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Nitrogen, Phosphorus, and Suspended Solids Concentrations in Tributaries to the Great Bay Estuary Watershed in 2015

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A Final Report to

The Piscataqua Region Estuaries Partnership

Submitted by

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PREP
Piscataqua Region Estuaries Partnership

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 sediment concentrations in tributaries to the Great Bay Estuary in 2015. The study design followed the tributary sampling design which was implemented by the New Hampshire Department of Environmental Services between 2001 and 2007 and sustained by the University of New Hampshire 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 2015 water quality data collected by UNH, so that PREP can calculates the nitrogen load from tributaries to the Great Bay Estuary. DES 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 (PREP, 2013).

University of New Hampshire researchers collected grab samples from the head-of-tide stations in the freshwater portion of eight tributaries to the Great Bay Estuary (Figure 1) 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), ammonia (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; 11%) for quality assurance.

The Water Quality Analysis Laboratory at the University of New Hampshire 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. Suspended solids concentrations were calculated using APHA method 2540-D. Nitrate concentration was determined using EPA method 353.2 and NH_4 using EPA method 350.1. Total suspended nitrogen was determined using EPA method 440.0. Dissolved organic carbon was determined using EPA method 415.1. Orthophosphate was measured using EPA method 365.1. Dissolved organic nitrogen (DON) was calculated by subtracting nitrate/nitrite and ammonia from TDN.

DOC is not a required parameter in the approved Quality Assurance Project Plan (PREP, 2013). Measurements of DOC were collected as ancillary data. The DOC results were quality assured using the methods and objectives in PREP (2013).

Physico-chemical parameters (water temperature, specific conductance, dissolved oxygen, and pH) were measured in the field using a YSI 556 multi-parameter instrument. A total of ten field duplicate readings were collected for each parameter (one station per sampling date; 11%) for quality assurance.

Quality Assurance Audit

UNH provided the field and laboratory data to the New Hampshire Department of Environmental Services to be quality assured and then added to the Environmental Monitoring Database (EMD).

Field sampling proceeded as planned.

- All of the 90 planned samples were collected for laboratory analysis (100%). 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:

- All of the field duplicate samples for DOC, TN, TDN, PN, NO_3/NO_2, and the field parameters were within data quality objectives.
- Phosphorus: Two of the 10 field duplicates had RPD values greater than the data quality objectives (<30%). The duplicate pairs collected in the Lamprey River (station 05-LMP) on 11/23/2015 had an RPD of 33.7% (14.7 and 20.7µg P/L). Because the RPD was relatively close to the data quality objectives the results were considered acceptable. The duplicate pairs collected in the Bellamy River (station 05-BLM) on 7/22/2015 had an RPD value of 57.8% (20.1 and 11.1 µg P/L). Following the guidelines presented in the QAPP, these duplicate pairs were invalidated.
- Ammonia: Three of the 10 field duplicates had RPD values greater than the data quality objectives (<30%). Two of the failing duplicate pairs were for low concentrations near the detection limit (<10x MDL of 5 µg N/L), which inflate RPD calculations. These results were considered acceptable. The duplicate pairs collected in the Bellamy River (station 05-BLM) on 7/22/2015 had an RPD of 31.7% (38.5 and 28.0 µg N/L). Because the RPD was relatively close to the data quality objectives the results were considered acceptable.
- Dissolved Organic Nitrogen: Three of the 10 field duplicates had RPD values greater than the data quality objectives (<30%). All of the failing duplicate pairs were for low concentrations near the calculated detection limit (<10x MDL of 90 µg N/L), which inflate RPD calculations. These results were considered acceptable. DON was calculated by subtracting nitrate/nitrite and ammonia from TDN. Similarly, the MDL for DON was calculated by subtracting the MDL for nitrate/nitrite (5 µg N/L) and ammonia (5 µg N/L) from the MDL of TDN (100 µg N/L).
- Orthophosphate: Four of the 10 field duplicates had RPD values greater than the data quality objectives (<30%). One of the failing duplicate pairs were for low concentrations near the detection limit (<10x MDL of 5 µg P/L), which inflate RPD calculations. These results were considered acceptable. The duplicate pairs collected in the Bellamy River (station 05-BLM) on 7/22/2015 had an RPD value of 55.2% (19.0 and 10.8 µg P/L), the Lamprey River (station 05-LMP) on 11/23/2015 had an RPD value of 41.1% (9.5 and 14.4 µg P/L), and the Exeter River (station 09-EXT) on 12/16/2015 had and RPD value

of 127.6% (35.9 and 7.9 µg P/L). Following the guidelines presented in the QAPP, these duplicate pairs were invalidated.

- Suspended Sediments: Five of the 10 field duplicates had RPD values greater than the data quality objectives (<30%). However, all of the failing duplicate pairs were for low concentrations (<5 mg/L). Given the natural variability of suspended sediment data, and the relative low concentrations observed, the results were considered acceptable.

Laboratory quality control samples:
The results of laboratory QC tests are shown on Tables 1-9. Most of the instances where QC results did not meet data quality objectives were for low concentrations (<10x MDL) or below the detection limit, which is acceptable. The results associated with the remaining failures were invalidated.

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 90 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 90 samples, one result had a higher sum of NO_3/NO_2 and NH_4 than TDN. For the samples collected at station 05-SFR on 10/28/2015 at 12:27, the sum of NO_3/NO_2 and NH_4 was 0.1% higher. Because of the relatively small difference between the values, the results were considered acceptable
- TP vs. PO_4: TP should be greater than or equal to PO_4. Out of 90 samples, five results had a concentration of PO_4 greater than TP. For three of the samples PO_4 was only slightly higher than TP (≤ 6% higher), which was considered acceptable. For the samples collected at station 05-LMP on 10/28/2015 at 10:12, PO_4 was 14% higher, and the samples collected at station 05-SFR on 10/28/2015 at 12:27, PO_4 was 16% higher. Discussion with UNH determined that only the TP collected at 05-LMP on 10/28/2015 should be invalidated because it was below the method detection limit, while the PO_4 was above detection limit. For the samples collected at 05-SFR on 10/28/2015 both TP and PO_4 should be invalidated, since it is impossible to tell which is the more robust value.

Results below detection limits:
Several of the results for ammonia (6), total phosphorus (1), orthophosphate (1), dissolved organic nitrogen (10), and total suspended solids (5) were reported below the reporting detection levels (5.0, 7.0, 5.0, 90 µg/L and 1 mg/L, respectively). These results are being reported as less than the reporting detection level (<RDL), not the values reported by the laboratory.

Consistency/Comparability:
The range of concentrations measured in 2015 were consistent with previous sampling efforts at these sites (Tables 1-9). Time series plots of the data at different stations were used to identify any unusual results. Unlike previous years, which showed nitrogen and phosphorus concentrations in the Cocheco River to be much higher than in other rivers, nitrogen and phosphorus concentrations were relatively similar in all rivers in 2015.

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 Table 10. 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 2015 water quality data collected by UNH, so that PREP can calculates 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 TP across stations and dates ranged from < 7.0 to 84.1 µg P/L. Unlike previous years, which showed total phosphorus concentrations in the Cocheco River (station 07-CCH) to be much higher than in other rivers, total phosphorus concentrations in 2015 were much more variable.

- The concentrations of TDN across stations and dates ranged from 155 to 879 µg N/L. The maximum concentrations most often occurred in the Cocheco River (station 07-CCH).

- The TSS concentrations ranged from <1.0 to 24.6 mg/L. The highest concentration was in the Cocheco River (station 07-CCH).

- The concentrations of NO_3/NO_2 across stations and dates ranged from 25 to 689 µg N/L. The maximum concentrations most often occurred in the Cocheco River (station 07-CCH).

- The average NH_4 concentration ranged from <5.0 to 117.4 µg N/L. The Salmon Falls River had the highest concentration (station 05-SFR).

- The concentrations of DON across stations and dates ranged from 0.0 to 331 µg N/L. The maximum concentrations occurred in the Winnicut River (station 02-WNC).

- The concentrations of DOC across stations and dates ranged from 2.27 to 13.94 mg C/L. The maximum concentrations occurred in the Great Works River (station 02-GWR).

- The concentrations of PN across stations and dates ranged from 31 to 331 µg N/L. The maximum concentrations occurred in the Exeter River (station 09-EXT).

- The average concentrations of PO_4 across stations and dates ranged from <5.0 to 58.2 µg P/L. The maximum concentrations occurred in the Great Works River (station 02-GWR).

References

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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	13 Lab Duplicates / 2 Failed DQO The failures were for a samples with a low concentrations (<10xMDL)
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	7 CRM tests / 0 Failed DQO 9 LFM tests / 0 Failed DQO
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of TDN concentrations in 2015 (160-880 µg/L) was similar to the range from 2008-2014 (170-2,920 µg/L).
Sensitivity	Not expected to be an issue for this project	NA	Lowest detected concentration above the RDL was 160 µg/L
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	80 routine samples and 10 field duplicates were collected (100% 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 / 2 Failed DQO 1 of the failures were close to the DQO so it was deemed acceptable. The results associated with the remaining failures were invalidated.
Precision-Lab	RPD < 15%	Lab Duplicates	10 Lab Duplicates / 3 Failed DQO 4 Lab Replicates / 4 Failed DQO The failures were for samples with low concentrations (<10xMDL)
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	5 CRM tests / 1 Failed DQO 16 LFM tests / 0 Failed DQO The failures were for a samples with a low concentrations (<10xMDL)
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of TP concentrations in 2015 (<7.0-84.1 µg/L) was similar to the range from 2001-2014 (3.0-162.0 µg/L).
Sensitivity	Not expected to be an issue for this project	NA	Lowest detected concentration above the RDL was 8.3 µg/L.
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	80 routine samples and 10 field duplicates were collected (100% 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 /5 Failed DQO The failures were for samples with a low concentration
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 2015 (<1.0-24.6 mg/L) was similar to the range from 2001-2014 (0.9-57 mg/L).
Sensitivity	Not expected to be an issue for this project	NA	Lowest detected concentration above the RDL was 1.3 mg/L.
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	80 routine samples and 10 field duplicates were collected (100% 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 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	17 CRM tests / 0 Failed DQO **NO DATA** for LFM tests
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of total suspended nitrogen in 2015 (31-331 µg/L) was similar to the range from 2014 (28-225 µg/L)
Sensitivity	Not expected to be an issue for this project	NA	Lowest detected concentration above the RDL was 31 µg/L.
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	80 routine samples and 10 field duplicates were collected (100% 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	4 Lab Duplicates / 0 Failed DQO
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	12 CRM tests / 1 Failed DQO 8 LFM tests / 0 Failed DQO The failure was for samples with low concentrations (<10xMDL)
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of nitrate/nitrite concentrations in 2015 (25-689 µg/L) was similar to the range from 2009-2014 (5-2,520 µg/L)
Sensitivity	Not expected to be an issue for this project	NA	Lowest detected concentration above the RDL was 25 µg/L
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	80 routine samples and 10 field duplicates were collected (100% of planned samples)

Table 6: Summary of Quality Control Samples for Ammonia

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 / 3 Failed DQO All of the failures were close to the DQO or were samples with low concentrations (<10xMDL)
Precision-Lab	RPD < 15%	Lab Duplicates	7 Lab Duplicates / 3 Failed DQO The failures were samples with low concentrations (<10xMDL or BDL)
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	10 CRM tests / 4 Failed DQO 9 LFM tests / 0 Failed DQO The failures were samples with low concentrations (<10xMDL)
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of ammonia concentrations in 2015 (<5.0-117.4 µg/L) was similar to the range for 2009-2014 (5.0-158 µg/L).
Sensitivity	Not expected to be an issue for this project	NA	Lowest detected concentration above the RDL was 5.0 µg/L
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	80 routine samples and 10 field duplicates were collected (100% 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	9 Lab Duplicates / 0 Failed DQO
Accuracy/Bias	RPD < 15% >85% and <115% recovery	Certified Reference Material Samples Laboratory Fortified Matrix Samples	9 CRM tests / 3 Failed DQO 12 LFM tests / 0 Failed DQO The failures were for samples with low concentrations (<10xMDL)
Comparability	Measurements should follow standard methods that are repeatable	NA	The range of dissolved organic carbon in 2015 (2.27-13.94 mg/L) was similar to the range for 2011-2014 (3.02-15.3 mg/L)
Sensitivity	Not expected to be an issue for this project	NA	Lowest detected concentration above the RDL was 2.27 mg/L
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	80 routine samples and 10 field duplicates were collected (100% 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 Dupes / 4 Failed DQO One of the failures was for samples with low concentrations (<MDL). The results associated with the remaining failures were invalidated.
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 orthophosphate in 2015 (<5.0-58.2 µg/L) was similar to the range for 2011-2014 (5.0-340.0 µg/L)
Sensitivity	Not expected to be an issue for this project	NA	Lowest detected concentration above the RDL was 5.6 µg/L.
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	80 routine samples and 10 field duplicates were collected (100% 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 / 3 Failed DQO All of the failures were close to the DQO or were for samples with low concentrations (<MDL)
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 dissolved organic nitrogen in 2015 (<90-347 µg/L) was similar to the range for 2010-2014 (6-516 µg/L)
Sensitivity	Not expected to be an issue for this project	NA	Lowest calculated concentration was 90 µg/L
Data Completeness	Valid data for 90% of planned samples (9 samples at each tributary)	Data Completeness Check	80 routine samples and 10 field duplicates were collected (100% 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 (µg N/L)	TDN (µg N/L)	$NO_2 + NO_3$ (µg N/L)	DON (µg N/L)	PN (µg N/L)	pH	TP (µg P/L)	PO_4 (µg P/L)	TSS (mg/L)	Spec. Cond (µS/cm)	Temp. (°C)
02-GWR	03/25/2015		5.61	11.76	82.1	42.2	473.2	207.7	223.3	53.0	6.4	19.3	19.2	3.4	151	0.8
02-GWR	04/22/2015		7.48	10.71	93.0	14.2	261.2	62.0	185.0	71.3	6.4	44.5	< 5	8.1	46	9.2
02-GWR	05/27/2015		4.76	5.60	65.5	16.3	251.0	83.8	150.9	67.6	7.1	23.0	21.2	3.4	132	23.2
02-GWR	06/24/2015		5.65	5.60	61.9	30.5	335.2	120.2	184.5	57.3	6.9	40.5	9.9	5.0	141	20.4
02-GWR	07/22/2015		7.22	4.41	51.8	32.3	413.6	117.4	264.0	51.9	7.8	19.6	9.5	8.2	143	23.3
02-GWR	08/26/2015	*	4.90	3.86	45.9	18.7	268.1	64.8	184.6	45.9	6.6	20.3	7.7	4.6	152	24.1
02-GWR	08/26/2015		5.12	3.99	47.3	15.5	244.8	72.8	156.5	43.1	6.7	19.9	10.2	4.6	153	23.8
02-GWR	09/23/2015		4.16	6.83	72.8	9.5	226.9	52.6	164.8	137.8	7.0	25.3	10.0	3.3	134	18.5
02-GWR	10/28/2015		5.95	8.14	69.0	< 5	219.0	36.4	179.2	162.7	7.3	61.6	58.2	2.1	162	8.2
02-GWR	11/23/2015		13.94	10.55	82.6	< 5	394.0	70.9	318.3	129.5	6.5	51.2	21.6	1.5	107	5.1
02-GWR	12/16/2015		6.84	10.51	84.3	11.7	302.9	119.9	171.3	85.7	6.1	34.2	9.7	2.6	154	5.9
02-WNC	03/25/2015		5.49	11.66	81.1	27.8	563.4	309.0	226.6	31.6	6.5	15.9	8.1	1.7	488	0.6
02-WNC	04/22/2015		4.29	9.37	83.3	13.8	230.3	115.5	101.0	43.2	6.7	47.0	30.2	2.8	165	10.1
02-WNC	05/27/2015	*	4.47	5.86	67.3	43.4	497.3	293.5	160.4	69.7	7.3	26.0	8.4	2.2	400	22.2
02-WNC	05/27/2015		4.32	6.02	69.1	44.1	553.4	294.1	215.2	75.5	7.3	26.0	5.6	1.3	400	22.2
02-WNC	06/24/2015		9.71	6.06	67.2	29.0	480.9	104.5	347.3	60.4	7.2	67.5	13.8	7.7	373	20.5
02-WNC	07/22/2015		7.32	4.24	49.5	65.8	475.9	186.3	223.7	54.0	7.9	55.4	11.0	14.1	490	23.1
02-WNC	08/26/2015		7.60	4.41	51.4	57.0	443.7	113.1	273.6	45.0	7.1	24.6	19.2	1.9	455	23.0
02-WNC	09/23/2015		4.47	6.74	69.6	24.7	296.7	79.4	192.7	147.7	6.8	12.4	9.4	1.4	410	16.9
02-WNC	10/28/2015		5.78	8.74	73.2	16.9	395.8	176.3	202.7	108.8	7.2	19.3	9.4	4.2	438	7.7
02-WNC	11/23/2015		8.43	10.67	83.0	15.0	449.1	159.5	274.7	56.1	6.5	31.1	13.4	4.6	376	4.8
02-WNC	12/16/2015		6.01	10.21	83.2	20.8	390.7	273.7	96.3	99.5	6.1	26.3	7.7	2.5	390	6.6
05-BLM	03/25/2015		4.92	12.87	93.3	68.7	411.8	246.5	96.6	40.7	6.4	12.3	8.5	3.2	230	2.1
05-BLM	04/22/2015		5.11	10.85	98.4	13.2	242.6	62.5	166.9	62.6	6.2	28.0	7.4	5.6	75	11.0
05-BLM	05/27/2015		4.69	8.97	108.1	28.1	403.8	184.9	190.8	65.9	8.5	37.1	14.3	3.3	274	25.0
05-BLM	06/24/2015		6.47	6.74	78.4	14.7	302.9	85.2	203.1	71.3	7.2	11.5	11.2	2.8	174	23.1
05-BLM	07/22/2015	*	5.56	7.57	93.3	28.0	405.9	138.7	239.2	48.4	9.0	**11.1**	**10.8**	1.3	345	25.9

Station ID	Collection Date		DOC (mg C/L)	DO (mg/l)	DO (%)	NH_4 (µg N/L)	TDN (µg N/L)	$NO_2 + NO_3$ (µg N/L)	DON (µg N/L)	PN (µg N/L)	pH	TP (µg P/L)	PO_4 (µg P/L)	TSS (mg/L)	Spec. Cond (µS/cm)	Temp. (°C)
05-BLM	07/22/2015		5.38	8.10	94.4	38.5	426.8	143.6	244.6	44.0	8.8	**20.1**	**19.0**	1.9	346	25.9
05-BLM	08/26/2015		5.28	7.26	89.6	22.0	315.2	79.9	213.3	61.7	7.5	22.4	11.1	4.8	301	26.0
05-BLM	09/23/2015		4.34	9.13	97.9	43.8	270.6	64.0	162.8	95.3	6.7	22.6	8.6	< 1	222	18.7
05-BLM	10/28/2015		2.99	10.61	88.2	30.9	157.3	67.8	< 90	93.3	7.3	15.6	13.7	3.7	259	7.3
05-BLM	11/23/2015		6.51	11.25	91.6	13.1	314.0	63.9	237.0	89.7	6.1	20.4	7.9	1.5	159	6.5
05-BLM	12/16/2015		5.88	11.39	93.1	15.4	296.3	78.7	202.3	57.8	6.0	15.7	13.3	14.0	187	6.5
05-LMP	03/25/2015	*	4.93	14.20	97.9	35.2	405.2	213.5	156.5	33.6	6.3	16.1	13.8	1.9	190	1.2
05-LMP	03/25/2015		4.88	13.89	98.2	40.1	421.9	229.9	151.9	31.3	6.4	15.4	14.5	2.7	192	1.2
05-LMP	04/22/2015		6.29	10.60	94.8	9.8	295.9	95.4	190.7	72.5	6.6	49.5	12.7	5.0	80	10.2
05-LMP	05/27/2015		5.07	6.97	80.3	13.2	324.6	86.0	225.4	92.7	7.3	13.8	11.3	2.6	199	22.4
05-LMP	06/24/2015		4.74	6.21	70.9	60.5	320.2	215.2	< 90	59.4	7.1	20.8	13.7	3.0	203	22.0
05-LMP	07/22/2015		6.31	5.88	70.7	16.2	358.5	88.3	254.0	77.1	7.7	28.1	14.0	2.2	191	24.8
05-LMP	08/26/2015		4.14	5.56	66.3	10.7	254.5	25.0	218.8	68.6	7.3	13.9	11.3	2.0	221	24.1
05-LMP	09/23/2015		4.99	6.74	72.4	21.7	206.3	49.6	135.0	115.9	6.8	26.6	16.6	2.1	78	19.0
05-LMP	10/28/2015		5.94	9.35	79.1	< 5	307.2	114.6	189.0	118.0	7.2	**< 7**	8.1	3.0	108	8.1
05-LMP	11/23/2015	*	6.37	11.20	88.2	10.8	273.8	123.0	140.0	77.3	5.7	20.7	**14.4**	2.8	155	5.2
05-LMP	11/23/2015		6.64	11.18	87.9	8.3	321.3	115.0	198.0	68.2	5.7	14.7	**9.5**	2.4	155	5.2
05-LMP	12/16/2015		5.08	11.16	88.3	11.1	311.1	161.5	138.5	61.4	5.6	79.3	7.2	3.2	145	5.4
05-OYS	03/25/2015		3.23	14.40	101.7	54.2	314.3	169.9	90.3	33.9	6.8	41.8	25.6	2.7	296	1.1
05-OYS	04/22/2015		4.56	10.40	92.9	21.6	217.9	124.7	< 90	81.1	6.8	49.1	14.0	10.9	104	10.3
05-OYS	05/27/2015		2.27	6.82	78.7	17.2	162.2	80.7	< 90	89.8	7.2	69.3	15.1	2.5	294	22.6
05-OYS	06/24/2015	*	8.25	5.82	64.1	38.6	540.1	239.7	261.8	102.3	6.9	44.2	20.9	7.4	247	20.2
05-OYS	06/24/2015		8.76	5.98	66.2	35.7	532.1	238.3	258.1	118.9	7.0	47.6	15.9	8.3	247	20.4
05-OYS	07/22/2015		6.38	5.50	64.5	16.0	419.5	114.4	289.1	70.3	7.5	43.1	16.9	2.2	337	23.3
05-OYS	08/26/2015		4.10	4.74	54.7	20.9	234.3	89.7	123.6	109.4	7.3	12.3	8.4	5.4	294	22.4
05-OYS	09/23/2015		5.48	5.04	52.5	9.6	259.8	32.0	218.2	239.6	6.2	27.6	8.9	3.8	342	17.4
05-OYS	10/28/2015		5.62	7.22	60.0	14.9	317.5	104.6	198.0	198.6	7.1	36.3	10.5	3.6	328	7.3
05-OYS	11/23/2015		8.53	10.81	85.7	20.4	535.1	223.6	291.0	179.5	5.8	34.5	21.9	9.1	239	5.5

Station ID	Collection Date		DOC (mg C/L)	DO (mg/l)	DO (%)	NH_4 (µg N/L)	TDN (µg N/L)	$NO_2 + NO_3$ (µg N/L)	DON (µg N/L)	PN (µg N/L)	pH	TP (µg P/L)	PO_4 (µg P/L)	TSS (mg/L)	Spec. Cond (µS/cm)	Temp. (°C)
05-OYS	12/16/2015		6.08	10.84	86.6	10.0	493.9	250.2	233.6	176.7	5.6	36.5	13.7	2.7	267	5.8
05-SFR	03/25/2015		4.00	13.87	97.9	117.4	478.0	239.6	121.0	46.2	6.3	53.5	11.0	1.7	148	1.1
05-SFR	04/22/2015		6.90	11.35	100.8	11.2	265.6	76.2	178.2	81.4	6.2	23.2	13.3	7.9	53	10.1
05-SFR	05/27/2015		4.55	7.28	82.7	< 5	412.7	298.7	112.3	115.9	7.2	19.8	8.4	3.2	149	24.7
05-SFR	06/24/2015		4.63	6.69	78.5	9.6	483.0	298.3	175.1	90.0	7.2	10.5	11.2	4.1	155	23.2
05-SFR	07/22/2015		5.75	5.76	69.2	< 5	464.7	301.9	161.3	76.8	7.9	56.8	50.6	3.3	166	24.8
05-SFR	08/26/2015		4.79	6.41	78.0	7.8	478.3	249.4	221.1	91.4	7.3	17.0	11.3	3.1	176	25.3
05-SFR	09/23/2015	*	3.70	7.03	79.7	23.0	333.7	192.0	118.7	145.3	7.1	16.2	17.2	3.1	176	21.6
05-SFR	09/23/2015		3.97	7.07	80.5	21.3	401.7	164.0	216.4	164.2	7.1	16.3	15.0	3.5	176	21.6
05-SFR	10/28/2015		2.39	9.52	82.8	16.5	164.3	149.3	< 90	78.6	7.2	**15.5**	**18.3**	1.7	107	9.2
05-SFR	11/23/2015		9.27	10.91	87.9	14.4	365.7	133.0	218.2	120.8	6.2	21.3	9.2	12.3	108	6.1
05-SFR	12/16/2015		5.16	11.46	92.1	59.9	426.5	202.2	164.4	73.9	5.8	38.4	27.1	3.0	128	6.0
07-CCH	03/25/2015		3.64	13.68	96.4	44.0	879.4	689.3	146.1	51.8	6.2	84.1	45.0	3.6	231	1.0
07-CCH	04/22/2015		4.11	10.64	95.4	12.2	154.9	83.0	< 90	199.8	6.3	68.9	8.8	24.6	65	10.5
07-CCH	05/27/2015		2.56	6.42	75.9	26.2	279.5	218.7	< 90	78.0	7.3	14.6	14.8	2.7	249	23.7
07-CCH	06/24/2015		2.50	6.52	74.7	91.4	375.0	261.2	< 90	75.0	7.2	38.4	34.4	< 1	275	22.2
07-CCH	07/22/2015		4.95	5.38	65.9	18.2	623.3	406.2	199.0	98.0	8.0	36.2	34.2	3.1	297	25.5
07-CCH	08/26/2015		6.57	6.90	83.8	10.7	556.0	251.5	293.8	287.9	7.4	40.1	22.4	4.8	256	25.2
07-CCH	09/23/2015		3.38	6.56	72.7	63.2	412.3	163.4	185.7	125.8	6.8	30.4	27.0	2.3	300	20.4
07-CCH	10/28/2015	*	3.87	9.90	84.2	8.8	456.6	376.6	< 90	113.1	7.3	24.9	18.7	4.6	173	8.3
07-CCH	10/28/2015		3.87	10.29	87.3	14.6	466.6	351.8	100.2	113.1	7.4	19.6	15.2	2.7	173	8.4
07-CCH	11/23/2015		6.47	11.48	90.6	15.3	418.8	211.3	192.1	109.9	6.2	8.3	8.1	5.0	142	5.3
07-CCH	12/16/2015		3.82	11.19	88.6	31.0	582.3	527.0	< 90	97.6	5.9	29.3	10.7	2.6	203	5.4
09-EXT	03/25/2015		5.66	11.89	82.3	42.5	458.2	226.4	189.2	50.1	6.3	41.5	21.6	2.4	230	0.4
09-EXT	04/22/2015	*	7.21	9.35	83.6	8.1	286.3	71.3	206.9	55.0	6.5	29.8	15.5	< 1	102	10.4
09-EXT	04/22/2015		7.95	9.11	81.8	5.0	327.9	80.9	242.1	56.2	6.6	38.7	15.6	< 1	103	10.6
09-EXT	05/27/2015		6.14	5.69	65.0	10.8	336.0	117.6	207.6	105.7	7.1	26.0	12.5	< 1	233	22.1
09-EXT	06/24/2015		7.84	4.48	51.5	44.4	457.8	154.8	258.6	56.1	6.8	39.4	10.7	3.5	225	22.0

Station ID	Collection Date		DOC (mg C/L)	DO (mg/l)	DO (%)	NH_4 (µg N/L)	TDN (µg N/L)	$NO_2 + NO_3$ (µg N/L)	DON (µg N/L)	PN (µg N/L)	pH	TP (µg P/L)	PO_4 (µg P/L)	TSS (mg/L)	Spec. Cond (µS/cm)	Temp. (°C)
09-EXT	07/22/2015		8.44	5.04	59.5	5.3	366.2	42.0	318.9	118.8	7.7	28.5	13.3	2.3	250	23.9
09-EXT	08/26/2015		6.42	4.06	48.0	11.2	328.5	48.9	268.3	56.3	7.0	17.3	11.6	1.3	255	23.7
09-EXT	09/23/2015		5.85	6.08	64.9	15.4	282.7	35.9	231.4	136.1	6.8	39.1	5.8	2.0	248	18.6
09-EXT	10/28/2015		6.96	6.63	56.5	< 5	279.3	42.8	233.6	331.1	7.2	40.9	8.4	2.5	269	8.4
09-EXT	11/23/2015		7.94	9.63	75.0	14.1	426.6	95.6	316.9	85.9	6.2	48.4	16.3	4.0	241	4.8
09-EXT	12/16/2015	*	6.82	9.34	84.5	17.5	337.8	128.8	191.6	57.3	5.7	38.1	**7.9**	3.9	239	5.7
09-EXT	12/16/2015		7.09	10.21	81.5	18.9	380.0	133.1	227.9	65.1	5.5	42.4	**35.9**	2.4	238	5.7

* Field duplicate sample

Bold values in blue were invalidated by DES

Figure 1: Sampling locations in the Great Bay Estuary, Coastal Basin

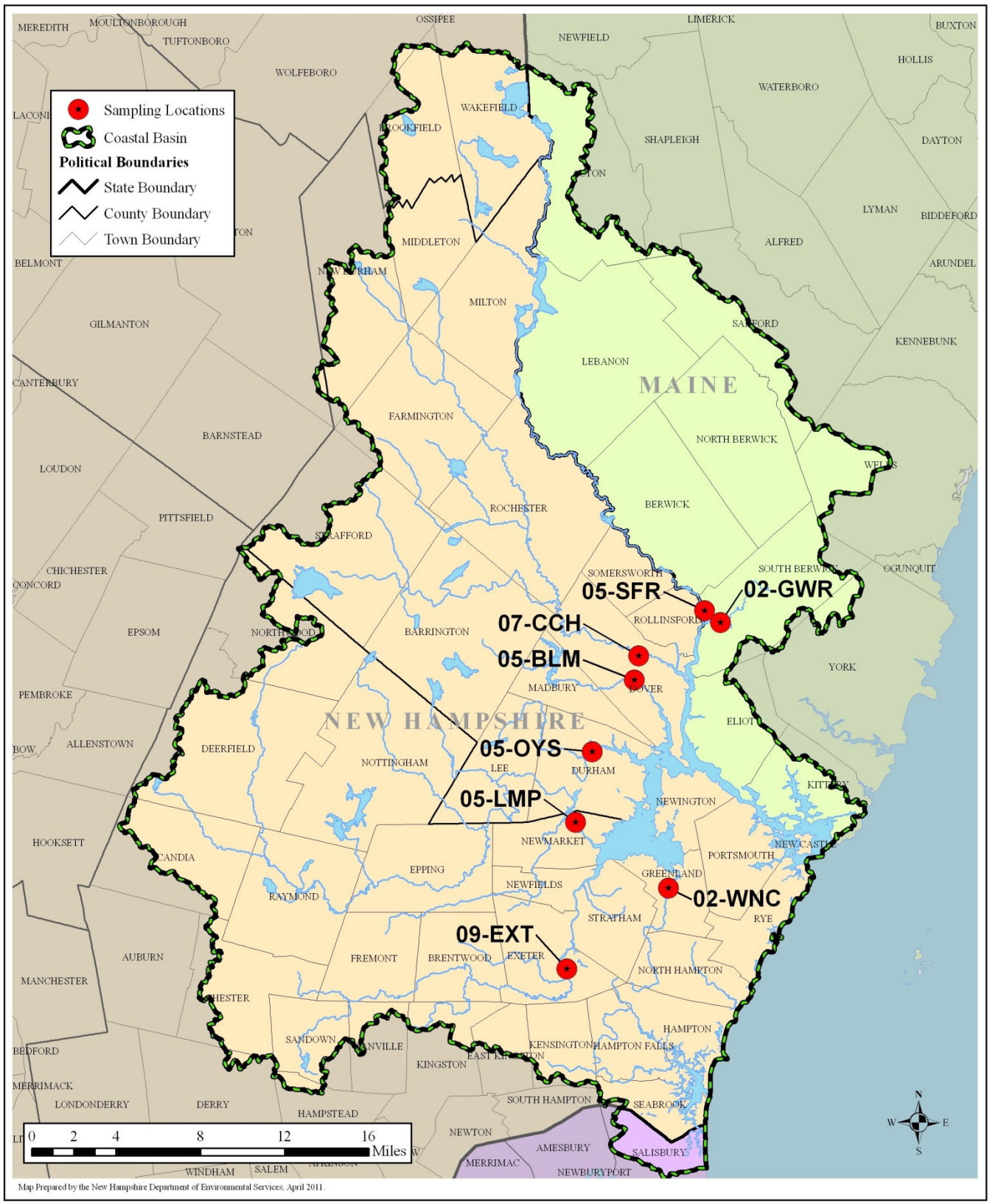

Figure 2: Total Phosphorus in Concentrations (µg P/L) at Tributary Stations

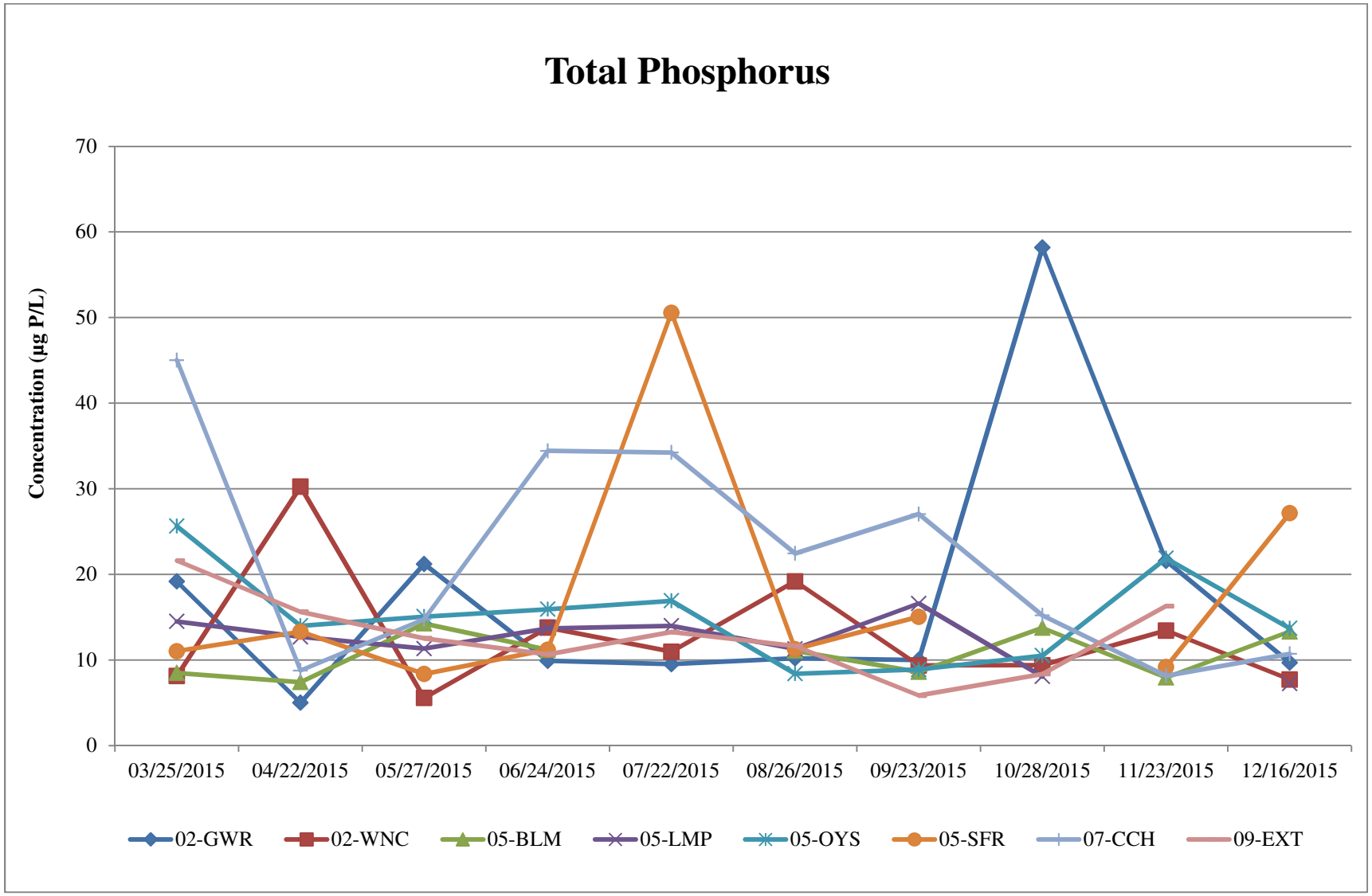

Figure 3: Total Dissolved Nitrogen Concentrations (in µg N/L) at Tributary Stations

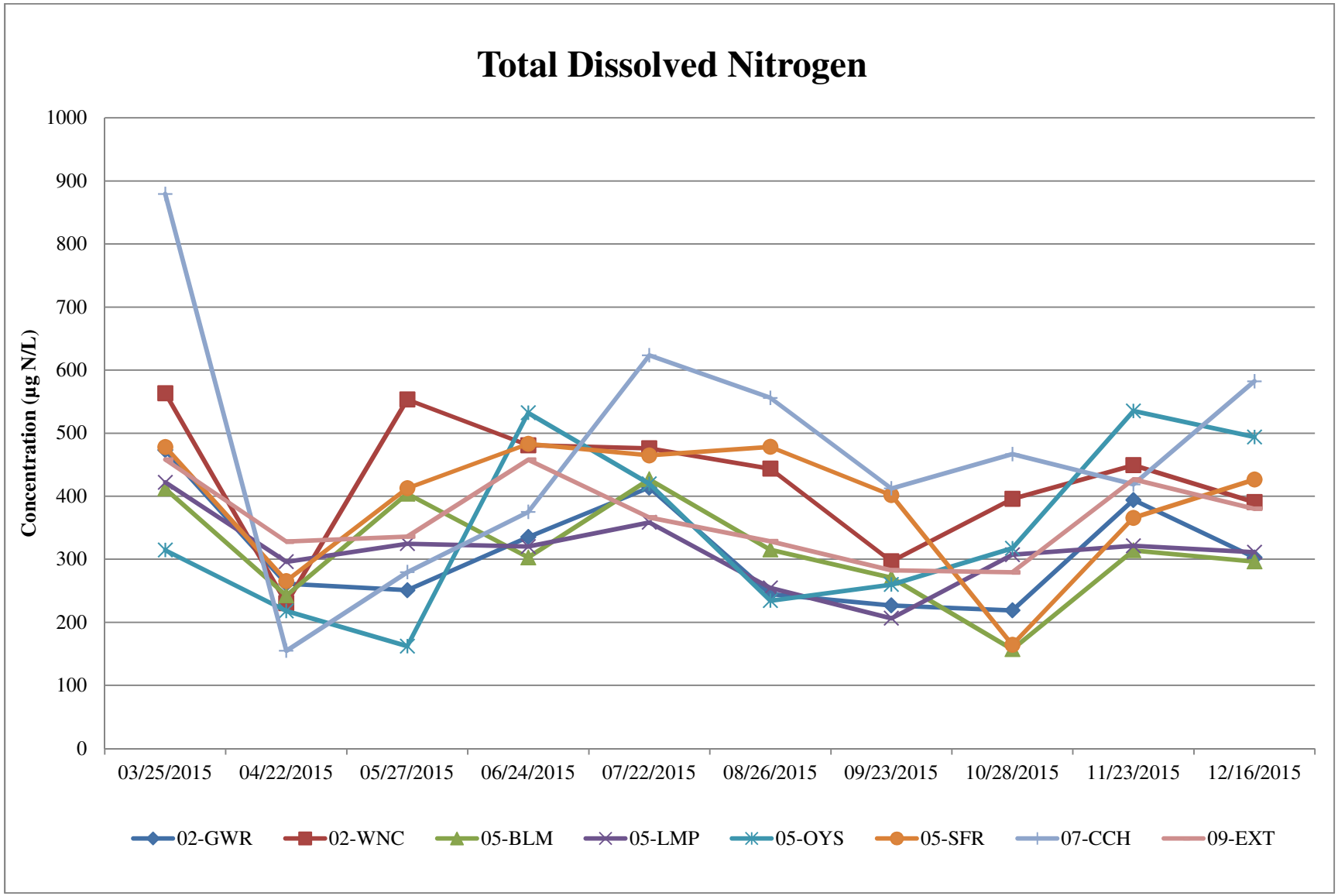

Figure 4: Total Suspended Solids Concentrations (in mg/L) at Tributary Stations

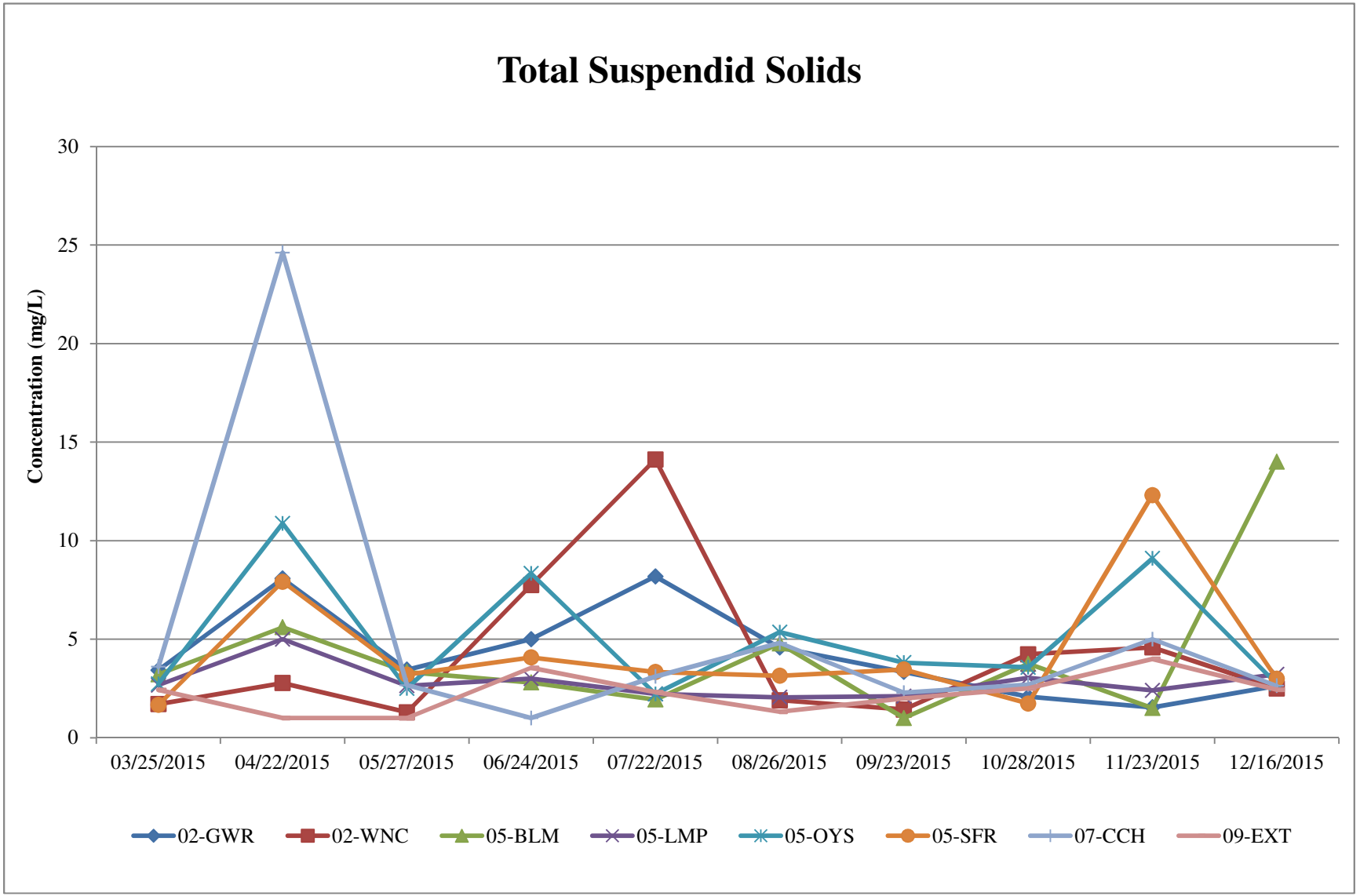

Figure 5: Nitrate/Nitrite Concentrations (in µg N/L) at Tributary Stations

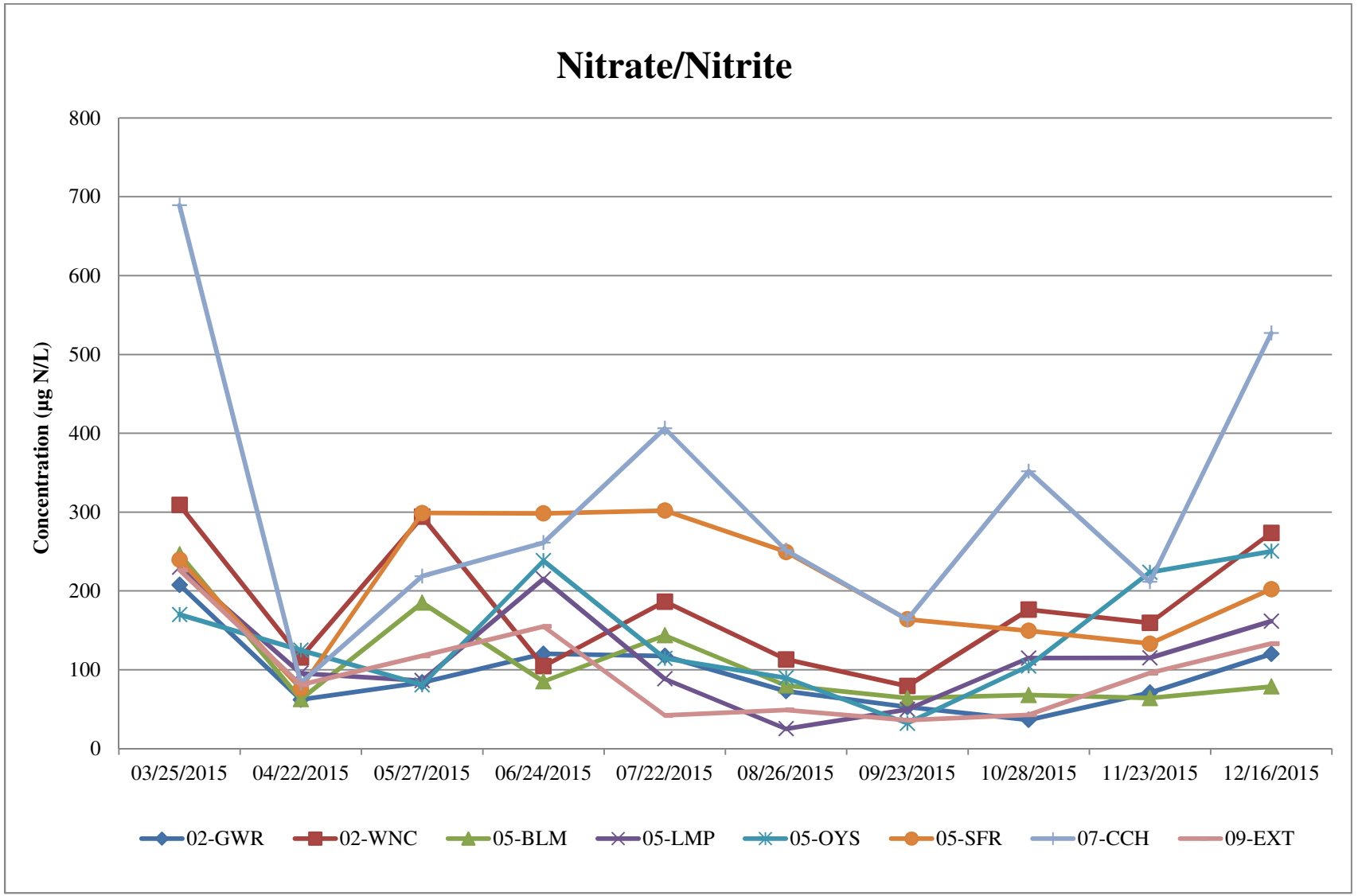

Figure 6: Ammonia Concentrations (in µg N/L) at Tributary Stations

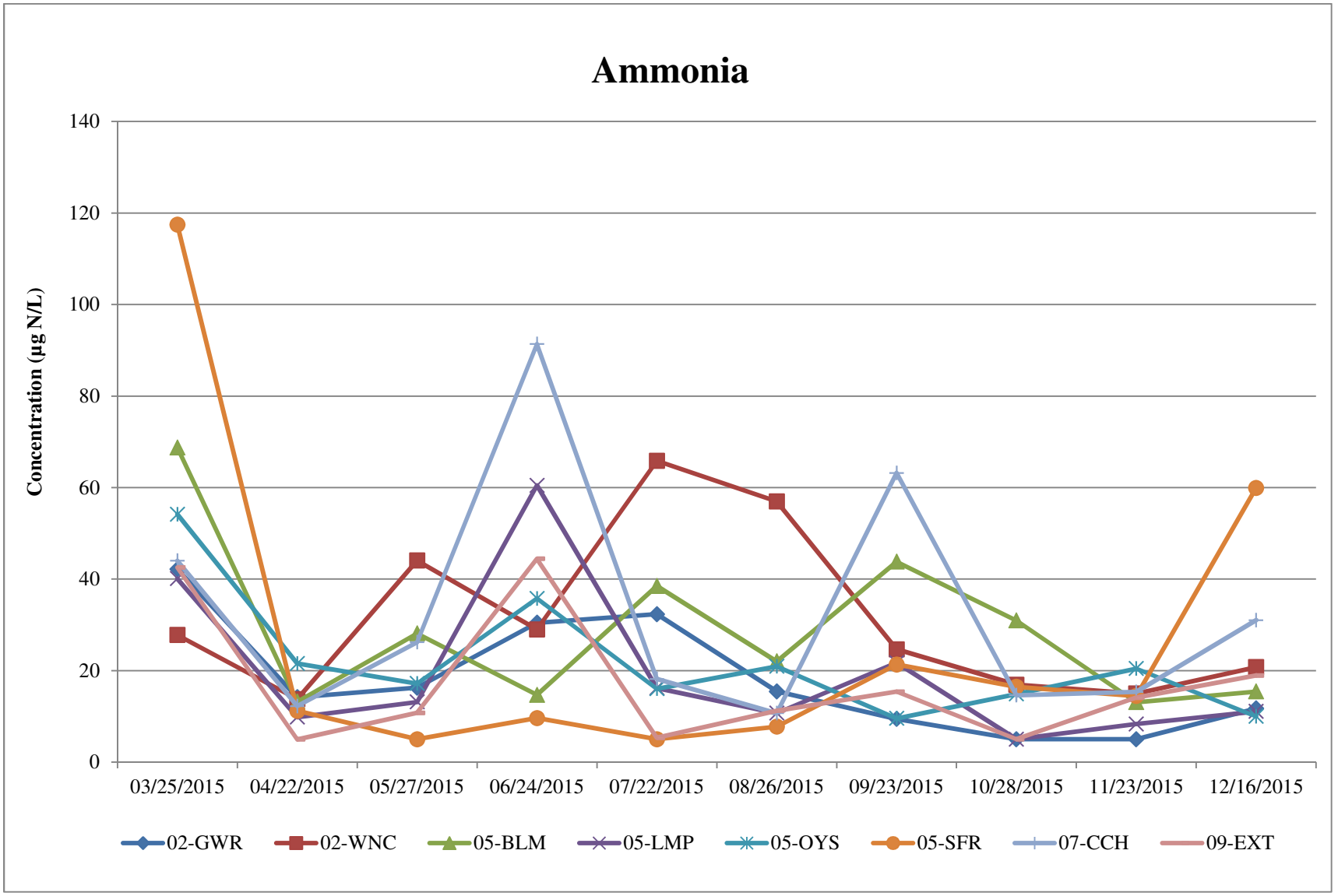

Figure 7: Dissolved Organic Nitrogen Concentrations (in µg N/L) at Tributary Stations

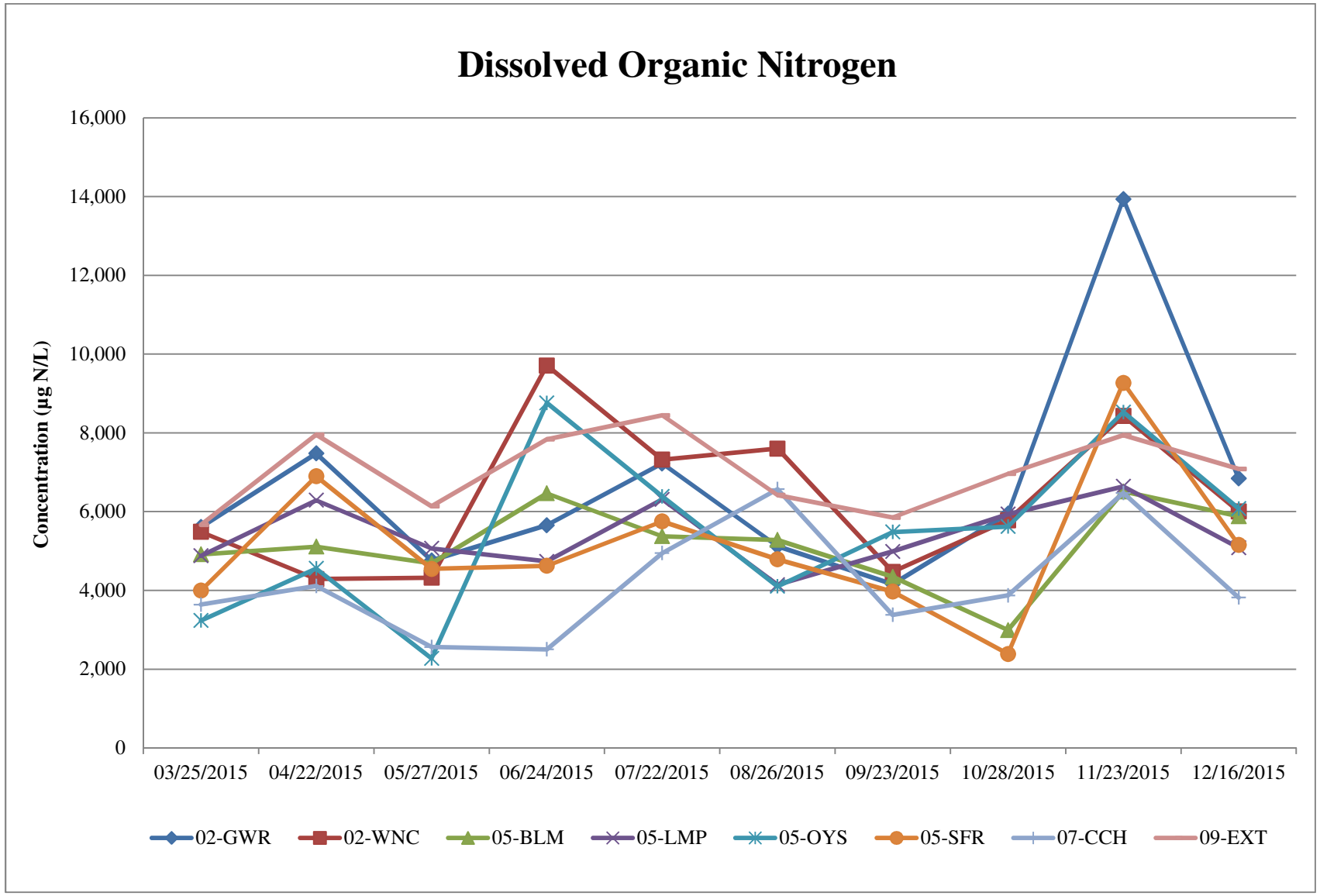

Figure 8: Dissolved Organic Carbon Concentrations (in mg C/L) at Tributary Stations

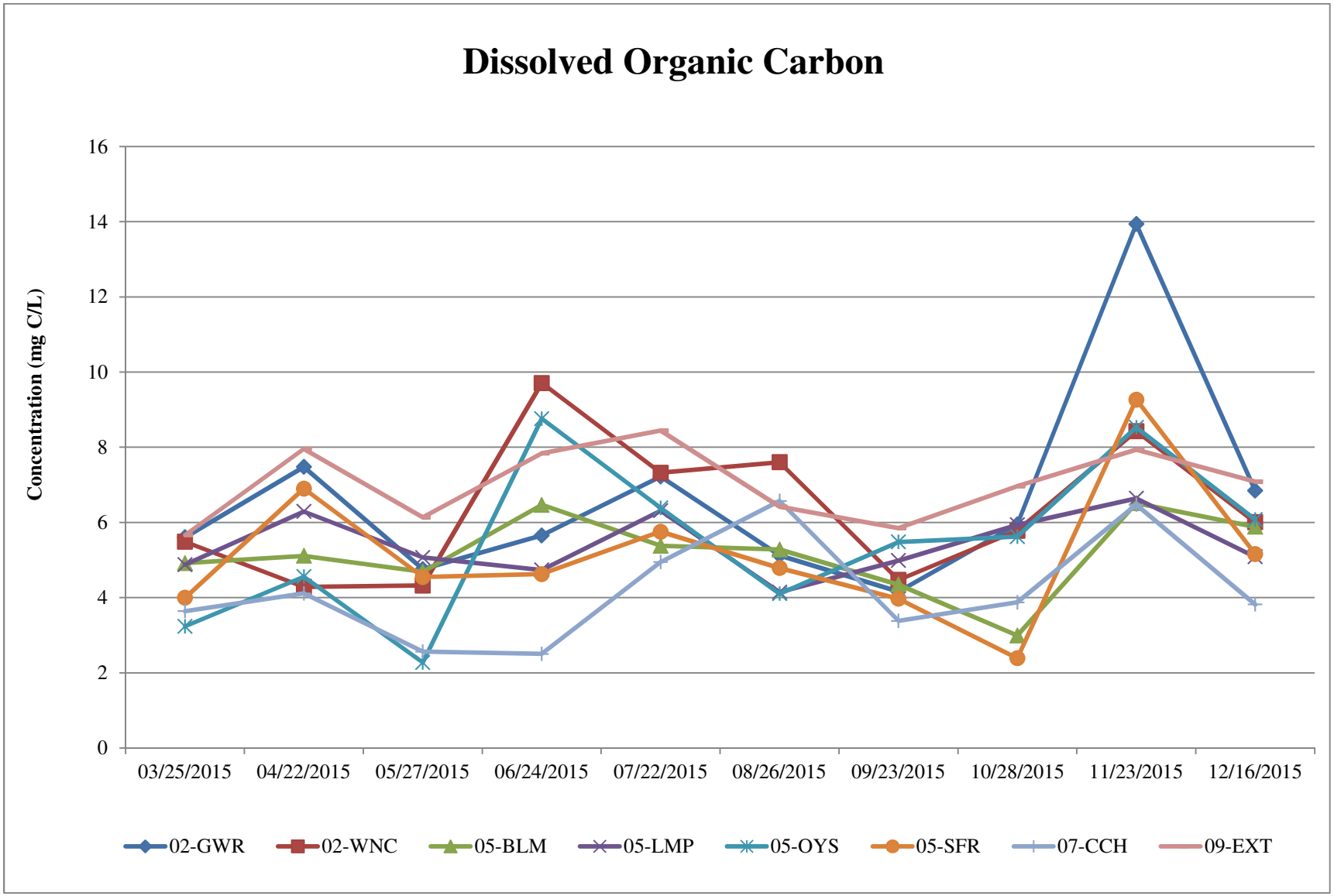

Figure 9: Total Suspended Nitrogen Concentrations (in µg N/L) at Tributary Stations

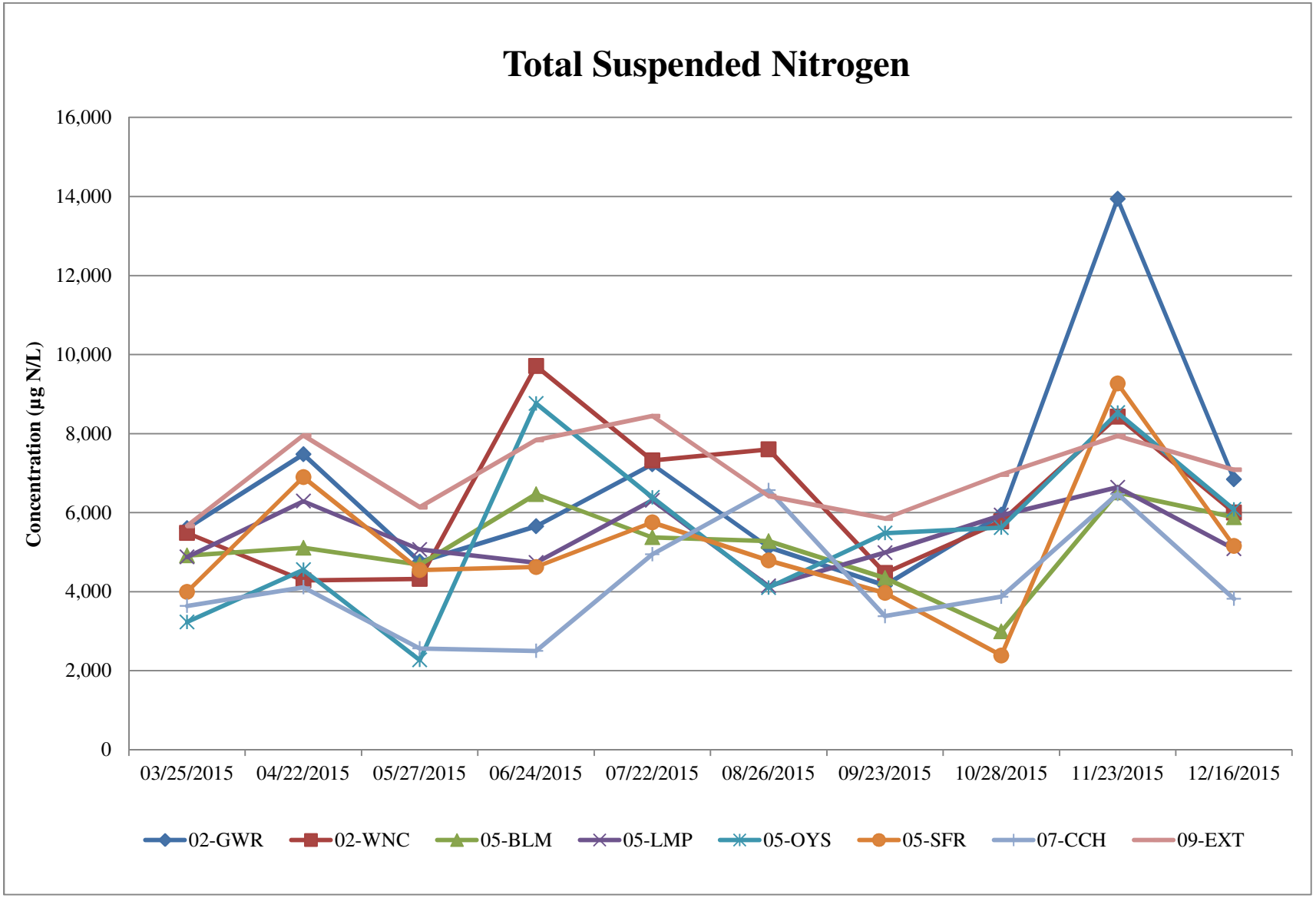

Figure 10: Orthophosphate Concentrations (in µg P/L) at Tributary Stations