Appendix A: Detailed Comments

Specific Comments on the Public Review Draft of the Staff Report for the Klamath River Total Maximum Daily Loads (TMDLs) and Action Plan Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California

August 27, 2009

I. INTRODUCTION

This appendix supports the preceding cover document to PacifiCorp's comment package on the Public Review Draft of the Staff Report for the Klamath River Total Maximum Daily Loads (TMDLs) and Action Plan Addressing Temperature, Dissolved Oxygen, Nutrient, and Microcystin Impairments in California (hereafter referred to as the "Draft TMDL"). This appendix contains specific comments on the Draft TMDL by chapter and section, and for appendices.

The Regional Board made the Draft TMDL publicly available in a piecemeal manner by posting chapters and appendices to the Regional Board's website over the course of a month, from June 15 to July 13, 2009. Given the piecemeal manner in which the Draft TMDL was issued by Regional Board, and the significant delays PacifiCorp faced in receiving other requested data and information underlying the Draft TMDL, PacifiCorp reserves the right to submit additional comments in the future on all chapters and appendices.

COMMENTS: CHAPTER 1. INTRODUCTION

1.6 Physical Setting

Page 1-21, Paragraph 1, Lines 7-10. The Draft TMDL incorrectly cites PacifiCorp generation as a factor that has "altered flow timing" with respect to monthly average flows in the Klamath River (as shown in Figure 1.10 on page 1-21). PacifiCorp generation has not and does not alter timing of monthly average flows. See PacifiCorp (2004b) or the FERC Final EIS on the Project relicensing. This incorrect reference to PacifiCorp generation should be removed.

Page 1-22, Paragraph 3. Lines 5-6. The Draft TMDL indicates that the dams "were originally run as peak demand generation facilities but are now used in other ways". What "other ways" are being referred to here? The Copco 1 and Copco 2 facilities continue to be operated as peaking facilities.

COMMENTS: CHAPTER 2. PROBLEM STATEMENT

2.1 Introduction

Page 2-2, Paragraph 1, Lines 3-4. The Draft TMDL indicates that water quality monitoring data were compiled "from several sources" to support the Draft TMDL analysis, including "data from eleven stations along the length of the Klamath River". However, the data used in the Draft TMDL does not include or cite many key water quality studies and data for the Klamath River Basin. Listed in the attached Appendix B to this comment document are key reports and documents that were not used or cited in the draft TMDL. Omission of these key reports and documents indicates that even a basic review of available reports and data was not completed, but rather a selective set of data were used in the TMDL analysis and development of load allocations to support a particular view of Klamath River conditions.

2.2 Water Quality Standards

Page 2-6, Paragraph 2. The Draft TMDL indicates that the Clean Water Act (CWA) requires that States develop TMDLs for temperature to ensure the "protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife." However, the temperature TMDLs presented in the Draft TMDL are inconsistent with the CWA because they do not determine, and would not establish, the thermal load limits necessary to ensure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife. This important omission is discussed in detail in section II.C of the main comment document that precedes this appendix.

2.3 Numeric Targets for the Klamath River Basin TMDLs

Page 2-16, Paragraph 1, Lines 1-3. The Draft TMDL indicates that the CA NNE boundary target is "based on a review of both regional and international studies and the recommendation of university and regional experts". Please cite the studies and provide documentation of the recommendation of experts for the target as it pertains to the Klamath River.

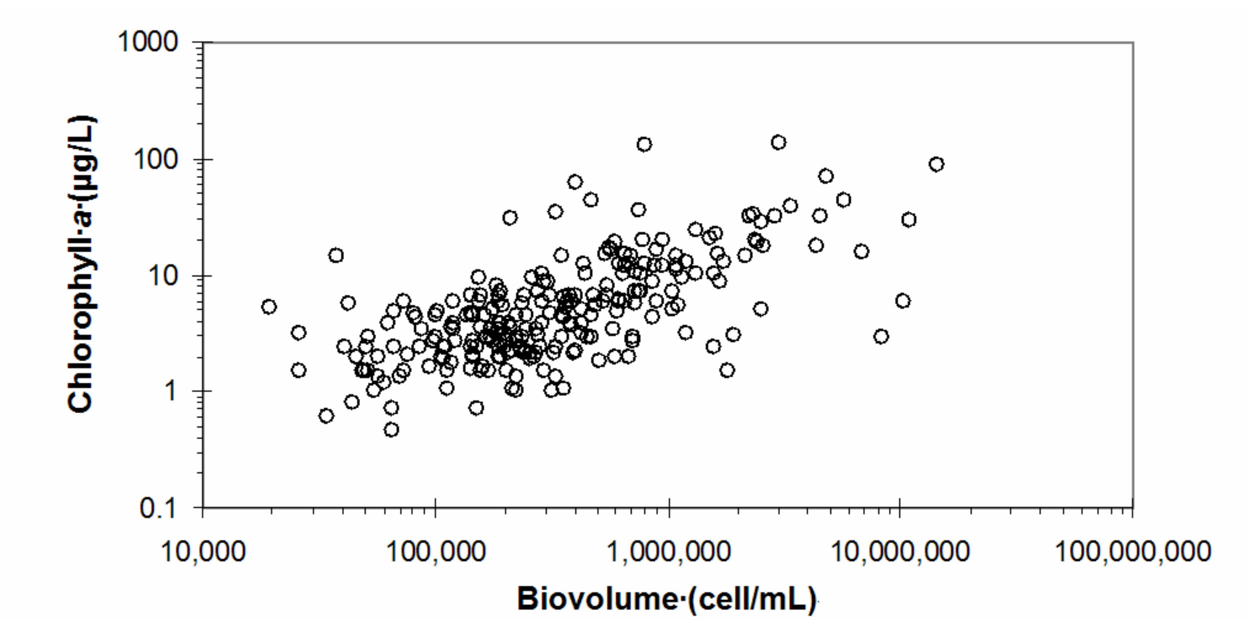
Page 2-16, Paragraph 1, Lines 5-6. The Draft TMDL incorrectly indicates that the Klamath headwaters are eutrophic. Upper Klamath Lake, which is the headwaters of the Klamath River, is well known to be hypereutrophic (e.g., Kann and Smith 1993, Eilers et al. 2001, Walker 2001, ODEQ 2002, Kann and Welch 2005, Wee and Herrick 2005, PacifiCorp 2006). Hypereutrophic lakes are very nutrient-rich lakes characterized by frequent and severe nuisance algal blooms and low transparency; they typically have greater than 40 micrograms/liter total chlorophyll and greater than 100 micrograms/liter phosphorus (Welch 1992, Cooke et al. 2005). Upper Klamath Lake typically exceeds these chlorophyll *a* and phosphorus concentrations.

Page 2-16, Last Paragraph 1, Lines 2-3. The Draft TMDL states that "Chlorophyll-a is a response variable to both water quality stressors (e.g., nutrients) and to impoundment conditions". However, the Draft TMDL presents no analysis and makes no references to support this statement.

Page 2-16, Last Paragraph 1, Lines 6-7. The Draft TMDL states that "Consistently high or episodic chlorophyll-a concentrations indicate the occurrence of algal blooms, which can be harmful to aquatic organisms". However, the Draft TMDL presents no analysis and makes no references to support this statement.

Page 2-16, Last Paragraph 1, Lines 8-9. The Draft TMDL states that "Prolonged conditions of high levels of chlorophyll-a are typical of hyper-eutrophic water bodies". This sentence should be deleted. While this statement is relevant to Upper Klamath Lake, it is not relevant to the reservoirs (the subject of this paragraph), which are eutrophic, not hypereutrophic.

Page 2-19 to 2-25. Starting on page 2-19, the Draft TMDL cites at length an analysis (in Draft form) by Kann and Corum (2009) that purports to show that increasing chlorophyll *a* concentration leads to increasing likelihood of exceeding the WHO guidelines for *Microcystis aeruginosa* abundance or microcystin concentration. The analysis by Kann and Corum (2009) suffers from several problems that call into question its conclusions. The most problematic is an error of logic that reverses cause and effect. The entire analysis is based on the observed correlation[1] between chlorophyll *a* concentration and *Microcystis* abundance (cells/mL). In both the design of the graph (Figure 2.1 on page 2-19) and the explanation of it, the Draft TMDL implies that *Microcystis* abundance is the response factor and chlorophyll *a* the independent variable, that is, that chlorophyll *a* causes the *Microcystis* abundance. This is obviously wrong. Chlorophyll *a* is not the independent variable, it is the response variable. In fact, *Microcystis* is not even necessarily the primary cause of chlorophyll *a*. A greater abundance of *any* algae or cyanobacteria will cause the abundance of chlorophyll *a* to increase. To demonstrate this point, Figure A1 below shows the correlation between chlorophyll *a* and algal biovolume in samples collected from the Project vicinity in 2000 through 2008 between January 1 and June 30 when *Microcystis* is typically not present. Figure 2.1 (on page 2-19) is based on data from samples collected only in July through October, the time of year when *Microcystis* is most likely to be at its greatest abundance.



[1] It is not possible to ascertain if the correlation is statistically significant because the TMDL shows only a graph with a logarithmic scale. There is no indication of the correlation coefficient or the P value. The wide spread of the data, and the substantial numbers of chlorophyll values with MSAE cell density = 0 may tend to weaken the significance of the correlation.

Figure A1. Correlation between chlorophyll a and algal biovolume in samples collected from the Project vicinity in 2000 through 2008 between January 1 and June 30 when Microcystis is typically not present.

The Draft TMDL goes on to state "The relationship illustrated in Figure 2.1 indicates that as chlorophyll *a* concentrations reach 10 µg/L and above, there is a sharp increase in Microcystis aeruginosa cell density above 20,000 cells/mL" (page 2-19). However, this is not what Figure 2.1 in the Draft TMDL shows. Instead, what Figure 2.1 shows is that between July and October for any particular range of *Microcystis* cell density that is greater than 20,000 cells/mL, the chlorophyll *a* values could range from less than 10 µg/L to more than 100 µg/L. To illustrate this point, the bar chart in Figure A2 below presents the results of a cross tabulation contingency table of the same data used in Figure 2.1. Figure A2 shows the percent of samples (i.e., the probability) in various ranges of biovolume at specified chlorophyll *a* values. For example, when chlorophyll *a* is less than 10 µg/L, 97 percent of samples are less than 1,750,000 biovolume units.

To turn this around to the way the Draft TMDL uses the Kann and Corum (2009) data, Figure A2 shows that when chlorophyll *a* is greater than 80 µg/L, the probability is the same (i.e., 33 percent) that corresponding biovolume is greater than 14,000,000 and less than 1,750,000. Further, for chlorophyll *a* between 50 and 80 µg/L, the probability that corresponding biovolume is greater than 14,000,000 is zero. Figure A2 shows that the Draft TMDL analysis is biased by the choice of data analyzed, and if analyzed data instead had included data from different times, the results would have been different.

Figure 2.2 (on page 2-20) in the Draft TMDL suffers from the same problems as in Figure 2.1, with the additional fact that, because *Microcystis* cell density and microcystin concentration are closely correlated – more closely, in fact, than *Microcystis* cell density and chlorophyll *a* – Figure 2.2 cannot add any independent information. It is simply a restatement of Figure 2.1. The fact is that there is no causal relationship between chlorophyll and microcystin toxin, only a correlation.

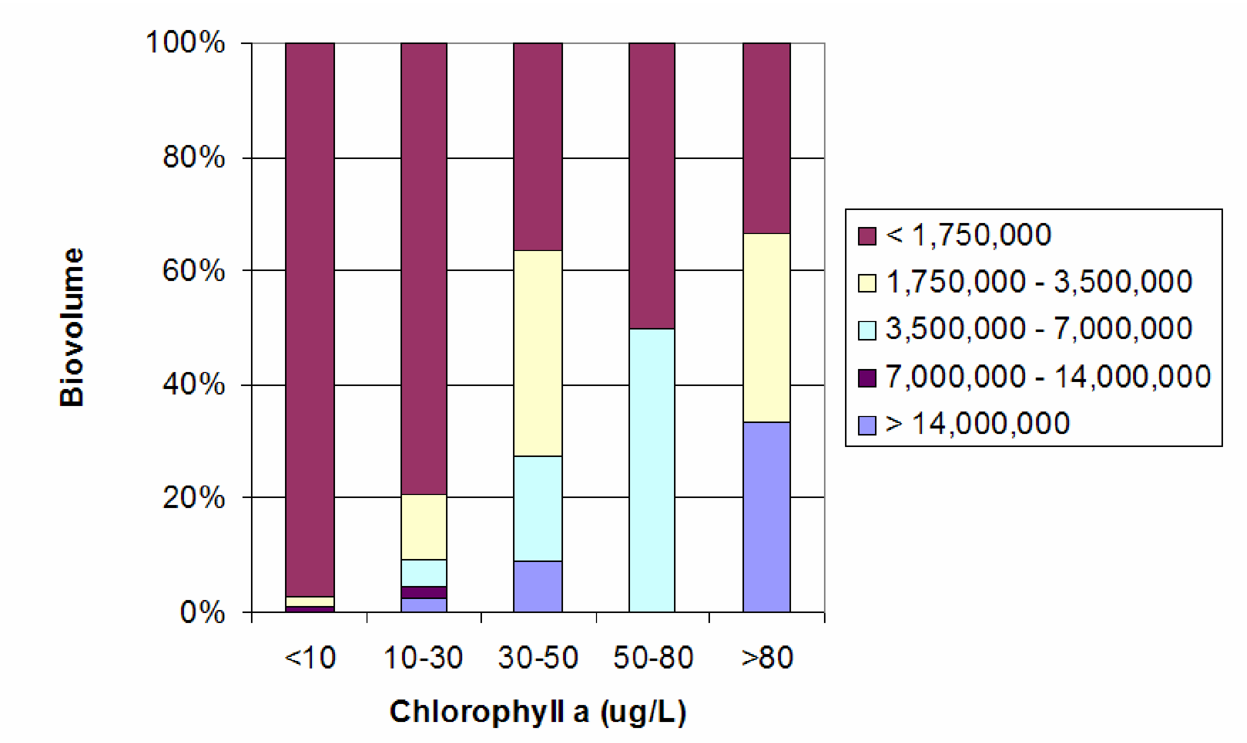


Figure A2. Bar chart showing the results of a cross tabulation contingency table of the same data used in Figure 2.1 of the Draft TMDL.

Pages 2-21 to 2-24, Figures 2.3, 2.4, and 2.6. These figures are misleading. The use of a logarithmic scale for chlorophyll *a* concentration makes the change in probability appear to be substantially more severe than it otherwise is. A logarithmic scale is typically used to fit data on one graph when the data ranges over several orders of magnitude. In this case, the data appear to range from 2 to less than 50, a range that would easily fit on a linear scale.

The chlorophyll *a* data used to develop Figures 2.3, 2.4, and 2.6 are not necessarily comparable to the data used as the primary basis for the 10 µg/L target value (i.e., Walker 1985). The Kann and Corum (2006) data (used to develop Figures 2.3, 2.4, and 2.6 in the Draft TMDL) were not collected in the same manner as most of the chlorophyll *a* data used by Walker (1985). The Kann and Corum (2006) data were collected with the intent of finding the maximum probable concentration of *Microcystis* at a particular location, and consisted of skimming the scum from the surface in areas of very dense wind-blown shoreline accumulations (see Kann and Corum 2006, page 23). The data used by Walker (1985) were from samples collected in a more standard manner, i.e. typically below the surface, or integrated over depth, at open water lake or reservoir sites.

Page 2-26, Paragraph 2, Line 1: The Draft TMDL states "The threshold analysis…supports the numeric targets proposed by the Regional Board….". This statement is not accurate. The threshold analysis *illustrates* the relationship between chlorophyll *a* and *Microcystis* in the Klamath reservoirs during the summer, and shows that when *Microcystis* is abundant chlorophyll *a* is high. It does *not* demonstrate that when chlorophyll *a* is high, *Microcystis* is abundant. The analysis in the Draft TMDL on this matter suffers from incorrect logic. The probability statements throughout this section make it seem as though the chlorophyll concentration causes the presence of toxic blooms, when in fact it is the reverse. The likelihood of chlorophyll *a* exceeding 10 µg/L increases when algal blooms are present. This is true without regard for the species involved. In this case the relation between chlorophyll and toxic blooms is greatly influenced by the decision to consider only months (June-August) when cyanobacteria are the dominant species in the community. By choosing a different period (Feb-May) it may be possible to say, in the style of this paragraph, that the likelihood of diatom dominance increases as chlorophyll increases above 10 µg/L.

2.4 Water Quality Conceptual Models Overview

Page 2-31, Paragraph 1, Line 2: Delete "likely". The Klamath *was* (and is) a highly productive system.

Page 2-32 to 2-34. The Draft TMDL discusses a hypothesized linkage between increased nutrient loading and increased incidence of fish disease. On page 2-32, the Draft TMDL states "The pathways that have resulted in major documented fish mortalities in the Klamath River in the last several years are illustrated as follows: increased nutrient loading (NA1) → elevated periphyton/macrophyte growth (NB1) and elevated suspended algae and blue-green algal growth (NB2) → increased polychaete habitat (NB4) → increased polychaete population and *Ceratomyxa shasta* (*C. shasta*) population and dosing (NB9)". However, the Draft TMDL presents no evidence or citations that such pathways "have resulted in major documented fish mortalities in the Klamath River", resulting in a statement and a subsequent discussion that is speculative. The Draft TMDL does not adequately acknowledge and describe important uncertainties on this topic.

The Draft TMDL describes that salmon below Iron Gate dam have a high parasite load, but should clarify that the "hotspot" of *C. shasta* density is actually located in the reach extending from the Shasta River to the Scott River, and that the reach just below Iron Gate dam has a relatively low *C. shasta* density (see Figure A3 below). The Draft TMDL states that "…parasite promoting factors included in the conceptual model… is that high densities of salmonids trapped in the reach below Iron Gate lead to increase shedding of the myxosporean spore…" (page 2-34). However, the Draft TMDL fails to mention that a major source of myxospores is from salmon spawners in Bogus Creek downstream of Iron Gate Hatchery. Bogus Creek fall Chinook escapement has averaged 9,000 fish since 2002. This constitutes about 30 percent of the total fall Chinook production for the Klamath River (Trinity River excluded). In fact, the number of fall Chinook that spawn in the mainstem Klamath River is a relatively small proportion of the total basin-wide escapement (see the FERC Final EIS on the Project relicensing.).

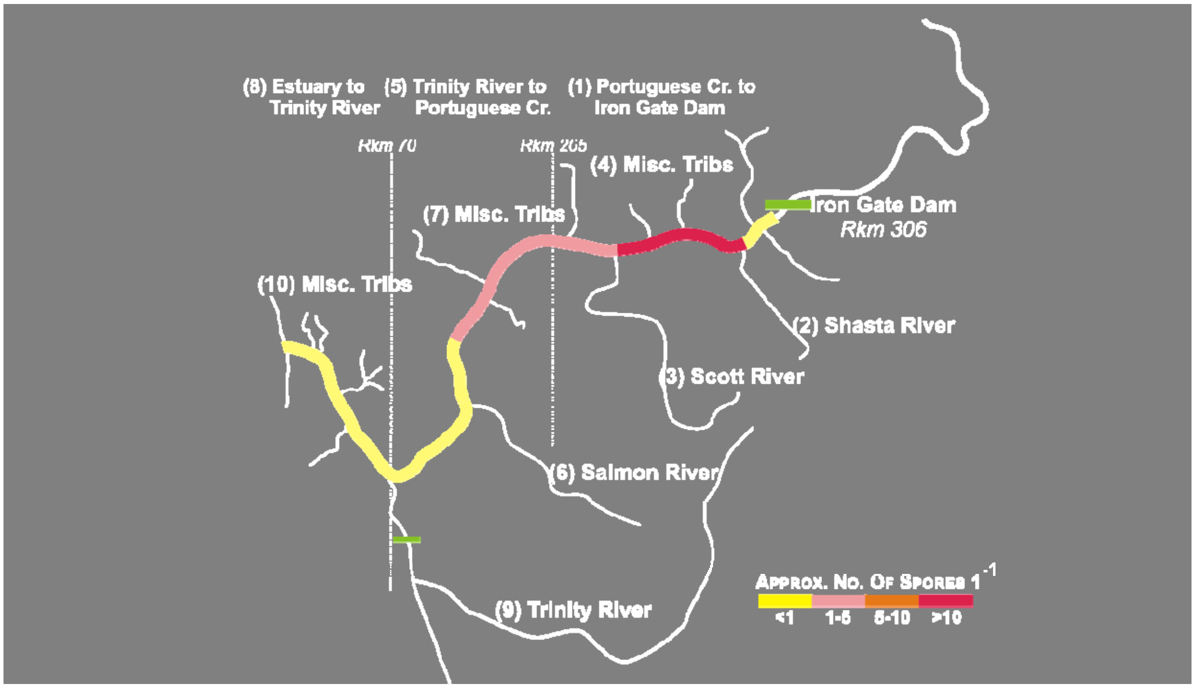


Figure A3. Density of C. shasta in the Klamath River below Iron Gate dam (Scott Foott, pers. comm.. 2008).

The Draft TMDL also erroneously suggests that the Project reservoirs may cause nutrient enrichment that contributes to increased *Cladophora* growth that in turn provides habitat for the *C. shasta* polychaete host *M. speciosa*. The Project reservoirs created by the dams (Iron Gate, Copco, and J.C. Boyle) help protect water quality in the lower basin by retaining a substantial portion of the enormous loads of nutrients and organic matter from upstream sources, notably Upper Klamath Lake. Also, the abundance and distribution of *Cladophora* in the Project area would be much greater in the absence of the Project reservoirs. These reservoir benefits are further discussed in detail in PacifiCorp (2006).

In addition, Stocking (2006) suggests that the Project reservoirs are beneficial in reducing the effects of *C shasta* infection. Stocking's data indicates that mortality due to *C. shasta* infection was both greatly reduced and delayed in rainbow trout groups exposed in the Upper Klamath River (from Link to Iron Gate dam) when compared to groups exposed in the Lower Klamath River (Iron Gate dam downstream). In general, mortality was reduced and delayed in the reservoir groups when compared to groups exposed in the free-flowing stretches of the river.

Stocking states that the presence of the four reservoirs in the upper basin likely has a significant influence on the abundance and distribution of the *C. shasta* actinospore. The infectious stage (actinospore) is viable for less than 10 days under laboratory conditions. Because of their higher capacity and longer retention time relative to the free-flowing stretches, the reservoirs may serve to dilute incoming spore densities and impede passage of the fragile actinospore by means of spore sedimentation. Stocking states that, if high spore densities resulted in the high mortality documented in exposure groups held in the Lower Klamath River, then it seems likely that continuity of water flow (absence of obstructions) is an important factor in explaining the differences between the Upper Klamath River and the Lower Klamath River results.

Page 2-33, Paragraph 2, Line 2: No evidence is presented to support the statement that algae, especially diatoms, and organic matter are elevated below Iron Gate reservoir. This statement must be supported with data or citations. Actual data collected by PacifiCorp suggest that suspended matter is not increased below Iron Gate dam compared to above Copco dam (see Figure A4 below). Examination of phytoplankton samples taken above and below Iron Gate dam does not support the statement that excess diatoms are released from the dam.

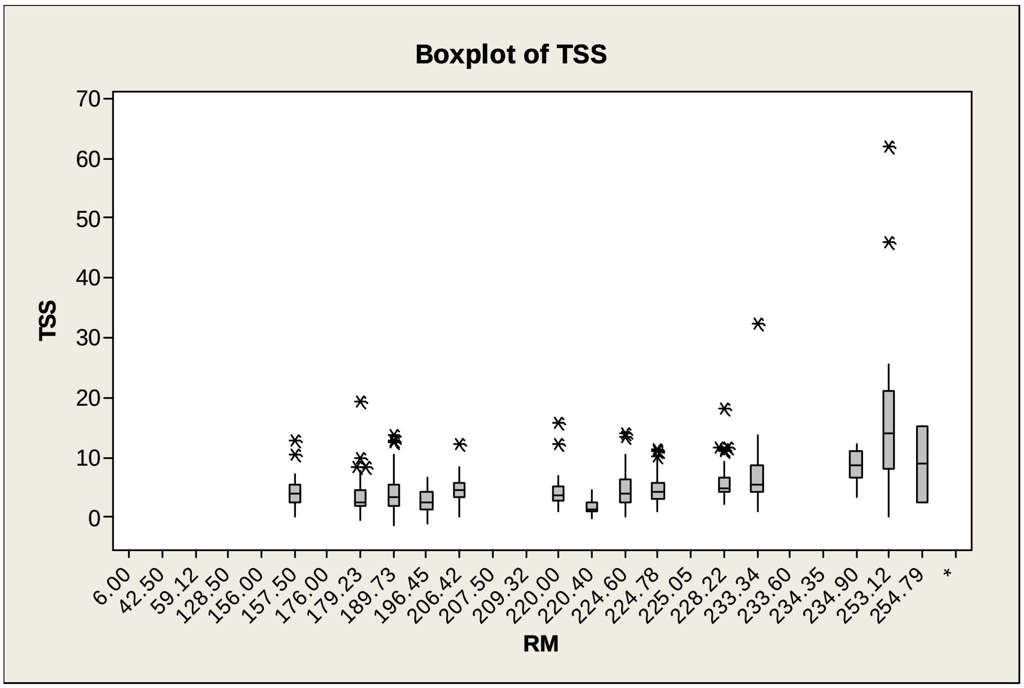


Figure A4. Suspended solids measured in the Klamath River in 2000 through 2008. (RM 206.42 = above Copco Reservoir, RM 189.73 = below Iron Gate dam).

Page 2-36, Paragraph 36, First Bullet under “Impoundments”. The Draft TMDL states that the Project reservoirs “have a small net retention of nutrients”. This is consistent with similar statements elsewhere in the Draft TMDL (e.g., page 4-20 and 4-21) that downplay any value or benefits from nutrient retention by the reservoirs. However, even the Draft TMDL’s own analysis indicates that nutrient retention by the reservoirs is significant. On page 4-19, the Draft TMDL states “[t}he TMDL model estimates are reasonably consistent with the estimates developed by Asarian and Kann (2009) through statistical analysis of empirical monitoring data” in which Kann and Asarian (2009) estimated that the reservoirs retain 8.3 percent of the inflowing load of total phosphorus and 13 percent of the inflowing load of total nitrogen on an annual basis. Further, Table 4.5 (page 4-20) in the Draft TMDL shows that annual nutrient retention in the reservoirs could be as much as 29 percent for total phosphorus and 33 percent for total nitrogen.

Using the Draft TMDL's annual load estimates (Table 4.2 on page 4-9), retention of the inflowing load of total phosphorus at a rate of 8.3 percent annually equates to a reduction of about 60,000 pounds of total phosphorus, and retention of the inflowing load of total nitrogen at a rate of 13 percent annually equates to a reduction of about 400,000 pounds of total nitrogen. Such levels of nutrient retention by the reservoirs are not "small" or "limited" as characterized by the Draft TMDL.

As described in PacifiCorp (2006), the total annual net retention of nutrients by Copco and Iron Gate reservoirs is substantial, particularly when both reservoirs are considered in combination. The observed concentrations of total inorganic nitrogen (TIN) and total nitrogen (TN) in particular are consistently lower in water released from Iron Gate reservoir than in the water entering Copco reservoir. These observations support the conclusion that Iron Gate and Copco reservoirs act as a net sink for both total nitrogen and total phosphorus over the long term (i.e., on a seasonal or annual basis).

Overall, the monthly nitrogen retention values summarized in PacifiCorp (2006) indicate that the reservoirs acted to retain a significant percentage of inflowing TN (21 percent) and TIN (42 percent) over the entire evaluation period of March-November 2002. Given the large inflowing nitrogen load of nearly 600 metric tons to Copco reservoir over the entire evaluation period of March-November 2002, the substantial net retention provided by Copco and Iron Gate reservoir is an important process for reducing downstream loads to the Klamath River below Iron Gate dam. Retention of these loads results in water quality improvements downstream in the Klamath River due to reduced incidence of attached algae and *Cladophora* growth.

In addition to downplaying reservoir retention of nutrients, the Draft TMDL also does not recognize the beneficial role of the reservoirs in shifting the timing of inflowing summertime nutrient "peaks" from upstream sources, notable Upper Klamath Lake. The travel times of flows in the river are important to understanding and explaining nutrient dynamics in the Klamath River. It is apparent that the very large loads of nutrients and organic matter in the Klamath River from Upper Klamath Lake and other upstream sources are often "event-driven" – that is, characterized by large "spikes" of organic matter delivered to the river following the collapse of large algae blooms that are typical in Upper Klamath Lake during the algae growing season. Therefore, it follows that such substantial nutrient "events" would have a downstream influence on nutrient concentrations at a particular point in space and time along the river. This influence would manifest itself in the form of a downriver "lag" in the event, the extent to which would depend on river travel times.

To assess potential "lag", Watercourse Engineering simulated the downstream movement of nutrient events using the RMA-2 dynamic hydraulic model and the RMA-11 water quality model (as described in PacifiCorp 2004). These simulations clearly illustrate the occurrence of a lag associated with travel time through the reservoirs. Figure A4 below shows notable decreases in the magnitude of the peak of the event in Copco reservoir, and the lag of the peak due to travel time through Copco reservoir. Similar decreases and lag times occur through Iron Gate reservoir. The reservoir lag times are considerable, allowing for processes such as decay and settling to occur. These simulated results also support empirical data findings of nutrient reductions in reservoirs and "lag" of peak nutrient concentration (see Figure A5 below).

These lag times are important to recognize and consider when assessing the roles of nutrient retention in the system. If the reservoirs are assumed as static, isolated systems, and inflow and outflow nutrient conditions are compared on a given day, as done by Kann and Asarian (2005) and Asarian and Kann (2006), it is easy to mistakenly identify that the reservoirs are sources of nutrients. For example, as identified in Figure 4-18 in late October, Copco reservoir inflows may indicate higher levels of total nitrogen than Iron Gate reservoir outflows. However, Iron Gate is actually further reducing the input from Copco reservoir because of the considerable lag. That is, TN in Copco reservoir inflows has been reduced as the "peak" passes through the reservoirs.

The lag effect from the reservoirs displaces the peak influx of nutrients further into the future. In the cases shown in Figures A5 and A6 below, the peak TN leaves Link dam in late July in the middle of the algae growth season. This peak does not manifest itself at Copco dam until some weeks later, and does not appear at Iron Gate dam until well into October, and then is considerably attenuated. This displacement of TN influx further into the future suggests the reservoirs have a beneficial effect on reducing downstream attached benthic algae (periphyton) in the river during the peak algae growing season. 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. Conversely, in the absence of the Copco and Iron Gate reservoirs, it is likely that attached benthic algae (periphyton) would increase in the river downstream of Iron Gate during the peak algae growing season. Nutrients released to the river system below Iron Gate dam in mid-summer rather than in late summer and early fall would have a considerably greater potential for being sequestered in algal biomass.

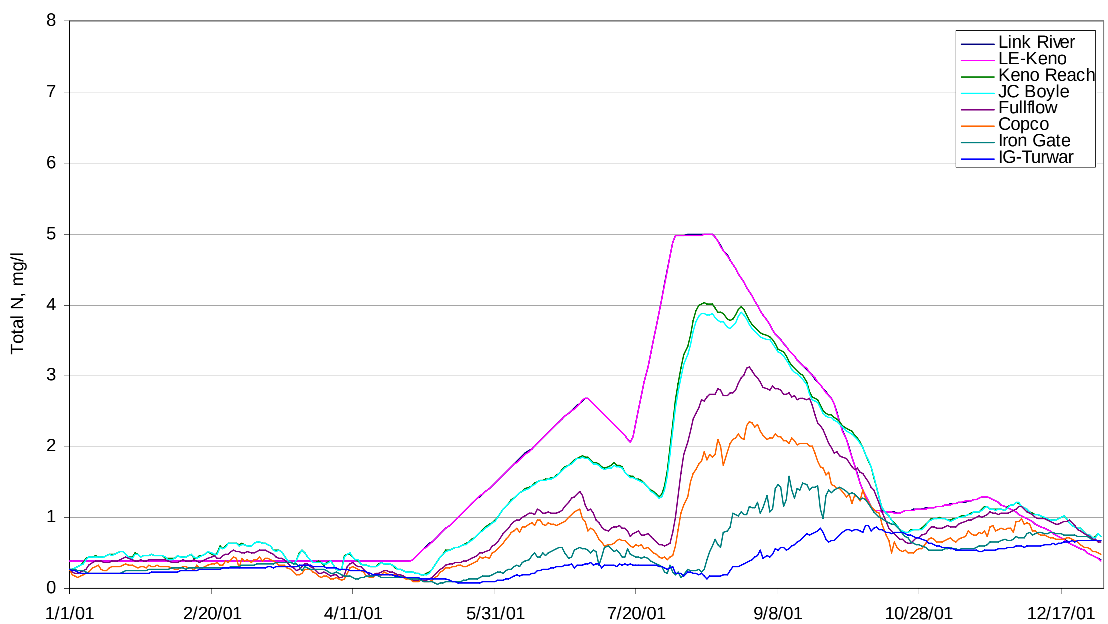


Figure A5. Model simulations of total nitrogen in the downstream direction for the Klamath River from Link dam to Iron Gate dam for existing condition (graphic labels correspond to the head of each reach).

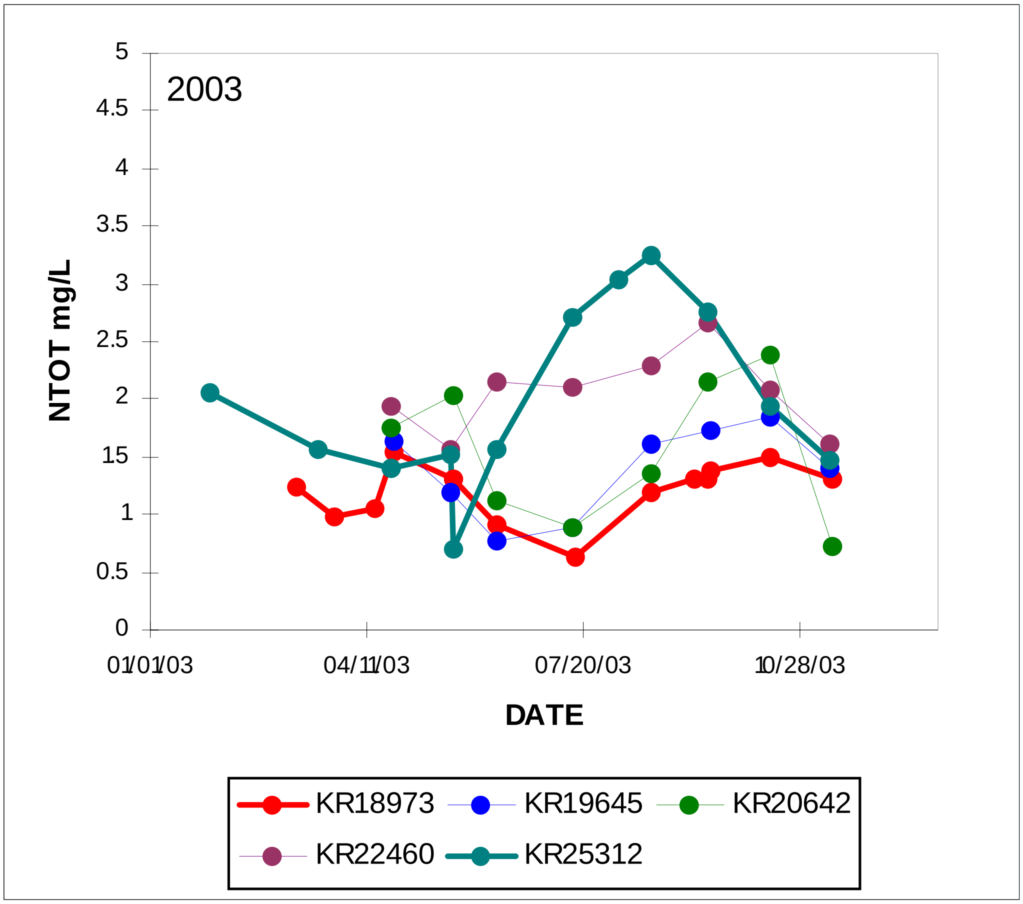


Figure A6. Observed total nitrogen values (NTOT; in mg/L) during 2003 in the Klamath River below Iron Gate dam (KR18973), above Iron Gate reservoir (KR19645), above Copco reservoir (KR20642), below J.C. Boyle dam (KR22460), and below Link dam (KR25312).

Page 2-37, Paragraph 1, Lines 3-5: There is no evidence to support the Draft TMDL's statement that there is increased deposition of organic matter below the dams in the river channel below the dams or that, if there were, it would increase polychaete habitat. This statement is purely speculative.

Page 2-37, Paragraph 2, Lines 1-3: The Draft TMDL discusses increased organic matter loading as a nutrient "risk cofactor." The increased organic load to the Klamath River comes from upstream sources, notably Upper Klamath Lake in Oregon. The Draft TMDL asserts that compliance with the Oregon TMDLs will result in compliant conditions at Stateline. The Draft TMDL must explain how increased organic matter loading is a risk factor in the case of compliant conditions at Stateline.

Page 2-42, Bullets 1-4. All of these bullets are general statements that can be found in any limnology book. Linkage to the Klamath River is necessary. For example, Bullet 1, Line 3: The Draft TMDL states "In waterbodies that have high concentrations of ionized ammonia and frequent excursions of high pH such as the Klamath River…." There is no evidence, data, or locally relevant citations presented to support the statement that the Klamath River has high concentrations of ionized ammonia, or to support a conclusion that NH4+ is a problem in the Klamath River. This statement must be supported by locally relevant data or citation.

2.5 Evidence of Water Quality Objective and Numeric Target Exceedances

Page 2-49 to 2-51. The Draft TMDL discusses temperature effects attributed to the Project reservoirs, and concludes "[i]n summary, the temperature alterations…result in adverse effects to salmonids" (page 2-51). However, the Draft TMDL discussion of the effects of reservoir "thermal lag" on migrating anadromous salmonids is speculative, incorrect, or lacks balance. In fact, as discussed in detail in the cover document of PacifiCorp's comment package, the Draft TMDL's temperature allocations and targets are based on "ideal" or near-ideal temperatures for salmonids in the generally colder waters of the Pacific Northwest, not the "thermal load which cannot be exceeded in order to assure protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife" in the Klamath River per 40 C.F.R. § 130.7(c)(2). The temperature effects of the Project are consistent with the protection and propagation of a BIP in the Klamath River.

Page 2-50, Paragraph 2, Lines 1-2: The Draft TMDL states "The temperature modeling indicates human impacts adversely affect both the rearing of juvenile salmonids and the reproductive success of adult salmonids." The temperature model is not evidence of adverse effect. It is just assumed by the authors. Statements about adverse effects must be supported by actual evidence, data or locally relevant citations.

In Figure 2.12 on page 2-50, the Draft TMDL compares modeling results for current conditions and estimated natural temperature for the 2000 simulation year. Compared to a hypothetical without-Project scenario, the thermal phase shift created by the presence of the reservoirs has a warming effect on Iron Gate and Copco tailrace water temperatures during fall. However, as discussed in detail in section II.C of the cover document preceding this appendix, current temperature conditions with the reservoirs in place remain within (i.e., cooler than) MWMT chronic effects thresholds to salmonids during fall just as often, and in some cases more often, as modeled without-Project temperature conditions.

The Draft TMDL erroneously implies that the cooler temperature releases at Iron Gate dam during late winter than modeled "natural" temperature conditions "may reduce the growth rates of salmonids rearing in the Klamath River, and may ultimately reduce the survival rate of salmonids in the ocean" (page 2-51). The Draft TMDL provides no substantive evidence for this assertion, but only implies that the cooler temperature releases at Iron Gate dam during late winter are adverse because "the optimal temperature range for juvenile salmonids is 10-15°C, with a lower limit of 4°C" (page 2-51). However, as discussed in detail in section II.C of the cover document preceding this appendix, both current and "natural" temperature conditions are below the optimal range for juvenile salmonids during the winter, and modeled Without-

Project temperature conditions are below 4°C (and therefore below the optimal range) more frequently than current conditions during the winter.

With regard to the temperature effects in the mainstem Klamath River, the Draft TMDL bases its case largely on a couple of simplistic graphical comparisons. The Draft TMDL presents a graph of "Current Conditions" and "Estimated Natural" temperatures (based on modeled results) downstream of Iron Gate dam (Figure 2.12 on page 2-50), and states that "the temperature alterations in Figure 2.12 results in adverse effects to salmonids" (page 2-51). However, the Draft TMDL provides little other model analysis, and no other specific direct analysis of biological effects.

Page 2-54, Paragraph 4, Lines 2-3: The Draft TMDL states "Some of the key sources [of nutrient loads] include…internal nutrient cycling from nutrient enriched sediments…." It should be made clear that this relates specifically to Upper Klamath Lake, not the Project reservoirs. There may be some internal release of nutrients from the reservoir sediments, but the resultant contribution to the load to the river is very small, if any. Because the reservoirs are a significant nutrient sink, the net result of the reservoirs is a decrease, not an increase in nutrient load to the river.

Page 2-55, Figure 2.16. The natural conditions background values for phosphorus assumed in the Draft TMDL are unrealistically low (somewhere between oligotrophy and mesotrophy). These assumed values in no way correspond to the documented historical evidence of the Klamath system, which has been eutrophic or hypereutrophic throughout recorded history. The "natural conditions" shown on the graph also display unrealistically small variability.

Page 2-56, Figure 2.17. Same comment as for previous graph (Figure 2.16).

Page 2-59 to 2-61. The Draft TMDL discusses chlorophyll *a* conditions and effects attributed to the Project reservoirs. As discussed in detail in the cover document of PacifiCorp's comment package, the Draft TMDL's chlorophyll *a* analysis and recommended target of 10 µg/L for the reservoirs is inappropriate, particularly in light of the naturally eutrophic nature of the upper Klamath River system, and the unrealistically large nutrient reductions that would be required for the target to be achieved. The 10 µg/L target was not selected with the naturally eutrophic Klamath River system in mind. Rather, it was selected for the Draft TMDL by the Regional Board as the most restrictive of several possible targets under the general, statewide Nutrient Numeric Endpoints (NNE) approach (Tetra Tech 2006).

As the Draft TMDL describes, the 10 µg/L target was chosen by Regional Board staff at a workshop, based on recommendations under the general NNE approach for the most restrictive of the 18 beneficial uses that have been designated for Copco and Iron Gate reservoirs – that is, Cold Freshwater Habitat (COLD) and Municipal Water Supply (MUN) beneficial uses. The Draft TMDL further acknowledges that the NNE-derived chlorophyll *a* target for the reservoirs is the most restrictive and is much lower than if based on other beneficial use categories, and states "10 µg/L summer average chlorophyll *a* provides one potential target for managing these reservoirs" (Appendix 2, page 6).

The 10 µg/L chlorophyll *a* target is not appropriate for the naturally eutrophic Klamath River system. Throughout the Draft TMDL, it is acknowledged that higher concentrations of nutrients results in higher levels of chlorophyll *a*, or that high levels of chlorophyll *a* are typical of nutrient-enriched water bodies (e.g., page 2-16). For example, as the Draft TMDL analyses show, achieving a chlorophyll *a* concentration of 10 µg/L would require total phosphorus load reduction of to the reservoirs of 90 percent, resulting in an average growing-season phosphorus concentration of 0.03 mg/L (Appendix 2, page 17). As previously discussed above, such phosphorus loads reductions are infeasible and unachievable. That, in turn, means that 10 µg/L chlorophyll *a* is not a reasonable target in this naturally-enriched system.

As a key rationale for the 10 µg/L chlorophyll *a* target for the reservoirs, the Draft TMDL incorrectly states that the 10 µg/L chlorophyll *a* target is "achieved above the reservoirs but not within the reservoirs, thus the reservoirs themselves are the cause of these impairments" (page 4-20). But, in apparent contradiction, based on modeling analyses, the Draft TMDL concludes that the Klamath River entering Copco reservoir (at Shovel Creek) "exhibit high chlorophyll-a concentrations in the middle of the year"…"largely due to upstream conditions being carried downstream", and "in many of these situations, chlorophyll-a data are not available for comparison" (Appendix 7, page 11).

The 10 µg/L chlorophyll *a* target for the reservoirs is inappropriate given the chlorophyll *a* levels in the river waters flowing into the reservoirs from upstream are frequently higher than 10 µg/L. Therefore, advected input of chlorophyll *a* alone could prevent achieving the target in the reservoirs. Data presented in the Draft TMDL clearly shows very high levels of chlorophyll *a* in the river from sampling sites above J.C. Boyle reservoir, at Keno dam, and at the Link River mouth (near the outlet of Upper Klamath Lake). The Draft TMDL states that "the high concentrations at these three stations are due in large part to residual algal biomass from Upper Klamath Lake" (page 2-60). Furthermore, the modeling analyses performed for the Draft TMDL to develop recommended TMDL allocations shows chlorophyll *a* levels in the river upstream of Copco reservoir ("Klamath River at Shovel Creek") that are much higher than 10 µg/L, particularly during summer, when the target is to be applied (as a "summer mean"). Figure 2 shows the Draft TMDL's model results for chlorophyll *a* levels in the river upstream of Copco reservoir (from Appendix 6, pages H-16 and H-19).

Page 2-60, Paragraph 2, Last line. The "very high means" noted on the graph (Figure 2.23) is likely attributable to different sampling objectives (e.g. public health vs. ecological). Lumping all data regardless of sampling objectives is inappropriate. In other words, differences are at least partly explainable by biased sampling techniques. Since Figure 2.23 uses data from a report that is unavailable to PacifiCorp, we cannot verify how the data were collected.

Page 2-61, Paragraph 2, Lines 2-6. The Draft TMDL states "Elevated levels of suspended algae in the Iron Gate reservoir outlet waters are then available as a food source for polychaetes in the river….", and "…fine particulate organic matter discharged from the outlet of Iron Gate reservoir is deposited in the river bottom sediments below the reservoir…" These statements are purely speculative. They are assumptions based on opinion with no supporting data and should be re-written. In fact, as discussed earlier in these comments, the Draft TMDL misinterprets cited study results, particularly by failing to provide the accurate context that the "hot spot" of infection is not directly below Iron Gate dam, but in the Beaver Creek area downstream of the Shasta River (Bartholomew et al. 2007).

Page 2-61, Paragraph 2, Lines 8-10. The Draft TMDL makes the totally baseless statement that Iron Gate reservoir is "the source of blue-green algae that continues to grow in backwater and slower sections within the river reaches below the dams". The implication is based on conjecture with no direct evidence. Unless supported by data or other credible references, this statement should be deleted. Also, we assume that if the Regional Board staff believes that Iron Gate reservoir is the source of blue-green algae within the backwater and slower sections of the river downstream, that Regional Board staff would also believe that Upper Klamath Lake is the source of blue-green algae to the river and reservoirs downstream of it.

Page 2-62, Paragraph 1, Line 1. The Draft TMDL states "The consistent presence of high concentrations of *Microcystis aeruginosa*…." (MSAE). The assumption of a "consistent presence" of high concentrations of MSAE is not supported by data. MSAE is highly variable in both time and space and is not consistent. For example, while Iron Gate and Copco reservoirs have had MSAE levels that met the health advisory guidelines annually since 2005, concurrently, sections (not all public access areas) of the Klamath River have been posted in 2005, 2008 and 2009.

Page 2-62, Paragraph 3, Line 1. The first sentence, "Every year since 2004 *Microcystis aeruginosa* counts have exceeded…" is wrong (see above comment) and contradicts Table 2.10.

COMMENTS: CHAPTER 3. ANALYTIC APPROACH

3.2 Modeling Approach

Page 3-2, Table 3.1 and elsewhere. The Bypass-Peaking Reach is referred to as Bypass/Full Flow Reach. It is our understanding that "Fullflow" was a name for this reach that is no longer used; "Bypass Reach" refers to the stretch of the river before the powerhouse release, and "Peaking Reach" refers to the stretch of the river below the powerhouse. Hence, "Bypass/Full Flow Reach" is a misnomer that needs to be corrected for the sake of clarity and consistency.

Page 3-6, Paragraph 1, Line 3. The test identifies that the TMDL model was "segmented similarly to the PacifiCorp model." Discussions with Regional Board staff and review of the code indicate that the same model geometries are used. The text suggests changes were made for the TMDL, which is erroneous.

Page 3-6, Paragraph 1, Line 5. Not all tributaries to the river were represented as boundary conditions. To state otherwise misrepresents the actual setup of the TMDL model.

Page 3-6, Paragraph 1, Line 9. Four vertical layers were chosen to represent the estuary. What was the basis for this decision? Typically this is part of geometric grid or mesh refinement wherein layers are added until results show no appreciable difference (typically a criterion is selected to define "appreciable"). Would the model be more accurate if more layers were used? Further, would the results differ significantly if the model domain was different? The answers to these questions should be included and thoroughly discussed in the TMDL and address the potential implications of these assumptions on load allowances specified by the TMDL.

Page 3-6, Paragraph 4, Line 2. The "multiple locations" at which the TMDL model was calibrated and corroborated are not listed, leaving in question the adequacy of calibration/validation, i.e., to ensure that the model functions adequately and appropriately for the purpose of TMDL formulation.

Page 3-6, Paragraph 4, Line 10. Please present a detailed account and the results of the "corroboration" process . Greater transparency in this regard is needed to ensure public confidence in the TMDL model. Corroboration is not a formal modeling term and does not replace validation of the model for an independent time period, casting doubt on the applicability of the model and reducing confidence in results appropriate for a TMDL. No performance measures are provided for model calibration.

Page 3-6, Paragraph 5, Line 1 and elsewhere. The Klamath River TMDL model above the estuary is divided into eight parts or reaches, which includes river and reservoir reaches. To call these reaches "segments" is confusing and misleading. Further, modeled reservoirs are divided into "segments" in the language of CE-QUAL-W2.

Page 3-6, Paragraph 5. Considering the availability of data and models from 2000 through 2004 that were provided to the Regional Board Staff early in the TMDL process, it is unfortunate that only data from one year are used to calibrate the TMDL model. As such, the TMDL model does not have a formal validation period. Thus, it may be fair to conclude that the TMDL model downstream of the Bypass-Peaking Reach is unreliable or of limited reliability in setting TMDL load allocations. As it stands, one can only have confidence for model applicability for 2000, and yet the TMDL model is relied upon to set load criteria for many years to come. Specifically, using only a single year on which to base the TMDL analysis provides no information on inter-annual variability – a considerable omission in a system with the size and complexity of the Klamath River.

Page 3-7, Paragraph 1, Lines 1-6. The draft TMDL states that 2002 simulations were restricted to the Oregon portion of the system due to resource limitations and lack of boundary conditions. Lack of boundary condition data is not a valid argument. No tributaries are modeled between Stateline and Fall Creek (entering Iron Gate Reservoir). Within Iron Gate Reservoir Fall, Jenny, and Camp Creeks are represented in the model and data from PacifiCorp for 2002 was made available to Regional Board Staff for Fall and Jenny Creek. Downstream of Iron Gate Dam, USFWS implemented a program that ran from 2002 through 2006 that included the most comprehensive water quality sampling of mainstem and tributary sites to date. Coupled with water quality sampling of PacifiCorp and the Yurok and Karuk Tribes, there is considerable data availability in years 2002 to present. This omission of additional model years when sufficient data were available to extend the models severely limits the TMDL analysis because of a complete lack of accounting for inter-annual variability. At the inception of the TMDL process, five years of simulations were available to the Regional Board and Oregon Department of Environmental Quality: 2000-2004. The intensive estuary work of 2004 falls within the range of available years.

Page 3-7, Paragraph 2, Lines 10-12. The sentence seems to imply that model sensitivity and uncertainty analysis are not "key practices." Further, one wonders why these are only considered "to a lesser extent." At a minimum an exploration of sensitivity is an integral part of model development and application. Uses of sensitivity analysis include:

- serving as an aid to confirming that the model is consistent with theory
- indicating the effects of errors in each of the variables and parameters, on the dependent variables
- identifying sensitive parameters or variables that must be reliably estimated
- indicating the relationship between control variables and decision variables to help ensure that a change in control variable can have a desirable effect on the decision variables, and
- identifying regions of "design invariance" where desirable levels of the decision variables are insensitive to possible errors of estimation in the model variables and parameters.

Without such an assessment, particularly because only one year of calibration for the California reaches was completed, the model's ability to reproduce reliable results under a scenario other than existing conditions (e.g., natural conditions) is undefined and thus highly uncertain. At a minimum a qualitative assessment can be completed (see Watercourse 2004, pages 216-221), and more rigorous sensitivity on full water quality simulation may be in order for such an important document as a TMDL (see Berger et al 2002).

Page 3-7, Paragraph 2, Lines 2-14. The peer reviews of the model brought up a host of comments regarding uncertainty, lack of calibration, sensitivity analysis, yet little of this critical review is reflected in the body of the TMDL. Uncertainty analyses or even model performance metrics that allow model uncertainty to be quantified are absent from this analyses. Models are only representations of physical systems and are by their nature imperfect, powerful and useful, but imperfect. Without a quantification and incorporation of model uncertainty into analyses, the models are insufficient to set TMDL load allocations. EPA (1997) states that "[T]he question of model accuracy is often crucial in situations where a given allocation is being negotiated or contested" (page 4-27). Further, [U]ncertainty analysis should be included as an integral component of water quality modeling. One of the primary purposes is to quantify the error in predicting water quality and evaluate the effect of input parameters on model output. Better management decisions can be made by quantifying this error. Such quantification also facilitates subsequent studies, such as risk assessments, to evaluate alternative allocations." (page 4-29) EPA (1997) identifies sensitivity analysis as a valid approach to defining uncertainty and dedicates a portion of an appendix (Appendix D) to this topic. The fact that sensitivity analysis is presented with reference to the EPA water quality model QUAL2E indicates that even in complex systems quantification of uncertainty is feasible and necessary. As stated in the TMDL "models are suitable tools for establishing Klamath River TMDL allocations and targets," but the tools must be appropriately developed, tested, and applied to carry out this task and this TMDL does not support this level of rigor.

Page 3-7, Paragraph 3, Lines 2-7. The draft TMDL notes that the "NNE approach is a risk based methodology," but without identification and clear quantification of uncertainty, risk based assessments are at best a challenge and at worst infeasible. Specifically, without sensitivity analysis, assessing interannual variability, defining uncertainty associated with field data, quantifying model uncertainty (as well as other sources of uncertainty) developing multiple Lines of evidence for response variables is infeasible.

3.3 Model Application to TMDL Determination

Page 3-8, Paragraph 4, Lines 1-4. The Draft TMDL states that "…targets should not be set lower than the value expected under natural conditions." However, the natural conditions baseline used in the Draft TMDL appear to be substantially lower than any conditions that have been experienced in the Klamath system (Herrick and Wee 2005, Eilers et al. 2001). The TMDL provides no evidence to justify the choice of "natural conditions" that are so far removed from documented natural conditions. The proposed natural conditions must be supported with data or locally relevant citations.

Page 3-8, Paragraph 4, Line 6. The Draft TMDL states that "…the frequency of scouring events…would also increase in a dams-out scenario." The assumption is incorrect. As discussed in detail in the hydrology and geomorphology sections of PacifiCorp (2004b), the frequency of scouring flows has not been altered by the presence of the dams. PacifiCorp reservoirs have limited active storage and high flow events pass without appreciable attenuation.

Page 3-8, Paragraph 4, Lines 8-10. There is reference to the "NNE benthic biomass scoping tool" and the reader is referred to section 2.3.2.1. Section 2.3.2.1 states that the "CA NNE scoping tools" are described in Chapter 3. There is no description of the models, data used in the models, simulation assumptions, or assessment of uncertainty. This lack of documentation and transparency provides little confidence in NNE results and is technically insufficient for use in TMDL load allocation analyses (e.g., Appendix 2 provides insufficient documentation for the application of BATHTUB to the Klamath River reservoirs).

Page 3-8, Paragraph 5, Line 1. As mentioned in previous comments, the model was only validated up to the Bypass-Peaking Reach, it may be fair to conclude that the TMDL model downstream of the Bypass-Peaking Reach is unreliable or at a minimum untested.

Page 3-9, Paragraph 2-3. The boundary conditions for the model were based on Oregon's TMDL (ODEQ 2002). Upon review, nutrient concentrations were actually set to values inconsistently low with expected conditions presented in the UKL TMDL, and possibly with expected natural conditions (Rounds and Sullivan 2009). Based on the ODEQ 2002 TMDL, mean annual average of total phosphorus is 0.11 mg/L and mean average from March to May is 0.03 mg/L. However, based on the natural condition model runs, the total phosphorus concentration at Link Dam ranges only from 0.015 to 0.045 mg/L.

Page 3-9, Paragraph 3, Lines 7-10. Two model simulations were made using different flow regimes, but results were compared and found "not to be substantially different." Presumably the TMDL is speaking to water quality conditions, but this is unclear. Also, the comparison of water temperatures at Stateline in Figure 4.5 is a poor example. Temperature is not a conservative constituent because of exchange across the air water interface, thus similar flows will produce similar temperatures as the river tends to converge on equilibrium temperature (i.e., that temperature which is in equilibrium with meteorological conditions). Further, Figure 4.5 states that "[P]ositive values represent an increase in temperatures due to reduced flow, but this figure presents water temperatures at Stateline – below the large springs below J.C. Boyle Reservoir. This is another example of a statement that has no technical basis or support presented in the document. Under these conditions, smaller flows would be influenced to a greater degree by the cold water spring inputs and may actually be cooler than under a higher flow conditions. Positive deviations in November may be due to the springs "warming" an otherwise cool river. Finally, all of these deviations are within 1°C of zero, which is probably within the resolution of the model. Without any quantification of uncertainty no definitive conclusions can be drawn from Figure 4.5 (or many other figures in the document).

Page 3-9, Paragraph 4, Line 6-7. (See also last bullet point, top of page 3-10) What is the rationale for using "natural" and "TMDL conditions" for California tributaries? Which conditions were applied to which tributaries?

Page 3-10, Bullet Point 3. "Natural conditions assume absence of all point sources." Review of the model files suggest that this would include accretions and depletions from ungaged inflow and storm water. It does not appear that these flows are included, but would occur under natural conditions. There is no discussion of this assumption or the ramifications to flow and water quality. In standard practice such steps may be acceptable upon completion of a sensitivity analysis to truly identify such assumptions as having a minimal impact on results.

Page 3-10, Paragraph 3, Line 1. It is unclear if this "series of iterative simulations" was based on current conditions or natural conditions? The process and assumptions are not described in sufficient detail to fully comment on the findings. As a simple example (and not intended to be all inclusive), even a brief description of what compliance and the definition used in the analysis is necessary for the reader to interpret this sentence.

Page 3-11, Paragraph 2, Lines 8-10. Site potential shade conditions are not clearly explained in the TMDL.

Page 3-11, Paragraph 2, Lines 10-12. (1) Is the noted flow goal of 45 cfs a regulatory requirement, or simply a goal? Further, is there a specifically assigned temperature to the additional waters that will form the 45 cfs increase in the Shasta River – additional warm water will do little to ameliorate warm water temperatures in this tributary? (2) There is no time line assigned to this goal, nor any of the tributaries, and no associated analysis indicating the uncertainty in attaining all tributary temperature goals in a consistent and coordinated fashion to attain the Klamath River TMDL. This is a considerable uncertainty in itself, and a clear and detailed discussion relating to these matters is required.

Page 3-12, Table 3.2. The validation results are presented, but no location is given and there is no discussion of these results. The mean absolute error of more than 3°C from 8/29/02 to 9/4/02 (location unknown) should be discussed in light of the potential implications on the Klamath River TMDL. Results at the mouth of the Shasta River are most applicable for this analysis; however, the draft TMDL makes no quantitative assessment of uncertainty and thus propagation of model error cannot be formally included in the Klamath River TMDL assessment and load allocations.

Page 3-15, Paragraph 1, Line 5-6. Changes in climate are noted here (as noted in Van Kirk and Naman (2008)), but the draft TMDL contains no technical evaluation of climate change for tributary effects or mainstem conditions. This is especially intriguing because natural conditions assumptions of 1°C and 2°C reductions in lower Scott River tributaries may actually see notable increases – not decreases - in stream temperature due to climate change. A comprehensive assessment of climate change is necessary to determine actual implications in light of TMDL analyses and load allocations.

Page 3-16, Paragraph 1 (following bullets), Lines 5-9. The model performance data is inappropriately presented. By combining the mean absolute error and bias all 18 validation sites (there is no description if calibration even occurred in this model) into a single statistic all detail is lost to the reader. Further, only the average bias of all sites at the mouth was provided – no mean absolute error was provided. Bias by itself is infamous for obscuring the true performance of a model and this is a critical omission. Finally, the average of averages in model performance statistic is poor form. Full presentation of model performance at all 18 sites (and calibration and validation data as available) should be included.

Page 3-16, Paragraph 2. This paragraph provides little confidence to the reader about the data, the model, and the results, and terminates with the qualitative statement that "there is uncertainty associated with these estimates." No attempt is made to quantify that uncertainty or to assess the potential implications on the Klamath River TMDL. For the Scott River inflow temperature the draft TMDL makes no quantitative assessment of uncertainty and thus propagation of model error cannot be formally included in the Klamath River TMDL assessment and load allocations.

Page 3-16, Paragraph 3, Line 2. The term 'de minimus' lacks technical definition in this case. No threshold values for temperature were introduced into the TMDL to define a level of significance or a level of effect for tributary contributions. This, the statement that changes in management of the Salmon River watershed will have no effect on the temperatures at the mouth is simply an opinion. Specific criteria should be developed for tributary contributions that can be systematically applied to the TMDL analysis.

Page 3-16, Paragraph 3, Line 5. It is unclear how temperature "data come from measured flows." Further, the Salmon River is forecast to be hard hit by climate change, and thus future flow regimes and temperature regimes will almost certainly change in timing and magnitude. Discussion of such changes is absent from the document.

Page 3-17, Paragraph 1. The draft TMDL states that "[N]either of these comparisons indicated a large temperature reduction at the mouth of the Trinity River would have occurred had ROD flows been implemented in 2000. Based on this comparison, we estimated stream temperature would be reduced by 0.5C under natural conditions." No information is presented to define a "large" temperature reduction, no statistics, tables, or figures are presented to illustrate the analysis data or findings. As with the other tributaries, no threshold values for temperature were introduced into the TMDL to define a level of significance or a level of effect for tributary contributions (e.g., what is "large") to support the Regional Board staff's professional judgment. The 0.5°C decrease is simply an opinion and has little basis in a technical TMDL. One could argue strongly that best available information would suggest that without Trinity Reservoir (natural condition) stream temperatures in summer under considerably lower flows would be notable higher. As with other tributaries, specific criteria should be developed that can be systematically applied to the TMDL analysis.

Page 3-17, Paragraph 1. The draft TMDL acknowledges the complexities and uncertainties associated with the tributaries. However, there is no discussion of how this uncertain affects the Trinity River, which carries the largest amount of nutrient loading – approximately 20 percent (see Figures.4-1 to 4-3). The implications of this load on the downstream reaches and estuary are not discussed. More detailed discussions of the Trinity River are required because these loads may be considerably more important with regards to impacts on downstream reaches due to the proximity to the estuary.

Page 3-17, Paragraph 2. A large number of scenarios are introduced in this section and the details quickly become confusing. Consider a table defining all simulations, acronyms and basic assumptions so the reader does not have to wade through the text trying to decipher what is what.

Page 3-18, Paragraph 2, Line 2. How is this different from "current conditions"?

Page 3-18, Paragraph 2, Line 10. This approach of developing a TMDL without dams and then adding dams dramatically limits the efficacy of the analysis. A more effective, flexible, and informative process would be utilize existing and natural conditions as two ends of the range and then start improving water quality conditions from existing conditions in an incremental fashion. This approach would provide keen insight on the magnitude of water quality improvements that would be required to achieve intermediate, measurable milestones. This information would be invaluable in identifying appropriate implementation measures for water quality improvement, where such activities would have the most impact, and when they should be implemented (some actions should proceed sooner, while others could occur at a later date). This information would also allow adaptive management to play a more proactive role and identify where additional information was needed and if load allocations need to be modified or implementation timelines adjusted. As written, the TMDL simply looks at an existing condition, and some future condition with no insight provided about how to attain that condition. Unfortunately, the approach severely limits the flexibility of Board Staff to implement TMDL compliance actions in an informed and logical manner. The focus on dam removal as a TMDL strategy has thus led to an invaluable opportunity missed – both in terms of what such an approach would have provided the regulating and regulated community in the basin, as well as assisting with the development of a cost-effective and efficient approach to implementation actions.

Page 3-18, Paragraph 4-8. There is no clear reason for reducing PO4 and organic matter, while holding nitrogen constant unless there is a clear strategy to seek phosphorus as the limiting nutrient as a TMDL strategy. At a minimum, a sensitivity analysis should be done here to determine the implications of (a) phosphorus limitation, (b) nitrogen limitation, and (c) the potential for co-limitation. Further, this is confounded by the fact that organic matter contains both N and P, so simply choosing to reduce phosphorus along with organic matter while holding nitrogen constant is not realistic.

Is phosphorus limiting and the worst case condition? If so, then the TMDL should be explicit that the strategy in the Klamath River TMDL is phosphorus limitation. In fact, a nutrient limitation strategy for meeting chlorophyll *a* targets in both the reservoir and river (benthic) reaches is not presented in the draft TMDL. This leaves the entire analysis with no real management strategy or basis, just a hope that sufficiently low nutrients will somehow attain compliance. Without such a strategy explicitly stated, this leaves little direction for implementation actions because the regulated community does not know which nutrient – phosphorus or nitrogen – should be targeted for management. In a system that has a history of eutrophication and has set specific targets for chlorophyll *a* for reservoirs and rivers a limiting nutrient strategy is pivotal – without a such a strategy resources will not be used in an efficient and effective manner and implementation goals will not be achieved.

COMMENTS: CHAPTER 4. POLLUTANT SOURCE ANALYSIS

4.1 Introduction

Page 4-1, Footnote. The calculation for conversion of organic matter to CBOD, and to CBOD ultimate is not presented in the analyses. Basic stoichiometric considerations and decay rates are not provided to convert among these parameters. As such the reader of the technical TMDL cannot interpret what Regional Board staff has used in calculating load allocations for CBOD.

Page 4-1, Paragraph 4, Bullet 1. Please show how the UKL TMDL compliance target for TP of 0.11 mg/L was converted to nutrient boundary conditions used in scenarios.

Page 4-2, Paragraph 1, Lines 1-3.The fourteen geographic source areas are described in narrative fashion, but the actual locations and sources within each is vague. A simple table and accompanying figure would provide a clear definition of each.

Page 4-2, Paragraph 2, Bullet point 2. Is it valid to treat Copco 1 and 2 "as a single source" since there is no data in Copco 2? Copco 2 has fundamentally different water quality response than Copco 1. For example, because the reservoir is small, does not stratify, and does not have hypolimnetic anoxia (because it does not stratify). The TMDL is silent on whether processes and water quality impairments identified for Copco 1 are automatically applied to Copco 2, where they may not be applicable.

Page 4-2, Paragraph 3, Line 1 and remainder of paragraph. This "river of renewal" is apparently taken from Stephan Most's book, River of Renewal – Myth and History in the Klamath Basin (citation) and subsequent documentary film. Not only does the draft TMDL fail to reference Mr. Most's work, but these sources have little technical basis. The subsequent discussion in this paragraph which uses "renewal process" and "renewal capabilities" is inappropriate in a technical document. These terms are undefined within the TMDL and not standard technical terms for aquatic system processes or analyses. Further, descriptions such as "less eutrophic" have little meaning in a technical analysis. There are standard technical terms (e.g., hypereutrophic, eutrophic, mesotrophic, oligotrophic) to define system limnological trophic status. However, the TMDL has failed to define even the most basic categorization for the river reaches in terms of trophic status (with the exception of Upper Klamath Lake which is described throughout the document as "naturally eutrophic"), making it difficult to describe spatial and temporal conditions in this large complex river. Such a categorization would be immensely useful in describing today's conditions in a scientific manner, as well as describing the status of the river under a fully implemented TMDL to indicate measurable improvement in water quality conditions. Finally, this paragraph is an overly simplistic discussion of the implications of mechanical reaeration, tributary dilution, nutrient cycling, and other factors leading to variability in longitudinal water quality conditions throughout the Klamath River, providing little useful scientific information to support TMDL analyses and load allocations.

Page 4-3, Paragraph 1, Lines 1-2. The draft TMDL identifies that source categories are "difficult to quantify exactly" – a statement that begs for uncertainty analysis in both the qualitative and, in particular, the quantitative tools employed in the analyses and load allocation. Given the complexity and size of the basin, not to mention interstate issues, it is hard to imagine that load allocations and robust implementation strategies and timelines can be developed without uncertainty analysis.

Page 4-3, Table 4.1. Are these source categories for Oregon, California, or both? Other comments include: (a) wetland conversion can affect water temperature under certain conditions, (b) if roads contribute to nutrients, then they can contribute to both organic matter and dissolved oxygen impairment (as explained in the paragraph immediately above the table), and (c) urban land use not included.

Page 4-4, Paragraph 1, Line 1 Volcanic geology is identified as a source of natural phosphorus and may suggest the Upper Klamath Lake is nitrogen limited , which may also explain why *Aphanizomenon flos aquae*, a nitrogen fixer, dominates in UKL. Regardless of the limiting nutrient, there is no discussion on nutrient management strategies in the TMDL. Similar to a previous comment on the lack of defining trophic status through the system (Page 4-2, Paragraph 3), that lack of a clear nutrient management strategy (e.g., N:P ratios and seeking a limiting nutrient to manage) provides little direction for successfully attaining water quality improvements within a TMDL framework.

Page 4-4, Paragraph 2, Lines 5-6. As stated in the comment above (Page 4-2, Paragraph 3), eutrophic is a state of a water body and "improving" a eutrophic condition has little meaning. In reality the river shifts to a lower trophic status. However, even here the trophic condition varies dramatically in space and time. The dynamic nature of the Klamath River longitudinally, through seasons and under different hydrologic year types (and in particular under periods of multiple drought years) is not addressed in the TMDL. This speaks to the inadequate period of analysis (only year 2000) and the inherent limitations associated with such an approach in a complex and highly dynamic system such as the Klamath River.

Page 4-4, Paragraph 3, Line 6. Alkalinity serves as a buffer if it is naturally in the water or introduced into the water through other means.

Page 4-4, Paragraph 1, Lines 6-7. The Draft TMDL states that "…the upper Klamath basin was characterized by high levels of nitrogen and phosphorus demonstrating the high natural background loading of nutrients." Here the Draft TMDL clearly admits that the upper Klamath Basin and Upper Klamath Lake has long been known for natural eutrophic conditions and high levels of organic matter. Upper Klamath Lake is the source of the Klamath River, and provides those eutrophic conditions and high loads to the Klamath River. Therefore, the Draft TMDL's recognition of this high natural background loading of nutrients fundamentally contradicts the Draft TMDL's allocations that assume and set "natural" conditions in the Klamath River for nutrient concentrations that are in the oligotrophic to mesotrophic range. See Figures 2.16 and 2.17.

Page 4-4, Paragraph 4, Line 2. Solar radiation, not air temperature, results in high heat load to the river.

Page 4-5, Footnote 2 Please correct "biological oxidation" to "biochemical oxidation."

Page 4-5, Paragraph 2, Line 1 (and Figure 4.1). Only loads from 2000 are taken into consideration, while loads almost certainly change from year to year. The lack of assessment of inter-annual variability in the draft TMDL provides no measure of, for example, interpreting reservoir benthic loading impacts because there is no information on year-to-year variability and an understanding of the range of potential conditions. Based on data in Figure 4.1, total phosphorus benthic loads in 2000 are a little over 1 percent of the load at Stateline. The range in benthic loads is probably small – reservoir stage is fairly constant year-to-year, the reservoir stratifies each year, and the reservoir experiences anoxia in the hypolimnion every year (albeit with some variability). However, the natural inter-annual range in total phosphorus at Stateline is probably considerably larger than the entire benthic load, not to mention the uncertainty in data and model runs etc. The TMDL simply lacks the technical rigor in the categories of inter-annual variability, sensitivity analysis of numerical tools, and overall uncertainty analysis to formulate robust load allocations and provide a strong basis for implementation actions.

Page 4-5, Paragraph 2, Line 6. Without the associated flow data in the Klamath River, Figures 4.1 through 4.3 lack a basis for identifying the value of tributary contribution in the form of direct dilution. That is, representing pollutant loading in terms of total annual mass is misleading. As the arrows get bigger moving downstream, it suggests that the river water quality is getting worse. However, the opposite is true. It would be useful to present the pollutant loads in terms of concentrations as well.

Page 4-5, Paragraph 2, Line 7-8. Why is the "total annual mass" used to quantify the pollutants? A large total annual mass may not significantly impact the water quality of the river if it is adequately diluted. Further, the main concern in the Klamath River is the problematic summer months, so a seasonal distribution of these pollutant loadings would be more useful, i.e., not just May through October, but monthly June through September.

Page 4-6 to 4-8, Figures 4.1-4.3. There is no discussion about the reductions in all three figures through the reservoirs. At a minimum, clear identification of in reservoir processes that reduce loading to downstream reaches would be important for near-term implementation strategies to ameliorate water quality impairment. Also, the figures report data to single pounds and single kilograms. This is misleading to the reader that the analysis is accurate to this level. Because there is no uncertainty analysis in the draft TMDL, there is no method for determining the appropriate significant figures in these figures or in Table 4.2.

Page 4-6 to 4-8, Table 4.2. As noted above, the data presented in the Table 4.2 (and Figures 4.1-4.3) suggests accuracy to single pounds, which suggest greater accuracy in the analysis than can possibly exist. The table does not represent the net reservoir benthic load from the sediments. Benthic load shown here is only that portion that emanates from the reservoir sediment under anoxic conditions. However, the reservoir also acts as a trap for organic sediments. Thus to assess the net effect of the reservoir both the accumulated flux of phosphorus to the bed (phosphorus in organic matter, sorbed to particulate matter) and from the bed should be presented. That is, the bed is also accumulating and storing phosphorus (and other nutrients) as well and should be included in the calculation. Correctly accounting for this will result in the already small loads identified in the TMDL being further reduced and becoming negative, i.e., reservoirs as net sinks.

Using values listed in Table 4.2 and assuming "Stateline to Iron Gate" inputs are loaded at Jenny Creek in Iron Gate reservoir, natural loss (no reservoirs) is greater than current loss (with reservoir) in location of Iron Gate reservoir. The loss (or load unaccounted for) in this reach for the natural condition baseline is approximately 48,000 lbs, while loss under existing conditions is approximately 31,000 lbs, calculated using values rounded to thousands of pounds as:

Natural loss = Copco out + Jenny Cr in + "sediment flux" - Iron Gate out
= 105+60+0-117 = 48 (thousand lbs)

Current loss = Copco out + Jenny Cr in + "sediment flux" - Iron Gate out
=702+60+4-735 = 31 (thousand lbs)

It seems counter intuitive that under natural conditions the loss is 50 percent greater when no reservoir is present to trap material.

A comparison of CBOD at Stateline under current and natural baseline conditions is approximately 55 percent and approximately 35 percent of the Trinity River CBOD load, respectfully. This is difficult to believe given that the Trinity River borders on mesotrophic to oligotrophic status and the Klamath River at Stateline is clearly eutrophic. This probably stems from using the reporting limit or method detection limit for CBOD when non-detects are encountered in the data. Clear documentation of how censored data were used in the construction of Table 4.2 is necessary in the TMDL documentation to effectively interpret these figures and table.

Page 4-9, Table 4.2. There is no explanation through data or citations for the magnitude of the loads attributed to Copco and Iron Gate reservoir. The total (presumed) sediment load from the reservoirs listed in this table amounts to 0.5% of the total load from other sources. This small percentage likely is well within the error of the model and thus indistinguishable from zero. This error and associated uncertainty should be provided to the reader. Presentation of data in this table to a precision of single pounds appreciably overstates the precision of the model. The TMDL provides no information about the precision of the model for any constituent.

4.2 Pollutant Source Area Loads

Page 4-11, Figure 4.4 Title should specify this data as daily maximum temperature.

Page 4-11 and 4-12, Figures 4.4 and 4.5. These graphs show only the difference between two model runs, with no reference to the actual temperatures. Without knowing the actual temperatures, it is impossible to adequately address the statements in the text. Secondly, Figure 4.4 shows the results of temperature comparison with no indication of what time scale is present, is this a daily maximum, a daily mean, a daily minimum, a running mean of some number of days...? Thirdly, these are comparisons of the output of two model runs. If the expected accuracy of the models is +/- 2 ºC, then a difference of 4 ºC might be due to fluctuations in the model only. This error and associated uncertainty should be provided to the reader.

Page 4-11, Paragraphs 1-3. Discussion of Fig 4-4 is confusing. There seems to be a distinction made between "discharge of irrigation return flows" and "impacts caused by irrigation diversion." Please clarify. Also, are the temperatures of return water from KSD and LRDC the same in natural and current conditions? If not, these should be clearly identified as sources of potential heat. A more fundamental issue is that temperature is one of the least conservative constituents because of the constant heat exchange across the air-water interface. There is no discussion of (a) if the river is at or near equilibrium temperature for this assessment (Figure 4.4), but presumably it is, (b) if the return flows from irrigation are at or near equilibrium, presumably they are, (c) the volume of irrigation return flows compared to the receiving water, and (d) the distance from Stateline to these return flow points is notable. The river will seek equilibrium temperature and this may make any difference in irrigation return flow negligible. A more focused discussion is necessary to interpret these results.

Page 4-12, Paragraph 1, Lines 5-15. An exceedance curve of deviations would be a valuable addition to assess these data. Although positive differences as much as 1.5°C occur, this is only one day in 365. The remainder of the differences is less than 1°C. Further, an exceedance plot would also illustrate the number of days when deviations were positive (warmer) and negative (cooler). However, without a quantification of uncertainty, data interpretation is challenging. Using information from Watercourse (2006) for temperature model simulations on the Klamath River below Iron Gate Dam, model uncertainty is probably on the order of 1°C (a function of time of year and location).

Page 4-12, Paragraph 2, Line 2. TP and TN loads include algae, correct?

Page 4-13, Figure 4.6. There is no supporting data or detailed documentation in the Draft TMDL document for the derivation of "natural conditions" baseline presented in these graphs. What are the flows and concentrations that make up these loads? It is especially confusing that the total phosphorus load is presumed to have increased nearly six-fold when the difference between "current" conditions (based on actual data) and "natural" conditions (based on groundwater and tributary streams) is only about two-fold. For example, the current average total phosphorus concentration in the Klamath River in the vicinity of the Project is about 0.18 mg/L. Assuming 0.18 mg/L is six-fold greater than "natural" conditions would require a "natural" concentration of 0.02 mg/L (assuming same flows). A total phosphorus concentration of 0.02 mg/L is unrealistic for this river, even substantially lower the current total phosphorus concentration in "natural" groundwater (at the J.C. Boyle bypass reach).

It is important to enumerate the load reduction for TP, TN, and CBOD (OM) required by Oregon to attain natural baseline conditions at Stateline. Over 300K pounds of the 700K pounds of phosphorus is from Stateline and above. Over 1.4 million pounds of the 3 million pounds of nitrogen is from Stateline and above. Almost 6 million pounds of the 14 million pounds of CBOD is from Stateline and above.

A range of years would provide considerable insight to the potential variability and ranges of loads. Also, should simulation from 2000 be applied for a TMDL that will be completed a decade later? Have UKL TMDL implementation actions improved water quality in the six years since adoption of that TMDL? At a minimum an assessment of available data should be carried out to assess current conditions at UKL and determine if indeed improvements have been observed. Such information would be useful to include in the Klamath River TMDL because if loads have been reduced (or increased, or stayed the same…or simply experienced a range of conditions) at Link Dam this would directly affect load allocation determination.

Page 4-13, Paragraph 1. In discussing Copco and Iron Gate it would be useful to see a graph and table showing current condition loads attributable to the other two sources discussed in this TMDL - these are California tributaries and reservoirs. PacifiCorp believes that reservoirs contribute no net load of either total phosphorus (TP), total nitrogen (TN), or organic matter (OM). Since the argument for nutrient load reductions in the reservoirs is that they change the "timing and form" of nutrients, perhaps these tables and graphs should show net load.

Page 4-13, Paragraph 1, Lines 6-11. The discussion on the Klamath Project nutrient load reductions is an important element of the TMDL and should be presented more fully herein. Please define annual and seasonal reductions/increases. There seems to have been an analysis or data review but the information is not reported in the draft TMDL and no references are cited. Although there is reference to the Lost River TMDLs (Oregon and California), a comprehensive assessment is not included in those documents. This seems to be a critical omission.

Page 4-13, Paragraph 2, Lines 3-4. The draft TMDL states that the analysis isolated the effects of each reservoir. However, review of the data indicates that this was only completed in a simplistic fashion. The conclusion is: the difference calculations actually do not isolate the reservoirs, but actually assess the impact of the reservoir and any upstream reservoirs. Thus, the results for Copco reservoir (Figure 4.7) include operations and effect of J.C. Boyle reservoir, and the results for Iron Gate Reservoir include operations and effects of Copco reservoir and J.C. Boyle reservoir. The results presented in the TMDL are incorrect and misleading.

Page 4-14, Paragraph 2, Lines 5-6. The Draft TMDL states that "…the presence of Copco Reservoir can increase Klamath River water temperatures by more than 5.4°F…." This is a misstatement of the facts. There is no "increase" in temperature; there is a change (of a week or two) in the time of year that a given temperature occurs in the river. The TMDL must be clear about this because the effect of an actual increase in temperature of 5.4°F could have a substantially different effect than a change in timing of existing temperatures. The TMDL has presented no data or locally relevant citations to support the notion that a shift in time of certain temperatures has had a demonstrably adverse effect on beneficial uses.

Page 4-14, Paragraph 3, Lines 6-8. Same comment as previous. The maximum temperature does not increase. Instead, the timing of the maximum temperature shifts.

Page 4-14, Figure 4.7 and elsewhere. Presenting only differences and not actual model simulated temperature (or other constituents presented in this manner in Chapter 4) provides limited insight to the reader as to the relative impact of the difference given the actual temperature or concentrations in the aquatic system. Please include the actual temperature plots of the two scenarios in addition to the difference between scenarios.

Page 4-15, Paragraph 2, Lines 4-6. The Draft TMDL states "…Copco reservoir heats the water…." This statement is false. Copco reservoir does not heat the water, the sun and the air (through radiation and convection) heat the water. This distinction is important because it biases the discussion of possible alternatives.

Page 4-15, Paragraph 2, Lines 1-9. On Page 4-14, the draft TMLD states that Copco Reservoir can increase water temperatures by more than 5.4°F. On page 4-15, the draft TMDL states that Copco can increase temperatures 6.3°F. Please clarify. The discussion of Copco Reservoir heating water "to a level close to equilibrium is erroneous" is vague and largely misleading. First, there is no analysis of equilibrium temperature conditions within the Klamath River upon which to base this discussion. Equilibrium temperature, by its very nature is highly dynamic in space and time, though monthly average estimates of equilibrium temperature could provide keen insight into system conditions. Second, review of available data would suggest that the springs below J.C. Boyle provide relatively cool waters in summer, relatively warm waters in winter, and have a more modest affect in the spring and fall when upstream river temperatures are similar to spring flow temperatures (PacifiCorp 2006). This influx of groundwater can thus impose a deviation below local equilibrium temperature during summer periods, but the question remains: are inflow waters to Copco Reservoir at equilibrium. Modeling associated with the Project FERC relicensing (PacifiCorp 2008a) suggests that inflowing waters are approaching equilibrium temperature by the time the reach Copco Reservoir. The next question is that if they are not at equilibrium (in summer) what is their fate in Copco? To answer this we need to look at a third point: stratification. If the discussion is restricted to certain months of the year (e.g., late spring through early fall) when Copco reservoir is stratified (as noted on page 4-16 in the draft TMDL) there are a wide range of temperatures vertically distributed in Copco reservoir. Inflowing waters will seek similar densities and some will be lost to mixing imparted due to inflows and density driven flows (Fischer et al, 1979). Thus, notably colder waters will sink to greater depths while warmer waters will intrude into near surface layers of the reservoir. Therefore, defining equilibrium temperature for a stratified reservoir is not a valid approach. Defining equilibrium temperature for a river is straightforward because the assumption of vertical and lateral mixing can be applied. Further, the TMDL is based on natural conditions and thus any reference to equilibrium temperature should be based on the local river setting. Finally, the statement that "the "water is close to equilibrium when entering Iron Gate Reservoir" is misleading. Water entering Iron Gate reservoir is likely slightly cooler than equilibrium temperature of the river at this location until midsummer, then probably warmer than equilibrium temperature of the river until some time in the fall (PacifiCorp, 2006(a)). Otherwise there would be no fall thermal lag as identified in Figure 4.7 and 4.8. This is a lengthy comment, but it is necessary because the draft TMDL identifies that the "concept of equilibrium temperature is taken into account and addressed in the temperature load allocation and implementation recommendations for these facilities." However, it is apparent that the TMDL assessment of temperature is based on a simplistic and incorrect set of arguments.

Page 4-15, Paragraph 4, Lines 1-2. There is no presentation of existing dissolved oxygen conditions to support this first sentence. Providing a chart of the dissolved oxygen conditions in Copco 1 and 2 and Iron Gate Reservoirs through the year with associated volume would be beneficial. Labeled on the chart should also be the required water quality standards. This statement could be supported by field data as well to get around the fact that only the year 2000 was modeled for the TMDL. Such data would also illustrate the inter-annual variability in volumes of water where dissolved oxygen conditions are undesirable.

Page 4-16, Paragraph 1, Lines 10-12. Temperature and dissolved oxygen conditions under existing and natural conditions scenarios are not presented for critical summer periods in the Copco and Iron Gate Dam reaches, nor are associated standards. Presentation of this information is required to support the statement that co-occurring dissolved oxygen and temperatures would meet standards under natural conditions. (It is not clear if this sentence refers to a "natural free flowing condition" or the TMDL natural conditions baseline – if there is a difference.)

Page 4-16, Paragraph 2, Lines 1-4. Internal nutrient loading in stratified reservoirs does little to exacerbate dissolved oxygen conditions because for internal loading to occur, anoxia must be present. Anoxia occurs primarily because of seasonal stratification and is largely driven by organic matter loading and sediment oxygen demand. Resulting loading from the sediments is generally limited to the hypolimnion. When the reservoir attains an isothermal condition in the fall, dissolved oxygen conditions are typically no longer of concern. Likewise any available nutrients that were contributed from the hypolimnetic volume during turnover are of minimal consequence because the shorter days and cooler temperatures limit algal growth. Copco and Iron Gate Reservoirs have very short residence times in the winter due to the relatively small storage, large inflows, and isothermal condition, so carryover of hypolimnetic nutrients from one season to the next is most likely insignificant.

Page 4-16, Table 4.3. Table states period is from May 2004-May 2005, while text refers to May 2005-May 2006. Likewise, annual values in table do not correspond to annual values in text, and it would be helpful to present all data in days or years, or both. Please clarify that these are "compromise" values (Appendix 2, section 3.2) used in analysis. How any of these values for residence time were determined is not described here or in Appendix 2. Residence time information is readily available from the CE-QUAL-W2 models of the reservoirs in model output.

Table 4.3 Hydraulic Parameters for Klamath Reservoirs (May 2004 – May 2005)

Impoundment	Residence Time (*T*, yrs)	Mean Depth (*z*, m)
Copco	0.0384	11.7
Iron Gate	0.0484	16.6

Page 4-17, Paragraph, Bullet points. The listed bullet points are largely not applicable to Iron Gate and Copco reservoirs, and the implications of internal loading on these reservoirs should be explained in the context of their physical and chemical characteristics. Basic processes information can be found in any basic limnology textbook and readily presented in light of conditions at Copco and Iron Gate reservoirs. Specifically, anoxia occurs primarily because of seasonal stratification and is largely driven by organic matter loading and sediment oxygen demand. Resulting loading from the sediments is generally limited to the hypolimnion. When the reservoir attains an isothermal condition in the fall, dissolved oxygen conditions are typically no longer of concern. Likewise any available nutrients that were contributed from the hypolimnetic volume during turnover are of minimal consequence because the shorter days and cooler temperatures limit algal growth. Copco and Iron Gate Reservoirs have very short residence times, on the order of days, during elevated flow conditions in winter due to the relatively small storage, large inflows, and isothermal condition, so carryover of hypolimnetic nutrients from one season to the next is most likely insignificant. This is an important distinction of the Klamath River reservoirs: lakes with longer residence times allow nutrients from the hypolimnion to mix throughout the entire water column during the fall and the onset of stratification in the subsequent spring captures some of these nutrients in the epilimnion making them available for primary production. Through time this cycle can shift a reservoir from a lower trophic state to a higher trophic state (i.e., eutrophication). Loading from the sediments is just over one percent of influent loads (as shown in Figures 4.1 to 4.3) and does not contribute widely to the reservoir water quality impairment (nor does it affect the river downstream to an appreciable degree because the contributions are small and any increases will occur later in the year during the waning periods of the annual algae growth season).

Before addressing each of the five bullet points, it should be noted that all of the process may happen somewhere in a lake or reservoir or river, but the important question is whether they are driving water quality conditions in these reservoirs.

- Bullet 1 – Wind driven currents are important in water quality and mixing considerations in lake environments. However, sediment disturbance by wind is a process that is more of a factor in shallow lakes. Copco and Iron Gate reservoirs are impoundments located in steep canyon areas and thus are deep with sloping sides. Because they are maintained at stable levels for hydropower purposes, macrophytes tend to ring these reservoirs dissipating wind energy and minimizing resuspension of sediment. This process (along with degassing and bioturbation) is probably small in the reservoirs.
- Bullet 2 – This bullet point describes the basic process of sediment release under anoxic conditions.
- Bullet 3 – High pH at the sediment surface may affect sediment flux, but under anoxic conditions pH is typically low under reduced conditions in the reservoir bottom waters. Both Copco and Iron Gate bottom waters during summer have pH values typically below 7.5 and sometimes well below 6.0. This may occur in shallow margins areas of the reservoir, but is probably not a dominant process.

- Bullet 4 – This bullet point erroneously suggests that shallow lakes experience seasonal stratification. Shallow lakes (e.g. Upper Klamath Lake) do not experience seasonal stratification because wind mixing imparts sufficient energy into the system to overcome density differences. The result is that shallow lakes often have weak, intermittent stratification, but not persistent stratification. Important to this discussion is that even short duration, weak stratification can produce anoxia and sediment nutrient release, which under subsequent mixing conditions can be introduced into the photic zone and support primary production. However, the main stem reservoirs are deep and experience strong seasonal stratification that precludes this condition from representing a dominant process.
- Bullet 5 – Reservoirs can produce large standing crops of BGA that are nitrogen fixers. However, nitrogen fixation does require energy and there has been no analysis to date if this process is occurring. The mere presence of heterocysts is not conclusive of actual nitrogen fixation. In addition, both reservoirs experience the persistent presence of considerable standing crop of both non-nitrogen fixing BGA (e.g., *Microcystis*) and nitrogen fixing BGA (e.g., *Aphanizenmenon*) which suggests that this is not a dominant process in the Project reservoirs.

In sum, these are valid points for UKL, but in the context of Chapter 4 discussions, they appear to be aimed at PacifiCorp reservoirs, where they are not readily applicable in describing dominant water quality processes. From an internal loading perspective, the critical process of fall turnover to reintroduction nutrients to the near-surface waters from deeper waters is not even mentioned in the draft TMDL. As noted above, the short residence time of the reservoirs in winter indicates that these nutrients would be exported downstream and not have notable carryover effects on water quality in subsequent years. This comment reflects an overall concern with the TMDL - that Regional Board staff may not fully grasp the complex inter-relationships at work in the Klamath River and reservoir reaches and are oversimplifying critical components in the TMDL analysis, leading to inappropriate load allocations.

Page 4-17, Paragraph 4. This analysis of benthic flux does not use a standard “control volume” approach. The analysis only estimates flux from the sediments into the water column and there is no discussion of nutrient flux to the sediments through settling and retention in the reservoirs. This has little meaning when evaluating the net effect of reservoirs on nutrient flux. Also, because comprehensive sediment diagenesis is not included in the models, benthic flux as represented in the model accounts for uncertainty from a number of different processes. Net reservoir benthic flux may be negative, i.e., a net loss of nutrients.

Page 4-18, Figure 4.9. Review of draft TMDL Appendix 6, Appendix K illustrates that DO plots for model calibration can readily be used to define the “critical growth period.” Specifically, the diurnal range of DO is minimal (well under 1 mg/L) until approximately mid-May. Subsequently the diurnal range begins to expand notably at sites throughout the Klamath River, wherein the diurnal range may extend from less than 2 mg/L to over 4 mg/L through August. As solar altitude and day length decrease more rapidly by mid-August, all traces show a reduction in diurnal DO, indicating the seasonal reduction in standing crop. By the end of September there is little or no diurnal range in DO. Important in assessing this information is that after approximately early-to mid-August the decline in standing crop may still produce notable diurnal variation in dissolved oxygen and pH, but that additional nutrient loading will most likely have minimal impact because standing crop is being constrained by light limitation (day length). Thus by early- to mid-September, by a conservative estimate, increased nutrient loading as shown in Figure 4.9 will have a negligible biostimulatory effect on standing crop. Figure 4.9 clearly indicates that much of the load will occur well outside of the biostimulatory period– on the order of half the load occurs after October 1. Further, these very modest increases in concentration prior to that date (typically less than 0.005 mg/L) are probably having little effect on a system that is typically nitrogen limited from June -September. In sum, the statement in paragraph 2 stating this "increase in bio-available phosphorus occurs during the growth period (see subsequent comment), contributing to biostimulatory conditions downstream of the reservoirs" is misleading because much of the load occurs after the growth season and is probably an overstatement of impacts. Further, any impacts of this small increase identified in Figure 4.9 on biostimulatory conditions downstream are not quantified and would probably have little or no effect due to the naturally elevated levels of phosphorus in the Klamath River system.

Page 4-19, Paragraph 3: Role of Copco and Iron Gate Reservoirs in Klamath River Nutrient Dynamics. To reiterate earlier comments, the TMDL definition of the critical growth period from May through October masks critical intra-seasonal dynamics in the Klamath River. Reservoirs do affect both timing and form of source load. Discussions have focused on annual or six month loading assessments presented in the draft TMDL and have missed critical within season dynamics. The fundamental flaw in this analysis is the omission of carefully examining TMDL model outputs which clearly show that the reservoirs dramatically reduce large nutrient pulses emanating from Oregon (in response to bloom conditions in UKL).

As described in detail in section III.D of the cover document preceding this appendix, PacifiCorp's water quality modeling consultant (Watercourse Engineering) performed model runs (using the Draft TMDL models recently obtained from Tetra Tech for review) that clearly show that TP and TN loads at Iron Gate dam are substantially lower under current conditions than under conditions assuming the dams are absent. This is due to the significant retention and loss of inflowing organic matter in the reservoirs that would not occur without the reservoirs.

As described in detail in section III.D of the cover document preceding this appendix, the peak nutrient loads coming from upstream sources are also shifted later into the fall than would occur without the reservoirs. This shift into the fall is important because, with dams in place, nutrients tend to leave the reservoirs later in the season after benthic algae standing crop in the river has started to diminish.

The simulation models used in the Draft TMDL have the ability to effectively characterize the impacts of the reservoirs on the dynamics of nutrient loads, but have not been used in the Draft TMDL to more fully account for these important processes. Detailed discussion of nutrient dynamics in the project area presented in detail in PacifiCorp (2006) provides additional information based on both model results and field data, none of which was referenced in the draft TMDL.

Page 4-19, Paragraph 5, Lines 10-11. Why would the TMDL model retention "not account for nitrogen exported downstream within living biomass?" All nitrogen forms (including algal biomass) are included in model output and the calculation is straightforward. Clearly, reservoirs can retain significant amounts of nutrients, all methods cited, and overall the table on page 4-20 represents clear positive retention, yet this information is not used in the TMDL to identify any positive implications the reservoir may have on nutrient conditions in the system. Finally, the terminology identified herein should be defined: a certain portion of nutrients entering the reservoir are lost through sedimentation and denitrification, while others are retained, but may be exported in a future time period. Please clarify terminology and consider quantifying loss versus retention to allow more complete consideration in TMDL analysis. (see also comment Page 4-19, paragraph 3: Role of Copco and Iron Gate Reservoirs in Klamath River Nutrient Dynamics).

Page 4-20. Table 4.5. Given the above discussion, it appears that the information in this table is incomplete – failing to capture considerable reductions during critical periods of the year. Presenting annual and semiannual (or longer) averaging periods and failing to account properly for travel time serves to significantly reduce beneficial impacts the reservoirs have on water quality. The simple model simulation exercise of placing the TMDL existing conditions (with dams) boundary conditions into the TMDL natural conditions baseline (no dams) indicates that the reservoirs have a profound impact on water quality all the way to the estuary in late-spring well into summer – the most critical period of primary production in the river. These findings indicate that reductions above Stateline need to occur early in the process and are paramount to any successful implementation actions in California.

Page 4-20, Paragraph 1 and Table 4.5. The Draft TMDL cites Kann and Asarian (2009); however, Kann and Asarian (2009) is only a Powerpoint presentation of preliminary information that specifically states "do not cite". In addition, the information presented in the Draft TMDL includes information that is not included in the Powerpoint presentation. The report by Kann and Asarian (2009) is not available. The Draft TMDL should delete reference to this information unless and until a report has been made available for public review. There have been substantial flaws with previous nutrient loading analyses by these authors (i.e., Kann and Asarian 2005, Asarian and Kann 2006, Kann and Asarian 2007) as described in PacifiCorp (2006), PacifiCorp (2008b), and Butcher (2008).

Page 4-20. Bullet Points.

Bullet 1 – The section addresses nutrients, but bullet 1 discusses oxygen allocations and implications for fisheries. This point is out of place or needs additional information to make it relevant to this section. Further, the draft TMDL is vague about where and when oxygen depletion occurs and which fishery (COLD or WARM) is affected.

Bullet 2 – Two useful points are presented herein. First, that excessive nutrient loads from upstream are responsible for biostimulatory conditions. Second, that a reservoir environment is a biostimulatory condition. The draft TMDL states that the reservoir condition creates impairment, without considering the ability of the reservoirs to reduce upstream nutrient loads that would create additional impairment downstream of the reservoirs if not retained. Benthic chlorophyll *a* targets will probably not be met in river reaches, indicating that even under extreme nutrient reductions (as presumed under the natural conditions baseline) challenges will remain. Thus, stating that the reservoirs cause the impairment is arbitrary.

Bullet 3 – The nutrient retention and export information in Table 4.5 is insufficient and misleading. Reservoirs provide substantial benefits and retention and loss plays a dominant role in regulating the amount and timing of nutrient loads downstream. The implications of markedly increased nutrient loads under the dam removal condition (natural baseline) on river reaches and the estuary needs to be more comprehensively and accurately assessed to determine implications of dam removal prior to achievement of TMDL goals.

Further, a more comprehensive and appropriate representation of actual reservoir dynamics in the TMDL would allow better assessment of potential implementation actions and key intermediate milestones en route to compliance.

Page 4-21. Paragraph 2 (before section 4.2.3), line 3. Oxygen deficits are presented here as if they occur throughout the reservoir during summer months. The TMDL should identify the location where deficits occur, e.g., hypolimnion..

Page 4-21, Paragraph 3, Line 7. There is a serious error in calculation of flow through the hatchery reported here. Actually, 16.1 mgd really equals 24.9 cfs, not "1,494.6 cfs".

Page 4-21. Paragraph 4, Lines 6-9. Average flows through the hatchery are less than 50 cfs with maximums up to approximately 50 cfs. The draft TMDL states that average flow through the hatchery are 1,494.6 cfs and maximum flows are 2,961.4 cfs.

Page 4-21. Paragraph 6, Lines 2-3. Please contact California Department of Fish and Game staff at the Iron Gate Hatchery. They have twice daily temperature readings which they use to manage water supply and temperature for the hatchery.

Page 4-22, Paragraph 1, Line 6. The Draft TMDL states here that the average flow in the hatchery is 7.5 mgd, but on page 4-21 it says the average flow through the hatchery is 16.1 mgd.

Page 4-22, Paragraph 2, Line 4. On page 4-22 the average flow through the hatchery was stated as 16.1 mgd, yet here it is stated at 7.5 mgd, considerably smaller.

Page 4-22, Paragraph 3, Lines 1-5. No data are presented for the hatchery discharges, not even the difference. The only information provided is the p-statistic for the statistical test applied. Further the Mann Whitney U Test is to assess if two populations are different and not to assess the differences between two populations.

Page 4-23, Paragraph 2 and 3. What are the Klamath temperatures used in these calculations? From these two paragraphs, it seems as if there might be two different sets of Klamath temperatures (natural conditions and CA compliant conditions) used in evaluating the impact of the tributaries. Analysis would be clearer if only one set of Klamath River temperatures were used and the scenarios just reflected changes to tributary temperatures. Hopefully, that is what was done, but this is not clear. Adding to confusion are figure captions that describe tributary compliant or tributary natural conditions (e.g. "Figure 4-10 "Shasta TMDL compliant Shasta River conditions") implying that only the tributaries had these conditions applied. Please clearly identify the source of Klamath River temperatures (natural or compliance conditions) used in these calculations. It would be useful to add this information to the figures, as well.

Page 4-23, Paragraph 4. The draft TMDL states that the California compliance scenario represents full compliance with the Shasta and Scott TMDLs and the Trinity ROD in the first sentence. The subsequent sentence states that for the "Shasta, Scott, and Trinity Rivers natural temperature estimates are meant to depict the absence of all anthropogenic impacts, representing full natural flows and site potential riparian conditions." These two sentences appear to be in conflict. For example, is the Regional Board staff defining the Shasta and Scott River TMDLs as implementing "natural" conditions for flow and temperature. The TMDL analyses for these tributaries should be used. For the Trinity River, ROD flows and associated temperatures should be used. There is no discussion of climate change, an important consideration in a TMDL that will take decades to implement.

Page 4-23, Paragraph 5. The Shasta River TMDL has a flow recommendation, but this information is not provided. No flow information (unlike the Scott River presentation) is provided. Determining loads without flow information provided is not feasible. This comment applies to the Salmon, Trinity, and minor tributaries as well.

Page 4-23, Paragraph 5. The draft TMDL identifies that "there is only a small difference" between the two scenarios in response that the Shasta River may warm the river in fall months. Throughout the TMDL, qualitative terms such as "slight difference," "negligible," "small," etc. are used to describe differences or results of analyses. These terms are vague and subject to different interpretation. Identifying a metric, most usefully based on model uncertainty, and examining results in a more rigorous manner (e.g., a basic exceedance plot), would provide considerably more information and form a more robust assessment. For example, if uncertainty analysis identified that the model was accurate to within 0.5°C, then an exceedance plot of the differences could be constructed and the probability of differences over 0.5°C could readily presented consistently throughout the entire document. Chapter 4 is filled with plots of differences that provide little analytical value (particularly because there are no tabular statistics on the differences, the scales are such that quantitative interpretation is difficult, and the data sets used to calculate the differences are not provided) and are left to subjective interpretation. This approach is insufficient to support a technical TMDL.

Page 4-24, Figure 4.11. Because model uncertainty was not quantified, these results cannot be interpreted in a meaningful manner. Further, when notable discrepancies occur, such as in November, some discussion in the text should follow. Why would fall temperatures be so much warmer under a TMDL compliance condition than under existing conditions? Lack of interpretation and investigation of model output throughout the draft TMDL, i.e., why discrepancies occur, suggests that the models may have been used as "black boxes" with emphasis on the final model output and minimal regard to why the values are what they are.

Page 4-24, Paragraph 1, Lines 1-3. The draft TMDL states that daily average temperatures regularly exceed 20 °C in the Klamath River. No figure is provided, no data presented. When does this occur? The river is not warm year-around. This begs the question of: what is the temperature of the Shasta River that makes it too warm to be a thermal refuge during summer months?

Related to this point is the definition of a thermal refugia. What is the definition for the purposes of the TMDL? It appears that Regional Board staff have made a determination that

20°C defines a thermal refugia. This is based on the statement that "temperatures above 20°C (68°F) have been shown to inhibit adult Chinook migration." Referring to seminal work by Strange (2006), "[R]esults from 2005 supported the conclusion from previous study years that the thermal threshold for migration inhibition for KRB adult Chinook occurs at mean daily water temperatures (MDTs) of 23.5°C during falling water temperature trends, at MDTs of 21.0°C during rising water temperature trends, and at MDTs of 22.0°C during stable temperature trends." (page 5) Further, this definition of a refugia would thus be based on adult migration and not over-summering juveniles. This designation of thermal refugia is insufficient.

Considerable thought has been given to the definition of thermal refugia and a single temperature is insufficient. Refugial areas in the Klamath River require several key attributes:

- persistence and stability (at a minimum these features must be continuously functional during the late spring through summer period).
- fish utilization (habitat, which may differ among species).
- appropriate temperatures for species present (each species may have a different thermal tolerance).
- appropriate flow (this may or may not include connectivity to the mainstem, but this is determined on a case-by-case basis. Protection of the watershed baseflow is critical).
- meteorological considerations (affects tributary stream temperatures as well as mainstem Klamath River)

Reclamation funded a four year study of thermal refugia in the Klamath River below Iron Gate Dam. This work was guided by an ad hoc science committee (USFWS, DFG, Yurok Tribe, Karuk Tribe, and others) which met each year prior to field season to provide review of study methods and results and input on study plans and flow schedules. The work was carried out cooperatively with the Yurok and Karuk Tribes, Watercourse Engineering, and Reclamation. Multiple thermal refugia were investigated representing upper river (Beaver Creek), middle river (Elk Creek) and lower river (Red Cap Creek). Intensive field surveys included mapping bed forms and fish counting polygons, collecting local velocities, extended period temperature monitoring, meteorological observations, exploring water temperatures in regions of upwelling, and extensive fish counts. In addition, many other creeks and areas were explored to further an understanding of refugial areas. Aerial FLIR was also implemented to capture a snapshot of a large number of potential refugial areas. All of the documentation associated with this work, as well as other associated literature, was supplied to Regional Board staff in April in response to a request for information. A brief summary based on this four-year Reclamation supported effort is included in Attachment B. In sum, the thermal refugia representation is not defined in the draft TMDL, and thus a quantitative approach to assessing refugial areas cannot be completed. There is considerable literature specific to the Klamath River available to draw from, but these sources were not considered in the TMDL analysis.

Page 4-25, Figure 4.12 Please provide year of the data (presumably 2000). Providing a range of years will also be useful for comparison. A more comprehensive presentation of the Shasta

River analysis is required. This figure presents information, but there is no technical appendix outlining approach, assumptions, or presentation of data. There is no quantitative discussion of uncertainty (Chapter three states the Regional Board staff have "moderate confidence" in the results, which in a technical TMDL has no meaning). Further, recent work in the Upper Shasta River (Jeffres et al 2008, Jeffres et al 2009) should be considered in the TMDL for natural conditions baseline. Jeffres et al (2009) identifies that assumptions basic to the cold water determination on the Shasta River were overstated. More recent studies indicate that spring temperatures at Big Springs Creek are probably between 2 and 4°C warmer than assumptions in the Shasta River TMDL. Further, these studies have identified severe limitations to riparian shading for extended reaches of the Shasta River due to soils conditions. These important findings indicate the Shasta River TMDL temperature analysis should be revisited. Available data suggest that water temperatures under an implemented TMDL for the Shasta River are probably too cold in the Klamath River TMDL analysis.

Page 4-25, Paragraph 2. A more comprehensive presentation of the Scott River analysis is required. There is no technical appendix outlining approach, assumptions, or presentation of data. There is no quantitative discussion of uncertainty (Chapter three states "there is uncertainty associated with those estimates," which in a technical TMDL has no meaning). Interannual variability is not discussed, but is considerable throughout the Klamath basin.

Page 4-27, Paragraph 1, Lines 1-4. See comment Page 4-24, Paragraph 1, Lines 1-3.

Page 4-27, Paragraph 1, Lines 4-6 and Figures 4.16 and 4.17 (page 4-28). This discussion of appropriate Scott River temperatures, boundary conditions and thermal refugia is unclear and confusing. Why are thermal refugia discussed herein and not under a separate section? Also, it is unclear what boundary conditions were finally used and why. There are limitations of the additional analysis conducted by Regional Board staff that indicate natural flows are overestimated and temperatures underestimated. Figure 4.17 provides a more likely estimate, but was this used in the TMLD analysis? Are Figures 4.13-4.15 ultimately used in any analysis? For Figure 4.16, why depict results that are in doubt? Or, is this the "revised" natural conditions. Are all these for year 2000, or is this analysis using other years of data?

Page 4-28, Paragraph 3. The 0.5°C decrease in Trinity River temperatures for natural baseline is arbitrary. One could argue strongly that best available information would suggest that without Trinity Reservoir (natural condition) stream temperatures in summer under considerably lower flows would be notable higher. Without presentation of the actual data (versus just the differences), this discussion and Figures 4.18 and 4.19 have little meaning. Overall, there is little discussion of temperature conditions on the Trinity River (considerable temperature work has been completed on this tributary, but no citations are present) how ROD flows may or may not have an affect, and how they may or may not compare to natural conditions.

Page 4-30, Paragraphs 2 and 3. None of the analyses completed for the selected tributaries are presented. There is no discussion of the approach, data, assumed meteorological conditions, what was considered in the sensitivity analyses, findings, or variability among the creeks. Several comments/limitations of this discussion:

- no discussion of the limitations of SSTEMP in such an application,

- no definition of what a "moderate" sized tributary is,
- no description of the range in tributary sizes and how such an application may differ for a "small" or "large" tributary,
- no presentation of conditions within these tributaries regarding riparian vegetation. The statement that solar radiation loads are important in stream temperature is widely accepted and the application of SSTEMP was not needed to arrive at that conclusion.
- no discussion if riparian shading was even used in the SSTEMP application.

The statement that the laws of thermodynamics are "universal" in nature has no real basis here because the discussion of shading is simply a modification of solar flux to a water surface, and has really nothing to do with thermodynamics of the heat budget formulation.

All creeks listed on page 4-30 are between approximately River Mile 108 and River Mile 50 – a region dominated by Douglas Fir forests. Yet the blanket assumption is that these analyses apply region-wide, without regard to aspect, soils, gradient, vegetation, geology, land use, and other factors that apply throughout the region. Subsequently, the draft TMDL concludes that riparian shade controls are needed in "many Klamath River tributaries" not subject to an existing TMDL. There is no basis for this statement. Each tributary has unique attributes and thermal regimes are not similar (as part of the four-year USBR study a FLIR flight from above Beaver Creek to approximately the Trinity River – over 100 miles – was flown and tributary temperatures defined). A tributary-by-tributary assessment of the potential for such shade to exist should be completed to prioritize creeks that have the highest potential for temperature management, thus avoiding inefficient use of funds and resources on tributaries that have little potential for management. Further, an assessment of the disturbance regime within tributaries is required to identify the potential and frequency for debris flows in response to local geomorphology, hydrology events, fire, and other natural and anthropogenic conditions.

Page 4-30, Paragraph 4. There is no description of recovery of these streams. It is correct that the 1997 flood had a notable effect on the thermal regimes of many tributary streams in the Klamath Basin. However, Regional Board staff has failed to incorporate tributary temperature data from recent years to learn that many of these streams recovered stream side vegetation over subsequent years to a sufficient density to return water temperature regimes to pre-1997 conditions. Large floods will occur as part of the natural hydrologic variability and fire cycles in the basin. Streams will be impaired and streams will recover. An assessment of individual tributaries is required to effectively identify conditions within tributaries to priorities and manage these unique systems appropriately.

Page 4-30, Paragraph 5, Lines 1-8. There is no presentation of the stream width analysis. The assumptions, riparian shading (or lack thereof), stream width to depth ratio, presumed flows, assumed meteorological conditions, modified hypoerheic exchange (which can be important in these small streams, particularly when excess coarse sediments are present), etc. to support the conclusions of a 1-2°C increase are absent. Thus, to present that these conditions are conservative is meaningless.

Page 4-30, Paragraph 5, Lines 8-12. The draft TMDL states that these streams at near equilibrium near the mouths (where the tributaries enter the Klamath River). This is incorrect for many tributaries, at least the summer periods where thermal conditions are of concern. If the tributaries were near equilibrium with meteorological conditions, they would probably be equal to or warmer than the Klamath River due to their smaller thermal mass. Under such conditions there would be no thermal refugial areas at creek mouths. The great value and benefit to the tributaries is that cool source waters, small channels, aspect, topographic and vegetation shading, hyporheic flow and groundwater interaction, and other factors keep them below equilibrium. This is why a tributary by tributary assessment is in order.

Page 4-31, Paragraph 1, Lines 1-2. There is no citation for the Watershed Sciences work. Further, an infrared image (e.g., FLIR, TIR) is roughly a snapshot in time and identifying thermal response to channel form (e.g., width) is extremely challenging to parse out of an aerial infrared image unless multiple flights of the same reach at different times of day are completed.

Page 4-31, Paragraph 2. Excessive sediment loads create unique dynamics in the Klamath River thermal refugia. In the upper system – above the Scott River – where annual flow ranges are modest, most tributaries enter at elevations that match that of the river, which essentially provides access to the creek (e.g., Bogus, Cottonwood, Beaver, Horse Creeks…Humbug Creek is an exception). As one progresses downstream and the river flow range increases dramatically, tributary mouths are often located well above the river, with the tributary crossing alluvium to reach the main stem. In certain cases these creek mouths are several feet above the Klamath River summer flow stage and become disconnected. Longitudinal location and complex geomorphology conditions have direct implications on thermal refugia formation. For example, the timing of winter floods and subsequent snowmelt hydrographs in tributary streams plays an important role in the alluvial conditions at the mouth of tributaries because the flows (and thus sediment delivery) are often not coincident. These dynamics are discussed in USBR (2005). In sum, this is a complex issue and unique to each tributary. This paragraph is speculative and adds little to the technical TMDL regarding temperature impacts associated with sediments and approaches to managing these unique and valuable resources.

Page 4-31. Effects of Suction Dredging on Thermal Refugia. Comments herein are not wholly related to suction dredging, but rather to thermal refugia. The draft TMDL does not define a thermal refugia. There are no thermal characteristics, sizes, habitat, fish use (number, species, period, lifestage), period of thermal protection, persistence (inter- and intra-annual). There is no formal discussion of how they are modified by natural conditions or by man made activities. Appendix 8 includes maps of known thermal refugia, but no specifics are provided, rather it simply looks like Regional Board Staff simply identified that nearly every named tributary below the Shasta River was a refugia. Some of these are not persistent through the summer or perhaps year-to year, some are not notably colder than the Klamath River, some are inaccessible to anadromous fish, others enter the river where the benefit of cold water is minimal due to limited habitat. The restriction of 1,500 feet above and below the refugial areas defined in Appendix 8 adds up to nearly 50 miles of river, or approximately 25 percent of the main stem below Iron Gate Dam (and this does not include the physical size of the refugia). What resources are available to manage this considerable length of river? A rapid assessment of all refugia, as per USBR (2006) is recommended to define the functional value of these unique areas.

Page 4-32, Paragraph 4 (after all numbered bullets). No data are given, no analysis assumptions are provided, no uncertainty analysis was completed, and no documentation on methods is included. This is a systematic problem throughout this and other TMDL chapters. The draft identifies that flow data from 2000 was used, but nothing is presented. There is a note that the best quality assurance data from 2000-2007 was used, but no sources are cited making it difficult to interpret or provide direction on other data sources. Analysts familiar with the Klamath Basin know that that there are winter data gaps, there are tributaries that are poorly represented, yet none of this information is presented. How were these issues addressed in the analysis? Analysis of all tributaries is required, and where data are unavailable, a clear basis for using surrogates or estimates should be documented.

Even a brief exercise yields immense insight, such as flows for the Shasta River near the mouth shown in the table below. A few minutes at the USGS website identifies the basic statistics for the period of record flows at the mouth, and the same for the 2000-07 flow period when water quality data was available. The 2000 flow of 180.8 cfs (from USGS) is similar to both the long-term mean and the 8 year mean (2000-2007). Even the simple statistics of maximum and mean annual flow provide insight valuable into system variability and potential loading conditions – flows can approximately range from 200 percent to 50 percent of the mean. This type of basic analysis was not completed at any systematic level in the TMDL. This results in load allocations that are not supportable or meaningful in implementing a long term TMDL.

Flow Statistic	**1934-2008**	**2000-2007**
Average	185.2	179.3
Maximum	364.1	358.5
Minimum	77.9	107.6
Year 2000		180.8
Source: http://waterdata.usgs.gov, Gage 11517500 SHASTA R NR YREKA CA		

Page 4-32, Paragraph 5 (last paragraph). This single paragraph represents the entire description of the nutrient and organic matter analysis carried out for the Shasta River contributions to the Klamath River. No data are given, no analysis assumptions are provided, no uncertainty analysis was completed, and no documentation on methods is included. Determining nutrient and organic matter loads for the Shasta River – or any Klamath River tributary for that matter – is not a trivial exercise. How Regional Board staff calculated nutrient and CBOD loads from the Shasta River based on TMDL compliant conditions should be fully explained and presented. To further confuse matters, the text describes the data in Figure 4.21 as the “current and California dissolved oxygen compliance scenario” yet the figure identifies this information as current and natural conditions baseline. Are the California dissolved oxygen compliance scenario and natural conditions baseline the same? Which case was used in the TMDL?

A more fundamental flaw with Figure 4.21 is the fact that the natural conditions baseline is unattainable at a minimum for phosphorus. Year-round data from Jeffres et al (2008 and 2009) throughout the Shasta Valley identify total phosphorus concentrations on the order of 0.15 mg/L as typical background river concentration. This background concentration in spring contributions (e.g., Big Springs, Carrick Spring, Boles Creek spring, Beaughan Creek spring, Hole in the Ground spring) , to the Shasta River typically ranges fro 0.15 mg/L to 0.20 mg/L. With a mean annual flow of 180 cfs, and an average background total phosphorus concentration of 0.15 mg/L (with winter season averages being similar when biological activity is at an annual minima) – largely derived from geologic sources – the load to the Klamath River is over 100,000 lbs/yr. Thus a natural conditions baseline load of roughly 30,000 lbs/yr is unachievable. Further, annual average concentrations of total N are on the order of 0.5 mg/L (with winter season averages being similar when biological activity is at an annual minima), leading to a load of approximately 300,000 lbs per year – well above the estimate of approximately 200,000 lbs/yr included in Figure 4.21. Winter concentrations are similar to annual values suggesting that a reasonable background concentration is also on the order of 0.5 mg/L, indicating that the natural conditions baseline load of approximately 80,000 lbs/yr background is probably unachievable. To the extent that the Jeffres et al (2008, 2009) data disagree with the Shasta River TMDL assumptions, the more recent, extensive, and detailed year-round monitoring of Jeffres et al work is probably the more appropriate as a starting point for TMDL analysis, and suggests that the Shasta River TMDL should be reexamined and load allocations reviewed in light of more recent data.

Page 4-34, Last Paragraph. There is no presentation of dissolved oxygen data. At a minimum a description of data used, methods for filling data gaps and other assumptions outlined, and graphical and tabular presentation of dissolved oxygen data along with corresponding dissolved oxygen saturation percentage should be provided. Without such information, review of assumptions is not possible. Review of the model input files identifies that all minor tributaries to the Klamath River are placed at 90 percent of saturation under current conditions and 100 percent of saturation under natural baseline condition. This important assumption undocumented in the TMDL. What is the basis for this assumption? Limited grab sample and water quality probe data suggest many of these tributaries are oligotrophic and, with perhaps the exception of sediment and in some cases temperature, have dissolved oxygen concentration at saturation. Why place a dissolved oxygen impairment on these tributaries where none may exist. At a minimum a sensitivity analysis should be completed and clear documentation of the conditions and results presented.

COMMENTS: CHAPTER 5. KLAMATH RIVER TMDLS – ALLOCATIONS AND NUMERIC TARGETS

5.1 Introduction

Page 5-1, Paragraph 3, Line 2. The temperature numeric targets are based on monthly averages, but from a biological perspective this may be an insufficient averaging period. Recommend weekly or semi-monthly targets and support with literature citation.

Page 5-2, Table 5.1. This table has several flaws. First, a target of zero increase above the estimated "natural" temperatures is not possible to meet – it is not measurable, it takes no account of interannual variability, or of seasonality. Second, instantaneous mass seems a very odd target because what the fish "see" is concentration. Mass is dependent not only on concentration, but on volume. By making the volume larger, the target could be met even at inadequate concentration. Third, the chlorophyll *a* target is unreasonably low, appropriate to a mesotrophic system, not the eutrophic to hypereutrophic system that exists, and has existed historically, in the Klamath River. Fourth, the *Microcystis* target seems too low since the WHO guideline is 20 µg/L, and the biomass target is tied to the biomass of all blue-green species – the TMDL provides no explanation for the logic of this target. Fifth, the nutrient target for the hatchery is tied to taking the dams out. The nutrient load for the hatchery should be set without regard to the presence or absence of the dams.

Watershed wide, Temperature. Allocations for shade are inappropriate, incorrect, and probably infeasible in most sub-basins. The draft TMDL is unclear if these apply to the mainstem: if so this is inappropriate. Sediment as a controllable factor is a weak surrogate for temperature control regarding stream width and hyporheic flow. Strongly encourage the Regional Board staff to identify site potential analysis on a tributary-by-tributary basis, versus an overly general blanket approach that will be difficult to implement, let alone manage.

Stateline, Temperature. Zero increase above natural baseline is not measurable and thus unenforceable. Further, lack of interannual variability in the draft TMDL assessment provides no means to account for a naturally warmer or cooler year. No sensitivity analysis was completed to determine the range of potential "natural" temperatures. How will this be assessed by Regional Board staff: how will natural temperatures be defined for 2010 or any future year? This approach is unenforceable except after the fact, which does little to protect the resources.

Page 5-3, Paragraph 4, Lines 5-9 and associated TMDL sections. The draft TMLD identifies that there are explicit and implicit margins of safety. The TMDL load allocations equations are:

- Temperature TMDL = Loading Capacity = ΣWLAs + ΣLAs + Natural Background + MOS (pg 5-4)
- Total Phosphorous TMLD = Loading Capacity = ΣWLAs + ΣLAs (pg 5-9)
- Total Nitrogen TMLD = Loading Capacity = ΣWLAs + ΣLAs (pg 5-10)
- Organic Matter TMLD = Loading Capacity = ΣWLAs + ΣLAs (pg 5-11)

In all cases the draft TMDL relies on an implicit margin of safety, wherein conservative assumptions are employed. No quantification of uncertainty was completed, no sensitivity analysis was presented, and no interannual variability was assessed to provide any idea of the magnitude of an implicit margin of safety for each parameter (Temperature, TP, TN, CBOD, dissolved oxygen). Such a margin of safety would assuredly be different for each parameter. Translating uncertainty (or conservative assumptions) in TP, TN, and CBOD to dissolved oxygen is not discussed. The approach presented in the draft TMDL provides little confidence that the load allocations are appropriate or achievable. Additional comments are included below for individual parameters

Page 5-4, Paragraph 1, Lines 1. It might be more clear to say that the intrastate temperature objective's intention is that any increase in temperature "doesn't increase adverse impact on beneficial uses." An increase in temperature may be acceptable, it would seem, if it didn't increase adverse impacts on the system. Perhaps temperature increases are an issue during "critical time periods," but they are probably not an issue year-round. An allocation of no temperature load is unmeasurable and inapplicable.

Temperature: Page 5-4, Paragraph 4. Taking credit, as a margin of safety (MOS), for periods of time during which beneficial uses (BUs) are not impaired does not appear to be consistent with the intention of MOS. An MOS is meant to ensure protection of beneficial uses in consideration of uncertainty and errors. This credit does not help to address the uncertainty of temperature values (or any other parameter in the draft TMDL) and application of the targets during times when beneficial uses are threatened. This seems like an incorrect use of MOS and creates an overly restrictive TMDL allocation. Specifically, how do these periods coincide with identified heating loads versus periods when BUs are not an issue? There is a brief note regarding periods when beneficial uses are not impaired and that the "timing of those periods changes from year to year and is difficult to predict but there is no analysis to support this statement. Further, the river is already impaired by temperature during certain "critical time periods." Is it unfair to make this the condition for MOS (margin of safety)? Overall, this seems like a simplistic approach given that you have a "comprehensive, dynamic numerical model" (page 5-9), which may be conservative, but may also be grossly over restrictive.

Page 5-5, Paragraph 2, Lines 7-10 Some set of nutrient allocations would have to be met above Copco even under "dams-out" conditions to prevent DO impairment and/or algae growth downstream. Are these load allocation for PacifiCorp upstream of Copco over and above the allocations that would be imposed in dams-out scenario?

Page 5-6, Figure 5.1. Here and throughout these loading diagrams, "Benthic load" should clearly be identified as "Net Benthic Load" or otherwise re-labeled (e.g. ."Load only from sediments to water column. Load lost from water column to sediments not included.").

Page 5-9, Paragraph 2, Line 2-4. Using a numerical model does not, in itself, provide a MOS. How was uncertainty reduced by the model and by how much? The model can actually magnify uncertainty and error. (As we say in modeling, "Garbage in, garbage out.") Models may increase precision of results (even to a ridiculous level, e.g. "load = 2,253,542 kg), but accuracy is not necessarily increased (Deas and Lowney 2000). We believe that not enough data were incorporated in model calibration and validation and there was not enough evaluation of uncertainty to make the statement that "uncertainty was reduced … by applying (this) model." There is no inherent implied MOS in this application of the model.

Page 5-9, Paragraph 2, Line 5. It is claimed that the model takes advantage of "data collected over multiple years," but the model was only calibrated based on 2000 data. It is true that data from multiple years was used to form certain boundary conditions where limited data were available, but the hydrology and meteorology – two principal drivers – were from 2000. Using multiple years of data may improve certain elements of model inputs, but may also lead to increased uncertainty by mis-matching in time hydrology and meteorological conditions with actual water quality responses. This is not discussed in the draft TMDL.

Page 5-9, Paragraph 2, Line 9-11. What is the basis for the statement that "the largest source of uncertainty in this system is the highly variable and dominant loading from UKL?" There is no analysis, no documentation, no citation, no quantification, or other description of this issue. Further, how does this relate to downstream reaches all the way to the estuary? This statement would mean that UKL boundary conditions have a larger impact on the estuary, than say Trinity River flows, lack of detailed estuary geometry, lack of detailed estuary data, etc. This line of questioning can be applied to all river reaches downstream.

Page 5-9 Paragraph 2, Lines 11-12. (Conservative Assumption). It is astonishing that the basis of the an implicit margin of safety for dissolve oxygen, nutrients, and organic matter TMDL allocations analysis consists of these four bullet points, plus a statement that uncertainty was reduced by applying a "comprehensive, dynamic numerical model." Klamath River water quality dynamics are complex, varying considerably in space and time. Even though the numerical model applied has a wide range of parameters, constants, coefficients, not all processes are modeled. There is only a single algae group on the mainstem reservoirs, there is a simple sediment model in both the river and reservoirs, the partitioning of organic matter at Link Dam is incorrect in the TMDL model, the two group algae model for low dissolved oxygen conditions in Keno Reservoir is completely untested and parameter values have no basis, representation of Iron Gate outlet works has been specified instead of simulated, there is undocumented code that has direct implications on model results, available data are limited in winter throughout the system, and only a single year is modeled for the California TMDL - just to mention a few model and data limitations. An implicit MOS approach in a basin such as the Klamath is inaccurate, inappropriate, and unacceptable. Comments on the individual bullet points follow.

Bullet point 1. Without a presentation of the current sediment oxygen demand (SOD) and its impact on oxygen levels in the river, this bullet point cannot be interpreted. Further, SOD is a small player in the overall dissolved oxygen conditions in the river reaches because of the limited deposition of organic matter (high shear environment) and the near continual mechanical reaeration in the Klamath River due to the high gradient (and once the river gradient diminishes below Orleans, dissolved oxygen is much less of an issue). SOD is a bit-player and although this is a conservative assumption, it is also negligible.

Bullet point 2. Please expand and explain this bullet point. "Timing of allocations" is based on the scenario with greatest loads from UKL has no basis, explanation, or citation. "Magnitudes of allocations are based on median loading conditions from UKL," would mean that 50 percent of the time loads are greater than those upon which allocations are based. This is incorrect. Loads are based on the 1995 conditions – one of seven years of data (1992-98) used in formulating the UKL TMDL load allocation. Further, 1995 is the second lowest year of the seven years, and less than 50 percent of the 7-year mean conditions. Thus, if the UKL is accepted as "representative" of a range of conditions from 1992-98, the majority of years (5 out of 7, or 71.4 percent of the time), TMDL compliant conditions as defined in the California TMDL will not be met. The representation of this in the California TMDL is erroneous, misleading, and presented with such brevity that without considerable data and information requests from Regional Bard staff, ODEQ, and EPA, such a condition would never have been identified. This is another example of the critical nature of uncertainty analysis and a clear limitation of modeling only a single year for TMDL load allocations in a complex basin such as the Klamath River. Multiple years must be simulated to represent the appropriate range of potential conditions such that reasonable load allocations can be determined. Further, selecting unrealistically low load allocations at the upstream boundary (Link Dam) is not conservative and will lead to unattainable TMDL allocations. Finally, the misleading presentation of information in the TMDL due to an inadequate description of the analysis approach and fundamental assumptions severely hampers the credibility of the Draft TMDL.

UKL TMDL model output for 40% reduction case. Highlighted row (1995) is the information used in the California TMDL (ODEQ, 2002).

Year	Outflow (kg/yr)	Percent of 7-yr Average
1992	13,854	21.6%
1993	114,637	178.5%
1994	50,860	79.2%
1995	30,237	47.1%
1996	103,839	161.7%
1997	83,970	130.8%
1998	52,057	81.1%
Mean	64,208	100.0%

Bullet point 3. This bullet point essentially translated to a simplistic approach that reduces all nutrients to low levels. There is no nutrient reduction strategy that targets one (N or P) – an approach that is fundamental to water quality management. In retrospect, this is not a surprise because no assessment of trophic status or nutrient limitation was completed for the Klamath River under existing or a TMDL compliant condition. Without a clear nutrient limiting strategy (even if that strategy is co-limitation), implementation actions will be severely hampered and valuable resources will be wasted. It is important to reduce both nutrients, but it is also important to identify a limiting nutrient so effective water quality improvement actions can be identified, prioritized, and implemented at an appropriate time. This may also be a conservative assumption, but it is also too simplistic and could ultimately hamper the effective implementation of the TMDL.

Bullet point 4. Basing analyses on low flow conditions does not necessarily provide a MOS. Higher flow doesn't mean less WQ impact as higher flows can result in higher loadings for similar in-stream concentrations. In short, this is not conservative, particularly if dam removal occurs prior to effective implementation of nutrient and organic matter reductions in Oregon.

5.2 Temperature-Related Numeric Targets and Allocations

Page 5-11 to 5-13 (including Figures 5.4, 5.5, and 5.6): Riparian Shade. The thermal benefits derived from riparian shade to a stream or other waterbody cannot simply be based on a single "effective shade" parameter. How these would be managed is unclear. Overall, these graphs are inappropriate for temperature load allocations for shade as applied globally in the Klamath River basin and may be infeasible and ineffective in certain watersheds.

There is no definition of riparian shade for the purposes of the TMDL. Riparian shade generally includes herbaceous and woody riparian shade. The occurrence and persistence of each type of vegetation varies from system-to-system and year-to-year. A combination of both usually provides the ultimate shade benefit to a river. Further, smaller streams benefit remarkably from herbaceous vegetation shading as well as woody riparian vegetation shading, while larger streams generally benefit more widely from the latter.

There is no description of the analysis, assumptions, citation, limitations, and how this is applied not only to the tributaries, but also the mainstem. The draft TMDL does not state whether this is applicable to only tributaries, or to the mainstem as well. Application of riparian shade as a prescription to temperature management in the mainstem is not applicable as a temperature control strategy and these figures, not similar assessment should be applied to the mainstem Klamath River in California. Even within tributaries such as the Scott, Shasta, Salmon (and certainly Trinity) Rivers, simple shading curves may not be applicable. Such shade curves may be most applicable in small streams regions such as the Navarro or Mattole Rivers where rivers flow through continuous forested tracts. This approach was not applied in the Shasta River (the draft TMDL has mis-stated this).

None of the species presented in Figures 5.4, 5.5, and 5.6 include typical riparian vegetation shading species useful in many of the tributaries. Ponderosa pines provide limited shade benefiting California in the Klamath basin. These are trees typical of drier climates and locations and although present in the basin are not typical riparian trees. Oak woodland, by definition is not a riparian ecosystem, although occasional oak trees can be located near rivers. Douglas fir and mixed hardwood conifer forests may be adjacent to streams in the lower basin where tributaries flow through large tracts of forests. However, there is no information provided for cottonwood, willow, birch, or alder – the typical riparian species used to thermal management in small streams. These are the species that would be functionally present in most tributaries to the Klamath basin, particularly in the interior reaches (approximately upstream of Happy Camp) where large tracts of coniferous forests are less common and true woody riparian species are the dominant streamside trees. In the lower basin, the Douglas fir and mixed hardwood may grow adjacent to streams, but alder, birch, and willow, along with big leaf maple, can still dominate streamside vegetation (and in many system herbaceous species are of vital importance, particularly at small flow rates). Because the data provided in Figures 5.4-5.6 largely precludes these important species, the data are of little value and should not be broadly adopted as shade standards in the Klamath basin.

The ranges of widths presented in Figures 5.4, 5.5, and 5.6 do not correspond to the appropriate stream sizes for such an approach. As noted above, this method may be useful for small streams coursing through continuous tracts of forest where trees are of sufficient size, density, and provide a continuous source of shade. The widths included in these figures extend up to 100 meters – well over 300 feet. The rule of thumb in temperature monitoring is that for riparian vegetation to be effective in temperature management (without topographic shading) woody vegetation height should be similar to stream width. Douglas fir and Ponderosa pines illustrating 30 percent effective shade for stream widths at 100 meters. For streams widths on the order of 100 meters there is little relief from riparian shading during the warmer summer months (Deas et al. 1997). Further, there is no definition of tree density and solar transmittance. It appears Regional Board staff have assumed 100 percent blockage by trees and continuous woody vegetation – akin to a wall being placed by the river edge. However, this is unrealistic. Actual riparian systems are complex and inconsistent in density, continuity, distance from river edge, species present etc. The important element of riparian shade strategies for temperature control is that without continuous, low transmittance vegetation over large river reaches temperature management is not feasible. Riparian vegetation shade presents meteorological conditions that may result in water temperatures several degrees below un-shaded conditions equilibrium water temperatures. Thus, if vegetation shading is not continuous, but rather intermittent, the river simply heats towards unshaded equilibrium in unshaded reaches. Deas et al (2006) illustrated this topographic shading in the Klamath River.

Topographic shading is mentioned in this section, but little is said about how this is included into the "effective shade" graphs. Topographic shading is due to local terrain and can include mountains, hills, stream banks, boulders, and other land features that cast shade. In fact, there is no real way to include topographic shading in the manner presented in the TMLD because topographic shading is a function of stream aspect, local topography and time of year. Small topographic shade elements (e.g., banks, in stream rocks and boulders) can have profound effects on small streams and should be defined on a stream-by-stream basis.

Time of year is not addressed in Figures 5.4, 5.5, and 5.6. However, day length and solar altitude are critical elements in assessing solar radiation reductions for aquatic systems and how they impact local temperatures. Summer solstice provides the longest day length and highest solar altitude in the Klamath Basin, but maximum temperatures do not occur until approximately August 1. What is the date that these figures apply, or are they seasonally averaged? If they are a seasonal average, what period is used for the average? Finally, there is no description of this analysis, source of data, assumptions (setback from bank, density, solar transmittance), or documentation.

Deleted:

Page 5-14, Paragraph 1 and elsewhere. The temperature load allocation for human-caused discharges is "zero temperature increase" is unachievable and unmeasurable.

Page 5-14, Paragraph 2. Definition of substantial human-caused sediment related channel alteration. It is unclear how an action that "increases channel width, decreased depth, or removes riparian vegetation to a degree that alters stream temperature dynamics and is caused by an increased sediment loading" can be measured against natural processes in the system. What is the baseline? What is the metric for sediment loading? How and where is this measured? How are legacy activities incorporated? Who is responsible for monitoring and assessing potential changes, let alone defining what fraction of the impact is due to natural processes or human-caused actions? To be applicable, a complete TMDL appendix outlining these and many other questions is required. Without such guidance from Regional Board staff, regulatory oversight will be vague and implementation of actions ineffective.

Page 5-15, Table 5.5. Presenting a range for the temperature numeric targets would be more beneficial. Does the table take climate change into account and upon what are the chosen values based? Monthly average temperatures have only limited biological value. Monthly averages represented in Table 5.6 are likewise of limited biological value.

Page 5-15, Last sentence. Instead of "increase above natural," should this read "increase above Oregon TMDL values"?

Page 5-16, Paragraph 2. Please define the "Thermal Plan."

Page 5-16, Paragraph 2, Lines 3-4. 'Temperature alterations caused by the reservoirs adversely effect beneficial uses.' See comments Temperature: Page 5-4, Paragraph 4 and Page 4-13, Paragraph 2.

Page 5-16, Paragraph 3, Lines 6-8. The Draft TMDL states "Because the upstream heat loads are outside of the control of the dam operators…, the allocations apply to the condition of the water as it enters the reservoirs." This is inconsistent with the treatment of nutrients. If the upstream heat loads are outside of the control of dam operators, it would seem to follow that upstream nutrient loads would likewise be outside the control of the dam operators.

Page 5-16, Paragraph 4, Lines 7-8. The appropriate scenario for determining allowable temperature increases (i.e. "natural increases") in California is: Oregon TMDL compliant at Stateline and "natural conditions" downstream. Please clarify that this is the scenario referred to. Again, without the Oregon TMDL, it is difficult to confirm where temperatures at Stateline would come from.

Page 5-17, Paragraph 1, Lines 5-10. Discussion states that "maximum temperatures periodically increase by approximately 0.5°." But this analysis and accompanying Figure 5.7 have little relevance because 0.5° is more resolution than temperature model warrants. Also, the statement implies a pattern of periodic increases, where no pattern is apparent. Overall, maximum temperatures are decreased by Copco year-round and only a few times are maximum temperatures increased. Without actual data to assess conditions within this reach, little can be said about daily range of temperatures. Further, Copco reservoir occupies a broad, open terrain, while upstream reaches are often referred to as the canyon, thus a reduced daily range due to more topographic shading than in upstream reaches makes little sense. Simplistic statements without supporting evidence reduce confidence in the TMDL findings.

Page 5-17, Paragraph 2 (and Figure 5.8). Presuming that the models can effectively represent increase of 0.1°C, i.e., that the accuracy of these models is 0.1°C, is erroneous. PacifiCorp (2004) provides extensive calibration statistics that indicate the models are probably accurate to 1.0°C. Misapplication of the model in this manner not only points to a clear need for uncertainty quantification, but also suggests that Regional Board staff do not fully appreciate the realistic application of numerical models.

Page 5-18, Table 5.7. The load allocations for reservoir tailrace waters are less than the model accuracy. Further, what is the proposed method used to measure the 0.1°C increases in Iron Gate daily average and maximum temperature? Standard temperature measuring devices (and the same ones used to collect calibrate data for the model) are on the order of 0.2°C. Given model accuracy and the accuracy of the data collected for model calibration, load allocations of 0.1°C are not supportable.

5.3 Dissolved Oxygen and Nutrient-Related Numeric Targets and Allocations

Page 5-19, Paragraph 4, Line 4. The 85% saturation value referred to is calculated at what pressure and air temperature?

Page 5-20, Tables 5.10, 5.12, and 5.13. The Draft TMDL allocations at Stateline, and for Copco and Iron Gate tailraces present a clear disconnect with the 2002 Upper Klamath Lake TMDL (ODEQ 2002). The Upper Klamath Lake TMDL seeks TP targets of 0.066 mg/L for inflows to the lake and 0.11 mg/L for the in-lake concentration, while the expectation in Tables 5.10, 5.12, and 5.13 is to achieve 0.030 to 0.039 mg/L TP. Even the allowable without-dams and natural conditions load capacities (as shown in Figure 5.9) would require about 84 percent TP reduction from existing loads (compared to 95 percent for the with-dams capacity). Given that Upper Klamath Lake is the primary source of water for the Klamath River, how does the Regional Board think it is possible for the much more restrictive river targets in the Draft TMDL to be achieved? One of the key aspects of TMDLs is that they must provide reasonable assurance that TMDL goals can be met.

Page 5-20, Table 5.10. The target values for total phosphorus are below the reporting limit for the analytical method. They therefore cannot be measured, and cannot be enforced. In addition, the targets are stated to a precision (3 decimal places) that is beyond the capabilities of the analytical method and, presumably, the model itself. In addition, the target values are extremely low relative to the actual conditions, and most likely too low relative to any reasonable historical condition. This comment applies to Table 5.12 and 5.13 as well.

Page 5-22, Paragraph 1, Line 1. PacifiCorp is assigned an allocation that requires reduction of nutrients upstream of its facility. This is contrary to the allocation for temperature where PacifiCorp was considered not responsible for the excess temperature coming from upstream – it is inconsistent. Additionally, it is illogical and unsupportable to assign an allocation upstream of a source.

Page 5-22, Paragraph 2 (after 4th bullet). The Draft TMDL needs to explain the logic that recognizes that there will be a flux of nutrients from the reservoir sediments, and then establishes a loading from the sediments of zero. There is, in fact, little or no empirical evidence that any release of nutrients from the sediments has any effect on algal growth in the reservoirs, or on conditions downstream. The nutrients stay sequestered in the very small volume of water deep in the reservoir and are released only late in the fall when the reservoirs destratify, well after the growing season. The TMDL assumes, but presents no evidence, that the sediment release (if indeed that is what it is) has any effect on the reservoirs.

Page 5-22, Last Paragraph. It is not clear that these figures (5.9-5.11) actually demonstrate the "difficulty of having dams on a naturally productive river." First, lower loads in "dams-in" scenario could result from a combination of factors, including the fact that reservoirs are a net sink of TP and TN. Also, the figures show that 40-80 percent of nutrient reduction applies to Oregon TMDL compliance. A California compliant river with dams only accounts for an additional 10-20% reduction, much of which may come from sedimentation losses. Recommend clearly identifying Oregon TMLD reductions.

Page 5-23, Figure 5.11. Please provide a table or explanation of why "CA compliance with dams" scenario would result in such a large change in CBOD load as compared to other scenarios.

Page 5-24, Paragraph 1, Figure 5.12, and Page 5-25, Paragraph 1. This presentation of a 'compliance lens' lacks rigor and presents an infeasible approach. The concept of applying a fixed volume where temperature and dissolved oxygen are both acceptable based on the reach average depth of a free-flowing river makes no physical sense: lentic and lotic systems are fundamentally different environments. The average reach depth (the draft TMDL is unclear if this is average depth or average hydraulic depth) for a free flowing river channel is not provided in the draft TMDL, but based on modeling efforts is probably on the order of 1.0 meter. Even if the average depth were 2.0 meters, relying on this thickness of a compliance lens within the reservoir is tenuous given thermal stratification, wind mixing, and seasonal thermal loading. That it, the chances that such a thin lens would persist in a biologically functional manner through the critical summer period would be quite small. Thus the volumes identified are probably too small.

Further, the definition states that the compliance lens applies to the width and length of the reservoir. This is an unattainable condition in reservoirs under stratified conditions. By definition, the thermocline within Copco and Iron Gate reservoirs does not extend the entire length of the reservoir. In shallower headwater areas the hypolimnion pinches out and there are no cold, deeper waters in the upper reaches of both reservoirs for considerable distances. Similarly, as the thermocline does not extend the full width of the reservoirs. Based on fundamental stratification dynamics and the morphology of reservoir systems, the compliance lens approach as defined in the draft TMLD cannot be achieved.

Also, Copco 2 does not stratify and how the compliance lens concept applies is unclear. Why are allocations for all other locations monthly averages, but for the compliance lens the calculations are based on instantaneous DO mass? Insufficient information is provided in the TMDL to allow the reader to determine how the DO mass was calculated.

Page 5-27, Table 5.17. These targets will be a function of assumptions throughout upstream river reaches, including tributaries. Previous comments regarding Link Dam boundary conditions and Shasta River boundary conditions (phosphorus), as well as other comments addressing the TMDL analysis will have to be reassessed in a subsequent draft of the TMDL.

Page 5-27, Table 5.18. No data are provided to support the values for these major tributaries. A comprehensive analysis of assumptions, approach, limitations, and uncertainty should be presented in the draft TMDL.

Page 5-28, Table 5.19. CBOD values included in this table are below both the method detection limit and method reporting limit for standard production laboratories. A minimum value of 2.0 mg/L would be appropriate.

COMMENTS: CHAPTER 6. IMPLEMENTATION PLAN

6.1 Introduction

A crucial element of TMDL implementation that is only briefly mentioned in the Draft Implementation Plan is the timeline or schedule for compliance with proposed TMDL allocations and targets. The timeline or schedule for compliance is a particularly important element of the TMDL implementation process for the Klamath River. On page 1, the Draft TMDL states that "[t]he regulatory process will accommodate for short term measures working in concert with longer-term programs to achieve full compliance over a longer time frame". The specific time frames associated with the Draft Implementation Plan's use of "short term", "longer-term", or "longer time frame" are not well defined.

6.2 Implementation of Allocations and Targets – Stateline

Page 6-8, Paragraph 2, Lines 13-17. The Draft TMDL states that allocations and targets presented in the Draft TMDL assume water quality conditions at Stateline (and by extension other downstream Klamath River locations in California) "once the Oregon TMDLs are fully implemented". The Draft TMDL further indicates that full implementation of the Oregon TMDLs are a "critical part of the solution in meeting water quality objectives in California". The Draft TMDL therefore assumes, and its success depends upon, substantial load reductions upstream in Oregon to meet California's draft TMDL objectives at Stateline. The need for substantial upstream load reductions indicates that the timeline or schedule for compliance in California is particularly important in evaluating the feasibility of a trading program and other implementation actions to obtain the necessary nutrient reductions consistent with the proposed TMDL allocations.

Also, because the Draft TMDL fundamentally links its success to the Oregon TMDLs, it is premature for the Regional Board to seek comments on their TMDLs for California, and proceed further with development of these TMDLs without the Upper Klamath River TMDL in Oregon also being completed and available for review.

6.3 Implementation of Allocations and Targets - Klamath Hydroelectric Project and Iron Gate Hatchery

Page 6-11 to 6-14. The implementation discussion is vague with respect to the Klamath Hydroelectric Project. The 60 day period listed on page 6-14 for PacifiCorp to submit its implementation plan is way too short, and unprecedented. Eighteen (18) months is more common, consistent with EPA TMDL guidance.

On page 6-15, the Draft TMDL discusses implementation for allocations associated with the Iron Gate Hatchery. On September 14, 2007 PacifiCorp submitted a revised Monitoring and

Reporting Plan (MRP) per Water Code Section 13267(b) Order issued by the Regional Board. PacifiCorp has been following the requirements of this proposed MRP since January 2008 per the terms of the Settlement Agreement with the Klamath River Keeper. In addition, PacifiCorp submitted the results of the 2007 chemical pollutant scan to the Regional Board per the 13267(b) Order referenced above. PacifiCorp considers these submittals to the Regional Board as necessary steps towards working towards the issuance of a renewed NPDES permit for the hatchery. PacifiCorp will continue working with the Department of Fish and Game and the Regional Board to assess discharge from the Iron Gate Hatchery through the NPDES renewal process addressing the need for additional measures, if necessary.

6.7 Klamath River Water Quality Accounting and Tracking Program

Page 6-55 to 6-57. The discussion about watershed trading/offsets is good to have, but vague regarding program components and responsibilities, other than mention of the KlamTrack program. The Draft TMDL recognizes that substantial reductions in nutrient and organic matter loads in the Klamath River will be needed to improve water quality to any substantial degree, and these reduction efforts should target the largest sources of nutrient loads – Upper Klamath Lake and the Lost River basin. PacifiCorp believes that water quality trading could be an important programmatic “tool” to be incorporated as part of the TMDL implementation processes in the Klamath River basin for the variety of stakeholders that will be affected by TMDL allocations and targets. As such, PacifiCorp has proposed to commit resources under AIP Interim Measure 11 (Nutrient Reduction Measures) to evaluate and, if warranted, design and implement a water quality trading program. Such a program would be developed cooperatively with the Regional Board within the framework of the Draft Implementation Plan, as well as considering TMDL implementation actions in Oregon through ODEQ.

COMMENTS: CHAPTER 7. MONITORING PROGRAM

Page 7-1. Paragraph 4. Please expand on the program identified in NRC (2004) and identify similarities and differences.

Page 7-3. Paragraph 4. The goals outlined by the Regional Board and ODEQ are not echoed in the Preliminary Review Draft: Klamath River Basin Water Quality Monitoring Plan (KBWQMCG), but rather drawn from KBWQMCG (Royer and Stubblefield 2009). Admittedly (and contrary to the statement on Page 7-5 under section 7.2.2 that states the plan is done), the plan is still in draft form, but much of the direction for the TMDL has been drawn from the KBWQMCG. Tables 7.3, 7.4, and 7.7 are drawn directly from processes involving the KBWQMCG and not properly referenced. Many participants have worked tirelessly on KBWQMCG issues and this information should be properly referenced. Much of this chapter has been drawn from the Blue-Green Algae working group and the KBWQQMCG, but these contributions are not properly cited.

Page 7-10, Table 7.3. Differences between the use of terms “trend monitoring” and “trend compliance monitoring” should be explained.

Page 7-14, Paragraph 3, Lines 7-10. The statement is made "… the results should be applied to determine whether microcystin exposures are a contributing factor to ecological impacts such as fish disease and fish health both within the reservoirs and below Iron Gate Dam". Please explain how this determination would be made.

Page 7-14, First Bullet. This bullet indicates that public health monitoring in the reservoirs would occur at four shoreline sites in coves. Open water sites are not mentioned, but should be sampled also, since the open water areas are used by the public also.

Page 7-19, Paragraph 2, Line 3. The 26 ng/g value listed here should be specified as ng/g wet weight.

Page 7-24. Section 7.6.1 Comprehensive Water Quality Monitoring. This program of parcel tracking to assess water quality conditions is misleading and inappropriate for application in the Klamath River. This was tried by the Regional Board below Iron Gate dam and provided little useful information (in fact, there is no mention of this work in the draft TMDL). This is an inappropriate method to develop a system wide mass balance (which is stated as a desired outcome). The ability to track a parcel of water through the system requires a very clear understanding of travel time, which is not addressed in any way in this section. The approach does not speak to dilution and the role of tributary inputs at any sufficient level to understand the approach. A more prudent approach would be to reduce the system to a reach-by-reach basis and complete information on individual reaches multiple times per year. For example a small study of Keno reservoir over a two week period, two or three times a year, would provide dramatically more information that this proposed approach. In the Keno dam to J.C. Boyle reach, which has a short transit time, a shorter study may be required, saving time and resources. The constituents seem well represented, but the timing issue of this program will result in little useful data.

Folded into this are several studies that appear to be part of this "comprehensive" parcel tracking program, but do not seem directly related. This is a confusing presentation of an important matter. For example:

- The estuary sampling does not seem related to the parcel tracking program (nor should it necessarily be related)
- The open ocean boundary condition is a very dynamic environment and trying to tie it into the parcel tracking will not provide sufficient information to form confident and robust decisions
- New flow gages and flow analyses may be useful but where is such work needed? This does not appear to tie in with the parcel tracking. How long of a record is necessary before a comprehensive understanding of the flow records can be confidently stated?
- Water monitoring for accretions is a great topic, but what defines "significant accretions" is unknown. This would vary by season, year type, and location in the system
- A bathymetric survey for the estuary is important for two reasons. The stated reason is that the initial survey may not have characterized important elements. An equally important

reason is that the estuary is not static and will change, probably frequently. Thus relatively frequent surveys would be valuable to ascertain the variability in the estuary and accommodate that in modeling (sensitivity analysis) to quantify uncertainty.

These tasks require considerable resources, funding, and ideally a level of cooperation and coordination. A framework, ideally developed with considerable public input, is required to identify, rank and prioritize monitoring actions to ensure effective and responsible use of funds and resources.

Page 7-27, Third Bullet. This bullet is titled "Below channelized section of Iron Gate Dam". Please specify what is being referred to here. What "channelized section" is this? Also, the statement is made "This station has recently been demonstrated to have the highest rate of parasite infection of fish within the Klamath system". This statement is incorrect and should be deleted. The higher rates occur downstream below the Shasta River near the confluence with Beaver Creek.

Page 7-29, Section 7.6.2. The second bullet point pertains to the Scott River and does not appear to be related to the Klamath River TMDL. Refugia temperatures are localized areas that probably do not have a broader affect on mainstem temperatures far from the refugia. Though groundwater in the Scott Valley may play a broader role, the valley is located well over 20 river miles upstream from the Klamath River and probably has little effect on Klamath River temperatures.

Page 7-30, Section 7.6.5. The bullet point identifies a "Periphyton Advisory Committee." Does such a committee exist? If it does exist it is so poorly communicated in the basin that key water quality analysts are unaware of its existence.

COMMENTS: APPENDICES

Appendix 1: Proposed Site-Specific Dissolved Oxygen Objective for the Klamath River in California.

Section 1.2.1, Paragraph 3, Lines 3-8. Note that the DO fluctuations, weekly averages, peaks, etc. are variable from year to year. And yet the comparisons are being made to the natural baseline scenario model output (T1BSR), which is only based on one year (2000) of data. This again shows how the Klamath River TMDL model is inappropriate as a tool in TMDL development because of such inadequacies. The importance of inter-annual variability in modeling is discussed in detail above. Furthermore, there is no discussion of model uncertainty in the TMDL.

Section 1.2.2, Paragraph 3, Line 1. Given that there are "four lines of evidence" against the appropriateness of the existing DO objectives presented in Table 3-1 of the Water Quality Control Plan for the North Coast Region (Basin Plan), it is inconsistent to now rely on the Basin Plan to "determine the variance from natural background that is allowed for other parameters". There is no reason given as to why this was done.

Section 1.2.2, Paragraph 3, Four bullet points. These comparisons are biologically meaningless. The response and variability is not linear across the various parameters (turbidity, pH, temperature, DO). Bullet point #4 might be reasonable, but there is no explanation given for the assumption that DO in ocean water would change in the same way as DO in fresh water. As such, the 10% correction factor that was supposedly derived from variances in the Basin Plan is, at best, questionable.

Section 1.2.2, Second to last paragraph, Lines 3-4. The two objectives are not equivalent. As detailed in Section 1.1.1, the existing DO objectives in Table 3-1 are based on grab samples along the river when dams are in place, i.e., "unnatural" conditions. In contrast, the alternative proposed in this section is based on simulated natural background scenario (T1BSR) that has questionable boundary conditions (see Appendix A and C). Also, Section 1.3, paragraph 3 of this appendix clearly states that the two are different. It is incorrect to claim that these two approaches are equivalent.

Section 1.3, Paragraph 3. This paragraph seems to suggest that it would not be a problem if natural conditions result in a loss of beneficial use:

> "A saturation-based DO objective does not provide adequate protection of beneficial uses if based on existing temperature conditions, though; because, as temperatures increase the allowable DO will decrease without regard to cause. A saturation-based DO objective based on an estimate of natural temperatures, however, ensures that only natural phenomena are considered when calculating appropriate DO objectives by this method."

Why is it so important to ensure that DO objectives are calculated based on natural phenomena? If the point is for DO objectives to be met, why does it matter whether the conditions are natural or not?

Section 1.3, Last paragraph, Lines 3-4. The following sentence is inaccurate:

> "…elevated loads of nutrients and organic material are released to the water column and flow downstream." The mention of elevated loads of nutrients suggests that there are large amounts of nitrogen and phosphorus. However, most of the nutrient load is phosphorus – not nitrogen. Further, soils do not release organic matter to the water column.

Appendix 3: Nutrient Dynamics in the Klamath.

Page 2, Paragraph 2, Lines 2-4. Calibration was neither precise nor based on much data and results of calibration probably do not suggest "that some of the original criticisms of the model are correct." In fact, other studies cited in this TMDL suggest that original model results as presented by PacifiCorp were correct. Use of more data in a more rigorous calibration and validation are necessary to make any such statements.

Page 2, Paragraph 3, Line 1. Models were designed to enhance analysis of systems characterized by sparse data. The lack of data makes an appropriately applied model's results more credible than direct evaluation or the scoping-level analyses described later in this appendix.

Page 3, Paragraph 1, Lines 3-5. "…the model predictions are strongly determined by the boundary conditions (upstream load and relative dilution provided by the downstream tributaries)." As noted, this is especially true in the Klamath River. A major flaw in this TMDL is the failure to use all available data and the misrepresentation of organic matter partitioning at the upstream boundary. A greater fraction of OM as refractory (as suggested by recent studies in the upper Klamath River) translates to even less retention in river reaches. This would markedly affect the dams-out scenario in which the Klamath is composed entirely of river reaches.

Page 3, Paragraph 2, Line 1. Simulations of more years to quantify this "year-to-year" variation are needed.

Page 3, Paragraph 2, Lines 4-5. This paragraph appropriately recognizes the uncertainty associated with data and its consideration in interpreting model results.

Page 3, Paragraph 4, Line 2. Usefulness of the model could be greatly improved by simulating several years, not just one.

Page 4, Paragraph 2, Lines 1-2. Will denitrification occur in a river running at 85 percent saturation? It seems like denitrification and fixation are equally unlikely.

Page 5, Paragraph 1. Watercourse also believes a mass balance/loading is the correct way to evaluate nutrient loss and retention, and that concentration trends are of little value in this evaluation.

Page 5, Paragraph 2. The unstated implication here is that the Asarian and Kann study cited should be discarded.

Page 7, Figure 1 and 2. These figures show no relationship between either TN or TP and flow and thus it is not clear why they are included.

Page 7, Paragraph 1, Line 3-4. The SPARROW model of removal is very coarse and based on rivers all over the US, most of which are of a quite different profile than the Klamath. We question the relevance of the SPAROW model in the Klamath. Also, because the SPAROW model is non-linear (exponential decay), using a median value of flow is inappropriate. It would be easy to apply the model to hourly flows and average results for a more accurate representation of removal.

Page 9, Paragraph 1, Line 5-7. The model being reviewed is not PacifiCorp's model, it is TetraTech's model and TetraTech should document "other relevant rate constants."

Page 9, Paragraph 3, Line 1-2. Nutrient cycling may not be accurate but that doesn't mean annual net retention (loss) is not. A reasonably calibrated RMA-11 can accurately represent annual net loss.

Page 9, Bullet point 1. Denitrification is probably not important in Klamath river reaches. Some simple estimates could put bounds on the contribution of denitrification.

Page 9, Bullet points 2 and 3. These processes would not affect annual retention or loss.

Page 9, Bullet point 4. How significant is riparian vegetation in long-term sequestration on the Klamath? Probably not very but, again, some simple estimates could put bounds around it if this is of concern.

Page 9, Paragraph 2. There are few ultimate sinks for nutrients in RMA-11 because there are few ultimate sinks in a fast free-flowing river like the Klamath.

Page 11, Paragraph 3, Line 3-6. SPARROW is likely not very relevant because, as noted, the Klamath is unusual with increasingly steep gradients. SPARROW is based on an average river type that includes many Eastern rivers. RMA11 is physics-based with significant detail but SPARROW takes into account nothing except flow and travel time – and those only coarsely.

Page 11, Paragraph 3, Line 6-8. RMA11 matches the analysis of Armstrong and Ward.

Page 11, Paragraph 3, Line 13-15. The relevant point is annual loss, so the seasonal estimates cited are of marginal value. Plus, of the two seasonal estimates, RMA11 matches one of them.

Page 14, Paragraph 2, Line 8-9. Given that the other studies are of marginal relevance in estimating annual loss of nutrients on the Klamath, how does author substantiate the statement that RMA-11 “may have some tendency to underestimate nutrient losses in the free-flowing reaches of the Klamath”?

Page 14, Paragraph 4, Line 4-5. Is author equating deeper reservoirs with shorter retention times? Please clarify.

Page 15, Paragraph 2. Another study of Kann and Asarian is considered of questionable value. Here, 2002 estimates are described as not reliable.

Page 15, Paragraph 3. Why should there be “large uncertainties” in flow measurements? Detailed flow should be readily available.

Page 15, Paragraph 4, Line 5-8. What is the use of measures like “standard error” in this analysis? Field data have natural variation. How does that cast doubt on the results?

Page 16, Paragraph 2, Title. Are these estimates of retention or loss?

Page 16, Last paragraph, Line 6-8. Where do these estimates of hydraulic residence time come from? Do they come from the model or flow-volume calculations?

Page 17, Table 5. Vollenweider (1976) is likely not appropriate. Kann and Asarian should have their work peer-reviewed. It would be useful to include W2 results to this table, as directly below:

Parameter	Method	Copco	Iron Gate
TP	W2	1.2%	6.1%

TN	W2	3.6%	17.6%

Page 18, paragraph 3. How was retention (loss?) calculated? Was this done hourly? For this analysis, only beginning and ending storage volumes were used with concentration. Why not just use Loss = QiCi - QoCo? What concentration was used – was it taken from somewhere in the reservoir?

Page 19-20, Table 6-9. Please explain how the 'Whole Year Retention" was "corrected for change in storage."

Page 23, Paragraph 1, Line 1-2. "Available monitoring data (are) insufficient to produce good estimates of nutrient retention and loss." But more recent data will provide much better estimates.

Page 23, Paragraph 1, Line 1-2. Given previous discussions, denitrification is probably NOT an important loss pathway in river reaches.

Page 23, End of Paragraph 3, 8-10. "Presence of reservoirs in series likely limits deep burial rates." This assumes that all settleable solids are all retained in Copco reservoir. But Copco produces algae which will die and settle in Iron Gate. Also, this brings in the interesting idea of removing not all, but some of the dams. Thus, allowing nutrients to continue settling while further scientific studies are conducted and scientific plans implemented to improve water quality in the Klamath.

Page 23, Paragraph 5, Line 2-4. What is the basis for Asarian and Kann's contention that "there is significant retention of TN between Iron Gate and Seiad"?

Page 23, Paragraph 6. The weight of evidence presented in this appendix suggests no reason to doubt model results.

Appendix 6: Klamath River Model for TMDL Development.

Page 7, Section 2.2.2. Given the data provided, the value of this "two-state algae transformation" modification is questionable. A very limited number of data (3) seem to be the basis for this modification (please see discussion of Figure 2-1, below), and the data do not really support the scheme. The calibration plots for Miller Island and Hwy 66 in 2000, Figures E-6 and E-16, respectively, suggest that just about any function that reduces algae concentrations from Miller Island to Hwy 66 would work just as well. Furthermore, it doesn't look as if this "phenomenon" exists in the 2002 "validation" data. In 2002, there is no large drop in chlorophyll *a* concentrations and the healthy-unhealthy hypothesis does not seem to fit. At the very least, the Regional Board staff should bring the 2002 data that they used in "validation" into this discussion.

Page 8, Paragraph 3, last line. So many things can effect algal growth that it is hard to accept the statement that "available data show no other explanation for the observed phenomenon." What phenomenon is being referred to?

Page 8, Figure 2-1. There are three chlorophyll *a* concentrations above 50 µg/L at Miller Island, as shown in this figure. Is this the phenomenon referred to? Are these three data points real (were they duplicated?) and are they representative of chlorophyll *a* at that time and in that location? These three data points appear to be the basis of the entire healthy-unhealthy algae hypothesis and implementation. The eleven other concentrations reported at Miller Island are all below 50 µg/L – similar in magnitude to chlorophyll *a* concentrations at Highway 66.

How does this low DO argument explain these data? Chlorophyll *a* at Highway 66 is uniformly lower than at Miller Island. (Actually only one data point at Miller Island creates a huge disparity and only three total at Miller Island are significantly higher). May to June is a period of high DO throughout the reservoir (both upstream at Miller Island and at Highway 66) but chlorophyll *a* is low at Highway 66.

Page 10, Equation 3. This equation is not a "Monod-type function."

Page 10, Last paragraph. Is "smoother" more accurate and more representative of natural processes? Does this modification improve the model?

Page 11, Section 2.2.4. Watercourse ran into some problems using the pH modifications. The numerical technique is not robust and can lead to errors.

Page 11, Paragraph 3, Equation (Ke). In this formula, is OM particulate or refractory or both (i.e., total)?

Page 12, Paragraph 2, Lines 13-19. Please clarify that the numbers given here are just an example and not values fixed for all simulations.

Page 12, Paragraph 2, Line 19. Both setting and decomposition affect the OM fractions.

Page 19, Paragraph 1, Lines 2-3. Sometimes, "it is preferable to use data collected during the modeling year" but only if the site is representative of boundary conditions.

Page 19, Paragraphs 1-3. Phosphorus data seem to come from Pelican Island, Fremont Bridge, and Miller Island, inconsistently.

Page 19, Paragraph 3. Boundary condition (BC) PO4 concentration is used as a calibration tool. This is not standard practice.

Page 19, Paragraph 4. The PO4 boundary condition is from Miller Island. But PO4 and TP used in OM boundary condition are from Pelican Marina. This is inconsistent. Please clarify whether PO4 concentrations from Pelican Island are good or not.

Page 20, Paragraph 1. Boundary condition TIC and alkalinity concentrations are used as a calibration tool to get pH in Lake Ewauna. This is not standard practice.

Page 20, Paragraph 1. In 2002, Miller Island data were not used to estimate PO4. Again, we question this method. Why are PO4 concentrations from UKL good to use in 2002, but not in 2000?

Page 33, Bullet Point 8, Line 1. Regional Board staff uses the assumption that "the majority of OM in the boundary condition is … labile." In fact, their assumption is that all OM in the boundary condition is labile. Available data suggest that the majority of OM in the boundary condition is not labile, but refractory. This incorrect assumption will have large consequences for water quality downstream and into the estuary.

Page 33, Bullet Point 9, Line 1. Denitrification in rivers is not significant, and thus should not be a concern in Appendix 3.

Page 34, Bullet Point 1, Line 3-6. We agree that the model is not good at predicting actual water quality concentration but that it "can be used to represent the overall water quality trends in response to external loading and internal stream dynamics." This being agreed upon, how good is the model for setting target concentrations and load allocations? This inability to predict values is not well incorporated in the discussion.

Page 34, Bullet Point 7, Line 2-3. Since the sediment diagenesis model is not activated, is there no SOD or benthic loads in the estuary model? Please clarify.

Page 35, Paragraph 1, Lines 3-4. We agree that uncertainty is inherent in the model (especially with a limited observed data set) and that the model should only be relied upon to reproduce "general trends."

Page 40, Section 3.3. Some calibrated parameters were changed during "validation." Please confirm that calibrated values were unchanged for all TMDL scenarios.

Page 40, Last paragraph, Line 1-2. In calibration, algae and OM parameters changed from reservoir to reservoir. We question the validity of changing these values in light of the lack of data to support the changes. Please provide more justification for the actual changes made (e.g., "algae growth rates were reduced in Copco because…"). This is especially important because only one year of data were used in calibration and validation.

Page 41, Paragraph 2, Line 2-5. Regional Board staff justify changing OM decay rates by stating that "as a significant portion of the more labile OM upstream in the system is lost through degradation, the remaining OM downstream becomes less labile." This is poor justification because the model already accounts for changing decay rates in partitioning between refractory and labile OM. As more labile OM is degraded upstream, the refractory fraction increases. In the model, refractory OM has a much slower decay rate. We see no reason to change OM decay rates.

Page 41, Table 3-3. Not mentioned in the discussion is the fact that NH4 decay and SOD parameters also change from reach-to-reach. Please explain rationale for changing these parameters reach-to-reach.

Page 43, Table 3-5. The table implies that parameter values remain constant reach-to-reach and for each scenario. Please confirm that this is true. Also, some parameters are not listed in this table. For example, "bed algae carrying capacity," a term added by the Regional Board to the RMA-11 model. In earlier versions of the TMDL model, this important parameter was not kept constant. Please include all important parameters and confirm that they remain constant reach-to-reach and for each scenario.

Page 44, last paragraph, Line 1. The model does not appear to "reproduce the supersaturation of DO during early summer well." Simulated DO is always 4-6 mg/L low in comparison to observed values in May.

Page 44, last paragraph, Line 3. Please clarify for the reader that the statement made here is not fact, but simply a supposition.

Page 45, Paragraph 2, Lines 6-10. There is SOD in W2. It is not clear that a fully dynamic interaction between bed and water column is necessary. Similar results might be obtainable by specifying seasonal SOD.

Page 47, Paragraph 6, Line 13-15. What is the rationale for explaining the over- and underprediction of water temperature in this reach as "likely due to differences between modeled and actual bathymetry…"?

Page 48, First sentence. If "the model's overprediction of chlorophyll *a* …is likely caused by inaccurate boundary conditions from UKL", then why would this overprediction of chlorophyll *a* not show up in all upstream reaches? As noted by RWB, the model simulates chlorophyll *a* "very well' in Lake Ewauna to Keno Reach (page 45, paragraph 3, line 1). Or, is the Regional Board staff saying inaccuracies in boundary nutrients led to poor chlorophyll *a* simulation downstream? Please clarify.

Page 48, Paragraph 4, Line 5. To say that the model "predicts concentrations within the range of observed data" is misleading and used in several places. Model results for NH4 and NO3 are not within any meaningful observed range.

Page 48, Paragraph 5. As in other places in this TMDL, the Regional Board states that calibrating a model to observed data "indicates that water quality dynamics …are reasonably represented." Calibrating at this level (one year of data) is simply a curve fitting exercise and doesn't indicate anything about the models ability to represent the dynamic nature of surface water quality.

Page 50, Paragraph 3, Line 1-2. Apparently, 2004 data were used to calibrate the estuary model. Why weren't data through 2004 used for the rest of the river? Why weren't data gaps identified and filled for the rest of the river through at least 2004?

Page 50, Paragraph 4, Line 7-8. Uncertainty in lab data is shown in estuary calibration figures. Why should this be done only for the estuary? It would be very useful to see error bars in the presentation of lab uncertainty throughout this TMDL.

Appendix 7: Response to Peer Review Comments on Draft Klamath River TMDLs.

Page 2, Response M1, Paragraph 1, Line 3-4. The response correctly identifies that the system is "naturally eutrophic." Further, under existing conditions the margin for error may in fact be modest. However, application of these models in the natural baseline and compliance scenarios where background concentrations are reduced to extremely low levels increases the margin for error dramatically.

Page 3, Comment M2, End of Paragraph 1. Is this "lens" stable and dependable? This question is really not answered in the Regional Board staff response.

Page 3, Response M2, Paragraph 1. With regards to the thickness of the compliance lens, setting this thickness to "depth of the river under pre-disturbance regime" seems rather arbitrary; it has no real basis in science or management. The minimum thickness should be whatever is required to maintain and assure stability.

Page 6, Comment C1, Paragraph 1. Characklis expresses concerns over the model's ability to predict values well. He recommends explicit treatment and discussion of uncertainty as part of the TMDL process. The comment response states that uncertainty was minimized in other ways, but there is no real presentation of information that provides confidence to the reader that uncertainty was effectively incorporated into the modeling and load allocations.

Page 6, Comment C1, Paragraph 1, Lines 12-15. "…reliance on deterministic modeling results without giving due attention to the levels of uncertainty attendant with these estimates can provide an incomplete picture to those seeking to interpret these analyses for decision making purposes." This seems to be what is happening with the natural conditions model. The model was set up with boundary conditions that are highly improbable, and this was confidently assumed without appropriate consideration.

Page 7, Comment C1, Paragraph 4. Dr. Characklis expresses concern about the limited data set used in these important simulations. His statement that "predictions based on water quality models, even the most advanced models parameterized with extensive data sets, are often highly divergent from observations…" is true and his concern about basing decisions on this model, calibrated with a limited data set and hardly validated at all, is valid. His other point is that relatively small deviations between current and natural scenario results are an inappropriate basis for load allocation and regulation. These small deviations, as noted elsewhere in our comments, are well within any inherent uncertainty and error in this model. We add our concern that, for this TMDL, the full model has only been applied to one year of observed conditions and the model has basically been customized to fit that one year of data. Four years of model data were available (2001-2004) to test this model over a considerably wider range of conditions.

Page 7, Comment C1, Paragraph 5. We agree that confidence intervals could have, and should have, been evaluated for this TMDL model. For instance, many years of climate data exist for the Klamath basin. Using a variety of existing historical climate conditions would yield a range of temperature responses for the river and provide a much better basis for decision making.

Page 7, Comment C1, Paragraph 6. We are agree with Characklis suggestion of considering a joint modeling and monitoring approach. This implies working together with all entities in the basin, and their contractors, sharing data/files, models, and approaches and being transparent. The monitoring work being conducted under the AIP Interim Measure No. 12 should further this effort.

Page 8, Response C1, Paragraph 2-3. The Regional Board staff response here seems to dismiss the Dr. Characklis' concerns about uncertainty and responds that uncertainty, even a good description of uncertainty, would take too much time and cost too much. We disagree with the Regional Board's response. Evaluation of uncertainty is necessary for a model to be useful, especially a complex model such as this one. In view of the time spent on "key best practices," and the importance of this TMDL, a description and good analysis of uncertainty should not be too much to expect and should not be significantly greater effort.

Page 8, Response C1, Paragraph 3, Line 6. Adjusting boundary conditions is not typically a part of normal calibration and doing so (i.e. calibrating by changing boundary conditions that are based on field observation) is questionable practice.

Page 9, Response C1, End of Paragraph 3. If the focus was on "acquiring and incorporating the most accurate and comprehensive data," then why was only one year (2000) incorporated in this model? More years of data should have been incorporated into the model to reduce uncertainty and improve confidence about the model's ability to make predictions.

Page 9, Response C1, Paragraph 5. In making its case for not incorporating uncertainty analyses, the Regional Board staff exaggerates the difficulty of uncertainty analysis. "Interval number, fuzzy parameter, Monte Carlo, and Bayesian analyses" are not required. Further, "4 days of continuous simulation" are not required to run the Klamath models, at least not in an efficient manner. Sensitivity can be performed in a systematic and limited manner, particularly with guidance from an experienced modeler who has performed calibration on the system. A straightforward and functional sensitivity analysis could be completed in a variety of ways, including:

- Identifying a subset of modeling parameters and boundary conditions to be tested (i.e., do not perform sensitivity on every single parameter),
- dividing the domain into sub-reaches for certain tests,
- running the model for shorter periods of time during critical periods of the year

Hundreds of scenarios are not required. At the very least a modest set of runs quantifying and bounding the uncertainty should have been performed.

Page 10, Response C1, Paragraph 7. The Regional Water Board staff state their belief that "the TMDL models are performing well and are suitable tools for establishing Klamath River TMDL allocations and targets." In agreement with Dr. Characklis' comments, we do not see the basis for this belief. These models have not been completely documented. Nor has uncertainty been quantified in any significant way. At present, these models are inadequate to describe the Klamath River system in the detail required for this TMDL.

Page 10, Comment C2, Paragraph 1. We agree that the algae models, as applied in this TMDL, do not represent algal (chlorophyll *a*) response to nutrients well enough to form the basis for specific nutrient targets.

Page 11, Response C2, Paragraph 1. What is "modern" water quality modeling technology as opposed to "dated" water quality modeling technology? More importantly, the statement that "algal biomass in riverine reaches is not related to nutrient concentrations" is misleading. For benthic algal growth this is very important. Further, the implications for the lower river and, in particular, the estuary, of these nutrients are paramount.

Page 11, Response C2, Paragraph 3. Calibration results are not predictions. Further, the response clearly states that Copco and Iron Gate reservoirs were not validated (or "corroborated" in the language used here). Further, a simple graphic showing unquantified "increases" during summer and fall provide no quantitative, or technical basis for load allocations, i.e., having "more" at one period than another hardly makes the model a useful tool for load allocations. A quantitative sensitivity and uncertainty analysis is required, with corresponding model performance metrics so decision makers have a clear grasp of the model and data capabilities. From the perspective of conservative assumptions for the margin of safety, this information provides little useful data.

Page 12, Response C3, Lines 4-8. How significant is this "release of dissolved inorganic nutrients into the water column"? What percentage of the total dissolved inorganic nutrients already in the water column does it represent? Also, there is no mention of settling that occurs in these reservoirs that would, in fact, trap some of these nutrients already in the water column and reduce the downstream river impacts from these nutrients. With free-flowing conditions, all the existing nutrients will simply be transported downstream, thus causing potential impairment in the lower river.

Page 13, Response C4. The response to comment C4 ignores the question completely. Dr. Characklis' specifically voiced his concerns on how the temperature reductions in Copco and Iron Gate would be achieved. The response to the comment vaguely states the objective of getting the temperature of current condition water to natural conditions. For example, the Regional Board staff appears to ignore the practicality in the comment that temperature changes of 0.1 and 0.3 degrees C across Copco and Iron Gate reservoirs, respectively, are unachievable (let alone measurable). Instead, staff seems to assume that dams will have to be removed. These temperature targets are derived from a "natural conditions" scenario but there is little basis to convince the reader that they are really necessary to protect beneficial uses.

Page 14, Response C5. Regional Board staff has devised a "compliance lens allocation" to protect fish. The comment is that this solution is conceptually interesting but untested and probably unsound. The Regional Board staff then responds that "how the allocation is met is ultimately the responsibility of PacifiCorp," but the definition of the compliance lens (the full length of the reservoir and the full width of the reservoir) is unattainable under a stratified condition because the thermocline is not coincident with the water surface (which defines the full length and width of the reservoir). For this novel, and potentially useful approach, considerably more thought and discussion is required prior to applying the concept as a regulatory requirement.

Page 14, Response C6. The response to climate change is inadequate. This is not a complicated analysis and is required for a TMDL with potentially long implementation timelines on the order of decades. The Upper Klamath Lake TMDL will take decades to implement and during this time notable climate changes may occur, increasing temperatures in an already compromised basin. Without a climate change assessment, realistic load allocations cannot be determined. Even a simple assessment can provide considerable insight (See Analysis F: Climate Change)

Page 17, Comment C10. Dr. Characklis states that the TMDL needs more sufficient data before it can accurately assess allocations. He states there is insufficient data to make any informed judgments. The response restates the section on climate change, but ignores Dr. Characklis' concerns on insufficient data.

Page 22, Response T6, Paragraph 1. The statements is made that the "temperature calibration…demonstrates the model's ability to represent both observed magnitude and trend." However, due to the undocumented 20 percent reduction in solar radiation to all reaches except the Project reservoirs, the calibration and subsequent application of the models to natural conditions is invalid.

Page 22, Comment T8, Paragraph 1. The peer reviewer makes an excellent point that implementation and the condition of the river in the interim are not considered by the proposed allocations and targets. We agree with the reviewer's concerns about the use of limited data and the claim of an "implicit margin of safety." As stated "an analysis of model uncertainty is absolutely warranted."

Page 23, Response T12, Paragraph 1, Line 6-7. The model was not calibrated for multiple years for the California portions, and because parameters were changed between the calibration and validation years, the outcome is suspect. Again, the model has simply demonstrated an ability to be somewhat calibrated to one year of observed data. It has not been fully or adequately calibrated for multiple years. We question the statement that "the year 2000 exhibited poor water quality, and thus was deemed a key consideration for TMDL development." Elsewhere, the document states that the year 2000 was chosen because it contained the only available data. How would one know that 2000 was a year of poor water quality without other years of data and where is that analysis? Would a range of conditions provide a better test for the model than a single year? (As a matter of note, the estuary model was not reviewed due to the limited public comment period.)

Page 26, Response T13, Paragraph 1. Regional Board staff seem to ignore the very important point made in this comment, which is that Regional Board staff should "consider how the TMDL targets can be met during the interim period between approval of the targets and decommissioning."

Page 29, Response K4, End of Paragraph 1. Are proposed DO objectives calculated from local air temperature and air pressure? We note that the Regional Board staff states that the "natural conditions baseline modeling scenario" didn't meet life-cycle and DO objectives.

Page 34, Response K13, Paragraph 1. Regional Board staff state that "excess accumulation of periphyton…appear to play an important role in high levels of parasite infection." Is this a hypothesis or does it derive from research? There is no citation associated with this statement.

Page 34, Comment and Response K14. The comment is correct – that tributary contributions play a dominant role in thermal refugia form and function, with different effects in the upper reaches than in the lower reaches. Different tributary contributing watershed areas for flow and mainstem stage and flow play vital roles. Review of the draft TMDL did not reflect the basic processes at work in refugial areas near creek-main stem confluences. There is extensive exploration of these processes in Klamath River refugia completed by USBR that were ignored in the draft TMDL.

Page 35, Comment K18, Paragraph 1. Again, uncertainty should be included when presenting model results and the model was not validated in California reaches.

Page 35, Response K19. Two citations were added to the document. Over half a dozen references on extensive thermal refugia work in the Klamath Basin were included with Chapter 4 comments. This seminal work – completed by Reclamation in cooperation with the Yurok and Karuk Tribes – was submitted the Regional Board staff in response to a request for thermal refugia information but this information was apparently not considered.

Appendix B:
List of Key Water Quality Studies and Data for the Klamath River Basin That Are Not Cited in the Draft TMDL

List of Key Water Quality Studies and Data for the Klamath River Basin That Are Not Cited in the Draft TMDL

On Page 4-1 (in paragraph 3, after bullet points), the Draft TMDL notes that the analyses draw upon the most current quality assured data available form ongoing monitoring. However, the data used in the Draft TMDL does not include or cite many key water quality studies and data for the Klamath River Basin. Listed below are key reports and documents that were not used or cited in the draft TMDL. Omission of these key reports and documents indicates that even a basic review of available reports and data was not completed, but rather a selective set of data were used in the TMDL analysis and development of load allocations.

All of the reports and documents cited below are publicly available, and therefore should be easily accessible by Regional Board staff. If Regional Board staff have difficulty in obtaining any of these reports or documents, PacifiCorp can provide copies upon request. Otherwise, PacifiCorp assumes that the listed documents are hereby incorporated into the record.

Water Quality Studies and Associated Data

City of Klamath Falls. 1986. Application for License. Salt Caves Hydroelectric Project. Volume II: Exhibit E. Sections 1.0, 2.0, and 3.0. Submitted to the Federal Energy Regulatory Commission. November 1986.

Deas, M.L. 2008. Nutrient and Organic Matter Fate and Transport in the Klamath River: June to September 2007. Prepared by Watercourse Engineering for PacifiCorp. November. http://www.pacificorp.com/File/File87149.pdf

E&S Environmental Chemistry, Inc. (E&S). 2008. Results of 2007 Phytoplankton Sampling in the Klamath River and Klamath Hydroelectric Project (FERC 2082). Prepared for PacifiCorp. December 12. http://www.pacificorp.com/File/File87148.pdf

PacifiCorp. 2004a. Final License Application. Volume 2. Exhibit E. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004b. Final Technical Report, Water Resources. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2004c. Final Technical Report, Fish Resources. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. February 2004.

PacifiCorp. 2005. Status Report. Klamath River Water Quality Modeling. Response to FERC AIR GN-2. Klamath Hydroelectric Project Study 1.3 (FERC Project No. 2082). PacifiCorp. Portland, Oregon. April 2005.

PacifiCorp. 2006. Causes and Effects of Nutrient Conditions in the Upper Klamath River. Klamath Hydroelectric Project (FERC Project No. 2082). PacifiCorp, Portland, Oregon. November 2006. 77 pp.

PacifiCorp. 2008a. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Klamath County, Oregon. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: Oregon Department of Environmental Quality, Portland. Prepared by: PacifiCorp, Portland, Oregon. February 2008.

PacifiCorp. 2008b. Application for Water Quality Certification Pursuant to Section 401 of the Federal Clean Water Act for the Relicensing of the Klamath Hydroelectric Project (FERC No. 2082) in Siskiyou County, California. Klamath Hydroelectric Project (FERC Project No. 2082). Prepared for: State Water Resources Control Board, Division of Water Quality, Water Quality Certification Unit, Sacramento. Prepared by: PacifiCorp, Portland, Oregon. February 2008.

Raymond, R. 2008. Water Quality Conditions During 2007 in the Vicinity of the Klamath Hydroelectric Project. Prepared for PacifiCorp. October. http://www.pacificorp.com/File/File87147.pdf

Risley, J.C. and S.A. Rounds. 2006. Evaluation and Review of Recent Klamath River Water-Temperature Modeling Studies. U.S. Geological Survey Administrative Letter.

U.S. Bureau of Reclamation (USBR). 2003. Klamath River Water Quality 2000 Monitoring Program - Project Report (including a Data Appendix). Prepared for the U.S. Bureau of Reclamation in cooperation with PacifiCorp by Watercourse Engineering, Inc. January 25.

U.S. Bureau of Reclamation (USBR). 2003. Klamath River Water Quality 2000 Monitoring Program – Attached Algae modeling Literature Review. Prepared for the U.S. Bureau of Reclamation in cooperation with PacifiCorp by Watercourse Engineering, Inc. January 25.

U.S. Environmental Protection Agency (EPA). 1978. Report on Iron Gate Reservoir Siskiyou County California. Working Paper 749. National Eutrophication Survey Working Paper Series. U.S. Environmental Protection Agency, Corvallis, Oregon.

Watercourse Engineering, Inc. (Watercourse). 2004. Klamath River Modeling Framework to Support the PacifiCorp Federal Energy Regulatory Commission Hydropower Relicensing Application. Prepared for PacifiCorp. March 9.

Watercourse Engineering, Inc. (Watercourse). 2006. Characterization of Organic Matter Fate and Transport in the Klamath River Below Link Dam to Assess Treatment/Reduction Potential. Prepared for U.S. Bureau of Reclamation, Klamath Basin Area Office. September 30.

Thermal Refugia

Sutton, R.J., M.L. Deas, S.K. Tanaka, T. Soto, and R.A. Corum. 2007. "Salmonid observations at a Klamath River thermal refuge under various hydrologic and meteorological conditions." River Res. Applic. 23: 775-785.

Tanaka, S.K. (2007). Modeling to Improve Environmental System Management: Klamath River Thermal Refugia and the Sacramento-San Joaquin Delta. Diss. University of California, Davis. 2007.

U.S. Bureau of Reclamation (USBR). 2002. Klamath River Thermal Refugia Study: Summer, 2002. Prepared by Watercourse Engineering, Inc. for the U.S. Bureau of Reclamation with assistance from the Yurok Tribal Fisheries Program. December.

U.S. Bureau of Reclamation (USBR). 2004. Klamath River Thermal Refugia Study: Flow and Temperature Characterization: Summer, 2003. Prepared by Watercourse Engineering, Inc. for the U.S. Bureau of Reclamation with assistance from the Yurok and Karuk Tribes. March.

U.S. Bureau of Reclamation (USBR). 2005. Klamath River Thermal Refugia Study: Flow and Temperature Characterization: Summer, 2004. Prepared by Watercourse Engineering, Inc. for the U.S. Bureau of Reclamation with assistance from the Yurok and Karuk Tribes. February 17.

U.S. Bureau of Reclamation (USBR). 2006. Klamath River Thermal Refugia Study: Flow and Temperature Characterization: Final Project Technical Report. Prepared by Watercourse Engineering, Inc. for the U.S. Bureau of Reclamation with assistance from the Yurok and Karuk Tribes. June 1.

Tributary Studies

Hoopa Valley Tribe. 2005. Hoopa Valley Tribal Fisheries, Trinity Basin Surface Water Data Review: 1995-2005 Water Years. Prepared by Martin Hydrographics. April.

Jeffres, C. A., E.M. Buckland, M.L. Deas, B.G. Hammock, J.D. Kiernan, A.M. King, N.Y. Krigbaum, J.F. Mount, P.B Moyle, A.L. Nichols, and S.E. Null. 2008. Baseline Assessment of Salmonid Habitat and Aquatic Ecology of the Nelson Ranch, Shasta River, California: Water Year 2007. Report prepared for the United States Bureau of Reclamation, Klamath Basin Area Office.

Jeffres, C.A., R. Dahlgren, M. Deas, J. Kiernan, A. King, R. Lusardi, J. Mount, P.Moyle, A. Nichols, S. Null, S. Tanaka, and A. Willis. 2009. Baseline Assessment of Physical and Biological Conditions Within Waterways on Big Springs Ranch, Siskiyou County, California. Report prepared for: California State Water Resources Control Board.

U.S. Fish and Wildlife Service (USFWS). 2003. Lewiston Dam Releases and Their Influence on Water Temperatures of the Trinity and Klamath Rivers, California: WY 2002. Prepared by Paul Zedonis for the Trinity River Restoration Program. Report Number AFWO-F-02-03. June.

U.S. Fish and Wildlife Service (USFWS). 2004. Lewiston Dam Releases and Their Influence on Water Temperatures of the Trinity and Klamath Rivers, California: April – October, 2003. Prepared by Paul Zedonis for the Trinity River Restoration Program. Report Number AFWO-F-01-04. June.

U.S. Fish and Wildlife Service (USFWS). 2005. Lewiston Dam Releases and Their Influence on Water Temperatures of the Trinity and Klamath Rivers, California: April – October, 2004. Prepared by Paul Zedonis for the Trinity River Restoration Program. Report Number AFWO-F-01-05. April.

Watercourse Engineering, Inc. (Watercourse). 2005. Trinity River Flow and Temperature Modeling Conceptual Framework. Prepared for Trinity County Planning Department Natural Resources Division. January.

Watercourse Engineering, Inc. (Watercourse). 2006. Trinity River Flow and Temperature Modeling Project. Prepared for Trinity County Planning Department Natural Resources Division. January.

Zedonis, P. 1997. A Water Temperature Model of the Trinity River. United States Department of Interior, Coastal California Fish and Wildlife Office Arcata, California. Prepared for Bureau of Reclamation, Sacramento, California. July.

Zedonis, P. 2005. The SNTEMP Model of the Trinity River: A Model Update. U.S. Fish and Wildlife Service. March 10.

Zedonis, P. A. and T. J. Newcomb. 1997. An evaluation of flow and water temperatures during the spring for protection of salmon and steelhead smolts in the Trinity River, California. U.S. Fish and Wildlife Service, Coastal California Fish and Wildlife Office. Arcata, CA. 31 pp.

Zedonis, P. and R. Turner. 2006. The Influence of Lewiston Dam Releases on Water Temperatures of the Trinity and Klamath Rivers, CA., April to October, 2005. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Data Series Report Number DS 2006-08, Arcata, California.