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[20] 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 summer time 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 Appendix A.

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.

Upper Klamath Basin

- Hydroelectric Reach[21] (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

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[20] 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 is technically a cyanobacteria, it is commonly referred to as an 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.

[21] 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.

- 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.

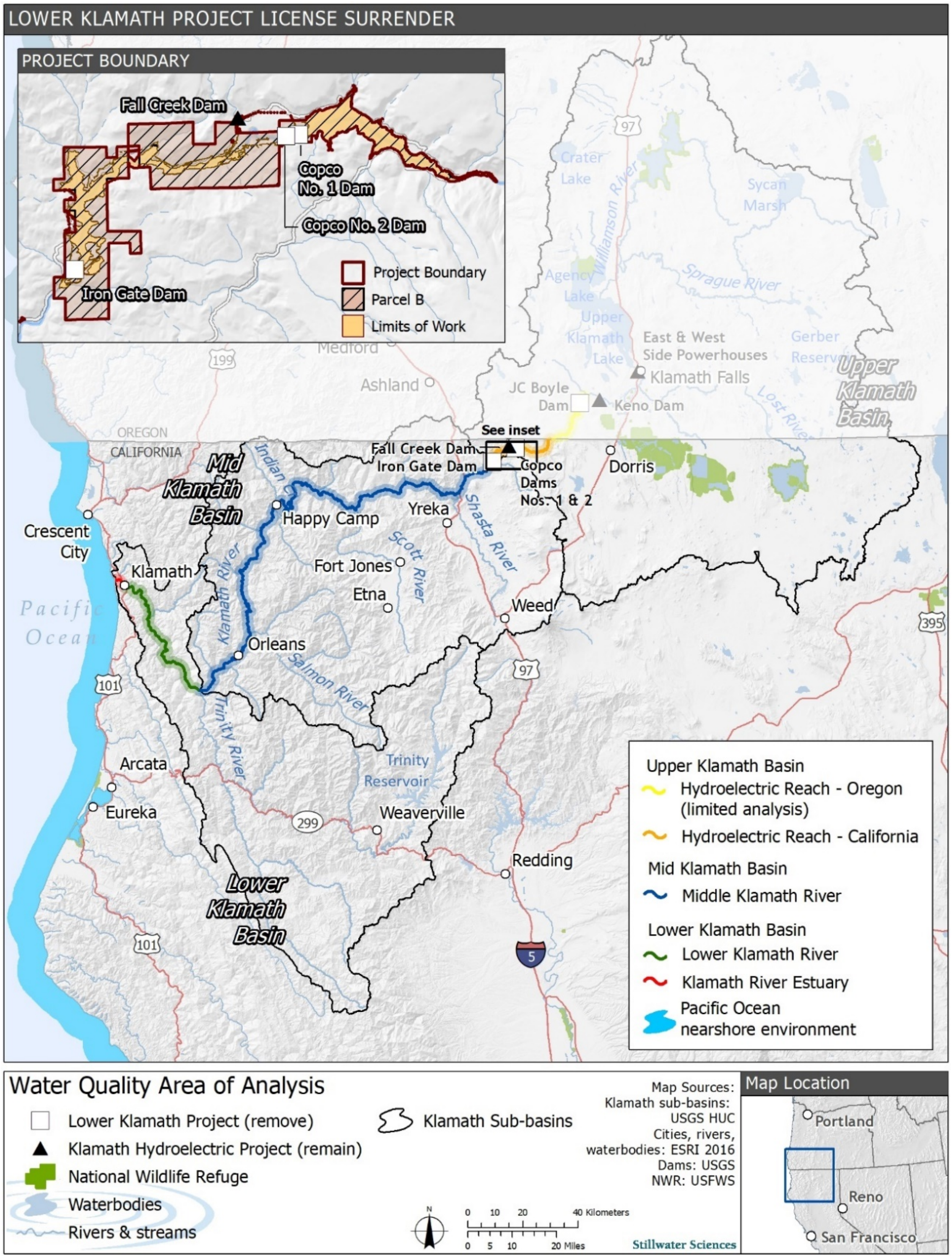


Figure 3.2-1. Klamath River Reaches Included in the Area of Analysis for Water Quality.

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.

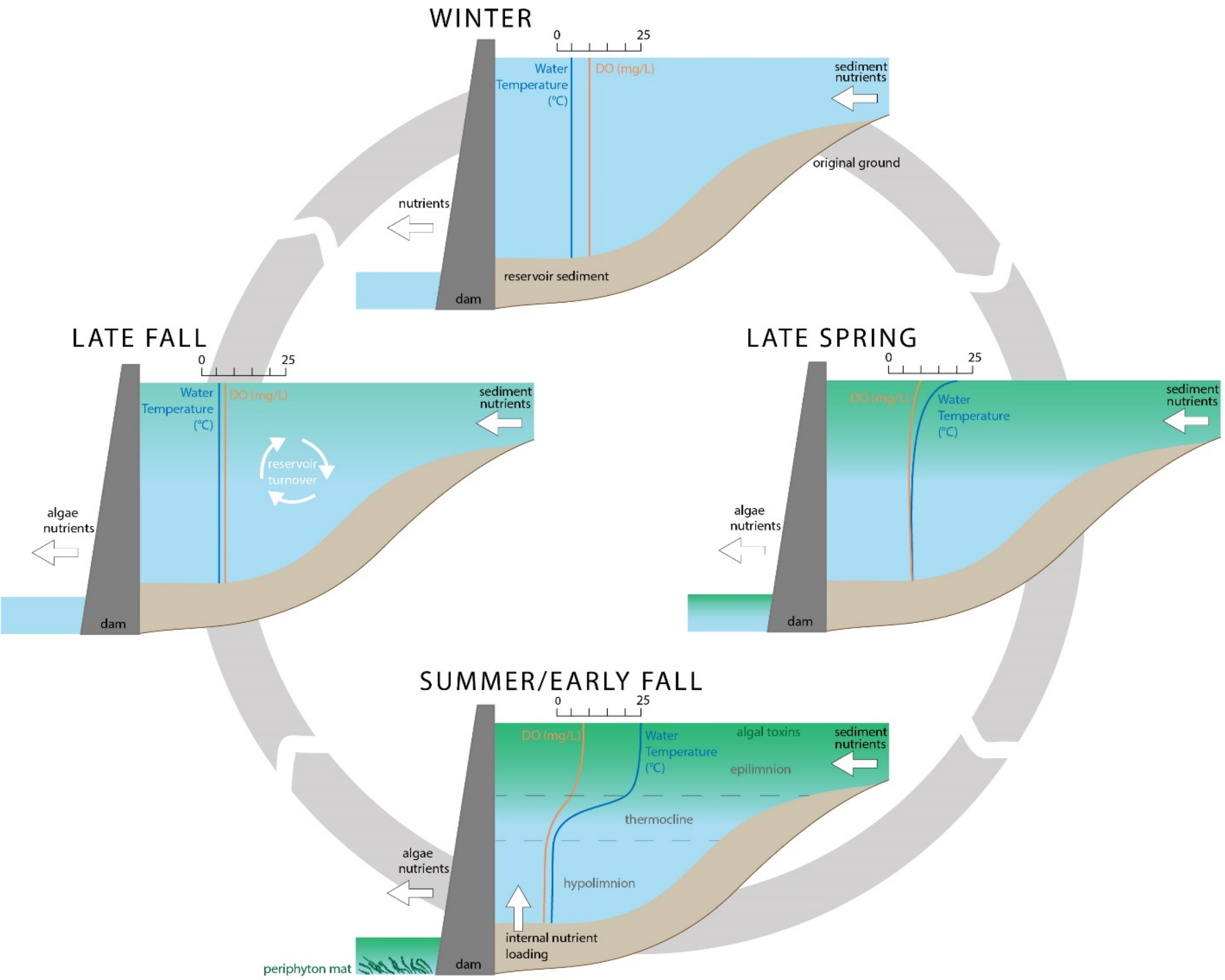
3.2.2.1 Overview of Water Quality Processes in the Klamath Basin

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:

- **River and reservoir water temperatures.** The primary effects of hydroelectric project operations on the natural temperature regime of streams and rivers are related to alterations in water surface area, depth, and velocity due to water diversions into or out of the stream corridor, including reservoir impoundments and conveyance through 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.



WINTER

LATE FALL

LATE SPRING

SUMMER/EARLY FALL

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. 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).
- **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. 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. 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 only a small fraction being retained in the reservoir sediments. Dissolved nutrients (e.g., orthophosphorus, 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 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. During reservoir turnover

when the stratification breaks down, these nutrient rich waters are mixed throughout the reservoir water column and the nutrients can be released downstream, resulting in a secondary (fall) phytoplankton bloom (which includes blue-green algae) (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 (2016). Water quality parameters analyzed in this EIR are represented by data collected within the past 10 to 17 years (2000–2017). 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[22] 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 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 power-peaking operations at the J.C. Boyle Powerhouse affect water temperatures in the river immediately downstream from the dam. While natural diel (24-hour) water temperature variations occur in the river, daily peaking operations at J.C. Boyle Powerhouse (river mile [RM] 225.2) result in an increase in the daily water temperature range in the Bypass Reach 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 2006a; Kirk et al. 2010). Water temperatures in the 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 Peaking Reach, which is downstream of the Bypass Reach, the flow diverted around the Bypass Reach rejoins the Klamath River (see Figure 2.3-1). At the upstream end of the Peaking Reach, the natural, cold groundwater input into the Bypass Reach, combined with fluctuations in river flow due to hydroelectric power operations in the Peaking Reach also produces an observed increase in daily water temperature range above the natural diel water temperature fluctuations (Kirk et al. 2010).

Further downstream in the 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

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[22] 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.

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 55–68°F) for full salmonid support in California (North Coast Regional Board 2010).

The Klamath River TMDL specifies the allowable increase in daily average (and daily maximum) water temperatures is 0.9°F (0.5°C) for Copco No. 1 and Copco No. 2 reservoir tailraces and 0.18°F (0.1°C) for the Iron Gate Reservoir tailrace to alleviate the late summer/fall warming caused by Lower Klamath Project reservoirs downstream of Iron Gate Dam under existing conditions. On average the Lower Klamath Project reservoirs increase late summer/fall water temperatures below Iron Gate Dam by approximately 4°F to 18°F (approximately 2°C to 10°C). 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 reservoir that can support cold water fish. In 2015, PacifiCorp installed a powerhouse intake barrier/thermal curtain in Iron Gate Reservoir under IM 11. 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 to the Middle and Lower Klamath River (see further discussion in Potential Impact 4.2.2-4). Results from the intake barrier/thermal curtain indicate that modest 1–2°C (1.8–3.6°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).

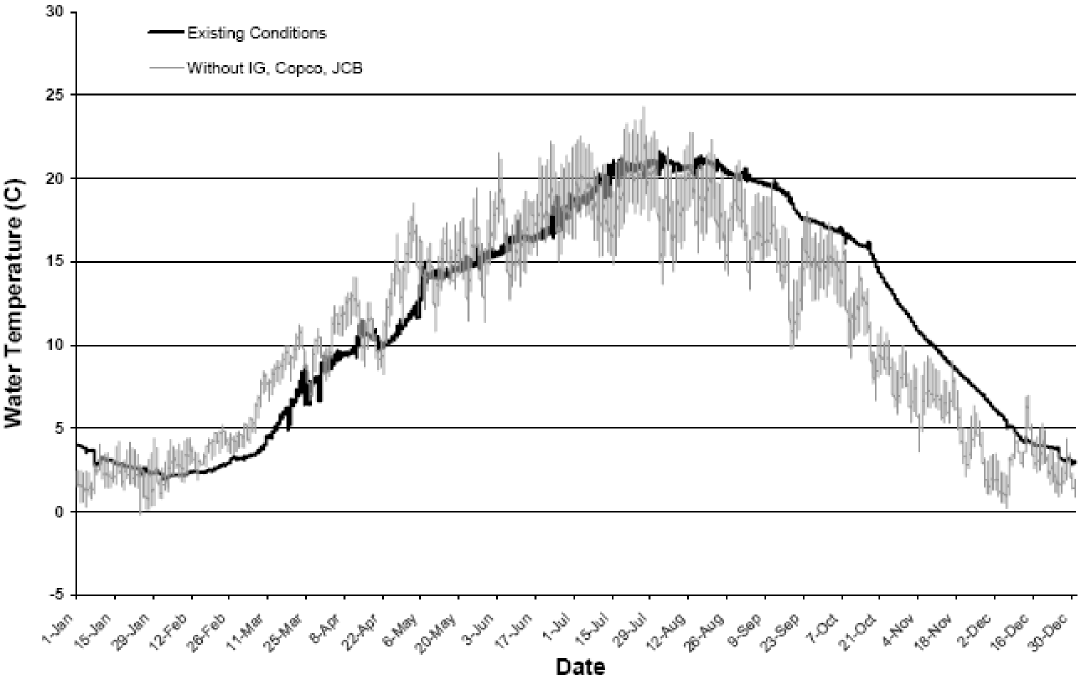

Figure 3.2-3. Simulated Hourly Water Temperature Downstream from Iron Gate Dam Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Dams. Source: PacifiCorp 2005.

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 1.8–4.5°F cooler in the spring and approximately 4–18°F 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; Asarian and Kann 2013). 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 during 2013 to 2015 under 2013 BiOp flows, with a maximum temperature of approximately 75°F in mid/late July in all three years (Watercourse Engineering, Inc. 2014, 2015, 2016).

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 1.8–7.2°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 2005; 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[23] 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[24] (55.4–68°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; Hanington 2013; Hanington and Ellien 2013) (see Appendix C for more detail).

Water temperatures in the Klamath River Estuary are linked to 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 salt water wedge results in thermal stratification of the estuary with cooler, high salinity ocean waters remaining near the estuary bottom, and warmer, low salinity river water near the surface. Under low-flow summertime conditions, when the mouth can close, surface water temperatures in the estuary have been observed at 64.4–76.5°F (Wallace 1998; Hiner 2006; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). Input of cool ocean water and fog along the coast minimizes extreme water temperatures much of the time (Scheiff and Zedonis 2011).

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[23] 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.

[24] Chronic (sub-lethal) effects temperature thresholds are detailed in Appendix 4 of North Coast Regional Board (2010).

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 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. 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).

Just downstream from Iron Gate Dam (RM 193.1), inorganic suspended material concentrations are generally low. 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 as well as resuspension of previously settled organic materials (YTEP 2005; Sinnott 2008; Armstrong and Ward 2008; Watercourse Engineering, Inc. 2011a, 2011b, 2012, 2013, 2014, 2015, 2016). Further downstream, 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)[25]. However, on a *seasonal* basis, total phosphorus (TP), and to a lesser degree total nitrogen (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. 2010; Oliver et al. 2014) (see Appendix C for additional details). Seasonal nutrient releases occur during periods of in-reservoir phytoplankton growth, and, in the case of TP, can also result in downstream transport of bioavailable nutrients to the Lower Klamath River where they can stimulate excessive 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,

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[25] 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 0.06–0.08 mg/L TP (mostly dissolved) (Asarian et al. 2010).

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 0.1–0.25 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 vary with flow, with the highest concentrations tending to occur during low flow years (e.g., 2001-2004) 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[26] (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 (2001–2015) indicate that TP concentrations in this portion of the river are generally 0.05–0.1 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.

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

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–October) and TN levels are consistently below 0.7 mg/L (June–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 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 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 blue-green algae blooms in the reservoirs. During daylight hours, blue-green algae produce dissolved oxygen (through photosynthesis), resulting in super-saturation of dissolved oxygen. During nighttime hours, blue-green algae 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 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 minimum surface dissolved oxygen concentrations generally co-occur with maximum water temperatures in July and August, the lowest surface dissolved oxygen concentrations tend to occur in October in Iron Gate Reservoir (see Appendix C, Figure C-32) (Raymond 2009a, 2010a; Asarian and Kann 2011). The low surface dissolved oxygen levels and their occurrence later in the season at Iron Gate Reservoir is believed to be associated with seasonal algal blooms, as dead algal cells are decomposed by aerobic organisms, exhausting dissolved oxygen in reservoir bottom waters and sediments (Asarian and Kann 2013).

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 immediately downstream from Iron Gate Dam, dissolved oxygen concentrations in this location regularly fall below 8.0 mg/L[27] 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). Daily fluctuations in dissolved oxygen (ranging from 1 to 3 mg/L per day) measured in the Klamath River immediately 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). 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 2013, 2014, 2014, 2015, 2016, 2017, Karuk Tribe of California 2012, 2013).

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

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[27] The Hoopa Valley Tribe surface-water quality objective for dissolved oxygen for COLD beneficial use is 8.0 mg/L (see Table 3.2-7).

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 2009−2015 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 2000−2005 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).

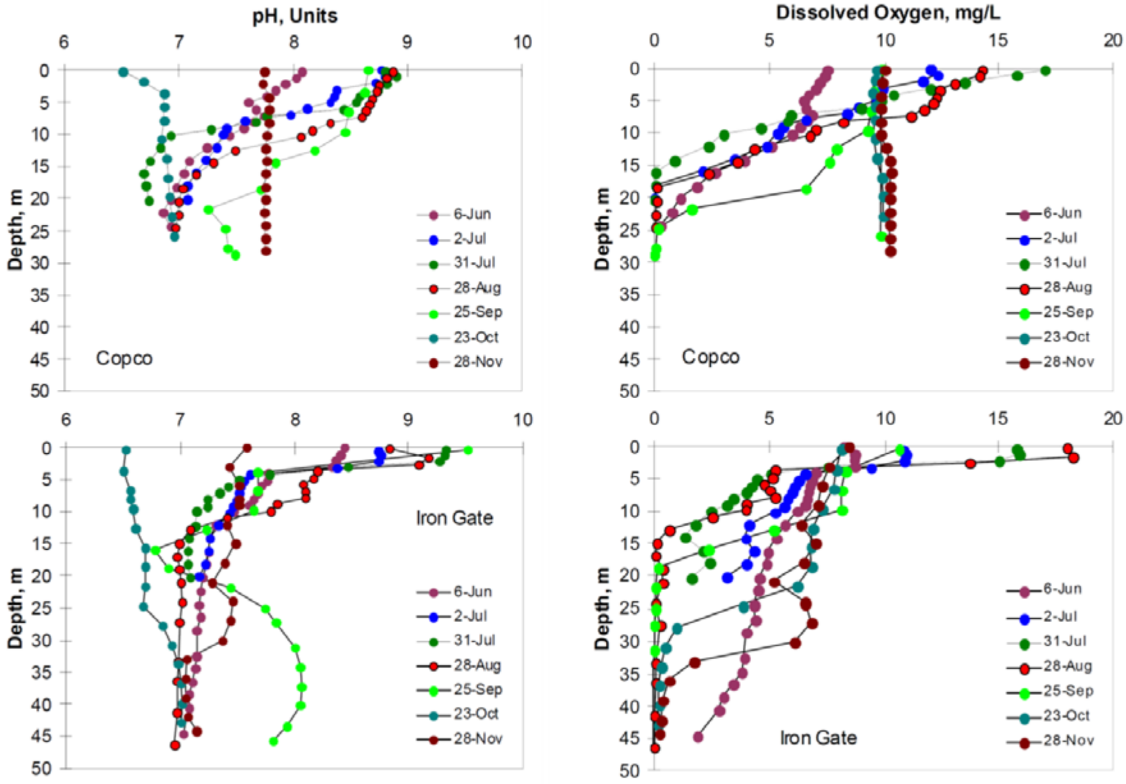

Figure 3.2-4. Vertical Profiles of pH and Dissolved Oxygen Measured During 2007 in Copco No 1. Reservoir at the Log Boom (top plot) and Iron Gate Reservoir at the Log Boom (bottom plot). Source: Adapted from Raymond 2008a.

Approximately 30 percent of samples collected in Copco No. 1 Reservoir and 5 to 20 percent of samples[28] collected in Iron Gate Reservoir surface waters (here, less than

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[28] PacifiCorp (2008) 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 (2008).

eight meters deep) exhibited pH values greater than 8.5 standard units (s.u.) (PacifiCorp 2008), 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 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). 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) (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; Asarian and Kann 2013) (see Appendix C for more detail). In the Klamath River Estuary, pH ranges between 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). 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 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). Diatoms (i.e., unicellular, photosynthetic microalgae) typically dominate in spring then decrease due to zooplankton[29] 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. Blue-green algae dominance increases during late summer and early fall because their ability to control their buoyancy which 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 been reported in humans exposed to algal toxins (OEHHA 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*[30], while species

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[29] Heterotrophic plankton that prey on diatoms

[30] 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

present in the Klamath River 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).

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).

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 (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 3.2-25; see Appendix C for more detail).

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to *Microcystis aeruginosa*. The relative proportion of microcystin contributions from *Anabaena flos-aquae* versus *Microcystis aeruginosa* has not been documented for the Klamath Basin.

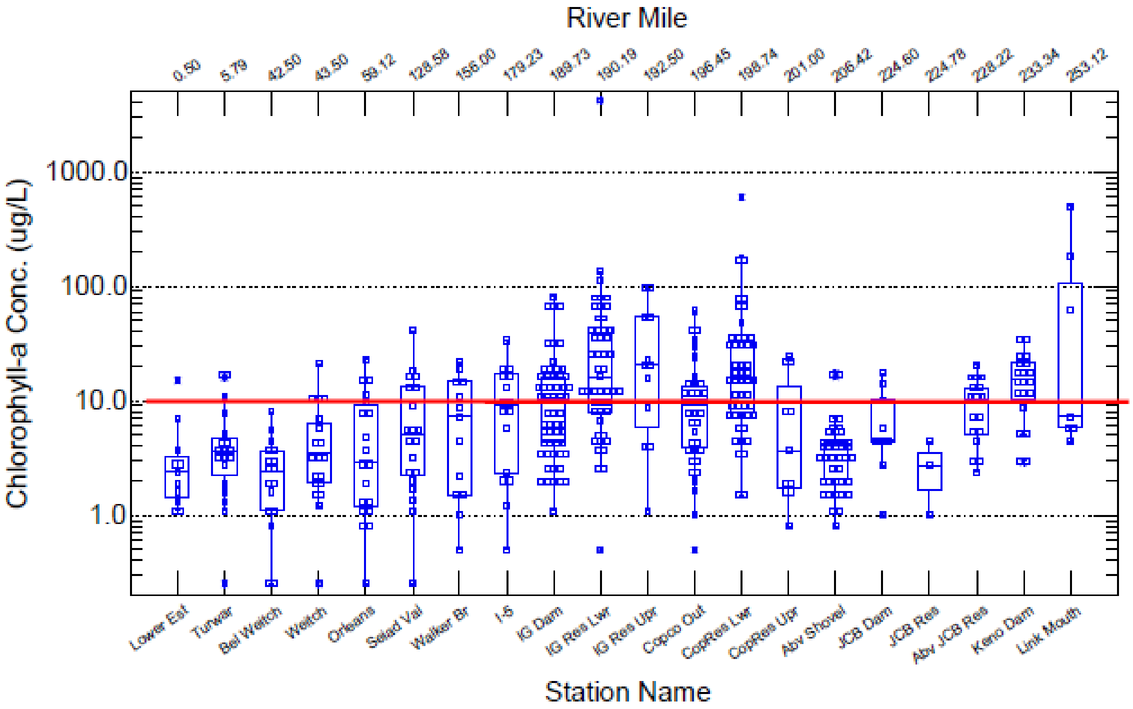

Figure 3.2-5. Longitudinal Analysis of Summer (May through September) Chlorophyll-*a* Concentrations from 2005–2007 Along the Klamath River. Note the Logarithmic Scale. Data from the Yurok Tribe, Karuk Tribe, North Coast Regional Water Quality Control Board, and PacifiCorp. Source: North Coast Regional Board 2010.

Summer and early fall chlorophyll-*a* measurements for the period 2005−2010 show higher concentrations in Copco No. 1 and Iron Gate reservoirs compared to the Hydroelectric Reach upstream of Copco No. 1, between the reservoirs, or below Iron Gate Dam. 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). 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). Phycocyanin, a pigment produced by blue-green algae, has been collected between May and November at some monitoring sites in the Klamath River downstream of Iron Gate Dam since 2007. At Seiad Valley (RM 132.7), phycocyanin is typically low from May through early August, increases to a peak in early September, and decreases until reaching low levels again by the end of October (Asarian and Kann 2013). Phycocyanin concentrations generally coincide with chlorophyll-a concentrations for the portion of the Klamath River at Seiad Valley.

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; Otten et al. 2015). 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 (1,000–73,000 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).

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 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).

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 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 2008a). The levels of microcystin bioaccumulation measured in 2007 exceeded the public health guidelines defined by Ibelings and Chorus (2007), indicating ingestion of the fish or mussels would potentially pose a health hazard to humans (Kann 2008a). 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). 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). 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 produced by the genus *Anabaena* of blue-green algae species was detected in Iron Gate Reservoir on September 3, 2005, in testing by the California Department of Health Services (Kann 2007a; Kann 2008b). In additional, monitoring conducted for the Karuk Tribe during 2005, 2006, 2007, 2008 in Copco No. 1 or Iron Gate reservoirs found no anatoxin-a detected (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

Water Column Contaminants

Data collected under the California Surface Water Ambient Monitoring Program (SWAMP) for the period 2001−2005 indicate that at eight monitoring sites from the Oregon-California state line to Turwar, the majority of inorganic constituents (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[31] (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[32] (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

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[31] Primary drinking water standards are limits for inorganic and organic contaminants to protect public health.

[32] Secondary drinking water standards are guidelines to prevent aesthetic effects (e.g., taste, odor, or color) or cosmetic effects (skin or tooth discoloration).

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 sampling[33] 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. Long-term exposure to dioxin in humans is linked to impairment of the immune system, the developing nervous system, the endocrine system, and reproductive functions. In the 2006 J.C. Boyle, Copco No. 1 and Iron Gate reservoir samples, measured levels were 2.48–4.83 pg/g (picograms per gram or parts per trillion [ppt] expressed as Toxic Equivalent Concentrations) and did not exceed USACE (1,000 pg/g), International Joint Commission for Great Lakes Science Advisory Board (10 pg/g), PSDDA (15 pg/g), or Washington State Department of Ecology (8.8 pg/g) (Shannon & Wilson, Inc. 2006, Dillon 2008, USEPA 2010) and the measured dioxin concentrations

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[33] 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.

were within the estimated background dioxin concentrations (2–5 ppt) 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 (2.5–210 pg/g) 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 2009–2011 to evaluate potential environmental and human health impacts of the downstream release of sediment deposits currently stored behind the Lower Klamath Project dams[34]. Sediment cores were collected during 2009–2010 at 37[35] 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[33] 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 composition of sediment and elutriate[36] 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).

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[34] 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).

[35] 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.

[36] 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 in the water between the grains of sediment (pore water). Standard elutriate tests do not reflect the full dilution of re-suspended sediments that would occur during dam removal.

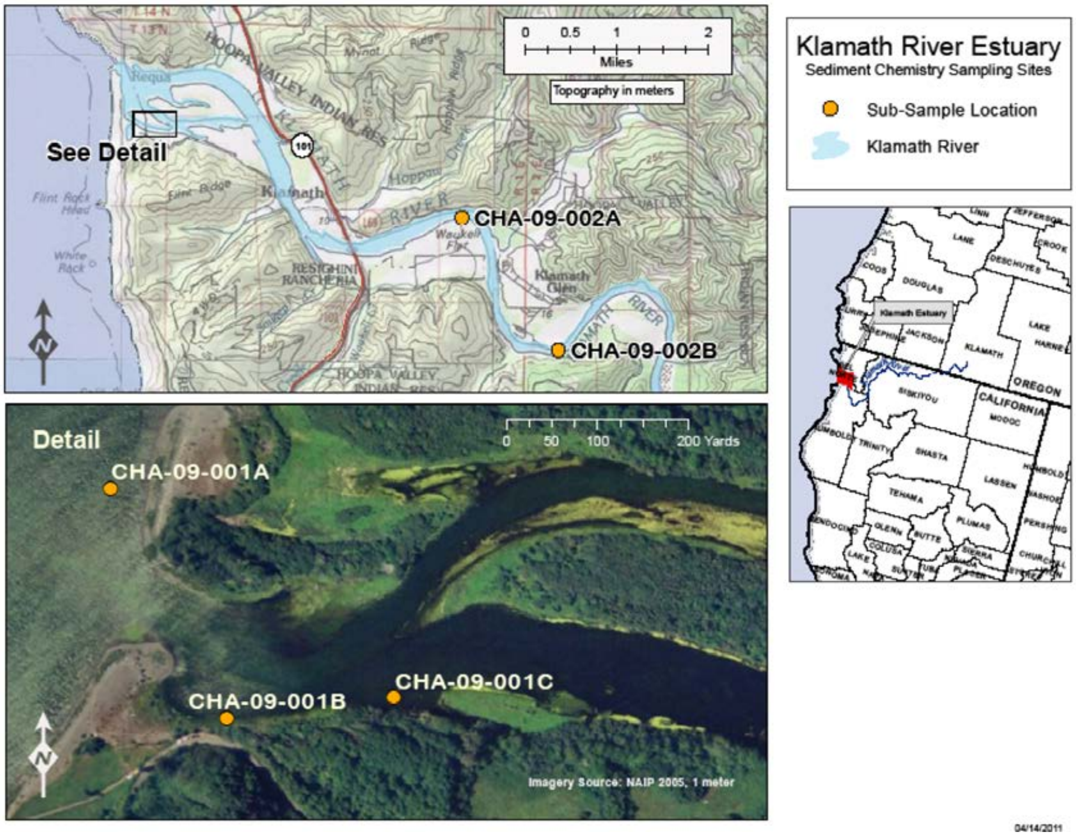

Figure 3.2-6. Klamath River Estuary Sediment Sampling Site Locations. Source: USBR 2011.

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’-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; the exception to this occurred in a single sample from J.C. Boyle Reservoir, where survival of the benthic amphipod *Hyalella azteca* indicated a moderate potential for sediment toxicity.

Lastly, analysis of the 2009–2010 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 milligrams per kilogram, dry weight (mg/kg) to 15 mg/kg in J.C. Boyle Reservoir, 6.3 mg/kg to 13 mg/kg in Copco No. 1 Reservoir, and 7.4 mg/kg to 10 mg/kg in Iron Gate Reservoir, which exceed USEPA total carcinogen residential screening levels (0.39 mg/kg) and CalEPA California Human Health residential (0.07 mg/kg) and commercial (0.24 mg/kg) screening levels. Peak total copper concentrations in Lower Klamath Project reservoir sediments (9.8−38 mg/kg) are greater than total copper concentrations in Klamath River Estuary sediments (19−26 mg/kg) (Eagles-Smith and Johnson 2012). Total copper 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 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]). Total lead concentrations in reservoir sediments range from 2.8 mg/kg to 25 mg/kg in J.C. Boyle Reservoir, 6.4 mg/kg to 10 mg/kg in Copco No. 1 Reservoir, and 5.1 mg/kg to 11 mg/kg in Iron Gate Reservoir, which are consistently below 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).

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 3–4 orders of magnitude lower than OEHHA thresholds of concern (2,500–15,000 ng/g wet weight) and PCB concentrations were below the lowest OEHHA threshold (i.e., fish contaminant goal of 3.6 ng/g wet weight) (Davis et al. 2010).

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). Toxicity equivalent quotients (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[37] (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;
- 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*.

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[37] 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).

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
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 & 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

North Coast Regional Board (Basin Plan 2018)[1,2]	Hoopa Valley Tribe (HVTEPA 2008)[3]	Yurok Tribe (YTEP 2004)[3]
Potable Water Supply		
Municipal and Domestic Supply (MUN)	Municipal and Domestic Supply (MUN)*	Municipal and Domestic Supply (MUN)
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[37] (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 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 3.2-4, Table 3.2-9, and Table 3.2-10) 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* (after Table 3.2-4, Table 3.2-9, and Table 3.2-10).

Other numeric values presented in Table 3.2-4 through Table 3.2-10, 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 3.2-4, Table 3.2-9, and Table 3.2-10).

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 3.2-4, Table 3.2-9, and Table 3.2-10).

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 3.2-4, Table 3.2-9, and Table 3.2-10).

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.
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.

Parameter	Description[1]
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]
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	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Stateline to Scott River – 90% October 1 through March 31 and 85% April 1 through September 30												
Stateline	10.4	9.6	8.5	7.6	7.0	6.3	6.3	6.4	6.9	7.8	9.5	10.6
Downstream Copco Dam	10.4	9.6	8.5	7.6	6.9	6.3	6.3	6.4	6.9	7.8	9.5	10.6
Downstream Iron Gate Dam	10.8	9.9	8.8	7.8	7.1	6.5	6.5	6.5	7.1	8.1	9.7	10.9
Upstream Shasta River	10.8	10.0	8.9	7.9	7.1	6.6	6.4	6.4	7.1	7.9	9.6	10.8
Downstream Shasta River	10.8	10.1	9.0	7.9	7.2	6.7	6.5	6.5	7.2	8.0	9.7	10.9
Upstream Scott River	10.9	10.2	9.1	8.1	7.2	6.7	6.4	6.5	7.1	7.9	9.8	10.9
Scott River to Hoopa – 90% all year												
Downstream Scott River	10.8	10.2	9.3	8.7	7.9	7.3	6.9	6.9	7.6	8.0	9.8	10.9
Seiad Valley	10.9	10.2	9.3	8.8	7.8	7.2	6.9	6.9	7.5	7.9	9.9	10.9
Upstream Indian Creek	11.0	10.3	9.4	8.9	8.0	7.3	7.0	7.0	7.5	7.9	9.9	10.8
Downstream Indian Creek	11.0	10.3	9.5	9.0	8.1	7.4	7.0	7.0	7.6	8.0	9.9	10.8
Upstream Salmon River	11.2	10.6	9.8	9.3	8.4	7.5	7.2	7.2	7.7	8.2	10.0	11.0
Downstream Salmon River	11.1	10.6	9.9	9.4	8.5	7.6	7.2	7.2	7.7	8.2	10.0	10.9
Hoopa to Turwar – 90% September 1 through May 31 and 85% June 1 through August 31												
Hoopa	11.0	10.6	10.0	9.5	8.5	7.2	7.0	6.9	7.8	8.3	10.1	11.0
Upstream Trinity River	11.0	10.6	10.0	9.5	8.5	7.2	7.0	6.9	7.8	8.3	10.0	11.0
Downstream Trinity River	10.9	10.6	9.9	9.5	8.6	7.4	7.1	7.0	7.9	8.4	10.0	10.9
Youngsbar	10.9	10.6	9.9	9.5	8.7	7.4	7.1	7.0	7.9	8.4	10.0	10.9
Turwar	10.9	10.5	9.9	9.5	8.6	7.2	6.9	6.8	7.6	8.1	9.8	10.8
Upper and Middle Estuary – 90% November 1 through May 31, 85% September 1 through October 31 and June 1 through July 31, 80% August 1 through August 31												
Upper Estuary	10.9	10.6	10.1	9.5	8.6	7.3	7.1	6.7	7.6	8.0	10.0	10.7
Middle Estuary	10.9	10.6	10.1	9.6	8.6	7.3	7.2	6.8	7.8	8.2	10.1	10.8
Lower Estuary – Narrative Objective												

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
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

Parameter	Criteria/Description[1]
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; the provision that site-specific criteria can be set equal to natural conditions and the procedure for defining natural conditions have 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 definition of natural conditions; the provision that site-specific criteria can be set equal to natural conditions and 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.

Parameter[1]	Description
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.
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.

Parameter[1]	Description
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]
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 causes by 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). 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 changes in sediment properties. 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). 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, 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[38] of the Proposed Project on this beneficial use, the water quality impact analysis assesses the narrative suspended material water quality objective using the predicted suspended sediment concentrations (SSCs)[39] 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 Jenson 1996).

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[38] 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.

[39] For the purposes of this report, SSC is considered equivalent to Total Suspended Solids (TSS). SSC and TSS are generally similar, but there are potential differences in the numeric values reported by each method (Gray et al. 2000). As needed, data from multiple sources reported as either TSS or SSC are used interchangeably. SSC is more commonly used in riverine systems while TSS is used for wastewater treatment plants.

Using a generalized "dose-response"[40] 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 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) that are similarly high. 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

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[40] 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.

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 0.023–0.029 mg/L for May–October and 0.024–0.030 mg/L for November–April. The numeric TN targets range from 0.252–0.372 mg/L for May–October and 0.304–0.395 mg/L for November–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).

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–October) (Tetra Tech 2009). As a result, the nutrient impact analysis for this EIR considers whether a general downward (or upward) trend in TP and TN toward (or away from) the 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[41] (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.

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

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

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[42] for drinking water and less than 8 ug/L total microcystins[42] 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).

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

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

Table 3.2-11. 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[43] 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 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

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[43] 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.

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.

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), and it was later used to inform development of the Klamath River TMDL model. 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 informative with respect to the analysis of potential water temperature impacts under the Proposed Project, particularly for reaches where the KRWQM was not run for the FERC relicensing process (see Section 3.2.5 *Potential Impacts and Mitigation* for additional discussion). Further, the Klamath “TMDL natural conditions scenario” (T1BSR) is useful for contextualizing 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 KRWQM and the Klamath River TMDL model do not include climate change projections or KBRA hydrology[44], 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 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 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

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[44] A quantitative comparison between KBRA and the NMFS and USFWS 2013 Joint Biological Opinion for the Klamath Irrigation Project (2013 BiOp Flows) indicates that KBRA Flows sufficiently bracket the range of 2013 BiOp Flows (see also Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project*), and so RBM10 model results still generally represent the expected trends under the Proposed Project

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. 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 2005–2008 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 2005–2008 study used hydrologic and nutrient data collected by a variety of tribal, federal, and state agencies, and PacifiCorp. The nutrient budget estimates for 2005–2008 improve upon estimates made for the earlier period 1998–2002 (Asarian and Kann 2006a) by using flow- and season-based multiple regression models for predicting daily nutrient concentrations and loads and quantification of uncertainty, relatively lower laboratory reporting limits, higher sampling frequency, and nutrient speciation (not just TN and TP). As compared to the 1998–2002 period, the nutrient budget estimates for 2005–2008 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), and it was later used to inform development of the Klamath River TMDL model. 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 informative with respect to the analysis of potential long-term dissolved oxygen impacts under the Proposed Project, particularly for reaches where the KRWQM was not run for the FERC relicensing process (see Section 3.2.5 *Potential Impacts and Mitigation* for additional discussion).

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 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* is analyzed as a separate water quality parameter in the Lower Klamath Project EIR because it is a surrogate measure of algal biomass and it 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 growth, so it is not discussed further in this section.

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, the model appears to over-predict chlorophyll-*a* under the “dams-out” scenario (Tetra Tech 2008) and is therefore not used for the Lower Klamath Project EIR analysis. The 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 chlorophyll-*a* target of 10 ug/l (i.e. reduction to) is a conservative estimate of mean summer chlorophyll-*a* concentrations required to move the system toward support of beneficial uses (Creager et al. 2006, Tetra Tech 2008).

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 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 (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 between grains of sediment, which can also be referred to as pore 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 2009–2010 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[45] sample data were also

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[45] 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

evaluated through comparison with a suite of regional, state and 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.

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sediment sample in order to estimate potential chemical concentrations in the water between the grains of sediment (pore water). Standard elutriate tests do not reflect the full dilution of re-suspended sediments that would occur during dam removal.

Hydroelectric Reach

The KRWQM did not model water temperatures within the Hydroelectric Reach. 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 (0.0–3.6°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).

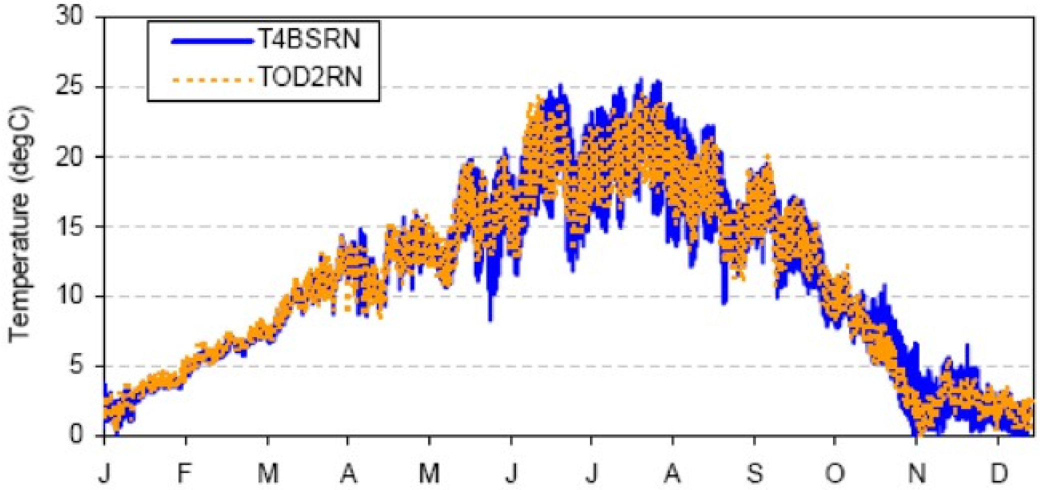

Figure 3.2-7. Predicted Water Temperature at the Oregon-California State Line (RM 214.1) for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional Board 2010.

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.

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 and 2013 BiOp flow regimes). Expected increases in summer and fall water temperatures in the Klamath Basin associated with climate change considerations are on the order of 1.8–5.4°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[46] 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.

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 1.8–5.4°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 (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). KRWQM results comparing existing conditions (all Lower Klamath Project dams in place) to four without-project scenarios[47] for 2001–2004 indicate that the reservoirs create a temporal

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[46] 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.

[47] 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).

shift by releasing generally cooler water from mid-January to April, variably cooler or warmer water from April through early August, and warmer water from August through November (PacifiCorp 2004a, Dunsmoor and Huntington 2006). Just downstream from Iron Gate Dam, this translates to an approximately 2°F to 5°F cooling during spring and an approximately 4°F 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 KRWQM indicates a lesser, albeit still measurable, warming of approximately 4°F to 9°F for most of October and November (Figure 3.2-9). 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 KRWQM model 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 3.2-8) (Deas and Orlob 1999, PacifiCorp 2005). As with the seasonal temperature effect, the dampening influence on diel temperature variation is considerably diminished farther downstream, at the confluence with the Scott River (RM 145.1; see Figure 3.2-9). The 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).

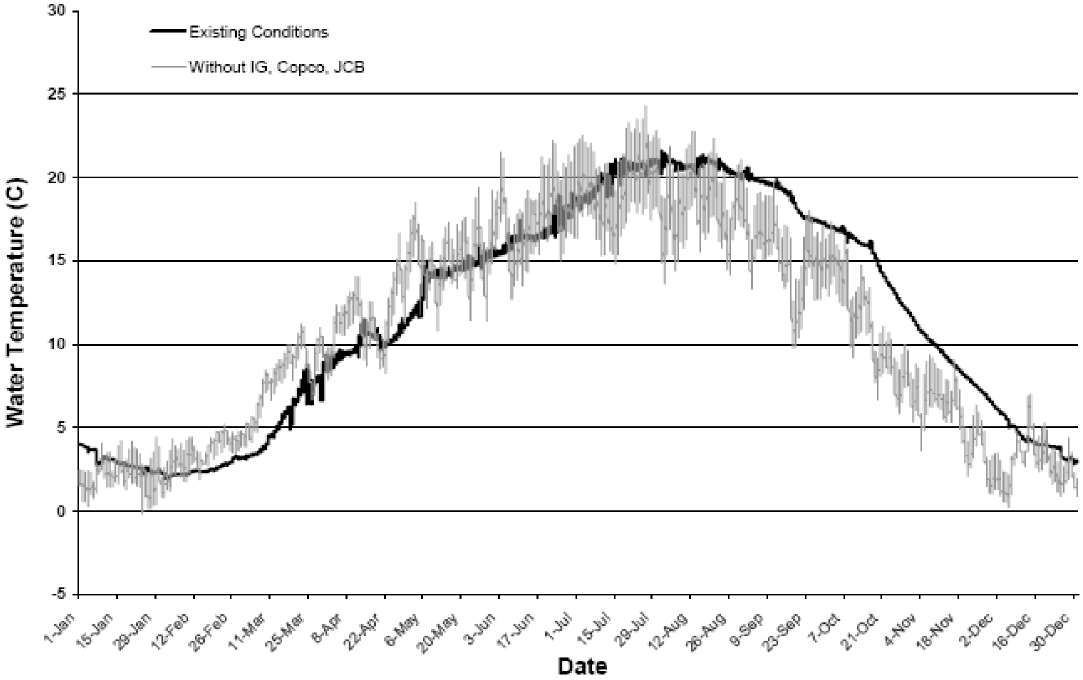

Figure 3.2-8. Simulated Hourly Water Temperature Downstream from Iron Gate Dam Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco No. 1, Copco No. 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2005.

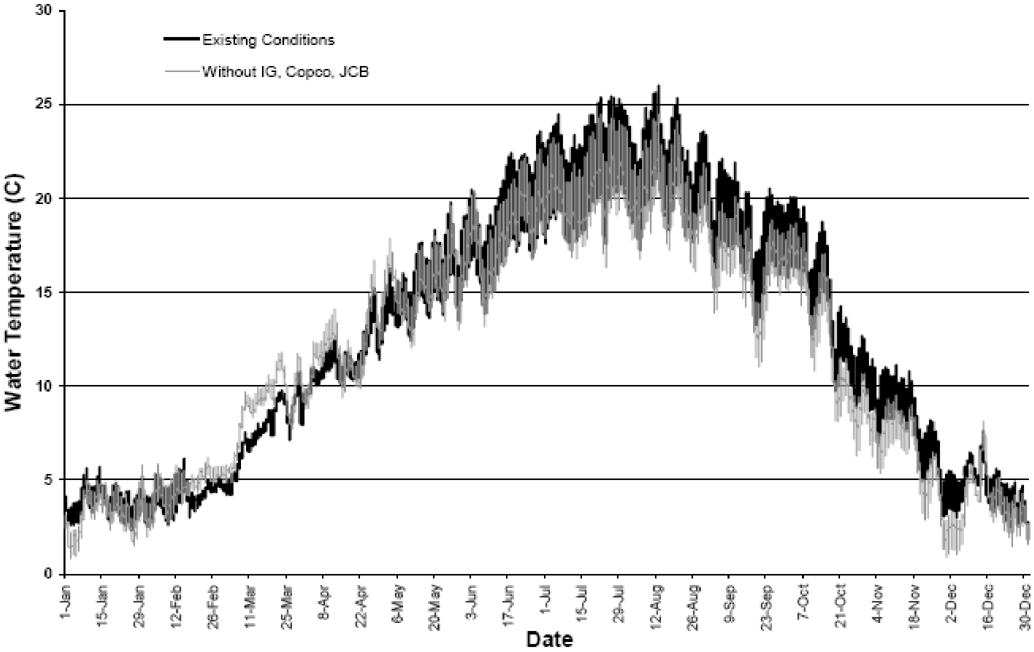

Figure 3.2-9. Simulated Hourly Water Temperature Immediately Upstream of the Scott River Confluence (RM 145.1) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco No. 1, Copco No. 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2005.

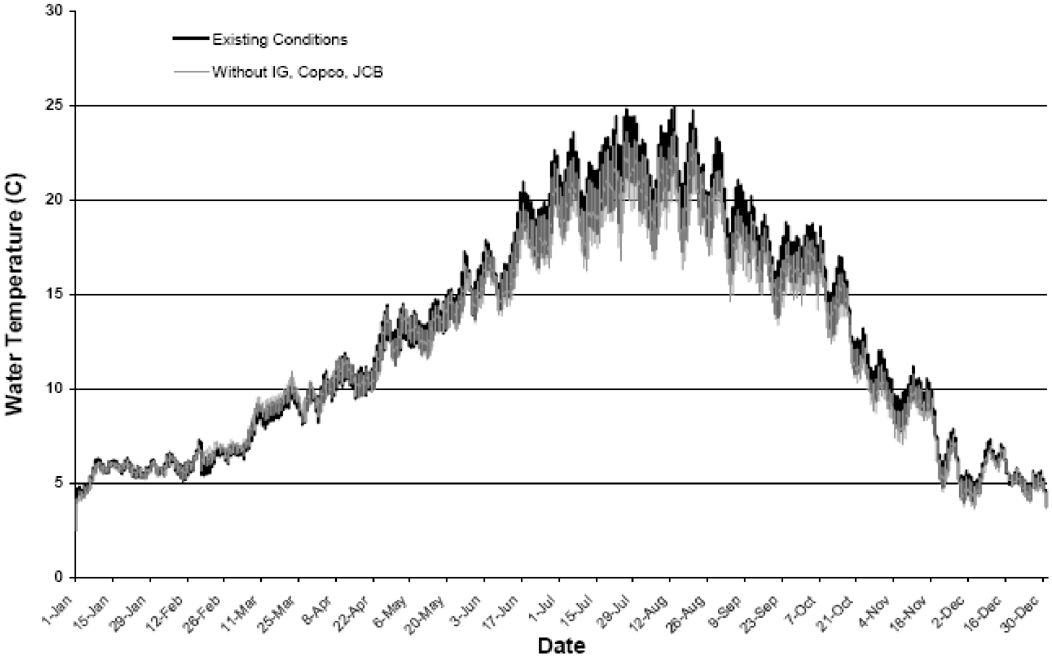

Figure 3.2-10. Simulated Hourly Water Temperature Downstream from the Salmon River Confluence (≈RM 66.3) Based on Year 2004 for Existing Conditions Compared to Hypothetical Conditions without J.C. Boyle (JCB), Copco No. 1, Copco No. 2, and Iron Gate (IG) Dams. Source: PacifiCorp 2005.

In agreement with 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°F to 18°F) during August through November and higher (by 4°F 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 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 1.8–4.1°F warmer than historical temperatures (Perry et al. 2011). This temperature range is slightly lower than that suggested by projecting Bartholow (2005) historical (1962–2001) estimates of 0.09°F per year, or approximately 4°F 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°F 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 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 (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*). 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[48]. Additionally, the Oregon Department of Environmental Quality has issued a final 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 water temperature 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

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[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 14, 2018).

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[50].

Significance

No significant impact

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 (Figure 2.7-11) and the three areas where

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[50] 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).

restoration actions are proposed within the Iron Gate Reservoir footprint (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[51] 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).

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[51] Between 2020 and 2021 (i.e., dam removal year 2 when drawdown would primarily occur under the KRRC's revised schedule), 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 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.

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 2,000–3,000 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 – 3,000 mg/L under modeled conditions to approximately 4,000–6,000 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).

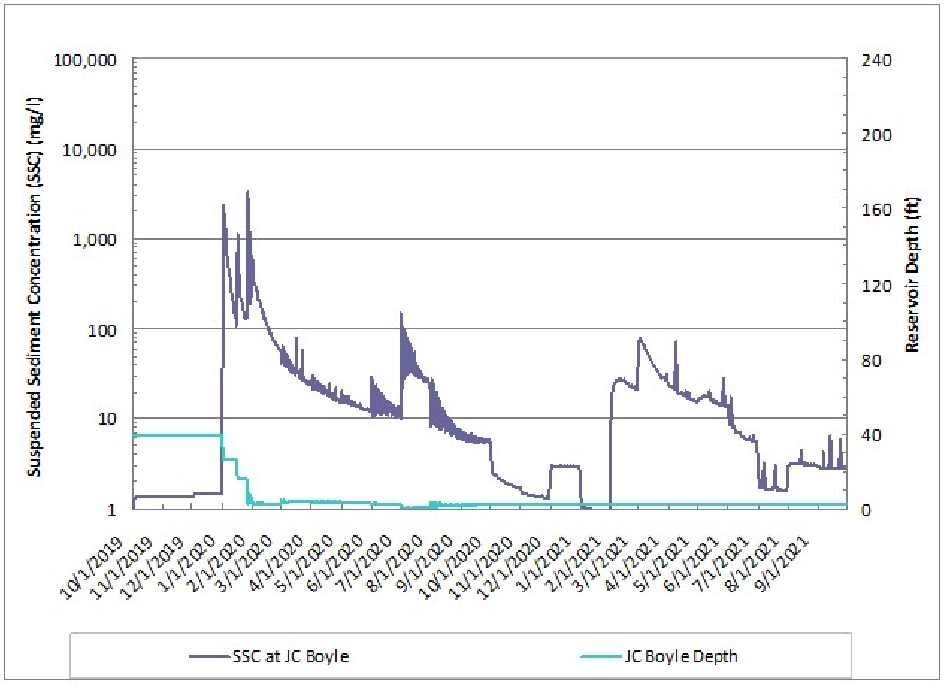

Figure 3.2-11. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Project Assuming Typical Dry Hydrology (WY2001). Dam removal year 1 is represented by the year 2019, dam removal year 2 is represented by the year 2020, and post-dam removal year 1 is represented by the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

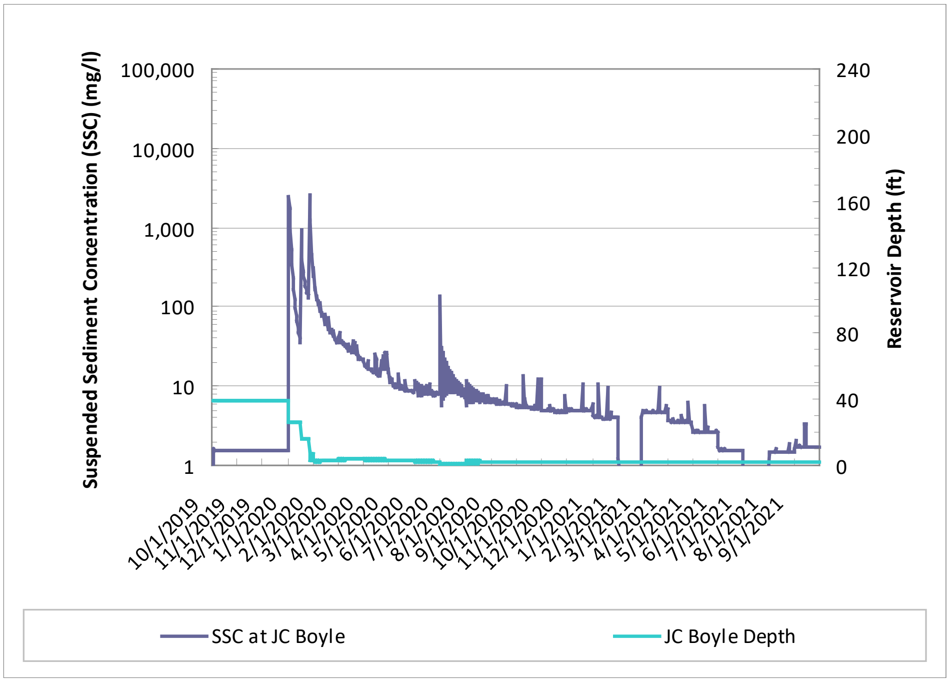

Figure 3.2-12. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Project Assuming Median Hydrology (WY1976). Dam removal year 1 is represented by the year 2019, dam removal year 2 is represented by the year 2020, and post-dam removal year 1 is represented by the year 2021.

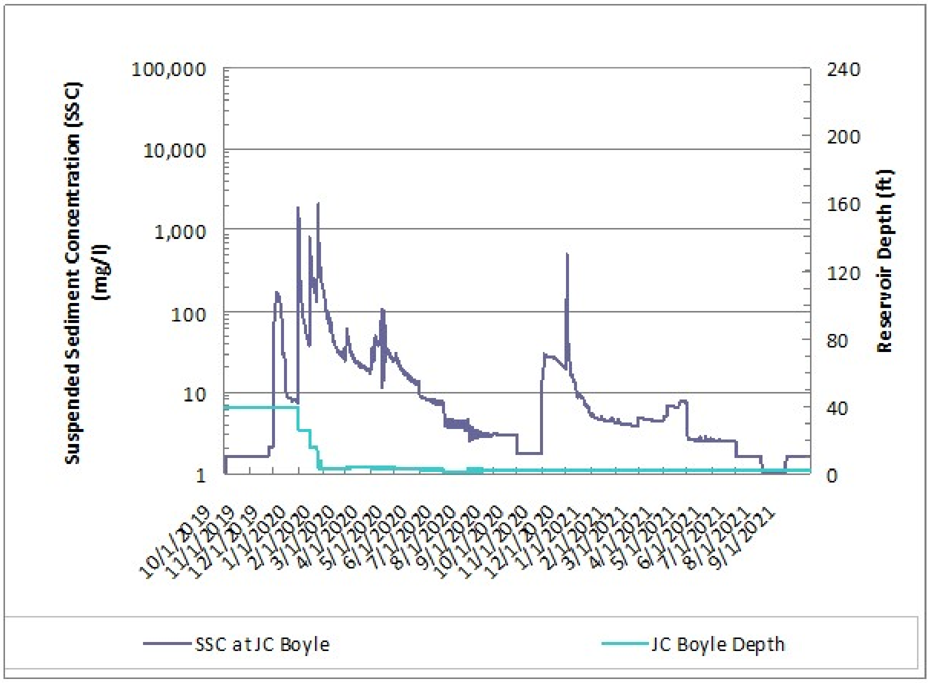

Figure 3.2-13. Suspended Sediment Concentrations Modeled at J.C. Boyle Reservoir Under the Proposed Project Assuming Typical Wet Hydrology (WY1984). Dam removal year 1 is represented by the year 2019, dam removal year 2 is represented by the year 2020, and post-dam removal year 1 is represented by the 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 3.2-14). Modeled SSCs downstream of Copco No. 1 Reservoir in dry, average and wet water year types peaked at approximately 7,000–8,000 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 7,000–8,000 mg/L under modeled conditions to approximately 14,000–16,000 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 14,000–16,000 mg/L under the higher maximum drawdown flows (i.e., 5 feet per day) to approximately 16,200–18,200 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.

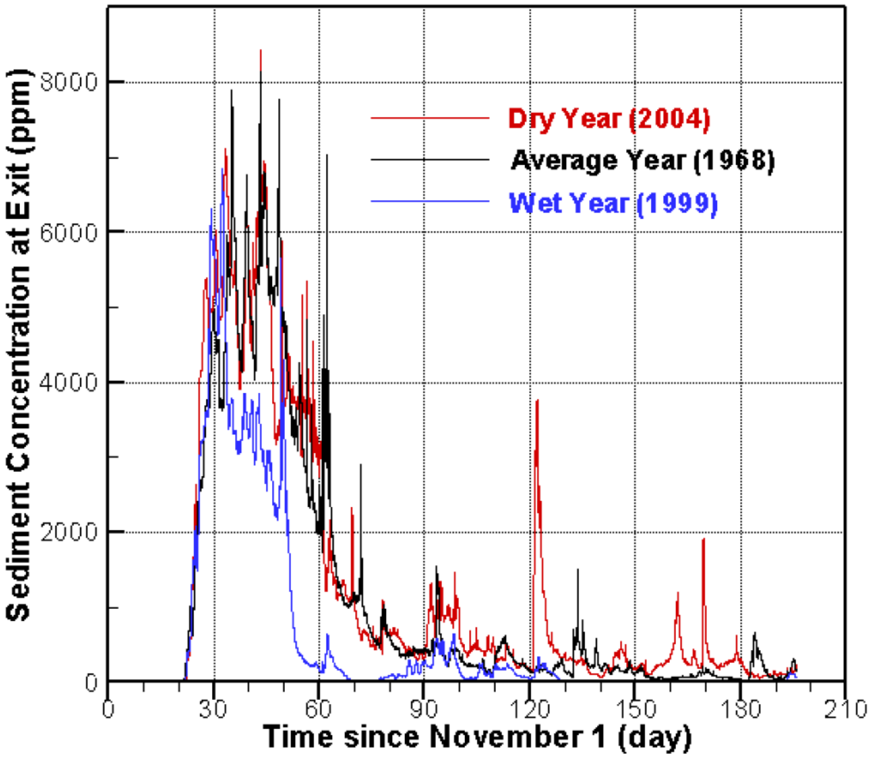

Figure 3.2-14. Sediment Concentration Downstream of Copco No. 1 Reservoir During Drawdown Using SRH-2D v3 Under Three Hydrological Scenarios. Drawdown began on November 15 and continued for six months. Source: USBR 2012.

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−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−April) and their germination would be sustained by dispersal over moist reservoir sediments during drawdown in the winter and early spring (January−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.[52]

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

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[52] 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.

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 to entering tributaries or Klamath River, and provide storage for sediment that may settle (CSQA 2003; Stubblefield et al 2006; Knox et al. 2008). The State Water Board's draft water quality certification includes Condition 13, which 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[53] (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 NMFS 2013 Biological Opinion mandatory flows are encompassed within the modeled range of flows (USBR 2016). Model predictions are discussed below and summarized in Table 3.2-13.

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[53] 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.

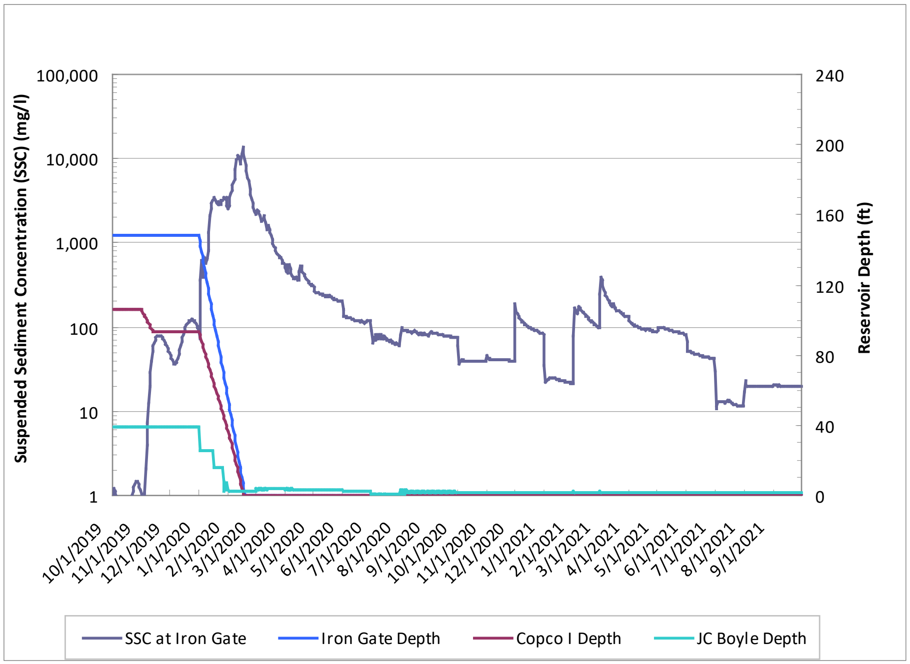

Figure 3.2-15. SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Project Assuming Typical Dry Hydrology (WY2001). Dam removal year 1 is represented by the year 2019, dam removal year 2 is represented by the year 2020, and post-dam removal year 1 is represented by the year 2021.

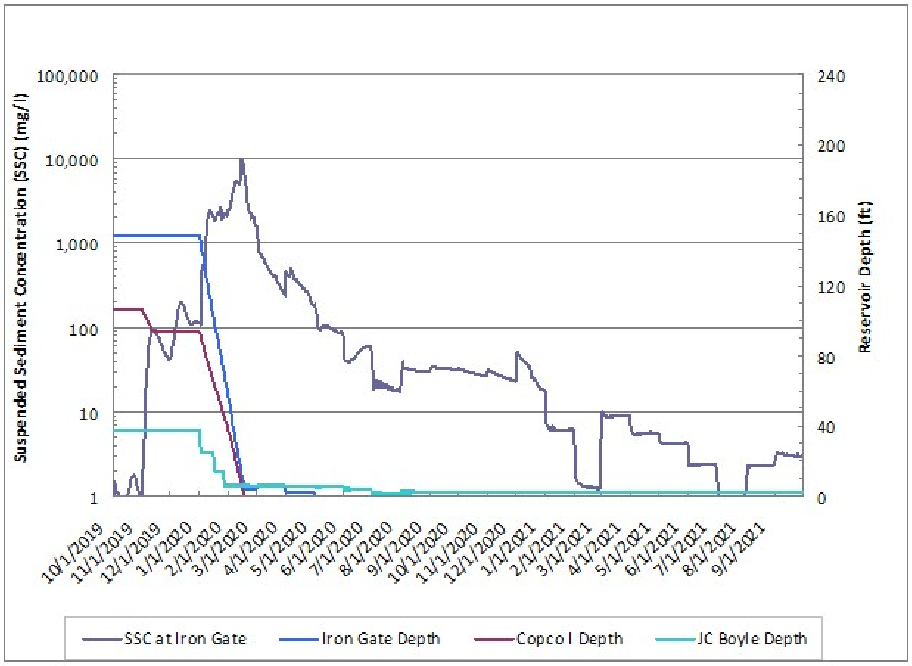

Figure 3.2-16. SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Project Assuming Median Hydrology (WY1976). Dam removal year 1 is represented by the year 2019, dam removal year 2 is represented by the year 2020, and post-dam removal year 1 is represented by the year 2021.

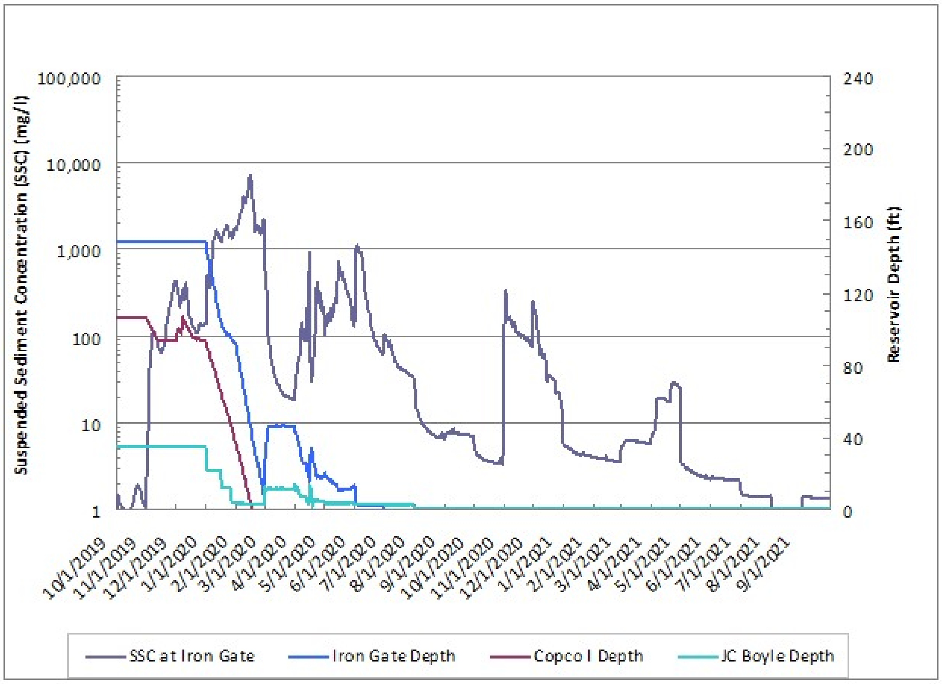

Figure 3.2-17. SSCs Modeled Downstream from Iron Gate Dam Under the Proposed Project Assuming Typical Wet Hydrology (WY1984). Dam removal year 1 is represented by the year 2019, dam removal year 2 is represented by the year 2020, and post-dam removal year 1 is represented by the year 2021.

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 200–400 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 returns 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 200–400 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 14,000–28,000 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 14,000–28,000 mg/L (under only drawdown flows at a 5 feet per day drawdown rate) to approximately 17,900–31,900 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. As such, 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[54]. 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[55] 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 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.

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 canal and 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

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[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 14, 2018).

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.

Significance
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. Measurements of organic suspended sediment between 2001 and 2003 and median turbidity values over the long-term historical record (1950–2001) 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 no decrease in algal-derived (organic) suspended material would occur within the Hydroelectric Reach due to the reservoirs no longer providing calm, slow-moving water conditions for algal-derived (organic) suspended material to settle out of the water column. 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 summertime algal-dominated (organic) suspended material in the Middle and Lower Klamath River would increase beyond a sustained 100 mg/L for two weeks (the water quality criterion adopted for significant adverse impacts on the COLD beneficial use for the Lower Klamath Project EIR analysis (see Section 3.2.3.1). If slight long-term increases in suspended materials did occur, 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 freshwater habitat (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.

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 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 short-term impact.

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[56]. Additionally, the Oregon Department of Environmental Quality has issued a water quality certification[57] 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 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"

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[56] 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).

[57] 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).

[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 TP 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 of potential benefit. 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 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–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.

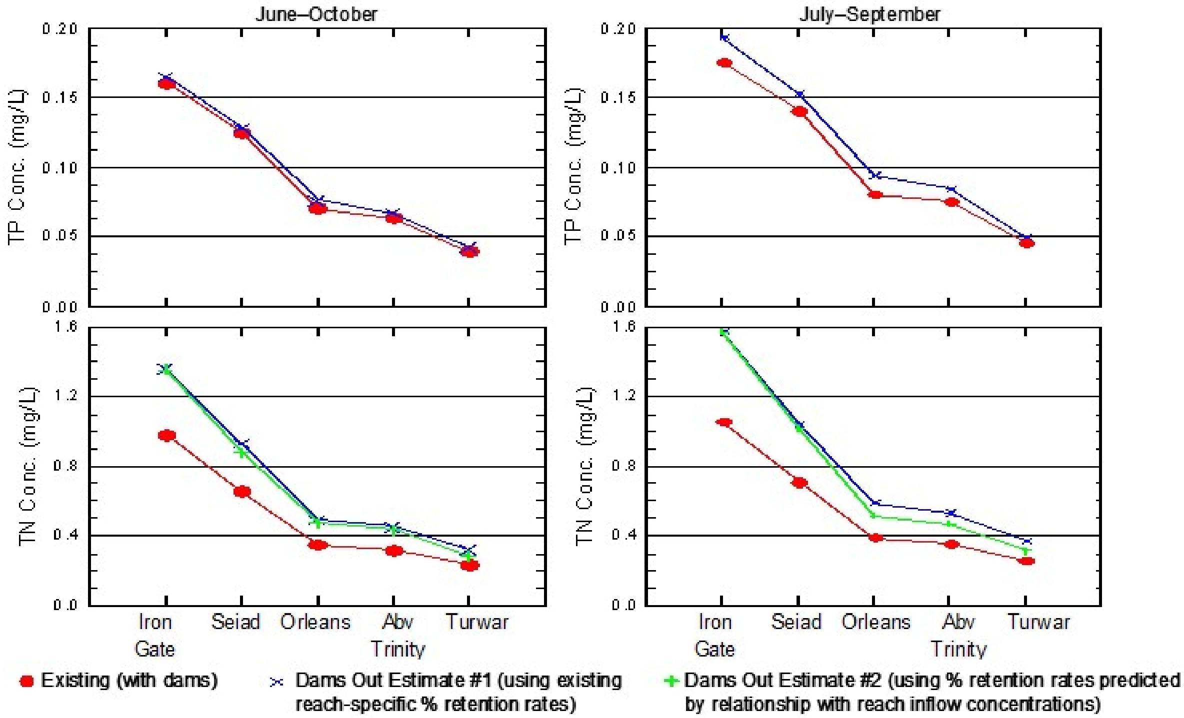

Figure 3.2-18. Comparison of Annual TP and TN Concentrations from Iron Gate Dam to Turwar (RM 5.6) for June–October and July–September 2007–2008: (a) Measured Current Conditions (Red Circle), (b) Dams-Out Estimate using Calculated Percent Retention Rates by Reach (Blue Cross), and (c) Dams-Out Estimate

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., 0.1–0.125 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 (Tetra Tech 2009), meaning that 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 results indicate that while resulting TP levels would 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, TN levels would continue to be in excess of the existing objective (0.2 mg/L TN) in all months, as would TN levels for the modeled “natural conditions” (T1BSR) and the modeled “dams-in” scenario (T4BSRN) (for the months of October through June) (North Coast Regional Board 2010). However, as noted previously, TN concentrations in the model may be over-predicted and therefore the Hoopa Valley Tribe objective may be met.

While there would be a slight 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 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 191–193.1 (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, as well as in 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
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 http://www.pacificorp.com/es/hydro/hl/kr.html# (PacifiCorp 2009).

[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[58] 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[59] 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 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 "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.

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[58] 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).

[59] 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).

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.

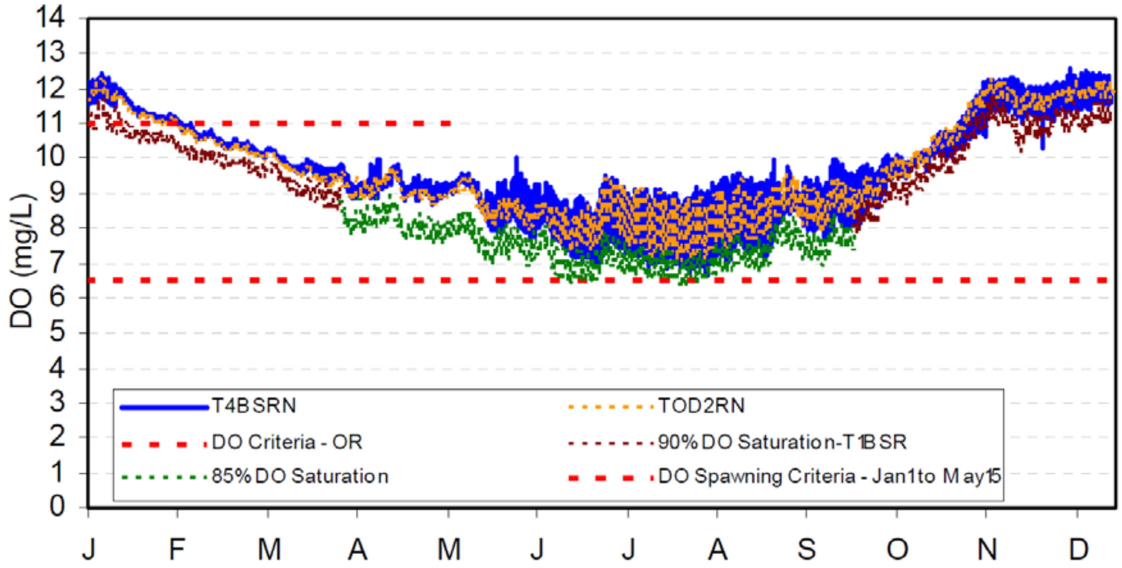

Figure 3.2-19. Predicted Dissolved Oxygen at the Oregon-California State Line (RM 214.1) for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional Board 2010.

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

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 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 KRWQM does not include nutrient retention in the mainstem river downstream from Iron Gate Dam and assumes relatively high nutrient contributions from tributaries (Asarian and Kann 2006b). These input assumptions lead to a likely overestimate of the increase in periphyton growth, and therefore a likely overestimate of modeled predicted daily variations in dissolved oxygen.

Like the 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 – 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 all 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[60] Hoopa Valley Tribe objective[61]. 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

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[60] 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.

[61] 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.

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, 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.

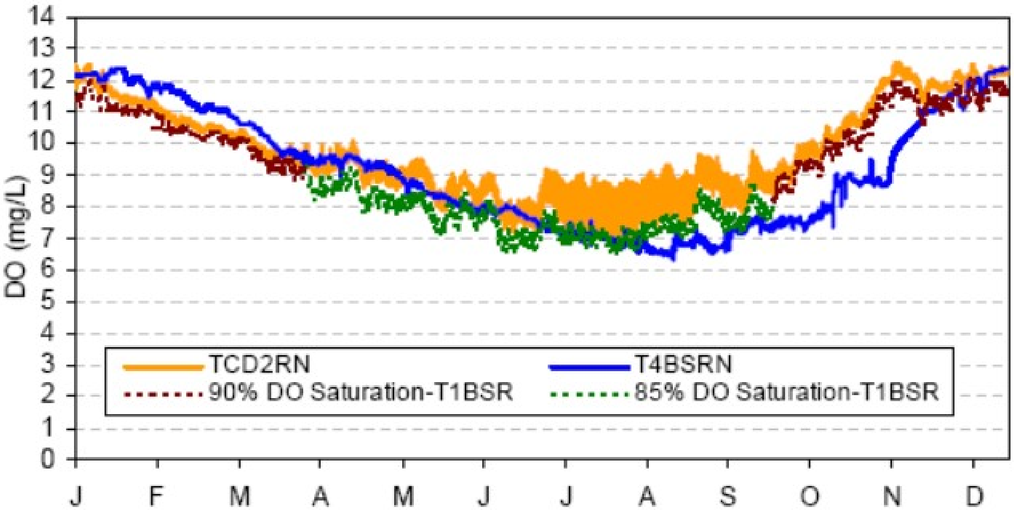

Figure 3.2-20. Predicted Dissolved Oxygen Downstream from Iron Gate Dam for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional Board 2010.

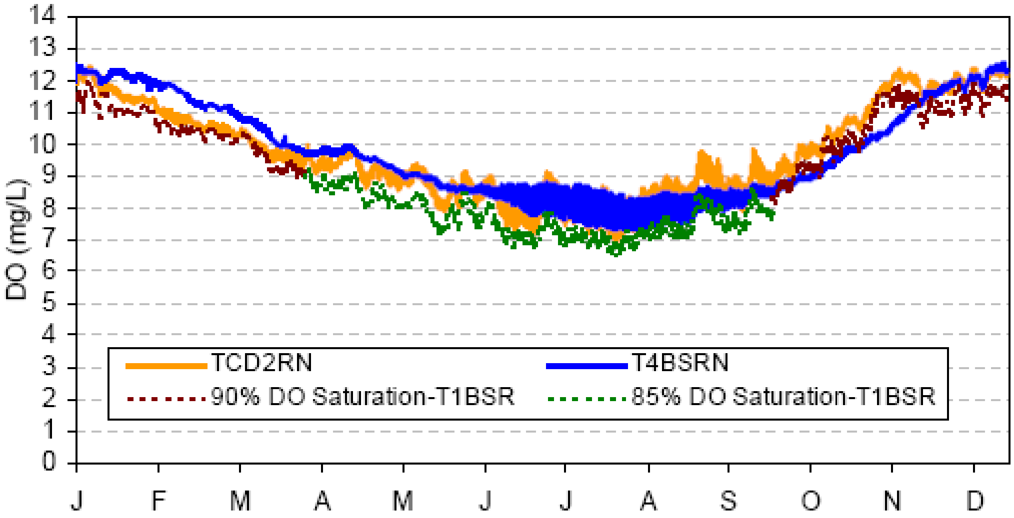

Figure 3.2-21. Predicted Dissolved Oxygen Downstream from the Mainstem Confluence with the Shasta River (RM 179.5) for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional Board 2010.

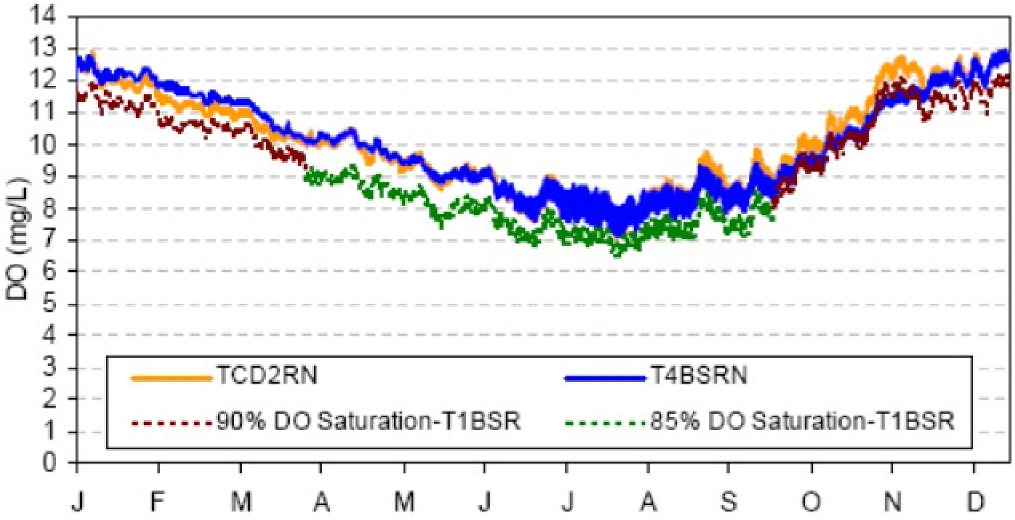

Figure 3.2-22. Predicted Dissolved Oxygen at Seiad Valley (RM 132.7) for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional Board 2010.

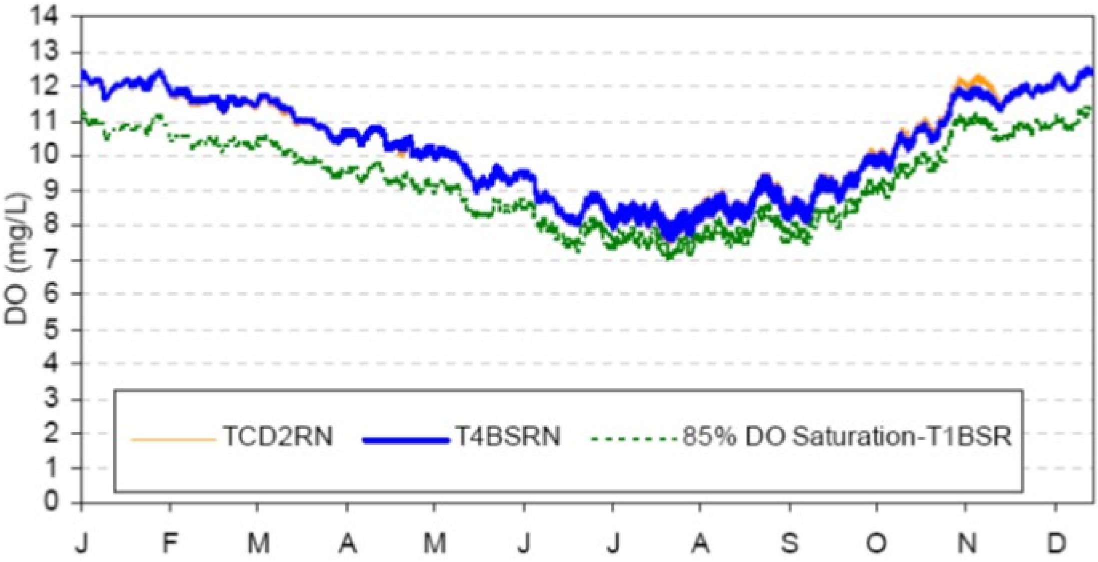

Figure 3.2-23. Predicted Dissolved Oxygen Just Upstream of the Confluence with the Trinity River (RM 43.3) for the Klamath River TMDL Scenarios Similar to the Proposed Project ("TMDL dams-out, Oregon" [TOD2RN] Scenario) and Existing Conditions ("TMDL dams-in" [T4BSRN] Scenario). Source: North Coast Regional 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 (7.0–8.5) 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.

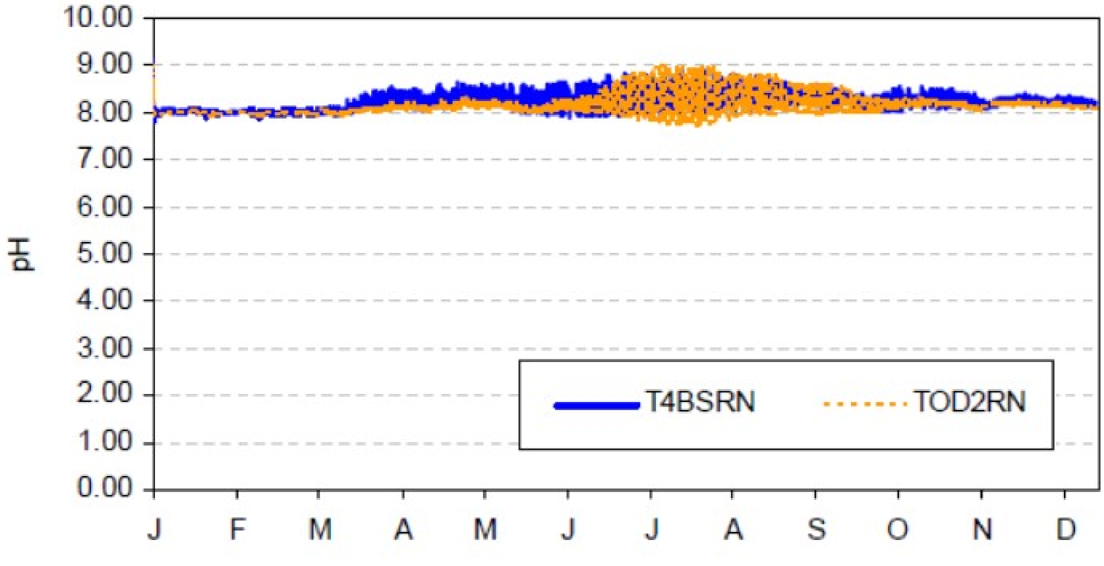

Figure 3.2-24. Predicted pH at the Oregon-California State Line (RM 214.1) for the Klamath River TMDL Scenarios Similar to the Proposed Project (TOD2RN Scenario) and the modeled existing conditions (T4BSRN Scenario). Source: North Coast Regional Board 2010.

The Proposed Project also would be expected to eliminate the occurrence of high pH (greater than 8.5 s.u.) and large daily fluctuations (0.5–1.5 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.

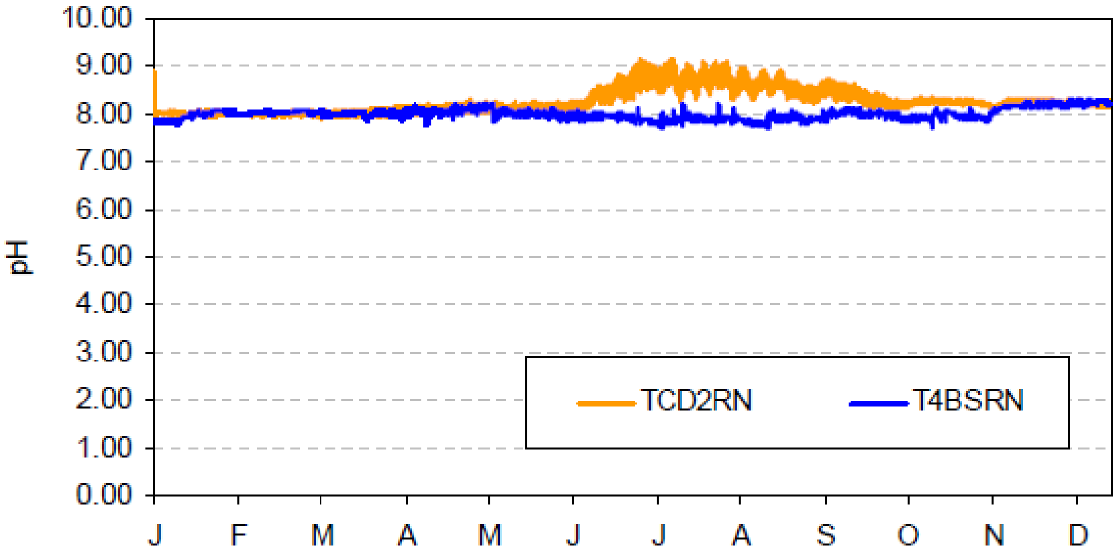

Figure 3.2-25. Predicted Klamath River pH Immediately Downstream from Iron Gate Dam for the Klamath River TMDL Scenarios Similar to the Proposed Project (TCD2RN Scenario) and the No Project Alternative (T4BSRN Scenario). Source: North Coast Regional Board 2010.

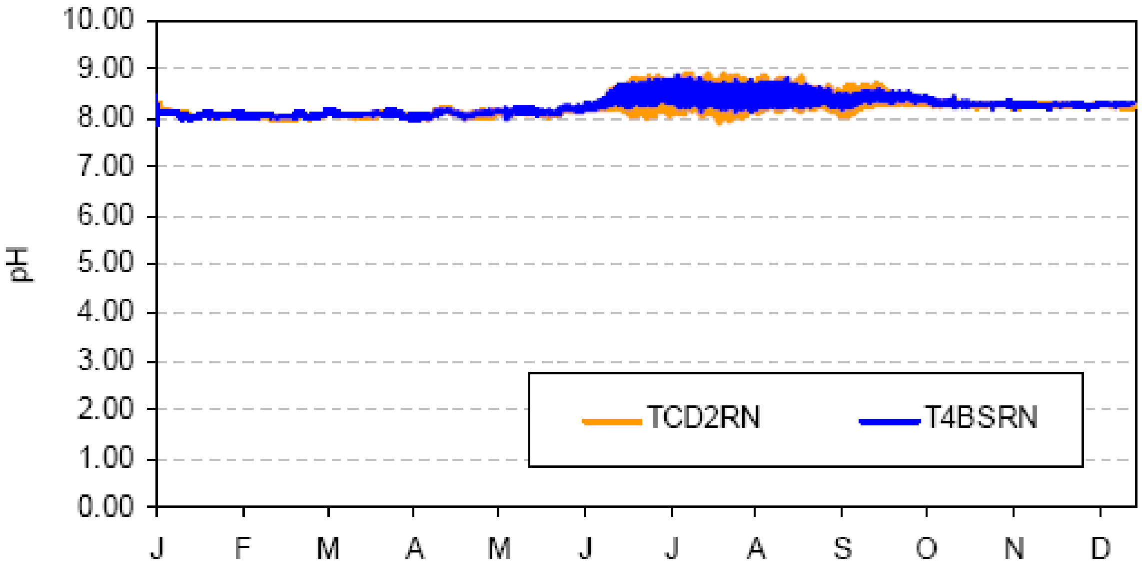

Figure 3.2-26. Predicted Klamath River pH upstream of the Scott River (RM 145.1) for the Klamath River TMDL Scenarios Similar to the Proposed Project (TCD2RN Scenario) and the No Project Alternative (T4BSRN Scenario). Source: North Coast Regional Board 2010.

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 (0.5–1.5 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 (7.0–8.5) 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 (6.5–8.5) 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 alter the periphyton community 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[62]. Additionally, the Oregon Department of Environmental Quality has issued a water quality certification[63] 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.

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[62] 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).

[63] 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).

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 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 (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.

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.

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 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 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). 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.

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[64]. Additionally, the Oregon Department of Environmental Quality has issued a water quality certification[65] 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.

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. 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[66] 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

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[64] 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).

[65] 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).

[66] 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.

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 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 2009–2010 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*).

	Exposure Pathway	Freshwater biota	Marine biota	Terrestrial biota	Humans
Pathway 1	Short-term exposure to sediments flushed downstream	🟢	🔵	--	--
Pathway 2	Long-term exposure to exposed reservoir terrace and or river bank deposits	--	--	⚫ (1)	🔵 (2)
Pathway 3	Long-term exposure to new river channels and river bed deposits	🔵	--	--	🔵
Pathway 4	Long-term exposure to marine / near shore deposits	--	🔵	--	--
Pathway 5	Long-term exposure to reservoir sediments	🟢	--	--	🟢

⚫	No adverse effects based on lines of evidence
🔵	One or more chemicals present, but at levels unlikely to cause adverse effects based on the lines of evidence
🟢	One or more chemicals present at levels with potential to cause minor or limited adverse effects based on the lines of evidence
🔴	At least one chemical detected at a level with potential for significant adverse effects based on the lines of evidence
--	This exposure pathway is incomplete(3) or insignificant(4) for this receptor group

Note:
This does not include an evaluation of the physical effects (e.g., dissolved oxygen in the water, suspended sediment)
(1) Qualitative evaluation conducted for this exposure pathway
(2) Limited quantitative, along with qualitative evaluations conducted for this exposure pathway
(3) Incomplete - receptor group is unlikely to come in contact with sediment-associated contaminants under this exposure pathway
(4) Insignificant - exposure pathway not considered a major contributor to adverse effects in humans based on best professional judgment

Figure 3.2-27. 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 (CalEPA OEHHA 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 water between grains of sediment, which can also be referred to as pore water) from the 2009–2010 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). As such, 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 2,000–3,000 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 fresh water quality criteria for samples from J.C. Boyle, Copco No. 1, and Iron Gate reservoirs (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 2009–2010 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 9,000–10,000 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 3,000–6,000 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 800–2,000 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, and upon notice from property owners, the KRRC shall assess visibly obvious sediment deposits along with Middle and Lower Klamath River 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 if they are consistent with physical sediment properties associated with Lower Klamath Project reservoir sediments (see Section 3.11.2.5 *Reservoir Sediment Storage and Composition*). Visibly obvious sediment deposits consistent with physical sediment properties associated with Lower Klamath Project reservoirs shall be tested for arsenic. 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 Middle and Lower 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.

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 SSC 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 2,000–3,000 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 SSC 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 2009–2010 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 2009–2010 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[33] 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 (representing the water between grains of sediment, which can also be referred to as pore water) from the 2009–2010 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 2009–2010 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 2009-2010 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[67] and 2,3,4,7,8-PECDF[68] (CDM 2011). The concentrations of detected inorganic or organic contaminants in Lower Klamath 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.

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[67] 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).

[68] 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).

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[69]), 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 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[70]. Additionally, the Oregon Department of Environmental Quality has issued a water quality certification[71] 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.

Significance

No significant impact

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[69] National Recommended Water Quality Criteria for Non-Priority Pollutants, Marine Criterion Continuous Concentration [chronic].

[70] 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).

[71] 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).

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 canal and 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). All of 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 (i.e., Glyfos Aquatic) 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 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 the inorganic and organic contaminants (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 goal would be reduced, resulting in an overall decrease in potential suspended material, nutrient, or water treatment chemical releases in the system as a whole.

Under the Proposed Project, water temperature effects from Iron Gate 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 contaminants 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; therefore, reductions in fish production and feed at Iron Gate Hatchery under the Proposed Project also would correspond to a reduction in total nitrogen (TN), total phosphorus (TP), and carbonaceous biological oxygen demand (CBOD)[72] loads from the hatchery. Thus, while Iron Gate Hatchery currently exceeds its TMDL allocation of zero net discharge of nitrogen, phosphorous and biological 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. Overall, the decrease in total hatchery fish production would maintain or improve return water quality conditions

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[72] Carbonaceous biological 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 biological oxygen demand (NBOD).

downstream of Iron Gate Hatchery as compared to existing conditions, so there would be no significant impact on water quality below 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[73] 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 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

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[73] 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*).

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.

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[74] 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

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[74] For the purposes of this report, SSC is considered equivalent to TSS (see Section 3.2.3.1 *Thresholds of Significance* for additional details).

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 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[75] 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.

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.

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[75] 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.

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, 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 (AFS FCS 2014).

Table 3.2-15. Potential General Treatment and Therapeutic Chemicals Used at California Department of Fish and Wildlife Hatcheries.

Chemical Name	Use	Regulatory Status
acetic acid	Control of external parasites	FDA LRP compound
carbon dioxide (gas)	Anesthetic	FDA LRP compound
sodium bicarbonate (baking soda)	Anesthetic	FDA LRP compound
formalin (formaldehyde)	Fungus and parasite treatment	FDA approved
povidone-iodine (PVP iodine)	Disinfectant for eggs	FDA LRP compound
potassium permanganate	Control of external parasites and bacteria	FDA DD chemical; USEPA registered pesticide with approved use in aquaculture
hydrogen peroxide	Control of fungal and bacterial infection	FDA approved
Chloramine-T (*N*-chloro tosylamide)	Control of external gill bacteria	FDA INAD
Terramycin (oxytetracycline)	Antibiotic	FDA approved
Aquaflor (florfenicol)	Antibiotic	FDA approved
penicillin G	Control and prevention bacterial infections	FDA approved
Romet-30 (sulfadimethoxine-ormetoprim)	Antibiotic	FDA approved
MS-222 (tricane mesylate)	Anesthetic	FDA approved

Source: ICF 2010.
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.

Fall Creek Hatchery operations and general treatment or therapeutic chemical use would be expected to be generally similar in the short term and long term to other CDFW hatcheries. 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 2.2ºF 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 in

Condition 12 *Hatcheries* 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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