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May 22, 2009

BROWN AND CALDWELL

Mr. Peter H. Rice, P.E.
City of Portsmouth Public Works
680 Peverly Hill Road
Portsmouth, NH 03801

Subject: **Review of NH DES Draft Wasteload Allocation Methodology**

Dear Mr. Rice,

As requested, Brown and Caldwell and Applied Science Associates have completed a technical review of the Methodology for Wasteload Allocation for the Cocheco River Watershed (Methodology) developed by the New Hampshire Department of Environmental Science (NH DES). This letter summarizes the findings of our technical review and makes conclusions and recommendations for the finalization of the Methodology in consideration of the lasting impact the results of the wasteload allocation will have on wastewater treatment facilities in the City of Portsmouth and the entire NH Seacoast Community.

1.1 Introduction

The New Hampshire Department of Environmental Services (NHDES) issued the *Methodology to Determine Wasteload Allocation for Wastewater Treatment Facilities* (WWTFs) *in the Cocheco River Watershed* (Methodology) on March 27, 2009. The purpose of the Methodology is to allocate nutrient loadings from each WWTF discharging to the Great Bay Estuary. This first evaluation will be used as a blueprint for allocations in other watersheds, including the Upper and Lower Piscataqua. For the Cocheco River, the nutrients of concern are nitrogen and phosphorus. However, the Methodology only addresses nitrogen loadings and does not address phosphorus loadings.

The following sections discuss the approach, assumptions, data used, and conclusions made in the Methodology. The discussion is structured around major parts of the methodology including:

- Use of mass balance model
- Estimation of nitrogen loading targets
- Determination of target "dry" condition nitrogen loading target
- Attenuation coefficients – USGS sparrow model & Cocheco River size classification
- Calculated point and non-point source nitrogen load to the Cocheco River assessment zone wasteload allocations - scenarios for different TN limits

1.2 Use of Mass Balance Model

The Methodology references the model described in "Mixing in Coastal Inland and Coastal Waters" (Fischer et al., 1979). This is a simple mass balance model to determine nitrogen wasteload allocation and, as such, is only appropriate for simple watersheds. This model is not appropriate for a complex estuary system like the Great Bay Watershed.

The dataset used by the NHDES to validate accuracy of model predictions is inconsistent and unrepresentative of the dataset used for model inputs. The authors use simplifications to estimate central tendency nitrogen concentrations, but notes that salinity must represent "steady state" conditions to be applicable. The salinity and nitrogen data used in the mass balance model were from median concentrations in sub-estuaries from sampling in 2002-2004 and used to compare model predictions for offshore waters in the Gulf of Maine in 2008. This modeling assumes that salinity concentrations during the 2002 – 2004 and 2008 periods were at steady state conditions and that these data are congruent. Steady state salinity conditions are unlikely to occur in the Great Bay Estuary due to the significant currents, tidal flushing and volume of stormwater runoff tributary to the estuary. Therefore the use of the Fischer model is not justified, and an alternative method of modeling the Great Bay Estuary is necessary

In addition, comparing the 2002-2004 and 2008 incongruent data sets and drawing conclusions from them cannot be supported with the sparse volume of data collected.

Besides the implications to the model, it is important to establish valid salinity concentrations in the development of the mass balance model because of the impact of salinity on nitrogen concentrations and fate in an estuary environment. Typically, there is an inverse, linear relationship between salinity and dissolved inorganic nitrogen concentrations in estuaries. Salinity also affects the stratification of estuarine waters and high runoff periods can lead to low salinity and high stratification within the water column. Ionic strength is also directly related to salinity and can affect the activity and nitrogen fixation of microorganisms.

The Methodology should address how the apparent lack of steady state salinity in the data affects the ability to apply the use of a simple mass balance model similar to the model referenced in the Methodology.

1.3 Estimation of Nitrogen Loading Targets

The Methodology used "dry" conditions represented by nitrogen concentration data from 2001 instead of "typical" conditions represented by data from 2007 to establish the nitrogen loading target for the Cocheco River Assessment Zone. Dry-condition nitrogen loading was shown as 111 tons per year and is a lower target than the

nitrogen loading under typical conditions of 136 tons per year. Using dry conditions as a basis establishes a lower allowable effluent nitrogen concentration from the WWTFs discharging to the Cocheco River. The reasoning behind the use of dry weather conditions versus typical conditions to represent the nitrogen loading target was not justified. Due to the large difference in nitrogen loading between dry and typical conditions (25 tons/year), the use of this approach must be justified with additional supporting information.

1.4 Determination of Target "Dry" Condition Nitrogen Loading Target

The Methodology indicates that data needed to calculate an accurate median value of salinity in the Cocheco River (assessment zone) was incomplete for this Assessment Zone ("not enough salinity measurements"). The method for back-calculating ocean flushing and salinity in the Cocheco River Assessment Zone for the 2001 "dry condition" used flushing rate (not tidal flow) and salt mass balance from 2007. The statement indicating justification due to a static water level in the estuary during dry conditions (compared to typical) is not supported by data. The justification that water level is static due to ocean water entering the estuary also indicates that during dry weather, the additional inflow from ocean water would carry higher salinity and different nitrogen background conditions in the estuary compared to "typical" conditions. The impact of ocean water inflow on the dry weather condition nitrogen loading target should be analyzed before using this as the basis for wasteload allocations. The flow and salinity data sets have been mixed, and therefore have no statistical relevance and cannot be used for comparative analysis.

1.5 Attenuation Coefficients –USGS Sparrow Model & Cocheco River Size Classification

The method for determining the size classification and, as a result, attenuation factor for the Cocheco River Estuary was not justified or supported clearly in the Methodology. Based on the USGS Sparrow model and associated attenuation coefficients referenced in the Methodology, the size classification of the stream being modeled has significant impacts on the value of the attenuation coefficient and the amount of attenuated or "lost" nitrogen in the stream or river.

The following were the flows defined in the Methodology for the Cocheco River in the Assessment Zone:

- Minimum flow (at the Farmington WWTP) of 72.1 cubic feet per second (cfs)
- Maximum flow (near Dover at the Tidal Dam) of 284.5 cfs.
- Mean stream flow (Sparrow model shapefiles) of 140.5 cfs

The following were the size classifications defined for small and medium-sized rivers using the USGS Sparrow model referenced in the Methodology:

- Medium stream flow (q) = 200 <q< 1000 cfs; or q<1000 cfs.
- Small stream flow of q< 200 cfs.

Note that the mean stream flow for the Cocheco River, based on Sparrow shapefiles, is 140.5 cfs and should be characterized as a small stream under the definitions presented in the Methodology.

The Methodology presents the attenuation coefficients calculated for certain stream sizes that were used in the Sparrow model referenced. Based on the size classification, the following were the attenuation factors (based on stream size):

- Medium streams:
  - Farmington: 35% to 42% loss of nitrogen per day
  - Rochester: 17% to 21% loss of nitrogen per day
- Small streams:
  - Farmington: 66-67% loss of nitrogen per day
  - Rochester: 38% loss of nitrogen per day

The Methodology characterizes the Cocheco River as strictly a medium stream using Sparrow model definitions and, what appears to be maximum flow. It is not clear or justified as to which flow for the Cocheco River was used to define overall stream size classification.

The model used in the Methodology averages the medium stream loss percentage through attenuation for Farmington. The following is the result of this averaging and the attenuation loss percentages used to determine the nitrogen load from the Rochester and Farmington WWTFs:

- Farmington: 39% loss to attenuation
- Rochester: 19% loss to attenuation

The Methodology refers to these attenuation loss percentages, but erroneously claims that "these selected attenuation factors predict that 39% and 19%, respectively, of the nitrogen discharged from the WWTFs will be delivered to the estuary." It is our understanding that an attenuation loss factor is used to calculate the amount of nitrogen "lost" through attenuation and not "delivered", as the Methodology states. Therefore, using the calculated attenuation factors for Farmington and Rochester of 39% and 19%, respectively, the calculated predictions for the percentage of nitrogen delivered to the estuary should be:

- Farmington: 61% delivered
- Rochester: 81% delivered

These delivered percentages of nitrogen loads are much higher than what is calculated in the Methodology and stress the need for justification for using a medium stream size classification and associated attenuation coefficient versus a small stream size classification. Note again that the mean stream flow for the Cocheco River, based on Sparrow shapefiles, is 140.5 cfs and would be characterized as a small stream under the definitions presented in the Methodology.

If the averages of small stream attenuation factors were used, the following would be the percentages of nitrogen loads from the Farmington and Rochester WWTFs lost to attenuation and delivered to the estuary:

- Farmington: 66.5% lost/attenuated, 33.5% delivered
- Rochester: 38% lost/attenuated, 62% delivered

As shown, the percent lost to attenuation based on a small stream size classification are significantly higher than the percent lost based on a medium stream size classification.

1.6 Calculated Point and Non-Point Source Nitrogen Load to the Cocheco River Assessment Zone

The Methodology states that WWTF loads were calculated using "at least monthly measurements of total nitrogen in effluent during 2008". It is unclear which data from WWTFs were used from the New Hampshire Estuaries Project (NHEP) measurements from 2006 to 2008, and why data from only 2008 appeared to be used to calculate WWTF nitrogen loads. It is also unclear and not justified in the Methodology how effluent data from WWTFs in 2008 can be evaluated against a dry weather condition nitrogen loading target during the dry year of 2001. The flows and associated WWTP effluent nitrogen loads during the dry weather year of 2001 would likely be lower than effluent nitrogen loads in 2008.

The assumptions made to estimate non-point source (NPS) nitrogen loading downstream of the tidal dam are not clear or justified in the Methodology. The Methodology notes that the NPS load downstream of the tidal dam was estimated "using average nitrogen yield from watersheds without upstream WWTFs (1.39 tons N/yr/sq.mi.)". The Methodology does not indicate where this nitrogen yield was acquired and does not give supporting reference information. It is imperative that this NPS nitrogen yield be representative of the watersheds and the land use it of the Cocheco River Assessment Zone that it is being applied to in this method. As understood, watershed characteristics (runoff, groundwater loads, etc) and land use in watersheds (i.e. agriculture, commercial/industrial use, transportation, etc.) have major influences on nitrogen yield from NPS. The Methodology should describe the watershed characteristics and land use for the nitrogen yield used to estimate NPS nitrogen load for the area downstream of the tidal dam.

1.7 Wasteload Allocations - Scenarios for Different TN Limits

Table 4, *Wasteload Allocations and Percent Reductions in NPS Needed to Reach Loading Target*, provides various scenarios for WWTF effluent TN limits versus non-point source (NPS) nitrogen reduction to meet the dry weather condition total nitrogen

loading target of 111 tons of nitrogen per year. These scenarios are predicated on the assumptions that the TN limits of 3, 5 and 8 mg/L could be met at the WWTF discharge. The assumption that effluent limits of 3 or 5 mg/L TN are achievable with biological nutrient removal (BNR) processes is not accurate. In reality, limits below 5 mg/L will be difficult to achieve on an annual average basis utilizing BNR systems. Further, with specific BNR treatment processes already utilized in the watershed, limits below 8 mg/L may be difficult to achieve. This is supported by ongoing WERF-funded research on the Limit of Technology (LOT) for BNR systems using actual data from operating BNR WWTFs in the US as case studies. This is also supported by previous EPA research into the LOT.

The assumption that TN limits of 3, 5, and 8 mg/L are achievable in New England climates provides the false hope that a significant reduction in point source TN discharge will provide for potentially achievable reductions in non-point source (NPS) TN by 30% (or less). As shown by data in the current WERF and past EPA studies, costly WWTF BNR upgrades targeted to meet limits of 3 or 5 mg/L TN will not achieve these results. Therefore, additional NPS reduction will be required, beyond a 30% reduction. These reductions in NPS are unlikely to be achieved as well, given that EPA has stated that NPS reductions above 10% are unlikely based on experiences in Lake Champlain and other regions where NPS nitrogen load reduction has been attempted in the US.

2. CONCLUSIONS

The overall approach used in the Methodology is not well defined or justified by supporting information shown in the Methodology. The assumptions used to determine the nitrogen loading target and attenuation coefficients from stream classification are not justified and appear to misrepresent conditions in the Cocheco River sub-estuary that underestimate background nitrogen concentrations and loads from non-point sources.

Furthermore, previous comments on the Proposed Nutrient Criteria for the Great Bay Estuary have not been addressed by NH DES. Despite the indication that these comments would be addressed before a method for wasteload allocation was developed, the nitrogen concentration thresholds for water quality based on dissolved oxygen and eelgrass health determined by the Proposed Nutrient Criteria for the Great Bay Estuary have been used as a basis for nitrogen wasteload allocation. It is recommended that the finalization process of the Methodology include steps to address comments on the Proposed Nutrient Criteria for the Great Bay Estuary.

The wasteload allocation is based upon background nitrogen levels which were developed as part of the previous estuaries study. These levels were derived to either support eel grass habitat or provide sufficient dissolved oxygen levels within the

estuary. Previous comments regarding the background level must be addressed before the wasteload allocation can be finalized.

3. RECOMMENDATIONS

Overall, it is recommended that the NH DES address these review comments and justify the major modeling assumptions and data used As it exists now, the Methodology does not use representative data in model assumptions and model results cannot be justifiably used to allocate nitrogen wasteloads in the Cocheco River sub-estuary and the Great Bay estuary.

Specifically, the use of a simple mass balance model to determine wasteload allocation in a complex sub-estuary system needs to be justified more clearly with supporting information and recent examples of where this approach has been previously used. It is recommended that the determination of target nitrogen loads in the Cocheco River sub-estuary and in future methods for other sub-estuaries be based on average or typical conditions rather than "dry weather" conditions to more accurately establish a representative baseline for wasteload allocation. This change would result in a higher allowable WWTF total nitrogen discharge.

The determination and use of attenuation coefficients must be better defined and justified in the final methodology. It is not clear how the use of "medium" stream attenuation coefficients can be applied to the Cocheco River when the flow data presented in the Methodology indicates the Cocheco River should be classified as a "small" stream using the associated small stream attenuation coefficients. This methodology leads to modeled nitrogen loads from the Rochester WWTF to the Great Bay that may be significantly higher than actual loads. Use of this methodology to model other sub-estuaries would overestimate nitrogen loads from other Seacoast Community WWTFs to the Great Bay estuary and lead to future NPDES permit effluent nitrogen limits that are misrepresentative. Utilizing a small stream attenuation coefficient would result in a higher allowable WWTF total nitrogen limit.

In cases where data is lacking, the use of assumptions to fill gaps in these data should be limited and should not be the primary method over collection of more data because of time constraints placed on NH DES by EPA. Alleviation of good science in order to meet schedule is not appropriate given the significant and lasting impact that the results of wasteload allocations will have on NH Seacoast Communities.

Overall, it appears that the Methodology has utilized overly conservative factors which have resulted in lower target total nitrogen limits for future WWTF NPDES permits. In addition, the reduction of non-point source nitrogen that will need to be achieved to meet water quality standards do not appear to be realistic. Therefore, even with total nitrogen limits at the limit of technology for the WWTF discharges, which is unachievable in New England, water quality standards, as derived by the NHDES cannot be met.

If you have questions regarding this evaluation, please contact me.

Very truly yours,

BROWN AND CALDWELL

Mark K. Allenwood, P.E.
N.E. Wastewater Practice Leader

cc: Richard Sweetman, ASA