Review of the Klamath River Model for the Klamath Hydropower Project FERC #2082

DRAFT

by

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Introduction

The Klamath River water quality model was developed as part of the Klamath River Hydropower Project by PacifiCorp. The Bureau of Land Management (BLM) contracted for a review of this model. This report consists of a review of both written documents and of model computer files.

The materials used in the review include

- documents provided by PacifiCorp and Watercourse Engineering (see Appendix A)
- model files provided by Watercourse Engineering (a total of approximately 23 CDs)

A detailed review of each CE-QUAL-W2 model file set was performed going through a check-list of items for each model in Appendix B. Also, water quality kinetic parameter values for the CE-QUAL-W2 and RMA11 models were summarized and compared in Appendix C.

This memorandum is broken into several sections:

- Review of the model set-up and calibration
- Review of Model Files for CE-QUAL-W2
- Review Model Kinetic Coefficients for CE-QUAL-W2 and RMA11 Models
- Review of model alternatives
- Review of SOD measurements in Lake Ewauna/Keno Dam
- Summary and Recommendations
- Appendices outlining materials reviewed, detailed check sheets for each of the CE-QUAL-W2 model sets, detailed review sheets for model water quality kinetic coefficients used in the CE-QUAL-W2 and RMA11 models, review of whether there was a correct mass balance between RMA11 and CE-QUAL-W2 models, and a review of a simple management strategy for Copco and Iron Gate reservoirs using the CE-QUAL-W2 models.

The basic philosophy of this review was to provide constructive comments to improve the science and engineering being applied to the Klamath basin. In order to guide the review, Table 1 shows a summary of all the model run periods for each model reach.

Table 1. Model Reach simulation periods

Reach	Calibration Period(s)	Validation Period(s)	Model Run Periods
Link River	May 21 to 23, 2002	July 16 to 18, 2002	MI: January 1, 2000 to December 31, 2000 and January 1, 2001 to December 31, 2001 MC&V: May 18 to 23, 2002 and July 13 to 18, 2002
Lake Ewauna/Keno	June 1 to 7, 2000 July 1 to 7, 2000 August 1 to 7, 2000 September 1 to 7, 2000 October 1 to 7, 2000	June 1 to 7, 2001 July 1 to 7, 2001 August 1 to 7, 2001 September 1 to 7, 2001 October 1 to 7, 2001	MI: January 1, 2000 to December 31, 2000 Appendix H: January 1, 2001 to December 31, 2001 MC&V: January 1, 2000 to December 31, 2000 and January 1, 2001 to December 31, 2001
Klamath River (Keno Reach)	May 20 to 23, 2002	September 10 to 12, 2002 July 14 to 17, 2002	MI: January 1 to December 31, 2000 MC&V: May 19 to 23, 2002, July 13 to 17, 2002, and September 9 to12, 2002
J. C. Boyle Reservoir	April 12 to October 18, 2000 (7 dates with vertical profiles)	none	MI: January 1 to December 31, 2000 MC&V: January 1, 2000 to December 31, 2000
Klamath River (Bypass & Peaking Reach)	May 20 to 23, 2002	July 15 to 18, 2002	MI: January 1 to December 31, 2000 MC&V: May 17 to 23, 2002 and July 12 to 18, 2002
Copco Reservoir	April 12 to October 18, 2000 (8 dates with vertical profiles)	none	MI: January 1 to December 31, 2000 MC&V: January 1, 2000 to December 31, 2000
Iron Gate Reservoir	April 12 to October 18, 2000 (8 dates with vertical profiles)	none	MI: January 1 to December 31, 2000 MC&V: January 1, 2000 to December 31, 2000
Klamath River (Iron Gate Dam to Tuwar)	June 5 to 7, 2000 August 7 to 9, 2000 June 9 to 12, 2003 August 18 to 21, 2003	none	MI: January 1 to December 31, 2000 MC&V: June 3 to 7, 2000, August 5 to 9, 2000, June 5 to 12, 2003, and August 14 to 21, 2003
MI: Model Implementation, Section 2		MC&V: Modal Calibration and Validation, Section 3	

Review of Model Set-Up and Calibration

This section is a review of the model set-up and calibration process. The following comments are provided in a tabular form for ease of evaluation.

Table 2. Model calibration comments.

#	Topic	Comment
1	pH	The CE-QUAL-W2 model computed pH, and hence required boundary condition data of total inorganic carbon and alkalinity. According to the RMA 11 model documentation, this model does not compute pH. Since the Klamath River has been water quality listed for pH, having a model capable of evaluating pH is an important modeling consideration. If this is indeed a parameter of interest, then either a model capable of modeling pH needs to be used for the entire basin or RMA11 needs to be modified to include pH computations.
2	W2 – RMA linkage issues	It is awkward, albeit possible, to use different models in different reaches of the Klamath basin. This is usually not the preferred approach because of issues with translation between models, especially when the models handle water quality parameters differently and the boundary conditions for the models are not tied together explicitly. <u>Issues with model linkage</u> • The downstream boundary condition (BC) of the Link River model was the Keno Dam water level (based on data) + 9'; the Keno reach was 10.2 ft of water elevation at downstream dam (JC Boyle), and the Bypass and peaking Reach use Copco Reservoir water levels + 39.21 ft. Why is this a potential problem? (1)There were never any data shown in the reports at the end of the river model domain to know whether this water level estimate was correct, (2) The purpose of the model is to provide a tool that can be predictive. In this case, the downstream BC of the river is always tied to water level data at the downstream dam, a location still further downstream from the river model's downstream boundary. In other words, you must know the water level downstream, before you can use this information upstream. Hence, this set-up is never predictive. You can never run the models in a truly predictive mode for water level. <u>How can this be avoided?</u> (1) Use the same model for the entire system such that the head BC at the end of the river reach is dependent on the water level at the upstream location of the downstream reservoir reach. This would necessitate solving the river and reservoir reaches simultaneously, as you would do with 1 model for the reach. (2) Less desirable is to set a downstream weir as the end BC for the river model such that the head and flow are related in a rational way and there is no dependency on downstream conditions. • RMA11 uses organic P and organic N compartments. When the CE-QUAL-W2 model is used as a boundary condition to the RMA11 model, there are no translation problems since W2 computes a derived variables

Organic P and Organic N and these can be used directly in RMA11. The problem comes in when RMA11 is the upstream model, and the results from the RMA11 model is being used as input to the CE-QUAL-W2 model. On p. 47 of the Klamath Modeling Framework Report, it was stated that "because CE-QUAL-W2 includes the algae fraction in organic N and organic P, the algal compartment of each nutrient [was] subtracted from the total." It is unclear from this statement how this was performed explicitly. For example, on p. 56 of the Klamath Modeling Framework, the following formula was presented on how to compute LDOM for the W2 model for the Spencer Creek inflow:

LDOM=Total P-Phosphate/0.005 where the 0.005 is a stoichiometric coefficient between organic matter and P. It was assumed that this technique was used for other inflows, but the technique was never clearly shown for this translation.

Apparently in RMA11, all the organic matter containing P is represented by the organic P state variable. This includes algae and other non-living dissolved and particulate forms of organic matter. In RMA11 a distinction is not made between organic P that settles and that does not settle since all organic P is associated with a settling velocity. The oxygen consumption by the breakdown of organic matter is represented in the BOD compartment. In W2, this is complicated by the use of organic matter compartments and BOD compartments.

In CE-QUAL-W2 the total P (as a derived variable) is represented as
Total phosphorus:

$$\delta_P\Phi_{LDOM}+\delta_P\Phi_{RDOM}+\delta_P\Phi_{LPOM}+\delta_P\Phi_{RPOM}+\sum\delta_{Palgae}\Phi_{algae}+\Phi_{PO4}+\sum\delta_{BODP}\Phi_{BOD}$$

where
δ_P: stoichiometric ratio of P to organic matter
δ_{BODP}: stoichiometric ratio of P to BOD
Φ_{RDOM}: concentration of refractory dissolved organic matter
Φ_{LDOM}: concentration of labile dissolved organic matter (LDOM)
Φ_{algae}: concentration of algae biomass (multiple algae groups allowed)
Φ_{LPOM}: concentration of labile particulate organic matter (LPOM)
Φ_{RPOM}: concentration of refractory particulate organic matter
Φ_{PO4}: concentration of dissolved orthphosphorus
Φ_{BOD}: concentration of BOD (multiple BOD groups allowed)

Hence, the proper formula for computing LDOM should have been

$$\Phi_{LDOM}=\frac{TP-[\delta_P\Phi_{RDOM}+\delta_P\Phi_{LPOM}+\delta_P\Phi_{RPOM}+\sum\delta_{Palgae}\Phi_{algae}+\Phi_{PO4}+\sum\delta_{BODP}\Phi_{BOD}]}{\delta_P}$$

Hence, the formula for Spencer Creek is correct if there is no BOD, algae, and particulate forms of organic matter. This may be valid for Spencer Creek, but it is not clear how this was done for the river-reservoir models. It seems probable that the BOD correction was not accounted for since it was never mentioned in the reports.

<u>What could be done?</u> (1) Confirm calculation technique of organic matter between river-reservoir reaches and if in error, the conversion can be correctly applied. (2) Clearly explain the conversion for all water quality variables between the 2 models since this was not found explicitly in the reports.

- The linkage of BOD between the RMA11 and CE-QUAL-W2 models may not have been done correctly or there may have been some confusion in the use of BOD for each model. The RMA11 manual shows that BOD is treated as BOD-ultimate in the computations – see User Manual p. 3.6. In CE-QUAL-W2, the BOD parameter can be any BOD value the user decides to use, i.e., BOD5, BOD10, BOD20, BOD-ultimate. What dictates the users' choice often depends on what form the boundary condition data is in. The model user chooses a coefficient, termed RBOD, which converts the BOD of the BC into the BOD-ultimate form for calculations. In all the W2 models evaluated, the term RBOD was set to 1.85. This is typical of a BOD5 boundary condition data. But if the RMA11 model uses BOD-ultimate in its calculations and then passes these to the CE-QUAL-W2 model, the current model coefficient for W2 assumes the BOD is BOD5. The W2 model then multiplies the BOD by the RBOD factor (1.85), and uses that value as BOD-ultimate.

  <u>What could be done?</u> (1) Check the BOD data and how the data were reported. If the data were in BOD5, then they would need to be corrected to BOD-ultimate for the RMA11 model. Then the W2 models would need to have the RBOD parameter set to 1.00 since the input would be assumed in ultimate form. (2) Also, the total organic matter leaving RMA11 model and being sent to W2 needs to be verified carefully and documented. A check on this calculation technique can be obtained by computing total C, total N, and total P leaving RMA11 and verifying that the CE-QUAL-W2 derived variables total C, total N and total P at the upstream entrance of the W2 model are in agreement with the RMA 11 model. Otherwise, it is unclear whether the translation was performed correctly.

  As a check on this conversion process, a check was made of the Total N, Total P, and Total Organic C coming out of the RMA11 model and going into the CE-QUAL-W2 model at the Link River-Lake Ewauna boundary. This is summarized in Appendix E.

- On p. 116 Figure 88 of the Appendix 4A of the Klamath River Modeling Framework, the inflow concentrations of BOD and LDOM coming into the Lake Ewauna/Keno reach from the Link River reach seem unbelievably

		high. For example, the peak BOD (is it BOD5 or BODu?) is shown to be over 50 mg/l, while the peak LDOM is about 45 mg/l. If one converts the LDOM to BOD using a stoichiometric coefficient of 1.4, this is equivalent to about 63 mg/l BOD-ultimate. These are very high. Recommendation: As mentioned earlier, re-check conversion. • During the calibration process, it was stated that “flow conditions are generally not passed from reach to reach. That is, historical flows were used as headwater boundary conditions for most reaches.” Hence, data were used rather than model predictions of flow. This is not standard modeling practice since the goal of modeling is to provide a model capable of simulating correctly the flow at various control points. There is no reason why flow routing between model segments could not have been done to test the model. There were no model-data calibration comparisons found in the written reports with a Klamath River model where all reaches were linked together. The only time this was performed was when the no-dam scenarios were simulated. Standard modeling practice as part of calibration is to ensure that the model reproduces (1) the correct flow and water level regime, then (2) temperature, and then finally (3) water quality. Standard modeling practice is to route flow, temperature and water quality from the headwaters to the end of the model domain between model reaches. What could be done? (1) Ensure that the model predictions of flow at the end of a reach agree with historical data. (2) Use model predictions of flow to route between reaches. Note that if the model reproduces the historical data, then the 2 approaches are identical. But this was not shown clearly in the report.
3	W2 Organic matter	On p. 23 of the Appendices to the Klamath River Modeling Framework Report (section B) on the model description is a figure describing the water quality model CE-QUAL-W2. This figure, shown in Figure 1, does not correctly describe how CE-QUAL-W2 handles organic matter. This is a concern because of comment #2 above and issues with translation of organic matter between the models. Figure 2 shows the corrected figure.

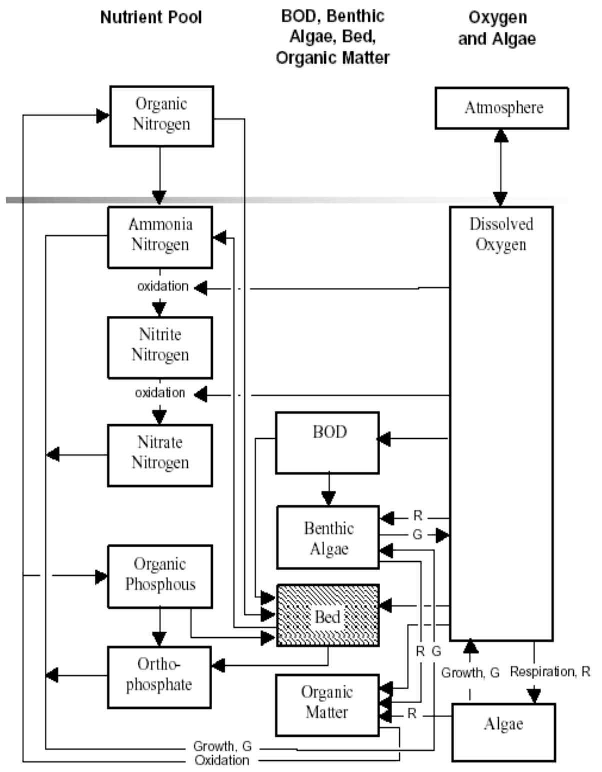

Figure 1. CE-QUAL-W2 model water quality cycles - existing figure.

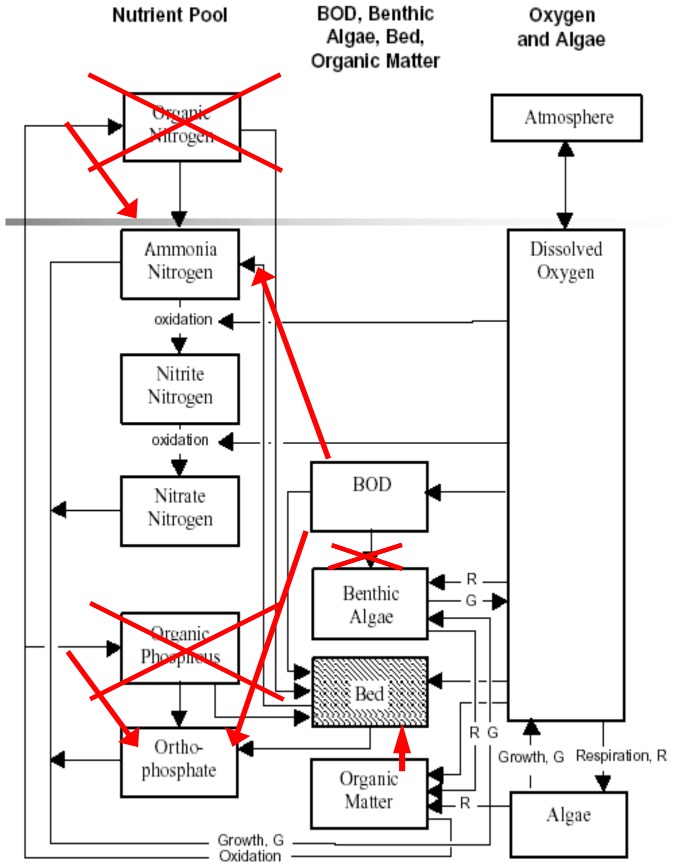

Figure 2. Corrected CE-QUAL-W2 water quality cycles.

		Note that in Figure 2 there is no flux BOD to the BED in W2 and there should also be links of growth and respiration for algae to the nutrients nitrate, ammonia and ortho-P. The other organic matter compartments, labile and refractory dissolved and particulate, are not represented either. What could be done? (1) Correct chart in report and (2) check that this chart was not used as a basis for translating organic matter between RMA11 and W2 and between field data and W2. Also, it should be noted that the W2 models used in the Klamath did not have benthic algae (epihyton/periphyton) turned on even though it has that capability and was used in the RMA 11 models.
4	Source code used for CE-QUAL-W2	The source code used for the W2 model was dated 6/12/03. The latest one available is from February 2004. It is suggested that the latest source codes be used especially if bug fixes corrected in the interim (see http://www.cee.pdx.edu/w2) are deemed important.
5	Met data	It is recognized that obtaining meteorological data for a water quality modeling project can be challenging. There were several issues with regard to the meteorological data development and the boundary conditions for the surface heat exchange: • Solar radiation from Klamath Falls was used everywhere in the domain. There were no comparisons to other gages in the region to assess how well this represented the system. What could be done? Usually in the development of the meteorological data, an attempt is made to show where all meteorological stations are located and how data compare. This is a critical boundary condition for the models. But there is nothing inherently incorrect in using this data set. • The dew point temperature was computed from the dry bulb, relative humidity and atmospheric pressure data. An adiabatic lapse rate correction was applied to the dry bulb temperature as a function of elevation. But this was not done in all cases for dew point temperature. In some cases, the dry bulb temperature was converted but the dew point was not. That means that the dew point temperature was based on the older uncorrected dry bulb temperature. Hence, in many cases this caused the relative humidity to be raised, sometimes above 100%. Since the evaporation is controlled by the relative humidity, this could affect evaporative heat transfer and bias the model results. For example, the Iron Gate CE-QUAL-W2 meteorological data files had the same dew point temperature as those for Lake Ewana/Keno even though the dry bulb temperatures were adjusted. What could be done? Unless field data suggest otherwise, be consistent in applying adiabatic lapse rates. If the dry bulb is adjusted, then the dew point should also be recomputed based on the corrected dry bulb. This would have the effect of keeping the relative humidity constant. • There was no mention of the importance or lack of importance of vegetative or topographic shade in the river reaches of the Klamath River.

		In the CE-QUAL-W2 model, the shade was assumed to be 0 for all reservoir segments. In many rivers flowing in narrow canyons, topographic shading can be important in assessing temperature dynamics. This should be evaluated and if deemed important a model should be chosen that can accurately account for the dynamic effects of shading.
6	BC data	• Water quality and temperature boundary condition data often show data gaps. Where there efforts to fill in these gaps when they were significant? For example, Figure 5 on p. 18 and Figure 6 on p. 19 in the Klamath Modeling Framework report, show a large data gap between JDAY 90 and 140 for temperature and dissolved oxygen. On Figure 11 on p. 28 there is a gap in the flow rate data for the Klamath Falls WWTP. These are just some examples of data gaps. What could be done? For some critical data, the gaps must be filled. Sometimes this is accomplished by using statistical data correlations, using data from other basins/discharges, or doing theoretical analyses to generate synthetic time series. These gaps become an issue when model alternatives are run with the same missing data – see for example, Figure 4.8-1 in the Water Resources FTR p. 4-20. If this is not a critical time of year, then this missing information is not important. But from a pure modeling perspective, filling data gaps is usually done to the best of one's ability to eliminate any issues with linearly interpolating boundary conditions between long periods of time. • In Table 5 on p. 5 in the Klamath Modeling Framework report, algae BCs for Link River reached as high as 22.8 mg/l biomass. How were algae biomass computed? Generally this would be based on chlorophyll a data and using as chlorophyll a to algae ratio. What could be done? Show the calculation technique and the value of the conversion used. Ensure that this is consistent between data conversions and models' assumed values. • For Lake Ewana/Keno, some of the BC data were averaged. For example, the Klamath Falls and South Suburban WWTP data were monthly averaged even though higher resolution data was available. There is no restriction in CE-QUAL-W2 in using more frequent BC data. Often by time-averaging BC data, one compromises the models ability to respond to dynamic events. What could be done? Use the actual data at its given frequency.
7	Water-balance	• In using CE-QUAL-W2 for a reservoir, a water balance is used to ensure that there is water continuity. The best way to illustrate this is to show model predictions of water level in the reservoir compared to field data. This is an essential part of the model calibration. What could be done? Show graphs of model predictions of water levels in the reservoirs compared to field data • Water balances were used for the reservoirs, but how the water necessary to match water levels was applied varied from reservoir to reservoir. For example, for Lake Ewana/Keno, the water balance flows were added as a distributed tributary; but for J. C. Boyle Reservoir, these were added or subtracted from Spencer Creek. Also, in some cases the added or subtracted flows to match water levels was excessively high. On p. 32 in the Klamath Modeling Framework Figure 18 a spike in inflow of 1200 cfs was followed by a negative spike of 1700 cfs. This fictitious flow is of the same order as the entire flow out of the Keno Dam. Similarly for JC Boyle at Spencer Creek, peak flows of 600 cfs were added even when river flows

		were on the order of 1000 cfs – a large fraction of the actual flow. This explains why there were numerical instabilities with this model application. <u>What could be done?</u> (1) Generally, one should smooth out or filter large inflows followed immediately by large outflows. This can set up instabilities and mix a system unnecessarily. If it is a large value that cannot be smoothed or filtered, then there may be a problem with the water balance or there may be a large unaccounted for source or sink. Showing the added flows was done and was helpful. But explanations need to accompany the graphs to explain large flow rates and what effect they have on the model. (2) Adding or subtracting 'accretion/depletion' flow from a side tributary is not usual practice. Either use a distributed tributary to spread this over the entire model domain, or alter the main inflow or outflow. If the flow is added/subtracted from a side tributary, there needs to be a rationale for doing so.
8	Bathymetry	• The report states that new bathymetry for the CE-QUAL-W2 model for Lake Ewana/Keno was available in 2003. Was this used in the model especially since the bathymetry for this section was very sensitive to the model predictions? • For the RMA model sections, the river widths in the model were based on "7X running average of measured widths". Why was this done? Usually one needs to use the actual measured widths in a model since the more physically correct the model is, generally the more accurate the model. • Unequal longitudinal grid spacing in the CE-QUAL-W2 models can degrade the numerical solution somewhat. If one uses segment lengths that vary from 135 ft to1600 ft in JC Boyle and from 121 ft to 1680 ft in Irongate, these are very large variations. To ensure that such unequal spacing does not affect the numerical solution, sensitivity tests should be performed to evaluate model sensitivity to this choice of spacing. If there are no issues, then the spacing is fine. • Vertical spacing in Lake Ewana/Keno and JC Boyle was a 1 m or less. In Copco and Iron Gate Reservoirs, the vertical spacing was 2 m and 2.5 m, respectively. Generally, this is very coarse for a stratified reservoir. The rationale for this was computational time. Furthermore, it was stated that sensitivity showed that they did not affect model results, the differences between 1 m and 2.5 m were 'insignificant'. As a test of this for Iron Gate reservoir, a test was made converting the grid to a 1 m spacing using the CE-QUAL-W2 supplied grid editor and running the supplied model for the year 2000. Figure 3 shows temperature and dissolved oxygen model predictions at segment 26 using the 2 different grids. Even though the same trends are noted for the 2 grids, generally the smaller 1 m grid had higher surface temperatures and lower dissolved oxygen values than the coarser 2.5 m grid. During the peak of the summer a typical temperature difference was 1°C.

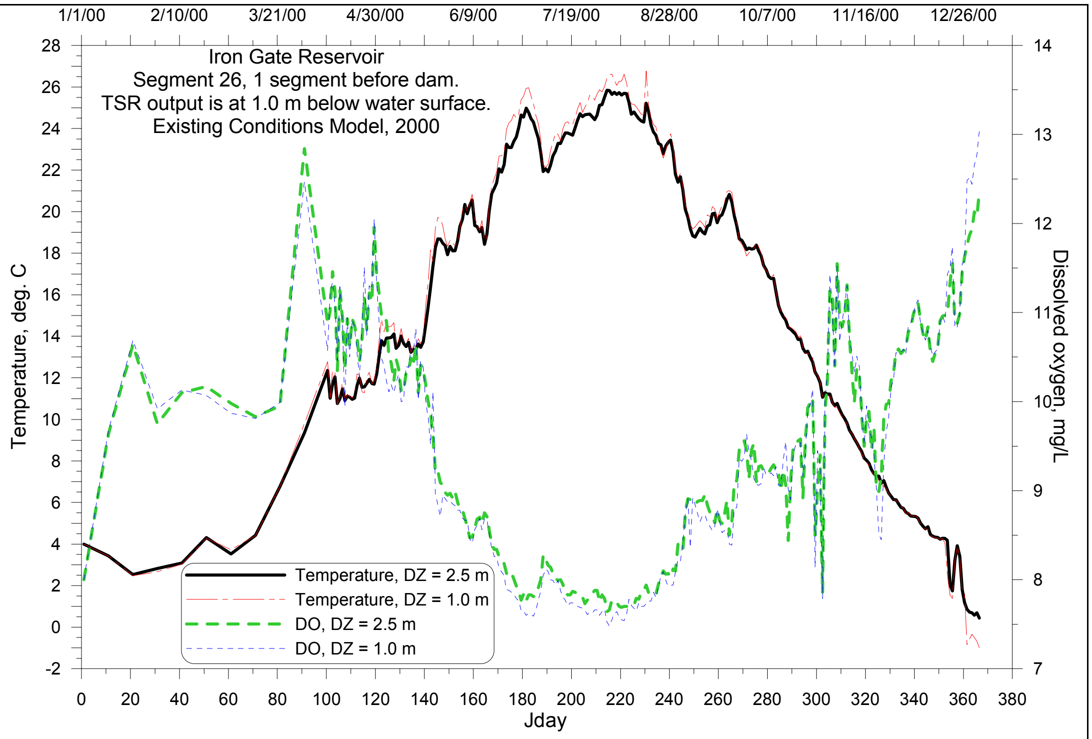

Figure 3. Temperature and dissolved model predictions contrasting 2.5 m and 1 m vertical grid spacing for Iron Gate Reservoir.

These runs with the 1 m grid took 3 times longer than the 2.5 m grid, but the overall computational time was still short and within reason (For a DZ = 1.0 m, 251 minutes runtime compared to 85 minutes for a DZ = 2.5 m, using a processor comparable to 1700 MHz. Newer computers which cost less than $1500 are 2X faster.)

The next 3 figures, Figure 4, Figure 5, and Figure 6, show profile comparisons of temperature, DO and pH at segment 26 in September 2000 comparing a 1 m and a 2.5 m grid.

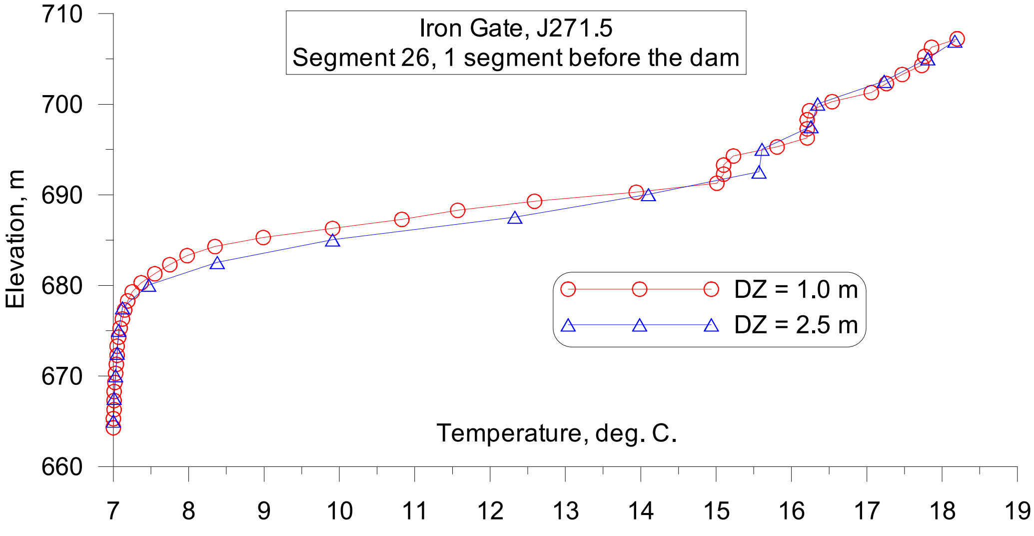

Figure 4. Iron Gate profiles of temperature with DZ=2.5m and DZ=1 m on day 271.5 at segment 26.

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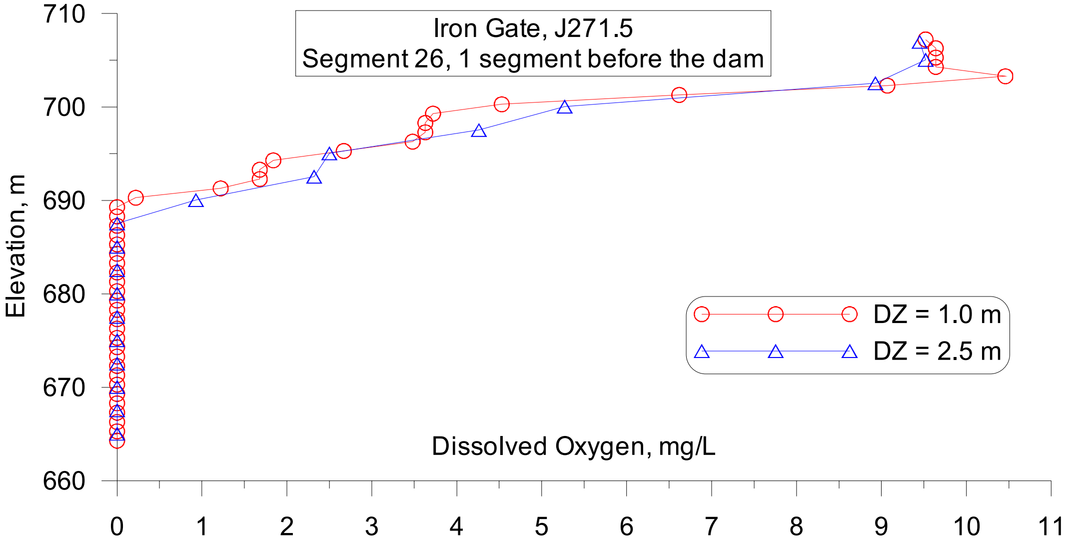

Figure 5. Iron Gate profiles of dissolved oxygen with DZ=2.5m and DZ=1 m on day 271.5 at segment 26.

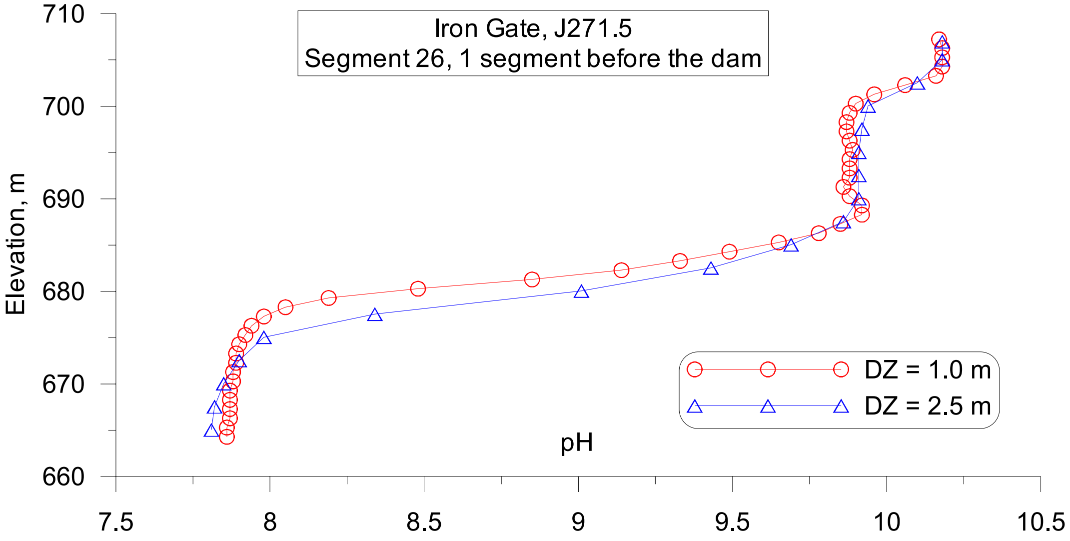

Figure 6. Iron Gate profiles of pH with DZ=2.5m and DZ=1 m on day 271.5 at segment 26.

The finer grid has a sharper thermocline in each case since there is less numerical mixing in the solution. The dissolved oxygen profile with greater resolution shows an oxygen increase just below the surface as a result of photo-inhibition of algae. This result is not evident in the coarser grid.

<u>Recommendation:</u> Use a grid for which the results are not biased. The added computational cost is worth not having predictions affected by a coarse numerical grid.

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<td>Data Organization</td>
<td>In the Klamath Modeling Framework report, data for model set-up for 2000 was presented. This was included only for the Link River/Lake Ewauna section for 2001 in Appendix H in the Appendices to the Modeling Framework report. It was not clear where the other 2001 boundary condition data were presented.</td>
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</table>

10	Model calibration	• In Appendix 4A of the Water Resources Report, p. 97 it was mentioned that the model was calibrated only for temperature and dissolved oxygen and not for nutrients and algae. As difficult as it is to calibrate for nutrients and algae, one really cannot calibrate for dissolved oxygen unless one knows that the nutrients and algae are calibrated. Since the model sensitivity showed that the models are sensitive to algae – suspended and benthic, it would be difficult to say the model is calibrated to dissolved oxygen. <u>Where is this an issue?</u> Primarily in using the models to predict the impact of management scenarios. If the nutrients and algae are large contributors to the DO budget, one would not have confidence in the models' ability to predict these for management alternatives. • In the RMA11 models, the phytoplankton algae growth rates were typically set to 0.01 day^{-1} while in the CE-QUAL-W2 model the growth rates were set much higher from 2-6 day^{-1}. Even though this was justified as the difference between riverine and lake/reservoir conditions, this does not seem like a reasonably value for the RMA11 model. Also, the very high value of 6 d^{-1} in Copco Reservoir seem extremely high for a single algae species. Even though this is extremely complicated and often critical information is lacking, an ideal situation would be for all the models to use generally similar kinetic coefficients. Then the characteristics of the waterbody would determine the rate of algae growth, rather than the modeler setting growth rates. This has been successfully performed in the Spokane River system (see http://www.cee.pdx.edu/w2/spokane) where river reaches are punctuated by reservoirs. In the rivers, periphyton grows; but in the reservoir phytoplankton grow. All of this is accomplished using the same kinetic parameters for the entire modeled system. Only in this way can you have a predictive model when using the model for management scenarios. • The value of light extinction for the RMA11 models (1.5 m^{-1}) is extremely high compared to the W2 model light extinction values (0.25 m^{-1} + contribution from algae and suspended solids). Why was there such a sharp difference in light extinction values between models? • SOD values in Lake Ewauna/Keno were thought to play a modest role in oxygen depletion. SOD values were set to 2 g/m^2/day for all model segments. This appears to be based on sediment oxygen demand work done in anther part of the study. Further comments are made in a later section of this review on this issue. One thing is certain, this reach is extremely complex and many forcing functions are acting in concert. In contrast, the model developed by Wells had SOD values ranging from 1-14 g/m^2/day based on SOD sampling by Oregon DEQ. <u>Suggestion:</u> (1) If the re-examination of the BOD-LDOM issues show that there was too much dissolved BOD coming into the model, then SOD may be more important. It was a critical part of the earlier CE-QUAL-W2 model especially in the region near the log rafts. (2) As a sensitivity analysis, use the SOD values used in the model developed by Wells and note the impact on model predictions. Also, compare the boundary conditions used in Wells to those used in this study especially with regard to organic matter loading. • Model calibration statistics for Lake Ewauna were compiled only for the 1st week of the 5 months June-July-August-September-October. This is not a

		standard calibration approach. Why was this done? Suggestion: Compute statistics for all model-data periods. If one wants to parse out statistics for shorter periods as a result of looking at seasonal changes or some other situation, this is appropriate. But the overall statistics should be shown. • It is admittedly very difficult to model the Lake Ewauna/Keno Dam system. The model predictions of DO and algae are not reasonable enough to consider using this model with a high degree of confidence for management scenarios. Much of this uncertainty can be a result of unknown or poorly understood boundary conditions. This system may have better predictive ability using multiple algal groups (see the Spokane model discussion on multiple algal groups – note link above). • There were no comparisons of model predictions of BOD and chlorophyll a to field data taken in 2000 for Lake Ewauna/Keno Dam. Suggestion: Use 2000 field data for model-data comparisons (FTR Chapter 1 p. 3-3 to p. 3-5 show that BOD data exist for this reach for 2000). This is such an important issue that if data exist there needs to be a model-data comparison to assist in guiding the calibration. One cannot know if one is calibrating DO correctly without these checks. [Similar comments can be made for other CE-QUAL-W2 model reservoir sections.] • The RMA11 model below Iron Gate, instead of using DO results from the upstream W2 model, used DO data from a Datasonde during model calibration. Even though this is acceptable to show that the model reproduces data over a river reach, the Iron Gate W2 model should be used to try to match these continuous data. This should be part of the calibration effort. Also, all the river-reservoir segments should be linked together with flow and water quality to check an overall system calibration to see if the entire system linked together can reproduce data, such as below Iron Gate reservoir. Without performing this, it is difficult to say that the linked model has predictive capability as a system model. • Since the Water Resources FTR p 3-3 shows that there was attached algae sampling in 2000 and 2001 for areas between RM 253 and RM 128.9, the river model should be compared to these data to see whether the RMA11 model is reasonable. • There was no hydrodynamic calibration done on the reservoir reaches. The purpose of the modeling effort is developing a system model which will look at the effects on reservoir operations on the rivers downstream. A hydrodynamic calibration needs to be done on the reservoirs to ensure the appropriate flows are passing downstream. The report presents results of temperature and dissolved oxygen vertical profiles illustrating that these constituents were calibrated. In order to properly calibrate temperature and dissolved oxygen the quantity and timing of water need to be calibrated first. • In the introduction of Section 3, Model Calibration and Validation the report states: "*Existing data are insufficient to test the actual hydrodynamic performance of these models*." Further explanation is needed as to why this is true. • There was no discussion comparing river stage levels with model results at the locations with USGS gage stations.

		• The temperature calibration on the river reaches seems to have consisted primarily of adjusting the evaporation formulation parameters. There was little or no discussion of how shade, solar radiation, other meteorological conditions, sediment temperature, heat lost to sediment that is added back to the water, channel depth and width, or river slope had effected the temperature calibration. • Reservoir model results show only seven or eight vertical profiles of temperature data. Were any time series data collected? In the report, on page 180 under Section 3.7 Copco Reservoir (and pg 188, Iron Gate Reservoir) there is a statement indicating there are hourly dissolved oxygen and temperature data but there are no model-data comparison plots or error statistics. • If a temperature instrument is maintained at a specific depth below the water surface in a reservoir then the model output used in comparison with the data should be at a fixed depth rather than at a fixed model layer. The only exception would be if the water level in the reservoir did not change more than the vertical grid thickness. • In section 3.2.1.1 Boundary Conditions (Link River) the report states: "*Due to the inherent variability and infrequent sampling interval of the grab data, the boundary condition values for nutrients, BOD, and algae were assumed to be a constant value for the calibration and validation period…"* The variability of the grab sample data does not justify keeping it constant during the model simulation periods, unless the data itself is suspect. The variability of the data should be included in the model input, not removed. If there were no data collected during the calibration and validation periods then the nearest two points in time when grab samples were taken should be interpolated or a more detailed analysis should be conducted of the data that is available. • The report does not specify the justification for the initial bed algae mass estimate of 5 g/m^2. • Error statistics for DO and temperature calibration are still coarse for most of the CE-QUAL-W2 systems. For temperature calibration, one should be able to achieve average temperature statistics at or less than 1^{o}C RMS error. The RMA model sections were so short that the ability of the model to predict the concentration or temperature is dependent on the inflow boundary condition rather than the kinetic coefficients. The full impact of the kinetic coefficients for the river is seen only when the system was run WOP (without project), but with untested model coefficients. • There was limited discussion of pH model-data comparisons in the system which would indicate how well the model was simulating algal productivity.
11	Model validation	This may be a philosophical issue, but the term validation is often not correctly used in the literature. According to Table 1, for the RMA models, calibration was usually for over a period of 3 days, and then validation was based on another 3 day period. Model validation is usually thought of as the application of the model to an independent set of data. If that were true, why not use the model for 1 hour for calibration and 1 hour for validation? Really, this is just model calibration to 2 sets of data. The term validation is often used to assume the model has met the test of acceptableness. Running a model for such a short time period is usually not of

		sufficient duration to be significant nor to assure the user that it is calibrated for situations other than the 2 that were used. <u>Suggestion:</u> Merely call the 2 time periods calibration periods and eliminate the term validation.
12	Model sensitivity	• The RMA11 model was sensitive to the Minimum reaeration value of 3 d^{-1}. This value seems high, why was this chosen for the model calibration? • There was no exploration of the sensitivity of the river model to the initial bed algae value. This should be done and hopefully new field data will help ascertain if model predictions of benthic algae were reasonable. • The model sensitivity analysis does not look at shade conditions (vegetative or topographic); meteorological conditions such as solar radiation or cloud cover; or the wind sheltering conditions (WSC). Shade and meteorological conditions are important aspects of the heat budget and should be included in the sensitivity analysis. • The list of model parameters in the sensitivity analysis for CE-QUAL-W2 included TSEDF and TSED but there were no model results showing their sensitivity. Both model parameters should be included in the sensitivity analysis and model results presented. • The sensitivity analysis did not include any discussion of how sensitivity of each model parameter was conducted and there was no presentation of model results. The report provided a summary table with general categories of sensitivity and did not characterize or quantify the sensitivity.
13	General comments	• The current report is confusing to follow because there are model input and boundary conditions discussed in Section 2, Model Implementation; Section 3, Model Calibration and Validation; and Appendix H, 2001 Lake Ewauna/Keno Reach Boundary Conditions – Graphical and Tabular Presentation. Model development and boundary conditions for all simulation periods should be presented and discussed together. • The authors use the phrases “formal calibration” and “not formally calibrated,” and “primary constituents” and “secondary constituents” without defining them. These phrases are used many times in the report and the reader is left to infer their meaning. • Equation 6.1 on page 98 should be cited in the Modeling Framework report. • All plots showing model-data comparisons should clearly indicate the location of the site relative to the upstream boundary condition or provide the RM location for landmarks, boundary condition locations and calibration points. • In Section 3.3 Lake Ewauna-Keno Dam Reach, pg 112, the report states: “*Additional field work and model testing completed during the summer of 2003…*” The data and the model results from 2003 should be presented in the report. • All model-data comparison plots should be sufficiently large to read and distinguish between model results and data collected. Vertical scales should not be so large that the variability in the data points can not be seen.

Review of Model Files for CE-QUAL-W2

As noted in the introduction, a detailed check list for each CE-QUAL-W2 model was performed and was summarized in Appendix B. This check list evaluated the following items for each model run shown in Table 1 for CE-QUAL-W2:

- Evaluate boundary condition (BC) files – What is their frequency? Are there any errors?
- Run the model file PREW2 and evaluate all model warnings and model errors
- Run the CE-QUAL-W2 bathymetry editor - Does the system look correct in plan view?
- Run the model – Does it run? Were there any run errors?

Summary comments from this review include:

Lake Ewauna/Keno Dam Model

a. Klamath Straits inflow temperatures were found to be at zero for several periods in 2000 and 2001 at the beginning and ending of the simulation.
b. Storm water concentration files (1-11) included alkalinity concentration above 200 mg/L for the existing condition and steady Flow scenarios for 2000. Alkalinity concentrations for 2001 were 52 mg/L.
c. There were no water balance files used for 2000 or 2001 for Existing Conditions scenario.
d. The particulate organic matter compartments were turned off for all of tributaries and the upstream boundary condition but the constituents were turned on to be simulated for both 2000 and 2001 and both existing conditions and steady flow. This is reasonable if the POM from algae is being tracked.
e. Minor issue: the preprocessor noted that the bottom selective withdrawal layer for withdrawal number 2 was below the bottom active layer for segment 51
f. No interpolation was used with the tributary inflows. This may not be a problem but the implications should be evaluated.
g. The solar radiation data appears to have several errors with excessively high values. Julian day 230.417 has solar radiation value of at 3810.802 W/m^2. Additional errors appear to occur from Julian day 230.458 to 230.542 and at 256.50.
h. The solar radiation data in 2001 appears to be about 5% higher than in 2000. The modeler may want to investigate why there is a difference between the two years, especially if the data were collected by the same instrument.
i. The wind direction data in 2000 is primarily from 270 to 335 deg (from north) and 145 to 175 deg and in 2001 is primarily from 280 to 340 deg and 145 to 175 deg. The grid orientation is primarily 15 to 65 deg but scattered over 0 to 160 and 310 to 360 deg. The modelers should test the sensitivity of the model to the direction of the wind. The wind sheltering coefficient was set at 1.0 for the 2000 and 2001 simulations. The report described using data from only one meteorological station. Often the wind sheltering coefficients are a calibration tool for vertical mixing since the wind data is often imperfect.

JC Boyle, Iron Gate, Copco Models

a. Winter water temperatures were observed to be well below freezing in the water column in January. The model documentation reports that little input data exist from late fall to mid spring and calibration was not conducted for these periods. Activating the ice cover calculation algorithm in CE-QUAL-W2 or some other consideration may improve the model results over the winter months.
b. Some branch inflow constituent input files contain isolated negative values for NH4, NO3, and LDOM. While this is unlikely to affect model results, the errors call into question the quality of the input data and the care in constructing the input data files. A review of the data gathering and/or generation process is worthwhile. The outlier values should be set to zero as a minimum course of action.
c. The preprocessor found a single value of wind speed greater than 20 m/sec. This data should be checked to make sure this is a valid value of wind speed.
d. The preprocessor program flags some formatting errors in several branch inflow and temperature input files. While only affecting the last day of the model run, these errors should be corrected.
e. The air temperature data were adjusted for elevation for application to some models. The dew point temperature was not adjusted, but probably should be adjusted to maintain the same relative humidity. Without adjusting dew point temperature, there are some winter relative humidity values well above 100%.
f. Model grid:
    i. The JC Boyle model has a segment (#4) with three more active layers than the adjacent segments. Insufficient flow through these cells probably results. In other words, there is a stagnant zone that in which only diffusion can occur vertically.
    ii. For the Copco model, the preprocessor identifies two cases of adjacent cell widths not meeting the 7 times maximum change in width criterion for numerical stability. This may not be not important if the model is stable.
    iii. The Iron Gate longitudinal grid length (DLX) has a segment (#8) which is much shorter than the adjacent segments—36 m compared to 513 and 403 m. This needs to be verified since numerical inaccuracies may result and the model will run for much longer simulation times as a result of this change in DLX.

Review of Model Kinetic Coefficients for CE-QUAL-W2 and RMA11 Models

Appendix C and Appendix D show the kinetic coefficients used in the CE-QUAL-W2 and RMA 11 models for each of the run simulations shown in Table 1. The objective of this effort was to

- Make sure of consistent use of coefficients between model scenarios
- Evaluate model coefficient changes from one model to another and evaluate consistency between simulations
- Ensure that reported values of coefficients were in agreement with written text

Summary comments from this review include:

1. **CE-QUAL-W2 model**
    a. Several notations are made in Table 4 and Table 5 showing inconsistencies in what was stated in the reports and what was included in the model files. The reports need to be updated with the appropriate parameter values.
    b. The value of the parameter CBHE should be at the default value of 0.3 W/m2. The values 7E-8 were the old default value before the W2 model was corrected by a bug fix. Also, the high values of 3 and 17.14 in Copco and Iron Gate are very unusual. Generally this parameter should not be raised to that high of a value in order to calibrate temperature. If one has to use a parameter value this high to match temperature data, something else may well be incorrect, such as model bathymetry. Using these high temperature heating/cooling rates with a sediment temperature of 7°C seems unjustifiable especially since the sediment temperature of the other systems was 12°C.
    c. Maximum algae growth rates of 6 d^{-1} in Copco and Iron Gate are unusually high values. It may reflect an issue with nutrient availability and having enough nutrients available to sustain a high growth rate (which should probably be less than 6d^{-1}).
    d. Why was AHSN set to 0 for JC Boyle Reservoir? This could be appropriate if you have N-fixing algae. But if this is the case, why only in JC Boyle reservoir?
2. **RMA11 model**
    a. The bed algae mortality rate of 0.0 d^{-1} is unrealistic. There must be some mortality rate. We realize though that this mortality could be factored in the RESP rate – which seems high at 0.6 d^{-1}.
    b. The algal growth rate of 0.01 d^{-1} and the respiration rate of 0.05 d^{-1} are unusual. This implies that phytoplankton will never grow. Is this realistic?
    c. Why was the Elevation of the site in m different for different runs for the Bypass and Peaking Reach (see Table 7 in Appendix D)?
    d. Why was the space step different in the Iron Gate to Turwar model between the calibration and the application?

Review of Model Alternatives

The primary alternatives considered with the model were 4 different scenarios: EC, SF, WOP, and WOPII for 2000 and 2001 where the model is run for the entire year. Running the WOP project with the RMA models for the full-length of the Klamath system is basically an untested model. The only RMA calibration occurred over periods of 3 days (calibration) and 3 days (validation) for short stretches of the Klamath River above Iron Gate. It has not been demonstrated that the results of the RMA models for the no dam scenario have been tested. More confidence could be placed in these alternatives simulations if the existing models passed flow, temperature and water quality from one system to the next during model calibration. Since the models were broken up and tested independently, the full-system model remains untested.

Note for example Figure 4.8-70 where DO below Iron Gate for the WOP alternative shows DO swings from 0 to over 16 mg/l. CE-QUAL-W2 predictions for the same time period show variation from approximately 4-12 mg/l. The cause of this high and low DO is obviously algae – for the RMA model benthic algae. And since the model has not been calibrated to algae, it is hard to view the predictions of the WOP alternative as being reasonable at this time. If the cause of this DO excursion is nutrients from

Link River, then luxuriant growth along the entire river length would be expected. But model predictions of DO for WOP above Iron Gate are not as dramatic as shown in this figure.

Alternatives that were not considered, but that could be easily examined with the reservoir models, are changes in the withdrawal of water from the reservoir systems. It may have a negative impact, but changing the withdrawal of water so stratification does not develop in Copco and Iron Gate could be evaluated with the W2 models. Since this was easy to perform with the existing Copco and Iron Gate CE-QUAL-W2 models, this alternative was performed and results summarized in Appendix F.

Review of SOD Measurements in Lake Ewauna/Keno Dam

The Water Resources FTR Chapter 9 includes sediment oxygen demand data (SOD) from the Klamath system. In this case, SOD measurements were taken to conclude that in Lake Ewauna/Keno Dam reach SOD is of moderate impact, whereas the "oxygen dynamics are controlled to a large extent by the nature of the water entering the system rather than sediment/water interactions in the impounded areas." This led the modeler for Lake Ewauna/Keno Dam to choose values of SOD at a maximum value of 2 g/m^2/day for this entire model reach.

The following comments can be made about the sampling methodology:

1. The details of the sediment testing are not mentioned. Were the samples put on ice after the coring? How long were they on ice before being analyzed in a laboratory? The cores were extracted up to 4 days before being taken to the laboratory. Did this affect the biological community?
2. The conclusion is reached that the BOD of the overlying water was responsible for most of the oxygen uptake, not the sediment uptake. But what was the source of the BOD above the sediment core? Was it from anoxic decay products released from the sediments, such as NH4, CH4, and other compounds with a high oxygen equivalent? If the water above the sediment is a result of decay products from the sediments, could not all the SOD be a result of sediment processes?
3. No data in Chapter 9 is shown for other nutrients, such as ammonia. These nutrient data should also be summarized in this chapter.
4. No mention was made of 2 other studies of SOD in Lake Ewauna/Keno Dam where chambers were used to measure in-situ SOD: an Oregon DEQ study in the early 1990s (where SOD values as high as 12-14 g/m^2/day were observed in chamber tests near the log raft area) and tests by the USGS in 2003 (where SOD values from approximately 2 to 3.7 g/m^2/day were obtained).

Measuring SOD is not easy. There are many issues with performing the test and locating a representative sampling location. And there is no doubt that the inflow from the Upper Klamath Lake and the Klamath Straights Drain add much organic matter to this reservoir stretch. But in this study little was said of the impact on SOD of the log raft operation which in an earlier CE-QUAL-W2 study of this reach was a dominant part of the study in terms of oxygen depletion and ammonia release.

Summary and Recommendations

This report is a summary of review comments on the model development for the Klamath River system. Both written documents and model files were examined. Detailed review comments, suggestions for improvement and questions are included in the body of this report.

Preparing a model of a large river system punctuated by stratified reservoirs is a challenging exercise. The consultant for PacifiCorp has invested much time and effort in preparing these models. Regardless there are many areas where the models can be improved to increase the reliability of model predictions.

Is the current model ready to evaluate management strategies with a high degree of confidence? There are many issues that need to be resolved before we can have confidence in the model's ability to postulate the impacts of a particular management strategy for the Klamath River. This is especially true since the entire system model has never been tested where flow and water quality are all transferred from one reach to the next and model predictions and data are compared. As the models are not calibrated for nutrients and algae, the dissolved oxygen model predictions for management alternatives cannot be viewed as being accurate. Drawing sweeping conclusions from the models at this point is not justified. Nevertheless, this is a process which can be improved – and with it, the models' ability to predict impacts would also improve.

Many recommendations were made throughout the body of this report in order to improve the model's predictive ability. These will not be repeated here in the interest of brevity. Using as a system model with only 1 model would improve eliminate issues with translation of one model to another in terms of water quality and boundary conditions. Also, this would simplify the model application considerably. Calibrating an entire system model, even if one kept the present model choice, is an important step in understanding how well the integrated model performs.

Appendix A: Review Documents

The table below summarizes the files available for review from the PacifiCorp web site. Many of these files were reviewed in detail for this report. The primary written review documents are itemized below:

- Klamath River Modeling Framework to Support the PacifiCorp Federal Energy Regulatory Commission Hydropower Relicensing Application, Draft 11-14-2003, prepared for PacifiCorp, by Watercourse Engineering, Inc. The report was provided on a CD by PacifiCorp.
- Chapters 1-3 in the Water Resources FTR, dated February 2004, provided from the web site.
- Chapter 4 in the Water Resources FTR, dated February 2004, provided from the web site.
- Chapter 9 in the Water Resources FTR, dated February 2004, provided from the web site.
- Appendix 4A from Water Resources Report Klamath River Modeling Framework, dated Draft 11-14-03
- RMA11 User Manual, provided on CD by Watercourse Engineering

Other information provided by Watercourse Engineering included approximately 22 CDs containing all the model files for CE-QUAL-W2 and RMA2/11 models.

Table 3. List of files available from PacifiCorp Relicensing web page: http://www.pacificorp.com/article/article1152.html.

Documents	Reviewed for this report
Klamath Draft License Application	
Cover Letter	
Table of Contents Vol. 1	
Table of Contents Vol. 2	
Initial Statement	
Executive Summary	
Exhibit A: Project Description	
Exhibit B: Project Operation and Resource Utilization	
Exhibit C: Construction History and Proposed Construction	
Exhibit D: Statement of Costs and Financing	
Exhibit E: Environmental Report	
Exhibit E: Table of Contents, Introduction and General Description	
Exhibit E: Water Use and Quality	
Exhibit E: Fish Resources	
Exhibit E: Fish Resources - Document	
Exhibit E: Fish Resources - Figures	
Exhibit E: Fish Resources - Figure E4.2-1 Site Plan	
Exhibit E: Fish Resources - Figure E4.2-2 Hatchery Complex	
Exhibit E: Fish Resources - Figure E4.2-3 Adult Fish Facilities	
Exhibit E: Botanical and Wildlife Resources	
Exhibit E: Botanical and Wildlife Resources - Document	
Exhibit E: Botanical and Wildlife Resources - Figures	
Exhibit E: Botanical and Wildlife Resources - Figure E5.1-1 - Terrestrial Study Area	

Exhibit E: Cultural Resources	
Exhibit E: Recreation Resources	
Exhibit E: Recreation Resources - Document	
Exhibit E: Recreation Resources - Figures	
Exhibit E: Figure E7.1-1 - Project Recreation Sites and Study Area	
Exhibit E: Land Management and Aesthetics	
Exhibit E: Land Management and Aesthetics - Document	
Exhibit E: Land Management and Aesthetics - Figures	
Exhibit E: Land Management and Aesthetics - Figure E8.1-1 - Land Ownership	
Exhibit E: Land Management and Aesthetics - Figure E8.1-2 - Zoning	
Exhibit E: Land Management and Aesthetics - Figure E8.1-3 - Existing Land Use	
Exhibit E: Land Management and Aesthetics - Figure E8.2-1 - Floodplain	
Exhibit E: Socioeconomics	
Exhibit E: Appendices	
Exhibit E: Appendices - E-1A Consultation Record	
Exhibit E: Appendices - E-8A Visual Resources Project Facilities	
Exhibit E: Appendices - E-8A Visual Resources Project Operations	
Exhibit F: Design Drawings	
Exhibit G: Maps	
Exhibit H: Applicant's Qualification to Operate the Project	
Klamath Draft Technical Reports	
Klamath Draft Technical Report - Water Resources	☑
Water Resources - Table of Contents	☑
Water Resources - Chapters 1, 2 and 3	☑
Water Resources - Chapter 4	☑
Water Resources - Chapter 5	☑
Water Resources - Chapter 6	☑
Water Resources - Chapters 7, 8 and 9	☑
Water Resources - Chapters 10, 11, 12 and 13	☑
Klamath Draft Technical Report - Water Resources - Appendices	☑
Water Resources - Appendix 2A, 2B - WQ Sample Sites & Constituents	
Water Resources - Appendix 3A - Quality Assurance	
Water Resources - Appendix 3A - Standard Operating Procedure	
Water Resources - Appendix 3B & 3C - Summary & Statistics of Data/All Sampling Sites	
Water Resources - Appendix 4A - WQ Modeling Framework	☑
Water Resources - Appendix 4B - River Geometry	☑
Water Resources - Appendix 4C - Meteorological Data	☑
Water Resources - Appendix 5A - Flow Information - Cover Sheets	☑
Water Resources - Appendix 5A - Part 1 - Link River	☑
Water Resources - Appendix 5A - Part 2 - Keno	☑
Water Resources - Appendix 5A - Part 3 - JC Boyle 1	☑
Water Resources - Appendix 5A - Part 3 - JC Boyle 2	☑
Water Resources - Appendix 5A - Part 4 - Iron Gate	☑

Water Resources - Appendix 5B - Flow Information - Cover Sheets	☑
Water Resources - Appendix 5B - Part 1 - Fall Creek	
Water Resources - Appendix 5B - Part 2 - Spring Creek	
Water Resources - Appendix 6A - Study Site Field Survey Data	
Water Resources - Appendix 6B - Bed Mobility Threshold Calculations	
Water Resources - Appendix 6C - Bedload Transport Calculations	
Water Resources - Appendix 8A - Tables of Macroinvertebrate Taxa and Metrics Results	
Klamath Draft Technical Report - Fish Resources	
Klamath Draft Technical Reports - Terrestrial Resources	
Klamath Draft Technical Report -Terrestrial Resources - Appendices	
Terrestrial Resources - Appendix Cover Sheets	
Terrestrial Resources - Appendix 2A - Plant Community Classification System Crosswalk	
Terrestrial Resources - Appendix 2B - Species Frequency and Abundance for Vegetation	
Terrestrial Resources - Appendix 2C - Description Stats for Veg Layer Aerial Cover	
Terrestrial Resources - Appendix 4A - Amphibian/Reptile Survey Observation Form	
Terrestrial Resources - Appendix 4B - Foothill Yellow-legged Frog Survey Datasheets	
Terrestrial Resources - Appendix 4C - Results of Amphibian and Reptile Surveys, 2002	
Terrestrial Resources - Appendix 5A - Tables	
Terrestrial Resources - Appendix 5B - Project Data Sheets for Avian Point Counts, etc.	
Terrestrial Resources - Appendix 5C - TES Plant Species Occurrence Records	
Terrestrial Resources - Appendix 5D - List of Plant SSP Observed during TES Surveys	
Terrestrial Resources - Appendix 5F-1 - Bird & Wildlife Point Counts/Search Surveys	
Terrestrial Resources - Appendix 5F-2 - Bird & Wildlife Point Counts/Search Surveys	
Terrestrial Resources - Appendix 5G - Rel. Abund. of Avian Species/Wetland & Riparian	
Terrestrial Resources - Appendix 6A - Site-specific Background Information	
Terrestrial Resources - Appendix 7A - Tables	
Klamath Draft Technical Report - Cultural Resources	
Klamath Draft Technical Report - Recreation	
Recreation - Table of Contents and Introduction	
Recreation - Recreation Flow Analysis	
Recreation - Recreation Visitor Surveys	
Recreation - Regional Recreation Analysis	
Recreation - Recreation Needs Analysis	
Recreation - Recreation Resource Management Plan	
Recreation - Literature Cited	
Klamath Draft Technical Report - Recreation Resources - Appendices	
Recreation - Appendix 2A - List and Profile of Phase I Interviewees	
Recreation - Appendix 2B - Phase I Interview Format	
Recreation - Appendix 2C- Add'l Info for BLM Planning-Hell's Corner	

Reach	
Recreation - Appendix 2D- List of Phase II Controlled Flow Participants	
Recreation - Appendix 2E - Phase II Controlled Flow Survey Instruments	
Recreation - Appendix 2F - Add'l Results JC Boyle Bypass Reach Controlled Flow Study	
Recreation - Appendix 2G - Add'l Results Hell's Corner Reach Controlled Flow Study	
Recreation - Appendix 2H - Add'l Info from Middle Klamath Phase I Effort	
Recreation - Appendix 3A - Rec Survey Questionnaire, Interview, and Count Forms	
Recreation - Appendix 3B - FERC Form 80	
Recreation - Appendix 4A - Question Form for Reg'l Rec Providers/Managers	
Recreation - Appendix 5A - Recreation Site Inventory and Condition Forms	
Recreation - Appendix 5B - Developed Recreation Site Photographs	
Recreation - Appendix 5C - Developed Recreation Site Plans	
Recreation - Appendix 5D - Dispersed Recreation Site and Use Area Photographs	
Recreation - Appendix 5E - Completed Inventory and Conditions Forms for Developed and Dispersed ...	
Recreation - Appendix 6A - Draft Annotated Outline Rec Resource Mgmt Plan	
Klamath Draft Technical Report - Land Use, Visual and Aesthetic Resources	
Klamath Draft Technical Report - Land and Visual Asthetics - Appendices	
--Would not open--	
Klamath Draft Technical Report - Socioeconomic Resources	
Klamath Relicensing Study Plans	
Klamath Study Plans - Complete List by Work Group	
New Study Plans - Draft Conceptual Outlines	
New Proposed - Fry Sampling at JC Boyle Reaches Study Plan	
Summary of Info-Investigation of Trout & Anadro. Fish Genetics-Klamath Hydro Proj Area (SP 1.17)	
Literature Based Characterization of Resident Fish Entrainment-Turbine Induced Mortality - Klamath	
Final Study Plans - Plenary Approved	
1.0 Aquatic Resources	
2.0 Terrestrial Resources	
3.0 Recreation Resources	
4.0 Land Use	
5.0 Visual Aesthetics	
7.0 Socioeconomics	
Relicensing Study Plans - Final Working Drafts	
1.7 Evaluation of Ramping Effects on Fish Downstream - August 13, 2003	
1.9 Fisheries Assessment - August 2003	
1.9 Fisheries Assessment - Appendix A	
1.9 Fisheries Assessment - Appendix B	
1.10 Fish Passage Planning and Evaluation - July 2003	
1.10 Klamath Study Plan - Attachment A	
1.10 Klamath Study Plan - Attachment B	
1.10 Klamath Study Plan - Attachment C	
1.12 Instream Flow Analysis Study Plan - August 2003	

1.12 Instream Flow Analysis Study Plan Appendices - August 2003	
1.16 Evaluation of Effects of Flow Fluctuation on Aquatic Resources w/in J.C. Boyle Peaking Reach	
1.18 Description of Migratory Behavior of Juvenile Salmon Smolts - July 2003	
1.22 Analysis Of Potential Klamath Hydro Project Effects On Water Quality Aesthetics- August 2003	
1.23 Sampling of Fisheries in Project - July 2003	
3.1 Recreation Flow Analyses – Phase II	
7.2 High Level Socioeconomic Analysis of the Landscape Options–Phase 2 - April 2003	
7.3 Analysis of Effects of Differences Between Proposed and Current Proj on Socio Environ - Phase 3	
Klamath Relicensing Meeting Dates and Summaries	
Master Schedule for Klamath Meetings	
Aquatics Work Group Meeting Summaries and Presentations	
09-27-01 Summary	
02-21-02 Summary	
03-08-02 Summary	
04-04-02 Summary	
05-09-02 Summary	
06-05-02 Summary	
07-10-02 Summary	
08-06-02 Summary	
09-03-02 Summary	
10-09-02 Summary	
11-05-02 Summary	
12-05-02 Summary	
01-07-03 Summary	
02-05-03 Summary	
Mollusks Study for Aquatics Meeting 2-5-03	
03-04-03 Summary	
04-08-03 Summary	
05-06-03 Meeting Summary	
05-07-03 Meeting Summary	
06-03-03 Meeting Summary	
06-03-03 Presentation: Overview of Approach to Fish Resources Analysis for the FERC Application	
06-04-03 Meeting Summary	
06-06-03 HSC Presentation - Approach to Instream Flow Analysis and Integration	
08-06-03 Meeting Summary	
08-06-03 Presentation: Peaking Reach Fish Stranding Observations	
09-10-03 Summary	
09-10 &11-03 Handout - Characterization of Resident Fish Entrainment &Turbine Induced Mortality	
09-10-03 Presentation - Movement of Rainbow Trout in the Klamath River (SP 1.15)	
09-10-03 Presentation - Geomorphology	
09-10-03 Presentation - Flows and Recreation - September 2003	
10-07-03 Summary	
11-04-03 Presentation - Trout Comparison - November 2003	
11-04-03 Presentation - Geomorphology Study Sediment Transport	

2002-2003 Upper Klamath HSC for Rainbow Trout Using Alternative Curve-Fitting Methodologies	
Initial analysis of Rainbow Trout Use and Availability of Cover in the Peaking and Bypass Reaches	
Analysis of Rainbow Trout Spawning in the Bypass Reach	
Cultural Work Group Meeting Summaries	
Fish Passage Work Group Meeting Summaries	
08-08-01 Summary	
10-11,12-01 Summary	
01-29-02 Meeting Summary	
03-06-02 Summary	
04-03-02 Summary	
06-04-02 Summary	
07-09-02 Summary	
08-07-02 Summary	
09-04-02 Summary	
10-10-02 Summary	
11-06-02 Meeting Summary	
12-04-02 Summary	
02-06-03 Summary	
03-05&06-03 Summary	
04-09-03 Summary	
05-05-03 Meeting Summary	
06-05-03 Meeting Summary	
08-07-03 Meeting Summary	
09-11-03 Summary	
10-08-03 Summary	
Plenary Group Meeting Summaries	
NEW! Klamath - Approach to Modeling Analysis and Integration	
05-06-02 (Day 1) Meeting Summary	
05-07-02 (Day Two) Summary	
06-03-02 Summary	
07-08-02 Summary	
08-08-02 Summary	
09-05-02 Plenary Meeting Summary	
10-11-02 Summary	
11-07-02 Summary	
12-06-02 Meeting Summary	
01-08-03 Summary	
02-06-03 Summary	
03-06-03 Summary	
04-10-03 Summary	
05-06-03 Meeting Summary	
06-06-03 Meeting Summary	
08-08-03 Meeting Summary	
09-12-03 Summary	
10-09-03 Summary	
Recreation-LandUse-Visual Meeting Summaries	
01-16-02 Summary	
06-05-02 Summary	
07-09-02 Summary	
10-08-02 Summary	
12-05-02 Summary	
03-04-03 Summary	
04-08-03 Summary	
Socioeconomics Work Group Meeting Summaries	
04-17-02 Summary	

06-05-02 Summary	
07-11-02 Summary	
08-06-02 Summary	
09-04-02 Summary	
10-09-02 Summary	
11-12-02 Summary	
03-06-03 Summary	
04-10-03 Summary	
05-06-03 Meeting Summary	
06-03-03 Meeting Summary	
08-07-03 Summary	
10-10-03 Summary	
Stakeholder Meeting Summaries	
12-06-01 Summary	
Terrestrial Work Group Meeting Summaries-Handouts-Maps	
12-12-01 Summary	
01-17-02 Summary	
1-31-02 Riparian Conference Call	
03-28-02 Summary	
3-28-02 Terrestrial Meeting Handouts	
04-24-02 Summary	
04-24-02 Meeting Agenda and Handouts	
06-06-02 Summary	
11-08-02 Summary	
11-08-02 Handouts	
12-10-02 Summary	
12-10-02 Handouts	
02-04-03 Maps	
06-24-03 Meeting Summaries-Handouts-Maps	
08-05-03 Summary	
08-05-03 Meeting Summary- Handouts	
10-10-03 Meeting Summary- Handouts	
Water Quality Work Group Meeting Summaries and Presentations	
WQ System Model Calibration Presentation 12-03-02	
WQ Full Flow Presentation 12-03-02	
09-26-01 Summary	
01-30-02 Meeting Summary	
03-05-02 Meeting Summary	
04-02-02 Summary	
05-08-02 Summary	
06-06-02 Summary	
07-11-02 Summary	
Presentation: Klamath System Bathymetry and Sediment Classification, Fall 2002	
08-05-02 Meeting Summary	
09/05/02 Meeting Summary	
10-08-02 Meeting Summary	
11-04-02 Summary	
12-03-02 Summary	
02-07-03 Summary	
03-03-03 Summary	
04-07-03 Meeting Summary	
06-02-03 Meeting Summary	
Klamath River Flow and WQ Modeling Presentation 6-2-03	
Klamath River WQ Studies Presentation 8-4-03	
09-09-03 Summary	
09-09-03 WQ Meeting Handout - WQ Modeling Status Report (SP 1.3)	

09-09-03 WQ Presentation to Work Group	
10-06-03 Summary	
10-06-03 Hydrology Presentation (SP 1.4) to Work Group	
11-03-03 Presentation-Spring 2003 Macroinvertebrate&BiValve Study Results (S.P. 1.19 & S.P. 1.20)	
11-03-03 WQ Modeling Presentation	
Klamath WQ Modeling Master Documentation 11-14-03	
WQ Modeling Update Presentation - December 2003	
Klamath WQ Modeling Master Appendices 11-14-03	
Klamath Relicensing Documents	
Lamprey Workshop Notes - April 11, 2003	
Lamprey Workshop Presentation April 11, 2003	
Fish Passage Technical Memos	
Technical Memo 6 - J.C. Boyle Fish Passage Facilities	
Klamath Final Technical Reports	
Preliminary Draft - Final Technical Reports	
Klamath Relicensing Study Status Reports - October 2002	
Klamath Relicensing Collaborative Process Protocol - FINAL	
Klamath Project Facilities and Operations Report	
Phase 1 Recreation Report - June 2002	
Fish Passage Options Assessment Stakeholder Letter	
Reach WQ Summaries - Draft	
Copco Bypass Reach WQ Summary (Draft)	
Copco Reservoir Reach WQ Summary (Draft)	
Iron Gate Reservoir Reach WQ Summary (Draft)	
J.C. Boyle Bypass Reach WQ Summary (Draft)	
J.C. Boyle Full-Flow Reach WQ Summary (Draft)	
J.C. Boyle Reservoir Reach WQ Summary (Draft)	
Keno River Reach WQ Summary (Draft)	
Klamath River Below IG Dam Reach WQ Summary (Draft)	
Lake Ewauna/Keno Reservoir WQ Summary (Draft)	
Link River Reach WQ Summary (Draft)	
Summary of First Stage Consultation Document Comments and Responses	
Aquatic Issues	
Cultural Issues	
Land Use Issues	
Project Operation and Hydrology/Channel Morphology Issues	
Recreation Issues	
Terrestrial Issues	
Visual Resources Issues	
Water Quality Issues	
First Stage Consultation Document	
First Stage Consultation Document	
First Stage Consultation Document Appendices	
Notice of Intent to Relicense Klamath River Projects	
Klamath Biological Opinion - USFWS 1996	
Klamath Biological Opinion - USFWS 1996	
Klamath Relicensing Presentation	
Klamath Relicensing Resource Reports	
Bathymetry and Sediment Classification Report Final - April 2003	
Entrainment Information - Klamath Relicensing	
Literature Based Characterization of Resident Fish Entrainment-Turbine Induced Mortality - Klamath	
Klamath Hydro Fish Salvage Info - February 2003	
Klamath Fish Salvage Data - February 2003	
Link River Hydroelectric Project Final Entrainment Study Report, Sept.	

2000	
Lamprey Entrainment Data at Eastside/Westside 1997-1999	
PGE Pit 4 Fish Entrainment Sampling - Final Report March 23, 2001 - Final	
Species Count for Fish Sampled at Klamath Hydro Project - 1998 and 1999	
Klamath Fish Assessment Data (Provisional) - Spring 2002	
Fish Assessment Data (Provisional) - Summer 2002	
Fish Assessment Data (Provisional) - Fall 2002	
New Report - Water Quality Database	
Klamath River WQ Monitoring Program - July 2002	
Klamath River WQ Grab Sampling SOP - July 2002	
Fish Passage Conditions on the Upper Klamath River, July 2000	
OSU Resident Fish Data 1999	
OSU Resident Fish Data 1998	
Distribution and Biology of Suckers in Lower Klamath Reservoirs, March 2000	
Ceratomyxa Shasta Fact Sheet - 2002	
Fisheries-Optimal Stock Size & Harvest Rate in Multistage Life History Models	
Klamath Relicensing Contacts Lists	
Klamath Consultation List	
Klamath Plenary Group - Updated 01-14-03	
Klamath Consultants List	

Appendix B: Model Checklist for CE-QUAL-W2

The model setup and model files for the CE-QUAL-W2 models were evaluated for appropriateness and whether the model was setup accurately. Two simulation years were evaluated, 2000 and 2001, but only two scenarios were evaluated, Existing Conditions and Steady Flow since the No Project scenario did not use CE-QULA-W2. There were four reservoir systems reviewed and these include: Lake Ewauna, J. C. Boyle Reservoir, Copco Reservoir and Iron Gate Reservoir.

Most model evaluations were coarse based on visually examining the models files with a random number of files plotted. In the model file evaluation summaries below, there is a field called "Errors (Yes/No)? Yes and No values in this field reflect only the coarse evaluations of these model files, examining for obvious errors in the files. Further analyses would be required to determine if there are any errors from model file development methodologies.

The model files were not compared with the report: Klamath River Modeling Framework to Support the PacifiCorp Federal Energy Regulatory Commission Hydropower Relicensing Application, Draft 11-14-2003, prepared for PacifiCorp, by Watercourse Engineering, Inc. In some cases there were plots of flow or temperature in the report, which could have been compared with plots of the model files, but this analysis was not conducted. Water quality data provided in the report was often provided as a table and this information was not compared to the model files. The main focus of this review was to evaluate the model development and files for general appropriateness.

Model Water body: **Lake Ewauna to Keno Dam** **Model year:** **2000**

Scenario: Existing Conditions

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Notes
Link River (USBC)	Daily	Hourly	Hourly	No	qin_lr00.npt, USGS Gage 11507500 and PacifiCorp West Turbine Gage, Temp: Link River Reach EC 2000 results, WQ: Link River reachEC 2000 results, most constituents are fairly constant
Klamath Falls Wastewater Treatment Plant	Daily	Daily	14 values/constant	No	qtr_wt00.npt, constant except DO
South Suburban Sanitation District	Monthly	Monthly	Monthly	No	qtr_ss00.npt
Columbia Plywood	Monthly	Monthly	constant	No	qtr_cp00.npt, Q constant, Temp: constant, WQ: constant, 2000 data from Columbia Plywood Monitoring Reports and 1992 Base Case Estimates
Lost River Diversion	Daily	semi-monthly (21)	21 values	No	qtr_ld00.npt, Q: PacifiCorp / USBR Gage, Temp: Wilson Reservoir USBR data, WQ: Wilson Reservoir USBR records, 2002 BOD USBR data and 1992 base case CTRfile, ALK is high, 200+
Collins Forest Products #1	Daily	Daily	14 values	No	qtr_cf00.npt
Collins Forest Products #2	Daily	Daily	14 values	No	qtr_cf200.npt
Klamath Straits Drain	Daily	Daily	14 values	Yes, Temp at zero	qtr_ks00.npt, Temp: USBR?, WQ: Estimated from grab and sonde data recorded by USBR and PacifiCorp and 1992 basecase CTR file, ALK high, 200+
Stormwater Runoff #1	Daily	Constant	14 values/constant	ALK was 200+?	qtr_0100.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #2	Daily	Constant	14 values/constant	ALK was 200+?	qtr_0200.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #3	Daily	Constant	14 values/constant	ALK was 200+?	qtr_0300.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+

Stormwater Runoff #4	Daily	Constant	14 values/constant	ALK was 200+?	qtr_0400.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #5	Daily	Constant	14 values/constant	ALK was 200+?	qtr_0500.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #6	Daily	Constant	14 values/constant	ALK was 200+?	qtr_0600.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #7	Daily	Constant	14 values/constant	ALK was 200+?	qtr_0700.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #8	Daily	Constant	14 values/constant	ALK was 200+?	qtr_0800.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #9	Daily	Constant	14 values/constant	ALK was 200+?	qtr_0900.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #10	Daily	Constant	14 values/constant	ALK was 200+?	qtr_1000.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #11	Daily	Constant	14 values/constant	ALK was 200+?	qtr_1100.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Point Source Accretion #2	Daily	Constant	6 values	No	qacc_0200.npt, 2000 A/D calculations from 2000 water balance(1/4 of accretion part only), Temp: constant at 12C, WQ: Conc for QDT, GW input created from 1992 Base case file on 01-05-04 by ES
Point Source Accretion #3	Daily	Constant	6 values	No	qacc_0300.npt, 2000 A/D calculations from 2000 water balance(1/4 of accretion part only), Temp: constant at 12C, GW input created from 1992 Base case file on 01-05-04 by ES
Point Source Accretion #4	Daily	Constant	6 values	No	qacc_0400.npt, 2000 A/D calculations from 2000 water balance(1/4 of accretion part only), Temp: constant at 12C, GW input created from 1992 Base case file on 01-05-04 by ES
Point Source Accretion #7	Daily	Constant	6 values	No	qacc_0700.npt, 2000 A/D calculations from 2000 water balance(1/4 of accretion part only), Temp: constant at 12C, GW input created from 1992 Base case file on 01-05-04 by ES

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
LD	daily	No	qwd.npt
NC	daily	No	qwd.npt
AD	daily	No	qwd.npt
#2	daily	No	qwd.npt
#3	daily	No	qwd.npt
#4	daily	No	qwd.npt
#7	daily	No	qwd.npt

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Lake Ewauna Dam outflow	Hourly	No	qou_ke00mod.npt, Modified from USGS Gage 11509500 Keno Dam, 1 flow pathway

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
met_00.npt	Air Temp	hourly	Yes	No	
	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	No	Measurement increment seems to change in data set
	Wind Dir	hourly	Yes	No	Wind direction is primarily from 270-335 deg and 145 to 175 deg, grid orientation is primarily 15 to 65 deg
	Cloud Cover	hourly	Yes	No	Constant for day, 0 to 8, unlcear how it was developed
	Solar Rad.	hourly	Yes	Yes	Jday 230.417 had Solar at 3810.802, Additional errors from 230.458 to 230.542 & 256.50

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Epiphyton growth rate [EG=0.001] <	Bottom selective withdrawal layer	No interpolation for	WSC set to 1.0 for whole simulation, Model uses static

0.1 for epiphyton group 1	[KBWD=11] > bottom active layer [KB=8] for withdrawal 2	tributaries, No water balance flows distributed	shading at 100% full solar, Particulate organic matter was turned off for all tributaries and USBC, but simulated
Epiphyton mortality to POM fraction [EPOM=0.000] < 0.5 for epiphyton group 1			
Oxygen to algal respiration stoichiometry [O2AR=1.400] /= 1.1 for algal group1			
Oxygen to algal production stoichiometry [O2AG=1.500] /= 1.4 for algal group1			
Oxygen to epiphyton production stoichiometry [O2EG=1.400] /= 1.4 for epiphyton group1			

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy3.npt	Yes	Yes, 0.61 m	Yes, 243.8 to 600 m	Yes	

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	Ran model from Jday 1 to 209

Model Water body: **Lake Ewauna to Keno Dam** **Model year:** **2001**

Scenario: Existing Conditions

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Notes
Link River (USBC)	Daily	Hourly	Hourly	No	qin_lr01.npt, USGS Gage 11507500 and PacifiCorp West Turbine Gage, Temp: Link River Reach EC 2001 results, WQ: Link River reach EC 2001 results, most constituents are fairly constant
Klamath Falls Wastewater Treatment Plant	Daily	Daily	14 values/constant	No	qtr_wt01.npt, constant except DO, CBOD, Coliform, and SS
South Suburban Sanitation District	Monthly	Monthly	Monthly	No	qtr_ss01.npt
Columbia Plywood	Monthly	Monthly	Semi-monthly, 14 values, constant	No	qtr_cp01.npt, Q constant, Temp: constant, WQ: constant, 2000 data from Columbia Plywood Monitoring Reports and 1992 Base Case Estimates
Lost River Diversion	Daily	Monthly	Semi-monthly, 16 values	No	qtr_ld01.npt, Q: PacifiCorp / USBR Gage, Temp: Wilson Reservoir USBR data, WQ: Wilson Reservoir USBR records, 2002 BOD USBR data and 1992 base case CTRfile, ALK is high, 100+
Collins Forest Products #1	Daily	Daily	14 values	No	qtr_cf01.npt, WQ: constant except CBOD and SS
Collins Forest Products #2	Daily	Daily	14 values	No	qtr_cf201.npt, WQ: CBOD constant except CBOD, SS and Coliform
Klamath Straits Drain	Daily	Daily	Semi-monthly, 16 values	Yes, Temp at zero	qtr_ks01.npt, Q: Q: PacifiCorp / USBR Gage, Temp: USBR?, WQ: Estimated from grab and sonde data recorded by USBR and PacifiCorp and 1992 basecase CT R file, ALK high, 100+
Stormwater Runoff #1	Daily	Constant	6 values/constant	No	qtr_0101.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #2	Daily	Constant	6 values/constant	No	qtr_0201.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #3	Daily, Same as #3, 7, 11	Constant	6 values/constant	No	qtr_0301.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #4	Daily, Same as #4, 5, 6, 8, 9, 10	Constant	6 values/constant	No	qtr_0401.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input

Stormwater Runoff #5	Daily, Same as #4, 5, 6, 8, 9, 10	Constant	6 values/constant	No	qtr_0501.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #6	Daily, Same as #4, 5, 6, 8, 9, 10	Constant	6 values/constant	No	qtr_0601.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #7	Daily, Same as #3, 7, 11	Constant	6 values/constant	No	qtr_0701.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #8	Daily, Same as #4, 5, 6, 8, 9, 10	Constant	6 values/constant	No	qtr_0801.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #9	Daily, Same as #4, 5, 6, 8, 9, 10	Constant	6 values/constant	No	qtr_0901.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #10	Daily, Same as #4, 5, 6, 8, 9, 10	Constant	6 values/constant	No	qtr_1001.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #11	Daily, Same as #3, 7, 11	Constant	6 values/constant	No	qtr_1101.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Point Source Accretion #2	Daily	Constant	6 values/constant	No	qacc_0201.npt, 2001 A/D calculations from 2001 water balance(1/4 of accretion part only), Temp: constant at 12C, Created from TDT_BR1 for 1992 Base case, WQ: Conc for QDT GW input created from 1992 Base case file on 10-18-02
Point Source Accretion #3	Daily	Constant	6 values/constant	No	qacc_0301.npt, 2001 A/D calculations from 2001 water balance(1/4 of accretion part only), Temp: constant at 12C, Created from TDT_BR1 for 1992 Base case, WQ: Conc for QDT GW input created from 1992 Base case file on 10-18-02
Point Source Accretion #4	Daily	Constant	6 values/constant	No	qacc_0401.npt, 2001 A/D calculations from 2001 water balance(1/4 of accretion part only), Temp: constant at 12C, Created from TDT_BR1 for 1992 Base case, WQ: Conc for QDT GW input created from 1992 Base case file on 10-18-02
Point Source Accretion #7	Daily	Constant	6 values/constant	No	qacc_0701.npt, 2001 A/D calculations from 2001 water balance(1/4 of accretion part only), Temp: constant at 12C, Created from TDT_BR1 for 1992 Base case, WQ: Conc for QDT GW input created from 1992 Base case file on 10-18-02

Withdrawals

Names	**Frequency Q**	**Errors? (Yes/No)**	**Notes**
LD	daily	No	qwd_01.npt
NC	daily	No	qwd_01.npt

AD	daily	No	qwd_01.npt
#2	daily	No	qwd_01.npt
#3	daily	No	qwd_01.npt
#4	daily	No	qwd_01.npt
#7	daily	No	qwd_01.npt

Operations

Names	**Frequency Q**	**Errors? (Yes/No)**	**Notes**
Lake Ewauna Dam outflow	Hourly	No	qou_ke01mod.npt, Modified from USGS Gage 11509500 Keno Dam, 1 flow pathway

Meteorological Data

Name	**Parameter**	**Frequency**	**Completeness (Yes/No)**	**Errors? (Yes/No)**	**Notes**
met_01.npt	Air Temp	hourly	Yes	No	
	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	No	Measurement increment seems to change in data set
	Wind Dir	hourly	Yes	No	Wind direction is primarily from 280-340 deg and 145 to 175 deg, grid orientation is primarily 15 to 65 deg
	Cloud Cover	hourly	Yes	No	Constant for day, 0 to 9, unlcear how it was developed
	Solar Rad.	hourly	Yes	Yes	Solar radaition appears to be about 5% higher than in 2000

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Epiphyton growth rate [EG=0.001] < 0.1 for epiphyton group 1	Bottom selective withdrawal layer [KBWD=11] > bottom active layer [KB=8] for withdrawal 2	No interpolation for tributaries, No water balance flows distributed	WSC set to 1.0 for whole simulation, Model uses static shading at 100% full solar, Particulate organic matter was turned off for all tributaries and USBC, but simulated
Epiphyton mortality to POM fraction [EPOM=0.000] < 0.5 for epiphyton group 1			
Oxygen to algal respiration stoichiometry [O2AR=1.400] /= 1.1 for algal group1			
Oxygen to algal production stoichiometry [O2AG=1.500] /= 1.4 for algal group1			
Oxygen to epiphyton production stoichiometry [O2EG=1.400] /= 1.4 for epiphyton group1			

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy3.npt	Yes	Yes, 0.61 m	Yes, 243.8 to 600 m	Yes	

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	Ran model from Jday 1 to 3, no difference between control file for 2000 and 2001 for Exisitng condition

Model Water body: **Lake Ewauna to Keno Dam** **Model year:** **2000**

Scenario: Steady Flow

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Notes
Link River (USBC)	Daily	Hourly	Hourly	No	qin_lr00.npt, Q: Calculated Flow from SS Flow Sheet, Temp: Link River Reach SF 2000 results, WQ: Link River Reach SF 2000 results - wq realtivly constant
Klamath Falls Wastewater Treatment Plant	Daily/ Same as EC	Daily/ Same as EC	14 values/constant/ Same as EC	No	qtr_wt00.npt, constant except DO
South Suburban Sanitation District	Monthly/ Same as EC	Monthly/ Same as EC	Monthly/ Same as EC	No	qtr_ss00.npt
Columbia Plywood	Monthly/ Same as EC	Monthly/ Same as EC	14 values/constant/ Same as EC	No	qtr_cp00.npt, Q constant, Temp: constant, WQ: constant, 2000 data from Columbia Plywood Monitoring Reports and 1992 Base Case Estimates
Lost River Diversion	Daily/ Same as EC	semi-monthly (21)/ Same as EC	18 values/ Same as EC except missing three values	WQ: Missing three values compared to EC	qtr_ld00.npt, Q: PacifiCorp / USBR Gage, Temp: Wilson Reservoir USBR data, WQ: Wilson Reservoir USBR records, 2002 BOD USBR data and 1992 base case CTRfile, ALK is high, 200+
Collins Forest Products #1	Daily/ Same as EC	Daily/ Same as EC	14 values/constant/ Same as EC	No	qtr_cf00.npt
Collins Forest Products #2	Daily/ Same as EC	Daily/ Same as EC	14 values/constant/ Same as EC	No	qtr_cf200.npt
Klamath Straits Drain	Daily/ Same as EC	Daily/ Same as EC	14 values/constant/ Same as EC	Yes, Temp at zero	qtr_ks00.npt, Temp: USBR?, WQ: Estimated from grab and sonde data recorded by USBR and PacifiCorp and 1992 basecase CT R file, ALK high, 200+
Stormwater Runoff #1	Daily/ Same as EC	Constant/ Same as EC	6 values/constant	ALK was 200+?	qtr_0100.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #2	Daily/ Same as EC	Constant/ Same as EC	6 values/constant	ALK was 200+?	qtr_0200.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case

					Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #3	Daily/ Same as EC	Constant/ Same as EC	6 values/constant	ALK was 200+?	qtr_0300.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #4	Daily/ Same as EC	Constant/ Same as EC	6 values/constant	ALK was 200+?	qtr_0400.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #5	Daily/ Same as EC	Constant/ Same as EC	6 values/constant	ALK was 200+?	qtr_0500.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #6	Daily/ Same as EC	Constant/ Same as EC	6 values/constant	ALK was 200+?	qtr_0600.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #7	Daily/ Same as EC	Constant/ Same as EC	6 values/constant	ALK was 200+?	qtr_0700.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #8	Daily/ Same as EC	Constant/ Same as EC	6 values/constant	ALK was 200+?	qtr_0800.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #9	Daily/ Same as EC	Constant/ Same as EC	6 values/constant	ALK was 200+?	qtr_0900.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #10	Daily/ Same as EC	Constant/ Same as EC	6 values/constant	ALK was 200+?	qtr_1000.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Stormwater Runoff #11	Daily/ Same as EC	Constant/ Same as EC	6 values/constant	ALK was 200+?	qtr_1100.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input, constant except TIC and ALK, ALK high, 200+
Point Source Accretion #2	Daily	Constant	6 values	No	qacc_0200.npt, 2000 A/D calculations from 2000 water balance(1/4 of accretion part only), Temp: constant at 12C, WQ: Conc for QDT, GW input created from 1992 Base

					case file on 01-05-04 by ES
Point Source Accretion #3	Daily	Constant	6 values	No	qacc_0300.npt, 2000 A/D calculations from 2000 water balance(1/4 of accretion part only), Temp: constant at 12C, WQ: Conc for QDT, GW input created from 1992 Base case file on 01-05-04 by ES
Point Source Accretion #4	Daily	Constant	6 values	No	qacc_0400.npt, 2000 A/D calculations from 2000 water balance(1/4 of accretion part only), Temp: constant at 12C, WQ: Conc for QDT, GW input created from 1992 Base case file on 01-05-04 by ES
Point Source Accretion #7	Daily	Constant	6 values	No	qacc_0700.npt, 2000 A/D calculations from 2000 water balance(1/4 of accretion part only), Temp: constant at 12C, WQ: Conc for QDT, GW input created from 1992 Base case file on 01-05-04 by ES

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
LD	daily	No	qwd.npt, not very steady
NC	daily	No	qwd.npt, not very steady
AD	daily	No	qwd.npt, not very steady
#2	daily	No	qwd.npt, not very steady
#3	daily	No	qwd.npt, not very steady
#4	daily	No	qwd.npt, not very steady
#7	daily	No	qwd.npt, not very steady

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Lake Ewauna Dam outflow	Daily	No	SS Flow Calculation Sheet, not very steady
			Ave: 42.71
			stdev: 25.83
			median: 31.12
			min: 9.61

					max: 118.54

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
met_00.npt	Air Temp	hourly	Yes	No	
same as Existing Condition	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	No	Measurement increment seems to change in data set
	Wind Dir	hourly	Yes	No	Wind direction is primarily from 270-335 deg and 145 to 175 deg, grid orientation is primarily 15 to 65 deg
	Cloud Cover	hourly	Yes	No	Constant for day, 0 to 8, unlcear how it was developed
	Solar Rad.	hourly	Yes	Yes	Jday 230.417 had Solar at 3810.802, Additional errors from 230.458 to 230.542 & 256.50

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Epiphyton growth rate [EG=0.001] < 0.1 for epiphyton group 1	Bottom selective withdrawal layer [KBWD=11] > bottom active layer [KB=8] for withdrawal 2	No interpolation for tributaries	WSC set to 1.0 for whole simulation, Model uses static shading at 100% full solar, Particulate organic matter was turned off for all tributaries and USBC, but simulated
Epiphyton mortality to POM fraction [EPOM=0.000] < 0.5 for epiphyton group 1			
Oxygen to algal respiration stoichiometry [O2AR=1.400] /= 1.1 for algal group1			
Oxygen to algal production stoichiometry [O2AG=1.500] /= 1.4 for algal group1			
Oxygen to epiphyton production stoichiometry [O2EG=1.400] /= 1.4 for epiphyton group1			

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy3.npt	Yes	Yes, 0.61 m	Yes, 243.8 to 600 m	Yes	Same as Existing Condition

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	Ran model from Jday 1 to 12, , control file same as Existing condition for 2000

Model Water body:	**Lake Ewauna to Keno Dam**	**Model year:**	**2001**
Scenario:	Steady Flow		

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Notes
Link River (USBC)	Daily	Hourly	Hourly	No	qin_lr01.npt, 2001 SF Link Dam calculated release + calculated East and West Turbine, Temp: Link River Reach EC 2001 results, WQ: Link River reach EC 2001 results, most constituents are fairly constant
Klamath Falls Wastewater Treatment Plant	Daily/ Same as EC	Daily/ Same as EC	14 values/constant/ Same as EC	No	qtr_wt01.npt, constant except DO, CBOD, Coliform, and SS
South Suburban Sanitation District	Monthly/ Same as EC	Monthly/ Same as EC	Monthly	Yes	qtr_ss01.npt, WQ: Same as Existing condition except TIC is 1/1000 of EC
Columbia Plywood	Monthly/ Same as EC	Monthly/ Same as EC	Semi-monthly, 14 values, constant/ Same as EC	No	qtr_cp01.npt, Q constant, Temp: constant, WQ: constant, 2000 data from Columbia Plywood Monitoring Reports and 1992 Base Case Estimates
Lost River Diversion	Daily/ Same as EC	Monthly/ Same as EC	Semi-monthly, 16 values/ Same as EC	No	qtr_ld01.npt, Q: PacifiCorp / USBR Gage, Temp: Wilson Reservoir USBR data, WQ: Wilson Reservoir USBR records, 2002 BOD USBR data and 1992 base case CTRfile, ALK is high, 100+
Collins Forest Products #1	Daily/ Same as EC	Daily/ Same as EC	14 values/ Same as EC	No	qtr_cf01.npt, WQ: constant except CBOD and SS
Collins Forest Products #2	Daily/ Same as EC	Daily/ Same as EC	14 values/ Same as EC	No	qtr_cf201.npt, WQ: CBOD constant except CBOD, SS and Coliform
Klamath Straits Drain	Daily/ Same as EC	Daily/ Same as EC	Semi-monthly, 16 values/ Same as EC	Yes, Temp at zero	qtr_ks01.npt, Q: Q: PacifiCorp / USBR Gage, Temp: USBR?, WQ: Estimated from grab and sonde data recorded by USBR and PacifiCorp and 1992 basecase CT R file, ALK high, 100+
Stormwater Runoff #1	Daily/ Same as EC	Constant	6 values/constant/ Same as EC	No	qtr_0101.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #2	Daily/ Same as EC	Constant	6 values/constant/ Same as EC	No	qtr_0201.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case

					Model Input
Stormwater Runoff #3	Daily, Same as #3, 7, 11/ Same as EC	Constant	6 values/constant/ Same as EC	No	qtr_0301.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #4	Daily, Same as #4, 5, 6, 8, 9, 10/ Same as EC	Constant	6 values/constant/ Same as EC	No	qtr_0401.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #5	Daily, Same as #4, 5, 6, 8, 9, 10/ Same as EC	Constant	6 values/constant/ Same as EC	No	qtr_0501.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #6	Daily, Same as #4, 5, 6, 8, 9, 10/ Same as EC	Constant	6 values/constant/ Same as EC	No	qtr_0601.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #7	Daily, Same as #3, 7, 11/ Same as EC	Constant	6 values/constant/ Same as EC	No	qtr_0701.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #8	Daily, Same as #4, 5, 6, 8, 9, 10/ Same as EC	Constant	6 values/constant/ Same as EC	No	qtr_0801.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #9	Daily, Same as #4, 5, 6, 8, 9, 10/ Same as EC	Constant	6 values/constant/ Same as EC	No	qtr_0901.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #10	Daily, Same as #4, 5, 6, 8, 9, 10/ Same as EC	Constant	6 values/constant/ Same as EC	No	qtr_1001.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Stormwater Runoff #11	Daily, Same as #3, 7, 11/ Same as EC	Constant	6 values/constant/ Same as EC	No	qtr_1101.npt, Temp: 1992Base simulation constant at 12C, WQ: 1992 Base Case Model Input
Point Source Accretion #2	Daily	Constant	6 values/constant/ Same as EC	No	qacc_0201.npt, 2001 A/D calculations from 2001 water balance(1/4 of accretion part only), Temp: constant at 12C, Created from TDT_BR1 for 1992 Base case, WQ: Conc for QDT GW input created from 1992 Base case file on 10-18-02
Point Source Accretion #3	Daily	Constant	6 values/constant/ Same as EC	No	qacc_0301.npt, 2001 A/D calculations from 2001 water balance(1/4 of accretion part only), Temp: constant at 12C, Created from TDT_BR1 for 1992 Base case, WQ: Conc

					for QDT GW input created from 1992 Base case file on 10-18-02
Point Source Accretion #4	Daily	Constant	6 values/constant/ Same as EC	No	qacc_0401.npt, 2001 A/D calculations from 2001 water balance(1/4 of accretion part only), Temp: constant at 12C, Created from TDT_BR1 for 1992 Base case, WQ: Conc for QDT GW input created from 1992 Base case file on 10-18-02
Point Source Accretion #7	Daily	Constant	6 values/constant/ Same as EC	No	qacc_0701.npt, 2001 A/D calculations from 2001 water balance(1/4 of accretion part only), Temp: constant at 12C, Created from TDT_BR1 for 1992 Base case, WQ: Conc for QDT GW input created from 1992 Base case file on 10-18-02

Withdrawals

Names	**Frequency Q**	**Errors? (Yes/No)**	**Notes**
LD	daily	No	qwd_01.npt, different than Existing Condition
NC	daily	No	qwd_01.npt, different than Existing Condition
AD	daily	No	qwd_01.npt, different than Existing Condition
#2	daily	No	qwd_01.npt, different than Existing Condition
#3	daily	No	qwd_01.npt, different than Existing Condition
#4	daily	No	qwd_01.npt, different than Existing Condition
#7	daily	No	qwd_01.npt, different than Existing Condition

Operations

Names	**Frequency Q**	**Errors? (Yes/No)**	**Notes**
Lake Ewauna Dam outflow	Hourly	No	qou_ke01mod.npt, SF flow calculations Keno Dam flow, 1 flow pathway, different than Exisitng Condition

Meteorological Data

Name	**Parameter**	**Frequency**	**Completeness (Yes/No)**	**Errors? (Yes/No)**	**Notes**
met_01.npt	Air Temp	hourly	Yes	No	

Same as Exisitng condition	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	No	Measurement increment seems to change in data set
	Wind Dir	hourly	Yes	No	Wind direction is primarily from 280-340 deg and 145 to 175 deg, grid orientation is primarily 15 to 65 deg
	Cloud Cover	hourly	Yes	No	Constant for day, 0 to 9, unlcear how it was developed
	Solar Rad.	hourly	Yes	Yes	Solar radaition appears to be about 5% higher than in 2000

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Epiphyton growth rate [EG=0.001] < 0.1 for epiphyton group 1	Bottom selective withdrawal layer [KBWD=11] > bottom active layer [KB=8] for withdrawal 2	No interpolation for tributaries, No water balance flows distributed	WSC set to 1.0 for whole simulation, Model uses static shading at 100% full solar, Particulate organic matter was turned off for all tributaries and USBC, but simulated
Epiphyton mortality to POM fraction [EPOM=0.000] < 0.5 for epiphyton group 1			
Oxygen to algal respiration stoichiometry [O2AR=1.400] /= 1.1 for algal group1			
Oxygen to algal production stoichiometry [O2AG=1.500] /= 1.4 for algal group1			
Oxygen to epiphyton production stoichiometry [O2EG=1.400] /= 1.4 for epiphyton group1			

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy3.npt	Yes	Yes, 0.61 m	Yes, 243.8 to 600 m	Yes	

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	Ran model from Jday 1 to 5, control file same as Existing condition for 2001, no difference between 2000 and 2001 cotnrol files for steady flow

Model Water body:	**J. C. Boyle Reservoir**	**Model year:**	**2000**
Scenario:	Existing Conditions		

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Notes
QIN_00.npt	hourly	hourly	hourly	No	USBC. No TIC or ALK outside ~J122-275
QTRSP_00.npt	daily	hourly	grab sample	No	Temperature: linear interpolated data gap (~J125-132). Periods of zero degrees.

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
None			

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure 1	hourly	No	
Structure 2	hourly	No	
Structure 3	constant value	No	
Structure 4	constant value	No	

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
MET_00.npt	Air Temp	hourly	Yes	No	Met data is same as 2000 Copco save for TAIR correction.
	Dew Point Temp	hourly	Yes	Yes	RH not corrected; some winter TDEW > TAIR
	Wind Spd	hourly	Yes	Yes	some data filling. Single value >20m/s
	Wind Dir	hourly	Yes	No	
	Cloud Cover	hourly	Yes	No	Integer values; max = 8

Solar Rad.	hourly	Yes	No	

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Check kinetic coefficients	missing heading line in qin_00.npt	some NH4 and LDOM negative values in January (cin_00.npt)	Trivial pre.err
Single wind speed outlier		NH4 negative on J1.213, 1.375	No shading
		LDOM negative on J1.213	No ice cover calculations, and water temperatures go negative

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy.npt	Yes	1 m	40 to 490	Yes	Grid bottom may have stagnant cells

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	

Model Water body: **J. C. Boyle Reservoir** **Model year:** **2001**

Scenario: Existing Conditions

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)		Notes
qin_01.npt	hourly	hourly	hourly	No		USBC
qtr_sf01.npt	daily	hourly	grab samples	No		UsesTemperatures and WQ from 2000

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
None			

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure 1	hourly	No	
Structure 2	hourly	No	zero value
Structure 3	hourly	No	constant value
Structure 4	hourly	No	constant value

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
MET_01.npt	Air Temp	hourly	Yes	No	
	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	No	some data filling
	Wind Dir	hourly	Yes	No	
	Cloud Cover	hourly	Yes	No	
	Solar Rad.	hourly	Yes	No	

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Check kinetic coefficients	no errors	Yes	

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy.npt	Yes	1 m	40 to 490	Yes	Grid bottom may have stagnant cells

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	

Model Water body: **J. C. Boyle Reservoir** **Model year:** **2000**

Scenario: Steady Flow

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Match Report?	Notes
qinsf_00.npt	daily	hourly	hourly	No		USBC
qtrsf_00.npt	daily	hourly	grab samples	No		Temperature: linear interpolated data gap (~J125-132). Periods of zero degrees.

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
None			

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure 1	daily	No	
Structure 2	daily	No	
Structure 3	constant value	No	
Structure 4	constant value	No	

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
MET_00.npt	Air Temp	hourly	Yes	No	Met data is same as 2000 Copco save for TAIR correction.
	Dew Point Temp	hourly	Yes	Yes	RH not corrected; some winter TDEW > TAIR
	Wind Spd	hourly	Yes	Yes	some data filling. Single value >20m/s

Wind Dir	hourly	Yes	No	
Cloud Cover	hourly	Yes	No	Integer values; max = 8
Solar Rad.	hourly	Yes	No	

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Check kinetic coefficients	qinsf_00.npt is missing a headline and has extra blank line at end of file	some NH4 and LDOM negative values in January (cin_00.npt)	trivial error
Single wind speed outlier		NH4 negative on J1.213, 1.375	
		LDOM negative on J1.213	

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy.npt	Yes	1 m	40 to 490	Yes	Grid bottom may have stagnant cells

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	

Model Water body:	**J. C. Boyle Reservoir**	**Model year:**	**2001**
Scenario:	Steady Flow		

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Match Report?	Notes
qin_01.npt	daily	hourly	hourly	No		USBC
qtr_sfsp01.npt	daily	hourly	grab samples	No		UsesTemperatures and WQ from 2000

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
None			

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure 1	daily	No	
Structure 2	daily	No	zero value
Structure 3	daily	No	constant value
Structure 4	daily	No	constant value

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
MET_01.npt	Air Temp	hourly	Yes	No	
	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	No	some data filling
	Wind Dir	hourly	Yes	No	
	Cloud Cover	hourly	Yes	No	
	Solar Rad.	hourly	Yes	No	

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Check kinetic coefficients	none	Yes	

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy.npt	Yes	1 m	40 to 490	Yes	Grid bottom may have stagnant cells

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	

Model Water body: **Copco Reservoir** **Model year:** **2000**

Scenario: Existing Conditions

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Match Report?	Notes
QIN_00.npt	hourly	hourly	hourly	No		USBC. TIC & ALK data available ~J122-275
QSP_00.npt				No		Flow is zero

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
None			

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure1	hourly	No	
Structure2	hourly	No	

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
MET_00.npt	Air Temp	hourly	Yes	No	
	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	Yes	some data filling. Single value >20m/s
	Wind Dir	hourly	Yes	No	
	Cloud Cover	hourly	Yes	No	Integer values; max = 8
	Solar Rad.	hourly	Yes	No	

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
cell widths (7x) could be resolved	no errors	some spring negative NO3 branch inflow concentrations	No shading
Check kinetic coefficients		NO3 negative on J148.625, 153.583 (cin_00.npt)	No ice cover calculations, and water temperatures go negative
Single wind speed outlier			

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy.npt	Yes	2 m	140-640	Yes	Could use smaller DZ

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	

Model Water body:	**Copco Reservoir**	**Model year:**	**2001**
Scenario:	Existing Conditions		

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Match Report?	Notes
QIN_01.npt	hourly	hourly	hourly	No		USBC
QSP_00.npt				No		no flow

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
None			

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure1	hourly	No	
Structure2	hourly	No	no flow

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
Met_01.npt	Air Temp	hourly	Yes	No	
	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	No	Some data filling
	Wind Dir	hourly	Yes	No	
	Cloud Cover	hourly	Yes	No	
	Solar Rad.	hourly	Yes	No	

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
cell widths (7x) could be resolved	no errors		

Check kinetic coefficients			

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy.npt	Yes	2 m	140-640	Yes	Could use smaller DZ

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	

Model Water body:	**Copco Reservoir**	**Model year:**	**2000**
Scenario:	Steady Flow		

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Match Report?	Notes
QINSP_00.npt	Daily	Daily	Daily	No		
QSPSF_00.npt				No		Flow is zero

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
None			

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure1	Daily	No	
Structure2	Daily	No	

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
MET_00.npt	Air Temp	hourly	Yes	No	same MET data as Existing_00
	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	Yes	some data filling. Single value >20m/s
	Wind Dir	hourly	Yes	No	
	Cloud Cover	hourly	Yes	No	Integer values; max = 8
	Solar Rad.	hourly	Yes	No	

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes

cell widths (7x) could be resolved	no errors	Yes	
Check kinetic coefficients			
Single wind speed outlier			

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy.npt	Yes	2 m	140-640	Yes	Could use smaller DZ

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	

Model Water body: **Copco Reservoir** **Model year:** **2001**

Scenario: Steady Flow

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Match Report?	Notes
QIN_01.npt	daily	hourly	hourly	No		USBC
QSP_01.npt				No		flow is zero

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
None			

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure1	Daily	No	
Structure2	Daily	No	

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
Met_01.npt	Air Temp	hourly	Yes	No	
	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	No	Some data filling
	Wind Dir	hourly	Yes	No	

Cloud Cover	hourly	Yes	No	
Solar Rad.	hourly	Yes	No	

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
cell widths (7x) could be resolved	no errors		
Check kinetic coefficients			

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy.npt	Yes	2 m	140-640	Yes	Could use smaller DZ

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	

Model Water body: **Iron Gate** **Model year:** **2000**

Scenario: Existing Conditions

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Match Report?	Notes
qin_00.npt	hourly	hourly	hourly	No		Assumed ALK before J125
qin_cc00.npt	single value	grab samples	grab samples	No		Q = 0.0001 cms
qtr_FC00.npt	single value	single value	single value	No		no flow
qtr_JC00.npt	hourly	grab samples	grab samples	No		

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
Withdrawal 1	daily	No	
Withdrawal 2	daily	No	

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure1	daily	No	constant value
Structure2	daily	No	
Structure3	daily	No	zero value

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
met_00.npt	Air Temp	hourly	Yes	No	Temperature is corrected
	Dew Point Temp	hourly	Yes	No	RH not corrected
	Wind Spd	hourly	Yes	Yes	some data filling. Single value >20m/s
	Wind Dir	hourly	Yes	No	

Cloud Cover	hourly	Yes	No	Integer values; max = 8
Solar Rad.	hourly	Yes	No	

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Check kinetic coefficients	extra blank lines at end of cin_cc00.npt	Yes	trivial error
Single wind speed outlier			No shading
			No ice cover calculations, and water temperatures go negative

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy.npt	Yes	2.5 m	36 to 513 m	?	Grid bottom may have stagnant cells;
					cell with DLX = 36 has adjacent cells with DLX = 513 & 403

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	

Model Water body: **Iron Gate** **Model year:** **2001**

Scenario: Existing Conditions

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Match Report?	Notes
qin_01.npt	hourly	hourly	hourly	No		
qin_CC01.npt	single value	grab samples	grab samples	No		Q = 0.001 cms
qtr_FC01.npt	single value	single value	single value	No		No flow
qtr_JC01.npt	daily	grab samples	grab samples	No		

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
Withdrawal 1	daily	No	Fortran integer Jday values
Withdrawal 2	daily	No	Fortran integer Jday values

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure1	daily	No	constant value
Structure2	daily	No	
Structure3	daily	No	zero value

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
	Air Temp	hourly	Yes	No	TAIR corrected
	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	No	some data gap filling
	Wind Dir	hourly	Yes	No	

Cloud Cover	hourly	Yes	No	
Solar Rad.	hourly	Yes	No	

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Check kinetic coefficients	Format error at end of qin_01.npt, tin_01.npt, & spill_01.npt	Yes	trivial error

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy2_5.npt	Yes	2.5 m	36 to 513 m	?	Grid bottom may have stagnant cells;
					cell with DLX = 36 has adjacent cells with DLX = 513 & 403

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	

Model Water body: **Iron Gate** **Model year:** **2000**

Scenario: Steady Flow

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Match Report?	Notes
qinsf_00.npt	hourly	hourly	hourly	No		ALK is constant
qin_cc00.npt	single value	grab samples	grab samples	No		Q = 0.001 cms
qtr_FC00.npt	single value	single value	single value	No		
qtr_JC00.npt	hourly	grab samples	grab samples	No		

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
Spillsf_00.npt	daily	No	

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure1	daily	No	constant value
Structure2	daily	No	
Structure3	daily	No	zero value

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
MET_00.npt	Air Temp	hourly	Yes	No	Temperature is corrected
	Dew Point Temp	hourly	Yes	No	RH not corrected
	Wind Spd	hourly	Yes	Yes	some data filling. Single value >20m/s
	Wind Dir	hourly	Yes	No	

Cloud Cover	hourly	Yes	No		Integer values; max = 8
Solar Rad.	hourly	Yes	No		

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Check kinetic coefficients	extra blank lines at end of cin_cc00.npt	Yes	trivial error
Single wind speed outlier			

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy2_5.npt	Yes	2.5 m	36 to 513 m	?	Grid bottom may have stagnant cells;
					cell with DLX = 36 has adjacent cells with DLX = 513 & 403

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)	Notes
Yes	No	

Model Water body: **Iron Gate** **Model year:** **2001**

Scenario: Steady Flow

Model Boundary Conditions

Tributaries

Names	Frequency Q	Frequency Temp	Frequency WQ	Errors? (Yes/No)	Match Report?	Notes
qin_01.npt	daily	hourly	hourly	No		
qin_CC01.npt	single value	grab samples	grab samples	No		Q = 0.001 cms
qtr_FC01.npt	single value	single value	single value	No		No flow
qtr_JC01.npt	daily	grab samples	grab samples	No		

Withdrawals

Names	Frequency Q	Errors? (Yes/No)	Notes
Spill_01.npt	daily	No	No flow/withdrawal

Operations

Names	Frequency Q	Errors? (Yes/No)	Notes
Structure1	daily	No	constant value
Structure2	daily	No	
Structure3	daily	No	zero value

Meteorological Data

Name	Parameter	Frequency	Completeness (Yes/No)	Errors? (Yes/No)	Notes
Met_01.npt	Air Temp	hourly	Yes	No	TAIR corrected
	Dew Point Temp	hourly	Yes	No	
	Wind Spd	hourly	Yes	No	some data gap filling
	Wind Dir	hourly	Yes	No	

Cloud Cover	hourly	Yes	No	
Solar Rad.	hourly	Yes	No	

Preprocessor

Warnings Notes	Error Notes	Pre.opt, Reasonableness? (Yes/No) (No kinetic coefficients)	Notes
Check kinetic coefficients	Blank lines at end of file in qtr_jc01.npt	Yes	trivial error

Bathymetry Editor

File Names	Phi, Correct?	DZ, Reasonable?	DLX, Reasonable?	Overall Reasonableness? (Yes/No)	Notes
bthy2_5.npt	Yes	2.5 m	36 to 513 m	?	Grid bottom may have stagnant cells;
					cell with DLX = 36 has adjacent cells with DLX = 513 & 403
					DZ could be smaller

W2 Code

Does it Run? (Yes/No)	Errors? (Yes/No)
Yes	No

Notes

Appendix C: CE-QUAL-W2 Parameter Values and Kinetic Coefficients

The model kinetic coefficients for the CE-QUAL-W2 models were evaluated for appropriateness and consistency between models. Two simulation years were evaluated, 2000 and 2001, but only two scenarios were evaluated, Existing Conditions and Steady Flow since the No Project scenario did not use CE-QUAL-W2. There were four reservoir systems reviewed and these include: Lake Ewauna, J. C. Boyle Reservoir, Copco Reservoir and Iron Gate Reservoir.

Models coefficients used in each model were compared with the list of coefficients listed in the report: Klamath River Modeling Framework to Support the PacifiCorp Federal Energy Regulatory Commission Hydropower Relicensing Application, Draft 11-14-2003, prepared for PacifiCorp, by Watercourse Engineering, Inc. and the default values list in the CE-QUAL-W2 User's Manual (Cole and Wells, 2003).

Year 2000

Table 4. CE-QUAL-W2 parameter values and kinetic coefficients for reservoir models, simulation year 2000

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
Spatial and Run Time Information											
LAT	Latitude, degrees	degrees		42.13	42.13	42.12	42.12	42.12	42.12	42.97	42.97
LONG	Longitude, degrees	degrees		121.95	121.95	122.05	122.05	122.33	122.33	122.42	122.42
EBOT	Bottom elevation of waterbody, m	m		1237.30 (report 1236.25)	1237.3	1143.75	1143.75	761.09	761.09	663.78	663.78
SLOPE	Waterbody bottom slope			0	0	0	0	0	0	0	0
DLT MAX	Maximum timestep, sec	sec		500	500	500	500	500	500	500	500
DLT MIN	Minimum timestep, sec	sec		5	5	5	5	5	5	5	5
Hydrodynamics and Longitudinal Transport											
AX	Longitudinal eddy viscosity (for momentum dispersion)	m^2/sec	1	1	1	1	1	1	1	1	1
DX	Longitudinal eddy diffusivity (for dispersion of heat and constituents)	m^2/sec	1	1	1	1	1	1	1	1	1
FI	Interfacial friction factor		0.01	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Temperature											
AFW	A coefficient in the wind speed formulation		9.2	9.2	9.2	18	18	9.2	9.2	6	6
BETA	Fraction of incident solar radiation absorbed at the water surface		0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
BFW	B coefficient in the		0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	wind speed formulation										
CBHE	Coefficient of bottom heat exchange	Wm^2/sec	0.3	0.3	0.3	7.00E-08	7.00E-08	3	3	17.14	17.14
CFW	C coefficient in the wind speed formulation		2.0	2.4 (report: 1)	2.4	1	1	1	1	1	1
TSED	Sediment (ground) temperature	°C		12.0	12.0	12	12	10	10	7	7
TSEDF	Heat lost to sediments that is added back to water column, fraction		0 to 1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
WINDH	Wind speed measurement height, m		2.0	2.0	2.0	2	2	2	2	2	2
WSC	Wind sheltering coefficient			1.0	1.0	1	1	1	1	1	1
Water Quality											
Light Extinction											
EXH20	Extinction for water	/m	0.25	0.25	0.25	0.25	0.25	0.5 (report 0.25)	0.5 (report 0.25)	0.25	0.25
EXSS	Extinction due to inorganic suspended solids	m^3/m/g	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EXOM	Extinction due to organic suspended solids	m^3/m/g	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EXA	Extinction due to organic algal type 1	m^3/m/g	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.45	0.45
Suspended Solids											
SSS	Suspended solids settling rate	m/day	1	1	1	1	1	1	1	1	1
PARTP	Phosphorous partitioning coefficient for suspended solids		0.0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Algae											

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
AC1	Stoichiometric equivalent between algal biomass and carbon, for algal type 1		0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
ACHLA1	Ratio between algal biomass and chlorophyll a, for algal type 1		145	145	145	145	145	145	145	145	145
AE1	Maximum algal excretion rate for algal type 1	/day	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
AG1	Maximum algal growth rate for algal type 1	/day	2	3.0	3.0	3	3	6 (report 3)	6	6 (report 3)	6
AHSN	Algal half-saturation constant for nitrogrn limited growth, for algal type 1	g/m^3	0.014	0.014	0.014	0	0	0.014	0.014	0.014	0.014
AHSP1	Algal half-saturation constant for phosphorous limited growth, for algal type 1	g/m	0.003	0.003	0.003	0.014	0.014	0.003	0.003	0.003	0.003
AK11	Fraction of algal growth rate at ALGT1 for algal type 1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
AK21	Fraction of maximum algal growth rate at ALGT2 for algal type 1		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
AK31	Fraction of maximum algal growth rate at ALGT3 for algal type 1		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
AK41	Fraction of algal growth rate at		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	ALGT4 for algal type 1										
AM1	Maximum algal mortality rate for algal type 1	/day	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
AN1	Stoichiometric equivalent between algal biomass and nitrogen, for algal type 1		0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
ANEQN1	Equation number for algal ammonium preference (either 1 or 2), for algal type 1		1 or 2	2	2	1	1	1	1	1	1
ANPR1	Algal half saturation constant for ammonium preference, for algal type 1		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
AP1	Stoichiometric equivalent between algal biomass and phosphorus, for algal type 1		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
APOM1	Fraction of algal biomass lost by mortality to detritus for algal type 1		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
AR1	Maximum algal respiration rate for algal type 1	/day	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
AS1	Algal settling rate for algal type 1	m/day	0.1	0.10	0.10	0.15	0.15	0.15	0.15	0.15	0.15
ASAT1	Saturation intensity at maximum photosynthetic rate for algal type	W/m^2	75	100	100	100	100	100	100	100	100

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	1										
AT11	Lower temperature for algal growth for algal type 1	^oC	5	5	5	5	5	5	5	5	5
AT21	Lower temperature for maximum algal growth for algal type 1	^oC	25	25	25	25	25	25	25	25	25
AT31	Upper temperature for maximum algal growth for algal type 1	^oC	35	35	35	35	35	35	35	35	35
AT41	Upper temperature for algal growth for algal type 1	^oC	40	40	40	40	40	40	40	40	40
Epiphyton- turned off											
EB1	Epiphyton burial rate for epiphyton type 1	/day	0.001	0.0	0.0	0.001	0.001	0.001	0.001	0.00001	0.00001
EC1	Stoichiometric equivalent between organic matter and carbon for epiphyton type 1		0.45	0.0	0.0	0	0	0	0	0	0
ECHLA1	Ratio between epiphyton biomass and chlorophyll a, for epiphyton type 1		145	67	67	67	67	67	67	67	67
EE1	Maximum epiphyton excretion rate for epiphyton type 1	/day	0.04	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
EG1	Maximum epiphyton growth rate for epiphyton type 1	/day	2.0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
EHS1	Epiphyton biomass limitation factor, for epiphyton type 1	g/m3	15	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
EHSN1	Epiphyton half-	g/m3	0.014	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	saturation for nitrogen limited growth, for epiphyton type 1										
EHSP1	Epiphyton half-saturation for phosphorus limited growth, for epiphyton type 1	g/m3	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
EK11	Fraction of epiphyton growth rate at ALGT1 for epiphyton type 1		0.1	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.01
EK21	Fraction of maximum epiphyton growth rate at ALGT2 for epiphyton type 1		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
EK31	Fraction of maximum epiphyton growth rate at ALGT3 for epiphyton type 1		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
EK41	Fraction of epiphyton growth rate at ALGT4 for epiphyton type 1		0.1	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.01
EM1	Maximum epiphyton mortality rate for epiphyton type 1	/day	0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
EN1	Stoichiometric equivalent between organic matter and nitrogen for epiphyton type 1		0.08	0.0	0.0	0	0	0	0	0	0
ENEQN1	Ammonia prefence factor for epiphyton type 1		1 or 2	1	1	1	1	1	1	1	1
EP1	Stoichiometric equivalent between organic matter and		0.005	0.0	0.0	0	0	0	0	0	0

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	Description	Units	Typical/ Default values	Existing Condition	Steady Flow	Existing Condition	Steady Flow	Existing Condition	Steady Flow	Existing Condition	Steady Flow
	phosphorus for epiphyton type 1										
EPOM1	Fraction of epiphyton biomass converted to particulate organic matter for epiphyton type 1		0.8	0.0	0.0	0	0	0	0	0	0
ER1	Maximum epiphyton respiration rate for epiphyton type 1	/day	0.04	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
ESAT1	Saturation intensity at maximum photosynthetic rate for epiphyton type 1	W/m^2	75	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1
ET11	Lower temperature for epiphyton growth for epiphyton type 1	^oC	5	0	0	0	0	0	0	0	0
ET21	Lower temperature for maximum epiphyton growth for epiphyton type 1	^oC	25	10	10	10	10	10	10	10	10
ET31	Upper temperature for maximum epiphyton growth for epiphyton type 1	^oC	35	30	30	30	30	30	30	30	30
ET41	Upper temperature for epiphyton growth for epiphyton type 1	^oC	40	45	45	45	45	45	45	45	45
Organic Matter											
LDOMDK	Labile DOM decay rate	/day	0.1	0.1	0.1	0.05	0.05	0.01	0.01	0.01	0.01
LPOMDK	Labile Detritus (POM) decay rate	/day	0.08	0.08	0.08	0.08	0.08	0.01	0.01	0.01	0.01
LRDDK	Labile to refractory DOM decay rate	/day	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
LRPDK	Labile to refractory POM decay rate	/day	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
OMK1	Fraction of organic matter decay rate at OMT1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
OMK2	Fraction of organic matter decay rate at OMT2		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
OMT1	Lower temperature for organic matter decay	°C	4	4	4	4	4	4	4	4	4
OMT2	Lower temperature for maximum organic matter decay	°C	25	25	25	25	25	25	25	25	25
POMS	Detritus (POM) settling rate	m/day	0.1	0.1	0.1	1	1	1	1	1	1
RDOMDK	Refractory DOM decay rate	/day	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
RPOMDK	Refractory Detritus (POM) decay rate	/day	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Nitrogen											
NH4DK	Ammonia decay rate (nitrification rate)	/day	0.12	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NH4K1	Fraction of nitrification rate at NH4T1		0.10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NH4K2	Fraction of nitrification rate at NH4T2		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
NH4T1	Lower temperature for ammonia decay	°C	5.0	5	5	5	5	5	5	5	5
NH4T2	Lower temperature for maximum ammonia decay	°C	25.0	20	20	20	20	20	20	20	20
Nitrate											
NO3DK	Nitrate decay rate (denitrification rate)	/day	0.03 to 0.15	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NO3K1	Fraction of denitrification rate		0.10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	at NO3T1										
NO3K2	Fraction of denitrification rate at NO3T2		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
NO3T1	Lower temperature for nitrate decay	°C	5.0	5	5	5	5	5	5	5	5
NO3T2	Lower temperature for maximum nitrate decay	°C	25.0	25	25	25	25	25	25	25	25
Dissolved Oxygen											
O2AG	Oxygen stoichiometric equivalent for algal growth (primary production)		1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
O2AR	Oxygen stoichiometric equivalent for dark respiration		1.1	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
O2LIM	Dissolved oxygen concentration at which anaerobic processes begin	g/m^3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
O2NH4	Oxygen stoichiometric equivalent for ammonia decay (nitrification)		4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57
O2OM	Oxygen stoichiometric equivalent for organic matter decay		1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
ORGC	Stoichiometric equivalent between organic matter and carbon		0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
ORGN	Stoichiometric equivalent between organic matter and nitrogen		0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
ORGP	Stoichiometric		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	equivalent between organic matter and phosphorus										
Tracer-off											
CG0DK1	(Tracer) 0-order decay rate	/day		0	0	0	0	0	0	0	0
CG1DK1	(Tracer) 1st-order decay rate	/day		0	0	0	0	0	0	0	0
CGQ101	(Tracer) Arhennius temperature rate multiplier			0	0	0	0	0	0	0	0
CGS1	(Tracer) Settling rate	m/day		0	0	0	0	0	0	0	0
Residence Time/Age											
CG0DK2	(Age) 0-order decay rate	/day	-1.0	-1	-1	-1	-1	-1	-1	-1	-1
CG1DK2	(Age) 1st-order decay rate	/day	0	0	0	0	0	0	0	0	0
CGQ102	(Age) Arhennius temperature rate multiplier		0	0	0	0	0	0	0	0	0
CGS2	(Age) Settling rate	m/day	0	0	0	0	0	0	0	0	0
Coliform											
CG0DK3	(Coliform) 0-order decay rate			0	0	0	0	0	0	0	0
CG1DK3	(Coliform) 1st-order decay rate	/day	0.20 to 5.52	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
CGQ103	(Coliform) Arhennius temperature rate multiplier		1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
CGS3	(Coliform) Settling rate	m/day		1	1	1	1	1	1	1	1
Sediments											
CO2REL	Sediment carbon dioxide release rate, fraction of SOD		0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NH4REL	Sediment release rate of ammonium, fraction of SOD		0.001	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
NO3S	De-nitrification rate from sediments	m/day	1.0	0.0	0.0	0	0	0	0	0	0
PO4R	Sediment release rate of phosphorus, fraction of SOD		0.001	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
SEDK	Sediment decay rate	/day	0.1	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
SOD	Zero-order sediment oxygen demand for each segment	g O_2/m^2day	0.3, 0.1 to 5.8	2	2	1 (report 3)	1 (report 3)	1 (report 2)	1 (report 2)	1 (report 3)	1 (report 3)
Carbonaceous Biochemical Oxygen Demand											
KBOD	5-day decay rate @ 20°C	/day	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TBOD	Temperature coefficient		1.0147	1.0147	1.0147	1.0147	1.0147	1.0147	1.0147	1.0147	1.0147
RBOD	Ratio of CBOD5 to ultimate CBOD		1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85
BODP	Phosphorus stoichiometry for CBOD decay		0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
BODN	Nitrogen stoichiometry for CBOD decay		0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
BODC	Carbon stoichiometry for CBOD decay		0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32

Year 2001

Table 5. CE-QUAL-W2 parameter values and kinetic coefficients for reservoir models, simulation year 2001

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
Spatial and Run Time Information											
LAT	Latitude, degrees	degrees		42.13	42.13	42.12	42.12	42.12	42.12	42.97	42.97
LONG	Longitude, degrees	degrees		121.95	121.95	122.05	122.05	122.33	122.33	122.42	122.42
EBOT	Bottom elevation of waterbody, m	m		1237.30 (report 1236.25)	1237.3	1143.75	1143.75	761.09	761.09	663.78	663.78
SLOPE	Waterbody bottom slope			0	0	0	0	0	0	0	0
DLT MAX	Maximum timestep, sec	sec		500	500	500	500	500	500	500	500
DLT MIN	Minimum timestep, sec	sec		5	5	5	5	5	5	5	5
Hydrodynamics and Longitudinal Transport											
AX	Longitudinal eddy viscosity (for momentum dispersion)	m^2/sec	1	1	1	1	1	1	1	1	1
DX	Longitudinal eddy diffusivity (for dispersion of heat and constituents)	m^2/sec	1	1	1	1	1	1	1	1	1
FI	Interfacial friction factor		0.01	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Temperature											
AFW	A coefficient in the wind speed formulation		9.2	9.2	9.2	18	18	9.2	9.2	6	6
BETA	Fraction of incident solar radiation absorbed at the water surface		0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
BFW	B coefficient in the		0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	wind speed formulation										
CBHE	Coefficient of bottom heat exchange	Wm^2/sec	0.3	0.3	0.3	7.00E-08	7.00E-08	3	3	17.14	17.14
CFW	C coefficient in the wind speed formulation		2.0	2.4 (report 1)	2.4	1	1	1	1	1	1
TSED	Sediment (ground) temperature	^oC		12.0	12.0	12	12	10	10	7	7
TSEDF	Heat lost to sediments that is added back to water column, fraction		0 to 1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
WINDH	Wind speed measurement height, m		2.0	2.0	2.0	2	2	2	2	2	2
WSC	Wind sheltering coefficient			1.0	1.0	1	1	1	1	1	1
Water Quality											
Light Extinction											
EXH20	Extinction for water	/m	0.25	0.25	0.25	0.25	0.25	0.5 (report 0.25)	0.5 (report 0.25)	0.25	0.25
EXSS	Extinction due to inorganic suspended solids	$m^3/m/g$	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EXOM	Extinction due to organic suspended solids	$m^3/m/g$	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
EXA	Extinction due to organic algal type 1	$m^3/m/g$	0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.45	0.45
Suspended Solids											
SSS	Suspended solids settling rate	m/day	1	1	1	1	1	1	1	1	1
PARTP	Phosphorous partitioning coefficient for suspended solids		0.0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Algae											

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
AC1	Stoichiometric equivalent between algal biomass and carbon, for algal type 1		0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
ACHLA1	Ratio between algal biomass and chlorophyll a, for algal type 1		145	145	145	145	145	145	145	145	145
AE1	Maximum algal excretion rate for algal type 1	/day	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
AG1	Maximum algal growth rate for algal type 1	/day	2	3.0	3.0	3	3	6 (report 3)	6 (report 3)	6 (report 3)	6 (report 3)
AHSN	Algal half-saturation constant for nitrogrn limited growth, for algal type 1	g/m^3	0.014	0.014	0.014	0	0	0.014	0.014	0.014	0.014
AHSP1	Algal half-saturation constant for phosphorous limited growth, for algal type 1	g/m	0.003	0.003	0.003	0.014	0.014	0.003	0.003	0.003	0.003
AK11	Fraction of algal growth rate at ALGT1 for algal type 1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
AK21	Fraction of maximum algal growth rate at ALGT2 for algal type 1		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
AK31	Fraction of maximum algal growth rate at ALGT3 for algal type 1		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
AK41	Fraction of algal growth rate at		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	ALGT4 for algal type 1										
AM1	Maximum algal mortality rate for algal type 1	/day	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
AN1	Stoichiometric equivalent between algal biomass and nitrogen, for algal type 1		0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
ANEQN1	Equation number for algal ammonium preference (either 1 or 2), for algal type 1		1 or 2	2	2	1	1	1	1	1	1
ANPR1	Algal half saturation constant for ammonium preference, for algal type 1		0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
AP1	Stoichiometric equivalent between algal biomass and phosphorus, for algal type 1		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
APOM1	Fraction of algal biomass lost by mortality to detritus for algal type 1		0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
AR1	Maximum algal respiration rate for algal type 1	/day	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
AS1	Algal settling rate for algal type 1	m/day	0.1	0.10	0.10	0.15	0.15	0.15	0.15	0.15	0.15
ASAT1	Saturation intensity at maximum photosynthetic rate for algal type	W/m^2	75	100	100	100	100	100	100	100	100

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	1										
AT11	Lower temperature for algal growth for algal type 1	°C	5	5	5	5	5	5	5	5	5
AT21	Lower temperature for maximum algal growth for algal type 1	°C	25	25	25	25	25	25	25	25	25
AT31	Upper temperature for maximum algal growth for algal type 1	°C	35	35	35	35	35	35	35	35	35
AT41	Upper temperature for algal growth for algal type 1	°C	40	40	40	40	40	40	40	40	40
Epiphyton- turned off											
EB1	Epiphyton burial rate for epiphyton type 1	/day	0.001	0.0	0.0	0.001	0.001	0.001	0.001	0.00001	0.00001
EC1	Stoichiometric equivalent between organic matter and carbon for epiphyton type 1		0.45	0.0	0.0	0	0	0	0	0	0
ECHLA1	Ratio between epiphyton biomass and chlorophyll a, for epiphyton type 1		145	67	67	67	67	67	67	67	67
EE1	Maximum epiphyton excretion rate for epiphyton type 1	/day	0.04	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
EG1	Maximum epiphyton growth rate for epiphyton type 1	/day	2.0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
EHS1	Epiphyton	g/m3	15	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	biomass limitation factor, for epiphyton type 1										
EHSN1	Epiphyton half-saturation for nitrogen limited growth, for epiphyton type 1	g/m3	0.014	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
EHSP1	Epiphyton half-saturation for phosphorus limited growth, for epiphyton type 1	g/m3	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
EK11	Fraction of epiphyton growth rate at ALGT1 for epiphyton type 1		0.1	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.01
EK21	Fraction of maximum epiphyton growth rate at ALGT2 for epiphyton type 1		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
EK31	Fraction of maximum epiphyton growth rate at ALGT3 for epiphyton type 1		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
EK41	Fraction of epiphyton growth rate at ALGT4 for epiphyton type 1		0.1	0.1	0.1	0.01	0.01	0.01	0.01	0.01	0.01
EM1	Maximum epiphyton mortality rate for epiphyton type 1	/day	0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
EN1	Stoichiometric equivalent between organic matter and nitrogen for epiphyton type 1		0.08	0.0	0.0	0	0	0	0	0	0
ENEQN1	Ammonia preference factor for epiphyton type		1 or 2	1	1	1	1	1	1	1	1

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	1										
EP1	Stoichiometric equivalent between organic matter and phosphorus for epiphyton type 1		0.005	0.0	0.0	0	0	0	0	0	0
EPOM1	Fraction of epiphyton biomass converted to particulate organic matter for epiphyton type 1		0.8	0.0	0.0	0	0	0	0	0	0
ER1	Maximum epiphyton respiration rate for epiphyton type 1	/day	0.04	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
ESAT1	Saturation intensity at maximum photosynthetic rate for epiphyton type 1	W/m^2	75	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1
ET11	Lower temperature for epiphyton growth for epiphyton type 1	^oC	5	0	0	0	0	0	0	0	0
ET21	Lower temperature for maximum epiphyton growth for epiphyton type 1	^oC	25	10	10	10	10	10	10	10	10
ET31	Upper temperature for maximum epiphyton growth for epiphyton type 1	^oC	35	30	30	30	30	30	30	30	30
ET41	Upper temperature for epiphyton growth	^oC	40	45	45	45	45	45	45	45	45

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	for epiphyton type 1										
Organic Matter											
LDOMDK	Labile DOM decay rate	/day	0.1	0.1	0.1	0.05	0.05	0.01	0.01	0.01	0.01
LPOMDK	Labile Detritus (POM) decay rate	/day	0.08	0.08	0.08	0.08	0.08	0.01	0.01	0.01	0.01
LRDDK	Labile to refractory DOM decay rate	/day	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
LRPDK	Labile to refractory POM decay rate	/day	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
OMK1	Fraction of organic matter decay rate at OMT1		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
OMK2	Fraction of organic matter decay rate at OMT2		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
OMT1	Lower temperature for organic matter decay	^{o}C	4	4	4	4	4	4	4	4	4
OMT2	Lower temperature for maximum organic matter decay	^{o}C	25	25	25	25	25	25	25	25	25
POMS	Detritus (POM) settling rate	m/day	0.1	0.1	0.1	1	1	1	1	1	1
RDOMDK	Refractory DOM decay rate	/day	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
RPOMDK	Refractory Detritus (POM) decay rate	/day	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Nitrogen											
NH4DK	Ammonia decay rate (nitrification rate)	/day	0.12	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NH4K1	Fraction of nitrification rate at NH4T1		0.10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NH4K2	Fraction of nitrification rate at NH4T2		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
NH4T1	Lower	^{o}C	5.0	5	5	5	5	5	5	5	5

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
	temperature for ammonia decay										
NH4T2	Lower temperature for maximum ammonia decay	°C	25.0	20	20	20	20	20	20	20	20
Nitrate											
NO3DK	Nitrate decay rate (denitrification rate)	/day	0.03 to 0.15	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NO3K1	Fraction of denitrification rate at NO3T1		0.10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NO3K2	Fraction of denitrification rate at NO3T2		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
NO3T1	Lower temperature for nitrate decay	°C	5.0	5	5	5	5	5	5	5	5
NO3T2	Lower temperature for maximum nitrate decay	°C	25.0	25	25	25	25	25	25	25	25
Dissolved Oxygen											
O2AG	Oxygen stoichiometric equivalent for algal growth (primary production)		1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
O2AR	Oxygen stoichiometric equivalent for dark respiration		1.1	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
O2LIM	Dissolved oxygen concentration at which anaerobic processes begin	g/m^3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
O2NH4	Oxygen stoichiometric equivalent for ammonia decay (nitrification)		4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
O2OM	Oxygen stoichiometric equivalent for organic matter decay		1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
ORGC	Stoichiometric equivalent between organic matter and carbon		0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
ORGN	Stoichiometric equivalent between organic matter and nitrogen		0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
ORGP	Stoichiometric equivalent between organic matter and phosphorus		0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Tracer-off											
CG0DK1	(Tracer) 0-order decay rate	/day		0	0	0	0	0	0	0	0
CG1DK1	(Tracer) 1st-order decay rate	/day		0	0	0	0	0	0	0	0
CGQ101	(Tracer) Arhennius temperature rate multiplier			0	0	0	0	0	0	0	0
CGS1	(Tracer) Settling rate	m/day		0	0	0	0	0	0	0	0
Residence Time/Age											
CG0DK2	(Age) 0-order decay rate	/day	-1.0	-1	-1	-1	-1	-1	-1	-1	-1
CG1DK2	(Age) 1st-order decay rate	/day	0	0	0	0	0	0	0	0	0
CGQ102	(Age) Arhennius temperature rate multiplier		0	0	0	0	0	0	0	0	0
CGS2	(Age) Settling rate	m/day	0	0	0	0	0	0	0	0	0
Coliform-off											
CG0DK3	(Coliform) 0-order decay rate			0	0	0	0	0	0	0	0

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
CG1DK3	(Coliform) 1st-order decay rate	/day	0.20 to 5.52	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
CGQ103	(Coliform) Arhennius temperature rate multiplier		1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
CGS3	(Coliform) Settling rate	m/day		1	1	1	1	1	1	1	1
Sediments											
CO2REL	Sediment carbon dioxide release rate, fraction of SOD		0.1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NH4REL	Sediment release rate of ammonium, fraction of SOD		0.001	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
NO3S	De-nitrification rate from sediments	m/day	1.0	0.0	0.0	0	0	0	0	0	0
PO4R	Sediment release rate of phosphorus, fraction of SOD		0.001	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
SEDK	Sediment decay rate	/day	0.1	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
SOD	Zero-order sediment oxygen demand for each segment	g O_2/m^2day	0.3, 0.1 to 5.8	2	2	1 (report 3)	1 (report 3)	1 (report 2)	1 (report 2)	1 (report 3)	1 (report 3)
Carbonaceous Biochemical Oxygen Demand											
KBOD	5-day decay rate @ 20°C	/day	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TBOD	Temperature coefficient		1.0147	1.0147	1.0147	1.0147	1.0147	1.0147	1.0147	1.0147	1.0147
RBOD	Ratio of CBOD5 to ultimate CBOD		1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85
BODP	Phosphorus stoichiometry for CBOD decay		0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
BODN	Nitrogen stoichiometry for CBOD decay		0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06

				Lake Ewauna		J. C. Boyle Reservoir		Copco Reservoir		Iron Gate Reservoir	
Variable	**Description**	**Units**	**Typical/ Default values**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**	**Existing Condition**	**Steady Flow**
BODC	Carbon stoichiometry for CBOD decay		0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32

Appendix D: RMA2/RMA11 Parameter Values and Kinetic Coefficients

The kinetic coefficients used in the RMA models and documented in the report: Klamath River Modeling Framework to Support the PacifiCorp Federal Energy Regulatory Commission Hydropower Relicensing Application, Draft 11-14-2003, prepared for PacifiCorp, by Watercourse Engineering, Inc. were compared. The No Project Scenario lumped several river and reservoir reaches together into three models which are listed in Table 6 The coefficients the three models were compared to the furthest upstream reach from the Existing Conditions Scenario and found to be similar. The model files were then compared for each reach between the scenarios and the two simulation years, 2000 and 2001. The variables were found to be the same between the files except where noted in the table.

Table 6. River Reach comparisons for RMA2\RMA11

No Project Scenario	Existing Conditions and Steady Flow Scenarios
Link to Keno	Link River, Lake Ewauna
Keno to IG	Keno Reach, J. C. Boyle Reservoir, Bypass & Full Flow Reach, Copco Reservoir, Iron Gate Reservoir
IG to Turwar	Klamath River from Iron Gate Dam to Turwar

Table 7. RMA2/RM11 parameter values and kinetic coefficients

		Link River same for all scenarios	Keno Reach same for all scenarios	Bypass and Peaking Reach same for all scenarios except elevation	Iron Gate Dam to Turwar same for all scenarios
Variable Name	Description, units	Value	Value	Value	Value
	Time step, hr	1	1	0.25 (RMA-2) 1.0 (RMA-11)	1
	Space step, m	75	75	75	75 (cal), 150 (application)
	Manning roughness coefficient	0.04	0.04	0.04	0.04
	Turbulence factor, Pascal -sec	100	100	100	100
	Longitudinal diffusion scale factor	0.1	0.1	0.1	0.1
	Slope Factor	0.8	0.9	0.95	0.8
ELEV	Elevation of site, m	1192	1192	964 (uses 1192 for EC, 2001, used 948 for No Project - Keno to IG reach)	520
LAT	Latitude of site, degrees	41.5	41.5	41.5	41.5
LONG	Longitude of site, degrees	122.45	122.45	122.45	122.45
EVAPA	Evaporative heat flux coefficient a, m hr -1 mb-1	0.000015	0.000015	0.000010	0.000015
EVAPB	Evaporative heat flux coefficient b, m hr -1 mb-1 (m/h) -1	0.000005	0.000010	0.000010	0.000010
EXTINC	Light Extinction coefficient, used when algae is not simulated, 1/m	1.5	1.5	1.5	0.25
ALP0	Chl a to algal biomass conversion factor, phytoplankton, mg Chl_a to mg -A	67	67	67	67
ALP1	Fraction of algal biomass that is nitrogen, phytoplankton, mg -N/mg A	0.072	0.072	0.072	0.072
ALP2	Fraction of algal biomass that is phosphorous, phytoplankton, mg -P/mg A	0.010	0.010	0.010	0.010
LAMB1	Linear algal self-shading coefficient, phytoplankton, 1/m	n/a	n/a	n/a	n/a
LAMB2	Non-linear algal self shading coefficient, phytoplankton, 1/m	n/a	n/a	n/a	n/a
MUMAX	Maximum specific growth rate, phytoplankton, 1/d	0.01	0.01	0.01	0.01
RESP	Local respiration rate of algae, phytoplankton,	0.05	0.05	0.05	0.05

	1/d				
SIG1	Settling rate of algae, phytoplankton, 1/d	0	0	0	0
KLIGHT	Half saturation coefficient for light, phytoplankton, KJ m-2 s-1	0.01	0.01	0.01	0.01
KNITR	Michaelis-Menton half saturation constant: nitrogen, phytoplankton, mg/l	0.01	0.01	0.01	0.01
KPHOS	Michaelis-Menton half saturation constant: phosphorous, phytoplankton, mg/l	0.001	0.001	0.001	0.001
PREFN	Preference factor for NH3-N, phytoplankton	0.6	0.6	0.6	0.6
ABLP0	Chl a to algal biomass conversion factor, bed algae, mg Chl_a to mg -A	50	50	50	50
ABLP1	Fraction of algal biomass that is nitrogen, bed algae, mg/l	0.07	0.07	0.07	0.07
ABLP2	Fraction of algal biomass that is phosphorus, bed algae, mg/l	0.01	0.01	0.01	0.01
LAMB1	Linear algal self shading coefficient, bed algae, 1/m	n/a	n/a	n/a	n/a
LAMB2	Non-linear self shading coefficient, bed algae, 1/m	n/a	n/a	n/a	n/a
MUMAX	Maximum specific growth rate, bed algae, 1/d	1	1	1	1.5
RESP	Local respiration rate of algae, bed algae, 1/d	0.6	0.6	0.6	0.6
MORT	Mortality, bed algae, 1/d	0	0	0	0.1
KBNITR	Half-saturation coefficient for nitrogen, bed algae, mg/l	0.01	0.01	0.01	0.01
KBPHOS	Half-saturation coefficient for phosphorus, bed algae, mg/l	0.002	0.002	0.002	0.002
KBLIGHT	Half-saturation coefficient for light, bed algae, KJ m-2 s-1	0.01	0.01	0.01	0.01
PBREFN	Preference factor for NH3-N, bed algae	0.75	0.75	0.75	0.75
BET1	Rate constant: biological oxidation NH3-N, 1/d	0.3	0.3	0.3	0.3
BET2	Rate constant: biological oxidation NO2-N, 1/d	0.5	0.5	0.5	0.5
BET3	Rate constant: hydrolysis Org N to NH3-N, 1/d	0.3	0.3	0.3	0.3
BET4	Rate constant: transformation Org P to P-D, 1/d	0.3	0.3	0.3	0.3
KNINH	First order nitrification inhibition coefficient, mg -1	n/a	n/a	n/a	n/a
ALP3	Rate O2 production per unit of algal photosynthesis, phytoplankton, mg -O/mg-A	1.6	1.6	1.6	1.6
ALP4	Rate O2 uptake per unit of algae respired, phytoplankton, mg-O/mg-A	1.6	1.6	1.6	1.6
ABLP3	Rate O2 production per unit of algal photosynthesis, bed algae, mg -O/mg-A	1.6	1.6	1.6	1.6

ABLP4	Rate O2 uptake per unit of algae respired, bed algae, mg -O/mg-A	1.6	1.6	1.6	1.6
ALP5	Rate O2 uptake per unit NH3-N oxidation, mg-O/mg-N	3.43	3.43	3.43	3.43
ALP6	Rate O2 uptake per unit NO2-N oxidation, mg-O/mg-N	1.14	1.14	1.14	1.14
K1	Deoxygenation rate constant: BOD, 1/d	0.3	0.3	0.3	0.3
	Minimum reaeration rate constant (Churchill formula applied), 1/d	3.0	3.0	3.0	3.0
SIG6	BOD settling rate constant, 1/d	0.0	0.0	0.0	0.0
Water Column					
THET1	Algal growth rate temperature factor	1.047			
THET2	Algal respiration rate temperature factor	1.047			
THET3	Algal settling rate temperature factor	1.047			
THET4	Organic nitrogen decay rate temperature factor	1.047			
THET5	Organic nitrogen settling rate temperature factor	1.024			
THET6	Ammonia nitrogen decay rate temperature factor	1.083			
THET7	Ammonia nitrogen benthic sources rate temperature factor	1.074			
THET8	Nitrite nitrogen decay rate temperature factor	1.047			
THET9	Organic phosphorous decay rate temperature factor	1.047			
THET10	Organic phosphorous settling rate temperature factor	1.024			
THET11	Orthophosphate benthic sources rate temperature factor	1.074			
THET12	BOD decay rate temperature factor	1.047			
THET13	BOD settling rate temperature factor	1.024			
THET14	DO benthic demand rate temperature factor	1.000			
THET15	DO reaeration rate temperature factor	1.024			
Bed					
BTHET1	Bed algae growth rate temperature factor	1.047			
BTHET2	Bed algae respiration rate temperature factor	1.047			
BTHET3	Bed algae settling rate temperature factor	1			
BTHET4	Bed organic nitrogen decay rate temperature factor	1			

BTHET5	Bed organic nitrogen settling rate temperature factor	1			
BTHET6	Bed ammonia nitrogen decay rate temperature factor	1			
BTHET7	Bed ammonia nitrogen benthic sources rate temperature factor	1			
BTHET8	Bed nitrite decay	1			
BTHET9	Bed phosphorous nitrogen decay rate temperature factor	1			
BTHET12	Bed BOD decay rate temperature factor	n/a			

Appendix E: Water Quality Characteristics between RMA 11 and CE-QUAL-W2

Link River was modeled using RMA11 for water quality and the output was used to develop the input to the CE-QUAL-W2 model for Lake Ewauna to Keno Dam. Model output from RMA 11 was compared with CE-QUAL-W2 input by calculating total nitrogen, phosphorus, and organic carbon and other constituents directly translated between the two models.

Table 8 below lists the RMA 11 model water quality constituents output in the left column and the CE-QUAL-W2 model water quality constituents input to the model in the right column. All stoichiometric equivalent coefficients used in the analysis were obtained from the W2 control file for the Lake Ewauna model.

Table 8: Water quality constituents simulated by RMA11 and CE-QUAL-W2

RMA11 output	CE-QUAL-W2 input
Arbitrary Non-Conservative	TDS
BOD	Tracer
DO	Coliform
Organic-N	Inorganic SS
NH3	PO_4
NO_2	NH_3
NO_3	NO_3
Organic-P	FE
PO_4	LDOM
Algae	RDOM
ISS assumed zero	CBOD
	Algae
	DO
	TIC
	ALK

Figure 7 shows a plot comparing the total nitrogen calculated from the RMA11 Link River model output compared with the total nitrogen calculated from the CE-QUAL-W2 (W2) model input. The total nitrogen from the RMA11 output was calculated as:

$$TotalN, RMA11 = ORGN + NH_3 + NO_3 + NO_2$$

Where all constituents are provided as model output. The total nitrogen for the W2 model input was calculated:

$$TotalN, W2 = LDOM\delta_{NLDOM} + 1.85 * BOD5\delta_{NBODu} + NH_3 + NO_3 + NO_2 + \mathrm{Algae}\delta_{N\mathrm{algae}}$$

Where 1.85 is the ratio of BODu to BOD5, δ_{NLDOM} is the stoichiometric equivalent between labile dissolved organic matter and nitrogen (0.08), δ_{NBODu} is the stoichiometric equivalent between ultimate

BOD and nitrogen (0.06) and $\delta_{N\mathrm{algae}}$ is stoichiometric equivalent between algae biomass and nitrogen (0.08). The third line in Figure 7 considers the W2 model input for total nitrogen minus the contribution from the labile dissolved organic matter.

Figure 8 shows a plot comparing the total phosphorus calculated from the RMA11 model output and the W2 model input. The total phosphorus was calculated from the RMA11 model output using the equation:

$$TotalP, RMA11 = ORGP + PO_4$$

Where all constituents are provided as model output. The total phosphorus for the W2 model input was calculated:

$$TotalN, W2 = LDOM\delta_{PLDOM} + 1.85 * BOD5\delta_{PBODu} + PO_4 + \mathrm{Algae}\delta_{P\mathrm{algae}}$$

Where 1.85 is the ratio of BODu to BOD5, δ_{PLDOM} is the stoichiometric equivalent between labile dissolved organic matter and phosphorus (0.005), δ_{PBODu} is the stoichiometric equivalent between ultimate BOD and phosphorus (0.004) and $\delta_{P\mathrm{algae}}$ is stoichiometric equivalent between algae biomass and phosphorus (0.005). The third line in Figure 8 considers the W2 model input for total phosphorus minus the contribution from the labile dissolved organic matter.

Figure 9 shows a plot comparing the total organic carbon calculated from the RMA11 model output and the W2 model input. The total organic carbon was calculated from the RMA11 model output four ways: the BOD model output is used as BOD5 concentrations, the BOD model output is used as BODu concentrations, the organic nitrogen, and the organic phosphorus.

When the BOD model output was assumed to be BOD5 the following equation was used:

$$TotalOrganicC, RMA11 = \mathrm{Algae}\delta_{\mathrm{Calgae}} + 1.85 * BOD5\delta_{CBODu}$$

When the BOD model output was assumed to be BODu the following equation was used:

$$TotalOrganicC, RMA11 = \mathrm{Algae}\delta_{\mathrm{Calgae}} + BODu\delta_{CBODu}$$

Where 1.85 is the ratio of BODu to BOD5, δ_{Calgae} is the stoichiometric equivalent between algae biomass and carbon (0.45) and δ_{CBODu} is stoichiometric equivalent between ultimate BOD and carbon (0.32). The total organic carbon was also calculated using the organic nitrogen and organic phosphorus:

$$TotalOrganicC, RMA11 = \left(\frac{\mathrm{ORGN}}{\delta_{\mathrm{NOM}}}\right)\delta_{COM}$$

$$TotalOrganicC, RMA11 = \left(\frac{\mathrm{ORGP}}{\delta_{\mathrm{POM}}}\right)\delta_{COM}$$

Where δ_{COM} is stoichiometric equivalent between organic matter and carbon (0.45), δ_{NOM} is stoichiometric equivalent between organic matter and nitrogen (0.08), and δ_{POM} is the stoichiometric equivalent between organic matter and phosphorus (0.005). The total organic carbon was calculated from the W2 model input file using the equation:

$$TotalOrganicC, W2 = LDOM\delta_{CLDOM} + 1.85 * BOD5\delta_{CBODu} + \mathrm{Algae}\delta_{C\mathrm{algae}}$$

Where 1.85 is the ratio of BODu to BOD5, δ_{CLDOM} is the stoichiometric equivalent between labile dissolved organic matter and carbon (0.45), δ_{CBODu} is the stoichiometric equivalent between ultimate BOD and carbon (0.32), and $\delta_{C\mathrm{algae}}$ is the stoichiometric equivalent between algae and carbon (0.45). Figure 9 also shows a line plotted which considers the W2 model input without the labile dissolved organic matter.

Figure 10 shows a plot comparing the total BODu calculated from the RMA11 model output and the W2 model input. Similar to the total organic carbon the RMA11 BOD model output could be interpreted as BOD5 or BODu so the total BODu was calculated in two ways:

When the BOD model output was assumed to be BOD5 the following equation was used:

$$TotalBODu, RMA11 = \mathrm{Algae}\delta_{O\mathrm{algae}} + 1.85 * BOD5$$

When the BOD model output was assumed to be BODu the following equation was used:

$$TotalBODu, RMA11 = \mathrm{Algae}\delta_{O\mathrm{algae}} + BODu$$

Where 1.85 is the ratio of BODu to BOD5 and $\delta_{O\mathrm{algae}}$ is the stoichiometric equivalent between algae biomass and dissolved oxygen (1.4). The total BODu from the W2 model input file was calculated by using the equation:

$$TotalBODu, W2 = LDOM\delta_{OLDOM} + 1.85 * BOD5 + \mathrm{Algae}\delta_{O\mathrm{algae}}$$

Where $\delta_{O\mathrm{algae}}$ is the stoichiometric equivalent between algae biomass and dissolved oxygen (1.4), δ_{OLDOM} is the stoichiometric equivalent between labile dissolved organic matter and dissolved oxygen (1.4) and 1.85 is the ratio of BODu to BOD5.

Figure 11 shows a plot comparing the BOD output from the RMA11 model and the BOD input to the W2 model. The figure shows there are large differences between the BOD values between the models. Figure 12 shows the algae biomass concentration output from RMA11 and the input concentration to W2. This figure indicates the values are the same between the two models. Figure 13 shows the dissolved oxygen concentration from the RMA11 model output and the W2 model input and shows they are the same between the two models.

Figure 14 shows the ammonia concentration from the RMA11 model output and the W2 model input and indicates they are the same between the two models. Figure 15 shows the nitrate and nitrite concentration from the RMA11 model output and the W2 model input and indicates they are the same between the two models. Figure 16 shows the phosphate concentration from the RMA11 model output and the W2 model input and indicates they are the same between the two models.

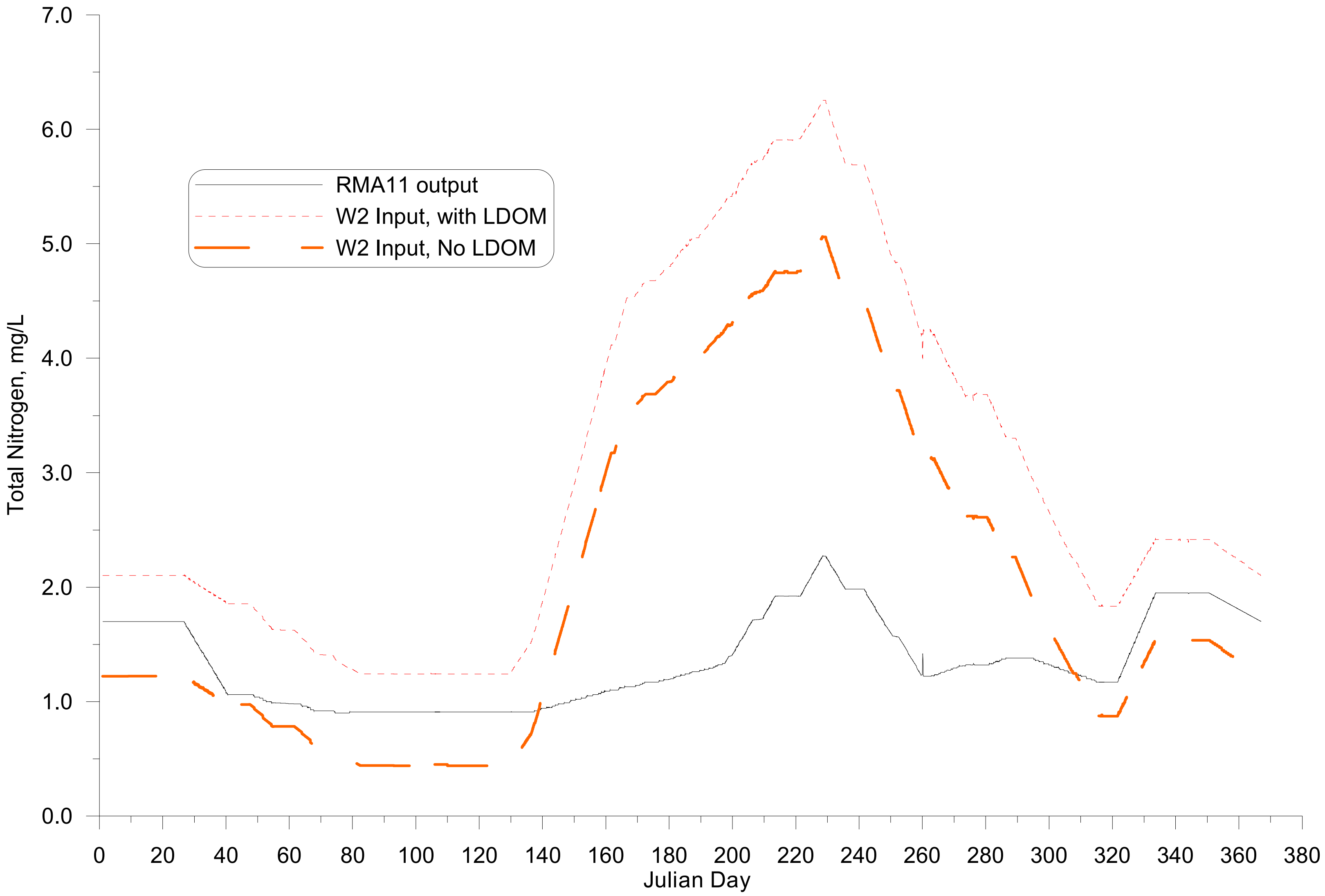

Figure 7: Total Nitrogen for Link River model output and Lake Ewauna model input

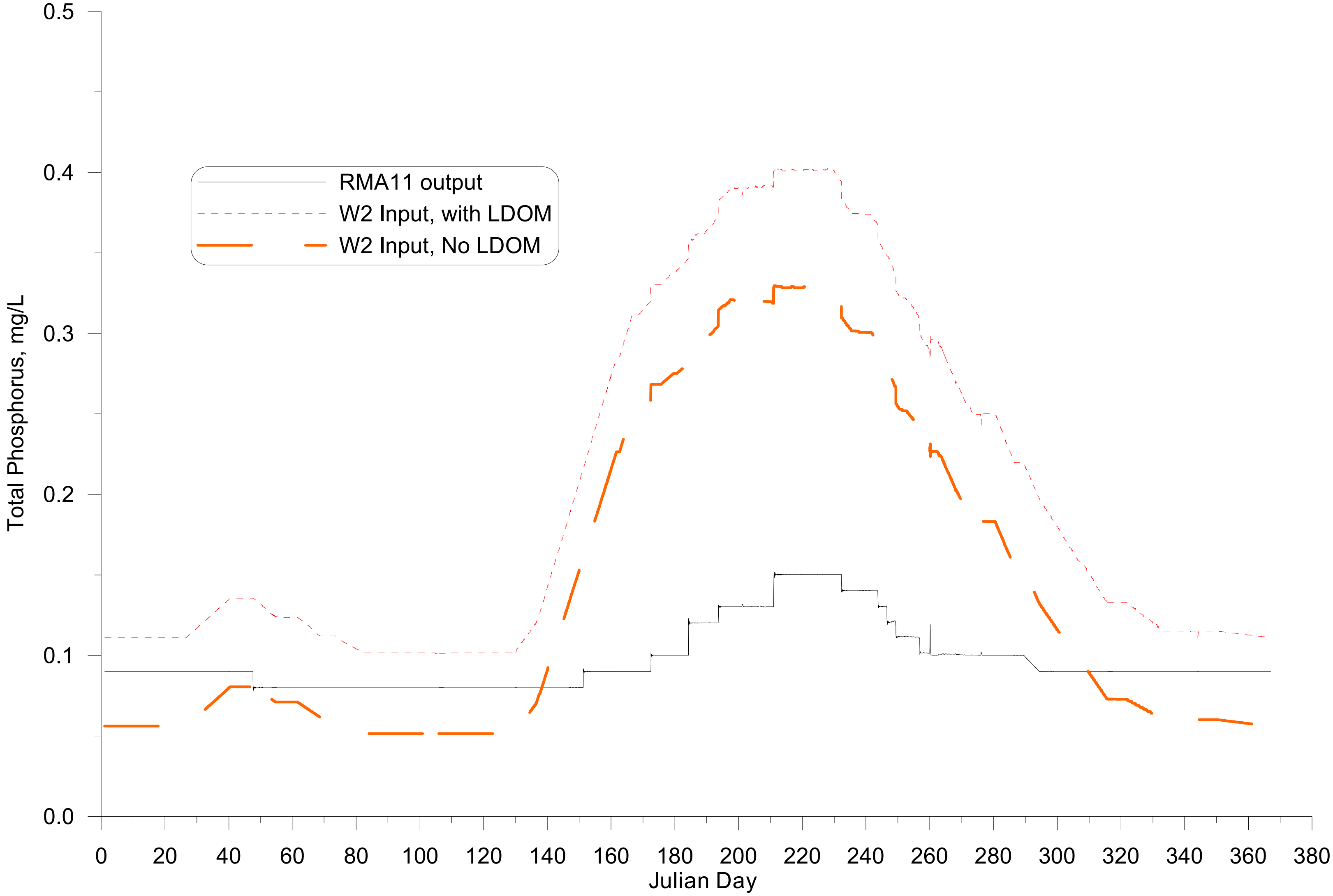

Figure 8: Total Phosphorus for Link River model output and Lake Ewauna model input

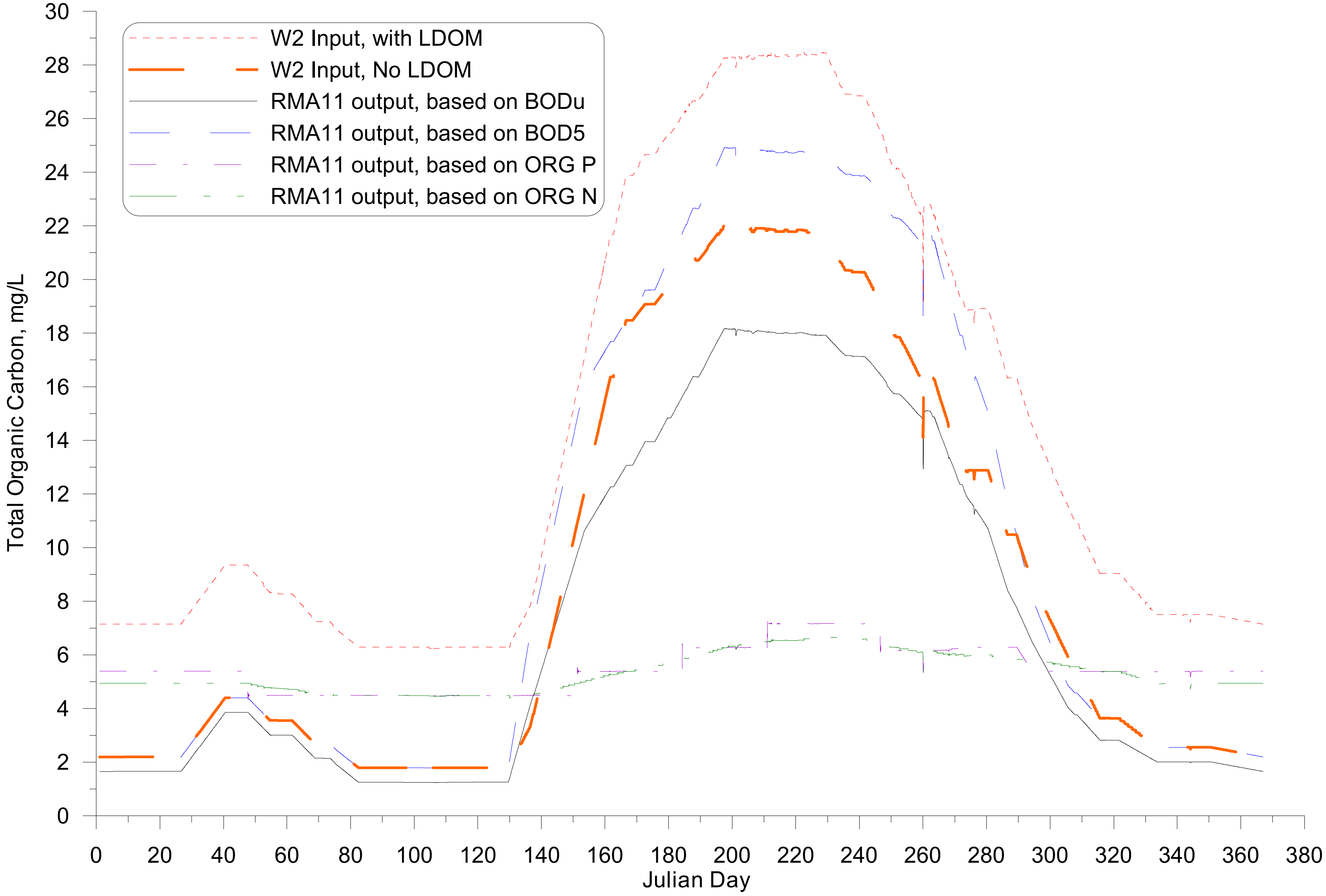

Figure 9: Total Organic Carbon for Link River model output and Lake Ewauna model input

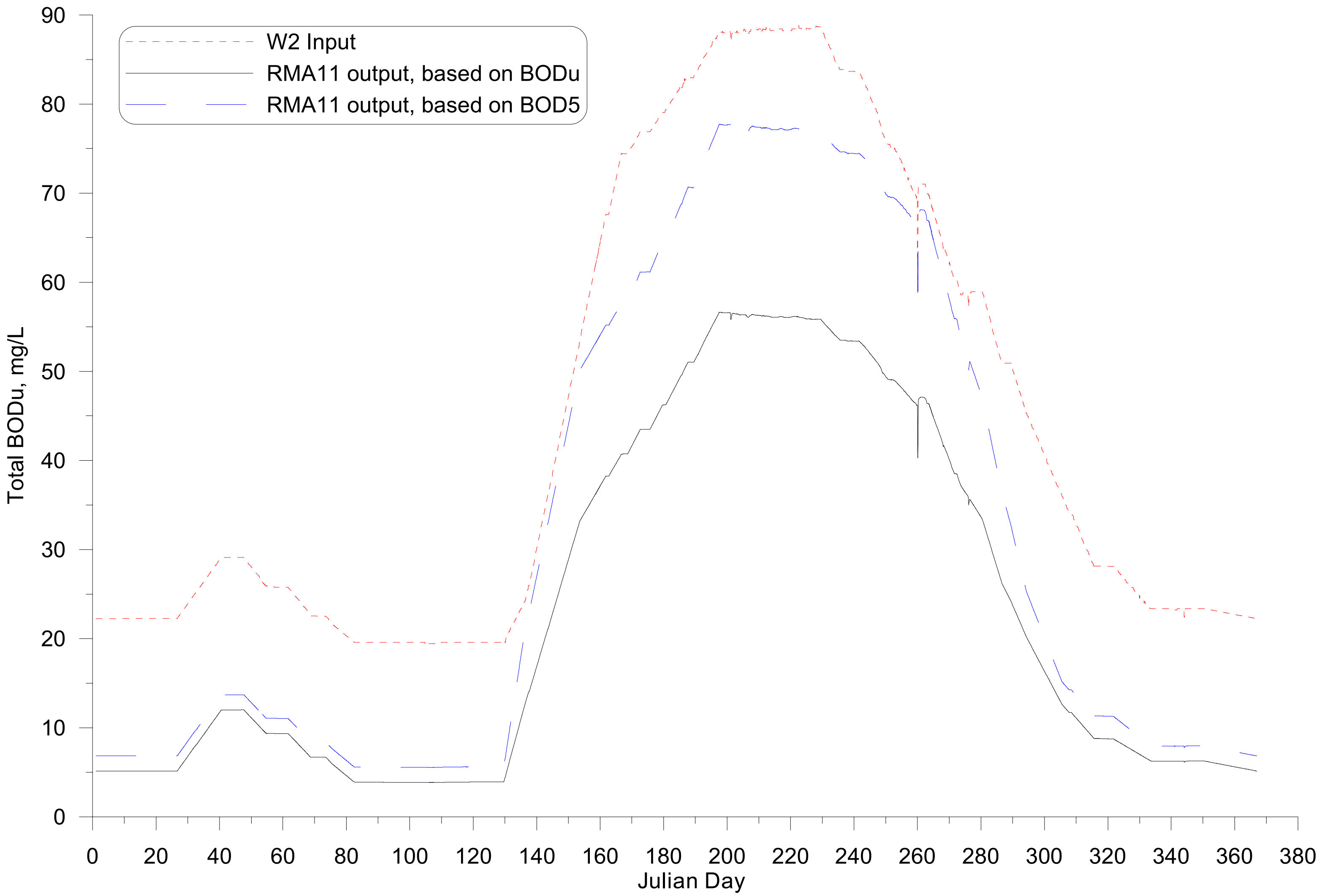

Figure 10: Total Ultimate Biochemical Oxygen Demand for Link River model output and Lake Ewauna model input

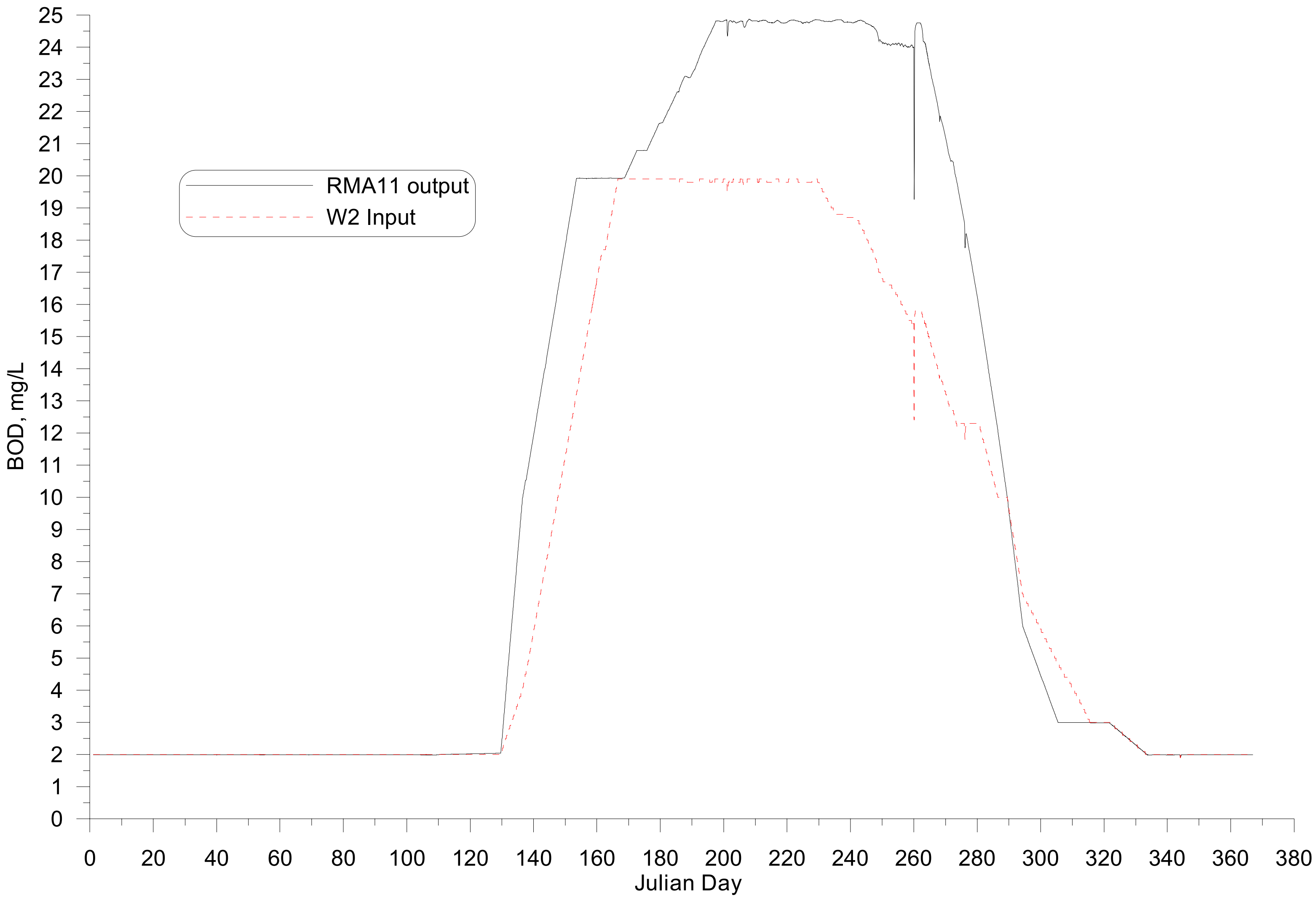

Figure 11: BOD5 for Link River model output and Lake Ewauna model input

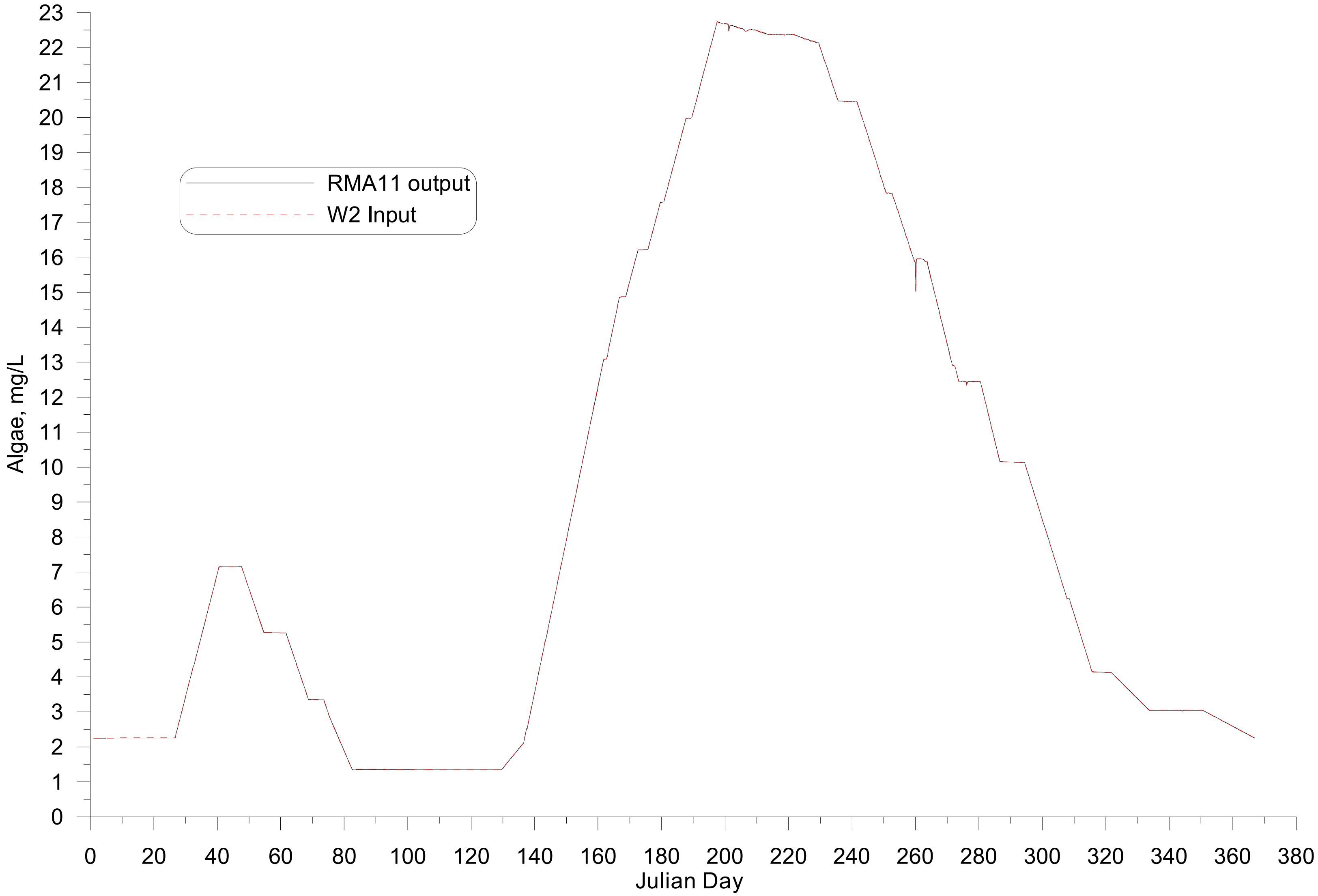

Figure 12: Algae concentration for Link River model output and Lake Ewauna model input

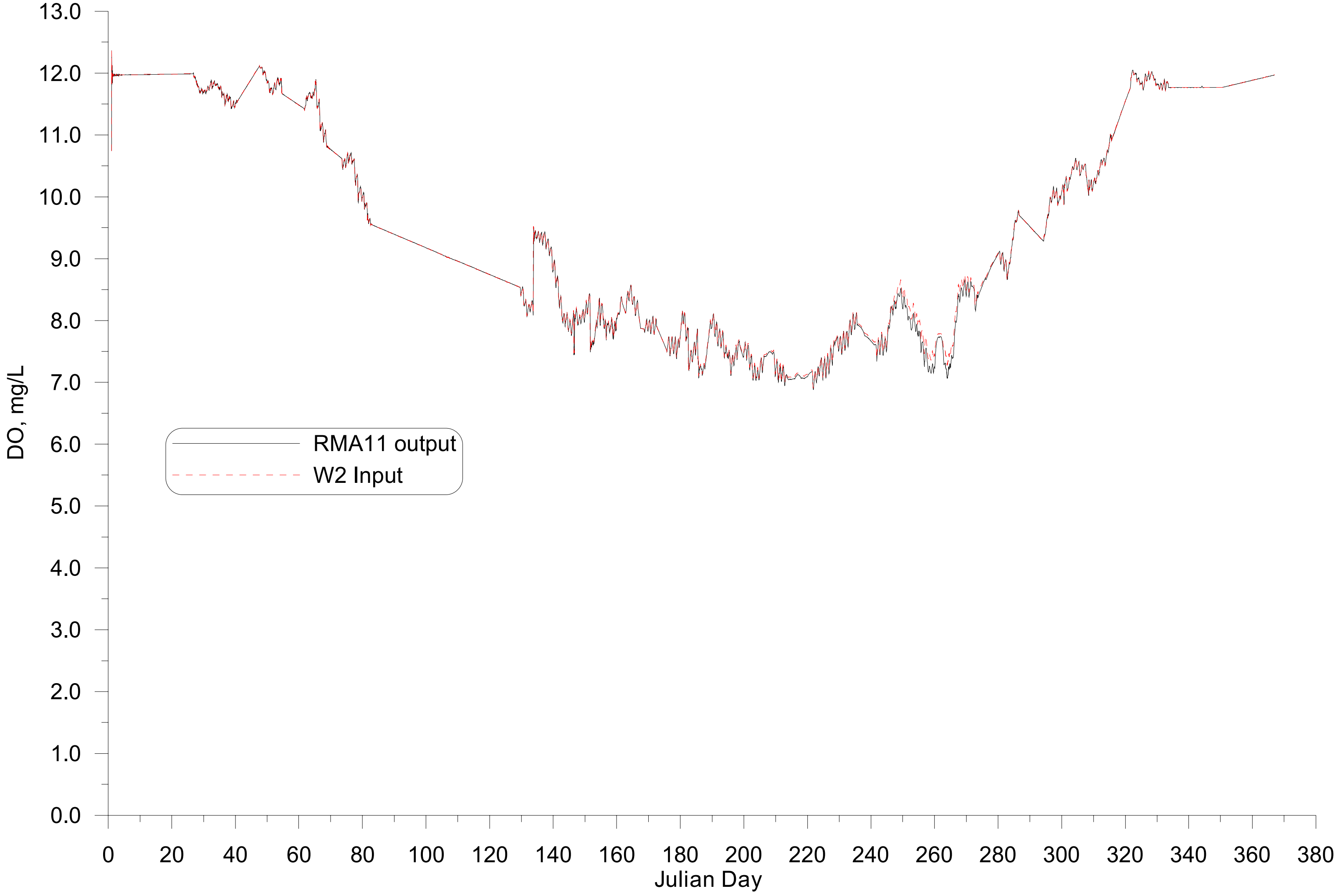

Figure 13: Dissolved oxygen concentration for Link River model output and Lake Ewauna model input

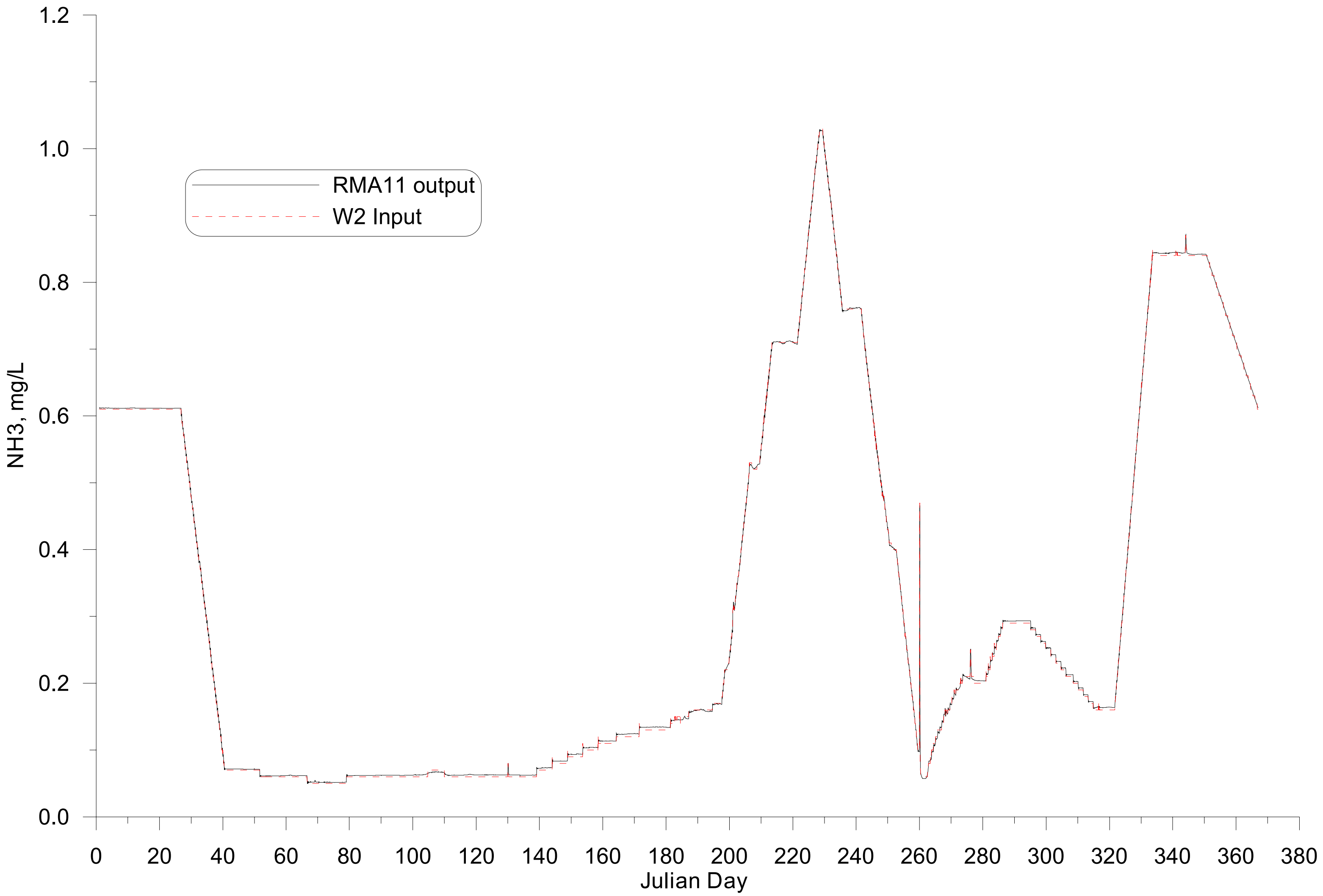

Figure 14: Ammonia for Link River model output and Lake Ewauna model input

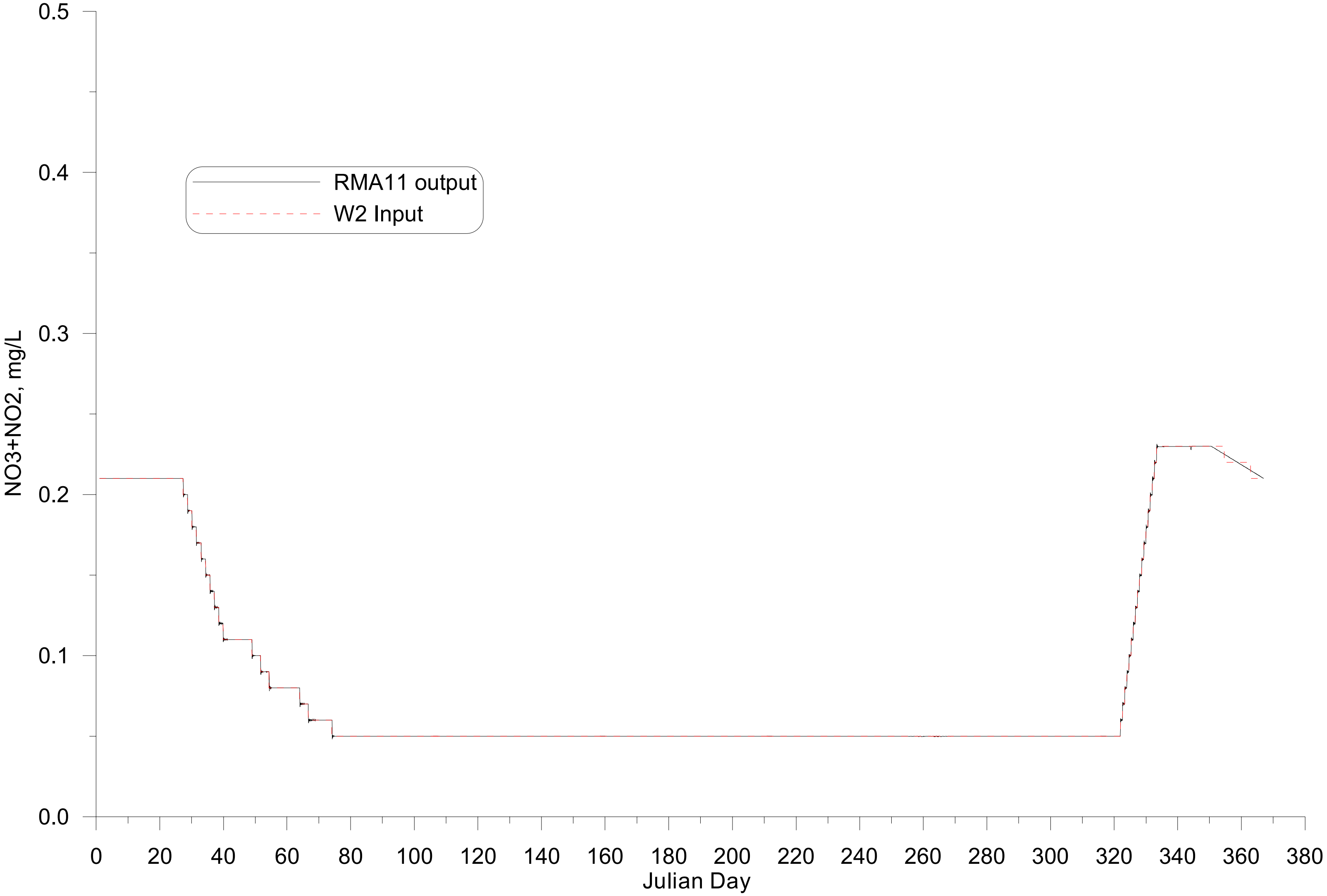

Figure 15: Nitrate and nitrite concentration for Link River model output and Lake Ewauna model input

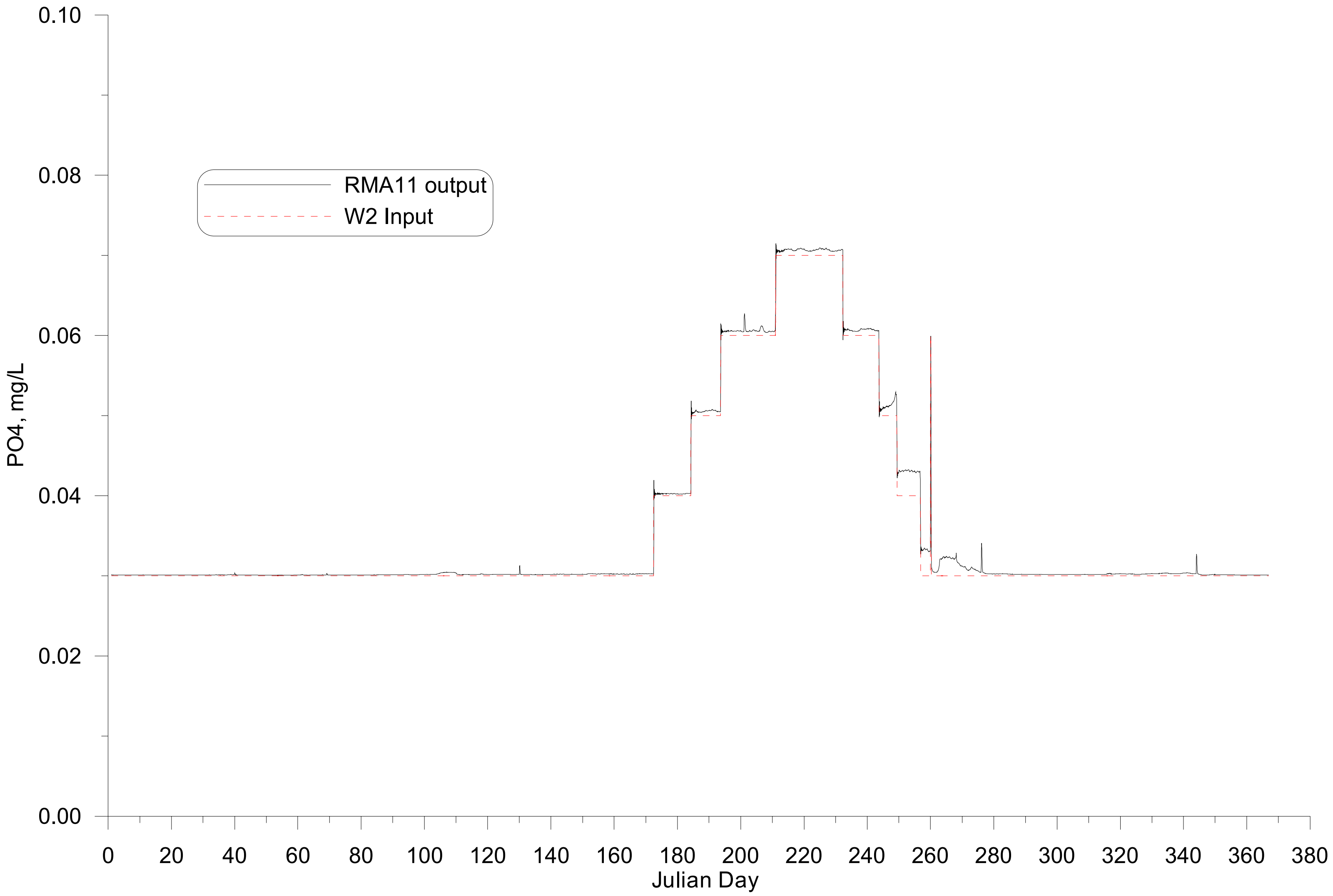

Figure 16: Phosphate for Link River model output and Lake Ewauna model input

Appendix F: Alternatives Analysis: Impact of Withdrawal Elevation on Iron Gate and Copco Reservoirs

Iron Gate Reservoir: Examination of withdrawal elevation effects

The Existing Conditions, 2000, Iron Gate model (DZ = 2.5 m) was used to examine the effect of variations in the penstock and hatchery withdrawal elevation. The base case consists of outflow at the penstock (elevation ~701 m) and small hatchery flow (1.4 m^3/s) at elevation ~687 m. There is additional spillway overflow until roughly May. This overflow was retained in the other two scenarios examined where the outtake structure flows were summed and applied to the lowest existing outlet at 687 m and to a hypothetical outlet at 670 m.

Figure 17 shows a summary of withdrawal flows for Iron Gate for 2000. Figure 18 and Figure 19 show temperature profiles at a segment near the Iron Gate dam illustrating the temperature impacts of the different outlet levels at JD 221.5 and JD 271.5, respectively. Figure 20 and Figure 21 show dissolved oxygen profiles at a segment near the Iron Gate dam illustrating the temperature impacts of the different outlet levels at JD 221.5 and JD 271.5, respectively. Figure 22 shows the temperature of the mixed withdrawals from Iron Gate for the 3 different outlet level configurations. Figure 23 shows the dissolved oxygen of the outlet to Iron Gate reservoir with the lower outlet levels in Iron Gate and the lower levels in Copco Reservoir.

The results from this analysis show that:

- downstream temperatures were much lower with the lower outlet. This is unusual since often the volume of cool water is limited. In discussions with Mike Deas, the model set-up using a very large sediment heating (cooling) coefficient coupled with a cool sediment temperature, artificially created too much cooling of the water in the hypolimnion. Once this model artifact is corrected, we do not expect the apparent temperature benefit to be as great as shown in Figure 22.
- dissolved oxygen conditions were lower with the lower outlet. While this may be true in the short term, if the problem with sediment oxygen demand is resolved (not necessarily an easy issue to fix), the oxygen levels could rise. It would be appropriate to re-run this simulation with different values of SOD for both Copco and Iron Gate reservoirs.

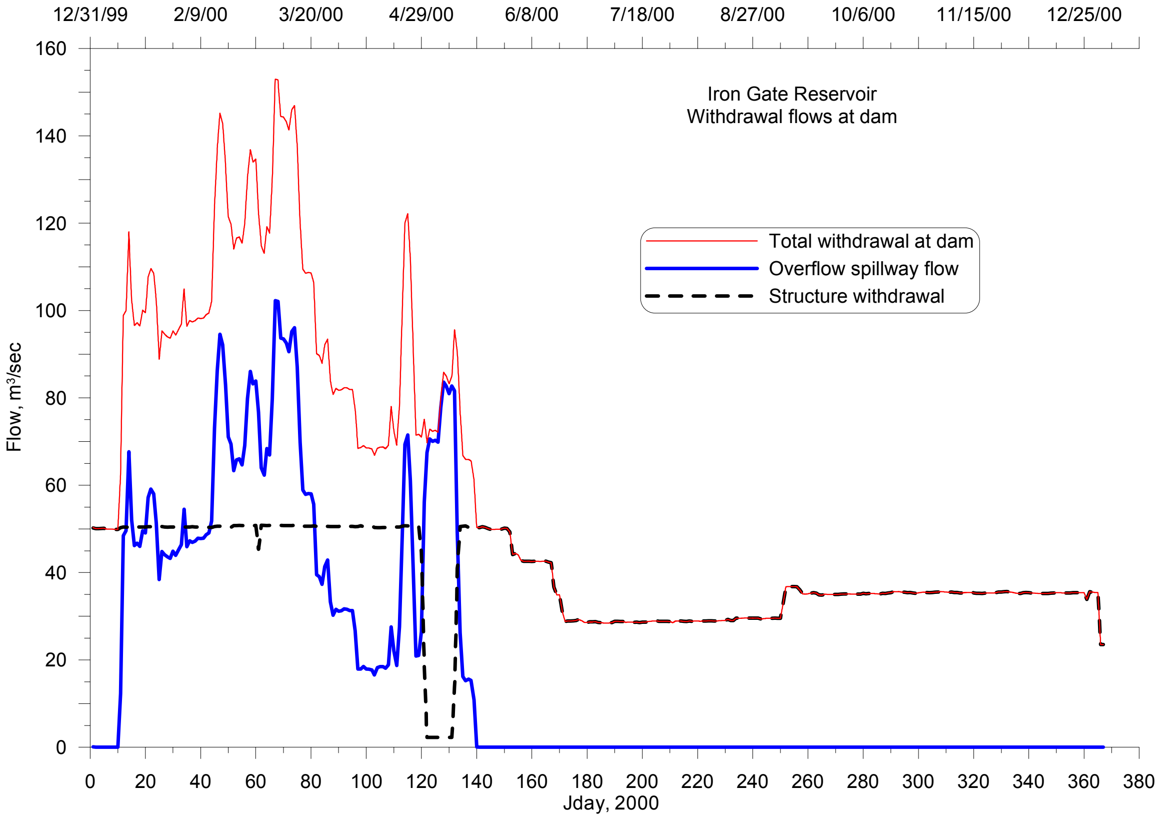

Figure 17. Withdrawal flows at Iron Gate dam.

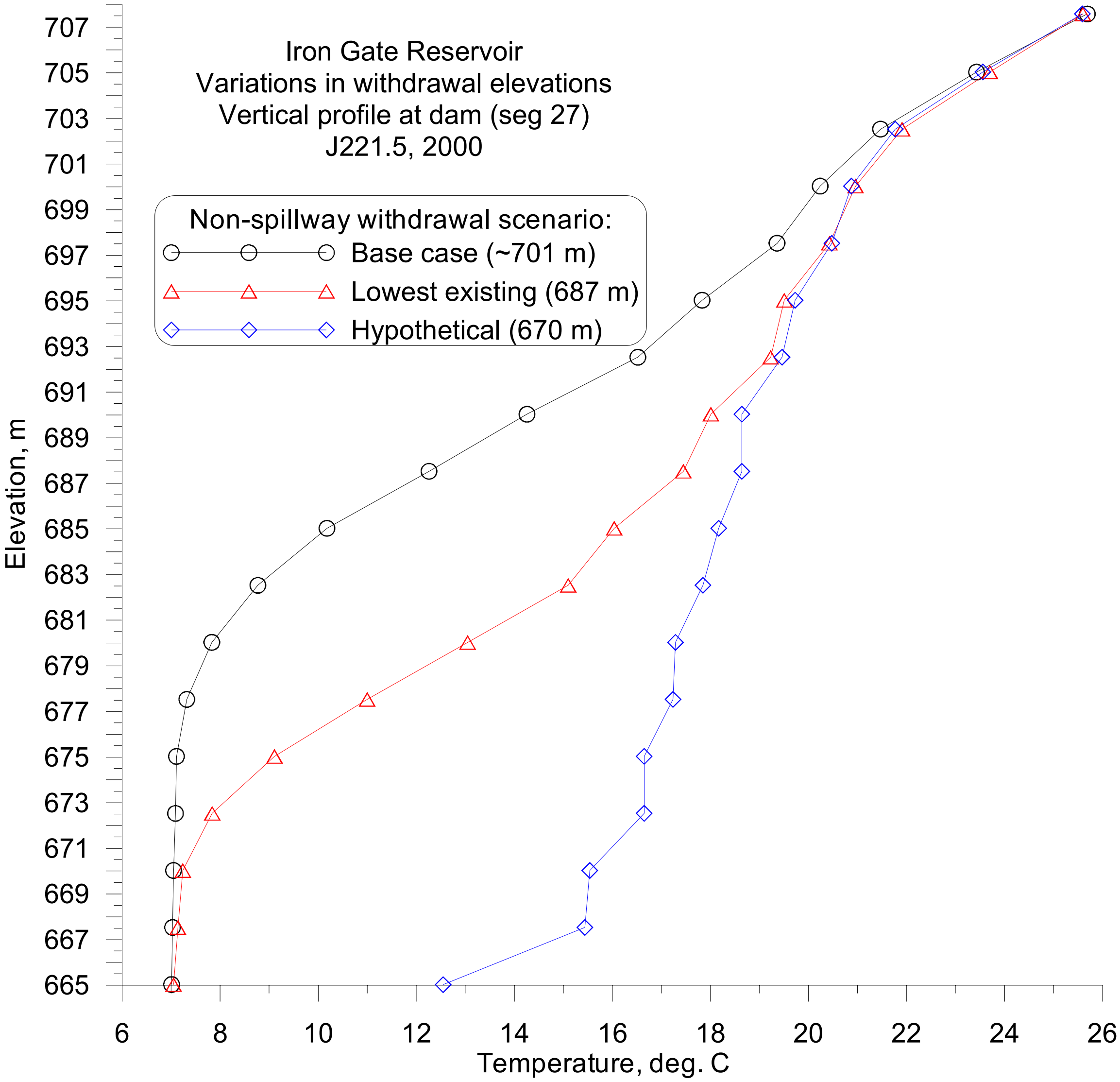

Figure 18. Temperature profiles in Iron Gate for JD 221.5 at segment 27 comparing different outlet elevations.

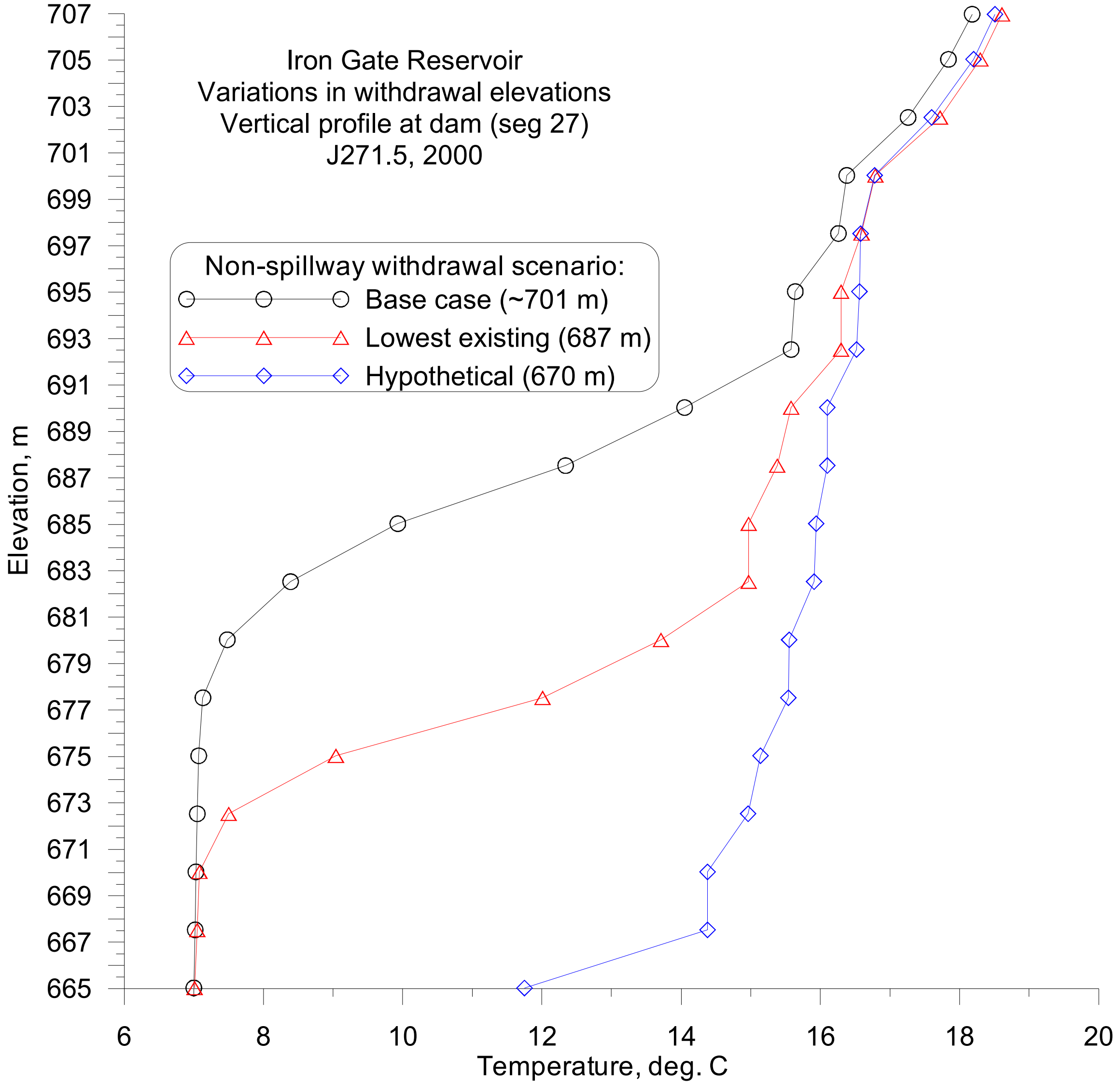

Figure 19. Temperature profiles in Iron Gate for JD 271.5 at segment 27 comparing different outlet elevations.

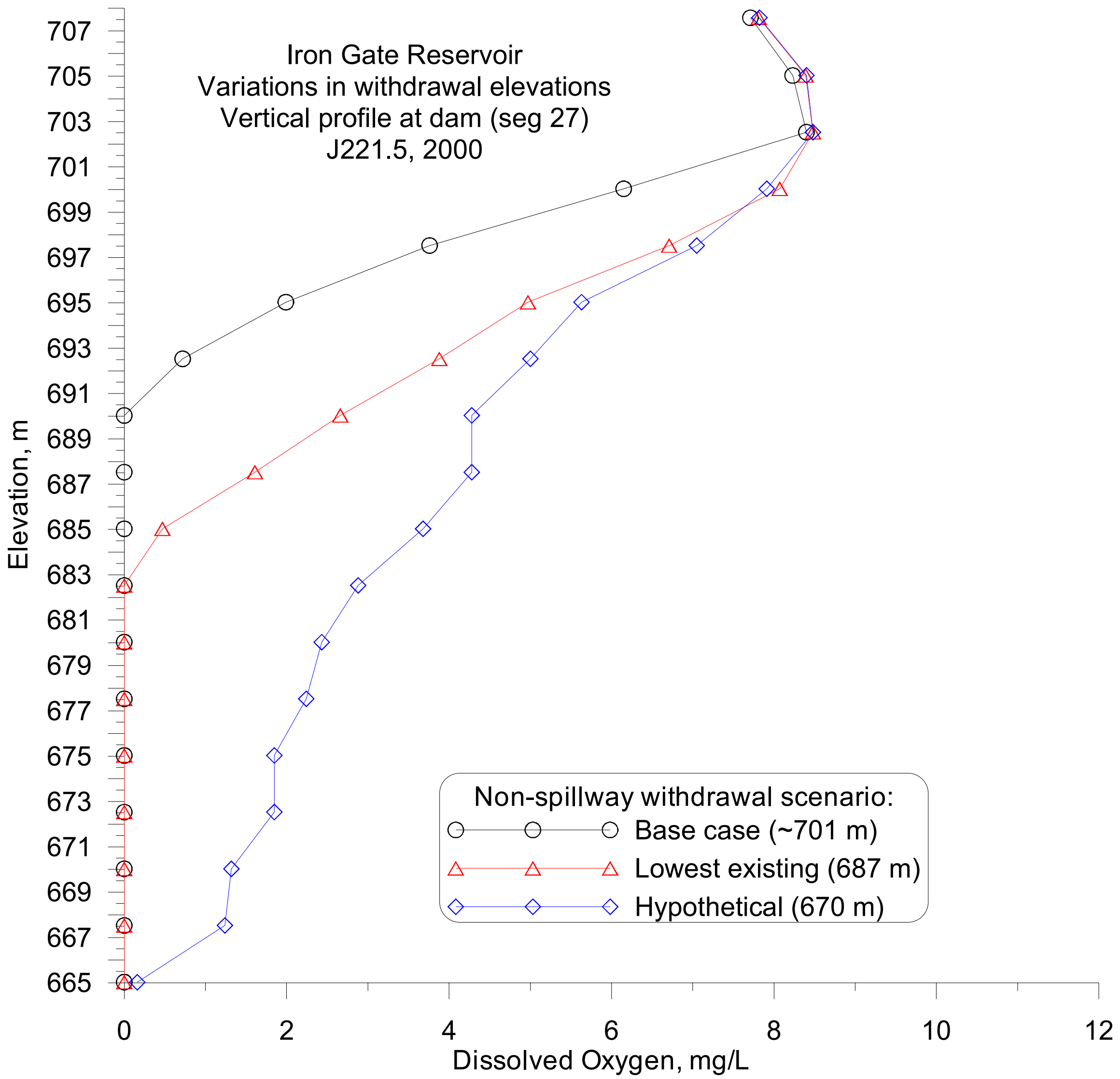

Figure 20. Dissolved oxygen profiles in Iron Gate for JD 221.5 at segment 27 comparing different outlet elevations.

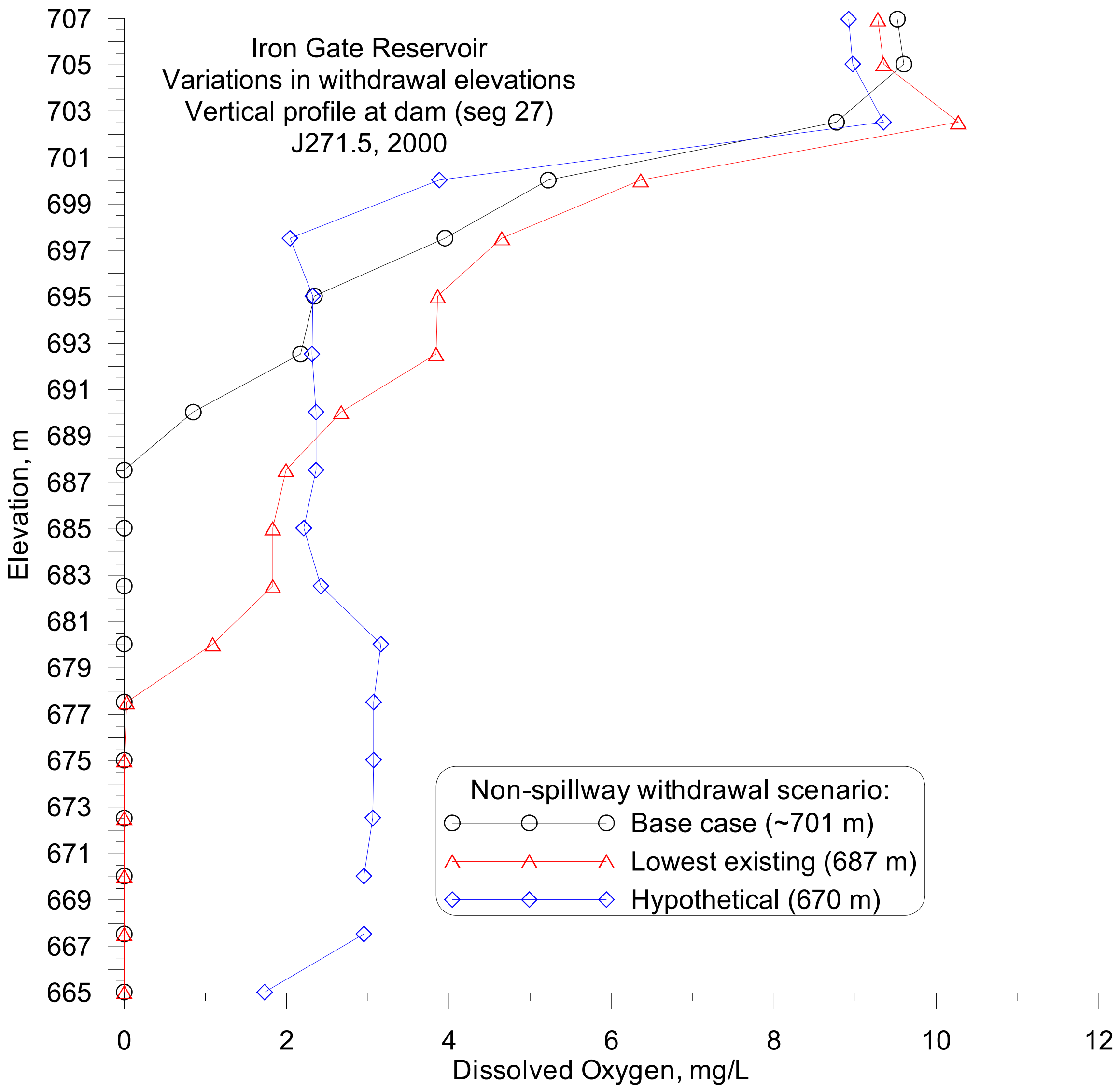

Figure 21. Dissolved oxygen profiles in Iron Gate for JD 271.5 at segment 27 comparing different outlet elevations.

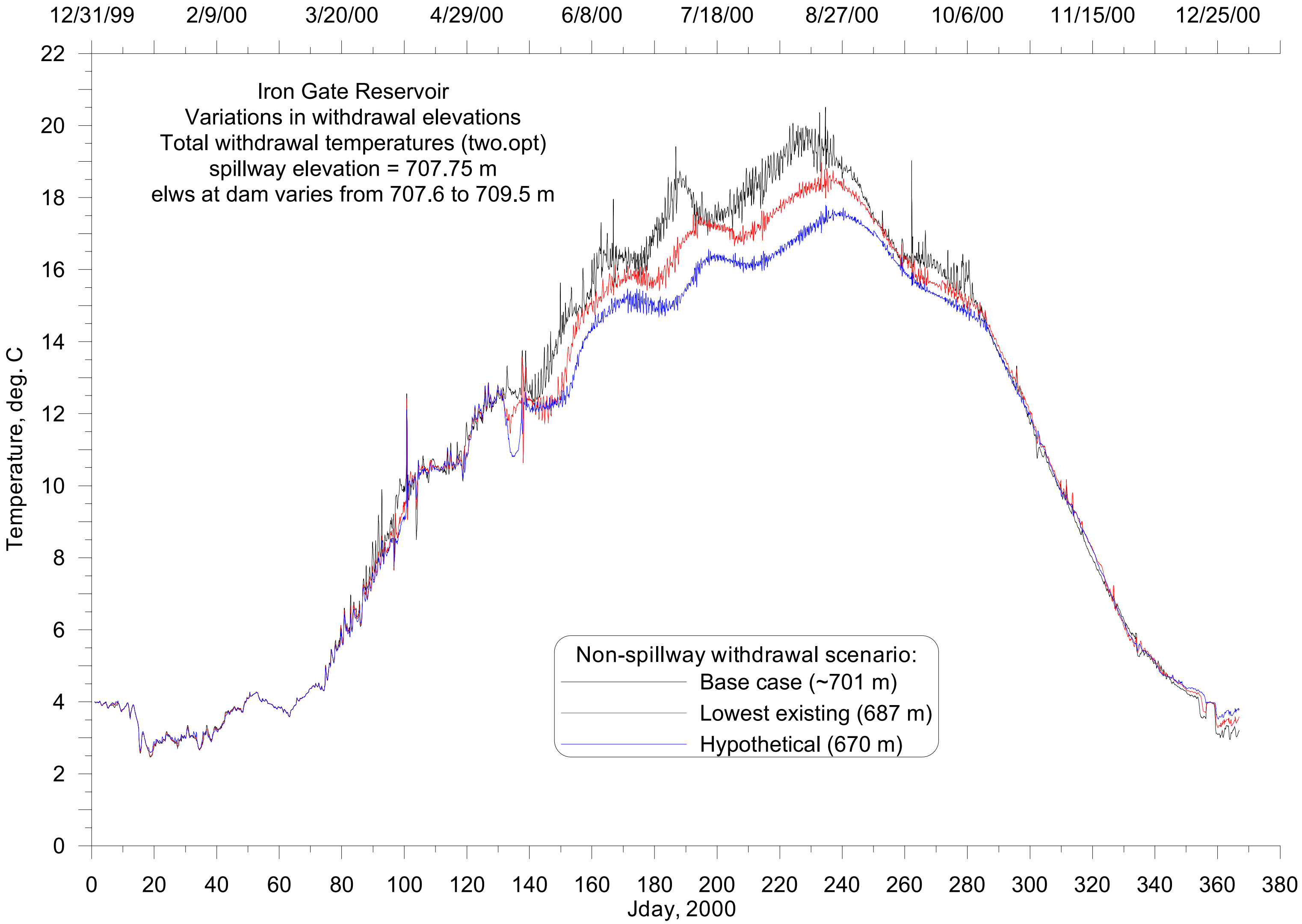

Figure 22. Temperature of mixed outlet water from Iron Gate reservoir using different outlet levels.

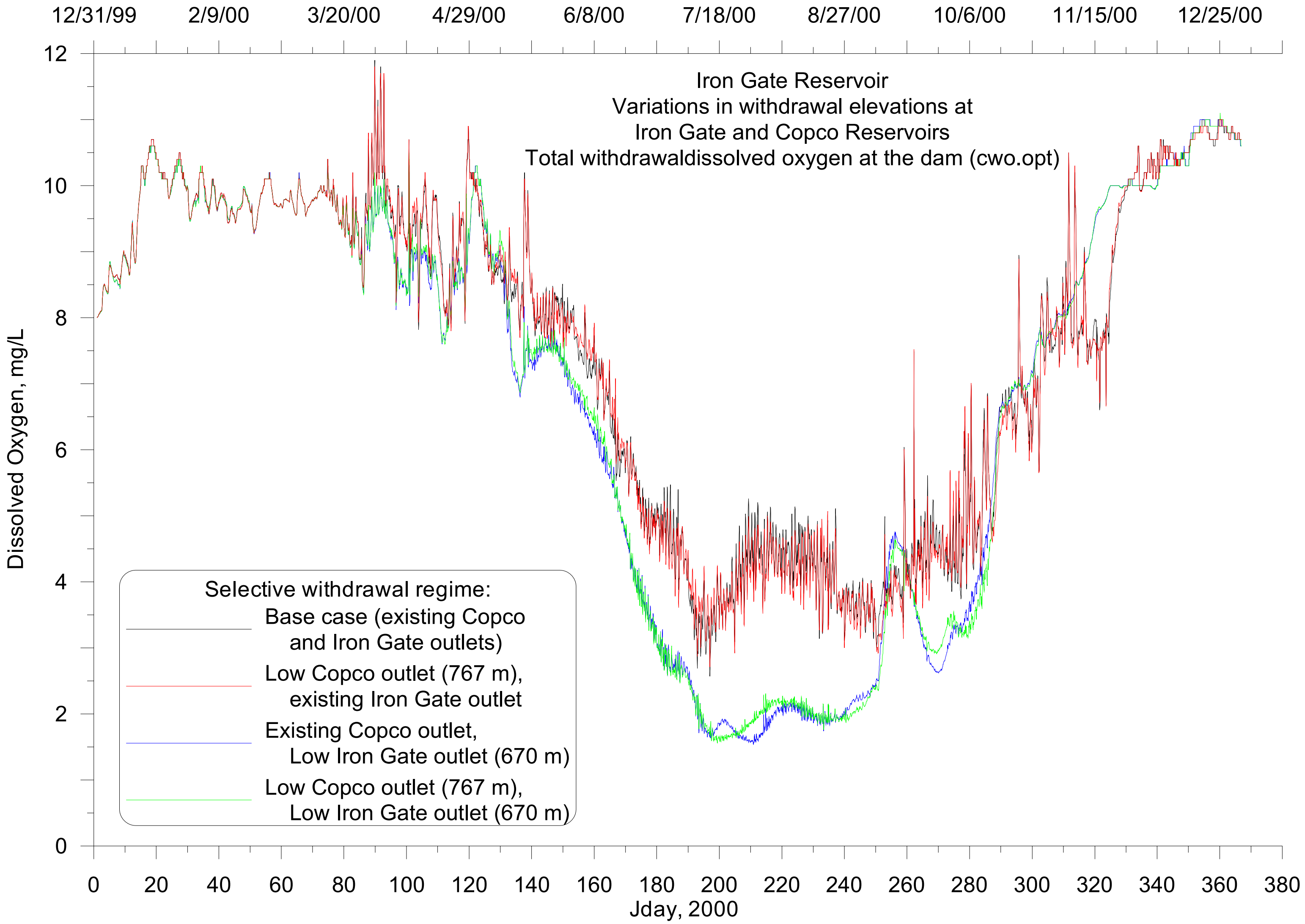

Figure 23. Impact on dissolved oxygen below Iron Gate reservoirs with lower outlet levels at both Copco and Iron Gate.

Copco Reservoir: Examination of withdrawal elevation effects

The Existing Conditions, 2000, Copco Reservoir model was used to examine the effects of varying the withdrawal elevation. The existing withdrawals occur at 2 elevations: ~787 m and 790 m. These flows were added together and placed at roughly 2 m above the grid bottom at an elevation of 767 m, replacing the existing outflows. Figure 24 and Figure 25 show comparisons of vertical profiles of temperature and dissolved oxygen, respectively, near the dam for Julian Day 211.5. The outlet temperature from the dam as a function of time is shown in Figure 26.

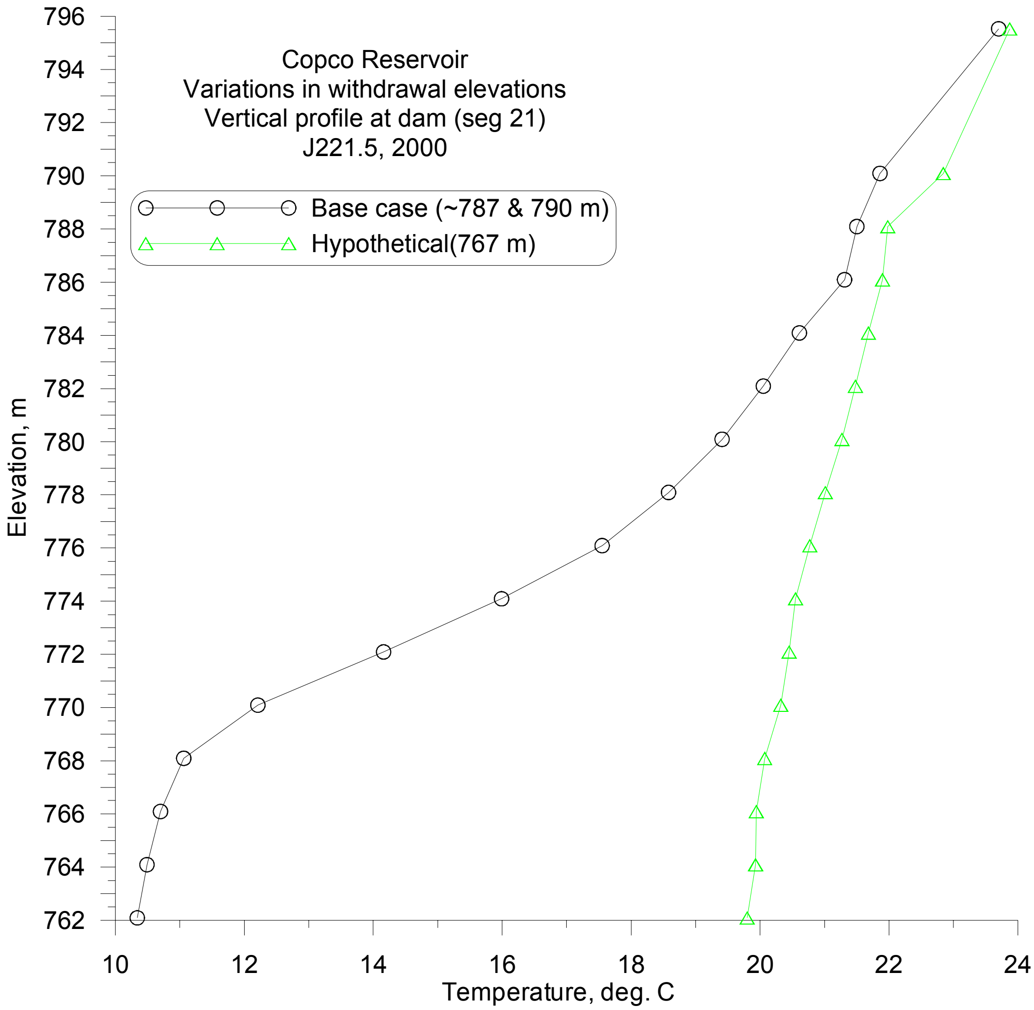

Figure 24. temperature profile at segment 21 of Copco Reservoir comparing the base simulation with a lower outlet level configuration on JD221.5.

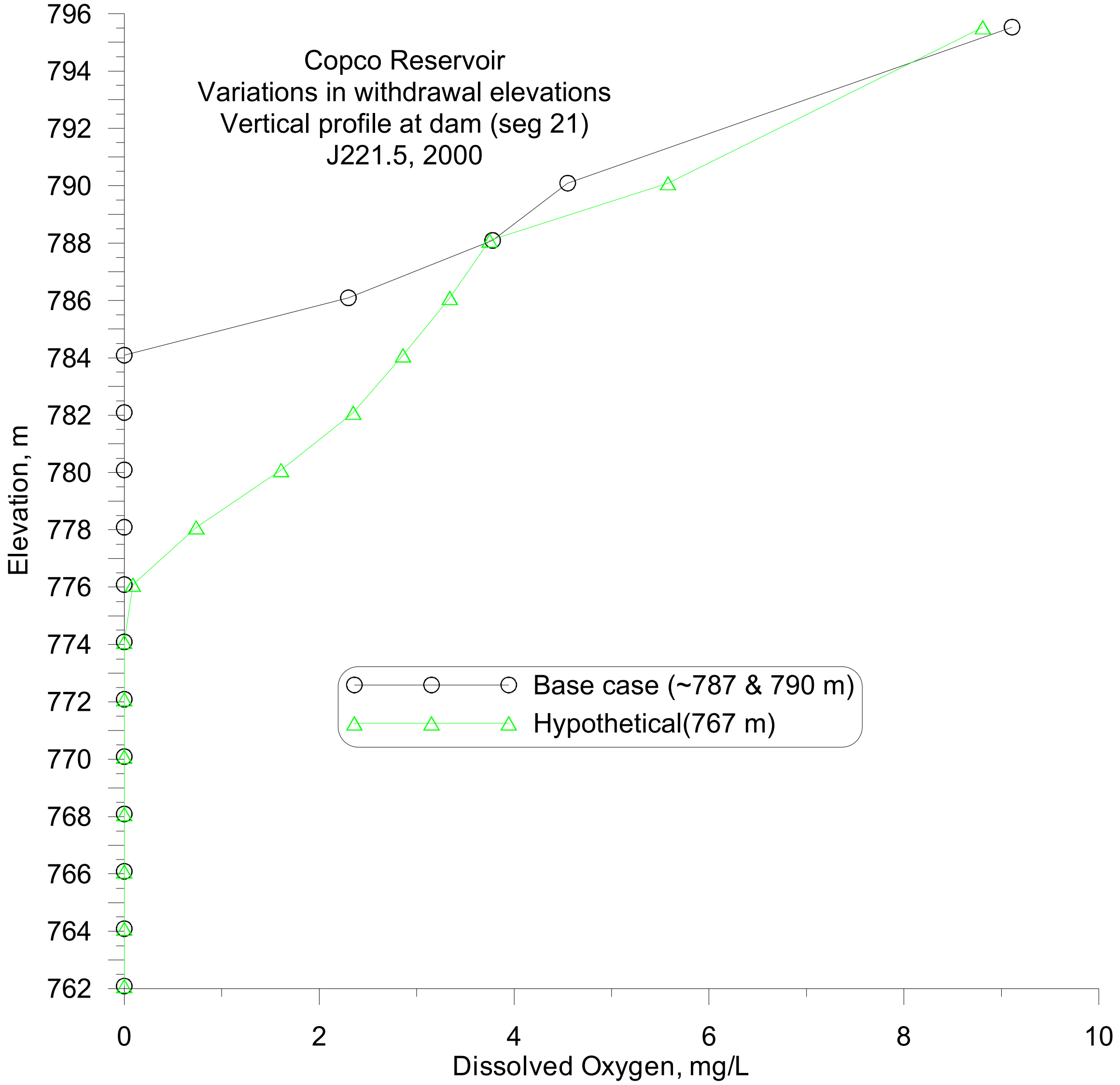

Figure 25. Dissolved oxygen profile at segment 21 of Copco Reservoir comparing the base simulation with a lower outlet level configuration on JD221.5.

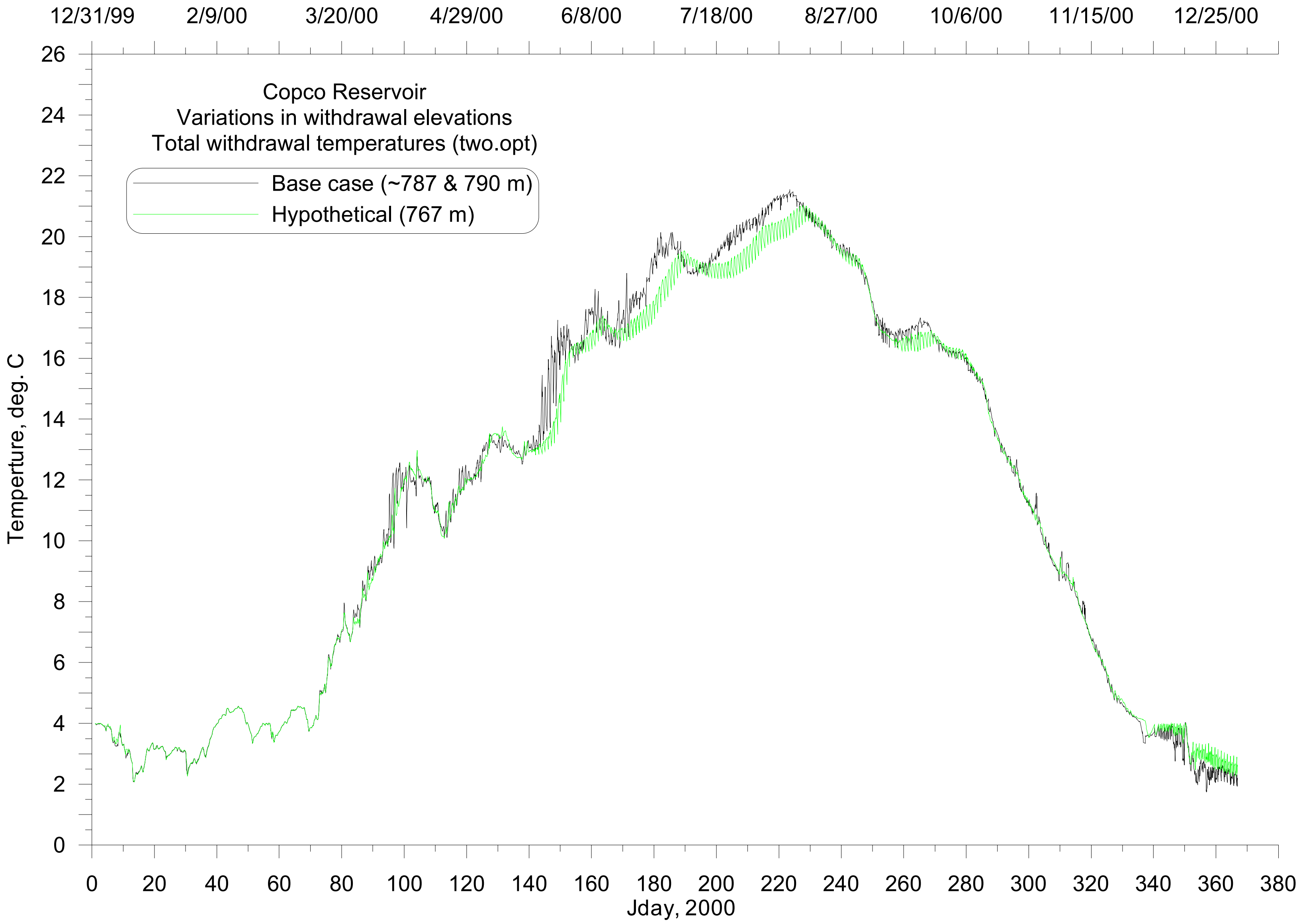

Figure 26. Temperatures released from Copco Reservoir during 2000 for the lowered outlet configuration.