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RESIGHINI RANCHERIA

A Federally Recognized Indian Tribe

ENVIRONMENTAL PROTECTION AUTHORITY

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April 16, 2007

Ms. Magalie R. Salas
Office of the Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, D.C. 20426

Re: Resighini Rancheria Responses to PacifiCorp's Responses to Comments from Various Stakeholders on the September 2006 FERC DEIS Klamath Hydroelectric Project, FERC Licensed Project Number 2082-027, Operated by PacifiCorp

Dear Ms. Salas:

Enclosed please find our response to PacifiCorp's responses to comments from various stakeholders on the September 2006 FERC DEIS, Klamath Hydroelectric Project, FERC Licensed Project Number 2082-027.

Sincerely,

Frank S. Dowd, III, Chairman

Enclosure

cc: Resighini Rancheria Tribal Council
Tribal Manager
Director, REPA

THE RESIGHINI RANCHERIA'S RESPONSES

TO

CAUSES AND EFFECTS OF NUTRIENT CONDITIONS IN THE UPPER KLAMATH RIVER

AND

PACIFICORP'S RESPONSES TO COMMENTS FROM VARIOUS STAKEHOLDERS ON THE SEPTEMBER 2006 FERC DEIS FOR HYDROPOWER LICENSE FOR THE KLAMATH HYDROELECTRIC FERC LICENSED PROJECT NUMBER 2082-027

PREPARED WITH THE ASSISTANCE OF KIER ASSOCIATES, *FISHERIES AND WATERSHED PROFESSIONALS*
BLUE LAKE AND ARCATA, CALIFORNIA

MARCH, 2007

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1.0 INTRODUCTION

These comments respond to issues regarding nutrients and algae in two recent PacifiCorp submissions to FERC: "Causes and Effects of Nutrient Conditions in the Upper Klamath River" (PacifiCorp 2006) and "PacifiCorp's Responses to Comments from Various Stakeholders on the September 2006 FERC DEIS for Hydropower License for KHP" (PacifiCorp 2007).

The intent of these comments is not to provide a comprehensive point-by-point response to every point made by PacifiCorp, but rather to respond to major issues of substance. Much of the content of PacifiCorp (2007) is a summary of PacifiCorp (2006). In such instances, we respond only to PacifiCorp (2006).

A major focus of the two PacifiCorp documents is to critique the methods and conclusions of recent Klamath River scientific studies, including Kann (2006), Kann and Asarian (2005, 2006), Asarian and Kann (2006a, 2006b), and Kann and Corum (2006). As detailed herein, many of the assertions raised PacifiCorp regarding these studies have little merit and do not substantially affect the integrity of the core conclusions of the studies.

The issues addressed here can be grouped into two related, yet distinct, categories: the effects of the Klamath Hydroelectric Project (KHP) on 1) Klamath River nutrient dynamics and 2) Klamath River phytoplankton distribution and abundance, including that of the toxigenic *Microcystis aeruginosa.*

Section 2.0-6.0 of these comments concern nutrient dynamics. Section 7.0 addresses *Microcystis* and phytoplankton.

2.0 PACIFICORP'S USE OF A LINEAR DECAY FUNCTION FOR ESTIMATING ORGANIC MATTER DECAY WITH AND WITHOUT PROJECT RESERVOIRS IS MISLEADING BECAUSE IT NEGLECTS THE KHP RESERVOIRS' ROLE IN ORGANIC MATTER PRODUCTION

In section 4.3, PacifiCorp (2006a) presents a theoretic framework to illustrate its view of the effects of the reservoir-caused increased retention time on organic matter decay. In its analysis, PacifiCorp divides the river into four reaches between Link Dam and the Pacific Ocean (including the impoundments), and then uses its water quality model to calculate travel times for each reach during typical summer flows for various with- and without project scenarios.[1] PacifiCorp summarizes:

> "The estimated travel time under existing conditions from Link dam to the Klamath River estuary is about 46 days. From Link dam to Iron Gate dam under existing conditions is about 42 days. By comparison, the estimated travel time under hypothetical without-Project conditions from Link dam to the Klamath River estuary is about 7 days, and from Link dam to Iron Gate dam is about 2 to 3 days."

PacifiCorp then applies a first-order decay rate for organic matter of 0.15 day^{-1} from a standard engineering handbook (Corbitt 1990) to the total travel times for the various scenarios. The resulting Figure 4-12 shows that the linear decay function predicts that:

> "The first-order reduction in organic matter from decay as illustrated in Figure 4-12 indicates that, under existing conditions, the processing of the loads to the upper Klamath River of upstream organic matter is largely completed by the time water travels past Iron Gate dam. By contrast, under hypothetical without-Project conditions, about 50 percent or more of the load of upstream organic matter would still be present as water travels past Iron Gate dam."

That the decomposition of algae would approximate a linear decay function is not surprising and we do not take issue with that basic idea; however, PacifiCorp's application of the linear decay function to attempt to predict the effects of KHP reservoirs on organic matter decomposition is of extremely limited utility for the following reason:

PacifiCorp's application of the linear decay function considers only the *decay* of organic matter, totally disregarding its *production.* This would be excusable had PacifiCorp properly emphasized that they were only looking at one side of the equation; however, they did not. Reservoirs increase retention time relative to free-flowing river reaches, offering more time for organic matter decay, *but also more time for organic matter production though phytoplankton growth.* Additionally, due to the low-turbulence conditions, project reservoirs offer more favorable environments for phytoplankton growth than do free-flowing river reaches. The massive blooms of phytoplankton measured by PacifiCorp (Kann and Asarian 2006) and others

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[1] The travel time from Link Dam to Keno Dam is listed in Table 4-1 as zero days, which seems implausible, but does not affect PacifiCorp's basic point, nor our response, so we make no further mention of it here

(Kann and Corum 2006) are strong evidence of high rates of organic matter *production.* It is not the amount of organic matter decay that matters, nor the amount of organic matter production, but the relative balance between the two.

A quick examination of Klamath River field data for a common metric of organic matter, total organic carbon (TOC), shows just how wrong the predictions of PacifiCorp's linear decay function are (Table 1 and Figure 1). Contrary to the linear decay function's prediction that organic matter concentrations would be near zero at Iron Gate Dam, field data actually show that these concentrations range between 33%-99% of the Link River Mouth load depending upon the year (Table 1). It should be noted here that substantially higher peak TOC concentrations were observed at Link Mouth than at Iron Gate. Also, interestingly, the TOC at Keno Dam is often higher than it is at Link River Mouth.

Table 1. Median total organic carbon (TOC) concentrations at mainstem Klamath River sites for the years 2001, 2002, and 2004. Same data as Figure 1, see that caption for additional notes.

	Total Organic Carbon					
	(mg/L)			(% of Link Mouth)		
Year	Link Mouth	Keno Dam	Iron Gate Dam	Link Mouth	Keno Dam	Iron Gate Dam
2001	17.0		5.6	100%		33%
2002	8.0	12.9	7.6	100%	161%	95%
2004	7.5	9.0	4.9	100%	120%	65%

Note that stations shown in Figure 1 and Table 1 were not necessarily sampled on the same days, and that sampling at some sites began earlier (and extended) later into the year than at other sites. Given this, we present this information not as an authoritative examination of longitudinal trends in TOC, but as a basis of comparison to show the fallacy of PacifiCorp's linear decay function.

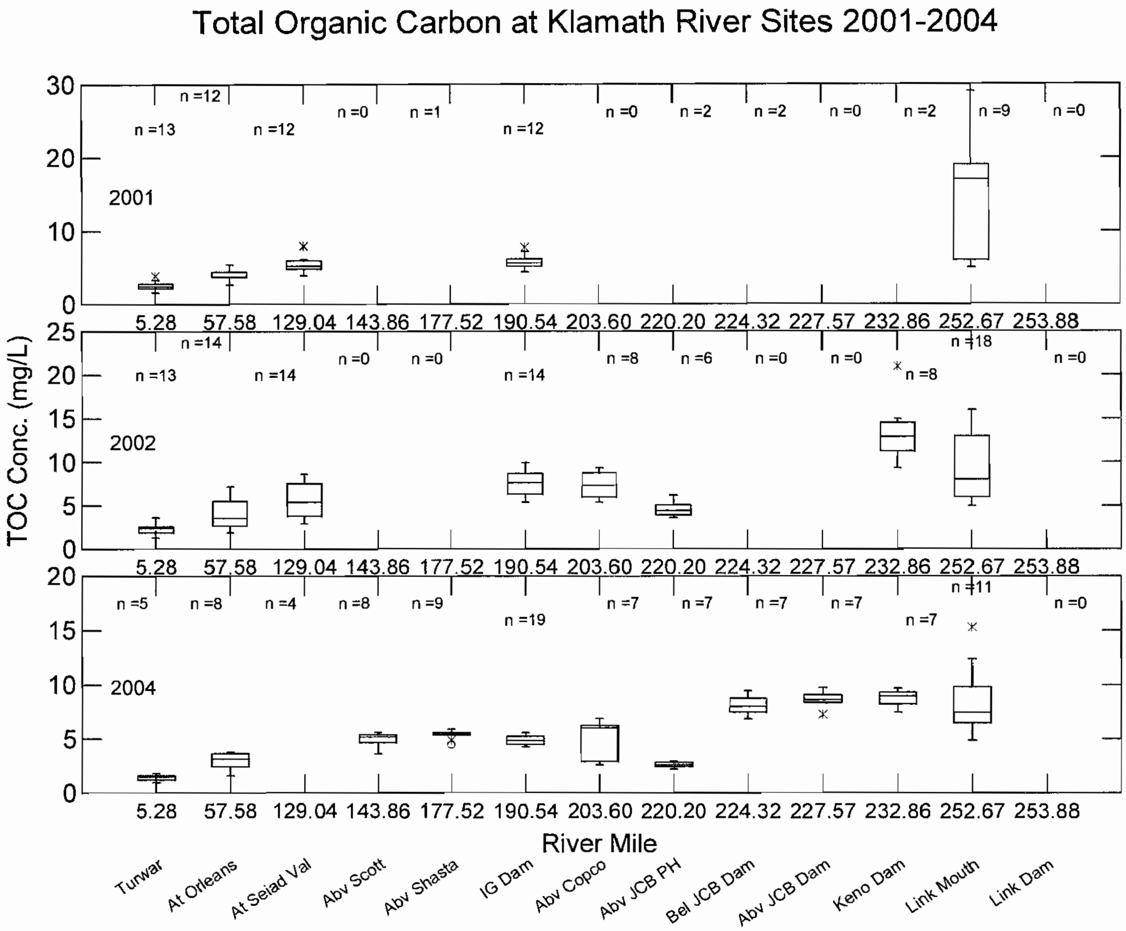

Figure 1. Box plots comparing total organic carbon (TOC) concentrations at mainstem Klamath River sites for the years 2001, 2002, and 2004. N is the number of days sampled for each site in each year. Boxes are shown only for sites with five or more samples in a year. The line inside each box is the median and the edges of each box are the 25th and 75th percentiles. Whiskers represent data points beyond 1.5 times the interquartile (75th-25th) range, while the individual points shown are outliers. Note that there were not enough data to make useful comparisons in 2000 and 2003 and that is why they are excluded from this figure. Data are from the same database used by Asarian and Kann (2006b). Refer to that document for details.

It should also be noted here that there is substantial uncertainty regarding what the linear decay factor is. The 0.15 rate used by PacifiCorp is not specific to Klamath River algae but was taken from a generalized engineering handbook (Corbitt 1990). This rate likely varies based on the source of the organic matter (e.g. algal species or leaf litter) and environmental factors such as temperature, dissolved oxygen, and turbulence. While PacifiCorp (2006) does cite Fallon and Brock (1979) in stating that kinetic data suggest that mineralization of nitrogen from algal material appears to be faster under aerobic than anaerobic conditions, it does not provide details regarding the magnitude of the difference.

Fallon and Brock (1979) found that after 2.5 days of aerobic incubation, approximately 23% of the radioactive labeled carbon in phytoplankton cells had been converted to CO_2, while only about 3% had been converted in the same period under anaerobic conditions (Fallon and Brock 1979, figure on p. 827). These differences decreased as time progressed, but the aerobic incubation still produced over twice as much CO_2 over the full 21 day study. Otsuki and Hanya (1972) also found that algal decomposition was faster in aerobic than in anaerobic conditions.

Theses studies would suggest that decomposition rates in aerobic (oxygen rich) free-flowing river reaches are likely higher than in the anaerobic (oxygen-poor) reaches within KHP reservoirs. We have not attempted to determine if algal and organic matter decomposition rates in PacifiCorp's water quality model vary depending on dissolved oxygen and temperature, or whether they are static.

In addition to the Fallon and Brock (1979) study cited by PacifiCorp (2006), other studies confirm that initial decomposition rates are high. In a study of four Danish Lakes, Hansen et al. (1986) found that 4 to 34% of C-14 labeled carbon in dead phytoplankton cells leached from the algal cells within 2 to 4 hours, 11 to 43% after 24 hours and 67 to 78% after 4 to 6 days. Cole et al. (1984) found that in Mirror Lake, New Hampshire, the conversion of particulate carbon (dead phytoplankton) to CO_2 was strongly influenced by water temperature; during summer the average rate over a 6-period was 6% per day but only 0.5% per day in winter. In a literature review of algal decomposition rates we were unable to find studies comparing decomposition rates in reservoirs versus rivers, nor the role that turbulence plays. Further investigation into the factors affecting algal decomposition rates in the Klamath River are needed.

3.0 RESPONSE TO PACIFICORP'S CRITIQUE OF ASARIAN AND KANN (2006B) EVALUATION OF PACIFICORP'S WATER QUALITY MODEL

3.1 Key findings of Asarian and Kann (2006b), and their implications for the usefulness of PacifiCorp's model in achieving its intended purpose

The main point made by Asarian and Kann (2006b) in their review of PacifiCorp's water quality model was:

> "Overall, the model poorly predicts nutrient dynamics in the Klamath River. Not only was the magnitude of predicted nutrient concentrations typically either consistently under-or over-predicted relative to observed data, but the modeled data showed strong consistent spatial bias that was absent in the field data."

In response, PacifiCorp (2007) states:

> "PacifiCorp acknowledges instances where model predictions and empirical data do not match. However, Asarian and Kann's (2006b) suggestion that the model's results for nutrient-dependent parameters are substantially biased and therefore should not be used shows a fundamental lack of understanding about the model's purpose and utility." (p. 19)

Later in the document, PacifiCorp explains the model's purpose:

> "The primary purpose and use of PacifiCorp's model was to identify key factors controlling water quality in the Project area, and to assess potential Project effects using relative comparisons of different 'scenarios' of facilities and operations. It is important to note that this relative comparison of scenarios helps to limit the effects of model uncertainty; that is, similar model uncertainty occurs in each of the scenarios to be compared and, when comparing model results, emphasis is placed on the relative differences between the scenarios, rather than the absolute values of model predictions." (p. 21)

We strongly disagree with PacifiCorp's statement that Asarian and Kann's (2006b) conclusions show "a fundamental lack of understanding about the model's purpose and utility".

We recognize that all models have uncertainty, and that knowledge of the degree of that uncertainty is critical when using model outputs to make decisions. Asarian and Kann's (2006b) analyses uncovered consistent and critically important biases in PacifiCorp's model outputs predictions, biases that were previously either unknown or undisclosed. These biases are substantial enough to render highly questionable the degree to which the model fulfills its purpose as being a useful tool for comparing results between different model scenarios. *Simply put, if observed field data show that the model overestimates nutrient retention in reservoirs, and underestimates nutrient retention in free-flowing river reaches, we question how this model can be used to compare the existing-condition scenario to the without-project scenario.*

Asarian and Kann (2006b) focused their analyses, interpretation, and conclusions on the comparison of longitudinal (and to a much lesser extent, temporal) trends in the model data versus the field data, *not* on comparing the absolute values. By examining key longitudinal trends, such as comparing concentrations above and below the KHP reservoirs with those of the free-flowing river reaches, insight was gained into PacifiCorp's model's underlying mechanisms and biases. As we discuss in more detail below, the model appears to over-estimate the nutrient retention in reservoirs, and under-estimate nutrient retention in the free-flowing reaches of the Klamath River.

Specifically, the key findings of Asarian and Kann (2006b) were:

> "1. The model outputs indicated that total nitrogen and total phosphorus concentrations were substantially lower below J.C. Boyle and Copco/Iron Gate reservoirs than they were at sites immediately upstream. In contrast, field samples showed that either no such decrease occurred or that the decrease was less pronounced than the model predicted.
>
> 2. The model outputs suggest that nitrogen concentrations remain essentially unchanged from Iron Gate Dam to the Klamath River estuary. In contrast, field samples show that nitrogen concentrations typically decrease substantially between those sites. It is unclear if the discrepancy is caused by

> improperly set tributary boundary conditions, inadequate calibration, or other model limitations." (p. 30)

These are not minor differences that can be glossed over. They merit careful scrutiny since they represent key longitudinal trends in Klamath River water quality that have obvious implications for PacifiCorp's stated purpose for its model, which is to compare results between different model scenarios.

Trend #1 above means that the model is over-predicting the decrease in nutrient concentrations from above to below the following KHP reservoirs: J.C. Boyle, Copco, and Iron Gate. In a modeled without-project-reservoirs scenario this effect would disappear, resulting in an apparent large increase in nutrient concentrations compared to existing-conditions model scenarios. Trend #2 indicates that the model appears to be under-predicting nutrient retention and dilution in the free-flowing river reach below Iron Gate Dam, which suggests that it may be doing the same in other river reaches, including its without-project model scenarios in reaches currently impounded by KHP dams. In without-project model scenarios these biases may produce large increases in nutrient concentrations compared to existing-conditions model scenarios.

3.2 The accuracy of model outputs and field data

Regarding the question of the accuracy of model outputs versus field data, PacifiCorp (2007) states:

> "Asarian and Kann's (2006b) assessment of the PacifiCorp model makes the mistake of holding up the empirical data as the benchmark for model veracity and accuracy. In other words, their analysis presumes the empirical data are perfect. PacifiCorp's modelers did not accept this premise for implementing the model – to do so would lead to adjustments in model coefficients that are driven simply by 'fitting the data' rather than by adjusting to reasoned and acceptable coefficient values." (p. 20)

First, Asarian and Kann (2006b) never suggested that the model coefficients should be adjusted in some "fitting the data" exercise. PacifiCorp's mention of the "fitting the data" is tangential, an altogether different concept than Asarian and Kann's (2006b) analysis comparing model outputs to field data to determine the accuracy of the model's predictions. In fact Asarian and Kann note at page 30: "The degree to which additional calibration could improve the model's performance is unclear at this time. Substantial improvement may require the inclusion of additional processes such as multiple algal groups and nitrogen fixation.")

Second, *field data, in general, should be regarded as more accurate than model data*, particularly when the trends observed in the field data are consistent through many different years and seasons and are readily explainable through logical reasoning and known scientific phenomena, such as with the trends #1 and #2 discussed above.

For instance, does PacifiCorp really believe that the model's predictions that nutrient concentrations are substantially lower below J.C. Boyle Reservoir, as compared to above J.C.

Boyle Reservoir, are more accurate than the extensive field data that indicate that this is not the case (part of the trend #1 identified above)?

In fact, it does not. According to PacifiCorp (2006):

> "Because of the short residence time, lack of stratification, and limited photic zone, the observed concentrations of total inorganic nitrogen (TIN), total nitrogen (TN), orthophosphate (PO4), and total phosphorus (TP) in outflowing waters from the reservoir are similar to those in inflowing waters (Figure 4-4), indicating the J.C. Boyle reservoir has no substantial effect on nutrients." (page 28).

And does PacifiCorp really believe that the model's prediction that total nitrogen (and to a lesser extent total phosphorus) concentrations are relatively similar at Iron Gate Dam and Klamath Glen (many miles downstream of Iron Gate), are more accurate than the extensive field data that shows that Turwar concentrations are in fact far lower than those at Iron Gate (trend #2 above)?

Again, it does not. According to PacifiCorp (2006b): "The concentrations of nitrate and phosphorous are steadily reduced with distance from Iron Gate dam. This condition is partly due to dilution, but also in response to uptake from seasonal periphyton growth in the river." (p. 4-24).

There are obviously uncertainties in all field data, which was understood, but perhaps not made sufficiently clear in Asarian and Kann (2006b). It should be expected that due to uncertainties in model outputs and field data, the two will not always match closely at any given point in time and space. But that is not the issue at hand. It is critically important to note that the two trends described above are not instances of moderate differences balanced between negative and positive – like PacifiCorp's citation of laboratory uncertainty of ± 20-25%. The differences were consistently skewed in one direction, *indicating a structural bias in the model.*

Additionally, as noted above, PacifiCorp does not dispute (with the possible exception of Iron Gate and Copco Reservoirs) that field data more accurately represent trends #1 and #2 than do the model outputs. Therefore, PacifiCorp's focus on the issue of the accuracy of model data versus the accuracy of the field data appears to be an extraneous attempt to discredit the analyses of Asarian and Kann (2006b) without real merit.

3.3 Potential causes of model bias

One potential explanation for why PacifiCorp's water quality model over-predicts the decrease in nutrient concentration occurring from above- to below reservoirs (trend #1) is the organic matter settling rate used by PacifiCorp. PacifiCorp set the organic matter settling rate at 5 meters per day, five times *higher* than the standard CE-QUAL-W2 rate of 1 meter per day used by TetraTech in its Klamath River TMDL model (Parker, pers. comm.).

3.4 Other extraneous arguments made by PacifiCorp

In attempting to refute Asarian and Kann's (2006b) conclusion that the model "poorly predicts nutrient dynamics in the Klamath River", PacifiCorp (2007) claims that the model predicts the "overall longitudinal reduction" (page 21) in chlorophyll and total nitrogen. The meaning of PacifiCorp's statement is unclear, but appears to focus only on the prediction that chlorophyll and total nitrogen is higher at Link Dam than it is at the Klamath River's mouth. Unfortunately, as described above, the model fails to predict major longitudinal trends in the reaches between those sites (model output is consistently biased with respect to observed field data). As such, the model should not be used to compare current conditions (with project) within these reaches with those expected under a "without project" scenario.

In defending its water quality model, PacifiCorp introduces a series of irrelevant arguments:

- "The PacifiCorp model has made a valuable contribution to furthering the understanding of water quality processes in this complex system – an understanding that is not possible based solely on existing data and information"

We have always been in agreement that this model (and models in general) contributes to furthering the understanding of water quality processes in complex systems. However, when consistent biases are present in such models (e.g., a consistent over- or under-prediction such as that described in Kann and Asarian (2006b)), their utility for predicted outcomes with respect to management actions is suspect.

- "The PSU review (Wells et al. 2004) was detailed, and nearly every one of the many comments made by Wells et al. (2004) was incorporated into the subsequent version of the model used by PacifiCorp"

Wells' comments concerned the structure of the model; he never reviewed the final model results after revisions, and thus was never able to assess its final performance.

- "The USGS review (Risley and Rounds 2006) closely examined the flow and water temperature components of the models and found them to be sound."

Asarian and Kann (2006b) never disputed this. We specifically stated that "the model accurately predicts flow and water temperature." Asarian and Kann (2006b) concerns the KHP's effect on Klamath River nutrients.

3.5 Final words regarding the use of PacifiCorp's water quality model

Developing a water quality model for a system as complex as the Klamath River is an extremely difficult task. While we appreciate the considerable effort that PacifiCorp has expended to develop and refine its water quality model, the model has substantial shortcomings and biases.

Consequently, we request that those, such as FERC, who might base management decisions on the model's results, should acknowledge these shortcomings and biases.

4.0 RESPONSE TO PACIFICORP'S CRITIQUE OF ASARIAN AND KANN'S (2005) RESERVOIR NUTRIENT BUDGETS

4.1 Summary of Kann and Asarian (2005) study

Kann and Asarian (2005) constructed nitrogen and phosphorus budgets for Iron Gate and Copco Reservoir, summarizing the results as follows:

> "These preliminary analyses indicate that for the Copco/Iron Gate Reservoir system, the April- November period is characterized by periods of positive and negative retention for both phosphorus and nitrogen (net positive values denote a sink and net negative values denote a source). Despite acting as net sinks for P and N over the entire Apr-Nov period, both Copco and Iron Gate Reservoirs can act as a nutrient source during critical periods (e.g., June through September), making nutrients available at such periods for downstream growth of algae and macrophytes."

4.2 Responses to PacifiCorp's comments regarding the Kann and Asarian (2005) study

PacifiCorp (2006) makes three main comments regarding the Kann and Asarian (2005) study. First, PacifiCorp questions the appropriateness of interpolating monthly and bi-weekly nutrient concentration data in order to generate a daily record. Second, PacifiCorp asserts that the effects of Upper Klamath Lake on Klamath River were not properly discussed in the study. Third, PacifiCorp contends that the issue of water residence time and travel time was not adequately considered in the calculation of reservoir retention.

4.2.1. Interpolating biweekly and monthly concentration data to derive daily concentrations

PacifiCorp (2006) cites several "important flaws" in the Kann and Asarian (2005) report that developed nutrient budgets for Iron Gate and Copco Reservoirs using PacifiCorp and U.S. Fish and Wildlife Service data from the year 2002. PacifiCorp asserts that:

> "A basic flaw of the Kann and Asarian (2005) analysis is that they derive a nutrient budget by extrapolating a daily time-series of 'nutrient loadings' from approximately monthly nutrient sample data. Such extrapolation is not only unacceptable as a basic analytical technique, but is particularly inappropriate for nutrients that are known to be dynamic and vary widely through time in this system."

It is prohibitively expensive to collect nutrient samples during every day of a study period, so such data collecting is rarely done. Interpolating concentrations between sample dates is, therefore, a common practice in the construction of nutrient budgets (Cook et al. 2005) and has been used previously in Klamath River studies, including the State of Oregon's Upper Klamath Lake Drainage Total Maximum Daily Load (ODEQ 2002).

Regardless of whether this serves as a common practice, the main function of interpolation is to obtain linear nutrient concentration estimates between instantaneous sample points. In this fashion, higher resolution (e.g., daily) hydrologic data for inflows and reservoir volumes can be incorporated into overall nutrient budgets. Moreover, computing budgets using only the instantaneous data would not appreciably change the conclusions in Kann and Asarian (2005)

That said, as was previously acknowledged in Kann and Asarian (2002), the resolution of the nutrient data is relevant in a system as complex and dynamic as the Klamath River. However, although biweekly data is the recommended frequency for construction of nutrient budgets (Cook et al. 2005), less frequently collected data can still yield useful preliminary information. Kann and Asarian (2005) noted this and chose the year 2002 because more frequently collected data were available- monthly PacifiCorp data for March through November 2002, with supplemental data from USFWS for June through mid-September 2002 at river stations.

On page 16, PacifiCorp (2006) states:

> "The daily loading extrapolations made by Kann and Asarian (2005) give the misleading impression of "data" availability and detail that do not exist. The Kann and Asarian (2005) report presents many detailed graphs and make conclusions about nutrient conditions in the reservoirs using this inferred pseudo-daily data – all based on only *monthly* nutrient data; for example:
>
>> 'Reservoir TN storage declines with inflow loading through mid-May, and then increases or remains steady through November. The retention pattern is one of positive retention between April and late May, and then alternating periods of negative and positive retention through November.'"

The inflection (change of direction) points described by Kann and Asarian in that quote have a basis in real data points. There were nutrient samples collected in late May on the date where retention changes from positive to negative. Reservoir storage (total mass in kilograms) stops declining in mid-May in part because reservoir water volume (for which there are daily data) begins to rise sharply. Also, contrary to PacifiCorp's assertion that data were "extrapolated" estimating values between known data points is properly called "interpolation", and is a commonly used technique.

As with PacifiCorp's water quality model, any scientific analysis contains uncertainty, and users of the information need to interpret results with adequate knowledge of the magnitude of uncertainty and any known directional biases in the results. Kann and Asarian (2005) recognized the limitation of the monthly sampling, including a disclaimer that "… in general a minimum of biweekly sampling is recommended to determine both among and within seasonal variation in nutrient sources and sinks."

However, we note that the main conclusions drawn by Kann and Asarian [see above: 4.1 Summary of Kann and Asarian (2005) study] are not drawn from looking at a few isolated days of negative retention; there were multiple sampling periods where the reservoirs demonstrated negative retention across the entire sampling period.

The upcoming May 2005 – May 2006 nutrient budgets for Iron Gate and Copco will substantially improve on the accuracy of the 2002 nutrient budgets given their increased spatial resolution (two sites in each reservoir during the period of thermal stratification, each with multiple depths), temporal resolution (bi-weekly data), and duration of the study (entire year).

It is also worth noting here that while PacifiCorp now criticizes the monthly (and at times even biweekly) resolution as being inadequate, in response to requests in early 2004 to increase their sampling frequency from monthly to bi-weekly, PacifiCorp (2004) responded:

> "Because Upper Klamath Lake above the Project and the several reservoirs within the Project serve to increase local residence time, and therefore dampen short-term variability, weekly or bi-weekly sampling is not required. Shorter interval sampling planned for 2004 will provide information on whatever short-term variation might exist in nutrient concentration."

It should be noted that the shorter-interval sampling referred to in PacifiCorp's statement, above, was conducted only at Link River and nowhere else in the KHP impact area. PacifiCorp had abundant opportunity to collect data having high spatial and temporal resolution in the KHP area. It chose not to do so.

4.2.2. Summarizing data by calendar month vs. sampling period

PacifiCorp (2006) often cites the tables in Kann and Asarian (2005) that summarized inflow and retention by calendar month. For instance:

> "Interestingly, there are *monthly* 'nutrient loading' values listed in Kann and Asarian's (2005) Tables 5 and 6 that are not discussed by the report's authors, but upon which a reviewer of the report can reach different conclusions." (p. 17)

Monthly results in Tables 5 and 6 were not emphasized in Kann and Asarian (2005) chiefly because summarizing data by calendar month produces arbitrary endpoints without biological significance nor direct relationship to sampling periods. In this fashion, calendar months can obscure details that are evident in the original 30-day sampling period data. For example, because the actual samples were typically collected closer to the middle of a calendar month (see Kann and Asarian 2005, p. 32 and Figure 2 below), a monthly summary thus splits the actual sampling intervals in two. This can skew results, because, for example, a sampling period could have negative retention for the entire period, yet is adjacent to two periods that had positive retention (see Figure 3 below). When the data are then summarized by calendar month, the resulting net retention is near zero. This effectively "averages out" significant periods of retention and does not provide a true representation of what occurred during that month (i.e. as describe in the previous sentence, the first half of the month had negative retention and the second half was positive).

Thus, contrary to PacifiCorp's assertion that "a reviewer of the report can reach different conclusions" based on calendar months, such calendar month summaries do not provide an appropriate representation of data trends.

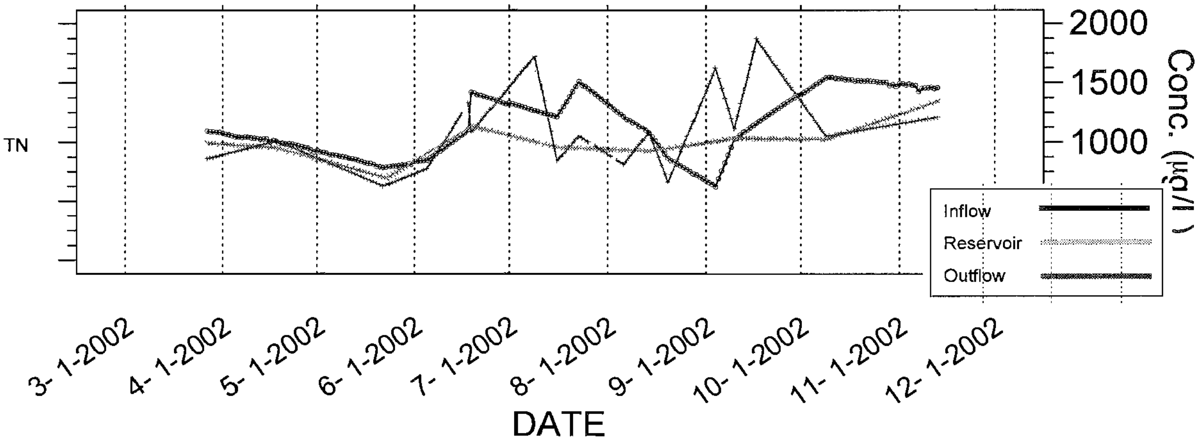

Fig. 2. Daily time series of Copco Reservoir total nitrogen concentrations, Apr-Nov 2002. Adapted from Fig. 11 in Kann and Asarian (2005).

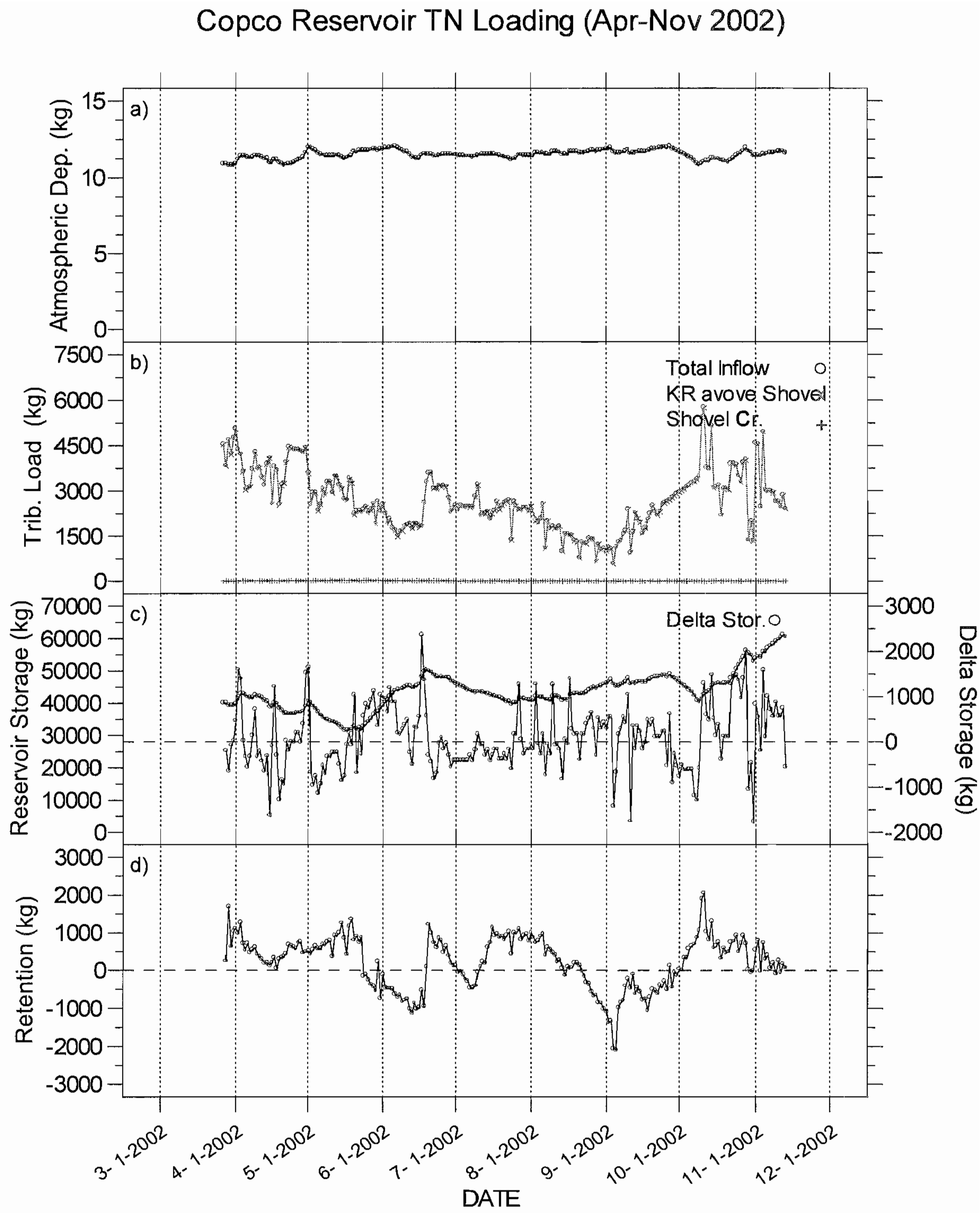

Fig. 3. Daily time series of Copco Reservoir total nitrogen loading (horizontal dashed line placed at zero for ΔStor and retention), Apr-Nov 2002. Adapted from Fig. 17 in Kann and Asarian (2005).

4.2.3. The role of UKL in Iron Gate and Copco nutrient budgets

On page 18 PacifiCorp (2006) extraneously states "Interestingly, Kann and Asarian (2005) make little mention of the very large inflowing nutrient loads to the reservoirs from the upstream Klamath River and Upper Klamath Lake."

The reason that UKL was not evaluated in Kann and Asarian (2005) is that the focus of the report was on the internal dynamics of Copco and Iron Gate Reservoirs, and how the reservoirs may impact those specific river reaches. . Although we agree with PacifiCorp that UKL contributes high loads of nutrients and organic matter to the Klamath River and is, therefore, a primary driver of water quality in the Klamath River, the question of relevance with respect to relicensing is how the project reservoirs alter nutrients in reaches downstream from UKL.

4.2.4. Accounting for travel time and retention time in the analysis of reservoir nutrient dynamics

Another emphasis in PacifiCorp's 2006 comments concerning the Kann and Asarian (2005) report is the need to take into account a "time lag":

> "It is important to note that the effect of Copco and Iron Gate reservoirs on upstream-downstream nutrient flux does not occur instantly, but rather over several days or weeks due to both the duration of the upstream conditions and the extended residence time of the reservoirs. Evidence of this lag effect is examined in this document. Because of this lag, it is expected that at times the nutrient concentration in release waters from Iron Gate reservoir on a given day may be greater than in the inflowing waters to Copco reservoir on the same day, even though the reservoirs act to retain and reduce the loads from these nutrient "events" as they move through the reservoirs. This lag effect was not recognized and accounted for in the analyses of Kann and Asarian (2005) and Asarian and Kann (2006). (p. 3)

PacifiCorp is correct that the reservoir nutrient budgets (Kann and Asarian 2005) can be affected by time lags. However, one assumption of such models is that measured loading represents integrated conditions over a period of time spanning mid-way to adjacent sample points. As such, lag effects should only be an issue if inflow concentrations spike suddenly and then decrease; however, if inflow and outflow concentrations change gradually from one sample to the next, the effect of the time lag will be muted. In any case, errors should be self-canceling over time (for example outflow concentration may spike relative to inflow as well), and should not affect results at aggregated time scales. Moreover, retention is calculated as (see footnote for details[2]): Net Retention = inflow – outflow - Δ reservoir storage

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[2] Inflow includes mainstem, tributaries, and atmospheric deposition.
Δ reservoir storage = current day's mass minus the previous day's mass.

Thus, the difference between previous storage and current storage is taken into account.

It is also important to note that the reservoirs are not solely, as PacifiCorp suggests, large retention ponds where the only process operating is the settling of upstream organic matter. They are also bio-reactors that grow abundant crops of phytoplankton, including nitrogen-fixing cyanobacteria. The reservoirs have their own internal dynamics that are influenced by upstream events, yet are distinct with their own timing. Examples include phytoplankton dynamics (e.g. algae growing, settling, and getting flushed into the turbine intakes and into the Klamath River below), lake turnover, and an anaerobic hypolimnion that can cause the release of phosphorus from the sediments.

These events would not be subject to the same time lag as inflows, but instead have their own unique and independent timing. Nutrient budget analyses should be able to identify the net effect of these events as well as upstream loading.

To support the existence of a lag effect in the Klamath River, PacifiCorp uses two main lines of evidence. First, it presents outputs from its water quality model (e.g. Figs. 4-18 and 4-19), which as detailed by Asarian and Kann (2006b) and summarized below, has substantial biases that severely limit the utility of making comparisons between with- and without-project scenarios. Second, PacifiCorp presents field data from the year 2003 (Figure 4-20), without explanation as to why that year was chosen, or if other years show similar results. An examination of data for other years (Figures A1-A7 in Asarian and Kann 2006a) shows variability among years, with some years (1998,2001) showing a longitudinal lag in peak concentrations similar to 2003, while others do not (1999,2002) or are unclear (2000). Also, part of the apparent longitudinal "lag" visible in time-series of nutrient concentrations (e.g. the figures cited above) is caused by the fall turnover (breakdown of thermal stratification) in Iron Gate and Copco Reservoirs, and thus is not the result of a simple lag in upstream concentrations. Rather, it is an example of what we note above, a process generated internally from within the reservoirs.

5.0 RESPONSE TO PACIFICORP'S CRITIQUE OF ASARIAN AND KANN'S (2006A) RIVER NUTRIENT BUDGETS

5.1 Summary of the Asarian and Kann (2006a) study

Asarian and Kann (2006a) constructed nitrogen budgets for free-flowing river reaches between Iron Gate Dam and the mouth of the Klamath River, summarizing the spatial variability in the results as follows:

> "An analysis of data from the June-October periods from 1998-2002 showed that the river reaches between Iron Gate Dam and Orleans typically showed positive nitrogen retention (assimilation/ denitrification) and that the river reaches below Orleans were more variable, having both periods of positive and negative retention (release) of nitrogen."

Then, a comparison was made between river and reservoir retention rates:

> "To estimate potential retention in the pre-reservoir historic river channel that is currently inundated by Copco and Iron Gate Reservoirs, we applied retention rates calculated for the Klamath River reach from Iron Gate to Seiad Valley in 2002. Given the proximity and gradient similarity of the river reaches, including their appearance in pre-KHP historic photos, the retention rates calculated for the Iron Gate-to-Seiad Valley portion of the river provide a reasonable estimation of retention rates for the historic pre-reservoir river channel. A comparison of temporal variability of river retention to reservoir retention showed that the river consistently provides moderate positive retention, while the combined retention of Iron Gate and Copco reservoirs alternates between positive and negative values. Thus, although overall reservoir nitrogen retention was positive for the entire evaluated period there were two significant periods in 2002 when the reservoirs were releasing nitrogen (i.e., retention was negative)."

Which concluded:

> "Thus, this exercise indicates that when retention due to pre-reservoir natural river processes is factored into the reservoir retention estimated in Kann and Asarian (2005), the reservoir effect on retention was minimal (4.6% of incoming load) or even negative (-3.3% of incoming load) for the periods evaluated.
>
> Overall these analyses confirm the importance of natural riverine nitrogen retention processes in the Klamath River system, and they underscore the need to factor these processes into evaluation of the hydrologic alterations attributable to the Klamath Hydroelectric Project."

5.2 Responses to PacifiCorp's comments regarding the Asarian and Kann (2006a) study

PacifiCorp (2006) makes four main comments regarding the Asarian and Kann (2006a) study. First, PacifiCorp questions the appropriateness of interpolating bi-weekly (every two weeks) nutrient concentration data to generate a daily record. Second, PacifiCorp states that retention should be compared on an absolute basis, rather than on relative basis (i.e., percent of inflow) as was done by Asarian and Kann (2006a). Third, PacifiCorp states that when comparing river and reservoir retention, it is most appropriate to use the retention rate for the entire lower Klamath River from Iron Gate to Klamath Glen, rather than to use retention rates from the most proximate and similar reach (Iron Gate to Seiad Valley) as was done by Asarian and Kann (2006a). Finally, PacifiCorp contends that the issue of water residence time and travel time was not adequately taken into consideration in the calculation of reservoir retention, river retention, and the comparison between the two.

PacifiCorp's (2006) four main comments regarding the Asarian and Kann (2006a) study are addressed in the following sections:

5.2.1. Interpolating biweekly data to derive daily concentrations for budget calculations

PacifiCorp (2006) states on page 19:

> "As in their 2005 report, Asarian and Kann (2006a) derive a *daily* "TN budget" from *monthly* or *bimonthly* nitrogen data. Asarian and Kann (2006a) derive these daily values by interpolating between dates of actual samples that were typically separated by a gap of 15 to 30 days, and up to as many as 45 days. These derived daily values again give the misleading impression of "data" availability and detail that do not exist."

First, this is an incorrect characterization of the methods used by Asarian and Kann (2006a). The vast majority of the data used for the nitrogen budgets were biweekly[3] and no gaps greater than 30 days were interpolated. Given their rare occurrence, the few 30-day gaps that were interpolated should have made little difference in overall trends and results. As described by Asarian and Kann (2006a) in their description of methods on page 15:

> "For the years 1998-2002, interpolations were performed only for sites and years with data of approximately bi-weekly or better temporal resolution. An examination of sampling frequency of available data shows that samples were missing occasionally, or that intervals between samples varied (Figs. 3-5). For example, even though there are bi-weekly data for most of the year at site KR18973 (Klamath River below Iron Gate Dam) in 1998, there is a month-long gap from May 12 to June 10. For purposes of this study we interpolated across such gaps when they were less than 30 days and where there were minimal gaps at a site in a given season. *The 1998-2002 biweekly data were used in the calculation of nitrogen loads as well as in the construction of reach-specific nutrient budgets.*" (emphasis added)

PacifiCorp's confusion on this topic may stem from the fact that Asarian and Kann (2006a) also calculated nitrogen loads using monthly data for 1996-1996 and 2003-2004 (presented in the "Nitrogen Loads" section of the report, not in "Nitrogen budgets"), but, due to the reduced sampling frequency, the data were not used for budgets or retention calculations.

Second, as discussed in the response above regarding PacifiCorp's comments on the Kann and Asarian (2005), far from being "inappropriate" (PacifiCorp 2006, p. 44), it is a common and accepted practice to interpolate bi-weekly data for the purpose of developing nutrient budgets. It should also be noted that PacifiCorp is no stranger to interpolation. Many of the most important boundary conditions in PacifiCorp's model (e.g. Link Dam biological oxygen demand, organic mater, and nutrients) are interpolated.

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[3] It should be noted here that Asarian and Kann (2006a) use the term "bi-weekly" to mean every two weeks (as was defined in the methods section). PacifiCorp appears to favor the term "bimonthly" to describe the same sampling frequency; due to linguistic ambiguities, both are considered acceptable usages.

Alternatives to interpolation were considered, but were not used.

For instance, sites could be compared on a single day basis as is done by PacifiCorp in its calculations of N flux (e.g. Figure 4-15), but this was not done because it did not allow the summing of loads to obtain seasonal totals. Another possibility for calculating seasonal summary loads would be to calculate the mean concentrations for each site across all dates in a season and then multiply it by the daily average flow, but this, in effect, treats each measurement as an independent random event, disregarding known temporal trends (e.g. that concentrations in the Klamath River below Iron Gate Dam generally rise through the summer months) and could lead to bias if a site had more samples collected at one time of the year than another site had. Further, that method would not flow-weight the mean concentration (flow-weighting provides more weight in the average to dates with higher flow, and less weight to dates with lower flow). *Overall, all these methods would have yielded relatively similar results, but interpolation was used because it provided a best combination of benefits*: it allowed the use of the largest amount of data possible, it minimized errors, was the easiest to compute, allowed for the calculation of seasonal total loads, and it allowed for examination of differences in retention pattern in different times of year.

5.2.2. What is the proper metric for comparing retention: absolute mass or relative mass?

PacifiCorp states that retention should be compared on an absolute basis, rather than on relative basis (percent of inflow) as done by Asarian and Kann (2006a):

> "Throughout their report, Asarian and Kann (2006a) use a 'standardized' metric of 'percent retention' or 'percent retention per mile' (calculated as the percent reduction between upstream and downstream loads for each day). However, this is misleading when comparing nutrient retention in different segments of the river because it does not consider the total mass of nutrients retained (TN in this case). For example, a net retention of 4 percent per mile at 1000 cfs would remove 115 kg per mile at Link River, 77 kg per mile at Keno dam, and only 45 kg per mile at Iron Gate based on average TN values at each site." (p 19)
>
> . . .
>
> "Bernot and Dodds (2005) also report that in systems where baseline N loads and concentrations are high, uptake of nitrogen is limited – that is, with chronic N loading, N export in rivers increases and the rate of increase is proportional to the load." (p. 20)

The question of which is the most important metric for comparing nitrogen retention has a complex answer. It depends on whether all retention processes are "saturated." That is, if inflow load to a reach increases, would retention also increase? Bernot and Dodds (2005) note that each retention process has an upper limit when it reaches saturation and additional loading will not be retained but will pass downstream (export).

The primary nitrogen retention processes operating in the Klamath River below Iron Gate Dam are likely denitrification and uptake (assimilation) by periphyton (attached algae), though the relative contributions of these processes are unknown at this time (Asarian and

Kann 2006). Biotic uptake (which includes periphyton) is generally saturated at a lower loading rate than denitrification (Bernot and Dodds 2005). Bernot and Dodds (2005) note that as stream size increases and chronic nitrogen loading increases, a stream is more likely to have its nitrogen retention processes saturated; however, those are relative statements and until special studies are conducted it is impossible to know whether the retention processes in the Klamath River are saturated. Also, some large rivers do have substantial denitrification occurring in their hyporheic zones (Sjodin et al. 1997)

An additional related issue is that inorganic forms of nitrogen (nitrate and ammonia) are the forms of nitrogen most available for retention, as nitrate is required for denitrification, and periphyton can use either nitrate or ammonia. It is important to note that the Asarian and Kann (2006a) nitrogen budgets were for total nitrogen. Due to their increased susceptibility to retention, the percent retention rates of inorganic forms of nitrogen are likely substantially higher than the percent retention rates calculated by Asarian and Kann (2006a) for total nitrogen.

During the summer months, total inorganic nitrogen (TIN) levels are often higher entering Copco reservoir than at Iron Gate Dam. Thus, the periphyton below Iron Gate do not currently experience as high TIN levels as would the periphyton in suitable low- to moderate gradient habitats that would be available between Keno Dam and Iron Gate Dam if the dams were removed.

Due to hydropower peaking, periphyton do not currently enjoy conditions suitable for substantial growth in the J.C. Boyle peaking reach above Copco Reservoir, even though there are substantial portions of suitable low- to moderate habitat in that reach.

Additionally, Iron Gate, Copco, and J.C. Boyle reservoirs inundate low-gradient areas that were historically periphyton habitats. Higher levels of nitrate in those same reaches could also lead to higher denitrification rates. *Thus, with dam removal, total nitrogen retention rates in low- to moderate gradient habitats above Iron Gate Dam may actually be higher than current retention rates between Iron Gate and Seiad Valley.*

Given these uncertainties regarding whether Klamath River retention processes are currently saturated, or would become saturated following dam removal, it is most accurate *to compare retention on both a relative percent basis and absolute mass basis.*

Table 2 compares river retention, reservoir retention, and "reservoir effect" retention (calculated as reservoir minus river) for 2002, by several metrics: kilogram per mile (kg/mi), as percent of inflow, and as percent of inflow per mile. All three metrics show similar results, that is that reservoir retention is slightly greater during the periods May 21 – October 16 and June 1- October 16, and that river retention is greater during the period July 1 - September 30, supporting the original conclusions of Asarian and Kann (2006a). River retention from Iron Gate to Seiad Valley was relatively similar between the years 1998-2002 (see Asarian and Kann 2006: Figure 10, Figure 26, and Table 10); 2002 was not an anomalous year for river retention.

Table 2. Comparison of retention in the river reach from Iron Gate to Seiad Valley with the combined retention in Iron Gate and Copco Reservoirs. For percent of inflow data, estimated reservoir-only effect was calculated by subtracting the %/mi retention of the Iron Gate-Seiad reach from the %/mi retention of the reservoir reach (see retention as percent of inflow portion of the table). Estimated reservoir-only effect was calculated by multiplying the %/mile retention by the number of miles in the reservoirs (16.61). Reservoir effect on kg/mile basis was calculated as reservoir retention minus river retention. No river data were available before May 21 or after October 16, so those time periods were not be included in this table. Table is adapted from Table 11 in Asarian and Kann (2006a) by adding column for estimated reservoir effect for kg/mi metric

	River: Iron Gate to Seiad 61.15 miles			Reservoirs: Combined Iron Gate / Copco 16.69 miles			Estimated Reservoir Effect (Reservoir River)	Retention as % of inflow				Retention as % of inflow per mile		
Time Period	Total Inflow	Retention	Retention	Total Inflow	Retention	Retention	Retent.	River 61.15 miles	River 16.69 miles	Reservoir. 16.69 mi.	Estimated Reservoir Effect	Reservoir	River	Estimated Reservoir Effect
	Kg	Kg	Kg/mi	Kg	Kg	Kg/mi	kg/mi	%	%	%	%	% / mile	% / mile	% / mile
5/21 - 5/31	30257	-5861	-96	26005	-6529	-391	-295	-19.4	-5.3	-25.1	**-19.8**	-1.50	-0.32	**-1.19**
6/1 - 6/30	69846	7622	125	71572	9438	565	441	10.9	3.0	13.2	**10.2**	0.79	0.18	**0.61**
7/1 - 7/31	66068	25301	414	75585	10359	621	207	38.3	10.5	13.7	**3.3**	0.82	0.63	**0.19**
8/1 - 8/31	62071	25808	422	48078	-19072	-1143	-1565	41.6	11.3	-39.7	**-51.0**	-2.38	0.68	**-3.06**
9/1 - 9/30	58972	18283	299	58281	21150	1267	968	31.0	8.5	36.3	**27.8**	2.17	0.51	**1.67**
10/1 - 10/16	41930	3398	56	58794	21095	1264	1208	8.1	2.2	35.9	**33.7**	2.15	0.13	**2.02**
5/21 - 10/16	329143	74551	1219	338314	36441	2183	**964**	22.6	6.2	10.8	**4.6**	0.65	0.37	**0.27**
6/1 - 10/16	298886	80412	1315	312309	42970	2575	**1260**	26.9	7.3	13.8	**6.4**	0.82	0.44	**0.38**
7/1 - 9/30	187111	69393	1135	181943	12436	745	**-390**	37.1	10.1	6.8	**-3.3**	0.41	0.61	**-0.20**

5.2.3. What is the appropriate river reach to compare retention with Iron Gate and Copco Reservoirs?

PacifiCorp states that when comparing river and reservoir retention, it is most appropriate to use the retention rate for the entire lower Klamath River from Iron Gate to Klamath Glen, rather than to use retention rates from the most proximate and similar reach (Iron Gate to Seiad Valley) as was done by Asarian and Kann (2006a). We strongly disagree with PacifiCorp's position on this issue, and consider Iron Gate to Seiad to be the best reach for the reasons outlined below. If Asarian and Kann (2006a) did an inadequate job of stating the reasons why Iron Gate to Seiad is the most appropriate reach to compare, then we clarify those reasons here. Also, it should be noted that PacifiCorp's comparison skews river retention lower, making reservoir retention seem relatively higher in comparison.

Iron Gate to Seiad Valley is clearly the most appropriate reach to use for the following reasons:
- Iron Gate to Seiad Valley is the geographically closest reach, located immediately downstream of the reservoirs, so climatic factors would be most similar.
- As noted above, Iron Gate to Seiad Valley reach has the most comparable nutrient concentrations, including inorganic forms of nitrogen that are more easily retained than organic forms. In summer, inorganic nitrogen is plentiful above Copco and present in moderate amounts at Iron Gate Dam. Typically, by the time water reaches Seiad Valley,

inorganic nitrogen is either not detected or detected in very low levels. Inorganic nitrogen levels generally remain very low downstream of Seiad Valley. This is the most important reason why including reaches downstream of Seiad Valley in a comparison of retention with the reservoirs is not appropriate.
- The gradient and channel morphology are similar (though gradient is similar in many reaches in the lower Klamath River)

In addition to the issues regarding the similarities between the Iron Gate to Seiad Valley reach and the reach inundated by Iron Gate and Copco Reservoirs, there are important data quality/quantity considerations:
- There are many USGS stream gages to help determine flow in the Iron Gate Dam to Seiad Valley reach (Iron Gate Dam, Seiad Valley, Scott River, and Shasta River). In other reaches, flows at monitoring sites (e.g. for Happy Camp, Martins Ferry, Johnson's Point) must be estimated by apportioning accretions based on watershed area, leading to uncertainty in flow.
- This reach also has the smallest amount of ungaged, unsampled accretions of any reach in the Klamath River, so there is less uncertainty regarding load contributions from such accretions (Asarian and Kann 2006).
- There is more high-resolution data for this reach than any other reach. Asarian and Kann (2006a) analyze 5 years of biweekly data. This large volume of data reduces uncertainty as similar patterns were observed in every year.
- Due to high nitrogen concentrations in the Iron Gate to Seiad Valley reach, there is substantially less error in retention calculations due to laboratory reporting limits than there is downstream. Nitrogen concentrations generally decrease with increasing distance downstream from Iron Gate Dam. Given the reporting limits for the laboratories most often used for the 1998-2002 Klamath River data, many sites downstream had nitrogen concentrations at or near the detection limits, which introduces error into the calculations (non-detects were generally set to be one half the detection limit). These reporting limit issues are likely the cause of at least some of the negative (and extreme positive) retention values observed further downstream.
- Seiad Valley is far enough downstream of Iron Gate that the reach has a long enough travel time that operating processes have a chance to act. Due to the inherent uncertainties and errors in making comparisons between sites (e.g. uncertainty in laboratory performance, uncertainty in whether the two samples represent water with the same history and, if not, how much did conditions change), comparing sites separated by reasonably long distance minimizes uncertainty and allows real effects to be more easily separated from the errors (e.g. it is much easier to detect at 20% change across one reach than it is to detect a 5% change across each of four separate reaches).

To give a specific example, the reasonably long distance from Iron Gate to Seiad means that the time of day at which a sample was collected should have less effect on nitrogen concentrations than it would for a site collected closer to Iron Gate. For instance, the water in a sample collected in the morning at the Interstate-5 bridge may never have been exposed to periphyton during daylight hours (periphyton take up more nutrients during daylight hours when they are photosynthesizing). Because if it was released from Iron Gate in late evening or night, the water could arrive at the Interstate-5 Bridge by morning (this, along with the short reach length, may explain some of the positive values shown in total nitrogen flux charted by PacifiCorp in Figure 4-16). Because Seiad Valley is approximately another two days travel time downstream of Iron Gate (Deas and Orlob 1999) at typical summer flows, all water at Seiad Valley has experienced two entire days of periphyton during daylight hours.

5.2.4. Water residence time and travel time

PacifiCorp contends that the issue of water residence time and travel time was not adequately considered in the calculation of reservoir retention (Kann and Asarian 2005), river retention (Asarian and Kann 2006), and the comparison between the two (Asarian and Kann 2006). Because the travel times through river reaches for which nitrogen budgets were constructed were relatively short (mostly on the order of 1-2 days), this is a negligible issue. The issue of water residence time in reservoir retention is addressed above in section 4.2.3.

6.0 EFFECTS OF PEAKING/BYPASS OPERATIONS ON DOWNSTREAM WATER QUALITY

Peaking and bypass operations decrease the nutrient removal capacity of the Klamath River by inhibiting growth of attached algae. This impairment of natural nutrient-removal capacity results in increased nutrient concentrations downstream, with attendant degradation of pH and dissolved oxygen conditions, as well as increased incidences of fish disease by increasing habitat for the polychaete worm that serves as host to the fish parasites *Ceratomyxa shasta* and *Parvicapsula minibicornis.*

PacifiCorp (2005) itself has previously acknowledged this peaking-flow diminishment of nutrient removal capacity. PacifiCorp (2006 and 2007) responded to many water quality-related issues in the two documents cited here, yet did not provide any response regarding the issue of how peaking and bypass operations affect nutrient removal capacity, despite the fact that the issues was raised in November 2006 by the Karuk Tribe, the Quartz Valley Indian Reservation, the Resighini Rancheria, and the Yurok Tribe in their comments to FERC regarding the draft Environmental Impact Statement for the Klamath Hydroelectric Project.

Details regarding how the peaking and bypass operation impact the Klamath River's nutrient removal capacity can be found in the comments that the Tribes noted above submitted to FERC.

Any comparison of current conditions to without-project conditions needs to take this into account.

7.0 RESPONSE TO PACIFICORP'S CRITIQUE OF KANN AND ASARIAN'S (2006) PHYTOPLANKTON REPORT AND THE VARIOUS KANN REPORTS REGARDING THE TOXIGENIC ALGAE *MICROCYSTIS AERUGINOSA*

In this section, we respond to PacifiCorp's (2007) assertions that scientific reports regarding *Microcystis aeruginosa* (MSAE) and phytoplankton written by Kann (2006), Kann and Asarian (2006b), and Kann and Corum (2006) are biased or incorrect.

PacifiCorp Comment:

Page 6
PacifiCorp states that MSAE "is present in many other lakes and reservoirs in the region and across the country, and can be safely managed."

Response:
Although toxic MSAE blooms are a common occurrence around the world, this has no specific bearing on their presence and magnitude in Copco and Iron Gate reservoirs. Furthermore, the magnitudes of cell counts and toxin in these reservoirs are among the highest recorded anywhere in the world. The question of relevance is not whether such blooms may occur elsewhere, but, what specific conditions allow such blooms to expand and proliferate in this federally-regulated Klamath River reservoir system?

PacifiCorp Comment:
Page 7
PacifiCorp (2007) states that "occurrences of MSAE blooms are not new, nor unusual in the Klamath River Basin. Blue-green algal blooms have occurred throughout the length of the Klamath River since the 1950's…"

Response:
Although blue-green blooms are a well documented and common feature in Upper Klamath Lake (UKL), and have been documented downstream prior to the construction of Iron Gate Dam, we are aware of no previous data showing MSAE occurring throughout the entire river system. In fact the major species responsible for the UKL blooms is not MSAE, but rather another blue-green species called *Aphanizomenon flos-aquae* (APFA). The fact that blooms of other blue-green algal species occur elsewhere in the Klamath Basin is not evidence for specific trends in MSAE in the KHP reservoirs. Moreover, although MSAE specifically has been documented in UKL, the most frequent occurrences were those in Agency Lake, about 25 miles north of the UKL outlet, with low frequency of occurrence at the outlet of UKL (see Kann 2006). Recent data from the KHP reservoirs show clearly that the MSAE blooms which occur in these reservoirs are the most consistent and widespread in the basin. Again, the relevant comparison is not whether MSAE is present elsewhere, but how does their magnitude and duration in the KHP reservoirs compare to that of other areas, and how do reservoir conditions contribute to the observed trends.

PacifiCorp Comment:
Page 7
PacifiCorp asserts that MSAE blooms are not caused by Project reservoirs, but are the consequence of a number of conditions in the Klamath River, and that MSAE will form blooms anywhere where conditions are appropriate for growth.

Response:
It is true that MSAE blooms are a consequence of a number of conditions in the Klamath River, and that MSAE will form blooms anywhere conditions are appropriate for growth. This is precisely the point when evaluating growth conditions caused by the project reservoirs; one cannot ignore the conditions that the reservoirs create (see below) when evaluating bloom occurrence. As evidenced by the extremely high density of MSAE observed in the reservoirs relative to the Klamath River's flowing river reaches, the

reservoirs are clearly creating conditions that are "appropriate for growth" of toxic MSAE blooms.

PacifiCorp Comment:
Page 7
PacifiCorp discuses some parameters that are conducive to blue-green algal and MSAE growth, noting that "conditions in the Klamath River are well suited to support MSAE growth wherever turbulence is low enough to permit buoyancy regulation to be effective".

Response:
This is precisely correct. The KHP reservoirs create the very low turbulence environment that permits buoyancy regulation to be effective. This is in direct contrast to the free-flowing river conditions of high turbulence that occur above the reservoir complex. The point here is that if PacifiCorp agrees that low turbulence environments "are well suited to support MSAE growth", then it cannot also be true as they assert on page 7 that "MSAE blooms are not caused by the Project reservoirs". Other conditions such as high nutrient concentrations are clearly necessary for MSAE blooms; *however, absent the type of low turbulence environment created in the KHP reservoirs, blooms of such high biomass and duration would not occur in those Klamath River reaches.*

PacifiCorp Comment:
Page 12
PacifiCorp states that it is invalid to compare reservoir sites to river sites "because rivers and reservoirs are different habitats with different characteristic algae species."

Response:
As noted above, it is precisely the conditions that are created by the reservoirs (e.g., the low turbulence environment discussed above) that result in the different characteristic algae species. Thus, when comparing river reaches (even if a particular reach is impounded) it is appropriate to compare different habitat types to ascertain the habitat conditions leading to characteristic algal species. Contrary to being "invalid", by comparing the two reaches we gain information on the distribution and growth characteristics of the various algal species – including MSAE, *which is rarely found in high abundance in the free-flowing river reaches above the reservoirs – and their controlling habitat factors.*

PacifiCorp Comment:
Page 11
PacifiCorp states that it is inappropriate to compare reservoir surface samples with river samples because they "represent a different aqueous environment and history"

Response:
Again, to the extent that the impoundments create these changes to the aquatic environment (e.g., decreased turbulence), it is precisely these changes in environmental conditions that are relevant to compare. For example, even though reservoir surface water represents a different environment than river samples upstream, all reservoir water began as upstream river water that subsequently became altered by changes in retention time, turbulence, etc. Thus, the

photic zone of the reservoir, due to these very alterations, is more conducive to MSAE growth than is the photic zone of the river.

PacifiCorp Comment:
Page 11
PacifiCorp states "Kann and Asarian (2006b) also erred in using only surface samples to characterize the phytoplankton in the reservoirs when depth-integrated samples were available in the data set they used."

Response:
This statement by PacifiCorp is false: see Figure 13 and 14; these figures from Kann and Asarian (2006b) show the depth-integrated samples as well as the samples taken at discrete depths. These depth-integrated data also clearly show higher biomass and proportion of blue-green algae relative to the river upstream of the reservoir (KRAC) in those same years.

PacifiCorp Comment:
Page 12
PacifiCorp states that the Kann and Asarian (2006) report ignores the "real differences that actually occur" in the longitudinal pattern in the reservoirs downstream from UKL, and that there is a clear decreasing trend in algal parameters through Iron Gate Reservoir.

Response:
First, as discussed above, to compare only stations among impounded river reaches ignores habitat conditions fostered by the free-flowing river. Second, even if reservoirs are compared only to each other, PacifiCorp's statement is still not supported by the data in Kann and Asarian 2006). For example, median values of total biomass and % N-Fixer bio-volume increase significantly in Iron Gate Reservoir compared to upstream JC Boyle Reservoir (Kann and Asarian 2006; e.g. Fig. 4 and Table 2). The consistent trend in these parameters is one where values decrease from UKL through JC Boyle reservoir, but then increase again in Copco and Iron Gate Reservoirs. Further, the distribution as a whole (not just the median) clearly shows significant increases in the Copco/Iron Gate reservoir complex (Figures 3-5: Kann and Asarian 2006).

PacifiCorp Comment:
Page 14
PacifiCorp states that Kann and Corum (2006) and Kann (2006) make the erroneous assertion that MSAE entering the Klamath system are rare and few, and that there is a fundamental bias in the method of algal enumeration.

Response:
First, as shown in Kann (2006; Figures 4 and 5) data collected by the Klamath Tribes from 1990-1997 shows relatively low biomass and colony density of MSAE in UKL over that entire 8 year period. During this period the algal enumeration method was not as outlined by PacifiCorp on page 14. During the years 1990-1997 enumeration was not based on a fixed number of algal units, but rather counts were based on obtaining a certain standard error as a percent of the mean; in this fashion many hundreds of cells were counted in a

minimum of 20 microscope fields. Although there is not overlapping data for the project reservoirs during this period, these data indicate that UKL MSAE levels (especially those at the lake's outlet) are low in comparison to Copco and Iron Gate levels observed in 2005 and 2006. Moreover, unlike project reservoirs where MSAE can periodically dominate the phytoplankton, MSAE remains low in relation to APFA in UKL.

Our point is not that MSAE does not enter the Klamath River from UKL, only that MSAE in UKL does not show the widespread dominance and high biomass levels observed in the project reservoirs. Moreover, even though high levels of APFA and lower levels of MSAE can and do serve as seed sources to the river downstream, both of these species decrease significantly by the time the river reaches the KRAC site upstream from Copco Reservoir. Both species then increase substantially in Copco and Iron Gate Reservoirs, although the relative dominance of MSAE is far greater than in UKL.

The increase in both species is driven by the specific habitat conditions provided by the reservoirs. Regardless of the seed source (upstream transport, or as PacifiCorp (2007) states on page 14 "birds, wind, boat trailers, and so forth") the habitat conditions necessary for MSAE to dominate must be present. We agree with PacifiCorp statement on page 15 that "the right conditions include warm, calm, water with a high light extinction coefficient, abundant nutrients, and sunshine conditions that widely occur, particularly during summer, in Upper Klamath Lake, the Klamath Reservoirs, and at certain hospitable locations throughout the length of the Klamath River, including the estuary". However, biomass and toxin data for the Klamath River system clearly show that the project reservoirs, relative to the river either upstream or downstream, consistently provide a combination of the environmental conditions that fosters MSAE growth and toxin production.

8.0 OTHER MISCELLANEOUS COMMENTS REGARDING PACIFICORP (2006)

P. 27
PacifiCorp postulated that denitrification would be higher in reservoirs than rivers, without providing any citations to support the statement.

Denitrification is known to occur in the hyporheic zones of rivers and streams (Sjodin et al., 1997 and Holmes, 1996). The amount of nitrogen removed from some rivers by denitrification can be substantial, especially those with a high rate of interchange between surface water and alluvial gravels. In Colorado's South Platte River, for example, denitrification rates varied between 2- and 100 mg of nitrogen per square meter per hour. During mid-summer, a 90% reduction of nitrate was achieved in one 6 km long reach. On an annual basis, close to half the nitrate input to a 100-km reach was removed by denitrification (Sjodin et al., 1997).

P. 27
PacifiCorp states:

> "Because N-fixation is an energy-consuming process, it becomes advantageous only when NO_3^- and NH_4^+ are no longer available (Welch

> 1992). Although *Aphanizomenon* is prevalent during summer in the Project reservoirs, ample concentrations of NO3- and NH4+ are nearly always available (for example, see TIN values in Figures 4-4, 4-5, and 4-6), which suggests that N fixation is likely not a substantial source of nitrogen as Kann and Asarian (2005) suggest."

We agree that the presence of *Aphanizomenon* and other species capable of fixing nitrogen does not necessary mean that nitrogen-fixation is occurring in substantial amounts; however, the figures referred to by PacifiCorp are for river stations above and below reservoirs, not in the reservoirs themselves. Additionally, PacifiCorp provides no literature citations regarding what TIN concentrations are "ample" to *Aphanizomenon*, or any analysis of TN/TP ratios that might provide more indication of the advantage (or lack thereof) for nitrogen fixation in KHP reservoirs.

P. 2,18,20,44
At several points throughout the document, PacifiCorp quotes the following Asarian and Kann's (2006) statement out of context: "the river consistently provides moderate positive retention, while the combined retention of Iron Gate and Copco reservoirs alternates between positive and negative values". Asarian and Kann made this statement explicitly regarding the reach between Iron Gate and Seiad Valley in 2002 (in fact, Asarian and Kann cited a specific figure when making that claim), whereas PacifiCorp makes it appears as though the statement was made in regards to *all river reaches in all years*. In its original context, the statement is well supported. In addition, with occasional exceptions, the Iron Gate to Seiad Valley reach had positive retention for most days during other years besides 2002 (see Figure 10 in Kann and Asarian 2005).

P. 50
PacifiCorp states:

> "Another process identified in the simulation results is that the lag displaces the peak influx of TN further into the future. Without the reservoirs, the simulations indicate that peak TN conditions would occur coincident with maximum standing crop of benthic algae in late July or early August. With the reservoirs, the simulations indicate that peak TN conditions are lagged by several weeks into late summer and early fall when the benthic algae community is in overall senescence due to lower solar altitude and decreased day length."

It should also be noted that the KHP reservoirs create a thermal lag which makes the reach below Iron Gate Dam warmer in the late summer and early fall than it would be absent the reservoirs. The factors limiting benthic algae in the Klamath River vary in time and space, and their relative importance are not well known due to a lack of data. While solar altitude and day length are certainly important, so is temperature. Thus, any summer benefit credited to this nutrient lag could be offset by the thermal lag extending the benthic algae growing season further into the fall than would occur naturally.

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