3.4 Algae

3.4.1 Area of Analysis

This section of the Klamath Facilities Removal Environmental Impact Statement/ Environmental Impact Report (EIS/EIR) analyzes potential effects of the Proposed Action and alternatives on algal communities in the Klamath River Watershed, excluding the Lost River watershed, Tule Lake watershed, and most of the Trinity River.

The area of analysis for algae is generally the same as for Aquatic Resources (Section 3.3, Aquatic Resources, Figure 3.3-1). Potential impacts were assessed within and across reaches of the Klamath Basin, as separated by changes in physiography (e.g., Upper and Lower Klamath Basins), the presence of the Four Facilities under analysis, and degree of marine influence. The area of analysis for algae has the following reaches:

1. Upstream of the influence of J.C. Boyle Reservoir, including the following:
   a. Upper Klamath Lake and Agency Lake
   b. Tributaries to Upper Klamath Lake (Sprague, Sycan, Wood and Williamson Rivers)
   c. Reclamation's Klamath Project facilities (e.g., Link River Dam, Keno Impoundment /Lake Ewauna)
2. Hydroelectric Reach: from the upstream end of J.C. Boyle Reservoir to Iron Gate Dam, including all sections categorized as mainstem, bypassed, and peaking reaches and including tributaries to the Klamath River (examples include Jenny, Spencer, Slate, Shovel, and Fall creeks).
3. Lower Klamath River: downstream of Iron Gate Dam, including the following:
   a. Major tributaries to the Klamath River (Shasta, Scott, and Salmon Rivers)
   b. Minor tributaries to the Klamath River (examples include Bogus, Beaver, Humbug, and Cottonwood creeks)
4. Klamath Estuary
5. Pacific Ocean marine nearshore environment (see Figure 3.2-1)

3.4.2 Regulatory Framework

Beneficial uses and water quality objectives for Oregon, California, the United States Environmental Protection Agency (USEPA), and the Hoopa Valley, Yurok and Karuk Tribes provide the regulatory framework for algae listed below. These uses and objectives are described in detail in Section 3.2.2. Oregon includes a narrative nuisance algae growth objective in which impairment of beneficial uses by algal growth is not allowed. Additionally, for natural lakes that do not thermally stratify, reservoirs, rivers and estuaries, the numeric average of 0.015 mg/l chlorophyll-*a* identifies Oregon water bodies where phytoplankton may impair the recognized beneficial uses (Table 3.2-3). California has a narrative biostimulatory water quality objective that limits nutrients to the extent that such growths cause nuisance or adversely affect beneficial uses (Table

3.2-3). Additionally, the algal concentration "targets" for the California Klamath River Total Maximum Daily Loads (TMDLs) were developed from an interpretation of the biostimulatory substances objective, using the California Nutrient Numeric Endpoint guidelines (North Coast Regional Water Quality Control Board [NCRWQCB] 2010a). For water column chlorophyll-*a* concentrations (i.e., phytoplankton) the California Klamath River TMDL target is 10 µg/L. For attached algal biomass (i.e., periphyton), the target is 150 $\mu g/m^2$ of chlorophyll-*a*. The Hoopa Valley Tribe also uses 150 $\mu g/m^2$ of chlorophyll-*a* as the water quality objective for nuisance periphyton growth (Table 3.2-6), which is applicable for River Mile (RM) ≈45-46 of the mainstem Klamath River.

3.4.2.1 Federal Authorities and Regulations

- Clean Water Act (Title 33 U.S.C. §1313 [1972])
- Safe Drinking Water Act (Title 42 U.S.C. CHAPTER 6A §300f-j [1973 as amended])
- Coastal Zone Management Act

3.4.2.2 State Authorities and Regulations

- Oregon Administrative Rules for Water Pollution Control (OAR 340-041)
- North Coast Region Basin Plan (as required by Sections 13240–13247 of California Porter-Cologne Water Quality Act)
- Oregon Administrative Rules for Water Pollution Control (OAR 340-041)
- California Ocean Plan

3.4.2.3 Tribal Authorities and Regulations

- Hoopa Valley Tribe Water Quality Control Plan

3.4.3 Existing Conditions/Affected Environment

Two algal communities are predominate in the Klamath Basin. The lakes and reservoirs are dominated by phytoplankton, small algae that float in the water column. Particular phytoplankton species (i.e., blue-green algae or cyanobacteria) frequently reach nuisance levels within the lakes and reservoirs. In addition, there are portions of the riverine reaches (e.g., backwater eddies and near shore shallows) that have become inoculated with phytoplankton from upstream lakes and reservoirs, which can also support nuisance levels of blue-green algae under certain conditions. The riverine portions of the Klamath River are dominated by periphyton (i.e., attached algae) or algae, fungi, and bacteria that attach to the stream bed and/or periphyton mats. Periphyton is generally dominated by diatoms and green algae. Submerged aquatic macrophytes may also be present in quite backwater areas in the Klamath River; however, no known quantitative or species-specific information has been collected. No surveys have been conducted to determine the relative distribution or biomass of aquatic macrophytes in the Klamath River. This section focuses on the potential impacts of the Proposed Action and the alternatives on the phytoplankton and periphyton communities.

3.4.3.1 Phytoplankton

A number of different groups contribute to the phytoplankton community, including diatoms, green algae, and cyanobacteria (i.e., blue-green algae). The phytoplankton community shifts seasonally in response to changing temperature, light and nutrient levels. Phytoplankton forms the base of the food web in the reservoirs. Phytoplankton is consumed by zooplankton, insects and some small fish, which are fed upon by larger fish, birds, mammals, and humans. Diatoms and green algae are generally considered to be beneficial components of the phytoplankton based on their important role in the food web. When phytoplankton communities reach higher levels of concentration in the water column (e.g., greater than 10-15 µg/L), the species composition shifts from the more beneficial green algal species to blue-green algal species. This happens quickly as biomass in the water column begins to increase exponentially, which results in nuisance conditions including: extreme diurnal dissolved oxygen (DO) and pH fluctuations due to the effect of photosynthesis and respiration of the algal biomass, high concentrations of cyanotoxins produced by toxigenic blue-green algal species (see also Section 3.2.3.7), DO crashes due to the decomposition of decaying algal biomass, and in extreme conditions, disruption of food webs from light limitation. Typically these nuisance conditions are dominated by blue-green algae species, most notably in Upper Klamath Lake, Copco 1 Reservoir, and Iron Gate Reservoir. Nuisance blooms of green algae are less common in the Klamath Basin. Blue-green algae reach very high densities in the summer months. Some blue-green algae, *Anabaena flos-aquae*, and *Microcystis aeruginosa,* produce toxins that are harmful to fish, mammals and humans (see Section 3.2.3.7).

The stable lacustrine[1] environment created at the Four Facilities, particularly in the larger Copco 1 and Iron Gate Reservoirs, coupled with high nutrient availability and high water temperatures in summer to fall, provides ideal conditions for phytoplankton growth. Blue-green algal species in particular thrive under warm water temperature, high nutrient, and stable water column conditions (Konopka and Brock 1978, Kann 2006), and out-compete other algal species such as diatoms in areas characterized by these conditions (Stillwater Sciences 2009).

In general, blooms of floating, or planktonic, algae (i.e., phytoplankton) can have important implications for water quality in freshwater systems, causing seasonal and daily fluctuations in nutrients, DO, and pH cycles. Within the Klamath Basin, blue-green algal productivity is locally and seasonally associated with extreme daily fluctuations in DO levels (high during the day and low at night), and elevated pH and free ammonia concentrations, which do not meet Oregon water quality standards during the summer months (Section 3.2.2.3). In California, the Klamath River watershed was listed for nutrient and temperature impairment from Iron Gate Reservoir to the Scott River, and the Klamath River mainstem was listed for organic enrichment/low DO in the reaches upstream of Iron Gate Reservoir and downstream of the Scott River in 1998. These listings were confirmed in the Klamath River TMDL (NCRWQCB 2010b). The factors contributing to ammonia toxicity (i.e., high ammonia concentrations, high pH, and elevated temperatures) have been documented independently, but concurrent measurements of these conditions are not available to demonstrate ammonia toxicity in California (Creager, pers. comm., 2011). Organic enrichment and DO depressions are

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

particularly of issue during the summer and fall months when water temperatures are relatively high.

Nuisance algal blooms that occur in the Klamath Basin are primarily composed of three species of blue-green algae: *Aphanizomenon flos-aquae*, *Anabaena flos-aquae*, and *M. aeruginosa*. Large blooms of *Aphanizomenon flos-aquae and Anabaena flos-aquae* can strongly influence pH, free ammonia, and DO concentrations as described above. As nitrogen fixers, these species can provide a source of inorganic nitrogen for additional primary production in reservoirs (Federal Energy Regulatory Commission [FERC] 2007), which allows them to outcompete other algal species when nitrogen becomes scarce in a lake or reservoir. In addition to its role as a nitrogen fixer, *Anabaena flos-aquae* produces a neurotoxin (i.e., anatoxin), which can cause irritation, muscle twitching, paralysis, and death.

Although *M. aeruginosa* is not a nitrogen fixer, there are also frequent instances of bloom densities that also create conditions that negatively influence diurnal pH and DO conditions. *M. aeruginosa* produces microcystin, a liver toxin that can have detrimental effects on the health of exposed vertebrates, including humans. These toxins can cause irritation, sickness, or in extreme cases, death.

Studies suggest that the presence of *M. aeruginosa* blooms could result in acute and chronic effects on fish including increased mortality, reduced fertility, reduced feeding; and habitat avoidance (Interagency Ecological Program 2007, Fetcho 2008, CH2M Hill 2009, Fetcho 2009, Teh et al. 2010) including potential adverse affects to endangered juvenile suckers in Upper Klamath Lake (VanderKooi et al. 2011; see Section 3.3.3.2 Physical Habitat Descriptions - Water Quality - Algal Toxins). The World Health Organization (WHO) guidelines for exposure to microcystin have been exceeded in Upper Klamath Lake (VanderKooi et al. 2011) and the middle and lower Klamath River on several occasions (Chorus and Bartram 1999, Fetcho 2006, Fetcho 2007, Fetcho 2008, Kann 2008, Kann and Corum 2009), and the Klamath River from Copco 1 Reservoir (RM 203.1) to Iron Gate Dam (RM 190.1) is listed as impaired for toxicity due to the presence of microcystin in the reservoirs (Section 3.2.2.3). Large *Anabaena flos-aquae* blooms occur in the Klamath Hydroelectric Project reservoirs, along with *M. aeruginosa*, and their toxin has been documented in the reservoirs and downstream (Raymond 2009).

3.4.3.2 Periphyton

Periphyton is generally dominated by diatoms and green algae. Blue-green algae can also occur in the periphyton community, but are a small component of the community and do not reach nuisance levels. Like phytoplankton in the reservoirs, periphyton also contributes substantially to the base of the food web in riverine systems. Periphyton in the Klamath River also plays an important role in nutrient dynamics, affecting nutrient fluxes and resulting in short-term changes in DO and pH. Monitoring at multiple locations along the mainstem Klamath River indicates that DO and pH patterns over a 24-hour period are driven by photosynthesis and respiration of large colonies of periphyton. Excessive swings in DO and pH can be stressful to aquatic biota, thus too much periphyton can adversely affect water quality and aquatic resources.

Benthic[2] algae documented within the Klamath Basin include nuisance filamentous green algae species such as *Cladophora* (FERC 2007), which can form dense mats in some places in the lower Klamath River. These mats tend to be patchy and occur in lower velocity areas. They are not a dominant feature of the river, but are an important habitat for the polychaete worm that is the intermediate host of the important fish parasites, *Ceratomyxa shasta* and *Parvicapsula minibicornis.* Periphyton abundance and community composition appears to be controlled in large part by nutrient availability and flow rates, with high flow rates frequently corresponding to low periphyton abundance, and nutrient enrichment corresponding to an increased abundance of *Cladophora*. However, data regarding the distribution, community composition, and biomass of periphyton in the Klamath River is limited.

3.4.3.3 Upper Klamath Basin Upstream of the Influence of J.C. Boyle Reservoir

Phytoplankton

Sediment core studies indicate that Upper Klamath Lake was likely a historically biologically productive lake (i.e., the lake produced abundant fish and blue-green algae blooms) as indicated by high nutrient concentrations (particularly phosphorus) in the sediments for the last thousand years (Eilers et al. 2001). Additional analysis of sediment cores suggests that Upper Klamath Lake water quality has changed substantially over the past 100 years as consumptive water use practices (e.g., irrigation, municipal uses, wetland diking and draining [i.e., conversion of wetlands to agricultural land]) and accompanying changes in land use practices throughout the upper Klamath and Lost River watersheds have increased (Walker 2001). Specifically, it appears that mobilization of phosphorus from agriculture and other nonpoint sources has pushed the lake from a naturally eutrophic state into its current hypereutrophic[3] state, allowing algal blooms to reach or approach their theoretical maximum (Walker 2001).

Evaluation of temporal and spatial patterns of algal community composition in Upper Klamath Lake reveals shifts between blue-green algae and diatom-dominated communities. Phytoplankton biovolumes in Upper Klamath Lake are dominated by beneficial diatoms in the spring (Kann 1997, Oregon Department of Environmental Quality [ODEQ] 2002, Sullivan et al. 2009), while summer and fall (June–October) algal blooms in Upper Klamath Lake are strongly dominated by noxious blue-green algal species (primarily *Aphanizomenon flos-aquae*) (Eilers et al. 2004, FERC 2007).

Downstream from the Link River to Keno Dam, temporal and spatial patterns of algal community composition are driven by blooms originating in Upper Klamath Lake. In 2008, a total of 141 algae species were identified in this reach, with most of these algae (98.8 percent) belonging to one of four algal groups: blue-green, cryptophytes, diatoms, and green (Sullivan et al. 2009). *Aphanizomenon flos-aquae* possessed the highest average density (61 percent) when present. As in Upper Klamath Lake, algal group composition in

[2] Relating to the bottom of a sea, stream, or lake or to the organisms that live there.
[3] Hypereutrophic: a state of water quality characterized by excessive concentrations of nutrients such as nitrogen and phosphorous and resulting in extremely high productivity. Such waters are often shallow, with intense algal blooms and periods of oxygen deficiency and high pH.

this reach is dominated by diatoms in the spring (56 percent of the total algal biovolume at mainstem sites), while in summer and fall blue-green algae represent the dominant species (76-80 percent of the total algae biovolume) (Sullivan et al. 2009). High mean algal abundances have been documented in the Klamath River at the Keno Bridge (Highway 66), Link River, and Upper Klamath Lake (at Freemont St. Bridge) (Raymond 2005, Sullivan et al. 2009). The prevalence of beneficial diatoms increases relative to noxious blue-green algal species (including nitrogen-fixing and bloom-forming blue-green algae) moving downstream (Kann and Asarian 2006). However, diatoms decrease again in abundance relative to blue-green algae within the Copco/Iron Gate Reservoir complex, as described in the Section 3.4.3.4.

The reach from Link River to Keno Dam has extremely poor water quality, especially during summer months, with water temperature exceeding 25ºC, pH approaching 10 units, dense algal blooms, and DO concentrations below 4 mg/L (National Research Council 2004, Deas and Vaughn 2006). Decomposition of the algae and organic matter transported from Upper Klamath Lake to this reach is largely responsible for the low DO concentration (see Section 3.2.3.5 and Appendix C, Section C.4.1.3 for more detail).

Periphyton

Periphyton is abundant in portions of the upper Klamath River. In the Klamath Basin, one periphyton species that can reach nuisance levels is Cladophora, which are common in nutrient enriched waters (Dodds 1991, FERC 2007), particularly with abundant nitrogen. Periphyton is of particular concern in the Sprague River, where the dominance of these species results in dramatic diurnal fluctuations in DO and pH (ODEQ 2002). Because *Cladophora* provide an ideal habitat for the polychaete host of both *C. shasta* and *P. minibicornis*, the presence of these species may result in an increased abundance of the polychaete host populations, potentially resulting in increased exposure to and incidence of fish disease (see Section 3.3.3.3).

3.4.3.4 Klamath River from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam

Phytoplankton

Excluding patterns of algal growth within the reservoirs, blue-green algae dominance and biovolume decrease from sites upstream of J.C. Boyle Reservoir (RM 224.7 to 228.3) downstream through this area of analysis (Kann and Asarian 2006). However; this decreasing trend is interrupted by large blooms of blue-green algae in Copco 1 and Iron Gate Reservoirs (Kann and Asarian 2006, Asarian et al. 2009). In these two reservoirs, a bloom of diatoms generally occurs in March, followed by a period of low chlorophyll-*a* concentrations (FERC 2007). Blue-green algae dominate the algal community during the late summer to fall months, with large blooms of *Anabaena flos-aquae* and *M. aeruginosa* in the reservoirs (Kann 2006, FERC 2007). The incidence and magnitude of *M. aeruginosa* in the reservoirs is high relative to stations upstream, where blooms of *Aphanizomenon flos-aquae* are more prevalent (Kann and Asarian 2006).

The documented presence of algal toxins in water and fish tissue corresponds with spatial and temporal patterns in the distribution of blue-green algal blooms within this reach. Recent data indicate that microcystin toxin occurs at undetectable or very low levels in the Klamath River directly upstream of J.C. Boyle Reservoir and reaches high concentrations in the Copco 1 and Iron Gate Reservoirs from July through October (Kann and Corum 2009). Since 2007, high levels of microcystin have prompted the posting of public health advisories around the reservoirs and along the length of the Klamath River during summer months (see Appendix C, Section C.6 for more detail). In 2010, the Klamath Hydroelectric Project reservoirs and the entire river downstream of Iron Gate Dam (including the estuary) were posted to protect public health due to elevated cyanobacteria cell counts and cyanotoxin concentrations. High toxin concentrations in the water column have significant implications for accumulation of microcystin toxin in muscle and/or liver tissues of yellow perch, hatchery salmon, and freshwater mussels (Kann 2008, Kann and Corum 2009). Section 3.3.3.3 Algal Toxins presents a discussion of algal toxins as related to fish health.

Moreover, the reservoirs serve as the primary source of blue-green algae and associated toxins for the areas downstream of Iron Gate Dam, as described in Section 3.4.3.5 and Appendix C, Section C.6.

Periphyton

Nuisance blooms among the periphyton have not been documented in the riverine portions of this reach. In the J.C. Boyle peaking reach, it has been noted that periphyton tends to be absent from the margins of the river that are alternately dried and wetted during peaking operations (Asarian, pers. comm., 2011).

3.4.3.5 Klamath River downstream of Iron Gate Dam

Phytoplankton

Although both *Anabaena flos-aquae* and *M. aeruginosa* have been observed just downstream of Iron Gate Dam and as far downstream as the Klamath Estuary, this area does not provide suitable habitat for species that generally only thrive in reservoir and lake environments. Accordingly, these species are generally documented at lower abundances in this area relative to the diatom species observed in the middle and lower Klamath River (Kann and Asarian 2006). Despite this relatively low abundance, however, algal toxins are a critical concern in this reach because they are released from the reservoirs in dissolved phase, as well as in intact algal colonies that can remain viable along the low-velocity margins of the river where little mixing occurs (Kann and Corum 2009). This creates problems associated with toxin bioaccumulation and toxicity in areas beyond those that provide suitable conditions for growth of blue-green algae (Kann and Corum 2009). Data collected from 2004 through 2009 indicate high levels of microcystin in Copco 1 and Iron Gate Reservoirs, with measured concentrations exceeding the California State Water Resources Control Board (SWRCB)/Office of Environmental Health and Hazard Assessment (OEHHA) public health threshold of 8 µg/L by over 1000 times in Copco Reservoir in 2006, 2007, 2008, and 2009 (see Appendix C, Section C.6.1.4) (Kann 2007a–2007d, Kann and Corum 2007 and 2009, Kann et al. 2010, Jacoby and Kann 2007) (see Appendix C, Section C.6.1.4). Data from 2007 also indicate microcystin bioaccumulation in juvenile salmonids reared in Iron Gate hatchery (Kann 2008; see Section 3.3.3.3 Algal Toxins for a discussion of algal toxins as related to fish health). Annual peaks in *M. aeruginosa* biovolume occur in the late summer to fall months (e.g., August and September) of most recent years directly downstream of Iron Gate Dam (Kann and Asarian 2006). The degree to which reservoir production of nitrogen-fixing blue-green algae contribute to overall nitrogen levels in the middle and lower Klamath River remains poorly understood (Stillwater Sciences 2009).

Periphyton

Sampling of periphyton in the Klamath River downstream of Iron Gate Dam revealed a shift in community composition, where nitrogen-fixing species are not present directly downstream of Iron Gate Dam but begin to appear by Seiad Valley and then make up an increasing percent of periphyton biomass at sites downstream. Nitrogen-fixing species are dominant at sites between Orleans and Turwar (Asarian et al. 2010; E. Asarian, pers. comm., 2011). The increased prevalence of nitrogen-fixing periphyton coincides with very low levels of inorganic nitrogen (ammonia and nitrate) concentrations in water samples.

In a single survey downstream of Iron Gate Dam, Eilers (2005) documented high periphyton coverage (near 80 percent) on stream rocks and periphyton chlorophyll content (near 50 micrograms per square centimeter [$\mu g/cm^2$]) immediately downstream of Iron Gate Dam (RM 189.7), and relatively low periphyton coverage (near 10 percent) on stream rocks several miles downstream near the Collier Rest Area at the I-5 bridge (RM 178).

Downstream of the Collier Rest Area, both periphyton coverage and chlorophyll content increased gradually to peak levels in the Klamath River near the mouth of the Salmon River (RM 67). *Cladophora* dominated the Shasta River site, where it made up one half of the periphyton community by biovolume; however, these species were not documented at any of the other tributary or mainstem Klamath River sites surveyed (Eilers 2005). As discussed previously, *Cladophora* provide suitable habitat for the polychaete worm that is the intermediate host for fish parasites. Periphyton biomass was generally found to be low to moderate in this study; however, it is believed that increased discharge (i.e., a doubling of flow from about 600 cfs around August 15 to about 1,200 cfs near the end of the month, settling at about 800 cfs by September 1, the start of the study) may have dislodged filamentous algae that had proliferated under the previous lower flow regime (Eilers 2005, FERC 2007). However, data regarding *Cladophora* biomass is limited, making it difficult to determine the primary factors that control the biomass and distribution of these species (E. Asarian, pers. comm., 2011).

3.4.3.6 Klamath Estuary

The algal community in the Klamath Estuary is dominated by phytoplankton, but has more periphyton in the upstream areas where the estuary has more riverine characteristics. The presence of brackish water in the estuary influences the types of algae present in different areas of the estuary. Like the lower Klamath River, the Klamath Estuary has an algal community composed primarily of diatoms and blue-green algae (Fetcho 2007, Fetcho 2008). Phytoplankton densities are generally lower in this area than those measured concurrently in the lower Klamath River. On one occasion, in September 2007, estuary concentrations of *M. aeruginosa* twice exceeded the Yurok

Tribe posting action level (40,000 cells/mL). On a separate occasion, in September 2005, concentrations exceeded the WHO guidelines for low risk recreational use (20,000 cells/mL) (Fetcho 2006, Fetcho 2008). These instances of elevated levels of *M. aeruginosa* corresponded with elevated levels measured in the lower Klamath River, suggesting that *M. aeruginosa* is transported from the Klamath Hydroelectric Project reservoirs into the lower river and subsequently into the estuary.

Although periphyton data for the estuary is unavailable, in part due to the difficulty of sampling in deeper areas, abundant periphyton cover has been documented in the south slough (Hiner 2006).

3.4.3.7 Marine Nearshore Environment

The algal community of the near shore Pacific Ocean is dominated by marine algae, including attached red and brown seaweeds, as well as many marine planktonic species. The freshwater algae discussed above are not expected to grow in this turbulent, saline environment, but may be carried into the ocean with the current. Toxins can also be washed into the ocean, but are expected to be rapidly diluted, and there have been no reports of problems relating to freshwater algal toxins in the Pacific Ocean near the mouth of the Klamath River.

3.4.4 Environmental Consequences

3.4.4.1 Effects Determination Methodology

Existing information regarding blue-green algal blooms in the Klamath Basin suggests that several critical factors determine the frequency and toxicity of such blooms in Upper Klamath Lake and the Klamath Hydroelectric Project reservoirs: water temperature, light levels (FERC 2007), flow rates (Kann 2006), nutrient availability/ratios (Chorus and Bartram 1999, Fetcho 2008) and wind-induced turbulence and mixing. In this nutrient-rich system, elevated temperatures and increased light levels that occur during the summer and early fall result in seasonal blue-green algal blooms in the Klamath River, and especially the reservoir reaches. Upstream areas in or in close proximity to the reservoirs generally have larger blooms relative to the downstream river reaches (Kann 2006, Kann and Corum 2009), and the highest *M. aeruginosa* cell density and microcystin toxin concentrations occur within and directly below the reservoirs (Kann and Corum 2009). This information indicates that the reservoirs provide ideal conditions (see Section 3.4.3.1) for proliferation of blue-green algal species, and serve as a source of algal cells and their toxins to downstream areas.

The Lead Agencies assessed the Proposed Action and alternatives' effects on toxic algal blooms based on the expected effects of the alternatives on water temperature, hydrodynamic conditions (water movement potential), and nutrient availability. The Lead Agencies used modeling data describing the expected effects of dam removal on water quality, as well as existing literature regarding the biology and ecology of blue-green algal species, to determine whether the alternatives would alter the spatial extent of the river that provides suitable growing conditions for blue-green algae.

The Lead Agencies evaluated specific metrics including the extent to which monthly mean and maximum water temperatures would be within the range from 18 to 25°C and exceed 28 °C, total suspended sediment and nutrient concentrations, and the presence or absence of lacustrine (i.e., lake-like) conditions. Nutrient and suspended sediment concentration data came from the TMDL and SRH-1D model output, respectively. The Lead Agencies obtained benthic chlorophyll-*a* data for evaluation of potential changes in periphyton biomass from the Nutrient Numeric Endpoint Analysis (NCRWQCB 2010a, Appendix 2). Mass balance nutrient budgets presented in Asarian et al. (2010) were also used to evaluate potential effects of the Proposed Project on periphyton. The Lead Agencies selected the temperature thresholds based on information regarding required temperatures for growth and toxicity of blue-green algae provided in the blue-green Algae Work Group assessment (2010) and Van Der Westhuizen and Eloff (1985). The Lead Agencies assessed changes in water quality (temperature, nutrient and suspended sediment concentrations) during the summer and early fall, at the Four Facilities and at various in-river locations throughout the project area. The Lead Agencies also used this information to evaluate Project-induced changes on other algal groups such as diatoms and periphyton.

3.4.4.2 Significance Criteria

For purposes of the EIS/EIR, impacts would be significant if they were to result in the following:

- An increase in the spatial extent, temporal duration, toxicity, or concentration of nuisance and/or noxious phytoplankton blooms, including blue-green algae.
- An increase in the spatial extent, temporal duration, or biomass of nuisance periphyton (e.g., *Cladophora*) growth.

3.4.4.3 Effects Determinations

<u>Alternative 1: No Action/No Project Alternative</u>

Phytoplankton

Continued impoundment of water in the reservoirs at the Four Facilities could support the growth of seasonal nuisance and/or noxious phytoplankton blooms in the reservoirs and subsequent transport to downstream reaches of the Klamath River. Under the No Action/No Project Alternative, none of the actions under consideration would be implemented. The Klamath Hydroelectric Project would continue current operations under the terms of an annual license until a long term license is finalized. Annual licenses would not include the actions associated with the Klamath Hydroelectric Settlement Agreement (KHSA) and Klamath Basin Restoration Agreement (KBRA). Some KBRA actions have already been initiated and would continue under the No Action/No Project Alternative. These include the Williamson River Delta Project, the Agency Lake and Barnes Ranch Project, fish habitat restoration work, and ongoing climate change assessments. Implementation of several Oregon and California TMDLs (Section 3.2.2.4) within the period of analysis is a reasonably foreseeable action associated with water quality under the No Action/No Project Alternative as the TMDLs are an unrelated regulatory action. Hydroelectric operations would continue as they have been, providing peaking power generation during the summer as demand requires and conditions allow.

However, increased water temperatures and nutrient loading associated with climate change could increase the spatial extent, temporal duration, toxicity, or concentration of blue-green algal blooms.

Continued impoundment of water at the Four Facilities could support long-term (>2 years following dam removal) growth of nuisance and/or noxious phytoplankton such as *M. aeruginosa* in the Hydroelectric Reach. Under existing conditions, nuisance phytoplankton blooms occur during summer and fall in Copco 1 and Iron Gate Reservoirs, with the most intense blooms generally occurring in the late summer (Section 3.4.3.4). High seasonal levels of algal toxins (microcystin) are linked to intense blue-green algae blooms (Section 3.2.3.7).

TMDLs for the Upper Klamath Lake drainage, the Upper Klamath River and Lost River in Oregon, the Lower Lost River in California, and the Klamath River in California include allocations and/or targets for nutrients and/or chlorophyll-*a* (Section 3.2.2.4); full and successful implementation of these TMDLs would result in a decreased spatial extent, duration, and concentration of phytoplankton blooms in the Upper and Lower Klamath Basin (see also analysis for chlorophyll-*a* under the No Action/No Project Alternative, Section 3.2.4.3.1.6). As discussed in Section 3.2, Water Quality, the timeframes for achieving water quality objectives with respect to the TMDLs will depend on the measures taken to improve water quality conditions. It is anticipated that full implementation would require decades to achieve.

Climate change is projected to result in increased water temperatures due to median annual increases in air temperatures of 3°C and decreases in snowpack (Snyder et al. 2004). The projected decreases in snowpack are associated with increased air temperatures and higher levels of rainfall relative to snowfall. Water temperature increases are generally expected to be more dramatic in the Lower Klamath Basin than in the Upper Basin over the next 50 years due to the cooling influence of ground water in the Upper Basin during the summer months (Hamilton et al. 2010). Between J.C. Boyle Reservoir and Iron Gate Dam, the benefits of substantial groundwater resources would not be realized because they are inundated by reservoirs or occur in bypass reaches (Hamilton et al. 2010). Higher intensity rainfall events are also expected to occur. Runoff from such events could increase the frequency with which the river exhibited high suspended sediment concentrations, which could increase the delivery of nutrients, such as phosphorous, to the system (Stillwater Sciences 2009). Increased summer temperatures and nutrient inputs would likely result in an increase in the magnitude, duration, and spatial extent of summer blooms of toxic blue-green algae.

Additionally, research conducted in the San Francisco Bay-Delta system indicates that increased temperatures could result in elevated toxicity of *M. aeruginosa* (i.e., increased microcystin concentrations produced by a bloom) (Mioni and Payton 2010). Under the No Action/No Project Alternative, an increase in the toxicity of seasonal phytoplankton blooms due to climate change would be a significant impact. The anticipated effects of climate change would also occur over a timescale of decades and may offset improvements expected from successful TMDL implementation throughout the Upper and Lower Klamath Basin, particularly in the case of potential elevated toxicity of *M. aeruginosa*. However, overall, the benefits of nutrient reductions under the TMDLs are anticipated to be of greater relative importance with respect to phytoplankton blooms under the No Action/No Project Alternative.

Existing seasonal nuisance and/or noxious phytoplankton blooms in the Upper and Lower Klamath Basin are adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease these blooms. Continued impoundment of water at the Four Facilities would result in no change from existing conditions.

Periphyton

Continued impoundment of water at the Four Facilities could support the growth of nuisance periphyton such as Cladophora spp. downstream of Iron Gate Dam. Under existing conditions, periphyton coverage is relatively high immediately downstream of Iron Gate Dam, with coverage decreasing further downstream near the I-5 Bridge (RM 178), and increasing again to peak levels near the mouth of the Salmon River (RM 67) (Section 3.4.3.5). Because *Cladophora* provide suitable habitat for the polychaete worm that is the intermediate host for fish parasites, the presence of large seasonal periphyton mats immediately downstream of the Hydroelectric Reach have been linked to the potential for increased exposure to and incidence of fish disease.

As described above for phytoplankton (i.e., blue-green algae), full and successful implementation of Oregon and California TMDLs would decrease nutrients in the Klamath River and would result in decreased spatial extent, temporal duration, and/or biomass of phytoplankton mats. As discussed in Section 3.2, Water Quality, the timeframes for achieving water quality objectives with respect to the TMDLs will depend on the measures taken to improve water quality conditions. It is anticipated that full implementation would require decades to achieve.

Conversely, increases in water temperature with climate change are likely to result in increased growth of periphyton in the Klamath River. Increased temperature through climate change may exacerbate biostimulatory conditions through increased periphyton metabolic and growth rates. Increases in nutrient availability under climate change may also cause a shift in periphyton community composition from that dominated by nitrogen-fixing periphyton species to that dominated by non-nitrogen fixers. It remains uncertain whether this change in community composition would result in a change in periphyton biomass. As with phytoplankton, the benefits of nutrient reductions under the TMDLs are anticipated to be of greater relative importance with respect to periphyton spatial extent, bloom duration, and biomass under the No Action/No Project Alternative.

Existing seasonal nuisance periphyton growth in the Upper and Lower Klamath Basin is potentially adverse. Full attainment of the Oregon and California TMDLs (implementation mechanism and timing unknown) would significantly decrease periphyton growth. Continued impoundment of water at the Four Facilities would result in no change from existing conditions.

The implications of potential changes in periphyton biomass and community composition for DO and the spread of fish disease are described in Sections 3.2.4.3 and 3.3.3.3, respectively.

Alternative 2: Proposed Action: Full Removal of Four Dams (Proposed Action)
Under the Proposed Action, the four major dams in the Klamath Hydroelectric Project (J.C. Boyle, Copco 1, Copco 2, and Iron Gate Dams) would be removed along with the ancillary facilities of each installation. This includes the entire dam, the powerhouses, spillways, and other infrastructure associated with the power generating facilities, as well as the transfer of the Keno Dam facilities to the United States Department of the Interior (DOI) and the implementation of the KBRA.

Upper Klamath Basin upstream of the influence of J.C. Boyle Reservoir
Phytoplankton
The Proposed Action could decrease the spatial extent, temporal duration, toxicity, or concentration of nuisance and/or noxious phytoplankton in the area of analysis. Dam removal activities would not affect the Klamath River upstream of J.C. Boyle Reservoir. Effects of KBRA in this reach are discussed in Section 3.4.4.3. Alternative 2: Full Removal of Four Dams – KBRA. **There would be no change from existing conditions from nuisance and/or noxious phytoplankton.**

Periphyton
The Proposed Action could decrease the spatial extent, temporal duration, or biomass of nuisance periphyton in the area of analysis. Dam removal activities would not affect the Klamath River upstream of J.C. Boyle Reservoir. Effects of KBRA in this reach are discussed in Section 3.4.4.3. Alternative 2: Full Removal of Four Dams – KBRA. **There would be no change from existing conditions from nuisance periphyton.**

Hydroelectric Reach
Short-Term Effects
Phytoplankton Under the Proposed Action, the short-term (<2 years following dam removal) increase in nutrients in the Hydroelectric Reach would be a less-than-significant impact (Section 3.2.4.3.2.3.). Additionally, by mid to late spring following reservoir drawdown (assuming drawdown Scenario 8), little to no reservoir habitat would be left, and blue-green algal blooms would be very limited if not eliminated from the Hydroelectric Reach. Thus, potential effects of increased nutrients on phytoplankton blooms in the Hydroelectric Reach are not considered further.

Periphyton While quiescent habitat for phytoplankton would be eliminated in the short-term by reservoir drawdown and dam removal (see above), periphyton growth in the riverine reaches of the Hydroelectric Reach could occur during the initial summer and fall months following drawdown. However, this is unlikely to occur due to increased short-term (<2 years following dam removal) nutrient availability under the Proposed Action since in the short-term, the increase in nutrients in the Hydroelectric Reach would be a less-than-significant impact (Section 3.2.4.3.2.3.). Additionally, higher flows during drawdown and late spring storm events would result in greater bed turnover (see Section

3.3.4.3, Bedload Sediment) and scouring, which would greatly limit, if not eliminate, short-term establishment of periphyton in the Hydroelectric Reach. Thus, potential effects of increased nutrients on short-term periphyton establishment in the Hydroelectric Reach is not considered further. The potential long-term effects of scour on periphyton biomass are discussed in greater detail below.

Long-Term Effects

Phytoplankton *Under the Proposed Action, removal of the reservoirs at the Four Facilities would eliminate lacustrine habitat behind the dams and could decrease the long-term spatial extent, temporal duration, or concentration of nuisance and/or noxious phytoplankton blooms.* This change, particularly within the larger Copco 1 and Iron Gate Reservoirs, would decrease or eliminate the system's support for excessive growth of blue-green algae over the long-term by eliminating quiescent habitat where these algal species can thrive. This change in suitable habitat would occur even if relatively high nutrient concentrations were to remain in the Klamath River system. This would substantially reduce the production of toxins from these reservoirs that are harmful to animals and humans. This would be a major benefit of the Proposed Action. Moreover, dam removal would allow the substantial groundwater resources within this area of analysis to cool water temperatures during the summer months (Hamilton et al. 2010). This would further reduce the suitability of conditions for blue-green algae growth and mitigate for the effects of climate change. The Proposed Action would provide a substantial long-term benefit with regard to phytoplankton in the Hydroelectric Reach. **Under the Proposed Action, long-term reductions in the growth of nuisance and/or noxious phytoplankton due to the elimination of the reservoirs in the Hydroelectric Reach would be beneficial.**

Periphyton *Under the Proposed Action, dam removal and the elimination of hydropower peaking operations could result in long-term increased biomass of nuisance periphyton in low-gradient channel margin areas downstream of J.C. Boyle Dam.* Periphyton growth in the Hydroelectric Reach downstream of J.C. Boyle Dam could be quite high on a seasonal basis following dam removal. This is because until full attainment of the Oregon and California TMDLs can be achieved, high nutrient inputs from the Upper Klamath Basin would continue to support periphyton growth and removal of the reservoirs and the hydropower peaking reaches would create suitable physical habitat suitable for periphyton. Thus, the overall effect of the Proposed Action could be to eliminate blooms of toxic blue-green algae in the reservoirs and replace them with colonies of periphyton in the newly created margins of low gradient river channels in the Klamath Hydroelectric Project Reach. However, the particular periphyton species that may become abundant in these areas is unknown (E. Asarian, pers. comm., 2011). Although there is potential for nutrient concentrations to increase in these areas, these increases are expected to be less than significant (see Section 3.2.4.3.2.3). Moreover, these nutrient inputs would be expected to decrease over time with implementation of the Oregon and California TMDLs and KBRA projects (see Section 3.4.4.3 Alternative 2: Full Removal of Four Dams – KBRA).

Potential increases in periphyton growth could also be disrupted by more frequent river bed turnover (see Section 3.3.4.3) and increased flow variability during storm flow, which may result in increased scouring of periphyton during late spring storm events, following dam removal (See NCRWQCB 2010a, Appendix 2). This potential outcome is supported by results from the Nutrient Numeric Endpoint Benthic Biomass Predictor for the "natural conditions" (i.e., point sources eliminated, large reductions in nutrient input from Upper Klamath Lake and Straits Drain, and dams out) scenario. The model predicts that periphyton growth in the Klamath River downstream of Iron Gate Dam can achieve the proposed 150 mg/m^2 maximum benthic chlorophyll-*a* target under the "natural conditions" scenario when more frequent scouring events are allowed to occur, a condition that would be supported if the dams were not in place (see NCRWQCB 2010a, Appendix 2). However, the benthic chlorophyll-*a* predictions are subject to uncertainty because of a lack of data regarding relationships between nutrient concentrations, flows, periphyton biomass and chlorophyll-*a* concentrations and between dam removal and the frequency of scouring events. In addition, these model results include the effect of large reductions in nutrient loading based on compliance with the Upper Klamath Lake TMDL, and do not provide information regarding the isolated effects of the Proposed Project on periphyton abundance. **Under the Proposed Action, long-term increases in nuisance periphyton growth due to increases in available habitat along channel margin areas of the Hydroelectric Reach downstream of J.C. Boyle Dam would be a significant impact.**

The above "significant impact" determination represents a conservative assessment of the effects of the Proposed Action on periphyton growth since there is inherent uncertainty in the Nutrient Numeric Endpoint predictions and it is possible that excessive periphyton growth would not be supported in the Hydroelectric Reach. Additional research prior to the time of dam removal would help resolve these uncertainties. Monitoring could also be conducted after dam removal which would help identify the actual changes in the periphyton community resulting from dam removal. The implications of potential changes in periphyton biomass and community composition for DO and the spread of fish disease are described in Sections 3.2.4.3 and 3.3.3.3, respectively. If projects were well-designed and implemented at a large enough scale, reductions in nutrient loading resulting from implementation of TMDL and KBRA projects (see Section 3.4.4.3 Alternative 2: Full Removal of Four Dams – KBRA) proposed to reduce nutrient loading from the Upper Klamath Basin could fully mitigate for potential increases periphyton biomass associated with changes in nutrient concentrations under the Proposed Action (E. Asarian, pers. comm., 2011).

Yreka Pipeline Relocation and Recreational Facilities Removal
Under the Proposed Action, removal of Iron Gate Dam would require relocation of the Yreka Water Supply Pipeline. The water supply pipeline for Yreka will have to be relocated from its present location under Iron Gate Reservoir. Once the reservoir is drawn down, the existing pipeline would be exposed to higher velocity water flow, debris during flood events, and other potentially damaging situations that it is currently not exposed to at the bottom of the reservoir. To address this, the pipeline will be suspended from a pipe bridge across the Klamath River. Potential impacts to algae from the installation of the

pipe bridge will be minimized or eliminated through the implementation of Best Management Practices (BMPs) for construction activities (Appendix B). Implementation of BMPs would ensure that impacts are constrained to the individual sites and their immediate area, and not transferred downstream in the Klamath River. **There will be no change from existing conditions from algae in the Hydroelectric Reach or the Klamath River downstream of Iron Gate Dam as a result of the Yreka water supply pipeline relocation.**

Under the Proposed Action, construction/deconstruction activities would include the demolition of various recreation facilities. The existing recreational facilities located along the banks of the reservoirs will be removed once the reservoirs are drawn down. Facilities such as campgrounds and boat ramps, currently located on the reservoir banks will need to be relocated down slope to be near the new river channel once the reservoir is removed. Impacts specific to the deconstruction of the Recreation Facilities are discussed in Section 3.20, Recreation. Once the reservoirs are drawn down, the existing recreational facilities would be well above the new river channel. The removal of the facilities is not expected to impact algae biomass or lifecycles. The potential for impacts during the facilities removal will minimized or eliminated through the implementation of BMPs for construction activities (Appendix B). Implementation of BMPs would ensure that impacts are constrained to the individual sites and their immediate area, and not transferred downstream in the Klamath River. **There would be no change from existing conditions from algae in the Hydroelectric Reach or the Klamath River downstream of Iron Gate Dam as a result of the removal of the recreational facilities.**

Klamath River Downstream of Iron Gate Dam

<u>Long-Term Effects</u>

Phytoplankton *Under the Proposed Action, removal of the reservoirs would eliminate lacustrine habitat behind the dams could substantially reduce or eliminate the transport of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins into the Klamath River downstream of Iron Gate Dam.* Reduced inputs of *M. aeruginosa* and *Anabaena flos-aquae* to the mainstem river downstream of Iron Gate Dam would result in a substantial reduction in the presence of toxic algal cells.

Increases in nutrient availability associated with delivery and deposition of sediments from the upper watershed could occur over the long term as a result of dam removal (DOI 2011; Section 3.3.4.3). However, possible summer through fall increases in nutrient concentrations, particularly directly downstream of Iron Gate Dam, following dam removal (see Section 3.2.4.3.2.3 Nutrients – Lower Klamath Basin) would not contribute significantly to blue-green algal blooms downstream of Iron Gate Dam due to the lack of the suitable hydrodynamic conditions required for extensive planktonic algal growth following implementation of the Proposed Action. This analysis suggests that the Proposed Action would have a positive effect on aquatic resources in the Klamath River downstream of Iron Gate Dam in the long-term based on reductions in downstream transport and concentrations of phytoplankton and microcystin toxins to this area. **Under the Proposed Action, long-term reductions in the growth of nuisance and/or noxious phytoplankton in the reservoirs in the Hydroelectric Reach would reduce or eliminate the transport of nuisance and/or noxious phytoplankton blooms and**

concentrations of algal toxins into the Klamath River downstream of Iron Gate Dam and would be beneficial.

Periphyton *Under the Proposed Action, dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels and periphyton biomass in the Klamath River downstream of Iron Gate Dam.* Periphyton growth could continue to be relatively high downstream of Iron Gate Dam on a seasonal basis following dam removal because of continuing nutrient inputs from the Upper Klamath Basin, as described for the J.C. Boyle to Iron Gate Dam reach. Despite the overall increases in absolute nutrient concentrations anticipated under the Proposed Action (see Section 3.2.4.3.2.3 Nutrients – Lower Klamath Basin), the relatively greater increases in Total Nitrogen (TN) may not result in significant biostimulatory effects on periphyton growth. Existing data indicate that the Klamath River is generally N-limited (TN:Total Phosphorus (TP) <10), with some periods of co-limitation by N and P (see also Section 3.2.3.4 and Appendix C, Section C.3.2.1). However, concentrations of both nutrients are high enough in the river from Iron Gate Dam (RM 190.1) to approximately Seiad Valley (RM 129.4) (and potentially further downstream) that nutrients are not likely to be limiting primary productivity (i.e., periphyton growth) in this portion of the Klamath River (FERC 2007, Hoopa Valley Tribe Environmental Protection Agency [HVTEPA] 2008, Asarian et al. 2010). In addition, N-fixing species dominate the periphyton communities in the lower reaches of the Klamath River where inorganic nitrogen concentrations are low (Asarian et al. 2010). Since these species can fix their own nitrogen from the atmosphere, increases in TN due to dam removal may not significantly increase their biomass, particularly if overall TN increases are less than those predicted by existing models due to implementation of TMDLs and general nutrient reductions in the Klamath Basin.

In addition to the effects of changes in nutrient concentrations, periphyton community composition and biomass may be affected by light levels and substrate stability. Light penetration would decrease following dam removal below Iron Gate Dam due to removal of the reservoirs, which serve as sediment catchment areas. This would have a reducing effect on periphyton growth downstream of Iron Gate Dam. In addition, potential increases in periphyton growth could be counteracted by more frequent river bed turnover (see Section 3.3.4.3) and increased flow variability during storm flow, which could result in increased scouring of periphyton during late spring storm events, following dam removal (NCRWQCB 2010a, Appendix 2). The magnitude of the effect of bed turnover and scouring on periphyton would likely decrease with distance downstream. As described for the Hydroelectric Reach, model results suggest that increased scouring may somewhat limit periphyton biomass following dam removal (NCRWQCB 2010a, Appendix 2).

Because of these many competing factors, some that may favor enhanced periphyton growth downstream of Iron Gate Dam (i.e., increased nutrients transport), and some that counteract this response (increased uptake of nutrients by periphyton in the Hydroelectric Reach, increased frequency and intensity of scouring events, decreasing nutrient concentrations due to TMDL implementation and KBRA nutrient reduction programs [see KBRA discussion below]), it is likely that increases in periphyton growth below Iron

Gate Dam would be less than significant. Moreover, the biological significance of potential increases in periphyton biomass is unknown due to uncertainty regarding the magnitude of increase in biomass required to generate a significant reduction in habitat quality for aquatic resources (NCRWQCB 2010a, Appendix 2).
Under the Proposed Action, long-term increases in nuisance periphyton in the Klamath River downstream of Iron Gate Dam would be a less than significant impact.

Klamath Estuary

Long-term Effects

Phytoplankton *Under the Proposed Action, removal of the reservoirs would eliminate lacustrine habitat behind the dams and could substantially reduce or eliminate the transport of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins into the Klamath Estuary.* Information regarding current conditions of algal biomass, population dynamics, and the likelihood of nutrient limitation on algal growth in the Klamath Estuary is limited. Consequently, it is difficult to determine the potential long-term effects that the Proposed Action would have on algae in the estuary. Existing information suggests that the removal of the Four Facilities would reduce or eliminate elevated *M. aeruginosa* levels within the estuary, because *M. aeruginosa* that is transported downstream originates in the reservoirs (Fetcho 2006, Fetcho 2008). **Under the Proposed Action, long-term reductions in the growth of nuisance and nuisance and/or noxious phytoplankton in the Hydroelectric Reach would reduce or eliminate the transport of algal cells and their associated toxins into the Klamath Estuary and would be beneficial.**

Periphyton *Under the Proposed Action, dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels and periphyton biomass in the Klamath Estuary.* As discussed for the lower Klamath River downstream of Iron Gate Dam, periphyton growth under the Proposed Action could be affected by increased nutrient availability following dam removal. However, since the long-term increase in nutrients in the Klamath Estuary would be a less-than-significant impact due to the implementation of TMDLs and KBRA (see Section 3.2.4.3.2.3 Nutrients – Lower Klamath Basin), it is likely that increases in periphyton growth would also be less than significant. Moreover, the biological significance of potential increases in periphyton biomass in the Klamath estuary is unknown due to uncertainty regarding the magnitude of increase in biomass required to generate a significant reduction in habitat quality for aquatic resources (NCRWQCB 2010a, Appendix 2). **Under the Proposed Action, long-term increases in the growth of nuisance periphyton in the Klamath Estuary would be a less than significant impact.**

Marine Nearshore Environment

Under the Proposed Action, dam removal and conversion of the reservoir areas could cause long-term increases in freshwater phytoplankton and periphyton species of concern. The marine nearshore environment is not a suitable habitat for the freshwater phytoplankton species of concern (i.e., *Aphanizomenon flos-aquae*, *Anabaena flos-aquae*, *M. aeruginosa*) or the freshwater periphyton species of concern (i.e., *Cladophora*). **While other marine algal species would occur in the marine near shore environment, because of short-term (< 2 years following dam removal) increases in both rates of sediment deposition (Section 3.2.4.3.2.2 Suspended Sediments – Lower Klamath Basin) and sediment-associated nutrient levels, (Section 3.2.4.3.2.3 Nutrients – Lower Klamath Basin) the marine nearshore environment would be a less-than-significant impact under the Proposed Action and are not expected to effect marine algal species.**

Keno Transfer

Implementation of the Keno Transfer could cause adverse effects to algae. The Keno Transfer would be a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in new impacts on algae compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (KHSA Section 7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

East and West Side Facilities

Decommissioning the East and West Side Facilities could cause adverse effects to algae. Decommissioning of the East and West Side canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA will redirect water flows currently diverted at Link River Dam into the two canals, back in to Link River. Following decommissioning of the facilities there will be no change in algae conditions in the Klamath River. **Therefore, implementation of the East and West Side Facility Decommissioning action would result in no change from existing conditions.**

KBRA

The KBRA, which is a component of the Proposed Action, encompasses several programs that could affect nuisance and/or noxious phytoplankton and periphyton blooms in the Klamath Basin through improvements to water quality, including:

- Phases I and II Fisheries Restoration Plans
- Wood River Wetland Restoration
- Water Use Retirement Program
- Interim Flow and Lake Level Program
- Upper Klamath Lake and Keno Nutrient Reduction

Beneficial effects of these projects on nutrients in the Klamath Basin would also be beneficial for nuisance and/or noxious phytoplankton and periphyton blooms.

Implementation of restoration actions, programs, and/or plans presented in the KBRA would accelerate restoration actions currently underway throughout the Klamath Basin (with the exception of the Trinity Basin) including KHSA implementation (i.e., dam removal) and reduce nuisance and/or noxious phytoplankton blooms through their beneficial effects on flow and water quality. Specific projects are addressed below.

Phase I Fisheries Restoration Plan

Implementation of the Phase I Fisheries Restoration Plan could result in a long-term reduction in nutrients and associated decreases in nuisance and/or noxious phytoplankton and periphyton blooms. Several ongoing resource management actions related to nutrient reductions may be amplified under the Phase I Plan (Section 3.2.4.3.2.10). Ongoing actions and types of new programs that could be implemented are described at a programmatic level for water quality. Anticipated benefits with respect to phytoplankton and periphyton are the same as those described for any Phase I project that would decrease nutrient levels in the Klamath Basin (Section 3.2.4.3.2.10).

The improvements in nuisance and/or noxious phytoplankton and periphyton blooms generated by implementation of the Phase I Fisheries Restoration Plan would contribute to the long-term water quality improvements anticipated from hydroelectric facility removal. **Resource management actions implemented under the KBRA Phase I Fisheries Restoration Plan would accelerate long-term decreases in nutrients and would reduce the prevalence of nuisance and/or noxious phytoplankton and periphyton blooms in the Klamath Basin and would be beneficial.**

Phase II Fisheries Restoration Plan

Implementation of the Phase II Fisheries Restoration Plan under the KBRA (KBRA Section 10.2) would include a continuation of the same types of resource management actions as under Phase I along with provisions for adaptive management of these actions and would therefore have the same impacts as Phase I. Anticipated benefits with respect to phytoplankton and periphyton are the same as those described for any Phase II project that would decrease nutrient levels in the Klamath Basin (Section 3.2.4.3.2.10). The improvements in nuisance and/or noxious phytoplankton and periphyton blooms generated by implementation of the Phase II Fisheries Restoration Plan would contribute to the long-term water quality improvements anticipated from hydroelectric facility removal. **Resource management actions implemented under the KBRA Phase II Fisheries Restoration Plan would accelerate long-term decreases in nutrients and would reduce the prevalence of nuisance and/or noxious phytoplankton and periphyton blooms in the Klamath Basin and would be beneficial.**

Wood River Wetland Restoration

Implementation of Wood River Wetland Restoration could result in reduced nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms. This project may decrease overall nutrient inputs to Upper Klamath Lake by inundating wetland (peat) soils and creating anaerobic conditions that support nutrient retention, particularly in the case of phosphorus (Snyder and Morace 1997). Specific options still need to be developed and studied as part of a separate project-level National Environmental Policy Act (NEPA) evaluation and Federal Endangered Species Act (ESA) consultation. The improvements in nuisance and/or noxious phytoplankton blooms generated by implementation of the Wood River Wetland Restoration Project would contribute to the long-term water quality improvements anticipated in the Klamath Basin from hydroelectric facility removal. **Under the KBRA, the Wood River Wetland Restoration Project would accelerate ongoing long-term improvements in nutrients and would reduce the prevalence of nuisance and/or noxious phytoplankton blooms in Agency Lake and would be beneficial.**

<u>Water Use Retirement Program</u>
Implementation of the Water Use Retirement Program could result in decreases in nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms. Anticipated benefits with respect to phytoplankton are the same as those described for this project under water quality, because it would decrease nutrient levels (i.e., decrease irrigation and fallowing of crop land and would decrease fertilizer [nutrient] inputs) in Upper Klamath Lake (see Section 3.2.4.3.2.10). The decreases in nutrient inputs to Upper Klamath Lake generated by implementation of the Water Use Retirement Program would contribute to the long-term water quality improvements anticipated from hydroelectric facility removal. **The KBRA Water Use Retirement Program would decrease long-term nutrients and would reduce the prevalence of nuisance and/or noxious phytoplankton blooms in Upper Klamath Lake and would be beneficial.**

<u>Interim Flow and Lake Level Program</u>
Implementation of the Interim Flow and Lake Level Program could result in decreases in nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms. Anticipated benefits with respect to phytoplankton are the same as those described for this project under water quality, because the project would decrease nutrient levels in the Upper Klamath Lake (see Section 3.2.4.3.2.10). The decreases in nutrient inputs to Upper Klamath Lake generated by implementation of the Interim Flow and Lake Level Program would contribute to the long-term water quality improvements anticipated from hydroelectric facility removal. **The KBRA Interim Flow and Lake Level Program would decrease long-term nutrients and would reduce the prevalence of nuisance and/or noxious phytoplankton blooms in Upper Klamath Lake and would be beneficial.**

<u>Upper Klamath Lake and Keno Nutrient Reduction</u>
Implementation of the Upper Klamath Lake and Keno Nutrient Reduction Program could result in decreases in nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms. KBRA (Appendix C-2, line 11) includes a program to study and reduce nutrient concentrations in the Keno Impoundment and Upper Klamath Lake in order to reduce dissolved oxygen and nuisance algal problems in both water bodies. Restoration actions to control nutrients have not been developed, and there are many possible actions that could require construction of treatment wetlands, construction of facilities, or chemical treatments of bottom sediment, among other possibilities. A nutrient reduction program in the Keno Impoundment and Upper

Klamath Lake would be designed to improve water quality (increasing seasonally low dissolved oxygen and reducing seasonal algal blooms) and fish passage through the Keno Impoundment in summer and fall months, however implementation of this nutrient reduction program will require future environmental compliance investigations and a determination on significance cannot be made at this time.

Alternative 3: Partial Facilities Removal of Four Dams

This alternative proposes to remove enough of the material from each dam to allow the river to retain a free-flowing condition and volitional fish passage under all river stages and flow conditions. Some portion of each dam and much of the appurtenant infrastructure could remain, such as the dam foundations, power houses, buildings, tunnels, and pipes. All tunnel openings would be sealed with concrete, remaining buildings would be fenced, and all hazardous materials would be removed from the site. This alternative would include the transfer of the Keno Facility to the DOI and implementation of the KBRA. **The Partial Facilities Removal of Four Dams Alternative effects on algae would be the same as those described for the Proposed Action.**

Alternative 4: Fish Passage at Four Dams

This alternative would provide upstream and downstream fish passage at the Four Facilities, but would not include implementation of the KBRA. The ongoing restoration actions, described in the No Action/No Project Alternative, would continue. The alternative would incorporate the prescriptions from the Departments of Interior and Commerce imposed during the FERC relicensing process, including fishway installation for both upstream and downstream migrations at all facilities and barriers to prevent juvenile salmonid entrainment into turbines. In addition to the fishways, there are a series of flow-related measures, including a condition that requires at least 40 percent of the inflow to the J.C. Boyle Reservoir to be released downstream. This alternative would limit generation of peaking power at J.C. Boyle Power Plant to one day per week as water supplies allow, and would include recreation flows one day a week. The flow requirements would reduce the overall power generation. **The Fish Passage at Four Dams Alternative effects on algae would be similar to those described for the No Action/No Project Alternative.**

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

Phytoplankton

Removal of Copco 1 and Iron Gate Dams would eliminate lacustrine habitat in the two largest reservoirs in the Hydroelectric Reach and could decrease the long-term spatial extent, temporal duration, or concentration of nuisance and/or noxious phytoplankton blooms in the Hydroelectric Reach and subsequent transport to the Klamath River from downstream of Iron Gate Dam to the Klamath Estuary. The removal of quiescent reservoir habitat in Copco 1 and Iron Gate Reservoirs would decrease or eliminate conditions in the Hydroelectric Reach that support excessive growth of blue-green algae. This change in suitable habitat would occur even if relatively high nutrient concentrations were to remain in the Klamath River system. The reduction in growth of nuisance and/or noxious phytoplankton in the Hydroelectric Reach would reduce the transport of algal cells and their associated toxins to the Klamath River downstream of Iron Gate Dam and the Klamath Estuary. This would substantially reduce the production of toxins from these reservoirs that are harmful to animals and humans. **Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, long-term reductions in the growth of nuisance and/or noxious phytoplankton due to the elimination of the two largest reservoirs in the Hydroelectric Reach would decrease levels of nuisance and nuisance and/or noxious phytoplankton and concentrations of algal toxins from the Hydroelectric Reach to the Klamath Estuary, and would be beneficial.**

Periphyton

Removal of Copco 1 and Iron Gate Dams and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels and periphyton biomass in the Hydroelectric Reach, the Klamath River downstream of Iron Gate Dam, and the Klamath Estuary. The effects of removing the two largest dams in the Hydroelectric Reach, Copco 1 and Iron Gate Dams, on nutrients under this alternative would be similar to removing all four dams under the Proposed Action (Section 3.2.4.3.5.3). Long-term increases in periphyton growth in the Klamath River downstream of Iron Gate Dam and in the Klamath Estuary could also occur and would be the same as those described under the Proposed Action. **Under the *Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative*, long-term increases in the growth of nuisance periphyton in the Hydroelectric Reach, the Klamath River downstream of Iron Gate Dam, and the Klamath Estuary would be a less than significant impact.**

Yreka Pipeline Relocation and Recreational Facilities Removal

Removal of Iron Gate Dam would require relocation of the Yreka Water Supply Pipeline. Under Alternative 5, Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate, the water supply pipeline for Yreka will have to be relocated from its present location under Iron Gate Reservoir. Once the reservoir is drawn down, the existing pipeline would be exposed to higher velocity water flow, debris during flood events, and other potentially damaging situations that it is currently not exposed to at the bottom of the reservoir. To address this, the pipeline will be suspended from a pipe bridge across the Klamath River. **There will be no impact to algae in the Hydroelectric Reach or the Klamath River downstream of Iron Gate Dam as a result of the Yreka water supply pipeline relocation.**

3.4.4.4 Mitigation Measures

<u>Mitigation Measure by Consequences Summary</u>

No mitigation measures are proposed beyond those described for water quality protection in Section 3.2, Water Quality.

3.4.4.5 Summary of Impacts on Algae

Table 3.4-1 summarizes the impacts of the Proposed Action and alternatives on algae.

Table 3.4.1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Upper Klamath Basin Upstream of the Influence of J.C. Boyle Reservoir				
Dam removal activities could decrease the spatial extent, temporal duration, toxicity, or concentration of nuisance and/or noxious phytoplankton in the area of analysis.	2, 3, 5	NCFEC	None	NCFEC
Dam removal activities could decrease the spatial extent, temporal duration, or biomass of nuisance periphyton in the area of analysis	2, 3, 5	NCFEC	None	NCFEC
Hydroelectric Reach				
Continued impoundment of water in the reservoirs could support long-term growth of nuisance and/or noxious phytoplankton such as *M. aeruginosa* in the Hydroelectric Reach.	1, 4	NCFEC	None	NCFEC
Removal of the reservoirs would eliminate lacustrine habitat behind the dams and could decrease the long-term spatial extent, temporal duration, or concentration of nuisance and/or noxious phytoplankton blooms in the Hydroelectric Reach.	2, 3, 5	B	None	B
Dam removal and the elimination of hydropower peaking operations could result in long-term increased biomass of nuisance periphyton in low-gradient channel margin areas within the Hydroelectric Reach.	2, 3	S	None	S
	5	LTS	None	LTS
Removal of Iron Gate Dam would require relocation of the Yreka Water Supply Pipeline which could impact algae.	2, 3, 5	NCFEC	None	NCFEC
Construction and deconstruction activities would include the demolition of various recreation facilities that could affect algae.	2, 3, 5	NCFEC	None	NCFEC

Table 3.4.1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Klamath River Downstream of Iron Gate Dam				
Continued impoundment of water in the reservoirs could support long-term growth of nuisance and/or noxious phytoplankton such as *M. aeruginosa* in the Hydroelectric Reach and subsequent transport into the Klamath River downstream of Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
Continued impoundment of water at the Four Facilities could support long-term growth of nuisance periphyton such as *Cladophora spp.* downstream of Iron Gate Dam.	1, 4	NCFEC	None	NCFEC
Removal of the reservoirs would eliminate lacustrine habitat behind the dams could substantially reduce or eliminate the transport of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins into the Klamath River downstream of Iron Gate Dam.	2, 3, 5	B	None	B
Dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels and periphyton biomass in the Klamath River downstream of Iron Gate Dam.	2, 3, 5	LTS	None	LST
Klamath Estuary				
Continued impoundment of water in the reservoirs could support long-term growth of nuisance and/or noxious phytoplankton such as *M. aeruginosa* in the Hydroelectric Reach and subsequent transport into the Klamath Estuary.	1, 4	NCFEC	None	NCFEC
Removal of the reservoirs would eliminate lacustrine habitat behind the dams could substantially reduce or eliminate the transport of nuisance and/or noxious phytoplankton blooms and concentrations of algal toxins into the Klamath Estuary.	2, 3, 5	B	None	B
Dam removal and conversion of the reservoir areas to a free-flowing river could cause long-term increases in nutrient levels and periphyton biomass in the Klamath Estuary.	2, 3, 5	LTS	None	LTS

Table 3.4.1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Marine Nearshore Environment				
Dam removal and conversion of the reservoir areas could cause long-term increases in freshwater phytoplankton and periphyton species of concern.	2, 3, 5	LTS	None	LTS
Keno Transfer				
Implementation of the Keno Transfer could cause adverse algae effects.	2, 3	NCFEC	None	NCFEC
East and Westside Facilities				
Decommissioning the East and West Side Facilities could cause adverse algae effects.	2. 3	NCFEC	None	NCFEC
KBRA				
Implementation of restoration actions, programs, and/or plans presented in the KBRA would accelerate restoration actions currently underway throughout the Klamath Basin and reduce nuisance and/or noxious phytoplankton blooms through their beneficial effects on flow and water quality.	2, 3	B	None	B
Implementation of the Phase I Fisheries Restoration Plan could result in a long-term reduction in nutrients and associated decreases in nuisance and/or noxious phytoplankton and periphyton blooms.	2, 3	B	None	B
Implementation of the Phase II Fisheries Restoration Plan under the KBRA (KBRA Section 10.2) would include a continuation of the same types of resource management actions as under Phase I along with provisions for adaptive management of these actions and would therefore have the same impacts as Phase I.	2, 3	B	None	B
Implementation of Wood River Wetland Restoration could result in reduced nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms.	2, 3	B	None	B

Table 3.4.1 Summary of Algae Impacts

Potential Impact	Alternative(s)	Significance Pursuant to CEQA	Proposed Mitigation	Significance After Mitigation Pursuant to CEQA
Implementation of the Water Use Retirement Program could result in decreases in nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms.	2, 3	B	None	B
Implementation of the Interim Flow and Lake Level Program could result in decreases in nutrient inputs to Upper Klamath Lake and associated decreases in nuisance and/or noxious phytoplankton blooms	2, 3	B	None	B

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