ATTACHMENTS

26 **Attachment 14**. Brown & Caldwell, Technical Memorandum: *Total Nitrogen Cost Updates* (Jan. 30, 2020).

26 **Attachment 15**. Brown & Caldwell, Technical Memorandum: *Total Phosphorus Treatment Cost Updates* (Jan. 30, 2020).

27 **Attachment 16**. City of Rochester, PowerPoint: *EPA Sewer Financial Impacts Debt Service & User Rates* (Feb. 20, 2020).

28 **Attachment 17**. GeoSyntec & VHB, Memorandum: *Preliminary Response to Environmental Protection Agency Region 1 Draft Great Bay Total Nitrogen General Permit (NPDES Permit No. NHG58A000)* (Apr. 15, 2020).

34 **Attachment 18**. Brown & Caldwell, Technical Memorandum: *Great Bay Ambient Monitoring Program Comments and Recommendations* (Apr. 14, 2020).

ATTACHMENT 1

Comments on the Draft National Pollutant Discharge Elimination System (NPDES) Great Bay Total Nitrogen General Permit for Wastewater Treatment Facilities in New Hampshire (NPDES General Permit: NHG58A000)

Prepared for
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1 Introduction

On January 7, 2020, the United States Environmental Protection Agency (US EPA) released the "Draft National Pollutant Discharge Elimination System (NPDES) Great Bay Total Nitrogen General Permit for Wastewater Treatment Facilities in New Hampshire" (US EPA, 2020a; herein, Draft GP) and an associated Fact Sheet for public comment (US EPA, 2020b; herein, Fact Sheet). The Draft GP specifies the load reductions that the US EPA deems necessary to achieve narrative water quality criteria in the Great Bay Estuary (GBE).

1.1 Legal Background

The City of Rochester's comments in Section 2.0 provide the legal background regarding the Draft GP. These comments are based on an evaluation of the Draft GP within the context of that legal background. While the character of our comments are technical in nature, we also evaluated whether key issues of the Draft GP and Fact Sheet may be found arbitrary and capricious for one of the following reasons:

- Where an agency fails to follow the law;
- Where an agency fails to examine the relevant data and articulate a satisfactory explanation for its action;
- Where the agency decision was not based on a consideration of the relevant factors or there has been a clear error of judgment;
- Where the agency has relied on factors that Congress has not intended it to consider, has entirely failed to consider an important aspect of the problem, has offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise; or
- Where an agency is too quick to dismiss relevant factors and fails to provide a logical nexus between its reasons for a decision and the decision itself.

1.2 Background on the Draft GP and Scope of Comments

The Fact Sheet (US EPA, 2020b) relied on estimates of non-point source[1] (NPS) nitrogen loads to the GBE from the PREP 2018 State of Our Estuary Report (SOOE; PREP, 2018) and from a modeling study undertaken by NHDES (2014) for NPS loads from the Lower Piscataqua River (Portsmouth Harbor) area of the GBE watershed. From information provided in these studies, US EPA determined that in a year with average precipitation, the NPS nitrogen load delivered to the GBE would be 117 kg ha^{-1} yr^{-1} (US EPA, 2020b, p. 28). The Fact Sheet also stated that the nitrogen load delivered by point sources (*i.e.*, the 17 wastewater treatment facilities [WWTFs] in the Draft GP) was 82.7 kg ha^{-1} yr^{-1}, for a total delivered load from point and non-point sources of 199.7 kg ha^{-1} yr^{-1} (US EPA, 2020b, p. 25).[2]

[1] Throughout these comments, the term "non-point sources" is used to refer collectively to non-point and stormwater point sources.
[2] US EPA states that the total delivered nitrogen load for the period from 2012 to 2016 was 189.3 kg ha^{-1} yr^{-1} (US EPA, 2020b, p. 26), but also notes that this period was subject to below average precipitation. US EPA scaled up the NPS load from the 2012-2016 period using a "normalization" procedure (US EPA, 2020b, p. 28) that increased the 2012-2016 load to 199.7 kg ha^{-1} yr^{-1} in a year of average precipitation.

The Fact Sheet alleges that nitrogen loading to the GBE should be maintained below 100 kg ha^{-1} yr^{-1} (hereafter, the loading threshold) to protect eelgrass, an indicator used by US EPA to evaluate the assimilative capacity of the GBE. The Fact Sheet proposes a pathway to achieve the loading threshold in which point source loads are reduced to 35.4 kg ha^{-1} yr^{-1} by imposing discharge limits on WWTFs and NPS loads are reduced to 64.6 kg ha^{-1} yr^{-1}. The latter of which is referred to in these comments as the NPS guidance value.

The City of Rochester, New Hampshire, retained Gradient to review the scientific basis of the Draft GP and Fact Sheet. Gradient's review focused on whether certain aspects of the Draft GP were arbitrary and capricious, as described in Section 1.1.

Our review identified the following key issues:

- The Draft GP and Fact Sheet entirely failed to consider background nitrogen loads and have specified a loading threshold that is not achievable.
- The Draft GP and Fact Sheet entirely failed to consider certain nitrogen sources in the GBE watershed that should be added to other components of background.
- The Draft GP and Fact Sheet entirely failed to consider relevant precedent information and site-specific data from the GBE. These data indicate that the loading threshold specified by US EPA corresponds to nitrogen concentrations in the GBE that approach background conditions at the mouth of the estuary and are below target concentrations developed for other estuaries in the Northeast that are protective of the same water quality indicator (*i.e.*, eelgrass).
- The Draft GP and Fact Sheet failed to consider whether the proposed loading threshold is likely to attain the current designated use of the GBE. While US EPA has advocated for better integration of the Use Attainability Analysis (UAA; US EPA, 2019a) process with regulatory developments, it did not consider several factors of a UAA that are important when using eelgrass health as a basis for judging designated use attainment.
- The Draft GP and Fact Sheet are devoid of any objective Water Quality Standards, arbitrarily predicate reopening of or reissuing the permit on "optional" NPS reductions, and failed to state the timeframe over which it would assess attainment of water quality standards.
- The Draft GP and Fact Sheet arbitrarily ignored nitrogen contributions to the GBE from Maine as they relate to attaining water quality standards. The loading threshold in the Fact Sheet corresponds to total nitrogen (TN) concentrations in the GBE that are lower than the value of 0.32 mg-N/L used by Maine to set discharge limits from its WWTFs. US EPA's approach therefore forces New Hampshire to atone for nitrogen loads from Maine that are designed to meet a less stringent standard.
- The approach used by US EPA to determine discharge limits amongst the regulated WWTFs in the Draft GP and Fact Sheet arbitrarily treats the Rochester WWTF differently from other WWTFs. US EPA's approach inappropriately results in a more stringent standard for Rochester.

Further details on the listed topics are provided in the following sections of this report.

2 The Draft GP and Fact Sheet entirely failed to consider background nitrogen loads and have specified a loading threshold that is not achievable.

The Draft GP and Fact Sheet entirely failed to consider background nitrogen loads when developing the loading threshold. Background loads are an important aspect of the problem because these loads represent irreducible loads to the GBE. If background loads approach or exceed the loading threshold or the NPS guidance value specified by US EPA, it would indicate that these thresholds defined in the Draft GP are unachievable. We evaluated background loads for the following two scenarios:

- **Scenario 1**: A scenario in which the entire GBE watershed is covered by natural vegetation, with no anthropogenic sources; and
- **Scenario 2**: A scenario in which the municipalities regulated in the Draft GP are eliminated and replaced with natural vegetation. Thus, there are no anthropogenic sources of nitrogen from the municipalities regulated in the Draft GP. Other anthropogenic loads outside of these municipalities and natural loads are the only contributors to the nitrogen load to the GBE in this scenario.

Note that both of these scenarios include only NPS loads and do not include any allotment for point sources. Our analysis shows that Scenario 1 corresponds to a background load that exceeds the US EPA guidance value for NPS loads (64.6 kg ha^{-1} yr^{-1}), and the upper end of the range approaches the loading threshold itself (100 kg ha^{-1} yr^{-1}). Scenario 2 shows that, if you remove human civilization from the municipalities regulated in the Draft GP, the background load from other human and natural sources in the watershed exceeds the loading threshold. Thus, neither the NPS guidance value nor the loading threshold are achievable.

2.1 Scenario 1: Background Loads from the Watershed under Natural Vegetation

To assess background loads under Scenario 1, we searched for watersheds in New Hampshire that are covered by natural vegetation and monitored for nitrogen loads. We found one such watershed to the northeast of the GBE watershed (Hubbard Brook) and three within the Lamprey and Oyster River basins, which are within the greater GBE watershed (Legere, 2007).

Hubbard Brook is a pristine forested watershed in New Hampshire that has been monitored for dissolved nitrogen loads for decades. The recent record (2000-2007) shows that the dissolved nitrogen load yielded from this pristine watershed on an annual basis is about 1.42 kg per hectare of the watershed (Bernal *et al.*, 2012). Ammonium was not included in the study by Bernal *et al.* (2012), but it would contribute to the dissolved nitrogen load. Thus, the load from Bernal *et al.* (2012) should be considered a lower bound value.

Within the Lamprey and Oyster River basins in the greater GBE watershed, there are data from one watershed with no developed or agricultural lands (Site Name: Pawtuck) and two watersheds that are almost entirely without developed or agricultural lands (>99.75% of land area without developed or agricultural cover; Site Names: Lamp14 and Lamp6). Annual dissolved nitrogen loads measured in stream discharge from these watersheds ranged from 1.22 to 1.7 kg per hectare of watershed area from data gathered from 2000 to 2006 (Legere, 2007).

The nitrogen loads reported by Bernal *et al.* (2012) and Legere (2007) were for dissolved nitrogen only. However, particulate nitrogen also contributes to the TN load. A review of available information identified two studies that reported the percent of TN that is in the particulate form for predominantly forested watersheds. A study of the Pawcatuck River by Fulweiler and Nixon (2005) found that 17% of the TN load was in the particulate form. Another study of the Hubbard Brook watershed found that 5.9% of the TN load was in the particulate form (Bormann *et al.*, 1969). This range of percentages for the particulate nitrogen fraction was used to scale up the dissolved loads reported by Legere (2007) and Bernal *et al.* (2012) to total (particulate plus dissolved) nitrogen loads.

Using the TN loads from the four naturally vegetated watersheds described above, we calculated what the nitrogen load to the GBE would be if the entire GBE watershed were covered with natural vegetation. We did this by applying the nitrogen load per hectare of watershed area for the four watersheds described above to the entire area of the GBE watershed, using Equation 2.1. To be consistent with the NPS modeling approach of NHDES (2014), which was relied upon by US EPA as discussed in greater detail below, we also applied a "delivery factor" to account for potential nitrogen removal in major rivers during the water's transit to the GBE.

$$L_i = F_{riv} Y_i \frac{A_{wshed}}{A_{estuary}} \qquad \text{Equation 2.1}$$

where,

L_i = nitrogen load to the GBE from contributing watershed areas in a given period (i) (units: kg ha^{-1} yr^{-1});
F_{riv} = river delivery factor (0.87 unitless – the same value used by NHDES [2014]);
Y_i = nitrogen yield per unit area of watershed in a given period (i) (units: kg ha^{-1} yr^{-1});
A_{wshed} = area of the GBE watershed (1,023 mi^2); and
$A_{estuary}$ = area of the GBE surface (21 mi^2).

Atmospheric deposition directly to the estuary surface contributes an additional background load that needs to be added to the loads contributed by rivers and streams running through naturally vegetated areas of the watershed. A study by NHDES (2014) determined atmospheric deposition to the estuary surface to be 5.8 kg ha^{-1} yr^{-1} during the 2009-2011 period.

The background loads from the naturally vegetated watershed and atmospheric deposition to the estuary surface correspond to measurements during specific periods (*i.e.*, 2000-2007 for background loads from Hubbard Brook, 2000-2006 for background loads from the watersheds in the Oyster and Lamprey River basins, and 2009-2011 for direct atmospheric deposition to the GBE). US EPA (2020b) noted that NPS loads tend to vary with precipitation and used a so-called "normalization" approach to adjust such loads to a year of average precipitation, using the following equation (Equation 2.2). Precipitation values and normalization factors are shown in Table 2.1.

$$L_{norm} = L_i \frac{P_{avg}}{P_i}$$ Equation 2.2

where,

L_{norm} = nitrogen load to the GBE normalized to average annual precipitation;
P_{avg} = average annual precipitation at Durham, New Hampshire, from 1987 to 2017 (45.2 inches);[3]
P_i = average annual precipitation at Durham, New Hampshire, during a specified period (i) when nitrogen loads were measured.

Table 2.1 Precipitation Values and Normalization Values Used in Background Nitrogen Loading Calculations

Period of Background Loading Data	Average Annual Precipitation at Durham, New Hampshire, During the Period (P_i)	Normalization Factor (P_{avg}/P_i)
2000-2006	46.4	0.97
2000-2007	46.4	0.97
2009-2011	53.6	0.84

Notes:
Annual precipitation was not reported at Durham, New Hampshire, in 2000. The average annual value shown for periods including 2000 omitted this year in the average. Data from nearby stations (*e.g.*, Greenland, New Hampshire; Rochester, New Hampshire) indicate that annual precipitation in 2000 was marginally above average in the region. It would not change the values in this table if a projected value had been used for the missing datum in 2000 at Durham, New Hampshire.

The delivered background loads to the GBE calculated from the data above range from 58.4 to 89.5 kg ha^{-1} yr^{-1}. Note that this NPS load corresponds to a hypothetical scenario in which the entire GBE watershed is covered by natural vegetation (*i.e.*, the only nitrogen inputs are atmospheric deposition and natural nitrogen fixation in soils). This range of background loads is almost entirely above the NPS guidance value in the Draft GP of 64.6 kg ha^{-1} yr^{-1}, and the upper end of the range is almost as high as the loading threshold of 100 kg ha^{-1} yr^{-1}. In Figure 2.1, we compare the measured background loads to US EPA's NPS guidance value and loading threshold. It is clear from this analysis that the NPS guidance value specified in the Fact Sheet is not achievable, since there is no basis to expect that the guidance value could be achieved even if the entire GBE watershed were converted to natural vegetation. Moreover, the upper end of the background load range is only slightly below the loading threshold specified in the Draft GP and Fact Sheet, meaning that achievement of US EPA's proposed target loading value would require an almost complete elimination of all anthropogenic sources in the GBE watershed.

[3] Note that US EPA (2020b, p. 28) made an error in the Fact Sheet by stating that it used average annual precipitation from 1988 to 2017. Upon inspection of the Durham, New Hampshire, precipitation record, we found that US EPA had actually calculated the average annual precipitation for the 1987-2017 period.

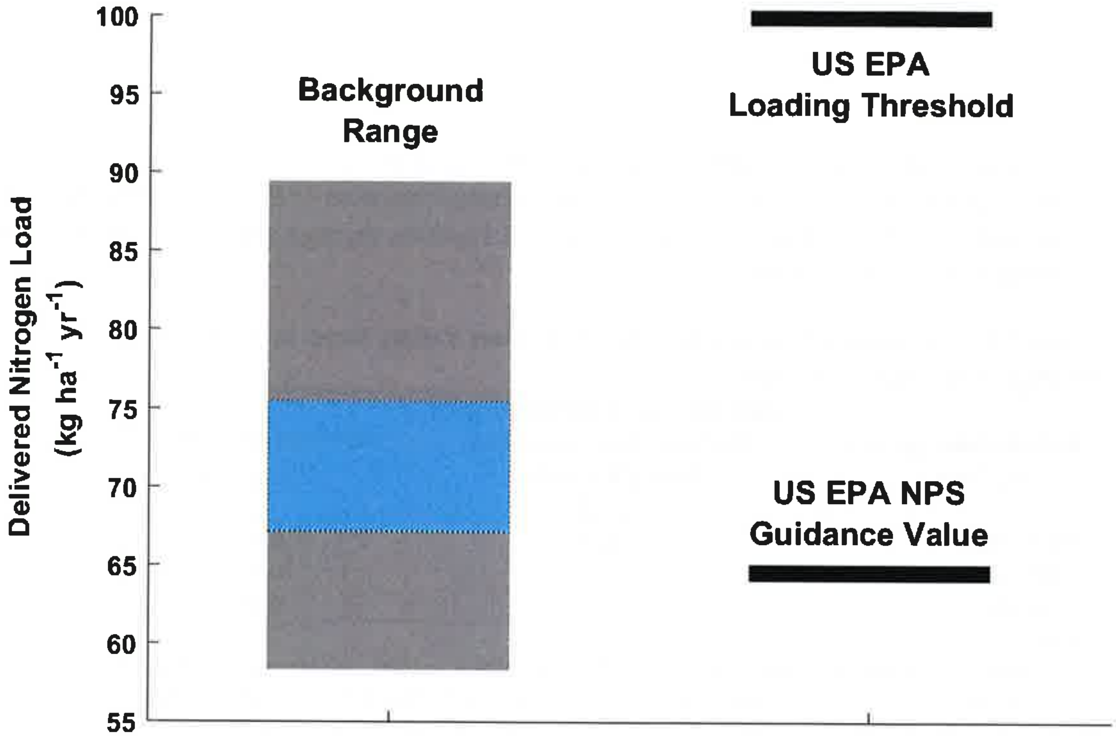

Figure 2.1 Comparison of Measured Background Loads to the Loading Threshold and NPS Guidance Value in the Fact Sheet. NPS = Non-point Source. The gray bar represents the range of background loads from naturally vegetated watersheds in the Oyster and Lamprey River Basins (tributaries to the GBE) and the blue bar (within the gray region) is the range of background loads from Hubbard Brook.

The data on background nitrogen loads also provide perspective on bias in the modeled nitrogen loads relied upon by US EPA in the Fact Sheet. The modeled nitrogen loads for the Lower Piscataqua River (LPR) area were derived from an NPS modeling study undertaken by NHDES (2014). The NHDES (2014) model is also the tool that US EPA proposes in the Fact Sheet that municipalities should use to determine the baseline NPS load for the purposes of the optional NPS load reduction pathway. To determine what the NHDES (2014) model predicts as a background load, we changed the land cover for all land areas in the model to natural vegetation (see Appendix A). In this configuration, the model simulates loads under a hypothetical scenario with no human sources (other than the anthropogenic component of atmospheric deposition). Under this scenario, the model predicts a load of 48.0 kg ha^{-1} yr^{-1} for the years 2009-2011. This load corresponds with a time when rainfall was above average (*i.e.*, average annual precipitation from 2009 to 2011 was 53.6 inches, compared to a long-term average of 45.2 inches from 1987 to 2017). Therefore, using US EPA's normalization approach (Equation 2.2) leads to the NHDES (2014) model predicting a load of 40.5 kg ha^{-1} yr^{-1} in a year of average precipitation – less than all of the measured background values discussed above by 17.9-49 kg ha^{-1} yr^{-1}. This range of values represents the magnitude of low bias in background loads for the NHDES model.[4] Further, since the NHDES (2014) model generally matched the NPS load reported by PREP from 2009-2011 (implying that its estimate of the total NPS load

[4] NHDES (2014) acknowledged that it omitted a natural source of nitrogen, *i.e.*, nitrogen fixation, which may contribute to the low bias in the background load calculated with the NHDES (2014) modeling framework.

to the GBE from both anthropogenic and background sources is approximately equal to the load determined by PREP), the model's underestimate of background means that it overestimated anthropogenic loads by a commensurate amount.

2.2 Scenario 2: Background Loads If Municipalities Regulated in the Draft GP Were Removed from the Watershed

To assess background loads under Scenario 2, we used the same NHDES (2014) NPS loading model relied upon by US EPA for the LPR area of the GBE watershed in the Fact Sheet. With this model, we evaluated an extreme scenario in which all of the towns subject to the Draft GP were removed and replaced with natural vegetation. We implemented this scenario in the NHDES (2014) model using the following procedure:

- All land areas in the following municipalities in the NHDES (2014) model spreadsheet were specified as natural vegetation: Rochester, Portsmouth, Dover, Exeter, Durham, Kittery, Somersworth, Berwick, North Berwick, Newmarket, South Berwick, Epping, Newington, Rollinsford, Newfields, and Milton. This means that land areas used for agriculture, residential lawns, golf courses/parks/sports fields, and impervious areas were set to zero and the acreage formerly associated with these areas was assigned to natural vegetation. In addition, the animal waste and human waste categories were removed from these municipalities (*i.e.*, contributed zero nitrogen to the GBE). Thus, human sources of nitrogen (other than the anthropogenic component of atmospheric deposition) were removed from the municipalities regulated in the Draft GP. This scenario and all calculations using the NHDES (2014) model are included as Appendix A.
- Lands falling outside the municipalities regulated in the Draft GP were left as-is, meaning that human and natural sources of nitrogen in these other areas were identical to those used by NHDES (2014) in its NPS load calculations to the GBE.

Under Scenario 2, the delivered NPS nitrogen load to the GBE is 97 kg ha^{-1} yr^{-1} (see calculations in Appendix A). This indicates that the majority of the NPS load to the GBE comes from areas of natural vegetation and municipalities that are not regulated in the Draft GP. Using the same normalization approach as US EPA (see Equation 2.2 and Table 2.1), the NPS load from the NHDES (2014) model corresponds to 81.8 kg ha^{-1} yr^{-1} in a year of average precipitation. From our prior analysis in Section 2.1, we also know that the NHDES (2014) NPS loads are biased low by 17.9-49 kg ha^{-1} yr^{-1}. We therefore added the low bias to the NHDES (2014) model result for Scenario 2. The results are shown in Table 2.2.

Results indicate that the loading threshold of 100 kg ha^{-1} yr^{-1} is at or *below* the range of background NPS loads contributed to the GBE by areas of natural vegetation and municipalities that are not regulated under the Draft GP (Table 2.1). Note that US EPA derives the 100 kg ha^{-1} yr^{-1} loading threshold for the sum of point and non-point sources of nitrogen to the GBE. Here, we show that the loading threshold is not even achievable from the perspective of background NPS loads alone. Thus, even if US EPA were to require municipalities regulated in the Draft GP to eliminate all WWTF and NPS nitrogen loads, there would be no basis to expect that it could achieve its loading threshold.

Table 2.2 Background Nitrogen Loads from Areas of Natural Vegetation and Municipalities That Are Not Regulated in the Draft GP

Source	NPS Nitrogen Load ($kg\ ha^{-1}\ yr^{-1}$)	
	Minimum	Maximum
Scenario 2 Implemented in the NHDES (2014) model	81.8	
Low bias for background loads in the NHDES (2014) model	17.9	49
Total	**99.7**	**130.8**

Notes:

Draft GP = Draft National Pollutant Discharge Elimination System (NPDES) Great Bay Total Nitrogen General Permit for Wastewater Treatment Facilities in New Hampshire; NPS = Non-point Source.

3 The Draft GP entirely failed to consider certain nitrogen sources in the GBE watershed that should be added to other components of background.

In the course of reviewing aerial imagery of the GBE watershed and reviewing search results from the US EPA ECHO Database,[5] we became aware of certain sources of nitrogen that were not considered in the Draft GP and Fact Sheet. Our search was not exhaustive, and there may be other sources that we did not identify through these initial search procedures. The sources that we identified include the following WWTFs:

- The Farmington, New Hampshire, WWTF began discharging its effluent into rapid infiltration basins adjacent to the Cocheco River in 2012 and does not currently operate under an NPDES permit (Farmington, New Hampshire, 2020). However, the wastewater discharged from this facility contributes a nitrogen load to the GBE. According to information from Discharge Monitoring Reports (DMRs) in the US EPA ECHO database, the Farmington WWTF discharged an average nitrogen load of 34 lb/day to the Cocheco River (upstream of Rochester, New Hampshire) from 2007 to 2010 under NPDES Permit NH0100854 (US EPA, 2020d). This daily nitrogen discharge corresponds to a load of 1.0 kg ha^{-1} yr^{-1}.[6] We did not identify any more recent data for this facility.
- The Rockingham County WWTF operates under NPDES permit NH0100609 and is located within the Exeter River Basin. We did not find information on the nitrogen load in wastewater discharged from this facility.

If US EPA chooses not to regulate, or lacks the authority to regulate, these sources of nitrogen loading to the GBE, it should include them as components of the background nitrogen load that are beyond the purview of the municipalities regulated under the Draft GP. The loads for these sources (and other sources that we may not have identified as of the date of these comments) should be added to the background loads in Table 2.2.

[5] The US EPA Enforcement and Compliance History Online (ECHO) Database was accessed on February 14, 2020, at https://echo.epa.gov/ (US EPA, 2020c).
[6] The calculated delivered load was not adjusted for a delivery factor through the Cocheco River due to lack of information with which to specify such a factor.

4 The Draft GP and Fact Sheet failed to consider relevant precedent information and site-specific data from the GBE that indicate the loading threshold is unsupported and unachievable.

Concentration is a measure of the amount of a pollutant in a defined volume of water and has long been used to regulate water quality and establish water quality standards because of its biological significance. *Load*, on the other hand, is the amount of a constituent discharged during a defined period. Within a watershed, the pollutant *load* is relatable to the surface water *concentration* using water quality modeling or site-specific data. This relationship between nutrient concentration and load is the basis for establishing a nutrient target and allocating nutrient loads as part of the Total Maximum Daily Load (TMDL) process, with the goal of achieving a desired water quality (US EPA, 1999, 2001; MassDEP, 2019).

Although US EPA specified a loading threshold (*i.e.*, 100 kg ha^{-1} yr^{-1}) in the Draft GP and Fact Sheet, it has previously used concentration thresholds to support TMDL development for a variety of pollutants and in a variety of settings, including for nitrogen in coastal bays to support the protection of eelgrass. Thus, when US EPA developed the Draft GP and Fact Sheet, it was aware that nitrogen loads are related to nitrogen concentrations, both from the abundant scientific literature on this topic, including its own guidance (US EPA, 1999, 2001), and its own past permitting experience (*e.g.*, Quashnet River, Hamblin Pond, Little River, Jehu Pond, and Great River in the Waquoit Bay System [MADEP, 2006]; Fiddlers Cove and Rands Harbor [MassDEP, 2017a]; Quissett Harbor [MassDEP, 2017b]; Wild Harbor [MassDEP, 2017c]; Lower Quiver River and Parks Bayou [MDEQ, 2008]; and Kings Bay, Hunter Spring, House Spring, Idiot's Delight Spring, Tarpon Spring, and Black Spring [FLDEP, 2014]). Yet, despite having this prior knowledge and experience, US EPA did not consider precedent use of nitrogen concentration thresholds to achieve eelgrass protection. US EPA also entirely failed to evaluate the data on nitrogen loads and concentrations for the GBE that are important considerations when setting a loading threshold. Had it simply considered the available data, US EPA would have realized that the proposed loading threshold corresponds to nitrogen concentrations below values that are protective of water resources and consistent with background values near the mouth of the GBE, as discussed further below.

4.1 Nitrogen Concentrations That Are Protective of Water Resources

Pollutant target levels that will achieve a desired biological outcome and/or a water quality standard can be developed in a number of ways. Nutrient criteria for coastal and estuarine water bodies are developed using an EPA-recommended process that considers site-specific data, historical information, reference conditions,[7] water quality modeling, and likely effectiveness in attaining and maintaining the desired water quality (US EPA, 2001). To ensure that nutrient criteria will be effective requires an understanding of the relationship between the nutrient criteria and the desired water quality parameter. In other words, the relationship between the causal variable(s) (*e.g.*, TN) and the response variable(s) (*e.g.*, chlorophyll *a*, eelgrass distribution and biomass, *etc.*) that support the criteria should be known and predictable.

[7] A reference condition is the comprehensive representation of data from several similar, minimally impacted, "natural" sites on a waterbody or from within a similar class of waterbodies. Reference conditions can be established using site-specific data, reviewing the historical record, modeling, and other factors (US EPA, 2001).

Excessive surface water concentrations of nitrogen have been linked to eutrophication and declines in eelgrass population (Benson *et al.*, 2013; Burkholder *et al.*, 1992; Latimer and Rego, 2010; Short and Wyllie-Echeverria, 1996; Tetra Tech, 2018). However, nitrogen in and of itself does not generally play a direct role in eelgrass declines, rather its role is indirect through a cascade of events (MEP Technical Team, 2003). Impacts on eelgrass distribution and growth are understood to primarily involve reductions in water clarity and light availability due to increased phytoplankton biomass and elevated chlorophyll *a* concentrations caused by nitrogen enrichment. In addition, declines in eelgrass have been linked to multiple causes and not just nitrogen enrichment (Vaudrey, 2008; PREP, 2018;[8] Suffolk County, New York, *et al.*, 2020; Tetra Tech, 2018). This limits the capacity to predict eelgrass health outcomes solely on the basis of nitrogen concentrations.

Despite these limitations, nitrogen concentration thresholds have been developed for several coastal estuaries in the Northeast, and these criteria have been used to develop TMDLs that were accepted by US EPA. Nitrogen concentration targets for the protection of eelgrass habitat in estuaries in the Northeast have ranged from 0.30 to 0.50 mg-N/L (Benson *et al.*, 2013;[9] MEDEP, 2018;[10] MEP Technical Team, 2003;[11] MassDEP, 2019[12]). Others have reported nitrogen thresholds that are even higher. For example, based on monitoring data collected between 2001 and 2003 in the Maryland coastal bays, researchers determined that, in order to maintain seagrass health, TN concentrations should remain below 0.65 mg-N/L (Maryland Dept. of Natural Resources, 2004). While these criteria are site-specific, it is reasonable to assume that a nitrogen concentration target for the GBE would fall within the same range.

As shown in the next section, the available data indicate that TN concentrations in the GBE are related to nitrogen loads. By quantifying the load-concentration relationship, we show that the TN concentrations associated with US EPA's loading threshold are below the nitrogen concentrations that are protective of eelgrass health in other coastal estuaries in the Northeast. Furthermore, the TN concentration associated with US EPA's loading threshold is consistent with background concentrations near the mouth of the GBE.

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8 "Main causes of temperate (between the tropics and the polar regions) seagrass loss are nutrient loading, sediment deposition, sea-level rise, high temperature, introduced species, biological disturbance (e.g., from crabs and geese), and wasting disease. Toxic contaminants such as herbicides that are used on land can also stress eelgrass. All of these causes are plausible in the Great Bay Estuary and many magnify each other" (PREP, 2018).

9 "Sites with healthy eelgrass had a tidally-averaged total nitrogen concentration of 0.34 mg-N/L and ebb tide TN of 0.37 mg-N/L. However, a more conservative tool for establishing acceptable TN levels for management of eelgrass habitat and restoration would be the 75th percentile of data. In this case the 75th percentile of tidally-averaged TN was 0.36 mg-N/L or a long term, ebb-tide TN of 0.38 mg-N/L in sites of healthy eelgrass" (Benson *et al.*, 2013).

10 "According to several studies in USEPA's Region 1, numeric total nitrogen criteria have been established for relatively few estuaries, but the criteria that have been set typically fall between 0.35 mg-N/L and 0.50 mg-N/L to protect marine life using dissolved oxygen as the indicator. While the thresholds are site-specific, nitrogen thresholds set for the protection of eelgrass habitat range from 0.30 to 0.39 mg-N/L. Based on studies in USEPA's Region 1 and the Department's best professional judgment of thresholds that are protective of Maine water quality standards, the Department is utilizing a threshold of 0.45 mg-N/L for the protection of aquatic life in marine waters using dissolved oxygen (DO) as the indicator, and 0.32 mg-N/L for the protection of aquatic life using eelgrass as the indicator" (MEDEP, 2018).

11 Nitrogen threshold values developed by SMAST as presented in Table 1 for Excellent/Good and Good/Fair ranged from 0.30 mg-N/L to 0.50 mg-N/L (long-term [>3 yr] average mid-ebb tide concentrations of TN [mg-N/L] in the water column) (MEP Technical Team, 2003).

12 "In order to restore and protect the Waquoit Bay sub-embayments, the N loadings, and subsequently the concentrations of N in the water, must be reduced to levels below the thresholds that cause the observed environmental impacts. This concentration will be referred to as the target threshold N concentration. The Massachusetts Estuaries Project (MEP) has determined that for the Waquoit Bay sub-embayments, target threshold N concentrations at the sentinel stations in the range of 0.374 mg-N/L to 0.5 mg-N/L are protective of water quality standards. The mechanism for achieving these target threshold N concentrations is to reduce the N loadings to the sub-embayments" (MADEP, 2019).

Without scientific support demonstrating how US EPA's proposed nitrogen load relates to eelgrass health in the GBE as the desired response variable, the currently proposed loading threshold is arbitrary, inconsistent with US EPA's own guidance for developing nutrient criteria (US EPA, 2001), and in stark and inexplicable contrast with comparable criteria that have been developed and accepted for other waterbodies.

4.2 Relationships between Nitrogen Loads and Concentrations in the GBE

Data for both nitrogen loads and concentrations for the GBE were available to US EPA when it was developing the Draft GP and Fact Sheet. For example, US EPA relied on nitrogen loading data to the GBE from PREP publications (*e.g.*, PREP, 2013, 2017, 2018). PREP has determined nitrogen loads to the GBE for multiple periods dating back to 2003. Using the same methods as US EPA in the Fact Sheet, we used the PREP loading data to calculate delivered nitrogen loads to the GBE for each period in which PREP has provided loading data. Results are summarized in Table 4.1 (further details provided in Appendix B).

Nitrogen concentrations within the GBE from long-term monitoring stations were also available to US EPA when it developed the Draft GP and Fact Sheet (PREP, 2012, 2017; NHDES, 2010, 2014, 2018; NOAA, 2020; US EPA, 2020b). For each period in which PREP provided data on nitrogen loads, we found the median TN concentration at each of the three long-term monitoring stations in the mainstem GBE, *i.e.*, Great Bay (GRBGB), Adams Point (GRBAP), and Coastal Marine Lab (GRBCML). These median nitrogen concentrations are listed in Table 4.1. The Adams Point and Great Bay monitoring stations are within Great Bay proper, whereas the Coastal Marine Lab monitoring station is in Portsmouth Harbor. Note that the monitored nitrogen concentrations are averaged on a daily basis from high and low tide measurements at Adams Point and Coastal Marine Lab. This type of averaging is important because nitrogen concentrations tend to be higher at low tide than at high tide. Thus, the Adams Point and Coastal Marine Lab data can be considered representative of daily average concentrations. However, measurements at the Great Bay (GRBGB) monitoring station were only made once per day, typically at low tide when nitrogen concentrations tend to be biased high relative to the daily average. Thus, the data from Adams Point (GRBAP) are the most representative data from Great Bay, and the monitoring data from the Great Bay station (GRBGB) are not relied upon for the regression analysis described below.

Table 4.1 Data from the GBE on Nitrogen Loads and Nitrogen Concentrations

Period	Nitrogen Load (kg ha^{-1} yr^{-1})	Median Total Nitrogen Concentration in the GBE		
		Adams Point (mg-N/L)	Great Bay (mg-N/L)	Coastal Marine Lab (mg-N/L)
2003-2004	227.9	0.360	0.4075	0.270
2005-2006	311.2	0.4285	0.391	0.294
2007-2008	257.4	0.3865	NA	0.33775
2009-2011	253.3	0.35475	0.3995	0.2535
2012	216.1	0.285	0.304	0.27875
2013	209.7	0.3815	0.343	0.2675
2014	215.0	0.301	0.342	0.2515
2015	163.3	0.2935	0.317	0.2075
2016	153.3	0.31125	0.3285	0.2035
2012-2016	189.3	0.30675	0.3285	0.228

Notes:
GBE = Great Bay Estuary.
The load for the 2012-2016 period in this table was calculated by US EPA (2020e) using the same methods described in these comments.

The available data demonstrate that nitrogen loads to the GBE and nitrogen concentrations measured at monitoring stations in the GBE are correlated (Figure 4.1). We therefore performed a linear regression analysis on the data to determine the nitrogen concentrations that correspond to the loading threshold of 100 kg ha^{-1} yr^{-1} proposed in the Draft GP and Fact Sheet. At the Coastal Marine Lab monitoring station, a 100 kg ha^{-1} yr^{-1} loading rate corresponds to a nitrogen concentration of 0.18 mg-N/L, which is approximately equal to the background concentration of TN of 0.2 mg-N/L in the Gulf of Maine adjacent to the GBE (NHDES, 2009, and references therein). This finding is consistent with our prior determination that the loading threshold is near the range of background loads and is therefore unachievable.

At the Adams Point monitoring station in Great Bay, the loading threshold corresponds to a nitrogen concentration of 0.25 mg-N/L. At this location, the loading threshold corresponds to a TN concentration that is even less than the low end of the range of values that are protective of water quality and eelgrass specifically (*i.e.*, 0.3-0.5 mg-N/L from Section 4.1).[13] The municipality of Rochester has invested in the development of a hydrodynamic model of the GBE that has also been used to evaluate the relationship between nitrogen loads and concentrations in the GBE (HDR, 2019). The model results are consistent with the correlation between loads and concentrations seen in the data.

Furthermore, the effective imposition of a 0.18 mg-N/L TN threshold *via* US EPA's loading threshold in the Draft GP near the mouth of the GBE (or a value of 0.25 mg-N/L for Great Bay) creates inconsistent targets for the achievement of water quality in the two adjacent states of Maine and New Hampshire. Maine has set a TN concentration threshold of 0.32 mg-N/L for the protection of eelgrass for its portion of the GBE (MEDEP, 2018), yet US EPA is effectively setting a threshold for the same indicator species of 0.18 mg-N/L for coastal New Hampshire's portion of the GBE. This glaring inconsistency is clearly problematic for the GBE, which does not confine itself to state boundaries.

[13] The same is true when considering the relationship of concentration to load at the GRBGB station, which is biased high due to having only low tide measurements.

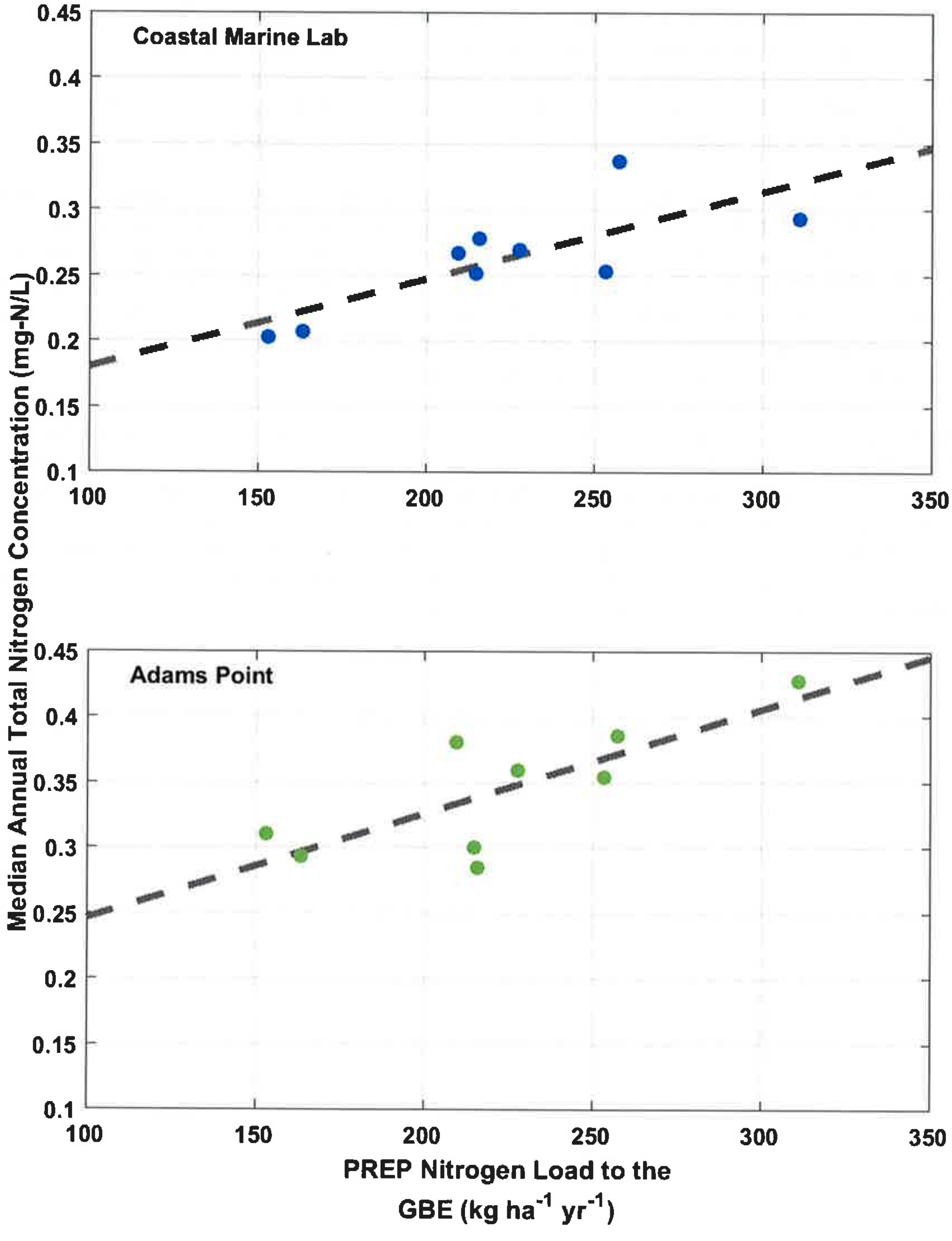

Figure 4.1 Correlation Between Nitrogen Loads and Concentrations at the Coastal Marine Lab and Adams Point Monitoring Stations in the GBE (r^2 = 0.61 and p = 0.023 for both panels). TN = Total Nitrogen. The correlation is similar whether using the mean or median annual TN concentration. Growing season median/average values also correlate with loads, however concentrations during the growing season are even lower than the annualized values.

Given the foregoing analysis, it is clear that US EPA did not consider relevant data from the GBE when it proposed the loading threshold. Furthermore, US EPA uses internally inconsistent arguments when it defends its selection of a single loading threshold for the entire GBE in the Fact Sheet. US EPA initially defends its selection of a single overall TN loading rate for the entire GBE despite its size and the numerous unique "assessment zones" by asserting that the "*entire Great Bay estuary is a single estuarine system* [emphasis added] characterized by different levels of mixing of the same source waters, continual exchange of waters among estuarine segments, the same sources for sediment, and the same climatic conditions" (US EPA, 2020b, p. 18). Four pages later, however, US EPA's characterization of the GBE undergoes a stark change as the agency defends its use of studies of much smaller estuaries (*e.g.*, Latimer and Rego, 2010), to establish a loading rate by asserting that "EPA recognizes that the Great Bay Estuary is much larger than the embayments evaluated in this study, but notes that the *Great Bay Estuary is comprised of many smaller sections that are comparable to the embayments evaluated in this study* [emphasis added]" (US EPA, 2020b, p. 22). Characterizing the GBE as "many smaller sections that are comparable to…embayments" for one purpose and an "entire …single estuarine system" for another is illogical and inconsistent. This is another clear example of the arbitrary and capricious approach US EPA relied upon in the Draft GP.

5 The Draft GP and Fact Sheet failed to show that the proposed loading threshold and indicator species (eelgrass) can demonstrate attainment of the designated uses of the GBE and failed to consider several factors of Use Attainability Analysis.

US EPA states in the Fact Sheet (US EPA, 2020b, p. 21) that it used 40 C.F.R. 122.44(d)(1)(vi)(A) (US EPA, 2019b) in the Draft GP (US EPA, 2020a). That part of the C.F.R. states that US EPA must establish effluent limits "*using a calculated numeric water quality criterion* for the pollutant which the permitting authority demonstrates *will attain and maintain applicable narrative water quality criteria* and *will fully protect the designated use*" [emphasis added]. In the Fact Sheet, the chosen indicator of designated use is eelgrass coverage (US EPA, 2020b).

US EPA has previously recommended that the Use Attainability Analysis process should be better integrated with regulatory developments. As US EPA's Office of Science and Technology states in a 2006 Memorandum to its regional water division directors:

> We need to work together with states and tribes to ensure that as we develop TMDLs, we also coordinate on issues related to use attainability as needed. In practice, information gathered to develop a TMDL, and the allocations in a TMDL, may point to the need to pursue a UAA. (US EPA, 2006)

To the best of our knowledge, an analysis has not been conducted for the GBE to demonstrate that achievement of the nitrogen loading threshold proposed in the Fact Sheet will attain and maintain designated use, which US EPA has predicated on eelgrass coverage. Such an analysis would be informative and in keeping with 40 C.F.R. 122.44(d)(1)(vi)(A) (US EPA, 2019b) and prior US EPA actions. As US EPA (2006) states, "We do not believe that setting unattainable uses advances actions to improve water quality."

Among the factors that would be considered in a UAA (40 C.F.R. 131.10[g]; US EPA, 2019c), the following are relevant as they relate to the use of the proposed loading threshold or the use of eelgrass as the indicator of achieving water quality standards for the GBE:

1. Naturally occurring pollutant concentrations prevent the attainment of the use;
2. Natural, ephemeral, intermittent, or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; and
3. Controls more stringent than those required by Sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

A number of known natural and human causes within the scope of the UAA factors listed above can substantially impact eelgrass abundance and distribution apart from nutrient loading. These include sediment deposition, sea-level rise, high temperature, introduced species, biological disturbance (*e.g.*, from crabs and geese), wasting disease, storms, and toxic contaminants (*e.g.*, herbicides) (Orth *et al.*, 2006; PREP, 2018; Unsworth *et al.*, 2015). Several of these factors directly affect eelgrass in the GBE, yet US EPA entirely failed to consider them in the context of attaining designated use. Two examples illustrated in the recent record are wasting disease and long-term change in hydrology. These two factors are discussed further below.

There have been documented changes in conditions in the GBE that are known to cause changes in eelgrass coverage. Two factors that are independent of nutrient loads – changing hydrologic flows (as driven by changes in precipitation) and wasting disease – are clearly evident in the monitoring record that extends to the 1980s. A conceptual diagram illustrating the nature of more recent changes in precipitation, eelgrass coverage, and nitrogen loads is shown in Figure 5.1. One aspect of the recent changes that is inconsistent with US EPA's proposition that eelgrass health is tied to nitrogen loads in the GBE is the observation that recent eelgrass coverage has decreased alongside substantial decreases in nitrogen loads. If nitrogen loads were the proximate cause of not attaining designated use, eelgrass coverage would not be expected to decline as the nitrogen load is lessened. In contrast, there have been substantial increases in long-term average precipitation alongside the eelgrass declines. Precipitation is a principal driver of hydrological flows into the GBE. There are clear relationships in the data between precipitation and eelgrass coverage, indicating that natural hydrological conditions are limiting attainment of designated uses, yet US EPA failed to consider this important aspect of the problem in the Draft GP and Fact Sheet.

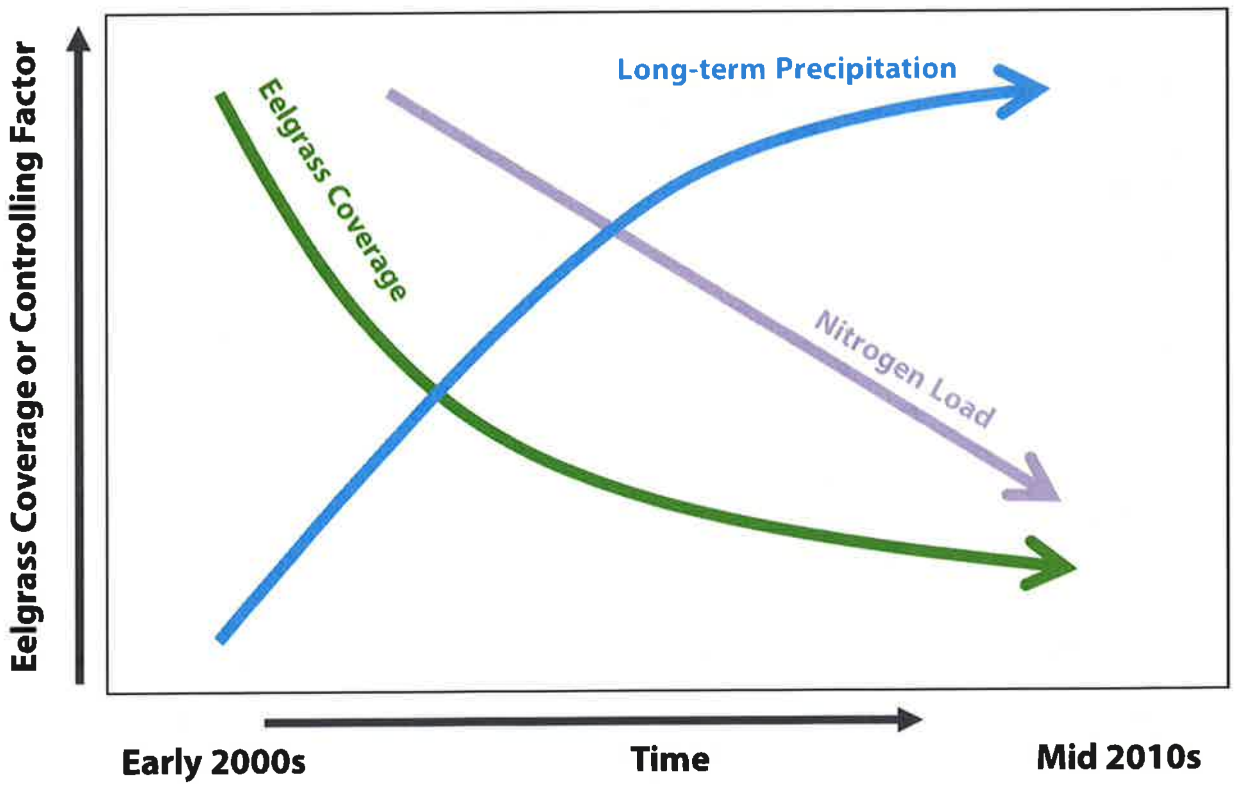

Figure 5.1 Conceptual Diagram of Recent Changes in Eelgrass and Potentially Controlling Factors

The most profound natural disturbance affecting eelgrass abundance that was ever documented was the wasting disease of 1931-1932 that decimated 90% of the eelgrass in the North Atlantic. Short *et al.* (1986) describe the following in their 1986 publication:

> A major decline of eelgrass populations has now been detected in the Great Bay Estuary on the New Hampshire-Maine border and the virtual disappearance of eelgrass from the outer estuary has been linked not to pollution but to a disease...the 1981-84 decline originated in the lower reaches of the Great Bay Estuary. Thus, eutrophication from one or more of the tidal tributaries was not the likely agent.

There have also been more recent significant declines in eelgrass abundance due to wasting disease, including in 1988-1989 in the GBE (PREP, 2018).

A review of historical eelgrass coverage in the GBE, as presented in Figure 5.2, illustrates the impact of both disease (c. 1988-1989) and a more recent decline in eelgrass coverage in the GBE. The more recent decline has occurred alongside a sharp increase in long-term average precipitation, which is shown in Figure 5.3. The abrupt increase in Figure 5.3 indicates a long-term regional change toward higher precipitation, consistent with findings in prior studies (*e.g.*, Hodgkins and Dudley, 2011). Precipitation is a principal driver of changes to watershed hydrology by way of higher flows (Wake *et al.*, 2019). Higher flows can alter sediment dynamics and contribute to turbidity *via* sediment mobilization (Leopold, 1994; Julien, 2010). Increases in turbidity are known to hinder eelgrass health (PREP, 2018). Data from the region have indicated that the increased precipitation has caused increased concentrations of colored dissolved organic matter (CDOM) in the Gulf of Maine and increased suspended sediment concentrations in parts of the GBE, both which can reduce light availability for eelgrass (PREP, 2018).

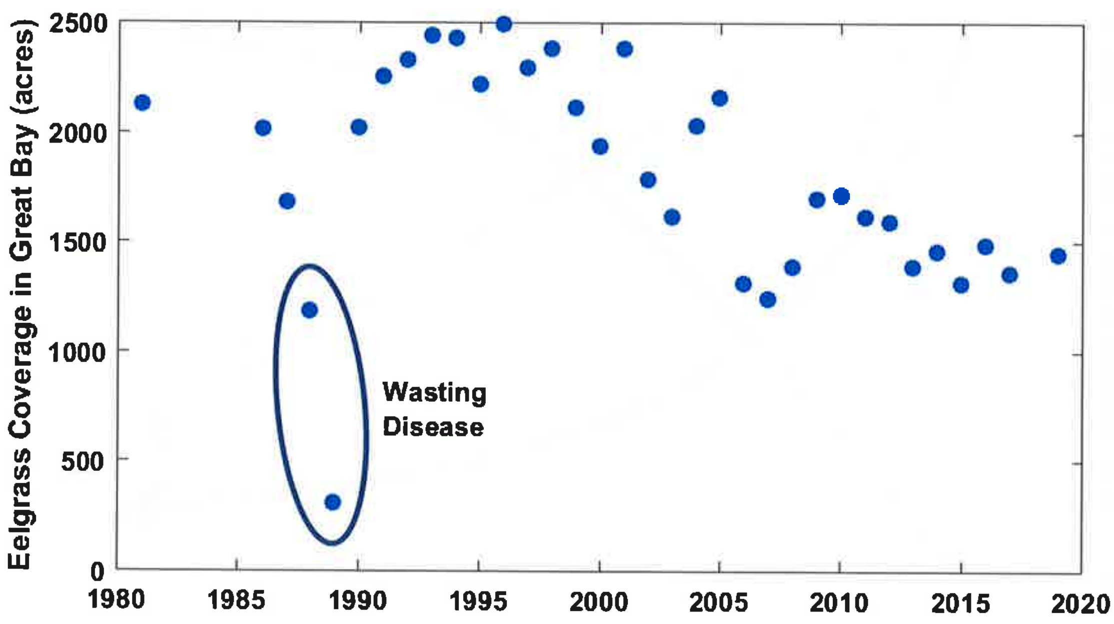

Figure 5.2 Record of Eelgrass Coverage in Great Bay and Natural Events Affecting Coverage.
Data sources: PREP (2017); Barker (2018, 2020).

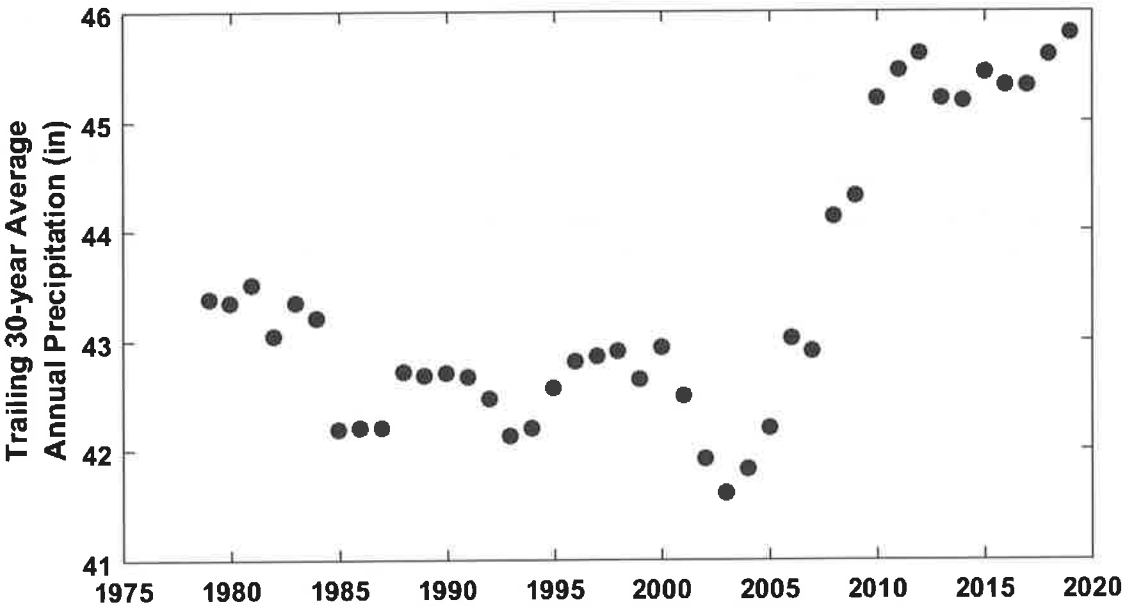

Figure 5.3 Record Long-term Average Annual Precipitation at Durham, New Hampshire. Data source: NOAA (2020).

The long-term change in watershed hydrology, as indicated by the change in long-term precipitation, co-varies with the recent record of eelgrass coverage in the Great Bay and Portsmouth Harbor areas (the two areas with the largest eelgrass coverage in the GBE; Figure 5.4). As average annual precipitation increases, eelgrass coverage decreases in lockstep at Portsmouth Harbor. Eelgrass coverage in Great Bay is more variable, but also indicates that eelgrass coverage declines as average annual precipitation increases. Here, several major storms are indicated on the plot – the year 2006, which experienced the so-called Mother's Day Storm (an extreme hydrologic event), and the years 1987 and 2007, which also experienced large (c. 100-yr) storms (see Figure 5.4). At Great Bay, these years affected by extreme storm events were associated with lower eelgrass coverage than other years with similar long-term average precipitation – a further indication of the role of hydrology in attaining designated uses. These relationships in the data from the GBE indicate there is an underlying hydrologic condition that has limited eelgrass coverage in the recent record that needs to be considered when attainment of designated use is predicated on eelgrass coverage as an indicator.

There is precedent for using effects of flow conditions to revise water use designations through a UAA (US EPA, 2006).[14] Similarly, Maryland used the UAA process to refine the designated uses for the Chesapeake Bay and associated tributaries due to both natural and human-caused conditions (*i.e.*, navigational dredging). Maryland used the UAA to demonstrate that the current designated uses for aquatic life protection cannot be obtained in all parts of the Chesapeake Bay and associated tributaries.[15] For example,

[14] Recreational beneficial uses are suspended during a defined storm event in the Los Angeles Region (see Case Study in US EPA, 2006, Appendix B).

[15] The Maryland UAA provided scientific data showing that natural and human-caused conditions that cannot be remedied are the basis for the non-attainment and proposes refined designated uses that Maryland has considered for the current water quality standards development and adoption processes. The determination of non-attainability of the current water quality standards in the Chesapeake Bay and its tidal tributaries is based on three of the six 40 CFR 131 (10)(g) factors (US EPA, 2019c) – (1) natural factors, (2) human-caused conditions that cannot be remedied, and (3) hydrologic modification (Patapsco River Navigation channels). Output from model-simulated attainment scenarios, TMDL model scenarios for the Patapsco River, and the

modeling was used to demonstrate that even under pristine conditions, the 5 mg/L dissolved oxygen criterion is not attainable during the summer months. In addition, a baywide underwater grass restoration goal of 185,000 acres was developed using historical and recent coverage information to refine the uses associated with the water clarity criterion.

Rather than proposing a nutrient threshold based on an indicator that is driven by other factors and waiting for it to fail in attaining the designated use for the GBE, US EPA should consider information that is readily available now and directly relevant to specific factors of a UAA. Such consideration would allow US EPA to develop a scientifically supportable threshold that has a much greater likelihood of meeting appropriately set, but still protective, designated uses for the GBE.

paleoecological record of the Chesapeake Bay ecosystem provide evidence that these conditions prevent attainment of current designated uses (see Case Study in Appendix F).

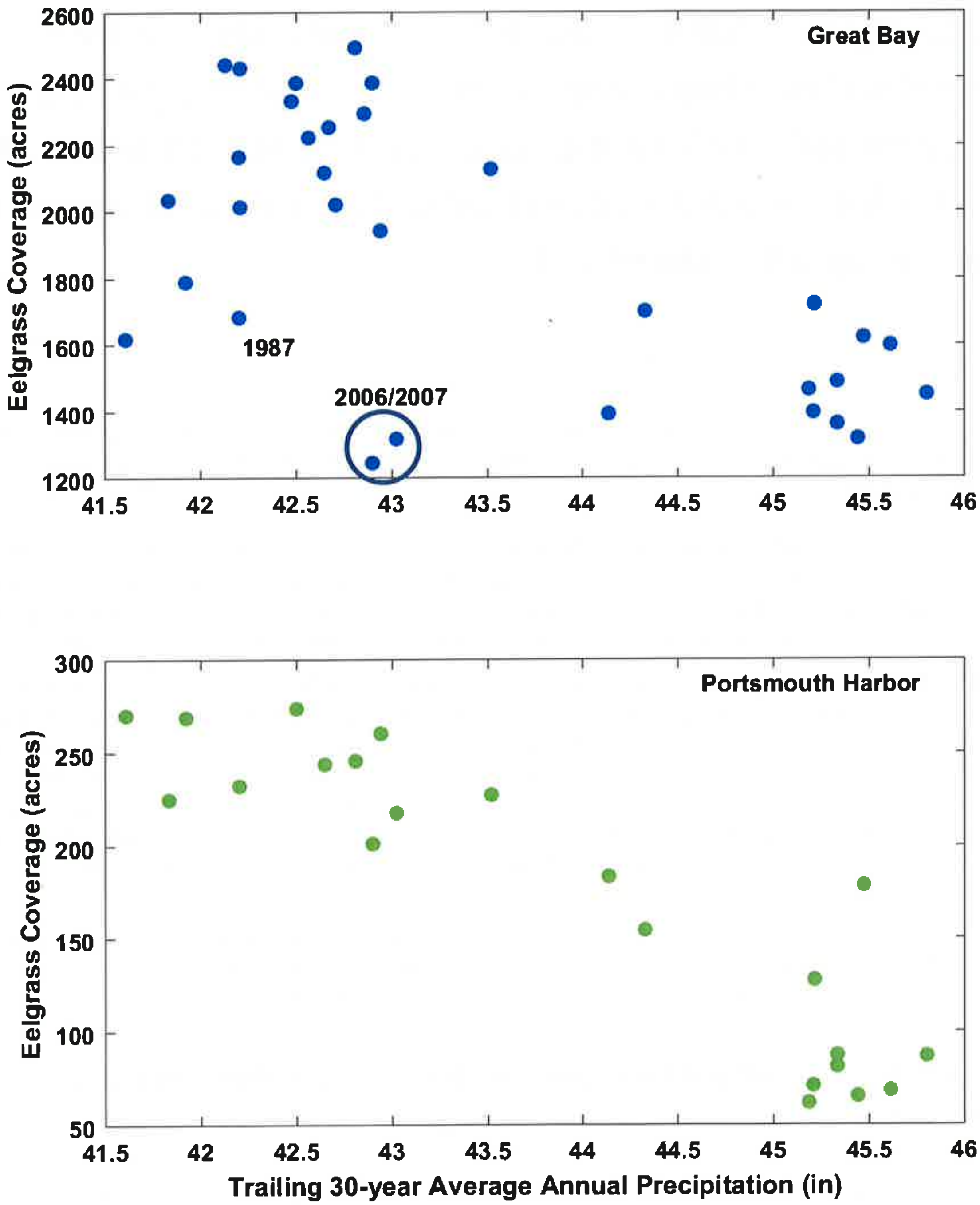

Figure 5.4 Correspondence of Eelgrass Coverage to the Trailing 20-year Average Precipitation at Durham, New Hampshire. The years 1988 and 1989 were omitted from the plot for Great Bay since these years were affected by wasting disease. The covariance of eelgrass coverage with long-term precipitation is clearly evident for trailing averages with periods from 10 to 45 years.

6 The Draft GP and Fact Sheet are devoid of any objective water quality standards, arbitrarily predicated reopening of or reissuing the permit on "optional" NPS reductions, and failed to state the time frame over which it would assess attainment of water quality standards.

The Draft GP and Fact Sheet failed to meet basic requirements and failed to incorporate important aspects of implementing nitrogen reduction strategies. The key issues are summarized below and discussed further in the following subsections:

- A letter from US EPA on March 16, 2020, and an internal US EPA memorandum on October 7, 2019, indicate that US EPA failed to provide any objective water quality standards. The failure to calculate a water quality standard is counter to the approach (*i.e.*, 40 C.F.R. 122.44(d)(1)(vi)(A) (US EPA, 2019b) that US EPA selected for establishing discharge limits in the Draft GP.
- US EPA is attempting to use the Draft GP as a tool to require reductions in NPS loads even though it does not have the authority to regulate NPSs. This attempted overreach is evidenced from the Draft GP itself, in which US EPA predicates reopening or reissuing the permit on "optional" NPS reductions. US EPA's attempt to regulate NPS loads is further articulated in an internal memo (US EPA, 2019d) in which the Agency states, "[T]he permit will not result in attainment of water quality standards unless nonpoint sources are addressed." Thus, US EPA views NPS load reductions as a prerequisite for attaining water quality standards and has inappropriately attempted to regulate NPS loads in the Draft GP.
- US EPA failed to state the timeframe over which it would assess attainment of water quality standards. As currently written, the Draft GP could arbitrarily allow US EPA to assess attainment at any moment from the effective date of the permit to sometime indefinitely into the future.

6.1 US EPA's Draft GP and Fact Sheet are devoid of any objective water quality standard.

The Fact Sheet makes the following statement, but does not state what achieving "water quality standards" means:

> In the event the activities described above are not carried out and water quality standards are not achieved, EPA may reopen the General Permit within the timeframe of the permit (5 years) or reissue the General Permit beyond the timeframe of the permit (5 years) and incorporate any more stringent nitrogen effluent limits for the WWTFs necessary to ensure compliance with water quality standards. Conversely, if water quality standards are

achieved before the activities described above are fully carried out, further nitrogen reductions from non-point source and stormwater point sources or from more stringent nitrogen effluent limits for the WWTFs may not be necessary (assuming that nitrogen loads do not increase from that level because of significant changes in land use, weather, atmospheric deposition or other reasons that can affect water quality). (US EPA 2020b, p. 31)

The critical element that controls reopening or reissuing the permit in the quote above is achievement of the water quality standards. Yet, the Draft GP and Fact Sheet failed to state any objective water quality standard. The only water quality standard stated in the Draft GP or Fact Sheet is the narrative New Hampshire water quality standard, which, by definition, is not objective and therefore requires translation to a numerical value for the purposes of a NPDES permit. US EPA states in the Fact Sheet (US EPA, 2020b, p. 21) that "EPA in this case relied upon subsection (A) to translate the relevant narrative criterion into a numeric limit," citing 40 C.F.R. 122.44(d)(1)(vi)(A)-(C) (US EPA, 2019b). The language of 40 C.F.R. 122.44(d)(1)(vi)(A) (US EPA, 2019b) is as follows (emphasis added):

> (A) Establish effluent limits *using a calculated numeric water quality criterion* for the pollutant which the permitting authority demonstrates *will attain and maintain applicable narrative water quality criteria* and *will fully protect the designated use*. Such a criterion may be derived using a proposed State criterion, or an explicit State policy or regulation interpreting its narrative water quality criterion, supplemented with other relevant information which may include: EPA's Water Quality Standards Handbook, October 1983, risk assessment data, exposure data, information about the pollutant from the Food and Drug Administration, and current EPA criteria documents…

40 C.F.R. 122.44(d)(1)(vi)(A) (US EPA, 2019b) requires that US EPA "[e]stablish effluent limits using a calculated numeric water quality criterion," yet the only numeric value provided by US EPA is the 100 kg ha^{-1} yr^{-1} loading threshold. In a letter from US EPA dated March 16, 2020 (Appendix C), the agency stated that "the proposed long-term nitrogen loading endpoint – 100 kg ha^{-1} yr^{-1} – drawn from multiple lines of evidence including the Latimer & Rego (2010) paper and others is not an enforceable limit or other such permit requirement" (US EPA, 2020f). By definition, a water quality criterion is an enforceable limit and, hence, since US EPA has stated that the loading threshold is not an "enforceable limit," it is not a water quality criterion. This fact puts US EPA in the awkward position of stating that it used 40 C.F.R. 122.44(d)(1)(vi)(A) (US EPA, 2019b) to establish effluent limitations, yet it entirely failed to calculate a numeric water quality criterion, which is a requirement of this part of the C.F.R.

The departure of US EPA's methods from C.F.R. 122.44(d)(1)(vi)(A) is further highlighted in an internal US EPA memorandum dated October 7, 2019 (US EPA, 2019d; Appendix D). The memo states "There is no nitrogen TMDL for Great Bay, nor has the state developed a numeric nitrogen criterion, so EPA and NHDES cannot rely on a wasteload allocation or numeric [water quality standard] to set permit limits." However, this statement is factually inconsistent with 40 C.F.R. 122.44(d)(1)(vi)(A) (US EPA, 2019b). The text of 40 C.F.R. 122.44(d)(1)(vi)(A) (as stated verbatim above) requires that US EPA use a calculated numeric water quality criterion that "will attain and maintain applicable narrative water quality criteria." If the state has not developed a numeric criterion, 40 C.F.R. 122.44(d)(1)(vi)(A) states that US EPA must develop a numeric criterion. Neither the lack of a TMDL nor the lack of numeric criteria from the state provides US EPA with a basis to depart from the requirements of 40 C.F.R. 122.44(d)(1)(vi)(A) (US EPA, 2019b) when developing NPDES permit limits.

Since the Draft GP and Fact Sheet are devoid of any objective water quality standards, neither the permitees nor US EPA have any objective basis for judging attainment of water quality standards. This is counter to the requirements of 40 C.F.R. 122.44(d)(1)(vi)(A) (US EPA, 2019b) and the epitome of being arbitrary and capricious.

6.2 US EPA has arbitrarily predicated reopening or reissuing the permit on "optional" NPS reductions.

The Draft GP (US EPA, 2020a) and Fact Sheet (US EPA, 2020b, pp. 29-31) discuss an "Optional Non-Point Source and Stormwater Point Source Nitrogen Reduction Pathway." After describing this optional pathway, the Draft GP and Fact Sheet make the following statement:

> In the event the activities described above are not carried out and water quality standards are not achieved, EPA may reopen the General Permit within the timeframe of the permit (5 years) or reissue the General Permit beyond the timeframe of the permit (5 years) and incorporate any more stringent nitrogen effluent limits for the WWTFs necessary to ensure compliance with water quality standards. Conversely, if water quality standards are achieved before the activities described above are fully carried out, further nitrogen reductions from non-point source and stormwater point sources or from more stringent nitrogen effluent limits for the WWTFs may not be necessary (assuming that nitrogen loads do not increase from that level because of significant changes in land use, weather, atmospheric deposition or other reasons that can affect water quality).

Thus, the Fact Sheet explicitly predicates reopening or reissuing the permit on achieving water quality standards (of which the Draft GP and Fact Sheet are devoid) or implementing the optional NPS reduction pathway. Both the Draft GP and Fact Sheet are, however, devoid of an actionable water quality criteria. Again, this is the epitome of US EPA being arbitrary and capricious.

6.3 US EPA failed to state the time frame over which it would assess attainment of water quality standards.

The Draft GP and Fact Sheet also do not state the time frame over which attainment of water quality standards would be assessed. For example, the Draft GP and Fact Sheet mention the 5-year time frame of the permit, but do not state that this period will be used for assessing whether water quality standards are achieved. As another example, the optional NPS load reductions discussed in the Draft GP and Fact Sheet provide a process that distributes load reductions over an approximately 20-year period. US EPA does not state whether this longer time frame will be used to assess whether water quality standards are achieved. As currently written, it appears that US EPA could arbitrarily and capriciously select a time frame for assessing attainment of water quality standards at any time from the effective date of the permit to sometime indefinitely into the future. The failure to define a time frame over which it would assess attainment of water quality standards makes any such determination by US EPA fundamentally arbitrary and capricious.

Despite having failed to state a time frame for assessing attainment of water quality standards, US EPA is well aware of the long lag times between implementation of control measures and the impacts of those measures on estuarine water quality. For example, US EPA has participated in the TMDL for TN in the Chesapeake Bay. Research by the United States Geologic Survey (USGS) undertaken to evaluate the TMDL showed that it can take multiple decades for the effects of nitrogen best management practices (BMPs) to fully reach the Bay (Sanford and Pope, 2013). An illustration from that study is shown in Figure 6.1, indicating that nitrogen traveling along some pathways to surface water bodies takes decades to get there. Numerous other studies have evaluated lag times for nitrogen traveling from source areas to surface waters and found similar results (*e.g.*, Tomer and Burkart, 2003; Saad, 2008; Tesoriero *et al.*, 2013). In fact, a study of the GBE found that the average age of groundwater discharging to the estuary was 23.2 ± 15 years (Ballestero *et al.*, 2004).

US EPA should consider information from the GBE as well as US EPA's prior experience in other estuaries, including the Scientific and Technical Advisory Committee (STAC), which "provides scientific and technical guidance to the Chesapeake Bay Program (CBP) on measures to restore and protect the Chesapeake Bay" (STAC, 2012).[16] In a report summarizing a STAC workshop on "Incorporating Lag-Times into the Chesapeake Bay Program," it stated:

> The general concept of lag-times is that the impact of events currently taking place in the watershed, including changes in land use and management practices, changes in point source loading rates, and specific natural events such as extreme floods or droughts, will not be entirely reflected in changes to water quality for periods of years to many decades...Consideration of lag-times also raises issues related to water quality monitoring, and evaluation of BMP effectiveness...The scientists who study the behavior of the system will also need to use models that explicitly evaluate observed water quality as a function of hydrologic conditions (including major flood and drought events) and the time history of the inputs of pollutants to the system. The only way that can be done is through models that explicitly consider lag-times in sediment and groundwater movement and explicitly consider the storage and release of pollutants from the watershed (from floodplains, soils, reservoir sediments, and groundwater). (STAC, 2012, p. 2)

Rather than failing to state a time frame for assessing water quality standard attainment, US EPA should be consistent with current science and its own understanding of lag times from prior nitrogen TMDLs and provide an appropriate time frame for assessing water quality standard attainment.

[16] STAC includes members from multiple stakeholders in the Chesapeake Bay Program, including universities (*e.g.*, Virginia Polytechnic Institute and University of Maryland), federal agencies (*e.g.*, USGS and the United States Department of Agriculture), and nonprofit groups (*e.g.*, The Nature Conservancy and the Chesapeake Research Consortium).

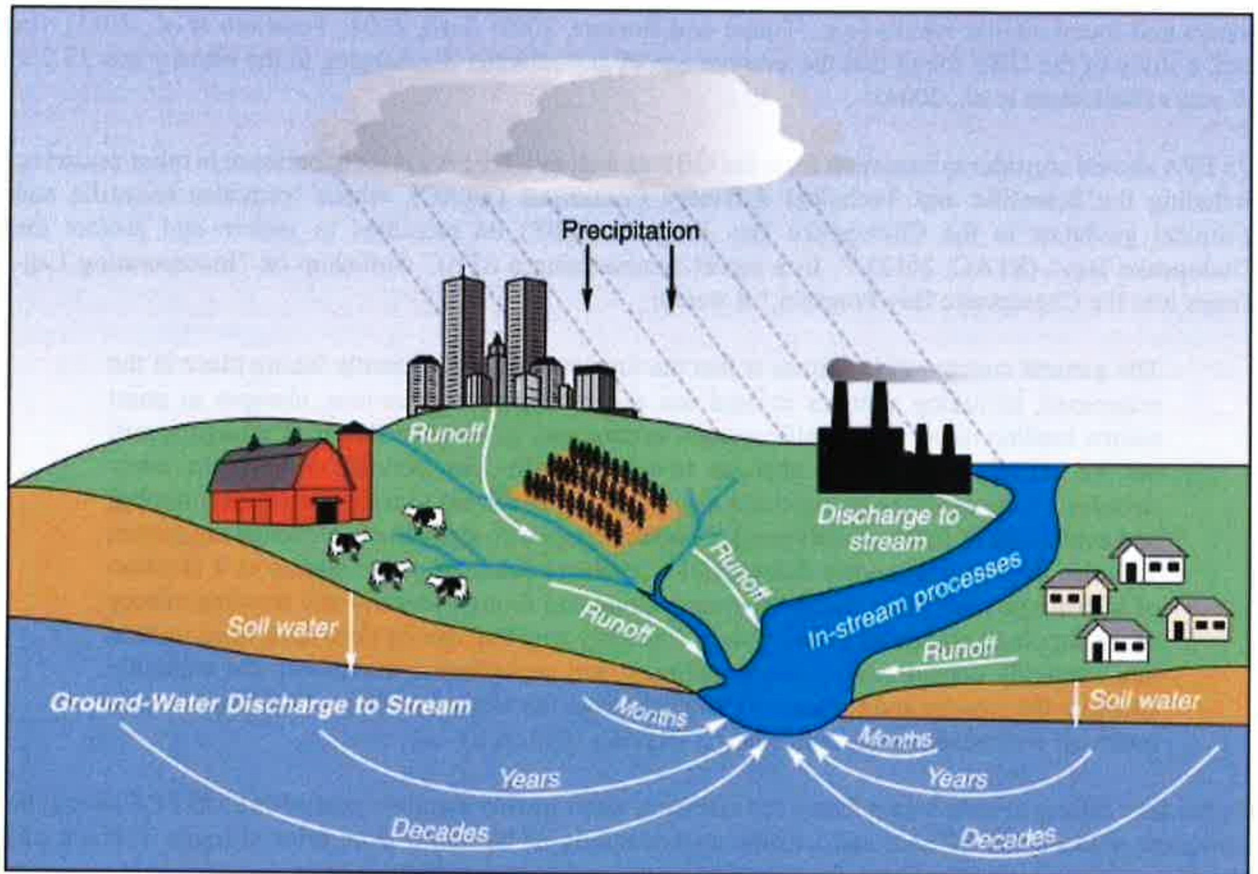

Figure 6.1 Illustration of Transport Pathways for Nitrogen and the Long Transport Timescales (Lag Times) for Nitrogen Transported *via* Groundwater to Surface Water Bodies. Source: Sanford and Pope (2013).

7 US EPA arbitrarily and capriciously ignored nitrogen contributions to the GBE from Maine as they relate to attaining water quality standards.

In the Fact Sheet, US EPA states that it based its decision to use the General Permit provisions of the Clean Water Act regulatory scheme on 40 CFR §122.28 (US EPA, 2019b), stating,

> When issued, the GBTN GP will enable the subject facilities to maintain compliance with the CWA, will provide timely responses to the permitting needs of the wastewater treatment industry and will help reduce the current backlog of administratively continued NPDES permits. Such an approach would, in EPA's judgment, be more expeditious and efficacious than individual permit issuances, because total nitrogen impacts can be addressed, and receiving water responses evaluated, on a system-wide, holistic level, resulting from a gross reduction in that pollutant from multiple sources in the watershed at roughly the same time. (US EPA, 2020b, pp. 4-5)

However, the use of the General Permit approach is fundamentally flawed, since the Draft GP only regulates a portion of the GBE watershed. Although the Draft GP applies only to nitrogen sources in New Hampshire, a substantial portion of the nitrogen load to the GBE originates in Maine, which encompasses nearly one third of the GBE watershed (PREP, 2017). Despite the GBE being under the influence of nitrogen loads from two states, the US EPA has chosen to regulate only WWTFs in New Hampshire. The terms and limitations imposed by the Draft GP ignore the sizable influence of Maine communities.

As an illustrative example of how arbitrary the Draft GP's approach is, we compared TN concentrations resulting from the loading threshold to TN concentrations that Maine has found protective of eelgrass. Standards related to Maine NPDES discharges are mandated by the Maine Department of Environmental Protection (MEDEP). MEDEP, after reviewing existing information from US EPA Region I, found a TN concentration of 0.32 mg-N/L to be protective of eelgrass populations (MEDEP, 2018). As explained more thoroughly in Section 4, the Draft GP would compel New Hampshire communities to achieve a TN load threshold of 100 kg/ha^{-1} yr^{-1}, which corresponds to TN concentrations between 0.18 mg-N/L and 0.29 mg-N/L at monitoring stations in the GBE. Thus, Maine communities will be permitted to discharge TN at rates significantly higher than New Hampshire communities, with New Hampshire communities having to bear the burden of Maine-generated effluent. This is clearly arbitrary and capricious.

8 The approach used by US EPA for determining discharge limits amongst the regulated wastewater treatment facilities (WWTFs) in the Draft GP and Fact Sheet arbitrarily treats the Rochester WWTF differently from other WWTFs.

In the Draft GP and Fact Sheet, US EPA specifies discharge limits for each WWTF in the New Hampshire portion of the GBE watershed. The discharge limits in Table 4 of the Fact Sheet list a TN load allocation for Rochester based on 8 mg-N/L of TN in its discharge (US EPA, 2020b). US EPA then applies a delivery factor to this load to account for the fact that some of the nitrogen discharged from Rochester is attenuated in the Cocheco River before reaching the GBE.

The procedure used by US EPA to specify discharge limits inappropriately takes the benefit of the delivery factor for Rochester and spreads it across the WWTFs that discharge directly to the GBE (*i.e.*, with no attenuation). Effectively, using the current construct of the Draft GP, Rochester would discharge 8 mg-N/L to the Cocheco River that would be attenuated by 24.44% to 6.0 mg-N/L when it reaches the head of tide in the GBE. Thus, while other WWTFs in the Draft GP are allowed to discharge 8 mg-N/L directly to the GBE, the Rochester WWTF is only allowed to discharge 6 mg-N/L. Such inconsistent treatment of the Rochester WWTF is inappropriate, and effectively gives the benefit of Rochester's delivery factor to other WWTFs that discharge directly to the GBE (*via* increased allowable loads at those other facilities). To avoid being arbitrary, US EPA must appropriately factor the unique situation of Rochester into the Draft GP by specifying a delivered concentration of 8 mg-N/L for all WWTFs rather than requiring Rochester to meet some stricter standard.

9 Conclusions

The Draft GP and Fact Sheet have multiple critical shortcomings as described in these comments. Any one of these shortcomings appears to meet the definition of arbitrary and capricious (see Section 1.1). However, in combination the evidence is overwhelming. The following key issues contribute to this finding:

- The Draft GP and Fact Sheet entirely failed to consider background nitrogen loads and have specified a loading threshold that is not achievable.
- The Draft GP and Fact Sheet entirely failed to consider certain nitrogen sources in the GBE watershed that should be added to other components of background.
- The Draft GP and Fact Sheet entirely failed to consider relevant precedent information and site-specific data from the GBE. These data indicate that the loading threshold specified by US EPA corresponds to nitrogen concentrations in the GBE that approach background conditions at the mouth of the estuary and are below target concentrations developed for other estuaries in the Northeast that are protective of the same water quality indicator (*i.e.*, eelgrass).
- The Draft GP and Fact Sheet failed to consider whether the proposed loading threshold is likely to attain the current designated use of the GBE. While US EPA has advocated for better integration of the Use Attainability Analysis (UAA; US EPA, 2019a) process with regulatory developments, it did not consider several factors of a UAA that are important when using eelgrass health as a basis for judging designated use attainment.
- The Draft GP and Fact Sheet are devoid of any objective Water Quality Standards, arbitrarily predicate reopening of or reissuing the permit on "optional" NPS reductions, and failed to state the timeframe over which it would assess attainment of water quality standards.
- The Draft GP and Fact Sheet arbitrarily ignored nitrogen contributions to the GBE from Maine as they relate to attaining water quality standards. The loading threshold in the Fact Sheet corresponds to TN concentrations in the GBE that are lower than the value of 0.32 mg-N/L used by Maine to set discharge limits from its WWTFs. US EPA's approach therefore forces New Hampshire to atone for nitrogen loads from Maine that are designed to meet a less stringent standard.
- The approach used by US EPA to determine discharge limits amongst the regulated WWTFs in the Draft GP and Fact Sheet arbitrarily treats the Rochester WWTF differently from other WWTFs. US EPA's approach inappropriately results in a more stringent standard for Rochester.

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Appendix A

Background Scenario Evaluated with the NHDES (2014) Model

ertilizer		Source: Animal Waste						Source: Human Waste		
arks, elds urf)	*via* Agriculture (lb/yr)	*via* Agriculture (lb/yr)	*via* Residential Lawns (lb/yr)	*via* Connected Impervious Area (lb/yr)	*via* Disconnected Impervious Area (lb/yr)	*via* Septic within 200 m of Waterways (lb/yr)	*via* Septic >200 m of Waterways (lb/yr)	*via* Septic within 200 m of Waterways (lb/yr)	*via* Septic >200 m of Waterways (lb/yr)	Total from the Four Sources (lb/yr)
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	250.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25,655.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9,558.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7,867.9
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,449.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,709.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,517.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17,458.9
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	354.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21,223.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22,762.9
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,887.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12,747.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9,592.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16,860.9
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7,988.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15,581.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	910.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	383.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	416.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,656.6
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,681.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13,481.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7,800.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5,558.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12,653.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,047.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5,865.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,838.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19,298.6
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11,413.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,156.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7,704.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23,771.6
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12,499.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13,289.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21,943.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,206.6
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,771.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5,928.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,001.9
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25,711.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,500.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17,290.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	263.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12,508.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20,765.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15,095.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13,890.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28,302.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19,631.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8,012.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	298.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18,907.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5,436.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,484.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	575,844.0
									Total in kg/ha-yr =	48.0

ertilizer		Source: Animal Waste						Source: Human Waste		
arks elds rf)	*via* Agriculture (lb/yr)	*via* Agriculture (lb/yr)	*via* Residential Lawns (lb/yr)	*via* Connected Impervious Area (lb/yr)	*via* Disconnected Impervious Area (lb/yr)	*via* Septic within 200 m of Waterways (lb/yr)	*via* Septic >200 m of Waterways (lb/yr)	*via* Septic within 200 m of Waterways (lb/yr)	*via* Septic >200 m of Waterways (lb/yr)	Total from the Four Sources (lb/yr)
	177.0	2.4	1.6	0.4	7.1	0.0	0.9	0.0	73.0	544.1
	914.3	1,948.6	165.2	651.4	1,366.7	0.0	207.8	0.0	23,400.4	61,910.9
	1,887.1	2,947.1	70.7	408.5	683.7	0.0	84.4	0.0	10,784.9	31,756.2
	202.6	943.6	14.9	20.0	130.2	0.0	14.8	0.0	1,666.4	11,445.6
	673.8	1,204.2	60.2	182.9	392.0	0.0	59.1	0.0	6,952.1	21,629.1
	1,867.6	3,103.0	84.1	217.3	463.7	0.0	76.0	0.0	11,066.6	30,432.7
	57.2	139.3	16.1	60.8	197.9	0.0	26.7	0.0	2,485.9	4,994.5
	1,640.2	4,444.2	35.0	183.8	611.8	0.0	79.6	0.0	9,405.4	36,845.5
	54.3	62.1	5.3	7.3	154.2	0.0	17.4	0.0	297.1	968.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21,223.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22,762.9
	961.0	487.0	24.5	86.8	217.3	0.0	28.2	0.0	3,590.0	9,686.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12,747.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9,592.7
	1,812.4	11,804.0	145.8	604.3	1,203.6	0.0	130.3	0.0	12,599.9	52,186.0
	755.9	2,964.7	75.3	293.8	642.0	0.0	98.3	0.0	11,746.5	28,124.1
	1,391.0	5,441.8	134.1	470.2	474.1	21.1	79.9	2,384.9	8,656.8	45,169.1
	112.8	58.1	21.4	97.2	154.6	0.0	20.5	0.0	2,028.3	4,061.6
	12.2	95.2	44.8	144.4	118.3	0.0	24.5	0.0	226.4	1,492.5
	132.9	53.4	0.2	9.9	42.4	0.0	3.6	0.0	146.9	857.4
	1,185.8	7,266.6	30.7	78.4	235.8	0.0	29.7	0.0	3,334.7	17,386.0
	615.6	744.3	53.1	164.0	209.5	0.0	40.7	0.0	3,849.7	11,012.6
	2,255.6	16,283.3	110.5	391.0	838.3	22.2	97.4	2,298.7	10,816.1	51,767.8
	1,746.8	457.5	47.9	128.9	301.5	0.5	40.0	61.9	4,793.3	18,263.7
	147.3	71.2	27.6	124.2	206.5	0.0	42.1	0.0	4,838.2	12,400.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12,653.7
	8.5	0.0	29.8	177.1	112.6	12.3	1.4	1,092.0	191.1	5,797.2
	377.5	455.0	19.2	86.6	162.8	0.0	31.2	0.0	4,521.4	12,947.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,838.4
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19,298.6
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11,413.4
	299.3	94.8	72.7	283.0	280.1	0.0	50.8	0.0	4,867.3	12,933.5
	542.6	1,342.3	38.0	174.1	460.9	0.0	57.8	0.0	5,977.2	18,279.1
	1,289.5	10,606.4	54.2	263.7	853.7	7.2	109.1	1,202.5	12,515.2	54,195.1
	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.9	3.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12,499.0
	1,014.5	1,202.0	252.1	1,246.9	1,354.7	0.0	253.3	0.0	27,566.2	56,266.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21,943.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,206.6
	65.1	184.8	69.4	298.6	254.1	19.3	44.9	2,107.8	4,090.3	12,565.3
	560.8	391.6	146.8	325.5	616.9	0.0	110.2	0.0	13,013.8	25,499.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,001.9
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1,352.3	1,281.4	63.7	155.0	624.2	0.0	67.8	0.0	9,566.6	42,158.4
	3,522.5	1,405.3	191.4	937.9	1,105.5	18.7	167.2	1,926.6	18,757.5	44,805.8
	511.2	403.6	90.1	304.7	639.3	0.0	78.7	0.0	7,956.2	32,315.6
	2.5	34.6	0.2	1.4	24.0	0.0	2.2	0.0	70.9	409.7
	506.4	218.3	28.1	67.8	295.7	0.1	36.0	9.9	3,501.8	18,554.2
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20,765.0
	2,097.8	4,301.9	160.0	627.8	874.6	35.2	91.9	3,483.0	9,988.1	44,613.5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13,890.7
	1,797.7	810.9	129.8	410.2	1,090.7	24.5	131.3	2,752.2	15,254.4	57,452.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19,631.5
	657.7	378.9	229.3	1,068.7	1,072.6	0.0	123.7	0.0	7,241.6	24,450.7
	96.0	6.5	0.5	3.5	7.9	0.0	0.9	0.0	56.9	509.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18,907.8
	536.2	195.2	47.7	172.6	368.7	0.0	48.8	0.0	4,402.3	13,128.6
	11.9	69.6	31.5	26.3	150.4	0.0	18.3	0.0	269.1	2,129.3
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	33,853.6	83,905.1	2,823.6	10,956.7	19,000.7	161.1	2,627.3	17,319.5	282,567.7	1,161,324.6
									Total in kg/ha-yr =	96.9

Appendix B

Methods for Calculating Delivered Loads to the GBE from Data Reported by PREP

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List of Tables

Piscataqua Region Estuaries Partnership (PREP) has reported total nitrogen (TN) loads to the Great Bay Estuary (GBE) in its State of Our Estuary (SOOE) reports (PREP, 2013, 2018). US EPA relies on the loads calculated by PREP in the Draft GP (US EPA, 2020a) and Fact Sheet (US EPA, 2020b). However, the extent of the GBE considered by PREP in its calculations did not include non-point source (NPS) loads from a portion of the estuary known as the Lower Piscataqua River (LPR). In addition, PREP considered point source loads from the LPR, but did so by applying so-called delivery factors, which account for how much of the discharged nitrogen in the LPR travels to upstream reaches of the estuary during tidal mixing. When it calculated TN loads in the Draft GP and Fact Sheet, US EPA included the NPS load from the LPR and removed the delivery factors for point source loads in the LPR (*i.e.*, all discharges from point sources in the LPR were assumed to reach the GBE regardless of any hydrological limitations on the transport of discharges due to tidal mixing) to estimate the TN load for the entire GBE. To be consistent with US EPA's approach to calculating loads, we used the same US EPA methods and TN load data relied upon by PREP to calculate loads in all periods during which PREP evaluated loads (*i.e.*, 2003-2016; see Comments, Table 4.1). The loads are composed of three parts: point source loads corrected to be delivered values to the GBE, NPS loads to a portion of the GBE calculated by PREP, and NPS loads not considered by PREP in the LPR. Our methods, which are consistent with US EPA's methods in the Draft GP and Fact Sheet for calculating TN loads to the GBE, are described further below.

B.1 Point Source Loads Corrected To Be Delivered Values to the GBE

In the PREP SOOE reports (PREP, 2013, 2018), wastewater treatment facility (WWTF; *i.e.*, point source) TN loads to the GBE are calculated based on delivery factors. For WWTFs that discharge to freshwater tributaries of the GBE, the delivery factors represent in-stream attenuation of nitrogen before reaching the heads of tide at the GBE. These delivery factors were applied to WWTFs in the Draft GP and Fact Sheet when US EPA calculated point source loads. For WWTFs in the LPR, however, PREP applied delivery factors that are intended to account for the amount of discharged TN that is transported to upstream reaches of the GBE *via* tidal mixing. US EPA did not apply these delivery factors in its calculations of point source loads in the Draft GP and Fact Sheet. We used US EPA's methodology to calculate point source loads to the GBE, using the same data that was relied upon by PREP in its SOOE reports (PREP, 2013, 2018).

For each of the individual years from 2012 to 2016, PREP did not report discharged loads for each individual WWTF in tabulated form. Instead, it tabulated only the total delivered load across all WWTFs in its Technical Support Document for the 2018 SOOE Report (PREP, 2017, Table NL-5). To convert the delivered loads considered by PREP to delivered loads to the GBE used by US EPA (correcting for differences in delivery factor assumptions), we calculated the ratio of the US EPA delivered load from 2012 to 2016 (82.7 kg ha^{-1} yr^{-1}) to the PREP delivered load (49.4 kg ha^{-1} yr^{-1}) for the same period. The ratio (1.67) was multiplied by the PREP delivered loads for each year from 2012 to 2016 to get equivalent US EPA delivered loads to the GBE in the respective years.

The periods evaluated by PREP and delivered WWTF loads to the GBE consistent with US EPA's methods are summarized in Table B.1.

Table B.1 Point Source Loads to the GBE Calculated Using US EPA's Methodology

Period	Delivered WWTF Load ($kg\ ha^{-1}\ yr^{-1}$)	Source
2003-2004	77.9	NHDES (2010, Appendix A, Table 4)
2005-2006	92.3	NHDES (2010, Appendix A, Table 4)
2007-2008	83.3	NHDES (2010, Appendix A, Table 4)
2009-2011	105.0	PREP (2012, Table NUT1-1)
2012	101.6	PREP (2017, Table NL-5)
2013	95.2	PREP (2017 Table NL-5)
2014	80.6	PREP (2017, Table NL-5)
2015	73.7	PREP (2017, Table NL-5)
2016	71.5	PREP (2017, Table NL-5)
2012-2016	82.7	US EPA (2020b)

Notes:
GBE = Great Bay Estuary; NHDES = New Hampshire Dept. of Environmental Services; PREP = Piscataqua Region Estuaries Partnership; US EPA = United States Environmental Protection Agency; WWTF = Wastewater Treatment Facility.

B.2 NPS Loads to a Portion of the GBE Calculated by PREP

PREP (2013, 2018) previously reported NPS loads to the GBE for all areas of the GBE watershed except the LPR. The PREP NPS loads are listed in Table B.2. The PREP NPS load to the GBE includes tributary loads, direct groundwater discharges to the estuary, and direct atmospheric deposition to the estuary.

Table B.2 NPS Loads to the GBE Reported by PREP, Excluding the LPR

Period	Delivered NPS Load ($kg\ ha^{-1}\ yr^{-1}$)	Source
2003-2004	142.3	NHDES (2010, Appendix A, p. 11)
2005-2006	208.5	NHDES (2010, Appendix A, p. 11)
2007-2008	164.3	NHDES (2010, Appendix A, p. 11)
2009-2011	139.2	PREP (2012)
2012	107.6	PREP (2017, Table NL-5)
2013	107.1	PREP (2017, Table NL-5)
2014	126.9	PREP (2017, Table NL-5)
2015	83.1	PREP (2017, Table NL-5)
2016	75.3	PREP (2017, Table NL-5)
2012-2016	100.0	US EPA (2020b)

Notes:
GBE = Great Bay Estuary; LPR = Lower Piscataqua River; NHDES = New Hampshire Dept. of Environmental Services; NPS = Non-point Source; PREP = Piscataqua Region Estuaries Partnership.

B.3 NPS Loads Not Considered by PREP in the LPR

US EPA calculated NPS loads from the LPR in the Draft GP and Fact Sheet using the NHDES (2014) modeling results. The NPS loads from this area were not included in the NPS loads reported by PREP. To account for variation in NPS loads during different periods due to variations in precipitation, US EPA used a so-called normalization approach, which was described in Section 2 of these Comments. We used the same approach as US EPA to calculate NPS loads from the LPR for different years, using the NHDES (2014) value for 2009-2011 (9.1 $kg\ ha^{-1}\ yr^{-1}$) as a baseline. Results are summarized in Table B.3. Although we used the same method as US EPA, US EPA did not specify which precipitation monitoring station that it used to calculate normalization factors in the Fact Sheet. We were not able to reproduce US EPA's normalization factors for the LPR using any of the precipitation monitoring stations in or around the LPR. In Table B.3, we used precipitation data from Durham, New Hampshire.

Table B.3 NPS Loads to the GBE from the LPR

Period	Average Annual Precipitation (inches)	Normalization Factor	Normalized Load (kg ha^{-1} yr^{-1})
2003-2004	45.7	0.85	7.8
2005-2006	61.0	1.14	10.4
2007-2008	57.8	1.08	9.8
2009-2011	53.6	1.00	9.1
2012	40.9	0.76	6.9
2013	43.9	0.82	7.5
2014	44.1	0.82	7.5
2015	37.8	0.70	6.4
2016	38.1	0.71	6.5
2012-2016[1]	–	–	6.6

Notes:
GBE = Great Bay Estuary; LPR = Lower Piscataqua River; NPS = Non-point Source.
(1) For the period between 2012 and 2016, we used the normalized load reported by US EPA (2020b) in the Fact Sheet and did not calculate a normalization factor.

References

New Hampshire Dept. of Environmental Services (NHDES). 2010. "Analysis of Nitrogen Loading Reductions for Wastewater Treatment Facilities and Non-Point Sources in the Great Bay Estuary Watershed, Appendix A: Watershed Nitrogen Loads to the Great Bay Estuary (Draft)." 40p.

New Hampshire Dept. of Environmental Services (NHDES). 2014. "Great Bay Nitrogen Non-Point Source Study." June 16, 234p.

Piscataqua Region Estuaries Partnership (PREP). 2012. "Final Environmental Data Report December 2012: Technical Support Document for the 2013 State of Our Estuaries Report." PREP Reports & Publications No. 265. 288p., December 7.

Piscataqua Region Estuaries Partnership (PREP). 2013. "State of Our Estuaries 2013." PREP Reports & Publications No. 259. 49p.

Piscataqua Region Estuaries Partnership (PREP). 2017. "Environmental Data Report December 2017: Technical Support Document for the 2018 State of Our Estuaries Report." 243p., December.

Piscataqua Region Estuaries Partnership (PREP). 2018. "State of Our Estuaries 2018." 52p.

US EPA. 2020a. "Draft National Pollution Discharge Elimination System (NPDES) Great Bay Nitrogen General Permit for Wastewater Treatment Facilities in New Hampshire." NPDES Permit No. NHG58A000, 38p.

US EPA. 2020b. "Fact Sheet: Draft National Pollution Discharge Elimination System (NPDES) Great Bay Nitrogen General Permit for Wastewater Treatment Facilities in New Hampshire." NPDES Permit No. NHG58A000, 50p.

Appendix C

Letter from US EPA Director of Water
March 16, 2020

From: James Gray <James.Gray@leg.state.nh.us>
Sent: Tuesday, March 17, 2020 12:26 PM
To: Blaine Cox <blaine.cox@rochesternh.net>
Cc: Sherilyn Burnett Young <sby@rathlaw.com>
Subject: Fwd: Great Bay general permit

See below:

Jim

James P Gray

NH State Senator

District 6

Office (603) 271-3092

Home (603) 332-7144

Sent from my iPhone

Begin forwarded message:

From: "Freise, Clark" <Clark.Freise@des.nh.gov>
Date: March 17, 2020 at 10:07:04 AM EDT
To: David Watters <David.Watters@leg.state.nh.us>, James Gray <James.Gray@leg.state.nh.us>
Cc: "Scott, Robert" <Robert.Scott@des.nh.gov>
Subject: FW: Great Bay general permit

Senators Gray and Watters,

At Commissioner Scott's request I reached out to EPA with Dean's request for a side meeting with Dr. Latimer. Please see EPA's email below. EPA and Dr. Latimer both state that Dean's representation of Dr. Latimer's position is incorrect. Dr. Latimer and EPA's position is clear that the three peer-reviewed papers along with other lines of evidence is sufficient scientific evidence to support the draft permit and fact sheet. EPA believes that the current, extended public comment process is the right process for stakeholders to provide comments of alternative scientific evidence to support or question the evidence they have used. They do not feel it would be appropriate to have a side meeting with individual stakeholders at this time while the public comment process is open. EPA has clearly stated that they have spent significant time and effort in providing open and collaborative communication in the drafting of the permit, but now the public comment process is the appropriate avenue for communication. DES agrees that EPA has provided many opportunities for discussion over the last two years, has provided multiple invitations for technical engagement, and has made it clear that they are open to alternative scientific evidence that might provide alternative monitoring requirements, endpoints or off-ramp descriptors throughout this process.

Please be aware, as we committed in our meeting with you, DES is setting up a workshop (we are strongly recommending remote participation) to discuss aspects of the draft permit that we think are important areas for enhanced public comment (e.g. monitoring and off-ramp descriptors) and encourage the Great Bay communities' participation. In particular, we have asked PREP to provide a discussion of their ongoing efforts on estuary health monitoring that should result in a significant report in 2021 that might be used to inform updates to those aspects of the general permit. DES has also been in discussions with the towns on methods by which disparities in how the towns and EPA might be measuring baselines and endpoints could best be addressed in the town's comments.

Best regards,

Clark

Assistant Commissioner

Department of Environmental Services

(603) 271-8806

From: Moraff, Kenneth <Moraff.Ken@epa.gov>
Sent: Monday, March 16, 2020 3:48 PM
To: Freise, Clark <Clark.Freise@des.nh.gov>
Cc: Latimer, Jim <Latimer.Jim@epa.gov>
Subject: Great Bay general permit

EXTERNAL: Do not open attachments or click on links unless you recognize and trust the sender.

Assistant Commissioner Freise:

Thank you for your note to EPA Region 1 about requests you have received to invite EPA's Dr. James Latimer to New Hampshire for a meeting. From a March 9, 2020 email written by a consultant for Dover, NH (Dean Peschel), we understand the stated purpose of this request is for Dr. Latimer to address statements attributed to him regarding the applicability of a peer-reviewed paper that he co-authored to the development by our agencies of a proposed nitrogen target to achieve water quality standards in the Great Bay estuary. The agencies relied on the peer-reviewed Latimer & Rego (2010) article as one among several lines of evidence to derive that proposed target in connection with a draft general NPDES permit for total nitrogen. Mr. Peschel claims that Dr. Latimer does not believe the use of this paper was "an appropriate or scientifically defensible way to set a nitrogen limit."

First, EPA Region 1 wishes to make clear that it views the peer-reviewed Latimer & Rego article, in combination with other sources described in the Fact Sheet of the Draft Permit, as providing a sufficient and reasonable basis to support the Draft Permit's total nitrogen loading endpoint. The Region has confirmed with Dr. Latimer that he concurs with this view.

Second, we note further that the proposed long-term nitrogen loading endpoint – 100 kg/ha/yr – drawn from multiple lines of evidence including the Latimer & Rego (2010) paper and others is not an enforceable limit or other such permit requirement. Rather, this endpoint is a proposed loading target that may change over time as part of the draft permit's proposed adaptive management approach. This adaptive management approach, under the terms of the draft permit, would be informed by expanded agency monitoring and modeling of the Great Bay estuary. This adaptive management plan would also be an open process, providing all stakeholders with an ongoing, real-time opportunity to inform the state of science for the estuary over multiple permit terms.

Third, we note that the proposed agency findings regarding the applicability of the peer-reviewed Latimer & Rego paper to the proposed long-term nitrogen loading endpoint in the draft permit are provisional, of course, pending the conclusion of the draft permit public comment period. Given that the public review and comment period for this draft general permit is ongoing, the proper vehicle for agency engagement (e.g., on the draft permit's proposed approach, terms, or scientific basis) is the submittal of formal comments to the docket. After the recently-extended public comment period closes, EPA will prepare an administrative record that responds to all comments, including any comments that may be submitted concerning the relevance of the Latimer & Rego (2010) peer-reviewed paper or other research to the final permit.

Finally, as you are aware, we disagree with the allegation by Mr. Peschel that our agencies "blocked all communication" concerning this draft nitrogen endpoint between stakeholders and EPA's Dr. Latimer. For over two years, the EPA and NHDES have engaged in robust discussions about all aspects of the proposed draft permit. This has included multiple in-person meetings with the communities and other stakeholders (some of which were focused solely on nitrogen endpoint science), numerous calls, and email conversations. Throughout this process, legal and scientific representatives from the communities were provided regular, repeated opportunities to ask questions of EPA's technical staff (including Dr. Latimer) and provide information that would lead the agencies to consider different long-term draft nitrogen endpoints. This engagement did not stop; our agencies' technical teams had determined that they had enough information to develop a draft permit and to begin the full, ordinary, public review process. Indeed, as noted above, our engagement with the communities continues – the public comment process is another opportunity for the communities to provide new science for agency consideration or to inquire about the applicability of the Latimer & Rego (2010) peer-reviewed study.

EPA Region 1 remains committed to early engagement, permit innovation, and transparent decision-making. Here, the agency worked for over two years to develop the approach proposed in the draft general permit and to work out, with NHDES, communities, and other stakeholders, how to meet the Great Bay's water quality standards. Armed with peer-reviewed science, significant pre-draft permit public input, and nonpoint source pollution targets developed by the state, EPA decided in 2019 to move to the next step in its permitting process: draft permit development and proposal.

The agency will respond to all public comments submitted as part of the notice and comment process on the draft permit. EPA also plans to continue engaging with stakeholders as we consider development of a final general permit.

Thank you for your attention to this matter.

Ken Moraff

Director, Water Division

EPA Region 1

cc: Dr. James Latimer

Appendix D

Internal US EPA Memorandum
October 7, 2019

Great Bay Estuary, NH
October 7, 2019

Background

The Great Bay estuary—an estuary of national significance and a critical resource in New Hampshire—has experienced low dissolved oxygen, macroalgae blooms, and declining eelgrass habitat for a number of years, all signs of eutrophication driven by excessive nitrogen loading. About 33% of the nitrogen is discharged by 17 wastewater treatment facilities (WWTFs); the rest is from non-point sources, notably stormwater runoff, septic systems, and atmospheric deposition.

EPA and NH DES have been working for years with Great Bay communities to reduce nitrogen from both point and nonpoint sources. Many communities have upgraded their WWTFs, and some are working to reduce stormwater loads.

As EPA and NH DES began working on the next round of NPDES permits (EPA is the permit authority, but we work closely with the state), communities in the watershed urged the agencies to consider an adaptive management approach that would allow them to invest in nonpoint source reduction first. The communities expressed their belief that nonpoint source controls would be more cost-effective, and that these reductions could avoid the need for expensive upgrades to wastewater treatment facilities. EPA and NH DES have developed such an approach, which would be embodied in a general permit for all WWTFs in the watershed.

EPA/NH DES permitting approach

There is no nitrogen TMDL for Great Bay, nor has the state developed a numeric nitrogen criterion, so EPA and NH DES cannot rely on a wasteload allocation or numeric WQS to set permit limits. Instead, we need to use the best available scientific information to identify the nitrogen reductions needed to meet water quality standards. Working with ORD, the region and NH DES developed an overall nitrogen reduction target for the watershed based on our best understanding of the science. To meet this target, nitrogen loads in the estuary need to be reduced by at least one-third (greater reductions may ultimately be needed, but as part of an adaptive management approach we chose to start with the smallest reduction that has a possibility of meeting WQS).

Ordinarily, the level of nitrogen reduction needed in Great Bay would drive the agencies to set WWTF permit limits at the limit of technology (often considered to be 3 mg/L). However, EPA and NH DES have developed a draft permit which largely accommodates the communities' desire to avoid further upgrades at WWTFs and focus instead on nonpoint sources. For the seven largest facilities (with flows over 2 mgd), the permit sets mass limits based on the communities' current flow levels and a nitrogen concentration of 8 mg/L. Almost all communities can meet these limits with existing facilities, avoiding the need for further capital investments.[1] For the

[1] One community (Rochester) may need additional treatment facilities to meet even these relaxed limits. Other communities could hypothetically need additional treatment if they significantly increase their flow, since the mass limit is based on existing discharge rates.

smaller facilities, the permit would set limits based on current flows and concentrations, essentially holding the load where it is today.

These relaxed WWTF limits will not significantly reduce nitrogen loads to Great Bay, and the permit will not result in attainment of water quality standards unless nonpoint sources are addressed (EPA and NH DES have calculated that without more stringent WWTF limits, nonpoint source nitrogen loads will need to be reduced by approximately 45% to meet the WQS-based loading target). For this reason, NHDES initially sought to require these nonpoint source reductions in the permit, as a condition of the state's section 401 certification.

The state has now shifted from that position. We have agreed that the nonpoint source reductions will not be required by the permit, but that the agencies will make clear in their supporting documentation (EPA's permit fact sheet and the state's 401 certification) that the relaxed point source limits are based on an assumption that the communities will reduce nonpoint source loads, consistent with their expressed preference to invest in those sources first. The agencies will state their expectation that these reductions—combined with the permit's "hold the load" approach at WWTF's—will be sufficient to meet WQS.

The permit recognizes that achieving nonpoint source reductions on this scale will take longer than one permit term, and sets forth an adaptive management approach, including four five-year phases of nonpoint source work. Implementation of this approach is not a permit requirement, but rather a recommended option for communities to achieve the nonpoint source reductions needed to avoid more stringent point source limits. Ambient water quality would be monitored over the course of this work, and targets could be adjusted based on the latest science. NH DES and EPA will state that if the expected nonpoint source reductions do not occur, future permits may need to establish tighter limits on WWTFs to ensure that WQS are ultimately met (and if the communities do not implement the planned nonpoint source activities, the permit could be reopened for modification if necessary).

Permittee engagement

EPA and NH DES engaged extensively with permittees over the past several years, both with groups of communities and with individual permittees (just in the past year, there have been seven face-to-face meetings as well as numerous calls and emails). These interactions have included extensive discussions of possible permit approaches and the scientific foundation for nitrogen limits. The NH governor's office participated in some of these meetings, and the governor has expressed support for expeditious resolution of the issue; for an adaptive management approach; and for a permit that addresses water quality concerns and meets legal requirements so it can withstand an appeal by environmental groups (which would create uncertainty for permittees and businesses). The region believes the draft general permit satisfies those interests.

One key reason to move forward expeditiously is that the permit is needed to establish nitrogen limits for the Pease WWTF in Portsmouth, NH, in order to allow a large employer to significantly expand their facility (Portsmouth and the company need to know what the nitrogen limit will be, in order to finalize their plans). New Hampshire estimates that 1,000 local jobs are at stake, and this is a key factor in the governor's interest in speedy issuance of the permit.

(b) (5) [redacted]

Peer review request

On Oct. 1, Dover and Rochester wrote to the AA for Water and the Region 1 RA to request that EPA conduct a "peer review" of the methodology behind the general permit. (b) (5) [redacted]

ATTACHMENT 2

From: Moraff, Kenneth <Moraff.Ken@epa.gov>
Sent: Monday, March 16, 2020 3:48 PM
To: Freise, Clark <Clark.Freise@des.nh.gov>
Cc: Latimer, Jim <Latimer.Jim@epa.gov>
Subject: Great Bay general permit

Assistant Commissioner Freise:

Thank you for your note to EPA Region 1 about requests you have received to invite EPA's Dr. James Latimer to New Hampshire for a meeting. From a March 9, 2020 email written by a consultant for Dover, NH (Dean Peschel), we understand the stated purpose of this request is for Dr. Latimer to address statements attributed to him regarding the applicability of a peer-reviewed paper that he co-authored to the development by our agencies of a proposed nitrogen target to achieve water quality standards in the Great Bay estuary. The agencies relied on the peer-reviewed Latimer & Rego (2010) article as one among several lines of evidence to derive that proposed target in connection with a draft general NPDES permit for total nitrogen. Mr. Peschel claims that Dr. Latimer does not believe the use of this paper was "an appropriate or scientifically defensible way to set a nitrogen limit."

First, EPA Region 1 wishes to make clear that it views the peer-reviewed Latimer & Rego article, in combination with other sources described in the Fact Sheet of the Draft Permit, as providing a sufficient and reasonable basis to support the Draft Permit's total nitrogen loading endpoint. The Region has confirmed with Dr. Latimer that he concurs with this view.

Second, we note further that the proposed long-term nitrogen loading endpoint – 100 kg/ha/yr – drawn from multiple lines of evidence including the Latimer & Rego (2010) paper and others is not an enforceable limit or other such permit requirement. Rather, this endpoint is a proposed loading target that may change over time as part of the draft permit's proposed adaptive management approach. This adaptive management approach, under the terms of the draft permit, would be informed by expanded agency monitoring and modeling of the Great Bay estuary. This adaptive management plan would also be an open process, providing all stakeholders with an ongoing, real-time opportunity to inform the state of science for the estuary over multiple permit terms.

Third, we note that the proposed agency findings regarding the applicability of the peer-reviewed Latimer & Rego paper to the proposed long-term nitrogen loading endpoint in the draft permit are provisional, of course, pending the conclusion of the draft permit public comment period. Given that the public review and comment period for this draft general permit is ongoing, the proper vehicle for agency engagement (e.g., on the draft permit's proposed approach, terms, or scientific basis) is the submittal of formal comments to the docket. After the recently-extended public comment period closes, EPA will prepare an administrative record that responds to all comments, including any comments that may be submitted concerning the relevance of the Latimer & Rego (2010) peer-reviewed paper or other research to the final permit.

Finally, as you are aware, we disagree with the allegation by Mr. Peschel that our agencies "blocked all communication" concerning this draft nitrogen endpoint between stakeholders and EPA's Dr. Latimer. For over two years, the EPA and NHDES have engaged in robust discussions about all aspects of the proposed draft permit. This has included multiple in-person meetings with the communities and other stakeholders (some of which were focused solely on nitrogen endpoint science), numerous calls, and email conversations. Throughout this process, legal and scientific representatives from the communities were provided regular, repeated opportunities to ask questions of EPA's technical staff (including Dr. Latimer) and provide information that would lead the agencies to consider different long-term draft nitrogen endpoints. This engagement did not stop; our agencies' technical teams had determined that they had enough information to develop a draft permit and to begin the full, ordinary, public review process. Indeed, as noted above, our engagement with the communities continues – the public comment process is another opportunity for the communities to provide new science for agency consideration or to inquire about the applicability of the Latimer & Rego (2010) peer-reviewed study.

EPA Region 1 remains committed to early engagement, permit innovation, and transparent decision-making. Here, the agency worked for over two years to develop the approach proposed in the draft general permit and to work out, with NHDES, communities, and other stakeholders, how to meet the Great Bay's water quality standards. Armed with peer-reviewed science, significant pre-draft permit public input, and nonpoint source pollution targets developed by the state, EPA decided in 2019 to move to the next step in its permitting process: draft permit development and proposal.

The agency will respond to all public comments submitted as part of the notice and comment process on the draft permit. EPA also plans to continue engaging with stakeholders as we consider development of a final general permit.

Thank you for your attention to this matter.

Ken Moraff
Director, Water Division
EPA Region 1

cc: Dr. James Latimer

ATTACHMENT 3

Memo

Date: December 2, 2019

To: Dean Peschel

From: Cristhian Mancilla
Thomas W. Gallagher, Namita Joshua

Subject: Development Of Great Bay Estuary System Total Nitrogen Model

1.0 Introduction

Both the United States Environmental Protection Agency (USEPA) and the New Hampshire Department of Environmental Services (NHDES), have proposed a maximum annual total nitrogen (TN) load of 100 kg/ha-yr for protection of eelgrass in the Great Bay Estuary System (GBES). This TN loading rate was derived from an empirical relationship between TN loads and eelgrass bed areal extent derived from other study areas and summarized in papers authored by Dr. James Latimer (USEPA) et al. It is questionable that the conditions in these other study areas, such as the magnitude of freshwater flows, nitrogen forms, residence time, water depth, and water clarity, are sufficiently similar to the GBES for application of the 100 kg/ha-yr loading rate as a guideline to the GBES. An alternative approach is to set a GBES average TN concentration that is protective of eelgrass health based on other study areas, as summarized in the literature. An advantage of this approach is that the TN concentration in a waterbody, to some extent, reflects local study area specific conditions that are not represented in the TN loading approach. However, for regulatory purposes, it is necessary to develop a tool that relates nitrogen loading to the GBES and resulting GBES water column concentrations; it will then be possible to compute the corresponding GBES TN load for any selected target TN concentration for protection of eelgrass. The same tool allows the assessment of the application of Latimer's empirical TN loading approach to the GBES.

This technical memorandum summarizes the completion of the calibration of a hydrodynamic model of the GBES; the development of a GBES nitrogen model; and the application of such nitrogen model to develop various combinations of point source (PS) and nonpoint source (NPS) nitrogen loads that achieve various GBES target TN concentrations.

2.0 Hydrodynamic Model Development And Calibration

2.1 Hydrodynamic Model Framework

The transport and mixing of pollutant loads introduced to rivers, lakes, reservoirs and coastal environments are controlled by the circulation characteristics of the receiving water body. The fate of a pollutant is strongly influenced by turbulent mixing created by the surface wind stress, currents and tides (astronomical or meteorological). At the same time, turbulent mixing leads to horizontal dispersion in the longitudinal and lateral directions, and to vertical dispersion throughout the water column. Coupled with turbulent mixing due to wind and currents are heat exchange processes between the water column and the atmosphere. All these mechanisms determine the spatial extent and magnitude of the pollutant. The processes that control the heat exchanges between the water and atmosphere are well documented (Ahsan and Blumberg, 1999; Cole and Buchak, 1995). The four major heat flux components- short-wave solar radiation, long-wave atmospheric radiation, sensible (conduction) and latent (evaporation) heat exchange- used are based on the formulae reported in Ahsan and Blumberg (1999). The complexity of the physical processes governing the evolution of an introduced constituent, such as a pollutant load, suggests the use of sophisticated hydrodynamic models. For this study, HDR's far-field hydrodynamic model (ECOMSED) has been applied to the Great Bay Estuary System.

The hydrodynamic model is a three-dimensional, time-dependent, estuarine and coastal circulation model developed by Blumberg and Mellor (1987). The model incorporates the Mellor and Yamada (1982) level 2-½ turbulent closure scheme to provide a realistic parameterization of vertical mixing. A system of curvilinear coordinates is used in the horizontal direction, which allows for a smooth and accurate representation of variable shoreline geometry. In the vertical scale, the model uses a transformed coordinate system known as the σ-coordinate transformation to allow for a better representation of bottom topography. Water surface elevation, water velocity in three dimensions, temperature and salinity, and water turbulence are predicted in response to weather conditions (winds and incident solar radiation), tributary inflows, tides, temperature and salinity (if applicable) at open boundaries connected to the water body.

The model has gained wide acceptance within the modeling community and regulatory agencies as indicated by the number of applications to important water bodies around the world. Among these applications are: Delaware River, Delaware Bay, and adjacent continental shelf (Galperin and Mellor 1990a,b), the South Atlantic Bight (Blumberg and Mellor, 1983), the Hudson Raritan estuary (Oey et al., 1985a,b,c), the Gulf of Mexico (Blumberg and Mellor, 1985), Chesapeake Bay (Blumberg and Goodrich 1990), Massachusetts Bay (Blumberg et al., 1993), St. Andrew Bay (Blumberg and Kim, 2000), New York Harbor and Bight (Blumberg et al, 1999) and Onondaga Lake (Ahsan and Blumberg 1999). In addition, the model has been applied in Perdido Bay and Escambia/Pensacola Bay (FL) as part of the water quality projects in these systems. The model has also been applied in several lake environments such as Lake Michigan and Green Bay (HydroQual, 1999), and Milwaukee Harbor and near shore Lake Michigan (HydroQual, 2007). In all these studies, model performance was assessed by means of

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extensive comparisons between predicted and observed data. The predominant physics were realistically reproduced by the model for this wide range of applications.

The model solves a coupled system of differential, prognostic equations describing the conservation of mass, momentum, temperature, salinity, turbulence energy and turbulence macroscale. The governing equations for velocity U_i = (u, v, w), temperature (T), salinity (S), and x_i = (x,y,z) are as follows:

$$\frac{\partial U_i}{\partial x_i} = 0 \tag{3-1}$$

$$\frac{\partial}{\partial t}(U,V) + \frac{\partial}{\partial x_i}\left[U_i(u,v) + f(-v,u)\right]$$

$$= -\frac{1}{\rho_o}\left[\frac{\partial P}{\partial x},\frac{\partial P}{\partial y}\right] + \frac{\partial}{\partial z}\left[K_M\frac{\partial}{\partial z}(u,v)\right] + (F_U,F_V) \tag{3-2}$$

$$\frac{\partial T}{\partial t} + \frac{\partial}{\partial x_i}(U_iT) = \frac{\partial}{\partial z}\left[K_H\frac{\partial T}{\partial z}\right] + F_T \tag{3-3}$$

$$\frac{\partial S}{\partial t} + \frac{\partial}{\partial x_i}(U_iS) = \frac{\partial}{\partial z}\left[K_H\frac{\partial S}{\partial z}\right] + F_S \tag{3-4}$$

The horizontal diffusion terms, (F_U, F_V), F_T and F_S, in Equations (3-2) through (3-4) are calculated using a Smagorinsky (1963) horizontal diffusion formulation (Mellor and Blumberg, 1985). Under the shallow water assumption, the vertical momentum equation is reduced to a hydrostatic pressure equation. Vertical accelerations due to buoyancy effects and sudden variations in bottom topography are not taken into account. The hydrostatic approximation yields:

$$\frac{P}{\rho_o} = g(\eta - z) + \int_z^{\eta} g\frac{\rho' - \rho_o}{\rho_o}dz' \tag{3-5}$$

where P is pressure, z is water depth, η(x,y,t) is the free surface elevation, ρ_o is a reference density, and $\rho = \rho(T,S)$ is the density.

The vertical mixing coefficients, K_M and K_H, in Equations (3-2) through (3-4) are obtained by appealing to a level 2-½ turbulence closure scheme and are given by:

$$K_M = \hat{K}_M + \upsilon_M, K_H = \hat{K}_H + \upsilon_H \tag{3-6}$$

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$$\hat{K}_M = q\lambda S_M, \hat{K}_H = q\lambda S_H \quad (3\text{-}7)$$

where $q^2/2$ is the turbulent kinetic energy, l is a turbulence length scale, S_M and S_H are stability functions defined by solutions to algebraic equations given by Mellor and Yamada (1982) as modified by Galperin et al. (1988), and υ_M and υ_H are constants. The variables q^2 and l are determined from the following equations:

$$\frac{\partial q^2}{\partial t} + \frac{\partial(uq^2)}{\partial x} + \frac{\partial(vq^2)}{\partial y} + \frac{\partial(wq^2)}{\partial z} = \frac{\partial}{\partial z}\left[K_q \frac{\partial q^2}{\partial z}\right]$$

$$+ 2K_M\left[\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial v}{\partial z}\right)^2\right] + \frac{2g}{\rho_o} K_H \frac{\partial \rho}{\partial z} - 2\frac{q^3}{B_1 l} + F_q \quad (3\text{-}8)$$

$$\frac{\partial(q^2 l)}{\partial t} + \frac{\partial(uq^2 l)}{\partial x} + \frac{\partial(vq^2 l)}{\partial y} + \frac{\partial(wq^2 l)}{\partial z} = \frac{\partial}{\partial z}\left[K_q \frac{\partial(q^2 l)}{\partial z}\right]$$

$$+ E_1 l\left\{K_M\left[\left(\frac{\partial u}{\partial z}\right)^2 + \left(\frac{\partial v}{\partial z}\right)^2\right] + \frac{g}{\rho_o} K_H \frac{\partial \rho}{\partial z}\right\} - \frac{q^3}{B_1 \tilde{\omega}} + F_l \quad (3\text{-}9)$$

where $K_q = 0.2q\lambda$, the eddy diffusion coefficient for turbulent kinetic energy; F_q and F_λ represent horizontal diffusion of the turbulent kinetic energy and turbulence length scale and are parameterized in a manner analogous to either Equation (3-6) or (3-7); $\tilde{\omega}$ is a wall proximity function defined as $\tilde{\omega} = 1 + E_2 (\lambda/\kappa L)^2$, $(L)^{-1} = (\eta - z)^{-1} + (H + z)^{-1}$, κ is the von Karman constant, H is the water depth, η is the free surface elevation, and E_1, E_2 and B_1 are empirical constants set in the closure model.

The basic Equations, (3-1) through (3-9), are transformed into a terrain following σ-coordinate system in the vertical scale and an orthogonal curvilinear coordinate system in the horizontal scale. The resulting equations are vertically integrated to extract barotropic variables, and a mode splitting technique is introduced such that the fast-moving, external barotropic modes and relatively much-slower internal baroclinic modes are calculated by prognostic equations with different time steps. Detailed solution techniques are described in Blumberg and Mellor (1987) and ECOM Users Manual (HydroQual, 2007).

The Great Bay consists of a vast area of tidal wetlands. Most of the southeast side of the Great Bay is submerged under average tidal conditions. Water storage that occurs in the wetlands during tidal cycling is expected to have an effect on hydrodynamic transport through much of the study area. These processes of wetting and drying need to be explicitly considered in hydrodynamic model calculations. An algorithm, based upon Flather and Heaps (1975) and Kim (1999), that permits the model to simulate the flooding and drying of tidal flats was incorporated into ECOMSED. The treatment is based on both total water depth ($D = H + \eta$) and elevation gradient with adjacent grid cells. For implementation of the flooding and drying scheme, a minimum threshold depth (D_{min}) and a critical elevation gradient (ε) are pre-assigned (via model input). Testing of the wetting/drying scheme has been conducted under various water bodies (i.e. Jamaica Bay, Hackensack River, etc.) and confidence has been established in application of this algorithm to the Great Bay hydrodynamic model.

2.2 Hydrodynamic Model Development

2.2.1 Model Configuration

The hydrodynamic model domain included the Great Bay Estuary System (Great Bay, Little Bay, the Upper and Lower Piscataqua River) and the tidal part of its tributaries (Squamscott River, Lamprey River, Winnicut River, Oyster River, Bellamy River, and Cocheco River). In addition, a 6 mile by 18 mile area of the adjancent coastal zone off the City of Portsmouth was included in the model. A map of the model grid is shown in Figures 1 and 2. The model domain consists of 68 x 161 cells in the horizontal direction with varying grid sizes. As shown in Figure 1, the model cells have a horizontal resolution of about 800 to 2000 m in the offshore area. To properly resolve the lateral variability of the Great Bay, grid cells vary from about 100 to 200 m within the Great Bay. The Great Bay itself is represented by about 45 x 20 horizontal grid cells. Figure 2 shows a detailed view of the computational grid in the Great Bay and Little Bay area. The grid cells in the tributaries are about 100 m in length and resolved with a single grid cell where the river becomes narrow, less than 100 m wide.

The model grid system has 10 equally spaced σ-layers in the vertical direction. The model bathymetry was determined based on various sources: USACE survey data in the tributaries and entrance to the Portsmouth Harbor, NOAA Electronic Nautical Charts in the coastal areas, detailed bathymetry survey data in the Great Bay collected by the Center for Coastal and Ocean Mapping (CCOM) in 2009, and detailed bathymetry survey data in the Squamscott River collected in the summer of 2011 by HYDROTERRA.

2.2.2 Model Forcing Functions

The boundary forcing functions of the hydrodynamic model consist of:

1. Water surface elevation along open ocean boundaries incorporating astronomical tide and low frequency variations of sea surface elevation;

2. Temporal variations of temperature and salinity along the open boundaries;

3. Freshwater inflows from rivers and wastewater treatment plants; and

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4. Meteorological information consisting of wind speed and direction, shortwave solar radiation, cloud cover, air temperature, atmospheric barometric pressure and relative humidity to compute surface wind stress and heat flux.

The details of these boundary conditions are described in this section.

Open Ocean Boundaries (Elevation, Temperature, Salinity)

Model forcing data at the open boundaries in the Gulf of Maine was obtained from the NOAA tide gage station at Fort Point, which is located at the mouth of Portsmouth Harbor. Hourly water elevations observed at this tide station were used to drive the model for all three model calibration years (2010, 2011 and 2017). The hydrodynamic model calibration for the years 2010 and 2011 was implemented in 2013 and, at that time, nearby offshore salinity and temperature data was not available. Therefore a fixed salinity value of 30 psu was assigned at the open boundaries throughout that modeling period. For the temporal variation of the offshore boundary water temperature for such modeling period, measured values at a nearby NOAA station in Portland, ME were used. The hydrodynamic model calibration for the year 2017 was implemented in 2019; salinity and temperature data at a nearby offshore location (Buoy Western Maine Shelf- B01) in the Gulf of Maine was found and retrieved. This data was employed for defining the model open boundaries throughout the year 2017 modeling period. Figures 3, 4 and 5 show the open boundary conditions for the modeling years 2010, 2011 and 2017.

Freshwater Sources

There are six USGS flow gages located in the tributaries in the study area: Lamprey, Exeter, Oyster, Cocheco, Salmon Falls, and Winnicut Rivers. The six gages are summarized in Table 1. The scale factors in Table 1 indicate the factor employed to compute each tributary's total flow contribution, accounting for the drainage areas from below the gages to each river's mouth. There is no flow gage in the Bellamy River and therefore a flow estimate was developed. Drainage area for the Bellamy River lies between the Cocheco and Oyster Rivers. Gaged flow at the Oyster River was used to estimate the flow in the Bellamy River by applying a ratio of drainage areas (0.686). The Salmon River flow gage was discontinued in 2005. Initially, Salmon River flow estimates were developed based on measured Cocheco River flows and considerations for the controlled nature of these rivers. Fortunately, during the model calibration stage of this study, the NHDES Dam Bureau was able to provide measured flow data at the Milton 3-Ponds Reservoir. Total flows used in the model for the calibration years are shown in Figure 6, 7 and 8. Table 2 presents a summary of the flows at these locations. In general, the statistics of the flows indicate that similar annual mean flows were observed at all tributaries for the years 2010 and 2011. The year 2017 reflects lower annual mean flows at all tributaries as compared to the years 2010 and 2011.

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Table 1. Summary of USGS Gages

Location	Gage #	Period of Flow Record	Drainage Area (mi^2)	Scale Factor
Lamprey near Newmarket	01073500	1934-present	183.0	1.168
Exeter at Haigh Road (Squamscott)	01073587	1996-present	63.5	1.995
Oyster near Durham	01073000	1934-present	12.1	1.564
Cocheco near Rochester	01072800	1995-present	85.7	2.159
Salmon Falls at Milton	01072100	1968-2005	108.0	3.093
Winnicut at Greenland	01073785	2002-present	14.1	1.333

Table 2. Modeling Period Flow Summary (Annual Average & Range, Unit: cfs)

Year	2010	2011	2017
Lamprey	440 (4 - 7650)	438 (13 - 2254)	339 (12-2496)
Squamscott	289 (2 - 5347)	297 (7 - 2114)	197(8-1776)
Oyster	73 (1 - 1674)	66 (2 - 572)	51(2-500)
Cocheco	364 (10 - 6563)	421 (13 - 2957)	295(9-264)
Salmon Falls	762 (27 - 6927)	811 (62 - 2961)	669(28-2812)
Winnicut	50 (1.2 - 1140)	42 (0.8 - 457)	34(1-327)
Bellamy	19 (0.3 - 448)	17 (0.5 - 153)	14(1-134)

In addition to river flows, the hydrodynamic model includes freshwater flows from the major sewage treatment plants (STP) in the study area. Table 3 lists the coordinates and freshwater discharge rates of these STPs and Figure 9 shows their corresponding locations.

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Table 3. Location and Discharge Rates for STPs

Name	Longitude, West	Latitude, North	Flow (MGD)	Waterbody
Exeter	70.93523	42.996477	2.25	Squamscott River
Newfields	70.935230	43.037960	0.07	Squamscott River
Newmarket	70.933979	43.075730	0.70	Lamprey River
Durham	70.903114	43.133975	1.11	Oyster River
Dover	70.831295	43.158058	3.34	Upper Piscataqua River
Rochester	70.965425	43.267495	3.92	Cocheco River
Portsmouth (Peirce Island)	70.739497	43.073145	5.90	Lower Piscataqua River
Pease	70.790490	43.103000	0.53	Lower Piscataqua River
Kittery	70.760278	43.089167	1.12	Lower Piscataqua River
South Berwick	70.808611	43.225278	0.34	Salmon Falls River

Meteorological Data

Meteorological data observed at the Pease International Tradeport Airport was used for the modeling study. Hourly wind data as well as air temperature, relative humidity, sky cover, and barometric pressure data for the calibration years were obtained from the NOAA. Figures 10, 11 and 12 show the meteorological data used for this study. The shortwave radiation shown in the figures are computed values based on the observed cloud cover data at the NOAA station.

2.3 Hydrodynamic Model Calibration

Model calibration was performed utilizing field monitoring data collected at various locations in the Great Bay Estuary System. There are seven water quality monitoring stations operating in the years 2010, 2011 and 2017: Coastal Marine Lab near Fort Point at the entrance to the Portsmouth Harbor, Salmon Falls River, Great Bay (2), Lamprey River, Oyster Rive, and another station located at the mouth of Squamscott River. These monitoring stations are shown in Figure 13. There are two monitoring stations in the middle of Great Bay; one managed by the University of New Hampshire and another one managed by the Centralized Data Management Office (CDMO) of the National Estuarine Research Reserve System (NERRS). A careful review of the data at these stations suggests that at certain times the data sensors were not operating

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correctly (sensor drifting, illogical values, etc.); erroneous data was removed from the database of measurements for comparison against computed model results.

Temperature

Comparisons of computed and observed water temperature for the years 2010, 2011 and 2017 at seven monitoring locations are shown in Figures 14, 15 and 16, respectively. Red lines indicate observed water temperature and blue and green lines indicate the model computed water temperature at surface and bottom, respectively. The figures show that the model computed water temperature tracks very well with data over the seasonal warming and cooling cycle in the study area as well as with sudden rises and drops associated with atmospheric heating and cooling processes for all years. The model-computed heat flux exchange processes based on the meteorological data observed at the Pease International Airport accurately calculated the water temperatures in the study area.

Salinity

Figures 17, 18 and 19 show the comparison of model computed and observed salinity at the same seven monitoring locations for the years 2010, 2011 and 2017, respectively. The figures show that model-computed salinity compares very well with the observed salinity at all stations. Salinity increases and decreases due to river inflow events are very well captured by the model. Model-computed salinity indicates that the salinity may decrease to below 5 PSU during high flow events in the middle of Great Bay and increase to above 25 PSU during low flow conditions. While the data are not available during high flow events that occurred in cold months when sampling is suspended, the computed and observed salinity agrees well during intermediate flow events such as in May and October 2011 periods (Figure 18).

The figures indicate that some stations show much higher variability in salinity than other stations. Both the observed and computed salinity at the Lamprey River and Squamscott River stations show higher variability (more than 15 PSU) than those at the middle of the Great Bay, Oyster River and Salmon Falls River stations. This is due to the horizontal gradient of the salinity at each location. For example, at Squamscott and Lamprey stations, incoming high tides bring in higher salinity water from the Great Bay and on reversing cycles during the low tide, the outgoing tides carry the lower salinity water from the upstream location. Whereas within the Great Bay proper, salinity remains relatively uniform spatially, and therefore, intra-tidal variation of salinity remains relatively flat.

Both the observed and computed salinity at the Coastal Marine Lab, which is located at the entrance to the Portsmouth Harbor, show that salinity remains at around 30 PSU most of the time except during high flow periods. The model-computed salinity appropriately tracks the measured range of salinity decrease during high flow periods and increase during low flow periods.

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3.0 Development Of GBES Total Nitrogen Model

Once the GBES hydrodynamic model was calibrated, a total nitrogen model of the GBES was developed and the results compared against measured data. There are different possible levels of complexity for simulating water column nitrogen in the GBES, and the selection of a modeling approach depends on a few factors such as: the specific overall goal of the study, the availability of data for defining all nitrogen related processes, the study timeframe and the level of project funding. Three possible modeling approaches for the simulation of GBES nitrogen, in order of decreasing complexity, are: a) a full eutrophication model (algae, nutrients, DO and organic carbon forms), b) the simulation of nitrogen alone with the specification of estimates of nitrogen water column nitrogen losses (e.g., settling of particulate organic matter and uptake by phytoplankton, eelgrass, and macroalgae) and the specification of estimates of nitrogen sources to the water column (e.g., sediment resuspension and diffusion from the sediment porewater) and c) the simulation of nitrogen as a conservative substance, that is, no physical, chemical, or biological reactions are assigned to water column nitrogen in the model. Given the complexity of the GBES, the data needs and the project timeframe, the implementation of a full eutrophication model is not recommended at this time. The second approach, where nitrogen alone is modeled and estimates of nitrogen sources and sinks are assigned (based on data and/or calibration needs) is a possible choice for the GBES; however, actual data for nitrogen sources and sinks is very limited or nonexistent. The more limited the data for nitrogen sources and sinks, the more uncertainty is introduced in the nitrogen model. Given the timeframe and available funding for this study, the third approach, where nitrogen is modeled as a conservative substance, was selected for the simulation of GBES nitrogen. The expectation at the beginning of this nitrogen modeling study was that, if the nitrogen model performed well against measured water column nitrogen levels in the GBES, this would indicate that potential water column nitrogen losses are approximately balanced by nitrogen sources to the water column. The model would then be considered a calibrated tool that relates nitrogen loading to the GBES to the resulting GBES water column concentrations. The modeling approach where nitrogen sources and sinks are estimated and assigned could eventually be implemented, if necessary to resolve any significant uncertainties.

3.1 Nonpoint Source TN Loads

Daily NPS TN loads for all GBES tributaries were developed by employing LOADEST (USGS load estimator). LOADEST is a FORTRAN program for estimating constituent loads in streams and rivers; given a time series of streamflow (and additional data variables and constituent concentrations), LOADEST develops regression models for the estimation of constituent loads as a function of river flow (and other variables when applicable). Explanatory variables within the regression model include various functions of streamflow, decimal time, and additional user-specified data variables (if required). The formulated regression model is then used to estimate loads over any desired time interval for which river flows are provided. LOADEST requires measured river flows and measured river TN concentrations. Daily river flows were obtained from USGS (consistent with river flows employed for developing the hydrodynamic model) and

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head-of-tide measured TN data was provided by NHDES for the 2008-2017 time period. Head-of-tide monitoring stations are shown in Figure 20. Table 4 provides a summary of the quantity of available TN data per tributary station (head-of-tide station). Figure 21 presents temporal plots of the tributary TN data. This TN data and measured USGS river flows were employed to develop LOADEST regression models for every tributary in Table 4 but the Great Works River. Temporal plots of TN loading regression results and measured TN data are shown in Figures 22 to 28; the upper panel in these plots depicts the river flow employed for the LOADEST regressions. Figure 29 present plots of computed versus measured TN loads. Overall, the LOADEST regressions perform reasonably well in replicating the available tributary loading data. Daily NPS loads were implemented for a better assessment of model-computed versus measured GBES water column TN concentrations. However, for the purposes of this study, computed water column TN concentrations will be used on either a growing season or an annual average. Salmon Falls River head-of-tide TN data was employed for deriving Salmon Falls and Great Works watershed LOADEST TN loads as there is no flow gage in the Great Works River; the NPS load calculation employed a river flow consistent with the hydrodynamic model Salmon Falls River flow, that is, the Great Works River flow was accounted for by adding its watershed area to the Salmon Falls River watershed area when scaling up the measured flows at Milton Dam. Cocheco River LOADEST TN load estimates and data are shown in Figure 25, however, such computed TN load was not employed. The Cocheco River head-of-tide TN concentration data reflects both background river (NPS) and Rochester WWTF TN (PS) loads and therefore, before developing a LOADEST load regression, the Rochester WWTF TN load should be subtracted from the measured TN load at the head-of-tide station. Rochester WWTF TN loads need to be isolated to be able to use the TN model in projection mode, i.e., assessment of NPS and PS TN reductions. Another factor that would need to be considered in estimating Cocheco NPS TN loads is the findings of a TN data study performed by HDR in the Cocheco River that indicates that a portion of Rochester WWTF TN load is attenuated in the river before reaching the estuary; this attenuation is dependent on river flow and temperature conditions. Although not included in the scope of work of the present study, a few approaches were implemented in trying to isolate the Rochester TN load that reaches the head-of-tide station (as a function of flow, season, etc.), but all methods resulted in unacceptable results. For this phase of the present study, based on a Cocheco River TN mass balance analysis performed by HDR in the past, a background river TN concentration of 0.5 mg/L was employed. Based on a Cocheco River study performed by NHDES in the past, a delivery factor of 75% was assigned to the Rochester WWTF TN load, that is, 75% of such discharge load reaches the estuary (25% is attenuated in the river).

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Table 4. Count of TN Measurements at Head-of-Tide Stations

Head Of Tide Area	Station ID	#TN Measurements
COCHECO RIVER	07-CCH	98
LAMPREY RIVER	05-LMP	98
SALMON FALLS RIVER	05-SFR	92
EXETER RIVER	09-EXT	101
BELLAMY RIVER	05-BLM	99
OYSTER RIVER	05-OYS	100
WINNICUT RIVER	02-WNC	96
GREAT WORKS RIVER	02-GWR	98

NHDES provided estimates of ungaged NPS TN loads to the GBES, both downstream of head-of-tide locations (tidal loads) and direct runoff to the estuary. NHDES provided annual average ungaged TN loads but they were included in the model with the seasonality of their respective river NPS TN loads in the case of tidal loads (downstream of head-of-tide locations) and the seasonality of the Lamprey River NPS TN loads in the case of direct runoff to the Piscataqua River and Great Bay proper. Table 5 presents a summary of the resulting annual average NPS TN loads for all GBES tributaries, including ungaged loads.

Table 5. Annual Average NPS TN Loads for the Years 2010, 2011 & 2017

	Average Loading Rate (lb/day)*		
	2010	2011	2017
Lamprey River	952	992	762
Squamscott River	571	721	467
Oyster River	107	112	91
Cocheco River	988	1,146	802
Salmon Falls River	1,598	1,806	1,524
Winnicut River	138	131	96
Bellamy River	64	61	47
Ungaged	1,049	1,049	1,049

***Scaled up from Head-of-Tide Station**

Note: Ungaged Load data received from NHDES

Note : Salmon Falls River Load = Salmon Falls River + Great Works River NPS Loads

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3.2 POINT SOURCE TN LOADS

Point source TN loads were developed on a monthly or annual basis, depending on effluent data availability. PS effluent TN data for the major dischargers was provided by the wastewater treatment facilities (WWTFs). Additional effluent TN data for a few small PSs was provided by NHDES. The location of all WWTFs is shown on Figure 30. The methodology employed for deriving monthly or annual WWTF TN loads from limited effluent TN data was specific to each WWTF. The different PS derivation approaches captured treatment changes over time specific to each WWTF and also intended, as much as data availability allowed, to capture seasonal variability and TN flow dependency when reflected in the dataset. PS loads explicitly included in the TN model are: Dover, Rochester, Pease, Peirce Island, Newmarket, Newfields, Exeter, Durham, Kittery and South Berwick. Tables 6, 7 and 8 provide the resulting monthly PS TN loads for all three modeling years, 2010, 2011 and 2017, respectively. The significant treatment improvements implemented by Dover and Rochester WWTFs in the 2014-2016 time period can be observed in these tables when comparing 2010-2011 versus 2017 loads for such dischargers. Table 9 presents annual average TN loads for all WWTFs included in the nitrogen model.

Table 6. Monthly Average PS TN Loads for the Year 2010

	Year 2010 Load in lbs/day									
	Dover	Durham	Newmarket	Exeter	Pease	Pierce	Rochester	Newfields	Kittery	S.Berwick
January	359	131	90	229	146	917	977	10	150	17
February	359	98	143	229	146	987	995	10	150	17
March	359	163	145	229	146	625	1,159	10	150	17
April	359	82	139	229	146	1,017	1,192	10	150	17
May	359	42	100	229	146	878	915	10	150	17
June	359	28	108	229	146	932	781	10	150	17
July	359	26	106	229	146	909	750	10	150	17
August	359	35	112	229	146	855	646	10	150	17
September	359	84	113	229	146	842	630	10	150	17
October	359	86	105	229	146	946	727	10	150	17
November	359	117	175	229	146	934	875	10	150	17
December	359	132	158	229	146	927	994	10	150	17

Note: Only 75% of the Rochester WWTF load above is delivered to the estuary.

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Table 7. Monthly Average PS TN Load for the Year 2011

	Year 2011 Load in lbs/day									
	Dover	Durham	Newmarket	Exeter	Pease	Pierce	Rochester	Newfields	Kittery	S.Berwick
January	359	131	90	229	145	863	808	10	150	17
February	359	97	143	229	145	907	778	10	150	17
March	359	109	145	229	145	1,031	1,158	10	150	17
April	359	98	139	229	145	1,029	1,176	10	150	17
May	359	81	100	229	145	980	1,088	10	150	17
June	359	27	108	229	145	963	859	10	150	17
July	359	27	106	229	145	914	697	10	150	17
August	359	17	112	229	145	876	777	10	150	17
September	359	48	113	229	145	968	873	10	150	17
October	359	86	105	229	145	951	988	10	150	17
November	359	120	174	229	145	1,026	1,069	10	150	17
December	359	88	158	229	145	972	1,042	10	150	17

Note: Only 75% of the Rochester WWTF load above is delivered to the estuary.

Table 8. Monthly Average PS TN Load for the Year 2017

	Year 2017 Load in lbs/day									
	Dover	Durham	Newmarket	Exeter	Pease	Pierce	Rochester	Newfields	Kittery	S.Berwick
January	205	138	177	523	146	1,290	355	10	150	17
February	127	156	175	412	146	1,136	355	10	150	17
March	226	161	193	386	146	1,243	355	10	150	17
April	570	237	201	453	146	1,261	355	10	150	17
May	229	183	165	418	146	985	355	10	150	17
June	288	35	132	388	146	1,007	355	10	150	17
July	75	20	76	396	146	897	355	10	150	17
August	74	99	24	328	146	1,040	355	10	150	17
September	124	107	12	243	146	949	355	10	150	17
October	64	36	14	328	146	800	355	10	150	17
November	105	94	20	349	146	794	355	10	150	17
December	133	115	15	356	146	776	355	10	150	17

Note: Only 75% of the Rochester WWTF load above is delivered to the estuary.

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Table 9. Annual Average PS TN Loads for the Years 2010, 2011 & 2017

Average Effluent Loading Rate (lb/day)			
	2010	2011	2017
Durham	85	77	115
Exeter	229	229	382
Newfields	10	10	10
Newmarket	124	124	100
Dover	359	359	185
Portsmouth	896	956	1,014
Rochester	665	707	266
Pease	146	145	145
Kittery	149	149	149
S. Berwick	17	17	17

Note : Rochester WWTF load is the load delivered to the estuary at a delivery efficiency factor of 75%

Figure 31 summarizes the annual TN loads from both PSs and NPSs. Total NPS loads, for the years included in this modeling study, average about 2 million lbs; total PS loads are about half of the total NPS loads for each of these years.

3.3 Oceanic Boundary

Based on limited oceanic TN data and an analysis performed by NHDES in 2009, an oceanic TN boundary of 0.2 mg/L was specified in the model. This TN value is also consistent with TN concentrations observed at the Coastal Marine Lab monitoring station, near Fort Point at the entrance to the Portsmouth Harbor, during low flow conditions (high salinity) when there is therefore mostly oceanic water (~95%).

4.0 Evaluation of TN Model Performance against Measured TN Data

The TN model was configured with the PS and NPS TN loads as described in Section 3 of this document. The TN model employed the transport field computed by the calibrated GBES hydrodynamic model described in Section 2. Measured TN data for the evaluation of the TN model performance was provided by NHDES for multiple stations. Figure 32 presents the location of five stations selected for model performance assessment. Figure 33 presents comparisons of measured TN data versus model-computed TN at five locations in the GBES system: Great Bay proper (GRBGB), Adams Point (GBBAP), Squamscott River (GRBSQ), Upper Piscataqua River (GRBUPR) and at the Coastal Marine Lab (GRBCML) in the Portsmouth Harbor. On this figure, the TN data is presented as daily averages (circles) in addition to daily maximum and minimum values (range around the average). The variation over a given day for

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the measured TN data represents either duplicates and/or low and high tide measurements. Computed TN concentrations represent daily average values. The lower right panel presents measured Lamprey River flow to provide an indication of the overall GBES flow conditions. The TN model performed very well in replicating the measured data, mainly at the Adams Point and Great Bay proper stations, locations that synthetize the overall TN loads in the system but also represent the critical area for the evaluation of eelgrass in the GBES. The model performance at Adams Point particularly is quite good, a location whose measured TN data reflects both low and high tide measurements as opposed to all other locations that have no consistent measurements for both tidal conditions. Occasional measured high TN concentrations not computed by the model, e.g., Squamscott River in the year 2017, could be the result of processes not accounted for by the model, for example, nitrogen associated with sediment resuspension events. In the specific case of the Squamscott River a possible reason for the occasional model misses could be the definition of local PS loads given the limited available effluent data; the year 2017 summer reflects very low flow conditions when the effects of PS loads are more evident in a tributary. A less stringent and probably more appropriate assessment of the model performance, as TN model results will be employed on an annual average basis, is presented in Figure 34. This figure presents a comparison of computed versus measured TN concentrations averaged over all three modeling years for the Adams Point, Upper Piscataqua River and the Coastal Marine Lab stations. There is a very good agreement level between computed and measured TN levels; this demonstrates that modeling TN as a conservative substance is a very reasonable assumption for the GBES.

The very satisfactory performance of the model in replicating measured GBES TN levels would indicate that potential water column nitrogen losses (settling of particulate organic matter, uptake by phytoplankton, eelgrass, and macroalgae) are approximately balanced by sources to the water column (sediment resuspension and diffusion from the sediment porewater).

5.0 Evaluation of TN Load Reductions and Resulting Great Bay TN Concentrations

As described earlier in this document, USEPA and NHDES have proposed a maximum annual TN load of 100 kg/ha-yr for protection of eelgrass in the GBES; the present study examines instead the determination of a GBES average TN concentration that is protective of eelgrass health based on other studies. The GBES TN model allows the calculation of the corresponding GBES TN load for any selected target TN concentration for protection of eelgrass. Therefore, the TN model was employed to develop various combinations of PS and NPS TN load reductions and to assess resulting Great Bay (proper) TN concentrations.

Two PS reduction scenarios are considered, TN monthly limits of 8.0 mg/L and monthly limits of 3.0 mg/L (limit of technology) for all WWTFs. For modeling purposes, a monthly limit of 8.0 mg/L is represented by an average effluent TN of 6.0 mg/L. The limit of technology scenario is represented by an average effluent TN of 3.0 mg/L. For these PS reduction scenarios, PS effluent flows are set at design flow levels. These PS reduction scenarios are combined with

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NPS TN load reductions of 0%, 20%, 30% and 40%. Figure 35 presents a comparison of annual PS TN loads for current conditions versus the scenario of a monthly limit of 8.0 mg/L. On this figure, the left axis is the PS TN load in lb and the right axis is the PS TN load in kg/ha-yr. The right axis represents the PS TN load normalized by the GBES surface area and it is included in this figure for comparison to empirical TN loading methodologies that employ such approach in characterizing waterbody TN loads. For example, when adding up all WWTF loads for the year 2010 (current conditions scenario), the total PS TN load is about 81 kg/ha-yr. Figure 36, similarly to Figure 35 but for NPS TN loads, presents annual NPS TN loads for current conditions. From this figure, for example, when adding up all NPS TN loads for the year 2010 (current conditions scenario), the total NPS TN load is about 166 kg/ha-yr.

The TN model was employed to compute GBES TN concentrations for all combinations of PS and NPS TN load reductions mentioned above for all three modeling years (8 reduced TN load scenarios). Scenario TN concentration results were evaluated at four locations: Adams Point, Great Bay proper, Upper Piscataqua River and Cocheco River. Table 10 presents computed annual average TN concentrations at the four selected locations. This table also presents the total TN load (PS + NPS) to the GBES (kg/ha-yr) corresponding to each model scenario. The current conditions scenario is also included in this table for comparison to the reduced TN load scenarios. A simplified version of Table 10, that is 3-year average results and for the Great Bay location only, is presented in Table 11. Tables 10 and 11 can be directly used for assessing GBES total TN loads for any selected target TN concentration for the protection of eelgrass. However, a regression between TN concentrations and TN loads for the Great Bay station (GRBGB) was developed using the load and concentration information contained in Table 10, for all reduced TN scenarios and for all three modeling years; the regression and corresponding equation are shown in Figure 37. The current conditions scenario loads and concentrations (3 years) were excluded from the regression as current conditions reflect a very uneven PS TN load distribution among all PSs and, furthermore, the location of each PS (determinant of the percent effluent TN that reaches Great Bay from each PS) weakens the load-concentration relationship. For example, for the current conditions scenario, Portsmouth WWTF is a significant portion of the total PS TN load to the system, however, its effect is quite minimal in the TN concentrations at the Great Bay station; therefore, the significant decrease in Portsmouth WWTF TN loads when going from current conditions to a reduced TN load scenario would have a minimal effect at the Great Bay station TN concentration.

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Table 10. Model–Computed Annual Average TN Concentrations

			2010		2011		2017	
	Scenario description [1]	Location	Average TN concentration (mg/L)	TN Load to Great Bay Estuary System (kg/ha/yr)	Average TN concentration (mg/L)	TN Load to Great Bay Estuary System (kg/ha/yr)	Average TN concentration (mg/L)	TN Load to Great Bay Estuary System (kg/ha/yr)
Scenario 1	NPS Calibration PS[4] at 6 mg/L [2]	Adams Point	0.33	203	0.36	220	0.34	183
		Great Bay	0.34		0.37		0.35	
		Piscataqua	0.38		0.41		0.39	
		Cocheco River	0.5		0.52		0.5	
Scenario 2	NPS 20% Reduction PS[4] at 6 mg/L [2]	Adams Point	0.3	170	0.32	183	0.3	154
		Great Bay	0.3		0.33		0.31	
		Piscataqua	0.34		0.36		0.35	
		Cocheco River	0.44		0.44		0.43	
Scenario 3	NPS 30% Reduction PS[4] at 6 mg/L [2]	Adams Point	0.28	153	0.3	165	0.29	139
		Great Bay	0.29		0.31		0.29	
		Piscataqua	0.32		0.33		0.32	
		Cocheco River	0.4		0.4		0.4	
Scenario 4	NPS 40% Reduction PS[4] at 6 mg/L [2]	Adams Point	0.27	136	0.28	146	0.27	125
		Great Bay	0.27		0.28		0.28	
		Piscataqua	0.3		0.3		0.3	
		Cocheco River	0.37		0.36		0.36	
Scenario 5	NPS Calibration PS[4] at 3 mg/L [3]	Adams Point	0.31	185	0.34	201	0.32	165
		Great Bay	0.32		0.35		0.33	
		Piscataqua	0.35		0.39		0.37	
		Cocheco River	0.45		0.49		0.46	
Scenario 6	NPS 20% Reduction PS[4] at 3 mg/L [3]	Adams Point	0.28	151	0.3	165	0.29	136
		Great Bay	0.28		0.31		0.29	
		Piscataqua	0.31		0.34		0.32	
		Cocheco River	0.39		0.41		0.39	
Scenario 7	NPS 30% Reduction PS[4] at 3 mg/L [3]	Adams Point	0.26	135	0.28	146	0.27	121
		Great Bay	0.27		0.29		0.28	
		Piscataqua	0.29		0.31		0.3	
		Cocheco River	0.35		0.37		0.35	
Scenario 8	NPS 40% Reduction PS[4] at 3 mg/L [3]	Adams Point	0.25	118	0.26	128	0.26	106
		Great Bay	0.25		0.27		0.26	
		Piscataqua	0.27		0.28		0.27	
		Cocheco River	0.32		0.33		0.32	
Current Condition	NPS Current Condition PS Current Condition	Adams Point	0.36 (0.32[5])	248	0.38 (0.37[5])	267	0.36 (0.34[5])	219
		Great Bay	0.36 (0.32[5])		0.39 (0.43[5])		0.37 (0.39[5])	
		Piscataqua	0.44 (0.42[5])		0.47 (0.52[5])		0.40 (0.44[5])	
		Cocheco River	0.68		0.68		0.53	

[1] Oceanic TN Boundary Condition = 0.20 mg/L for all scenarios
[2] Point Source TN at 6.0 mg/L represents a TN monthly limit of 8.0 mg/L
[3] Point Source TN at 3.0 mg/L represents limit of technology
[4] Point Source Flow is at Design Flow
[5] Average of Monthly Data

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Table 11. Model-Computed Average TN Concentration at the Great Bay Station (Years 2010, 2011 & 2017)

PS TN Concentration (mg/L) [2][3][4]	NPS % TN Load Reduction	Average TN concentration (mg/L)	TN Load to Great Bay Estuary System (kg/ha/yr)
6	0	0.35	202
6	20	0.31	169
6	30	0.30	152
6	40	0.28	136
3	0	0.33	184
3	20	0.29	151
3	30	0.28	134
3	40	0.26	118
Current [5] Conditions	0	0.37	245

[1] Oceanic TN boundary Condition = 0.20 mg/L for all scenarios
[2] Point Source TN at 6.0 mg/L represents a TN monthly limit of 8.0 mg/L
[3] Point Source TN at 3.0 mg/L represents limit of technology
[4] Point Source Flow is at Design Flow
[5] Point Source Flow is at Actual flow

The regression on Figure 37 can be used to estimate the expected Great Bay TN concentration for any total TN load to the GBES. For example, the maximum annual TN load of 100 kg/ha-yr proposed by USEPA and NHDES would produce a Great Bay TN concentration of 0.24 mg/L. The TN concentration-load regression also indicates that every 100 kg/ha-yr of TN load produces a TN concentration increase of 0.1 mg/L in Great Bay. This equation also indicates that, on average, the oceanic TN boundary of 0.2 mg/L produces 0.14 mg/L at the Great Bay location; that is, the oceanic boundary concentration, with no GBES PS or NPS TN loads, produces a TN concentration of 0.14 mg/L at Great Bay. A review of possible target TN concentrations for the protection of eelgrass indicates a range from 0.35 mg/L to 0.40 mg/L; such range is highlighted in yellow on the TN concentration-load regression figure. The maximum annual TN load to GBES of 100 kg/ha-yr proposed by USEPA and NHDES corresponds to a computed annual average Great Bay TN concentration of 0.24 mg/L, a TN concentration level substantially below the protective levels for eelgrass. In the case that growing season averages are being considered for the selection of target TN concentrations, Table 12, similarly to Table 10, presents computed TN concentrations at the four selected locations but in terms of growing season averages (April to September). A simplified version of Table 12, is presented in Table 13. For tables 12 and 13, the GBES TN loading is computed only for the growing season months.

Table 12. Model-Computed Growing Season Average TN Concentrations

			2010 Growing Season (April-September)		2011 Growing Season (April-September)		2017 Growing Season (April-September)	
	Scenario description [1]	Location	Average TN concentration (mg/L)	TN Load to Great Bay Estuary System (kg/ha/yr)	Average TN concentration (mg/L)	TN Load to Great Bay Estuary System (kg/ha/yr)	Average TN concentration (mg/L)	TN Load to Great Bay Estuary System (kg/ha/yr)
Scenario 1	NPS Calibration PS at 6 mg/L [2]	Adams Point	0.3	108	0.34	172	0.34	185
		Great Bay	0.31		0.35		0.34	
		Piscataqua	0.36		0.4		0.39	
		Cocheco River	0.49		0.52		0.51	
Scenario 2	NPS 20% Reduction PS at 6 mg/L [2]	Adams Point	0.28	94	0.3	145	0.3	156
		Great Bay	0.29		0.31		0.31	
		Piscataqua	0.33		0.35		0.35	
		Cocheco River	0.44		0.45		0.44	
Scenario 3	NPS 30% Reduction PS at 6 mg/L [2]	Adams Point	0.27	87	0.29	131	0.29	141
		Great Bay	0.28		0.29		0.29	
		Piscataqua	0.32		0.33		0.32	
		Cocheco River	0.41		0.41		0.41	
Scenario 4	NPS 40% Reduction PS at 6 mg/L [2]	Adams Point	0.26	80	0.27	118	0.27	126
		Great Bay	0.27		0.28		0.28	
		Piscataqua	0.3		0.3		0.3	
		Cocheco River	0.39		0.37		0.37	
Scenario 5	NPS Calibration PS at 3 mg/L [3]	Adams Point	0.29	90	0.32	153	0.32	167
		Great Bay	0.29		0.33		0.33	
		Piscataqua	0.33		0.37		0.36	
		Cocheco River	0.43		0.47		0.46	
Scenario 6	NPS 20% Reduction PS at 3 mg/L [3]	Adams Point	0.26	76	0.29	126	0.29	137
		Great Bay	0.27		0.29		0.29	
		Piscataqua	0.3		0.32		0.32	
		Cocheco River	0.37		0.4		0.39	
Scenario 7	NPS 30% Reduction PS at 3 mg/L [3]	Adams Point	0.25	69	0.27	113	0.27	122
		Great Bay	0.26		0.28		0.28	
		Piscataqua	0.28		0.3		0.3	
		Cocheco River	0.35		0.36		0.36	
Scenario 8	NPS 40% Reduction PS at 3 mg/L [3]	Adams Point	0.24	61	0.25	99	0.25	107
		Great Bay	0.25		0.26		0.26	
		Piscataqua	0.27		0.28		0.27	
		Cocheco River	0.32		0.33		0.32	
Current Condition	NPS Current Condition PS Current Condition	Adams Point	0.34 (0.28[5])	151	0.37 (0.37[5])	218	0.36 (0.38[5])	222
		Great Bay	0.34 (0.32[5])		0.38 (0.42[5])		0.37 (0.39[5])	
		Piscataqua	0.44 (0.41[5])		0.46 (0.50[5])		0.40 (0.43[5])	
		Cocheco River	0.7		0.7		0.54	

[1] Oceanic TN boundary Condition = 0.20 mg/L for all scenarios
[2] Point Source TN at 6.0 mg/L represents a TN monthly limit of 8.0 mg/l
[3] Point Source TN at 3.0 mg/L represents limit of technology
[4] Point Source Flow is at Design Flow
[5] Average of Monthly Data

Table 13. Model-Computed Growing Season Average TN Concentration at the Great Bay Station (Years 2010, 2011 & 2017)

PS TN Concentration (mg/L) [2][3][4]	NPS % TN Load Reduction	Average TN concentration (mg/L)	Growing Season TN Load to Great Bay Estuary System (kg/ha/yr)
6	0	0.33	155
6	20	0.30	131
6	30	0.29	120
6	40	0.28	108
3	0	0.32	137
3	20	0.28	113
3	30	0.27	101
3	40	0.26	89
Current Conditions[5]	0	0.36	197

[1] Oceanic TN boundary Condition = 0.20 mg/L for all scenarios
[2] Point Source TN at 6.0 mg/L represents a TN monthly limit of 8.0 mg/L
[3] Point Source TN at 3.0 mg/L represents limit of technology
[4] Point Source Flow is at Design Flow
[5] Point Source Flow is at Actual Flow

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6.0 Study Conclusions

USEPA and NHDES have proposed a maximum annual TN load of 100 kg/ha-yr for protection of eelgrass in the GBES. This empirical approach was derived from waterbodies that do not reflect the GBES conditions. A more appropriate approach is to set a GBES TN concentration that is protective of eelgrass guided by protective TN concentration levels as summarized in the literature; this approach, to some extent, reflects GBES specific conditions that are not represented in a generic empirical TN loading approach. However, for the determination of NPS and PS loads that meet any selected target TN concentration, it is necessary to develop a tool that relates TN loading to the GBES and resulting GBES water column concentrations.

The GBES hydrodynamic model was calibrated against data for the years 2010, 2011 and 2017 utilizing continuous field monitoring data. A GBES TN model, which models nitrogen as a conservative substance, was developed and results compared against measured GB TN levels (2010, 2011 and 2017). For developing the GBES TN model, daily NPS TN loads for all GBES tributaries were developed by employing LOADEST with head-of-tide TN data provided by NHDES and monthly or annual average PS TN loads were developed employing effluent TN data provided by the WWTFs and NHDES. TN data for assessing the model performance in replicating measured GBES TN levels was provided by NHDES. The TN model performed very well in replicating GBES measured TN data; this would indicate that potential water column nitrogen losses are approximately balanced by sources to the water column. The TN model was then used to assess various combinations of PS and NPS TN load reductions and the resulting GBES TN concentrations.

Multiple studies indicate that a water column TN concentration between 0.35 and 0.40 mg/L is protective of eelgrass. On an annual basis, the average TN loading rate to GBES (average of years 2010, 2011 and 2017) is 245 kg/ha-yr; the GBES TN model indicates a corresponding Great Bay average TN concentration of 0.37 mg/L. This TN concentration is almost at the lower range of TN concentrations that are protective of eelgrass. Based on the various combinations of PS and NPS TN load reductions assessed with the GBES TN model, a TN loading to GBES of 100 kg/ha-yr corresponds to a computed annual average Great Bay TN concentration of 0.24 mg/L; a TN concentration level substantially below the protective levels for eelgrass.

A modeling tool that links nitrogen loading to the GBES and resulting water column GBES TN concentrations has been developed and properly validated against data. The model is quite useful in assessing combinations of PS and NPS TN load reductions and their corresponding resulting water column nitrogen concentrations. This validated nitrogen model is crucial in developing a scientifically defensible site-specific nitrogen threshold for the protection of GBES eelgrass population.

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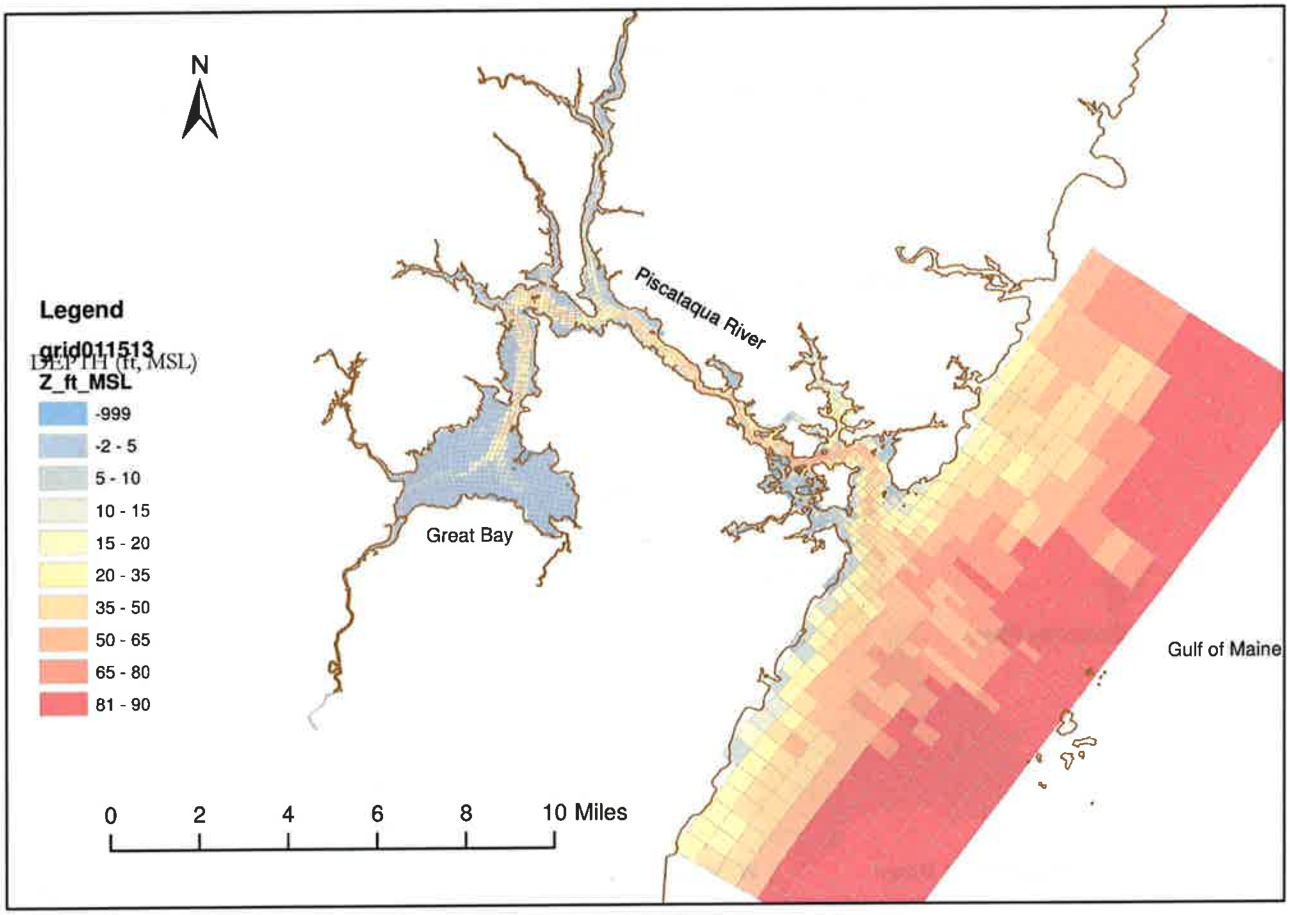


FIGURE 1. Map of Hydrodynamic Model Domain

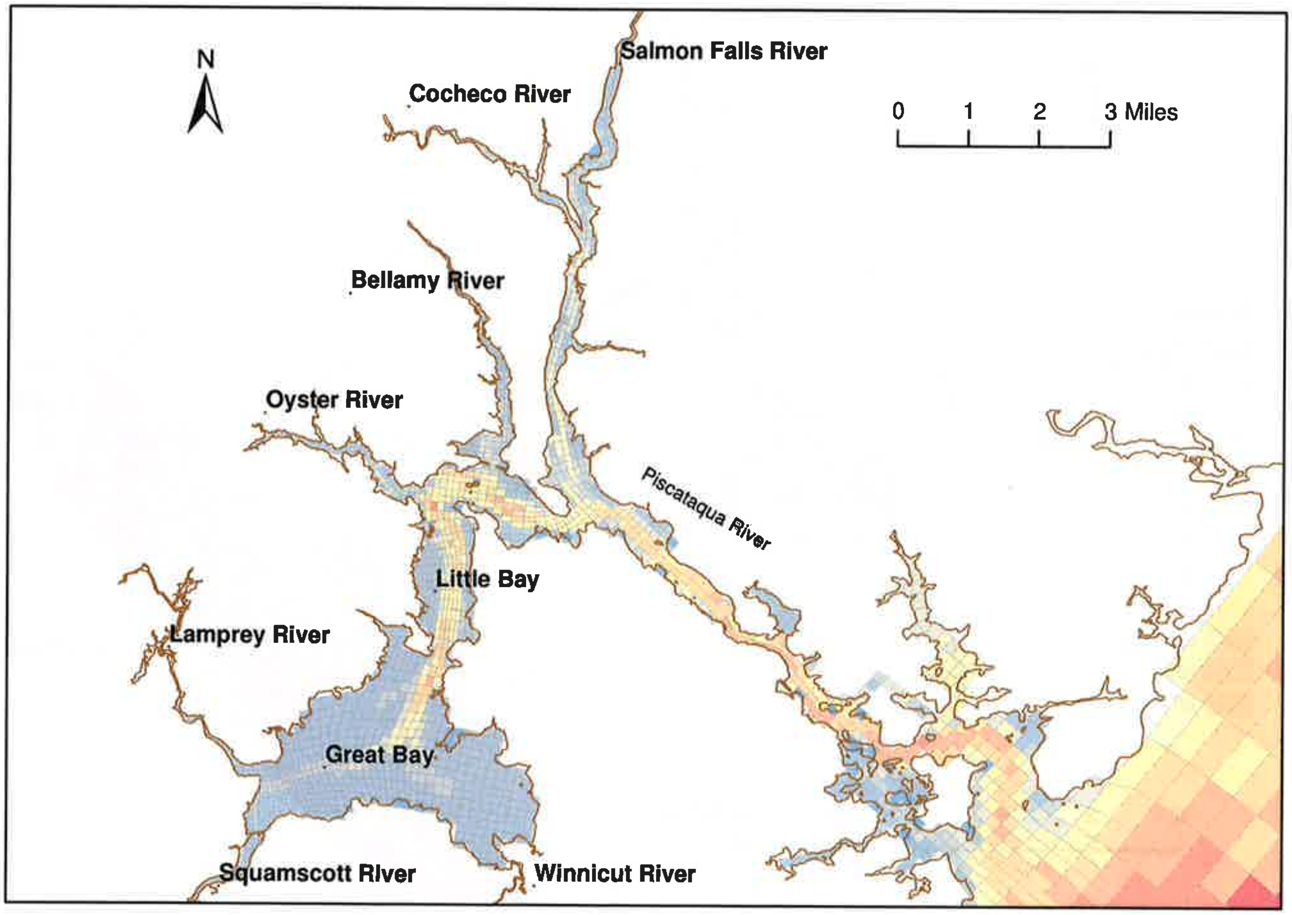
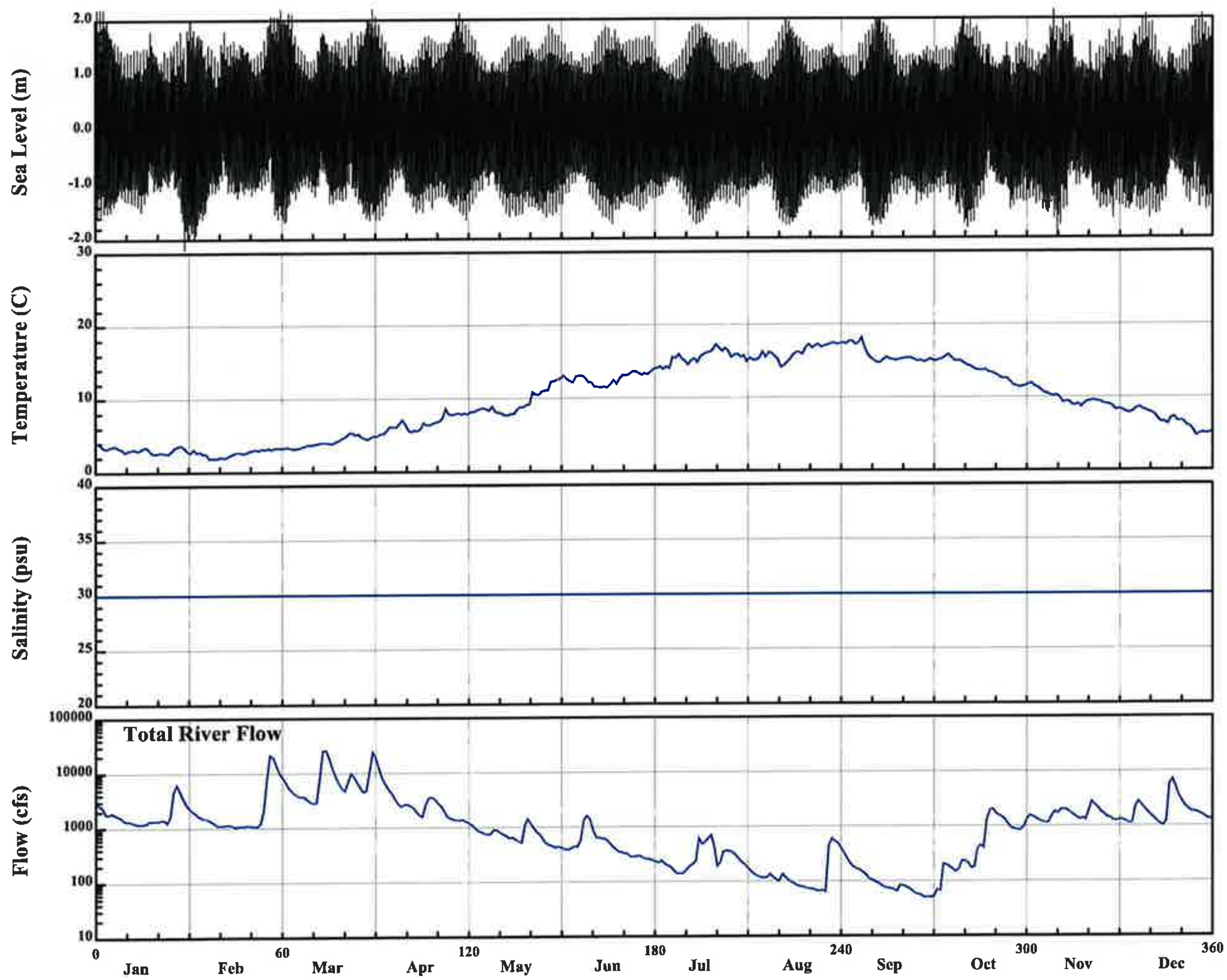


FIGURE 2. Zoom-In View of the Model Grid



2010

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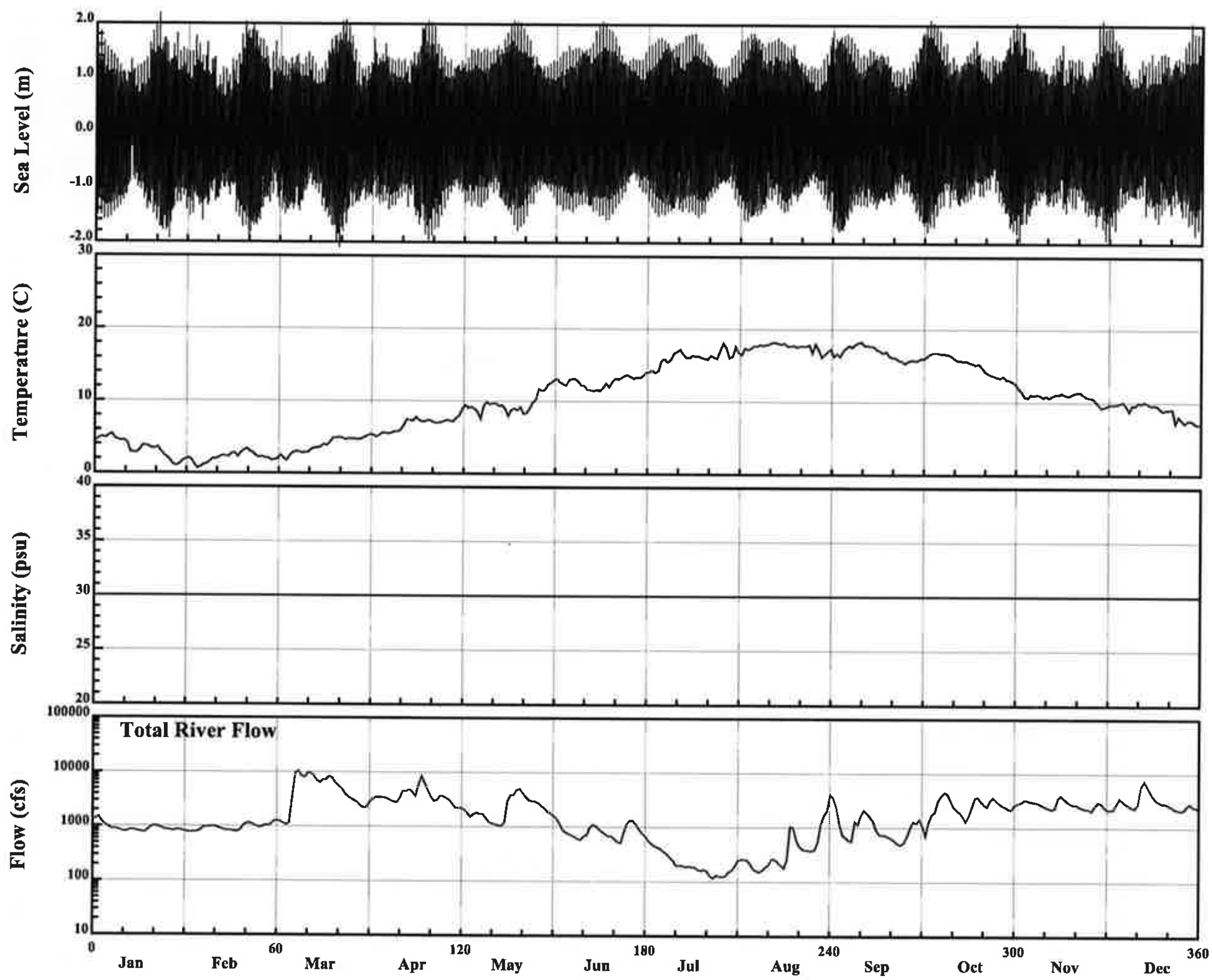
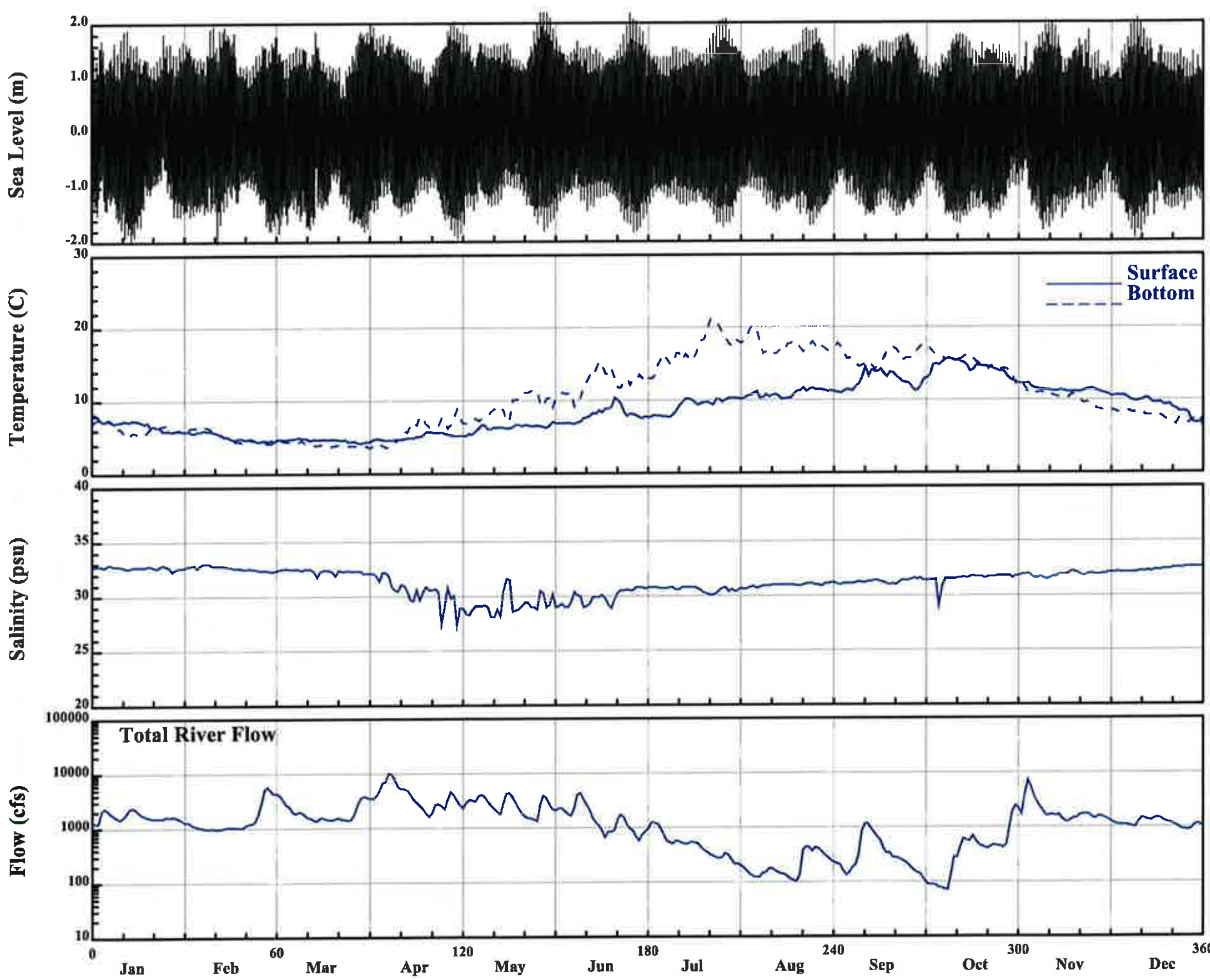
DATE: 10/24/2019 TIME: 10:33:51



2011

DATE: 10/24/2019 TIME: 10:34:06



2017

/marr5/gbay0010/HYDRO/2013GRID/PLOTS/RUNDATA/rundata.gdp
DATE: 10/24/2019 TIME: 10:31:06

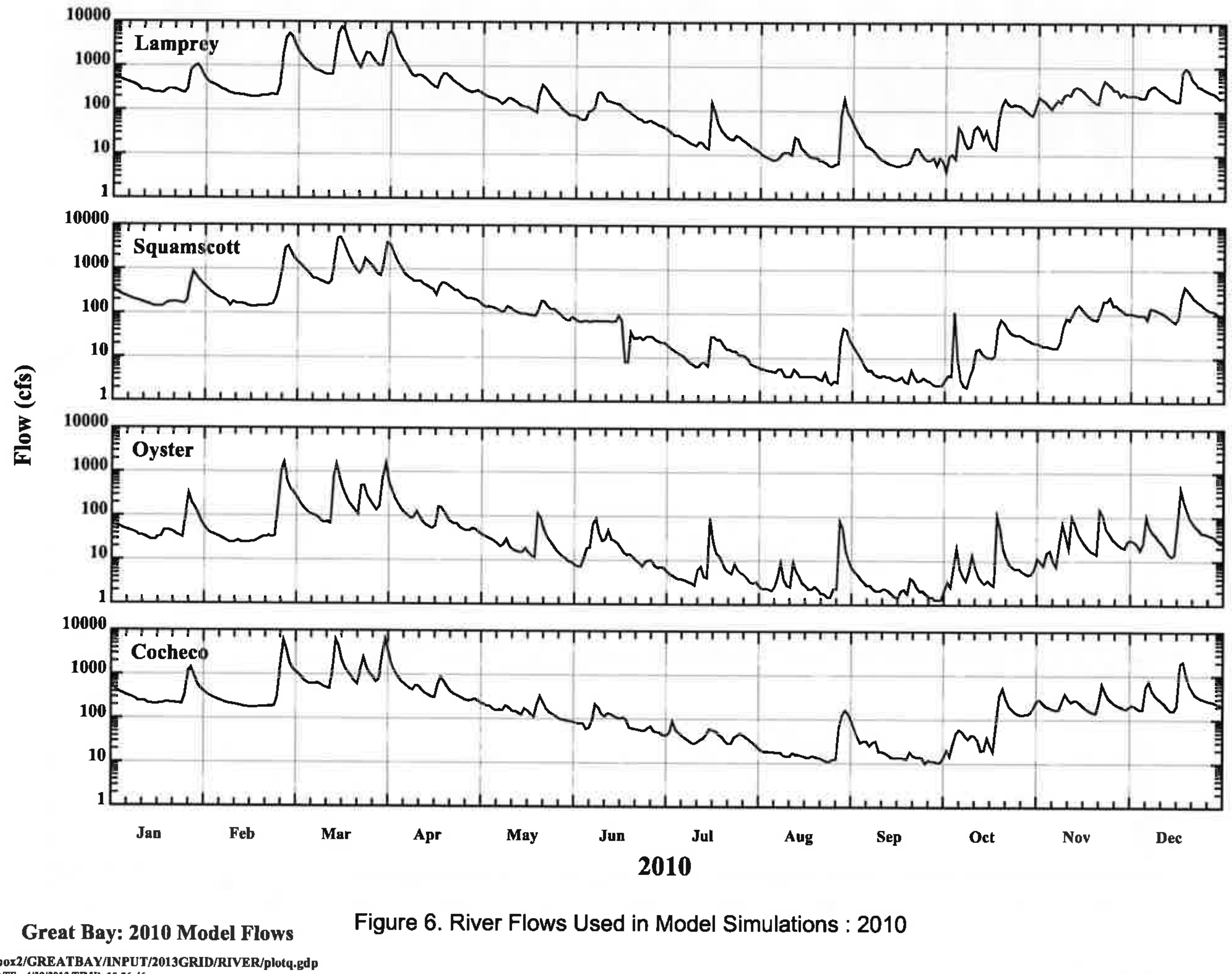


Figure 6. River Flows Used in Model Simulations : 2010

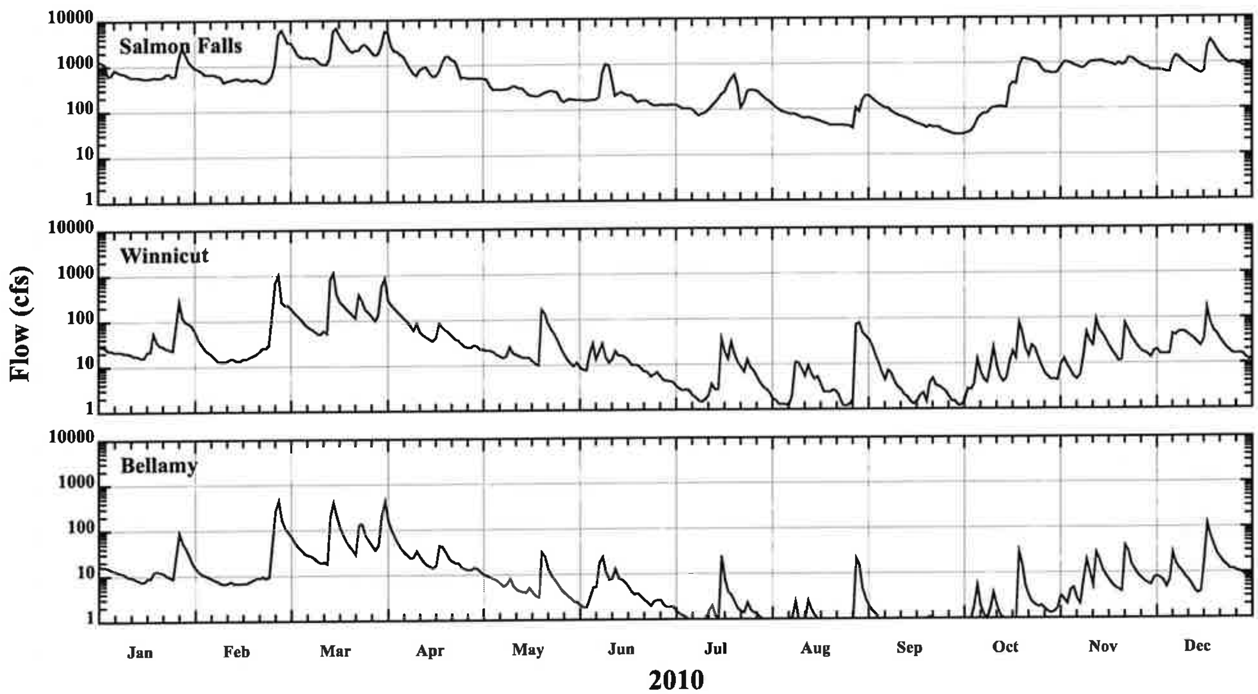


Figure 6. River Flows Used in Model Simulations : 2010 (Cont.)

Great Bay: 2010 Model Flows

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DATE: 4/29/2013 TIME: 15:36:46

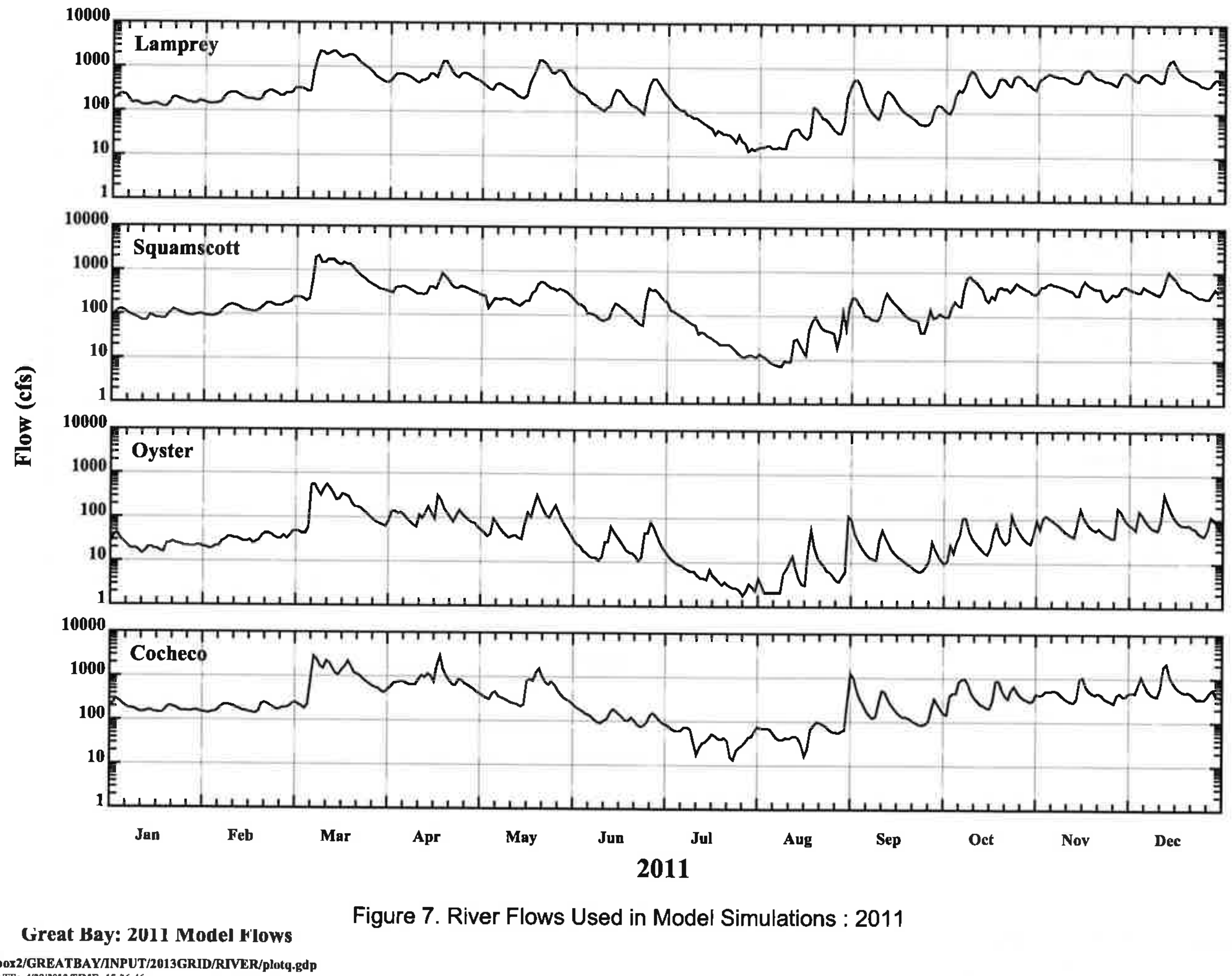


Figure 7. River Flows Used in Model Simulations : 2011

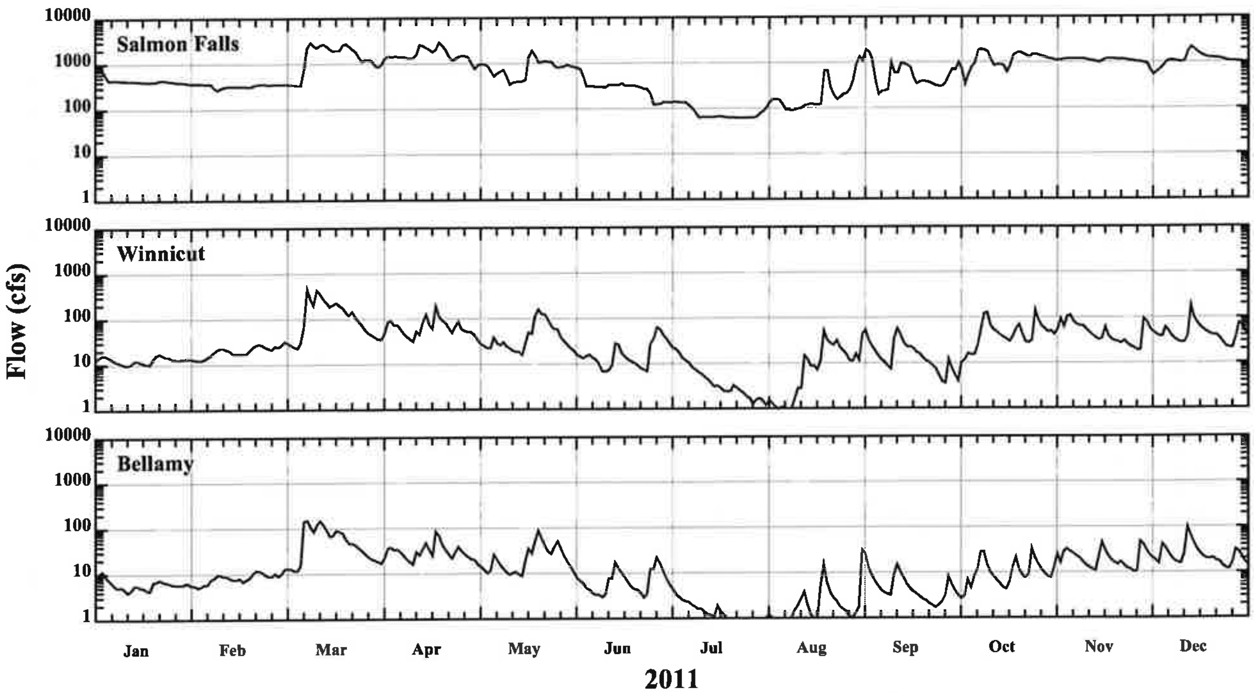


Figure 7. River Flows Used in Model Simulations : 2011 (Cont.)

Great Bay: 2011 Model Flows

/tbox2/GREATBAY/INPUT/2013GRID/RIVER/plotq.gdp
DATE: 4/29/2013 TIME: 15:36:46

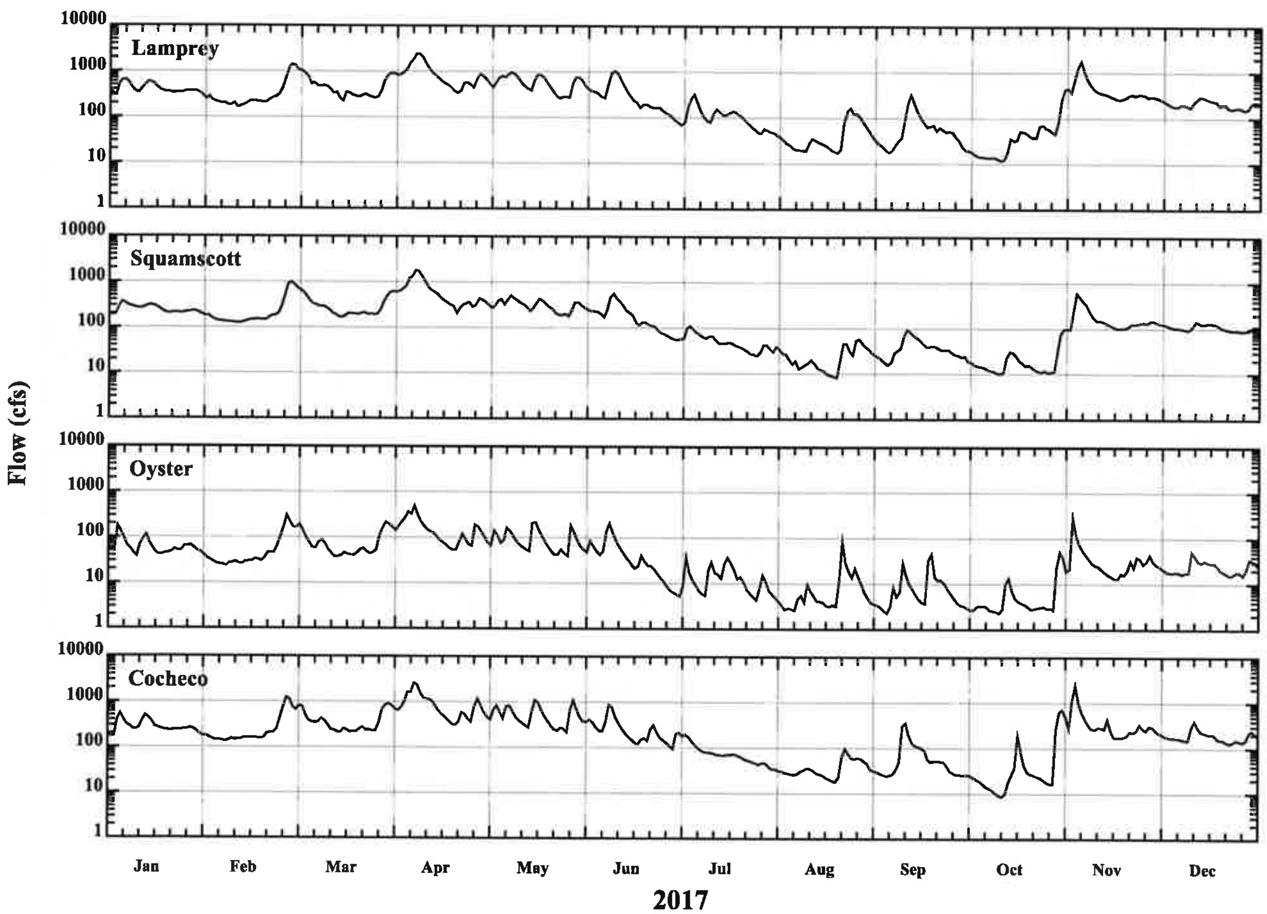


Figure 8. River Flows Used in Model Simulations : 2017

Great Bay: 2017 Model Flows

DATE: 10/24/2019 TIME: 10:55:56

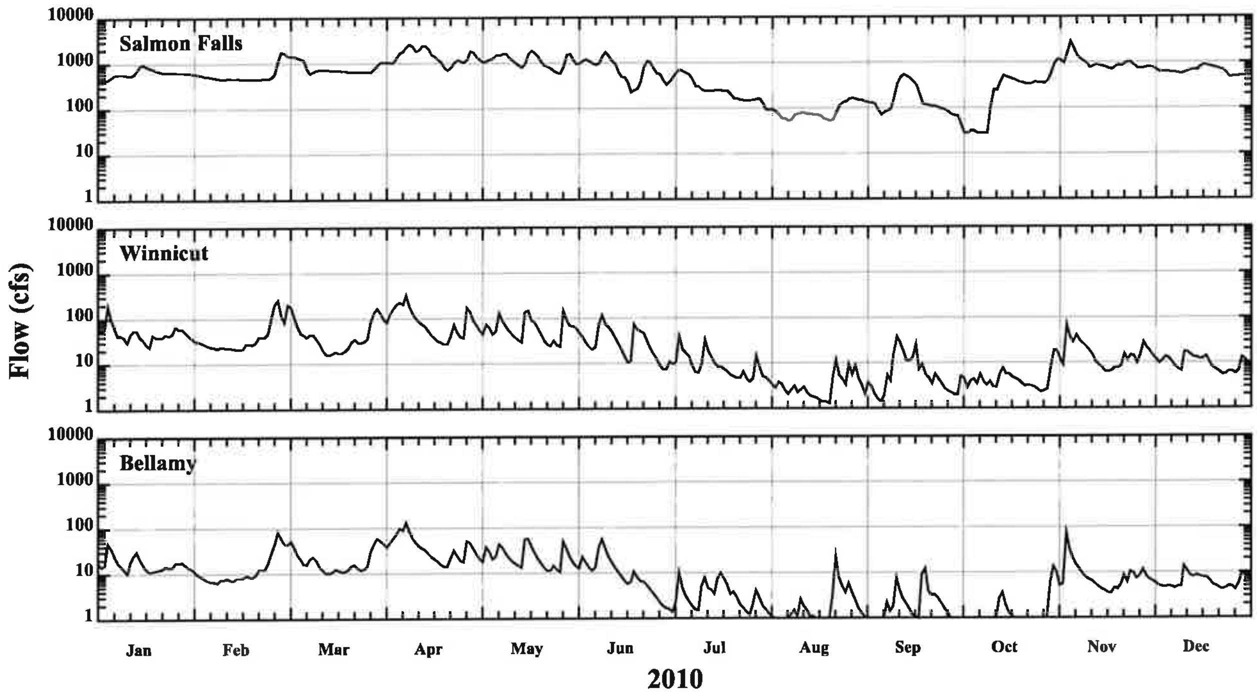
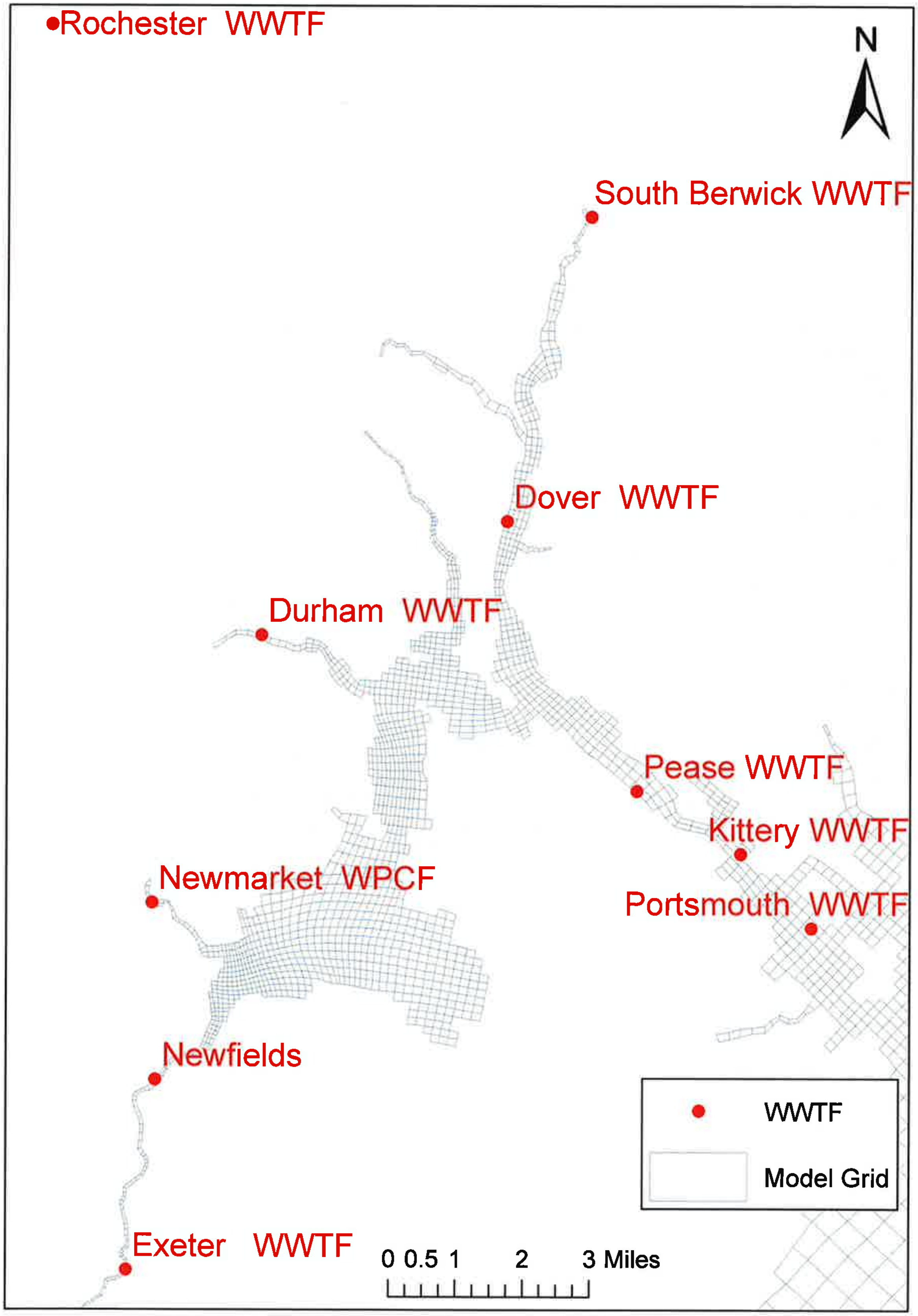


Figure 8. River Flows Used in Model Simulations : 2017 (Cont.)

Great Bay: 2017 Model Flows

DATE: 10/24/2019 TIME: 10:55:56


Rochester WWTF
N
South Berwick WWTF
Dover WWTF
Durham WWTF
Pease WWTF
Kittery WWTF
Newmarket WPCF
Portsmouth WWTF
Newfields
Exeter WWTF
0 0.5 1 2 3 Miles
WWTF
Model Grid

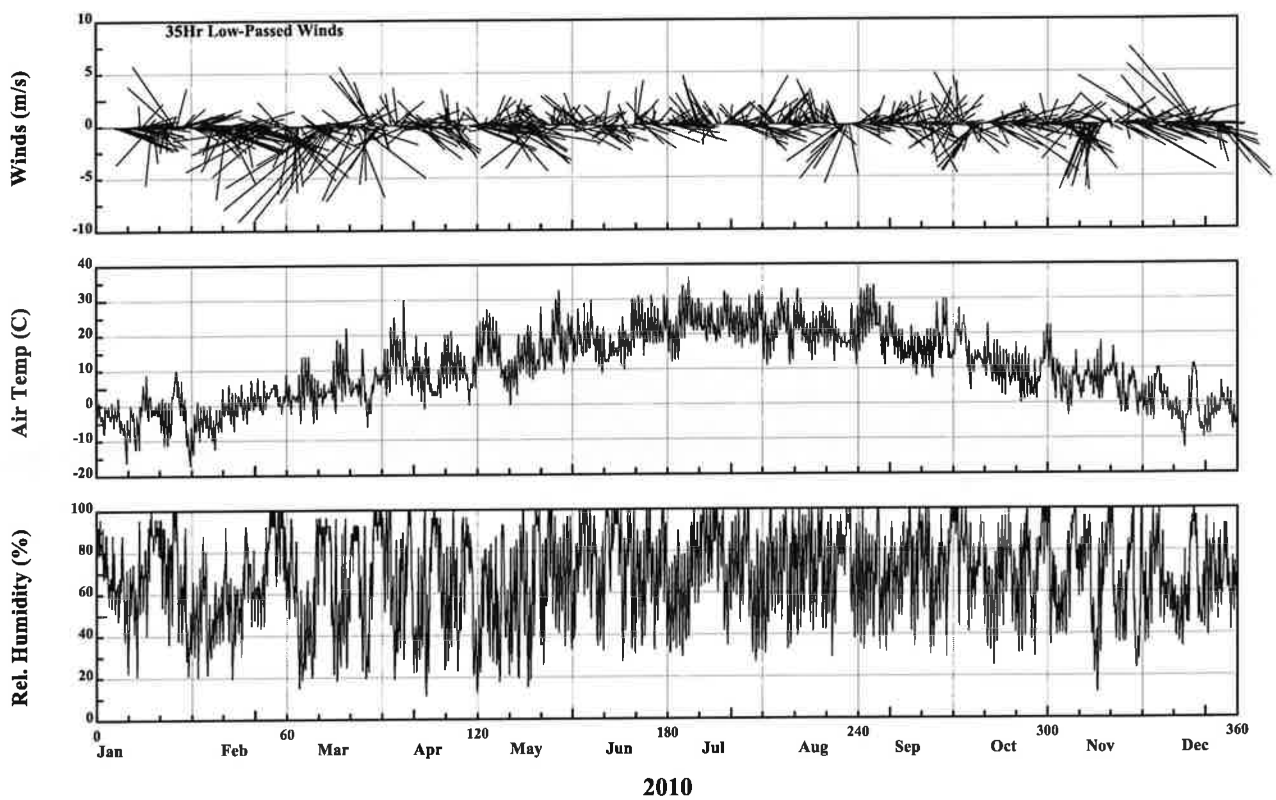


Figure 10. Meteorological Forcing Data : 2010

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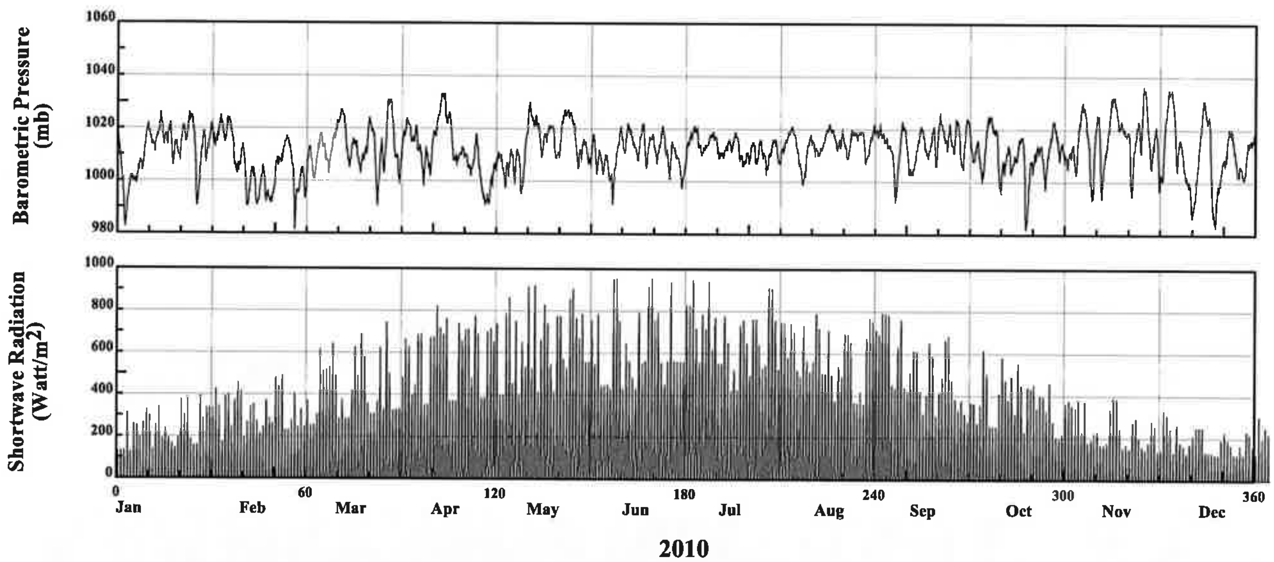

Figure 10. Meteorological Forcing Data : 2010 (Cont.)

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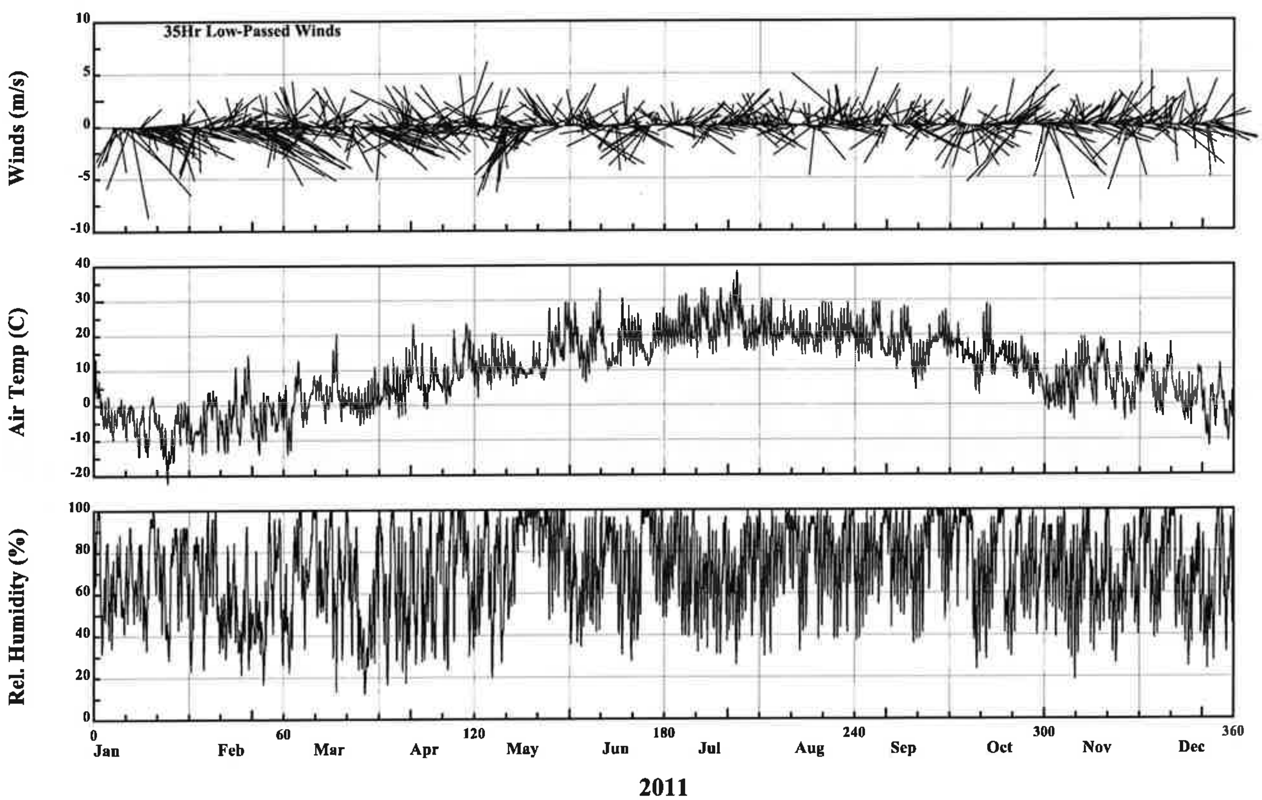

Figure 11. Meteorological Forcing Data : 2011

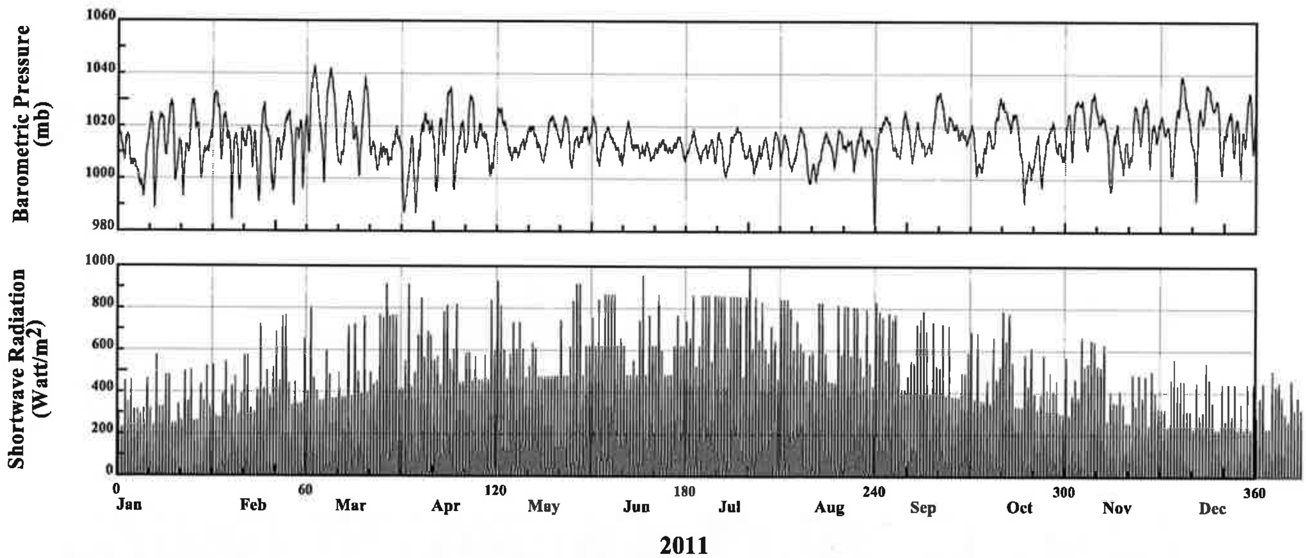

Figure 11. Meteorological Forcing Data : 2011

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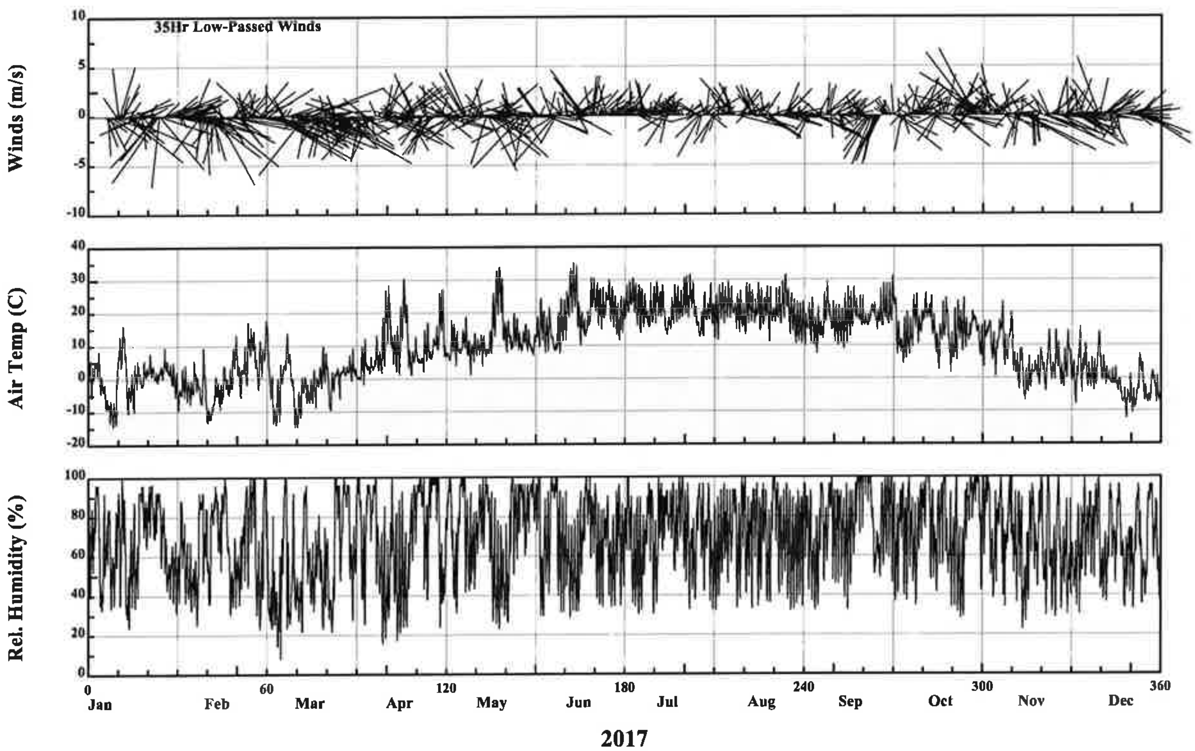

Figure 12. Meteorological Forcing Data : 2017

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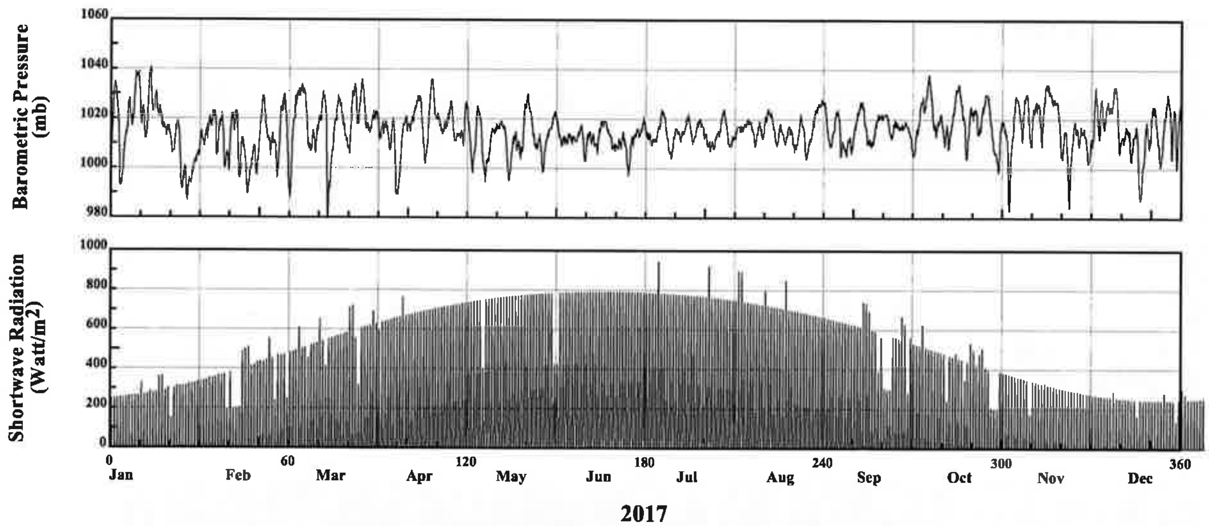

Figure 12. Meteorological Forcing Data : 2017 (Cont.)

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DATE: 10/23/2019 TIME: 21:38:40

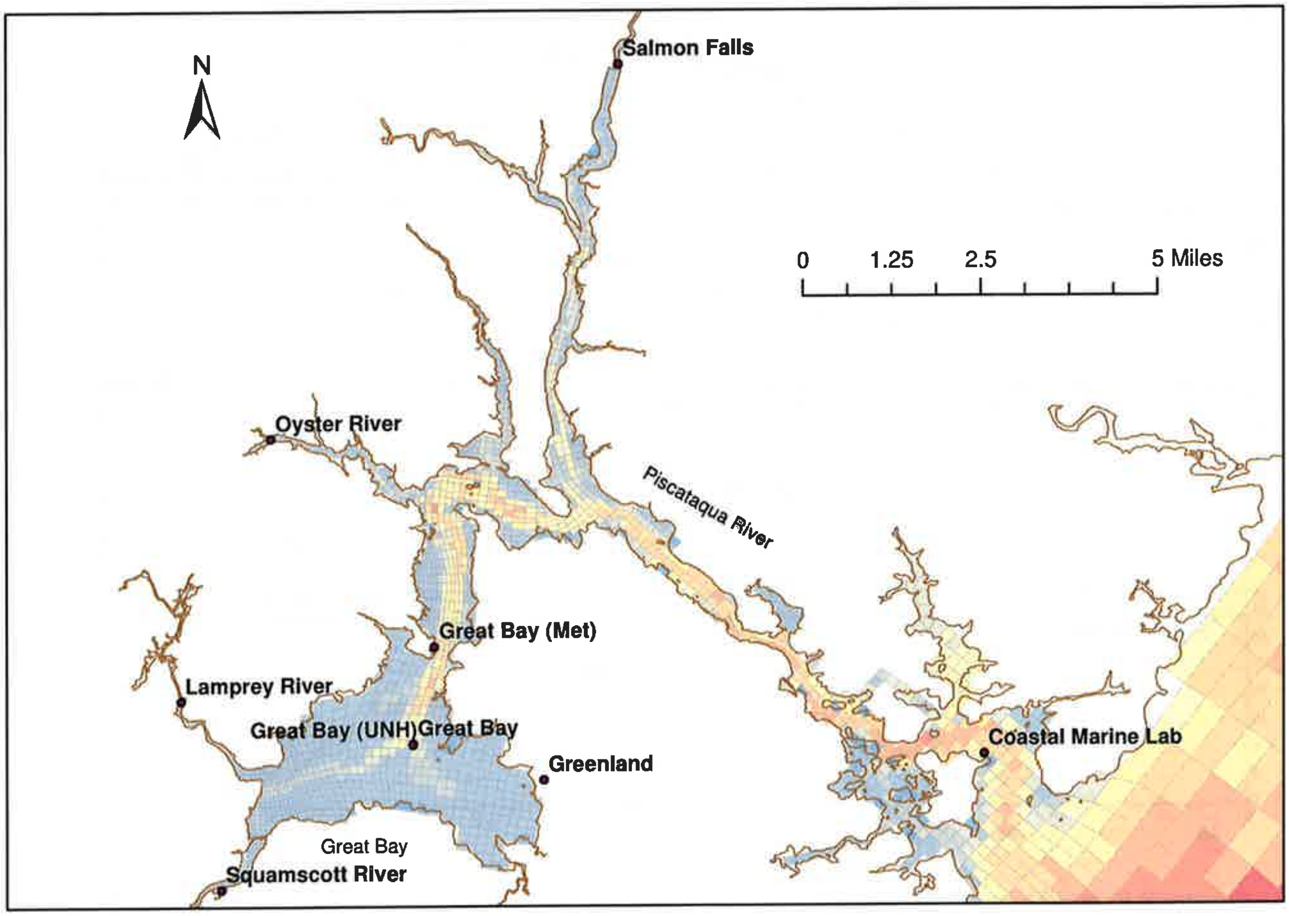


FIGURE 10. Location of Continuous Monitoring Stations

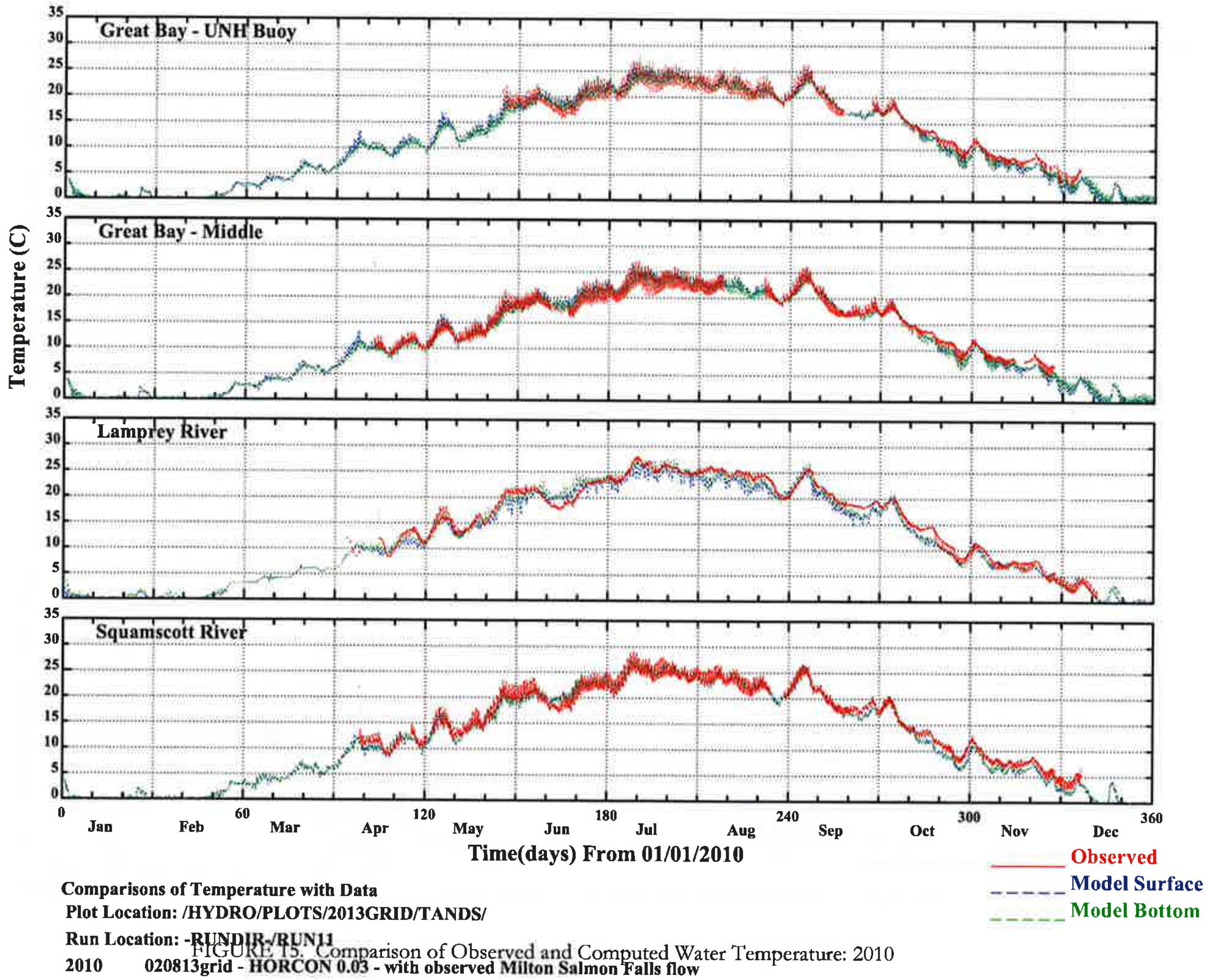


FIGURE 15. Comparison of Observed and Computed Water Temperature: 2010

DATE: 9/18/2013 TIME: 13: 8: 5

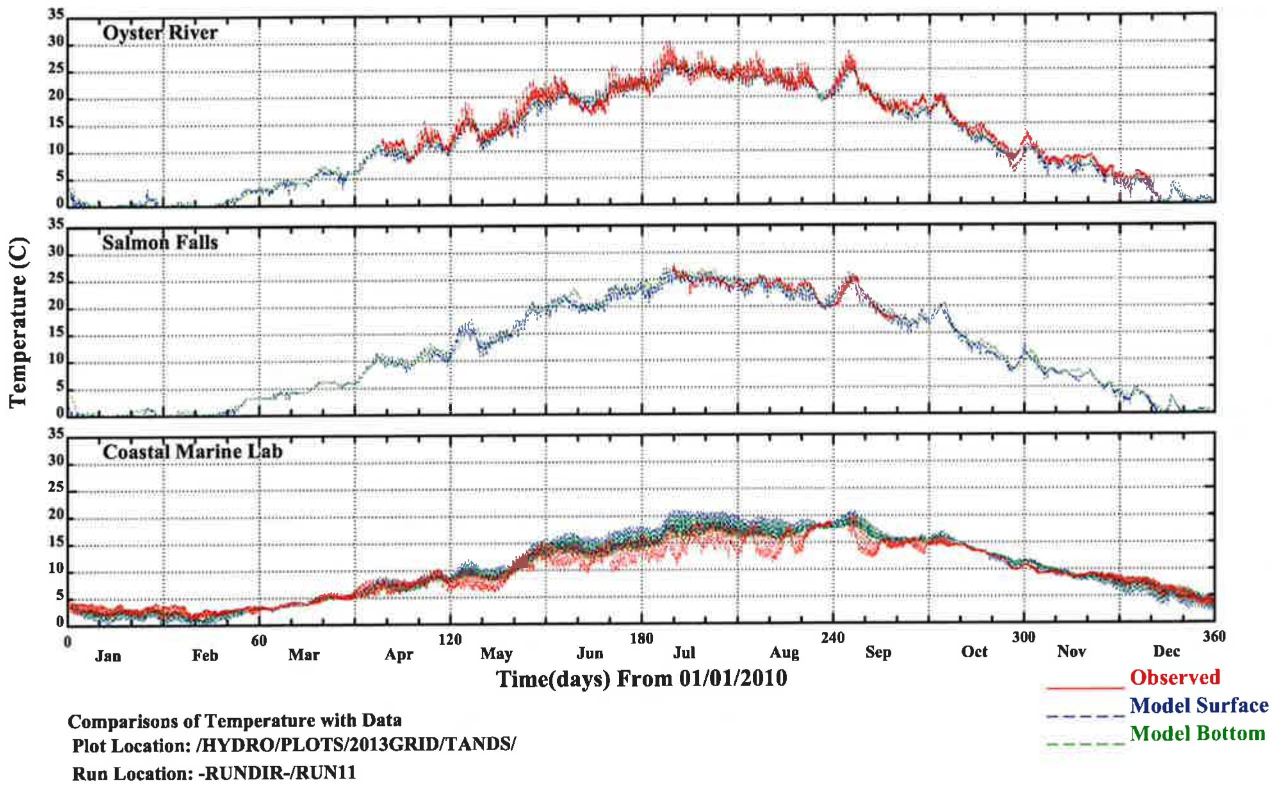


FIGURE 13. Comparison of Observed and Computed Water Temperature: 2010 (Cont.)

DATE: 9/18/2013 TIME: 13: 8: 5

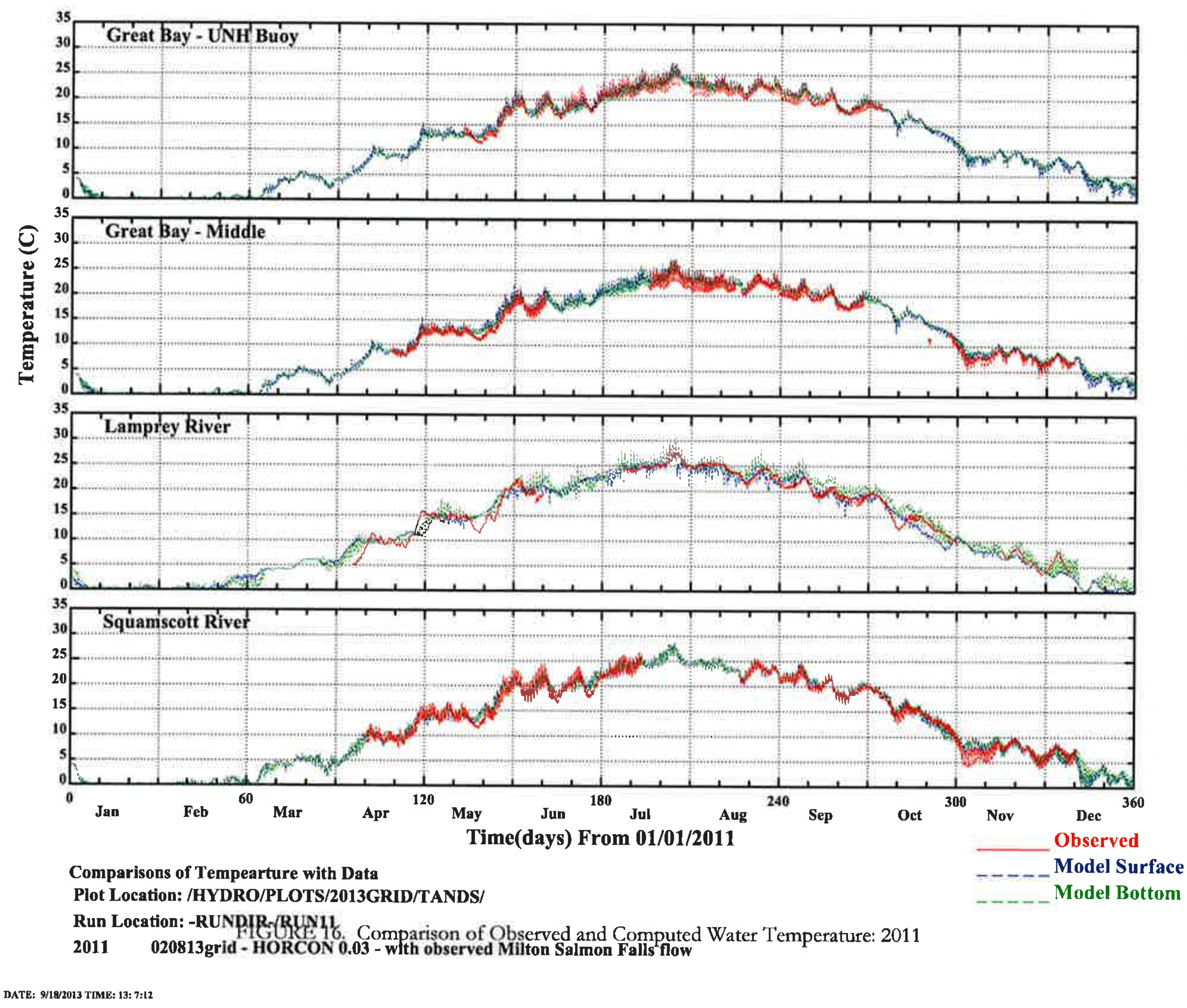
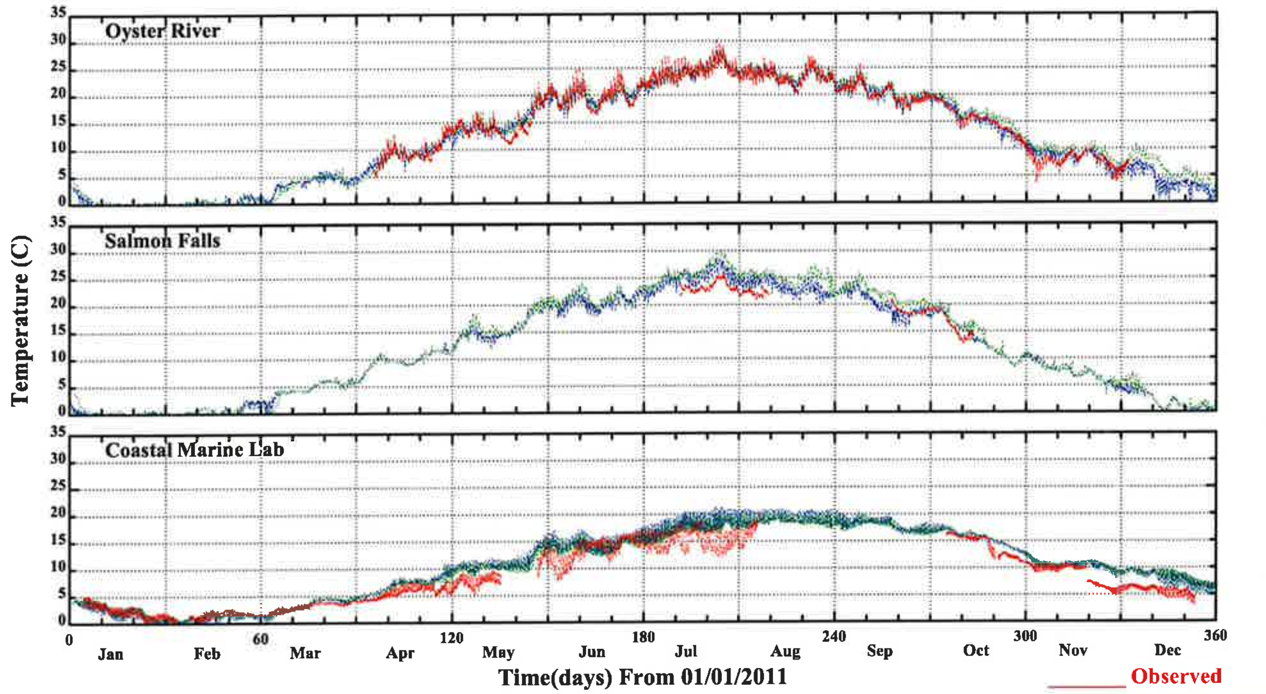


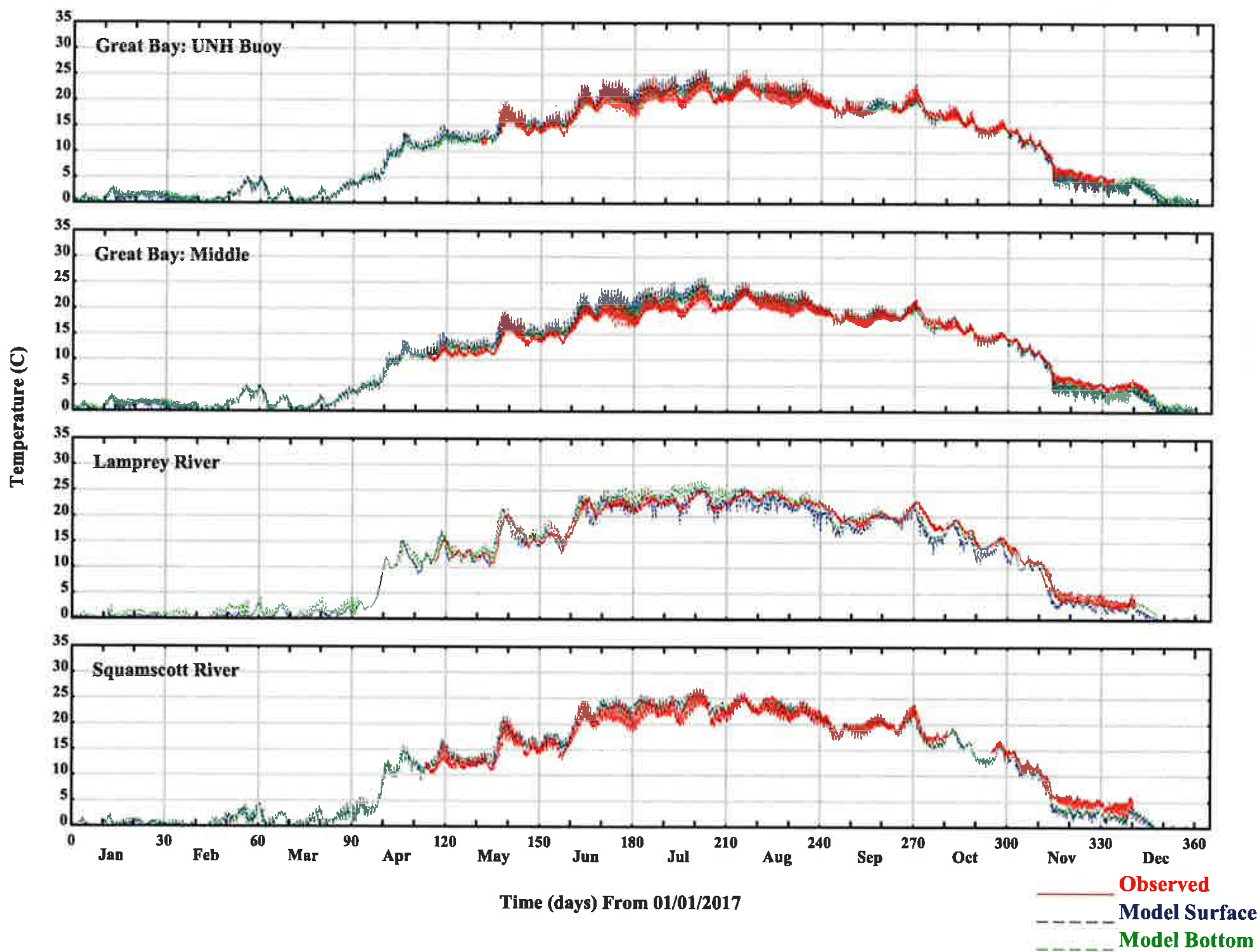
FIGURE 16. Comparison of Observed and Computed Water Temperature: 2011



Comparisons of Tempearture with Data
Plot Location: /HYDRO/PLOTS/2013GRID/TANDS/
Run Location: -RUNDIR-/RUN11
2011 020813grid - HORCON 0.03 - with observed Milton Salmon Falls flow

FIGURE 16. Comparison of Observed and Computed Water Temperature: 2011 (Cont.)

DATE: 9/18/2013 TIME: 13: 7:12



RUN02:-FLAG-

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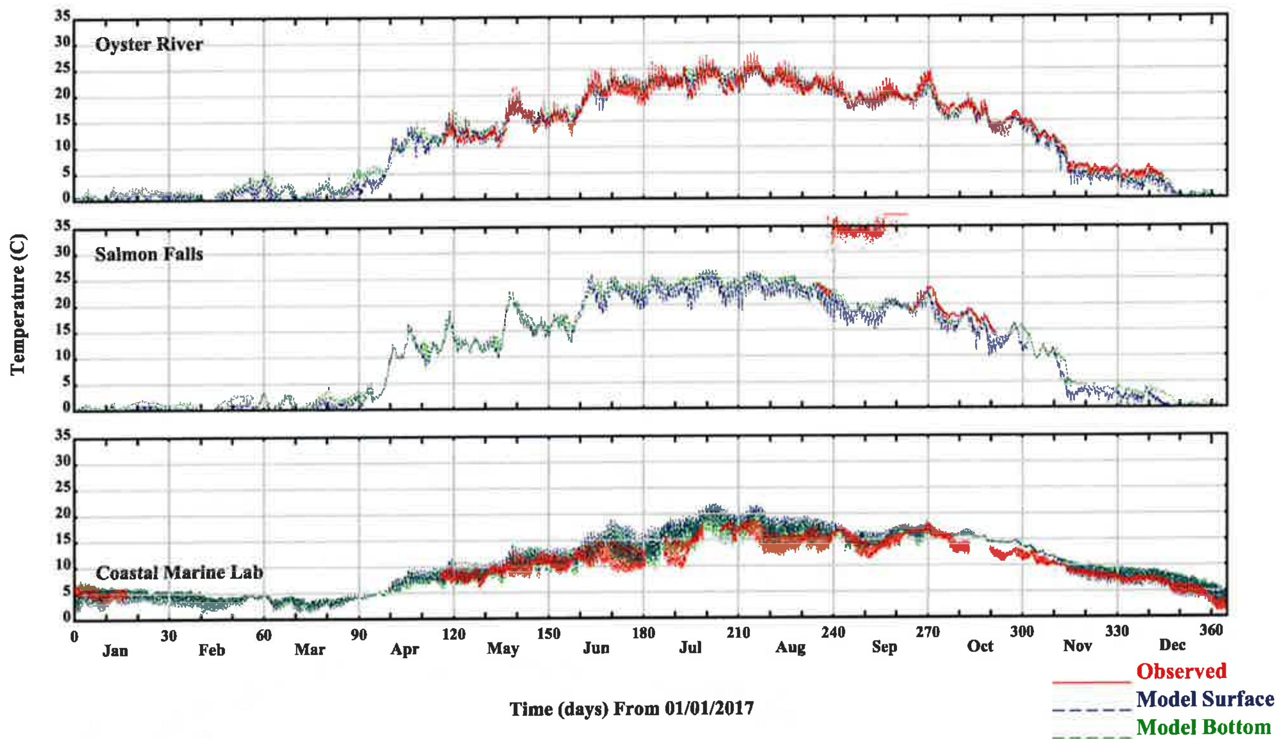
DATE: 10/29/2019 TIME: 15:51:32



RUN02:-FLAG-

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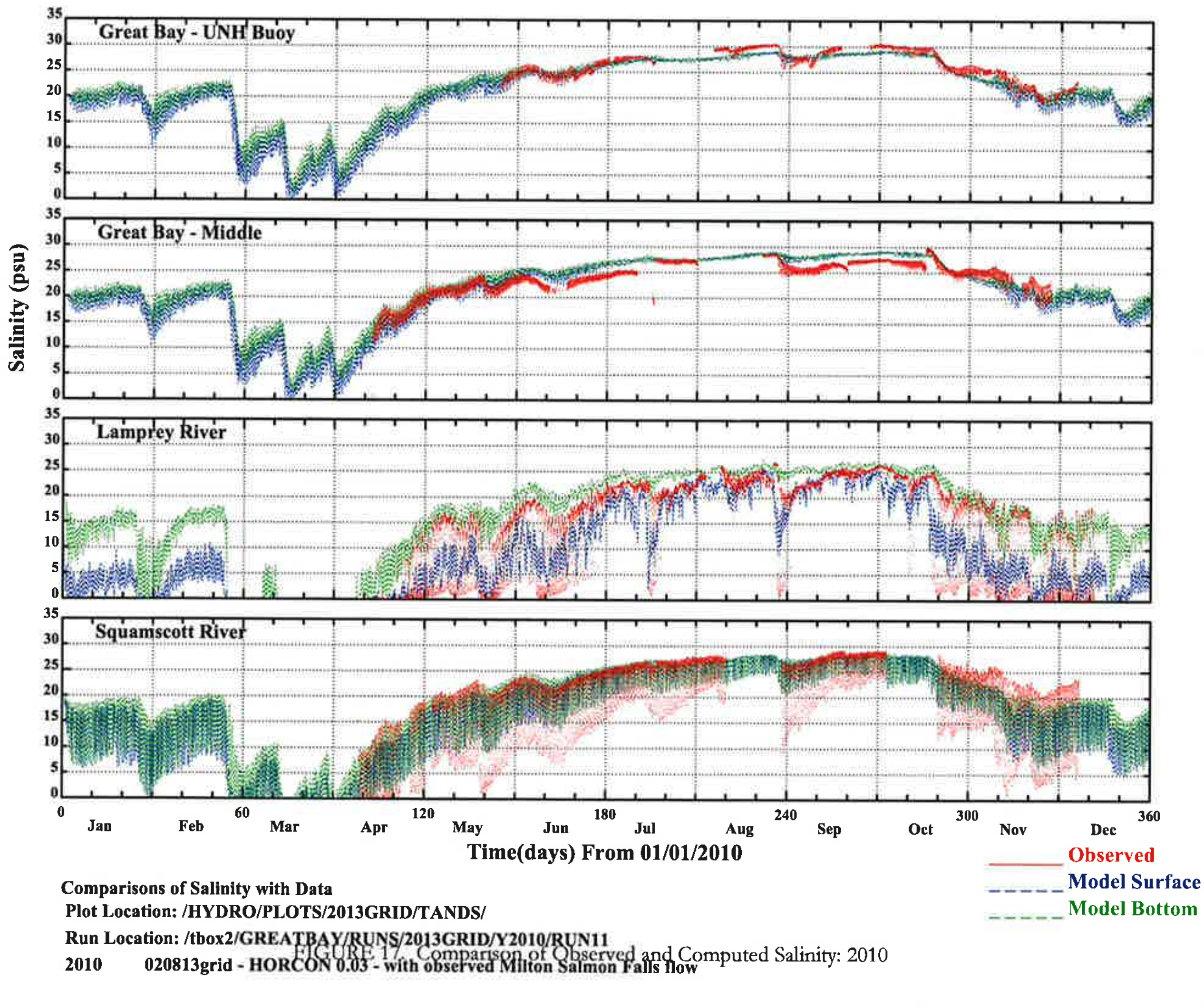


FIGURE 17. Comparison of Observed and Computed Salinity: 2010

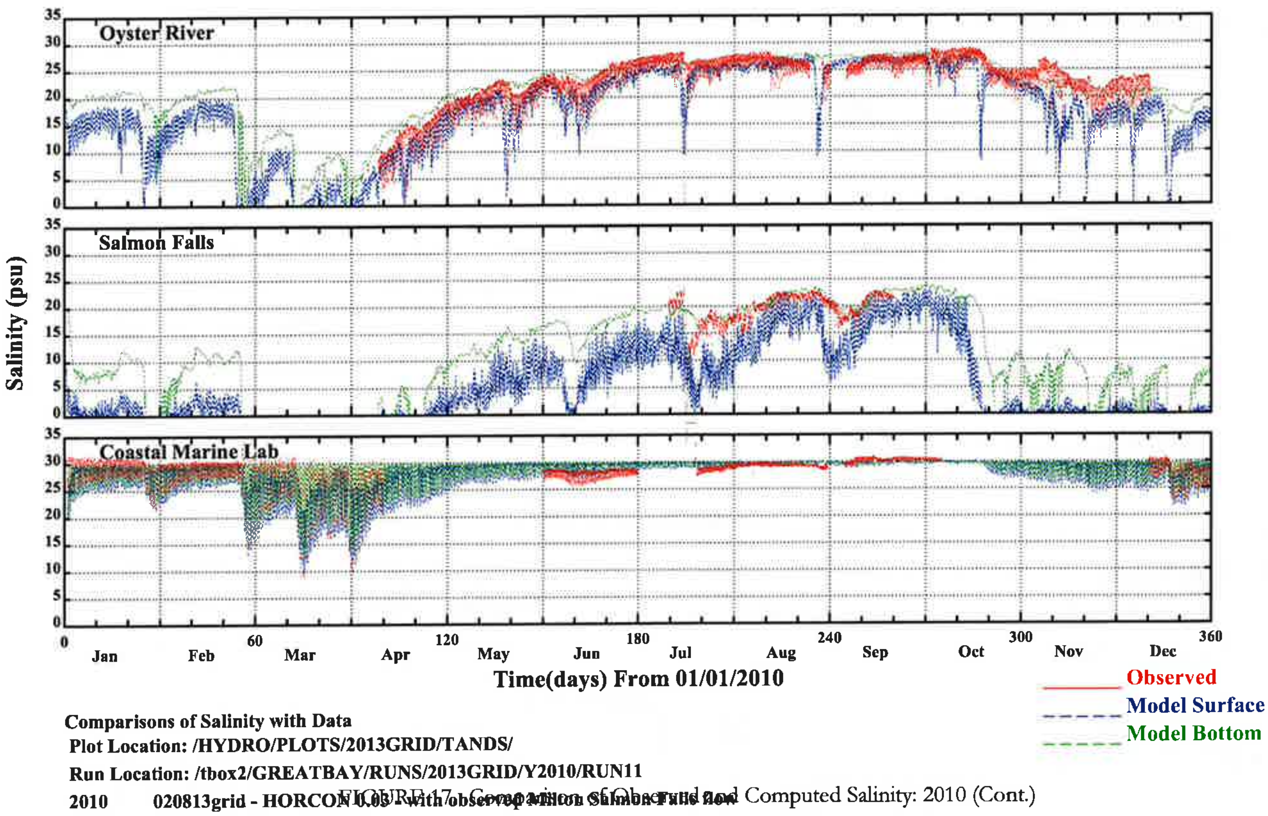
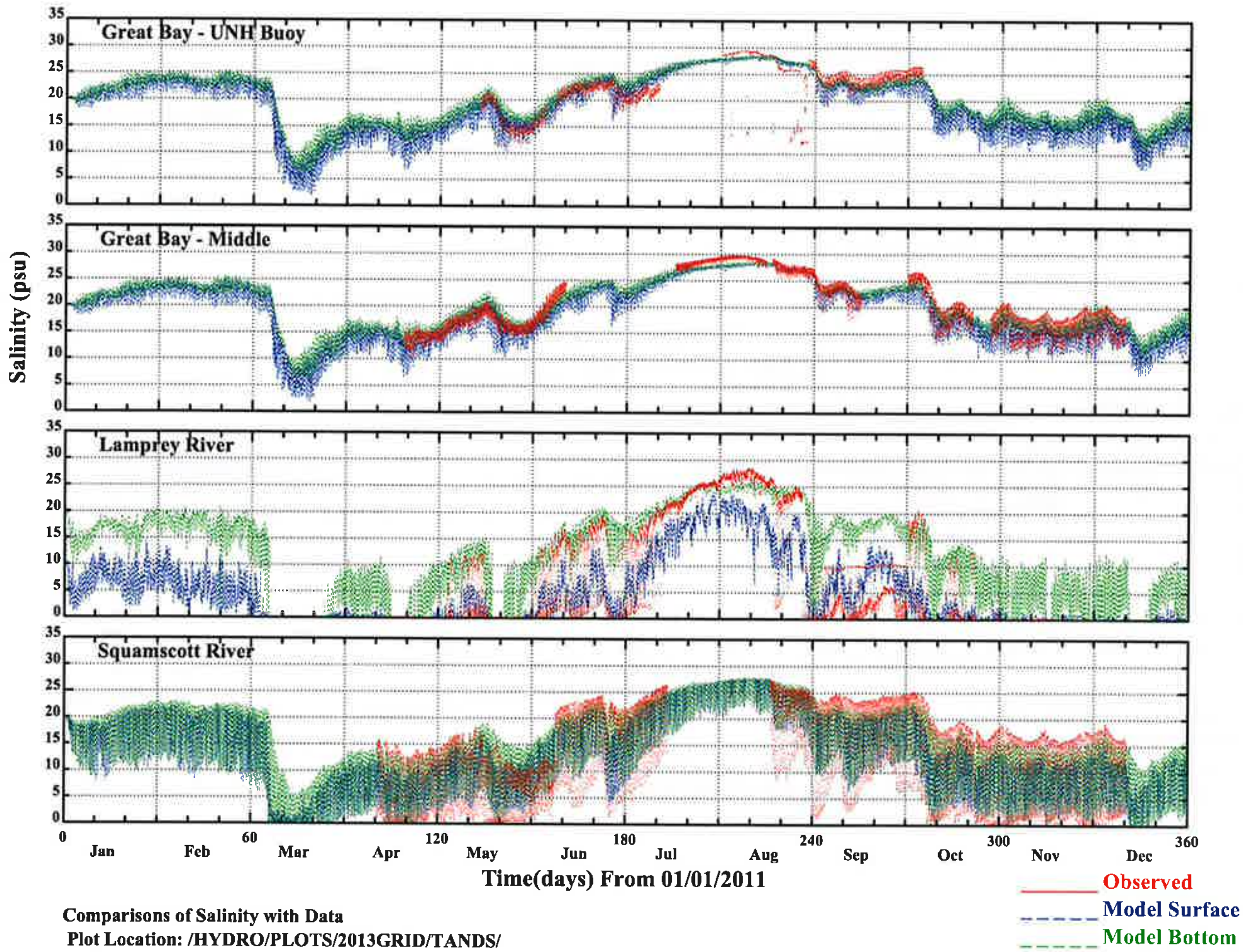


FIGURE 17 - Comparison of Observed and Computed Salinity: 2010 (Cont.)

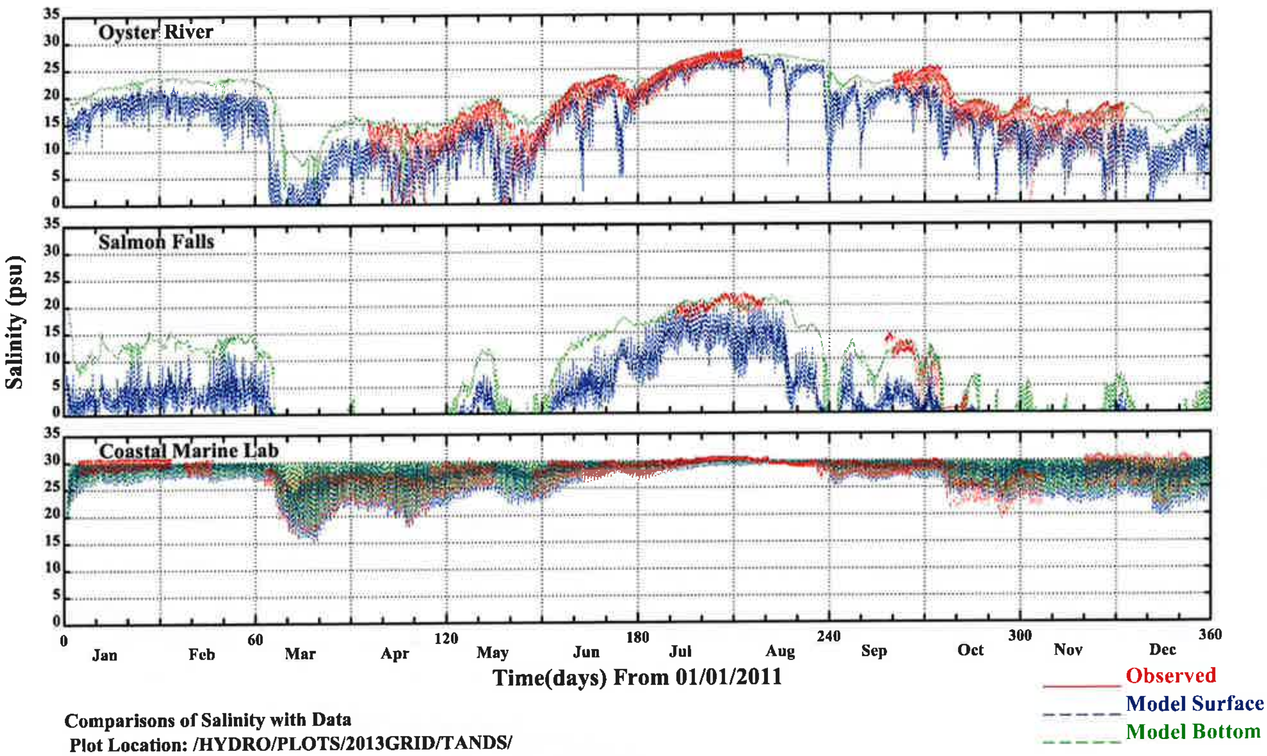
DATE: 9/18/2013 TIME: 13: 7:53



Comparisons of Salinity with Data
Plot Location: /HYDRO/PLOTS/2013GRID/TANDS/
Run Location: /tbox2/GREATBAY/RUNS/2013GRID/Y2011/RUN11
2011 020813grid - HORCON 0.03 - with observed Milton Salmon Falls flow

FIGURE 18: Comparison of Observed and Computed Salinity: 2011

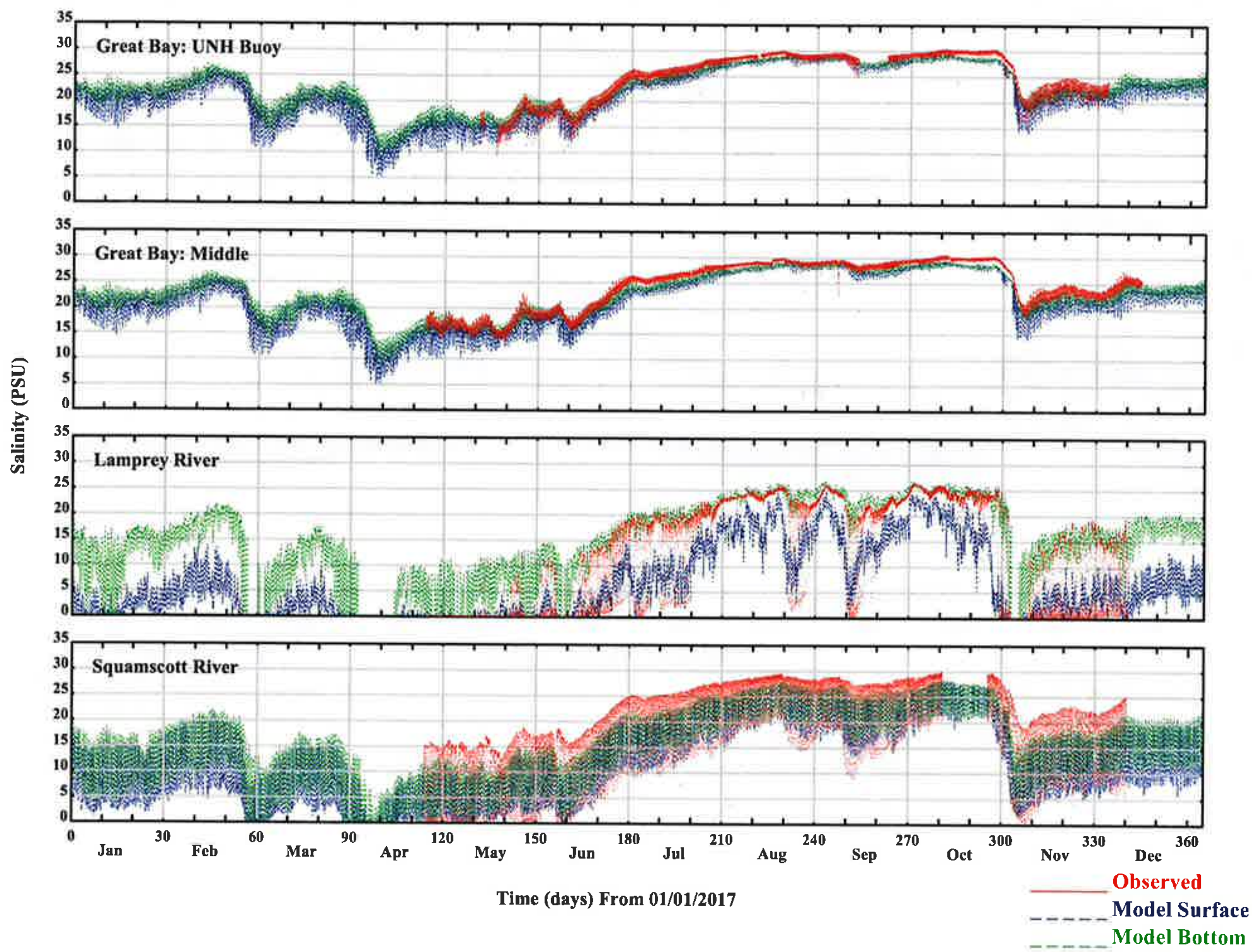
DATE: 9/18/2013 TIME: 13: 6:56



2011 020813grid - HORCON 0.03 - with observed Milton Salmon Falls flow

FIGURE 18. Comparison of Observed and Computed Salinity: 2011 (Cont.)

DATE: 9/18/2013 TIME: 13: 6:56



RUN02:-FLAG-

FIGURE 19. Comparison of Observed and Computed Salinity: 2017

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DATE: 10/29/2019 TIME: 15:50:29

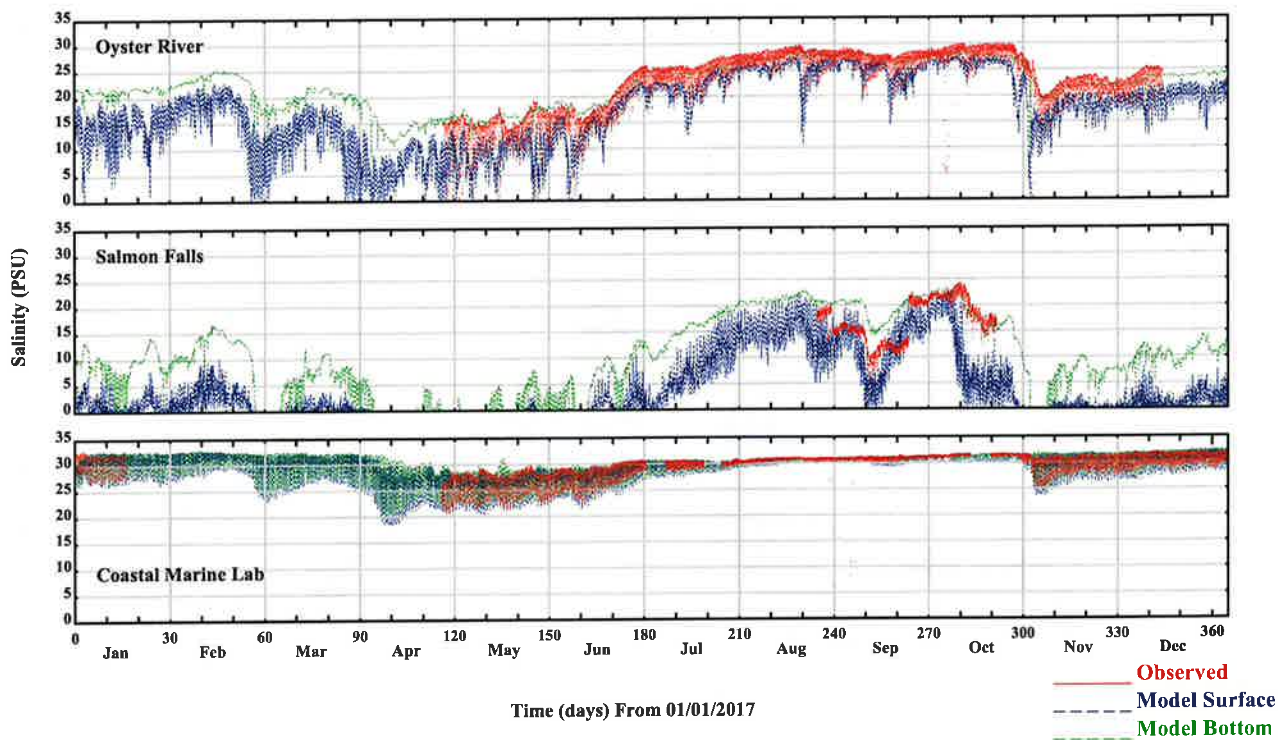

FIGURE 19. Comparison of Observed and Computed Salinity: 2017 (Cont.)

RUN02:-FLAG-

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DATE: 10/29/2019 TIME: 15:50:29

2 / 2

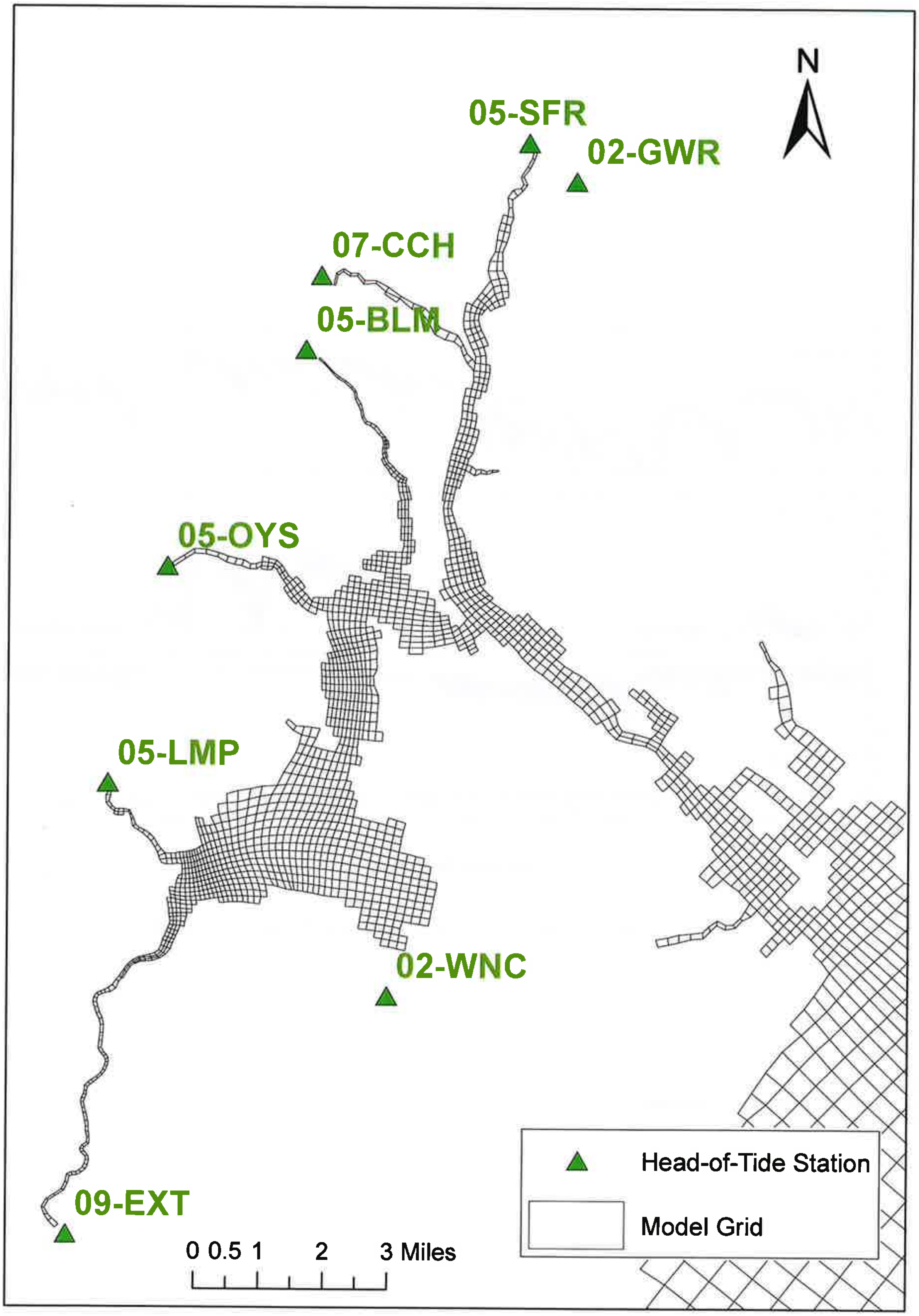


Figure 20. Head-of-Tide Monitoring Stations

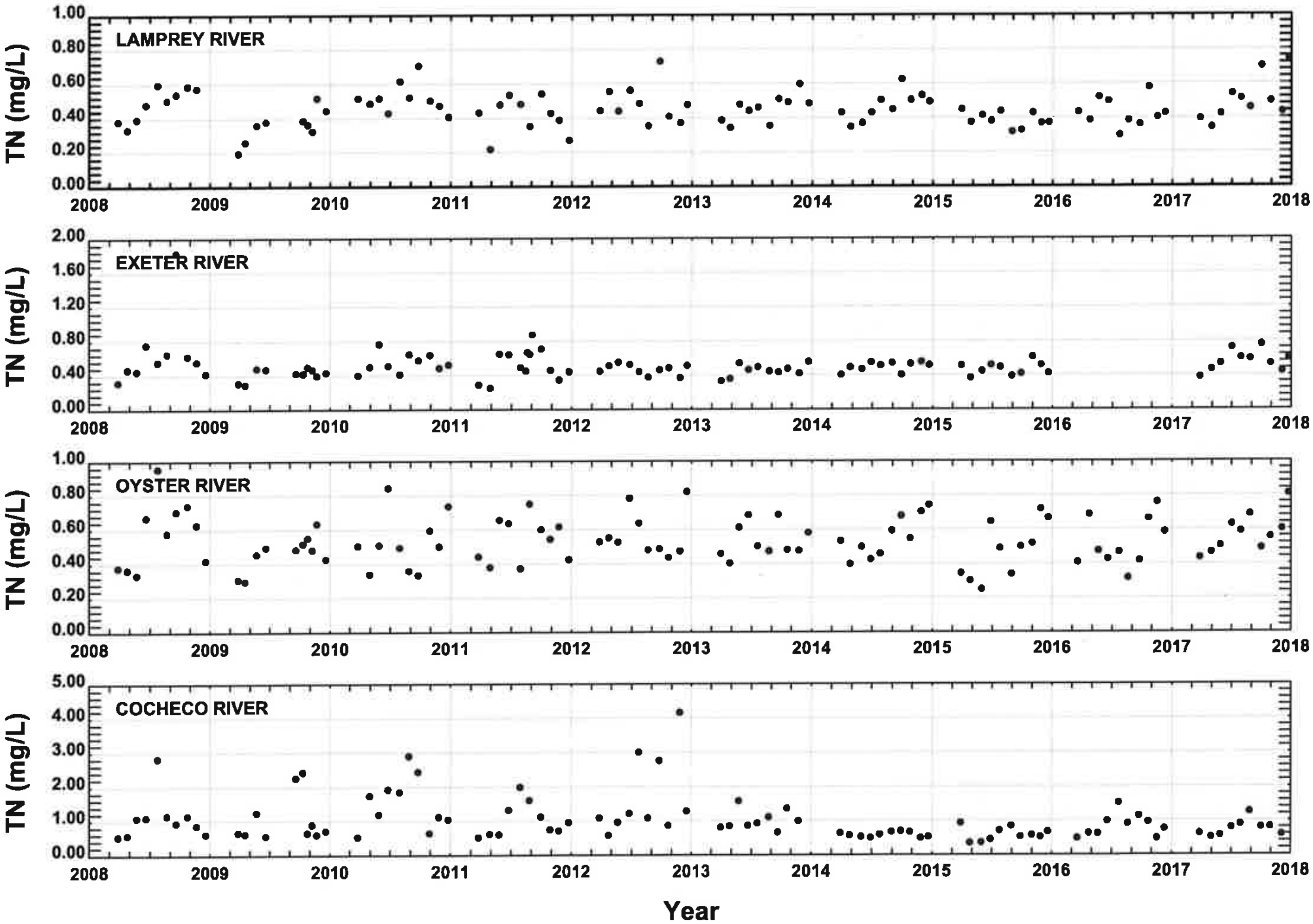
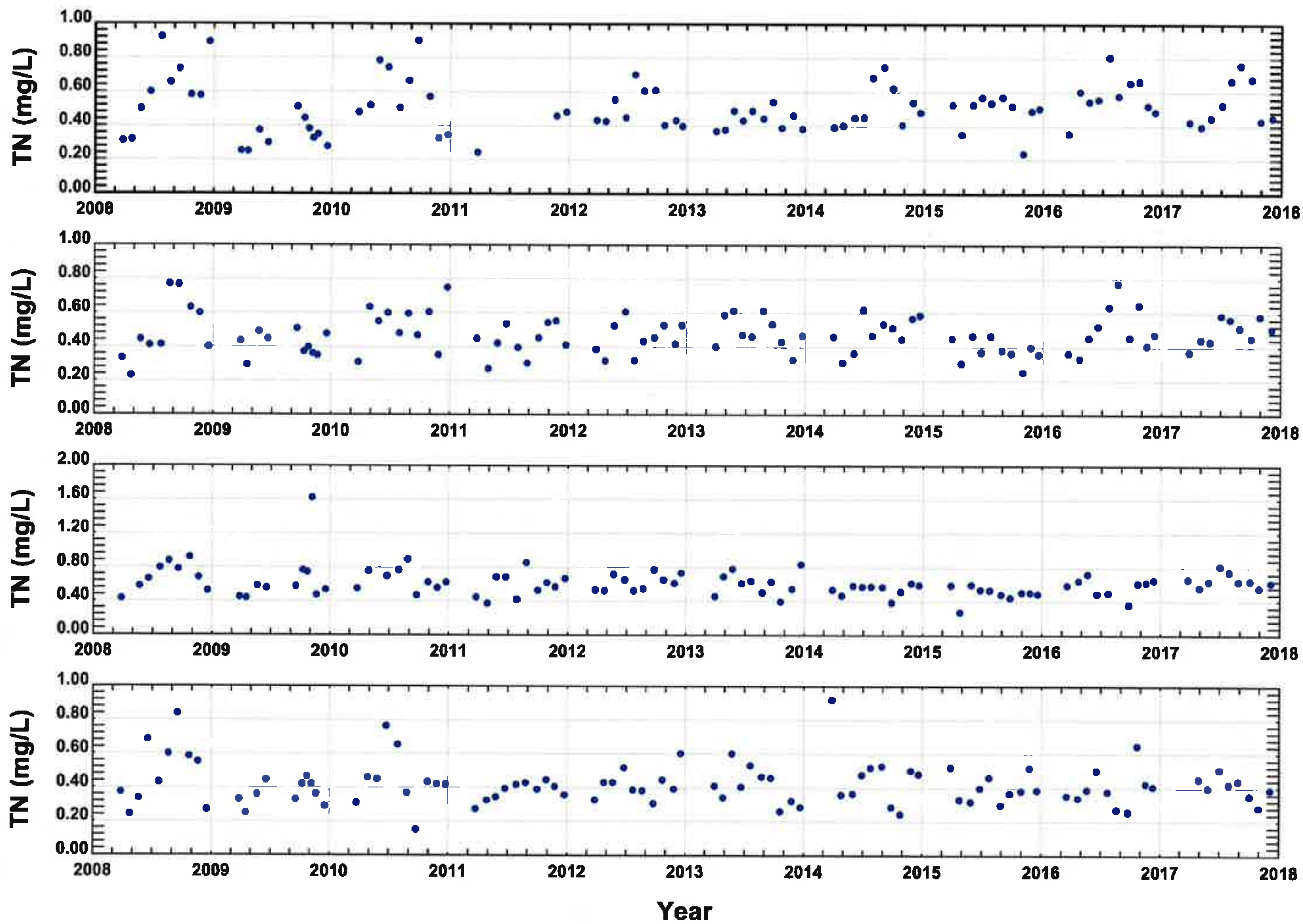
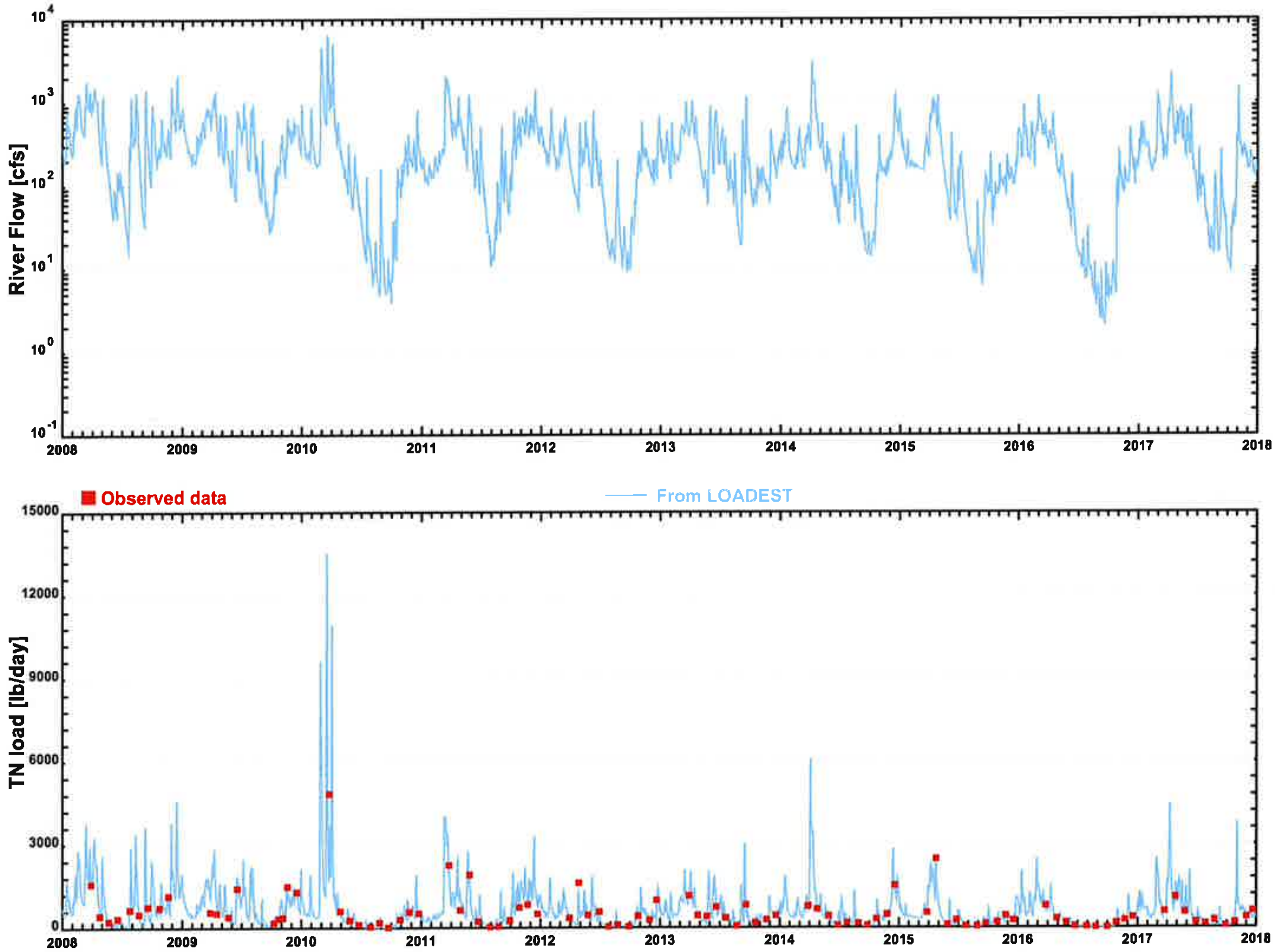


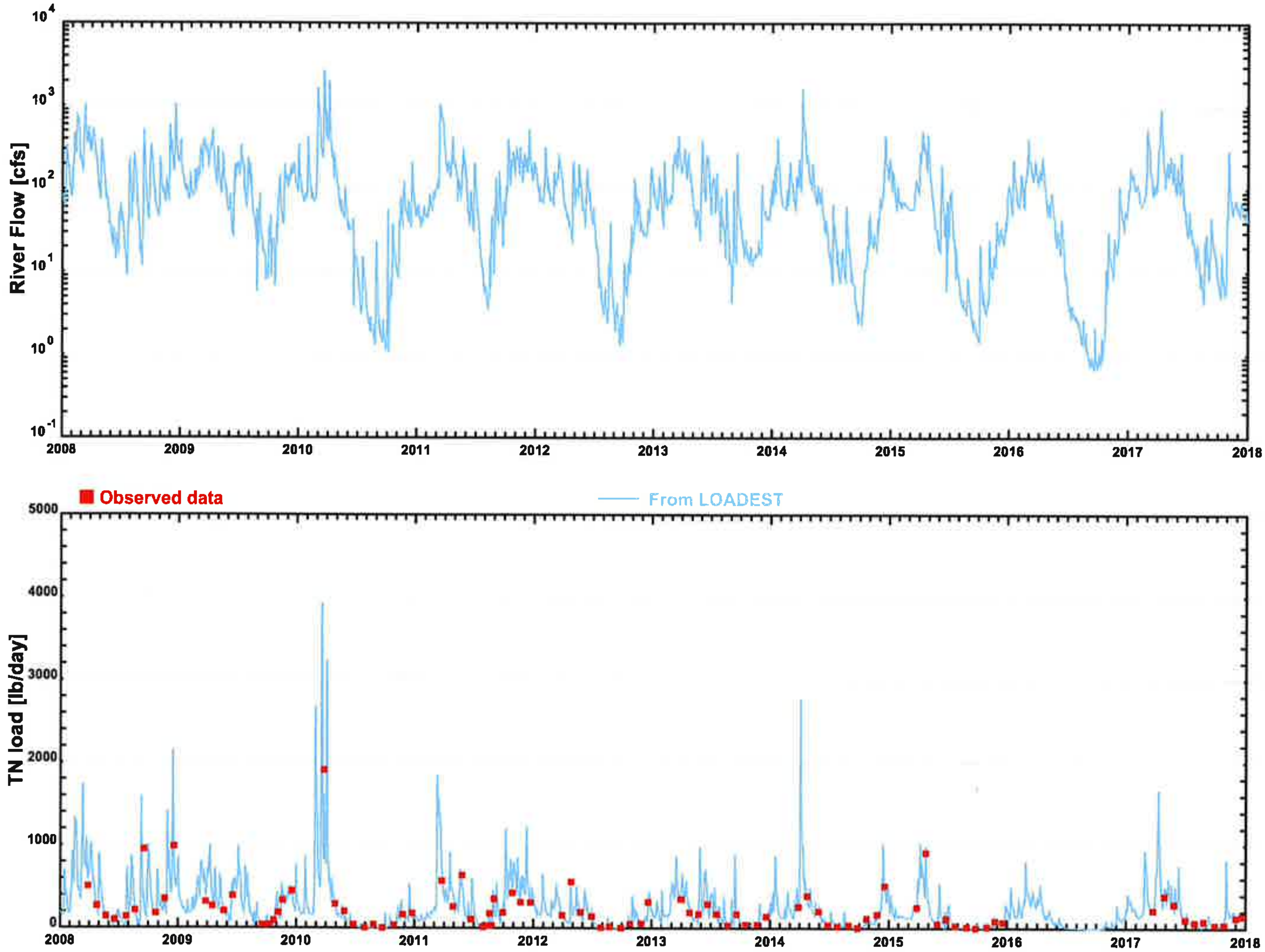
Figure 20. Time Series Plots of TN data measured at Head-of-Tide Locations (Years 2008-2017)



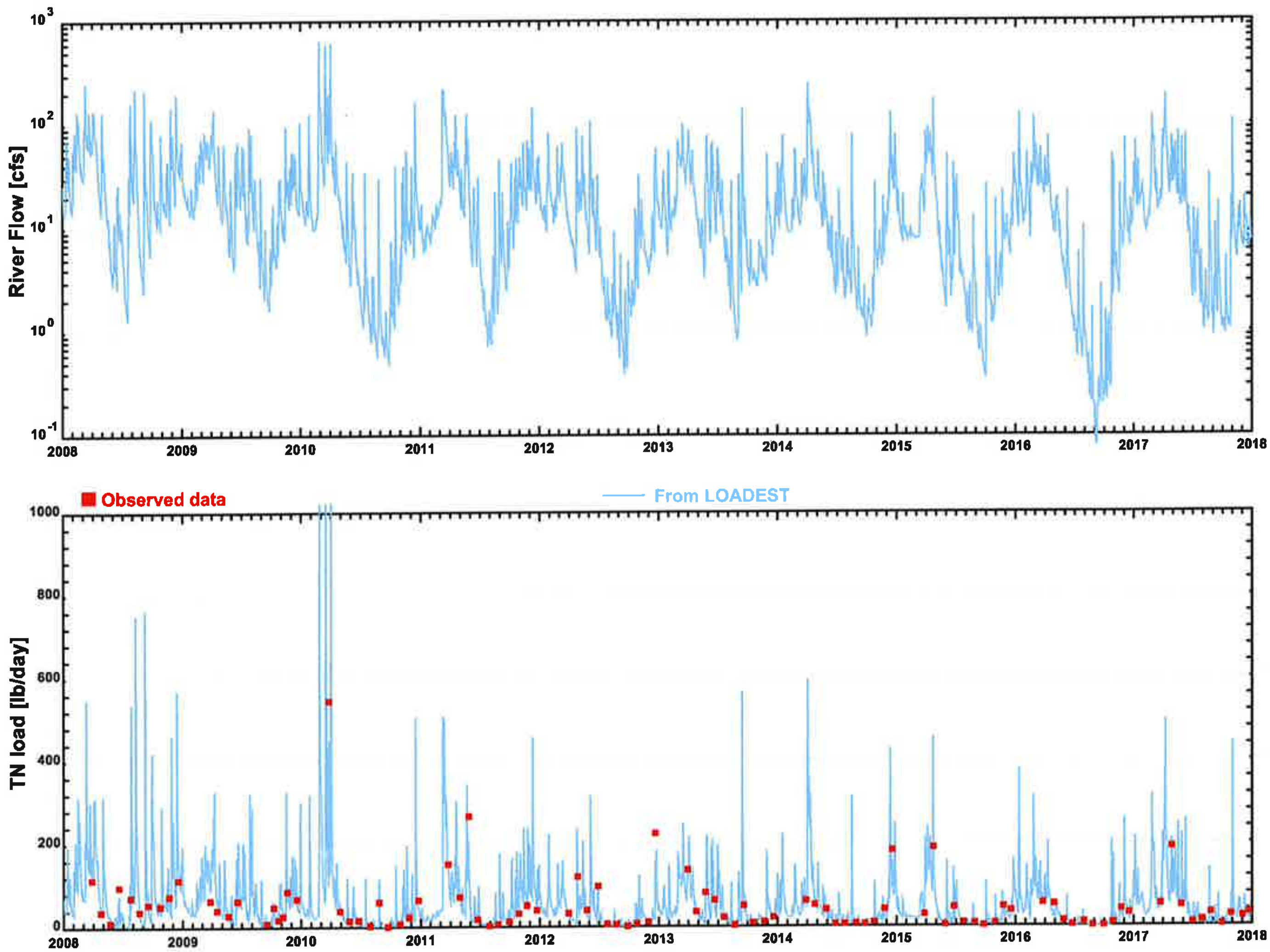
TN (mg/L)
1.00
0.80
0.60
0.40
0.20
0.00
2.00
1.60
1.20
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Year



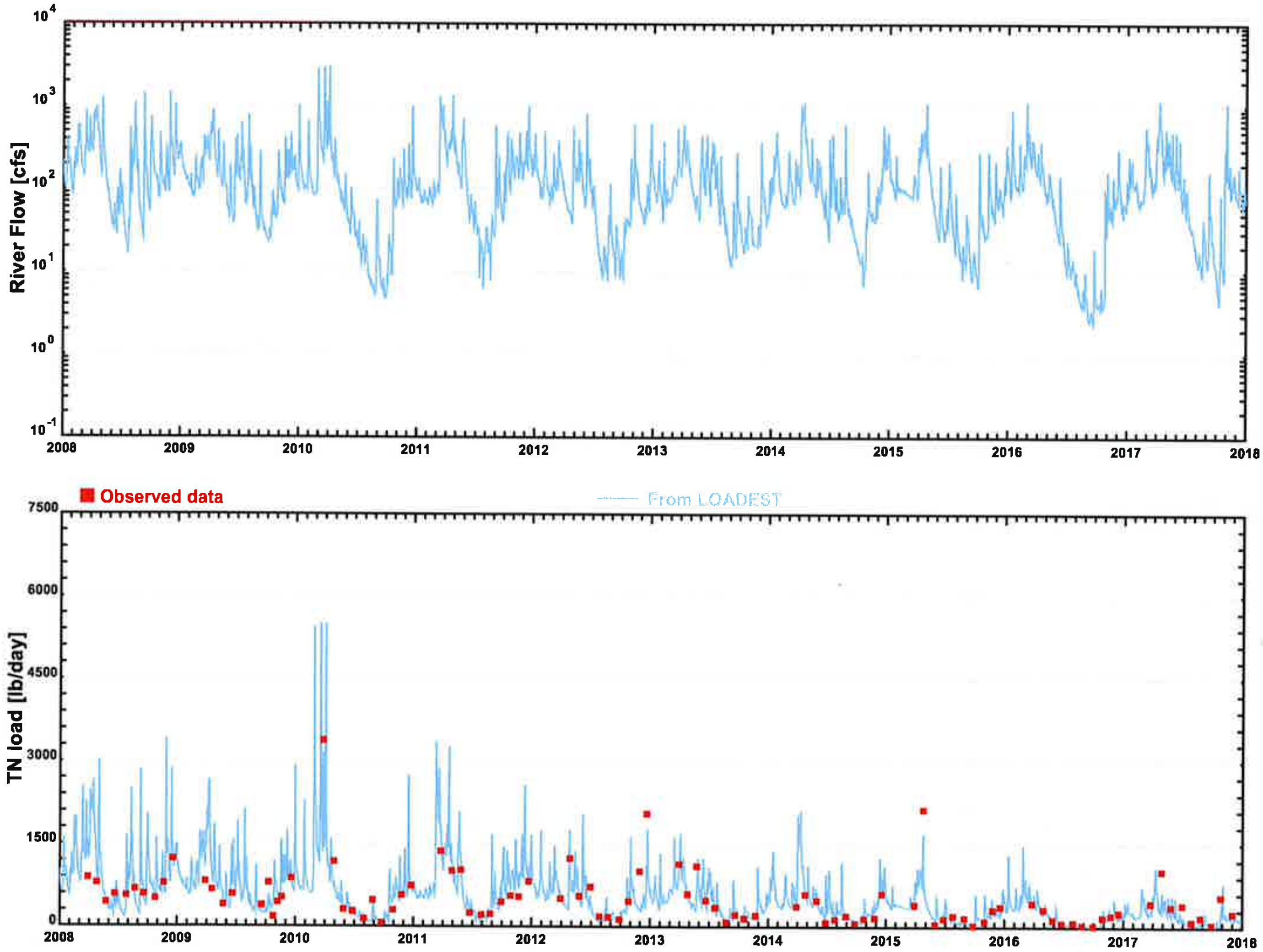
05-LMP - Lamprey River



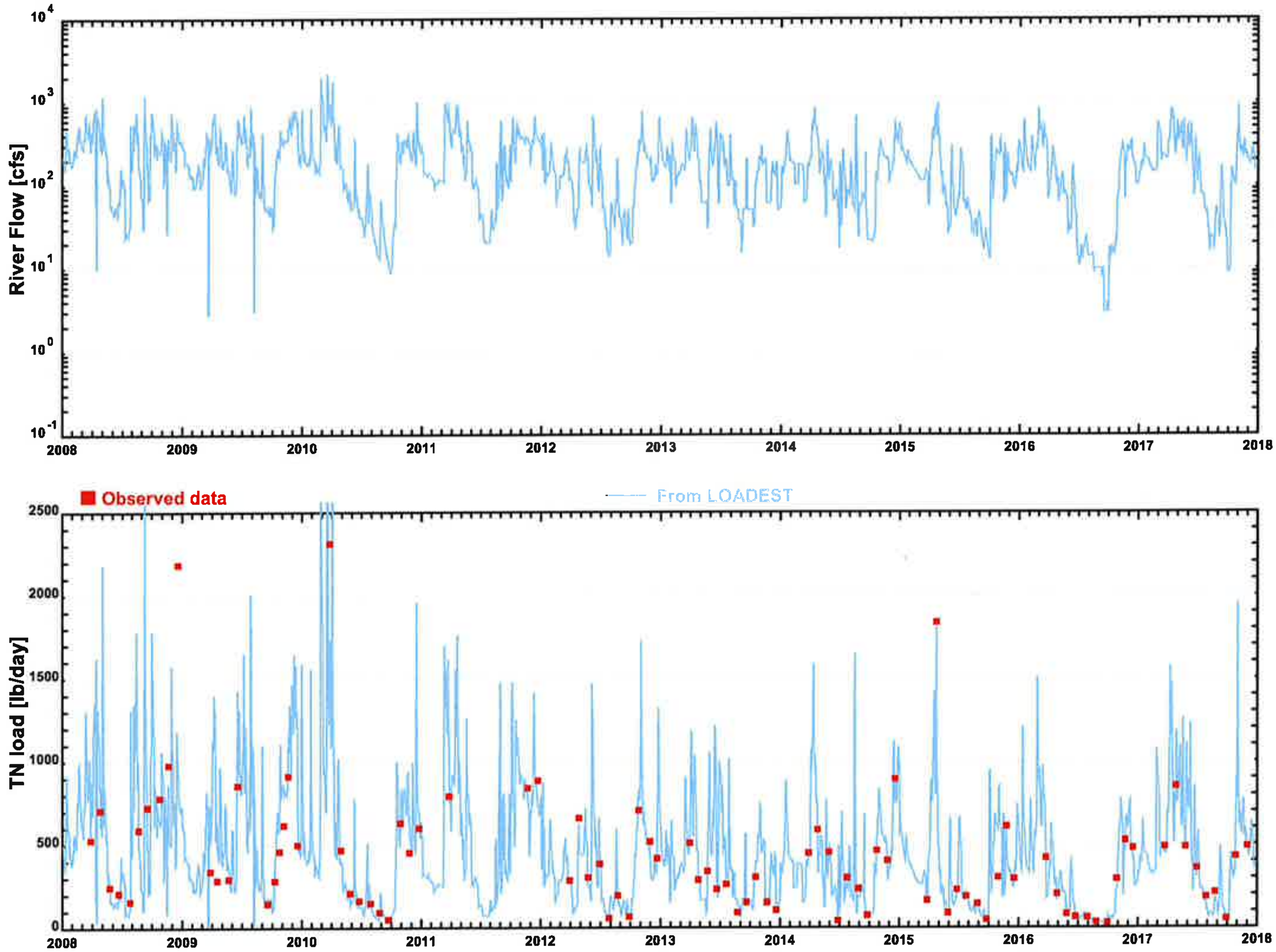
09-EXT - Exeter River



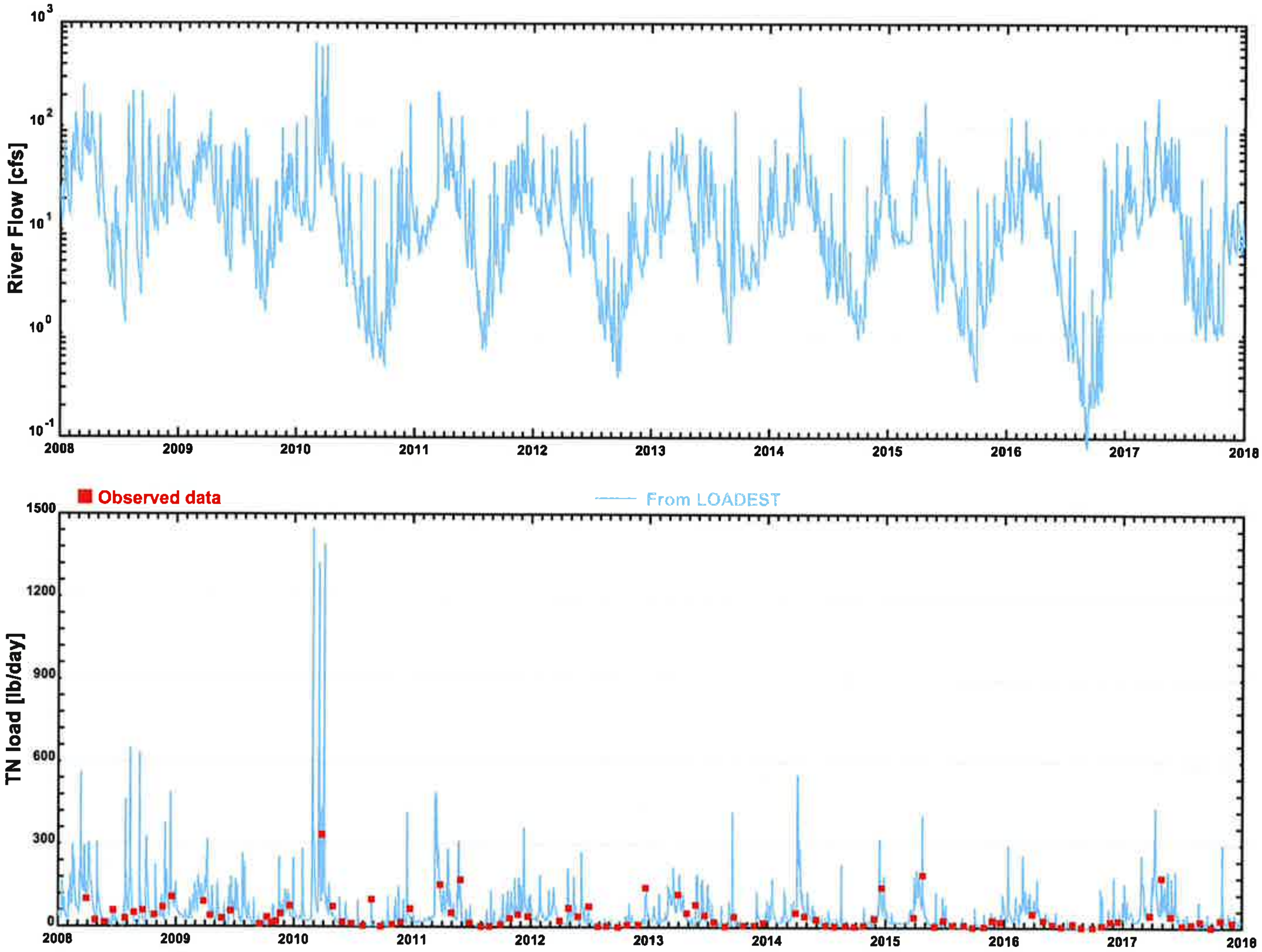
05-OYS - Oyster River



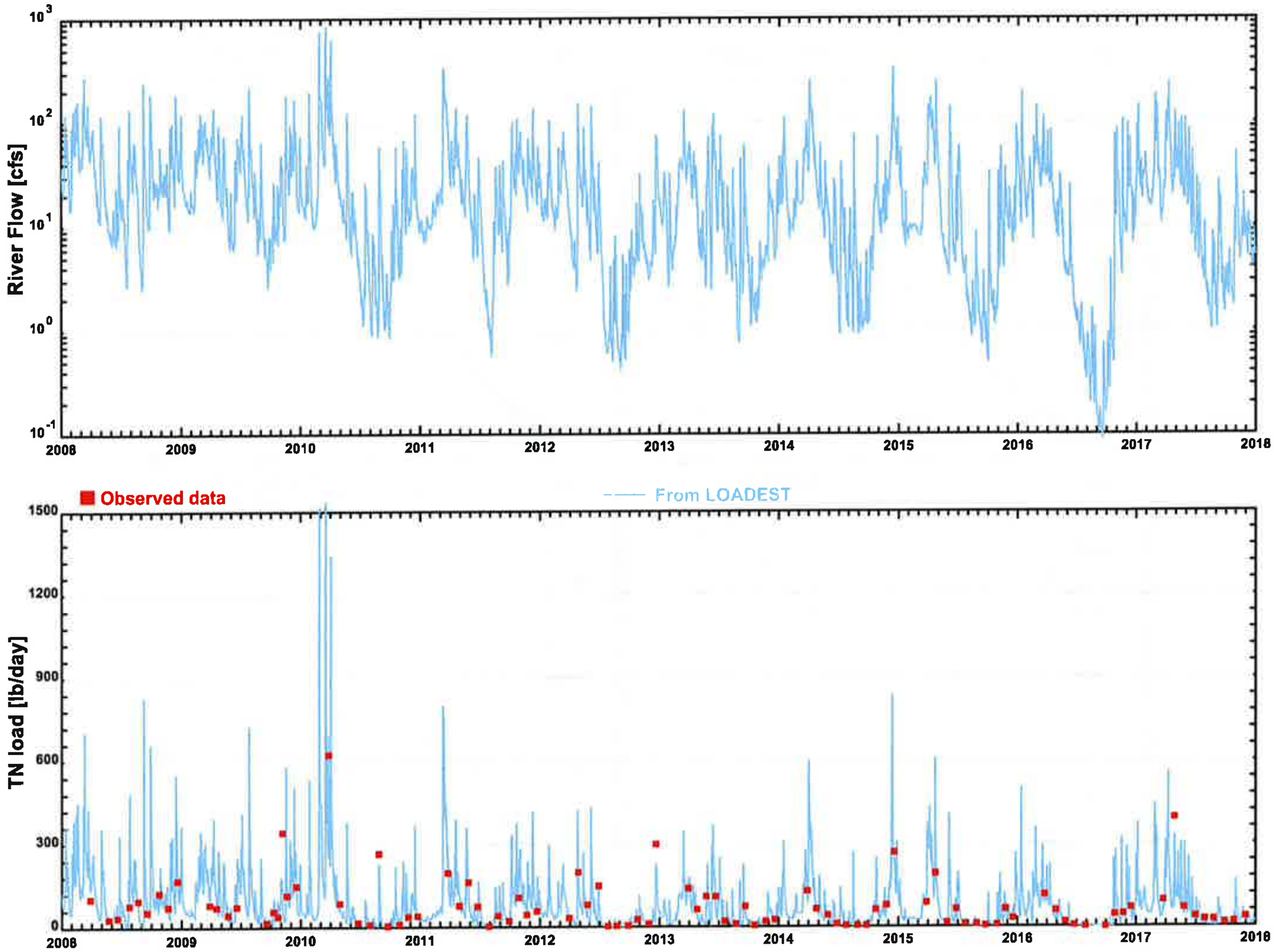
07-CCH - Cocheco River



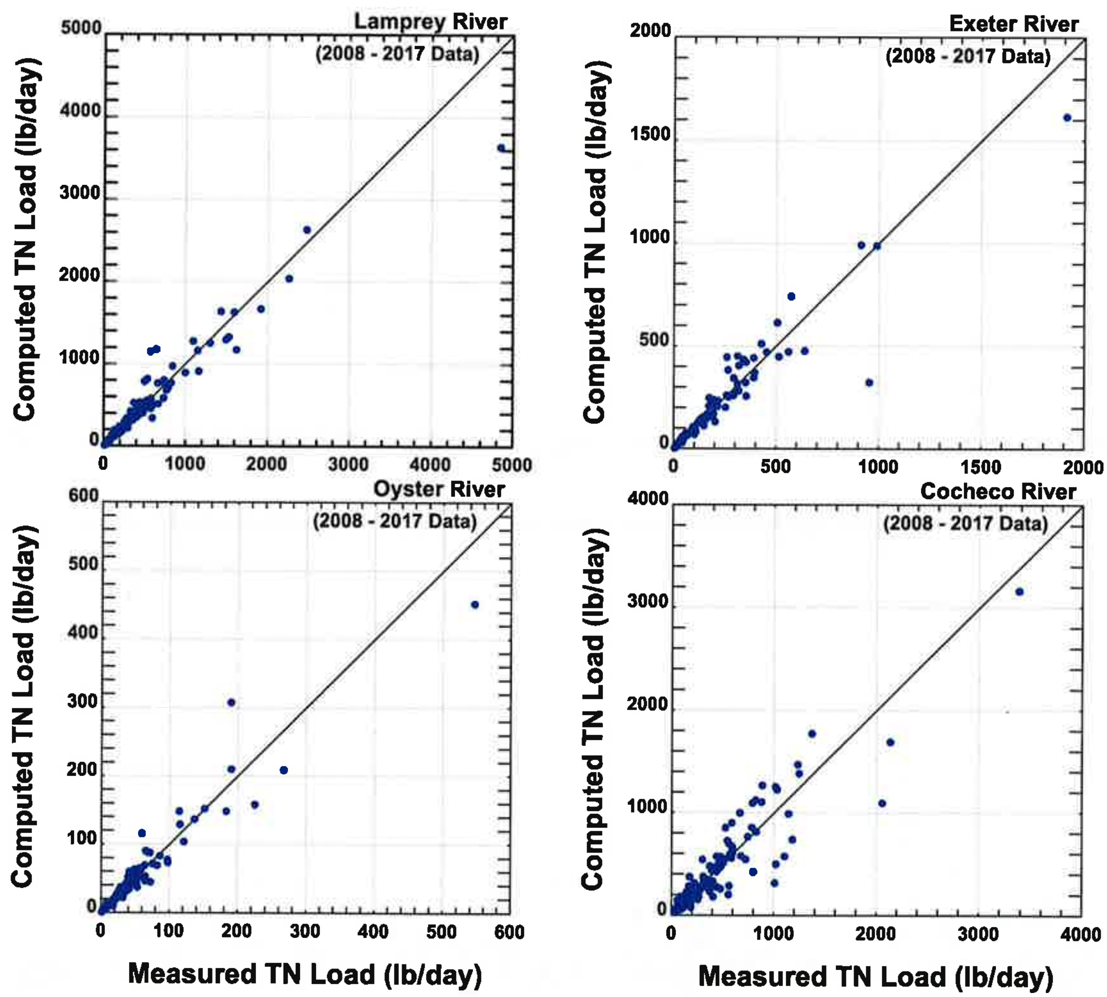
05-SFR - Milton Dam

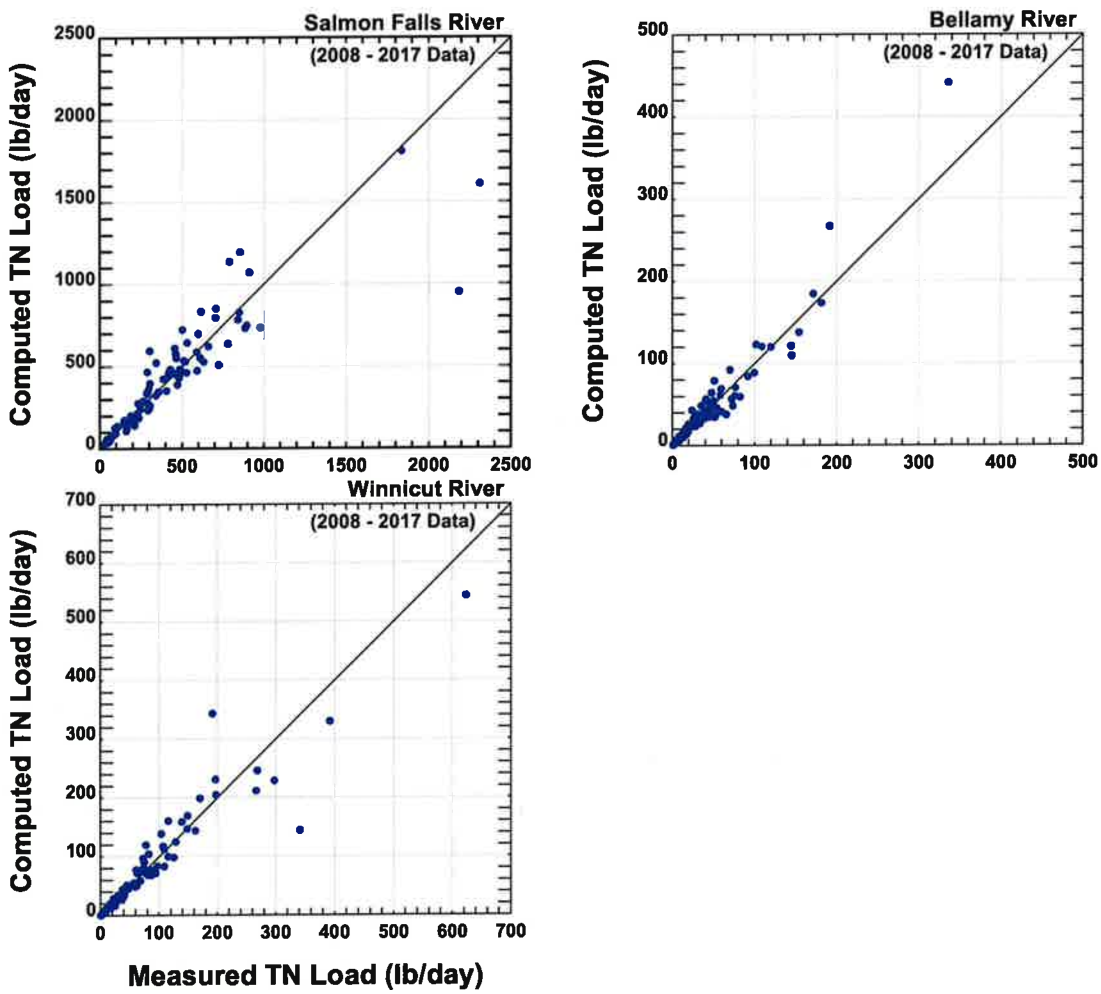


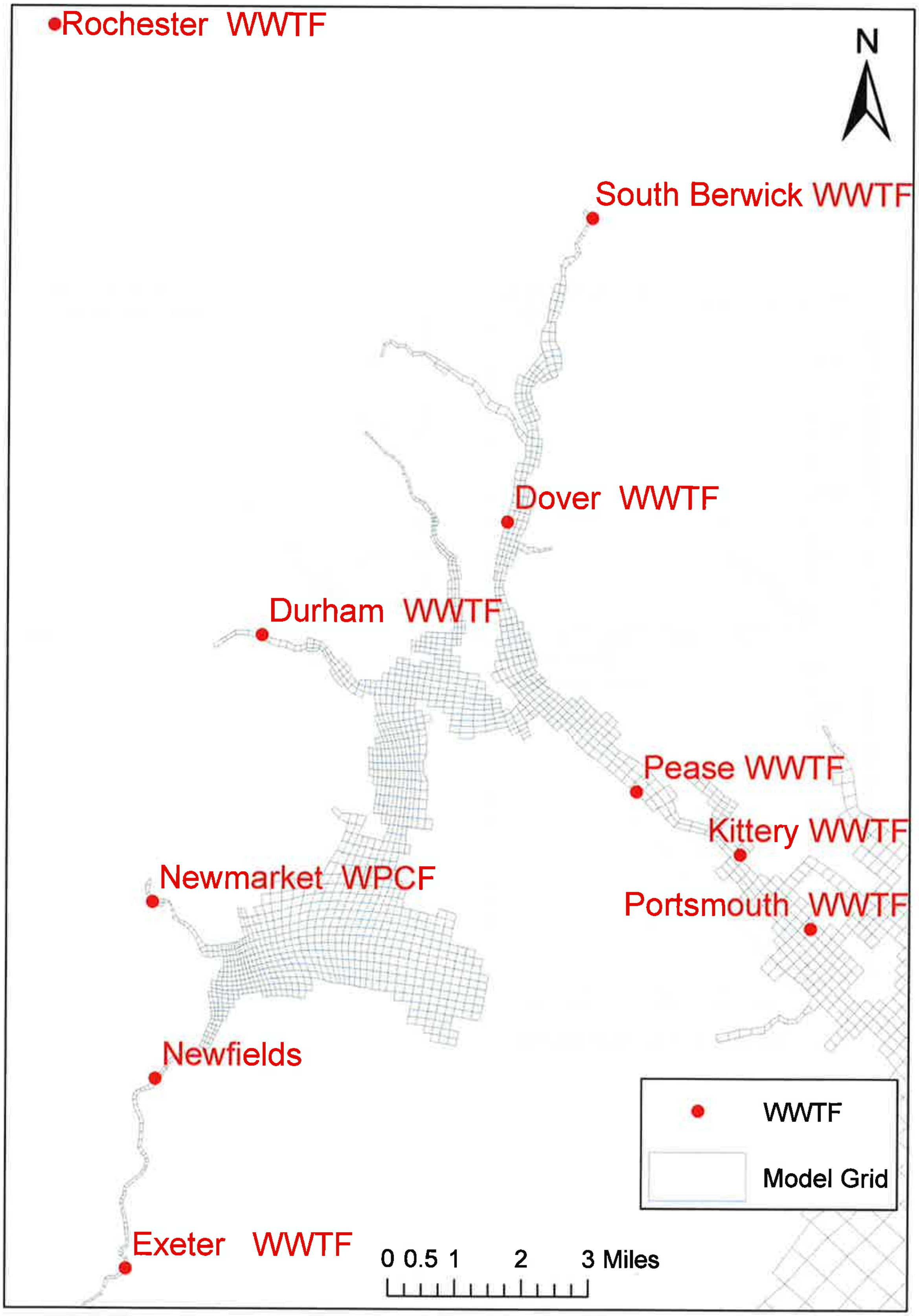
05-BLM - Oyster River

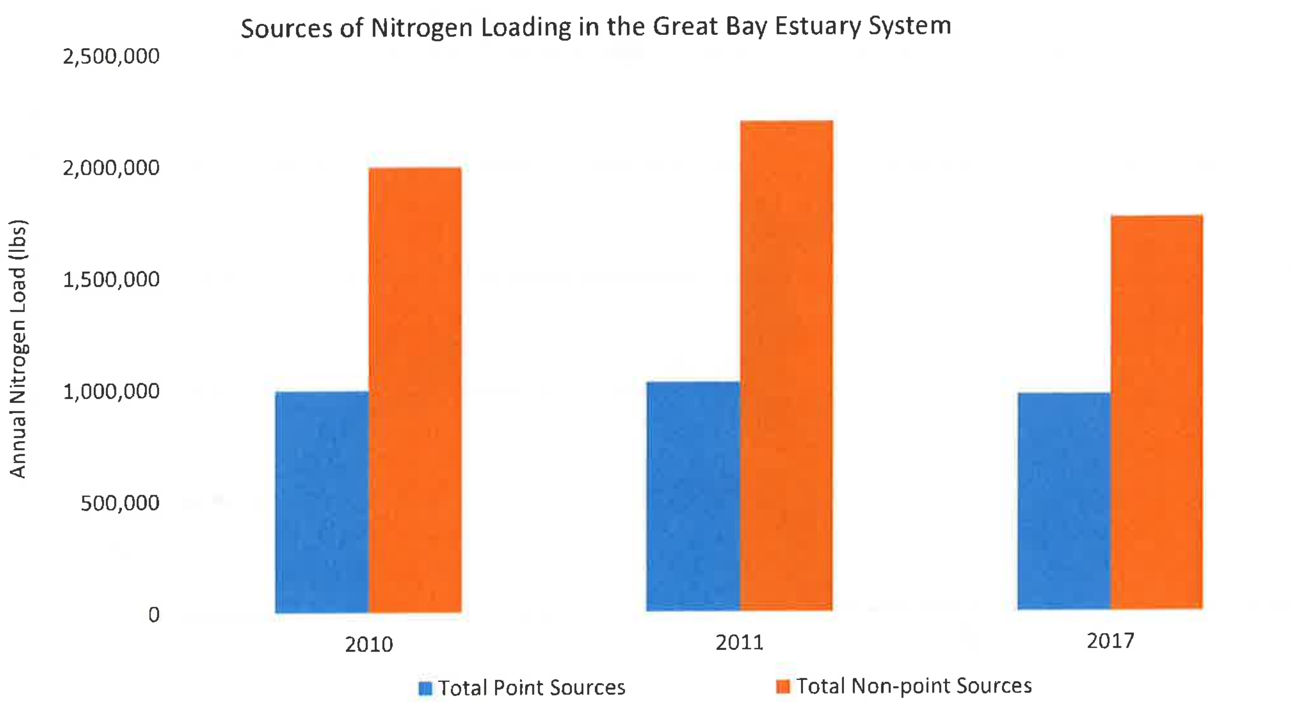


02-WNC - Winnicut River


Lamprey River
(2008 - 2017 Data)
Exeter River
(2008 - 2017 Data)
Oyster River
(2008 - 2017 Data)
Cocheco River
(2008 - 2017 Data)
Computed TN Load (lb/day)
Measured TN Load (lb/day)
0
1000
2000
3000
4000
5000
500
1500
100
200
300
400
600


Salmon Falls River
(2008 - 2017 Data)
Bellamy River
(2008 - 2017 Data)
Winnicut River
(2008 - 2017 Data)
Computed TN Load (lb/day)
Measured TN Load (lb/day)
0
500
1000
1500
2000
2500
100
200
300
400
600
700


Rochester WWTF
N
South Berwick WWTF
Dover WWTF
Durham WWTF
Pease WWTF
Kittery WWTF
Newmarket WPCF
Portsmouth WWTF
Newfields
WWTF
Model Grid
Exeter WWTF
0 0.5 1 2 3 Miles



Sources of Nitrogen Loading in the Great Bay Estuary System
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Annual Nitrogen Load (lbs)
2010
2011
2017
Total Point Sources
Total Non-point Sources

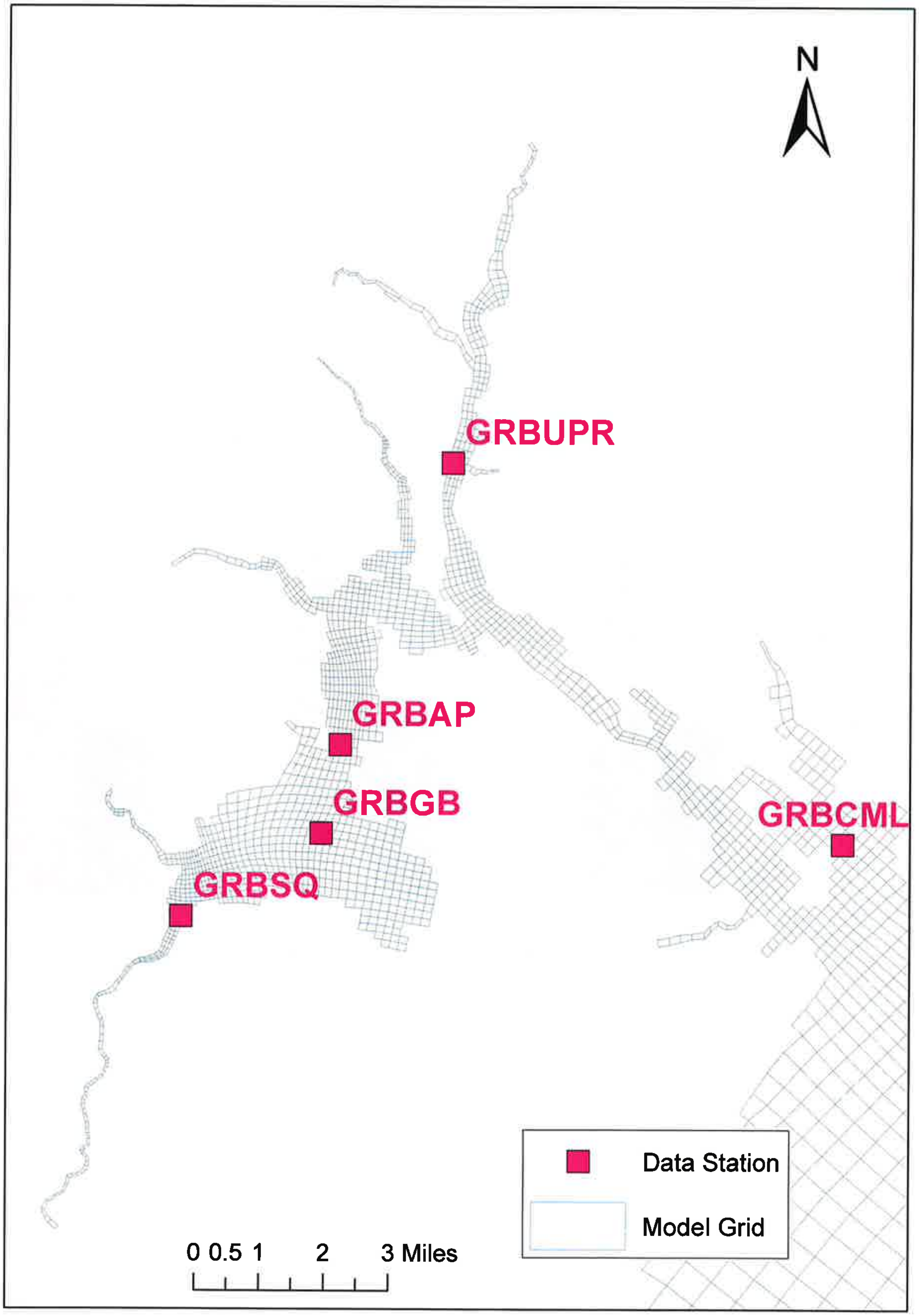
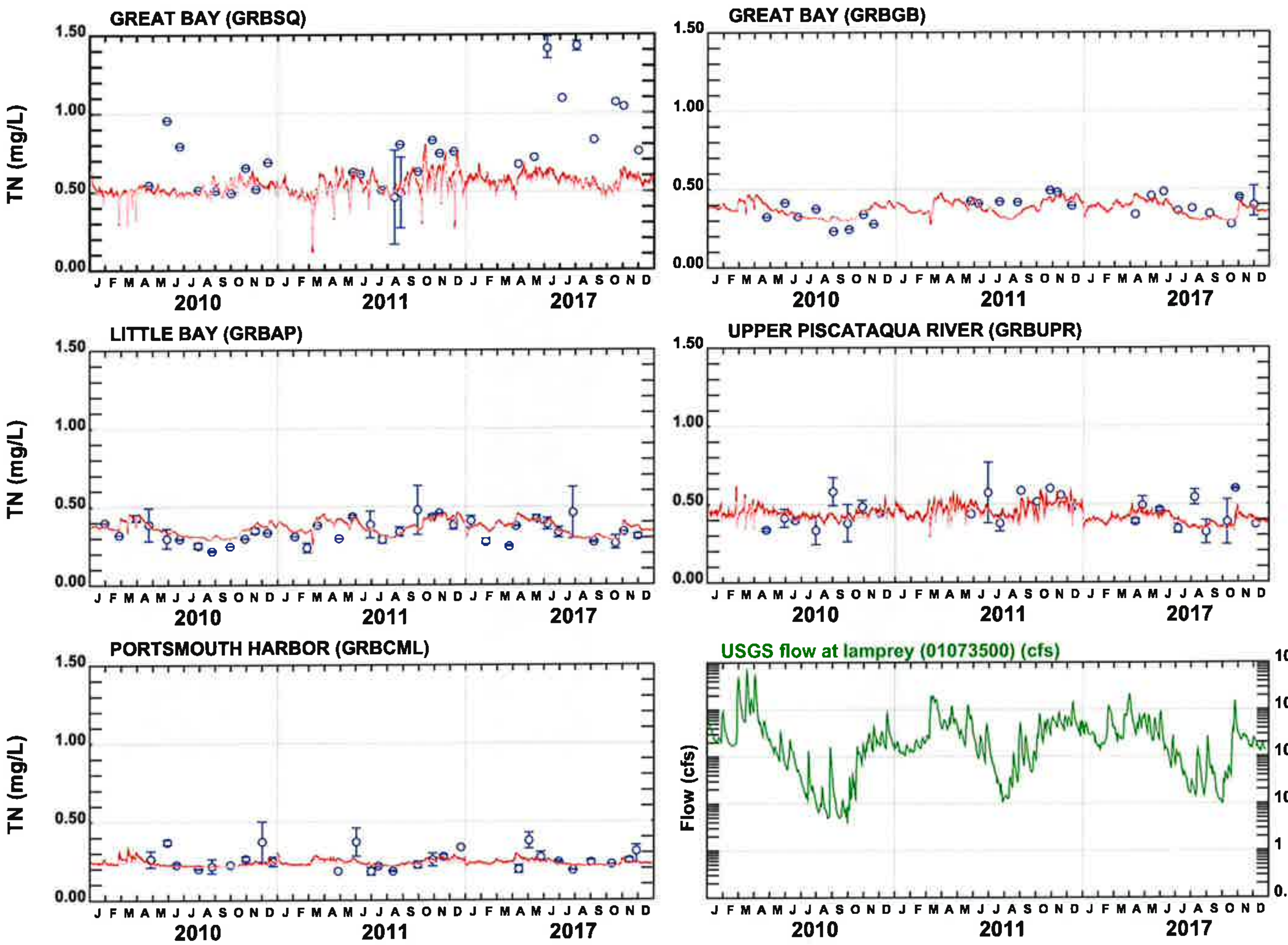
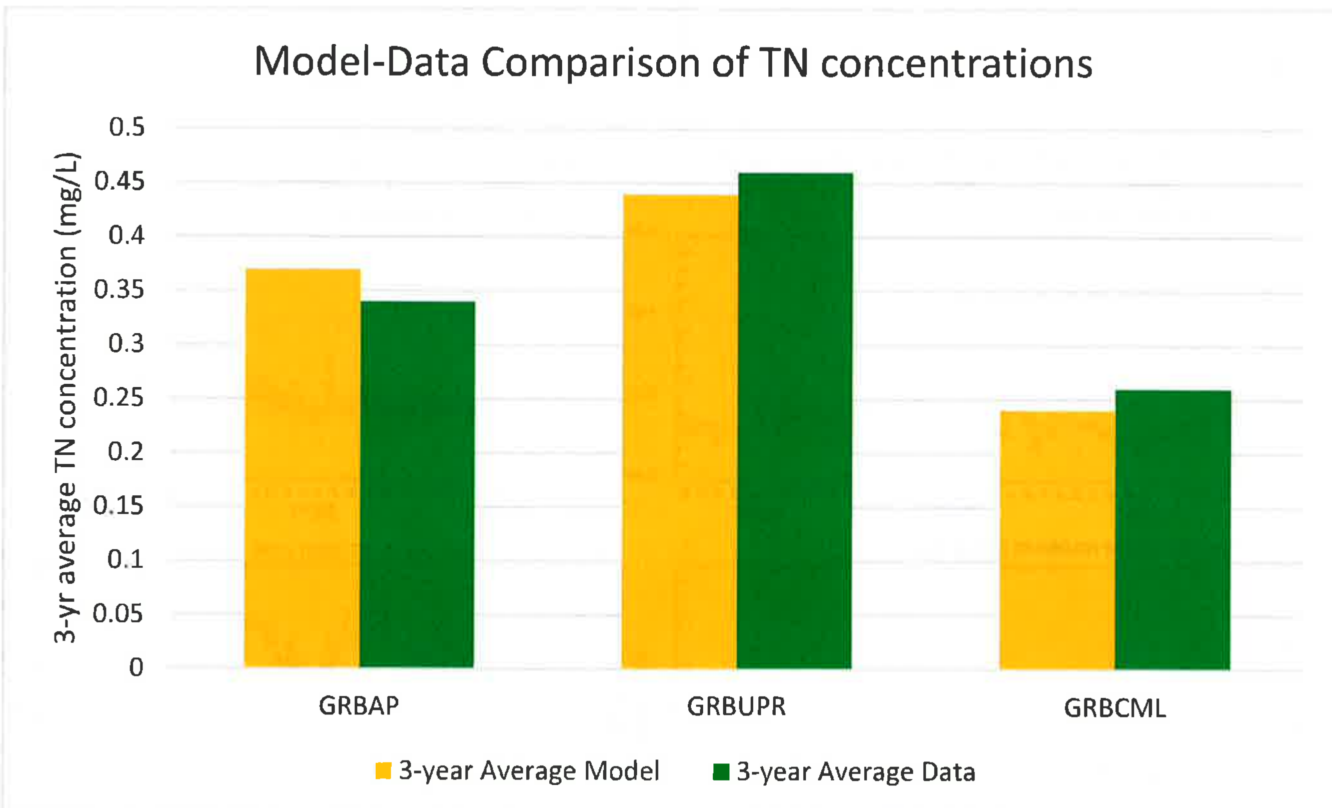
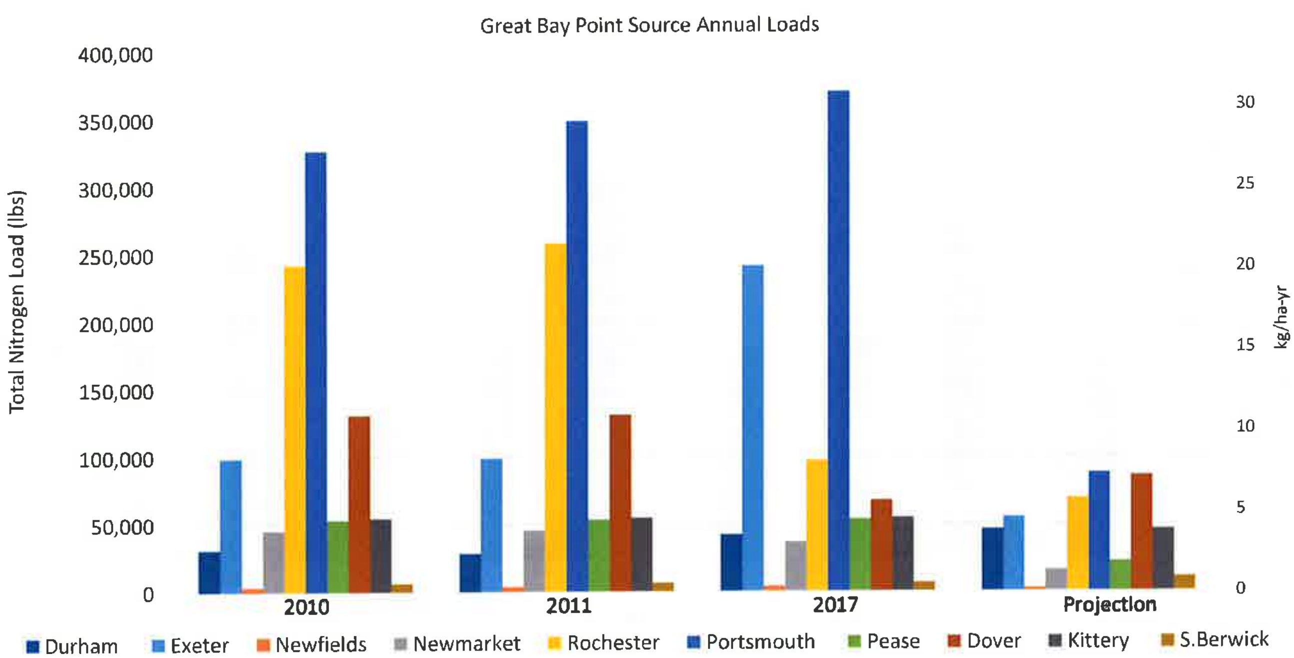


Figure 32. Data Stations for TN Model Assessment

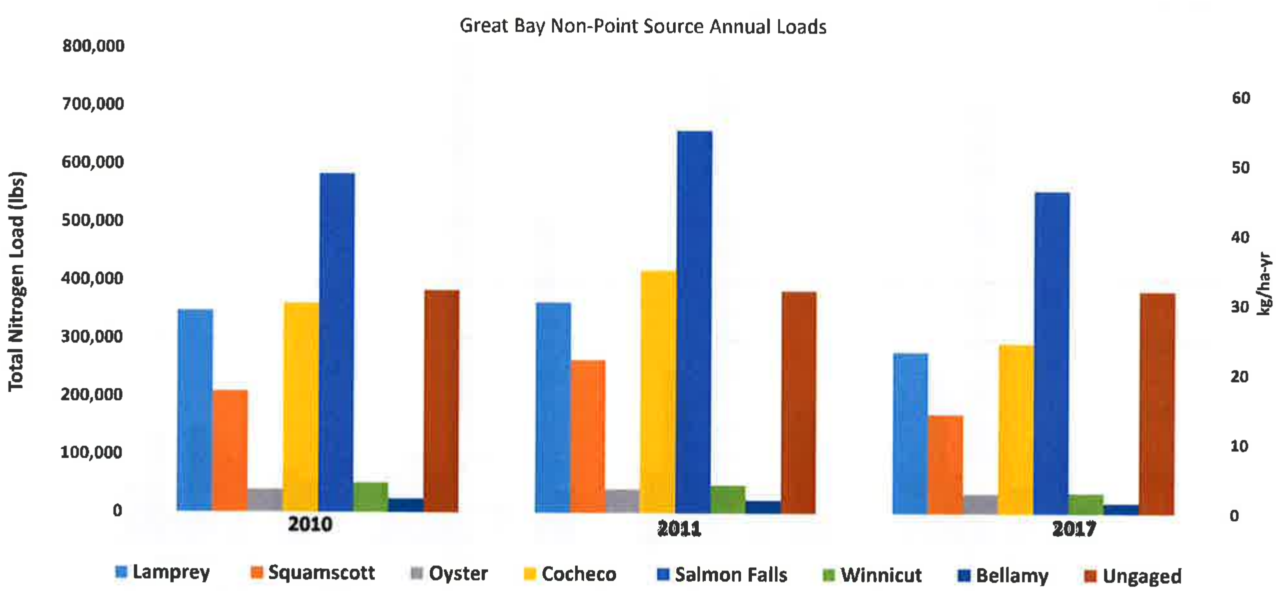


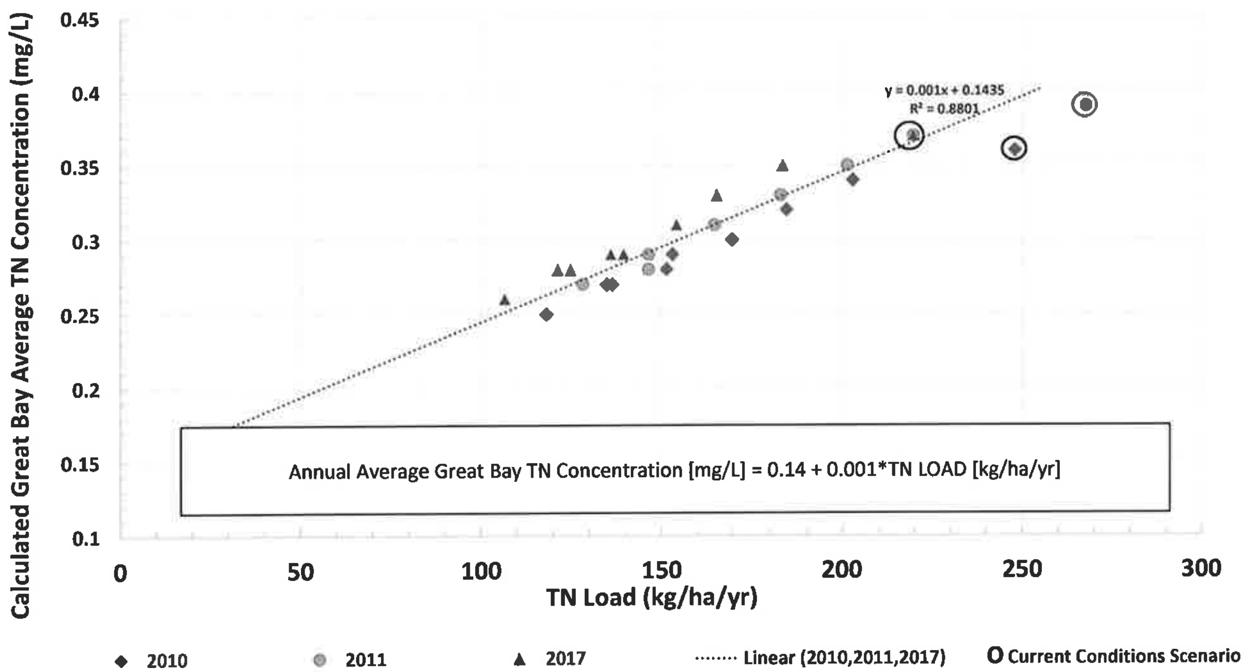
This run uses Calibration Run (RUNS525354)
RED = Surface Model Output LTRED = Bottom Model Output BLUE = Calibration Data


Model-Data Comparison of TN concentrations
3-yr average TN concentration (mg/L)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
GRBAP
GRBUPR
GRBCML
3-year Average Model
3-year Average Data



Great Bay Point Source Annual Loads
Total Nitrogen Load (lbs)
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
kg/ha-yr
30
25
20
15
10
5
0
2010
2011
2017
Projection
Durham
Exeter
Newfields
Newmarket
Rochester
Portsmouth
Pease
Dover
Kittery
S.Berwick


Great Bay Non-Point Source Annual Loads
Total Nitrogen Load (lbs)
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
kg/ha-yr
60
50
40
30
20
10
0
2010
2011
2017
Lamprey
Squamscott
Oyster
Cocheco
Salmon Falls
Winnicut
Bellamy
Ungaged



Calculated Great Bay Average TN Concentration (mg/L)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
50
100
150
200
250
300
TN Load (kg/ha/yr)
y = 0.001x + 0.1435
R² = 0.8801
Annual Average Great Bay TN Concentration [mg/L] = 0.14 + 0.001*TN LOAD [kg/ha/yr]
2010
2011
2017
Linear (2010,2011,2017)
O Current Conditions Scenario