

CHESAPEAKE BAY PROGRAM BLIND AUDIT

Fiscal Year 2022 Final Report

PREPARED FOR:

**Maryland Department of Natural Resources
Resource Assessment Administration
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INTRODUCTION

The purpose of this Blind Audit Program is to provide samples of specific nutrient analytes at concentrations commonly found in estuarine systems for analysis by laboratories that analyze water samples collected from the Chesapeake Bay, its tributaries, or similar systems. The concentrations of these samples, which are unknown to the recipient analysts, are compared to their prepared concentrations, or in the case of particulate samples, the range of values reported.

In the early years of the Chesapeake Bay Program, U.S. EPA provided blind audit samples on an irregular basis to laboratories analyzing Chesapeake Bay water samples. However, these audit samples were designed for waste water and drinking water applications rather than for estuarine water applications. Consequently, the concentrations were much higher than normally occur in the Bay and did not provide a reasonable estimate of accuracy for low level nutrient concentrations. For example, a blind audit concentration of 1.0 mg NH₄-N/L would be comparable to National Pollutant Discharge Elimination System (NPDES) water samples, but would be at least an order of magnitude greater than concentrations normally occurring in most parts of Chesapeake Bay.

The only continuous program providing an estimate of laboratory performance has been the Chesapeake Bay Coordinated Split Sample Program (CSSP). Data generated from this program provide the only long term quality assurance and quality control (QA/QC) data base to compare nutrient measurements provided by laboratories analyzing water samples collected from Chesapeake Bay and its tributaries. Samples for CSSP are natural water samples collected from Chesapeake Bay or a tributary. A common unfiltered water sample is distributed to the various field/laboratory personnel who, in turn, subsample into dissolved and particulate fractions. These are analyzed and the results compared to those of other participating laboratories. Resulting data analysis can show how field filtration techniques and/or laboratory practices affect data variability. CSSP samples are each subject to cumulative errors of analytical determinations from variation in both field and laboratory procedures. Also, these data sets cannot definitively determine the accuracy of laboratory analyses.

The current Blind Audit Program has been designed to complement the CSSP. Blind Audit particulate samples distributed to participants have less (or at least consistent) cumulative errors associated with field filtering and subsampling procedures. Prepared concentrates of dissolved substances, whose concentrations are unknown to the analysts, are provided so that laboratory accuracy can be assessed.

This is the twenty-third year of the Blind Audit Program and it is the continued intent of this program to provide unknown, low level dissolved and particulate nutrient samples to laboratories analyzing Chesapeake Bay Program nutrients, as well as to other laboratories interested in participating in the Blind Audit Program.

MATERIALS AND METHODS

Blind Audit samples were sent to participating laboratories on 2 February 2022 and 17 May 2022. Participating laboratories and contact personnel are found in Table 1.

Parameters measured were: total dissolved organic nitrogen, total dissolved organic phosphorus, nitrate+nitrite, ammonium, orthophosphate and dissolved organic carbon. High and low concentration samples were provided for each analyte. Particulate carbon, nitrogen and

phosphorus, chlorophyll and total suspended solids, were also provided for those laboratories that routinely analyze these parameters. Chlorophyll-a samples were natural population samples collected from the mouth of the Patuxent River.

Dissolved Blind Audit concentrates were prepared by careful dilution of high quality standards using 18.3 megohm deionized water (ASTM Type 1). The concentrates were sealed in 20 mL ampoules for shipment to participants. One ampoule contained a concentrate of an organic nitrogen compound and an organic phosphorus compound to be diluted for the analysis of low level total dissolved nitrogen and total dissolved phosphorus. A second ampoule contained a concentrate of an organic nitrogen compound and an organic phosphorus compound to be diluted for the analysis of higher level total dissolved nitrogen and total dissolved phosphorus. A third ampoule contained a concentrate to be diluted for the analysis of low level inorganic nutrients (ammonium, nitrate and orthophosphate). A fourth ampoule contained a concentrate to be diluted for the analysis of higher level inorganic nutrients. The fifth and sixth ampoules contained a low and high concentration of dissolved organic carbon, respectively. At each participating laboratory, an aliquot from each ampoule was diluted and analyzed according to accompanying instructions for preparation and dilution. These Blind Audit samples were then inserted randomly in a typical analytical batch. Final concentrations were reported for each diluted concentrate according to the dilution instructions provided.

Particulate analytes are measured by analyzing suspended material concentrated on filter pads. There are no commercially available suspensions of pure carbon, nitrogen or phosphorus compounds, so a natural sample was subsampled onto filter pads for analysis by participating laboratories. A batch water sample was collected from the CBL pier, and subsampled for particulate samples of carbon, nitrogen and phosphorus. Particulate C/N samples were vacuum filtered (≤ 10 in Hg, or 5 psi) from the batch sample with care, taken to shake (or constantly stir) the batch before each filtration to ensure homogeneity. Samples were dried completely (overnight at 47°C) before shipment. Two samples on 25 mm GF/F pads were sent to each laboratory for analysis.

The same general procedure was followed for particulate phosphorus samples in which they were concentrated by vacuum filtration on 47 mm GF/F pads.

Filter pads were sent to each laboratory for the analysis of particulate C, N, and P. The volume of sample filtered was noted in the instructions so that each laboratory could report concentrations in mg/L. Samples for chlorophyll a analysis were filtered from natural population samples onto 47 mm GF/F filter pads. Replicate pads were provided to participating laboratories.

Total suspended solids blind audits were prepared as follows: A suspension of a known mass of infusorial earth in deionized water was homogenized with a magnetic stirrer. While stirring continued, an aliquot was transferred by pipette into a screw cap vial for each participating laboratory. Detailed instructions explaining how to prepare this concentrate for total suspended solids analysis were also provided.

Samples were sent in coolers via next day carrier to the participating laboratories. A cold temperature was required for chlorophyll samples, so frozen cold packs were utilized in those participants' coolers.

RESULTS

Tables and figures summarizing results from the fall 2021 and spring 2022 audits are at the end of the report. In the past data review was requested of participants if submitted data was approximately more than twenty percent outside of the mean of all data submitted for that parameter, and there did not appear to be high degree of variability across results. This practice has been abandoned, as it was inefficient and not in keeping with the standard practices of other similar exercises. Some parameters, such as chlorophyll, have an inherently higher degree of variability. Review of chlorophyll data is requested less often than other parameters.

Concentrations were assessed statistically by calculating the mean and standard deviation of each sample set, then calculating how many standard deviations separated each laboratory's reported concentration from that mean (Table 2). The percent recovery of each laboratory's reported concentration relative to the prepared concentration was also calculated for the dissolved analytes (Table 3 and Appendix 1).

Dissolved Fraction

Total Dissolved Nitrogen:

Results from both the fall 2021 and spring 2022 audits were similar past audits. While no laboratories reported a concentration $> \pm 3$ SD from the mean, five observations (5/54) reported value fell into "warning" category ($> \pm 2$ SD from mean), and the percent coefficient of variation (%CV) for all four groupings were below 15% (range: 3.5-12.9). Higher %CV were seen with the fall 2021 and spring 2022 results for the lower concentration sample (12.5 & 12.9%). In both surveys this higher %CV ($>10\%$) was driven by a single value, that when excluded brought the %CV for each set below 10%. Despite the negative impact of these values they were not anomalous enough to fall outside the ± 3 SD limit.

Total Dissolved Phosphorus:

One laboratory reported a concentration $> \pm 3$ SD from the mean, and four observations (4/56) reported fell into the "warning" category ($> \pm 2$ SD from mean). The fall 2021 reported TDP (low concentration) value, and both sample cohorts for spring 2022 did not agree with each other well (23.2, 28.2, and 19.5%CV, respectively), and many did not recover the prepared values either (36 pass, 7 warnings, 8 failures) across all four groupings. This is comparable to the previous year (FY21). Poor recovery across the entire cohort usually indicates error in either the preparation of the sample or calculation of the expected value, but the range of values reported does not fit that hypothesis. It should be noted with TDP as well that exclusion of a single observation from each survey cohort significantly lessens the degree of variance.

Ammonium:

All reported concentrations for both audits were consistently close to other laboratories' reported concentrations for the fall 2021 and spring 2022 surveys, with only one (1/58) reported value falling into the "warning" category ($> \pm 2$ SD from mean), no values failed. The percent coefficient of variation (%CV) for three of the four groupings were outside of the ten percent threshold (21.6, 10.4, and 14.1%), which matched the pattern from FY21, but to a lesser degree. Twenty-four (of 58) reported values differed from the expected value by more than 10% (<90 , or $>110\%$ recovery), and ten of those exceeded the 20% threshold, though it should be noted these variances were dispersed across the cohort (similar to FY21), while in the past one or two laboratories are often responsible for the bulk of the flagged values.

Nitrate + Nitrite:

There was reasonably good agreement among all laboratories for both concentration levels, for both audits. Four (4/58) reported values that fell into “warning” category ($> \pm 2$ SD from mean), and two values were flagged as “fail.” Three of the four percent coefficients of variation (%CV) were below the ten percent threshold (range: 4.7-9.8). The fall 2021 low concentration grouping had a %CV of 14.7, which was weighted heavily by one value. Seven reported values differed from the expected value by more than 10% (<90 , or $>110\%$ recovery), and two of those exceeded the 20% threshold (one per season, both low concentration samples).

Orthophosphate:

Reasonably good agreement was found among all laboratories for both concentration levels, for both audits. Only three values overall warranted a flag; three (3/58) reported values fell into the “warning” category ($> \pm 2$ SD from mean), and no values failed. The percent coefficients of variation (%CV) for three of the four groups were below the ten percent threshold and the other was just above (11.1%, F21, low concentration) This was driven completely by a single submission in each grouping, one that was significantly high, and the other low. Dropping these values would lower the %CV of each group well below the 10% threshold. Thirteen reported values differed from the expected value by more than 10% (<90 , or $>110\%$ recovery), while two of these exceeded the 20% threshold.

Dissolved Organic Carbon:

Particularly good agreement was found among all laboratories for low and high concentrations for both audits. Five (3/44) reported values fell into the “warning” category ($> \pm 2$ SD from mean), and no reported value failed. The percent coefficients of variation (%CV) for both low concentration and high groups, for all groupings were below the ten percent threshold (F21, 7.4 & 4.7%. S22, 9.8 & 8.3%). Eleven reported values exceeded the expected value by more than ten percent, and three values exceeded the failure threshold ($</> 20\%$).

Particulate Fraction

Again it should be noted that particulate carbon, nitrogen and phosphorus samples were filtered from a common estuarine water sample and, consequently, are not true blind audit samples produced from pure constituents. Particulate results are graphically presented in Figures 1 and 4.

Particulate Carbon:

Particularly good agreement was found among all laboratories for the fall 20210 and spring 2022, with coefficients of variation of 3.6 and 3.7%, and it should be noted that this was better than the previous Blind Audit surveys (FY18, 5.0-9.0%. FY19, 9.0-9.9%. FY20 5.3-6.9) and comparable to last year (FY21, 2.6-3.2%). No values received a warning flag ($> \pm 2$ SD from mean), and none failed.

Particulate Nitrogen:

Coefficients of variance for both surveys were high, 28.9 and 16.4%. The Fall 2021 %CV was driven heavily by one value that was almost twice the concentration of the lowest value in the cohort. Despite this it only qualified for warning flag ($> \pm 2$ SD from mean). The spring 2021 results had a more uniform distribution despite exceeding the %CV threshold (16.4%). Overall only two (2/18) value received a warning flag ($> \pm 2$ SD from mean), and none failed.

Particulate Phosphorus:

Reasonable agreement was found among all laboratories for the fall 2021 and spring 2022, with coefficients of variation of 10.1% and 9.5%, and it should be noted that this was similar to the previous four Blind Audit surveys (FY18, 10.4-19.2%. FY19, 8.7-14.9%. FY20, 6.7-9.6%. FY21, 7.1-14.6%). Two (2/17) of the reported values from both surveys received a warning flag ($> \pm 2$ SD from mean), and none failed.

Chlorophyll a:

Chlorophyll a results for the fall 2021 and spring 2022 audit displayed the degree of variability (%CV 21.1%, 29.1%, respectively) expected for a multi-laboratory comparison of low concentrations of an environmentally transitory compound, and consistent with past audits; %CV F17 23.1%, S18 23.3%, F18 25.3%, and S19 26.2%, F19 28.3%. Two values were flagged with a warning or failing label ($> \pm 2$ SD from mean), and none failed.

Total Suspended Solids:

The usual good agreement was found among all laboratories for the fall 2021 and spring 2022, with coefficients of variation of 2.7 and 2.4%, which is the least combined variability of the last five audits (FY18, 7.7-9.7%. FY19, 4.5-7.6%. FY20, 5.5-6.6%. FY21, 4.4-4.9%). Two values were flagged with a warning label ($> \pm 2$ SD from mean), and none failed. All but one reported value (32/33) fell within 10% (< 90 , or $> 110\%$ recovery) of the expected value. The other value fell in the warning category.

DISCUSSION

Several important issues should be considered when assessing whether individual Blind Audit results are within acceptable limits.

Variation Associated With An Analytical Method: As we have noted in previous Blind Audit Reports, analytical variability is associated with any quantitative determination. The method detection limit (MDL) is often used to express that level of variation. Total dissolved nitrogen data provide a good example. The detection limit at CBL has been determined to be 0.05 mg N/L. Any total dissolved nitrogen measurement has a potential 0.05 mg N/L variability associated with it. This variability, when expressed as a percent of the TRUE concentration, can be extremely large for low level concentrations and fairly low for higher concentrations. For example, a 0.20 mg N/L concentration has an analytical variability of 25% associated with it; whereas, a 1.20 mg N/L concentration has an analytical variability of 4%.

Acceptance Limits of Provided Dissolved Samples: Companies that prepare large quantities of performance evaluation samples assign acceptable confidence limits around the TRUE value. In one case (SPEX, CertiPrep), the mean recovery and standard deviation are later reported along with the true concentration and the 95% confidence interval (CI). The 95% CI is the mean recovery \pm two standard deviations and is developed from regression equations from Water Pollution Performance Evaluation Studies. A recently purchased set of these standards gave a true total P value of 3.00 mg P/L with a 95% CI of 2.47-3.42 mg P/L. The lower end of the 95% CI recovery allows 82% recovery of the true concentration. This type of statistical analysis was not performed on the Blind Audit Program samples prepared for this study prior to their distribution to the participants.

Parameters assessed in the Blind Audit do not have predetermined acceptance limits, so we are following the statistical procedure of ERA (Environmental Resource Associates), an approved source of wastewater and drinking water proficiency samples, and the State of Wisconsin Proficiency Testing program. They average the results for each parameter and at each

concentration, then calculate the standard deviation from the mean. Results that are within two standard deviations PASS and those greater than three standard deviations FAIL. Results between two and three standard deviations receive the WARN flag.

Most of the data comparisons based on standard deviations showed similar characteristics (Table 2); that is, the reported concentrations were similar, and one or two concentrations fell slightly beyond one standard deviation from the mean of all data for that portion of the study. Apparently, it is a statistical “reality” in small sample sets with little variability between individual values, that at least one value will lie just beyond one standard deviation from the mean. Thus, for most of the data sets compared by means and standard deviations, all the reported concentrations “passed.” It should be noted that the number of observations in the “warning” category has been consistent over previous studies, and that only a few values in any study are flagged as “failed.” However this recent round of Blind Audit had an uptick in the number of results flagged as “warning.” This should be watched closely with future studies. The number of “failed” results was consistent with previous studies.

Data sets with relatively small standard deviations yielded more potentially extraneous “warning” points. For example, in the fall 2015 blind audit of high level ammonium concentration, the prepared concentration was 0.361 mg N/L and the mean reported concentration was 0.365 mg N/L and reported concentrations ranged from 0.337-0.395 mg N/L. The coefficient of variation was 4%. Thirteen laboratories reported results for this high level sample that were within two standard deviations (S.D. 0.014 mg N/L) of the mean. Since the standard deviation was so small, two laboratories’ reported results for this sample that were between two and three standard deviations of the mean, so were labeled WARN. Thus, by that measure of accuracy, most of the data “passed” and two were “warned.” This ammonium data comparison points toward a form of circular reasoning in these statistical assessments. The data being evaluated are also the data that were used to calculate the mean and standard deviation to which the data are being compared. All of the reported fall 2015 high level ammonium data were within 9% of the prepared concentration.

Data were also assessed by comparing reported concentrations to those that had been prepared (Table 3). Groupings of data in PASS, WARN, and FAIL categories were arbitrarily set. Reported data that were within 10% of the prepared concentration were considered as PASS. Reported data that were 80-90% or 110 -120% of the prepared concentration were tabulated as WARN. Reported data that were <80% or >120% of the prepared concentration were tabulated as FAIL.

When comparing reported concentrations to those prepared, the lower concentration ranges had more data that fell in WARN and FAIL categories than the higher level concentrations, i.e., there was less accuracy at the lower concentration ranges (Table 3). The acceptance criteria for low concentration samples are quite narrow. For example, for spring 2016 blind audit of 0.014 mg N/L prepared for ammonium has a PASS category (+/-10%) of only 0.013 - 0.015 mg N/L. For the spring 2016 blind audit, eight out of twelve participating laboratories reported results that fell in the WARN or FAIL category, indicating that their reported concentrations were greater than +/-10% of the prepared concentration in this low range. These results could be interpreted as an inability for all participants to accurately measure low level ammonium from concentrates provided to them. It would be important to know if there is also difficulty in measuring natural low level samples. An alternative interpretation would be that it may be appropriate to broaden the acceptance boundaries for very low concentrations of prepared samples. There was also a broad range in percentage recovery of low level ammonium reported values in past audits; however, when comparing with other participants, the coefficient of variation remains remarkably small. For example, fall 2019 reported data based on comparisons with other participants, the

low level ammonium mean was 0.042 mg N/L, S.D. 0.005, C.V. 10.8%.

There was less divergence between participants for the fall 2012 through fall 2014 low level ammonium samples than in audits of fall 2011 and spring 2012. For these most recent prepared ammonium samples, the proportion of the standard deviation to the mean was approximately the same as it had been for the last few years. Variation around the mean for low level ammonium reported concentrations resulted in coefficients of variation of 16% for fall 2015 concentration of 0.025 mg NH₄-N/L; 19% for spring 2016 concentration of 0.014. For the spring 2014 audit, the coefficient of variation for 0.022 mg NH₄-N/L was 20% mg NH₄-N/L. The coefficient of variation was 16% for 0.042 mg NH₄-N/L (Fall 2006) and 39% for 0.036 mg NH₄-N/L (Spring 2007). This indicates that inter-laboratory comparisons of any ammonium data prepared by most laboratories from concentrates below 0.042 mg N/L may be improving. In fact, since spring 2017 all but one observed coefficient of variation for low level ammonium was below 20%, and five of those six values were below 15%. This was not the case for fall 2020 as %CV for each survey was above 15%, 16.7 and 27.6%. The variance at the low level (27.6%) was the highest of all reported parameters. The trend seems to have reversed somewhat with the FY22 with %CV 21.6 (mean 0.0211 mg-N/L), though still high historically.

Acceptance Limits of Provided Particulate Samples:

For each study, particulate carbon, nitrogen, phosphorus and chlorophyll a samples were filtered from a common estuarine water sample and, consequently, are not true blind audit samples made from pure constituents. There is no “true” or prepared concentration with which to compare. The standard deviation was less than 10% of the mean reported concentrations for particulate carbon and nitrogen for the fall 2021 and spring 2022 audits.

Over the years, the concentration of particulate constituents provided to the participants has varied randomly over approximately a five-fold range. For example, particulate carbon in spring 1998 was approximately 0.45 mg C/L, and in fall 2018 was approximately 2.2 mg C/L. Particulate phosphorus in spring 2014 was 0.0091 mg P/L and in spring 1999 was 0.0529 mg P/L.

Reporting Data Accurately:

Most data originally reported by all participants for both these blind audits appeared, on casual inspection, to be reported accurately. Subtle entry or calculation errors may have gone undetected.

The fall 2007 and spring 2008 audits were the first pair of audits in which no participant noted any discrepancies when all were contacted to review their data. No results were miscalculated (and later corrected), or had “slipped a decimal” or exhibited some other obvious entry error that could have been easily avoided. After years of reporting “difficulties,” participants had improved their reporting practices. This improvement in reporting did not extend to the fall 2008 through fall 2010 audits. At last, for the spring 2011 audit, no participant noted any discrepancies when all were contacted to review their data. We had returned to that condition where no results were miscalculated (and later corrected), or had “slipped a decimal” or exhibited some other obvious entry error that could have been easily avoided. Unfortunately, for the fall 2011 blind audit, results were reported and then later corrected. Over the next five audits (spring 2012 through spring 2014) no participant noted any discrepancies when all were contacted to review their data. This improvement in reporting did not extend to the next audits; fall through spring 2021. Results were reported late, or reported and then later corrected, or even retracted. For the sake of fairness across the participant cohort, as well as consistency in reference to other similar studies, all initial data submissions will be considered final. There will be no opportunity to review or alter data after it is submitted.

The number of significant figures reported in analytical results can significantly affect data comparability in a blind audit study. If a laboratory reports only two significant figures (for whatever reasons) and an audit sample has a prepared concentration expressed in three significant figures, then substantial under or over estimates of the comparative concentration can be reported. For example, if a 0.032 mg P/L sample has been prepared and a laboratory only reports two significant figures, i.e., 0.03 mg P/L, then the results expressed are 86% of the prepared value. During the 2000 study, all participants reported three significant digits for most parameters. It is noteworthy that the 2000 study's coefficients of variation were, generally, smaller than in the previous two years, probably a result of comparisons of data containing the appropriate number of significant digits. Unfortunately, some 2001 through spring 2021 participants reported only two significant digits for some analytes, thus potentially giving substantial under or over estimates for the comparisons.

CONCLUSION

Now that forty-nine rounds of the Blind Audit Program have been completed, some consistent patterns have been observed that warrant action or further investigation:

1. Results for particulate carbon and nitrogen were generally consistent between laboratories. Reported concentrations of particulate analytes have usually been similar between laboratories participating in the Blind Audit Program. This was true again this year. Observed %CV values from fall 2015 through spring 2021 (22 surveys) all below 20%. All but two below 15%. While particulate carbon exhibited lower than normal %CV values for both surveys (3.6 and 3.7%), particulate nitrogen saw an increase in %CV (28.9 and 16.4%). However one value should be considered anomalous (despite only being >2 SD above the mean), and its exclusion brings the %CV for that survey down to 13%.
2. In contrast to particulate carbon and nitrogen, particulate phosphorus concentrations have shown more variability between participating laboratories in some audit years. This year all participants reported particulate phosphorus concentrations were consistent with each other (7.1 and 14.6%). Note, spring 2020 demonstrated the best agreement during the period of fall 2015 through spring 2021 (22 surveys) with %CV of 6.7. Fall 2021 and Spring 2022 maintained the trend (10.1 and 9.5%CV).
3. For all participating laboratories in both audits, there was remarkable consistency between participating laboratories in the measurement of total suspended solids from suspensions of infusorial earth. %CV values for both studies were outstanding; 2.7 and 2.4%.
4. Most of the chlorophyll a results for the fall 2021 and spring 2022 audits displayed agreement that was remarkable for multi-laboratory comparison of low concentrations of an environmentally transitory compound. It may not be possible to achieve better agreement due to the more challenging nature of the analysis.
5. Reported concentrations of dissolved analytes were usually similar between laboratories participating in the Blind Audit Program. No laboratory reported concentrations for individual analytes that were widely different from the range of the other reported concentrations for both blind audits. This indicates that most participating laboratories usually execute and report these measurements with accuracy and precision, reporting the appropriate number of significant digits.
6. When comparing reported concentrations to those prepared, the lower concentration ranges had more data that fell beyond +/- 10% of the prepared sample than the higher level

concentration ranges, i.e., there was less accuracy at the lower concentration ranges. This was particularly apparent for total dissolved phosphorus, ammonium and orthophosphate. The categories for PASS, WARN, and FAIL for low concentration samples are quite narrow. Therefore, for very low concentrations of prepared samples, it may be appropriate to broaden the acceptance boundaries.

7. Care should continue to be taken when completing report forms. For the fall 2021 and spring 2022 blind audits, a few results were reported with insufficient significant digits, or were illegible and required clarification.

Table 1. Participants in Fall 2021 and Spring 2022 Blind Audit Program.

Participant Institution	Point of Contact	Phone	Email
Old Dominion University, Water Quality Laboratory (ODU)	Suzanne Doughton	757-451-3044	sdoughte@odu.edu
University of Maryland, Horn Point Laboratory (HPL)	Erica Kiss	410-221-8317	ekiss@umces.edu
Virginia Institute of Marine Science, Analytical Service Center (VIMS)	Carol Pollard	804-684-7213	pollard@vims.edu
Virginia Division of Consolidated Laboratory Services (DCLS)	Jay Armstrong	804-648-4480 x328	jay.armstrong@dgs.virginia.gov
Maryland Department of Health (MDH)	Cynthia Stevenson	443-681-3851	cynthia.stevenson@maryland.gov
University of Maryland Chesapeake Biological Laboratory (CBL)	Jerry Frank	410-326-7252	frank@umces.edu
Delaware Department of Natural Resources (DNREC)	Kathy Knowles	302-739-9276	kathy.knowles@state.de.us
Academy of Natural Science of Philadelphia (ACNAT)	Melissa Bross	215-299-1142	mab582@drexel.edu
Pennsylvania DEP, Bureau of Laboratories (PADEP)	Cristina Vega Ramirez Anthony Friedline	717-346-8230	cvegaramir@pa.gov anfriedlin@pa.gov
Massachusetts Water Resources Authority, Central Laboratory (MWRA)	Jennifer Constantino	617-660-7808	jennifer.constantino@mwra.com
Hampton Roads Sanitation District, Central Environmental Laboratory (HRSD)	Reggie Morgan Kim Fielder	757-460-4210 757-460-4261	rmorgan@hrsd.com amoore@hrsd.com
Occoquan Watershed Monitoring Lab (OWML)	Dongmei Alvi	703-361-5606	dongmei@vt.edu
University of Connecticut Center for Environmental Science & Engineering (UCONN)	Chris Perkins	860-486-2668	christopher.perkins@uconn.edu
New Jersey Department of Health (NJDH)	Doug Haltmeier	609-530-2801	douglas.haltmeier@doh.nj.gov
Sprague River Water Quality Laboratory (SRWQL)	Teresa Coley	541-827-5243	teresa.coley@klamathtribes.com
University of Maryland Appalachian Laboratory (AL)	Katie Kline	301-689-7122	kkline@umces.edu
Interstate Environmental Commission (IEC)	Evelyn Powers	347-803-0422	epowers@iec-nynjct.org

Table 2. Summary of Mean Concentration and Standard Deviation for Each Group of Analytes in the Fall 2021 and the Spring 2022 Blind Audit, Including Distribution of Reported Concentrations from the Mean.

Parameter	Concentration in mg/L		Number of Laboratories			
			Standard Deviations from Mean			
			<1	1-2	2-3	>3
	Mean	S.D.	PASS	PASS	WARN	FAIL
Fall 2021						
Total Dissolved Nitrogen	0.3537	0.0454	10	2	1	0
Total Dissolved Phosphorus	0.0204	0.0022	12	1	0	1
Total Dissolved Nitrogen	0.6956	0.0533	12	1	2	0
Total Dissolved Phosphorus	0.0581	0.0038	12	3	1	0
Ammonium	0.0211	0.0044	9	5	0	0
Nitrite+nitrate	0.0696	0.0047	10	2	1	1
Phosphate	0.0193	0.0021	9	4	1	0
Ammonium	0.0592	0.0061	11	4	1	0
Nitrite+nitrate	0.2125	0.0110	13	1	2	0
Phosphate	0.0371	0.0021	11	4	1	0
Dissolved Organic Carbon	2.1360	0.1590	9	1	1	0
Dissolved Organic Carbon	10.3194	0.4830	7	3	1	0
Total Suspended Solids	35.0688	0.9595	10	6	1	0
Chlorophyll	9.4111	2.0479	11	2	1	0
Particulate Carbon	1.9293	0.0699	7	3	0	0
Particulate Nitrogen	0.3100	0.0895	9	0	1	0
Particulate Phosphorus	0.0262	0.0026	6	2	1	0
Spring 2022						
Total Dissolved Nitrogen	0.2255	0.0290	7	4	1	0
Total Dissolved Phosphorus	0.0328	0.0092	11	0	1	0
Total Dissolved Nitrogen	0.8832	0.0305	10	3	1	0
Total Dissolved Phosphorus	0.0540	0.0105	11	1	2	0
Ammonium	0.0429	0.0061	8	5	0	0
Nitrite+nitrate	0.1440	0.0141	12	0	0	1
Phosphate	0.0231	0.0015	11	2	0	0
Ammonium	0.2564	0.0165	9	6	0	0
Nitrite+nitrate	0.8593	0.0401	12	2	1	0
Phosphate	0.0461	0.0026	11	3	1	0
Dissolved Organic Carbon	3.0990	0.3032	8	3	0	0
Dissolved Organic Carbon	8.4563	0.7003	10	0	1	0
Total Suspended Solids	47.9719	1.1713	13	2	1	0
Chlorophyll	7.5500	2.1952	9	3	1	0
Particulate Carbon	1.1994	0.0449	7	2	0	0
Particulate Nitrogen	0.2132	0.0350	8	0	1	0
Particulate Phosphorus	0.0211	0.0020	5	2	1	0

Table 3. Summary of Prepared and Reported Concentrations for Each Analyte and Percent Recovery of the Prepared Concentrations by Participating Laboratories

Parameter	Prepared Concentration mg/L	Reported Concentration Range mg/L		Number of Laboratories		
		Min	Max	Within 90% - 110% of Prepared Concentration	Within 80 - 90%, or 110- 120% of Prepared Concentration	<80%, or >120% of Prepared Concentration
Fall 2021		Min - Max		PASS	WARN	FAIL
Total Dissolved Nitrogen	0.3530	0.2370	0.4090	10	1	2
Total Dissolved Phosphorus	0.0190	0.0051	0.0257	7	1	1
Total Dissolved Nitrogen	0.7060	0.5680	0.7490	13	2	0
Total Dissolved Phosphorus	0.0560	0.0415	0.0683	12	2	2
Ammonium	0.0210	0.0139	0.0300	6	3	5
Nitrite+nitrate	0.0701	0.0366	0.0814	11	2	1
Phosphate	0.0186	0.0160	0.0240	8	4	2
Ammonium	0.0640	0.0450	0.0710	10	5	1
Nitrite+nitrate	0.2102	0.1900	0.2370	14	2	0
Phosphate	0.0371	0.0323	0.0409	14	2	0
Dissolved Organic Carbon	2.00	1.96	2.57	8	2	1
Dissolved Organic Carbon	9.99	9.75	11.40	10	1	0
Total Suspended Solids	36.3	33.1	36.4	17	0	0
Spring 2022						
Total Dissolved Nitrogen	0.2170	0.1880	0.2950	8	3	1
Total Dissolved Phosphorus	0.0290	0.0250	0.0603	7	2	3
Total Dissolved Nitrogen	0.8680	0.8265	0.9462	14	0	0
Total Dissolved Phosphorus	0.0490	0.0400	0.0802	10	2	2
Ammonium	0.0420	0.0326	0.0535	7	2	4
Nitrite+nitrate	0.1401	0.1320	0.1900	12	0	1
Phosphate	0.0223	0.0208	0.0260	10	3	0
Ammonium	0.2550	0.2270	0.2849	11	4	0
Nitrite+nitrate	0.8407	0.8102	0.9790	14	1	0
Phosphate	0.0446	0.0410	0.0526	13	2	0
Dissolved Organic Carbon	3.00	2.55	3.61	6	4	1
Dissolved Organic Carbon	7.99	7.89	10.50	9	1	1
Total Suspended Solids	50.0	44.9	49.5	15	1	0

*The prepared sample concentration was quite low, so the acceptance boundaries are narrow.

Appendix 1 Fall 2021 and Spring 2022 Reported Concentrations, Prepared Concentrations and Recoveries**University of Connecticut Center for Environmental Science and Engineering (UConn)**

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	0.3490	P	0.353	98.9		0.2010	P	0.217	92.6
TDP (mg P/L)	0.0240	F	0.019	126.3		0.0250	W	0.029	86.2
TDN (mg N/L)	0.7280	P	0.706	103.1		0.8400	P	0.868	96.8
TDP (mg P/L)	0.0560	P	0.056	100.0		0.0500	P	0.049	102.0
NH4 (mg N/L)	0.0180	W	0.021	85.7		0.0420	P	0.042	100.0
NO23 (mg N/L)	0.0680	P	0.0701	97.0		0.1420	P	0.1401	101.4
PO4 (mg P/L)	0.0190	P	0.0186	102.2		0.0260	W	0.0223	116.6
NH4 (mg N/L)	0.0590	P	0.064	92.2		0.2530	P	0.255	99.2
NO23 (mg N/L)	0.2090	P	0.2102	99.4		0.8290	P	0.8407	98.6
PO4 (mg P/L)	0.0350	P	0.0371	94.3		0.0410	P	0.0446	91.9
DOC (mg C/L)	2.08	P	1.997	104.1		2.58	W	2.996	86.1
DOC (mg C/L)	10.02	P	9.985	100.4		8.04	P	7.988	100.6
TSS (mg/L)	35.6	P	36.3	98.1		48.30	P	50	96.6
CHL (ug/L)	9.65	NA	NA	NA		3.05	NA	NA	NA
PC (mg C/L)	1.9195	NA	NA	NA		1.2390	NA	NA	NA
PN (mg N/L)	0.2555	NA	NA	NA		0.1840	NA	NA	NA
PP (mg P/L)	0.0220	NA	NA	NA		0.0185	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Academy of Natural Science of Philadelphia (ACNAT)

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	0.2790	F	0.353	79.0		0.1950	W	0.217	89.9
TDP (mg P/L)	0.0230	F	0.019	121.1		0.0388	F	0.029	133.8
TDN (mg N/L)	0.5680	W	0.706	80.5		0.8750	P	0.868	100.8
TDP (mg P/L)	0.0650	W	0.056	116.1		0.0522	P	0.049	106.5
NH4 (mg N/L)	0.0264	F	0.021	125.7		0.0390	P	0.042	92.9
NO23 (mg N/L)	0.0686	P	0.0701	97.9		0.1340	P	0.1401	95.6
PO4 (mg P/L)	0.0179	P	0.0186	96.2		0.0224	P	0.0223	100.4
NH4 (mg N/L)	0.0672	P	0.064	105.0		0.2460	P	0.255	96.5
NO23 (mg N/L)	0.2040	P	0.2102	97.1		0.8410	P	0.8407	100.0
PO4 (mg P/L)	0.0370	P	0.0371	99.7		0.0458	P	0.0446	102.7
DOC (mg C/L)	*	*	1.997	*		*	*	2.996	*
DOC (mg C/L)	*	*	9.985	*		*	*	7.988	*
TSS (mg/L)	34.0	P	36.3	93.7		47.00	P	50	94.0
CHL (ug/L)	*	NA	NA	NA		*	NA	NA	NA
PC (mg C/L)	1.8900	NA	NA	NA		1.2300	NA	NA	NA
PN (mg N/L)	0.2575	NA	NA	NA		0.2220	NA	NA	NA
PP (mg P/L)	0.0248	NA	NA	NA		0.0213	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Appendix 1 Cont'. Fall 2021 and Spring 2022 Reported Concentrations, Prepared Concentrations and Recoveries**Virginia Institute of Marine Science, Analytical Service Center (VIMS)**

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration		Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration		Spring 2022 Percent Recovered	
TDN (mg N/L)	0.3823	P	0.353		108.3		0.2345	P	0.217		108.1	
TDP (mg P/L)	0.0202	P	0.019		106.3		0.0315	P	0.029		108.6	
TDN (mg N/L)	0.7012	P	0.706		99.3		0.9462	P	0.868		109.0	
TDP (mg P/L)	0.0568	P	0.056		101.4		0.0496	P	0.049		101.2	
NH4 (mg N/L)	0.0139	F	0.021		66.2		0.0535	F	0.042		127.4	
NO23 (mg N/L)	0.0701	P	0.0701		100.0		0.1440	P	0.1401		102.8	
PO4 (mg P/L)	0.0170	P	0.0186		91.4		0.0218	P	0.0223		97.8	
NH4 (mg N/L)	0.0557	W	0.064		87.0		0.2849	W	0.255		111.7	
NO23 (mg N/L)	0.2152	P	0.2102		102.4		0.8102	P	0.8407		96.4	
PO4 (mg P/L)	0.0360	P	0.0371		97.0		0.0454	P	0.0446		101.8	
DOC (mg C/L)	*	*	1.997		*		*	*	2.996		*	
DOC (mg C/L)	*	*	9.985		*		*	*	7.988		*	
TSS (mg/L)	36.1	P	36.3		99.4		48.70	P	50		97.4	
CHL (ug/L)	10.70	NA	NA		NA		9.63	NA	NA		NA	
PC (mg C/L)	1.9665	NA	NA		NA		1.2560	NA	NA		NA	
PN (mg N/L)	0.2890	NA	NA		NA		0.2100	NA	NA		NA	
PP (mg P/L)	0.0264	NA	NA		NA		0.0219	NA	NA		NA	

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Hampton Roads Sanitation District, Central Environmental Laboratory (HRSD)

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration		Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration		Spring 2022 Percent Recovered	
TDN (mg N/L)	*	*	0.353		*		*	*	0.217		*	
TDP (mg P/L)	*	*	0.019		*		*	*	0.029		*	
TDN (mg N/L)	0.7490	P	0.706		106.1		0.9140	P	0.868		105.3	
TDP (mg P/L)	0.0590	P	0.056		105.4		0.0510	P	0.049		104.1	
NH4 (mg N/L)	*	*	0.021		*		*	*	0.042		*	
NO23 (mg N/L)	*	*	0.0701		*		*	*	0.1401		*	
PO4 (mg P/L)	*	*	0.0186		*		*	*	0.0223		*	
NH4 (mg N/L)	0.0580	P	0.064		90.6		0.2440	P	0.255		95.7	
NO23 (mg N/L)	0.2100	P	0.2102		99.9		0.8340	P	0.8407		99.2	
PO4 (mg P/L)	0.0400	P	0.0371		107.8		0.0500	W	0.0446		112.1	
DOC (mg C/L)	2.24	W	1.997		112.2		3.30	W	2.996		110.1	
DOC (mg C/L)	10.40	P	9.985		104.2		8.37	P	7.988		104.8	
TSS (mg/L)	36.2	P	36.3		99.7		47.10	P	50		94.2	
CHL (ug/L)	6.07	NA	NA		NA		4.88	NA	NA		NA	
PC (mg C/L)	*	NA	NA		NA		*	NA	NA		NA	
PN (mg N/L)	*	NA	NA		NA		*	NA	NA		NA	
PP (mg P/L)	*	NA	NA		NA		*	NA	NA		NA	

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Appendix 1 Cont'. Fall 2021 and Spring 2022 Reported Concentrations, Prepared Concentrations and Recoveries**University of Maryland, Horn Point Laboratory (HPL)**

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	*	*	0.353	*		*	P	0.217	*
TDP (mg P/L)	*	*	0.019	*		*	P	0.029	*
TDN (mg N/L)	*	*	0.706	*		*	P	0.868	*
TDP (mg P/L)	*	*	0.056	*		*	P	0.049	*
NH4 (mg N/L)	*	*	0.021	*		*	P	0.042	*
NO23 (mg N/L)	*	*	0.0701	*		*	P	0.1401	*
PO4 (mg P/L)	*	*	0.0186	*		*	P	0.0223	*
NH4 (mg N/L)	*	*	0.064	*		*	P	0.255	*
NO23 (mg N/L)	*	*	0.2102	*		*	P	0.8407	*
PO4 (mg P/L)	*	*	0.0371	*		*	P	0.0446	*
DOC (mg C/L)	*	*	1.997	*		*	*	2.996	*
DOC (mg C/L)	*	*	9.985	*		*	*	7.988	*
TSS (mg/L)	34.9	P	36.3	96.1		48.15	P	50	96.3
CHL (ug/L)	10.93	NA	NA	NA		8.56	NA	NA	NA
PC (mg C/L)	*	NA	NA	NA		*	NA	NA	NA
PN (mg N/L)	*	NA	NA	NA		*	NA	NA	NA
PP (mg P/L)	*	NA	NA	NA		*	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Delaware Department of Natural Resources (DNREC)

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	0.3610	P	0.353	102.3		0.2310	P	0.217	106.5
TDP (mg P/L)	0.0208	P	0.019	109.5		0.0289	P	0.029	99.7
TDN (mg N/L)	0.7190	P	0.706	101.8		0.8800	P	0.868	101.4
TDP (mg P/L)	0.0578	P	0.056	103.2		0.0523	P	0.049	106.7
NH4 (mg N/L)	0.0212	P	0.021	101.0		0.0365	W	0.042	86.9
NO23 (mg N/L)	0.0750	P	0.0701	107.0		0.1320	P	0.1401	94.2
PO4 (mg P/L)	0.0217	W	0.0186	116.7		0.0252	W	0.0223	113.0
NH4 (mg N/L)	0.0515	W	0.064	80.5		0.2580	P	0.255	101.2
NO23 (mg N/L)	0.2070	P	0.2102	98.5		0.8460	P	0.8407	100.6
PO4 (mg P/L)	0.0409	W	0.0371	110.2		0.0526	W	0.0446	117.9
DOC (mg C/L)	2.04	P	1.997	102.2		2.90	P	2.996	96.8
DOC (mg C/L)	10.40	P	9.985	104.2		7.89	P	7.988	98.8
TSS (mg/L)	34.0	P	36.3	93.7		48.90	P	50	97.8
CHL (ug/L)	12.55	NA	NA	NA		9.81	NA	NA	NA
PC (mg C/L)	1.9100	NA	NA	NA		1.2000	NA	NA	NA
PN (mg N/L)	0.2755	NA	NA	NA		0.2005	NA	NA	NA
PP (mg P/L)	0.0273	NA	NA	NA		0.0189	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Appendix 1 Cont'. Fall 2021 and Spring 2022 Reported Concentrations, Prepared Concentrations and Recoveries**Division of Consolidated Laboratory Services (DCLS)**

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	0.3750	P	0.353	106.2		0.2260	P	0.217	104.1
TDP (mg P/L)	0.0200	P	0.019	105.3		0.0370	F	0.029	127.6
TDN (mg N/L)	0.7200	P	0.706	102.0		0.8840	P	0.868	101.8
TDP (mg P/L)	0.0540	P	0.056	96.4		0.0760	F	0.049	155.1
NH4 (mg N/L)	0.0200	P	0.021	95.2		0.0420	P	0.042	100.0
NO23 (mg N/L)	0.0720	P	0.0701	102.7		0.1480	P	0.1401	105.6
PO4 (mg P/L)	0.0190	P	0.0186	102.2		0.0230	P	0.0223	103.1
NH4 (mg N/L)	0.0630	P	0.064	98.4		0.2500	P	0.255	98.0
NO23 (mg N/L)	0.2150	P	0.2102	102.3		0.8740	P	0.8407	104.0
PO4 (mg P/L)	0.0370	P	0.0371	99.7		0.0460	P	0.0446	103.1
DOC (mg C/L)	2.57	F	1.997	128.7		3.34	W	2.996	111.5
DOC (mg C/L)	10.90	P	9.985	109.2		8.40	P	7.988	105.2
TSS (mg/L)	36.0	P	36.3	99.2		49.00	P	50	98.0
CHL (ug/L)	8.92	NA	NA	NA		8.32	NA	NA	NA
PC (mg C/L)	1.8950	NA	NA	NA		1.2150	NA	NA	NA
PN (mg N/L)	0.2730	NA	NA	NA		0.1965	NA	NA	NA
PP (mg P/L)	0.0268	NA	NA	NA		0.0215	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
 "W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

University of Maryland, Chesapeake Biological Laboratory (CBL)

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	0.3800	P	0.353	107.6		0.2200	P	0.217	101.4
TDP (mg P/L)	0.0202	P	0.019	106.3		0.0266	P	0.029	91.7
TDN (mg N/L)	0.7400	P	0.706	104.8		0.9100	P	0.868	104.8
TDP (mg P/L)	0.0580	P	0.056	103.6		0.0480	P	0.049	98.0
NH4 (mg N/L)	0.0228	P	0.021	108.6		0.0424	P	0.042	101.0
NO23 (mg N/L)	0.0806	W	0.0701	115.0		0.1490	P	0.1401	106.4
PO4 (mg P/L)	0.0187	P	0.0186	100.5		0.0217	P	0.0223	97.3
NH4 (mg N/L)	0.0649	P	0.064	101.4		0.2810	W	0.255	110.2
NO23 (mg N/L)	0.2330	W	0.2102	110.8		0.8530	P	0.8407	101.5
PO4 (mg P/L)	0.0379	P	0.0371	102.2		0.0463	P	0.0446	103.8
DOC (mg C/L)	1.96	P	1.997	98.1		3.28	P	2.996	109.5
DOC (mg C/L)	10.11	P	9.985	101.3		8.38	P	7.988	104.9
TSS (mg/L)	33.8	P	36.3	93.1		48.80	P	50	97.6
CHL (ug/L)	9.97	NA	NA	NA		8.37	NA	NA	NA
PC (mg C/L)	1.8200	NA	NA	NA		1.1300	NA	NA	NA
PN (mg N/L)	0.2720	NA	NA	NA		0.1920	NA	NA	NA
PP (mg P/L)	0.0267	NA	NA	NA		0.0211	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
 "W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Appendix 1 Cont'. Fall 2021 and Spring 2022 Reported Concentrations, Prepared Concentrations and Recoveries**Virginia Polytechnic Institute, Occoquan Watershed Monitoring Laboratory (OWML)**

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	0.2370	F	0.353	67.1		0.1880	W	0.217	86.6
TDP (mg P/L)	0.0230	F	0.019	121.1		0.0250	W	0.029	86.2
TDN (mg N/L)	0.5870	W	0.706	83.1		0.8850	P	0.868	102.0
TDP (mg P/L)	0.0550	P	0.056	98.2		0.0400	P	0.049	81.6
NH4 (mg N/L)	0.0290	F	0.021	138.1		0.0510	F	0.042	121.4
NO23 (mg N/L)	0.0710	P	0.0701	101.3		0.1380	P	0.1401	98.5
PO4 (mg P/L)	0.0200	P	0.0186	107.5		0.0230	P	0.0223	103.1
NH4 (mg N/L)	0.0710	W	0.064	110.9		0.2540	P	0.255	99.6
NO23 (mg N/L)	0.2180	P	0.2102	103.7		0.8700	P	0.8407	103.5
PO4 (mg P/L)	0.0370	P	0.0371	99.7		0.0460	P	0.0446	103.1
DOC (mg C/L)	2.10	P	1.997	105.0		2.55	W	2.996	85.1
DOC (mg C/L)	9.75	P	9.985	97.7		8.06	P	7.988	100.9
TSS (mg/L)	35.2	P	36.3	97.0		47.50	P	50	95.0
CHL (ug/L)	4.65	NA	NA	NA		3.38	NA	NA	NA
PC (mg C/L)	1.9315	NA	NA	NA		1.1250	NA	NA	NA
PN (mg N/L)	0.2570	NA	NA	NA		0.3080	NA	NA	NA
PP (mg P/L)	*	NA	NA	NA		*	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Maryland Department of Health (MDH)

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	0.4090	W	0.353	115.9		0.2230	P	0.217	102.8
TDP (mg P/L)	0.0195	P	0.019	102.6		0.0298	P	0.029	102.8
TDN (mg N/L)	0.7080	P	0.706	100.3		0.8420	P	0.868	97.0
TDP (mg P/L)	0.0579	P	0.056	103.4		0.0472	P	0.049	96.3
NH4 (mg N/L)	0.0220	F	0.021	104.8		0.0326	F	0.042	77.6
NO23 (mg N/L)	0.0717	P	0.0701	102.3		0.1430	P	0.1401	102.1
PO4 (mg P/L)	0.0205	W	0.0186	110.2		0.0237	P	0.0223	106.3
NH4 (mg N/L)	0.0559	W	0.064	87.3		0.2270	W	0.255	89.0
NO23 (mg N/L)	0.2150	P	0.2102	102.3		0.8530	P	0.8407	101.5
PO4 (mg P/L)	0.0388	P	0.0371	104.6		0.0463	P	0.0446	103.8
DOC (mg C/L)	2.04	P	1.997	102.2		3.10	P	2.996	103.5
DOC (mg C/L)	9.87	P	9.985	98.8		8.06	P	7.988	100.9
TSS (mg/L)	36.0	P	36.3	99.2		48.50	P	50	97.0
CHL (ug/L)	8.47	NA	NA	NA		7.48	NA	NA	NA
PC (mg C/L)	1.8650	NA	NA	NA		1.1700	NA	NA	NA
PN (mg N/L)	0.2810	NA	NA	NA		0.2035	NA	NA	NA
PP (mg P/L)	0.0235	NA	NA	NA		0.0201	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Appendix 1 Cont'. Fall 2021 and Spring 2022 Reported Concentrations, Prepared Concentrations and Recoveries**Massachusetts Water Resource Authority, Central Laboratory (MWRA)**

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	0.3750	P	0.353	106.2		*	P	0.217	*
TDP (mg P/L)	0.0257	F	0.019	135.3		*	F	0.029	*
TDN (mg N/L)	0.7330	W	0.706	103.8		*	P	0.868	*
TDP (mg P/L)	0.0683	F	0.056	122.0		*	F	0.049	*
NH4 (mg N/L)	0.019	P	0.021	90.5		*	W	0.042	*
NO23 (mg N/L)	0.0681	P	0.0701	97.1		*	P	0.1401	*
PO4 (mg P/L)	0.0166	W	0.0186	89.2		*	P	0.0223	*
NH4 (mg N/L)	0.0611	P	0.064	95.5		*	P	0.255	*
NO23 (mg N/L)	0.2050	P	0.2102	97.5		*	P	0.8407	*
PO4 (mg P/L)	0.0362	P	0.0371	97.6		*	P	0.0446	*
DOC (mg C/L)	*	*	1.997	*		*	*	2.996	*
DOC (mg C/L)	*	*	9.985	*		*	*	7.988	*
TSS (mg/L)	33.1	P	36.3	91.2		*	W	50	*
CHL (ug/L)	10.50	NA	NA	NA		*	NA	NA	NA
PC (mg C/L)	2.0600	NA	NA	NA		*	NA	NA	NA
PN (mg N/L)	0.5570	NA	NA	NA		*	NA	NA	NA
PP (mg P/L)	0.0320	NA	NA	NA		*	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Old Dominion University, Water Quality Laboratory (ODU)

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	0.3600	P	0.353	102.0		0.2370	P	0.217	109.2
TDP (mg P/L)	0.0185	P	0.019	97.4		0.0285	P	0.029	98.3
TDN (mg N/L)	0.7150	P	0.706	101.3		0.8820	P	0.868	101.6
TDP (mg P/L)	0.0591	P	0.056	105.5		0.0499	P	0.049	101.8
NH4 (mg N/L)	0.0179	W	0.021	85.2		0.0420	P	0.042	100.0
NO23 (mg N/L)	0.0744	P	0.0701	106.1		0.1380	P	0.1401	98.5
PO4 (mg P/L)	0.0187	P	0.0186	100.5		0.0224	P	0.0223	100.4
NH4 (mg N/L)	0.0579	P	0.064	90.5		0.2520	P	0.255	98.8
NO23 (mg N/L)	0.2200	P	0.2102	104.7		0.8350	P	0.8407	99.3
PO4 (mg P/L)	0.0385	P	0.0371	103.8		0.0454	P	0.0446	101.8
DOC (mg C/L)	2.00	P	1.997	100.2		3.16	P	2.996	105.5
DOC (mg C/L)	9.76	P	9.985	97.7		8.32	P	7.988	104.2
TSS (mg/L)	35.2	P	36.3	97.0		48.30	P	50	96.6
CHL (ug/L)	10.69	NA	NA	NA		8.90	NA	NA	NA
PC (mg C/L)	2.0350	NA	NA	NA		1.2300	NA	NA	NA
PN (mg N/L)	0.3820	NA	NA	NA		0.2020	NA	NA	NA
PP (mg P/L)	0.0259	NA	NA	NA		0.0255	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Appendix 1 Cont'. Fall 2021 and Spring 2022 Reported Concentrations, Prepared Concentrations and Recoveries**Pennsylvania Department of Environmental Protection, Bureau of Laboratories (PADEP)**

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	*	*	0.353	*		*	*	0.217	*
TDP (mg P/L)	*	*	0.019	*		*	*	0.029	*
TDN (mg N/L)	0.6600	P	0.706	93.5		0.8900	P	0.868	102.5
TDP (mg P/L)	0.0590	P	0.056	105.4		0.0510	P	0.049	104.1
NH4 (mg N/L)	*	*	0.021	*		*	*	0.042	*
NO23 (mg N/L)	*	*	0.0701	*		*	*	0.1401	*
PO4 (mg P/L)	*	*	0.0186	*		*	*	0.0223	*
NH4 (mg N/L)	0.0450	F	0.064	70.3		0.2390	P	0.255	93.7
NO23 (mg N/L)	0.1900	P	0.2102	90.4		0.8600	P	0.8407	102.3
PO4 (mg P/L)	0.0360	P	0.0371	97.0		0.0430	P	0.0446	96.4
DOC (mg C/L)	2.21	W	1.997	110.7		3.11	P	2.996	103.8
DOC (mg C/L)	10.30	P	9.985	103.2		8.07	P	7.988	101.0
TSS (mg/L)	35.0	P	36.3	96.4		46.00	P	50	92.0
CHL (ug/L)	8.12	NA	NA	NA		9.29	NA	NA	NA
PC (mg C/L)	*	NA	NA	NA		*	NA	NA	NA
PN (mg N/L)	*	NA	NA	NA		*	NA	NA	NA
PP (mg P/L)	*	NA	NA	NA		*	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
 "W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

New Jersey Department of Health (NJDH)

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	*	*	0.353	*		*	*	0.217	*
TDP (mg P/L)	0.0227	W	0.019	119.5		0.0316	P	0.029	109.0
TDN (mg N/L)	*	*	0.706	*		*	*	0.868	*
TDP (mg P/L)	0.0593	P	0.056	105.9		0.0582	W	0.049	118.8
NH4 (mg N/L)	0.0215	P	0.021	102.4		0.0527	F	0.042	125.5
NO23 (mg N/L)	0.0814	W	0.0701	116.1		0.1900	F	0.1401	135.6
PO4 (mg P/L)	0.0160	W	0.0186	86.0		0.0208	P	0.0223	93.3
NH4 (mg N/L)	0.0610	P	0.064	95.3		0.2820	F	0.255	110.6
NO23 (mg N/L)	0.2370	W	0.2102	112.7		0.9790	F	0.8407	116.5
PO4 (mg P/L)	0.0323	W	0.0371	87.1		0.0456	P	0.0446	102.2
DOC (mg C/L)	2.15	P	1.997	107.7		3.61	F	2.996	120.5
DOC (mg C/L)	10.60	P	9.985	106.2		8.93	W	7.988	111.8
TSS (mg/L)	34.2	P	36.3	94.2		48.10	P	50	96.2
CHL (ug/L)	*	NA	NA	NA		*	NA	NA	NA
PC (mg C/L)	*	NA	NA	NA		*	NA	NA	NA
PN (mg N/L)	*	NA	NA	NA		*	NA	NA	NA
PP (mg P/L)	*	NA	NA	NA		*	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
 "W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Appendix 1 Cont'. Fall 2021 and Spring 2022 Reported Concentrations, Prepared Concentrations and Recoveries**Sprague River Water Quality Laboratory (SRWQL)**

	Fall 2021 Reported Concentration			Fall 2021 Prepared Concentration			Fall 2021 Percent Recovered			Spring 2022 Reported Concentration			Spring 2022 Prepared Concentration			Spring 2022 Percent Recovered		
TDN (mg N/L)	0.3530	P		0.353			100.0			0.1957	P		0.217			90.2		
TDP (mg P/L)	0.0240	F		0.019			126.3			0.0603	F		0.029			207.9		
TDN (mg N/L)	0.6670	P		0.706			94.5			0.8265	P		0.868			95.2		
TDP (mg P/L)	0.0650	W		0.056			116.1			0.0802	F		0.049			163.7		
NH4 (mg N/L)	0.0300	F		0.021			142.9			0.0445	P		0.042			106.0		
NO23 (mg N/L)	0.0640	P		0.0701			91.3			0.1412	P		0.1401			100.8		
PO4 (mg P/L)	0.0240	F		0.0186			129.0			0.0234	P		0.0223			104.9		
NH4 (mg N/L)	0.0630	P		0.064			98.4			0.2504	P		0.255			98.2		
NO23 (mg N/L)	0.2090	P		0.2102			99.4			0.8452	P		0.8407			100.5		
PO4 (mg P/L)	0.0360	P		0.0371			97.0			0.0465	P		0.0446			104.3		
DOC (mg C/L)	*	*		1.997			*			*	*		2.996			*		
DOC (mg C/L)	*	*		9.985			*			*	*		7.988			*		
TSS (mg/L)	36.4	P		36.3			100.3			49.50	P		50			99.0		
CHL (ug/L)	10.35	NA		NA			NA			7.84	NA		NA			NA		
PC (mg C/L)	*	NA		NA			NA			*	NA		NA			NA		
PN (mg N/L)	*	NA		NA			NA			*	NA		NA			NA		
PP (mg P/L)	*	NA		NA			NA			*	NA		NA			NA		

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

University of Maryland Appalachian Laboratory (AL)

	Fall 2021 Reported Concentration			Fall 2021 Prepared Concentration			Fall 2021 Percent Recovered			Spring 2022 Reported Concentration			Spring 2022 Prepared Concentration			Spring 2022 Percent Recovered		
TDN (mg N/L)	0.3580	P		0.353			101.4			0.2600	W		0.217			119.8		
TDP (mg P/L)	0.0192	P		0.019			101.1			0.0300	P		0.029			103.4		
TDN (mg N/L)	0.7220	P		0.706			102.3			0.8840	P		0.868			101.8		
TDP (mg P/L)	0.0575	P		0.056			102.7			0.0510	P		0.049			104.1		
NH4 (mg N/L)	0.0186	W		0.021			88.6			0.0370	W		0.042			88.1		
NO23 (mg N/L)	0.0725	P		0.0701			103.4			0.1380	P		0.1401			98.5		
PO4 (mg P/L)	0.0184	W		0.0186			98.9			0.0250	W		0.0223			112.1		
NH4 (mg N/L)	0.0603	P		0.064			94.2			0.2480	P		0.255			97.3		
NO23 (mg N/L)	0.2094	P		0.2102			99.6			0.8400	P		0.8407			99.9		
PO4 (mg P/L)	0.0345	P		0.0371			93.0			0.0480	P		0.0446			107.6		
DOC (mg C/L)	2.11	P		1.997			105.7			3.16	P		2.996			105.5		
DOC (mg C/L)	11.40	W		9.985			114.2			10.50	F		7.988			131.4		
TSS (mg/L)	35.1	P		36.3			96.7			44.90	W		50			89.8		
CHL (ug/L)	*	NA		NA			NA			*	NA		NA			NA		
PC (mg C/L)	*	NA		NA			NA			*	NA		NA			NA		
PN (mg N/L)	*	NA		NA			NA			*	NA		NA			NA		
PP (mg P/L)	*	NA		NA			NA			*	NA		NA			NA		

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

Appendix 1 Cont'. Fall 2021 and Spring 2022 Reported Concentrations, Prepared Concentrations and Recoveries**Interstate Environmental Commission (IEC)**

	Fall 2021 Reported Concentration		Fall 2021 Prepared Concentration	Fall 2021 Percent Recovered		Spring 2022 Reported Concentration		Spring 2022 Prepared Concentration	Spring 2022 Percent Recovered
TDN (mg N/L)	0.3800	P	0.353	107.6		0.2950	F	0.217	135.9
TDP (mg P/L)	0.0051	F	0.019	26.6		*	*	0.029	*
TDN (mg N/L)	0.7170	P	0.706	101.6		0.9060	P	0.868	104.4
TDP (mg P/L)	0.0415	F	0.056	74.1		*	*	0.049	*
NH4 (mg N/L)	0.0153	F	0.021	72.9		0.0420	P	0.042	100.0
NO23 (mg N/L)	0.0366	F	0.0701	52.2		0.1350	P	0.1401	96.4
PO4 (mg P/L)	0.0220	W	0.0186	118.3		0.0221	P	0.0223	99.1
NH4 (mg N/L)	0.0526	W	0.064	82.2		0.2760	P	0.255	108.2
NO23 (mg N/L)	0.2030	P	0.2102	96.6		0.9200	P	0.8407	109.4
PO4 (mg P/L)	0.0397	P	0.0371	107.0		0.0440	P	0.0446	98.7
DOC (mg C/L)	*	*	1.997	*		*	*	2.996	*
DOC (mg C/L)	*	*	9.985	*		*	*	7.988	*
TSS (mg/L)	35.4	P	36.3	97.5		48.80	P	50	97.6
CHL (ug/L)	10.19	NA	NA	NA		8.65	NA	NA	NA
PC (mg C/L)	*	NA	NA	NA		*	NA	NA	NA
PN (mg N/L)	*	NA	NA	NA		*	NA	NA	NA
PP (mg P/L)	*	NA	NA	NA		*	NA	NA	NA

*Sample not sent to participant: sample not requested, parameter or concentration range not routine, or no value submitted by participant
"W" Warn and "F" Fail based on standard deviation of all participants' reported concentrations (see Table 2)

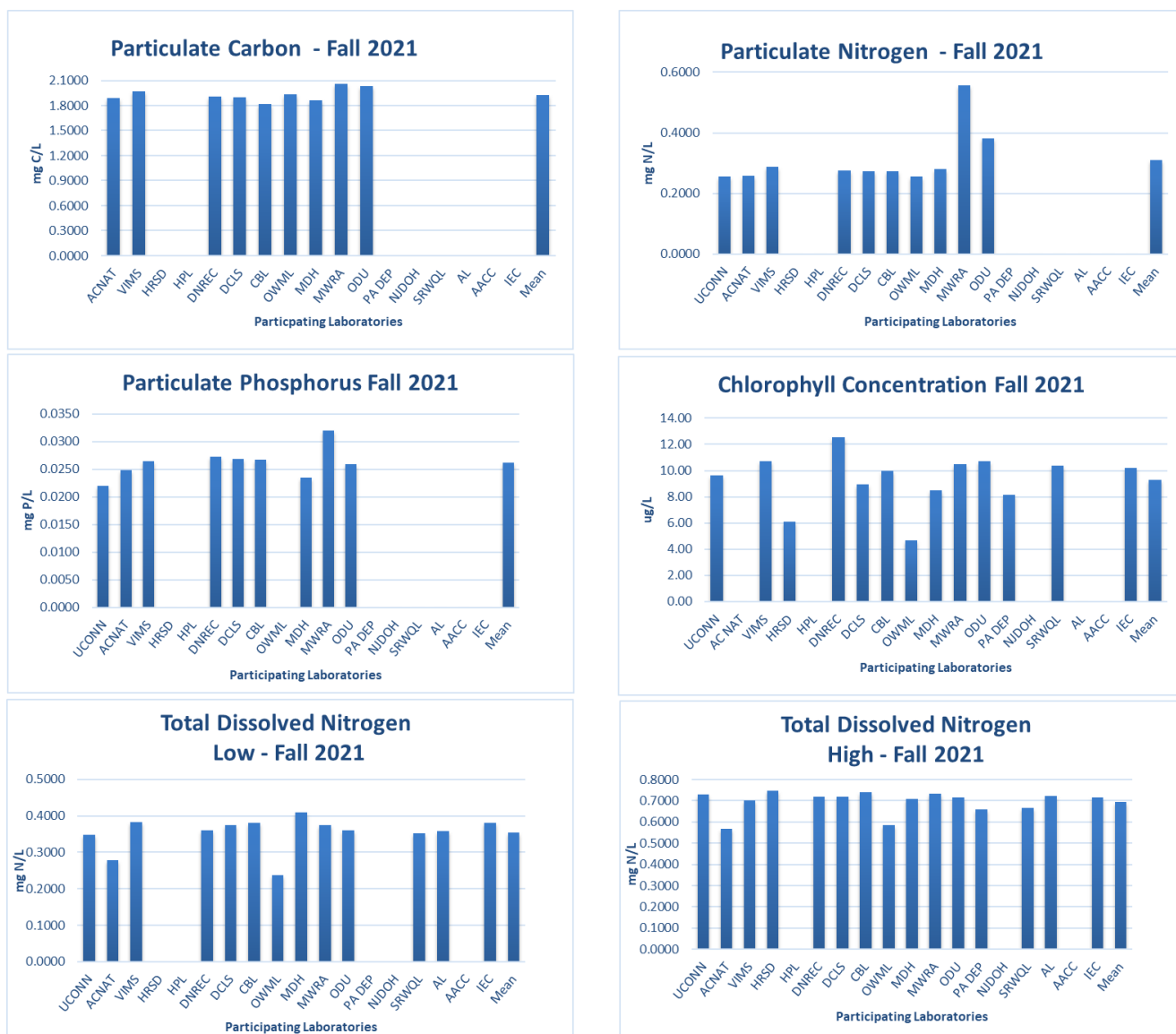


Figure 1. Particulate carbon, nitrogen and phosphorus; chlorophyll a, and total dissolved nitrogen. Fall 2021

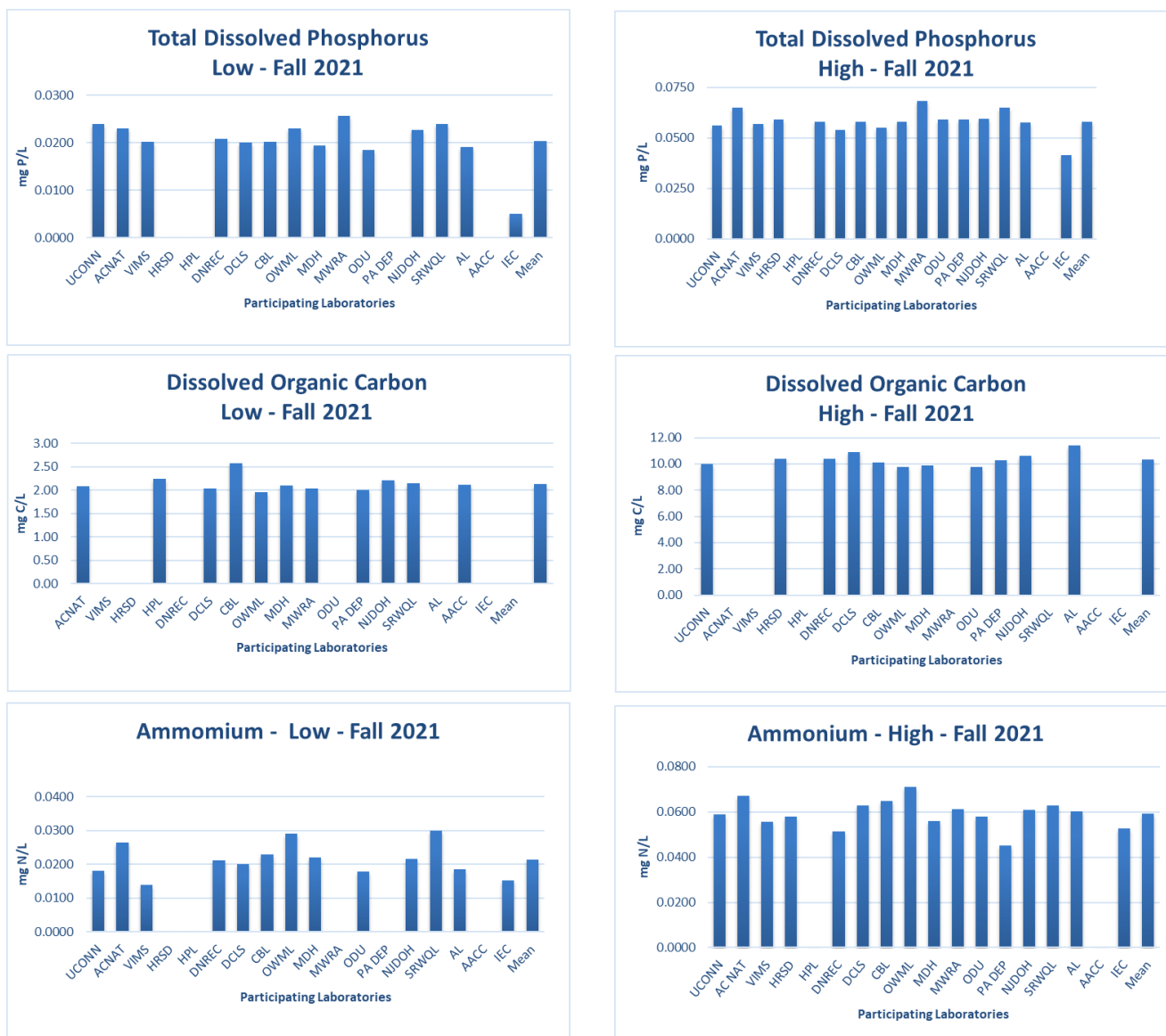


Figure 2. Total dissolved phosphorus; dissolved organic carbon, and ammonium. Fall 2021



Figure 3. Nitrite plus nitrate, orthophosphate, and total suspended solids. Fall 2021



Figure 4. Particulate carbon, nitrogen and phosphorus; chlorophyll a, and total dissolved nitrogen. Spring 2022.

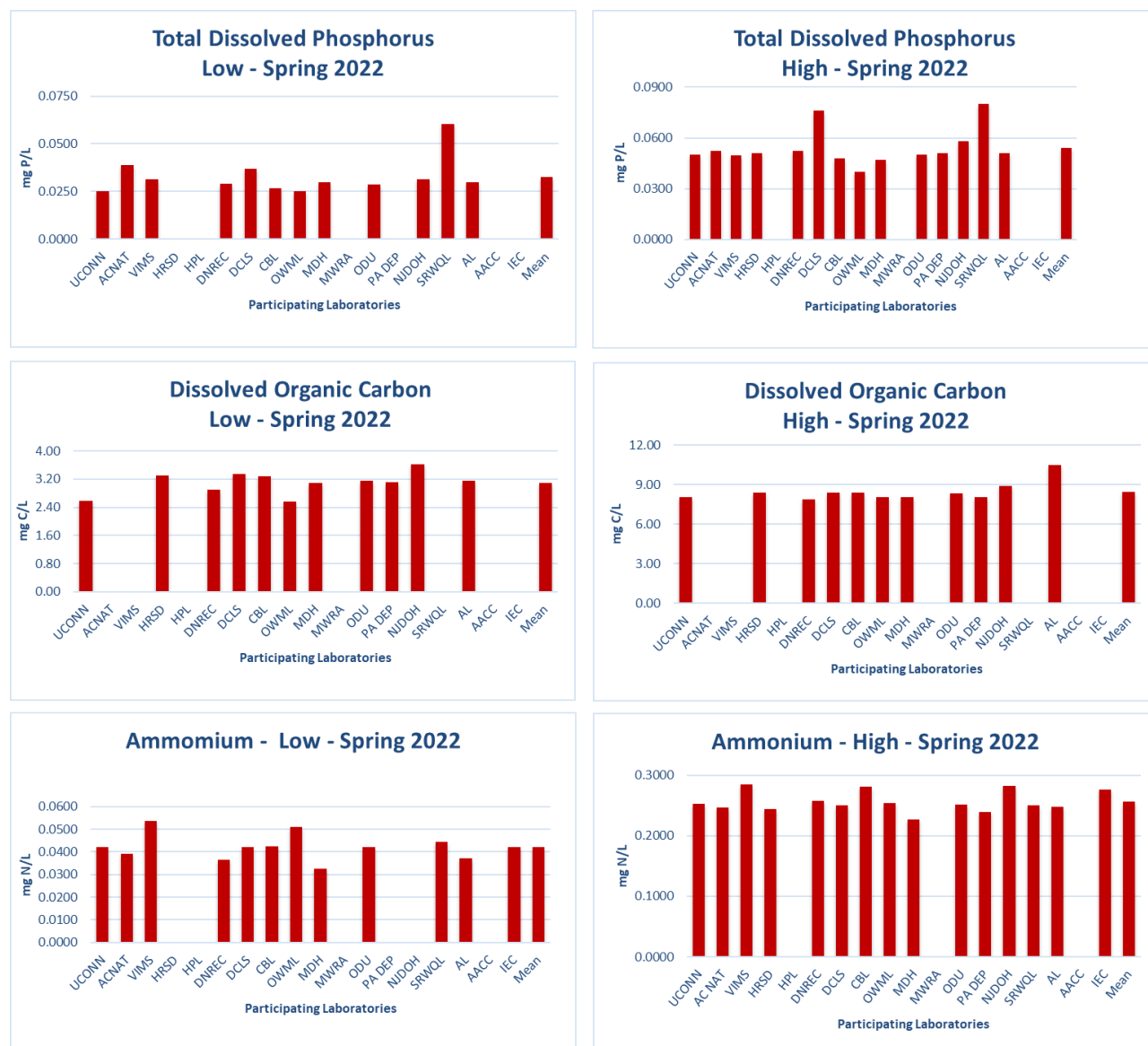


Figure 5. Total dissolved phosphorus; dissolved organic carbon, and ammonium. Spring 2022.



Figure 6. Nitrite plus nitrate, orthophosphate, and total suspended solids. Spring 2022.