



Wes Moore, Governor
Aruna Miller, Lt. Governor
Josh Kurtz, Secretary
David Goshorn, Deputy Secretary

Quality Assurance Project Plan

for the
Maryland Department of Natural Resources
Chesapeake Bay
Shallow Water Quality Monitoring Program
July 2023

EPA Document Control #: 230227

Tawes State Office Building – 580 Taylor Avenue – Annapolis, Maryland 21401
410-260-8DNR or toll free in Maryland 877-620-8DNR – dnr.maryland.gov – TTY Users Call via the Maryland Relay

**Quality Assurance Project Plan for the
Maryland Department of Natural Resources
Chesapeake Bay Shallow Water Quality Monitoring Program
July 2023**

Prepared by:
Tom Parham, Mark Trice, Brian Smith, and Diana Domotor
Resource Assessment Service/Tidewater Ecosystem Assessment
Maryland Department of Natural Resources
Tawes Building, D-2
580 Taylor Avenue
Annapolis, MD 21401

Website Address:
<http://dnr.maryland.gov>

Toll Free in Maryland:
1-877-620-8DNR, ext.: 8630
Out of state call: 410-260-8630
TTY users call via the MD Relay:
711 (within MD)
Out of state call: 1-800-735-2258

© 2023 Maryland Department of Natural Resources

The facilities and services of the Maryland Department of Natural Resources are available to all without regard to race, color, religion, sex, sexual orientation, age, national origin or physical or mental disability. This document is available in alternative format upon request from a qualified individual.

Wes Moore, Governor

Aruna Miller, Lt. Governor



Printed on Recycled Paper

**Quality Assurance Project Plan
for the
Maryland Department of Natural Resources
Chesapeake Bay
Shallow Water Quality Monitoring Program
July 2023**

Concurrence

Preparer/Author

| | |
|---|---|
| Name: Thomas Parham, Principal Investigator Title: Director, Tidewater Ecosystem Assessment Division Organization: Maryland Department of Natural Resources | Signature: <i>Th. A. Parham</i> Date: 10/24/23 |
|---|---|

Management/Supervisor

| | |
|---|--|
| Name: Richard A. Ortt, Jr., Title: Director, Resource Assessment Service Organization: Maryland Department of Natural Resources | Signature: <i>Richard A. Ortt, Jr.</i> Date: 10/24/2023 |
|---|--|

Quality Assurance Officer

| | |
|--|--|
| Name: David Goshorn, Ph.D., Title: Quality Assurance Officer, Deputy Secretary: Maryland Department of Natural Resources | Signature: <i>David M. Goshorn</i> Date: 10/24/23 |
|--|--|

EPA Region 3

| | |
|--|---|
| Name: Kaylyn S. Gootman Title: Chesapeake Bay Program Project Manager Organization: U.S. Environmental Protection Agency | Signature: <i>Kaylyn S. Gootman</i> Date: 10/30/23 |
|--|---|

Approval

EPA Region 3

| | |
|---|---|
| Name: Durga Ghosh Title: R3 Approving Official Organization: CBP / USGS | Signature: <i>Durga Ghosh</i> Date: 10/30/2023 |
|---|---|

Note: This approval action represents EPA's determination that the document(s) under review comply with applicable requirements of the EPA Region 3 Quality Management Plan [<https://www.epa.gov/sites/production/files/2020-06/documents/r3qmp-final-r3-signatures-2020.pdf>] and other applicable requirements in EPA quality regulations and policies [<https://www.epa.gov/quality>]. This approval action does not represent EPA's verification of the accuracy or completeness of document(s) under review and is not intended to constitute EPA direction of work by contractors, grantees or subgrantees, or other non-EPA parties.

TABLE OF CONTENTS

| | |
|--|----|
| 1. INTRODUCTION AND PROJECT DESCRIPTION | 1 |
| 2. METHODS AND PERFORMANCE MEASURES | 11 |
| 3. FIELD MEASUREMENTS AND SAMPLING | 17 |
| 4. LABORATORY ANALYSIS | 20 |
| 5. DATA MANAGEMENT, VERIFICATION AND DOCUMENTATION | 21 |
| 6. PROJECT QUALITY ASSURANCE/QUALITY CONTROL | 26 |
| 7. DATA ANALYSIS AND REPORTING..... | 28 |
| 8. PROJECT ORGANIZATION AND RESPONSIBILITY | 28 |
| 9. REFERENCES | 30 |
| 10. APPENDICES | 31 |

LIST OF TABLES

| | |
|---|----|
| Table 1 Shallow-water monitoring for 2023: Bay segment, sample type(s) and Designated Uses for which the collected data will be used to assess water quality criteria | 4 |
| Table 2. Water Quality Mapping Cruise Schedule (April through October 2023) | 5 |
| Table 3. 2023 Continuous monitoring stations | 8 |
| Table 4. 2023 Water quality mapping calibration stations..... | 9 |
| Table 5. <i>In situ</i> monitor performance checks and acceptance criteria | 11 |
| Table 6. Discrete sample performance checks and acceptance criteria..... | 11 |
| Table 7. Continuous monitoring <i>in situ</i> water column parameters | 12 |
| Table 8. Water Quality Mapping <i>in situ</i> water column parameters | 14 |
| Table 9. Shallow Water Monitoring Program Grab Sample Water Column Parameters, Detection Limits, Methods, References, and Holding Times and Conditions..... | 15 |
| Table 10. NASL methods..... | 20 |

| | |
|--|-----|
| Table 11. Acceptable drift tolerances for YSI 6600V2/EXO sondes following post-calibration check | 22 |
| Table 12. Deployment dates for Maryland DNR Continuous Monitoring Sites..... | 96 |
| Table 13. Sampling Matrix for Maryland DNR Water Quality Mapping Systems | 100 |

LIST OF FIGURES

| | |
|---|----|
| Figure 1. Map of 2023 continuous monitoring stations and water quality mapping systems, with progress of assessment..... | 10 |
| Figure 2. Conceptual diagram of continuous monitoring data management components, including automated data submission from DNR to the Bay Program | 25 |
| Figure 3. Conceptual diagram of water quality mapping data management components, including automated data submission from DNR to the Bay Program..... | 25 |
| Figure 4: Continuous Monitoring Field Sheet..... | 40 |
| Figure 5: Continuous Monitoring Calibration Sheet..... | 67 |
| Figure 6: Water Quality Mapping Calibration Sheet | 74 |

ACRONYMS AND ABBREVIATIONS

| | |
|-----------------|---|
| AA | - Autoanalyzer |
| AMQAW | - Analytical Methods and Quality Assurance Workgroup (a workgroup of the Chesapeake Bay Program's Monitoring Subcommittee) |
| BGA | - Blue-Green Algae |
| C | - Carbon |
| C4 | - Chesapeake Center for Collaborative Computing |
| CBP | - EPA's Chesapeake Bay Program CBPO - EPA's Chesapeake Bay Program Office |
| CBL | - University of Maryland's Chesapeake Biological Laboratory |
| CDMA | - Code Division Multiple Access |
| CHLA | - Chlorophyll <i>a</i> |
| cm | - Centimeter |
| CSSP | - Coordinated Split Sample Program |
| d | - Day |
| DI | - Deionized |
| DIWG | - Data Integrity Workgroup (a workgroup of the Chesapeake Bay Program, formerly AMQAW) |
| DNR | - Maryland Department of Natural Resources |
| DO | - Dissolved Oxygen |
| DU | - Designated Use |
| EM | - Emission |
| EPA | - U.S. Environmental Protection Agency |
| EST | - Eastern Standard Time |
| EX | - Excitation |
| FGDC | - Federal Geographic Data Commission |
| FNU | - Formazin Nephelometric Units |
| FS | - Full Scale |
| g | - Gram |
| h | - Hour |
| ITAT | - Integrated Trends Analysis Team |
| K _d | - Diffuse Attenuation Coefficient for Downward Irradiance |
| L | - Liter |
| m | - Meter |
| MDE | - Maryland Department of the Environment |
| MDH | - Maryland Department of Health |
| min. | - Minute |
| mg | - Milligram |
| ml or mL | - Milliliter |
| mm | - Millimeter |
| mS | - Millisiemens |
| mV | - Millivolts |
| N | - Nitrogen |
| NASL | - Nutrient Analytical Services Laboratory |
| NERR | - National Estuarine Research Reserve |
| NH ₄ | - Ammonium |
| NIST | - National Institute of Science and Technology |
| nm | - Nanometer |
| no. | - Number |
| NO ₂ | - Nitrite |

| | |
|------------------|--|
| NO ₂₃ | - Nitrate + Nitrite |
| NO ₃ | - Nitrate |
| NOAA | - National Oceanic and Atmospheric Administration |
| NTU | - Nephelometric Turbidity Units |
| OD | - Optical Density |
| ODO | - Optical Dissolved Oxygen |
| P | - Phosphorus |
| PAR | - Photosynthetic Active Radiation |
| PC | - Particulate Carbon (Organic) |
| PC | - Personal Computer |
| PE | - Phycoerythrin |
| PHEO | - Pheophytin |
| PIP | - Particulate Inorganic Phosphorus |
| PN | - Particulate Nitrogen |
| PO ₄ | - Phosphate |
| PP | - Particulate Phosphorus |
| ppt | - Parts Per Thousand |
| QA | - Quality Assurance |
| QAO | - Quality Assurance Officer (Unless otherwise noted, this refers to the DNR QAO) |
| QAPP | - Quality Assurance Project Plan |
| QA/QC | - Quality Assurance/Quality Control |
| QC | - Quality Control |
| R/V | - Research Vessel |
| RFU | - Relative Fluorescence Units |
| SAS | - Statistical Analysis System |
| Sat% | - Percent Saturation |
| SAV | - Submerged Aquatic Vegetation |
| SpCond | - Specific Conductance |
| STAR | - Scientific, Technical Assessment and Reporting Team |
| TCP/IP | - Transmission Control Protocol/Internet Protocol |
| TDN | - Total Dissolved Nitrogen |
| TDP | - Total Dissolved Phosphorus |
| TMAW | - Tidal Monitoring and Analysis Workgroup |
| TMDL | - Total Maximum Daily Load |
| TN | - Total Nitrogen |
| TP | - Total Phosphorus |
| TPP | - Total Particulate Phosphorus |
| Trib | - Bay Tributary |
| TSS | - Total Suspended Solids |
| TVS | - Total Volatile Solids |
| µg | - Microgram |
| USDI | - U.S. Department of the Interior |
| USGS | - U.S. Geological Survey |
| VIMS | - Virginia Institute of Marine Science |
| VSS | - Volatile Suspended Solids |
| YSI | - Yellow Springs Instruments |
| °C | - Degrees Celsius |

PREFACE

This document is intended to describe in detail the activities conducted under the Shallow Water Monitoring Program of the Maryland Department of Natural Resources Chesapeake Bay Water Quality Monitoring Program. This program includes water quality mapping and continuous monitoring in the tidal tributaries of Maryland's Chesapeake Bay. This program is funded through The State of Maryland, the United States Environmental Protection Agency Chesapeake Bay Program, the National Oceanic and Atmospheric Administration Chesapeake Bay Office and National Estuarine Research Reserve System program, Maryland Environmental Service, the National Aquarium in Baltimore, the University of Maryland Center for Environmental Science, the Oyster Recovery Partnership, and the National Marine Sanctuary Foundation.

LIST OF PREPARERS

Editors:

Diana Domotor, Data Analyst, Tidewater Ecosystem Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, D-2, Annapolis, Maryland 21401.

Tom Parham, Director, Tidewater Ecosystem Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, C-2, Annapolis, Maryland 21401.

Brian Smith, Program Manager, Monitoring Integration, Tidewater Ecosystem Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, D-2, Annapolis, Maryland 21401.

Mark Trice, Program Chief, Water Quality Informatics, Tidewater Ecosystem Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, D-2, Annapolis, Maryland 21401.

Contributors:

Maureen Balan, Natural Resources Biologist, Monitoring and Non-Tidal Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 1919 Lincoln Drive, Annapolis, Maryland 21401.

Lauren Cunningham, Natural Resources Biologist, Monitoring and Non-Tidal Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 1919 Lincoln Drive, Annapolis, Maryland 21401.

Jerry Frank, Manager of Analytical Services/Advanced Senior Faculty Research Assistant, Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, Maryland, 20688-0038.

Kristen Heyer, Manager, Water Quality Monitoring, Monitoring and Non-Tidal Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 1919 Lincoln Drive, Annapolis, Maryland 21401.

Ceana Hoburn, Faculty Research Assistant, Chesapeake Biological Laboratory, University of Maryland, Center for Environmental Science, Solomons, Maryland, 20688-0038.

Jamie Strong, Natural Resources Biologist, Monitoring and Non-Tidal Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 1919 Lincoln Drive, Annapolis, Maryland 21401.

DISTRIBUTION LIST

This Quality Assurance Project Plan is available on-line by using publication type 'Quality Assurance Project Plan' to search the Monitoring News and Reports page of the Maryland Department of Natural Resources (DNR) Eyes on the Bay website:

<https://eyesonthebay.dnr.maryland.gov/eyesonthebay/stories.cfm>.

1. INTRODUCTION AND PROJECT DESCRIPTION

1.1 Background

The Chesapeake Bay Program Monitoring and Analysis Subcommittee's Tidal Monitoring and Analysis Workgroup (TMAW) had undertaken the role of redesigning the Tidal Monitoring Network. The Tidal Monitoring Network focuses on meeting the Water Quality Protection and Restoration goals and objectives of the Chesapeake 2014 Agreement. The Scientific, Technical Assessment & Reporting (STAR) team formed the Integrated Trends Analysis Team (ITAT). Many TMAW goals have been subsumed by similar ITAT goals. Water quality monitoring information is used to define nutrient and sediment conditions necessary to protect living resources (water quality to support crabs, oysters, and fish) and vital habitats (water quality to support submerged aquatic vegetation - SAV). The information is also used to develop and assess water quality criteria with the goal of removing the Bay and its tidal rivers from the list of impaired waters. Water quality information is required to support refinement, calibration and validation of the Chesapeake Bay Eutrophication and Watershed Models.

As part of the Tidal Monitoring Network, the Maryland Department of Natural Resources (DNR) and its federal, state and local partners are working together to implement a comprehensive and coordinated monitoring program to assess the Bay's shallow water habitats, which is required by the development of the new water quality criteria. Until 2002, sparse water quality data were collected in shallow portions of Chesapeake Bay and its tributaries. This presented a major gap in data for use in evaluation of new Designated Use Areas and Water Quality Criteria.

Through the 2023 Shallow Water Quality Monitoring Program, water quality and habitat measurements will be made using water quality mapping technology and fixed continuous monitors to provide characterization of shallow water habitats that are key to living resources. The goal of the program is to conduct assessments for a minimum of three years in each of the Chesapeake Bay segments. Water quality mapping was piloted by the states of Maryland and Virginia, as well as academic researchers, and was extensively tested by Maryland in the Magothy River, Severn River, and Tangier Sound from 1999 to 2002. Continuous monitoring was initially implemented by Maryland in the Pocomoke River to monitor water quality in response to the *Pfiesteria piscicida* outbreak in 1998. The implementation of shallow water monitoring technology is coordinated between States and their partners employing similar equipment and methodology to ensure bay-wide compatibility and comparisons. Detailed information describing these technologies and the 1998 - 2023 results can be found on DNR's Eyes on the Bay web site (<http://www.eyesonthebay.net/>.)

CONTINUOUS MONITORING

Maryland DNR is conducting continuous monitoring in 12 Chesapeake Bay segments in 2023 and water quality mapping in one segment (Figure 1, Table 1). This design comprises monthly water quality mapping cruises with three continuous monitoring sites in the segment. Monitoring covered in this QAPP will primarily be conducted April through October.

In the Maryland portion of the Chesapeake Bay and associated tributaries (Figure 1), twelve sites deployed in the Patapsco and Potomac Rivers, Fishing Bay, as well as sites associated with the National Estuarine Research Reserve (NERR) System will be deployed year-round, weather permitting. The remaining eight continuous monitoring sites (Table 3) will be deployed by the end of April and will be removed by early November annually. Sites are generally located in shallow water habitats to provide spatial diversity within the segment. Where applicable, continuous monitoring sites will be used as calibration sites for water quality mapping cruises. Continuous monitoring sites will be serviced on a two-to-four-week basis unless water quality readings demonstrate that more frequent service intervals are

required. Results since 2003 indicate that the YSI™ V2 model sondes can be deployed for two-week periods throughout most of the annual sampling period without compromising data integrity. YSI™ EXO model sondes are equipped with more advanced anti-fouling technology and can, therefore, be deployed for up to a month without compromising data integrity. Sites deployed year-round will be exchanged monthly between November and March under the assumption that less biofouling, which may compromise data integrity, occurs during cold weather months. Should both of these assumptions prove untrue, deployment duration will be re-evaluated.

During each site visit, instruments in the water will be checked against the replacement instrument, as well as another Hydrolab™ or YSI™ EXO instrument to provide a third comparison. A discrete water sample will be collected for chlorophyll, pheophytin, and turbidity (using total suspended solids---TSS) calibration during each site visit. At five sites associated with the NERR System, as well as one site associated with a designated National Marine Sanctuary, a subset of nutrients (VSS, NH₄, PO₄, NO₂, NO₂₃, TDN, TDP) will be collected (Table 9). The same protocols and naming conventions outlined in the Chesapeake Bay Mainstem 117(e) grant and the approved Quality Assurance Project Plan (QAPP) for the Maryland Department of Natural Resources Chesapeake Bay Water Quality Monitoring Program - Chemical and Physical Properties Component will be observed. Per grant agreements with the respective funding agencies, no nutrient or pigment samples will be collected by DNR at two sites deployed adjacent to the National Aquarium in Baltimore, one site deployed in the Middle Branch of the Patapsco River, and at three sites in Fishing Bay.

A light reading and Secchi depth reading will also be collected. Light readings will be measured using LI-COR™ equipment, comprised of a deck reference sensor and a LI-COR™ flat sensor. Simultaneous deck and submersed measurements will be recorded to assess the variability in incident surface irradiance due to changing atmospheric conditions. A detailed description of light measurements is included in Appendix 4.

The replacement instrument will then be left at the site for approximately two to four weeks (see above). The instrument that was at the site for the previous weeks will be delivered to the field office for data download, post-calibration, cleaning and servicing. Detailed instrument calibration procedures are included in Appendix 5.

WATER QUALITY MAPPING

Water quality mapping (DataFlow) is a system, usually deployed in a small boat, of geospatial equipment and water quality probes that measure water quality parameters from a flow-through stream of water collected near the water's surface. This system allows data to be collected rapidly (approximately every four seconds) while the boat is traveling at speeds of up to 25 knots. Since the system is compact enough to deploy from a small boat, it allows sampling in shallow water and the ability to map an entire small tributary in less than one day. Water is pumped through a ram (pipe), over the sensors, and then discharged overboard. Sensors are deployed on a YSI 6600 sonde with a flow-through chamber. A Raymarine A70D or Garmin model GPSMAP168 sounder chart plotting receiver and depth-finder global positioning system (GPS) is also part of the system. Each water quality measurement is associated with a date, time, water depth, and GPS coordinate (NAD83) reported to six decimal places. A preliminary 2023 survey schedule is presented in Table 2. The eight water quality parameters measured are: water temperature, specific conductance, salinity (calculated from specific conductance and water temperature), dissolved oxygen, pH, turbidity (NTU), fluorescence, and total chlorophyll (estimated from fluorescence). All parameters will follow the same naming conventions as outlined in the existing Chesapeake Bay Mainstem 117(e) grant and approved Water Quality Project Plan.

Water quality mapping uses the same YSI 6600 instrument package as used for the continuous monitoring program. Detailed instrument calibration procedures for the instrument are included in Appendix 6. Each segment will be monitored once a month (Figure 1, Table 2), April through October.

During each water quality mapping cruise, five calibration samples will be collected during TANMH Northern and Southern surveys and two calibration samples will be collected during TANMH Western surveys for use in the development of regressions for chlorophyll, turbidity, total suspended solids, and light attenuation. Sample collection stations are listed in Table 4. Samples for total suspended solids and chlorophyll, as well as a light reading and Secchi depth reading, will also be collected at each calibration station. Light readings will be measured using LI-COR™ equipment, comprised of a deck reference sensor and a LI-COR™ flat sensor. Simultaneous deck and submersed measurements will be recorded to assess the variability in incident surface irradiance due to changing atmospheric conditions. A detailed description of light measurements is included in Appendix 4.

Table 1. Shallow-water monitoring for 2023: Bay segment, sample type(s) and Designated Uses (DU) for which the collected data will be used to assess water quality criteria.

| Tributary | Segment Name | Sample Type(s) | Shallow Water DU | | | Open Water DU | | | Spawning/ Nursery DU | | | Deep Water DU | | |
|----------------|--------------------|-----------------------|------------------|----------------|------|---------------|----------------|------|-------------------------|----------------|------|---------------|----------------|------|
| | | | Chl <i>a</i> | K _d | D.O. | Chl <i>a</i> | K _d | D.O. | Chl <i>a</i> | K _d | D.O. | Chl <i>a</i> | K _d | D.O. |
| Back R. | BACOH | Cont. Moni. | NO | NO | NO | NO | NA | NO | NO | NO | NO | * | * | * |
| Bush R. | BSHOH | Cont. Moni. | NO | NO | NO | NO | NA | NO | NO | NO | NO | * | * | * |
| Chesapeake Bay | CB1TF | Cont. Moni. | NO | NO | NO | NO | NA | NO | NO | NO | NO | * | * | * |
| | CB3MH ¹ | Cont. Moni. | NO | NO | NO | NO | NA | NO | NO | NO | NO | NA | NA | NO |
| Fishing Bay | FSBMH | Cont. Moni. | NO | NO | NO | NO | NA | NO | NO | NO | NO | * | * | * |
| Patapsco R. | PATMH ¹ | Cont. Moni. | NO | NO | NO | NO | NA | NO | NO | NO | NO | NA | NA | NO |
| Patuxent R. | PAXTF | Cont. Moni. | NO | NO | NO | NO | NA | NO | NO | NO | NO | * | * | * |
| | WBRTF | Cont. Moni. | NO | NA | NO | NO | NA | NO | NO | NA | NO | * | * | * |
| Potomac R. | POTOH | Cont. Moni. | NO | NO | NO | NO | NA | NO | NO | NO | NO | * | * | * |
| | POTMH ¹ | Cont. Moni. | NO | NO | NO | NO | NA | NO | NO | NO | NO | NA | NA | NO |
| Tangier Sound | TANMH | Cont. Moni. | YES | YES | YES | YES | NA | YES | * | * | * | * | * | * |
| | | Water Quality Mapping | | | | | | | | | | | | |
| Wicomico R. | WICMH | Cont. Moni. | NO | NO | NO | NO | NA | NO | NO | NO | NO | * | * | * |

YES: Data from this project are expected to be used to assess these criteria

NO: Data from this project cannot be used to assess these criteria.

NA: Criteria does not apply to this Designated Use category.

*: This segment does not contain this Designated Use

¹ CB3MH, PATMH, and POTMH also have Deep Channel Designated Use for D.O.

Table 2. Water Quality Mapping Cruise Schedule (April through October 2023), weather permitting.

| River System | April | May | June | July | Aug | Sept | Oct |
|------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Tangier Sound ¹ (TANMH) | 20 th | 22 nd | 20 th | 17 th | 14 th | 18 th | 23 rd |

¹ Water Quality Mapping for TANMH will be conducted using separate cruises for northern, southern, and western portions of the segment.

DNR will provide matching funds and will solicit other funding sources to expand shallow water monitoring capabilities. DNR will also provide staff, equipment and other resources to enhance shallow water monitoring with its partners and will coordinate with existing long-term water quality monitoring programs to ensure better understanding of estuarine processes.

1.2 Objectives and Problem Definition

The objectives of the Shallow Water Monitoring Program are to 1) assess the Chesapeake Bay water quality criteria for dissolved oxygen, water clarity and chlorophyll in shallow and open water habitats, 2) determine attainment or non-attainment of shallow water and open water habitats for their designated uses, 3) provide spatially and temporally intensive data in shallow water habitats to improve water quality mapping using interpolation, 4) assess SAV habitats and identify potential SAV restoration sites, 5) provide information to better understand ecosystem processes and the impact of extreme events (e.g. hurricanes, high flows) in shallow water and open water environments, and 6) provide information for calibrating the Chesapeake Bay Eutrophication and Watershed Models.

As objectives are achieved, they will provide the basis for management decisions. For example, if the monitoring results determine that a water body is out of attainment, the water body will be listed in the 305(b) report to the U.S. Environmental Protection Agency. If the causes of non-attainment are determined to be anthropogenic, the water body will be placed on the 303 (d) list requiring a TMDL (total maximum daily load). Another example is the identification of potential SAV restoration sites. Shallow water monitoring data will be used by the SAV restoration strategy project to help select or eliminate sites from consideration for SAV restoration projects.

Spatially intensive water quality mapping provides information on variability and patchiness that is invaluable in establishing water quality criteria, and in determining attainment of those criteria. For example, spatial information on turbidity can be correlated to the spatial coverage of living resources such as bay grasses (SAV). This information can be used to determine and assess water clarity criteria necessary to support SAV growth, address the progress of meeting ambitious SAV restoration goals, and target specific areas for successful SAV restoration. Spatially intensive data can also help pinpoint localized areas of water quality concern, such as areas of low dissolved oxygen that can cause fish kills, and their possible links to nearby land uses or point sources. Spatial data can also be aggregated across watershed units to aid in the evaluation of entire systems.

Temporally intensive (continuous) monitoring provides information on the temporal variability of water quality. Continuous monitoring captures events that occur on short time scales (hours to days) or during times when it is impractical to deploy field crews. Continuous monitoring can capture early morning lows in dissolved oxygen as well as daytime and nighttime values of water quality parameters to provide

scientists with the information necessary to fully assess instantaneous water quality criteria in shallow water habitats. Continuous monitoring provides early warning of potential harmful algal blooms and low-dissolved oxygen related fish kills, allowing managers to coordinate appropriate supplemental sampling (e.g., plankton sampling). Continuous monitoring is instrumental in documenting the water quality impacts of episodic storm events.

1.3 Sampling Design

1.3.1 Parameters

Parameters measured *in situ* include turbidity, specific conductance (to calculate salinity), water temperature, dissolved oxygen, fluorescence (used to estimate total chlorophyll), pH and depth (see Appendices 9 and 10). *In situ* turbidity and chlorophyll fluorescence measurements are surrogates for K_d (light attenuation coefficient) and chlorophyll *a*, respectively; therefore, discrete measurements of photosynthetic active radiation (PAR) and chlorophyll *a* are needed to establish regression models that relate *in situ* turbidity to K_d and chlorophyll fluorescence to chlorophyll *a*. In addition, blue-green algal concentration (cells/mL or µg/L) and Relative Fluorescence Units (RFUs) will be quantified at select sites by measuring phycoerythrin (marine and estuarine waters) pigment concentrations.

Grab samples that are filtered on site will be collected at water quality mapping calibration stations and at continuous monitoring stations. Processed samples will be taken and sent to the Chesapeake Biological Laboratory's Nutrient Analytical Services Laboratory for analysis. Samples from five continuous monitoring sites associated with the NERR System, as well as one site associated with a designated National Marine Sanctuary, will be analyzed for a subset of nutrients (TSS, VSS, NH_4 , PO_4 , NO_2 , NO_{23} , TDN, TDP), as well as chlorophyll and pheophytin. In addition, Secchi depth and photosynthetic active radiation (PAR) measurements will be taken at calibration stations to calculate light attenuation (K_d). See Appendix 4 for details of the procedure for calculating light attenuation. See next section (Methods and Performance Measures) for a list of all parameters and the methods associated with them.

1.3.2 Spatial and Temporal Aspects

Maryland DNR is responsible for conducting shallow water monitoring in 50 Chesapeake Bay Program segments. Each segment will be assessed for a three-year period. Available resources will dictate the number and locations of segments assessed. These segments will be prioritized considering the following factors:

- Need for making listing or delisting decisions
- Potential importance as restoration site for living resources (e.g., oysters, SAV)
- Importance as living resource habitat
- Modeling needs
- Availability of partners to share costs and labor
- Logistics and efficiency considerations
- Geographic, size, and habitat type representation/equitability considerations
- Determine effect of major management action (before/after)

Continuous monitoring instruments will be deployed at predetermined sites in Maryland's tidal tributaries. Continuous monitoring sampling sites are chosen to be representative of a tidal tributary's upstream and downstream conditions. Continuous monitoring sampling sites primarily utilize existing structures for instrument mounting (e.g., piers and pilings), so the location of such structures is taken into consideration when choosing sites. Additionally, areas of SAV restoration are also taken into consideration when choosing continuous monitoring sampling sites. Sampling sites for the 2023 season are depicted on the map in Figure 1.

Ten Chesapeake Bay tributary segments and two Chesapeake Bay mainstem segments have been identified for shallow water monitoring in Maryland in 2023, ranging from small to large systems with spatial coverage throughout Maryland (some systems have continuous monitors only):

- Back River (Tenth year of assessments for this small system on the Upper Western Shore)
 - Station located at Riverside.
- Bush River (Twenty-first year of monitoring for this small system on the Upper Western Shore)
 - Station located at Otter Point Creek (NERRS Site).
- Chesapeake Bay – CB1TF (Seventeenth year of monitoring for this large bay segment)
 - Station located at Havre de Grace.
- Chesapeake Bay – CB3MH (Twentieth year of monitoring for this large bay segment)
 - Station located at Sandy Point South Beach.
- Fishing Bay (Eighth year of assessments for this large system on the Lower Eastern Shore)
 - Stations located at the mouth of the Transquaking River where it meets Fishing Bay, near the mouth of Fishing Bay, and a water quality vertical profiler south-southwest of the Fishing Point portion of Elliott Island.
- Patapsco River (Twenty-fourth year of monitoring for this large system on the Upper Western Shore)
 - Stations located at Masonville Cove, the National Aquarium in Baltimore, and the Middle Branch.
- Patuxent River (Twenty-first year of monitoring for this large system in the Patuxent River Basin)
 - Stations located at Mataponi Creek (NERRS Site), Jug Bay (NERRS Site) and Iron Pot Landing (NERRS Site) and near the mouth of the river.
- Potomac River (Twentieth year of monitoring in the Potomac River Basin)
 - Stations located at St George’s Creek and Malloes Bay National Marine Sanctuary. (Additional sites in Virginia maintained by Virginia DEQ, VIMS, and George Mason University).
- Tangier Sound (Third year of monitoring for this large system on the Lower Eastern Shore)
 - Stations located at Daugherty Creek, Deal Island, and the Karen Noonan Center; Third year of water quality mapping.
- Wicomico River/Monie Bay (Eighteenth year of monitoring for this mid-sized system on the Lower Eastern Shore)
 - Station located at Little Monie Creek (NERRS Site).

DNR will also maintain the water quality instruments associated with three buoys that are part of NOAA’s Chesapeake Bay Interpretive Buoy System (CBIBS). These buoys are located near the mouth of the Severn River in the Central Chesapeake Bay, the mainstem Middle Central Chesapeake Bay, and the mouth of the Potomac River in the Lower Central Chesapeake Bay. A fourth buoy has been deployed near the mouth of the Patapsco River. More information and real-time data can be found on the NOAA CBIBS website (<https://buoybay.noaa.gov/>). Calibration and nutrient data from CBIBS buoys can be downloaded through the Chesapeake Bay Program Water Quality Database (https://www.chesapeakebay.net/what/downloads/cbp_water_quality_database_1984_present).

Latitude and longitude values of continuous monitoring and water quality mapping calibration site locations for 2023 are provided in Tables 3 and 4. Detailed location data collected by GPS on water quality mapping cruises will be associated with each data point measured during the cruise and submitted to the Bay Program as part of routine data submissions.

Table 3. **2023 Continuous monitoring stations.**

| Tributary | Segment | Station Name | Station | Years deployed | LAT (NAD83) | LONG (NAD83) |
|----------------|---------|-------------------------|---------|----------------|----------------|---------------|
| Back River | BACOH | Riverside | XIF7918 | 2014 – present | 39° 17.887' N | 76° 28.218' W |
| Bush River | BSHOH | Otter Point Creek | XJG7035 | 2003 – present | 39° 27.047' N | 76° 16.474' W |
| Chesapeake Bay | CB1TF | Havre de Grace | XKH2949 | 2007 – present | 39° 32.867' N | 76° 05.088' W |
| | CB3MH | Sandy Pt. - South Beach | XHF0460 | 2004 – present | 39° 00.450' N | 76° 24.020' W |
| Fishing Bay | FSBMH | Profiler* | XCH7886 | 2023 | 38° 17.806' N | 76° 01.404' W |
| | | Fishing Bay – Lower + | XCI3607 | 2023 | 38° 13.557' N | 75° 59.339' W |
| | | Fishing Bay - Upstream | XDH2399 | 2022 - present | 38° 22.285' N | 76° 00.142' W |
| Patapsco River | PATMH | Masonville Cove Pier | XIE4742 | 2013 – present | 39° 14.680' N | 76° 35.831' W |
| | | Aquarium West | XIE7135 | 2016 – present | 39° 17.126' N | 76° 36.526' W |
| | | Aquarium East – Surface | XIE7136 | 2016 – present | 39° 17.128' N | 76° 36.477' W |
| | | Aquarium West - Bottom | XIE7136 | 2016 – present | 39° 17.128' N | 76° 36.477' W |
| | | Middle Branch | XIE5525 | 2022 - present | 39° 15.516' N | 76° 37.517' W |
| Patuxent River | PAXTF | Jug Bay | PXT0455 | 2003 – present | 38° 46.877' N | 76° 42.822' W |
| | | Mataponi | MTI0015 | 2003 – present | 38° 44.599' N | 76° 42.446' W |
| | WBRTF | Iron Pot Landing | WXT0013 | 2003 – present | 38° 47.760' N | 76° 43.248' W |
| Potomac River | POTOH | Mallows Bay Buoy | XDA8236 | 2018 – present | 38° 28.217' N | 77° 16.366' W |
| | POTMH | St. George's Creek | XBF7904 | 2006 – present | 38° 07.866' N | 76° 29.604' W |
| Tangier Sound | TANMH | Karen Noonan Center | XCH3277 | 2021 - present | 38° 13.216' N | 76° 02.317' W |
| | | Deal Island | XCI0132 | 2021 - present | 38° 10.116' N | 75° 56.833' W |
| | | Daugherty Creek | XAI8482 | 2021 - present | 37° 58.450' N | 75° 51.833' W |
| Wicomico River | WICMH | Little Monie | LMN0028 | 2006 – present | 38° 12.513' N | 76° 48.276' W |

* Deployed approximately 200-yards south of the 2022 deployment location.

+ Replaced station XCH6891 in May 2023. New station deployed 6.3km south-east of XCH6891 deployment location.

Table 4. 2023 Water quality mapping calibration stations.

| StationName | WaterBody | LAT (NAD83) | LONG (NAD83) | ConMon Station |
|-------------|-------------|---------------|---------------|-------------------|
| EE3.1 | TANMH North | 38° 11.811' N | 75° 58.393' W | |
| XCH3277 | TANMH North | 38° 13.216' N | 76° 02.317' W | YES |
| XBI6201 | TANMH North | 38° 06.239' N | 75° 59.890' W | |
| XBI5751 | TANMH North | 38° 05.715' N | 75° 54.851' W | |
| XCI0132 | TANMH North | 38° 10.116' N | 75° 56.833' W | YES |
| EE3.2 | TANMH South | 37° 58.883' N | 75° 55.454' W | |
| XBI3751 | TANMH South | 38° 03.722' N | 75° 54.840' W | |
| XBI1219 | TANMH South | 38° 01.263' N | 75° 58.084' W | |
| XAI6645 | TANMH South | 37° 56.610' N | 75° 55.488' W | |
| XAI8482 | TANMH South | 37° 58.450' N | 75° 51.833' W | YES |
| XBH8055 | TANMH West | 38° 07.991' N | 76° 04.496' W | |
| XBH0760 | TANMH West | 38° 00.720' N | 76° 03.923 W | |

Multiple surveys are required to map larger water bodies. Mapping data acquired during three Tangier Sound (TANMH) surveys will be combined.

Maryland DNR staff will be responsible for maintaining all continuous monitoring sites and will conduct all water quality mapping cruises.

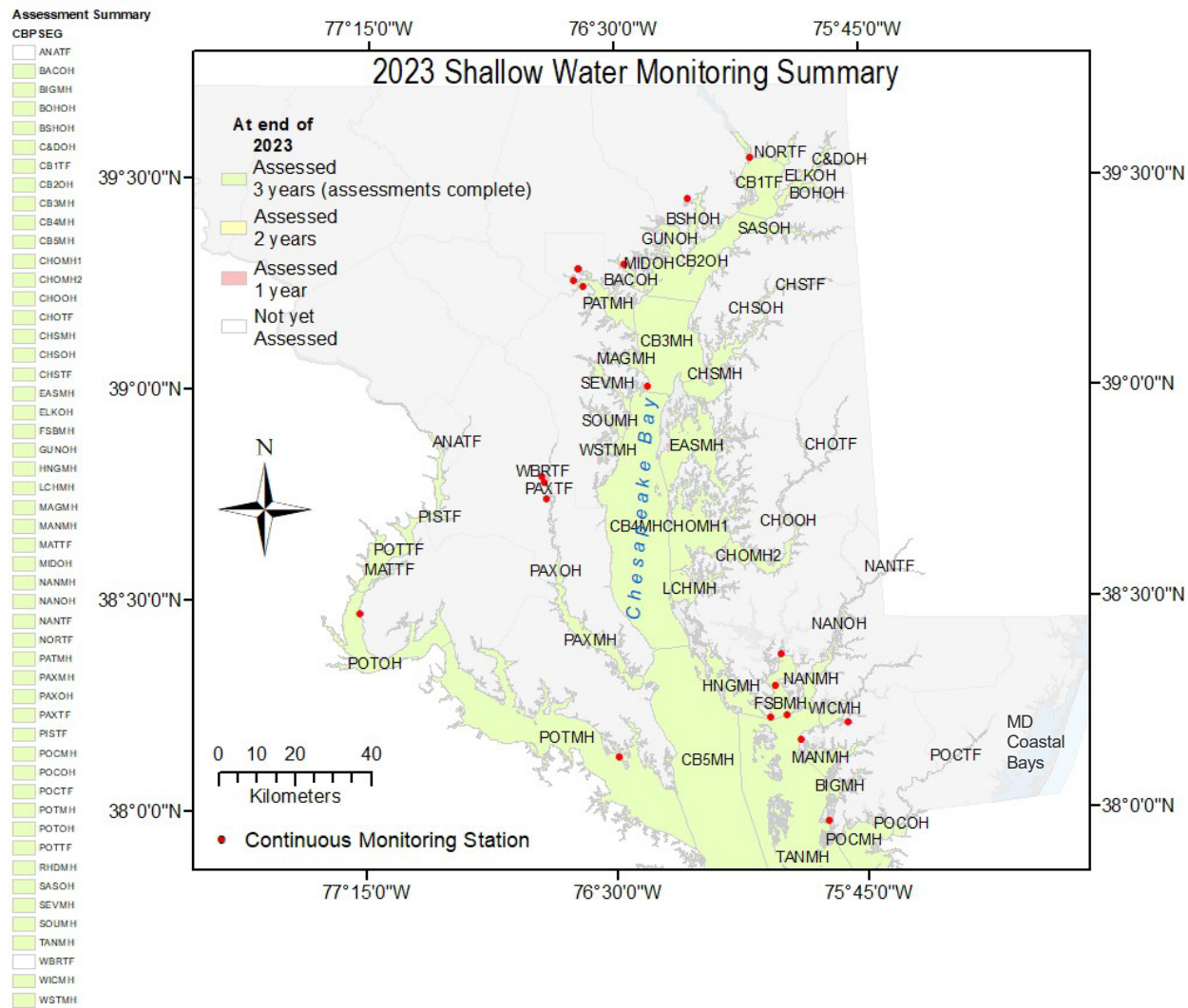


Figure 1. Map of 2023 continuous monitoring stations and water quality mapping systems, with progress of assessment. NOTE: The Chesapeake Bay Program and the Maryland Department of the Environment gave approval for discontinuing assessment of C&DOH after one year because the segment met its SAV acreage goal in 2015.

2. METHODS AND PERFORMANCE MEASURES

The Chesapeake Bay Shallow Water Quality Monitoring Program measures a number of physical and chemical parameters that are indicative of the Bay's eutrophication problem. Several "natural" properties such as salinity and temperature in the water column provide important information for interpretation of water quality indicators. For example, water clarity criteria differ based on salinity regime.

Tables 5 and 6 summarize Quality Control checks utilized in the Shallow Water Monitoring Program.

Tables 7 (Continuous Monitoring) and 8 (Water Quality Mapping) list parameters measured *in situ* along with resolution, range, accuracy and equipment used.

Table 9 lists the parameters measured in the laboratory (from grab samples taken at calibration stations), their detection limits, methods references, and holding times and conditions.

Table 5: *In situ* monitor performance checks and acceptance criteria.

| | Performance Checks | Acceptance Criteria |
|--------------------|--|-------------------------------------|
| Precision | Comparison of readings from deployed sonde against new sonde and discrete sonde when switching (continuous monitoring only). | See Table 11 |
| Bias | Post-deployment calibration | See Table 11 |
| Accuracy | Pre-deployment calibration | |
| Representativeness | Daily checks of real-time data. Auto-notification of problems. Visual inspection to reject spikes | |
| Comparability | Use identical YSI equipment at all sites. | |
| Completeness | Data verification checks | Percentage of accepted data values. |
| Sensitivity | Manufacturer's specifications for each probe type. | See Appendix 1 |

Table 6: Discrete sample performance checks and acceptance criteria.

| | Performance Checks | Acceptance Criteria |
|-------------------|---|---|
| Precision | Intra-lab: replicate 1/10 samples. Inter-lab: quarterly Chesapeake Bay split samples. | Replicate control limits (For each parameter) |
| Bias and Accuracy | Analyze SRMs with each run. Spike 1/20 samples. Semi-annual blind audit sample. Semi-annual USGS ref. samples. Field blanks for nutrient samples. | % Recover of SRM % Recovery of Spikes ± 3 std. dev. of mean ± 3 pseudo-σ of mean |
| Comparability | Use standard procedures for collecting and analyzing samples. | |
| Completeness | Number of reported values vs. number of samples submitted for analysis. | |
| Sensitivity | MDL calculated for each parameter according to 40 CFR, Part 136B. | See Table 9 |

Table 7. Continuous monitoring *in situ* water column parameters.

| Parameter (Units) | Resolution | Range | Accuracy | Equipment |
|---------------------------------------|--|--|---|---|
| Specific Conductance (mS/cm=mmhos/cm) | 0.001 to 0.1 mS/cm (range-dependent) | 0 to 100 mS/cm | +0.5% of reading + 0.001 mS/cm | YSI 6600 6560 probe |
| | 0.0001 to 0.01 mS/cm (range-dependent) | 0 to 200 mS/cm | 0-100 mS/cm: $\pm 0.5\%$ of reading or 0.001 mS/cm, whichever is greater. 100-200 mS/cm: $\pm 1\%$ of reading | YSI EXO@ 599870 probe~ |
| | 0.0001 to 0.01 mS/cm (range-dependent) | 0 to 100 mS/cm | $\pm 1\%$ of reading or 0.002 mS/cm, whichever is greater | YSI EXO@ 599827 probe~ |
| Dissolved Oxygen (mg/L) | 0.01 mg/L | 0 to 50 mg/L | 0 to 20 mg/L: $\pm 1\%$ of reading or 0.1 mg/L, whichever is greater; 20 to 50 mg/L: $\pm 15\%$ of reading | YSI 6600 6150 ROX probe+ |
| | 0.01 mg/L | 0 to 50 mg/L | 0 to 20 mg/L: $\pm 1\%$ of reading or 0.1 mg/L, whichever is greater; 20 to 50 mg/L: $\pm 5\%$ of reading | YSI EXO@ 599100-01 probe |
| Dissolved Oxygen (% saturation) | 0.1 % | 0 to 500 % | 0 to 200%: $\pm 1\%$ of reading or 1% air saturation, whichever is greater. 200 to 500%: $\pm 15\%$ of reading | YSI 6600 6150 ROX probe+ |
| | 0.1 % | 0 to 500 % | 0 to 200%: $\pm 1\%$ of reading or 1% air saturation, whichever is greater. 200 to 500%: $\pm 5\%$ of reading | YSI EXO@ 599100-01 probe |
| Fluorescence | 0.1 RFU | 0 to 100 RFU | NA | YSI 6600 6025 probe |
| | 0.01 RFU | 0 to 100 RFU | NA | YSI EXO@ probes used: 599102-01, 599103-01; both have the same specifications |
| Total Chlorophyll | 0.1 $\mu\text{g/L}$ | EM 470 nm; EX 650 to 700 nm; ~0 to 400 $\mu\text{g/l}$ | NA | YSI 6600 6025 probe |
| | 0.01 $\mu\text{g/L}$ | ~0 to 400 $\mu\text{g/l}$ | NA | YSI EXO@ probes used: 599102-01, 599103-01; both have the same specifications |
| Photosynthetic Active Radiation (PAR) | See Appendix 4 | See Appendix 4 | See Appendix 4 | LI-192SA and LI-190R-BNC-2 |
| pH (pH units) | 0.01units | 0 to 14 units | ± 0.2 units | YSI 6600 probes used: 6561, 6561FG and 6579 (hemispherical); all have the same specifications |
| | 0.01units | 0 to 14 units | ± 0.1 pH units within $\pm 10^\circ\text{C}$ of calibration temperature; ± 0.2 pH units for entire temp range | YSI EXO@ 599702 probe |

| | | | | |
|--|--|--|---|--------------------------------|
| Salinity (ppt) | 0.01 ppt | 0 to 70 ppt | ±1% of reading or 0.1 ppt, whichever is greater | YSI 6600 6560 probe |
| | 0.01 ppt | 0 to 70 ppt | ±1% of reading or 0.1 ppt, whichever is greater | YSI EXO@ 599870 probe~ |
| | 0.01 ppt | 0 to 70 ppt | ±2% of reading or 0.2 ppt, whichever is greater | YSI EXO@ 599827 probe~ |
| Secchi depth (m) | NA | 0.1 m (lower limit) | NA | Secchi disk (20 cm or 25.2 cm) |
| Turbidity (NTU/FNU)& | 0.1 NTU | 0 to 1000 NTU | +2% of reading or 0.3 NTU, whichever is greater | YSI 6600 6136 probe* |
| | 0-999 FNU: 0.01 FNU; 1000-4000 FNU: 0.1 FNU | 0 to 4000 FNU | 0-999 FNU: 0.3 FNU or ±2% of reading, whichever is greater; 1000-4000 FNU: ±5% of reading | YSI EXO@ 599101-01 probe |
| Water Temperature (°C) | 0.01°C | -5 to 50 °C | +0.15 °C | YSI 6600 6560 probe |
| | 0.001°C | -5 to 50 °C | -5 to 35°C: ±0.01°C 35 to 50°C: ±0.05°C | YSI EXO@ 599870 probe~ |
| | 0.001°C | -5 to 50 °C | ±0.2°C | YSI EXO@ 599827 probe~ |
| Depth (shallow sensor) | 0.001 m | 0 to 9.1 m | +0.018 m | YSI 6600^ |
| | 0.001 m | 0 to 10 m | ±0.04% FS (±0.004 m) | YSI EXO@^ |
| Depth (medium sensor) | 0.001 m | 0 to 61 m | +0.12 m | YSI 6600^ |
| | 0.001 m | 0 to 100 m | ±0.04% FS (±0.04 m) | YSI EXO@^ |
| Blue-Green Algae PE** (Marine and Estuarine waters) | 1cell/mL or 0.1 RFU | ~ 0 to 200,000 cell/mL or 0 to 100 RFU | NA | YSI 6600 6132 probe |
| | 0.01 µg/L or 0.01 RFU | 0 to 280 µg/L or 0 to 100 RFU | NA | YSI EXO@ 599103-01 probe |

Note: Only a subset of the above parameters (specific conductance, dissolved oxygen, salinity, Secchi depth, water temperature, depth) will be recorded at two locations in Fishing Bay.

+ Between 1998 and 2009, the older model 6562 rapid pulse dissolved oxygen probe was used in some instruments. Beginning in 2010, the 6150 ROX optical dissolved oxygen probe was used exclusively.

* Between 1998 and 2004 the older model 6026 turbidity probe was in use in some instruments. Beginning in 2005, the 6136 turbidity probe was used exclusively.

^ The depth sensors are built into the YSI 6600 and EXO instruments, and do not have an individual probe model number. Some instruments in the DNR inventory do not have depth sensors.

@ Beginning in 2014, YSI EXO instruments were used at select sites.

& YSI 6600 instruments output turbidity measurements in Nephelometric Turbidity Units (NTU). YSI EXO instruments output turbidity measurements in Formazin Nephelometric Units (FNU). 1 NTU = 1 FNU and the different unit names is due to different methods used to measure turbidity.

** Beginning in 2016, YSI EXO sondes with Blue-Green Algal PE probes have been deployed adjacent to the National Aquarium in Baltimore.

~ Beginning in 2016, some YSI EXO instruments were equipped with wiped conductivity/temperature probes (599827) to improve data integrity.

Table 8. Water Quality Mapping *in situ* water column parameters.

| Parameter (Units) | Resolution | Range | Accuracy | Equipment |
|---------------------------------------|--------------------------------------|---|--|--|
| Specific Conductance (mS/cm=mmhos/cm) | 0.001 to 0.1 mS/cm (range-dependent) | 0 to 100 mS/cm | ±0.5% of reading + 0.001 mS/cm | YSI 6600 6560 probe |
| Dissolved Oxygen (% saturation) | 0.1 % | 0 to 500 % | 0 to 200%: ±1% of reading or 1% air saturation, whichever is greater; 200 to 500%: ±15% of reading | YSI 6600 6150 ROX probe+ |
| Dissolved Oxygen (mg/L) | 0.01 mg/L | 0 to 50 mg/L | 0 to 20 mg/L: ±1% of reading or 0.1 mg/L, whichever is greater; 20 to 50 mg/L: ±15% of reading | YSI 6600 6150 ROX probe+ |
| Fluorescence | 0.1 RFU | 0 to 100 RFU | NA | YSI 6600 6025 probe |
| Total Chlorophyll | 0.1 µg/L Chl | EM 470 nm; EX 650 to 700 nm; 0 to 400 µg/l | NA | YSI 6600 6025 probe |
| Photosynthetic Active Radiation (PAR) | See Appendix 4 | See Appendix 4 | See Appendix 4 | LI-192SA and LI-190R-BNC-2 |
| pH (pH units) | 0.01units | 0 to 14 units | ±0.2 units | YSI 6600 6561 probe |
| Salinity (ppt) | 0.01 ppt | 0 to 70 ppt | ±1% of reading or 0.1 ppt, whichever is greater | YSI 6600 6560 probe |
| Secchi depth (m) | NA | 0.1 m (lower limit) | NA | Secchi disk (20 cm or 25.2 cm) |
| Turbidity (NTU) | 0.1 NTU | 0 to 1000 NTU | ±2% of reading or 0.3 NTU, whichever is greater | YSI 6600 6136 probe* |
| Water Temperature (°C) | 0.01°C | -5 to 50 °C | ±0.15 °C | YSI 6600 6560 probe |
| Depth | 0.001 m | 0 to 9 m | ±0.02 m | Garmin GPSmap 168 sounder or Raymarine A70D Plotter/Sounder |
| Position | 15 m | NA | ±5 m; ±2-3 m with Northstar | Garmin GPSmap 168 sounder or Raymarine A70D Plotter/Sounder |

+ Between 1998 and 2009, the older model 6562 rapid pulse dissolved oxygen probe was used for water quality mapping surveys. Beginning in 2010, the 6150 ROX optical dissolved oxygen probe was used exclusively.

* Between 1998 and 2004 the older model 6026 turbidity probe was in use in some instruments. Beginning in 2005, the 6136 turbidity probe was used exclusively.

Sources for Tables 7 and 8:

YSI Incorporated. 2006. YSI 6-Series Manual, Revision D. Available at: <http://www.ysi.com>

YSI Incorporated. 2012. YSI EXO User Manual, Revision C. Available at: <http://www.exowater.com>

GARMIN 2009 GPSMAP® 168 Sounder. Available at <https://www.garmin.com/en-US/>

Raymarine A70D Chartplotter/Fishfinder. Available at <http://www.raymarine.com>

Northstar 952X Differential GPS. [No longer available online.](#)

Table 9. Shallow Water Monitoring Program Grab Sample Water Column Parameters, Detection Limits, Methods, References, and Holding Times and Conditions.

| Parameter (Units) | Detection Limit (or Range) | Method Reference | Holding Time and Condition |
|--|----------------------------|---|----------------------------|
| Orthophosphate (mg/L as P) | 0.0034 mg/L | EPA method 365.1, Rev. 2.0 (1993) Aquakem 250 | Freezing-28 d |
| Total Diss. Phosphorus (mg/L as P) | 0.0015 mg/L | #4500-P.B.5, #4500 P.E, and EPA Method 365.1 | Freezing-28 d |
| Particulate Phosphorus (mg/L as P) | 0.0010 mg/L | EPA 365.1, Rev. 2.0 Aquakem 250 | Freezing-28 d |
| Particulate Inorganic Phosphorus (mg/L as P) | 0.0010 mg/L | EPA 365.1, Rev. 2.0 Aquakem 250 | Freezing-28 d |
| Nitrite (mg/L as N) | 0.0009 mg/L | EPA method 353.2, Rev. 2.0 (1993) Aquakem 250 | Freezing-28 d |
| Nitrite + Nitrate (mg/L as N) | 0.0009 mg/L | EPA method 353.2, Rev. 2.0 (1993) and ASTM D7781-14. Aquakem 250 | Freezing-28 d |
| Ammonium (mg/L as N) | 0.009 mg/L | 4500-NH3 G-2011 | Freezing-28 d |
| Total Dissolved Nitrogen (mg/L as N) | 0.05 mg/L | EPA 353.2, Standard Methods #4500-N C, 4500-NO3 F Aquakem 250 and Auto Analyzer II | Freezing-28 d |
| Dissolved Organic Carbon (mg/L as C) | 0.21 mg/L | SM 5310B-2011 | Freezing-28 d |
| Particulate Nitrogen (mg/L as N) | 0.0263 mg/L | EPA method 440.0 (EPA 1997) | Freezing-28 d |
| Particulate Carbon (mg/L as C) | 0.0633 mg/L | EPA method 440.0 (EPA 1997) | Freezing-28 d |
| Total Suspended Solids (mg/L) | 2.4 mg/L | EPA Method 160.2 and Standard Methods 208 E. | Freezing-28 d |
| Volatile Suspended Solids (mg/L) | 0.9 mg/L | EPA Method 160.2 and Standard Methods 208 E. | Freezing-28 d |
| Chlorophyll a (µg/L) | 0.62 µg/L | EPA 446.0, SM10200H | Freezing-28 d |
| Pheophytin (µg/L) | 0.74 µg/L | EPA 446.0, SM10200H | Freezing-28 d |

References:

American Public Health Association (APHA), *Standard Methods for the Examination of Water and Wastewater*, [Method Number 10200H](#), 20th Edition, 2005.

American Public Health Association (APHA), *Standard Methods for the Examination of Water and Wastewater*, [4500-NH3 D. Ammonia-Selective Electrode Method](#), 20th Edition, 1998.

American Public Health Association (APHA), *Standard Methods for the Examination of Water and Wastewater*, [4500-NH3 G. Automated Phenate Method](#), 20th Edition, 1998.

American Public Health Association (APHA), *Standard Methods for the Examination of Water and*

Wastewater, [Method Number 2540 E Fixed and Volatile Solids Ignited at 550°C](#), 20th Edition, 1998.

American Public Health Association (APHA). 1975. [Method 208D, total non-filterable residue dried at 103-105°C \(total suspended matter\)](#), in *Standard Methods for the Examination of Water and Wastewater*, 14th Edition. APHA: Washington, D.C. 1193 p.

Arar, E. J. Method 446.0: [In Vitro Determination of Chlorophylls a, b, c + c and Pheopigments in 1 2 Marine and Freshwater Algae by Visible Spectrophotometry](#). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-15/005, 1997.

Aspila, I., H. Agemian and A. S. Y. Chau. 1976. [A semi-automated method for the determination of inorganic, organic and total phosphate in sediments](#). *Analyst* 101:187-197.

ASTM D7781-14, [Standard Test Method for Nitrite-Nitrate in Water by Nitrate Reductase](#), ASTM International, West Conshohocken, PA, 2014, www.astm.org

D'Elia, C. F., P. A. Steudler and N. Corwin. 1977. [Determination of total nitrogen in aqueous samples using persulfate digestion](#). *Limnol. Oceanogr.* 22:760-764.

Hydrolab Corporation. June 1981. *Hydrolab Digital 4041 Operation and Maintenance Instructions*. Austin, TX. (HWQIUM-S4041)

Hydrolab Corporation. Revision A, February 1985. *Hydrolab Surveyor II Operating Manual*. Austin, TX. (HWQIUM-S2)

Hydrolab Corporation. Revision B, April 1995. *H2O Water Quality Multiprobe – Operating Manual*. Austin, TX. (HWQIUM-S3)

Hydrolab Corporation. Revision G, April 1999. *DataSonde 4 and Minisonde Water Quality Probes – User's Manual*. Austin, TX. (HWQIUM-S4a)

Hydrolab Corporation. Edition 3, February 2006. [Hydrolab DS5X, DS5, and MS5 Water Quality Probes – User Manual](#). Loveland, CO. (HWQIUM-S5)

O'Dell, J.W. Method 350.1: [Determination of Ammonia Nitrogen by Semi-Automated Colorimetry](#). Environmental Monitoring Systems Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH, Revision 2.0, 1993

O'Dell, J.W. Method 353.2: [Determination of Nitrate-Nitrite Nitrogen by Automated Colorimetry](#). Environmental Monitoring Systems Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH, Revision 2.0, 1993

O'Dell, J.W. Method 365.1: [Determination of Phosphorus by Semi-Automated Colorimetry](#). Environmental Monitoring Systems Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH, Revision 2.0, 1993

Parsons, T. R., Takahashi, M. and B. Hargrave. 1977. *Biological Oceanographic Processes*. Pergamon Press. Oxford. 332 p. (Pages 71-85).

Smith, R. C. 1969. An underwater spectral irradiance collector. *J. Mar. Res.* Vol. 27: 341-351.

Sugimura, Y. and Y. Suzuki. 1988. [*A high temperature catalytic oxidation method for the determination of non-volatile dissolved organic carbon in seawater by direct injection of a liquid sample.*](#) *Mar. Chem.* 24:105 - 131.

US Environmental Protection Agency (EPA). 1997. US EPA Method 440.0. [*Determination of Carbon and Nitrogen in Sediments and Particulates of Estuarine/Coastal Waters Using Elemental Analysis. Revision 1.4.*](#) National Exposure Research Laboratory, Office of Research and Development, US Environmental Protection Agency: Cincinnati, OH.

US Environmental Protection Agency (EPA). 1993. [*Methods for the Determination of Inorganic Substances in Environmental Samples*](#) EPA-600/R-93/100.

US Environmental Protection Agency (EPA). 1979. [*Methods for Chemical Analysis of Water and Wastes.*](#) EPA-600/4-79-020. 460 p.

Valderrama, J. C. 1981. [*The Simultaneous Analysis of Total Nitrogen and Total Phosphorus in Natural Waters.*](#) *Mar. Chem.* 10:109-122.

Welch, P.S. 1948. Chapter 11 in *Limnological Methods*. Blakiston: Philadelphia, PA. pp. 159-167.

Xylem. 2020. [*EXO User Manual, Revision K.*](#) Yellow Springs, OH. (YSIUM-S6)

Yellow Springs Instrument, Inc. March 2012. [*6-Series Multiparameter Water Quality Sondes – User Manual, Revision J.*](#) Yellow Springs, OH. (YSIUM-S6)

Zhang, J. AND G. A. Berberian. Method 366.0 [*Determination of Dissolved Silicate in Estuarine and Coastal Waters by Gas Segmented Continuous Flow Colorimetric Analysis.*](#) U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-15/010, 1997.

Zimmerman, C. F., C. W. Keefe, AND J. Bashe. Method 440.0 [*Determination of Carbon and Nitrogen in Sediments and Particulates of Estuarine/Coastal Waters Using Elemental Analysis.*](#) U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-15/009, 1997.

3. FIELD MEASUREMENTS AND SAMPLING

3.1. Continuous Monitoring

Each continuous monitoring station is equipped with a YSI 6600 or YSI EXO sonde. Beginning in 2004, all YSI 6600 data sondes were equipped with Extended Deployment Systems (EDS). The EDS has a wiper system that allows the continuous monitoring sondes to be deployed for longer periods of time without suffering a degradation of data quality as a result of biofouling. Starting in 2007, some instruments were converted from EDS to the V2 model, which supports four optical ports. Between 2009 and 2015, all sondes used for continuous monitoring utilized V2 technology. In addition to chlorophyll

fluorescence and turbidity, the additional two optical ports may be configured for 6150 optical dissolved oxygen and blue-green algal probes. Beginning in 2014, new EXO model instruments were purchased to replace older YSI 6600 models as the SWM Program began to transition to this newer technology. All EXO2 sondes have a central wiper system and most have a copper-alloy sensor guard which will further reduce biofouling and associated degradation of data quality. Most continuous monitoring sondes record nine water quality parameters every 15 minutes. The nine water quality parameters measured continuously are water temperature, specific conductance, salinity (calculated from specific conductance and temperature), dissolved oxygen, turbidity (NTU/FNU), fluorescence and total chlorophyll (estimated from fluorescence), pH, and depth. The exception is two stations in Fishing Bay. These locations will utilize EXO1 sondes which record a subset (water temperature, specific conductance, salinity (calculated from specific conductance and temperature), dissolved oxygen, depth) of these parameters every 15-minutes. EXO sondes that will be deployed at the National Aquarium in Baltimore in the Patapsco River will also be configured with total algal sensors that measure both chlorophyll *a* and blue-green algal concentrations in µg/L and RFU.

Since 2008, YSI 6600 model sonde sensors have been wrapped in copper tape (2" diameter; 3.5 mm thickness) to inhibit biological growth. Starting in 2010, several sondes have also been equipped with anti-fouling probes and probe guards that utilize copper housings to further reduce biological growth on sensors. Continuous monitoring sondes are positioned in the water column in either a floating configuration that suspends the sonde at some distance below the surface (usually 1-meter), or in an anchored configuration that fixes the sonde at some distance above the bottom (between 0.3m and 0.8m above bottom). The sonde is positioned in the water column in either a floating configuration or a fixed configuration depending on the geographic area being monitored, the monitoring goals for that segment, and the total water depth at a particular site.

Continuous monitoring 6600 sondes in a floating configuration are suspended from a float inside of a 4-inch diameter PVC pipe with 2-inch diameter holes drilled every 4 inches below the waterline to allow for water exchange. There are three floating configurations for EXO sondes. The first configuration suspends the sonde inside a 4-inch PVC tube perforated with 2-inch diameter holes to allow for water exchange and a stack of small floats inside of the tube. The second configuration suspends a 4-inch diameter by 3-foot PVC tube with 2-inch diameter holes with sonde inside utilizing a large orange inflatable buoy. The third configuration suspends the sonde from a small, floating buoy. All sonde tubes are painted below the water line with black antifouling paint (Petit Trinidad™ SR or similar). 6600 sondes in a fixed configuration are also housed inside a perforated 4-inch diameter PVC pipe, and a bolt is used to hold the negatively buoyant sonde at a fixed depth above the sediment bottom. EXO sondes in a fixed configuration are either housed in a 4-inch diameter PVC tube perforated with 2-inch diameter holes, or inside a crab pot-like structure that rests on the bottom and suspends the instrument 0.3m off bottom in a horizontal PVC tube tethered to a pier with a cable. At selected sites, telemetry is used to transmit the data in near real-time to DNR's Eyes on the Bay web site (<http://www.eyesonthebay.net>). The telemetry system is comprised of a field component located at each sampling site and an office component located at the central DNR building in Annapolis. The field component consists of either a Campbell Scientific CR1000 data logger, a NexSens 3100-iSIC, or NexSens iSIC V2 data logger housed in a weather resistant fiberglass-reinforced polyester enclosure. Each unit also contains a battery, solar panel and a digital CDMA modem. Every hour, the computer server located at DNR contacts the data logger located at each telemetered sampling site via TCP/IP communications and then uploads, archives, and updates the data display on the Eyes on the Bay web site. These data are available immediately on the Internet, allowing the public to view near real-time water quality data. Details of the steps for installing, calibrating, deploying, and retrieving the YSI instruments are provided in Appendix 2.

In addition to the parameters measured by the sondes, Secchi depth and light attenuation (Appendix 4) are

measured every two to four weeks from April to October and monthly between November and March, and grab samples are taken and filtered on-site or immediately after returning to the field office. See Appendix 7 for a description of the filtering procedures. The processed samples are sent to the Nutrient Analytical Services Laboratory (NASL) at the Chesapeake Biological Laboratory for analysis. These results will be used to analyze relationships between the water quality parameters measured by each continuous monitor and nutrient components. Some of the lab data are also used to check the YSI data for accuracy. The following parameters are analyzed at NASL: ammonium, total dissolved nitrogen, particulate nitrogen, nitrite, nitrite + nitrate, particulate phosphorus, total dissolved phosphorus, orthophosphate, particulate carbon, total suspended solids, volatile suspended solids, particulate inorganic phosphorus, chlorophyll *a*, and pheophytin. Samples from five sites associated with the NERR System, as well as one site associated with a designated National Marine Sanctuary, will be analyzed for a subset of nutrients (TSS, VSS, NH₄, PO₄, NO₂, NO₂₃, TDN, TDP), pheophytin, and chlorophyll *a*. Samples from the remaining sites, with the exception of two sites adjacent to the National Aquarium in Baltimore, one site in the Middle Branch of the Patapsco River, and three sites in Fishing Bay will be analyzed for chlorophyll *a*, pheophytin, and TSS only. No samples will be collected by DNR at the National Aquarium, Middle Branch, and Fishing Bay sites. At the Aquarium sites, however, the National Aquarium in Baltimore collects weekly samples that are analyzed for total dissolved nitrogen, total dissolved phosphorus, and Biological Oxygen Demand (BOD).

3.2 Water Quality Mapping

Water quality mapping is conducted using a system deployed on a small boat. The system is comprised of geospatial equipment and water quality probes that measure water quality parameters from a flow-through stream of water collected near the water's surface. The eight water quality parameters measured are: water temperature, specific conductance, salinity (calculated from specific conductance and temperature) dissolved oxygen, turbidity (NTU), fluorescence, total chlorophyll (estimated from fluorescence) and pH.

On the smaller vessels, water is pumped through a ram (pipe), across the sensors, and then discharged overboard. The water quality mapping system includes a Raymarine A70D or a Garmin model GPSMAP168 Sounder chartplotting receiver and depth-finder, a YSI 6600 sonde with a flow-through chamber, a YSI 6150 ROX dissolved oxygen probe, a 6561 pH probe, a YSI 6560 conductivity/temperature probe, a 6136 turbidity probe, and a 6025 chlorophyll probe. The sonde transmits data from the sensors to a ruggedized computer. Each water quality datum is associated with a date, time, water depth, and GPS Latitude and Longitude coordinates (NAD83).

Water quality mapping allows data to be collected rapidly (approximately every four seconds) while the boat is traveling at speeds of up to 25 knots. The water quality mapping system for the smaller vessels are compact and can be fit onto a small boat, allowing sampling in shallow water and the ability to map an entire small tributary, such as the Severn River, in less than a day. The distance between samples depends on vessel speed; generally, at least one observation is collected every 30 meters (~100 feet). Details of the steps for calibrating, initializing and running the water quality mapping system are provided in Appendix 3.

The water quality mapping system samples water at depths of approximately 0.5m below the surface. At calibration stations, grab samples also are collected at 0.5m depth and filtered on site. See Appendix 3 for a description of the filtering procedures. Processed samples are sent to the Chesapeake Biological Laboratory Nutrient Analytical Services Laboratory (NASL). Parameters analyzed at NASL are chlorophyll *a*, pheophytin, and TSS. In addition, Secchi depth and photosynthetic active radiation (PAR) measurements are taken at calibration stations to calculate light attenuation (K_d) (Appendix 4). The

calibration station locations are selected to:

- 1) sample the greatest possible range of water quality conditions found during each cruise.
- 2) sample a broad spatial area.
- 3) overlap with long-term fixed monitoring and continuous monitoring stations. For more details on equipment and sampling design, see [Boynton et al. 2002](#), Rohland et al. 2002, and [Bailey et al. 2008](#).

4. LABORATORY ANALYSIS

All laboratory-measured parameters are analyzed at the University of Maryland Center for Environmental Science's Chesapeake Biological Laboratory (CBL), Nutrient Analytical Services Laboratory (NASL). For details, refer to Appendix 15 in the Quality Assurance Project Plan for the Maryland Department of Natural Resources Chesapeake Bay Water Quality Monitoring Program Chemical and Physical Properties Component for the Period July 2023 (Cain and Parham 2023).

Appendix 15 is an aggregation of NASL methods documents. Table 10 lists the documents covered in Appendix 15.

Table 10. NASL methods

| Water Column Chemistry | Method | Revised |
|---|---|---------------|
| Ammonium Method | <i>Standard Operating Procedure for Determination of Dissolved Inorganic Ammonium (NH₄) in Fresh/Estuarine/Coastal Waters (References Standard Methods 4500-NH₃ G-2011)</i> | 15-April-2022 |
| Cadmium Nitrate Method | <i>Standard Operating Procedure for Determination of Dissolved Inorganic Nitrate plus Nitrite (NO₃+NO₂) in Fresh/Estuarine/Coastal Waters Using Cadmium Reduction (References EPA 353.2, Rev. 2.0 (1993))</i> | 15-April-2022 |
| Enzyme Catalyzed Nitrate Method | <i>Standard Operating Procedure for Determination of Dissolved Inorganic Nitrate plus Nitrite (NO₃+NO₂) in Fresh/Estuarine/Coastal Waters Using Enzyme Catalyzed Reduction (References ASTM D7781-14)</i> | 1-March-2022 |
| Nitrite Method | <i>Standard Operating Procedure for Determination of Dissolved Inorganic Nitrite (NO₂) in Fresh/Estuarine/Coastal Waters (References EPA 353.2, Rev. 2.0 (1993))</i> | 1-March-2022 |
| Orthophosphate Method | <i>Standard Operating Procedure for Determination of Dissolved Inorganic Orthophosphate (PO₄) in Fresh/Estuarine/Coastal Waters (References EPA 365.1, Rev. 2.0 (1993))</i> | 15-April-2022 |
| Total Dissolved Nitrogen Enzyme Catalyzed Nitrate Method | <i>Standard Operating Procedure for Determination of Total Dissolved Nitrogen (TDN) and Total Nitrogen (TN) in Fresh/Estuarine/Coastal Waters Using Alkaline Persulfate Digestion of Nitrogen to Nitrate and Measured Using Enzyme Catalyzed Reduction (References EPA 353.2, Standard Methods #4500-N C, 4500-NO₃ F)</i> | 1-May-2019 |
| Total Dissolved Nitrogen Cadmium Nitrate Method | <i>Standard Operating Procedure for Determination of Total Dissolved Nitrogen (TDN) and Total Nitrogen (TN) in Fresh/Estuarine/Coastal Waters Using Alkaline Persulfate Digestion of Nitrogen to Nitrate and Measured Using Cadmium Reduction (References EPA 353.2, Standard Methods #4500-N C, 4500-NO₃ F)</i> | 1-May-2019 |
| Total Dissolved Phosphorus Discrete Photometric Analyzer Method | <i>Standard Operating Procedure for Determination of Total Dissolved Phosphorus (TDP) and Total Phosphorus (TP) in Fresh/Estuarine/Coastal Waters Using Alkaline Persulfate Digestion of Phosphorus to Orthophosphate (PO₄) with Colorimetric Analysis by Random Access Discrete Photometric Analyzer (References Standard Methods #4500-P.B.5, #4500 P.E, and EPA Method 365.1)</i> | 1-May-2019 |

| | | |
|---|---|---------------|
| Total Dissolved Phosphorus Auto Analyzer II System Method | <i>Standard Operating Procedure for Determination of Total Dissolved Phosphorus (TDP) and Total Phosphorus (TP) in Fresh/Estuarine/Coastal Waters Using Alkaline Persulfate Digestion of Phosphorus to Orthophosphate (PO₄) (References Standard Methods #4500-P.B.5, #4500 P.E, and EPA Method 365.1)</i> | 1-May-2019 |
| Total and Dissolved Organic Carbon Method | <i>Standard Operating Procedure for Determination of Dissolved Organic Carbon/Non-Purgeable Organic Carbon (DOC/NPOC), and Total Organic Carbon (TOC) in Fresh/Estuarine/Coastal Waters using High Temperature Combustion and Infrared Detection. (References: SM 5310B-2011)</i> | 15-April-2022 |
| Particulate Carbon and Nitrogen Method | <i>Standard Operating Procedure for Determination of Carbon and Nitrogen in Particulates and Sediments of Fresh/Estuarine/Coastal Waters, Plant and Animal Tissue, and Soils Using Elemental Analysis. (Reference Method: EPA 440.0)</i> | 15-May-2022 |
| Particulate Phosphorus Method | <i>Determination of Total Particulate Phosphorus (TPP) and Particulate Inorganic Phosphorus (PIP) in Fresh/Estuarine/Coastal Waters (Reference Method: EPA 365.1, Rev. 2.0)</i> | 15-May-2022 |
| Total Suspended Solids and Total Volatile Solids Methods | <i>Determination of Total Suspended Solids (TSS) and Total Volatile Solids (TVS) in Waters of Fresh/Estuarine/Coastal Waters. (Reference Method: EPA Method 160.2 and Standard Methods 208 E.)</i> | 1-May-2019 |
| Chlorophyll Spectrophotometric Method | <i>Standard Operating Procedure for Spectrophotometric Determination of Chlorophyll α in waters and sediments of Fresh/Estuarine/Coastal Areas. (References: EPA 446.0, SM10200H)</i> | 1-May-2022 |

Current versions of NASL methods documents are maintained on-line by NASL and may be accessed at the following URL: <<https://www.umces.edu/nasl/methods>>.

To ensure that samples are processed within the holding times, samples are packed in ice immediately after filtering and taken to the field office and stored in a freezer. The frozen or refrigerated samples are packed in ice and driven to NASL weekly to be processed. NASL staff processes and analyzes the samples within the holding time periods established under the specific parameter method reference and listed in Table 9.

5. DATA MANAGEMENT, VERIFICATION AND DOCUMENTATION

5.1 Continuous Monitoring

At most continuous monitoring stations, sondes are retrieved, calibrated and replaced every two to four weeks from April to October. Two sites adjacent to the National Aquarium in Baltimore, the Masonville Cove and Middle Branch sites in the Patapsco River, the Mallows Bay site in the Potomac River, the three National Estuarine Research Reserve (NERR) sites on the upper Patuxent, one NERR site at Otter Point Creek on the Bush River, one NERR site in Little Monie Creek, and two sites in Fishing Bay are maintained year-round unless severe icing or insufficient water depth during the winter prohibits deployment. For these stations, continuous monitoring sondes are generally retrieved, calibrated, and replaced monthly between November and March.

In the field, before a continuous monitoring sonde is replaced, a three-way *in situ* match-up is conducted. The new (freshly calibrated) sonde is suspended in the water next to the PVC tube or crab-pot like structure, at the same depth of the old (deployed) sonde in the tube or pot. For bottom mounted sondes, an instrument is lowered to the bottom and then brought up 0.3-0.8 off the bottom. A discrete check sonde (either a Hydrolab or similar YSI EXO instrument) is also suspended in the water at the same depth. A synchronized reading is taken at the next sonde-data-storage 15-minute interval with the old, new and check sondes. A second synchronized reading is taken at the following 15-minute interval with

just the old and the new sondes if personnel deem it necessary. After one or two synchronized readings have been taken, a water column profile is conducted using the discrete sonde. The water column profile may be taken either before or after the first synchronized reading (Appendix 2). After conducting the water column profile, the old sonde is removed from the PVC tube or crab pot-like structure and the tube is cleaned with a brush (Webster™ duster or similar) to remove biofouling and clear debris from inside and outside of the tube. A scouring pad is used to remove biofouling from any telemetry cables or the floating mechanism (if applicable). Once everything has been cleaned, the new sonde is placed in the PVC tube or crab pot-like structure. A clean crab pot-like structure can be deployed to house the new sonde if the old crab pot-like structure is heavily fouled.

The three-way comparison assures that the new and old sondes are both reading each parameter within a certain tolerance (Table 11). The check sonde allows for notation on whether the parameters are fluctuating or stable (Appendix 2).

The retrieved sonde is returned to the field office and placed in a bucket of 100% air saturated water. The sonde must rest in the air saturated water for approximately 20 minutes to equilibrate to the temperature and pressure (often the sonde is left overnight). After equilibration, a dissolved oxygen check is conducted as outlined in Appendix 2, the data are uploaded to a personal computer using YSI's Ecowatch™ or KOR™ software, and the remaining post-calibration procedures are conducted as outlined in Appendix 2.

After post-calibration procedures have been completed, data are subjected to a series of quality assurance (QA) and quality control (QC) checks to ensure that the data are not erroneous and that they are within the range of the sensor instrumentation (Appendix 1). Data from the three-way *in situ* match-up are first used to determine if a specific probe has drifted outside of an acceptable range (Table 11). Data may be rejected during the QA/QC checks when post-calibration drift exceeds the limits stated in Table 11 in both the post-calibration and the *in situ* comparables or when data are clearly associated with probe failures. Section 5.3 describes the data management procedures common to the continuous monitoring and water quality mapping projects.

Data from telemetered stations are examined daily by DNR staff. Automated programs also alert DNR staff when equipment malfunctions and probe failures may be occurring at real-time continuous monitoring stations. To ensure the quality of the data presented on the Eyes on the Bay (<http://www.eyesonthebay.net>) website, the real-time data is replaced with the QA/QC'd data generated after continuous monitoring sonde replacement. While every effort is made to ensure the quality of the data presented on Eyes on the Bay, DNR places disclaimers on the web site that state the following:

NOTE: Data from the current year are provisional and have not yet been through our rigorous Quality Assurance procedures.

At the end of the monitoring season, DNR staff conducts additional QA/QC procedures to discover problem data which may not have been detected earlier. Staff members plot all of the data and then thoroughly research any outliers or other unusual values. For example, staff members compare values outside the normal range to historic values and values elsewhere in the Bay, consider weather events, and

Table 11. Acceptable drift tolerances for YSI 6600V2/EXO sondes following post-calibration check.

| Parameter | Value |
|----------------------|---|
| Chlorophyll | ±5 % of true value or 5.0 µg/L (whichever is greater) |
| Dissolved Oxygen | ±0.5 mg/L |
| pH | ±0.2 pH units |
| Specific Conductance | ±5 % of true value |
| Turbidity | ±5 % of true value or 5.0 NTU (whichever is greater) |
| Water Temperature | ±0.2 °C |

consult with field staff regarding possible legitimate causes for those values. In cases where data are determined, by the Quality Assurance Officer, to be unreliable, the reason(s) values are determined to be unacceptable are documented with error codes and comments. Unreliable data are masked. No data are discarded. Only data considered reliable are published in reports or on the web.

Federal Geographic Data Commission compliant metadata records are routinely generated to describe the continuous monitoring project years, and are available on-line by using publication type 'Metadata' to search the Monitoring News and Reports page of the Eyes on the Bay website (<https://eyesonthebay.dnr.maryland.gov/eyesonthebay/stories.cfm>).

5.2 Water Quality Mapping

Water Quality Mapping (WQM) is generally conducted once monthly in tributaries or Chesapeake Bay segments from April-October (Table 4, Figure 1). For tributaries with submerged aquatic vegetation restoration, specific monitoring projects, or in polyhaline segments, sampling may begin in March and end in November. In 2023, mapping surveys will be conducted in one Maryland Chesapeake Bay segment: TANMH.

Cruise tracks vary depending on the system. In general, a square-wave pattern is followed by alternately sampling shallow shoreline areas and open, deeper waters while traveling up and downriver. Alternative cruise paths may be followed if tributary size or shape dictates otherwise. Cruise patterns are selected to obtain representative coverage of shallow water habitats and open waters so that segment-wide criteria can be assessed as accurately as possible. Navigational issues and placement of representative calibration sites also determine ultimate cruise tracks for WQM.

During data collection, field personnel keep a logbook and document any incidents or observations that may affect the integrity or interpretation of the data. Such observations may include perturbation of bottom sediments by the boat, observances of algal blooms or equipment malfunctions. After data collection, field personnel use the Shallow Water Monitoring QA/QC macro (See Appendix 13) to format data, discover and evaluate anomalous values, and to add error codes based on field notes and range checks where appropriate.

Original data files are named with a three-letter segment designation and an eight-digit date (e.g., SEV05272005). Files that have been through the QAQC process are labeled with a "Q". After initial QA/QC by field personnel, data files are reviewed again by a data analyst. Scatter plots are generated to discover anomalous values. Data are also viewed using Geographic Information System (GIS) software tools, a procedure that can highlight positional errors and highlight errors that might only be observed within a geographical display.

Preliminary maps of chlorophyll, dissolved oxygen, turbidity, water temperature and salinity are created and posted to the Water Quality Mapping Data page of the Eyes on the Bay website (<https://eyesonthebay.dnr.maryland.gov/sim/DataflowDataMenu.cfm>). Maps are generated using a default inverse distance weighted interpolation procedure. These maps give an overall perspective of water quality conditions and are meant for general reference, not for detailed analysis.

Federal Geographic Data Commission compliant metadata records are routinely generated to describe the water quality mapping project years, and are available on-line by using publication type 'Metadata' to search the Monitoring News and Reports page of the Eyes on the Bay website (<https://eyesonthebay.dnr.maryland.gov/eyesonthebay/stories.cfm>).

5.3 Data Management

All shallow water monitoring data (continuous monitoring and water quality mapping) are maintained in a Shallow Water Monitoring database as part of Maryland DNR's Water Quality Monitoring Program. Data that are rejected during QA/QC checks are never deleted. Data determined to be unreliable are masked with an appropriate error code (see Appendix 11) rather than deleted. This ensures that all raw data are archived and available for future re-evaluation. Techniques and technologies may be developed which will enable utilization of data that have been previously rejected. After the data from a deployment have undergone QA/QC checks, the QA/QC'd data files are transferred to an internal network directory where they are inserted into DNR's Shallow Water Monitoring database. Redundant backup copies of all raw data and QA/QC'd data are also maintained.

Maryland Continuous Monitoring

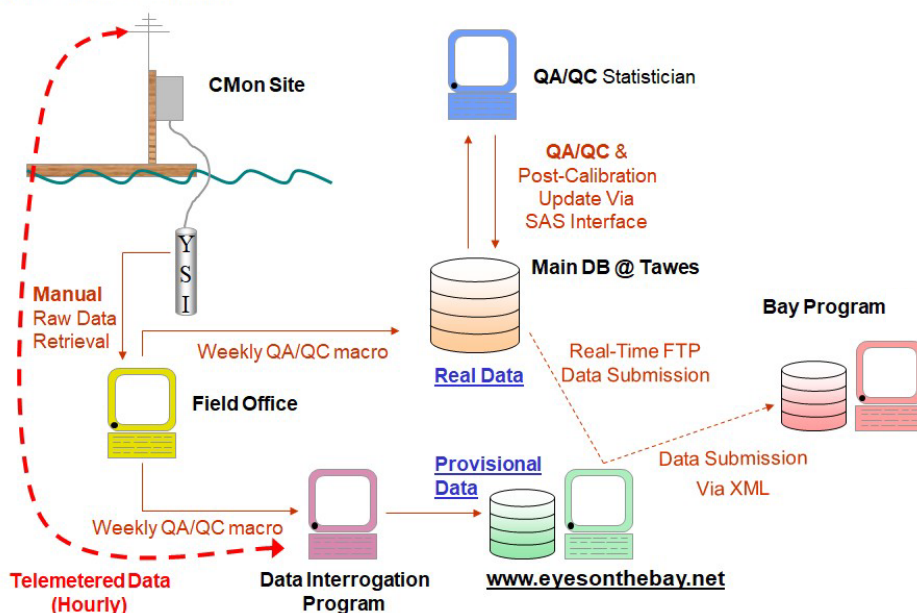


Figure 2. Conceptual diagram of continuous monitoring data management components, including automated data submission from DNR to the Chesapeake Bay Program - Chesapeake Center for Collaborative Computing (C4).

Maryland Water Quality Mapping

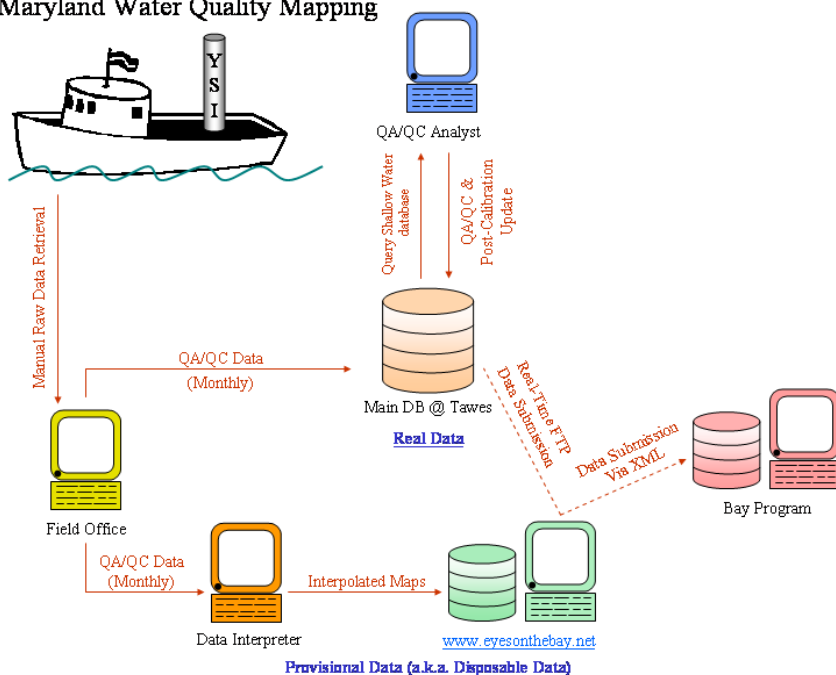


Figure 3. Conceptual diagram of water quality mapping data management components, including automated data submission from DNR to the Chesapeake Bay Program - Chesapeake Center for Collaborative Computing (C4).

5.4 Documentation and Records

Documentation and records maintained by the continuous monitoring project and the water quality mapping project include: YSI Calibration and Post-Calibration Procedures (Appendix 5 and 6), Continuous Monitoring and Water Quality Mapping Filtering Methods (Appendix 7), Photosynthetic Active Radiation Protocol (Appendix 4), Continuous Monitoring Procedures (Appendix 2), Water Quality Mapping Procedures (Appendix 3), Continuous Monitoring Instrument Calibration and Comparison Tables and Calibration Log (Appendix 5), Continuous Monitoring Data Verification and Management Procedures (Appendix 12), Water Quality Mapping Data Verification and Management Procedures (Appendix 13) and the Log of Significant Changes (Appendix 14).

6. PROJECT QUALITY ASSURANCE/QUALITY CONTROL

NOTE: On September 10, 2007, the deionized (DI) water generator used by Maryland DNR was upgraded from an in-line filter cartridge type to a reverse osmosis/UV sterilization type. This apparatus is a Thermo Scientific Barnstead Dlamond™ TII Water System. All manufacturer recommendations are followed regarding cartridge replacement and system sanitation. Refer to Thermo Scientific. 2007. Barnstead Dlamond TII Type II Water System Operation Manual and Barnstead Dlamond TII Type II Storage Reservoir Operation Manual). A log is kept at the front of the DI System Manual to document all changes and updates made to the system. Also, beginning in 2010, along with filtered samples for nutrient analysis, blank DI samples are sent to CBL to check for contamination of DI water used in filtering samples.

An initial quality assurance (QA) and quality control (QC) check is performed by field staff members, who inspect all data for outliers and mask outliers in the data set as deemed appropriate before reporting any data. Field staff also masks any data for parameters that did not post-calibrate within specifications. See Tables 7 and 8 in Section 2 and Table 11 in Section 5 for limits on accuracy and instrument drift. See Appendices 5 and 6 (YSI Calibration and Post-Calibration Procedures) and Appendices 12 and 13 (Continuous Monitoring and Water Quality Mapping Data Verification and Management Procedures) for a description of QA/QC and calibration procedures used by the field staff. Additional quality assurance and control is performed by members of DNR staff to identify any erroneous data missed in the initial QA/QC and compare current data to historical data.

6.1 Accuracy

The accuracy (closeness to the true value) of the collected data is controlled and assured by the proper use, calibration, and maintenance of both field and laboratory equipment for the measurement of physical and chemical parameters. All instruments are identified by a unique number, used as an index for documentation of calibration, repair, and preventive maintenance.

Daily quality control checks (including the running of blanks and standards) are used to control and assure laboratory accuracy. See Cain and Parham (2023; Appendix 15) for details on the frequency of running blanks and standards and for additional procedures for laboratory quality assurance and control.

Accuracy of laboratory results is also assessed through laboratory participation in the Chesapeake Bay Coordinated Split Sample Program (CSSP), the Blind Audit Program and the United States Geological Survey (USGS) Standard Reference Sample Program. More information on these programs can be found on the CBP webpage Quality Assurance/Split Sample and Blind Audit Programs. This interlaboratory testing program involves the distribution of identical surface water samples to participating state, federal and academic monitoring agencies. CSSP was established in June 1989 to establish a measure of comparability between sampling and analytical operations for water quality monitoring throughout the Chesapeake Bay and its tributaries. Samples are processed according to standard protocols and the results are evaluated quarterly to ensure comparable data is being produced. The

protocols are available in the Chesapeake Bay Coordinated Split Sample Program Implementation Guidelines Rev. 4 (EPA 2010) and its revisions.

Results are analyzed by appropriate statistical methods to determine if results differ significantly among labs. When a difference occurs, discussion begins regarding techniques and potential methods changes to resolve discrepancies through the Data Integrity Workgroup (DIWG – a Chesapeake Bay Program workgroup, formerly AMQAW - Analytical Methods and Quality Assurance Workgroup).

Additionally, CBL participates two times per year in the United States Geologic Survey (USGS) reference sample program and permits USGS to release the results to the Chesapeake Bay Program Quality Assurance Officer.

Procedures to control and assure the accuracy of field measurements involve the calibration of field instruments, the verification of these calibrations, equipment maintenance, and collection of filter blanks.

6.2 Precision

Precision (repeatability) of the chemical analytical methods is determined and documented from duplicate analyses. The protocols for duplicate analyses in the laboratory are described in the Standard Operating Procedures for CBL, referenced in Appendix 15 in the Quality Assurance Project Plan for the Maryland Department of Natural Resources Chesapeake Bay Water Quality Monitoring Program Chemical and Physical Properties Component for the Period July 2023 (Cain and Parham 2023).

6.3 Data Review and Data Verification

Data review and data verification ensure the quality assurance and quality control of data. These are discussed in Section 5 above.

6.4 Audits

Performance audits for chemical analyses conducted at the University of Maryland Center for Environmental Science's Chesapeake Biological Laboratory Nutrient Analytical Services Laboratory (NASL) are based on the results of samples distributed by the EPA Chesapeake Bay Program Blind Audit Program. These samples must fall within the 95% confidence interval for acceptance. If results fall outside this range, corrective actions for each parameter and measurement are taken. NASL prepares the blind audit samples for all participating laboratories and also analyzes some of those samples. For dissolved nitrogen and dissolved phosphorus, a laboratory quality assurance officer determines the concentrations in the ampules, prepares the concentrates, and seals the ampules. A different person then analyzes the sample blindly. For the particulate fractions (particulate carbon/particulate nitrogen and particulate phosphorus), samples are filtered and then placed in pouches in the freezer until they are ready to be sent to the other CBP participating laboratories. As of May 2022 the following labs were participating in the Blind Audit program: College of William and Mary - Virginia Institute of Marine Science, Analytical Services Center; Delaware DNREC-DWR; Hampton Roads Sanitation District - CEL; Maryland Department of Health; Virginia Tech Occoquan Watershed Monitoring Lab, Division of Environmental Sciences, Inorganics Analytical Laboratory; Massachusetts Water Resource Authority; New Jersey Public Health, E&A Lab, New Jersey State Police HQ Campus; Old Dominion University, Water Quality Laboratory; Patrick Center for Environmental Research - Academy of Natural Sciences of Philadelphia; Pennsylvania Department of Environmental Protection - Bureau of Laboratories; Sprague River Water Quality Laboratory; University of Maryland, CES, Appalachian Laboratory; University of Maryland, CES, Chesapeake Biological Laboratory; Virginia Division of Consolidated Laboratory Services; Anne Arundel County Community College Environmental Center; and the Interstate Environmental Commission (IEC/NY-NJ-CT).

Final annual audit reports can be viewed at <https://www.umces.edu/blind-audit-results-nasl>.

Once annually, the EPA Chesapeake Bay Program quality assurance officer conducts an on-site audit of the Shallow Water Quality Monitoring laboratory and field programs. The DNR Quality Assurance Officer communicates on a weekly basis with the field program staff and confers with the laboratory quality assurance officers to ensure that all aspects of the program are being conducted properly.

6.5 Data Quality Indicators

To ensure that data are of the quality required to support Chesapeake Bay Program management decisions, Maryland's Shallow Water Quality Monitoring Program strives to provide monitoring data of known and consistent quality to the CBPO by generally following the guidelines outlined in Section E of the [*Methods and Quality Assurance for Chesapeake Bay Water Quality Monitoring Programs, May 2017*](#) (EPA 2017). These guidelines recommend precision goals of field and lab measurements of <20 percent of the coefficient of variation, accuracy goals within 80 to 120 percent, and completeness goals of 100 percent. Detection limit ranges are provided in Tables 7, 8, and 9 above.

7. DATA ANALYSIS AND REPORTING

As noted previously, the objectives of the Shallow Water Monitoring Program are to 1) assess the newly developed Chesapeake Bay water quality criteria for dissolved oxygen, water clarity and chlorophyll in shallow and open water habitats, 2) determine attainment or non-attainment of shallow water and open water habitats for their designated uses, 3) provide spatially and temporally intensive data in shallow water habitats to improve water quality mapping using interpolation, 4) assess SAV habitats and identify potential SAV restoration sites and 5) provide information to better understand ecosystem processes in shallow water and open water environments.

Regression models for use in calculating K_d from *in situ* turbidity, chlorophyll and salinity data have been developed and continue to be refined as new data become available. The K_d models have been used in five reporting cycles for water clarity acreage assessments.

Real-time data (uploaded from transmitters hourly) and near-time data (uploaded every two weeks) will be available on the DNR Eyes on the Bay web site (<http://www.eyesonthebay.net>). These data are not quality assured and will be identified as such. Archived data from prior years (2001 – 2022) are “Quality Assured” and also available for download on the Eyes on the Bay web site. Semi-annual progress reports will be provided to the Chesapeake Bay Program in January and July.

8. PROJECT ORGANIZATION AND RESPONSIBILITY

This section lists the individuals responsible for the major aspects of Maryland's Shallow Water Quality Monitoring Program.

Director and Principal Investigator: Thomas Parham, Director, Tidewater Ecosystem Assessment, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, tom.parham@maryland.gov, 410-260-8633.

RESPONSIBILITIES: The director and principal investigator is responsible for overseeing the administrative aspects of the program including fiscal management, coordination among other DNR managers and coordination with cooperating agencies and institutions. This individual is also responsible for technical design, conduct and data analysis of the program.

Quality Assurance Manager: Dave Goshorn, Ph.D., Deputy Secretary, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, david.goshorn@maryland.gov, 410-260-8110.

RESPONSIBILITIES: The quality assurance officer is responsible for documenting and assuring the conduct of field, laboratory, and data management procedures that comprise this study.

Field Sampling Operations: Kristen Heyer, Program Manager, Water Quality Monitoring, Monitoring and Non-Tidal Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, kristen.heyer@maryland.gov, 410-990-4600.

RESPONSIBILITIES: This individual is responsible for administration of field sampling activities including sample collection, sample storage and sample delivery to laboratories at all continuous monitoring sites and most water quality mapping sites.

Instrument Management: Lauren Cunningham/Maureen Balan, Monitoring Field Office, Monitoring and Non-Tidal Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, lauren.cunningham@maryland.gov, maureen.balan@maryland.gov, 410-263-3369.

RESPONSIBILITIES: These individuals are responsible for the management of all continuous monitoring equipment.

Instrument Management: Jamie Strong, Natural Resources Biologist, Monitoring Field Office, Monitoring and Non-Tidal Assessment, Resource Assessment Service, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, jamie.strong@maryland.gov, 410-990-4508.

RESPONSIBILITIES: This individual is responsible for the management of all water quality mapping and vertical profiler equipment.

Laboratory Analyses/Water Column Chemistry: Jerry Frank, Manager of Analytical Services/Advanced Senior Faculty Research Assistant, Chesapeake Biological Lab, University of Maryland, Center for Environmental Science, Solomons, Maryland 20688-0038, frank@cbl.umces.edu, 410-326-7252.

RESPONSIBILITIES: This individual is responsible for analysis of water samples for suspended solids, nutrients and chlorophyll.

Data Management, Processing and Quality Assurance/Quality Control: Mark Trice/Brian Smith/Renee Karrh/Rebecca Burrell, Tidewater Ecosystem Assessment, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, 410-260-8630.

RESPONSIBILITIES: These individuals are responsible for overseeing the management and processing of field and laboratory data collected under this program and maintaining existing data management software.

Data Analysis and Report Preparation: Mark Trice/Brian Smith/Renee Karrh/Rebecca Burrell, Tidewater Ecosystem Assessment, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, 410-260-8630.

RESPONSIBILITIES: These individuals are responsible for statistical analyses, GIS mapping, and report preparation under this program.

9. REFERENCES

- Boynton, W.R., R.M. Stankelis, F.M. Rohland, J.M. Frank, J.M. Lawrence, B. Bean, H. Pine, M. Quigley, and M. Kaumeyer. 2002. *Maryland Chesapeake Bay Water Quality Monitoring Program, Ecosystem Processes Component (EPC), [Level One Report No. 19](#) (Data), Data Report, January - December 2001*. Prepared for the Maryland Department of Natural Resources. University of Maryland Center for Environmental Sciences, Chesapeake Biological Laboratory, P.O. Box 38, Solomons, MD.
- Testa, J.M., L.A. Harris, W.R. Boynton, C.L.S. Hodgkins, J.L. Humphrey, and M.C. Day. 2015. *Chesapeake Bay Water Quality Monitoring Program Ecosystem Processes Component (EPC), [Level 1 report No. 32](#). Jul. 1984 - Dec. 2014*. Ref. No. [UMCES]CBL 2015-043. Prepared for the Maryland Department of Natural Resources. University of Maryland Center for Environmental Sciences, Chesapeake Biological Laboratory, P.O. Box 38, 146 Williams Street, Solomons, MD.
- Cain, B., Parham, T. 2022. Quality Assurance Project Plan for the Maryland Department of Natural Resources Chesapeake Bay Water Quality Monitoring Program - Chemical and Physical Properties Component for the period July 1, 2022 - June 30, 2023. Prepared by Maryland Department of Natural Resources, Tidewater Ecosystem Assessment for U.S. Environmental Protection Agency Chesapeake Bay Program.
- Boynton, W.R., E.M. Bailey, S.M. Moesel, and L.A. Moore. 2007. *[Chesapeake Bay Water Quality Monitoring Program, Ecosystem Processes Component \(EPC\), Quality Assurance Project Plan, FY2008, July 2007-June 2008](#)*.
- U.S. Environmental Protection Agency (EPA). 1996. *[Recommended Guidelines for Sampling and Analysis in the Chesapeake Bay Monitoring Program](#)*. Chesapeake Bay Program, August 1996. CBP/TRS 148/96; EPA 903-R-96-006.
- U.S. Environmental Protection Agency (EPA). 2010. *Chesapeake Bay Coordinated Split Sample Program Implementation Guidelines Revision 4, December 2010*. Chesapeake Bay Program: Annapolis, MD. <http://archive.chesapeakebay.net/pubs/quality_assurance/CSSP_Guidelines_12-17-10.pdf>.
- U.S. Environmental Protection Agency (EPA). 2017. *Methods and Quality Assurance for Chesapeake Bay Water Quality Monitoring Programs, May 2017*, CBP/TRS-319-17. Chesapeake Bay Program: Annapolis, MD. <<https://www.chesapeakebay.net/documents/CBPMethodsManualMay2017.pdf>>.

10. APPENDICES

| | |
|--|-----------|
| Appendix 1. YSI 6600V2/EXO Specification Sheets | 32 |
| Appendix 2. Continuous Monitoring Procedures..... | 35 |
| Appendix 3. Water Quality Mapping Procedures..... | 41 |
| Appendix 4. Photosynthetic Active Radiation Protocol..... | 46 |
| Appendix 5. YSI 6600V2 and EXO Calibration and Post-Calibration Procedures (Continuous Monitoring)..... | 49 |
| Appendix 6. YSI 6600 Calibration and Post-Calibration Procedures (Water Quality Mapping)..... | 68 |
| Appendix 7. Continuous Monitoring and Water Quality Mapping Filtering Methods | 75 |
| Appendix 8. Continuous Monitoring Parameters | 79 |
| Appendix 9. Water Quality Mapping Parameters | 80 |
| Appendix 10. Continuous Monitoring and Water Quality Mapping Error Codes..... | 81 |
| Appendix 11. Continuous Monitoring Data Verification and Management Procedures | 83 |
| Appendix 12. Water Quality Mapping Data Verification and Management Procedures ... | 91 |
| Appendix 13. Log of Significant Changes | 94 |

Appendix 1. YSI 6600V2 Specification Sheets

| YSI 6600 VZ Sensor Specifications | | | |
|--|---|--|--|
| | Range | Resolution | Accuracy |
| ROX™ Optical Dissolved Oxygen* % Saturation | 0 to 500% | 0.1% | 0 to 200%: ±1% of reading or 1% air saturation, whichever is greater; 200 to 500%: ±15% of reading |
| ROX™ Optical Dissolved Oxygen* mg/L | 0 to 50 mg/L | 0.01 mg/L | 0 to 20 mg/L: ±0.1 mg/L or 1% of reading, whichever is greater; 20 to 50 mg/L: ±15% of reading |
| Dissolved Oxygen** % Saturation ET✓ 6562 Rapid Pulse™ Sensor* | 0 to 500% | 0.1% | 0 to 200%: ±2% of reading or 2% air saturation, whichever is greater; 200 to 500%: ±6% of reading |
| Dissolved Oxygen** mg/L ET✓ 6562 Rapid Pulse™ Sensor* | 0 to 50 mg/L | 0.01 mg/L | 0 to 20 mg/L: ±0.2 mg/L or 2% of reading, whichever is greater; 20 to 50 mg/L: ±6% of reading |
| Conductivity*** 6560 Sensor* ET✓ | 0 to 100 mS/cm | 0.001 to 0.1 mS/cm (range dependent) | ±0.5% of reading + 0.001 mS/cm |
| Salinity | 0 to 70 ppt | 0.01 ppt | ±1% of reading or 0.1 ppt, whichever is greater |
| Temperature 6560 Sensor* ET✓ | -5 to +50°C | 0.01°C | ±0.15°C |
| pH 6561 Sensor* ET✓ | 0 to 14 units | 0.01 unit | ±0.2 unit |
| ORP | -999 to +999 mV | 0.1 mV | ±20 mV |
| Depth Deep Medium Shallow Vented Level | 0 to 656 ft, 200 m 0 to 200 ft, 61 m 0 to 30 ft, 9.1 m 0 to 30 ft, 9.1 m | 0.001 ft, 0.001 m 0.001 ft, 0.001 m 0.001 ft, 0.001 m 0.001 ft, 0.001 m | ±1 ft, ±0.3 m ±0.4 ft, ±0.12 m ±0.06 ft, ±0.02 m ±0.01 ft, 0.003 m |
| Turbidity* 6136 Sensor* ET✓ | 0 to 1,000 NTU | 0.1 NTU | ±2% of reading or 0.3 NTU, whichever is greater** |
| Nitrate/nitrogen**** | 0 to 200 mg/L-N | 0.001 to 1 mg/L-N (range dependent) | ±10% of reading or 2 mg/L, whichever is greater |
| Ammonium/ammonia/nitrogen**** | 0 to 200 mg/L-N | 0.001 to 1 mg/L-N (range dependent) | ±10% of reading or 2 mg/L, whichever is greater |
| Chloride**** | 0 to 1000 mg/L | 0.001 to 1 mg/L (range dependent) | ±15% of reading or 5 mg/L, whichever is greater |
| Rhodamine* | 0-200 µg/L | 0.1 µg/L | ±5% reading or 1 µg/L, whichever is greater |

* Maximum depth rating for all optical probes is 200 feet, 61 m. Turbidity and Rhodamine are also available in a Deep Depth option (0 to 200 m).
 ** Rapid Pulse is only available on 6600 V2-2 (two optical ports version).
 *** Report outputs of specific conductance (conductivity corrected to 25° C), resistivity, and total dissolved solids are also provided. These values are automatically calculated from conductivity according to algorithms found in *Standard Methods for the Examination of Water and Wastewater* (ed 1989).
 **** Freshwater only. Maximum depth rating of 50 feet, 15.2 m. 6600 V2-2 has 3 ISE ports; not available on the 6600V2-4.

**In YSI AMCO-AEPA Polymer Standards.

| | Range | Detection Limit | Resolution | Linearity |
|-------------------------------------|---|-----------------|--------------------------|-----------------|
| Blue-Green Algae Phycocyanin* | ~0 to 280,000 cells/mL† 0 to 100 RFU | ~220 cells/mL‡ | 1 cell/mL 0.1 RFU | R² > 0.9999** |
| Blue-Green Algae Phycocyanin* | ~0 to 200,000 cells/mL† 0 to 100 RFU | ~450 cells/mL‡ | 1 cell/mL 0.1 RFU | R² > 0.9999*** |
| Chlorophyll* 6025 Sensor* ET✓ | ~0 to 400 µg/L 0 to 100 RFU | ~0.1 µg/L‡ | 0.1 µg/L Chl 0.1% RFU | R² > 0.9999**** |

* Maximum depth rating for all optical probes is 200 feet, 61 m. Also available in a Deep Depth option (0 to 200 m).
 † RFU = Relative Fluorescence Units.
 ‡ Explanation of Ranges can be found in the 'Principles of Operation' section of the 6-Series Manual, Rev D.
 § Estimated from cultures of *Microcystis aeruginosa*.
 ¶ Estimated from cultures *Synechococcus* sp.
 §§ Determined from cultures of *Isodryopsis* sp. and chlorophyll a concentration determined via extractions.
 **For serial dilution of Rhodamine WT (0-400 µg/L).
 ***For serial dilution of Rhodamine WT (0-8 µg/L).
 ****For serial dilution of Rhodamine WT (0-500 µg/L).

| YSI 6600 VZ Sonde Specifications | | | |
|-------------------------------------|------------------------------|--|--|
| Medium | Fresh, sea or polluted water | Software | EcoWatch* |
| Temperature Operating Storage | -5 to +50°C -10 to +60°C | Dimensions Diameter Length, no depth Length, with depth Weight | 3.5 in, 8.9 cm 19.6 in, 49.8 cm 21.6 in, 54.9 cm 7 lbs, 3.18 kg (batteries installed, with depth) |
| Communications | RS-232, SDI-12 | Power External Internal | 12 V DC 8 C-size alkaline batteries |

Appendix 1 (continued). YSI EXO Specification Sheets

| EXO Sensor Specifications | | | |
|---------------------------|--------------------------------------|-------------------------------------|--|
| Sensor | Range | Resolution ¹ | Accuracy ² |
| Conductivity (Non-Wiped) | 0 to 200 mS/cm | 0.001 to 0.01 mS/cm | ±0.5% of reading or 0.001 mS/cm, whichever is greater (0 to 100 mS/cm) ±1.0% of reading (100 to 200 mS/cm) |
| Temperature | -5 to 50 °C | 0.001 °C | -5 to 35 °C: ±0.01 °C (-5 to 35 °C) ±0.05 °C (35 to 50 °C) |
| Conductivity (Wiped) | 0 to 100 mS/cm | 0.001 to 0.01 mS/cm | ±1.0% of reading or 2 µS/cm, whichever is greater |
| Temperature | -5 to 50 °C (23 to 158°F) | 0.001 °C | ±0.2 °C |
| Depth or Vented Level | 0 to 10, 100 or 250 m | 0.001 m | ±0.04% Full Scale |
| | 0 to 10 m | 0.001 m | ±0.03% Full Scale |
| Dissolved Oxygen | 0 to 500% air saturation | 0.1% air saturation | ±1% of reading or 1% saturation, whichever is greater (0 to 200%) ±5% of reading (200 to 500%) |
| | 0 to 50 mg/L | 0.01 mg/L | ±0.1 mg/L or 1% of reading, whichever is greater (0 to 20 mg/L) ±5% of reading (20 to 50 mg/L) |
| fDOM | 0 to 300 ppb QSU | 0.01 ppb QSU | Linearity: $r^2 \geq 0.999$ for 0 to 300 for serial dilution of 300 ppb Quinine Sulfate Solution Minimum Detection Limit of 0.1 ppb Quinine Sulfate Equivalents |
| ISE Ammonium | 0 to 200 mg/L-N (NH_4^+) | 0.01 mg/L | ±10% of reading or ±2 mg/L-N, whichever is greater |
| ISE Chloride | 0 to 1000 mg/L-Cl (Cl^-) | 0.01 mg/L | ±15% of reading or ±5 mg/L-Cl, whichever is greater |
| ISE Nitrate | 0 to 200 mg/L-N (NO_3^-) | 0.01 mg/L | ±10% of reading or ±2 mg/L-N, whichever is greater |
| pH | 0 to 14 pH units | 0.01 pH units | ±0.1 within ±10 °C of calibration temperature ±0.2 for all other temperatures |
| ORP | -999 to 999 mV | 0.1 mV | ±20 mV |
| Rhodamine | 0 to 100 RFU | 0.01 RFU | ±5% or 0.1 µg/L whichever is greater Linearity: $r^2 > 0.999$ |
| | 0 to 1,000 µg/L | 0.01 µg/L | |
| TAL-Chlorophyll | 0 to 100 RFU or 0 to 400 µg/L chl | 0.01 RFU or 0.01 µg/L of pigment | Linearity: $r^2 \geq 0.999$ for Rhodamine WT across full range |
| TAL-Phycocyanin | 0 to 100 RFU or 0 to 400 µg/L PC | | |
| TAL-Phycocerythrin | 0 to 100 RFU or 0 to 400 µg/L PE | | |
| Turbidity | 0 to 4000 FNU, NTU | 0.1 FNU, NTU | 0 to 999 FNU: 0.3 FNU or ±2% of reading, whichever is greater 1000 to 4000 FNU: ±5% of reading |
| UV Nitrate (NitraLED) | 0 to 10 mg/L-N (NO_3^-) | 0.01 mg/L-N | ±0.4 mg/L-N or 5% of reading, whichever is greater (full temp range) |

¹ Range dependent.

² Specifications indicate typical performance and are subject to change.

Calculated Parameters

The following parameters are calculated from one or more sensors listed above.

- Absolute Pressure
- DO% LocalB
- Resistivity
- Total Algae cells/mL
- Vertical Position
- Ammonia
- Gauge Pressure
- Salinity
- Total Dissolved Solids
- Water Density
- DO% Local
- nLF Conductivity
- Specific Conductivity
- Total Suspended Solids

Appendix 1 (continued). YSI EXO Specification Sheets (continued)

| EXO1 Specifications | |
|---------------------|--|
| Battery Life | 90 days* |
| Communications | Computer Interface: USB Output Options: USB with signal output adapter (SOA); RS-232 & SDI-12 with DCP-SOA. |
| Diameter | 4.70 cm (1.85 in) |
| Length | 64.77 cm (25.50 in) |
| Peripheral Ports | 1 power communication port |
| Sample Rate | Up to 4 Hz |
| Sensor Ports | 4 |
| Warranty: 3 yrs | Sonde; handheld |
| Warranty: 2 yrs | Cables; conductivity/temperature and optical sensors; electronics base for pH, pH/ORP, ammonium, chloride, and nitrate sensors |
| Warranty: 1 yr | Optical DO cap and replaceable reagent modules for pH and pH/ORP sensors |
| Warranty: 3 mos | Replaceable reagent modules for ammonium, chloride, and nitrate sensors |
| Weight | 1.42 kg (3.15 lbs) |

*Typically 90 days at 20°C at 15-minute logging interval; temperature/conductivity, pH/ORP, DO, and turbidity sensors installed on EXO1. Battery life is heavily dependent on sensor configuration.

| EXO2 Sonde | |
|-----------------------|--|
| Ports | 7 sensor ports (6 ports available when central wiper used) Peripheral ports: 1 power communication port; 1 auxiliary expansion port |
| Size | Diameter: 7.62 cm (3.00 in) Length: 71.10 cm (28.00 in) |
| Weight | 3.60 kg (7.90 lbs) with 5 probes, guard and batteries installed |
| Sondes | |
| Operating Temperature | -5 to 50°C |
| Storage Temperature | -20 to 80°C (except 0 to 60°C for pH and pH/ORP sensors) |
| Depth Rating | 0 to 250 m (0 to 820 ft) |
| Communications | Computer Interface: Bluetooth wireless technology, RS-485, USB Output Options: USB with signal output adapter (SOA); RS-232 & SDI-12 with DCP-SOA |
| Sample Rate | Up to 4 Hz |
| Battery Life | 90 days** |
| Data Memory | 512 MB total memory; >1,000,000 logged readings |

Appendix 2. Continuous Monitoring Procedures

Revised: May 2020

Installation:

- To collect seamless continuous data, two instruments are needed for each site. Deploy the first instrument at the site for two to four weeks. At the end of the deployment, replace this instrument with the second instrument. Upon retrieval, post-calibrate and clean the first instrument and prepare it to be deployed the next week.
- Use a 4" or 6" diameter PVC gasketed drainpipe to install a site. The length depends on the depth of the selected site.
- Coat the PVC pipe and a wooden 2x4 or 2x6 with an effective anti-fouling paint to prevent biological growth.
- Drill 2" diameter holes down the length of the PVC pipe that will typically lie below the water line to allow water to pass through the tube.
- Attach the tube to the wooden 2x4 or 2x6 using two copper-coated or stainless-steel clevis hangers. Then attach the 2x4 or 2x6 to a piling or pier using lag bolts.
- Install a stainless-steel stop bolt at either 0.3m, 0.5m, or 0.8m from the bottom of the tube, dependent upon the site to be installed, to ensure proper instrument depth and to prevent the loss of a sonde. Wrap the stop bolt in flexible plastic tubing to prevent electrolysis that can occur from the copper-alloy sensor guard contacting the dissimilar metal of the stop bolt.
- Place a chain through the tube, wrap the chain around the piling or pier, and lock it with a combination or key lock to prevent loss of equipment, theft, or vandalism.
- Depending on instrument type and location, instruments may also be deployed suspended below a small, floating buoy, or inside a crab pot-like structure that is tethered to a pier with a cable and that rests on the bottom and suspends the instrument 0.3m off bottom in a horizontal PVC tube.

Calibration:

- Calibrate each instrument using laboratory quality standards directly prior to each deployment (see Appendix 5).
- For YSI 6600 instruments only, synchronize the internal clock in the instrument with the official time using either a calibrated watch or www.time.gov. A radio-controlled clock that automatically synchronizes to the Atomic Clock in Boulder, CO can also be used. Time is always set in Eastern Standard Time.

Deployment:

- Deploy the instrument at a fixed site at a regular interval, e.g., weekly, bi-weekly, or monthly.
- Record the date, time of deployment, and initials on the corresponding calibration log, and note any extra samples taken. Fill out the header information on the deployment site's corresponding Continuous Monitoring Field Data Sheet (Figure 4).
- Leave the old 6600 or EXO sonde in place inside the PVC tube or crab pot-like structure while suspending the freshly calibrated 6600 or EXO sonde at the same depth, adjacent to the old one. Allow both instruments to take at least one simultaneous reading at a sonde-data-storage 15-minute interval in order to compare the data from the two instruments. This comparison is used during QA/QC process to ensure both instruments were taking accurate measurements. It is encouraged to leave the instruments in place for a second overlapping simultaneous reading at the next sonde-data-storage 15-minute interval.
- Use a YSI, Hydrolab, or similar instrument with a display unit to take an additional simultaneous reading. These readings are recorded on the calibration log and field data sheet. The real-time display makes it possible to note any sudden fluctuations or trends in the water quality parameters.

- At the exact time of sample reading, take a grab sample using an Alpha bottle or sampling hose with a pump attached suspended at the same depth as the sondes.

Sample Processing:

- The grab sample is filtered immediately after it is taken or placed on ice and filtered as soon as possible. Sample is filtered according to Chesapeake Bay Program protocol (see Appendix 7).
- Processed sample is iced down in the field, and frozen in a freezer upon return to the field office. It is then sent to the lab for analysis at the end of the week via courier.

Water Column Profile:

Water column profiles should be taken at each continuous monitoring station when the YSI 6600 or EXO sondes are being replaced. This profile will be done with the check instrument (e.g., Hydrolab or EXO1) and will measure the following parameters that will be recorded on the field data sheet:

- Depth
- Water Temperature (°C)
- pH
- Specific Conductance (µmhos/cm)
- Dissolved Oxygen (mg/l)
- Salinity (ppt)

There should be NO layer code associated with these additional measurements. Layer codes are assigned only to those measurements taken at the same depth as the grab sample.

The following procedure should be followed for the profile discrete readings:

If total depth < 3.0 m:

Floating Stations:

Take discrete readings at the same depth at which the YSI is suspended (1.0 m). This should be done at the exact instant that the YSI is logging its data. Next take discrete readings at 0.3 m from the bottom. You must also take readings at 0.5 m depth, and 0.5 m intervals, e.g. 1.5, 2.0, 2.5, etc. You do not need to take readings within 0.2 m of a depth you already measured.

Examples:

Total depth = 1.7 m:

Discrete readings at 1.0; then 1.4 and 0.5 m. You do not need to sample 1.5 m since it is within 0.2 m of the bottom reading

Total depth = 2.9 m:

Discrete readings at 1.0; then 2.6, 2.0, 1.5 and 0.5 m. You do not need to sample 2.5 m since it is within 0.2 m of the bottom reading.

Total depth = 2.4 m:

Discrete readings at 1.0; then 2.1, 1.5 and 0.5 m. You do not need to sample 2.0 m since it is within 0.2 m of the bottom reading

Fixed Stations (0.3 m above bottom):

Take discrete readings at the same depth at which YSI is fixed (0.3 m from the bottom.) This should be done at the exact instant that the YSI is logging its data. You must also take readings at 0.5 m, and any 0.5 m intervals, e.g., 1.5, 2.0, 2.5, etc. You do not need to take readings within 0.2 m of a depth you already measured.

Examples:

Total depth = 0.7 m:

Discrete readings at 0.4 m only. You do not need to sample 0.5 m since it is within 0.2 m of the bottom reading.

Total depth = 1.9 m:

Discrete readings at 1.6, 1.0 and 0.5 m. You do not need to sample 1.5 m since it is within 0.2 m of the bottom reading.

Total depth = 1.5 m:

Discrete readings at 1.2 and 0.5 m. You do not need to sample 1.0 m since it is within 0.2 m of the bottom reading.

Fixed Stations (0.5 m above bottom)

Take discrete readings at the same depth at which YSI is fixed (0.5 m from the bottom.) This should be done at the exact instant that the YSI is logging its data. You must also take readings at 0.5 m, and any 0.5 m intervals, e.g., 1.5, 2.0, 2.5, etc. You do not need to take readings within 0.2 m of a depth you already measured.

Example:

Total depth = 1.9 m:

Discrete readings at 1.4, 1.0 and 0.5 m.

Fixed Stations (0.8 m above bottom)

Take discrete readings at the same depth at which YSI is fixed (0.8 m from the bottom.) This should be done at the exact instant that the YSI is logging its data. Next take discrete readings at 0.3 m above bottom. You must also take readings at 0.5 m, any 0.5 m intervals, e.g. 1.5, 2.0, 2.5, etc. You do not need to take readings within 0.2 m of a depth you already measured.

Example:

Total depth = 1.9 m:

Discrete readings at 1.1; then 1.6m and 0.5 m. You do not need to sample 1.5 m since it is within 0.2 m of the bottom reading.

If Total Depth \geq 3.0 m:

Floating Stations:

Take discrete readings at the same depth at which the YSI is suspended (1.0 m). This should be done at the exact instant that the YSI is logging its data. Next take discrete readings at 0.3 m from the bottom. You must also take readings at 0.5 m depth, and 1.0 m intervals, e.g. 2.0, 3.0, etc. You do not need to take readings within 0.2 m of a depth you already measured.

Examples:

Total depth = 3.4 m:

Discrete readings at 1.0; then 3.1, 2.0 and 0.5 m. You do not need to sample 3.0 m since it is within 0.2 m of the bottom reading

Fixed Stations (0.3 m above bottom):

Take discrete readings at the same depth at which YSI is fixed (0.3 m from the bottom.) This should be done at the exact instant that the YSI is logging its data. You must also take readings at 0.5 m, and any 1.0 m intervals, e.g., 2.0, 3.0, etc. You do not need to take readings within 0.2 m of a depth you already measured.

Examples:

Total depth = 3.2 m:

Discrete readings at 2.9, 2.0, 1.0 and 0.5 m. You do not need to sample 3.0 m since it is within 0.2 m of the bottom reading.

Stations sampled 0.5 m above bottom:

Take discrete readings at the same depth at which YSI is fixed (0.5 m from the bottom.) This should be done at the exact instant that the YSI is logging its data. You must also take readings at 0.5 m, and any 1.0 m intervals, e.g. 1.0, 2.0, 3.0, etc. You do not need to take readings within 0.2 m of a depth you already measured.

Examples:

Total depth = 3.5 m:

Discrete readings at 3.0, 2.0, 1.0 and 0.5 m.

Stations sampled 0.8 m above bottom:

Take discrete readings at the same depth at which the YSI is fixed (0.8 m from the bottom). This should be done at the exact instant that the YSI is logging its data. Next take discrete readings at 0.3 m from the bottom. You must also take readings at 0.5 m depth, and 1.0 m intervals, e.g., 2.0, 3.0, etc. You do not need to take readings within 0.2 m of a depth you already measured.

Examples:

Total depth = 3.2 m:

Discrete readings at 2.4 m; then 2.9, 2.0, 1.0 and 0.5 m.

Retrieval:

- After both instruments have taken at least one simultaneous reading, remove the old instrument. It is best to take a second simultaneous reading whenever possible.
- Record the time of retrieval on the calibration log and field data sheet and note any extra samples taken. Review the field data sheet for correctness and then initial.
- Brush out the instrument tube with a Webster-type brush, on the inside and outside. Use a scouring pad to remove biofouling from any telemetry cables, sonde deployment lines, or the floating mechanism (if applicable).
- Deploy the fresh instrument into the PVC tube or crab pot-like structure. A clean crab pot-like structure can be deployed to house the new sonde if the old crab pot-like structure is heavily fouled.
- Wrap the old instrument in a damp towel and take it back to the lab for post-calibration and cleaning.

Post-calibration/cleaning:

- Post-calibrate sensors on each retrieved instrument against laboratory standards to ensure that it was taking accurate measurements. It is best to complete sensor post-calibration procedures the day after the instrument is retrieved, after allowing the instrument to equilibrate to standard temperature and pressure overnight in a 100% saturated air environment before conducting the post-calibration. If using an Optical Dissolved Oxygen sensor, the dissolved oxygen can be post-calibrated within 20 minutes of returning from the field by placing the instrument in a bucket of 100% air saturated water and allowing temperature and pressure to equilibrate. If field staff members are unable to post-calibrate the instrument the day after retrieval, ensure that the instrument is post-calibrated by the second day after retrieval.
- After completion of post-calibration, thoroughly clean each instrument and prepare it for re-deployment the following week.

Figure 4 on the following page is an annotated example of a Continuous Monitoring Field data sheet.

NOTE: Beginning May 18, 2009, in order resolve a data management issue, continuous monitoring grab sample bottle number and grab sample duplicate bottle numbers are labeled as follows.

Most continuous monitoring stations are sampled more than one time in a given month. Same numbers will change depending on the visit for the month. The sample bottle number of the first sample collected in a month for a station will be the base sample number from 1 to 99. The sample bottle number of the second sample of the month for the same station will be a 100 series number (101-199). If there is a third sample at the same station for the month, it will be a 200 series number (201-299). For example, a sample bottle collected during the first sampling of a month might have a sample number 5. The second sampling of the month of that station then will have the sample number 105. If there is a third sampling of that station in the month, it will have the sample number 205.

| Grab samples collections in one month | | | |
|---------------------------------------|----------|----------|----------|
| Bottle Numbers example | 1st time | 2nd time | 3rd time |
| bottle number 6 | 6 | 106 | 206 |
| bottle number 6 replicate | 706 | 806 | 906 |
| | | | |
| bottle number 14 | 14 | 114 | 214 |
| bottle number 14 replicate | 714 | 814 | 914 |

All NERRS sites get one duplicate sample done every month. The duplicate sample numbers for NERRS sites are 900 series numbers. For example, if sampling Jug Bay (which has a base sample number of 1) for the second time in a month, the sample bottle number will be 101 and the duplicate sample bottle number will be 901.

Figure 4: Continuous Monitoring Field Sheet

Weather Code:
(Blank) = Not Recorded
10 = None
11 = Drizzle
12 = Rain
13 = Rain, Heavy
14 = Squally
15 = Frozen Precipitation

Time Grab Samples
Were Collected - Also
First Overlapping
Sonde Records

Wind Direction: (Blank) = Not Recorded
N = from the North (0°)
NE = from the North Northeast (22.5°)
E = from the East (90°)
SE = from the East Southeast (112.5°)
S = from the South (180°)
SW = from the South Southwest (202.5°)
W = from the West (270°)
NW = from the West Northwest (292.5°)
ENE = from the Northeast (45°)
SSE = from the Southeast (135°)
WSW = from the West Southwest (247.5°)
NNW = from the Northwest (315°)

Instrument
Alpha - Numeric
Designation

Tide State:
E = Ebb
F = Flood
H = High Slack
L = Low Slack

Cloud Cover (%):
0-10 = Clear
11-50 = Scattered to Partly
51-90 = Partly to Overcast
91-100 = Overcast

Wave Height (m):
0.00 = Flat Calm
0.09 = Slight Ripple
0.20 = Ripple < 1 foot (0.1 - 0.3 m)
0.40 = 1 - 2 feet (0.2 - 0.5 m)
0.75 = 2 - 4 feet (0.5 - 1.25 m)
1.00 = 4 - 6 feet (1.25 - 1.8 m)
2.10 = 6 - 8 feet (1.8 - 2.5 m)
3.00 = 8 - 13 feet (2.5 - 4 m)

Wind Velocity (knots):
0-1 = Calm
1-3 = Light and Variable
4-6 = Small Waves, Not Breaking
7-10 = Scattered Whitecaps
11-16 = Numerous Whitecaps
17-21 = Moderate Waves, Many Whitecaps
22-27 = Large Waves, Whitecaps Everywhere

Only Use If A Grab Sample Was Taken

The Depth of the Measurements You Are Recording for Water Quality, Licor or Grab Samples

The Depth of the Measurements You Are Recording for Water Quality, Licor or Grab Samples

Follow Protocols for Profile Sampling and Licor Sampling

Follow Protocols for Profile Sampling and Licor Sampling

Enter Licor data (3 significant digits)

BS = Below Surface
This is the Layer Code to Use When You Have a Grab Sample

Leave Layer Code Field Blank if No Grab Sample Taken

Sample #

Replicate #

QH or QY
This is the Layer Code to Use For Your Check Sonde QH = HydroLab QY = VSI Sonde

Must have "0" in this field if there is data entered in that row

Must have "0" in this field if there is data entered in that row

Three-Letter Station ID
- Two-Digit Year
- Two-Digit Week

Time of Last Reading Sonde Was In Water For

Person Filling Out Field Sheet

Number of Grab Samples

Another Person On Run

Survey
1. Submitter: **FIELD OFFICE - TURNBART**
2. Sampling Station Number: **1234**
3. Start Date: **04/06/23**
4. End Date: **04/06/23**
5. Start Time: **1415**
6. End Time: **1445**
7. Number of Samples: **02**
8. Sequence Number: **01260**
9. Date: **04/06/23**
10. Total Study: **0423**
11. Depth M: **1.7**
12. Study: **22**
13. Sonde: **0**
14. Category: **MIN**
15. Depth M: **1.7**
16. Study: **22**
17. Sonde: **0**
18. Category: **MIN**
19. Depth M: **1.7**
20. Study: **22**
21. Sonde: **0**
22. Category: **MIN**
23. Depth M: **1.7**
24. Study: **22**
25. Sonde: **0**
26. Category: **MIN**
27. Depth M: **1.7**
28. Study: **22**
29. Sonde: **0**
30. Category: **MIN**
31. Depth M: **1.7**
32. Study: **22**
33. Sonde: **0**
34. Category: **MIN**
35. Depth M: **1.7**
36. Study: **22**
37. Sonde: **0**
38. Category: **MIN**
39. Depth M: **1.7**
40. Study: **22**
41. Sonde: **0**
42. Category: **MIN**
43. Depth M: **1.7**
44. Study: **22**
45. Sonde: **0**
46. Category: **MIN**
47. Depth M: **1.7**
48. Study: **22**
49. Sonde: **0**
50. Category: **MIN**
51. Depth M: **1.7**
52. Study: **22**
53. Sonde: **0**
54. Category: **MIN**
55. Depth M: **1.7**
56. Study: **22**
57. Sonde: **0**
58. Category: **MIN**
59. Depth M: **1.7**
60. Study: **22**
61. Sonde: **0**
62. Category: **MIN**
63. Depth M: **1.7**
64. Study: **22**
65. Sonde: **0**
66. Category: **MIN**
67. Depth M: **1.7**
68. Study: **22**
69. Sonde: **0**
70. Category: **MIN**
71. Depth M: **1.7**
72. Study: **22**
73. Sonde: **0**
74. Category: **MIN**
75. Depth M: **1.7**
76. Study: **22**
77. Sonde: **0**
78. Category: **MIN**
79. Depth M: **1.7**
80. Study: **22**
81. Sonde: **0**
82. Category: **MIN**
83. Depth M: **1.7**
84. Study: **22**
85. Sonde: **0**
86. Category: **MIN**
87. Depth M: **1.7**
88. Study: **22**
89. Sonde: **0**
90. Category: **MIN**
91. Depth M: **1.7**
92. Study: **22**
93. Sonde: **0**
94. Category: **MIN**
95. Depth M: **1.7**
96. Study: **22**
97. Sonde: **0**
98. Category: **MIN**
99. Depth M: **1.7**
100. Study: **22**
101. Sonde: **0**
102. Category: **MIN**
103. Depth M: **1.7**
104. Study: **22**
105. Sonde: **0**
106. Category: **MIN**
107. Depth M: **1.7**
108. Study: **22**
109. Sonde: **0**
110. Category: **MIN**
111. Depth M: **1.7**
112. Study: **22**
113. Sonde: **0**
114. Category: **MIN**
115. Depth M: **1.7**
116. Study: **22**
117. Sonde: **0**
118. Category: **MIN**
119. Depth M: **1.7**
120. Study: **22**
121. Sonde: **0**
122. Category: **MIN**
123. Depth M: **1.7**
124. Study: **22**
125. Sonde: **0**
126. Category: **MIN**
127. Depth M: **1.7**
128. Study: **22**
129. Sonde: **0**
130. Category: **MIN**
131. Depth M: **1.7**
132. Study: **22**
133. Sonde: **0**
134. Category: **MIN**
135. Depth M: **1.7**
136. Study: **22**
137. Sonde: **0**
138. Category: **MIN**
139. Depth M: **1.7**
140. Study: **22**
141. Sonde: **0**
142. Category: **MIN**
143. Depth M: **1.7**
144. Study: **22**
145. Sonde: **0**
146. Category: **MIN**
147. Depth M: **1.7**
148. Study: **22**
149. Sonde: **0**
150. Category: **MIN**
151. Depth M: **1.7**
152. Study: **22**
153. Sonde: **0**
154. Category: **MIN**
155. Depth M: **1.7**
156. Study: **22**
157. Sonde: **0**
158. Category: **MIN**
159. Depth M: **1.7**
160. Study: **22**
161. Sonde: **0**
162. Category: **MIN**
163. Depth M: **1.7**
164. Study: **22**
165. Sonde: **0**
166. Category: **MIN**
167. Depth M: **1.7**
168. Study: **22**
169. Sonde: **0**
170. Category: **MIN**
171. Depth M: **1.7**
172. Study: **22**
173. Sonde: **0**
174. Category: **MIN**
175. Depth M: **1.7**
176. Study: **22**
177. Sonde: **0**
178. Category: **MIN**
179. Depth M: **1.7**
180. Study: **22**
181. Sonde: **0**
182. Category: **MIN**
183. Depth M: **1.7**
184. Study: **22**
185. Sonde: **0**
186. Category: **MIN**
187. Depth M: **1.7**
188. Study: **22**
189. Sonde: **0**
190. Category: **MIN**
191. Depth M: **1.7**
192. Study: **22**
193. Sonde: **0**
194. Category: **MIN**
195. Depth M: **1.7**
196. Study: **22**
197. Sonde: **0**
198. Category: **MIN**
199. Depth M: **1.7**
200. Study: **22**
201. Sonde: **0**
202. Category: **MIN**
203. Depth M: **1.7**
204. Study: **22**
205. Sonde: **0**
206. Category: **MIN**
207. Depth M: **1.7**
208. Study: **22**
209. Sonde: **0**
210. Category: **MIN**
211. Depth M: **1.7**
212. Study: **22**
213. Sonde: **0**
214. Category: **MIN**
215. Depth M: **1.7**
216. Study: **22**
217. Sonde: **0**
218. Category: **MIN**
219. Depth M: **1.7**
220. Study: **22**
221. Sonde: **0**
222. Category: **MIN**
223. Depth M: **1.7**
224. Study: **22**
225. Sonde: **0**
226. Category: **MIN**
227. Depth M: **1.7**
228. Study: **22**
229. Sonde: **0**
230. Category: **MIN**
231. Depth M: **1.7**
232. Study: **22**
233. Sonde: **0**
234. Category: **MIN**
235. Depth M: **1.7**
236. Study: **22**
237. Sonde: **0**
238. Category: **MIN**
239. Depth M: **1.7**
240. Study: **22**
241. Sonde: **0**
242. Category: **MIN**
243. Depth M: **1.7**
244. Study: **22**
245. Sonde: **0**
246. Category: **MIN**
247. Depth M: **1.7**
248. Study: **22**
249. Sonde: **0**
250. Category: **MIN**
251. Depth M: **1.7**
252. Study: **22**
253. Sonde: **0**
254. Category: **MIN**
255. Depth M: **1.7**
256. Study: **22**
257. Sonde: **0**
258. Category: **MIN**
259. Depth M: **1.7**
260. Study: **22**
261. Sonde: **0**
262. Category: **MIN**
263. Depth M: **1.7**
264. Study: **22**
265. Sonde: **0**
266. Category: **MIN**
267. Depth M: **1.7**
268. Study: **22**
269. Sonde: **0**
270. Category: **MIN**
271. Depth M: **1.7**
272. Study: **22**
273. Sonde: **0**
274. Category: **MIN**
275. Depth M: **1.7**
276. Study: **22**
277. Sonde: **0**
278. Category: **MIN**
279. Depth M: **1.7**
280. Study: **22**
281. Sonde: **0**
282. Category: **MIN**
283. Depth M: **1.7**
284. Study: **22**
285. Sonde: **0**
286. Category: **MIN**
287. Depth M: **1.7**
288. Study: **22**
289. Sonde: **0**
290. Category: **MIN**
291. Depth M: **1.7**
292. Study: **22**
293. Sonde: **0**
294. Category: **MIN**
295. Depth M: **1.7**
296. Study: **22**
297. Sonde: **0**
298. Category: **MIN**
299. Depth M: **1.7**
300. Study: **22**
301. Sonde: **0**
302. Category: **MIN**
303. Depth M: **1.7**
304. Study: **22**
305. Sonde: **0**
306. Category: **MIN**
307. Depth M: **1.7**
308. Study: **22**
309. Sonde: **0**
310. Category: **MIN**
311. Depth M: **1.7**
312. Study: **22**
313. Sonde: **0**
314. Category: **MIN**
315. Depth M: **1.7**
316. Study: **22**
317. Sonde: **0**
318. Category: **MIN**
319. Depth M: **1.7**
320. Study: **22**
321. Sonde: **0**
322. Category: **MIN**
323. Depth M: **1.7**
324. Study: **22**
325. Sonde: **0**
326. Category: **MIN**
327. Depth M: **1.7**
328. Study: **22**
329. Sonde: **0**
330. Category: **MIN**
331. Depth M: **1.7**
332. Study: **22**
333. Sonde: **0**
334. Category: **MIN**
335. Depth M: **1.7**
336. Study: **22**
337. Sonde: **0**
338. Category: **MIN**
339. Depth M: **1.7**
340. Study: **22**
341. Sonde: **0**
342. Category: **MIN**
343. Depth M: **1.7**
344. Study: **22**
345. Sonde: **0**
346. Category: **MIN**
347. Depth M: **1.7**
348. Study: **22**
349. Sonde: **0**
350. Category: **MIN**
351. Depth M: **1.7**
352. Study: **22**
353. Sonde: **0**
354. Category: **MIN**
355. Depth M: **1.7**
356. Study: **22**
357. Sonde: **0**
358. Category: **MIN**
359. Depth M: **1.7**
360. Study: **22**
361. Sonde: **0**
362. Category: **MIN**
363. Depth M: **1.7**
364. Study: **22**
365. Sonde: **0**
366. Category: **MIN**
367. Depth M: **1.7**
368. Study: **22**
369. Sonde: **0**
370. Category: **MIN**
371. Depth M: **1.7**
372. Study: **22**
373. Sonde: **0**
374. Category: **MIN**
375. Depth M: **1.7**
376. Study: **22**
377. Sonde: **0**
378. Category: **MIN**
379. Depth M: **1.7**
380. Study: **22**
381. Sonde: **0**
382. Category: **MIN**
383. Depth M: **1.7**
384. Study: **22**
385. Sonde: **0**
386. Category: **MIN**
387. Depth M: **1.7**
388. Study: **22**
389. Sonde: **0**
390. Category: **MIN**
391. Depth M: **1.7**
392. Study: **22**
393. Sonde: **0**
394. Category: **MIN**
395. Depth M: **1.7**
396. Study: **22**
397. Sonde: **0**
398. Category: **MIN**
399. Depth M: **1.7**
400. Study: **22**
401. Sonde: **0**
402. Category: **MIN**
403. Depth M: **1.7**
404. Study: **22**
405. Sonde: **0**
406. Category: **MIN**
407. Depth M: **1.7**
408. Study: **22**
409. Sonde: **0**
410. Category: **MIN**
411. Depth M: **1.7**
412. Study: **22**
413. Sonde: **0**
414. Category: **MIN**
415. Depth M: **1.7**
416. Study: **22**
417. Sonde: **0**
418. Category: **MIN**
419. Depth M: **1.7**
420. Study: **22**
421. Sonde: **0**
422. Category: **MIN**
423. Depth M: **1.7**
424. Study: **22**
425. Sonde: **0**
426. Category: **MIN**
427. Depth M: **1.7**
428. Study: **22**
429. Sonde: **0**
430. Category: **MIN**
431. Depth M: **1.7**
432. Study: **22**
433. Sonde: **0**
434. Category: **MIN**
435. Depth M: **1.7**
436. Study: **22**
437. Sonde: **0**
438. Category: **MIN**
439. Depth M: **1.7**
440. Study: **22**
441. Sonde: **0**
442. Category: **MIN**
443. Depth M: **1.7**
444. Study: **22**
445. Sonde: **0**
446. Category: **MIN**
447. Depth M: **1.7**
448. Study: **22**
449. Sonde: **0**
450. Category: **MIN**
451. Depth M: **1.7**
452. Study: **22**
453. Sonde: **0**
454. Category: **MIN**
455. Depth M: **1.7**
456. Study: **22**
457. Sonde: **0**
458. Category: **MIN**
459. Depth M: **1.7**
460. Study: **22**
461. Sonde: **0**
462. Category: **MIN**
463. Depth M: **1.7**
464. Study: **22**
465. Sonde: **0**
466. Category: **MIN**
467. Depth M: **1.7**
468. Study: **22**
469. Sonde: **0**
470. Category: **MIN**
471. Depth M: **1.7**
472. Study: **22**
473. Sonde: **0**
474. Category: **MIN**
475. Depth M: **1.7**
476. Study: **22**
477. Sonde: **0**
478. Category: **MIN**
479. Depth M: **1.7**
480. Study: **22**
481. Sonde: **0**
482. Category: **MIN**
483. Depth M: **1.7**
484. Study: **22**
485. Sonde: **0**
486. Category: **MIN**
487. Depth M: **1.7**
488. Study: **22**
489. Sonde: **0**
490. Category: **MIN**
491. Depth M: **1.7**
492. Study: **22**
493. Sonde: **0**
494. Category: **MIN**
495. Depth M: **1.7**
496. Study: **22**
497. Sonde: **0**
498. Category: **MIN**
499. Depth M: **1.7**
500. Study: **22**
501. Sonde: **0**
502. Category: **MIN**
503. Depth M: **1.7**
504. Study: **22**
505. Sonde: **0**
506. Category: **MIN**
507. Depth M: **1.7**
508. Study: **22**
509. Sonde: **0**
510. Category: **MIN**
511. Depth M: **1.7**
512. Study: **22**
513. Sonde: **0**
514. Category: **MIN**
515. Depth M: **1.7**
516. Study: **22**
517. Sonde: **0**
518. Category: **MIN**
519. Depth M: **1.7**
520. Study: **22**
521. Sonde: **0**
522. Category: **MIN**
523. Depth M: **1.7**
524. Study: **22**
525. Sonde: **0**
526. Category: **MIN**
527. Depth M: **1.7**
528. Study: **22**
529. Sonde: **0**
530. Category: **MIN**
531. Depth M: **1.7**
532. Study: **22**
533. Sonde: **0**
534. Category: **MIN**
535. Depth M: **1.7**
536. Study: **22**
537. Sonde: **0**
538. Category: **MIN**
539. Depth M: **1.7**
540. Study: **22**
541. Sonde: **0**
542. Category: **MIN**
543. Depth M: **1.7**
544. Study: **22**
545. Sonde: **0**
546. Category: **MIN**
547. Depth M: **1.7**
548. Study: **22**
549. Sonde: **0**
550. Category: **MIN**
551. Depth M: **1.7**
552. Study: **22**
553. Sonde: **0**
554. Category: **MIN**
555. Depth M: **1.7**
556. Study: **22**
557. Sonde: **0**
558. Category: **MIN**
559. Depth M: **1.7**
560. Study: **22**
561. Sonde: **0**
562. Category: **MIN**
563. Depth M: **1.7**
564. Study: **22**
565. Sonde: **0**
566. Category: **MIN**
567. Depth M: **1.7**
568. Study: **22**
569. Sonde: **0**
570. Category: **MIN**
571. Depth M: **1.7**
572. Study: **22**
573. Sonde: **0**
574. Category: **MIN**
575. Depth M: **1.7**
576. Study: **22**
577. Sonde: **0**
578. Category: **MIN**
579. Depth M: **1.7**
580. Study: **22**
581. Sonde: **0**
582. Category: **MIN**
583. Depth M: **1.7**
584. Study: **22**
585. Sonde: **0**
586. Category: **MIN**
587. Depth M: **1.7**
588. Study: **22**
589. Sonde: **0**
590. Category: **MIN**
591. Depth M: **1.7**
592. Study: **22**
593. Sonde: **0**
594. Category: **MIN**
595. Depth M: **1.7**
596. Study: **22**
597. Sonde: **0**
598. Category: **MIN**
599. Depth M: **1.7**
600. Study: **22**
601. Sonde: **0**
602. Category: **MIN**
603. Depth M: **1.7**
604. Study: **22**
605. Sonde: **0**
606. Category: **MIN**
607. Depth M: **1.7**
608. Study: **22**
609. Sonde: **0**
610. Category: **MIN**
611. Depth M: **1.7**
612. Study: **22**
613. Sonde: **0**
614. Category: **MIN**
615. Depth M: **1.7**
616. Study: **22**
617. Sonde: **0**
618. Category: **MIN**
619. Depth M: **1.7**
620. Study: **22**
621. Sonde: **0**
622. Category: **MIN**
623. Depth M: **1.7**
624. Study: **22**
625. Sonde: **0**
626. Category: **MIN**
627. Depth M: **1.7**
628. Study: **22**
629. Sonde: **0**
630. Category: **MIN**
631. Depth M: **1.7**
632. Study: **22**
633. Sonde: **0**
634. Category: **MIN**
635. Depth M: **1.7**
636. Study: **22**
637. Sonde: **0**
638. Category: **MIN**
639. Depth M: **1.7**
640. Study: **22**
641. Sonde: **0**
642. Category: **MIN**
643. Depth M: **1.7**
644. Study: **22**
645. Sonde: **0**
646. Category: **MIN**
647. Depth M: **1.7**
648. Study: **22**
649. Sonde: **0**
650. Category: **MIN**
651. Depth M: **1.7**
652. Study: **22**
653. Sonde: **0**
654. Category: **MIN**
655. Depth M: **1.7**
656. Study: **22**
657. Sonde: **0**
658. Category: **MIN**
659. Depth M: **1.7**
660. Study: **22**
661. Sonde: **0**
662. Category: **MIN**
663. Depth M: **1.7**
664. Study: **22**
665. Sonde: **0**
666. Category: **MIN**
667. Depth M: **1.7**
668. Study: **22**
669. Sonde: **0**
670. Category: **MIN**
671. Depth M: **1.7**
672. Study: **22**
673. Sonde: **0**
674. Category: **MIN**
675. Depth M: **1.7**
676. Study: **22**
677. Sonde: **0**
678. Category: **MIN**
679. Depth M: **1.7**
680. Study: **22**
681. Sonde: **0**
682. Category: **MIN**
683. Depth M: **1.7**
684. Study: **22**
685. Sonde: **0**
686. Category: **MIN**
687. Depth M: **1.7**
688. Study: **22**
689. Sonde: **0**
690. Category: **MIN**
691. Depth M: **1.7**
692. Study: **22**
693. Sonde: **0**
694. Category: **MIN**
695. Depth M: **1.7**
696. Study: <

Appendix 3. Water Quality Mapping Procedures

Revised: April 2018

The Water Quality Mapping project currently uses two different types of equipment units. They are referred to as “old unit” and “laptop unit.” Procedures for the two units are detailed below.

Water Quality Mapping Procedures (Old Unit)

Equipment Setup:

1. Attach stainless steel ram to boat, before or after launching boat, using pre-drilled holes through the port or starboard side transom of the boat with two bolts, two lock washers, and two nuts provided. Securely tighten with a 15/16” wrench or another suitable tool.
2. Attach depth finder transducer bracket to ram by inserting metal rod up through hole in splash plate making sure that pointed side of transducer is facing the bow (front) of boat. Also make sure the transducer is below the boat hull and water line. Securely tighten setscrew with 9/16” wrench or another suitable tool.
3. Launch research vessel.
4. After launching, insert gray PVC pipe with attached Rule 1100 live well pump down through stainless steel ram and securely tighten with lever on ram.
5. Attach YSI Sensor Unit stand (big white thing about three feet tall with flow meter alarm and GPS antenna) to starboard or port side of research vessel using bolts, lock-washers, and nuts provided or other suitable means
6. Connect 1” diameter black hose to ram pump with a hose clamp or quick connect assembly and attach other end of hose to the **intake** port of the YSI Sensor Unit stand with a hose clamp or quick connect assembly. This port connects directly to grey YSI Flow-cell.
7. Connect the other 1” diameter clear hose to the YSI Sensor Unit stand **outflow** port and leave the other end of hose hanging over the starboard side or back of the boat.
8. Unscrew calibration cup from YSI and insert the probe end of the meter into the YSI grey flow-cell that is already mounted on the YSI meter stand, turn until meter will turn no more and then tighten it.
9. Prime the DATAFLOW ram by removing Rule 1100 pump head and pouring water into pipe until full. Replace Rule 1100 pump head.

External Power Hook-up:

1. Take YSI 9 pin cable and attach it to the YSI meter. Attach the other end of cable to the designated “J3” connector on the case housing of the Processor Unit (small yellow suitcase).
2. Attach one end of GPS cable to the connector on side of the Sensor Unit and connect the other end of cable to the designated “J4” connector on the Processor Unit.
3. Attach one end of the 12 pin Flow meter cable to the connector on the side of the Sensor unit and connect the other end of the cable to the designated “J2” connector on the Processor Unit.
4. Connect the end of the transducer cable to the designated “J5” connector on the side of the Processor Unit.
5. Attach 3 pin Power cable (cable with power winch plug on one end) to the designated “J1” connector on the Processor Unit.
6. Take the 26 pin Computer monitor cable and attach one end to the “pig tail” on back of the monitor and the other end to the designated “J6” connector on the side of the Processor Unit.
7. Take the end of the keyboard cable and attach it to the designated “J7” connector on the Processor Unit.

8. Take the power winch plug and connect to the battery box wired with a power winch outlet and 12-volt DC battery.
9. Plug the Rule 1100 pump into the power winch outlet, already installed on the research vessel.
10. Flip DATAFLOW power switch to on.
11. Flip alarm horn switch to on when flow meter reaches 3.0 lpm on flow meter display.

Data Logging:

1. Turn on GPS by pushing the power button on the Garmin GPSmap168 Sounder.
2. When computer has booted up, double click the "DATAFLOW" icon, then click ok when the next box appears, it should say "Labview for Windows". Click the "OK" button.
3. The setup for logging data has to be adjusted in the Labview software. This is done by scrolling down the page and making the following changes to the software settings: YSI byte count = 152; Bytes to write to YSI = 75; GPS port # = 2; pH offset = 30; Chlorophyll offset = 42; DO offset = 63; Turbidity offset = 38, Turbidity length = 5; Battery offset = 71; Conductivity offset = 23.
4. To start logging data, click the small white arrow on upper left of screen. Enter a file name when the file dialog box appears, file name should be the name of the river system you are sampling and the date (i.e., Choptank040607). Click "Save". DATAFLOW is now operational and logging data.
5. To stop logging click the green "run" button on the display screen. This will tell the program to complete its routine and stop. You can also click the red "stop sign" button beside the green "run" button.

Downloading the Data after each run:

1. Plug a USB flash drive into the USB port located inside the Dataflow Box.
2. Click "File" in the DATAFLOW window then click "Open". Change "Files of type" to "All Files". Find the filename that was saved for that run.
3. Right click the filename, then choose "Copy".
4. Exit out of File window by hitting "Esc", then minimize the Dataflow window by clicking the "_" button in the top right corner.
5. Double click "My Computer", then double click "Removable Disk". Sometimes the drive will be titled as the name brand. (i.e., USDISK 20X, Lexar Media, etc.).
6. Right click inside the "Removable Disk" window and select "Paste".
7. After the file has been transferred to the Flash drive, click the "X" in the upper right corner.
8. Next shut the computer down by clicking the "start" button in the lower left corner, then click "Shut down".
9. Remove flash drive and close up the Dataflow box.
10. Flip the horn switch, then the power switch off and unplug Dataflow box from battery.

Cruise tracks:

Cruise tracks will vary from one tributary to the next depending on its size and shape, and navigational hazards, but will either follow a 6ft. contour along each shore, or a "square wave" pattern traversing from shallow water to deeper water over the length of the tributary; stopping at 4 to 6 calibration stations.

Calibration stations:

At each calibration station collect a physical profile using a Hydrolab™, a Secchi depth measurement, a whole water sample for any CBL nutrients and chlorophyll filtering, and a PAR profile using a LiCor.

Hydrolab profile:

Collect the 0.5 m readings first. Start times are recorded as the exact minute that the 0.5 m readings are

collected. You must also simultaneously collect the whole water sample for Chlorophyll and Nutrient analysis at this time. Then lower the sonde to the bottom and take readings 0.3 m above the bottom and every 0.5 m or 1.0 m intervals to the surface depending on the total depth (see below).

If total depth is < 3 m.:

Hydrolab readings will be collected at 0.5 m from the surface and at 0.5 m intervals, and 0.3 m above the bottom.

If total depth is 3 m. or > than 3 m.:

Hydrolab readings will be collected at 0.5 m from the surface and at 1.0 m intervals, and 0.3 m above the bottom.

Whole water samples will be collected from the outflow of the DATAFLOW unit. Collection must be done simultaneously with the 0.5 m Hydrolab™ readings. A numbered 2 qt. bottle will be rinsed 3 times and filled to be used for CBL nutrient samples and a chlorophyll sample. All processed samples will be immediately placed on ice until delivery to the office

As conditions permit, CBL nutrient and chlorophyll filtering will begin as soon as possible. Filtrate will be collected from the PP units only. In addition to standard filtrate samples, 1 TSS (numbered) pad and 1 chlorophyll (unnumbered Whatman) pad will be submitted for analysis. For the Corsica River only, 1 PP (unnumbered Whatman) pads, 1 VSS/TSS (numbered) pad, 2 PC/PN pads, and 1 chlorophyll (unnumbered Whatman) pad will also be submitted for analysis.

Water Quality Mapping Procedures (Laptop Unit)

Equipment Setup:

*Note: When using the DATAFLOW Laptop unit, the Garmin model GPSMAP168 Sounder chartplotting receiver and depth-finder (or any other brand of GPS Chartplotter/Depth Sounder i.e., Raymarine, Furuno, Lowrance, etc.) **must** be hardwired directly to the vessel using the “power/data” cable supplied as well as a Sealevel SeaLINK single-port USB to RS-232 serial adapter. The YSI must also have internal batteries.*

1. Before launching the research vessel, attach stainless steel ram to the research vessel using pre-drilled holes through port or starboard side transom of research vessel with two bolts, two lock washers, and two nuts provided. Securely tighten with a 15/16” wrench or another suitable tool.
2. Launch research vessel.
3. After launching, insert gray PVC pipe with attached Rule 1100 live well pump down through stainless steel ram and securely tighten with lever on ram.
4. Attach YSI Sensor Unit stand (~3 ft. tall board with sonde clamps and grey flow cell) to starboard or port side of research vessel using bolts, lock washers and nuts provided or other suitable means.
5. Connect 1” diameter **black hose** to ram pump with a hose clamp or quick connect assembly and attach other end of hose to **intake port** of YSI Sensor Unit stand with a hose clamp or quick connect assembly. This port connects directly to grey YSI Flow-cell.
6. Connect 1” diameter **clear hose** to YSI Sensor Unit stand **outflow port** and leave other end of hose hanging over starboard side or back of research vessel.
7. Unscrew calibration cup from YSI and insert probe end of meter into grey YSI Flow-cell already mounted to YSI meter stand, turn until meter will turn no more and then tighten.
8. Prime DATAFLOW ram by removing Rule 1100 pump head and pouring water into pipe until full. Replace Rule 1100 pump head.

External Hook-up:

1. Attach a YSI 9-pin cable to the YSI meter. Attach the other end of cable to 9-pin connector on back of laptop.
2. Plug SeaLevel USB plug (which is installed to Garmin GPS Chartplotter/Depth sounder power/data cable) into USB port on side of laptop.
3. Plug Rule 1100 pump into power winch outlet, already installed on research vessel.
4. Turn on Garmin Chartplotter.
5. Turn on laptop.

Data Logging:

1. When laptop has booted up, double click “DATAFLOW” icon. A window should open with the heading, “Labview for Windows”. Click “OK”.
2. Setup for logging data has to be adjusted in the Labview software. This is done by scrolling down the page and making the following changes to the software settings:

| | |
|-----------------------|-----|
| YSI byte count | 152 |
| Bytes to write to YSI | 75 |
| GPS port # | 3 |
| pH offset | 30 |
| Chlorophyll offset | 42 |
| DO offset | 63 |
| Turbidity offset | 38 |
| Turbidity length | 5 |
| Battery offset | 71 |
| Conductivity offset | 23 |

3. To start logging data, click the small white arrow on upper left corner of screen.
4. Enter a file name when file dialog box appears. File name should be a combination of the name of river system being sampled and the date of sampling (i.e., Choptank040607). Click “Save”. DATAFLOW should now be operational and logging data.
5. To stop logging click the green “RUN” button on the display screen. This will tell the program to complete its routine and stop. You can also click the red “STOP SIGN” button above the green “RUN” button.

Downloading the Data after each run:

1. Plug a USB flash drive into the USB port located on the right side of laptop.
2. Click “File” in the DATAFLOW window, then click “Open”.
3. Change “Files of type” to “All Files”. Find the filename that was saved for that run.
4. Right click the filename, then choose “Copy”.
5. Exit out of File window by hitting “Esc”, then minimize DATAFLOW window by clicking “_” button in top right corner.
6. Double click “My Computer”, then double click “Removable Disk”. Sometimes the drive will be titled as the name brand of USB flash drive (e.g., USDISK 20X, Lexar Media, etc.).
7. Right click inside “Removable Disk” window and select “Paste”.

8. After the file has been transferred to USB flash drive, click “X” button in upper right corner.
9. Shut down computer by clicking “Start” button in lower left corner, then click “Shut Down” button.
10. Remove USB flash drive.
11. Turn GPS unit off and unplug DATAFLOW pump.

Appendix 4. Photosynthetic Active Radiation Protocol - May 15, 2003,

Underwater Photosynthetically Active Radiation (PAR, 400-700nm)

Downwelling light penetrating the water column (PAR) is measured underwater at several depths to calculate the light attenuation coefficient, K_d . Simultaneous deck and submersed PAR intensity measurements are taken to account for variability in incident surface irradiance due to changes in cloud cover. Data collected from this procedure may be used to estimate the depth of the photic zone.

1) Equipment: Manufactured by LI-COR, Inc.

- A. LI-192SA, flat cosine Underwater Quantum Sensor
- B. LI 190R-BNC-2 air (deck) reference sensor.
- C. Data Logger (LI-1400 or LI-1500)

2) Parameters:

- 1. EPARU_Z Downwelling PAR, measured underwater with sensor pointed up.
(μM , micromoles/second-meter² = μE , microEinsteins)
- 2. EPAR_S PAR measured in air, on board vessel or pier, recorded concurrently with each underwater depth reading (μM)
- 3. SDEPTH Sample depth at which PAR reading is recorded (meters)

3) Procedure:

- 1. PAR is determined from the sunny (or unshaded) side of a vessel or pier during daylight hours. Both deck and submersed probes must be away from the shadow of the vessel.
- 2. Check the sensor operation by connecting the deck sensor and underwater sensor to corresponding ports of the Li-Cor data logger and turn the power on. Check battery level. Cover the sensor and check to see if the output is very near zero. Place the sensor under a light source to assure that it has a positive reading. A negative reading indicates that the polarity of the sensor is reversed and is plugged into the cable backwards. A very positive or negative reading in the dark indicates a possible short in the cable or some other electrical short.

In the field, mount the deck sensor in a location which is level and unobstructed by shadows. Ensure that sensors are positioned properly on the deck sensor mounting and the lowering frame. Connect deck sensor and underwater sensor to corresponding ports of the data logger and turn the power on.

- 3. Set instrument averaging constant to display results from previous 10 or 15 seconds.
- 4. Lower the frame until the sensor is just below the surface of the water. At a depth of 0.1 meter (~4 inches), simultaneously record the deck sensor and the underwater readings for the “surface” measurement. If wave action prevents this, take the initial reading at 0.5 meters. The depth of the underwater sensor diffuser below the surface of the water is determined with a calibrated pole or non-stretching rope.

5. Lower the frame and take subsequent measurements at depths appropriate to the monitoring location and purpose of the project (see below). Allow the instrument output to stabilize, at least for the averaging period, then record both deck and underwater readings at each depth.

The simultaneous deck and submersed readings are recorded on the field sheet.

Shallow Water Monitoring (DataFlow and Fixed Continuous Monitors)

LiCor readings will be collected from the sunny side of the boat; both deck (out of water) and underwater readings will be recorded simultaneously. Allow readings to stabilize before recording data. This normally takes several seconds.

If the total depth is < 3 m:

Record both deck and underwater readings at 0.10m and at 0.25m intervals until 10 % of first underwater reading is reached. **

If the total depth is equal to or > 3 m:

Record both deck and underwater readings at 0.10m and at 0.5m intervals until 10% of first underwater reading is reached.

** If depth is < 0.5m make sure to record at least 3 different depth readings.

Example: If total depth is 0.25m record data from 0.05m, 0.10m and 0.20m

4) Quality control

1. The deck cell should have the highest PAR value, and the underwater sensor output should decrease as the sensor is lowered.
2. Periodically check that sensors are linear and not out of calibration with respect to each other.
3. PAR sensors should be returned to LICOR, Inc. every year, prior to each field season.
4. Replicate PAR profiles are recommended to make sure readings are correct.

5. Reporting

Report the PAR values from the deck sensor and each underwater measurement under the following C4 data base method codes:

- | | |
|-----------------|--|
| a. EPARU_Z F01: | Flat cosine sensor LI-192SA |
| b. EPAR_S F01: | Deck (reference) sensor LI-190R-BNC-2 |
| c. SDEPTH: | Sample depth at which PAR reading is recorded, in meters |

5) Light Attenuation (K_d) Calculations

To calculate the light attenuation coefficient (K_d), adjust each underwater PAR value by multiplying by the ratio of:

$$\frac{\text{Maximum EPAR_S in profile;}}{\text{EPAR_S from that DEPTH}}$$

Using adjusted PAR values, calculate K_d by one of the methods below.

- 1) Correlation Coefficient: Plot the natural log of each adjusted PAR value on the x-axis vs. depth, in meters. The slope of the line times (-1) is K_d ; the y-intercept is the depth of the photic zone.

Raw data for this calculation can be retrieved from the Chesapeake Center for Collaborative Computing (C4). Under CBP Water Quality Database, “click to get data” and select the “Light Attenuation Data”.

- 2) SAV 2-point Method: Calculate K_d from the (adjusted) PAR values from two different depths according to the equation:

$$K_d = - \frac{(\ln(\text{adjusted PAR deep}) - \ln(\text{adjusted PAR shallow}))}{(\text{Deep Depth} - \text{Shallow Depth})}, \quad \text{or}$$

$$K_d = \frac{\ln \text{adjusted PAR deep/adjusted PAR shallow}}{\Delta \text{Depth (m)}}$$

Calculated K_d using this method can be retrieved from the Chesapeake Center for Collaborative Computing (C4) (<http://www.chesapeakebay.net/data>). Under CBP Water Quality Database, “click to get data”, then select “Water Quality Data”. The Chesapeake Center for Collaborative Computing (C4) calculates K_d based on the SAV 2-point method and automatically adjusts the underwater values if air sensor values are present for each depth. PAR values are taken between the most consistent, shallowest, underwater depths and as close to 1 meter below the surface that is available. In most tributary mid-channels, the calculator will select values from Depths = 0.1 and 1.0 meters. In Maryland mainstem, values are usually from Depths = 0.5 and 1.5 meters; in Virginia mainstem, K_d data are calculated with Depths = 1.0 and 2.0 meters.

The C4 K_d calculator will not calculate K_d for any sampling event with only one PAR reading in the first 2 meters of the water column, or if underwater PAR values are negative.

Appendix 5. YSI 6600V2 and EXO Calibration and Post-Calibration Procedures (Continuous Monitoring)

Revised 5/25/2022

YSI 6600V2 CALIBRATION

I. SET UP

- A. Remove calibration cup and set up the YSI in a clamp stand with probes facing up.
- B. Attach wipers using the supplied allen wrench to the chlorophyll, turbidity, optical dissolved oxygen (ODO), and blue green algae probes (if applicable). Newer chlorophyll and turbidity probes have a black ring around the base of the wiper shaft. These newer chlorophyll and turbidity probes use a copper wiper. Older chlorophyll probes without the black ring use an orange wiper and older turbidity probes without the black ring use a black wiper. Use a copper wiper for the ODO and blue green algae probes. Remember to align the screw on the wiper with the flat side of the wiper shaft. Be sure the sponge portion of the wiper is touching the probe face firmly but is not smashed down flat.
- C. Remove waterproof cap from the 9-pin sonde connector and inspect connector for cleanliness, bent pins, etc. If the connector is dirty, use a q-tip and electronics cleaner to clean it. Attach sonde cable from laptop to sonde.
- D. Launch Ecowatch Lite and select TERMINAL. Choose the appropriate com port to connect to.
- E. Next, type “menu” at the # prompt.
- F. Select SYSTEM, then DATE AND TIME, then TIME.
- G. Using a reliable time source, enter the correct time, then press <Enter> simultaneously with the correct time. (Obtain the time by consulting a calibrated ConMon watch, www.time.gov, or the computer clock) ***All times must be entered in Eastern Standard Time (EST).***
- H. Press <Esc> until you are back to the main menu.

II. DEPTH

- A. If the sonde requires depth for the deployment, it will need to be calibrated. The depth needs to be corrected for barometric pressure. Check the current barometric pressure using the barometer in the lab.
- B. Consult the barometric pressure/depth chart in the front of the logbook. In Ecowatch, go to CALIBRATE, then PRESSURE-ABS. Type the corrected depth value from the chart and hit <Enter>. When the readings have stabilized, hit <Enter>. Record the calibrated depth on the calibration sheet.

III. SPECIFIC CONDUCTANCE

- A. Attach open-ended calibration cup securely to the sonde and rinse probes 3 times with DI water.
- B. Rinse probes 3 times with conductance standard to be used.
- C. Set the stone upright with probes facing up. Gently shake the conductance standard and then fill the calibration cup with the standard until the standard level is above the probes. If any air bubbles are apparent in the conductivity block, remove them by shaking the meter gently or dislodging them with a pipette.
- D. From the CALIBRATE menu select CONDUCTIVITY, then SPECIFIC CONDUCTANCE.
- E. Enter the conductance of the standard ***in mS/cm***. Example: 6668 μ S = 6.668mS.
- F. Allow the readings to stabilize. While the readings stabilize check the sonde temperature probe by placing a lab thermometer into the standard near the temperature probe on the

sonde. Compare the YSI temperature with the thermometer temperature. If the difference is greater than 0.2°C, then there is a problem with the temperature probe and it will need to be replaced.

- G. Once the specific conductance readings have stabilized, record the specific conductance reading in $\mu\text{S}/\text{cm}$ before calibration on the calibration sheet and press <Enter>. Record the after-calibration value $\mu\text{S}/\text{cm}$ on the calibration sheet.
- H. Press <Esc> to return to the main menu.
- I. Select ADVANCED then CAL CONSTANTS. Record CONDUCTIVITY CELL CONSTANT on the calibration sheet. If the cell constant is out of the acceptable range, it indicates a problem with the probe and it will need to be replaced.
- J. Press <Esc> to return to the main menu.

IV. PH

- A. With the open-ended calibration cup securely attached to the sonde, rinse probes 3 times with DI water.
- B. Rinse probes 3 times with pH 7 buffer.
- C. Set the sonde upright with probes facing up. Fill calibration cup with pH 7 buffer until the level is above the pH and temperature probes.
- D. From the main menu, select CALIBRATE, then PH, then 2-POINT.
- E. Enter <7> at the 1st point prompt and allow at least 30 seconds for the pH and temperature readings to stabilize.
- F. When pH and temperature readings have stabilized, record pH reading and temperature on the calibration sheet. Press <Enter> and record calibrated pH and pH mV readings on the calibration sheet.
- G. Pour pH 7 buffer back into the appropriate container. Rinse probes 3 times with DI water.
- H. Rinse probes 3 times with pH 10 buffer.
- I. Fill calibration cup with pH 10 buffer until the standard level is above the pH and temperature probes.
- J. Enter <10> at the 2nd point prompt and allow at least 30 seconds for the pH and temperature readings to stabilize.
- K. When the pH and temperature readings have stabilized, record pH reading and temperature on the calibration sheet. Press <Enter>, and record pH and pH mV after calibration on the calibration sheet.
- L. Calculate pH slope by subtracting the pH 10 mV from the pH 7 mV. If the slope is outside of the acceptable range, it indicates a problem and the probe will need to be replaced.
- M. Pour pH 10 buffer back into the appropriate container and rinse probes 3 times with DI water. Remove open-ended calibration cup. Press <Esc> until you have returned to the main menu.

V. CHLOROPHYLL

- A. Prepare 0.5 mg/l Rhodamine WT solution from the stock solution (if needed)
 - a. Retrieve 100mg/l Rhodamine stock solution from refrigerator.
 - b. Warm to room temperature by placing in a warm water bath for 5-10 minutes.
 - c. Rinse clean 1000-ml volumetric flask 3 times with DI water.
 - d. Fill 1000-ml volumetric flask halfway with DI water.
 - e. Rinse 5-ml volumetric pipette once with stock solution. Release rinse into sink **with water running** to allow waste to be flushed.
 - f. Pipette exactly 5.0 ml of the stock solution into 1000 ml volumetric flask using a

- volumetric pipette.
- g. Dilute 1000 ml flask to the line with DI to form a 0.5 mg/l Rhodamine WT solution. Cap tightly, invert, and swirl several times to homogenize.
- h. Return stock solution to the refrigerator.
- i. Rinse all waste in the sink and flush with plenty of water.

NOTE: 0.5 mg/l solution is unstable and must be used **within 24 hours**. Store solution in the dark.

- B. Using the tall calibration cup filled with DI water, place the probes down into the DI water making sure that the temperature probe is submerged.
- C. From the CALIBRATE menu select OPTIC C-CHLOROPHYLL, then CHL UG/L, then 2-POINT. Enter <0> as the first standard. Press <Enter>.
- D. If necessary, press <3> to engage wipers to remove any air bubbles or gently raise the sonde up and down in the solution until the air bubbles are gone.
- E. Allow chlorophyll and temperature readings to stabilize for at least 24 seconds. Record chlorophyll concentration on the calibration sheet. Press <Enter> and record the chlorophyll concentration after calibration on the calibration sheet. Remove the probes from the cup of DI water.
- F. Rinse a clean, dry, tall calibration cup base 3 times with DI water. Fill it $\frac{3}{4}$ full with the 0.5 mg/l Rhodamine solution.
- G. Wipe the probes off with a kim-wipe. With the readings on the screen still scrolling, place the probes face down into the rhodamine standard, making sure the temperature probe is submerged. Allow the temperature to stabilize and note the temperature of the standard on the calibration sheet.
- H. Using the temperature reading obtained in step G, look up corresponding chlorophyll value from the chlorophyll/temperature chart in the folder. Enter this concentration as the second point in the calibration and press <Enter>.
- I. Check for air bubbles and run wipers if necessary or gently raise the sonde up and down until the air bubbles are gone.
- J. Allow chlorophyll and temperature readings to stabilize for at least 24 seconds. Record chlorophyll concentration before calibration on the calibration sheet. Press <Enter> and record calibrated chlorophyll concentration on the calibration sheet. Remove probes from the rhodamine standard.
- K. Return to the calibrate menu by pressing <Esc>.

VI. TURBIDITY

- A. Rinse probes with DI water and place them down into the tall calibration cup filled with clean DI water.
- B. From the CALIBRATE menu select TURBIDITY. Select 2-POINT and enter <0> as the first standard. Press <Enter>.
- C. Check for air bubbles and run the wipers if necessary or gently raise the sonde up and down until the air bubbles are gone.
- D. Allow turbidity and temperature readings to stabilize. Record turbidity reading on the calibration sheet. Press <Enter> and record the calibrated turbidity concentration on the calibration sheet. Press <Enter> again.
- E. Remove probes from DI water. Dry off probes with a kim-wipe.
- F. Gently fill a clean, dry, tall calibration cup $\frac{3}{4}$ full, with clean 126 NTU solution. Carefully pour the solution down the inner wall of the calibration cup to minimize any air bubbles.
- G. Lower the probes face down into the turbidity solution.
- H. Enter <126> as second standard. Press <Enter>

- I. Check for air bubbles and run the wipers if necessary or gently raise the sonde up and down until the air bubbles are gone.
- J. Allow turbidity and temperature readings to stabilize. Record turbidity reading on the calibration sheet. Press <Enter> and record calibrated turbidity reading on the calibration sheet.
- K. Remove the sonde from the beaker. Press <Esc> until you return to the main menu.
- L. Upon completion of all calibrations, remove the small ODO wiper and replace it with the large brush wiper that is used for deployment.

VII. DEPLOYMENT SET-UP

- A. Turn on the following parameters by selecting REPORT from the main menu: Date, Time, Temp, SpCond, Sal, DO%, DO mg/l, Depth, pH, pH mV, Turb, Chl, Fluor, Batt. Press <Esc> to return to the main menu. Initiate data logging by selecting RUN, then UNATTENDED SAMPLE. Enter INTERVAL (15 minutes), START DATE (Ideally one day before deployment), START TIME (typically 23:59:01), DURATION (365 days), FILE NAME and SITE. The file name will be the 3-letter station code (found on the front of the logbook) followed by the last 2 digits of the year and the week number. For example, JUG1105 indicates that the file is for Jug Bay, the year 2011, and the 5th week of the year. **NOTE:** *Start Time should always be 59 seconds prior to a quarter hour. For example: HH:59:01, HH:14:01, HH:29:01, HH:44:01. Also, some stations have special instructions for their setup. Please consult the logbooks for them.* Press <Enter>.
- B. Record file name, start date/time, sampling interval, free disk space (in kb), and battery life in logbook. Make sure the stop date is 1 year after the start date.
- C. If battery life is less than 11.0V, change batteries. If free disk space is less than 100 kb, delete all files by returning to the main menu, selecting FILE, then DELETE ALL FILES. **NOTE:** *You should check to make sure that all files have been successfully uploaded to the server before deleting them.*
- D. Press <Esc> until asked to *Exit Menu (Y/N)?* then press <Y>. Disconnect sonde cable from sonde.
- E. Screw on waterproof connector cap.
- F. Wrap the top half of the sonde in cling wrap and electrical tape. Label the sonde with the file name and date of calibration.

VIII. DISSOLVED OXYGEN (Ideally performed day before deployment)

- A. Fill a clean 5-gallon bucket 2/3 full, with tap water. Sparge the water with an aquarium pump and air-stone for at least two hours prior to dissolved oxygen calibration.
- B. Remove calibration cup from the stone. Place clean probe guard on the sonde and place sonde into the 5-gallon bucket. Ensure no air bubbles are coming into direct contact with the probe faces.
- C. Allow the sonde to come to equilibrium (at least 20 minutes).
- D. After enough time has elapsed, remove the waterproof connector cap from 9-pin sonde connector and attach a sonde cable from laptop to sonde.
- E. Launch Ecowatch Lite and select TERMINAL. Choose the appropriate com port to connect to.
- F. Next, type “menu” at the # prompt.
- G. Select CALIBRATE from the main menu, then OPTIC-O DISSOLVED OXYGEN, then ODO SAT%, then 1-POINT.
- H. Take current barometric pressure from the lab barometer, enter the pressure in mmHg at the prompt, and press <Enter>.
- I. Once the ODO% and temperature readings have stabilized, record the chart DO value

(obtained from the pressure/temperature chart), meter DO mg/L, meter DO%, barometric pressure, and temperature on the calibration sheet. Press <Enter> to calibrate. Record the calibrated DO mg/L and DO% on the calibration sheet.

- J. Return to the main menu by pressing <Esc>. Select ADVANCED, then CAL CONSTANTS. Record ODO Gain. If the gain is outside of the acceptable range, it indicates a problem with the probe and it will need to be changed. Leave the sonde in the bubbler until the day of deployment. Press <Esc> until you return to the main menu.
- K. If the instrument is going to a site with telemetry, from the ADVANCED menu select SYSTEM and select SAMPLE AND HOLD.
- L. Press <Esc> until asked *to Exit Menu (Y/N)?* then press <Y>. Disconnect sonde cable from sonde.

IX. DISSOLVED OXYGEN CHECK (Performed the morning of deployment)

- A. Verify DO calibration by connecting the sonde cable to the sonde and launching EcoWatch Lite as you would to calibrate. From the main menu select FILE, then QUICK VIEW FILE. Note the most recent several samples, and check that the readings are stable.
- B. Record the last reading's temperature, DO mg/L, and DO%.
- C. Check the barometric pressure and record the chart DO from the temperature/pressure chart.
- D. If samples are consistent and accurate within 0.2mg/L of the true DO value according to the chart, **DO NOT** recalibrate the sonde.
- E. If samples are not within 0.2mg/L of true DO, recalibrate the sonde according to step IX-G through IX-J. You will not need to wait for equilibrium. Record changes on calibration sheet.
- F. If readings are off by greater than 0.5mg/L of true DO, do not recalibrate and do not deploy sonde until the DO issue is resolved.
- G. Once DO check is complete, press <Esc> until asked *to Exit Menu (Y/N)?* then press <Y>. Disconnect the sonde cable from the sonde and replace connector cap. Remove sonde from the water bucket and wrap the probe section of the sonde in a damp towel for transport.

YSI 6600V2 POST CALIBRATION

X. NOTES

- A. During Post Calibration, the idea is to preserve the condition of the sonde after deployment. Thus, it is important **not** to clean the sensors or remove any fouling that may have been deposited. However, you may carefully clean the sides of the probes, as long as you preserve the fouling on the sensor faces themselves.
- B. To avoid contamination of the 5-gallon bucket of 100% air-saturated water, it is advised to replace the fouled probe guard with a clean probe guard before placing the sonde in the bucket. The cling wrap should also be removed before placing the sonde in the bucket.
- C. Because most sondes will exhibit biological fouling or sediment buildup on the probes after a deployment, they will tend to contaminate any standards with which they come in contact. Therefore, a second set of dirty standards are used to perform post calibrations.
- D. Clean standards are typically rotated into dirty standards at the end of each field week. When the dirty standards become significantly contaminated with biological material or dirt, they should be discarded and replaced with clean standards.

XI. DISSOLVED OXYGEN (ideally performed the day after retrieving meter)

- A. Place the sonde in the 5-gallon bucket of 100% air-saturated water (The aquarium pump

and air-stones should have been running for at least 2 hours). The sonde should be in the bucket for at least 20 minutes. Allow sonde to continue to log data while coming to equilibrium. Connect the sonde cable to sonde and access the last several readings according to **steps X-A in the Calibration Procedures**. If able to connect and access the last readings, skip to step C. If not, proceed to step B.

- B. If there was a problem-sonde malfunction, batteries died, etc.-you may run a post calibration by accessing the main menu, selecting RUN, then DISCRETE SAMPLE.
- C. Check barometric pressure using the lab barometer.
- D. Record temperature, barometric pressure, meter DO mg/L, and meter DO%. Also record the chart DO from the temperature/pressure chart. If the meter DO is more than 0.5mg/L off from the chart value, make a note on the calibration sheet.
- E. Use this opportunity to record the depth post calibration, if applicable, as well as battery voltage.
- F. Press <Esc> until you have returned to the main menu. Stop logging by selecting RUN, UNATTENDED SAMPLE, and then STOP LOGGING.
- G. Press <Esc> until you have returned to the main menu. Upload the data file from the last deployment by, from the main menu, selecting FILE, then QUICK UPLOAD. Select PC6000 and press <Enter>. This will automatically upload the most recent deployment data onto the computer. It will be stored on the desktop. Go to the desktop, find the correct file and cut it from the folder. Go to the M drive and find the CON MON folder. From there go to the CONTINUOUS MONITORING folder, then the DATA-WQ folder. Next select the DNR folder. Select the folder with the appropriate year and then the folder with the appropriate month. Paste the file into the folder of the month that the instrument was deployed in (do not paste it into the station folder as this will be done later).
- E. After uploading the latest file from the instrument, take the instrument out of the bucket. Remove the probe guard and then remove the brush wiper from the DO probe. Replace the brush wiper with a black wiper.
- F. Check the probes for fouling and record it on the calibration sheet. Inspect each probe on the sonde. Using the selections available at the bottom of the Rhodamine calibration chart, give each probe a “fouling grade.” This is noted for each probe on the far right of the calibration sheet. If a probe or sonde exhibits particularly severe fouling, you may wish to take a picture of it with the digital camera.
- H. The meter is now ready to complete the post calibration process, or it can be stored in a calibration cup with DI water until the post calibration can be completed. If continuing with the post calibration process, press <Esc> until you have returned to the main menu and then continue with section **XII**. If storing the instrument for post calibration at a later time, press <Esc> until asked to *Exit Menu (Y/N)?* then press <Y>. Disconnect the sonde cable from sonde and replace waterproof connector cap.

XII. SPECIFIC CONDUCTANCE

- A. If not already connected to the sonde, remove waterproof connector cap from the 9-pin sonde connector and attach sonde cable from laptop to sonde. Launch Ecowatch Lite and select TERMINAL. Choose the appropriate com port to connect to. Next, type “menu” at the # prompt.
- B. Remove closed calibration cup or probe guard from the sonde. Attach an open-ended calibration cup securely to the sonde.
- C. Gently rinse probes 3 times with DI water and 3 times with the conductance standard that was used to calibrate the sonde. Take care not to dislodge fouling from conductance block
- D. Set the sonde upright in clamp stand with probes facing up. Fill calibration cup with dirty

conductance standard until the standard level is above the probes. Pour standard gently down the side of the calibration cup to prevent dislodging dirt or growth from the sensors. If any air bubbles are present in the conductivity block remove them by shaking the meter gently or dislodging them with a pipette.

- E. From the main menu, select RUN then select DISCRETE SAMPLE. Make the sampling interval 4 seconds.
- F. While the readings are stabilizing, check the temperature probe. Place a lab thermometer into the solution close to the meter temperature probe. Allow both to stabilize. Record both temperature readings on the calibration sheet.
- G. Once specific conductance and temperature readings have stabilized, record the conductance readings on the calibration sheet. If the readings are out of range, make a note on the calibration sheet (a list of acceptable limits can be found in the lab near the calibration stations). Pour the specific conductance standard back into the appropriate container.

XIII. PH

- A. With an open-ended calibration cup securely attached to the sonde, gently rinse the probes 3 times with DI water, taking care not to dislodge any fouling from the pH probe.
- B. Gently rinse probes 3 times with pH 7 buffer.
- C. Set the sonde upright in clamp stand with probes facing up. Gently pour standard down the side of the calibration cup until the buffer is above the pH and temperature probes.
- D. Allow at least 30 seconds for the sonde to stabilize. When pH and temperature readings have stabilized, record pH, pH mV and temperature on the calibration sheet. Remember to make a note if the readings are out of the acceptable limits. Pour pH 7 buffer back into the appropriate container.
- E. Gently rinse probes 3 times with DI water, and then 3 times with pH 10 buffer.
- F. Gently pour pH 10 buffer down the side of the calibration cup until the standard level is above the pH and temperature probes.
- G. Allow at least 30 seconds for the meter to stabilize.
- H. When pH and temperature readings have stabilized record pH, pH mV, and temperature on the calibration sheet. Remember to make a note if the readings are out of the acceptable limits. Calculate the pH slope by subtracting the pH 10 mV from the pH 7 mV. Pour pH 10 buffer back into the appropriate container and remove the open-ended calibration cup.

XIV. CHLOROPHYLL AND TURBIDITY

- A. Gently rinse the sides of the probes with DI water, while avoiding the optical sensors.
- B. Fill a clean, dry, tall black top calibration cup $\frac{3}{4}$ full, with clean DI water.
- C. Place probes down into DI water being sure to submerge the temperature probe. Check all optics for air bubbles and run wipers if necessary, or gently raise the sonde up and down in the DI water until air bubbles are gone.
- D. Make sure the wipers park correctly. If the wipers do not activate themselves, press <3> to manually activate them. On the calibration sheet, note if they wipe correctly and if they park 180° from the sensor.
- E. Allow the chlorophyll, turbidity, and temperature readings to stabilize. Record the chlorophyll and turbidity readings on the calibration sheet.
- F. Remove probes from DI water and carefully dry probes with a kim-wipe. Do not clean off the optic sensors.
- G. Fill a clean, dry, tall black top calibration cup $\frac{2}{3}$ full, with the 0.5 mg/L Rhodamine solution (see **section VI-A**). Place probes down into the Rhodamine solution making sure

- that the temperature probe is submerged.
- H. Check chlorophyll optic for air bubbles and run wipers if necessary, or gently raise the sonde up and down in the solution until air bubbles are gone. Allow chlorophyll and temperature readings to stabilize. Record temperature, chlorophyll reading, and Rhodamine equivalent value (obtained from the chlorophyll/temperature chart in the logbook) on the calibration sheet.
 - I. Remove the meter from the Rhodamine solution and rinse gently with DI water. Gently wipe off probes with a kim-wipe.
 - J. Fill a clean, dry, tall black top calibration cup 2/3 full, with the dirty 126 NTU turbidity solution.
 - K. Lower probes down into calibration cup making sure that the temperature probe is submerged.
 - L. Check chlorophyll optic for air bubbles and run wipers if necessary, or gently raise the sonde up and down in the solution until air bubbles are gone. Allow turbidity and temperature readings to stabilize. Record turbidity reading on the calibration sheet.
 - M. Remove the meter from the turbidity solution and rinse gently with DI water.
 - N. You are now finished with the post calibration. Press <Esc> until asked *to Exit Menu (Y/N)?* then press <Y>. Disconnect sonde cable from sonde and replace waterproof connector cap. Securely attach a calibration cup with ½ inch of DI water in the bottom to the sonde.

The meter should now be cleaned and stored for next deployment.

YSI EXO CALIBRATION

I. NOTES

- A. Prior to calibration the correct parameters will need to be turned on for each user. **This will only need to be done the first-time using KOR on each computer.** Launch the KOR program. Click on the <File> tab at the top left corner of the screen then click on “Settings”. In the “General Settings” tab under “Automation Settings” make sure “Automatically Update Instrument Time to PC Time” is turned on. Everything else should be turned off. Do not change any of the settings under “File Export”, “Startup Options”, or “Language Settings”.
- B. Staying in the “Settings”, click on each of the parameter tabs and adjust everything accordingly:

DO: Turn on %Sat and mg/L. %CB and %RTB should be turned off **ORP:** mV should be turned off

Algae: Phycocyanin RFU and ug/L should be turned on. Cells/mL should be off Phycoerythrin RFU and ug/L should be turned on Cells/mL should be off

PAR: Channel 1 and Channel 2 should both be off **pH:** pH and mV should both be on

Barometer: Barometer should be enabled and the mmHg unit selected **Rhodamine WT:** Rhodamine WT should be enabled and the ug/L should be selected. RFU should be turned off.

Conductivity: Conductivity should be enabled and the uS/cm unit selected Specific Conductivity should be enabled and the mS/cm unit

selected.

Resistivity should be disabled

TDS should be enabled and the mg/L unit selected Salinity should be enabled and the ppt unit selected

NLF Conductivity should be enabled and the uS/cm unit selected Water Density should be disabled

NitraLED: mg/L should be turned off

Chlorophyll: ug/L and RFU should both be turned on

Sonde: Both cable power and battery voltage should be enabled

Depth: Depth should be enabled and the m unit selected. Vertical Position should be disabled. Absolute Pressure should be enabled and the psi a unit

Selected. Gage pressure should be disabled

Temperature: Temperature should be enabled and the C unit selected; RFU should be disabled

fDOM: fDOM should be enabled and the QSU unit selected **Turbidity:**

Turbidity should be enabled and the FNU unit selected

TSS should be enabled and the mg/L unit selected

GPS: GPS should be enabled and the GPS decimal degrees unit selected

Altitude should be enabled and the m unit selected

Wiper: Wiper position should be enabled **ISE:**

Everything should be turned off

Once all these settings are selected, click on the <Save> button at the bottom right of the “Settings” box.

- C. If calibrating the smaller EXO1 sondes, only DO and Specific Conductance will need to be calibrated. All calibrations will be done with a black plastic probe guard on.
- D. Prior to beginning calibration gather the necessary standards needed for calibration. Fill the pre-labeled EXO calibration cups with the appropriate pH or specific conductance standard. Each cup should be rinsed 3 times with DI water and 3 times with the appropriate standard. Fill a pre-labeled V2 calibration cup with turbidity standard. Make sure the turbidity calibration cup is clean and dry before adding the standard. Make the rhodamine chlorophyll standard and, if needed the rhodamine blue green algae standard. Detailed instructions on how to make these standards can be found in sections VI and VIII below.
- E. If there is an out-of-range error message for any parameter during calibration, there is a problem with the probe. The probe will either need to be troubleshot or replaced.

II. SET UP

- A. Remove plug from the right pin connector on the top of the EXO2 sonde. If calibrating an EXO1 sonde remove the plug from the lone pin connector on the top. Inspect the connector for cleanliness and bent pins. Clean with a lint-free towel and apply Krytox if necessary. Attach the large blue adapter to the pin connector.
- B. On the main KOR screen click the <Connect> button under the “Instrument Connection Panel” on the right side of the screen. If a SmartQC Notification pops

up click <OK>.

- C. Select the appropriate sonde for the desired station as denoted on the weekly meter schedule. Grab a calibration log sheet and the calibration book for the appropriate station.

III. DEPTH

- A. Remove the storage cup from the sonde, keeping the black probe guard on.
- B. Obtain the barometric pressure from the lab barometer. Refer to the “Non-Vented Depth Calibration Sheet” to determine the Depth Offset. This sheet can be found either at the front of the calibration logbook, on the wall in the lab, or in the YSI EXO manual.
- C. Click on the <Instruments and Sensors> tab at the top of the screen. Under the “Overall SmartQC Score” heading, scroll down to the “Depth Sensor” box. Click on the box.
- D. Under the “Depth Settings” change the offset to the offset obtained in step B.
- E. Click the <Apply Sensor Settings> button. Click <Yes> when the 1st dialog box opens up and click <OK> on the 2nd.
- F. Click on the “Calibration” heading at the top of the screen. Under the “Select Parameter to Calibrate” heading, scroll down to the Depth box and hit the small arrow to the left of the box. Another box will appear below the Depth box. Click on the <Calibrate> button. The calibration box will appear.
- G. When “Data Stability” reads “Stable” click the <Apply> button on the bottom right of the screen.
- H. Click <Complete Calibration> on the next screen. Click <Exit> on the next screen.
- I. Record the Depth offset and the pre-calibration and post-calibration depth readings on the calibration log sheet.

IV. SPECIFIC CONDUCTANCE

- A. Rinse the probes and the black probe guard with DI water and then with the appropriate specific conductance standard based on the sonde deployment location. If you are unsure what standard to use, refer to past calibration sheets in the calibration logbook. Place the sonde in the specific conductance calibration cup.
- B. In the calibration section of KOR, under the “Select Parameter to Calibrate” heading click on the small arrow to the left of the Conductivity box. Another box will appear below the Conductivity box. Click the <Calibrate> button in the Sp. Cond. line.
- C. In the “Standard Value” box enter the correct specific conductance value in mS/cm.
- D. When “Data Stability” reads “Stable,” click the <Apply> button at the bottom right of the screen. Click the <Complete Calibration> button at the bottom of the screen.
- E. Record the pre-calibration value on the “Meter reads” line of the calibration log sheet and record the post-calibration value on the “changed to” line. Record the cell constant on the appropriate line of the calibration log sheet. Record the YSI temperature on the calibration log sheet. Click the <Exit> button at the bottom of the screen.

- F. Remove the sonde from the specific conductance calibration cup.
- G. Place a lab thermometer in the specific conductance calibration cup. Allow the temperature to stabilize. Record the thermometer temperature on the calibration log sheet. Compare the temperature values of the sonde and the lab thermometer. If the temperature is off by $>0.2^{\circ}\text{C}$ the probe will need to be changed and the specific conductance calibration repeated.

V. PH

- A. Rinse the probes and the black probe guard with DI water and then with the pH 7 rinse. Place the sonde in the pH 7 calibration cup.
- B. In the calibration section of KOR, under the “Select Parameter to Calibrate” heading click on the small arrow to the left of the pH box. Another box will appear below the pH box. Click the <Calibrate> button.
- C. Once the “Data Stability” reads “Stable,” click the <Apply> button at the bottom right of the screen. Click the <Add Another Cal Point> button at the bottom of the screen.
- D. Rinse the probes and black probe guard with DI water and then with the pH 10 rinse. Place the sonde in the pH 10 calibration cup.
- E. Once the “Data Stability” reads “Stable” click the <Apply> button at the bottom right of the screen. Click the <Complete Calibration> button at the bottom of the screen.
- F. Record the temperature, the pre-calibration, and post-calibration values on the appropriate lines of the calibration sheet. Also record the pH mV readings. Calculate the slope by subtracting the pH10 mV reading from the pH7 mV reading. Record the slope on the calibration log sheet. Click the <Exit> button at the bottom of the screen.
- G. Remove the sonde from the pH 10 calibration cup.

VI. CHLOROPHYLL

- A. Prepare 0.5 mg/l rhodamine WT solution from the stock solution (if needed)
 - a. Retrieve 100mg/l rhodamine stock solution from refrigerator.
 - b. Warm to room temperature by placing in a warm water bath for 5-10 minutes.
 - c. Rinse clean 1000-ml volumetric flask 3 times with DI water.
 - d. Fill 1000-ml volumetric flask halfway with DI water.
 - e. Rinse 5-ml volumetric pipette once with stock solution. Release rinse into sink **with water running** to allow the waste to be flushed.
 - f. Pipette exactly 5.0 ml of the stock solution into 1000 ml volumetric flask using a volumetric pipette.
 - g. Dilute 1000 ml flask to the line with DI to form a 0.5 mg/l rhodamine WT solution. Cap tightly, invert, and swirl several times to homogenize. Place standard in a tall V-2 calibration cup and place in a dark box.
 - h. Return stock solution to the refrigerator.
 - i. Rinse all waste in the sink and flush with plenty of water.
- B. Rinse the probes and black probe guard with DI water. Remove probe guard and dry the probe guard and sonde probes with a lint-free towel. Place the probe guard

- back onto the sonde.
- C. Place the sonde in the chlorophyll calibration cup.
- D. In the calibration section of KOR, under the “Select Parameter to Calibrate” heading click the small arrow to the left of the TAL-PE or TAL-PC box. Another box will appear below the TAL-PE or TAL-PC box. Click on the <calibrate> button in the Chlorophyll (ug/L) line.
- E. Allow the temperature to stabilize. Once it is stable use the EXO Rhodamine WT calibration chart to determine the standard value. The chart can be found in the front of the calibration logbook, on the wall in the lab, or in the YSI EXO manual. Enter the chart value in the “Standard Value” box.
- F. Once “Data Stability” reads “Stable” click the <Apply> button at the bottom of the screen. Click the <Add Another Cal Point> button.
- G. Remove the sonde from the chlorophyll calibration cup. Rinse the probes and black probe guard with DI water. Place the sonde in a calibration cup with clean DI water.
- H. Change the “Standard Value” to 0
- I. Once “Data Stability” reads “Stable” click the <Apply> button at the bottom of the screen. Click the <Complete Calibration> button at the bottom of the screen.
- J. Record the chlorophyll zero calibration information on the Chlorophyll zero line of the calibration log sheet. Record the rhodamine temperature in the temperature line, and the chlorophyll standard value in the Rhodo WT equivalent line of the calibration log sheet. Record the chlorophyll standard calibration information on the Meter reads line of the calibration log sheet. Click the <Exit> button at the bottom of the screen.

VII. TURBIDITY

- A. Keep the sonde in the calibration cup of DI water.
- B. In the Calibration section of KOR, under the “Select Parameter to Calibrate” heading, click the arrow to the left of the Turbidity box. Click the <Calibrate> button.
- C. Once “Data Stability” reads “Stable” click the <Apply> button at the bottom right of the screen. Click the <Add Another Cal Point> button at the bottom right of the screen.
- D. Remove the sonde from the DI water calibration cup. Dry off the probes and black probe guard with a lint-free towel. Place the sonde in the turbidity calibration cup. The standard value will always be 124.0 FNU and should not need to be changed
- E. Once “Data Stability” reads “Stable” click the <Apply> button at the bottom right of the screen. Click the <Complete Calibration> button at the bottom right of the screen
- F. Record the appropriate information on the calibration log sheet. Click the <Exit> button at the bottom right of the screen.

VIII. BLUE GREEN ALGAE (WHEN NECESSARY)

- A. Prepare blue green algae PE rhodamine solution from stock solution.
 - a. Retrieve stock solution from the refrigerator. We will use chlorophyll standard stock solution.

- b. Warm to room temperature
 - c. Rinse a clean 1000-mL volumetric flask 3 times with DI water
 - d. Fill flask halfway with DI water.
 - e. Pipette exactly 0.2mL of stock solution into the flask.
 - f. Fill the flask to the line with DI water, cap tightly and invert flask several times to homogenize.
 - g. Return stock solution to the refrigerator.
 - h. Fill the EXO calibration cup to the top of the green tape with the blue green algae solution. Store in a dark box.
- B. Rinse the probes and black probe guard with DI water. Dry off the probes and black probe guard with a lint-free towel. Place the probe guard back onto the sonde.
 - C. Place the sonde in the blue green algae calibration cup.
 - D. In the calibration section of KOR, under the “Select Parameter to Calibrate” heading click the small arrow to the left of the TAL-PE box. Another box will appear below the TAL-PE box. Click on the <calibrate> button in the Phycoerythrin (ug/L) line.
 - E. Allow the temperature to stabilize. Once it is stable use the EXO Rhodamine WT calibration chart to determine the standard value. The chart can be found in the front of the calibration logbook, on the wall in the lab, or in the YSI EXO manual. Enter the chart value in the “Standard Value” box.
 - F. Once “Data Stability” reads “Stable” click the <Apply> button at the bottom of the screen. Click the <Add Another Cal Point> button.
 - G. Remove the sonde from the blue green algae calibration cup. Rinse the probes and black probe guard with DI water. Place the sonde in a calibration cup with clean DI water.
 - H. Change the “Standard Value” to 0
 - I. Once “Data Stability” reads “Stable” click the <Apply> button at the bottom of the screen. Click the <Complete Calibration> button on the bottom right of the screen.
 - J. Record the blue green algae zero calibration information on the BGA zero line of the calibration log sheet. Record the rhodamine temperature in the temperature line, and the blue green algae standard value in the Rhodo WT equivalent line of the calibration log sheet. Record the blue green algae standard calibration information on the Meter reads line of the calibration log sheet.
 - K. Click the <Exit> button on the bottom right of the screen.

IX. WIPER

- A. The EXO2 sonde has one central wiper. Remove the probe guard and place an EXO brush wiper on the central wiper shaft with the brush facing down toward the sonde body and tighten the set screw with an allen key. Click the <Home> tab at the top of the screen. Click on the <View Live Data> icon in the center of the screen.
- B. Click the <Start Wiping> button at the top of the screen. Watch the wiper. It should turn twice in one direction, twice in the opposite direction, and park with the brush in the garage. If the wiper wipes correctly and parks correctly no calibration is needed.

- C. If the wiper does not park correctly, click on <Calibration> at the top of the page.
 - D. Under “Select Parameters to Calibrate” click on the small arrow next to the Wiper box. Another box will appear below the Wiper box. Click on the <Calibrate> button.
 - E. Click the <Jog Left> or <Jog Right> buttons as needed. Click the <Apply> button at the bottom right of the screen. Click the <Complete Calibration> button at the bottom right of the screen.
 - F. Exit KOR by clicking <Home> at the top of the screen, and clicking <Disconnect> under the “Instrument Connection Panel.”
- X. DISSOLVED OXYGEN** (Ideally performed the day before deployment)
- A. Remove the calibration cup and the black probe guard from the sonde. Place a copper probe guard on the sonde and place it in a bubbling bucket of water (The bubbler should have been running for at least 1 hour to allow the water to come to full saturation).
 - B. Allow the sonde to come to equilibrium (~15 minutes)
 - C. Open the KOR software and connect to the sonde as before. Click on the <Calibration> tab at the top of the screen.
 - D. Under “Select Parameter to Calibrate” heading click on the small arrow to the left of the DO box. Another box will appear below the DO box. Click the <Calibrate> button next to DO (% sat).
 - E. Obtain the barometric pressure from the barometer in the lab. Enter the barometric pressure in the “Barometer” line
 - F. Once “Data Stability” reads “Stable” click the <Apply> button at the bottom right of the screen. Click the <Complete Calibration> button at the bottom right of the screen.
 - G. Record the barometric pressure, pre-calibration value, and post-calibration value in the appropriate section of the calibration log sheet. Record the DO gain (found at the top of the screen) on the calibration log sheet. Proceed to Deployment and Setup.
- XI. DEPLOYMENT AND SETUP**
- A. Click on <Deployment> at the top of the screen. Click on the <Create Template from Sonde> button at the top of the screen. Change the File Name Prefix. This should be the 3-letter code for the station where it will be deployed (found on the front of the calibration logbook), the 2-digit year, and the 2-digit week. For example, a file with the name JUG2217 means that it is deployed at Jug Bay in the year 2022, in the 17th week of the year).
 - B. If the station is at a telemetered station, click on the “Advanced” tab. Change the logging mode to “Sample and Hold.” Click on the “DCP Adapter Output” tab and ensure the appropriate SDI-12 parameters are selected and are in the correct order. Click on the <Save and Apply Template to Sonde> button on the bottom. When asked if you would like to start internal logging click <Yes>. Select “Next Interval” under “Select Deployment Start Time.” If the sonde will not be deployed for several days, you can select to start the internal logging at a specific date and time instead of the next interval.

- C. Record all the programming information at the bottom of the calibration log sheet. Record the number of days of free disk space. Click on <Live Data> at the top of the screen to retrieve battery voltage.
- D. Exit KOR by clicking <Home> at the top of the screen and clicking <Disconnect> under the “Instrument Connection Panel.”

XII. DISSOLVED OXYGEN CHECK (Performed the morning of deployment)

- A. Verify DO calibration by connecting the sonde to the KOR software as before. Click on <Instrument and Sensors> at the top of the page. Under “Sonde Settings” scroll through “Logged Measurement Files”. Locate the current file in the list.
- B. Click the <Import> button next to the current file. Click on <Recorded Data> at the top of the screen. Click the <Search> button at the top left of the page. Select the file that was just imported and click <View Selected Recorded Data>.
- C. Obtain the barometric pressure from the barometer in the lab. Look at the top line of data. Record the temperature and barometric pressure on the calibration log sheet. Using a DO chart that can be found either in the front of the calibration logbook or on the wall in the lab, record the chart DO value. Record the DO (mg/L) and DO(%sat) on the calibration log sheet. DO should read within 0.2mg/L of the chart value. If the readings are not within 0.2mg/L, recalibrate the DO as before, and restart the logging as before. Record any changes on the calibration log sheet. Wait for at least one 15-minute data logging interval and perform another DO check. If the DO is still off by >0.5mg/L do not recalibrate and do not deploy the sonde until the issue is resolved.
- D. Record the battery voltage from the KOR recorded data. If the batteries are reading <5.4V change them. While still connected to KOR, remove the battery cap using the EXO battery cap wrench. Clean out the threads and the o-rings on the battery cap. Replace the old batteries with new ones. Grease the o-rings on the battery cap and put it back on.
- E. Exit KOR by clicking <Home> at the top of the screen and clicking <Disconnect> under the “Instrument Connection Panel.”

YSI EXO POST CALIBRATION

XIII. NOTES

- A. During Post Calibration, the idea is to preserve the condition of the sonde after deployment. Thus, it is important *not* to clean the sensors or remove any fouling that may have been deposited. However, you may carefully clean the sides of the probes, as long as you preserve the fouling on the actual sensor faces themselves.
- B. To avoid contamination of the bubbler bucket water it is advised that, before placing a sonde in the bucket, a clean probe guard is placed over the probes. Also, the cling wrap should be cut away before placing the sonde in the bucket.
- C. Inspect each probe on the sonde. Using the selections available at the bottom of the Rhodamine calibration chart, give each probe a “fouling grade.” This is noted for each probe on the far right of the calibration sheet.

- D. Because most sondes will exhibit biological fouling or sediment buildup on the probes after a deployment, they will tend to contaminate any standards with which they come in contact. Therefore, a second set of dirty standards are used to perform post calibrations.
- E. Clean standards are typically rotated into dirty standards at the end of each field week. When the dirty standards become significantly contaminated with biological material or dirt, they should be discarded and replaced with clean standards.
- F. Rinse each pre-labeled calibration cup 3x with DI water and 3X with the appropriate standard. Fill each pre-labeled calibration cup with the appropriate standard.

XIV. DISSOLVED OXYGEN (ideally performed the day after retrieving meter)

- A. Place the sonde in the bubbler (The bubbler should have been running for at least 1 hour). The sonde should be in the bubbler for at least 30 minutes. Allow sonde to continue to log data while coming to equilibrium. Check the barometric pressure using the barometer in the lab. Connect the sonde cable to the sonde and open KOR. Connect to the sonde as before. Click on <Instrument and Sensors> at the top of the page. Scroll down to the bottom of the “Logged Measurement Files.” Click the <Import> button next to the most recent file. Double check to make sure that it has the correct file extension (three letter code, 2-digit year, and 2-digit week).
- B. After the file is imported click on <Recorded Data> at the top of the screen. Click on the <Search> button at the upper left of the screen. Select the file that was just imported and click <View Selected Recorded Data>. If there are multiple files with the file name select them all and put a note on the calibration log sheet.
- C. Look at the most recent reading. Record the temperature and barometric pressure on the calibration log sheet. Look up the DO chart value using the chart in the front of the calibration logbook or the chart on the wall in the lab. Record the chart value on the calibration log sheet. Record DO mg/L, DO %Sat, Depth, and Battery. Compare the sonde reading to the chart value. If the sonde is off by >0.5mg/L make a note. Record the pressure corrected depth offset on the calibration log sheet. This can be found on the depth calibration sheet in the front of the calibration logbook or on the wall in the lab.
- D. Click on the <Export to CSV> button at the top of the page. Download the file to the M drive. It should go in: Con Mon/Continuous Monitoring/Data-WQ/DNR. From here select the appropriate year and month in which to save the file. Rename the file with the file extension and the word “raw” at the end. An example would be JUG2217raw. Click the <Save> button.
- E. Stop logging by clicking <Deployment> at the top of the screen, followed by the <Stop Deployment> button.
- F. Pull the sonde out of the bubbling bucket and remove the probe guard. Click on <Home> at the top of the screen. Click on the <View Live Data> button, followed by the <Start Wiping> button. Check that the wiper wipes and parks correctly. Note it on the calibration log sheet. Assign fouling grades to each probe. The fouling grades can be found in the front of the calibration logbook or on the wall in the lab. Remove the wiper and place the probe guard back on the sonde. Add about 1/2” of DI water to a storage cup and place the sonde/probe guard in the storage

- cup. Tighten the storage cup.
- G. Disconnect the sonde from KOR and place the sonde on the shelf until time allows for the remainder of the post-calibration procedure.

XV. SPECIFIC CONDUCTANCE

- A. Connect to KOR as before. Click on the <View Live Data> button.
- B. Rinse the sonde and black probe guard with DI water and then with specific conductance standard. **NOTE: The sonde will be posted with the same specific conductance standard that was used for calibration.**
- C. Place the sonde in the pre-filled specific conductance standard calibration cup. Wait for the readings to stabilize and record the specific conductance reading on the calibration log sheet. If the sonde is reading off by >5% of the standard, make a note on the sheet.
- D. Also note the temperature of the sonde on the calibration sheet. Remove the sonde from the calibration cup. Place a standard lab thermometer in the calibration cup and record the temperature on the calibration log sheet. If the sonde temperature is off by >0.2C from the lab thermometer, make a note on the sheet.

XVI. PH

- A. Rinse the probes and the black probe guard with DI water and then with pH 7 rinse. Place the sonde in the pre-filled pH 7 calibration cup. Allow the readings to stabilize. Record the temperature, the pH reading, and the pH mV on the calibration log sheet. If the pH reading is off by >0.2 make a note on the sheet.
- B. Rinse the probes and black probe guard with DI water and then with pH 10 standard. Place the sonde in the pre-filled pH 10 calibration cup. Allow the readings to stabilize. Record the temperature, the pH reading, and the pH mV on the calibration log sheet. If the pH reading is off by >0.2 make a note on the sheet.
- C. Calculate the pH slope by subtracting the pH 10 mV from the pH 7 mV. If the slope is out of range, make a note on the sheet.

XVII. CHLOROPHYLL, TURBIDITY, AND BLUE GREEN ALGAE (if applicable)

- A. Rinse the probes and black probe guard with DI water. Gently place the sonde in a tall V2 calibration cup filled with DI water.
- B. Wait for readings to stabilize. Once the readings have stabilized record the 0 values for the chlorophyll, turbidity, and blue green algae (if applicable) on the calibration log sheet. If any of the values are off by >5 make a note on the sheet.
- C. Remove the calibration cup and dry off the probes and black probe guard with a lint-free towel. Do not wipe away any fouling that is on the optic sensor faces. Place the instrument into the V-2 chlorophyll calibration cup.
- D. Allow the readings to stabilize. Record the temperature and the chlorophyll value on the calibration log sheet. Record the sonde chlorophyll reading. If the sonde reading is off by more than 5 ug/L or 5% (whichever is greater) make a note on the sheet.
- E. Remove the instrument from the chlorophyll standard. Rinse the probes and probe guard with DI water. Dry them off with a lint-free towel. Place the instrument in the V-2 turbidity calibration cup.

- F. Allow the readings to stabilize. Record the turbidity value on the calibration log sheet. If the value is off by more than 5 FNU or 5% (whichever is greater) make a note on the sheet. Remove the sonde from the calibration cup and rinse with DI water.
- G. If necessary, dry the probes and probe guard with a lint-free towel and place the instrument in the EXO blue green algae calibration cup. Record the temperature, the rhodamine value, and the sonde reading on the calibration sheet.
- H. Disconnect from KOR by clicking <Home> at the top of the screen, followed by clicking <Disconnect> under the “Instrument Connection Panel.”
- I. The sonde should now be cleaned and stored.

Figure 5 on the following page is an example of a Continuous Monitoring Calibration Sheet.

Figure 5: Continuous Monitoring Calibration Sheet


| EXO/ V2 CALIBRATION LOG | | | | METER | | Page # | |
|------------------------------|--|---------------------------------------|--|------------------------------|--|------------------|--------|
| CALIBRATION | | | | POST CALIBRATION | | | |
| Date | | Time (EST) | | Date | | Time | |
| Deployment site: | | | | Initials | | | |
| Initials | | | | | | | |
| B.P. | | Depth offset | | B.P. | | Depth offset | |
| | | Depth | | | | Depth | |
| | | → | | Stopped Logging? | | YES | NO |
| | | | | | | Upload? | YES NO |
| Specific Conductance | | | | Specific Conductance | | | |
| Sp. Cond. Std. | | μS/cm | | Sp. Cond. Std. | | μS/cm | |
| Meter reads | | μS/cm | | Meter reads | | μS/cm | |
| changed to | | μS/cm | | | | Fouling Grade | |
| Cond. Cell Const. | | (Un-WPD 4.6-5.45/WPD 0.42-0.52) | | | | | |
| Temperature Check | | | | Temperature Check | | | |
| Thermometer temp | | °C | | Thermometer temp | | °C | |
| YSI temp: | | °C | | YSI temp: | | °C | |
| pH 7 | | | | pH 7 | | | |
| Temperature | | °C | | Temperature | | °C | |
| Meter pH reads | | → | | Meter pH | | Fouling Grade | |
| pH mV | | mV (Range 0 ± 50) | | pH mV | | mV | |
| pH 10 | | | | pH 10 | | | |
| Temperature | | °C | | Temperature | | °C | |
| Meter pH | | → | | Meter pH | | | |
| pH mV | | mV (Range -180 ± 50) | | pH mV | | mV | |
| Slope (pH7 mV - pH10 mV) | | (Range 165 - 180) | | Slope | | | |
| Chlorophyll (2-point) | | | | Chlorophyll (2-point) | | | |
| Chlorophyll zero | | → μg/L | | Chlorophyll zero | | μg/L | |
| Temperature | | °C | | Temperature | | °C | |
| Rhodo WT equivalent | | μg/L | | Chlorophyll Std | | μg/L | |
| Meter reads | | → μg/L | | Meter reads | | μg/L | |
| Turbidity (2-point) | | | | Turbidity (2-point) | | | |
| Turb zero | | → NTU | | Turb zero | | NTU | |
| Turb Std | | NTU | | Turb Std | | NTU | |
| Meter reads | | → NTU | | Meter reads | | NTU | |
| BGA (2-point) | | | | BGA (2-point) | | | |
| BGA zero | | → μg/L | | BGA zero | | μg/L | |
| Temperature | | °C | | Temperature | | °C | |
| Rhodo WT equivalent | | μg/L | | Rhodo WT equivalent | | μg/L | |
| Meter reads | | → μg/L | | Meter reads | | μg/L | |
| Dissolved Oxygen | | | | Dissolved Oxygen | | | |
| Temperature | | °C | | Temperature | | °C | |
| Bar. Pressure | | mm Hg | | Bar. Pressure | | mm Hg | |
| D.O. Saturation | | % → | | Chart D.O. | | mg/L | |
| D.O. Gain | | (Range 0.8 - 1.7) | | Meter D.O. | | mg/L | |
| PROGRAMMING | | | | Notes | | | |
| Parameters: (Circle) | | Date Time Temp SpC Sal DO% DO pH pHmV | | Temperature | | °C | |
| | | Turb Chl Fluor Batt Depth | | Bar. Pressure | | mm Hg | |
| Set time to: (v2 only) | | : EST | | Chart D.O. | | mg/L | |
| Log to filename | | | | Meter D.O. | | mg/L | |
| Start Date / Time / interval | | / / min | | D.O. Saturation | | % % | |
| Started Logging | | YES NO | | (Last 2 bucket readings) | | Wiper? YES NO | |
| Free Disk Space | | days changed Y N | | Battery (V) | | | |
| Battery Life (V) | | | | DATA SET COMPARISON | | | |
| Field/Cal Notes | | DO Check | | meter | | old new Discrete | |
| | | / / | | time | | | |
| | | Temp | | Temp. | | °C | |
| | | B.P. | | Sp. Cond | | μS/cm | |
| | | Chart | | Salinity | | ppt | |
| | | Meter | | D.O. | | mg/l | |
| | | DO % | | D.O. | | % % | |
| | | Re-Cal? Y N | | pH | | | |
| | | Batt Check | | Turb. | | NTU | |
| | | Changed Y N | | Chloro | | μg/L | |
| | | *Batts should be changed if <5.4 | | total depth = | | m secchi = | |
| | | | | sample depth = | | m | |

Appendix 6. YSI 6600/V2 Calibration, Daily Check, and Post-Calibration Procedures (Water Quality Mapping)

Revised: April 2017

Calibration

1. SETUP

- A. Remove waterproof cap from the 9-pin sonde connector and attach sonde cable from laptop to the sonde.
- B. Launch “Ecowatch” and select the sonde icon  from the TOOLBAR menu.
- C. Choose *COM 1* (or sometimes *COM 4* depending on which laptop you use) when prompted to select COM port then press <Enter>.
- E. Type **menu** at the # prompt and select *SYSTEM*.
- F. Select *Date & Time*, then select *Time*.
- G. From a reliable time source, such as the radio controlled clock or the phone operator, enter correct time of day in Eastern Standard Time, then press <Enter> simultaneously with correct time. Time has now been set.
- H. Return to the main menu by pressing <Esc>.
- I. Next select *Report*.
- J. Select the following parameters prior to calibration:
 - Time, Temp C, SpCond mS/cm, Sal ppt, pH, pH mV,
 - Turbidity NTU, Chl ug/L, Chl RFU, ODO Sat%, ODO mg/l,
 - Battery volts.
- K. Press Esc until you are back to the main menu.

2. Dissolved Oxygen

- A. Fill a clean 5-gallon bucket 2/3 full, with tap water. Sparge the water with an aquarium pump and air-stone for at least two hours prior to calibration,
- B. Remove calibration cup from the sonde and inspect ODO probe to ensure that the optical sensor is free of scratches, chips, or other major damage.
- C. Place a YSI probe guard onto the sonde.
- D. Place the sonde into the 5-gallon bucket for at least 30 minutes before calibrating. Make sure that the ODO probe and temperature probe are fully submerged. Position sonde in bucket so that the air bubbles do not contact probes.
- E. From the main menu, select *CALIBRATE* then *OPTIC-O DISSOLVED OXY*.
- F. Next choose *ODO SAT%* then *ONE POINT*. Take current Barometric Pressure from a reliable barometer in the room. Log in Barometric Pressure in mmHg and press <Enter>.
- G. Allow ODO% to stabilize for at least 30 seconds. Record temperature, barometric pressure, chart DO value (obtained from pressure/temperature chart), meter ODO mg/l and ODO Sat%. Press <Enter> and record adjusted ODO mg/l and ODO Sat%. Press <Enter>.
- H. Return to the Calibrate menu by pressing <Esc>.

3. Chlorophyll

- A. Prepare 0.5 mg/l Rhodamine WT solution from stock solution.
 - 1) Retrieve 100 mg/l Rhodamine stock solution from refrigerator.
 - 2) Allow stock solution to reach ambient temperature using a warm

water bath

- 3) Rinse clean 1000-ml volumetric flask 3 times with DI.
 - 4) Fill 1000-ml volumetric flask halfway with DI water.
 - 5) Using a volumetric pipette, pipette exactly 5.0 ml of the stock solution into 1000 ml volumetric flask
 - 6) Bring 1000 ml flask to the line with DI to form a 0.5 mg/l Rhodamine WT solution. Cap tightly, invert and swirl several times to homogenize.
- B. Fill a clean calibration cup (the taller one) with **black top** attached 3/4 full with DI water. Remove probe guard and place probes down into DI water allowing at least three inches between probes and the bottom of the calibration cup.
 - C. Select *OPTIC C - CHLOROPHYLL*, from the Calibrate menu, then *CHL UG/L*, then *TWO POINT*. Enter “0” as the first standard. Press <Enter>.
 - D. Check optics for air bubbles. If air bubbles exist, **gently** raise the sonde up and down in the solution until all air bubbles are gone.
 - E. Allow readings to stabilize and record chlorophyll blank concentration. Press <Enter> and record calibrated chlorophyll blank concentration. Press <Enter> again.
 - F. Rinse calibration cup (the taller one) 3 times with Rhodamine solution, then fill cup $\frac{3}{4}$ full, with the 0.5 mg/l Rhodamine solution.
 - G. Using lab thermometer, record temperature of Rhodamine standard in the calibration cup.
 - H. Dry probes with Kimwipes then place probes down into Rhodamine standard allowing at least three inches between probes and the bottom of calibration cup.
 - I. Using temperature reading obtained in step G, look up corresponding Chlorophyll value from Chlorophyll/Temperature chart in the folder. Enter this concentration (e.g., 22°C = 113ug/l) as the second point in the calibration and press <Enter>.
 - J. Check for air bubbles over optics. If air bubbles exist, **gently** raise the sonde up and down in the solution until all air bubbles are gone.
 - K. Allow readings to stabilize.
Record chlorophyll concentration and temperature. Press <Enter> and record calibrated chlorophyll concentration. Press <Enter> again.
 - L. Return to the Calibrate menu by pressing <Esc>.

4. Turbidity

- A. Fill a clean calibration cup (the taller one) with **black top** attached 3/4 full with DI water.
- B. Rinse probes with DI and place probes down into calibration cup allowing at least three inches between probes and the bottom of the calibration cup.
- C. From the Calibrate menu select *TURBIDITY*, then *2 POINT*.
- D. Enter the first standard as “0”. Press <Enter>.
- E. Check for air bubbles over optics. If air bubbles exist, **gently** raise the sonde up and down in the solution until air bubbles are gone
- F. Allow readings to stabilize. Record turbidity concentration. Press <Enter> and record calibrated turbidity concentration. Press <Enter> again.
- G. Remove probes from calibration cup and dry off all probes with a Kimwipe. This will prevent the turbidity standard from becoming diluted.
- H. Fill a **clean, dry** calibration cup (the taller one) with **black top** attached 3/4 full

with clean 126 NTU solution. Carefully pour the solution down the inner wall of the calibration cup to minimize any air bubbles.

- I. Place probes down into calibration cup allowing at least three inches between probes and the bottom of the calibration cup.
- J. Enter second standard as 126. Press <Enter>.
- K. Check for air bubbles over optics. If air bubbles exist, **gently** raise the sonde up and down in the solution until air bubbles are gone.
- L. Allow readings to stabilize. Record turbidity concentration. Press <Enter> and record calibrated turbidity concentration. Press <Enter> again.
- M. Return to the Calibrate menu by pressing <Esc>.

5. Specific Conductance

- A. Attach open-ended calibration cup securely to the sonde and rinse probes 3 times with DI water.
- B. Rinse probes 3 times with specific conductance standard 12900 μ S/cm.
- C. Set meter upright with probes facing up. Gently swirl clean 12900 μ S/cm standard and fill calibration cup until the standard level is above all of the probes. If any air bubbles are apparent in the conductivity block, remove them by shaking the meter gently or dislodging them with a cotton swab.
- D. Select *CONDUCTIVITY*, then *SP COND* from the Calibrate menu.
- E. Enter the conductance of the standard **in mS/cm**.
Ex: 12900 μ S/cm = 12.90 mS/cm. Press <Enter>.
- F. Allow readings to stabilize. Record specific conductance reading in μ S/cm and press <Enter>.
- G. Record calibrated specific conductance reading in μ S/cm. Press <Enter> again.
- H. Return to Calibrate menu by pressing <Esc>.

6. pH

- A. With calibration cup securely attached to meter, rinse probes 3 times with DI water.
- B. Rinse probes 3 times with pH 7 buffer.
- C. Set meter upright with probes facing up. Fill calibration cup with **clean** pH 7 standard.
- D. Select *pH* from the calibrate menu, then *2-POINT*.
- E. Enter “7” as the 1st point and press <Enter>. Allow at least 60 seconds for meter to stabilize. If readings fail to stabilize, try unplugging the laptop from the power source and pull YSI stand away from the wall.
- F. When readings have stabilized record temperature and pH reading. Press <Enter> and record calibrated *pH* and *pH/mV* reading. Press <Enter>.
- G. Rinse probes 3 times with DI water. Then rinse 3 times with pH 10 buffer.
- H. Fill the calibration cup with **clean** pH 10 buffer.
- I. Enter 10 as the 2nd point and press <Enter>, allow at least 60 seconds for meter to stabilize.
- J. When readings have stabilized record temperature and pH reading. Press <Enter>, record calibrated *pH* and *pH/mV* reading. Press <Enter>.
- K. Return to the Main menu by pressing <Esc>
- L. Select *Report*, then unmark *pH/mV* by pressing “C”.
- M. Press <Esc> until asked to *Exit menu (Y/N)?*, then press “Y”.

DAILY CHECK


Day before each run: Set up YSI V2 to be checked the following morning by rinsing probes with DI. Place probe guard onto YSI V2 and place in a clean 5-gallon bucket filled 2/3 full, with tap water, with submerged air stone and air pump running. Position sonde in the bucket so that the air bubbles do not contact probes.

Morning of run:

- A. Attach the sonde cable to sonde in 5-gallon bucket and launch *Ecowatch* as you would to calibrate.
- B. Type "menu" at the # prompt, then select *Report*.
- C. **MAKE SURE THAT ONLY THE FOLLOWING PARAMETERS ARE CHECKED UNDER THE REPORT MENU:**
 - Time, Temp C, SpCond. mS/cm, Sal ppt, pH, Turb., Chl ug/L, Chl RFU, ODOsat %, ODO mg/L, and Battery volts.
- D. Return to the Main menu by pressing <Esc> and select *Run*, then *Discrete Sampling*, then *Start Sampling*.
- E. Allow readings to stabilize for at least 30 seconds. Record Temperature, Barometric Pressure, Chart DO mg/L (from pressure/temperature chart), meter ODO mg/l, and ODO% Saturation.
Refer to "Ranges for Daily Check" page if meter ODO is off by +/- 0.2mg/L from chart DO. Remove the sonde from bucket and remove probe guard.
- F. Fill a clean calibration cup (the taller one) with **black top** attached 3/4, with DI water.
- G. Place probes down into calibration cup allowing at least three inches between probes and the bottom of the calibration cup.
- H. Check optics for air bubbles. If air bubbles exist, **gently** raise the sonde up and down in the solution until the air bubbles are gone.
- I. Record Chlorophyll and Turbidity "0" once readings have stabilized. If Chlorophyll "0" is off by 1µg/L or if Turbidity "0" is off by 2 NTU, re-calibrate using the procedures listed in the Calibration section.
- L. Attach a clean, dry open-ended calibration cup to the sonde. Rinse calibration cup and probes three times with clean 12900µS/cm specific conductance standard. Place the sonde in ring stand with probes facing up. Fill calibration cup with clean 12900µS/cm specific conductance standard. Wait for the meter to stabilize and record specific conductance reading. Re-calibrate specific conductance if meter is off by +/- 645µS/cm.
- M. Rinse probes three times with DI then three times with pH 7 buffer.
- N. Pour clean pH 7 buffer into calibration cup, wait until readings stabilize, then record temperature and pH 7 reading. If readings fail to stabilize, try unplugging the laptop from the power source and pull YSI stand away from the wall.
- O. Rinse probes three times with DI then three times with pH 10 buffer.
- P. Pour clean pH 10 buffer into calibration cup, wait until readings stabilize, then record temperature and pH 10 reading.
- Q. Recalibrate pH 7 and pH 10 if either value is off by +/- .2 units

POST CALIBRATION

- A. Set YSI V2 up like you would for "**Day before each run**" procedure in Daily Check section. Place the sonde into the 5-gallon bucket for at least 30 minutes before post calibrating.

- B. Remove waterproof cap from the 9-pin sonde connector and attach sonde cable from laptop to the sonde.
- C. Launch “Ecowatch” and select the sonde icon  from the TOOLBAR menu.
- D. Choose *COM 1* (or sometimes *COM 4* depending on which laptop you use) when prompted to select COM port then press <Enter>.
- E. Type **menu** at the # prompt and select *REPORT*.
- F. Select **the following** parameters to be post calibrated:
 - **Time, Temp C, SpCond mS/cm, Sal ppt, pH, pH mV, Turbidity NTU, Chl ug/L, Chl RFU, ODO Sat%, ODO mg/l, Battery volts.**
- G. Return to the Main menu by pressing <Esc> and select *Run*, then *Discrete Sampling*, then *Start Sampling*.

1) Dissolved Oxygen

- A. Allow ODO% to stabilize for at least 30 seconds. Record temperature, barometric pressure, chart DO value (obtained from pressure/temperature chart), meter ODO mg/l and ODO Sat%.
- B. Remove the sonde from bucket and remove probe guard.

2) Chlorophyll and Turbidity

- A. Fill a tall clean **black top** calibration cup $\frac{3}{4}$ full, with DI water. Place probes down into DI water allowing at least three inches between probes and the bottom of the cup.
- B. Check optics for air bubbles. If air bubbles exist, **gently** raise the sonde up and down in the solution until all air bubbles are gone.
Allow readings to stabilize. Record chlorophyll and turbidity "0" value.
- C. Rinse calibration cup 3 times with 0.5 mg/l Rhodamine WT solution (obtained from step 3A in the Calibration procedure), then fill a tall clean cup $\frac{3}{4}$ full, with the 0.5 mg/l Rhodamine solution.
- D. Wipe probes dry with a Kimwipe. Place probes down into Rhodamine standard allowing at least three inches between probes and the bottom of calibration cup.
- E. Check optics for air bubbles. If air bubbles exist, **gently** raise the sonde up and down in the solution until the air bubbles are gone.
- F. Record Chlorophyll value, temperature, and Rhodamine equivalent value (obtained from Chlorophyll/Temperature chart in folder) after readings have stabilized.
- G. Remove the sonde from calibration cup, rinse probes with DI and dry all probes with a Kimwipe. Fill a clean, tall, dry calibration cup with black top $\frac{3}{4}$ full, with 126 NTU standard.
- H. Place probes down into Turbidity standard allowing at least three inches between probes and the bottom of the cup.
- I. Check optics for air bubbles. If air bubbles exist, **gently** raise the sonde up and down in the solution until the air bubbles are gone.
- J. Record Turbidity value after readings have stabilized.

3) Specific Conductance

- A. Attach open-ended calibration cup securely to the sonde.
- B. Rinse probes 3 times with DI then 3 times with 12900 μ S/cm conductance standard.

- C. Set meter upright with probes facing up. Fill calibration cup with clean 12900µS/cm conductance standard until the standard level is above conductivity block and temperature probe. If any air bubbles are apparent in the conductivity block, remove them by shaking the meter gently or dislodging them with a cotton swab.
- D. Record specific conductance when readings have stabilized.

4) pH

- A. With the calibration cup securely attached to the sonde, rinse probes 3 times with DI water.
- B. Rinse probes 3 times with pH 7 buffer.
- C. Set meter upright with probes facing up. Pour **clean** pH 7 standard into the calibration cup until the buffer level is above pH and temperature probes.
- D. Allow at least 60 seconds for meter to stabilize. If readings fail to stabilize, try unplugging the laptop from the power source and pull YSI stand away from the wall.
- E. When readings have stabilized, record pH, pH mV and temperature.
- F. Rinse probes 3 times with DI water and then 3 times with pH 10 buffer.
- G. Pour **clean** pH 10 standard into calibration cup until the standard level is above pH and temperature probes.
- H. Allow at least 60 seconds for meter to stabilize.
- I. When readings have stabilized, record pH, pH mV and temperature.
- J. Return to the Main menu by pressing <Esc>
- K. Select *Report*, then unmark pH/mV by pressing “C”.
- L. Press <Esc> until asked to *Exit menu (Y/N)?* then press “Y”.

Figure 6 on the following page is an example of a Water Quality Mapping calibration sheet.

Figure 6: Water Quality Mapping Calibration Sheet

| | | | | | |
|-------------------------------------|--------|--------|--------|--------|--------|
| Date | | | | | |
| Time | | | | | |
| Calibration Type: Cal, Post, Check | | | | | |
| River/Area Being Tested | | | | | |
| Set Time? | Yes | No | Yes | No | Yes |
| Initials | | | | | |
| DISSOLVED OXYGEN (mg/L) | | | | | |
| Temperature: °C | | | | | |
| Bar. Pressure: mmHg | | | | | |
| Chart D.O.: mg/L | | | | | |
| Meter D.O.: mg/L | | | | | |
| -Adjusted to: mg/L | | | | | |
| D.O. Saturation : % | | | | | |
| -Adjusted to: | | | | | |
| CHLOROPHYLL (µg/L) | | | | | |
| Chlorophyll zero: µg/L | | | | | |
| -Adjusted to: µg/L | | | | | |
| Temperature: °C | | | | | |
| Rhodo WT equivalent: µg/L | | | | | |
| Meter Reads: µg/L | | | | | |
| -Adjusted to: µg/L | | | | | |
| TURBIDITY (NTU) | | | | | |
| Turbidity zero: | | | | | |
| -Adjusted to: | | | | | |
| Turbidity standard: | 126 | 126 | 126 | 126 | 126 |
| Meter Reads: | | | | | |
| -Adjusted to: | | | | | |
| SPECIFIC CONDUCTANCE (µS/cm) | | | | | |
| Sp. Cond. Std.: µS/cm | 12,900 | 12,900 | 12,900 | 12,900 | 12,900 |
| Meter Reads: µS/cm | | | | | |
| -Adjusted to: µS/cm | | | | | |
| pH 7 | | | | | |
| Temperature: °C | | | | | |
| Meter Reads: | | | | | |
| -Adjusted to: | | | | | |
| pH mV: (-50 to 50) | | | | | |
| pH 10 | | | | | |
| Temperature: °C | | | | | |
| Meter Reads: | | | | | |
| -Adjusted to: | | | | | |
| pH mV: (-230 to -130) | | | | | |
| Notes: | | | | | |

Appendix 7. Continuous Monitoring and Water Quality Mapping Filtering Methods
(Revised May 2009)

A. PARTICULATE SAMPLE FILTRATION, PROCESSING AND STORAGE

1. Chlorophyll

Chlorophyll samples are filtered in the same manner for all programs.

- a) For every depth sampled, clean a 47mm bell with deionized (DI) water. Set up unit for filtering. Be sure that there is a trap in line between the manifold and the vacuum source.
- b) Place a Whatman 47mm GF/F glass fiber filter pad (pore size = 0.7 μ m) on the filter frit. Always use clean forceps when handling the filter pads.
- c) Mix sample thoroughly by agitating and shaking the sample bottle vigorously, then rinse graduated cylinder three times with sample.
- d) Agitate the sample again before measuring in the graduated cylinder. Fill graduated cylinder with sample and filter desired volume through filtration unit. Be sure to use a graduated cylinder that is close to the volume being filtered (ex: if you are only filtering 80 ml of sample use a 100 ml graduate). Keep the vacuum pressure below 10 inches of Hg (around 8" Hg is good).
- e) Filter sufficient volume of sample (50 - 1500 ml) to solidly color the filter pad.
- f) Record the total volume filtered on the foil square.
- g) Agitate the squirt bottle of MgCO_3 , as it settles rapidly. Add approximately 1 ml of MgCO_3 suspension (1.0 g MgCO_3 in 100 ml of DI water) to the last 25 ml of sample in the filtration bell.

NOTE: Samples for dissolved parameters are not to be collected from this filtrate.

- h) Using forceps (1 or 2 pair), fold filter in half with sample inside and remove filter pad.
- i) Place pad in pre-marked foil square, and carefully fold foil square in thirds, horizontally. Then fold the ends in to seal the filter inside. Be sure forceps do not touch sample residue on the filter pads, because the sample will adhere to the forceps.
- j) Be sure that foil square is marked with date, station, depth of sample, volume of sample filtered, and sample number.
- k) Place foil packet into zip-lock plastic bag or pad container. When sampling on the small boats or a land run place the foils in a bag or pad container in the ice chest and place them in the appropriately labeled bag in the Field Office freezer when you return to the office. The bags for the chlorophyll samples go in the bin marked CBL in the freezer.
- l) Record sample station number, date, volume filtered (mL), depth (m), layer, start time, end time and field scientist sign-off on the CBL volume sheet. Record the study code, submitter code, data category code and replicate number, if not already pre-filled, on the CBL volume sheet. This sheet is submitted to the laboratory with the samples. When you return the samples to the Field Office freezer, place the volume sheet in the rack on the side of the freezer marked "CBL".

NOTE: The filter pads for chlorophyll samples should be exposed to as little direct sunlight as possible. Store as soon as possible.

2. Particulate Carbon/ Particulate Nitrogen (PC/PN)

PC/PN samples are filtered in the same manner for all programs.

- a) Follow steps A.1.a. through A.1.d. above setting up two 25 mm filter bells using two pre-combusted 25 mm GF/F filters (pore size = 0.7 μ m). The PC/PN pads come from CBL.
- b) Filter 10-200 ml through each filter. Filter enough sample to leave noticeable color on the filter pad.
- c) Make sure filter is sucked dry and the same volume is filtered for both pads.
- d) Record the volume filtered (total volume through one pad - do not add the volumes for the 2 pads together) on the foil square and in the appropriate field on the CBL volume sheet.

NOTE: Samples for dissolved parameters are not to be collected from this filtrate.

- e) Using forceps, fold each filter in half.
- f) Place both filters in a foil square labeled with date, CBL sample number, station, sample layer, PC/PN, and volume filtered. Be sure that the pads are not overlapping in the foil square to keep them from freezing together.
- g) Fold the foil square as described in step A.1.i. above and then place folded foil in zip-lock bag or pad container and put in a cooler on ice.
- h) Upon return to the Field Office, place the foils in their appropriate zip-lock bag in the sample freezer and place the bag in the CBL bin. Put the completed CBL volume sheet in the rack on the side of the freezer marked "CBL".

3. Particulate Phosphorus/ Particulate Inorganic Phosphorus (PP/PIP)

- a) Follow steps A.1.a. through A.1.d. above setting up and rinsing two 47 mm filter bells and flasks. The filters used are two Whatman 47 mm GF/F filters (same pads we use for chlorophyll). These filters are Pre-Combusted and are received from CBL.
- b) Filter 50 ml of sample through each filter pad.
- c) Use the filtrate as an equipment rinse and discard.
- d) Then filter enough additional (another 50 - 450 ml) to leave a noticeable color on the filter pad.
- e) Record the total volume filtered through each pad being sure to add the 50 ml rinse water (total volume through one pad – do not add the volumes for the 2 pads together) on the foil square and in the appropriate field on the CBL volume sheet.
- f) Use this filtrate to fill up the tubes for the dissolved parameter analysis. See section B (Filtered dissolved nutrient sample collection) below.
- g) After collecting filtrate, make sure filter is sucked dry.
- h) Rinse the filter pad using at least three - 10 ml rinses of DI water, sucking the pad dry after each rinse.
- i) Using forceps, fold each filter in half.
- j) Place both filters in a foil square labeled with date, PP/PIP, CBL sample number, station, sample layer, and volume filtered (this is the total volume of sample through each pad, including the initial 50 ml rinse). Be sure that the pads are not overlapping in the foil square to keep them from freezing together.
- k) Fold the foil square as described in step A.1.i. above. Place foil square in zip-lock bag or pad container and put in the cooler on ice until you return to the field office.
- l) Upon return to the Field Office, place the foils in their appropriate zip-lock bag in the sample freezer and place the bag in the CBL bin. Put the completed CBL volume sheet in the rack on the side of the freezer marked "CBL".

4. Total Suspended Solids/ Volatile Suspended Solids (TSS/VSS)

The instructions below apply to samples processed for TSS/VSS for Dataflow and Continuous Monitoring programs.

- a) Follow steps A.1.a. through A.1.d. above setting up and rinsing one 47 mm filter bell and flask. The filter used is a pre-combusted and pre-weighed 47 mm GF/F filters (pore size = 0.7 μ m). The VSS pads come in individually numbered petri dishes from CBL. Remove one pad from its individual petri dish and place it on the filter screen. Record the pad number from the petri dish on the TSS/VSS foil label in the space marked "Pad #" and in the appropriate field on the CBL volume sheet. Remove the Pad # tape from the petri dish and affix it to the CBL volume sheet.
- b) Filter 50 - 500 ml through the filter pad leaving a noticeable color on the pad.
- c) Make sure the filter is sucked dry and rinse the filter pad using at least three - 10 ml rinses of DI water, sucking the pad dry after each rinse. If the sample is very salty (e.g., Lower Chesapeake, Coastal Bays) you should rinse an extra 1-2 times.
- d) Using forceps, fold the filter in half. Place the filter in a foil square labeled with date, TSS/VSS, CBL sample number, station, sample layer, volume filtered, and VSS pad number. Record the total volume filtered through the pad in the appropriate field on the CBL volume sheet.
- e) Fold the foil square as described in step A.1.i. above. Place foil square in zip-lock bag or pad container and put in the cooler on ice until you return to the field office.
- f) Upon return to the Field Office, place the foils in their appropriate zip-lock bag in the sample freezer and place the bag in the CBL bin. Put the completed CBL volume sheet in the rack on the side of the freezer marked "CBL".

5. Total Suspended Solids (TSS) Only

The instructions below apply to samples processed for TSS only for Dataflow and Continuous Monitoring programs.

- a) Follow steps A.1.a. through A.1.d. above setting up and rinsing one 47 mm filter bell and flask. The filter used is a pre-weighed 47 mm GF/F filters (pore size = 0.7 μ m). The TSS pads are individually numbered from CBL. Remove one pad from the pad container and place it on the filter screen numbered side down (this will allow number to be visible when pad is folded after filtering).
- b) Filter 50 - 500 ml through the filter pad leaving a noticeable color on the pad.
- c) Make sure the filter is sucked dry and rinse the filter pad using at least three - 10 ml rinses of DI water, sucking the pad dry after each rinse. If the sample is very salty (e.g., Lower Chesapeake, Coastal Bays) you should rinse an extra 1-2 times.
- d) Using forceps, fold the filter in half. Place the filter in a foil square labeled with date, TSS, CBL sample number, station, sample layer, and volume filtered. Record the total volume filtered through the pad in the appropriate field on the CBL volume sheet.
- e) Fold the foil square as described in step A.1.i. above. Place foil square in zip-lock bag or pad container and put in the cooler on ice until you return to the field office.
- f) Upon return to the Field Office, place the foils in their appropriate zip-lock bag in the sample freezer and place the bag in the CBL bin. Put the completed CBL volume sheet in the rack on the side of the freezer marked "CBL".

B. DISSOLVED NUTRIENT SAMPLE FILTRATION & COLLECTION

NOTE: The filtrate collected for this sample must come from either the TSS or PP/PIP filtration set-up. If you cannot get enough water through these pads to fill all tubes, then use plain GF/F filters to get enough

filtrate. The filtrate may not come from pads that are in contact with MgCO_3 (CHLA).

1. Total Dissolved Nitrogen & Phosphorus (TDN/TDP)

NOTE: NERRS TDN/TDP samples are processed using whole water in place of filtrate.

- a) Rinse the TDN/P tube with whole water.
- b) Flick all remaining water droplets out of the test tube and cap.
- c) Rinse the 10 ml graduated cylinder 3 times with whole water.
- d) Fill the graduated cylinder with 10 ml of whole water.
- e) Carefully, pour the 10 ml of whole water into the test tube and cap tightly.
- f) Store the test tube in the freezer.
- g) If on a land run or small boat, store the tubes on ice in a cooler and place in the Field Office freezer when you return from the field.

2. Nitrate, Nitrite, Ammonia, Orthophosphate

The following steps are to be completed for collection of all filtrate for the samples below:

- a) Run 50 ml of sample water through the filter.
- b) Use this 50 ml of filtrate to rinse the flask and then discard.
- c) Run more sample water through the filter and collect in the flask.
- d) Rinse the 3 like-numbered AA vials (4 ml polystyrene cups) and 3 caps three times with filtrate.
- e) Fill the AA vials with filtrate to just below the ridge where the caps are seated.
- f) Snap the caps on the vials. You should hear them snap twice to be fully seated.
- g) Store 3 AA vials in the freezer.
- h) If on a land run or small boat, store the tubes on ice in a cooler and place in the Field Office freezer and refrigerator when you return from the field.

C. QUALITY CONTROL SAMPLES (IF APPLICABLE)

1. Clean Check (Blanks)

The clean check is performed by using clean, dry pads that are analyzed as if they had been in contact with actual samples.

- a) Place clean, dry pads in foils for appropriate parameters to be analyzed as if they had been used for real samples.
- b) A TSS blank is done at one CHL/TSS continuous monitoring station once per month.

2. Duplicate/Replicate Samples

Field duplicate and replicate samples are collected to check for accuracy of field collection and preparation of the samples.

- a) All NERRS sites get one duplicate sample done every month. A NERRS duplicate sample consists of one chlorophyll pad and 3 nitrate, nitrite, ammonia, and orthophosphate AA vials.
- b) One set of replicate samples is done at one CHL/TSS continuous monitoring station once per week. Replicates consist of one additional processed CHL pad and one additional processed TSS pad per sample.
- c) For Dataflow, one out of every ten stations will have a replicate sample for CHL and TSS. Replicates consist of one additional processed CHL pad and one additional processed TSS pad every tenth station.

Appendix 8. Continuous Monitoring Parameters

Revised: 5/29/2007

| Parameter | Format/Units | Field Name | Method Code |
|--|---|---------------|-------------|
| Date | mmddyyyy | SAMPLE_DATE | |
| Time | hh:mm:ss (24 hr clock – EST) | SAMPLE_TIME | |
| Station | | STATION | |
| Tributary | | WATER_BODY | |
| Segment | | CBSEG_2003 | |
| Sonde (YSI Sonde Name) | Variable Length (e.g., “Gina” or Serial Number) | SONDE | |
| Latitude | Decimal Degrees (NAD83) | LATITUDE | |
| Longitude | Decimal Degrees (NAD83) | LONGITUDE | |
| Sample Depth Value | meters (+) | SAMPLE_DEPTH* | |
| Sample Depth Reference | BS = Floating Below Surface B = Bottom*** S = Surface *** | LAYER_CODE* | |
| Water Column Depth | meters (+) | TOTAL_DEPTH** | |
| Battery Voltage | Volts | BATT | |
| Water Temperature | °C | WTEMP | F01 |
| Specific Conductance | ms/cm | SPCOND | |
| Salinity (From YSI Sonde) | Ppt | SALINITY | F01 |
| Dissolved Oxygen Saturation | % | DO_SAT | F02 |
| Dissolved Oxygen Concentration | mg/l | DO | F02 |
| pH | Su | PH | F01 |
| Turbidity | NTU or FNU | TURB_NTU | F01 |
| Fluorescence | % FS (FS = Full Scale) | FLUOR | |
| Pre-calibrated Total Chlorophyll | µg/l | TCHL_PRE_CAL | |
| Post-calibrated Chlorophyll <i>a</i> # | µg/l | CHLA | |

* The SAMPLE_DEPTH should always be used in conjunction with the LAYER_CODE for descriptive information on where the sonde is located in the water column.

** The TOTAL_DEPTH only applies to fixed depth sonde and is adjusted to account for the distance the sonde is fixed above the bottom.

*** S and B layer codes are used to distinguish samples where there is both a surface and bottom instrument deployed at the same location.

The POST-CALIBRATED CHLOROPHYLL *a* field is currently not populated. Values will be calculated when a robust algorithm is developed.

Appendix 9. Water Quality Mapping Parameters

Revised: 1/7/2004

| Parameter | Format/Units | Field Name | Method Code |
|--|---|---------------|-------------|
| Date | Mmddyyyy | SAMPLE_DATE | |
| Time | hh:mm:ss (24 hr clock – EST) | SAMPLE_TIME | |
| Cruise Track | AAAmddyyyy (AAA = 3 Letter Trib Code) | STATION | |
| Tributary | | WATER_BODY | |
| Primary Segment | | PRI_SEG | |
| Sonde (YSI Sonde Name) | Variable Length (e.g., “Gina” or Serial Number) | SONDE | |
| Latitude | Decimal Degrees (NAD83) | LATITUDE | |
| Longitude | Decimal Degrees (NAD83) | LONGITUDE | |
| Sample Depth Value | meters (+) | SAMPLE_DEPTH* | |
| Sample Depth Code | BS = Floating Below Surface AB = Fixed Above Bottom VP = Vertical Profile | LAYER_CODE* | |
| Water Column Depth | meters (+) | TOTAL_DEPTH | |
| Boat Speed | knots | BOAT_SPEED | |
| Battery Voltage | volts | BATT | |
| Water Temperature | °C | WTEMP | F01 |
| Specific Conductance | ms/cm | SPCOND | |
| Salinity (From YSI Sonde) | ppt | SALINITY | F01 |
| Dissolved Oxygen Saturation | % | DO_SAT | F01 |
| Dissolved Oxygen Concentration | mg/l | DO | F01 |
| pH | su | PH | F01 |
| Turbidity | NTU | TURB_NTU | F01 |
| Fluorescence | % FS (FS = Full Scale) | FLUOR | |
| Pre-calibrated Total Chlorophyll | µg/l | TCHL_PRE_CAL | |
| Post-calibrated Chlorophyll <i>a</i> # | µg/l | CHLA | |

* The SAMPLE_DEPTH should always be used in conjunction with the LAYER_CODE for descriptive information on where the sonde is located in the water column.

The POST-CALIBRATED CHLOROPHYLL *a* field is currently not populated. Values will be calculated when a robust algorithm is developed.

Appendix 10. Continuous Monitoring and Water Quality Mapping Error Codes

Revised: 5/28/2018

| Category | Code | Description | Immediate Data Impacts | Suggested Uses |
|----------|------|---|--------------------------------------|----------------------------------|
| Comments | CAB | Algal Bloom - No Sample Taken | Comment - No Impact on Data Value | Field Observation |
| Comments | CAS | Algal Sample Taken (Sample #) | Comment - No Impact on Data Value | Field Observation |
| Comments | CBF | Biofouling | Comment - No Impact on Data Value | |
| Comments | CCS | Calibration Sample Taken | Comment - No Impact on Data Value | Water Quality Mapping Specific |
| Comments | CDB | Disturbed Bottom | Comment - No Impact on Data Value | Field Observation |
| Comments | CFK | Fish Kill | Comment - No Impact on Data Value | Field Observation |
| Comments | CFL | Negative Fluorescence Value Not Flagged | Comment - No Impact on Data Value | Continuous Monitoring Specific |
| Comments | CLF | Flow Low | Comment - No Impact on Data Value | Water Quality Mapping Specific |
| Comments | CSC | Site Location Change | Comment - No Impact on Data Value | Continuous Monitoring Specific |
| Comments | CSW | Salinity Calibrated at the Wrong Level | Comment - No Impact on Data Value | |
| Comments | CTC | Time Change | Comment - No Impact on Data Value | NA to Data Post 2003 |
| Comments | CTF | Temperature Probe Failure | Comment - No Impact on Data Value | |
| Comments | CTS | Time Skip | Comment - No Impact on Data Value | Improper Time Recording By Sonde |
| Comments | CTW | Turbid Water | Comment - No Impact on Data Value | Field Observation |
| Comments | CWD | Instrument at Wrong Depth (Depth Value) | Comment - No Impact on Data Value | Continuous Monitoring Specific |

Appendix 10. Continuous Monitoring and Water Quality Mapping Error Codes continued...

| Category | Code | Description | Immediate Data Impacts | Suggested Uses |
|----------------------|------|---|-----------------------------------|--|
| General Probe Codes | GB0 | Blocked Optic | Data Invalid - Hide Data Value | Extreme Single-Point Turbidity and Chlorophyll Spikes |
| General Probe Codes | GNV | Negative Value | Data Invalid - Hide Data Value | |
| General Probe Codes | GPC | Post Calibration Out of Range | Data Invalid - Hide Data Value | |
| General Probe Codes | GPF | Probe Failure | Data Invalid - Hide Data Value | |
| General Probe Codes | GSC | Seal Compromised | Data Invalid - Hide Data Value | |
| General Probe Codes | GWL | Wiper Lost | Data Invalid - Hide Data Value | |
| General Probe Codes | GWM | Wiper Malfunction | Data Invalid - Hide Data Value | Evident Biofouling on Optics |
| Non-Probe Codes | NIR | Instrument Removed | Data Invalid - Hide Data Value | Instrument Removed from Water for Short Duration (Within a Deployment) |
| Non-Probe Codes | NIS | Invalid Data Due To Incorrect YSI Setup | Data Invalid - Hide Data Value | |
| Non-Probe Codes | NND | No Data | Data Invalid - Hide Data Value | Missing Data Values |
| Non-Probe Codes | NNF | Ram Clogged / No Flow | Data Invalid - Hide Data Value | Water Quality Mapping Specific |
| Non-Probe Codes | NOW | Instrument Out of the Water | Data Invalid - Hide Data Value | |
| Non-Probe Codes | NPF | Power Failure | Data Invalid - Hide Data Value | |
| Non-Probe Codes | NQR | Data Rejected Due To QA/QC Checks | Data Invalid - Hide Data Value | |
| Specific Probe Codes | PDF | Depth Port Frozen | Data Invalid - Hide Data Value | |
| Specific Probe Codes | PDP | DO Poisoning (Anoxia) | Data Invalid - Hide Data Value | Membrane Degraded Due to Low DO |
| Specific Probe Codes | PSW | Salinity Calibrated at the Wrong Level | Data Invalid - Hide Data Value | |

Appendix 11. Continuous Monitoring Data Verification and Management Procedures

Revised: 5/25/2022

The continuous monitoring project currently uses two different types of instruments: YSI 6600 and EXO water quality sondes. Procedures for the two instruments are detailed below.

YSI 6600 Procedures

1. Open raw .DAT file in Ecowatch Lite and rearrange parameters into the following order: DATE, TIME, BATT, DEPTH, TEMP, SP. COND, SALINITY, DO%, DOCONC, PH, TURBIDITY, CHL, FLUOR
2. Using the file naming convention of the station three-letter designation followed by the two-digit year and the two-digit week, export files from Ecowatch in .CSV format (e.g., JUG0718.csv would be the 18th week of 2007).
3. Delete all data that were taken when the sonde was not in the water on station (i.e., transit time from the field office to the station). Use the logbooks to determine this time.

NOTE: For BGA data files, delete all out of water data and save BGA file for inserting into web data file.

4. If the data is from a station where the instrument is floating one meter from the surface, then delete all data in the DEPTH field (it is understood to be 1 meter at all times). If there is no column for depth, be sure to insert one in between the BATT and TEMP columns.
5. Run the QA/QC macro by clicking the “REARRANGE CONTMON DATA” button on the “DNR CONTMON” tab of the macro dialog (Figure A11_1). When this button is clicked, the existing data columns are rearranged, new data columns are added, and error code columns are added. Error code fields are designated by the suffix “_A”. The columns are ordered as follows:

SAMPLE_DATE
SAMPLE_TIME
STATION
SONDE
TOTAL_DEPTH
TOTAL_DEPTH_A
BATT
BATT_A
WTEMP
WTEMP_A
SPCOND
SPCOND_A
SALINITY
SALINITY_A
DO_SAT
DO_SAT_A
DO
DO_A
PH
PH_A
TURB_NTU

TURB_NTU_A
 FLUOR
 FLUOR_A
 TCHL_PRE_CAL
 TCHL_PRE_CAL_A
 CHLA
 CHLA_A
 COMMENTS

6. Examine the data from the previous deployment, if applicable, and note any overlapping data records resulting from the three-way *in situ* match-up. The overlapping record(s) should then be deleted from the more recent deployment to ensure that the data are continuous from deployment to deployment.

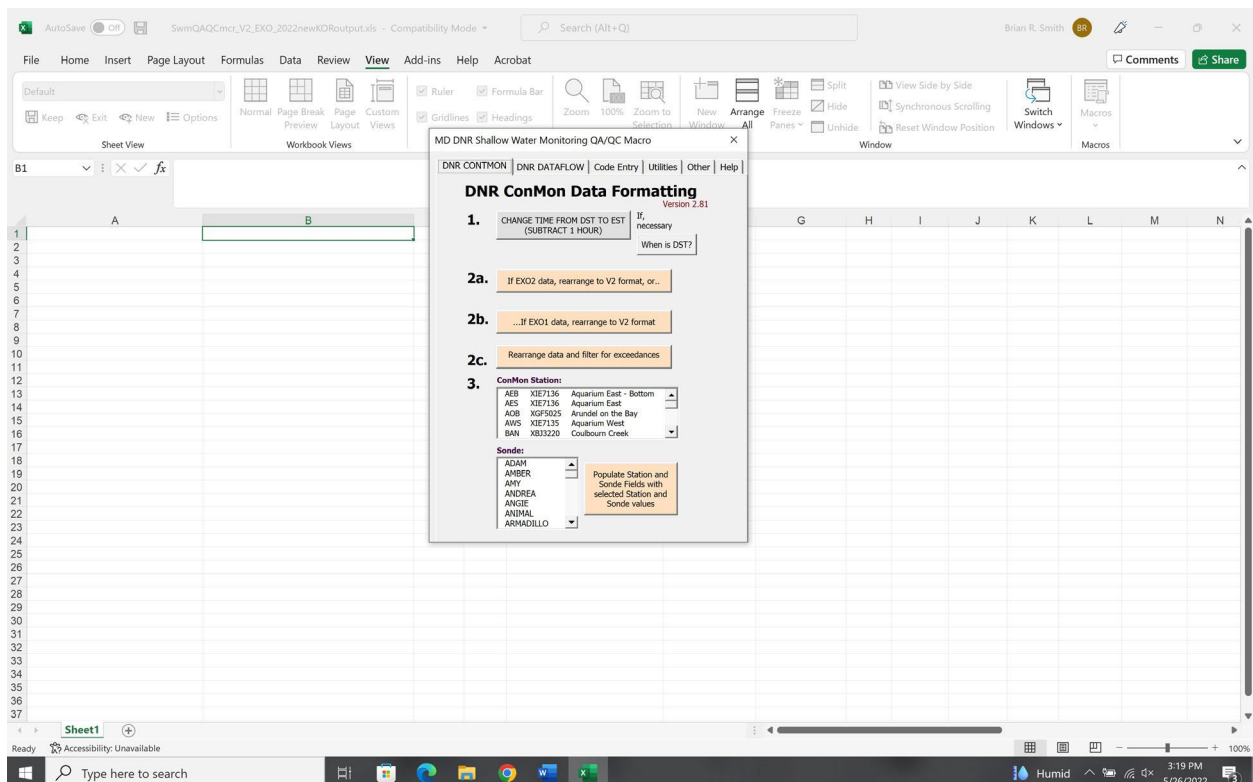
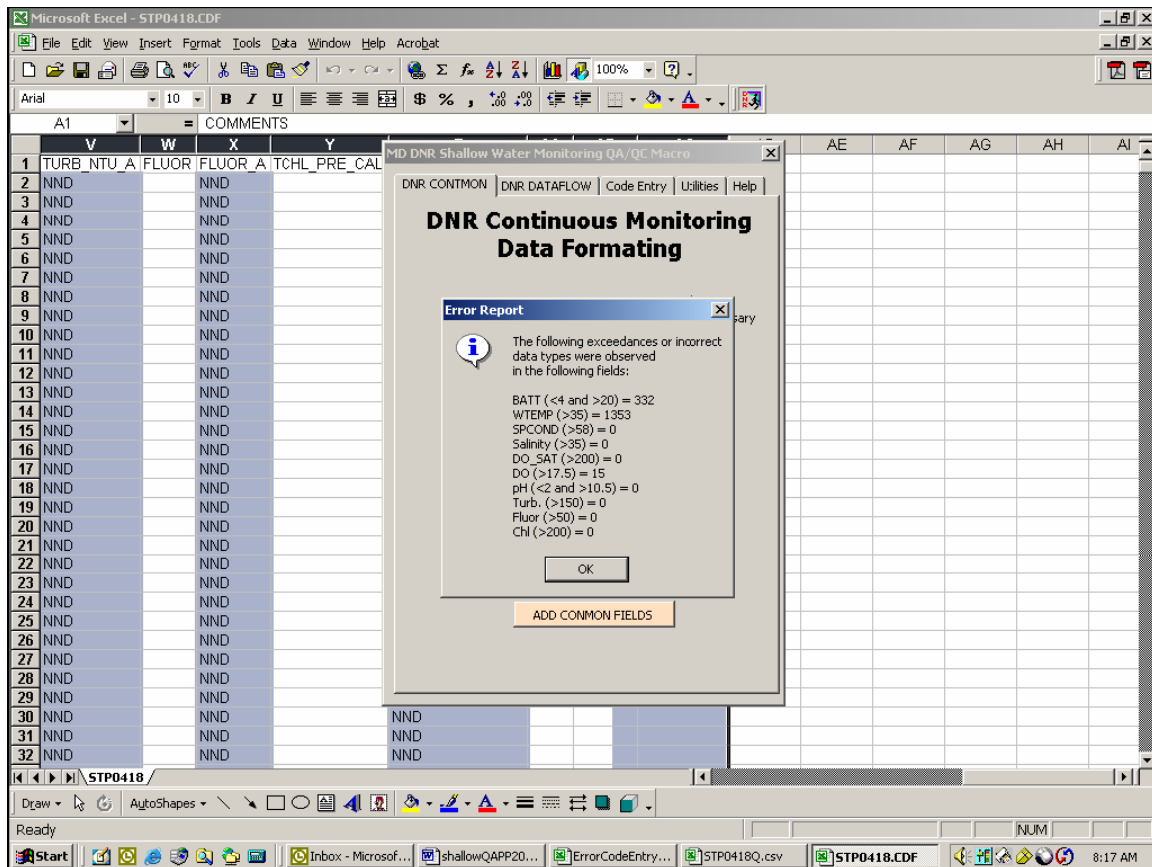


Figure A11_1. Screenshot of the QA/QC macro for continuous monitoring data formatting.

7. When clicked, the “REARRANGE CONTMON DATA” button also flags negative values with the GNV error code, flags missing data with the NND error code, highlights values outside of set tolerance levels in red (Table A11_1), and returns an overview summary of exceedances (Figure A11_2). Tolerance levels are purposefully large to accommodate the diversity of data collected throughout Maryland’s Coastal and Chesapeake Bays.

Table A11_1. Tolerance levels are automatically checked by the QA/QC macro.

| Parameter | Tolerance |
|--------------|--------------|
| BATT | <4 and >20 |
| WTEMP | >35 |
| SPCOND | >50 |
| Salinity | >35 |
| DO_SAT | >200 |
| PH | >17.5 |
| DO | <2 and >10.5 |
| TURB | >150 |
| FLUOR | >50 |
| TCHL_PRE_CAL | >200 |



Figure

A11_2. Screenshot of exceeded tolerances.

8. Select the Station and Sonde information for the deployment being reviewed into the macro dialog box and click “ADD COMMON FIELDS”. This inserts the station name and sonde name into each record.

9. Flagging Values with the QA/QC Macro:

Sound data management practices dictate that data should never be deleted. As such, we employ a data management system in which all original data values are retained in the database, but erroneous data are masked with an error code (see Appendix 11 for list of error codes). Each parameter value field also has an error code field associated with it and is designated with the suffix “_A” (e.g., DO_A). Error codes should only be written to the error code fields. Comments should only be written to the COMMENTS field. Because the data file is comma separated, a comma should never be used to separate comments in the COMMENTS field; a semi-colon can be used instead. The following steps outline how the QA/QC Macro can be used to insert error codes and comments.

a) Go to the “CODE ENTRY” tab of the QA/QC macro to access all of the tools necessary to enter error codes and comments in selected cells (Figure A11_3).

b) Use the “SELECT CELLS” box to select the cells of the spreadsheet in which you want to enter error codes or comments.

c) After the cells have been selected, choose a “PREDEFINED CODE” or “CUSTOM CODE” by selecting the appropriate button.

NOTE: Custom codes should only be used for comments. They should never be used for error codes because the database only recognizes predefined error codes.

d) Select either a “PROBE SPECIFIC”, “GENERAL PROBE”, “NON-PROBE” or “COMMENTS” code by clicking the appropriate radio button, or if applicable, type in a custom comment.

e) Select the appropriate code and click the “ENTER CODE” button.

f) Repeat Steps b-e as necessary.

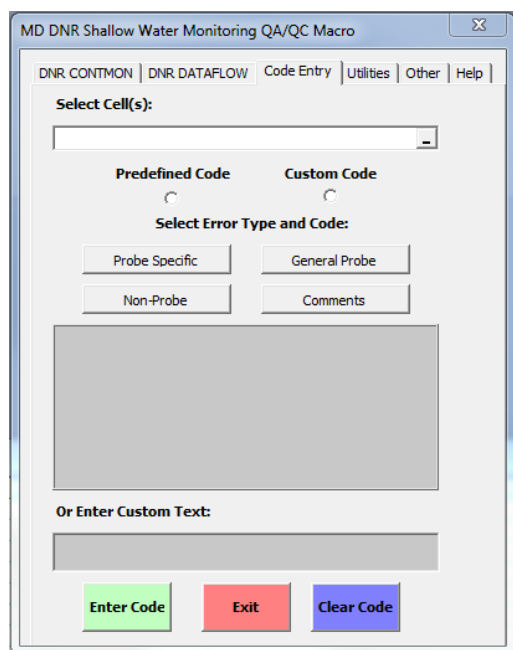


Figure A11_3. Screenshot of QA/QC macro's code entry screen.

10. Using the procedures outlined above in Step 9 to flag data, identify any suspicious data by inspecting the values flagged in red and the original data graphed in Excel. Common anomalies include abnormal spikes in chlorophyll and turbidity, abnormal dips in specific conductance, and abnormally high dissolved oxygen readings due to high dissolved oxygen charge. Post-calibration and *in-situ* field checks should also be used to identify when probes are reading incorrectly.

NOTE: Do not be too quick to flag data. Flagging data is necessary to remove obvious outliers from the data set. Strange things can and do occur in Maryland waters, and we do not want to flag an anomaly just because it seems out of place. Anomalies should be identified, but must not be flagged unless there is proper justification. If you feel a period of data is questionable, but should not be excluded, keep it unflagged in the data set, but mention it in the comments field.

NOTE: All negative turbidity data is flagged by QA/QC macro. All turbidity data $>$ or $=$ to -5 must be recoded as verifiable data as this is within tolerance of the sensor and DNR's current standards.

NOTE: Specific Conductance/DO protocol. Dissolved Oxygen Concentration (DOC) is a calculated parameter which utilizes salinity in the calculation. In situations where salinity is flagged or removed due to fouling or failure, the DO concentration must be examined closely to determine its accuracy. D.O. percent saturation (DOP) is a direct reading and never deleted unless the probe is determined to be failing or fouled. In systems where the Specific Conductance is less than 5000 $\mu\text{S}/\text{cm}$, DOP and DOC are always retained. In systems higher than 5000 $\mu\text{S}/\text{cm}$, DOP is retained and DOC must be verified using the solubility chart in the YSI manual. Generally, all DOC data is retained in warmer months based on the solubility chart and DNR's current tolerances. However, when water temperatures are lower, the salinity has greater effect on DOC and can be pulled outside of DNR's tolerances.

11. Once all of the error codes and comments have been entered into the data file, close the macro and save the file as a Comma Separated Value (.CSV) file using the same naming convention as above with a "Q" added to the end (e.g., JUG0718Q.csv).

12. Next select the Utilities tab of the QA/QC Macro and convert file to web upload format.

13. Then select the Other tab and insert headers. Lastly, select the Utilities tab and adjust the times and then save as .CSV file without Q.

The resulting .CSV file can then be imported into DNR's database. The QA/QC'd data can also be posted to the Eyes on the Bay (www.eyesonthebay.net) website to overwrite any existing provisional real-time data.

There should be four files when a data set is complete. In our example, these files would be:

JUG0718.dat (Raw data - no editing),

JUG0718a.csv (Raw file ready to import into excel, or some other distinction similar to "a" to differentiate it from the final web formatted file),

JUG0718Q.csv (Final QA/QC'd file with erroneous data masked), and

JUG0718.csv (Web formatted file that has undergone complete QA/QC)

YSI EXO Procedures

1. In KOR software Choose the “Instrument and Sensors” tab. Under “Sonde Settings” scroll through “Logged Measurement Files”.

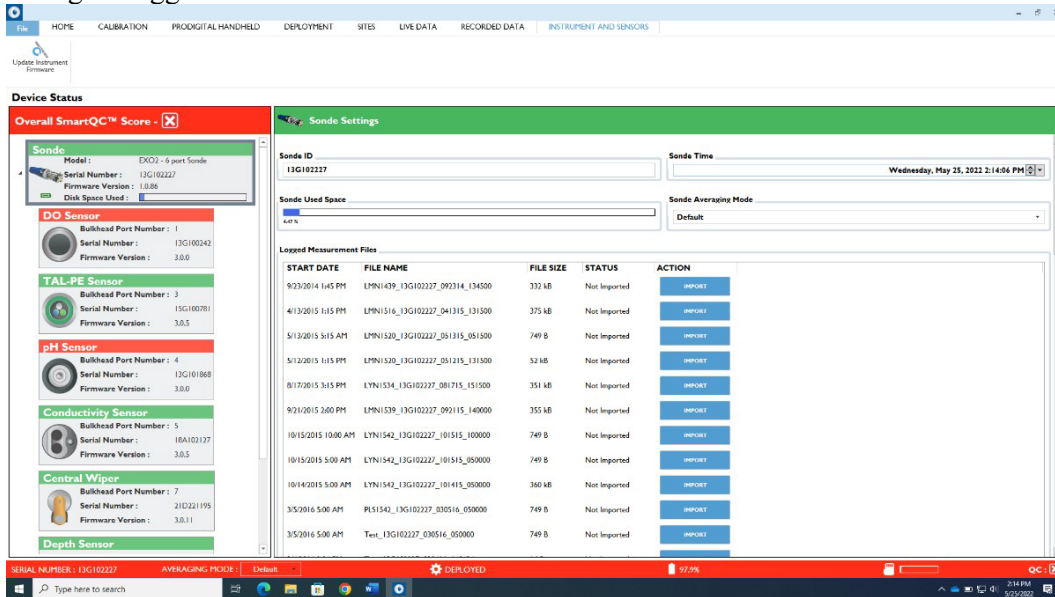


Figure A11_4. Screenshot of KOR Instrument and Sensors tab.

2. Choose the file you want from the list under “Logged Measurement Files” and click “Import” for the correct file. Once the file is imported go to the “Recorded Data” tab. Click “Search.” In the “Select Data to View” box, select the correct file and click “View Selected Recorded Data”

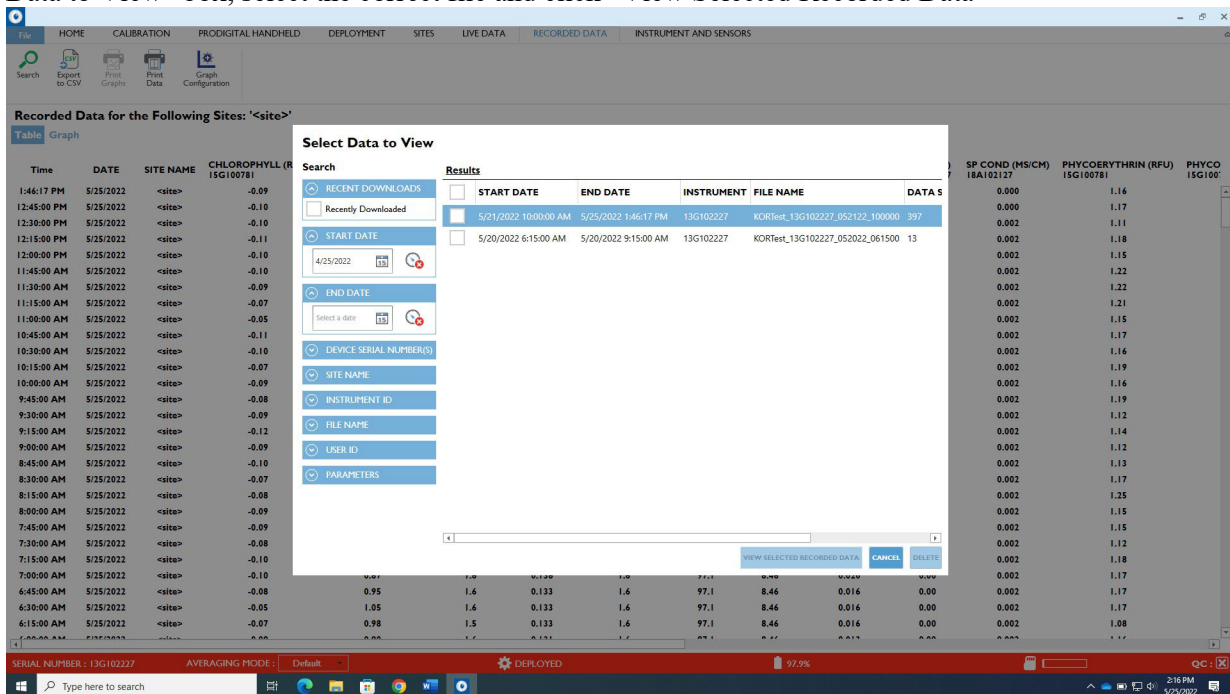


Figure A11_5a. Screenshot of KOR select file screen.

3. Click on the “Export to CSV” button. Save the file to the standard location for data files using the standard continuous monitoring naming convention, adding the word “raw” at the end, in the .csv format.

Using the file naming convention of the station three-letter designation followed by the two-digit year and the two-digit week. (e.g., JUG0718raw.csv would be the 18th week of 2007).

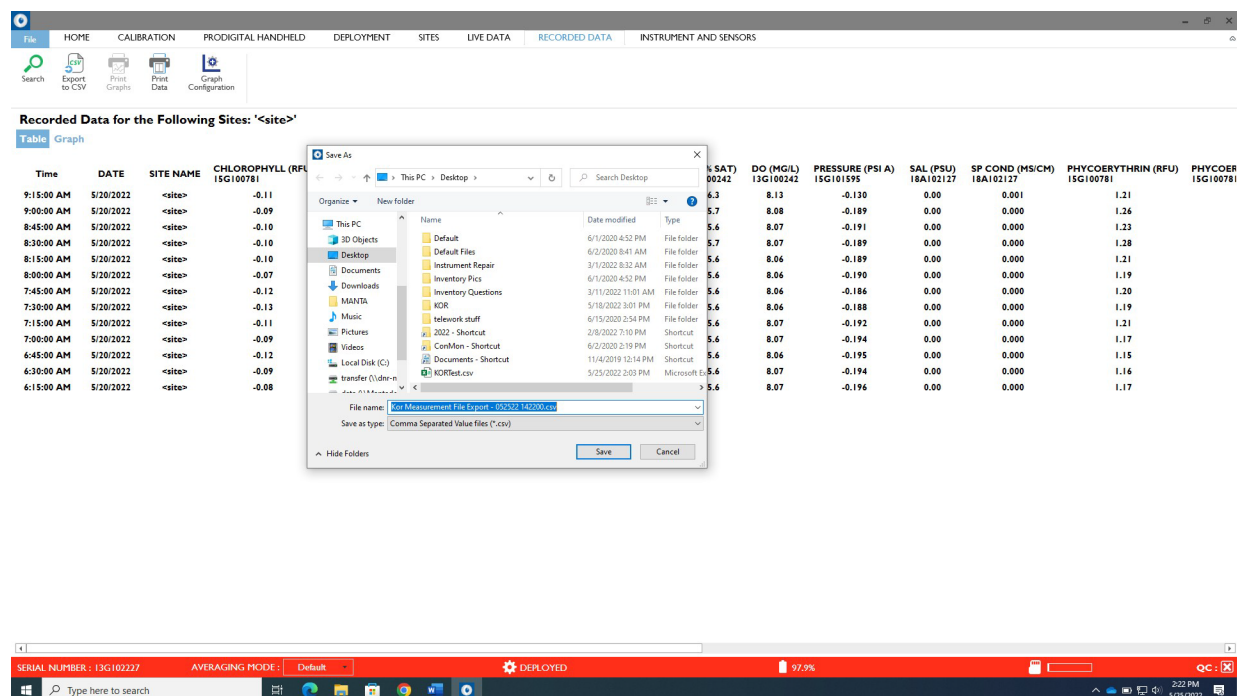


Figure A11_5b. Screenshot of KOR save file screen.

NOTE: If file contains BGA data, copy and paste the BGA data into a separate excel file.

4. Using Microsoft Excel, open the .csv file. Run the 2a or 2b button depending on the type of data.

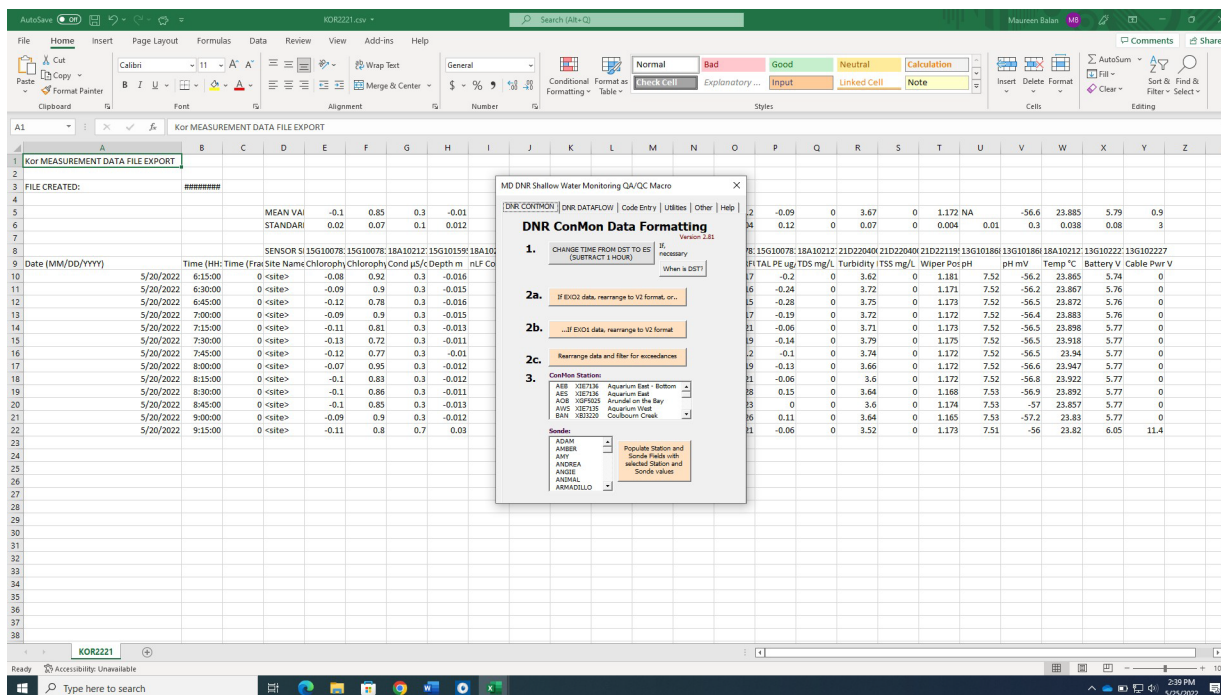


Figure A11_6. Screenshot of QA/QC macro's code EXO entry screen.

Delete all data that were taken when the sonde was not in the water on station (i.e., transit time from the field office to the station). Use the logbooks to determine this time.

NOTE: For BGA data files, delete all out of water data and save BGA file for inserting into web data file.

5. Follow the procedures for YSI 6600 water quality sondes from this point.

NOTE: For EXO data, if fluorescence is negative and chlorophyll concentration is greater than or equal to the probe detection limit of 0.09 ug/L, neither value will be flagged (remove the "GNV" flag from fluorescence) and the comment code "CFL" (Negative Fluorescence value not flagged) will be added. If fluorescence is negative and chlorophyll concentration is less than 0.09 ug/L, the fluorescence value will be flagged with "GNV" and the chlorophyll value will be flagged with "NQR" (Data Rejected due to QA/QC checks).

Appendix 12. Water Quality Mapping Data Verification and Management Procedures

Revised: 5/10/2007

- 1) Open raw .txt file created by DATAFLOW / Labview Software in Excel
- 2) Use the file naming convention of the segment three-letter designation followed by the two-digit month, the two-digit day and the four-digit year and save the raw data file
- 3) Delete all data from probe/sensor warm up, until they reach equilibrium. If there is excessive (more than one minute) data collected while boat is stationary after initial start-up at boat ramp that should also be deleted. Remove all data that has no associated GPS coordinate data, or data that are instrument error codes or 'garbage' characters.
- 4) Run the QA/QC macro by clicking the "ROX sensor" box, then clicking the "REARRANGE DATAFLOW DATA" button on the "DNR DATAFLOW" tab of the macro dialog (Figure A12_1). When this button is clicked, the existing data columns are rearranged, new data columns are added, and error code columns are added. Error code fields are designated by the suffix "_A". The columns are ordered as follows:

SAMPLE_DATE
SAMPLE_TIME
STATION
WATER_BODY
PRI_SEG
SONDE
LATITUDE
LONGITUDE
TOTAL_DEPTH
TOTAL_DEPTH_A
BOAT_SPEED
BOAT_SPEED_A
BATT
BATT_A
WTEMP
WTEMP_A
SPCOND
SPCOND_A
SALINITY
SALINITY_A
DO_SAT
DO_SAT_A
DO
DO_A
PH
PH_A
TURB_NTU
TURB_NTU_A
FLUOR
FLUOR_A
TCHL_PRE_CAL
TCHL_PRE_CAL_A

Figure A12_1. Screenshot of the QA/QC macro for continuous monitoring data formatting.

- 5) When clicked, the “REARRANGE DATAFLOW DATA” button also flags negative values with the GNV error code, flags missing data with the NND error code, highlights values outside of set tolerance levels in red (Table A11_1 in Appendix 11) and returns an overview summary of exceedances (Figure A11_2 in Appendix 11). Tolerance levels are purposefully large to accommodate the diversity of data collected throughout Maryland’s Coastal and Chesapeake Bays.

Enter the Date, Station, select Water Body, select Primary Segment and select Sonde information for the deployment being reviewed into the macro dialog box and click “POPULATE DATAFLOW FIELDS”. This inserts these parameters into each record.

6) Flagging Values with the QA/QC Macro:

Sound data management practices dictate that data should never be deleted. As such, we employ a data management system in which all original data values are retained in the database, but erroneous data are masked with an error code (see Appendix 12 for list of error codes). Each parameter value field also has an error code field associated with it and is designated with the suffix “_A” (e.g., DO_A). Error codes should only be written to the error code fields. Comments should only be written to the COMMENTS field. Because the data file is comma separated, a comma should never be used to separate comments in the COMMENTS field; a semi-colon can be used instead. The following steps outline how the QA/QC Macro can be used to insert error codes and comments.

- a) Go to the “CODE ENTRY” tab of the QA/QC macro to access all of the tools necessary to enter error codes and comments in selected cells (Figure A12_1).
- b) Use the “SELECT CELLS” box to select the cells of the spreadsheet in which you want to enter error codes or comments.
- c) After the cells have been selected, choose a “PREDEFINED CODE” or “CUSTOM CODE” by selecting the appropriate button.

NOTE: Custom codes should only be used for comments. They should never be used for error codes because the database only recognizes predefined error codes.

- d) Select either a “PROBE SPECIFIC”, “GENERAL PROBE”, “NON-PROBE” or “COMMENTS” code by clicking the appropriate radio button, or if applicable, type in a custom comment.
 - e) Select the appropriate code and click the “ENTER CODE” button.
 - f) Repeat Steps b-e as necessary.
- 7) Using the procedures outlined above in Step 7 to flag data, identify any suspicious data by inspecting the values flagged in red and the original data graphed in Ecowatch. Common anomalies include abnormal spikes in chlorophyll and turbidity, abnormal dips in specific conductance, and abnormally high dissolved oxygen readings due to high dissolved oxygen charge. Post-calibration and *in-situ* field checks should also be used to identify when probes are reading incorrectly.

*NOTE: **Do not be too quick to flag data.** Flagging data is necessary to remove obvious outliers from the data set. Strange things can and do occur in Maryland waters, and we do not want to flag an anomaly just because it seems out of place. Anomalies should be identified but must not be flagged unless there is proper justification. If you feel a period of data is questionable, but should not be excluded, keep it unflagged in the data set, but mention it in the comments field.*

- 8) Once all of the error codes and comments have been entered into the data file, close the macro and save the file as a Comma Separated Value (.CSV) file using the same naming convention as above with a “Q” added to the end (e.g., SEV05242004Q.csv).

The resulting .CSV file can then be imported into DNR’s database.

There should be two files when a data set is complete. In our example, these files would be:

SEV05242004R.csv (Raw data - no editing),

SEV05242004Q.csv (Final QA/QC’d file with erroneous data masked)

Appendix 13. Log of Significant Changes

MARYLAND DEPARTMENT OF NATURAL RESOURCES SHALLOW WATER MONITORING (SWM) PROGRAM

Log of Significant Changes

| Date Initiated | Procedural Changes |
|--------------------|---|
| 2003 | Beginning in 2003, YSI6026 turbidity sensors were upgraded to YSI6136 turbidity sensors. This process took two years. Since the beginning of the 2005 sampling season, turbidity data has exclusively been collected with the YSI6136. |
| 2007 | Beginning in 2007, YSI6562 dissolved oxygen sensors were upgraded to YSI6150 ROX optical sensor. This process is ongoing. |
| July 1, 2007 | Beginning in 2007, SWM samples from the Chesapeake Bay Shallow Water Monitoring sites were no longer processed for silicates. |
| September 10, 2007 | Upgraded Deionized Water generator to a reverse osmosis/UV system. |
| January 2009 | Dissolved Organic Carbon (DOC) samples were collected in previous years during continuous monitoring and water quality mapping. Beginning in 2009, DOC will cease being collected on water quality mapping surveys. Continuous monitoring DOC samples are collected only at Maryland Coastal Bay stations. |
| January 2010 | A full suite of nutrient samples will no longer be collected from all continuous monitoring sites and water quality mapping surveys. Samples from six continuous monitoring sites and water quality mapping surveys in the Corsica River will be analyzed for the same full suite of nutrients as those measured for the Chesapeake Bay Mainstem Program (chlorophyll <i>a</i> , pheophytin, total dissolved nitrogen, particulate nitrogen, nitrite, nitrite + nitrate, ammonium, total dissolved phosphorus, particulate phosphorus, orthophosphate, particulate carbon, total suspended solids and volatile suspended solids) plus particulate inorganic phosphorus. Samples from an additional five continuous monitoring sites associated with the NERR System will be analyzed for a sub-set of nutrients (VSS, NH ₄ , PO ₄ , NO ₂ , NO ₃ , TDN, TDP), pheophytin, and chlorophyll <i>a</i> . Samples from the remaining continuous monitoring sites and water quality mapping surveys will be analyzed for TSS, pheophytin, and chlorophyll <i>a</i> only. |
| April 2010 | Beginning in 2010, blank DI samples are sent to CBL to check for contamination of DI water used in filtering samples for nutrient analyses. |
| April 2010 | Between 1998 and 2009, the older model 6562 rapid pulse dissolved oxygen probe was used in some instruments for continuous monitoring and water quality mapping. Beginning in 2010, the 6150 ROX optical dissolved oxygen probe was used exclusively. |
| April 2011 | Starting in 2011, water samples from the continuous monitoring site at Masonville Cove will be analyzed for a sub-set of nutrients (NH ₄ , PN, PP, NO ₃ , NO ₂ , TSS, TN, TP), pheophytin, and chlorophyll <i>a</i> . |
| March 2012 | Starting in 2012, water samples from the continuous monitoring site at Masonville Cove will be analyzed for only TSS, pheophytin, and chlorophyll <i>a</i> . |
| March 2014 | Beginning in 2014, water samples from the continuous monitoring stations in Harris Creek will be analyzed for alkalinity. |
| July 2014 | Beginning in 2014, YSI EXO2 instruments were deployed at select sites. More EXO2 instruments are expected to replace older YSI 6600 instruments over the next several years as the SWM Program transitions to this newer technology. |

| | |
|------------|--|
| April 2017 | Beginning in 2017, select sites equipped with EXO2 model sondes, which possess more advanced anti-fouling technology, will have monitors deployed for up to a month at a time. Also beginning in 2017, a larger vessel, the R/V Kerhin, will be used for water quality mapping cruises in the deeper, mainstem portion of CB4MH. Procedural differences between water quality mapping cruises using a smaller and larger vessel are discussed in QAPP. |
| April 2022 | Beginning in 2022, YSI EXO1 instruments were used at two off-bottom stations deployed in Fishing Bay. EXO1 instruments are equipped with fewer sensor ports, therefore, only a subset of parameters (water temperature, specific conductance, salinity (calculated from specific conductance and temperature), dissolved oxygen, depth) are collected at these two stations. |

Note: Because Shallow Water Monitoring assesses segments on a three-year time scale, stations are necessarily relocated on a regular basis. Rather than include these station location changes in the Log of Significant Changes, all system sampling dates for continuous monitoring and water quality mapping are listed in Tables 12 and 13, respectively.

For changes in detection limits of measured parameters, see Cain and Parham (2023; Appendix 13). The most current versions of NASL methods documents and detection limits are maintained on-line by NASL and may be accessed at the following URL: <https://www.umces.edu/nasl/methods>.

Table 12. Deployment dates for Maryland DNR Continuous Monitoring Sites.

| Tributary | Station Name | Stream Code | Years deployed |
|----------------------|--------------------------------|-------------|--|
| Back River | Lynch Point | XIF4935 | 2014 2015 2016 |
| Back River | Riverside | XIF7918 | 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 |
| Big Annemessex River | Coulbourn Creek | XBJ3220 | 2011 2012 2013 |
| Bohemia River | Long Point | XJI8369 | 2007 2008 2009 |
| Bush River | Church Point | XJG7461 | 2008 2009 2010 |
| Bush River | Lauderick Creek | XJG4337 | 2003 2004 2005 2006 2007 |
| Bush River | Otter Point Creek | XJG7035 | 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 |
| C&D Canal | Back Creek | XKI2087 | 2015 |
| Chesapeake Bay | Annapolis CBIBS (Buoy) | XGF7832 | 2011 2012 |
| Chesapeake Bay | Arundel on the Bay | XGF5025 | 2017 2018 2019 |
| Chesapeake Bay | Bay Bridge (Profiler) | XHF0488 | 2010 |
| Chesapeake Bay | Bay Bridge (Profiler) - Bottom | XHF0488 | 2010 |
| Chesapeake Bay | Profiler | XHG4413 | 2011 |
| Chesapeake Bay | CBOS Baltimore Approach | XGF9082 | 2006 |
| Chesapeake Bay | Camp Tockwogh | XJH1222 | 2015 2016 2017 |
| Chesapeake Bay | Dares Beach | XEE3591 | 2017 |
| Chesapeake Bay | Dares Beach Pier | XEE3691 | 2017 2018 2019 |
| Chesapeake Bay | Down's Park | XHF6841 | 2009 2010 2011 |
| Chesapeake Bay | Fort Howard | XIF1735 | 2009 2010 2011 |
| Chesapeake Bay | Gooses Reef - Bottom (Buoy) | XEF3551 | 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 |
| Chesapeake Bay | Gooses Reef – Surface (Buoy) | XEF3551 | 2010 2011 2012 2013 2014 2015 2016 2017 2018 |
| Chesapeake Bay | Gratitude Marina | XHG8442 | 2009 2010 2011 |
| Chesapeake Bay | Hoopers Island | XCG8862 | 2018 2019 2020 |
| Chesapeake Bay | Love Point | XHG2318 | 2009 2010 2011 |
| Chesapeake Bay | Point Lookout | XBG4203 | 2018 2019 2020 |
| Chesapeake Bay | Pleasure Island | XIF3760 | 2015 2016 2017 |
| Chesapeake Bay | Sandy Pt. - East Beach | XHF0561 | 2004 2005 2006 2007 |
| Chesapeake Bay | Sandy Pt. - South Beach | XHF0460 | 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 |
| Chesapeake Bay | Seashore Beach | XDF0255 | 2018 2019 2020 |
| Chesapeake Bay | Stump Point | XKH2870 | 2007 2008 2009 |
| Chesapeake Bay | Susquehanna Flats | XKH0375 | 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 |
| Chesapeake Bay | Havre de Grace | XKH2949 | 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 |
| Chesapeake Bay | Tolchester | XIG2853 | 2015 2016 2017 |
| Chesapeake Bay | Taylor's Island | XDG6518 | 2017 |
| Chesapeake Bay | Taylor's Island Pier | XDG5922 | 2018 2019 |
| Chesapeake Bay | Tilghman Island | XFF2293 | 2017 2018 2019 |
| Chester River | Deep Landing | CHE0348 | 2003 2004 2005 2006 |

Table 12. Deployment dates for Maryland DNR Continuous Monitoring Sites, continued...

| Tributary | Station Name | Stream Code | Years deployed |
|-----------------------|---------------------------------|--------------------|---|
| Chester River | Kent Narrows Inside | XGG8359 | 2007 2008 2009 |
| Chester River | Kent Narrows Outside | XGG8458 | 2007 2008 2009 |
| Chester River | Rolph's Wharf | XIH0077 | 2003 2004 2005 2006 |
| Chicamacomico River | Drawbridge | CCM0069 | 2000 2001 2002 2003 |
| Choptank River | High Banks | CHO0417 | 2006 2007 2008 |
| Choptank River | Horn Point Lab | XEH5622 | 2006 2007 2008 |
| Choptank River | Jamaica Pt | XEI7405 | 2006 2007 2008 |
| Choptank River | Harris Creek (Profiler) | XFG4618 | 2012 2013 2014 2015 2016 2017 2018 2019 |
| Choptank River | Harris Creek - Downstream | XFG2810 | 2013 2014 2015 2016 2017 2018 2019 |
| Choptank River | Harris Creek - Upstream | XFG6431 | 2013 2014 2015 2016 2017 2018 2019 |
| Choptank River | Mulberry Pt. | XFG5054 | 2006 2007 2008 |
| Choptank River | Williston Lake | XFI9597 | 2011 2012 2013 |
| Choptank River | Williston Lake Pier | MZC0016 | 2014 2015 2016 2017 2018 |
| Corsica River | Emory Creek | XHH5046 | 2005 2006 |
| Corsica River | Possum Point - Bottom | XHH4931 | 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 |
| Corsica River | Possum Point - Surface | XHH4931 | 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 |
| Corsica River | Sycamore Pt. | XHH3851 | 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 |
| Corsica River | The Sill - Bottom | XHH4916 | 2006 2007 2008 2009 2010 2011 |
| Corsica River | The Sill - Surface | XHH4916 | 2006 2007 2008 2009 2010 2011 |
| Eastern Bay | CBEC | XGG6667 | 2005 2006 2007 2008 |
| Eastern Bay | Hambleton Point | XFG9164 | 2004 2005 2006 |
| Eastern Bay | Kent Point | XGF0681 | 2004 2005 2006 |
| Elk River | Hollywood Beach | XKI0256 | 2007 2008 2009 |
| Elk River | Locust Point Marina | XKI3890 | 2007 2008 2009 |
| Fishing Bay | Fishing Bay (Profiler) | XCH7886 | 2023 |
| Fishing Bay | Fishing Bay (Profiler) | XCH8085 | 2022 |
| Fishing Bay | Fishing Bay | XCH8097 | 2003 2004 2005 |
| Fishing Bay | Fishing Bay - Downstream | XCH5196 | 2022 |
| Fishing Bay | Fishing Bay – Marker Downstream | XCH6891 | 2022 2023 |
| Fishing Bay | Fishing Bay – Lower | XCI3607 | 2023 |
| Fishing Bay | Fishing Bay - Upstream | XDH2399 | 2022 2023 |
| Gunpowder River | APG @ Edgewood | XJG2718 | 2003 2004 2005 |
| Gunpowder River | Mariners Point Park | XJF4289 | 2003 2004 2005 |
| Honga River | House Point | XCG9168 | 2008 2009 2010 |
| Honga River | Muddy Hook Cove | XCG5495 | 2008 2009 2010 |
| Little Choptank River | Casson Pt. | XEG2646 | 2005 2006 2007 |
| Little Choptank River | Gary's Creek | XEG4991 | 2005 2006 2007 |
| Magothy River | Cattail Creek | CTT0014 | 2000 2001 |
| Magothy River | Stonington | XHF3719 | 2000 2001 2002 2003 |
| Magothy River | Whitehurst | CTT0001 | 2002 2003 |
| Manokin River | Westover | XBI6387 | 2011 2012 2013 |

Table 12. Deployment dates for Maryland DNR Continuous Monitoring Sites, continued...

| Tributary | Station Name | Stream Code | Years deployed |
|------------------|---------------------------------|--------------------|--|
| Middle River | Cutter Marina | MDR0038 | 2003 2004 2005 |
| Middle River | Strawberry Point | FRG0002 | 2003 2004 2005 |
| Nanticoke River | Sharptown | XEJ2464 | 2012 2013 2014 |
| Nanticoke River | Tyaskin | XCI9167 | 2012 2013 2014 |
| Nanticoke River | Vienna | XDJ8905 | 2012 2013 2014 |
| Northeast River | Carpenters Point | XKH2797 | 2007 2008 2009 |
| Northeast River | Charlestown | XKI5022 | 2007 2008 2009 |
| Patapsco River | Baltimore Harbor (Fort McHenry) | XIE5748 | 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 |
| Patapsco River | Fort Armistead | XIE2581 | 2009 2010 2011 |
| Patapsco River | Aquarium West | XIE7135 | 2016 2017 2018 2019 2020 2021 2022 2023 |
| Patapsco River | Aquarium East - Surface | XIE7136 | 2016 2017 2018 2019 2020 2021 2022 2023 |
| Patapsco River | Aquarium East - Bottom | XIE7136 | 2016 2017 2018 2019 2020 2021 2022 2023 |
| Patapsco River | Fort Smallwood | XHF9808 | 2009 2010 2011 |
| Patapsco River | Masonville Cove | XIE4741 | 2009 2010 2011 2012 |
| Patapsco River | Masonville Cove - Bottom | XIE4741 | 2010 2011 2012 |
| Patapsco River | Masonville Cove Pier | XIE4742 | 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 |
| Patapsco River | Middle Branch | XIE5525 | 2022 2023 |
| Patuxent River | Benedict | XED0694 | 2003 2004 2005 |
| Patuxent River | Chesapeake Biological Lab | XCF9029 | 2003 2004 2005 |
| Patuxent River | Iron Pot Landing | WXT0013 | 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 |
| Patuxent River | Jug Bay | PXT0455 | 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 |
| Patuxent River | King's Landing | PXT0311 | 2003 2004 2005 |
| Patuxent River | Mataponi | MTI0015 | 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 |
| Patuxent River | Pin Oak | XDE4587 | 2003 2004 2005 2006 2007 |
| Pocomoke River | (Beverly / Cedar Hall Warf) | POK0043 | 1999 2000 2001 2002 |
| Pocomoke River | Rehobeth | POK0087 | 2000 2001 2002 |
| Pocomoke River | Pocomoke City | POK0187 | 2012 2013 2014 |
| Pocomoke River | Pocomoke Sound | XAJ5327 | 2012 |
| Pocomoke River | Shelltown | POK0009 | 1999 2000 2001 2002 2012 2013 2014 |
| Pocomoke River | Snow Hill | POK0316 | 2012 2013 2014 |
| Potomac River | Blossom Pt | XDB4544 | 2006 2007 2008 |
| Potomac River | Breton Bay (Pawpaw Point) | XCD5599 | 2006 2007 2008 2009 |
| Potomac River | Fenwick | XFB0231 | 2004 2005 2006 2007 2008 |
| Potomac River | Indian Head | XEB5404 | 2009 2010 2011 2012 2014 |

Table 12. Deployment dates for Maryland DNR Continuous Monitoring Sites, continued...

| Tributary | Station Name | Stream Code | Years deployed |
|--------------------|-------------------------|--------------------|---|
| Potomac River | Mallows Bay Buoy | XDA8236 | 2018 2019 2020 2021 2022 2023 |
| Potomac River | Mattawoman | XEA3687 | 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 |
| Potomac River | Piney Point | XBE8396 | 2004 2005 2006 2007 2008 |
| Potomac River | Piscataway | XFB2184 | 2004 2005 2006 2007 2008 |
| Potomac River | Pope's Creek | XDC3807 | 2006 2007 2008 |
| Potomac River | Port Tobacco | XDB8884 | 2007 2008 |
| Potomac River | Ragged Point (Profiler) | XCE0055 | 2007 2008 |
| Potomac River | Sandy Point (Profiler) | XBE5486 | 2009 |
| Potomac River | Sage Point | XBF6843 | 2004 2005 |
| Potomac River | St George's Creek | XBF7904 | 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 |
| Potomac River | St Mary's College | XCF1440 | 2008 2009 |
| Potomac River | Swan Pt. | XCC8346 | 2006 2007 2008 |
| Potomac River | Wicomico Beach | XCC9680 | 2006 2007 2008 |
| Rhode River | SERC | XGE3275 | 2004 2005 2006 2007 2009 2010 2011 |
| Sassafras River | Budd's Landing | XJI2396 | 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 |
| Sassafras River | Betterton | XJH2362 | 2006 2007 2008 2009 2010 2011 |
| Sassafras River | Georgetown Yacht Basin | XJI1871 | 2006 2007 |
| Severn River | Ben Oaks | SEV0116 | 2002 2003 |
| Severn River | Sherwood Forest | XHE1973 | 2002 2003 |
| South River | Beard's Creek | XGE7059 | 2004 2005 2006 |
| South River | Cedar Point | XGE5984 | 2005 |
| South River | Harness Cr. Downstream | ZDM0001 | 2004 2006 2007 2008 2011 2012 |
| South River | Harness Cr. Upstream | ZDM0002 | 2004 2006 2007 2008 |
| Tangier Sound | Daugherty Creek | XAI8482 | 2021 2022 2023 |
| Tangier Sound | Karen Noonan Center | XCH3277 | 2021 2022 2023 |
| Tangier Sound | Deal Island | XCI0132 | 2021 2022 2023 |
| Transquaking River | Bestpitch | TRQ0088 | 2003 2004 2005 |
| Transquaking River | Decoursey Bridge | TRQ0146 | 2000 2001 |
| Tred Avon River | Tred Avon | XFG0995 | 2009 |
| West River | Shady Side | XGE0284 | 2004 2005 2006 |
| West River | Chesapeake Yacht Club | XGE0320 | 2011 2012 2013 |
| Wicomico River | Little Monie Creek | LMN0028 | 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 |
| Wicomico River | Upper Ferry | WIW0144 | 2006 2007 2008 |
| Wicomico River | Whitehaven | XCJ6023 | 2006 2007 2008 |

Table 13. Maryland DNR Water Quality Mapping Systems - Years Sampled

| River System | Years Sampled |
|-------------------------|---|
| Back River | 2014 2015 2016 |
| Big Annemessex River | 2011 2012 2013 |
| Bohemia River | 2007 2008 2009 |
| Bush River | 2003 2004 2005 |
| C&D Canal | 2015 |
| Corsica River | 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 |
| Chesapeake Bay/CB2OH | 2015 2016 2017 |
| Chesapeake Bay/CB3MH | 2009 2010 2011 |
| Chesapeake Bay/CB4MH | 2017 2018 2019 |
| Chesapeake Bay/CB5MH | 2018 2019 2020 |
| Chester River | 2003 2004 2005 2006 |
| Choptank River | 2006 2007 2008 |
| Eastern Bay | 2004 2005 2006 |
| Elk River | 2007 2008 2009 |
| Fishing Bay | 2003 2004 2005 |
| Gunpowder River | 2003 2004 2005 |
| Honga River | 2008 2009 2010 |
| Little Choptank River | 2005 2006 2007 |
| Magothy River | 2001 2002 2003 |
| Manokin River | 2011 2012 2013 |
| Middle River | 2003 2004 2005 |
| Nanticoke River | 2012 2013 2014 |
| Northeast River | 2007 2008 2009 |
| Patapsco River | 2009 2010 2011 |
| Patuxent River | 2003 2004 2005 2006 |
| Pocomoke River | 2012 2013 2014 |
| Potomac River | 2006 2007 2008 |
| St Mary's River | 2004 2005 2006 2007 2008 |
| Sassafras River | 2007 2008 2009 |
| Severn River | 2001 2002 2003 |
| South River | 2004 2005 2006 |
| Susquehanna River/CB1TF | 2007 2008 2009 |
| Tangier Sound | 2021 2022 2023 |
| West/Rhode Rivers | 2004 2005 2006 |
| Wicomico River | 2006 2007 2008 |