RESIGHINI RANCHERIA

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July 19, 2004

Magalie R. Salas, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

RE: Klamath Hydroelectric KHP, FERC No. P-2082-027
Scoping Document 1 Comments

Below are comments regarding the Federal Energy Regulatory Commission (FERC) Environmental Impact Statement (EIS) Scoping Document 1 (SD 1) for the Klamath Hydroelectric KHP (KHP), FERC KHP No. P-2082-027.

At the request of the Klamath Basin Tribal Water Quality Work Group (Work Group), whose members include the Resighini Rancheria, Yurok, Hoopa, and Karuk Tribes, and the Quartz Valley Indian Community, a team of specialists assembled by the Work Group's consultant, Kier Associates, reviewed SD 1. The same team reviewed PacifiCorp's Final License Application (FLA). Much of the content of these comments is based on comments that were submitted to FERC and PacifiCorp in response to PacifiCorp's FLA. The comments below address what the review team, the Resighini Environmental Protection Authority and the Business Council view as deficiencies in the proposed scope of the KHP alternatives and identification of environmental issues identified in SD 1, and provide suggestions for improving SD 1. The text is organized by the same section numbering system as SD 1.

We look forward to our government to government consultation with the FERC later this year where we can further discuss our concerns about water quality issues and the impact of PacifiCorp's Klamath Hydroelectric Project on the Klamath River Basin.

Sincerely,

Kathy N. Dowd, Vice-Chairperson
Resighini Rancheria Business Council

The development of the KHP has profoundly altered the Klamath River. In the area impacted by the KHP, the Klamath River was once approximately 62 miles of free-flowing river and 2 miles of Lake Ewauna. In its present configuration, the KHP impact area is approximately 37 miles of reservoirs; 5 miles of bypass reaches, where the river is almost entirely diverted; a 16-mile peaking reach, where flow rates fluctuate drastically on a daily basis; and only 6 miles of free-flowing river (PacifiCorp 2004). Such development has greatly altered the hydrologic, physical, chemical, and biological processes of the Klamath River. *If the EIS is to accurately and fully assess the environmental impacts of the KHP, it must describe and quantify how these changes in river processes has affected the fish and other aquatic resources of the entire Klamath River.*

In its FLA, PacifiCorp (2004) claimed that the KHP provides a net benefit to the water quality of the Klamath River. PacifiCorp attempts to support this claim by stating that water quality exiting the KHP is better than water quality entering the KHP at the upstream end. To understand the impacts of the KHP, FERC should not ask "Is the present-day quality of water exiting the KHP better than that which is entering it?", but, rather "How do present-day water quality conditions within and below the KHP-impacted reaches of the Klamath River compare to those which would occur without the KHP, or with some mix of KHP and no-KHP alternatives?" This is the question that the EIS must address.

3.0 Request for Information

Many of the documents listed in the reference section at the end of these comments are available on the Internet. For such references, a URL address is listed below the citation. FERC should download and review these documents for assistance in the EIS preparation. All electronic documents listed in the reference section have also been e-filed at the FERC website. While some of the important and relevant contents of these reference documents are highlighted and explained in the text of the comments presented here, many of the documents contain extensive background information that should prove highly useful to FERC in preparing the EIS.

The Klamath Resource Information System (KRIS) is a computer database that contains a variety of documents, photos, and data related to fish and water quality in the Klamath River basin that FERC will find useful while preparing the EIS. The contents of the KRIS Klamath-Trinity Version 3.0 database are available online at www.krisweb.com and CD-ROMs of the database are available by contacting Kelly D. Sheen of the Trinity County Resource Conservation District at ksheen@tcrcd.net or (530) 623-6004. A set of KRIS Klamath-Trinity Version 3.0 CDs is being mailed to FERC as part of these comments.

4.0 Proposed Actions and Alternatives

The "Proposed Actions and Alternatives" section of SD 1 is incomplete and insufficient because it does not consider a full range of proposed actions and alternatives to the KHP.

The "Proposed Actions and Alternatives" section of the EIS needs to include and evaluate a *No Dams Alternative.* The No Dams Alternative should analyze environmental conditions of the Klamath River from upper Klamath Lake to the Pacific Ocean with all KHP dams removed, including: Link River, Keno, J.C. Boyle, Copco No. 1, Copco No. 2 and Iron Gate. As described in these comments, KHP dams and reservoirs have potentially significant impacts on the Klamath River, its water quality, and upon the native anadromous fish resources. Given these impacts on the Klamath River and their economic consequences, the removal of all KHP dams is a reasonable alternative that should be given full consideration in the proposed EIS.

In evaluating the environmental impacts of the No Dams Alternative, the EIS should examine an array of issues, including how dam removal would affect water quality and how sediments behind the dam would affect the river downstream.

4.3 Retirement of Additional Developments

The wording for this section is brief and vague; it does not answer the important question of *which* additional developments would be considered for removal. This alternative needs to be presented more clearly. Logical choices of facilities to consider for removal in this alternative are Iron Gate Dam and Copco 1 and Copco2 dams, the three most downstream dams in the KHP. A panel of leading scientists appointed by the National Academy of Sciences recommended in their final report (NAS 2003) that Iron Gate Dam be considered for removal to reopen habitat that is currently blocked above the dam. The panel also stated that the current FERC relicensing process represents an opportunity to determine whether or not Iron Gate Dam should be removed.

5.0 Scope of Cumulative Effects and Environmental Issues

5.1 Cumulative Effects

The "Cumulative Effects Analysis and Environmental Issues" sections of SD 1 are incomplete concerning the identification of key issues associated with the KHP that cumulatively effect the Klamath River within the KHP area, and in the reaches downstream of Iron Gate to the Pacific Ocean. In addition to the resources already identified in SD 1, the following aspects of water quality appear to be effected cumulatively by the KHP and should be addressed in the EIS:

- excessive nutrient levels, especially forms of nitrogen
- pH
- ammonia toxicity
- taste and odor compounds

FERC's SD 1 recognizes that the KHP has cumulative adverse impacts on Klamath River stream temperatures and dissolved oxygen (DO). It fails, however, to recognize that nutrients, algae, and pH contained in waters exiting the KHP can adversely impact water quality in the mainstem Klamath River below the Iron Gate Reservoir. The interrelationships between these water quality constituents are complex, and can create severe water quality conditions for salmonids. A thorough investigation of these nutrient, algae, and pH constituents is necessary in the EIS.

Nutrients, particularly the cycling of nitrogen, have a significant impact on primary productivity and water quality in the Klamath River, yet they are given insufficient attention in SD 1. Any nutrients contributed by the KHP would act with other nutrient and thermal loading sources to cumulatively impact the mainstem Klamath River by stimulating the growth of benthic algae and rooted macrophytes. This will further degrade water quality, sometimes to the point of being lethal to salmon and other fish species.

Algal growth in response to nutrient-laden water released from Iron Gate Reservoir appears to have an appreciable impact on diurnal dissolved oxygen concentrations. Further, the Klamath River is subject to elevated pH levels resulting from algal growth because the Klamath is a weakly or moderately buffered system with alkalinities ranging from 50 to 120 mg $CaCO_3$ per liter (Deas and Orlob, 1999). An increase in pH can have a direct impact on the levels of certain constituents, such as the unionized form of ammonia, that are highly toxic to fish, even in low concentrations, particularly at elevated temperatures (U.S. EPA, 1986; 1999). The ammonium ion (NH_4^+) changes to the lethal unionized form of ammonia (NH_3) in conditions of high pH and high water temperature (Goldman and Horne, 1983). At a water temperature of 25.0 °C and a pH of 7.6, 2.1 percent of the ammonia present will become unionized, at pH 8.0 it is 5.0 percent, at 8.6 it is 17.4 percent, at pH 9.0 it is 34.6 percent, and at pH 9.6 67.7 percent of the ammonia present will be unionized ammonia (Emerson et al., 1975).

In 1996 and 1997, California's North Coast Regional Water Quality Control Board (NCRWQCB) coordinated a water quality survey of the mainstem Klamath River and many of its tributaries. The pH values measured at many sites frequently exceeded the NCRWQCB (2001) Basin Plan objective that pH should not rise above 8.5 in the Klamath River (Figure 1). The highest pH values recorded were 9.7 in the Klamath River just above Cottonwood Creek (upstream of the Shasta River) and 9.2 in the Klamath River below the Shasta River. These high pH values most probably result from a combination of algal blooms in KHP reservoirs, excessive attached algal and macrophyte growth in riverine sections, with the algal photosynthesis creating alkaline conditions during the day.

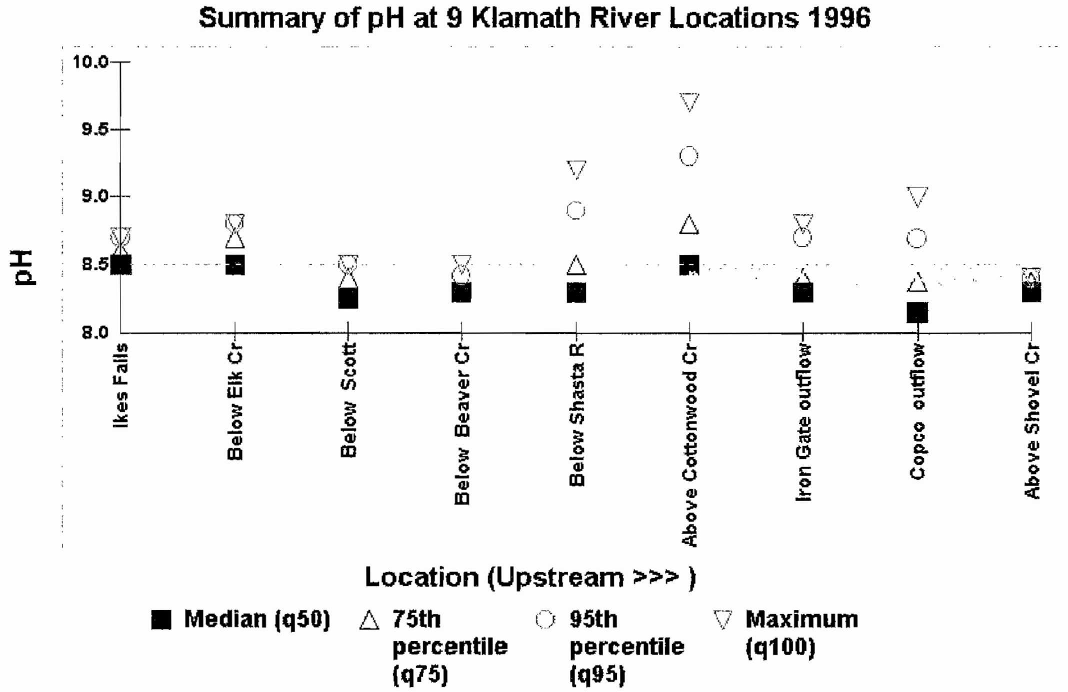
Summary of pH at 9 Klamath River Locations 1996

Figure 1. This chart shows a summary of pH data collected at nine Klamath River locations in 1996. Each site was sampled 18 to 22 times from April through October, between the hours of 6am and 8pm. The reference value of 8.5 shown on the chart is the NCRWQCB (2001) Basin Plan objective for pH. The data are from the NCRWQCB's water quality reconnaissance study. The chart is from the Klamath Resource Information System (KRIS v 3.0).

Other datasets have documented high pH levels on the Klamath. Klamath River water quality data for the years 2001-2003 collected with automated probes by the USFWS (2003), Yurok Tribe, and Karuk Tribe indicate that pH values of over 8.5 occurred at eight of the nine of Klamath River sites monitored. The same data indicate that pH rose to 9.0 or above in the Klamath River at Iron Gate Bridge, Seiad Valley, and Martins Ferry. The data also show in 2002, daily maximum pH in the Klamath River was at or above 9.0 on 21 days from July 30 through September 4 at Iron Gate Bridge and on 27 days from August 1 through September 30 at Seiad Valley.

Excessive algae growth in the Klamath River has been implicated in lethal nighttime sags in DO (Kier Associates, 1999, Deas and Orlob, 1999). Figure 2 shows that at 3 a.m. on August 10, 1997, the U.S. Fish and Wildlife Service measured a D.O. value of 3.1 ppm at Big Bar on the Klamath River below Orleans (Halstead, 1997). This low D.O. reading is in the range of severely stressful, or lethal, for salmon (Davis, 1975; Deas and Orlob, 1999). At the time of this USFWS water quality testing, juvenile salmon and even more resilient fish species such as suckers and dace, were observed succumbing to disease and dying (Halstead, 1997). These D.O. sags were almost certainly related to nocturnal algal respiration, either by macrophytes, attached algae (Halstead, 1997), or by algae entrained in the water column (Kier Associates, 1999). The frequency of these extremely low D.O events in the Klamath River is unknown as they occur at night when sampling is rare, but conditions measured during the day in 1996 and 1997 showed frequent daytime supersaturated D.O. conditions and elevated pHs indicating high diurnal photosynthetic activity. In the Klamath River, when photosynthetic activity causes supersaturation of D.O. during daylight hours, D.O. is often below saturation during early moring hours (Deas et al., 1999).

While the 3.1 ppm D.O. measured at Orleans is one of the lowest D.O. levels recorded in the Klamath River below Iron Gate Dam, it is not the only measurement documenting D.O. levels substantially below saturation. Klamath River water quality data for the years 2001-2003 collected with automated probes by the USFWS (2003), Yurok Tribe, and Karuk Tribe indicate that daily minimum D.O. levels below 5.0 ppm occurred for extended periods of time at multiple Klamath River sites in 2001. Daily minimum D.O. levels were below 5.0 ppm at Happy Camp from August 29 through September 11, reaching a low of 3.2 ppm on September 11. Daily minimum D.O. levels were below 5.0 ppm at Iron Gate Bridge on 23 days in August, including six days below 4.0 ppm and two days at 3.4 ppm. In the Klamath River at Seiad Valley, daily minimum D.O. levels dropped to 4.9 ppm on July 14, and 4.2 on July 27.

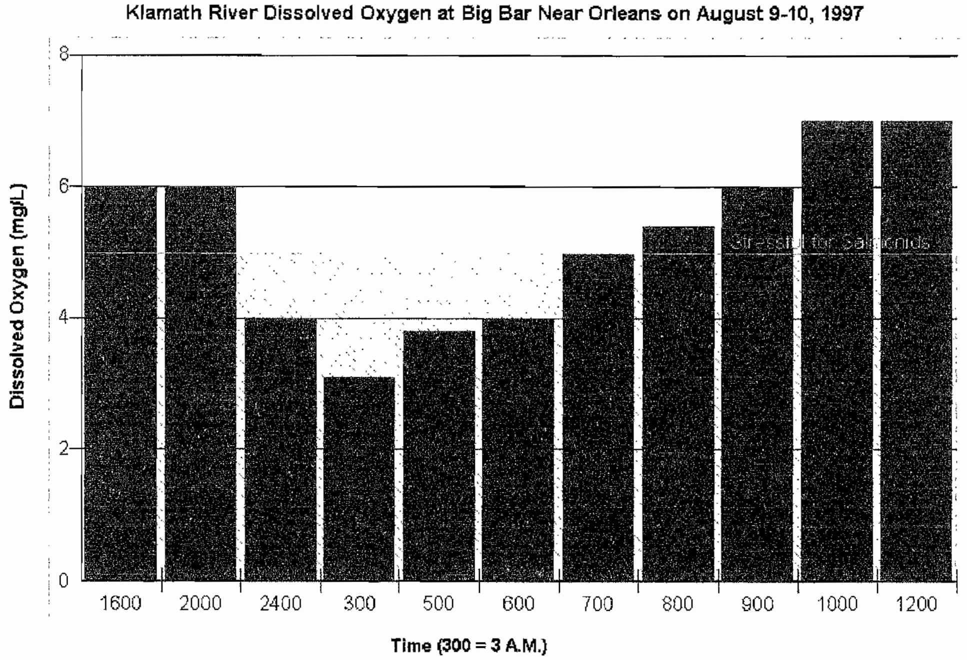

Figure 2. Dissolved oxygen of the mainstem Klamath River taken during the evening and night of August 9 and morning of August 10, 1997 at the Big Bar fish trap near Orleans by the U.S. Fish and Wildlife Service (Halstead, 1997). The chart is from KRIS Version 3.0.

Water quality data collected on August 6, 1997, just prior to the juvenile fish kill and the D.O. sag described above, indicate pulses of unionized ammonia in KHP-impacted waters. Unionized ammonia levels were calculated by using temperature, pH and total ammonia. The NCRWQCB Section 104(b) data collected in the J.C. Boyle peaking reach above Shovel Creek showed a spike in unionized ammonia to 0.030 milligrams per liter. Winchester et al. (1995), in a study of the Lost River, used a threshold of 0.025 mg/L of unionized ammonia as a toxicity threshold based on work by the U.S. EPA (1986). Unionized ammonia increased substantially below Copco 2 (Figure 3) to 0.057 mg/L, nearly double the amount found above Shovel Creek. While unionized ammonia levels coming out of Iron Gate Reservoir dropped to levels similar to those above Shovel Creek, they were the highest measured in the 1997 season (Figure 4) and they were above the levels recognized as capable of damaging the gills of rainbow trout (Thurston et al., 1984).

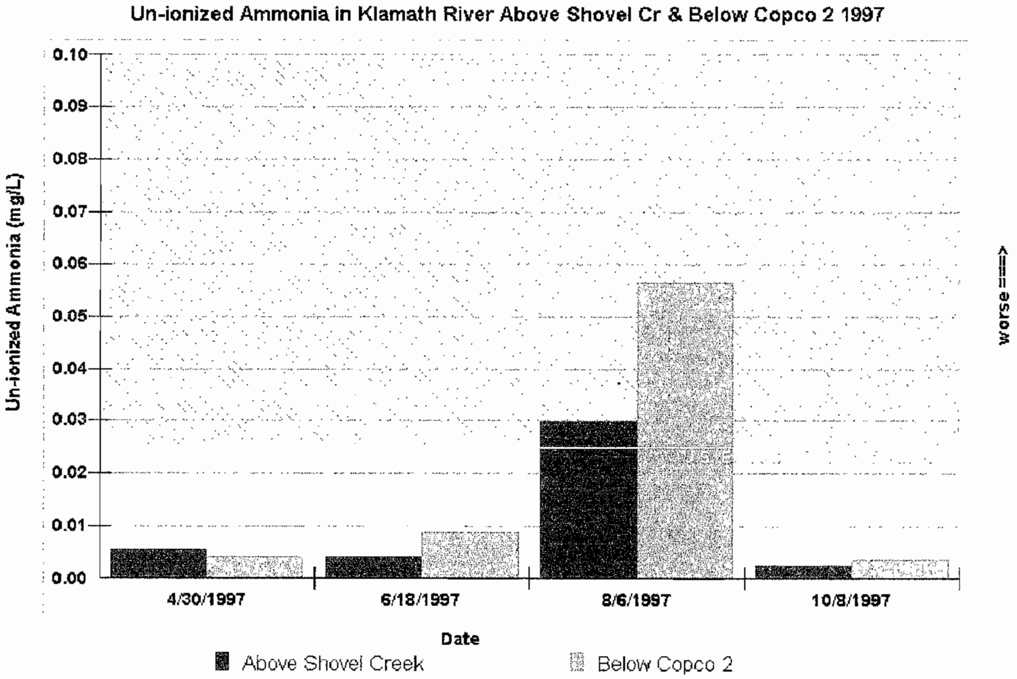

Figure 3. Unionized ammonia in the mainstem Klamath River during 1997 above Shovel Creek and below Copco 2 reservoir shows an increase between the two locations which was most pronounced on August 6, 1997. Data are from the NCRWQCB 104(b) study.

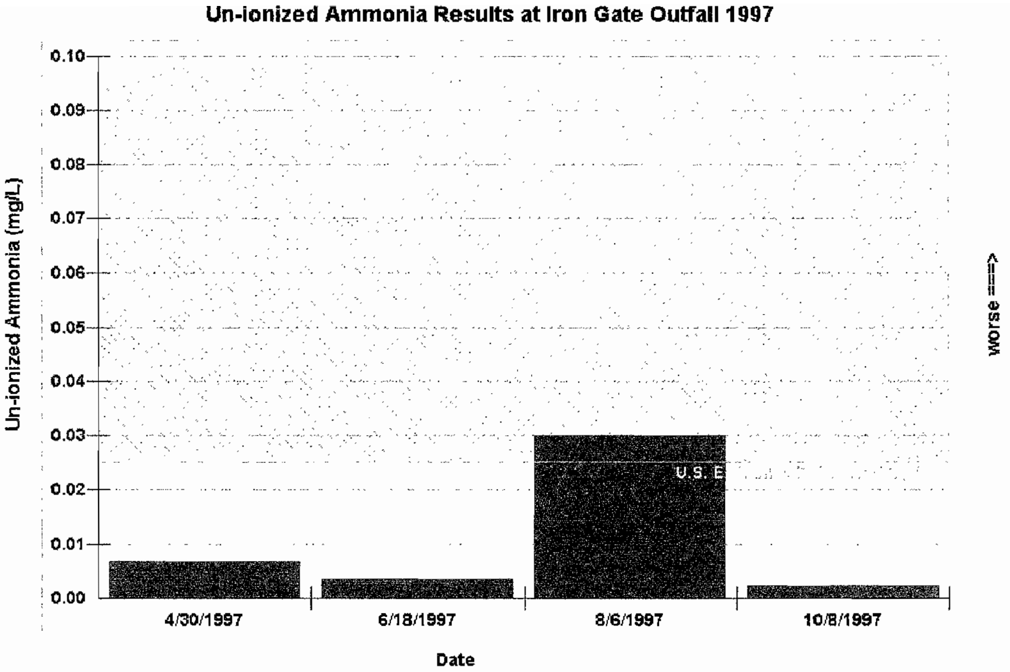

Figure 4. Unionized ammonia below Iron Gate Reservoir in 1997 was highest on August 6, 1997, just prior to a major fish kill downstream. Data are from NCRWQCB 104(b) study.

Further, the peak of unionized ammonia at Iron Gate on August 6, 1997 was roughly coincident with the adverse water quality conditions downstream at Orleans and a juvenile fish kill, suggesting a potential linkage that warrants further investigation. KHP reservoirs may be contributing to these unionized ammonia peaks to the extent that they are adding additional nitrogen to the system (either through algal, *Aphanizomenon flos-aquae,* fixation of nitrogen or internal sediment contributions), contributing to photosynthetically elevated pH, and to increased ammonia levels. These linkages with KHP operations need to be evaluated in the EIS.

Relatively high levels of unionized ammonia were also detected many miles below the KHP. In June of 1997, an unionized ammonia level of more than 0.050 mg/L was measured above Orleans at Ike's Falls. This suggests that photosynthetic activity was high enough at that location to increase pH up to levels where very high percentages of ammonia are converted to the unionized form, and it further underscores the need to evaluate such dynamics in the EIS.

As noted earlier, pH, and, to a lesser extent temperature, are the essential water quality parameters that determine the equilibrium between ammonium ion and unionized ammonia (US EPA, 1999). The high pH condition that drives the transformation of ammonium ion to unionized ammonia is likely caused by the photosynthesis of algal blooms in the KHP reservoirs, as well as macrophytes and attached algae in nutrient-impacted free-flowing sections of the river.

The effects of KHP operations on the dynamics of nutrients, algal growth, pH, and the subsequent effects on ammonia toxicity to salmon were not been evaluated in PacifiCorp's FLA nor were they identified in FERC's SD 1. These effects of KHP operation need to be addressed, assessed, and made clear in the EIS.

Taste and odor compounds

The KHP may cumulatively affect taste and odor compounds in the Klamath River. Taste and odor compounds come from a diverse group of sources, including municipal wastewater treatment discharges, refinery wastes, and wastes from slaughterhouses (EPA 1996). A potential taste and odor compound source in the Klamath River is algae. As it grows and decays, algae can produce undesirable tastes and odors in water (EPA 1996 and Droste 1997). Taste and odor-causing compounds are often volatile and can be removed to a significant extent by aeration (Droste 1997). Adding oxygen to water can improve the taste of water to a limited extent (Droste 1997). The stagnation and anaerobic conditions found in KHP reservoirs likely contribute to problems with taste and odor in the Klamath River. Removal of the reservoirs may ameliorate these effects.

PacifiCorp conducted a survey of recreational users in the KHP area. Thirty-six percent of recreational users indicated that water quality affected their visit to the Klamath River and many respondents commented on the excessive algae, green water, foam, suds, and bad odors found in the KHP reservoirs and river reaches (PacifiCorp 2004).

Fish growing in water containing taste and odor compounds can take these compounds into their tissues. Recreational fishing can be adversely affected by off-flavored fish because eating such fish becomes less desirable. This, in turn, can have negative economic effects on recreational economies, including bait and tackle sales and boat and cottage rentals (EPA 1986).

The EIS should evaluate the taste and odor compounds that occur throughout the KHP area and determine whether they are having a negative economic impact. FERC should also try to determine what factors contribute to the creation of these compounds, whether and how the KHP contributes to them, and identify solutions for preventing or removing them.

Water temperature

Section 5.2.2 of SD 1 identified that water temperature are potentially cumulatively affected by the KHP and identifies the following three issues related to water temperature in the Klamath River below Iron Gate dam:

- "The effects on aquatic resources of retiring additional developments"
- "The effects of water quality conditions on aquatic resources in KHP reservoirs, affected reaches, and the lower Klamath River, and the potential benefits of measures to improve water quality"
- "The potential effects of implementing proposed and alternative measures to improve water quality, including D.O augmentation in Iron Gate reservoir,

aeration of waters released from Iron Gate dam, and installation of a low-level outlet at Iron Gate reservoir."

The following section of our comments provides information that should assist FERC in its effort to answer the questions above.

Due to its thermal mass, Iron Gate Dam releases cooler water into the mainstem Klamath in spring, and warmer water in late summer and fall, than would exist absent the KHP (PacifiCorp 2004). The KHP decreases water temperature in the spring and summer by at least 5° C, and increases streamflow temperatures in late summer and autumn by at least 5° C. Due to variations in weather, the timing and magnitude of these temperature deviations will vary from year to year. The differences between temperatures with- and without the KHP are shown in Figure 5, from Kanz (2004a).

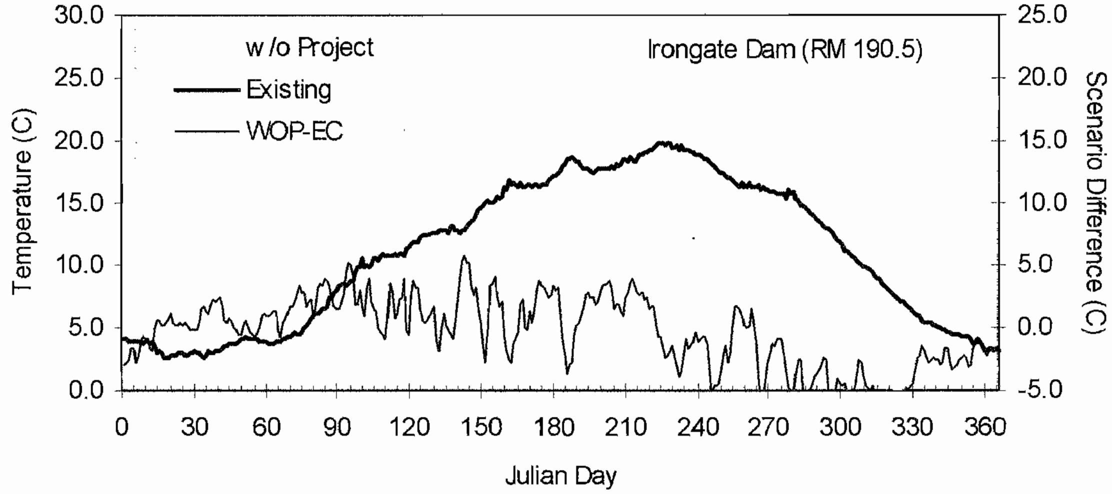

Figure 5. Results from the Water Course Engineering model showing a comparison of water temperatures below Iron Gate with and without the KHP, and the difference between the two. The chart, from Kanz (2004a), was originally generated by Water Course Engineering.

These stream temperature alterations are perhaps the KHP's single greatest documented impact on water quality. The impact of these thermal alterations on the growth and survival of the river's salmon and other aquatic resources needs to be analyzed in the EIS as part of "The effects of water quality conditions on aquatic resources in KHP reservoirs, affected reaches, and the lower Klamath River, and the potential benefits of measures to improve water quality". For example, in addition to direct thermal tolerance issues, temperature also interacts significantly with the ammonium compounds present in the river to drive toxic conditions, as well as with DO saturation dynamics and the growth of algae.

Warmer water temperatures in late summer and fall affect fall run Chinook salmon that are arriving to spawn in reaches of the Klamath River below Iron Gate Dam. Bell (1986) states that preferred spawning temperatures are between 5.6-17.2 °C, which temperatures are exceeded below Iron Gate well into September. National Marine Fisheries Service

(1996) characterized properly functioning conditions for adult Pacific salmon as between 10-13.9 °C and temperatures from 13.9 to 15.5 °C as "at risk." McCullough (1999) noted that egg size and development was substantially altered when adults were exposed to temperatures over 17.5 °C.

Since the construction of Iron Gate dam, there has been a shift in the timing of the fall Chinook spawning run arguably due to the KHP's impact on river temperatures (Michael Belchik, pers. comm.). The compression of the run timing of fall Chinook not only makes fish more vulnerable to harvest but can cause higher densities in the stream as they join later-running Trinity River fish in the lower Klamath River. High concentrations of salmon in combination with high water temperatures are thought to have contributed to the September 2002 Klamath River fish kill (CDFG, 2003 and Guillen, 2003).

The egg stage is the most temperature-sensitive salmonid life history phase (Hicks 2000). Reiser and Bjornn (1979) defined optimum temperatures for salmon and steelhead egg incubation as 4.4-14.4°C. These temperatures are exceeded well into September below Iron Gate. Eggs laid in the Klamath River below Iron Gate at higher than optimal conditions are likely to have higher pre-hatch mortality, a greater rate of developmental abnormalities, and lower weight as alevins (McCullough, 1999).

Warmer stream temperatures through December would then accelerate hatching and alevin emergence. Stream temperatures in January then drop below those that would occur absent the KHP. McCullough (1999) notes that optimal growth temperatures for Chinook salmon are between 10-15.6 °C, while Klamath River temperatures at Iron Gate Dam remain below 5 °C through mid-February and continue to be below optimum levels into March.

It is likely that juvenile fall Chinook salmon emerging from the gravel early and then having to withstand KHP-depressed stream temperatures and related depressed food production experience slower growth and a decreased rate of survival.

The EIS's analysis of how the KHP may contribute to cumulative temperature impacts needs to include a discussion of how global climate change will affect the Klamath River. Rising atmospheric concentrations of carbon dioxide and other greenhouse gases could lead to an increase in global mean temperatures (NAS 2003). A recent National Academy of Science report (NAS 2003) provides a description of what may occur:

> A detailed model of the Klamath basin region at 25 mi resolution has been developed by Snyder et al. (2002). Use of the model demonstrates three important kinds of changes in the hydrology of the Klamath watershed that could occur over the next century: (1) warming, especially at high elevations in spring (April, May); (2) higher total precipitation, especially in spring; and (3) an increase in the ratio of rainfall to snowfall and large decreases in spring snowpack. The changes modeled by Snyder et al. (2002) have strong implications for management of water resources and all aquatic species, but especially salmonids (NAST 2001, O'Neal 2002).

> For salmonids, the most important potential changes include altered timing of snowmelt, lower base flows, and additional warming of water in summer.

Given that high water temperatures are widely recognized as a problem for anadromous fish in the Klamath River, global climate change has the potential to cause additional decline in the basin's fish stocks and should be part of the context within which the KHP is evaluated in the EIS.

5.1.2 Temporal Scale

According to SD 1, the EIS will evaluate possible cumulative effects "30 to 50 years into the future". This temporal scope is too narrow. It lacks sufficient long-term vision or history to address the questions raised by the Klamath Basin Tribes and their Water Quality Work Group. The Tribes involved in the Work Group have lived in the Klamath River basin and have relied on its salmon and other fish for subsistence for over 10,000 years, giving them a longer-term view of conditions in the basin. When the KHP last received a license in 1956, salmon and steelhead were still abundant (Coots, 1967). Spring Chinook and coho salmon that returned each year to the reaches above Iron Gate were lost altogether to the development of PacifiCorp's Iron Gate Dam (Kier Associates, 1991).

The Pacific Ocean alternates roughly every 25 years from rich ocean conditions off northern California, Oregon and Washington to poor conditions, while ocean areas off Alaska show the opposite trend (Hare et al., 1998). A recent science assessment prepared for the NCRWQCB (ISRP, 2003) points out that if fresh water habitats are not improved by 2015-2020 period, when ocean conditions upon which Klamath River salmon depend will once again oscillate, strong salmon stocks may become endangered and weaker stocks will go extinct. That period is less than mid-way through the proposed KHP re-license period. The further loss of Pacific salmon stocks threatens the existence of the Tribes; therefore, the *urgency* of improving conditions before 2015-2020 needs to be acknowledged and addressed by the EIS.

5.2 Resource Issues: Water Resources (5.2.1) and Aquatic Resources (5.2.2)

This section discusses important issues related to water quality that should be addressed in the EIS. These issues are either inadequately addressed or missing altogether in SD 1.

The following key processes which govern the balance between nutrients, algae, and pH need to be evaluated and quantified in the EIS in order to thoroughly understand their impacts on Klamath River water quality throughout the KHP and downstream in the mainstem Klamath to the Pacific Ocean. Evaluating how the presence of KHP reservoirs and their operations (bypass and peaking) affect these processes is necessary to judge how the KHP affects water quality and aquatic resources like anadromous fish. These key processes include:

A. dilution
B. nutrient cycling in reservoirs
C. algae blooms in reservoirs, including nitrogen fixation
D. assimilative capacity of periphyton and macrophytes in river reaches
E. denitrification/nitrification in river reaches

A. Dilution

Even if one were to assume that the Klamath River did not have the capacity to assimilate nutrients, the quality of the free-flowing river (i.e. without the KHP dams) would improve as it flows through the presently KHP-impacted area simply by the dilution of poor quality Klamath River water from Upper Klamath Lake by the high quality water additions from the river's many tributary streams and springs. These inputs include springs in the J.C. Boyle bypass reach (225 cfs) and tributaries between Link River dam and Iron Gate dam. The tributaries are Spencer Creek (approximately 20 to 200 cfs), Shovel Creek (10 to 100 cfs), Fall Creek (30 to 100 cfs) and Jenny Creek (30 to 500 cfs), although Spencer, Shovel, and Jenny creeks all have irrigation diversions, so the actual quantity of water entering the KHP could be less than suggested here (PacifiCorp 2004). The sum of these tributary and spring inputs ranges from 315 to 1125 cfs. In comparison, the U.S Bureau of Reclamation (2003) *Klamath Irrigation KHP Operations Plan* calls for low-flow summer releases from Iron Gate dam ranging from 515-1149 cfs depending on water year type.

B. Nutrient Cycling in Reservoirs

Reservoirs are often sources of nutrients at various times of the year, particularly when sediment nutrient loading and nitrogen fixation occur. The KHP reservoirs clearly can have an impact on nutrient cycling in the system because they increase hydraulic residence time, which allows particulates to settle out. Nutrients are not necessarily mired in the reservoir sediments and can be exported downstream seasonally. The reservoirs may not be nutrient sinks at all, but may be merely affecting the timing of nutrient movement through the system.

During periods of low dissolved oxygen in the hypolimnion of the Copco and Iron Gate reservoirs nitrates are converted to ammonia, and phosphate is released from the sediments, resulting in relatively high levels of ammonia and orthophosphate (PacifiCorp 2004). During such periods, ammonia levels in reservoir outflows are higher than reservoir inflows (Figure 6). Although J.C Boyle reservoir does not stratify it also elevates ammonia levels in the river (Figure 7). As the water at the surface of Iron Gate and Copco Reservoirs cools during the fall, the vertical density gradient decreases and the reservoirs become isothermal (mixed) around the middle of November (PacifiCorp 2004). PacifiCorp's own data concerning these water quality issues underscores the need to evaluate the seasonal dynamics of nutrient cycling in the KHP reservoirs. These processes should be evaluated on a seasonal basis and discussed in the EIS.

The way to determine whether pulses of nutrient releases occur is to conduct detailed analysis, such as a detailed temporal (a minimum of biweekly sampling) comparison of inflow water quality for each reservoir with that of outflow water quality. The existing water quality grab samples taken by PacifiCorp may not be extensive enough to detect nutrient pulses. The existing water quality data suggest that a pulse of phosphorus was released from Iron Gate and Copco reservoirs after the breakdown of stratification in November 2002 (Figure 8). The lowest levels of phosphorus are at the end of the J.C. Boyle bypass reach ("KR u/s JCB PH") where spring water is diluting Klamath River flows. Downstream of the bypass reach, phosphorus levels climb steadily, suggesting, again, that phosphorus is being released from Iron Gate and Copco reservoirs.

PacifiCorp may conduct a detailed study of nutrient cycling in the KHP, as California's State Water Resources Control Board requested it as part of its comments on PacifiCorp's FLA: "SWRCB staff will expect PacifiCorp to prepare a study plan for the review and approval of the SWRCB that includes mass based nutrient cycling and flow through the KHP" (Kanz 2004b). The results of such as a study are needed in order to properly assess the environmental impacts of the KHP.

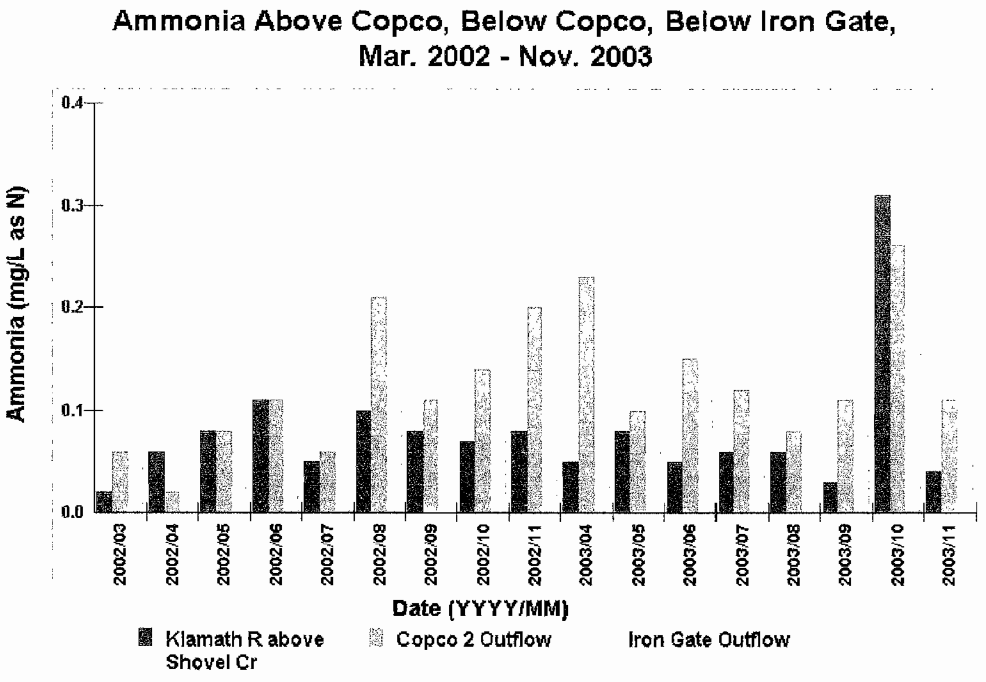

Figure 6. Ammonia levels were generally higher in the outflow of Copco 2 and Iron Gate reservoirs than they were in the Klamath River above Shovel Creek, suggesting that the reservoirs are degrading water quality. August 2002, June 2003, and July 2003 showed the most dramatic

differences. The values shown are the mean of all ammonia measurements for each month. Data are from PacifiCorp's 2000-2003 water quality database.

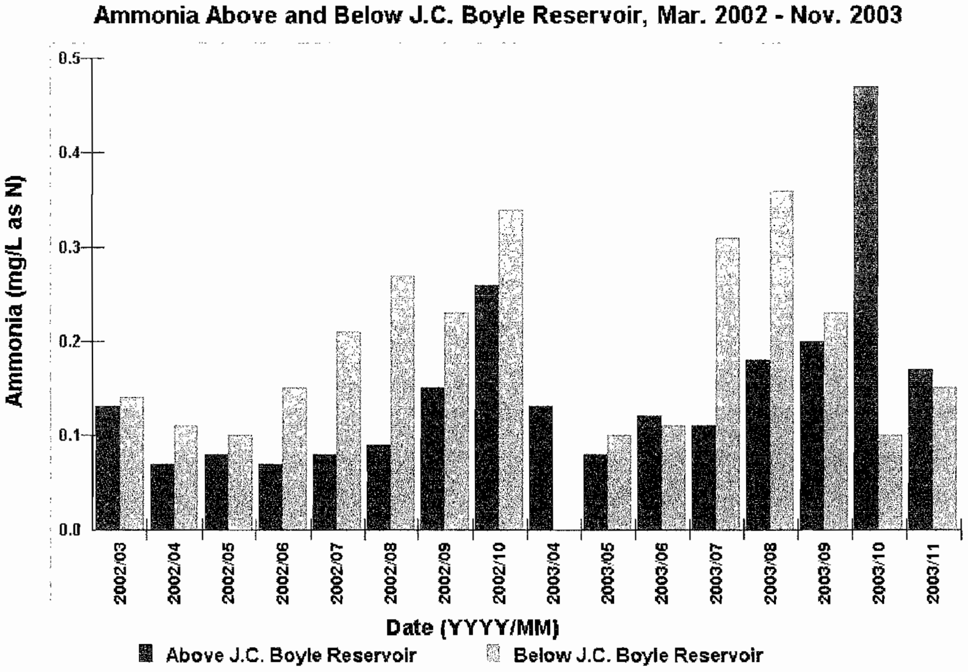

Figure 7. Monthly mean ammonia levels increased significantly from above J.C. Boyle Reservoir to below J.C. Boyle reservoir, indicating the reservoir may be degrading water quality. July and August showed the greatest differences. Data are from PacifiCorp.

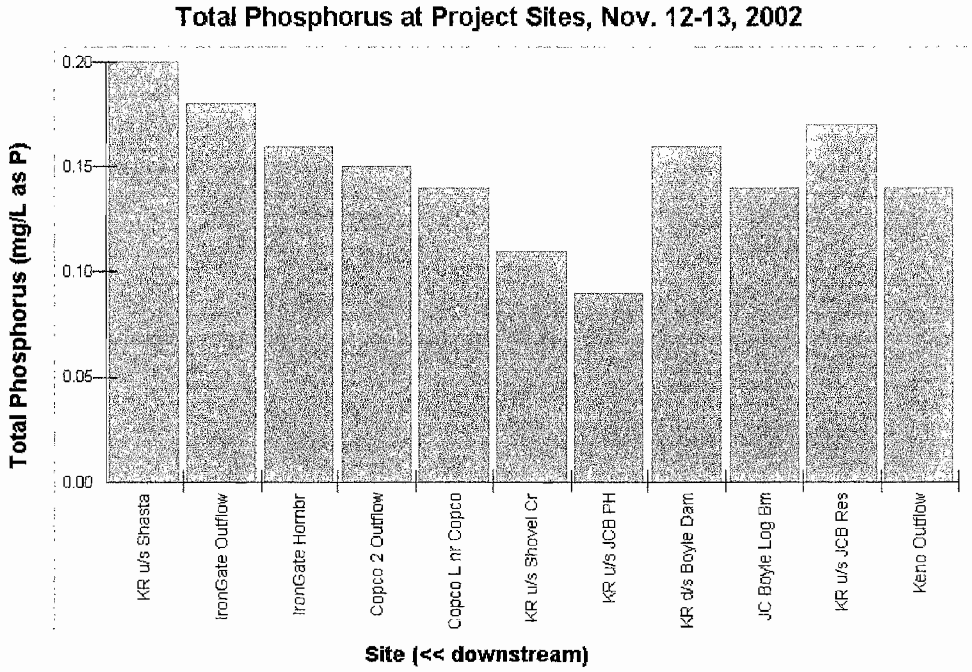

Figure 8. Total phosphorus levels at 11 sites in the Klamath River and at the surface of KHP reservoirs on November 12-13, 2002, near the time when the reservoirs have mixed following summer stratification. Data are from PacifiCorp 2000-2003 water quality database.

C. Nitrogen Fixation by Algae Blooms in KHP Reservoirs

An environmental issue listed in section 5.2.2 of SD 1 is, "The potential effect of KHP operations on algae blooms in KHP reservoirs." It is unclear if the phrase "KHP operations" refers to flow rates and reservoir-downs, or if refers to the fact that the construction of KHP dams has created reservoirs where algae blooms will seasonally occur as long as the reservoirs are in place and receive phosphorus-rich inflow. Neither does the statement in SD 1 also make clear whether the EIS will also examine whether and how algae blooms in KHP reservoirs affect water quality in the Klamath River along its entire length. The statement should be re-written to clarify that the EIS will contain a detailed quantitative analysis of the cause of algae blooms in KHP reservoirs, how those algae blooms affect water quality both in KHP reservoirs and all downstream reaches of the Klamath River, and whether, as one might expect, dam removal would eliminate the algae blooms.

Atmospheric nitrogen occurs primarily in an inert form (N_2) that few organisms can use because it is extremely stable. Nitrogen-fixing organisms have the ability to split the molecule in half and combine it with hydrogen to form ionized ammonia (NH_4^+), which then can be assimilated, into cells. The blooms of the cyanobacteria (also called blue-green algae) *Aphanizomenon flos-aquae* in KHP waters are fixing nitrogen gas from the air and adding it to KHP waters, potentially exacerbating downstream water quality problems. The *A. flos-aquae* blooms occur during the summer months, the same time of year that water temperatures are highest and water quality is most stressful for salmonids.

KHP reservoirs provide ideal conditions for *A. flos-aquae* to thrive and to fix nitrogen. Free-flowing river reaches do not support *A. flos-aquae* blooms. They are, instead, inhabited by periphytic algal species and macrophytes that do not fix nitrogen. In the absence of KHP reservoirs *A. flos-aquae* blooms and associated nitrogen fixation would not occur in the presently impacted KHP Klamath River reaches. Deas and Orlob (1999) note that phytoplankton growth in the Klamath River is strongly nitrogen-limited. Nitrogen-limited conditions foster blooms of nitrogen-fixing cyanobacteria, particularly when hydrodynamic conditions such as those created by the KHP reservoirs exist.

The large growths of periphyton in the Klamath River downstream of Iron Gate require sufficient quantities of nitrogen and phosphorus. If algae blooms and sediment loading in KHP reservoirs are causing an increase in nitrogen levels in the water downstream of Iron Gate, then there would likely be an increase in periphyton growth below Iron Gate. This is an important matter, because water quality below Iron Gate is poor during the summer and fall and, as discussed above, excessive periphyton growth can degrade water quality by increasing daily dissolved oxygen fluctuations and the availability of unionized ammonia, which in turn lead to fish stress or mortality.

It is important to quantify and to include in FERC's EIR the extent of nitrogen added to the river system during algae blooms in KHP reservoirs. Current water quality modeling efforts by PacifiCorp does not include the process of nitrogen fixation by *A. flos-aquae*, or the internal loading processes that have such a high potential to contribute nutrients to the system.

The total quantity of nitrogen contributed by the reservoirs from both nitrogen fixation and internal sediment loading can be estimated from seasonal mass balance calculations taken from measurements of nitrogen going into and out of each reservoir, as well as the change in nitrogen mass within each reservoir (Jacob Kann, pers. comm.). The creation of such a nutrient budget requires regular temporal measurements of flow and nutrient concentrations into and out of the reservoirs, as well as nutrient concentration and water volume within the reservoirs. The nutrient budget should be calculated on a monthly basis to seasonal variation, rather than just an annual budget. PacifiCorp (2004b) has proposed to collect additional water quality data that will be useful in constructing a nutrient budget, but has not explicitly committed to calculating a mass-balance nutrient budget. FERC should perform the required calculations, or request that PacifiCorp do so.

While extremely useful and necessary, a mass-balance nutrient budget alone is not sufficient to determine the quantity of nitrogen fixed in Project reservoirs because the method produces only the net result of processes. It will not distinguish between the contributions of nutrient settling, internal sediment loading, and nitrogen fixation. To better be able to predict how the reservoirs vary from what a restored river (with dams decommissioned) would do, it is necessary to know the magnitude of each of the reservoirs' internal nutrient-cycling processes.

If FERC and PacifiCorp cannot find a quantitative method to estimate the mass of nitrogen being fixed in Project reservoirs, then an attempt should be made to determine the relative order of magnitude of nitrogen fixation. There are at least two methods for determining this, both of which should be conducted:

- The acetylene reduction method (Goldman and Horne, 1983)
- Phytoplankton sampling in which the cell types of *A. flos-aquae* are counted and the ratio between vegetative cells, heterocysts, and akinetes is calculated.

In response to an Additional Study Request to conduct acetylene reduction assays, PacifiCorp (2004c) stated, "The acetylene reduction assay is useful for determining nitrogen fixation over very short intervals (a matter of hours) at a single location. This would at best provide only a quick snapshot of the nitrogen fixation process in space and time." Indeed, due to the variations in time and space, it would take a substantial number of acetylene reduction assays to accurately determine the mass of nitrogen being fixed. Performing even a limited number acetylene reduction assays would at least determine if nitrogen fixation is occurring. This snapshot would still be useful. Currently, no data exists on how much nitrogen fixation is occurring in Project reservoirs. The best time to perform the acetylene reduction assays would when *A. flos-aquae* blooms are growing rapidly, such as in June.

Another method for providing a qualitative estimate of the amount of nitrogen fixation occurring in Project reservoirs would be to sample phytoplankton, including identifying algal species and counting the abundance of *A. flos-aquae* cell types. *A. flos-aquae* grow in filaments, with long chains of cells attached end-to-end. They have three cells types. Vegetative cells are the *A. flos-aquae*'s most common and typical cells. Heterocysts are specialized cells that are capable of fixing nitrogen (NAS, 2003). Akinetes are specialized resting cells that senesce into a dormant stage, enabling *A. flos-aquae* to survive adverse conditions. Depending on environmental conditions, *A. flos-aquae* will produce differing amounts of each type of cell. The ratio between the cell types gives an indication of how much nitrogen is being fixed, with more heterocysts indicating more nitrogen fixation. PacifiCorp's 2004 water quality study plan does not propose to conduct phytoplankton sampling in reservoirs. FERC should request that PacifiCorp add reservoir phytoplankton sampling to its study plan for 2004 or 2005. PacifiCorp will already be collecting water quality samples in Project reservoirs in 2004, so the expense of adding phytoplankton sampling in 2004 should be minimal.

D. The Assimilative Capacity of Periphyton in KHP-Impacted River Reaches

Benthic algae, also know as periphyton or attached algae, can take up nutrients dissolved in water and assimilate them into their cells as they grow. This can enhance water quality by removing nutrients from the water. The assimilative capacity of Klamath River periphyton to remove nutrients from water should be quantified. A critical issue for the EIS to address is an analysis of the nutrient-stripping capability of the free-flowing river reaches versus the net gain or loss from the KHP reservoirs, together with the impact of how peaking and bypass operations in the KHP-impacted reaches reduce this capacity.

An environmental issue listed in section 5.2.2 of SD 1 reads "The effects of flow fluctuations caused by load following (peaking) operation on aquatic resources in the J.C. Boyle peaking reach." The analysis of the peaking reach in the EIS should be expanded to look not only at the effects of peaking on invertebrates and fish in the peaking reach but also at how peaking affects the ability of the river to strip nutrients from the water in the peaking reach – which in turn may affect water quality far downstream.

The development of the reservoirs along the Klamath River likely significantly reduced the amount of benthic algae in the KHP-impacted area because they inundate free-flowing river reaches where the benthic algae live. Power peaking operations in the reach below J.C. Boyle have reduced the amount of benthic algae in the KHP area (PacifiCorp 2004). PacifiCorp's FLA (2004) acknowledged that this has impacts on fish populations in the peaking reach, however they did not acknowledge that peaking operations may also have impacts on local and downstream water quality caused by reducing the assimilative capacity of benthic algae. There are three reasons for the decrease of benthic algae in the KHP flow-peaking area:

- diurnal desiccation of near-shore areas
- reduced light penetration during peak flows

- high velocities and associated scour

Only diurnal desiccation of near-shore areas is discussed in any detail in the FLA. During peaking operations, flows in the J.C. Boyle peaking reach are ramped daily from a 325 cfs base flow to a 1500 cfs flow (one turbine) or a 3000 cfs flow (two turbines). The result is that the edges of the river alternate between wet and dry, dramatically decreasing algal biomass at the edges of the channel.

Peaking flows occur at times of peak electrical demand, which in the summer is typically weekday afternoons and early evenings (PacifiCorp 2004). During peak flows, water depths are greater than they would be were J.C. Boyle operating as a run-of-the-river facility. This, along with possible increases in turbidity, can decrease the amount of light available to benthic algae during photosynthetic hours. This would lead to less algae growth, less algae biomass, and less nutrient removal. High flows (1500-3000 cfs) during peaking may also scour benthic algae from the substrate and prevent their establishment and growth.

Just as peaking affects periphyton (and, hence, water quality), so do bypass operations. The low flows in the J.C. Boyle bypass reach result in a narrow channel width. This affects the amount of periphyton that can grow in the channel bottom, which affects the amount of nutrients that the periphyton can removed from the water column, which affects downstream water quality. This effect on downstream water quality needs to be addressed and quantified in FERC's EIS.

Benthic algae are included in PacifiCorp's water quality model, but the model is not calibrated and verified for nutrients, so the effects of algae cannot be reliably determined from the model (Wells et al. 2004). A more comprehensive survey of benthic algae and the role that it plays in dissolved oxygen concentration dynamics as well as nutrient conditions within the KHP area need to be explored and included in the modeling effort in order to compare With- and Without-Project alternatives.

E. Denitrification in River Reaches

Denitrification is the process in which certain organisms can convert nitrate (NO_3) to atmospheric nitrogen (N_2). The result is enhanced water quality, due to the reduction in productivity that occurs because a form of nitrogen readily available to organisms (nitrate) is converted into a stable form of nitrogen that is essentially unusable by most organisms (atmospheric nitrogen). In order for denitrification to occur, adequate nitrate levels and low levels of dissolved oxygen must be present.

Denitrification is known to occur in the hyporheic zones of rivers and streams. The hyporheic zone is the area of water-saturated sediment beneath and beside streams where ground water and surface water mix (Edwards, 1998). Denitrification most often occurs when the following conditions exist: low hydraulic conductivity, long flow path, reduced oxygen supply, adequate nitrate supply, and adequate supply of labile organic carbon (Edwards, 1998).

The amount of nitrogen removed from some rivers through denitrification is extraordinary, especially those with a high rate of interchange between surface water and gravel alluvium (Sjodin et al., 1997). Colorado's South Platte River receives substantial nitrate input from municipal wastewater discharges and irrigation returns. In the South Platte, denitrification rates varied between 2 and 100 milligrams of nitrogen per square meter per hour, depending upon location and season.

Because of temperature-dependent processes, denitrification rates were highest during mid-summer, when a 90% reduction of nitrate occurred in a 6-kilometer long reach. On an annual basis, close to half the nitrate input to a 100-km reach of the South Platte was removed by denitrification (Sjodin et al., 1997). In reference to the South Platte's high denitrification rates, Sjodin et al. (1997) concludes: "A generally similar picture could be expected for any river, such as the large tributaries of the Platte (e.g., Boulder Creek, Cache la Poudre River, etc.), with a large hyporheic exchange and strong augmentation of the nitrate budget by agriculture or municipal waste."

It is unknown how much denitrification is currently occurring in KHP river reaches. Reservoir development has flooded the alluvial reaches in the low-gradient areas of the KHP. The remaining river reaches are of a higher gradient, with less gravel and hence less hyporheic function and less denitrification potential. Dam removal may increase denitrification in river reaches. The amount of denitrification occurring in the river reaches needs to be investigated and quantified in the EIS, as does the amount of denitrification that would occur if KHP reservoirs were removed. Sjodin et al. (1997) calculated denitrification through the use of a mass-balance model based on detailed hydrologic information and field quantification of the rates of nitrate accrual through surface and subsurface input of water as well as nitrification. This methodology should be applied to the Klamath River. The results could be used to improve PacifiCorp's water quality model, which currently does not include denitrification in river reaches.

Water Quality Modeling

PacifiCorp has completed a water quality modeling effort on the Klamath River as part of its KHP re-licensing bid. Its model, however, contained a number of errors and false assumptions and it lacked proper calibration and verification. The model's predictions of water quality parameters and the conclusions drawn from those results cannot be viewed as accurate nor can they be justified. Wells et al. (2004) completed a detailed examination of the model and included recommendations for improving its predictions. Until the recommendations put forth by Wells et al. (2004) are met and proper calibration and verification of the model are completed, PacifiCorp's water quality model cannot be used to predict the outcomes of alternative Klamath River management scenarios.

The Klamath Mainstem Total Maximum Daily Load (TMDL) plan is being developed concurrent with PacifiCorp's request to FERC to re-license the KHP. In the TMDL effort, the U.S. Environmental Protection Agency (U.S. EPA) has contracted with TetraTech, Inc. to develop a water quality model similar to PacifiCorp's that will be used to predict water quality parameters in the Klamath River basin from Upper Klamath Lake to the Pacific Ocean. The modeling effort by TetraTech, Inc. is currently underway and could benefit the FERC EIS process significantly. It is recommended that FERC consult with the U.S. EPA, the California State Water Resources Control Board, Oregon's Department of Environmental Quality, and the Klamath basin Tribes concerning a combined and improved Klamath River water quality modeling effort.

Conclusion

The suggestions provided in the comments above should help FERC to improve the scope of the EIS, so that the impacts of the Klamath Hydroelectric Project to water quality can be fully and accurately determined in the EIS.

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