ATTACHMENT 1

Review of:
The Development of a Stressor-Response Model for the Red River of the North

RESPEC
June 2016

Prepared For:

Cities of Breckenridge, Moorhead, Roseau, Warroad, and Thief River Falls

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Introduction

In its report, The Development of a Stressor-Response Model for the Red River of the North (June 2016; hereafter, the Report), RESPEC developed total nitrogen (TN) and total phosphorus (TP) targets for the Red River of the North to assist the International Joint Commission (IJC) in its efforts to develop a collaborative, scientific, and watershed-based approach to reducing nutrients with the goal of restoring and protecting aquatic ecosystem health and water uses in the Red River watershed and Lake Winnipeg. This effort, which focused primarily on assessing the U.S. portion of the Red River (bounded by MN and ND) was hampered by natural conditions present throughout the Red River (sediment, turbidity) that significantly limit plant growth, the primary metric used by Minnesota in assessing aquatic life protection.

As a consequence, the Report relied on artificial methods to encourage plant growth where it does not normally occur. In addition, the Report utilized biometrics with no approved or apparent relationship to aquatic life use impairment thresholds as a basis to evaluate the effect of nutrients on algal conditions in the river. Based on these evaluations, the Report proposes restrictive nitrogen and phosphorus targets for consideration by the IJC. As discussed below, the methods and the proposed endpoints should not be used to establish nutrient management goals because none of the conditions assessed bears a reasonable relationship to actual ecological conditions or aquatic life use protection needs.

Primary Issues of Concern

1. The recommended nutrient target limits presented in the Report (at 64) were based on a skewed evaluation of non-representative data and are not related to any accepted metric of aquatic life use impairment. Consequently, the recommended nutrient target limits are not scientifically defensible.

The study included an evaluation of periphyton growth at 30 locations along the main stem of the river. In order to evaluate periphyton growth, which naturally occurs on the *bottom* of the river[1] when growing conditions are favorable, the researchers used glass slides on a *floating* apparatus in an effort to maximize the growth of periphyton and overcome the naturally high turbidity in the river which precludes growth on the benthic substrate. (Report at 23-24). Consequently, the biomass and periphytic communities observed on these floating sample chambers do not reflect the natural or existing condition of the river and cannot be used to infer any information with respect to actual aquatic ecosystem health or impairment.

The biological metrics, used to assess whether the artificially-grown periphytic algal communities are desirable, included measures such as saprobity metrics, nutrient tolerance, and nitrogenuptake metabolism group (Report at 39 – 44). While these metrics are found in the literature, we are not aware of any basis for relating these metrics or the proposed“thresholds” used in the report to use impairment or attainment. Consequently, the use of these metrics cannot serve as the basis for establishing an aquatic or ecosystem impairment

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[1] Minnesota Rules (7050.0150 Subpart 4.Y) define periphyton as algae on the bottom of a water body. In rivers or streams, these forms are typically found attached to logs, rocks, or other substrates, but when dislodged the algae will become part of the seston.

threshold for TN or TP without a showing that uses are impaired when the metric exceeds a specific threshold. Moreover, as noted above, the evaluation of these metrics was based on growing conditions that are not representative of actual or reasonably projected conditions in the river. Therefore, the relevance of these measurements to assessing aquatic ecosystem health in this system is completely unknown.

In developing the proposed nutrient target limits, the report ignored the vast majority of the data collected and considered only three locations which the authors claimed exhibited the strongest taxonomic response to TN and TP. These sites were characterized as having the lowest biomass and most desirable communities of periphytic algae (Report at 63). A site with the lowest biomass is not a presumed condition that is required for a healthy aquatic ecosystem. In fact, periphyton biomass was low (< 100 mg/m^2) through the entire river to the US-Canada border (a distance of approximately 350 miles), even under the artificially maximized growing conditions used. Similarly, phytoplankton growth, as measured by chlorophyll-a concentration, was also uniformly low and would not have been considered impaired under Minnesota regulations.

> "In light of the complications within the Middle zone of the Red River where suspended sediment was found to limit periphytic algal productivity, the analysis shown in Figure 7-14 sought to determine which sites from the study had the strongest taxonomic response to phosphorus and nitrogen so that <u>only nutrient results from these sites would be used for nutrient target averaging</u>." (Report at 63)(Emphasis added.)

> "[n]utrient averages of the <u>three sites having the strongest negative correlation with high nutrients were calculated</u> resulting in 0.15 mg/L for TP and 1.15 mg/L for TN." (Report at 64) (Emphasis added.)

The average TP and TN concentrations for these three sites, which the reports suggests exhibit a "strong taxonomic response," was used to set the nutrient target limits. This is a skewed analysis with no objective relationship to overall ecosystem protection needs. The majority of the study sites did not show a "strong taxonomic response" even though the location of the periphtyometers at the water surface should have ensured adequate surface light. The "strong" response, to the degree it exists, represents only a minor portion of the overall river. The apparent "strong" response was speculative, based on esoteric endpoints and confounded influences of non-nutrient parameters which were not identified. (Report at 50)

2. The recommended nutrient target limits establish TN concentrations claimed necessary to protect aquatic ecosystem health. The establishment of a TN target is inconsistent with MPCAs adopted RES criteria and are not scientifically defensible because they are based *on metrics that are not accepted use impairment metrics.*

The Minnesota Pollution Control Agency adopted river eutrophication standards (RES) in 2014 to protect aquatic life uses from the effects of cultural eutrophication. The RES are based on measurements of TP, phytoplankton chlorophyll-a, biochemical oxygen demand, and dissolved oxygen flux. TN is generally not considered a nutrient of concern with regard to eutrophication in rivers because TP is generally considered the limiting nutrient for fresh water systems. Consequently, the claim in this report that TN must be controlled to protect aquatic ecosystem health, in addition to TP, requires specific documentation of the efficacy of such additional regulation. The apparent basis for establishing the recommended nutrient target limit for TN was a taxonomic metric for nitrogen uptake metabolism by periphytic algae – this is not an impairment endpoint for aquatic life and is therefore irrelevant to setting protective ecosystem criteria.

> A stressor-associated shift was also seen between the river zones with the nitrogen uptake metabolism metric shown in Figure 7-8 and was accomplished through direct, constrained ordination procedures. (Report at 59)(Emphasis added.)
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> The nitrogen-influenced metric shifted between the zones from taxonomic groups that were tolerant of excessive nitrogen to those dependent upon it, which matches the dramatic increase in total nitrogen and its constituents between the Headwater and Middle/Mouth zones (Table 7-1). (Report at 60)(Emphasis added.)

We are not aware of any thresholds for this metric that delineate use attainment from impairment. Consequently, the use of this metric cannot serve as the basis for establishing an impairment threshold for TN without a showing that uses are impaired when the metric exceeds a specific threshold. Moreover, the taxonomic measurements were taken from surface mounted samplers in an effort to maximize periphyton growth in a system with limited periphyton growth. Such measurements are not representative of actual conditions in the river and its relationship to aquatic ecosystem health is unknown. Therefore, the recommended TN target has not been shown to be necessary in this system.

3. The primary assessment metric, periphyton growth, was based on surface mounted samplers that have nothing to do with actual plant growth conditions in the river.

The report discusses the use of floating substrates to overcome the high level of TSS present in the river and maximize the growth of periphyton. (Report at 23-24). These data artificially increase the actual level of periphyton present, are not representative of actual conditions in the river, and cannot be used as the basis for establishing nutrient concentrations to protect aquatic ecosystem health.

The Report notes at the outset that the river contains a substantial amount of suspended solids that limit algal growth. These sediments are primarily contributed by the prevalent soils and are fine-sized particles which remain suspended in the water column. (Report at 6) These sediments significantly limit light and influence eutrophication response in the river. (Report at 21). As discussed in the Report, surface mounted samplers were used to overcome the light limitation of the ambient water and maximize algal growth.

> Although identifying existing in situ substrate (e.g., wood, rocks, or mud) would have provided a more natural estimate of periphytic algal growth in the river, the project team determined that floating periphytometers were necessary to accurately survey the attached algae along the river reach (see Section 6.1). (Report at 23)
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> Artificial substrates (periphytometers) that consist of float-mounted racks with glass microscope slides, as demonstrated in Figure 6-1, were employed to collect periphyton (attached algae) samples from the Red River during the summer of 2015. … Colonization slides floated just below the surface (approximately 1 inch). (Report at 24)

> Periphytometers were retrieved after approximately 4 weeks of repeated visits to ensure maximum colonization yet no biomass sloughing. Flows within the Red River were low during the time of deployment, which created ideal growth conditions. (Report at 35)

As described, the periphyton data were developed in a manner to disregard ambient limitations to algal growth and maximize periphyton growth by limiting the effect of turbidity or biomass sloughing. The results of such testing are artificial and have no bearing on actual periphyton growth in the river or the ability of nutrients to stimulate such growth under natural conditions.

4. The Report claims to have followed USEPA's stressor-response guidance (2010) in developing the proposed nutrient targets, but it is clear that this was not done. The analyses presented in the report are scientifically deficient and do not support the proposed nutrient targets.

The USEPA Guidance on Using Stressor-Response Relationships to Derive Numeric Nutrient Criteria (USEPA, 2010) was finalized after review of the draft document by the EPA Science Advisory Board (SAB, 2010). The SAB noted that for stressor-response relationships to result in scientifically defensible numeric nutrient criteria, the metrics used in the evaluation must be clearly linked to aquatic life use impairment, confounding factors must be identified and accounted for, and the explanatory power of the analysis must be sufficient to establish criteria without significant over-protection or under-protection. None of these key components were considered in the development of the proposed nutrient targets.

Several metrics were included in the analysis, including: periphyton chlorophyll-a (mg/m^2), various periphyton taxonomic metrics (saprobity metrics, nitrogen uptake metabolism metrics, percent nutrient tolerance), phytoplankton chlorophyll-a (µg/L), and phytoplankton cyanobacteria bio-volume. Of these, only phytoplankton chlorophyll-a concentration is used as a numeric use impairment indicator (by MPCA), and the observed levels of periphyton and phytoplankton chlorophyll-a are well below the level indicative of use impairment. (Report at 38, Table 7-1). The taxonomic metrics have no reported thresholds for use impairment, but these taxonomic metrics appear to be the basis for the proposed nutrient targets.

The stressor-response guidance indicates that confounding factors must be identified and accounted for – not ignored by use of artificial means. (See, USEPA, 2010 at 5, 11).

> [C]onceptual model diagrams provide a graphical means of identifying potentially *confounding variables*, which are defined as variables that can influence estimates of the stressor-response relationships (see Section 3.1). (Guidance at 5)

For example, clear lakes would require a lower TP concentration to meet a chlorophyll-a threshold concentration while lakes with naturally colored water would require a higher level of TP before the chlorophyll-a threshold was exceeded because color reduces the amount of light transmittance through the water, thus limiting algal growth. Consequently, the water quality criteria developed for Florida lakes provided separate TP criteria for colored and clear lakes. The Report claims that it addressed confounding factors as described in the USEPA Guidance, when in fact it expressly sought to disregard the confounding factors influencing nutrient dynamics and plant growth in this system.

> "Covariables in the partial RDA allowed for the effect of nutrients on the algal community to be more fully discerned without the influence of TSS. Coincidentally, this step satisfies the final step (Step 4) of the USEPA stressor-response guidance [USEPA, 2010] of evaluating the stressor with regard to a confounding variable". (at 60) (Emphasis added.)

Rather than accounting for the effect of TSS on the ability of nutrients to influence the algal community (e.g., nutrient impact not expressed due to high TSS), the analysis presented in the report claims a nutrient-related effect on the algal community if the TSS present in the river could be removed. This is contrary to the intent of the Stressor-Response Guidance and has no bearing on the nutrient concentration targets necessary to protect aquatic ecosystem health under the conditions actually existing in the river.

The Stressor-Response Guidance and the SAB review both discuss the importance of the coefficient of determination (R^2) for the regression models used to relate nutrient concentrations to the metrics being evaluated. The R^2 measures the proportion of variance in the response that is explained by the regression model. When this proportion of explained variance is low, the confidence interval around the regression becomes large, making the uncertainty in the nutrient target unacceptable. By way of example, the SAB commented that a large degree of scatter remains for a $R^2 = 0.19$, resulting in an unacceptable interval between the upper and lower 90% confidence interval. By comparison, the coefficient of determination reported for periphyton was 0.15 and 0.16 for phytoplankton. (Report at 60) The Report does not present upper and lower confidence intervals so there is no way of knowing whether the proposed nutrient targets are acceptable with respect to variability.

5. Reported effects on taxonomic metrics and algal growth may not be related to instream nutrient concentrations but may be caused by adjacent land use characteristics.

Related to the lack of confounding factors analysis, the Report presents information suggesting that the observed taxonomic metrics may be in response to *adjacent land use characteristics* and *not* a response to nutrient concentrations in the river, particularly with regard to the saprobity groupings which respond to oxygen saturation and BOD concentration.

> Previous surveys by NDDH personnel indicated significant dips in DO adjacent to these wetlands following minor flooding events. Personnel hypothesized a potential relationship between the wetlands and DO because of potentially high BOD being introduced from the wetlands. As is commonly observed, dense algal blooms occur in these oxbow wetlands, which result from their retention and uptake of nutrients and the subsequent excessive bacterial respiration associated with the dead algae decomposition. The MPCA DO data discussed above (consistently measured below 5 mg/L) were collected from an area of the river within the stressor-response study algal sample sites that were seen to be closely associated with the percentage of riparian wetlands, as shown in Figure 7-13. (Report at 61)(Emphasis added.)

> [j]ust upstream of this sampling site is a small tributary that exhibits excessive algal growth, as seen from somewhat dated (ca. 1991) aerial imagery (Figure 7-20) from Google Earth. These same aerial views of the areas immediately adjacent to the algae clogged streams indicated abundant agricultural practices in the area with a high potential for nutrient runoff. This interesting pattern is not proof of causation but it definitely warrants additional

investigation into the potential source of high BOD/low DO and subsequent stressor influence on the biological communities. (Report at 62) (Emphasis added.)

The coefficient of determination associated with adjacent land use characteristics explained the greatest amount of variance in the data. Ignoring this fact demonstrates that the analysis was skewed and that confounding factors received no serious consideration.

Conclusions and Recommendations

As noted above, the Report relied on data that are not representative of actual conditions in the Red River of the North. Consequently, the nutrient endpoints developed from an evaluation of those data have no relevance to conditions in the river or nutrient requirements to ensure the restoration and protection of aquatic ecosystem health. In addition, the report employed metric targets (saprobity metrics, nitrogen uptake metabolism metrics, percent nutrient tolerance, and phytoplankton cyanobacteria bio-volume) that are not recognized as measures of use attainment by Minnesota, North Dakota, or Canada. Consequently, the nutrient endpoints bear no relationship to use attainment and should not be used as a basis for restoring and protecting aquatic ecosystem health and water uses. Finally, the recommended nutrient targets were developed without a proper consideration of confounding factors. Not only did the methodology attempt to negate the influence of natural suspended solids and turbidity in the river, but it also ignored how adjacent land use characteristics influenced the response and presumed the observed effects were caused by the ambient nutrient concentration. Because of these manifest deficiencies, the proposed nutrient endpoints are not scientifically defensible. Notwithstanding these flaws in the analysis, the recommended nutrient endpoints would suggest that the entire river is impaired. This conclusion is in direct conflict with the MPCA/USEPA approved River Eutrophication Standards which indicate that the levels of phytoplankton and periphyton biomass found are well below the thresholds for use impairment.

Based on these evaluations, it is apparent that algal growth in the river is greatly reduced by the ambient light limitations in the river, and cultural eutrophication is not causing excessive algal growth or other use impairments in the Red River of the North. The future focus should be on the restoration of aquatic ecosystem health and water uses in Lake Winnipeg, where use impairments and TP targets are more easily defined.