedance Probabilities, Respectively.

p < 0.01
p < 0.05

P-values based on the results of paired heteroscedastic t-tests of the KBRA Flows and 2019 BiOp Flows for the period 1980−2011 for each time-step (i.e., month)

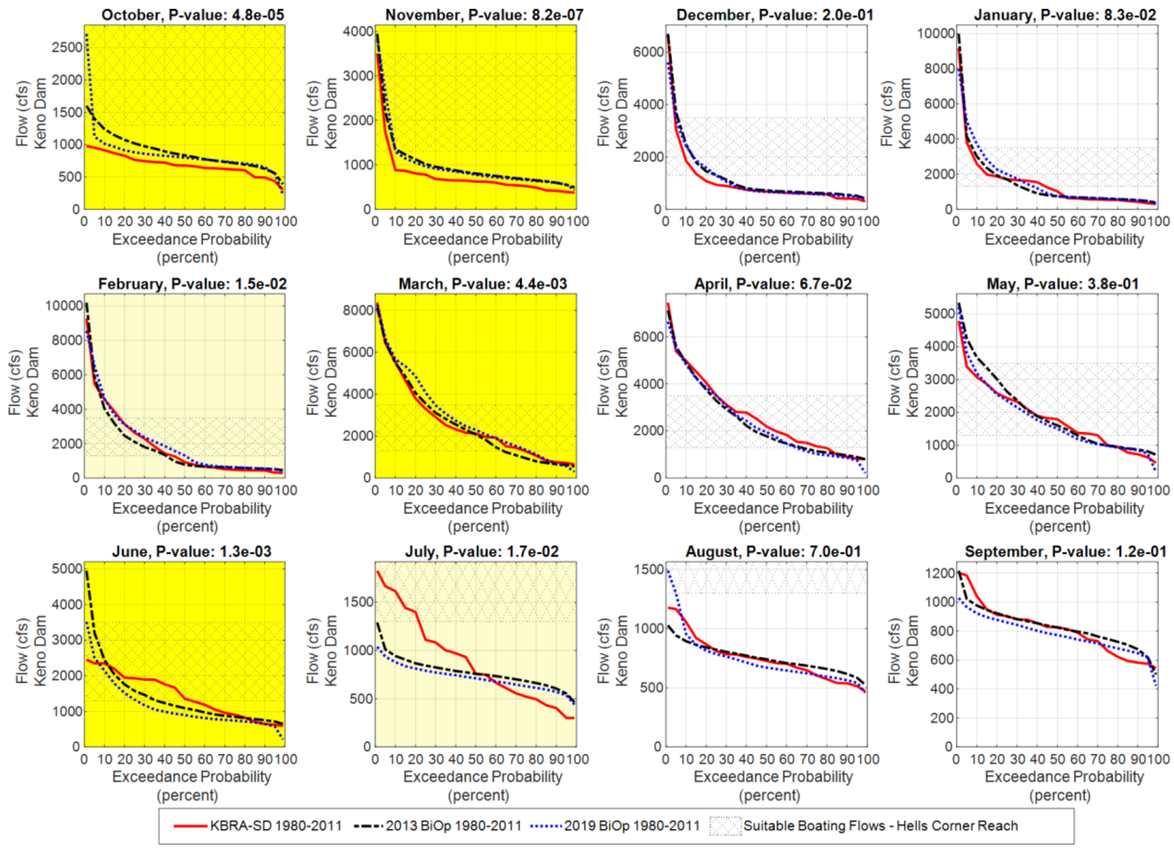

Figure S-4. Consideration of Whitewater Boating Flows (Rafting) in the Hell's Corner Reach: Monthly Flow Exceedance Curves at Keno Dam for the KBRA Flows (KBRA-SD 1980−2011), 2013 Joint Biological Opinion Flows (2013 BiOp 1980−2011), and 2019 Biological Opinion Flows (2019 BiOp 1980−2011) Along With The Range of Suitable Whitewater Boating Flows (Rafting) in the Hell's Corner Reach in Grey Cross-Hatching. Source: USBR 2019. Note: The Scale on the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Years Correspond to the 10 Percent, 50 Percent, and 90 Percent Flow Exceedance Probabilities, Respectively.

p < 0.01
p < 0.05

P-values based on the results of paired heteroscedastic t-tests of the KBRA Flows and 2019 BiOp Flows for the period 1980−2011 for each time-step (i.e., month)

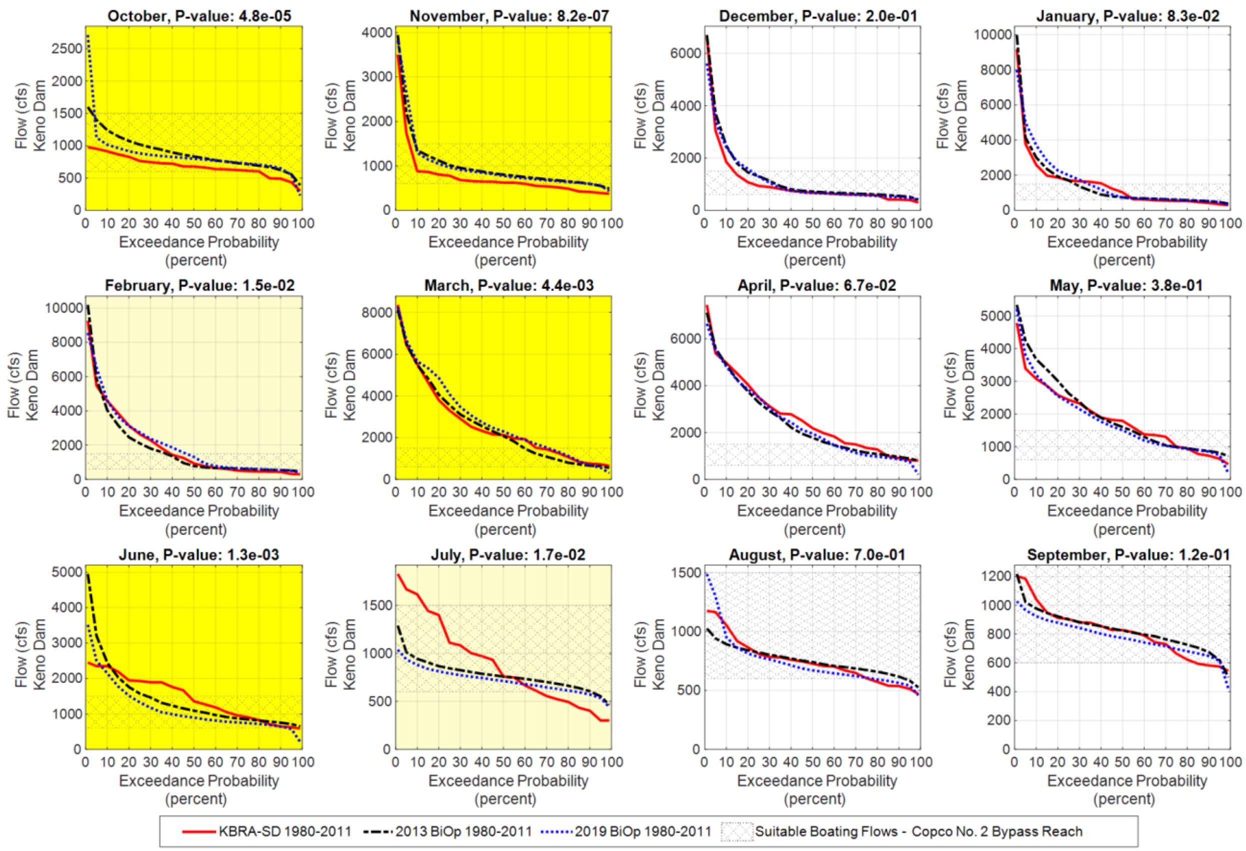

Figure S-5. Consideration of Whitewater Boating Flows in the Copco No. 2 Bypass Reach: Monthly Flow Exceedance Curves at Keno Dam for the KBRA Flows (KBRA-SD 1980−2011), 2013 Joint Biological Opinion Flows (2013 BiOp 1980−2011), and 2019 Biological Opinion Flows (2019 BiOp 1980−2011) Along With The Range of Suitable Whitewater Boating Flows in the Copco No. 2 Bypass Reach in Grey Cross-Hatching. Source: USBR 2019. Note: The Scale on the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Years Correspond to the 10 Percent, 50 Percent, and 90 Percent Flow Exceedance Probabilities, Respectively.

$p < 0.01$

$p < 0.05$

P-values based on the results of paired heteroscedastic t-tests of the KBRA Flows and 2019 BiOp Flows for the period 1980−2011 for each time-step (i.e., month)

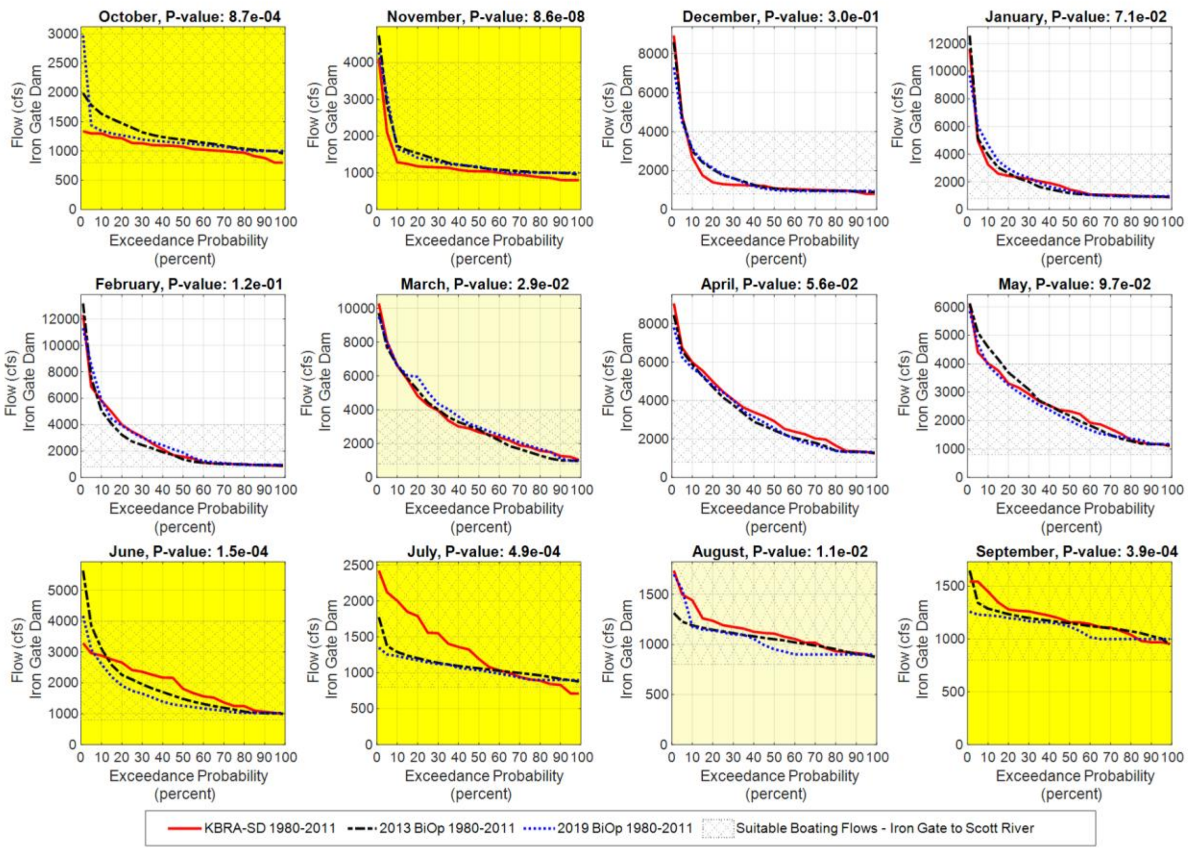

Figure S-6. Consideration of Whitewater Boating and Fishing Flows in the Iron Gate Dam to Salmon Creek Reach: Monthly Flow Exceedance Curves at Iron Gate Dam for the KBRA Flows (KBRA-SD 1980−2011), 2013 Joint Biological Opinion Flows (2013 BiOp 1980−2011), and 2019 Biological Opinion Flows (2019 BiOp 1980−2011) Along With The Range of Suitable Whitewater Boating and Fishing Flows in the Iron Gate Dam to Salmon Creek Reach in Grey Cross-Hatching. Source: USBR 2019. Note: The Scale on the Y-Axis (Flow in cfs) Varies Significantly Between Months. Wet, Median, and Dry Water Years Correspond to the 10 Percent, 50 Percent, and 90 Percent Flow Exceedance Probabilities, Respectively.

Conversely, in October the projected average number of days of whitewater boating would increase under the 2013 BiOp Flows relative to the KBRA Flows since the 2013 BiOp Flows exceed 1,000 cfs in 30 percent of years, but the KBRA Flows are always below 1,000 cfs. Upper Klamath River flows in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches would be within the range of acceptable flows for whitewater boating under 2013 BiOp Flows in October under some water year types, especially wet water years, but acceptable whitewater boating flows would not occur under KBRA Flows. Thus, the projected average number of days of whitewater boating for all water year types in October between Keno Dam and Iron Gate Dam would be greater under 2013 BiOp Flows than under the KBRA Flows.

Overall, the projected annual average number of days that would support whitewater boating for all water year types in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches of the Upper Klamath River would decrease under the 2013 BiOp Flows compared to those modeled in the 2012 KHSA EIS/EIR under the KBRA Flows, since the decreases in July through September are expected to be greater than the increase in October.

The average number of days that fishing could occur in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches of the Upper Klamath River would increase under the 2013 BiOp compared to the KBRA Flows. In addition to detailing the percent of time that flows would be exceeded, the monthly flow exceedance curves also indicate the percent of years when the flows would occur. The percent of years within the acceptable flow range for fishing (i.e., 200 cfs to 1,500 cfs in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches) can be estimated by subtracting the percent exceedance from one hundred percent, if the minimum flow is always greater than the minimum acceptable fishing flow (i.e., 200 cfs). Under the 2013 BiOp and KBRA Flows, the percent of years within the acceptable fishing flow range is generally similar and the average number of days available for fishing would also remain generally similar for most months except June and July. In those months, the 2013 BiOp Flows would be within the acceptable fishing flow range more frequently (approximately 70 percent of years in the Keno Reach during June;100 percent of years in the Keno Reach during July) than the KBRA Flows (approximately 50 percent of years in the Keno Reach during June; approximately 85 percent of years in the Keno Reach during July). The frequency of suitable fishing flows would vary between the reaches due to variations in the suitable maximum and minimum flows for fishing within each reach, but there would be an overall net increase in the projected average number of days with acceptable fishing flows under the 2013 BiOp Flows compared to under the KBRA Flows in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches of the Upper Klamath River.

Downstream of Iron Gate Dam, a comparison of the monthly exceedance curves for the 2013 BiOp and KBRA Flows at Iron Gate Dam (Figure) indicates that the number of days flows are within the acceptable range for flow-dependent recreational activities would be generally similar under 2013 BiOp and KBRA Flows. Most of the variations between the 2013 BiOp and KBRA Flows at Iron Gate Dam occur within the acceptable range of flows for whitewater boating, boating, or fishing and those variations would not alter the number of days flow-dependent recreational activities could occur. Differences between the 2013 BiOp and KBRA Flows outside of the acceptable range of flows downstream of Iron Gate Dam occur infrequently, are relatively small (i.e., less than 10 percent change in frequency of exceedance), and primarily occur for either dry (represented by a 90 percent exceedance) or wet (represented by a 10 percent exceedance) water year types. In May, KBRA Flows would exceed 4,000 cfs in approximately 10 percent of years, but 2013 BiOp Flows would exceed 4,000 cfs in approximately 18 percent of years. In June, KBRA Flows would always be within the range of acceptable flows for whitewater boating, but 2013 BiOp Flows would exceed 4,000 cfs in approximately 5 percent of years (i.e., very wet years). These variations between the KBRA and 2013 BiOp Flows would decrease the average number of days within the acceptable flow range for whitewater boating and fishing in the Klamath River from Iron Gate to its confluence with the Salmon River under the 2013 BiOp Flows. In July, KBRA Flows would not exceed 800 cfs in approximately 10 percent of years (i.e., dry water years), but 2013 BiOp Flows would always exceed 800 cfs. Similarly, the KBRA flows in October would not exceed 800 cfs in approximately 5 percent of years (i.e., very dry water years), but 2013 BiOp Flows would always exceed 800 cfs. The result of these variations would increase the average number of days within the acceptable flow range for whitewater boating and fishing in the Klamath River downstream of Iron Gate Dam under the 2013 BiOp Flows. The overall net change in the average number of days within the acceptable flow range for recreational activities between the 2013 BiOp and KBRA Flows would be minimal downstream of Iron Gate Dam, but the exact number of days under 2013 BiOp Flows would vary slightly from those modeled in the 2012 KHSA EIS/EIR analysis under the KBRA Flows. As such, the average number of days for flow-dependent recreational activities estimated in the 2012 KHSA EIS/EIR analysis downstream of Iron Gate Dam is generally representative of trends and conditions under the 2013 BiOp Flows.

S.3.2 Changes in 2012 KHSA EIS/EIR Model Results Due to Variations Between KBRA Flows and 2019 BiOp Flows

In the Keno, J.C. Boyle Bypass, and Hell's Corner reaches of the Upper Klamath River, differences between the average number of days with acceptable flows for whitewater boating under the 2019 BiOp Flows and the KBRA Flows, as shown by the monthly flow exceedance curves at Keno Dam (Figure S-1 to Figure S-), would likely result in a net decrease in the number of days that flows are within the acceptable range for whitewater boating under the Proposed Project. Whitewater boating requires a minimum flow of 1,000 cfs to 1,300 cfs in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches, while whitewater boating cannot occur when the maximum flows exceed 4,000 cfs in the Keno Reach, 1,800 cfs in the J.C. Boyle Bypass Reach, or 3,500 cfs in the Hell's Corner

Reach of the Klamath River (Table S-1). Much of the variations between the 2019 BiOp Flows and KBRA Flows during winter and spring occur within the acceptable range of flows for whitewater boating and these variations would not alter the number of days that whitewater boating could occur during this time period. However, during summer and fall months, variations between the 2019 BiOp Flows and KBRA Flows would alter the number of days available for whitewater boating, since they would change the frequency that flows would be within the acceptable range. In May and June, the projected average number of days of whitewater boating under KBRA Flows for all water year types between July and September would range from 5.7 days in June in the J.C. Boyle Bypass Reach to 21.6 days in June in the Hell's Corner Reach. However, 2019 BiOp Flows in May and June would be slightly less frequently within the range of acceptable whitewater boating flows than KBRA Flows primarily due to slightly lower flows during drier water year types that do not meet the minimum flows for whitewater boating, slightly higher flows during wetter water year types that exceed the maximum flows for whitewater boating, or a combination of both. In July through September, KBRA Flows would exceed 1,000 cfs during wet water years, with KBRA Flows exceeding 1,300 cfs during wet water years in July, resulting in suitable flows for whitewater boating opportunities during wetter water year types (i.e., exceedance probability less than approximately 35 percent in July and less than approximately 12 percent in August and September). Under the KBRA Flows, the projected average number of days of whitewater boating for all water year types between July and September would range from 2.3 days in August in the J.C. Boyle Bypass Reach to 13.8 days in July in the Hell's Corner Reach (Table S-3). However, the 2019 BiOp Flows would remain below 1,000 cfs in July and September except during very wet water year types (i.e., exceedance probability less than approximately 5 percent) and 2019 BiOp Flows would exceed 1,000 cfs in August only during wet water year types (i.e., exceedance probability approximately 10 percent or less). Thus, the number of days whitewater boating could occur between July and September in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches of the Klamath River would decrease under the 2019 BiOp Flows compared to the KBRA Flow model results. Conversely, the average number of days of whitewater boating in October in the Klamath River between Keno and Iron Gate dams would increase under the 2019 BiOp Flows relative to the KBRA Flows (i.e., less than one day) since the 2019 BiOp Flows exceed 1,000 cfs in very wet to wet water year types (i.e., exceedance probability less than approximately 5 to 10 percent), but the KBRA Flows are always below 1,000 cfs.

Overall, the annual average number of days supporting whitewater boating for all water year types in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches of the Upper Klamath River would decrease under the 2019 BiOp Flows compared to under the KBRA Flows, since decreases in May through September are expected to be greater than the increase in October.

The average number of days that fishing could occur in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches of the Upper Klamath River would increase under the 2019 BiOp Flows compared to the KBRA Flows. In addition to detailing the percent of time that flows would be exceeded, the monthly flow exceedance curves also indicate the percent of years when the flows would occur. The percent of years within the acceptable flow range for fishing (i.e., 200 cfs to 1,500 cfs in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches) can be estimated by subtracting the percent exceedance from one hundred percent, if the minimum flow is always greater than the minimum acceptable fishing flow (i.e., 200 cfs). Under the 2019 BiOp Flows and the KBRA Flows, the percent of years within the acceptable fishing flow range is generally similar (i.e., less than 10 percent change in frequency of exceedance) and the average number of days available for fishing would also remain generally similar for most months except June and July. In those months, the 2019 BiOp Flows would be within the acceptable fishing flow range more frequently (approximately 80 percent of years in the Keno Reach during June; 100 percent of years in the Keno Reach during July) than the KBRA Flows (approximately 50 percent of years in the Keno Reach during June; approximately 85 percent of years in the Keno Reach during July). While the specific frequency that flows are within the acceptable range for fishing would vary between the reaches due to variations in the suitable maximum and minimum flows for fishing between reaches, there would be an overall net increase in the projected average number of days with acceptable fishing flows under the 2019 BiOp Flows compared to under the KBRA Flows in the Keno, J.C. Boyle Bypass, and Hell's Corner reaches of the Upper Klamath River.

Downstream of Iron Gate Dam, a comparison of the monthly exceedance curves for the 2019 BiOp and KBRA Flows at Iron Gate Dam (Figure) indicates that the number of days that flows are within the acceptable range for flow-dependent recreational activities would be generally similar under 2019 BiOp Flows and the KBRA Flows. Most of the variations between the 2019 BiOp Flows and the KBRA Flows at Iron Gate Dam occur within the acceptable range of flows for whitewater boating, boating, or fishing and those variations would not alter the number of days flow-dependent recreational activities could occur. Differences between the 2019 BiOp Flows and KBRA Flows outside of the acceptable range of flows downstream of Iron Gate Dam are consistently relatively small (i.e., less than 10 percent change in frequency of exceedance) and occur during winter months (i.e., January through March), so there would be a minimal change in the average number of days within the acceptable flow range for recreational activities between the 2019 BiOp and KBRA Flows downstream of Iron Gate Dam. As such, the average number of days for flow-dependent recreational activities estimated in the 2012 KHSA EIS/EIR analysis downstream of Iron Gate Dam is generally representative of trends and conditions under the 2019 BiOp Flows.

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