Date: June 1, 2007

Subject: Technical review comments for *Idaho Pend Oreille River Model: Model Development and Calibration Technical Report EWR-02-06 November 2006* and *Idaho Pend Oreille River Model: Model Scenario Simulations Technical Report EWR-01-07 March 2007.*

The following memorandum contains comments and corrections from the Seattle District Corps of Engineers regarding the November 2006 *Idaho Pend Oreille River Model: Model Development and Calibration Technical Report EWR-02-06* and the March 2007 DRAFT *Idaho Pend Oreille River Model: Model Scenario Simulations Technical Report EWR-01-07* prepared by Portland State University for the Idaho Department of Environmental Quality. Comments were provided by Kent Easthouse, Seattle District Corps of Engineers and Mike Schneider, U.S. Army Engineering Research and Development Center Coastal and Hydraulic Laboratory.

General Comments

The Pend Oreille River CE-QUAL-W2 temperature model developed and calibrated by Portland State University is a well developed model that addresses the thermal budget on the Pend Oreille River in Idaho with and without Albeni Falls Dam and point sources. The general findings from model runs seem reasonable; that the temperature regime in the Pend Oreille River has not changed substantially due to Albeni Falls Dam and point sources. However, several conditions used in the model merit further discussion because of the importance modeling results have on the overall Pend Oreille River Total Daily Maximum Load analysis. The following comments were prepared with intent of strengthening the temperature model and results.

I. Idaho Pend Oreille River Model: Model Development and Calibration

Model Geometry

Bathymetry

Comment: The critical nature of the upstream boundary of the grid was mentioned many times in this report. The available bathymetry defining the Pend Oreille River/Lake Pend Oreille transition near the upstream boundary appears to be sparsely defined compared to other channel reaches in the study area. The subsurface bathymetry was developed through liberal interpolation/extrapolation from observed data. The delineation of the channel features near the upstream boundary would likely be a critical area for establishing the exchange of water between Lake Pend Oreille and the Pend Oreille River.

Model Grid Development

Comment: Some caution should be applied in the interpretation of simulated properties near the channel bottom where large changes in depth are present between neighboring model segments.

Isolated grid cells can retain constituent properties for long periods of time and can result in erroneous results. The segments corresponding to the 10K (segment 39) and 35K stations (segment 136) have isolated cells near the channel bottom through which no flow is passed. Diffusion is the only transport mechanism for water quality constituents of interest in these isolated cells located near the channel bed.

Comment: In the application of natural conditions without Albeni Falls Dam, a different grid was used to represent the Pend Oreille River. This observation was based on some of the temperature profile figures shown in the Draft "model scenario simulations". Some discussion of the alternative grid applied to this scenario should be presented this report.

Boundary Conditions

Upstream Boundary Conditions

Comment: The upstream boundary located at the Railroad Bridge does not coincide with observed flow or water quality data. The model calibration used a methodology to map the temperature profile from data collected at a sampling station in Lake Pend Oreille to conditions at the bridge. The mesh could have been extended to include a larger portion of Lake Pend Oreille with station (ALFLPS) defining the upstream boundary. In this case, the stratified approach flow into the Pend Oreille River and the bridge could have been used to calculate water temperatures instead of imposing these conditions. The upstream boundary could have also been moved downstream to the Long Bridge (Station AFPORLB) where detailed temperature data were available for the critical time of the year. These upstream boundary conditions cannot evaluate the relative contributions from Lake Pend Oreille or the Clark Fork River on the thermal loading on the Pend Oreille River. The modeling scenario simulations assume the thermal profile at the upstream boundary was independent from Albeni Falls Dam operations. Furthermore, the natural conditions scenario includes the flow regulation from upstream dam operations on the Clark Fork River basin.

Comment: One interesting question not addressed by the current Pend Oreille modeling study involves the influence of the Clark Fork River flows and water quality on conditions in both Lake Pend Oreille and the Pend Oreille River. There is some evidence supporting the conclusion that the water quality in the Clark Fork River and Pend Oreille River are coupled. The finding from a study investigating the total dissolved gas exchange at Albeni Falls Dam (Schneider, 2007) noted the occurrence of elevated TDG levels in the forebay of Albeni Falls Dam during spillway releases at Cabinet Gorge Dam located on the Clark Fork River. The estimated time of travel from Cabinet Gorge Dam to Albeni Falls Dam was on the order of one week during the 2003 season. The elevated TDG pressures suggested dissolved oxygen concentrations in the Pend Oreille River can be directly impacted by releases from Cabinet Gorge Dam. The short travel time between these projects also suggests a closer relationship between the thermal loadings of both systems.

Comment: Model calibrated with 2004 and 2005 data but only run for 2004 hydrograph. 2004 was a low water year while 2005 and 2006 were normal and high flow years, respectively.

Recommend also running the model for average (2005) and high (2006) water years to note any differences in temperature predictions.

Comment: How do upstream boundary conditions deal with changing lake levels during the year? Are current and natural conditions dealt with in a similar manner? Do natural conditions simulate the rise and fall of Lake Pend Oreille during the May-September time period? How were upstream boundary condition lake elevations decided?

Downstream Boundary Conditions

Comment: The short Pend Oreille River reach below Albeni Falls Dam to the Idaho/Washington border is shallow and during low flow conditions can exhibit some additional thermal exchange during warm summer conditions. A reference is made to “larger errors associated with turbine flow rates” when discussing the discharge boundary condition at Albeni Falls Dam. The differences between the project flows and Pend Oreille River flows as measured at the USGS gaging station near Newport do show a small difference generally during high river flows when spillway releases contribute a significant volume of water to the Pend Oreille River.

Tributaries

Comment: The Priest River can contribute a thermal load to the Pend Oreille River that is not completely mixed in the forebay of Albeni Falls Dam (Schneider, 2007). This is more noticeable during peak runoff conditions on the Priest River when temperature gradients are present between the Priest and Pend Oreille Rivers. Well mixed conditions on the main stem Pend Oreille River at the confluence of tributary inflows is not strictly consistent with observed conditions.

Meteorology

Comment: The meteorologic data available from the NOAA weather station at Sand Point was different from that shown in the report. Hourly air and dew point temperatures as well as wind speed and direction data were available for most of the year and should have been incorporated accordingly.

Calibration

Hydrodynamics

Comment: The water surface slope and calculated stage at Albeni Falls Dam appear to be well represented by the model for existing conditions. The flow and stage data for the natural conditions scenario was not discussed in the draft “Simulations report”. These details should be included in the Final report.

Temperature

Comment: The predictive errors are largest near the upstream boundary and become smaller at Albeni Falls Dam. In general, the closer the temperature simulations are to observed boundary conditions the smaller the predictive error. In this case, the upstream boundary designation is a source of error and simulated atmospheric heating and cooling processes drive the main stem temperatures predictions closer to observed conditions. The absolute mean errors for water temperature at the dam are small. It would have been informative to have the heat budget summarized for each of the calibration years noting the incoming aggregate temperature, the outgoing water temperature at Albeni Falls Dam, and the seasonal patterns of heat exchange.

Comment: Based on figures shown in Appendix B, model errors at many stations/depths are largest during the time period of April-August and less during September-November, likely due to spring/summer stratification in Lake Pend Oreille, and the larger heating/cooling impact on water temperatures during the spring/summer months. In general, the critical time period of June-August is when water quality standards will be applied and therefore it is important to know the model's error during this specific time period. Suggest calculating model errors for critical time periods (i.e. June-August) at each station in addition to the complete data set to note if any difference in errors exists.

Comment: How was the model calibrated/verified for the deeper segments in the Pend Oreille River where isolated deep zones are 20 to 30 meters deep? The calibration data are for the more uniform sections of the river where river depths were in the 10 to 12 meter depth range. The deep zones found in the river may represent a completely different temperature regime than the average depths found in the majority of the river from which calibration/verification data were obtained. How does the model simulate temperature changes in these deep zones without any calibration/verification data to see how accurate the simulations were? Suggest this item be discussed in the report.

Dissolved Oxygen

Comment: The dissolved oxygen supersaturation caused by dam spillway operations were not considered in this evaluation.

Summary

The important model findings as summarized in the **"**Idaho Pend Oreille River Model Development and Calibration" report Summary Section and associated comments are listed in the following section. The report citation is listed followed by a corresponding reviewers comment.

"In general, the model reproduces the river responses to the known boundary conditions. The average absolute mean error (AME) of model predicted temperatures compared with vertical profile data was 0.37 degrees Celsius. Model predictions compared with continuous temperature data had an error of 0.51 degrees Celsius."

Comment: The predictive errors were generally greater during the summer months when Lake Pend Oreille becomes strongly stratified. The bias in the temperature predictions at the dam is small (average error -.14) but near the upstream boundary at station ALFPORLB the prediction bias was as large at 0.84 C (calculated temperature cooler than observed values). If the ability of the model is to predict observed conditions to within 0.5 C (average absolute error) and 0.7 rms, can two simulated conditions differing by only 0.3 C be considered significantly different at a high level of confidence? The variability of the water temperature estimates along with temporal and spatial variability should be carefully considered when comparing the results of model scenarios simulations.

"Model error for temperature was greatest nearest the upstream boundary condition, but improved at sites closer to Albeni Falls dam. The larger error near the upstream boundary condition was due to data reflecting seiching action in Lake Pend Oreille. Only a small portion of the lake is simulated by the model. Sites downstream toward the dam were not affected by seiching and thus model predictions improved downstream."

Comment: If higher lake levels allows for the transport of slightly cooler water into the Pend Oreille River, shouldn't the seiching events be felt to some degree in the Pend Oreille River especially when the total travel time is typically one week or less?

"The model was very sensitive to the upstream boundary conditions. Differences between model predictions and data were often due to the sparseness of data measured at the upstream boundary condition. Travel times from the upstream boundary to Albeni Falls dam were shown in Figure 83. Generally the shorter the travel time within a system, the greater influence the boundary condition has on model predictions. The travel time in 2004 ranged from less than 3 days to 9 days."

Comment: The temperature data was very rich near the upstream boundary (hourly temperature data for multiple depths). The short-coming of the model simulation in this region was how the upstream boundary was implemented.

"Important calibration parameters included algae growth rate, algae temperature coefficients, periphyton half saturation coefficient, periphyton growth rate, and periphyton temperature coefficients."

Comment: The focus of this hydrodynamic and water quality model was to quantify the thermal budget on the Pend Oreille River. Does the above comment imply that these parameters are critical to achieving this goal (some additional explanation is needed)?

"Improvements that could be made to the model include the following:

• Use the new v3.5 model with macrophytes rather than just periphyton

• Attempt to improve the water quality boundary condition at Pend Oreille Lake by modeling the lake itself (this may not be important in the short term), or by adjusting boundary condition data to account for diurnal dynamics

• Gather data on periphyton/macrophyte densities and compare with model predictions

• Monitor water quality at the upstream boundary condition continuously for temperature, dissolved oxygen and pH. There is little continuous water quality data available in the study area to evaluate diurnal dynamics of temperature, dissolved oxygen, and pH."

Comments: Addressing the influence of Clark Fork River on Lake Pend Oreille and the resultant influence on the water quality loading to the Pend Oreille River would result in a better understanding of the temperature management alternatives throughout the basin.

II. Idaho Pend Oreille River Model: Model Scenario Simulations

Evaluation of Existing Conditions to Natural Conditions

Time Series Plots

Daily Average Temperatures

Comment: How do model scenario 1, existing conditions, and model scenario 8, natural conditions, simulate changing elevation of Lake Pend Oreille at the upstream boundary of the model? Do both scenarios incorporate changing lake elevations or do the scenarios hold the lake elevations constant at some predetermined level? If elevations are held constant throughout the year, an explanation of what elevation is used and why is needed. Lake elevation appears to play an important role in upstream boundary condition temperatures and thus changing lake elevations need to be accurately simulated in model runs.

Comment: Figure 4 data does not seem to be accurate. The shape of the line seems odd and the temperatures seem too cold.

Comment: Comparing the 1 m volume-weighted bottom temperature at segment 39 and 136 should be expanded to explain why these segments were chosen, how these isolated deep hole segments were calibrated/verified, and a description of the models ability to accurately reflect temperature dynamics at the bottom of deep holes with the existing grid pattern. Segments 39 and 136 appear to represent single width segments that may poorly represent riverine processes because there would be no advection transport but only diffusive transport.

Comment: The report should explain how model errors are dealt with when comparing model runs. What are the errors associated with each model scenario run and how are these errors factored into comparing results of two model scenarios. Because there appears to be very little temperature differences between scenarios, model errors become more significant when comparing runs.

Comment: Was 2004 the only year simulated? 2004 was a low water year; suggest running the model for average and high water years to note any differences.

Comment: For Figure 7, please explain why the daily average bottom temperature for scenario 8 stops increasing around day 200, holds steady from about day 200 to day 210 (at no other time during the year a steady temperature is maintained for multiple days) and then rises in a similar manner to scenario 1 (seems to be offset or shifted) and ultimately intersects scenario 1's line around day 220.

Longitudinal Profile Snapshots

Comment: For Figures 16 to 21, scenario 1 elevation on August 8^{th} and 16^{th} are shown as about 628 meters (2060.5 feet) but scenario 8 elevations on August 8^{th} and 16^{th} appear to be about 622 to 623 meters (2040.7 to 2044.1 feet). The natural condition lake elevation seems too low for early August. Historical records show that the lowest pre-dam lake elevation recorded was 623.7 meters on February 17, 1936. Generally, in early August the pre-dam lake elevation ranged from about 624.5 to 625.5 meters, depending on flow.

Evaluation of Albeni Falls Dam on Temperature

Time Series Plots

Daily Average Temperatures

Comment: How do model scenario 1 and 4 account for changing elevations of Lake Pend Oreille? Are elevations held constant during the year or do they change?

Comment: Figure 45 data does not seem to be accurate (Similar to Figure 4 noted above). The shape of the line seems odd and the temperatures seem too cold.