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Nitrogen, Phosphorus, and Suspended Solids Concentrations in Tributaries to the Great Bay Estuary Watershed in 2018

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Final Report

Submitted by

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Introduction

Nitrogen, phosphorus, and sediment loads to the Great Bay Estuary are a constant concern. The Piscataqua Region Estuaries Partnership (PREP) calculates the nitrogen load from tributaries to the Great Bay Estuary for its State of Our Estuaries reports. Therefore, the purpose of this study was to collect representative data on nitrogen, phosphorus, and suspended solids concentrations in tributaries to the Great Bay Estuary in 2018. The study design followed the tributary sampling design, which was implemented by the New Hampshire Department of Environmental Services (NHDES) between 2001 and 2007 and sustained by the University of New Hampshire (UNH) from 2008 to the present, so as to provide comparable data to the previous loading estimates. The purpose of this memorandum is to document the results of quality assurance checks on the 2018 water quality data collected by UNH for the Great Bay Estuary Tidal Tributary Monitoring Program, so that PREP can calculate the nitrogen load from tributaries to the Great Bay Estuary. This program was previously established in the NHDES Environmental Monitoring Database with a project identifier of "GBETTMP." PREP reviewed these data to ensure that they met data quality objectives for PREP and for Section 305b water quality assessments.

Methods

Sampling and Analytical Methods

The field sampling and laboratory analysis methods have been documented in the approved Quality Assurance Project Plan or QAPP (PREP, 2018): https://scholars.unh.edu/prep/406/

UNH researchers collected grab samples from the head-of-tide stations in the freshwater portion of eight tributaries to the Great Bay Estuary (Figure 1 & Table 11) on a monthly frequency from March to December. The samples were analyzed for total dissolved nitrogen (TDN), total phosphorus (TP), orthophosphate (PO_4), total suspended solids (TSS), ammonium (NH_4), nitrate/nitrite (NO_3/NO_2), total suspended nitrogen (PN), dissolved organic nitrogen (DON), and non-purgeable organic carbon, which is equivalent to dissolved organic carbon (DOC). A total of ten field duplicate samples were collected for each parameter (one station per sampling date) for quality assurance.

The Water Quality Analysis Laboratory at UNH used USGS Method I-4650-03 (alkaline persulfate digestion) to determine TP and high temperature catalytic oxidation (Merriam et al., 1996) to determine the TDN concentrations in samples. TSS concentrations were calculated using EPA method 160.2. NO_3/NO_2 concentration was determined using EPA method 353.2 and NH_4 using EPA method 350.1. PN was determined using EPA method 440.0. DOC was determined using EPA method 415.1. PO_4 was measured using EPA method 365.2. DON was calculated by subtracting NO_3/NO_2 and NH_4 from TDN.

DOC is not a required parameter in the approved QAPP (PREP, 2018). Measurements of DOC were collected as ancillary data. The DOC results were quality assured using the methods and objectives in PREP (2018).

Physicochemical parameters (water temperature, specific conductance, dissolved oxygen, and pH) were measured in the field using a YSI Pro DSS multi-parameter instrument. A total of ten

field duplicate readings were collected for each parameter (one station per sampling date) for quality assurance.

Quality Assurance Audit

UNH provided the field and laboratory data to PREP to be quality assured; the data were then sent to NHDES to be added to the Environmental Monitoring Database: https://www.des.nh.gov/organization/divisions/water/wmb/emd/index.htm

Field sampling proceeded as planned.

- 89 of the 90 planned samples were collected for laboratory analysis (99%). One sample was not collected due to high quantities of ice. In addition, there was one incomplete sample (TSS was not taken) due to a broken sampling bottle. This meets the data quality objective for completeness (80% of planned samples).

The results of quality control samples for TDN, TP, TSS, PN, NO_3/NO_2, NH_4, DOC, PO_4, and DON have been summarized in Tables 1 through 9. All of the data quality objectives for laboratory results for the study were substantially met. There were no major deviations from the planned laboratory methods.

Field Duplicate Samples

Below, relative percent difference (RPD) is calculated as:

$$RPD = \frac{|x_1 - x_2|}{\left(\frac{x_1 + x_2}{2}\right)} \times 100\%$$

- Total Dissolved Nitrogen: All data quality objectives met.
- Phosphorus: All data quality objectives met.
- Suspended Solids: One of the 10 field duplicates had RPD values greater than the data quality objectives (<30%). The duplicate pair collected in the Lamprey River (station 05-LMP) on 10/24/2018 had an RPD value of 32% (1.50 and 2.07 mg N/L). These data were invalidated.
- Total Suspended Nitrogen: All data quality objectives met.
- Ammonium: Two of the 10 field duplicates had RPD values greater than the data quality objectives (<30%). The duplicate pair collected in the Bellamy River (station 09-EXT) on 4/25/2018 had an RPD value of 43% (0.005 and 0.007 mg N/L). The duplicate pair collected in the Lamprey River (station 05-LMP) on 10/24/2018 had an RPD value of 33% (0.007 and 0.009 mg N/L). These data were invalidated.
- Dissolved Organic Carbon: All data quality objectives met.
- Orthophosphate: One of the 10 field duplicates had RPD values greater than the data quality objectives (<30%). The duplicate pair collected in the Exeter River (station 09-EXT) on 12/20/2018 had an RPD value of 31% (0.011 and 0.015 mg P/L). These data were invalidated.
- Dissolved Organic Nitrogen: All data quality objectives met.
- Water Temperature: All data quality objectives met.

Laboratory Quality Control Samples

The results of laboratory QC tests are shown on Tables 1 through 9, measured by RPD and % recovery, calculated as:

$$R = \frac{|x_1 - x_2|}{(x_2)} \times 100\%$$

All of the instances where QC results did not meet data quality objectives were for low concentrations (<10x minimum detection limit (MDL)) or below the MDL, which is acceptable.

Logical Tests

Laboratory results for nitrogen and phosphorus species were checked to verify that dissolved species were not greater than total species.

- TN vs. TDN: TN should be greater than or equal to TDN. Out of the 89 results for TN and TDN, there were no results that had higher TDN values than TN.
- TDN vs. NO_3/NO_2 + NH_4: TDN should be greater than or equal to the sum of NO_3/NO_2 and NH_4. Out of 89 samples for NO_3/NO_2 + NH_4 and TDN, there were no results that had higher NO_3/NO_2 + NH_4 than TDN.
- TP vs. PO_4: TP should be greater than or equal to PO_4. Out of 89 samples for TP and PO_4, there were no results that had higher PO_4 than TP.

Results Below Reporting Limits:

Reporting Limits (RLs) have been established by the UNH lab. Values lower than the RL are shown as "<[RL]" in Table 10. For example, if the RDL is 0.1 and the returned value was 0.05, the value in Table 10 will show "<0.1." The RLs for the parameters are as follows: TDN = 0.05 mg N/L; TP = 0.007 mg P/L; TSS = 1.00 mg/L; PN (Total Suspended Nitrogen) = 0.01 mg N/L; NO_3/NO_2 = 0.005 mg N/L; NH_4 = 0.005 mg N/L; DOC = 0.1 mg C/L; PO_4 = 0.001 mg P/L; DON = 0.05 mg N/L.

Twenty results (3 for TSS; 17 for NH_4) were flagged (i.e., censored) as being below the RL. These results are noted in Table 10. While results below the RL are not necessarily invalid, they are regarded as less accurate than results at or above the RL.

Consistency/Comparability:

The ranges of concentrations measured in 2017 were consistent with previous sampling efforts at these sites. For most of the parameters, the ranges were narrower than the ranges seen in 2016. Time series plots of the data at different stations were used to identify any unusual results.

Results and Discussion

The quality assured results for TP, TDN, TSS, NO_3/NO_2, NH_4, PN, PO_4, DON, and DOC concentrations, as well as the field parameters for each station visit are shown in Tables 1

through 9. Figures 2 through 10 show the monthly concentrations for each analyte at each station.

The purpose of this memorandum is to document the results of quality assurance checks on the 2018 water quality data collected by UNH, so that PREP can calculate the nitrogen load from tributaries to the Great Bay Estuary. The following are some general observations, which can be made based on the quality assured data:

- The concentrations of TDN across stations and dates ranged from 0.28 to 0.94 mg N/L. The maximum concentrations most often occurred in the Cocheco River (station 07-CCH) and the Winnicut River (station 02-WNC).

- The concentrations of TP across stations and dates ranged from 0.009 to 0.126 mg P/L. The maximum concentrations most often occurred in the Cocheco River (station 07-CCH) and the Winnicut River (station 02-WNC).

- The TSS concentrations ranged from 1.03 to 13.70 mg/L. The highest concentrations were in the Bellamy River (station 05-BLM), Cocheco River (station 07-CCH) and the Exeter River (station 09-EXT).

- The concentrations of PN across stations and dates ranged from 0.03 to 0.28 mg N/L. The maximum concentrations occurred in the Oyster River (station 05-OYS).

- The concentrations of NO_3/NO_2 across stations and dates ranged from 0.043 to 0.659 mg N/L. Concentrations in the Cocheco River (station 07-CCH) were notably higher than other stations, except in early spring and late fall. Concentrations in the Salmon Falls River (station 05-SFR) were notably higher than other stations (with the exception of the Cocheco River), except in early spring and late fall.

- The concentrations of NH_4 across stations and dates ranged from <0.005 to 0.121 mg N/L. No clear comparative statements can be made between stations, based on the data.

- The concentrations of DOC across stations and dates ranged from 3.37 to 16.18 mg C/L. The maximum concentrations occurred in the Winnicut River (station 02-WNC) and the Exeter River (station 09-EXT).

- The average concentrations of PO_4 across stations and dates ranged from <0.002 to 0.072 mg P/L. The maximum concentrations occurred in the Cocheco River (station 07-CCH) and the Oyster River (station 05-OYS).

- The concentrations of DON across stations and dates ranged from 0.1 to 0.56 mg N/L. The maximum concentrations occurred in the Winnicut River (station 02-WNC).

Summary

The 2018 water quality data for the GBETTMP project was checked by PREP for potential errors. All quality control steps and changes to the dataset have been documented in this memo.

References

Matso, K and J.D. Potter. "Great Bay Estuary Tidal Tributary Monitoring Program: Quality Assurance Project Plan, 2018" (2018). *PREP Reports & Publications*. 406. https://scholars.unh.edu/prep/406

Merriam, J.L, W.H. McDowell, and W.S. Currie. 1996. A high-temperature catalytic oxidation technique for determining total dissolved nitrogen. *Soil Science Society of America Journal* 60: 1050-1055.

Table 1: Summary of Quality Control Samples for Total Dissolved Nitrogen.

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Results
Precision-Overall	RPD < 30%	Field Duplicates	10 Field Duplicates / 0 Failed DQO
Precision-Lab	RPD < 15%	Lab Duplicates	14 Lab Duplicates / 0 Failed DQO
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	20 CRM tests / 0 Failed DQO
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of TDN concentrations in 2018 (0.28 – 0.94 mg N/L) was within the range from 2008-2015 (0.17 – 2.92 mg N/L).
Sensitivity	Not expected to be an issue for this project	NA	NA
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	89 routine samples and 10 field duplicates were collected (99% of planned samples)

Table 2: Summary of Quality Control Samples for Total Phosphorus.

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Results
Precision-Overall	RPD < 30%	Field Duplicates	10 Field Duplicates / 0 Failed DQO
Precision-Lab	RPD < 15%	Lab Duplicates	10 Lab Duplicates / 0 Failed DQO
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	22 CRM tests / 0 Failed DQO
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of TP concentrations in 2018 (0.009 – 0.126 mg P/L) was similar to the range from 2001-2015 (0.003 – 0.162 mg P/L).
Sensitivity	Not expected to be an issue for this project	NA	NA
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	89 routine samples and 10 field duplicates were collected (99% of planned samples)

Table 3: Summary of Quality Control Samples for Total Suspended Solids.

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Results
Precision-Overall	RPD < 30%	Field Duplicates	10 Field Duplicates / 1 Failed DQO
Precision-Lab	RPD < 15%	Lab Duplicates	**NO DATA**
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	**NO DATA**
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of TSS concentrations in 2018 (1.03 – 13.70 mg/L) was within the range from 2001-2015 (1 – 57 mg/L).
Sensitivity	Not expected to be an issue for this project	NA	NA
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	89 routine samples and 10 field duplicates were collected (99% of planned samples)

Table 4: Summary of Quality Control Samples for Total Suspended Nitrogen.

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Results
Precision-Overall	RPD < 30%	Field Duplicates	10 Field Duplicates / 0 Failed DQO
Precision-Lab	RPD < 15%	Lab Duplicates	**NO DATA**
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	21 CRM tests / 0 Failed DQO **NO DATA** for LFM tests
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of PN in 2018 (0.03 – 0.28 mg N/L) was similar to the range from 2001-2015 (0.03 – 0.33 mg N/L).
Sensitivity	Not expected to be an issue for this project	NA	NA
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	89 routine samples and 10 field duplicates were collected (99% of planned samples)

Table 5: Summary of Quality Control Samples for Nitrate/Nitrite.

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Results
Precision-Overall	RPD < 30%	Field Duplicates	10 Field Duplicates / 0 Failed DQO
Precision-Lab	RPD < 15%	Lab Duplicates	11 Lab Duplicates / 3 Failed DQO The failures were for samples with low concentrations (<10x MDL)
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	20 CRM tests / 0 Failed DQO
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of NO_3/NO_2 concentrations in 2018 (0.043 – 0.659 mg N/L) was within the range from 2009-2015 (0.005 – 2.52 mg N/L).
Sensitivity	Not expected to be an issue for this project	NA	NA
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	89 routine samples and 10 field duplicates were collected (99% of planned samples)

Table 6: Summary of Quality Control Samples for Ammonium.

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Results
Precision-Overall	RPD < 30%	Field Duplicates	10 Field Duplicates / 2 Failed DQO
Precision-Lab	RPD < 15%	Lab Duplicates	16 Lab Duplicates / 4 Failed DQO The failures were for samples with low concentrations (<10x MDL)
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	27 CRM tests / 0 Failed DQO 5 LFM tests / 0 Failed DQO
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of NH_4 concentrations in 2018 (<0.005 – 0.121 mg N/L) was similar to the range from 2009-2015 (0.005 – 0.158 mg N/L).
Sensitivity	Not expected to be an issue for this project	NA	NA
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	89 routine samples and 10 field duplicates were collected (99% of planned samples)

Table 7: Summary of Quality Control Samples for Dissolved Organic Carbon.

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Results
Precision-Overall	RPD < 30%	Field Duplicates	10 Field Duplicates / 0 Failed DQO
Precision-Lab	RPD < 15%	Lab Duplicates	18 Lab Duplicates / 0 Failed DQO
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	27 CRM tests / 0 Failed DQO
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of DOC in 2018 (3.37 – 16.18 mg C/L) was similar to the range from 2011-2015 (2.27 – 15.3 mg C/L).
Sensitivity	Not expected to be an issue for this project	NA	NA
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	89 routine samples and 10 field duplicates were collected (99% of planned samples)

Table 8: Summary of Quality Control Samples for Orthophosphate.

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Results
Precision-Overall	RPD < 30%	Field Duplicates	10 Field Duplicates / 1 Failed DQO
Precision-Lab	RPD < 15%	Lab Duplicates	**NO DATA**
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	**NO DATA**
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of PO_4 in 2018 (<0.002 – 0.072mg P/L) was within the range from 2011-2015 (<0.005 – 0.340 mg/L).
Sensitivity	Not expected to be an issue for this project	NA	NA
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	89 routine samples and 10 field duplicates were collected (99% of planned samples)

Table 9: Summary of Quality Control Samples for Dissolved Organic Nitrogen.

Data Quality Indicators	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Results
Precision-Overall	RPD < 30%	Field Duplicates	10 Field Dupes / 0 Failed DQO
Precision-Lab	RPD < 15%	Lab Duplicates	**NO DATA**
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	**NO DATA**
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of DON in 2018 (0.1 – 0.56 mg N/L) was similar to the range from 2010-2015 (<0.09 – 0.52 mg N/L).
Sensitivity	Not expected to be an issue for this project	NA	NA
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	75 routine samples and 10 field duplicates were collected (94% of planned samples)

Table 10: Validated Laboratory Results and Field Data at Tributary Stations

Station ID	Collection Date	DOC (mg C/L)	DO (mg/l)	DO (%)	NH_4 (mg N/L)	TDN (mg N/L)	$NO_2 + NO_3$ (mg N/L)	DON (mg N/L)	DIN (mg N/L)	PN (ug N/L)	pH	TP (mg P/L)	PO_4 (mg P/L)	TSS (mg/L)	Spec. Cond (uS/cm)	Temp. (°C)
02-GWR	03/28/2018	5.58	13.3	100.9	*<0.005*	0.32	0.120	0.20	0.123	40.81	7.0	0.020	0.009	3.81	152.7	3.9
02-GWR	03/28/2018	5.25	13.3	99.5	*<0.005*	0.32	0.119	0.19	0.121	55.00	6.7	0.023	0.007	4.50	150.4	3.3
02-GWR	04/25/2018	5.45	10.2	93.0	*<0.005*	0.28	0.093	0.18	0.096	43.97	6.7	0.031	0.008	*<1*	132	11.2
02-GWR	05/23/2018	5.99	7.8	84.2	0.014	0.36	0.066	0.28	0.080	60.21	6.7	0.028	0.006	2.50	153.6	19.0
02-GWR	06/27/2018	5.25	5.2	58.7	0.012	0.28	0.072	0.20	0.084	73.44	6.5	0.030	0.024	3.12	164	21.0
02-GWR	07/25/2018	6.79	6.4	80.1	0.006	0.39	0.089	0.30	0.095	77.70	6.8	0.029	0.007	1.33	164.2	26.6
02-GWR	08/22/2018	10.55	5.2	58.5	0.015	0.50	0.121	0.36	0.135	79.00	6.7	0.034	0.009	3.33	163.1	21.6
02-GWR	09/26/2018	11.36	7.1	71.2	0.015	0.42	0.099	0.30	0.114	52.10	6.8	0.078	0.015	3.90	154.4	15.7
02-GWR	10/24/2018	9.99	9.3	77.1	*<0.005*	0.35	0.069	0.28	0.067	57.85	7.1	0.029	0.009	2.50	156.9	7.4
02-GWR	11/28/2018	8.26	11.9	90.6	0.007	0.30	0.043	0.25	0.050	76.57	7.0	0.018	0.012	9.64	63.9	3.5
02-WNC	03/28/2018	5.72	12.5	97.9	*<0.005*	0.46	0.266	0.19	0.269	31.97	7.5	0.033	0.010	2.41	386.4	4.9
02-WNC	04/25/2018	7.19	9.6	91.4	0.011	0.49	0.227	0.25	0.238	44.54	7.2	0.022	0.007	2.14	387.7	12.9
02-WNC	05/23/2018	8.64	7.5	77.8	0.053	0.71	0.094	0.56	0.147	57.75	7.2	0.046	0.013	2.50	447.6	16.8
02-WNC	05/23/2018	8.78	7.5	77.7	0.056	0.72	0.110	0.55	0.166	61.88	7.2	0.049	0.014	2.42	446	16.8
02-WNC	06/27/2018	8.12	5.6	61.7	0.027	0.55	0.144	0.38	0.171	79.36	6.9	0.039	0.035	2.22	418	20.0
02-WNC	07/25/2018	9.36	5.8	69.4	0.037	0.52	0.098	0.39	0.135	60.85	7.1	0.125	0.020	3.64	455.4	24.4
02-WNC	08/22/2018	14.24	6.9	75.7	0.023	0.65	0.116	0.51	0.139	44.85	7.2	0.060	0.019	1.67	410.4	20.1
02-WNC	09/26/2018	16.18	8.3	84.0	0.014	0.65	0.159	0.48	0.172	55.95	7.2	0.070	0.026	6.19	354.7	15.9
02-WNC	10/24/2018	9.79	10.3	86.3	0.015	0.69	0.296	0.38	0.311	66.71	7.4	0.092	0.013	3.33	423.1	7.8
02-WNC	11/28/2018	6.99	11.3	88.1	0.033	0.48	0.081	0.37	0.114	50.45	7.3	0.013	0.012	2.58	183.4	4.3
02-WNC	12/20/2018	4.77	12.9	89.5	0.022	0.66	0.471	0.17	0.493	35.14	7.0	0.110	0.009	2.46	362.9	0.9
05-BLM	03/28/2018	5.11	13.0	101.4	0.006	0.30	0.107	0.18	0.113	36.86	7.1	0.036	0.009	4.55	182.5	5.0
05-BLM	04/25/2018	6.22	10.7	100.3	*<0.005*	0.35	0.057	0.29	0.062	104.58	6.9	0.022	0.008	4.21	154.5	12.3
05-BLM	05/23/2018	6.42	9.2	104.3	0.021	0.42	0.070	0.33	0.090	59.90	7.1	0.025	0.006	4.33	215.4	21.9
05-BLM	06/27/2018	4.68	8.1	96.7	0.063	0.40	0.138	0.20	0.201	63.46	7.3	0.036	0.025	5.00	545	24.3
05-BLM	07/25/2018	6.96	9.3	113.5	0.016	0.42	0.131	0.27	0.148	44.72	7.2	0.037	0.014	1.88	277.6	25.0
05-BLM	07/25/2018	6.34	9.2	112.0	0.020	0.41	0.134	0.26	0.154	53.85	7.2	0.036	0.011	2.13	277	25.2
05-BLM	08/22/2018	10.57	7.1	81.8	0.009	0.45	0.069	0.37	0.078	100.00	6.8	0.048	0.010	4.38	178.5	22.4
05-BLM	09/26/2018	9.97	9.3	98.2	0.017	0.52	0.103	0.40	0.120	135.57	7.1	0.075	0.029	10.00	166.1	17.9
05-BLM	10/24/2018	9.61	10.3	88.5	*<0.001*	0.41	0.135	0.27	0.141	101.78	7.2	0.041	0.011	3.33	187.8	8.9

Table 10 (cont'd): Validated Laboratory Results and Field Data at Tributary Stations

Station ID	Collection Date	DOC (mg C/L)	DO (mg/l)	DO (%)	NH_4 (mg N/L)	TDN (mg N/L)	$NO_2 + NO_3$ (mg N/L)	DON (mg N/L)	DIN (mg N/L)	PN (ug N/L)	pH	TP (mg P/L)	PO_4 (mg P/L)	TSS (mg/L)	Spec. Cond (uS/cm)	Temp. (°C)
05-BLM	11/28/2018	8.22	12.5	95.4	*<0.005*	0.31	0.055	0.26	0.060	46.84	7.1	0.041	0.007	2.58	126.1	3.8
05-BLM	12/20/2018	6.10	13.3	96.1	0.023	0.36	0.147	0.19	0.170	41.08	7.1	0.016	0.009	2.92	152.7	2.1
05-LMP	03/28/2018	4.49	13.1	101.7	0.022	0.35	0.160	0.17	0.182	40.53	7.1	0.031	0.008	2.22	185.1	4.7
05-LMP	04/25/2018	4.78	10.6	97.7	*<0.005*	0.30	0.104	0.19	0.109	38.38	6.9	0.021	0.006	*<1*	151.9	11.7
05-LMP	05/23/2018	6.03	8.8	92.0	0.017	0.51	0.148	0.35	0.165	72.85	7.0	0.027	0.005	1.79	203.6	17.7
05-LMP	06/27/2018	5.40	6.0	68.7	*<0.005*	0.37	0.124	0.24	0.129	84.10	6.8	0.016	0.013	4.50	224	22.0
05-LMP	07/25/2018	7.58	7.6	92.6	*<0.005*	0.39	0.080	0.31	0.081	79.98	7.1	0.031	0.006	1.86	221.5	25.5
05-LMP	08/22/2018	7.64	7.6	87.0	0.012	0.54	0.116	0.41	0.128	63.76	7.0	0.041	0.006	1.03	139.1	21.7
05-LMP	08/22/2018	7.60	7.6	86.6	0.014	0.52	0.113	0.40	0.127	71.37	6.9	0.039	0.007	1.16	138.9	21.0
05-LMP	09/26/2018	8.65	8.7	88.3	0.024	0.47	0.105	0.34	0.128	69.08	6.9	0.030	0.012	2.69	147.6	16.3
05-LMP	10/24/2018	11.12	11.1	94.6	**0.007**	0.48	0.071	0.40	0.078	44.48	7.2	0.041	0.005	**2.07**	148.2	8.4
05-LMP	10/24/2018	11.18	11.2	94.4	**0.009**	0.49	0.082	0.40	0.091	48.60	7.2	0.035	0.006	**1.50**	145.6	8.0
05-LMP	11/28/2018	11.24	11.2	88.7	0.006	0.29	0.083	0.20	0.089	66.59	7.2	0.015	0.010	4.71	107.9	5.0
05-LMP	12/20/2018	13.95	14.0	98.2	0.012	0.35	0.181	0.15	0.194	35.10	7.0	0.009	0.008	1.67	138.4	0.8
05-OYS	03/28/2018	12.76	12.8	96.8	0.027	0.44	0.255	0.16	0.282	36.26	5.8	0.022	0.012	1.74	267.7	3.9
05-OYS	04/25/2018	10.17	10.2	94.5	0.008	0.46	0.137	0.31	0.145	52.42	7.1	0.018	0.006	2.89	233.7	12.0
05-OYS	05/23/2018	8.85	8.9	92.9	0.016	0.47	0.078	0.38	0.094	95.23	7.3	0.024	0.007	3.67	272.4	17.7
05-OYS	06/27/2018	5.81	5.8	64.1	0.018	0.32	0.127	0.18	0.145	94.92	6.8	0.020	0.016	2.00	318	20.1
05-OYS	06/27/2018	5.69	5.7	62.6	0.015	0.33	0.125	0.19	0.140	82.27	6.9	0.019	0.016	1.92	318	20.2
05-OYS	07/25/2018	6.07	6.1	70.9	0.030	0.47	0.127	0.31	0.157	87.83	7.0	0.044	0.016	2.22	346.8	23.1
05-OYS	08/22/2018	6.37	6.4	70.9	0.032	0.66	0.131	0.50	0.163	281.19	7.0	0.071	0.009	13.70	233.2	20.5
05-OYS	09/26/2018	8.15	8.2	81.6	0.056	0.65	0.214	0.38	0.270	104.20	7.1	0.110	0.056	6.50	274.4	15.4
05-OYS	10/24/2018	10.44	10.4	88.0	0.023	0.65	0.337	0.29	0.359	113.45	7.3	0.052	0.019	5.00	284.5	8.2
05-OYS	11/28/2018	12.14	12.1	93.5	*<0.001*	0.31	0.082	0.22	0.088	80.97	7.1	0.020	0.018	7.81	155.5	4.6
05-OYS	12/20/2018	13.65	13.7	95.5	0.012	0.42	0.250	0.16	0.263	44.81	6.9	0.009	0.008	2.58	226.8	0.8
05-SFR	03/28/2018	13.44	13.4	103.9	0.078	0.36	0.149	0.14	0.227	41.88	7.1	0.024	0.005	2.69	144.3	4.5
05-SFR	04/25/2018	11.44	11.4	102.4	0.037	0.29	0.106	0.15	0.143	49.81	6.9	0.020	0.007	*<1*	113.7	10.4
05-SFR	05/23/2018	9.13	9.1	100.1	0.121	0.61	0.184	0.31	0.305	89.29	7.0	0.039	0.003	4.17	165.5	19.8
05-SFR	06/27/2018	6.82	6.8	80.8	*<0.005*	0.49	0.278	0.21	0.281	119.03	7.0	0.012	0.011	3.33	191	23.9
05-SFR	07/25/2018	8.67	8.7	106.4	*<0.005*	0.57	0.277	0.29	0.277	92.90	7.4	0.045	0.008	2.05	233.1	25.7

Table 10 (cont'd): Validated Laboratory Results and Field Data at Tributary Stations

Station ID	Collection Date	DOC (mg C/L)	DO (mg/l)	DO (%)	NH_4 (mg N/L)	TDN (mg N/L)	$NO_2 + NO_3$ (mg N/L)	DON (mg N/L)	DIN (mg N/L)	PN (ug N/L)	pH	TP (mg P/L)	PO_4 (mg P/L)	TSS (mg/L)	Spec. Cond (uS/cm)	Temp. (°C)
05-SFR	08/22/2018	7.40	7.4	86.5	0.007	0.61	0.267	0.34	0.274	111.08	6.9	0.040	0.002	4.17	158	23.2
05-SFR	09/26/2018	8.68	8.7	93.4	0.018	0.36	0.236	0.10	0.254	71.00	7.2	0.073	0.007	3.46	166.8	19.0
05-SFR	09/26/2018	8.66	8.7	93.1	0.016	0.38	0.231	0.13	0.247	72.96	7.1	0.068	0.006	3.80	165.1	18.9
05-SFR	10/24/2018	11.02	11.0	95.6	0.021	0.44	0.208	0.21	0.228	58.24	7.3	0.045	0.005	1.43	138.5	9.0
05-SFR	11/28/2018	13.09	13.1	98.9	0.010	0.32	0.188	0.12	0.198	47.69	7.3	0.009	0.009	3.73	103	3.4
05-SFR	12/20/2018	14.23	14.2	100.6	0.019	0.37	0.201	0.14	0.221	33.43	7.1	0.013	0.008	1.49	131	1.0
07-CCH	03/28/2018	13.19	13.2	101.9	0.020	0.47	0.350	0.11	0.370	46.32	7.5	0.049	0.030	6.84	214	4.4
07-CCH	04/25/2018	10.90	10.9	99.5	0.016	0.40	0.243	0.14	0.259	50.68	6.9	0.047	0.015	1.61	186.1	11.0
07-CCH	05/23/2018	9.23	9.2	99.6	0.024	0.69	0.345	0.32	0.370	52.07	7.1	0.126	0.016	1.48	257.6	19.1
07-CCH	06/27/2018	7.05	7.1	81.6	0.010	0.62	0.424	0.19	0.434	76.05	7.1	0.032	0.025	4.50	312	22.6
07-CCH	07/25/2018	8.73	8.7	107.8	0.014	0.94	0.659	0.27	0.673	96.68	7.5	0.051	0.019	1.62	371.6	26.0
07-CCH	08/22/2018	7.84	7.8	90.1	0.026	0.68	0.354	0.30	0.379	53.55	7.0	0.077	0.028	5.45	189.6	22.3
07-CCH	09/26/2018	9.38	9.4	97.0	0.027	0.74	0.402	0.32	0.429	75.82	7.2	0.116	0.055	5.91	227.7	17.0
07-CCH	10/24/2018	11.58	11.6	96.9	*<0.005*	0.51	0.344	0.16	0.346	60.89	7.4	0.098	0.056	5.26	174	7.7
07-CCH	11/28/2018	13.71	13.7	101.6	0.026	0.35	0.113	0.21	0.139	58.26	7.3	0.031	0.030	6.52	149.8	2.7
07-CCH	11/28/2018	14.49	14.5	102.8	0.025	0.36	0.115	0.22	0.141	55	7.19	0.034	0.029	6.00	147	2.3
07-CCH	12/20/2018	14.18	14.2	98.3	0.094	0.51	0.308	0.11	0.402	46.79	7.2	0.079	0.072	2.35	194.8	0.4
09-EXT	03/28/2018	12.47	12.5	97.8	0.021	0.31	0.115	0.18	0.136	30.41	7.2	0.026	0.010	2.19	225.6	5
09-EXT	04/25/2018	9.94	9.9	93.5	**0.007**	0.35	0.056	0.28	0.063	35.87	6.85	0.018	0.006	1.32	193.3	12.6
09-EXT	04/25/2018	9.96	10.0	93.6	**<0.001**	0.34	0.057	0.28	0.062	41.92	6.84	0.022	0.007	1.61	192.6	12.5
09-EXT	05/23/2018	7.58	7.6	78.9	0.047	0.65	0.075	0.52	0.121	69.97	6.89	0.051	0.008	4.41	230.8	17.3
09-EXT	06/27/2018	6.2	6.2	68.3	0.017	0.44	0.115	0.31	0.132	68.05	6.71	0.032	0.026	9.91	244	20.09
09-EXT	07/25/2018	6.81	6.8	82.8	0.010	0.54	0.140	0.39	0.150	46.62	7.01	0.069	0.018	3.20	244.4	25.2
09-EXT	08/22/2018	6.9	6.9	78	0.009	0.57	0.122	0.44	0.132	48.56	6.96	0.051	0.025	5.56	210.4	21.4
09-EXT	09/26/2018	8.72	8.7	88.2	0.019	0.52	0.098	0.40	0.117	54.90	6.95	0.057	0.007	3.33	177.3	16
09-EXT	10/24/2018	10.55	10.6	88.5	0.006	0.43	0.053	0.38	0.059	68.58	7.22	0.028	0.009	7.08	220.3	7.7
09-EXT	11/28/2018	12.1	12.1	93.6	*<0.005*	0.32	0.077	0.24	0.082	67.92	7.18	0.077	0.011	7.60	120.6	3.9
09-EXT	12/20/2018	13.4	13.4	92.8	0.024	0.43	0.195	0.21	0.220	38.29	6.97	0.016	**0.011**	4.19	196.5	3.4
09-EXT	12/20/2018	13.65	13.7	103.6	0.022	0.41	0.186	0.21	0.208	39.57	6.94	0.020	**0.015**	4.33	201.3	3.7

Bold and underlined values were invalidated through the QA/QC process.
Cells highlighted in yellow indicate duplicate samples.
Red italicized values were below the Reporting Limit (RL). The value is shown as being less than the given RL.

Figure 1: Sampling Locations in the Great Bay Estuary Coastal Basin

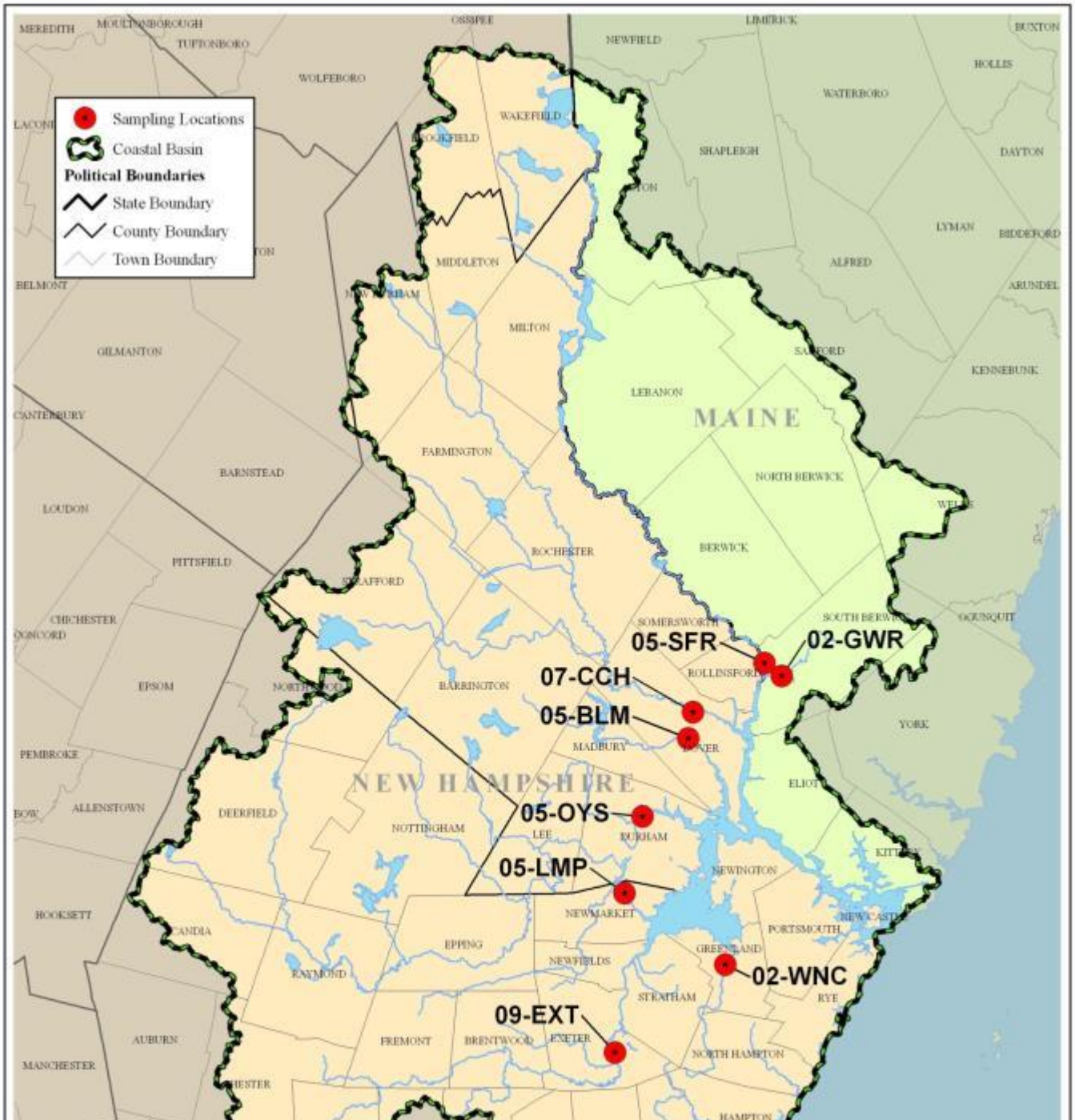

Table 11: Sampling Locations in the Great Bay Estuary, Coastal Basin.

Project ID	Station ID	Town	Station Description	Latitude	Longitude
GBETTMP	05-BLM	Dover	Route 108 bridge	43.179894	-70.878219
GBETTMP	05-LMP	Newmarket	Route 108 bridge	43.082056	-70.934961
GBETTMP	05-OYS	Durham	Route 108 bridge	43.130853	-70.918606
GBETTMP	05-SFR	Rollinsford	Route 4 bridge	43.227206	-70.811456
GBETTMP	07-CCH	Dover	Route 9 bridge	43.196489	-70.874139
GBETTMP	09-EXT	Exeter	High Street bridge	42.980923	-70.944114
GBETTMP	02-WNC	Greenland	Route 33 bridge	43.036067	-70.847983
GBETTMP	02-GWR	South Berwick	Brattle Street bridge	43.218870	-70.796660

Figure 2: Total Phosphorus Concentrations (in mg P/L) at Tributary Stations. (December data for station 02-GWR missing due to ice.)

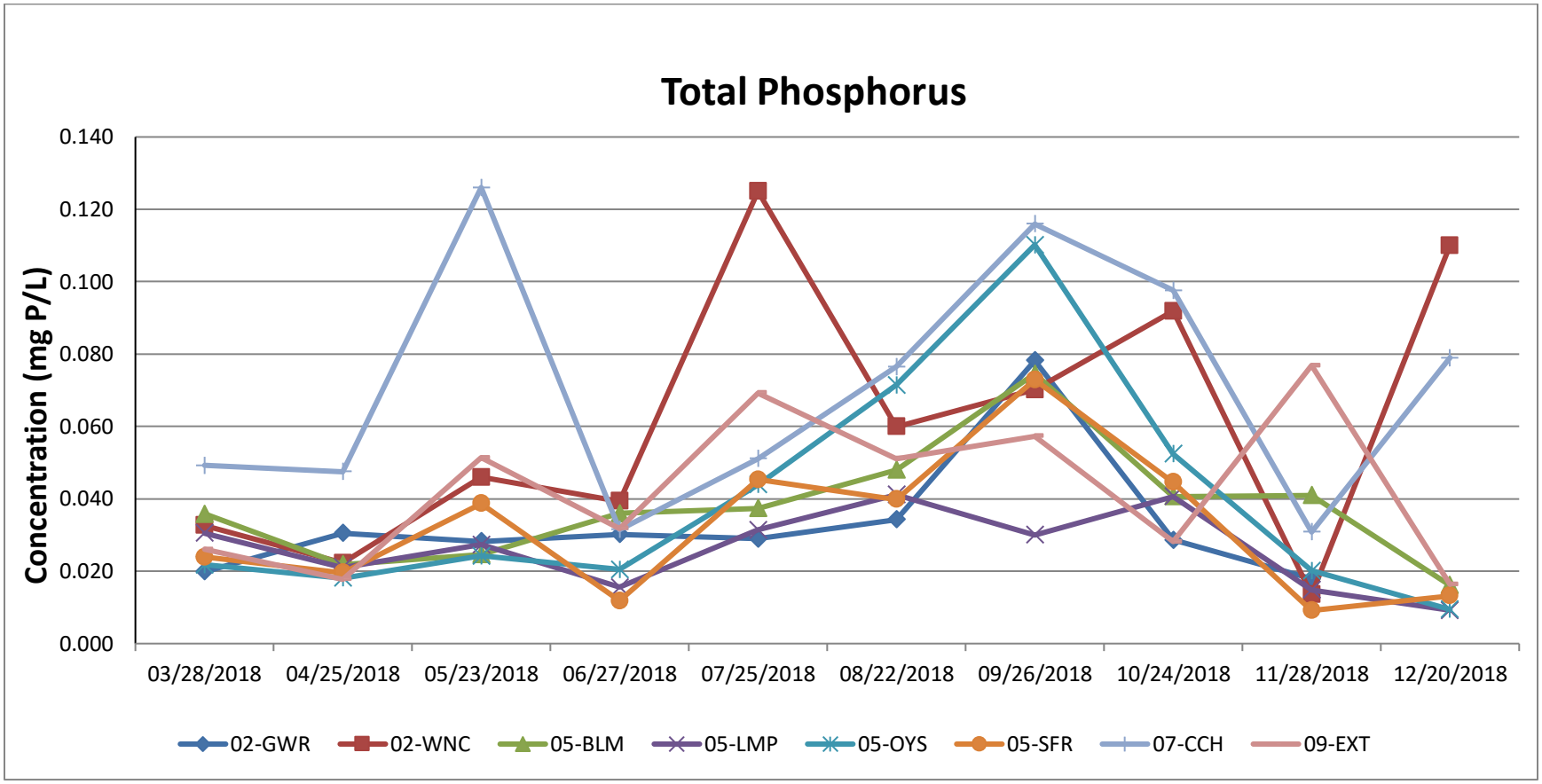

Figure 3: Total Dissolved Nitrogen Concentrations (in mg N/L) at Tributary Stations. (December data for station 02-GWR missing due to ice.)

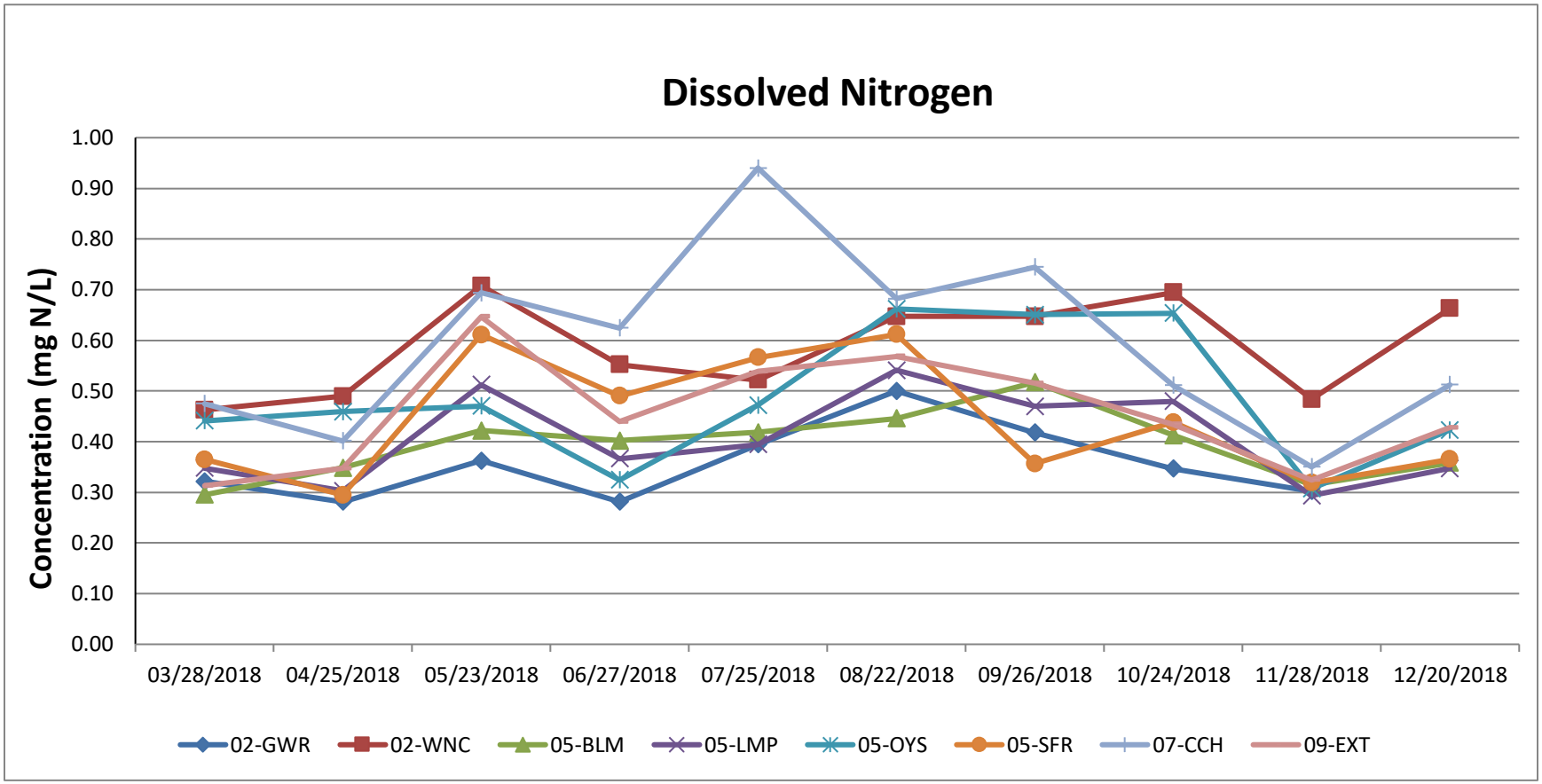

Figure 4: Total Suspended Solids Concentrations (in mg/L) at Tributary Stations. (Some data missing due to ice or invalidated through QA/QC process.)

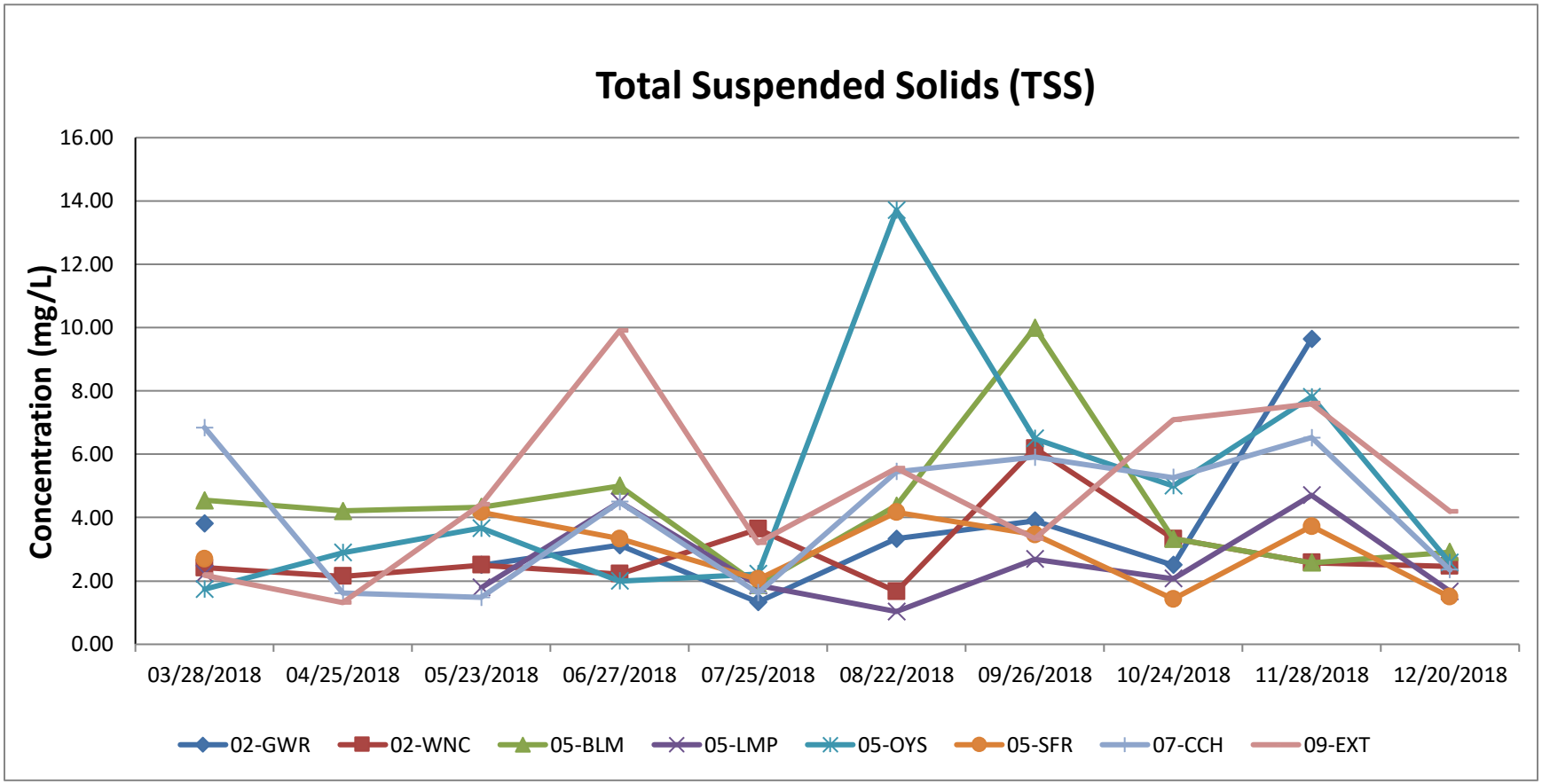

Figure 5: Nitrate/Nitrite Concentrations (in mg N/L) at Tributary Stations. (December data for station 02-GWR missing due to ice.)

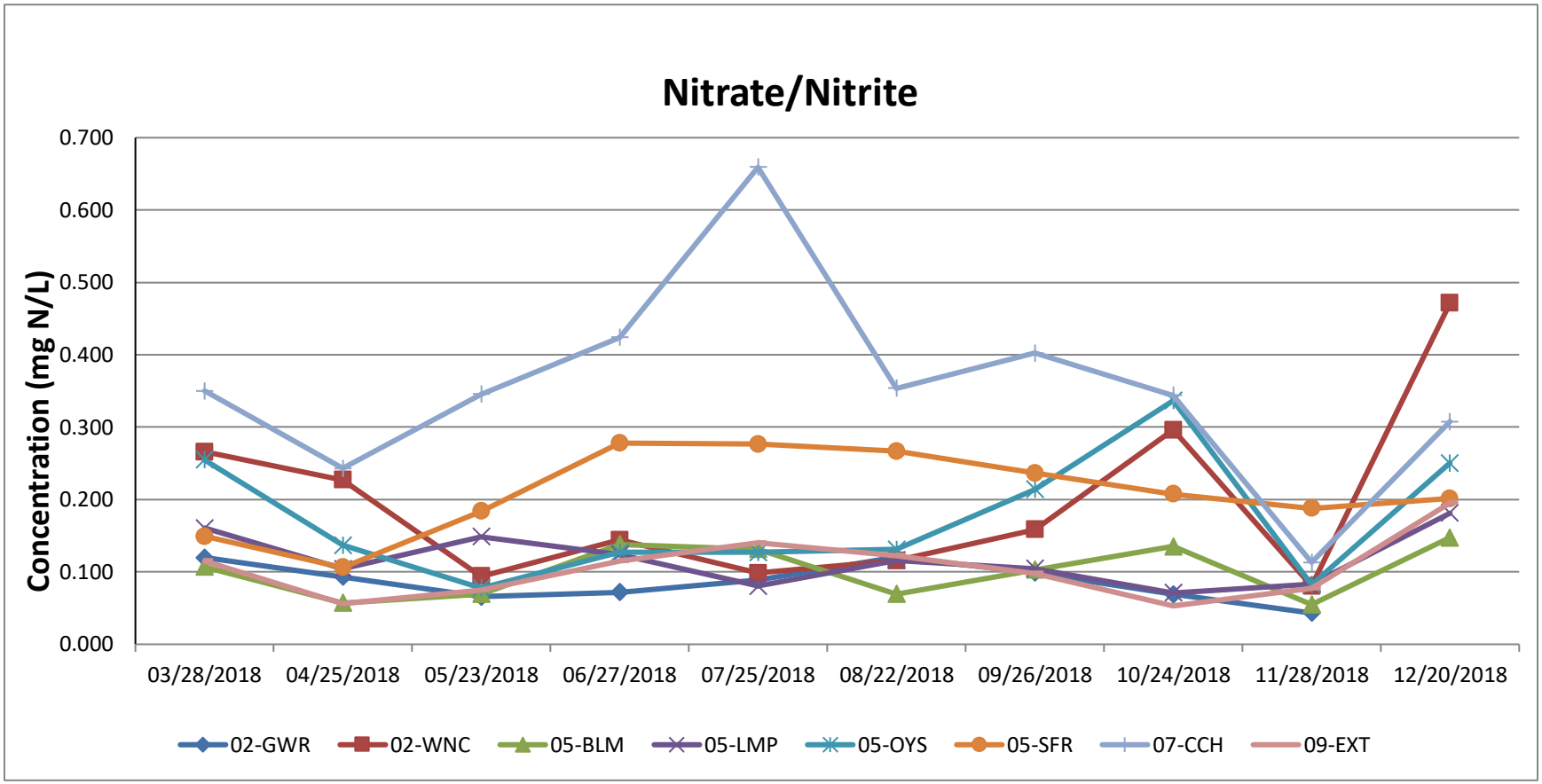

Figure 6: Ammonium Concentrations (in mg N/L) at Tributary Stations. (Some data missing due to ice or invalidated through QA/QC process.)

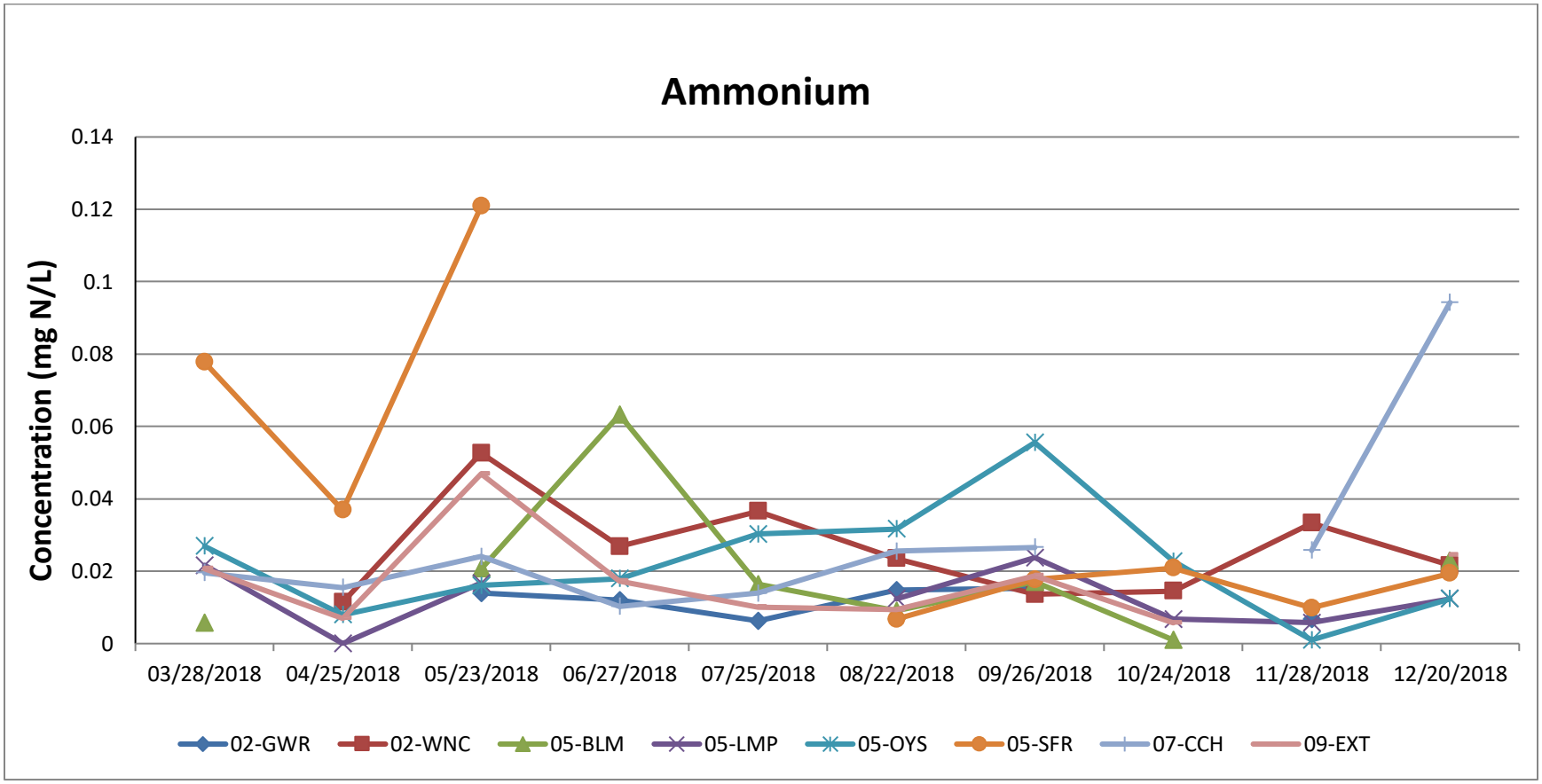

Figure 7: Dissolved Organic Nitrogen Concentrations (in mg N/L) at Tributary Stations. (December data for station 02-GWR missing due to ice.)

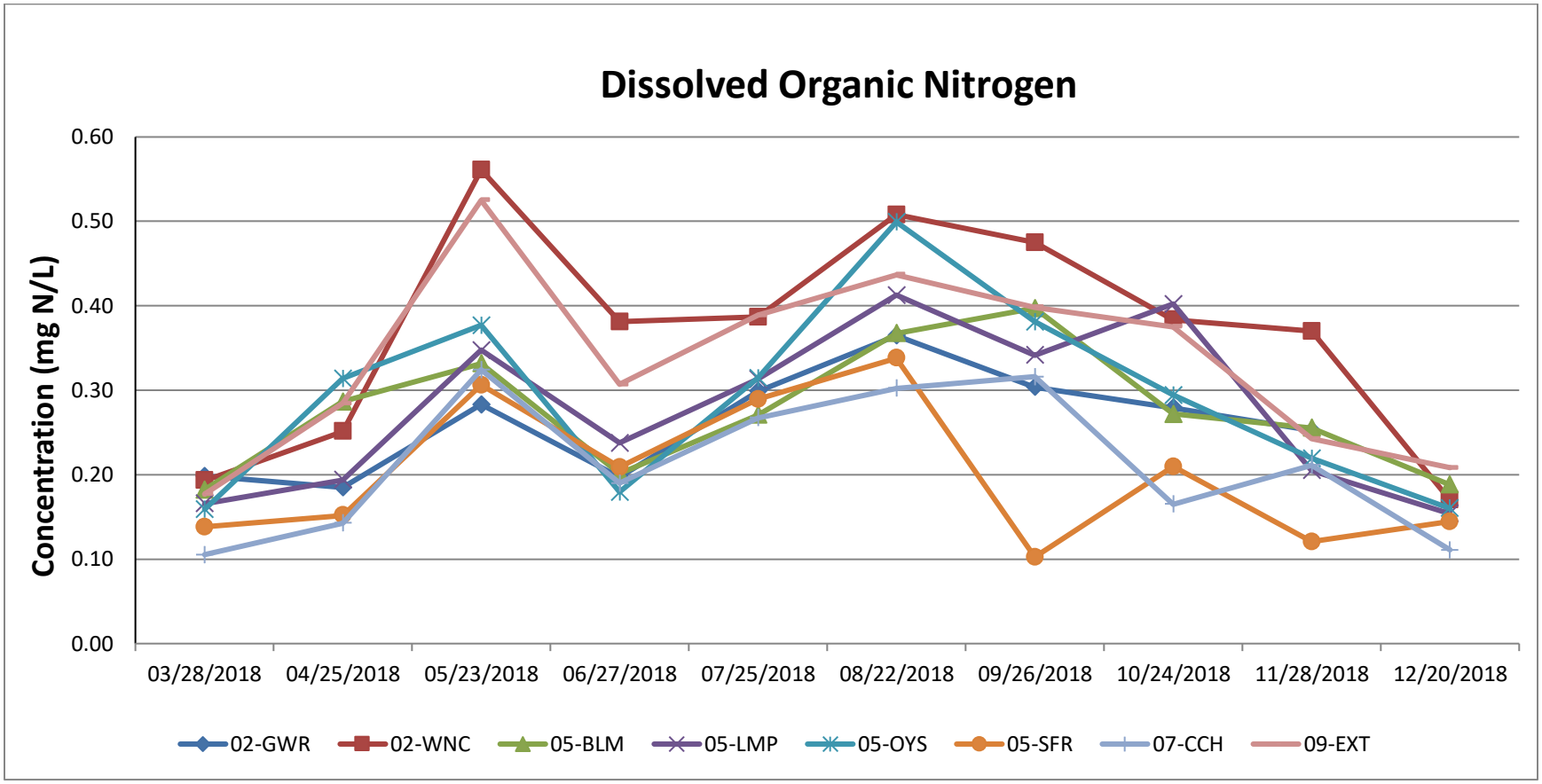

Figure 8: Dissolved Organic Carbon Concentrations (in mg C/L) at Tributary Stations. (December data for station 02-GWR missing due to ice.)

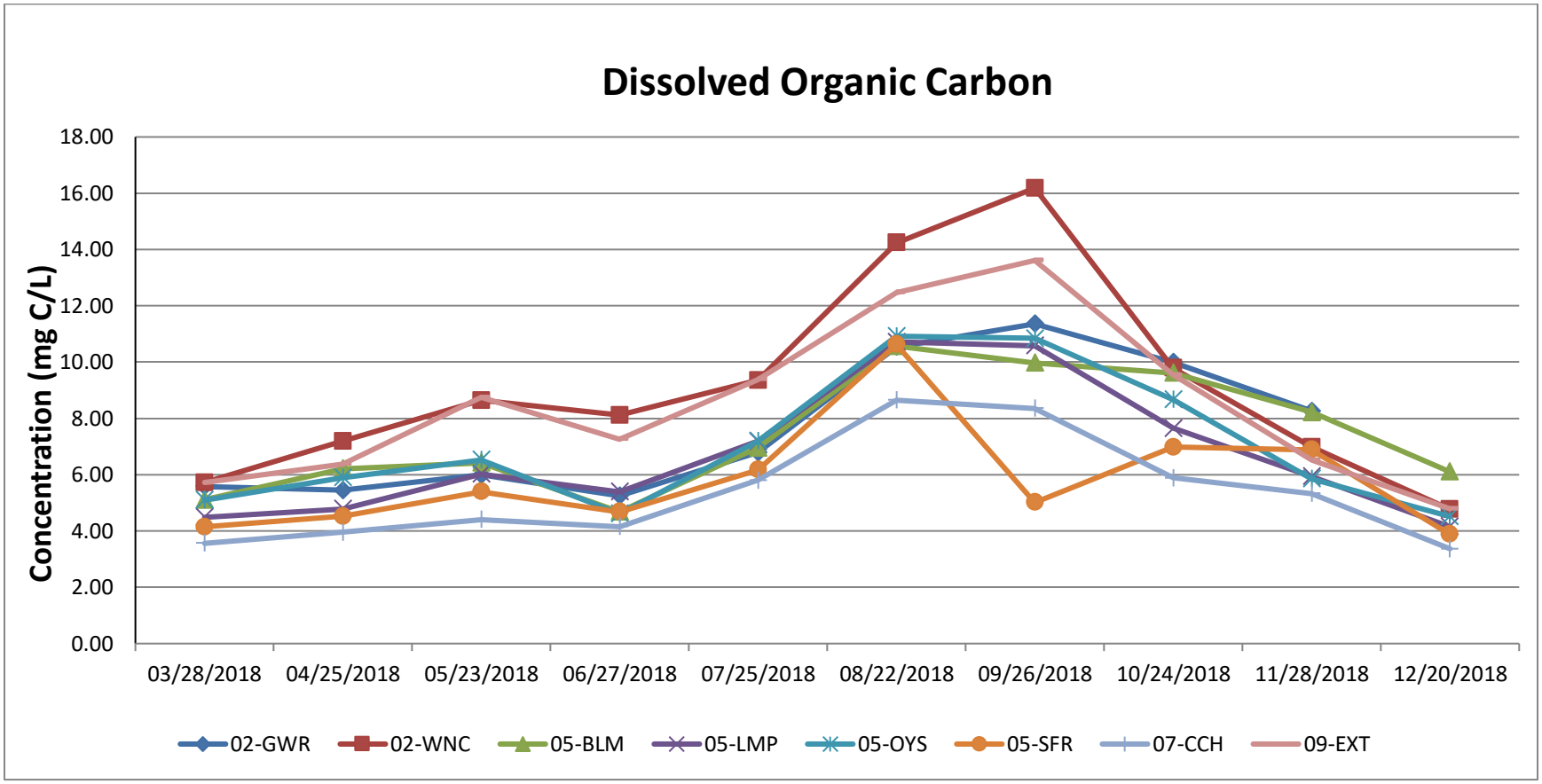

Figure 9: Total Suspended Nitrogen Concentrations (in mg N/L) at Tributary Stations. (December data for station 02-GWR missing due to ice.)

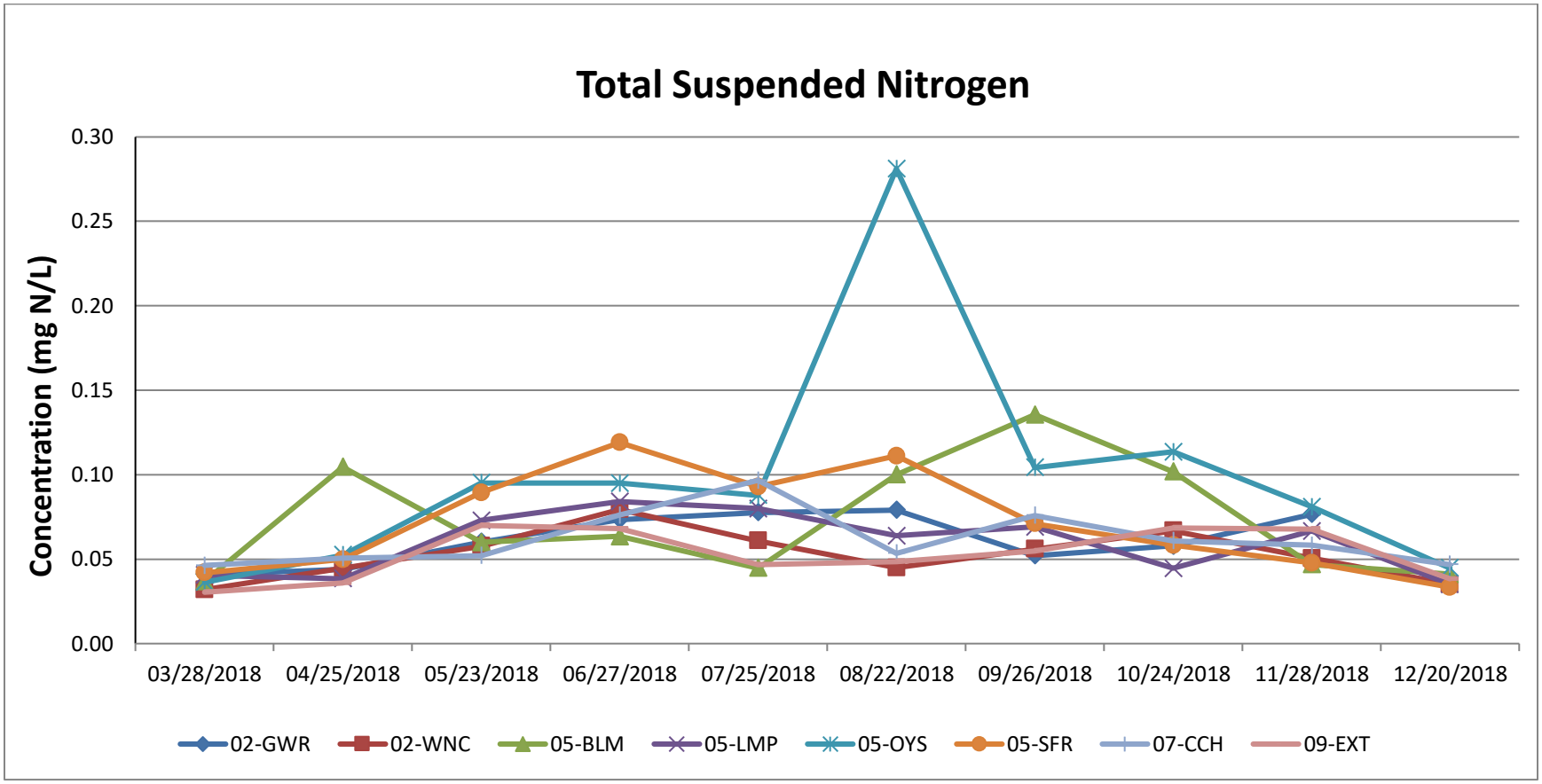

Figure 10: Orthophosphate Concentrations (in mg P/L) at Tributary Stations. (December data for station 02-GWR missing due to ice.)