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December 6, 2019

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Commissioner Sission
Commissioner Yohe
International Joint Commission International Joint Commission U.S. Section
1717 H Street NW, Suite
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United States

Chair Béland
Commissioner Lickers
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234 Laurier Avenue West, 22nd FLR
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RE: Scientific opinion on proposed numeric nutrient targets for the Red River proposed by the International Red River Board, IJC Reference 81R

Dear Chairs Corwin, Béland and Commissioners:

I was contacted by the Minnesota cities of Breckenridge, Moorhead, Roseau, and Warroad (the cities) to provide technical input on proposed numeric nutrient criteria for the Red River of the North that are under consideration by the International Joint Commission (IJC). It is my understanding that the IJC is considering proposed stream criteria of 0.15 mgP/L for total phosphorus (TP) and 1.15 mgN/L for total nitrogen (TN) to protect aquatic life uses in the river. Because I have previously worked with the IJC on nutrient control requirements to protect the Great Lakes and have extensive experience on evaluating eutrophication in rivers and streams associated with periphyton and/or algal growth, the cities requested that I provide an opinion on the scientific validity of the numeric nutrient criteria under consideration.

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Qualifications

As the IJC is aware, my career has been devoted to the development of technical procedures to evaluate fate and transport of pollutants, with an extensive focus on nutrient dynamics and impact assessment. In this regard, I hold the Louis Berger Chair for Computing and Engineering in the Civil and Environmental Engineering Department at Tufts University. I have published over 200 papers, reports and software packages, and authored seven textbooks concerning the evaluation of water quality in lotic and lentic systems over a career spanning 50 years. My research has been used in several decision-making contexts including transboundary systems. For example, (a) the 1978 Great Lakes Water Quality Agreement and subsequent revisions, and (b) the Abrud, Aries and Mures River system involving Romania and Hungary (Chapra & Whitehead 2009). I was presented the Department of Commerce Special Achievement Award in 1978 for research and publications on Great Lakes eutrophication, and the 2009 Chandler-Misener Award for an outstanding article in the Journal of Great Lakes Research. Most recently, I was presented the Wesley W. Horner Award for the "Parsimonious Model for Assessing Nutrient Impacts on Periphyton-Dominated Streams" (ASCE, 2014).

Questions Considered

I was asked to consider the following questions regarding the technical information that lead to the development of the numeric stream nutrient criteria under consideration by the IJC:

1. Did the RESPEC Report use scientifically accepted methods to derive numeric nutrient criteria for TN and TP?
2. Are the concerns raised by Hall & Associates on behalf of the cities scientifically valid?
3. Does the Consensus Report address and resolve any valid concerns identified by the cities and its consultant Hall & Associates with the RESPEC report?
4. Are the nutrient criteria under consideration scientifically defensible?

Materials Reviewed

I was provided with the following documents for review:

- RESPEC. June 2016. The Development of a Stressor-Response Model for the Red River of the North. Topical Report RSI-2611. Prepared for International Red River Board, US Section.
- Hall & Associates. July 11, 2018. Review of: The Development of a Stressor-Response Model for the Red River of the North. RESPEC. June 2016.
- Walter Dodds & Helen Baulch. Consensus report for the International Joint Commission on RESPEC 2016 report "The development of a stressor-response model for the Red River of the North".

The June 2016 RESPEC Report (The Development of a Stressor-Response Model for the Red River of the North) provides the information used to derive the proposed criteria for TP and TN. The Hall & Associates Report (June 4, 2018) provides a critique of the evaluations and conclusions presented in the RESPEC Report. The Consensus Report is characterized as a peer review of the RESPEC report, with a specific focus on addressing the comments prepared by Hall & Associates. My review considered all the above information but is also intended to

provide an independent assessment of whether the suggested numeric criteria for the Red River of the North are scientifically defensible.

Evaluation

- **General Observations concerning the Reviewed Materials**

Over the course of my 50-year career I have reviewed many analyses that were intended to document "stressor-response" relationships due to nutrient impacts on aquatic life uses. I co-authored the USEPA guidance document for lake nutrient TMDLs (Gibson et al 2000) and have worked with US States to develop stream nutrient criteria (e.g., Flynn et al. 2015; Suplee et al. 2015). I am also very familiar with the USEPA guidance documents specifically developed to ensure scientifically defensible stressor-response nutrient criteria for streams.[1] The title of the RESPEC Report led me to believe that the document would include information and analysis sufficient to support scientifically valid stressor-response based nutrient criteria. Such information would typically include development of a quantitative relationship to predict the response of phytoplankton and periphyton to nutrient inputs to the Red River of the North, accounting for the multiple confounding factors that influence such growth and the effect of "excessive" plant growth on system water quality.[2] This type of approach is the most relevant for developing a site-specific water quality standard and requires the establishment of a nutrient-sensitive endpoint that represents a threshold above which an aquatic life use impairment is likely to occur. Once a threshold is established, the relationship between the nutrient and the response variable may be evaluated, using the site-specific calibrated model that accounts for confounding factors, to determine the numeric nutrient criterion necessary to ensure that the impairment endpoint is not exceeded.

The RESPEC Report presents numerous response metrics based on site-specific data from a floating periphytometer study and from surface samples of phytoplankton collected along the length of the river at a single point in time. Within the Report, taxonomic changes in periphyton and phytoplankton species were used as the major indicator of stressor response and adverse ecological effect. Detailed statistical evaluations are presented in the report to relate the influence of nutrient concentrations on the various response metrics, but no evaluation is presented to identify a threshold for aquatic life use impairment associated with any plant growth metric. Moreover, the RESPEC report did not contain documentation demonstrating that the changing metrics selected provide confirmation of significant ecological impairment.

Without a well-documented and defined impairment threshold, the proposed TP and TN endpoints were merely derived as the average concentration from observations at three stations having the strongest "negative" correlation with elevated nutrient concentrations (RESPEC at 64). The report identifies these sites as having the lowest periphyton biomass, the most desirable phytoplankton communities, and the lowest primary production in comparison with another group of sites. The report then states that the recommended endpoints should be considered nutrient targets to prevent nuisance algal growth in the Red River.

In my opinion, this is not a scientifically defensible method for deriving numeric nutrient criteria to protect aquatic life uses. Plant growth occurs in all healthy ecosystems and its variations are profound. In fact, without plant growth, higher-order organisms would have little capability of

[1] USEPA. 2010. Using Stressor-Response Relationships to Derive Numeric Nutrient Criteria. EPA-820-S-10-001

[2] See the discussion in USEPA (2010) at 37 (Deriving candidate criteria) and at 65 (Evaluate model accuracy).

surviving. While the analyses presented in the report show that lower productivity, less biomass, and potentially "less desirable" communities of periphyton and phytoplankton are associated with lower concentrations of TP and TN, no attempt was made to demonstrate how any of the measured plant growth metrics (artificially induced with floating periphytometers or from actual in-stream data) were indicative of significant system ecological impairment (commonly known as eutrophication). Thus, while productivity may be higher and communities "less desirable", it is not apparent that monitored conditions exceed a threshold that would be considered impaired (i.e., is ecologically significant and hence to be avoided). For example, you might consider an ambient dissolved oxygen concentration of 8.0 mg/L to be more desirable than an ambient DO of 6.0 mg/L, but that does not justify setting a DO criterion of 8.0 mg/L to protect aquatic life. Consequently, the proposed endpoints are not justified because they are not grounded in any demonstrable significant adverse impact from eutrophication or, for that matter, even the existence of a eutrophic condition.

It is noteworthy that most assessments of eutrophic use impairment are based on algal growth as assessed using chlorophyll-*a* concentration and the Minnesota Pollution Control Agency (MPCA) uses a growing season average periphyton chlorophyll-*a* concentration of 150 mg/m^2 and a phytoplankton chlorophyll-*a* concentration of 40 µg/L (southern rivers growing season average) as thresholds for use impairment in streams. The data presented in the report show very low levels of periphyton growth throughout most of the river (See, Table 2-3 and Figure 7-3) using data from *floating* periphytometers to ensure maximum growth. These data, of course, would significantly overestimate the actual attached plant growth occurring in the system, as suspended solids limit light penetration in the Red River of the North. Even so, these data suggest that nuisance algal growth is not occurring in this river, even under artificially ideal growing conditions. Similarly, phytoplankton samples were collected when the river flow was low and conditions for maximizing chlorophyll-*a* concentration were highest. Even under these conditions, the chlorophyll-*a* concentration was low in comparison with the MPCA standard, which is a growing season average and not an instantaneous maximum, or a "low-flow only" criterion. Together, these data indicate that the river is not impaired due to excessive algal growth under the current water quality and nutrient levels in the system.

- **Recommendation for TN Control Is Not Scientifically Defensible**

The RESPEC Report includes a recommendation for a total nitrogen endpoint of 1.15 mg/L to address a presumed eutrophication-based use impairment in the Red River of the North. My research has focused on the evaluation and control of eutrophication through the application of environmental models to predict the fate and transport of nitrogen and phosphorus in lotic and lentic systems. By and large, lentic systems (lakes) are more sensitive to eutrophication than lotic systems (rivers). My work in the Great Lakes system has demonstrated that phosphorus control is generally the only control necessary to limit excessive algal growth in these systems. Through this research, a phosphorus control strategy for the Great Lakes has been quite successful in reducing algal growth in these lakes. Based on this understanding, I was surprised to see the TN endpoint recommendation in the RESPEC Report.

Typically, algal growth control in fresh waters is accomplished by limiting the amount of phosphorus entering the system. Controlling nitrogen can also have negative ecological effects as it provides a competitive advantage for nitrogen fixing blue-green algal forms that can severely impair a freshwater system. The State of Minnesota has premised all its adopted nutrient criteria for lakes and streams on this understanding. Consequently, a justification for nitrogen

control in fresh waters requires demonstrating that phosphorus control is either incapable of controlling algal growth, or that nitrogen control alone, or in combination with phosphorus control, is necessary to reduce algal growth. The RESPEC Report does not contain any such demonstration and, therefore cannot serve as a scientifically defensible basis for the recommended TN endpoint. The Consensus Report cited "literature" supporting the need for TN control. However, as I have noted above, there is no consensus that TN control is necessary in fresh waters, and, if anything, the consensus is that it is not generally a good idea (Schindler et al. 2015). Moreover, while TP control has been shown to effectively limit algal growth in freshwater systems, I am not aware of any demonstration showing TN control is similarly effective or routinely necessary to preclude excessive algal growth.

The authors of the Consensus Report have suggested that a simple correlation analysis, as presented in Figure 2 of their analysis, is sufficient to make this demonstration. That is simply not correct and is not consistent with extensive literature to the contrary. Moreover, the relationship did not consider the correlation between TN and TP in the data. Consequently, the figure cannot be used to justify the need for TN control, absent a more robust and thorough analysis explaining why phosphorus control would be incapable of achieving the intended goal.

- **Necessary Goal of RESPEC Report Not Achieved**

As noted in my general comments, the stressor-response approach for numeric nutrient criteria development requires the identification of a nutrient-sensitive endpoint (e.g., excessive phytoplankton growth that would cause low DO at night) that represents a threshold above which an aquatic life use impairment is likely to occur. In fact, the Consensus Report noted that the Scope of Work under which the RESPEC Report was prepared included a requirement to identify such biological thresholds along a stressor (nutrient) gradient. The Consensus Report determined that specific biological thresholds were not identified by RESPEC. Without the identification of a specific biological threshold and an appropriate stressor-response relationship, scientifically defensible nutrient criteria cannot be developed. The RESPEC Report contains neither of these necessary components. Consequently, there is no confidence that the recommended endpoints are necessary to protect the aquatic life uses of the Red River of the North.

- **Periphytometer Data Should Not be used as the Basis for Nutrient Endpoints**

The RESPEC Report details how conditions in the Red River of the North presently limit the response of periphyton (and phytoplankton growth) to nutrient concentrations in the receiving water. Specifically, elevated suspended solids levels limit light penetration. Consequently, floating periphytometers (approximately one inch below the water surface) were used to evaluate the degree of periphytic growth that could occur if light penetration was not limiting. While this condition maximizes periphytic growth, it is not representative of actual conditions in the river or a rational basis for projecting future periphyton growth under "improved" suspended solids conditions.

Periphyton grow primarily on the river bottom, and even under an improved light regime in the Red River of the North, such growth would not reflect the growth found one inch from the surface. To use such information to set a scientifically defensible nutrient criteria, one would have to know the degree of light penetration occurring under the assumed future lower TSS level (see, Consensus Report at 5 which assumes a 100 mg/L TSS level or less will exist in the future). The RESPEC and Consensus Report nowhere address this critical factor (light penetration) that

controls plant growth in the River. Thus, while the use of floating periphytometers may be useful in identifying the forms of periphytic algae that are present in the river and possible maximum growth levels when growing conditions are optimized, these data are not representative of the relative biomass of these species occurring under existing conditions or reasonably expected to occur in the future. Failure to account for the effects of TSS on the light regime of the river was a fundamental deficiency of both reports.

Response to Specific Questions Posed

1. **Did the RESPEC Report use scientifically accepted methods to derive numeric nutrient criteria for TN and TP?**

No. As discussed above, the numeric nutrient criteria proposed in the RESPEC Report were not based on scientifically accepted methods and had several critical deficiencies. Nutrient criteria are developed to protect designated uses from excessive plant growth and the report failed to identify a threshold metric necessary to protect aquatic life uses or demonstrate the level of plant growth that would be excessive. Without these thresholds, numeric nutrient criteria cannot be scientifically determined. Furthermore, there was no attempt to determine whether TP and/or TN control was necessary to attain the desirable communities of periphyton and phytoplankton assessed in the report. The report merely assumed that the average concentration of TP and TN at the headwater stations was necessary to support lower biomass and more desirable communities. The report presents no scientifically defensible basis for this assumption, which is contrary to Liebig's Law of the Minimum[3], a law of nature underpinning nutrient control strategies throughout the United States and the Great Lakes.

2. **Are the concerns raised by Hall & Associates scientifically valid?**

The Hall Report identified several areas of concern. On review, these concerns focus on three primary areas: lack of an impairment threshold, use of periphytometer data to represent conditions in the river, and the need for TN control to achieve use attainment. In general, these were valid critiques that identified fundamental deficiencies with the RESPEC Report.

In particular, regarding TN control, I concur that far more detailed evaluations are needed to demonstrate the need for TN control. Moreover, the RESPEC Report indicates that the explained algal variance attributed to nutrients was relatively small (15% for periphyton, 16% for phytoplankton) for the specific metrics considered. The explained variance is very low and suggests that the confidence interval around the analysis is very large. If these confidence intervals were reported, it would likely show a range in criteria that make the results of very limited use. I agree with this assessment.

3. **Did the Consensus Report resolve the primary technical issues identified in the Hall Report?**

The Consensus Report characterizes itself as a peer review of the RESPEC Report. As part of this review, the Consensus Report considered five questions. The first question addressed review of the comments in the Hall Report. Overall, the Consensus Report concluded that the concerns identified by the Hall Report were not sufficient to invalidate the RESPEC Report and supported

[3] Simply put, Liebig's Law of the Minimum states that growth is dictated not by total resources available, but by the scarcest resource (the limiting factor).

the proposed TN and TP criteria. I disagree with this finding of the Consensus Report for the reasons discussed above, and those discussed in greater detail below.

The authors attempted to support their conclusion by presenting plots of periphyton chlorophyll-*a* versus nutrient concentration for sites with TSS concentrations below 100 mg/L. They claimed a strong relationship between nutrient concentration and periphyton chlorophyll-*a*, and recommend that the simple relationships (Figure 1, Figure 2) should be included in the RESPEC Report to support the conclusions given the low explanatory power of the multivariate analyses. (Consensus Report at 5). Those relationships are presented below.

Figure 1: Periphyton Chl-a vs TP

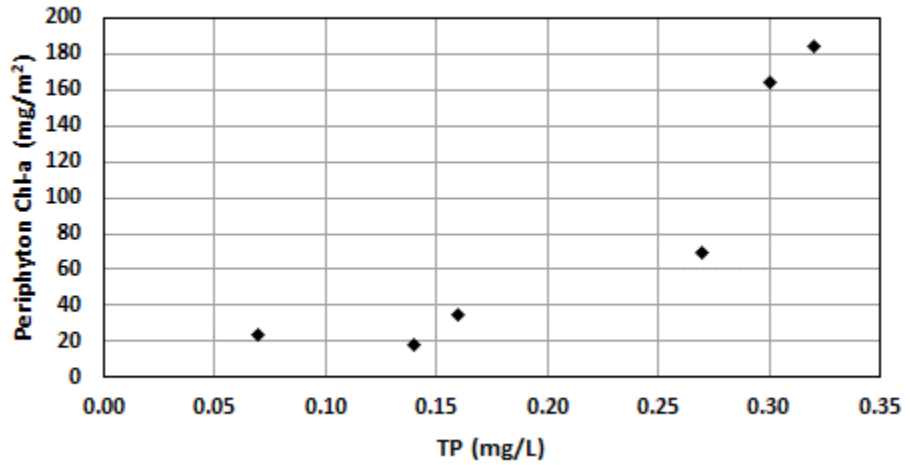
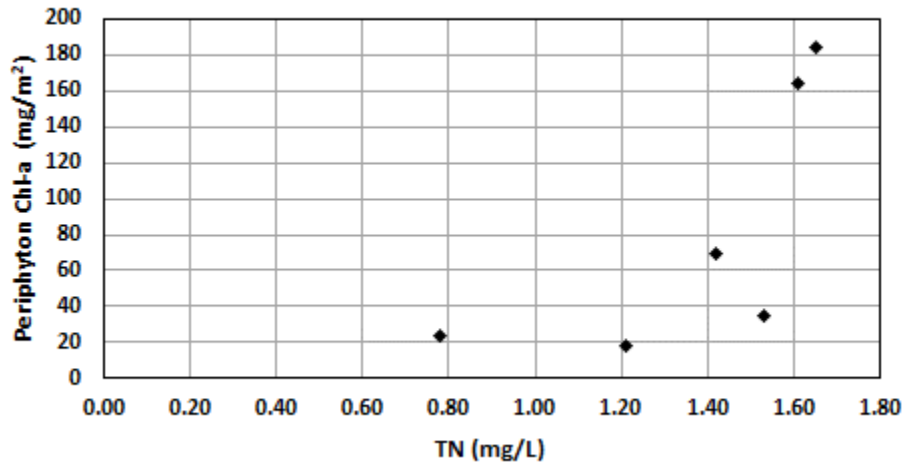


Figure 2: Periphyton Chl-a vs TN

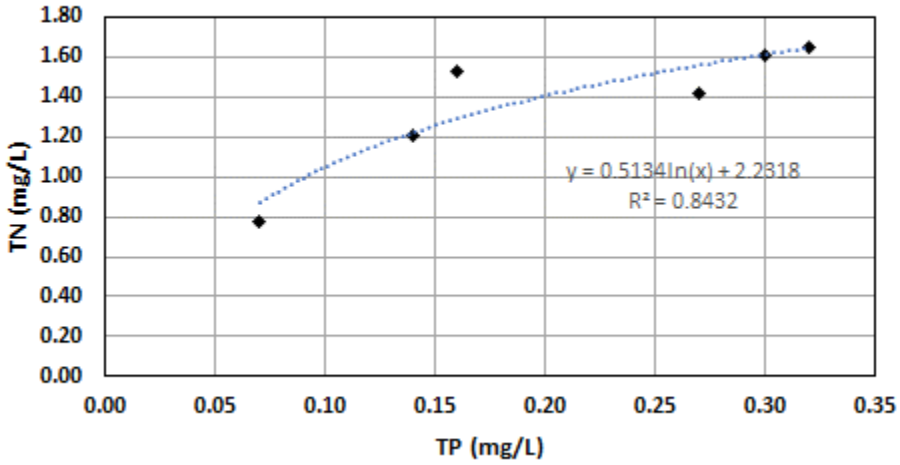


The suggestion that these relationships support the proposed criteria is not scientifically defensible. The simple relationships present maximum periphyton growth on surface mounted slides as if it represents conditions expected to occur in the river. It does not. Moreover, the

maximum periphyton levels at the proposed nutrient criteria concentrations are less than 40 mg chlorophyll-*a*/m^2. This is an exceedingly low level of periphyton biomass and is not recognized as a threshold of impairment by anyone that I am aware of. For example, the State of Montana (Suplee et al. 2009) used public perception surveys to determine that mean bottom algae levels < 150 mg chlorophyll-*a* /m^2 were found to be desirable. These results were consistent with earlier work in the literature suggesting that 100-150 chlorophyll-*a* /m^2 represents a benthic algae nuisance threshold (Horner et al. 1983, Welch et al. 1988, etc.) as well as the Minnesota Pollution Control Agency (MPCA) growing season average periphyton chlorophyll-*a* concentration of 150 mg/m^2.

Moreover, these data are presented as "cause and effect" relationships. However, as I illustrate below in Figure 3, the TP and TN concentrations from Figure 1 and Figure 2 are themselves correlated! Consequently, these data are also insufficient to determine whether TN should be regulated. Finally, I would note that all the periphyton measurements are associated with nutrient levels that far exceed growth limiting concentrations (typically in the 10-20 µg/L range). Thus, it is not apparent why periphyton growth more than "doubled" from 0.27 mg/L TP to 0.32 mg/L TP. It is possible that this was simply a function of measurement variability. In any event, without a more detailed assessment, it is not possible to attribute this apparent change in plant growth to TP concentrations as all conditions had sufficient TP present to allow maximum growth to occur. The fact that periphyton growth was over five times greater at some stations indicates that other unidentified confounding factors are influencing growth.

Figure 3: TP vs TN



The remaining four questions addressed in the Consensus Report focused on the development and application of the stressor-response model in the RESPEC Report. The Consensus Report identified specific charges in the original scope of work and noted that a key goal of the RESPEC Report was "to develop a stressor-response model for the Red River and to use the model to identify biological thresholds/criteria which quantify the thresholds at which biologic response variables in the Red River respond to nutrients". With respect to this goal, the Consensus Report noted, "They did not identify specific biological "thresholds" (point 6), rather they found conditions in least impacted areas and used those to recommend criteria." Thus, the Consensus Report in fact agreed with the Hall Report regarding a major deficiency that precluded the development of valid stressor-response based nutrient criteria.

This is the crux of the matter. Notwithstanding the other serious deficiencies of the analysis, without a threshold to evaluate use attainment, a scientifically defensible nutrient target cannot be identified.

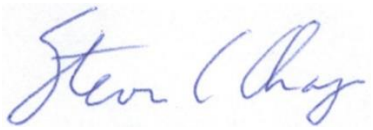
4. Are the nutrient criteria under consideration scientifically defensible?

No. The evaluations presented in the RESPEC Report evaluated numerous biological metrics but did not show how any of these metrics affect aquatic life uses or at what threshold value aquatic life uses would be impaired. Consequently, there is no way of evaluating whether the proposed numeric criteria are appropriate. In addition, the Report did not present a stressor-response relationship along a nutrient concentration gradient, contrary to the explicit scope of work requirement. Instead, the criteria were determined as the average concentration from three sites with an artificially maximized periphyton chlorophyll-*a* concentration of 19.5 mg/m^2. I cannot imagine any circumstance where this level of periphyton growth would represent a threshold for aquatic life impairment. If the effect of confounding factors such as TSS are properly considered, the actual amount of periphyton growth in the river would be much lower and the necessary numeric nutrient criteria will be much higher than the proposed limits.

Conclusion

I hope that you find my observations helpful in determining the best path forward for protecting aquatic life uses in the Red River of the North in a cost-effective and sustainable fashion. At this point, I do not see any defensible basis presented for asserting that a TP criterion of 0.15 mg/L and a TN criterion of 1.15 mg/L are required to protect or restore uses in the river.

Sincerely,



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