External Peer Review for Dissolved Oxygen TMDL – Basin Plan Amendment for the First Twelve Mile Segment of the New River Downstream of the International Boundary

by

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Introduction

This report provides a scientific peer review of the Draft New River Dissolved Oxygen (DO) Total Maximum Daily Load (TMDL) proposal. The primary objective is to assess whether the scientific portion of the proposed rule is based upon sound science, data, methods, and practices?

This assessment is based upon my careful reading of two reports: CRWQCB (2008) and Tetra Tech (2007). In addition, I received several model run files:

- Nr_TMDL_currentScenario1-25-08Run.xls
- Nr_TMDL_noflowMexico1-25-08Run.xls
- Nr_TMDL_NutrientRemovaFiltrationlBorderRun.xkl
- Nr_TMDL_NutrientRemovaFiltrationlBorderPlusNCentralRun.xls

These files were critical in discerning the underlying assumptions made by the modelers. Finally, my critique is informed by my 35-year experience in water-quality modeling and management as well as my intimate knowledge of the modeling software employed for the analysis (Chapra et al. 2009).

Issues

This report is organized around 7 issues delineated in a memo addressed to me from the Colorado River Basin Regional Water Quality Control Board (Zeywar, 2008). However, because of my area of expertise, much of my analysis focuses on the efficacy of the modeling work and, in particular, App. F (Tetra Tech 2007).

Project Definition and Watershed Description

The section on the Project Definition is clearly written and no technical issues were identified.

The Watershed Description was also well-written. However, it included little description of the river's morphometry and ecology. Thus, I had to rely on the model run files to better understand the river's physics, chemistry and biology.

Data and Source Analysis

The source analysis appeared reasonable. However, the water-quality data seemed quite meager. In particular, the lack of sufficiently detailed information for many water-quality variables was striking.

Critical Conditions and Seasonal Variations

This section, which describes the critical condition/seasonality with the strongest impact on organic matter loading, was somewhat vague. This may be due to the meager data available to adequately assess seasonal variations.

I think that the statement at the end of the section is poorly worded: "Because the materials that cause low DO may stay in the New River for few months, controlling these materials throughout the year is important." Because the river has such a short travel time (a few days according to the model run files), I would think that there would not be great carry over of loadings from season to season. However, if the statement is referring to the deposition of organic matter to the sediments, the conclusion is justified. In addition, I agree that the system should be managed on a whole-year basis based on (a) the oxygen data (which does not appear to exhibit strong seasonal variability) and (b) the fact that the cooler winters have lower flows.

Numeric Targets

The numeric target for dissolved oxygen for this TMDL is the standard 5 mg/L that is routinely used to protect aquatic life in warm-water rivers across the United States.

TMDL Calculation and Allocations and Linkage Analysis

This review is intended to address several key model-related issues that bear on the adequacy of the TMDL calculation:

1. Was the model applied in a technically competent and ethical manner?
2. Was the model adequately calibrated and validated?
3. Is the resulting tool adequate to determine the oxygen TMDL?

My answers to these questions are based on the following:

1. Careful reading of Appendix F (Tetra Tech 2007).
2. Examination of four model run files representing the current scenario as well as 3 key control scenarios.
3. Reruns of the four model scenarios with the current version of Q2K (Chapra et al. 2009).

The reruns yielded no inconsistencies between the reported simulations and the current version of the model.

Technical competence and integrity of model application. The application appears to have been implemented in a technically competent and ethical fashion. I could uncover no major flaws in the model application process outlined in the report and exhibited in the data files. In addition, the modelers performed the sequence of tasks that I expect to see in a sound modeling exercise:

1. Specification of boundary conditions and loadings.
2. Calibration and validation of physics (in particular, comparison of model-simulated travel time with measurements).

3. Calibration and validation of biochemistry with particular emphasis on mechanisms closely related to the quality variable of concern (in this case, dissolved oxygen).

Because of the data-poor nature of this study, these three steps required more professional judgment than is typically necessary for such exercises. I, therefore, checked their choice of kinetic parameters carefully and found none that were beyond the typical range of literature values. Further, there was no indication that the analysts chose parameters in order to bias the outcomes. Therefore, I concluded that the model was applied in a technically-competent and honest manner.

Adequacy of model calibration and validation. Model calibration and validation are usually critical for establishing the credibility of water-quality models. This assertion stems from the fact that biological and chemical mechanisms are typically more uncertain and difficult to quantify than physical processes. Consequently, given an adequate representation of the system's transport, the credibility of most water-quality models hinges on the quantity and quality of system-specific biological and chemical data (Chapra 2003).

Because the data available for the present application is meager to say the least, I originally suspected that the resulting calibration/validation would be highly uncertain. Further, regardless of the data, the validation itself was also not very convincing because the validation conditions were quite similar to those of the calibration.

However, as I learned more about the characteristics of this system, I have revised these conclusions. This relates to the fact that the actual level of required data also depends on the (1) nature and complexity of the system being modeled and (2) the type of management questions being addressed. For the present case, because both the system and the management question being addressed are relatively simple and straightforward, the current model application is adequate to develop a TMDL for dissolved oxygen. This conclusion is based on a two observations:

1. The system's short travel time (< 2.5 days) means that there is not sufficient time for reactions to dominate. Therefore, the system's oxygen regime is primarily dictated by the exogenous forcing functions; that is, the upstream boundary condition (U.S./Mexico border) and loadings (U.S. point sources).
2. The system is sufficiently deep and turbid that attached plants do not seem to be important. The absence of high plant activity means that the TMDL is primarily governed by bacterially-driven oxidation processes. If this were not the case, the calculation would have been complicated by the additional consideration of plant-driven photosynthesis and respiration. Thus, much more information (e.g., nutrient and plant biomass concentrations as well as diel data) would have been essential to adequately assess the model's efficacy.[1]

These two observations imply that at this juncture the system is primarily physically rather than biochemically driven. Hence, the model predictions will not be as sensitive to kinetic parameter variability as it is to the system's physical regime (travel time and weirs) and forcing functions (boundary condition and loadings). Consequently, model credibility should be more correlated with the adequacy of the characterization of the physics and forcing functions than on the kinetics.

[1] It should be noted that if control measures significantly reduce the river's turbidity, plant activity could become more dominant in the future. Hence, as suggested below, some monitoring should be directed towards assessing whether this is occurring.

These points are reinforced by inspecting the model calibration simulations. As in Figure 1, the boundary condition induces the low oxygen levels in the upper portion until the inflows and weirs start to induce step changes in the oxygen profile as the water flows downstream.

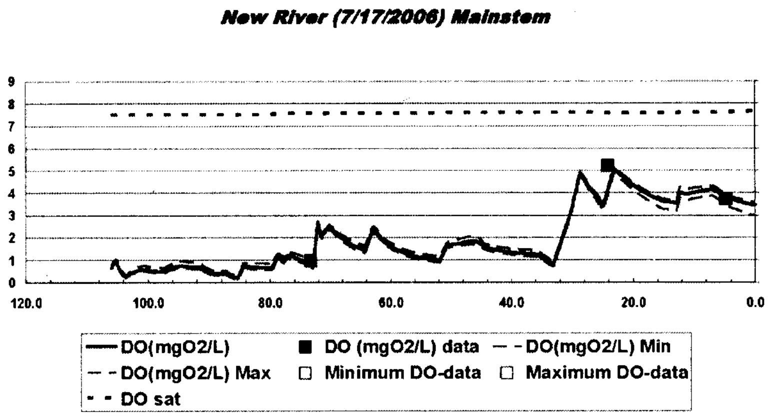

Figure 1 Copy of Fig. 3-3 from Tetra Tech (2007) showing oxygen calibration for the New River on July 17, 2006.

Adequacy of model to determine the oxygen TMDL. Because of the aforementioned characteristics, I conclude that despite the small amount of data, the reported Q2K application is an adequate tool to specify the proposed oxygen TMDL for the New River. Put another way, I believe that if the boundary conditions and forcing functions are changed (as in the proposed TMDL), the model provides a sufficiently accurate estimate of the resulting improvements in dissolved oxygen.

Implementation Plan

I think that the implementation plan appears reasonable. I especially liked the cooperation between the U.S. and Mexico which appears essential to achieve the project's objectives.

Monitoring Plan

Although the proposed monitoring plan is generally adequate for detecting seasonal trends, I would suggest that soluble reactive phosphorus (i.e., inorganic P), total phosphorus and chlorophyll *a* also be measured to provide a more complete representation of the system's future state. I recommend these measurements because I would anticipate that as the river is cleaned up, it might move from allochthonous bacterial-driven system (i.e., organic carbon/nitrification) to a more autochthonous plant-driven system. In particular, if the remedial measures improve light penetration, sections of the river might become dominated by phytoplankton and/or attached plants.

If such a shift were in fact to occur, it could result in daily variations becoming more critical than seasonal trends of daily averages. Consequently, it would probably be prudent to measure daily variations in several of the water-quality variables. At the minimum, two samples can be collected at dawn and dusk which are typically when extreme values occur for plant-influenced parameters such as oxygen and pH. An even better approach would employ setting out several data sondes to measure key water-quality variables (e.g., temperature, oxygen, pH, conductivity and turbidity) on a diel basis at critical points along the system. These would not have to necessarily be run continuously for the entire year, but could be deployed for several days at critical times during the year.

Conclusions

Based on my examination of the provided materials, I conclude that the Q2K model was applied to the New River in a technically competent and ethical manner. Although the quantity of data was less than normally required, I believe that the model was adequately calibrated to provide a reasonable estimate of the impact of load reductions on seasonal concentrations of dissolved oxygen. Consequently, I conclude that the resulting tool is adequate to determine the oxygen TMDL.

References

Chapra, S.C. 2003. Engineering Water Quality Models and TMDLs, *Journal of Water Resources Planning and Management*, 129(4):247-256.

Chapra, S.C., Pelletier, G.J. and Tao, H. 2009. *QUAL2K: A Modeling Framework for Simulating River and Stream Water Quality, Version 2.11: Documentation and Users Manual.* Civil and Environmental Engineering Dept., Tufts University, Medford, MA.

CRWQCB. 2008. *Draft: Total Maximum Daily Load and Implementation Plan for Dissolved Oxygen for the First Twelve Mile Segment of the New River Downstream of the International Boundary, Imperial County, California*, California Regional Water Quality Control Board, Colorado River Basin Region, Palm Desert, California, November 13, 2008.

Tetra Tech. 2007. *New River QUAL2K Water Quality Model for the New River Dissolved Oxygen TMDL.* Prepared for: United States Environmental Protection Agency Region 9 San Francisco, California and California Regional Water Quality Control Board Colorado River Basin Region Palm Desert, California, TETRA TECH, INC., San Diego, CA.

Zeywar, N. 2008. External Peer Review for Dissolved Oxygen TMDL – Basin Plan Amendment for the First Twelve Mile Segment of the New River Downstream of the International Boundary. Memo from Colorado River Basin Regional Water Quality Control Board, November 14, 2008