



Robert L. Ehrlich, Jr., *Governor*

Michael S. Steele, *Lt. Governor*

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# Quality Assurance Project Plan

for the

**Maryland Department of Natural Resources**

**Chesapeake Bay**

**Shallow Water Quality Monitoring Program**

**for the period July 1, 2006 - June 30, 2007**

1 July 2006

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

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Robert L. Ehrlich, Jr., Governor

Michael S. Steele, Lt. Governor



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Maryland Department of Natural Resources  
Chesapeake Bay  
Shallow Water Quality Monitoring Program  
for the period July 1, 2006 - June 30, 2007**

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## ACRONYMS AND ABBREVIATIONS

AA	- Autoanalyzer
AMQAW	- Analytical Methods and Quality Assurance Workgroup (a workgroup of the Chesapeake Bay Program's Monitoring Subcommittee)
C	- Carbon
CBP	- EPA's Chesapeake Bay Program
CBPO	- EPA's Chesapeake Bay Program Office
CBL	- University of Maryland's Chesapeake Biological Laboratory
cm	- Centimeter
CMC	- Chlorophyll Measurement Computer
CSSP	- Coordinated Split Sample Program
d	- Day
DHMH	- Maryland Department of Health and Mental Hygiene
DI	- De-Ionized
DNR	- Maryland Department of Natural Resources
DO	- Dissolved Oxygen
DOC	- Dissolved Organic Carbon
EPA	- U.S. Environmental Protection Agency
g	- Gram
h	- Hour
L	- Liter
m	- Meter
MDE	- Maryland Department of the Environment
min.	- Minute
mg	- Milligram
ml or mL	- Milliliter
mm	- Millimeter
N	- Nitrogen
NIST	- National Institute of Science and Technology
nm	- Nanometer
no.	- Number
NO <sub>2</sub>	- Nitrite
NO <sub>23</sub>	- Nitrate + Nitrite
NO <sub>3</sub>	- Nitrate
OD	- Optical Density
P	- Phosphorus
PAR	- Photosynthetic Active Radiation
PC	- Particulate Carbon (Organic)
PC	- Personal Computer
PIP	- Particulate Inorganic Phosphorus
PN	- Particulate Nitrogen
PO <sub>4</sub>	- 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

QC	- Quality Control
R/V	- Research Vessel
SAS	- Statistical Analysis System
SAV	- Submerged Aquatic Vegetation
Si	- Silicon
SMCRP	- St. Mary's College River Project
TDN	- Total Dissolved Nitrogen
TDP	- Total Dissolved Phosphorus
TMDL	- Total Maximum Daily Load
trib	- Bay Tributary
TSS	- Total Suspended Solids
USDI	- U.S. Department of the Interior
USGS	- U.S. Geological Survey
°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 Maryland Department of Natural Resources, the U.S. Environmental Protection Agency, the National Oceanographic Atmospheric Administration, and local governments.



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This Quality Assurance Project Plan is also available on-line on the Maryland Department of Natural Resources (DNR) Eyes on the Bay web site: <http://www.eyesonthebay.net> and the DNR Bay Monitoring web site: <http://www.dnr.state.md.us/bay/monitoring/index.html>

## 1. INTRODUCTION AND PROJECT DESCRIPTION

### 1.1 Background

The Chesapeake Bay Program Monitoring and Analysis Subcommittee's Tidal Monitoring and Analysis Workgroup (TMAW) has undertaken the role of redesigning the Tidal Monitoring Network. The new Tidal Monitoring Network focuses on meeting the Water Quality Protection and Restoration goals and objectives of the new Chesapeake 2000 Agreement. Water quality monitoring information will be used to define the 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), and 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 available to support refinement, calibration and validation of the Chesapeake Bay Water Quality Model.

As part of the new Tidal Monitoring Network, 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 required by the development of the new water quality criteria. Currently, sparse water quality data is collected in shallow portions of Chesapeake Bay and its tributaries. This presents a major data gap in light of the new Designated Use Areas and Water Quality Criteria.

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. Water quality mapping has been piloted by the states of Maryland and Virginia and 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 will be 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 - 2006 results can be found on DNR's Eyes on the Bay web site at <http://www.eyesonthebay.net>.

Maryland DNR has initiated shallow water monitoring in 17 Chesapeake Bay segments in 2006 (Figure 1, Table 1). This design comprises monthly water quality mapping cruises with approximately 2 continuous monitoring sites in each segment. Monitoring will be conducted April through October 2006. Monitoring will resume in April 2007 and continue through October 2007.

Approximately two continuous monitoring sites will be deployed between April - October 2006 in each of 17 Maryland Chesapeake Bay segments (Figure 1, Table 3). Sites will be located in shallow water habitats to provide spatial diversity within the segment. The continuous monitoring sites will be used as calibration sites for the water quality mapping cruises. Each continuous monitoring site will be serviced on a bi-weekly basis unless water quality readings demonstrate that weekly intervals should be maintained. Results from 2003 - 2005 indicate that the YSI 6600 EDS (Extended Deployment Systems) can be deployed for 2-week periods throughout at least a portion of the annual sampling period, without compromising data integrity. During each site visit, instruments in the water will be checked against the replacement instrument, as well as another Hydrolab or YSI instrument to provide a third comparison. Also during each site visit, a discrete water sample will be collected for chlorophyll, turbidity and TSS calibration. A full suite of nutrients, including total volatile solids (TVS) and particulate inorganic phosphorus (PIP) will also be collected using the same protocols and naming conventions as outlined in

the Chesapeake Bay Mainstem 117(e) grant and approved QAPP. The replacement instrument will then be left at the site for approximately two weeks (see above). The instrument that was at the site for the previous weeks will be delivered to the field office for post-calibration, cleaning and servicing. Detailed instrument calibration procedures are included in the QAPP. 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 the QAPP.

Water quality mapping (DataFlow) is a shipboard system 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 six water quality parameters measured are water temperature, salinity, dissolved oxygen, pH, turbidity (NTU), and fluorescence (used to estimate chlorophyll *a*). 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. The water is pumped through a ram (pipe), through the sensors, and then discharged overboard. Water quality mapping includes a Garmin model GPSMAP168 sounder chartplotting receiver and depth-finder global positioning system (GPS), a YSI 6600 Sonde with a flow-through chamber. Each water quality measurement is associated with a date, time, water depth, and GPS coordinate (NAD83) reported to six decimal places.

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 is 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 South River in less than one day.

Water quality mapping uses the same YSI 6600 instrument package as the continuous monitoring program. Detailed instrument calibration procedures for the instrument are included in the QAPP. Each tributary system will be monitored once a month (Figure 1, Table 2), April through October. During each water quality mapping cruise, six calibration samples will be collected to develop a regression for chlorophyll, turbidity, total suspended solids, and light attenuation (Table 4). Detailed instrument calibration procedures are included in the QAPP. 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 the QAPP.

**Table 1.** Shallow-water monitoring for 2006: Bay segment, sample type(s) and Designated Uses 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 a	Kd	D.O.	Chl a	Kd	D.O.	Chl a	Kd	D.O.	Chl a	Kd	D.O.
Sassafras R.	SASOH	Cont. Monit,	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
Bush R.	BSHOH	Cont. Monit,	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
Patapsco R	PATMH	Cont. Monit.	YES	YES	YES	YES	NA	YES	*	*	*	*	*	*
Chesapeake Bay	CB3MH	2 Cont. Monit at Sandy Point State Park	NO	NO	NO	NO	NA	NO	*	*	*	NA	NA	NO
South R.	SOUMH	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	*	*	*	*	*	*
Rhode R.	RHDMH	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	*	*	*	*	*	*
West R.	WSTMH	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	*	*	*	*	*	*
Patuxent R.	PAXMH	Water Quality Mapping (partial segment)	YES	YES	YES	YES	NA	YES	*	*	*	NA	NA	NO
	PAXTF	Cont. Monit	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
	WBRTF	Cont. Monit	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
Potomac R.	POTMH	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	*	*	*	NA	NA	NO
	POTOH	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
	POTTF	Cont. Monit Water Quality Mapping	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
	MATTF	Cont. Monit Water Quality Mapping	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
	PISTF	Cont. Monit Water Quality Mapping	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
Wicomico	WICMH	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	*	*	*	*	*	*
Little Choptank	LCHMH	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	*	*	*	*	*	*
Choptank R.	CHOMH2	Cont. Monit., Water Quality Mapping	YES	YES	YES	YES	NA	YES	*	*	*	NA	NA	NO
	CHOMH1	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
	CHOOH	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
Eastern Bay	EASMH	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	*	*	*	*	*	*
Chester R.	CHSOH	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
	CHSTF	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*
Corsica R.	Not applicable	Cont. Monit, Water Quality Mapping	YES	YES	YES	YES	NA	YES	YES	YES	YES	*	*	*

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

**Table 2.** Water Quality Mapping Cruise Schedule (April through October 2006).

<b>River system</b>	<b>April</b>	<b>May</b>	<b>June</b>	<b>July</b>	<b>Aug</b>	<b>Sept</b>	<b>Oct</b>
<b>Chester River:</b> 3 segments- tidal fresh, oligohaline, and mesohaline	24	24	26	25	22	26	12
<b>Choptank River:</b> 4 segments – tidal fresh, oligohaline, mesohaline <sup>2</sup> , mesohaline <sup>1</sup>	5-6	1-2	6-7	5-6	2-3	6-7	4-5
<b>Corsica River:</b>	3	4	5	3	3	5	5
<b>Eastern Bay, Miles River, and Wye River:</b>	25	25	27	26	23	27	30
<b>Little Choptank:</b>	4	1	7	3	1	6	3
<b>Patuxent River:</b> mesohaline (partial)	28	19	7	5	16	5	TBD
<b>Potomac River:</b> 3 segments – tidal fresh, oligohaline and mesohaline	10,11,14	15,16,19	12,13,16	17,18,21	7,8,11	11,12,15	23,24,27
<b>Rhode River:</b>	26	23	28	27	28	28	11
<b>South River:</b>	26	22	28	27	29	28	10
<b>West River:</b>	26	23	28	27	28	28	11
<b>Wicomico River:</b>	5	4	8	5	1	6	3

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 resource 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.

The dates defined within this scope of work are for implementation of the shallow water monitoring for calendar year 2006 and reflect the work to be funded and completed within the budget period of July 1, 2006 - June 30, 2007.

## **1.2 Objectives and Problem Definition**

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, 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 water quality models.

These objectives lead to 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. This information 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 and total chlorophyll (to estimate chlorophyll *a*), pH and depth (see Appendices 10 and 11). *In situ* turbidity and chlorophyll fluorescence measurements are surrogates for  $K_d$  and chlorophyll *a*; therefore, discrete measurements of PAR and chlorophyll *a* are needed to establish regression models that relate *in situ* turbidity and chlorophyll fluorescence to  $K_d$  and chlorophyll *a*. Grab samples that are filtered on site are also collected at water quality mapping calibration stations and at continuous monitoring stations. Processed grab samples will be taken and sent to the Chesapeake Biological Laboratory's Nutrient Analytical Services Laboratory to be analyzed for the same suite of nutrients as those measured for the Chesapeake Bay Mainstem Program (chlorophyll *a*, total dissolved nitrogen, particulate nitrogen, nitrite, nitrite + nitrate, ammonium, total dissolved phosphorus, particulate phosphorus, orthophosphate, dissolved organic carbon, particulate carbon, silicic acid, total suspended solids and volatile suspended solids) plus particulate inorganic phosphorus, and to the Maryland Department of Health and Mental Hygiene's Environmental Chemistry Laboratory for chlorophyll *a*, pheophytin and turbidity. In addition, Secchi depth and photosynthetic active radiation

(PAR) measurements are 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 all 50 Chesapeake Bay Program segments. Segments will be assessed for a three-year period. Available resources will dictate the number of segments assessed in each three-year period. 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)

The continuous monitoring instruments will be deployed at predetermined sites in Maryland's tidal tributaries. The two continuous monitoring sampling sites are each 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 2006 season are depicted on the map in Figure 1.

Fourteen Chesapeake Bay tributaries have been identified for shallow water monitoring in Maryland in 2006, ranging from small systems to large systems with spatial coverage throughout Maryland:

- Bush River (Fourth year of assessments for this small system on the Upper Western Shore)
  - Stations located at Otter Point Creek (NERRS Site) and Lauderick Creek (Harford County), no Water Quality Mapping in year four.
- Chester River (Fourth year of assessments for this mid-sized system on the Upper Eastern Shore)
  - Stations located at Rolph's Wharf and Deep Landing, reduced Water Quality Mapping
- Choptank River (First year of assessments for this mid-sized system on the Eastern Shore)
  - Stations located at Mulberry Point, Horn Point Laboratory, Jamaica Point and High Banks
- Corsica River (Second year of assessments for this small-sized system on the Upper Eastern Shore)
  - Stations located at Cedar Point and Sycamore Point and proposed stations to be located off-shore on pilings at Possum Point and the Sill.
- Eastern Bay (Including Miles and Wye Rivers) (Third year of assessments for this large system on the Upper Eastern Shore)
  - Stations located at Kent Point, Hambleton Point and CBEC
- Little Choptank (Second year of assessments for this small system on the Lower Eastern Shore)
  - Stations located at Casson Point and Gary's Creek
- Patapsco River (Seventh year of assessments for this large system on the Upper Western Shore)
  - Station located at Fort McHenry in Baltimore Harbor, no Water Quality Mapping
- Patuxent River (Fourth year of assessments for this large system in the Patuxent River Basin)



- Stations located at Pin Oak, Mataponi Creek (NERRS Site), Jug Bay (NERRS Site) and Iron Pot Landing (NERRS Site), reduced Water Quality Mapping in Lower Pax to support SAV restoration projects.
- Potomac River (Third year of assessments in the Potomac River Basin, but first year for system-wide monitoring)
  - Stations located at Piney Point, St Georges Creek (St. Mary's), Swan Point, Wicomico Beach (Wicomico River), Pope's Creek, Blossom Point, Mattawoman Creek, Fenwick Shores, Piscataway Creek, Occoquan Creek, and Neabsco Creek with an additional proposed station to be located in Breton Bay.
- Rhode River (Third year of assessments for this small system on the Upper Western Shore)
  - Station located at Smithsonian Environmental Research Center
- Sassafras River (First year of assessments for this small system on the Upper Eastern Shore)
  - Stations located at Betterton Beach and Georgetown Yacht Basin
- South River (Third year of assessments for this small system on the Upper Western Shore)
  - Stations located at Harness Creek (2) and Beards Creek
- West River (Third year of assessments for this small system on the Upper Western Shore)
  - Station located at Shady Side
- Wicomico River/Monie Bay (First year of assessments for this mid-sized system on the Lower Eastern Shore)
  - Stations located at Whitehaven and Upper Ferry, and a proposed station to be located at Monie Creek.

Detailed latitude and longitude continuous monitoring and water quality mapping calibration site location for 2006 is 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.** 2006 Continuous monitoring stations.

Tributary	Segment	Station Name	Station	Years deployed	Lat (NAD 83)	Long (NAD 83)	
Sassafras R.	SASOH	Betterton Beach	XJH2362	2006	39° 22.302' N	76° 03.751' W	
		Georgetown Yacht Basin	XJI1871	2006	39° 21.793' N	75° 52.940' W	
Bush R.	BSHOH	Lauderick Creek	XJG4337	2003 - Present	39° 24.233' N	76° 16.365' W	
		Otter Point Creek	XJG7035	2003 - Present	39° 27.047' N	76° 16.474' W	
Patapsco R.	PATMH	Fort McHenry	XIE5748	2006	39° 15.678' N	76° 35.178' W	
Chesapeake Bay	CB3MH	Sandy Pt. - East Beach	XHF0561	2004 - Present	39° 00.504' N	76° 23.963' W	
		Sandy Pt. - South Beach	XHF0460	2004 - Present	39° 00.450' N	76° 24.020' W	
South R.	SOUMH	Beards Creek	XGE7059	2004 - Present	38° 56.968' N	76° 34.124' W	
		Harness Creek (Inside)	XDM0002	2004, 2006	38° 56.159' N	76° 30.463' W	
		Harness Creek (Outside)	XDM001	2004, 2006	38° 56.189' N	76° 30.443' W	
Rhode R.	RHDMH	SERC	XGE3275	2004 - Present	38° 53.157' N	76° 32.489' W	
West R.	WSTMH	Shady Side	XGE0284	2004 - Present	38° 50.203' N	76° 31.676' W	
Patuxent R.	WBRTF	Iron Pot Landing	WXT0013	2003 - Present	38° 47.760' N	76° 43.248' W	
	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	
	PAXMH	Pin Oak	XDE4587	2003 - Present	38° 24.528' N	76° 31.308' W	
Potomac R.	POTMH	Piney Point	XBE8396	2004 - Present	38° 08.265' N	76° 30.349' W	
		St. George's Creek	XBF7904	2006	38° 07.866' N	76° 29.604' W	
		Popes Creek	XDC3807	2006	38° 23.757' N	76° 59.346' W	
		Swan Pt.	XCC8346	2006	38° 18.321' N	76° 55.432' W	
		Wicomico Beach (Wicomico R)	XCC9680	2006	38° 19.652' N	76° 51.958' W	
	POTOH	Blossom Pt	XDB4544	2006	38° 24.506' N	77° 06.615' W	
	POTTF	Fenwick	XFB0231	2004 - Present	38° 40.196' N	77° 06.908' W	
		Neabsco Creek	XEA6046	2006	38° 40.196' N	77° 06.908' W	
		Occoquan	XEA9461	2006	38° 39.352' N	77° 13.928' W	
	PISTF	Piscataway	XEA3687	2004 - Present	38° 33.555' N	77° 11.322' W	
	MATTF	Matawoman	XFB2184	2004 - Present	38° 42.094' N	77° 01.556' W	
	Wicomico R	WICMH	Upper Ferry	WIW0144	2006	38° 20.533' N	75° 41.353' W
			Whitehaven Ferry	XCJ6023	2006	38° 16.028' N	75° 47.707' W
Monie Bay			TBD	2006	TBD	TBD	
Little Choptank	LCHMH	Casson Point	XEG2646	2005 - Present	38° 32.562' N	76° 15.353' W	
		Gary's Creek	XEG4991	2005 - Present	38° 34.930' N	76° 10.927' W	
Choptank R.	CHOMH2	Horn Point Laboratory	XEH5622	2006	38° 35.610' N	76° 07.725' W	
		Jamaica Pt	XEI7405	2006	38° 37.354' N	75° 59.469' W	
	CHOMH1	Mulberry Pt.	XFG5054	2006	38° 44.961' N	76° 14.638' W	
	CHOOH	High Banks	CHO0417	2006	38° 47.865' N	75° 55.893' W	
Eastern Bay	EASMH	Hambleton Point	XFG9164	2004 - Present	38° 49.165' N	76° 13.552' W	
		Kent Point	XGF0681	2006	38° 530.64' N	76° 21.918' W	
		CBEC	XGG6667	2006	38° 56.568' N	76° 13.296' W	
Chester R.	CHSOH	Rolph's Wharf	XIH0077	2003 - Present	39° 09.998' N	76° 02.319' W	
	CHSTF	Deep Landing	CHE0348	2003 - Present	39° 14.415' N	76° 57.513' W	

**Table 4.** 2006 Water quality mapping calibration stations.

<b>Station Name</b>	<b>Water Body</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Continuous Monitoring Station</b>
CHE0348	Chester River	39.2401	-75.9588	YES
ET4.1	Chester River	39.2437	-75.9249	
ET4.2	Chester River	38.9923	-76.2151	
GYI0001	Chester River	39.0900	-76.2003	
XGG9992	Chester River	38.9995	-76.1791	
XHG0859	Chester River	39.0139	-76.2349	
XHG1579	Chester River	39.0257	-76.2017	
XHG6496	Chester River	39.1063	-76.1730	
XHH6419	Chester River	39.1076	-76.1345	
XIH0077	Chester River	39.1667	-76.0387	YES
XIH3581	Chester River	39.2252	-76.0314	
CHO0367	Choptank River	38.0909	-75.1634	
CHO0417	Choptank River	38.1311	-75.0982	YES
CHO0490	Choptank River	38.0173	-75.0164	
EE2.1	Choptank River	38.1549	-76.0977	
ET5.2	Choptank River	38.0807	-76.0587	
TUK0022	Choptank River	38.1646	-75.0809	
XEG5627	Choptank River	38.0933	-76.1217	
XEG6966	Choptank River	38.1159	-76.0568	
XEG7539	Choptank River	38.1245	-76.1022	
XEG8519	Choptank River	38.1414	-76.1356	
XEG8593	Choptank River	38.1428	-76.0113	
XEH5622	Choptank River	38.0935	-76.1288	YES
XEH7912	Choptank River	38.1313	-76.1469	
XEH8132	Choptank River	38.1415	-76.1111	
XEI7405	Choptank River	38.1226	-75.1578	YES
XFG0809	Choptank River	38.0130	-76.1506	
XFG0965	Choptank River	38.0155	-76.0585	
XFG3973	Choptank River	38.0656	-76.0459	
XFG4620	Choptank River	38.0766	-76.1332	
XFG5054	Choptank River	38.0827	-76.0773	YES
XFH2312	Choptank River	38.0385	-76.1468	
XFI1515	Choptank River	38.0248	-75.1408	
COR0056	Corsica River	39.0558	-76.0718	
XHH3851	Corsica River	39.0628	-76.0816	YES
XHH4528	Corsica River	39.0749	-76.1198	
XHH4916	Corsica River	39.0818	-76.1392	YES
XHH4931	Corsica River	39.0812	-76.1149	YES
EE1.1	Eastern Bay	38.8800	-76.2515	

**Table 4 (Continued)**

<b>Station Name</b>	<b>Water Body</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Continuous Monitoring Station</b>
XFG9210	Eastern Bay	38.8200	-76.3160	
XGF0681	Eastern Bay	38.8440	-76.3653	YES
XGG4301	Eastern Bay	38.9057	-76.3306	
XGG5115	Eastern Bay	38.9191	-76.3073	
XGG5932	Eastern Bay	38.9326	-76.2794	
EE 2.2	Little Choptank	38.5261	-76.3041	
XEG0138	Little Choptank	38.5023	-76.1041	
XEG1995	Little Choptank	38.5285	-76.1747	
XEG2646	Little Choptank	38.5427	-76.2559	YES
XEG3623	Little Choptank	38.5601	-76.2940	
XEG4991	Little Choptank	38.5822	-76.1821	YES
LE1.3	Patuxent River	38.3398	-76.4849	
XCF9029	Patuxent River	38.3167	-76.4526	
XDE4587	Patuxent River	38.4088	-76.5218	YES
AQU0037	Potomac River	38.4201	-77.3532	
LE2.2	Potomac River	38.1576	-76.5980	
LE2.3	Potomac River	38.0215	-76.3477	
RET2.1	Potomac River	38.4035	-77.2691	
RET2.2	Potomac River	38.3525	-77.2051	
RET2.4	Potomac River	38.3626	-76.9906	
TF2.3	Potomac River	38.6082	-77.1739	
TF2.4	Potomac River	38.5301	-77.2654	
XEA6046	Potomac River	38.6000	-77.2570	
XBD9558	Potomac River	38.1588	-76.7368	
XBE2100	Potomac River	38.0348	-76.5012	
XBE6753	Potomac River	38.1106	-76.5785	
XBE8396	Potomac River	38.1378	-76.5058	YES
XBE9300	Potomac River	38.1543	-76.6659	
XBF0320	Potomac River	38.0057	-76.4679	
XBF3534	Potomac River	38.0595	-76.4440	
XBF5231	Potomac River	38.0867	-76.4483	
XBF6903	Potomac River	37.9483	-76.3283	
XBG2601	Potomac River	38.0443	-76.3334	
XCC4530	Potomac River	38.2415	-76.9503	
XCC8346	Potomac River	38.3054	-76.9239	YES
XCC9680	Potomac River	38.3255	-76.8660	
XCD0517	Potomac River	38.1744	-76.8056	
XCD3596	Potomac River	38.2246	-76.6732	
XCD3765	Potomac River	38.2272	-76.7247	

**Table 4 (Continued)**

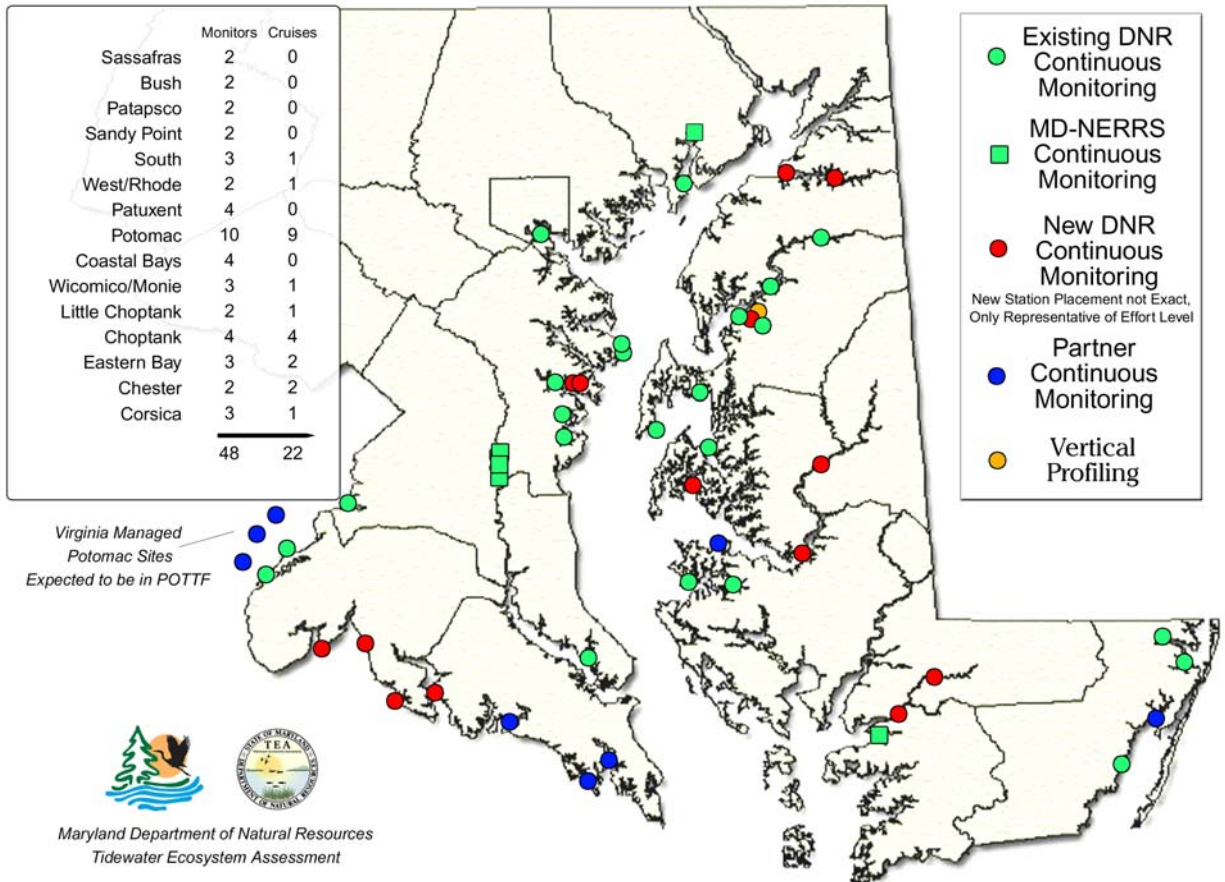
<b>Station Name</b>	<b>Water Body</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Continuous Monitoring Station</b>
XCD5599	Potomac River	38.2572	-76.6682	
XCD6674	Potomac River	38.2760	-76.7095	
XCD7202	Potomac River	38.2859	-76.8300	
XCE1407	Potomac River	38.1894	-76.6556	
XCE2643	Potomac River	38.2092	-76.5960	
XDA0338	Potomac River	38.3383	-77.2700	
XDA6515	Potomac River	38.4417	-77.3083	
XDB4544	Potomac River	38.4084	-77.1103	YES
XDB4877	Potomac River	38.4142	-77.0391	
XDB8278	Potomac River	38.4697	-77.0371	
XDC3807	Potomac River	38.3960	-76.9891	YES
XEA6046	Potomac River	38.6000	-77.2570	YES
XEA9461	Potomac River	38.6559	-77.2321	
XEA3687	Potomac River	38.5593	-77.1887	YES
XFB0231	Potomac River	38.6699	-77.1151	YES
XFB2184	Potomac River	38.7016	-77.0259	YES
XFB8683	Potomac River	38.8103	-77.0284	
WT8.2	Rhode/West River	38.0536	-76.0349	
WT8.3	Rhode/West River	38.0091	-76.0341	
XGE0284	Rhode/West River	38.0034	-76.0279	
XGE2488	Rhode/West River	38.0404	-76.0209	
XGE3275	Rhode/West River	38.0526	-76.0415	YES
XGF1780	Rhode/West River	38.0273	-76.0330	
WT8.1	South River	38.1163	-76.0461	
XGE5492	South River	38.0901	-76.0132	
XGE6281	South River	38.1036	-76.0314	
XGE7059	South River	38.1161	-76.0687	YES
XGF5404	South River	38.0905	-76.1595	
ZDM0001	South River	38.1027	-7.5077	YES
XBF7904	St. Mary's River	38.1311	-76.4934	
SGC0041	St. Mary's River	38.1660	-76.5210	YES
XBF9130	St. Mary's River	38.1510	-76.4495	
XBF9949	St. Mary's River	38.1657	-76.4177	YES
XCF1336	St. Mary's River	38.1887	-76.4398	
TBD	Wicomico River	TBD	TBD	YES
WIW0089	Wicomico River	38.1300	-75.0919	
WIW0144	Wicomico River	38.0089	-75.0226	YES
WIW0198	Wicomico River	38.0186	-75.1198	
XCI3696	Wicomico River	38.0594	-75.0061	
XCJ5200	Wicomico River	38.0868	-75.1657	

**Table 4 (Continued)**

<b>Station Name</b>	<b>Water Body</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Continuous Monitoring Station</b>
XCJ6023	Wicomico River	38.1005	-75.1285	YES
XFG9164	Wye and Miles Rivers	38.8194	-76.2259	YES
XFH7523	Wye and Miles Rivers	38.7926	-76.1282	
XGG2084	Wye and Miles Rivers	38.8670	-76.1929	
XGG3479	Wye and Miles Rivers	38.8909	-76.2007	
XGG4898	Wye and Miles Rivers	38.9135	-76.1689	
XGG5959	Wye and Miles Rivers	38.9312	-76.2340	
XGG6667	Wye and Miles Rivers	38.9428	-76.2216	YES

Maryland DNR staff will be responsible for maintaining all continuous monitoring sites except for the Piney Point and St. George's monitors which will be operated by St. Mary's College River Project (SMCRP) using the same protocols and equipment as outlined in this QAPP. Maryland DNR will also perform joint maintenance of the HPL site on the Choptank with staff from the University of Maryland Horn Point Laboratory. Maryland DNR will conduct all water quality mapping cruises except for portions of the Potomac River which will be conducted in cooperation with Chesapeake Biological Lab (CBL) and SMCRP. CBL will conduct water quality mapping cruises in the lower and upper Potomac River. SMCRP will conduct water quality mapping cruises on St. Mary's and Wicomico (Potomac) Rivers, St. Indigoe's Creek, Breton Bay, and small adjoining areas of the mainstem Potomac.

# Maryland DNR - 2006 Proposed Tidal Monitoring Sites



**Figure 1.** Map of 2006 continuous monitoring stations, water quality mapping systems, vertical profiling station and Maryland long-term tidal water quality monitoring stations.

## 2. METHODS AND PERFORMANCE MEASURES

The Chesapeake Bay Shallow Water Quality Monitoring Program measures several 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 the salinity regime.

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

**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.	See Table 10
Bias	Post-deployment calibration Fluorescence color blank	See Table 10
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 $\pm 3$ std. dev. of mean $\pm 3$ pseudo- $\sigma$ 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



Tables 7 and 8 list parameters measured *in situ* along with the 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 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
Dissolved Oxygen (mg/L)	0.01 mg/L	0 to 50 mg/L	0 to 20 mg/L; 2% of reading or 0.2 mg/L, whichever is greater; 20 to 50 mg/L; 6% of reading	YSI 6600 6562 probe
Dissolved Oxygen (% saturation)	0 to 500 %	0 to 500 %	0 to 200%; 2% of reading or 2% air saturation, whichever is greater; 200 to 500%; 6% of reading	YSI 6600 6562 probe
Fluorescence	0.1%FS	0 to 400 µg/L Chl; 0 to 100% FS	NA	YSI 6600 6025 probe
Total Chlorophyll	0.1 µg/L Chl	EM 470 nm; EX 650 - 700 nm; 0 - 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-190SA
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	5% of reading or 2 NTU, whichever is greater	YSI 6600 6136 probe*
Water Temperature (°C)	0.01°C	-5 to 45 °C	0.15 °C	YSI 6600 6560 probe
Depth	0.001 m	0 - 9 m	0.02 m	

\* Between 1998 and 2003 the older model 6026 turbidity probe was in use in some instruments. Beginning in 2005, the 6136 turbidity probe was used exclusively.

**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 (mg/L)	0.01 mg/L	0 to 50 mg/L	0 to 20 mg/L; 2% of reading or 0.2 mg/L, whichever is greater; 20 to 50 mg/L; 6% of reading	YSI 6600 6562 probe
Dissolved Oxygen (% saturation)	0 to 500 %	0 to 500 %	0 to 200%; 2% of reading or 2% air saturation, whichever is greater; 200 to 500%; 6% of reading	YSI 6600 6562 probe
Fluorescence	0.1%FS	0 to 400 µg/L Chl; 0 to 100% FS	NA	YSI 6600 6025 probe
Total Chlorophyll	0.1 µg/L Chl	EM 470 nm; EX 650 - 700 nm; 0 - 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-190SA
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	5% of reading or 2 NTU, whichever is greater	YSI 6600 6136 probe*
Water Temperature (°C)	0.01°C	-5 to 45 °C	0.15 °C	YSI 6600 6560 probe
Depth	0.001 m	0 - 9 m	0.02 m	
Position	15 m	NA	5 m	Handheld Garmin e-Trex Global Positioning Unit

\* Between 1998 and 2003 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:

Rohland, F.M., W.R. Boynton, R.M. Stankelis, B.W. Bean, H.J. Pine. 2002. *Maryland Chesapeake Bay Water Quality Monitoring Program, Ecosystem Processes Component (EPC), Quality Assurance Project Plan for Water Quality Monitoring in Chesapeake Bay for FY 2003, July 2002-June 2003, Revision 7.* Prepared for the Maryland Department of Natural Resources, September 30, 2002. University of Maryland Center for Environmental Sciences, Chesapeake Biological Laboratory, P.O. Box 38, Solomons, MD. Technical Report Series No. TS-343-01-CBL. Ref. No. [UMCES]CBL 01-0306b.

YSI Incorporated. January 2002. YSI 6-Series Manual. Available online at:  
[http://www.yei.com/extranet/EPGKL.nsf/8cb9f9b96c40c0f685256b1a006610d1/5fc62de987236efb85256c8d00765458/\\$FILE/069300B.pdf](http://www.yei.com/extranet/EPGKL.nsf/8cb9f9b96c40c0f685256b1a006610d1/5fc62de987236efb85256c8d00765458/$FILE/069300B.pdf)

**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)	0.0006 mg/L	EPA method 365.1 (EPA 1979)	Freezing-28 d
Total Diss. Phosphorus (mg/L as P)	0.0015 mg/L	Valderrama (1981)	Freezing-28 d
Particulate Phosphorus (mg/L as P)	0.0024 mg/L	Aspila et al. (1976)	Freezing-28 d
Particulate Inorganic Phosphorus (mg/L as P)	0.0024 mg/L	Aspila et al. (1976) (without combusting the pad)	Freezing-28 d
Nitrite (mg/L as N)	0.0002 mg/L	EPA method 353.2 (EPA 1979)	Freezing-28 d
Nitrite + Nitrate (mg/L as N)	0.0007 mg/L	EPA method 353.2 (EPA 1979)	Freezing-28 d
Ammonium (mg/L as N)	0.003 mg/L	EPA method 350.1 (EPA 1979)	Freezing-28 d
Total Dissolved Nitrogen (mg/L as N)	0.02 mg/L	D=Elia et al. (1977) Valderrama (1981)	Freezing-28 d
Particulate Nitrogen (mg/L as N)	0.0105 mg/L	EPA method 440.0 (EPA 1997)	Freezing-28 d
Diss. Organic Carbon (mg/L as C)	0.15 mg/L	Sugimura and Suzuki (1988)	Freezing-28 d
Particulate Carbon (mg/L as C)	0.0759 mg/L	EPA method 440.0 (EPA 1997)	Freezing-28 d
Silicic Acid (mg/L as Si)	0.01 mg/L	Technicon (1977)	4 °C - 28 d
Total Suspended Solids (mg/L)	2.4 mg/L	EPA method 160.2 (with slight modification) EPA (1979); APHA (1975)	Freezing-28 d
Total Volatile Solids	0.9 mg/L	APHA method 208 E (with modification) APHA (1975)	Freezing-28 d
Turbidity* (NTU)	0.5 NTU	EPA method 180.1 (nephelometric)	4 °C - 48 h
Chlorophyll <i>a</i> (µg/L)	0.1 µg/L	APHA (1981)	Freezing-28 d
Pheophytin <i>a</i> (µg/L)	0.1 µg/L	APHA (1981)	Freezing-28 d

\* See Appendix 5 for a description of the turbidity method used by the Maryland Department of Health and Mental Hygiene.

References For Table 9:

American Public Health Association (APHA). 1981. Method 1002 G, chlorophyll (trichromatic), in *Standard Methods for the Examination of Water and Wastewater*, 17<sup>th</sup> ed.

- American Public Health Association (APHA). 1975. Method 208D, total nonfilterable residue dried at 103-105°C (total suspended matter), in *Standard Methods for the Examination of Water and Wastewater*, 14<sup>th</sup> Edition. American Public Health Association: Washington, D.C. 1193 p.
- American Public Health Association (APHA). 1975. Method 208E ( with modification). Total volatile and fixed residue at 550° C in *Standard Methods for the Examination of Water and Wastewater*, 14<sup>th</sup> Edition. American Public Health Association: Washington D.C. 1193 p.
- 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.
- 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 System Water Quality Instrumentation Manual* (HSWQIM). 1984-1998 (multiple editions). Published by Hydrolab Corporation, P.O. Box 50116, Austin, Texas.
- Michael, Bruce and Elizabeth Ebersole. 2002. 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, 2002 - June 30, 2003. Prepared by Maryland Department of Natural Resources, Tidewater Ecosystem Assessment for U.S. Environmental Protection Agency Chesapeake Bay Program.
- Parsons, T.R., Takahashi, M. and B. Hargrave. 1977. *Biological Oceanographic Processes*. Pergammon 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.
- Technicon Industrial Systems. 1977. Industrial Method No. 186-72W/B, in *Silicates in Water and Seawater*. Technicon Industrial Systems: Tarrytown, NY.
- 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). 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.

### **3. FIELD MEASUREMENTS AND SAMPLING**

#### **3.1. Continuous Monitoring**

Each continuous monitoring station is equipped with a YSI 6600 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. Each continuous monitoring sonde records nine water quality parameters every 15 minutes. The nine water quality parameters measured continuously are water temperature, specific conductance, salinity, dissolved oxygen, turbidity (NTU), fluorescence and total chlorophyll (used to estimate chlorophyll *a*), pH and depth. 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. The sonde is positioned in the water column in either a floating configuration or a fixed configuration depending on the geographic area being monitored and the monitoring goals for that segment.

Continuous monitoring sondes in a floating configuration are suspended from a float inside of a 4-inch diameter PVC pipe with 2-inch holes drilled every 4 inches below the waterline to allow for water exchange. The sonde tubes are painted below the water line with black antifouling paint (interlux Micron Extra or similar). 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. 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 Bay Program offices in Annapolis. The field component consists of an electrical box housing a CR10X data logger, which stores data collected by the data sonde, a battery and solar panel to supply power, and either an analog or digital cellular modem. Several times a day, the computer server located at the Bay Program office contacts the data logger located at each 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 general 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 sonde, Secchi depth and light attenuation (Appendix 4) are measured bi-weekly from April to October, and grab samples are taken and filtered on-site or immediately after returning to the lab. 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 and to the Maryland Department of Health and Mental Hygiene (DHMH) for analysis. These results will be used to analyze relationships between the water quality parameters measured by each continuous monitor and nutrient component. Some of the lab data are also used to check the YSI data for accuracy. The following parameters are analyzed at NASL: total dissolved nitrogen, particulate nitrogen, nitrite, nitrite + nitrate, ammonium, total dissolved phosphorus, particulate phosphorus, orthophosphate, dissolved organic carbon, particulate carbon, silicic acid, total suspended solids, volatile suspended solids (Appendix 8), and particulate inorganic phosphorus. Parameters analyzed at DHMH include chlorophyll *a*, pheophytin and turbidity (Appendix 9).

#### **3.2 Water Quality Mapping**

Water quality mapping is conducted using water a shipboard system 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 seven water quality parameters measured are water temperature, salinity, specific conductance, dissolved oxygen, turbidity (NTU), fluorescence (used to estimate chlorophyll *a*) and pH. The water is pumped through a ram (pipe), through the sensors, and then discharged overboard. The water quality mapping system includes a Garmin model GPSMAP168 Sounder chartplotting receiver and depth-finder, a YSI 6600 sonde with a flow-through chamber, a YSI 6562 dissolved oxygen probe, a YSI 6560 conductivity/temperature probe, a 6026 turbidity probe, and a 6025 chlorophyll probe. The sonde transmits the data from the sensors to a ruggedized computer. Each water quality datum is associated with a date, time, water depth, and GPS coordinate (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 is 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 approximately 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 approximate 0.5-m depths below the surface. At calibration stations, grab samples also are collected at 0.5-m depth and filtered on site. See Appendix 3 for a description of the filtering procedures. The processed samples are sent to the Nutrient Analytical Services Laboratory (NASL) at the Chesapeake Biological Laboratory and to the Maryland Department of Health and Mental Hygiene (DHMH) for analysis. Parameters analyzed at NASL are total dissolved nitrogen, particulate nitrogen, nitrite, nitrite + nitrate, ammonium, total dissolved phosphorus, particulate phosphorus, orthophosphate, dissolved organic carbon, particulate carbon, silicic acid, total suspended solids, volatile suspended solids (Appendix 8), and particulate inorganic phosphorus. Parameters analyzed at DHMH include chlorophyll *a*, pheophytin and turbidity (Appendix 9). 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 and Rohland et al. 2002.

#### **4. LABORATORY ANALYSIS**

Turbidity is analyzed at the Maryland Department of Health and Mental Hygiene's (DHMH) Environmental Chemistry Division for only those samples collected by DNR personnel. Active chlorophyll *a* is analyzed by DHMH for all samples collected. For details, refer to DHMH's chlorophyll analysis Standard Operating Procedures available 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 1, 2002 - June 30, 2003 (Michael and Ebersole 2002).

All other laboratory-measured parameters are analyzed at the University of Maryland's Chesapeake Biological Laboratory (CBL), Nutrient Analytical Services Laboratory. For details, refer to CBL's Standard Operating Procedures available 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 1, 2002 - June 30, 2003 (Michael and Ebersole 2002).

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. Turbidity samples are delivered to DHMH on the day they are collected for analysis that day or the day after. The frozen samples are packed in ice and driven to NASL and DHMH weekly to be processed. NASL and DHMH process and analyze 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 continuous monitoring stations, the sondes are retrieved, calibrated and replaced every two weeks from April to October. Three National Estuarine Research Reserve (NERR) sites on the upper Patuxent and 1 NERR site at Otter Point Creek on the Bush River are maintained year round unless severe icing during the winter prohibits deployment. For these stations the continuous monitoring sondes are retrieved, calibrated and replaced every two weeks 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 next to the PVC tube, at the same depth of the old (deployed) sonde in the tube. The discrete check sonde (usually a Hydrolab) is also suspended in the water at the same depth. A synchronized reading is taken at the next 15-minute interval with the old, new and check sondes. A second synchronized reading is taken at the next 15-minute interval with just the old and the new sondes. After two synchronized readings have been taken, a water column profile is conducted (Appendix 14). After the water column profile, the old sonde is removed from the PVC tube and the tube is cleaned with a Webster duster brush to remove biofouling and clear debris from the inside and outside of the tube as well as from any telemetry cables or the floating mechanism (if applicable). Once everything has been cleaned, the new sonde is placed in the PVC tube. This three-way comparison assures that the new and old sondes are both reading each parameter within a certain tolerance. The check sonde allows for notation on whether or not the parameters are fluctuating or stable (Appendix 2).

The retrieved continuous monitoring sonde is brought back to the field office where it is allowed to equilibrate overnight to standard temperature and pressure in a 100% saturated air environment. 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 software, and the remaining post-calibration procedures are conducted as outlined in Appendix 2.

After post-calibration has been completed, the data are subjected to intense 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 is first used to determine if a specific probe has drifted outside of an acceptable range (Table 10). Data may be rejected

**Table 10.** Acceptable drift tolerances for YSI 6600EDS sondes following post-calibration check.

Parameter	Value
Chlorophyll	±5 % of true value
Dissolved Oxygen	±0.5 mg/L
pH	±0.2 pH units
Specific Conductance	±5 % of true value
Turbidity	±5 % of true value
Water Temperature	±0.2 °C

during the QA/QC checks when post-calibration drift exceeds the limits stated in Table 10 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 that are common to the continuous monitoring and water quality mapping projects.

Data from telemetered stations are examined daily by DNR staff. Additionally, several automated programs have been put in place that examine the real-time data and notify DNR staff via e-mail when chlorophyll levels (algal blooms) and low dissolved oxygen events may be occurring so that supplemental sampling may be conducted. Automated programs also alert DNR staff via e-mail 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: Results displayed in "Current Results" are provisional and have not undergone full Quality Assurance/Quality Control procedures. Results in "Archived Results" also may not have undergone full Quality Assurance/Quality Control procedures. Although Maryland DNR believes the data presented here are correct, we cannot guarantee their accuracy at this time. Due to the technologies being used for turbidity, fluorescence and depth measurements, these results in particular may be subject to inaccuracies.

At the end of the monitoring season, DNR staff check for additional erroneous data, perform data QA/QC procedures and calculate chlorophyll *a*. Staff plot all of the data and then thoroughly research any outliers or other unusual values. For example, staff compare values outside the normal range to historic values and values elsewhere in the Bay, consider weather events, and consult with field staff regarding possible legitimate causes for those values. In cases where values are not legitimate, they are masked in the database with the approval of the field staff and the Quality Assurance Officer.

## **5.2 Water Quality Mapping**

Water Quality Mapping (WQM) is generally conducted once monthly in each sampled tributary from April-October. For tributaries with submerged aquatic vegetation restoration, specific monitoring projects, or in polyhaline segments sampling may begin in March and end in November. In 2006, 14 systems are being monitored in Maryland. 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 determines ultimate cruise tracks for WQM.

During data collection, field personnel keep a detailed logbook that documents 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, observations of algal blooms or equipment malfunctions. After data collection, field personnel use the Shallow Water Monitoring QA/QC macro (See Appendix 14) to format data, highlight erroneous values, and add appropriate error codes based on field notes. Original data files are named with a three-letter segment designation, an eight digit date and an "R" for raw data file (e.g. SEV05272005R). Files that have been through the QAQC process are labeled with an "Q", instead of a "R". After initial QA/QC by field personnel, data files are reviewed by a data analyst,

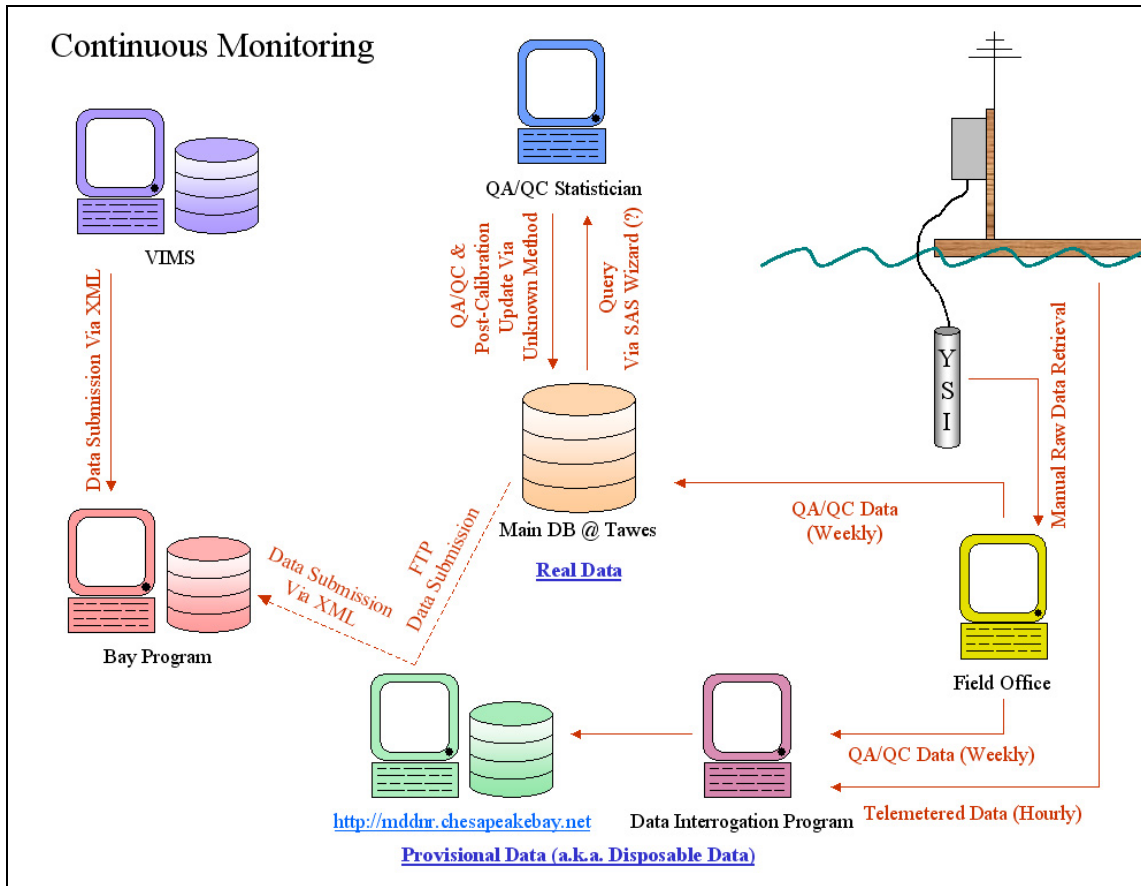


which includes the added step of viewing data within a GIS context. This procedure can highlight positional errors and elucidate errors that can only be viewed within a geographical display.

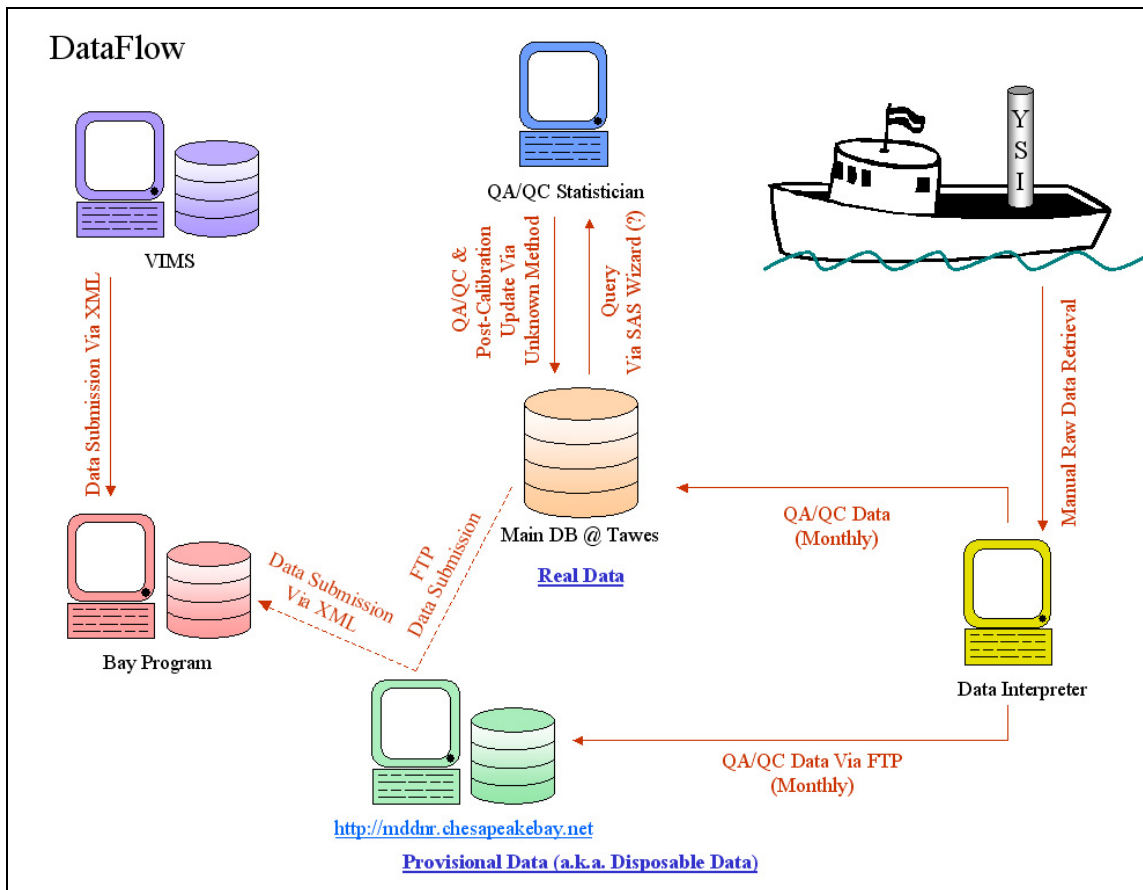
Preliminary maps of chlorophyll, dissolved oxygen, turbidity, water temperature and salinity are created and placed on the Internet at [www.eyesonthebay.net](http://www.eyesonthebay.net). Maps are interpolated using a default inverse distance weighted procedure. These maps give an overall perspective of water quality conditions and are meant for general reference, not for detailed analysis. In the near future, a searchable water quality mapping database system will be placed on the Eyes on the Bay website. CBP-compliant metadata is being created for WQM data, and will be available in association with any data downloads from the website.

### **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. Erroneous data are masked with an appropriate error code (see Appendix 12) rather than deleted. This ensures that all raw data are archived should the need ever arise to evaluate those values in the future. The potential also exists that future techniques and technologies may make it possible to utilize data that were 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 automatically inserted into DNR's Shallow Water Monitoring database. Backup redundant copies of all raw data and QA/QC'd data are also kept. A new data submission system is currently being developed and tested that would automatically submit data from the Shallow Water Monitoring database to the Bay Program via FTP and XML communications protocols (Figures 2 and 3). This new data submission method will streamline data submission and sharing between DNR and Bay Program by reducing the Bay Program's role in data management. Any changes made to DNR's database will be automatically transmitted to the Bay Program and mirrored in their database. This will significantly reduce or eliminate issues associated with data versioning. This new system will ensure that both DNR and the Bay Program are working from the same dataset at all times.



**Figure 2.** Conceptual diagram of continuous monitoring data management components, including automated data submission from DNR to the Bay Program.



**Figure 3.** Conceptual diagram of water quality mapping data management components, including automated data submission from DNR to the Bay Program.

#### 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 13), and Water Quality Mapping Data Verification and Management Procedures (Appendix 14).

### 6. PROJECT QUALITY ASSURANCE/QUALITY CONTROL

An initial quality assurance (QA) and quality control (QC) check is performed by field staff, who inspect all data for outliers and mask outliers in the data set as deemed appropriate before reporting any data. Field staff also mask any data for parameters that did not post-calibrate within specifications. See Tables 7, 8 and 10 in Sections 2 and 5 for limits on accuracy and instrument drift. See Appendix 5 and 6 (YSI Calibration and Post-Calibration Procedures) and Appendices 13 and 14 (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 TEA staff to identify any erroneous data missed in the initial QA/QC, compare current data to historical data, and to post-calibrate certain parameters such as chlorophyll.

### **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 Michael and Ebersole (2002; Appendices VII and VIII) 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 DNR's participation in the Chesapeake Bay Coordinated Split Sample Program (CSSP), a split sampling program in which the coordinated split samples are analyzed by five laboratories involved in Chesapeake Bay monitoring. 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. DNR follows the protocols in the *Chesapeake Bay Coordinated Split Sample Program Implementation Guidelines* (EPA 1991) and its revisions. Split samples are collected quarterly. 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 Analytical Methods and Quality Assurance Workgroup.

Additionally, CBL and DHMH participate two times per year in the United States Geologic Survey (USGS) reference sample program and permit 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 and DHMH, found in Appendices VII and VIII of 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 1, 2002 - June 30, 2003 (Michael and Ebersole 2002).

### **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's Chesapeake Biological Laboratory 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. CBL prepares the blind audit samples for all CBP 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 - Old Dominion University's Applied Marine Research Laboratory, University of Maryland's Horn Point Laboratory, Virginia Institute of Marine Science, Virginia Division of Consolidated Laboratory Services, Pennsylvania Department of Environmental Resources, Virginia Polytechnic Institute's Occoquan Laboratory, Maryland Department of Health and Mental Hygiene, District of Columbia Department of Health, Philadelphia Academy of Science and, finally, Chesapeake Biological Laboratory, itself.

Once annually, the EPA Chesapeake Bay Program quality assurance officer conducts an onsite audit of the mainstem 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 *Recommended Guidelines for Sampling and Analysis in the Chesapeake Bay Monitoring Program, August 1996* (EPA 1996). 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 the completeness goals of 100 percent. Detection limit ranges are provided in Tables 2 and 3 above.

### **7. DATA ANALYSIS AND REPORTING**

As noted above, 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 will be developed to calculate chlorophyll *a* from *in situ* chlorophyll fluorescence data and *K<sub>d</sub>* from *in situ* turbidity data. These regression models are still in development, but will likely be multiple regression models that utilize additional *in situ* and discrete parameters.

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. Semi-annual progress reports will be provided to the Chesapeake Bay Program January 15, 2007 and July 15, 2007.

## **8. PROJECT ORGANIZATION AND RESPONSIBILITY**

This section lists the individuals responsible for the major aspects of the Chemical and Physical Properties Component of Maryland's Chesapeake Bay Water Quality Monitoring Program.

Director and Principal Investigator: Bruce Michael, Tidewater Ecosystem Assessment, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, bmichael@dnr.state.md.us, 410-260-8630.

**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 the technical design, conduct and data analysis of the program.

Quality Assurance Officer: Bruce Michael, Tidewater Ecosystem Assessment, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, bmichael@dnr.state.md.us, 410-260-8630.

**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: Sally Bowen, Project Chief, Monitoring Field Office, Tidewater Ecosystem Assessment, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, sbowen@dnr.state.md.us, 410-990-4528.

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

Field Sampling Operations: Paul W. Smail, University of Maryland Center for Environmental Science, Chesapeake Biological Laboratory, PO Box 38 Solomons, MD 20688, smail@cbl.umces.edu 410-326-7434

**RESPONSIBILITIES:** This individual is responsible for administration of the field sampling activities including sample collection, sample storage and sample delivery to laboratories for water quality mapping in the lower Patuxent estuary and parts of the Potomac River.

Field Sampling Operations: Henry Bush, St. Mary's College River Project, 18952 East Fisher Rd St. Mary's City, Maryland 20686, hbbush@smcm.edu, (240) 895-4361.

**RESPONSIBILITIES:** This individual is responsible for administration of the field sampling activities including sample collection, sample storage and sample delivery to laboratories for continuous monitoring and water quality mapping in the St. Mary's River.

Field Sampling Operations: R. Chris Jones, Chair, Department of Environmental Science and Policy, George Mason University, 4400 University Dr. MSN 5F2, Fairfax, VA 22030, rcjones@gmu.edu, (703) 993-1127

RESPONSIBILITIES: This individual is responsible for administration of the field sampling activities including sample collection, sample storage and sample delivery to laboratories for the continuous monitoring stations on the Potomac River maintained by George Mason University staff.

Field Sampling Operations: Bryant Thomas, Virginia Department of Environmental Quality, Northern Regional Office, 13901 Crown Court, Woodbridge, Virginia 22193, [bhthomas@deq.virginia.gov](mailto:bhthomas@deq.virginia.gov), (703) 583-3843

RESPONSIBILITIES: This individual is responsible for administration of the field sampling activities including sample collection, sample storage and sample delivery to laboratories for the continuous monitoring stations on the Potomac River maintained by Virginia Department of Environmental Quality (VA DEQ).

Field Sampling Operations: Vincent Kelly, Senior Faculty Research Assistant, Horn Point Laboratory, 2020 Horns Point Road, P.O. Box 775, Cambridge, MD 21613, [vkelly@hpl.umces.edu](mailto:vkelly@hpl.umces.edu), (410) 221-8206

RESPONSIBILITIES: This individual is responsible for administration of the field sampling activities including sample collection, sample storage and sample delivery to laboratories for the continuous monitoring station at Horn Point Laboratory on the Choptank River.

Instrument Management: John Zimmerelli, Monitoring Field Office, Tidewater Ecosystem Assessment, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, [zimmerelli@dnr.state.md.us](mailto:zimmerelli@dnr.state.md.us), 410-990-4534.

RESPONSIBILITIES: This individual is responsible for the management of all continuous monitoring equipment.

Instrument Management: Waldo Nelson, Monitoring Field Office, Tidewater Ecosystem Assessment, Maryland Department of Natural Resources, 580 Taylor Avenue, Annapolis, Maryland 21401, [wnelson@dnr.state.md.us](mailto:wnelson@dnr.state.md.us), 410-990-4517.

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

Laboratory Analyses/Water Column Chemistry: Carl Zimmerman, Chesapeake Biological Lab, University of Maryland, Center for Environmental Science, Solomons, Maryland 20688-0038, [carlz@clb.umces.edu](mailto:carlz@clb.umces.edu), 410-326-7252.

RESPONSIBILITIES: This individual is responsible for total suspended solids and any nutrient analysis of water samples .

Chlorophyll Analyses/Water Column Chemistry: Asoka Katumuluwa, Chief, Division of Environmental Chemistry, Laboratory Administration, Maryland Department of Health and Mental Hygiene, [katumuluwaA@dohmh.state.md.us](mailto:katumuluwaA@dohmh.state.md.us), 410-767-5034.

RESPONSIBILITIES: This individual is responsible for administration of the chlorophyll and turbidity analysis of water samples.



Data Management: Chris Trumbauer/Waldo Nelson/Bill Romano/Mark Trice/Ben Cole/Tyrone Lee/Tony Allred, 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 of field and laboratory data collected under this program; managing historical field and laboratory data collected under this program; and maintaining existing data management software.

Data Analysis and Report Preparation: Mark Trice/Bill Romano/Ben Cole, 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. Technical Report Series No. TS-357-02-CBL.
- D'Elia, Christopher F., Erin E. Connor, Nancy L. Kaumeyer, Carolyn W. Keefe, Kathryn V. Wood, and Carl F. Zimmerman. 1997. *Nutrient Analytical Services Laboratory: Standard Operating Procedures*. Chesapeake Biological Laboratory, University of Maryland, Center for Environmental Science, Solomons, Maryland, 20688-0038. Technical Report Series No. 158-97.
- Michael, Bruce, Elizabeth Ebersole, Mark Trice, Christopher Heyer. 2005. *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, 2005 - June 30, 2006*. Prepared by Maryland Department of Natural Resources, Tidewater Ecosystem Assessment for U.S. Environmental Protection Agency Chesapeake Bay Program.
- Halka, Jeff. 2002. Personal Communication between Mark Trice, Maryland Department of Natural Resources, and Jeff Halka, Maryland Geological Survey.
- Rohland, F.M., W.R. Boynton, R.M. Stankelis, B.W. Bean, and H.J. Pine. 2002. *Maryland Chesapeake Bay Water Quality Monitoring Program, Ecosystem Processes Component (EPC), Quality Assurance Project Plan for Water Quality Monitoring in Chesapeake bay for FY 2003, July 2002-June 2003, Revision 7*. Prepared for the Maryland Department of Natural Resources, September 2002.. University of Maryland Center for Environmental Sciences, Chesapeake Biological Laboratory, P.O. Box 38, Solomons, MD. Technical Report Series No. TS-343-01-CBL. Ref. No. [UMCES]CBL 01-0306b.
- 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). 1991. *Chesapeake Bay Coordinated Split Sample Program Implementation Guidelines, May 1991*. Chesapeake Bay Program: Annapolis, MD. CBP/TRS 58/91.

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## Appendix 1. YSI 6600EDS Specification Sheet

<b>YSI 6600 EDS (Extended Deployment System)</b>		
<b>Dissolved Oxygen % Saturation</b>	Range	0 to 500%
	Resolution	0.1%
	Accuracy	0 to 200%; ±2% of reading or 2% air saturation, whichever is greater; 200 to 500%; ±6% of reading
<b>Dissolved Oxygen mg/L</b>	Range	0 to 50 mg/L
	Resolution	0.01 mg/L
	Accuracy	0 to 20 mg/L; ±2% of reading or 0.2 mg/L, whichever is greater; 20 to 50 mg/L; ±6% of reading
<b>Conductivity †</b>	Range	0 to 100 mS/cm
	Resolution	0.001 to 0.1 mS/cm (range-dependent)
	Accuracy	±0.5% of reading + 0.001 mS/cm
<b>Temperature</b>	Range	-5 to +45°C
	Resolution	0.01°C
	Accuracy	±0.15°C
<b>pH</b>	Range	0 to 14 units
	Resolution	0.01 unit
	Accuracy	±0.2 unit
<b>ORP</b>	Range	-999 to +999 mV
	Resolution	0.1 mV
	Accuracy	±20 mV
<b>Salinity</b>	Range	0 to 70 ppt
	Resolution	0.01 ppt
	Accuracy	±1% of reading or 0.1 ppt, whichever is greater
<b>Shallow Depth</b>	Range	0 to 30 feet (0 to 9 m)
	Resolution	0.001 feet (0.001 m)
	Accuracy	±0.06 feet (±0.02 m)
<b>Medium Depth</b>	Range	0 to 200 feet (0 to 61 m)
	Resolution	0.001 feet (0.001 m)
	Accuracy	±0.4 feet (±0.12 m)
<b>Deep Depth</b>	Range	0 to 656 feet (0 to 200 m)
	Resolution	0.001 feet (0.001 m)
	Accuracy	±1 feet (±0.3 m)
<b>Vented Level</b>	Range	0 to 30 feet (0 to 9 m)
	Resolution	0.001 feet (0.0003 m)
	Accuracy	±0.01 feet (0.003 m)
<b>Turbidity</b>	Range	0 to 1,000 NTU
	Resolution	0.1 NTU
	Accuracy	±5% of reading or 2 NTU, whichever is greater
	Depth	200 feet (60.96 m)
<b>Chlorophyll</b>	Range	0 to 400 µg/L
	Resolution	0.1 µg/L Chl; 0.1%FS
	Depth	200 feet (60.96 m)
<b>Rhodamine</b>	Detection Limit	0.5 µg/L
	Resolution	0-200 µg/L as true dye; 1,000 µg/L as dye tracer
	Accuracy	±1 µg/L or ±5% reading
	Depth	200 feet (60.96 m)

† 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).

## **Appendix 2. Continuous Monitoring Procedures**

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Revised: June 2005

### **Installation:**

- To collect seamless continuous data, two instruments are needed for each site. Deploy the first instrument at the site for a week. At the end of the week, replace this instrument with the second instrument. During the next week, post-calibrate and clean the first instrument and prepare it to be deployed the next week.
- Use a 4" diameter PVC pipe to install a site. The length depends on the depth of the selected site.
- Coat the PVC pipe with an effective anti-fouling paint to prevent biological contamination.
- Drill 2" 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 a wooden 2x4 using two copper or stainless steel clevis hangers. Then attach the 2x4 to a piling or pier using lag bolts.
- Place a chain through the tube, and lock it with a combination or key lock to prevent theft or vandalism.

### **Calibration:**

- Calibrate each instrument using laboratory quality standards directly prior to each deployment (see Appendix 5).
- Synchronize the internal clock in the instrument and all watches with the official time. The official time is available by calling 410-844-1212. A radio-controlled clock that automatically synchronizes to the Atomic Clock in Boulder, CO can also be used.

### **Deployment:**

- Deploy the instrument at a fixed site at a regular interval, e.g., weekly or bi-weekly.
- Record the date, location, weather conditions, tide, time of deployment, and initials on the calibration log.
- Leave the instrument that was deployed the prior week in place inside the PVC tube while suspending the freshly calibrated instrument at the same depth, right next to the old one. Allow both instruments to take at least one simultaneous reading 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
- Use a Hydrolab (or similar) instrument with a display unit to take an additional simultaneous reading. The real-time display makes it possible to note any sudden fluctuations or trends in the water quality parameters.
- At exact time of sample reading, take a grab sample using a Kemmerer type apparatus suspended at the same depth as the sondes.

### **Sample Processing :**

- Grab sample is filtered immediately after it is taken. 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 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 EDS sondes are being replaced. This profile will be done with the check instrument (e.g., Hydrolab) and will measure the following parameters:

- 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.

The following procedure should be followed for the profile:

**If total depth < 3.0 m:****Floating Stations:**

Take Hydrolab 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 Hydrolab 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:*

*Hydrolab 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:*

*Hydrolab readings at 1.0; then 2.6, 2.0, 1.5 and 0.5 m.*

*Total depth = 2.4 m:*

*Hydrolab 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 Hydrolab 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:*

*Hydrolab readings at 0.4 m only*

*Total depth = 1.9 m:*

*Hydrolab 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:*

*Hydrolab 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.*

### **Lower Patuxent Stations (0.5 m above bottom)**

Take Hydrolab 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. 1.5, 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:*

*Hydrolab readings at 1.4, 1.0 and 0.5 m.*

### **If Total Depth $\geq$ 3.0 m:**

#### **Floating Stations:**

Take Hydrolab 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 Hydrolab 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:*

*Hydrolab 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 Hydrolab 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:*

*Hydrolab readings at 2.9, 2.0, 1.0 and 0.5 m.*

### **Lower Patuxent Stations (0.5 m above bottom):**

Take Hydrolab 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:*

*Hydrolab readings at 3.0, 2.0, 1.0 and 0.5 m.*

### **Retrieval:**

- After both instruments have been allowed to take at least one simultaneous reading, remove the old instrument.
- Record the date, location, weather conditions, tide, time of retrieval, and initials on the calibration log.
- Brush out the instrument tube with a Webster-type brush, on the inside and outside.
- Deploy the fresh instrument in its place.
- 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 each retrieved instrument against laboratory standards to ensure that it was taking accurate measurements. Preferably complete this post-calibration the day after the instrument is retrieved, allowing the instrument to equilibrate to standard temperature and pressure overnight in 100% saturated air environment before conducting the post-calibration. If field staff are unable to 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.



### **Appendix 3. Water Quality Mapping Procedures**

*W. Nelson*

Revised: May 2005

#### **Water Quality Mapping Procedures**

The following procedures should be followed when collecting data for the DATAFLOW project.

##### **Equipment Set up:**

1. Attach stainless steel ram to boat, before or after launching boat, using pre-drilled holes thru the port side transom of the boat with two bolts, two lock washers, and two nuts provided. Securely tighten with a 15/16" wrench or other suitable tool.
2. Attach depth finder transducer bracket to ram by inserting metal rod up thru 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 boat hull and water line. Securely tighten setscrew with 9/16" wrench or other suitable tool.
3. Launch research vessel.
4. After launching insert gray PVC pipe with attached Rule 1100 live well pump down thru 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 port side of research vessel using bolts, lock-washers, and nuts provided.
6. Connect 1" diameter black hose to ram pump with a hose clamp and attach other end of hose to the **intake** port of the YSI Sensor Unit stand with a hose clamp, 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 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 2-12 volt DC gel cell 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 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”.
3. 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. Severn040603). Click “Save”. DATAFLOW is now operational and logging data.
4. 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.
5. Close the program by clicking on the “X” in the top right corner of the display and shut down the computer by clicking the start button on the lower left of the display screen.
6. Turn off flow alarm horn, Turn off GPS/Sounder, turn off YSI power, and then turn off Ram pump.

### 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 6 calibration stations.

### Calibration stations:

At each calibration station collect a physical profile using a Hydro lab, collect a whole water sample for CBL nutrients and DHMH chlorophyll filtering, collect a 16 oz. whole water sample for turbidity, and a PAR profile using a LiCor.

### Hydrolab profile:

Collect the 0.5 m readings first. Record the exact minute that the 0.5 m readings are collected as the start time. 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 DHMH chlorophyll sample. A labeled 16 oz. bottle will also be rinsed and filled simultaneously with the 2-quart bottle to be submitted to DHMH for turbidity analysis. All whole water and processed samples will be immediately placed on ice until delivery to the office or courier.

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

#### **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-190SA air (deck) reference sensor.
- C. Data Logger (LI-1000 or LI-1400)

#### 2) Parameters:

- 1. EPARU\_Z      Downwelling PAR, measured underwater with sensor pointed up.  
( $\mu\text{M}$ , micromoles/second-meter<sup>2</sup> =  $\mu\text{E}$ , microEinsteins)
- 2. EPAR\_S      PAR measured in air, on board vessel or pier, recorded concurrently with each underwater depth reading ( $\mu\text{M}$ )
- 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 sonde, 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. 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 stored by pressing "Enter". Each record will be stored with a time stamp which will flash on the data logger readout. Record this time. All readings can be subsequently retrieved at the end of the cruise.

#### Shallow Water Monitoring (Data Flow 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 CIMS data base method codes:

- a. EPARU\_Z F01: Flat cosine sensor LI-192SA
- b. EPAR\_S F01: Deck (reference) sensor LI-190SA
- 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:

$$\frac{\text{Maximum EPAR}_S \text{ in profile}}{\text{EPAR}_S \text{ from that DEPTH}}$$

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 CIMS Data Hub. 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:

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

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

Calculated  $K_d$  using this method can be retrieved from the CIMS Data Hub (<http://www.chesapeakebay.net>). Under CBP Water Quality Database, “click to get data”, then select “Water Quality Data”. CIMS 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 CIMS  $K_d$  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 6600EDS Calibration and Post-Calibration Procedures (Continuous Monitoring)

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MD DNR

Revised 3/21/2006

### I. SET UP

- A. Remove calibration cup, and set up the YSI with probes facing up.
- B. Trim the DO membrane with an x-acto knife, as closely as possible to the o-ring. Any extra pieces of the membrane hanging off may attract fish or crabs.
- C. Attach non-EDS wipers to the chlorophyll and turbidity probes. Always use an orange wiper for the chlorophyll probe and a white wiper for the turbidity probe. Remember to align the screw on the wiper with the flat side of the probe post. Be sure the sponge portion is touching the probe firmly, but is not smashed down flat.
- D. Remove waterproof cap from the 9-pin sonde connector and attach sonde cable from laptop to sonde. Inspect connector for cleanliness, bent pins, etc.
- E. Launch Ecowatch and select SONDE from the COMM menu. Choose COM 1 when prompted to select COM port.
- F. Next, type "menu" at the # prompt.
- G. Select SYSTEM, then DATE AND TIME, then TIME.
- H. Enter the correct time. (Obtain the time by consulting a calibrated ConMon watch, or dialing 410.844.1212) **All times must be entered in Eastern Standard Time (EST).**
- I. Return to main menu. Select REPORT.
- J. Select only the following parameters to be reported:  
Temp C, SpCond ms/cm, DO mg/l, pH, pH mV, Turbid NTU, Chl ug/L

### II. QUICK CHECKS

- A. From the MAIN MENU, select RUN, and then DISCRETE. Enter SAMPLE INTERVAL as 4 seconds, and then RUN SAMPLE. Observe the DO% reading and make sure that the D.O. shows a high to low trend (you may ignore the first two readings.)
- B. Allow the sonde to continue in discrete mode. Press "3" to activate wipers. Check to see that both wipers complete their cycle by wiping twice clockwise and then once counter-clockwise, parking at 180° from the sensor. If wipers are not functioning properly, return to the # prompt and type "RESET".
- C. While the sonde is still in discrete mode, place your finger over the turbidity optic (without touching it) and make sure that it jumps to a high number. Remove finger and wait for turbidity reading to decrease back to zero (12 sec.)
- D. While the sonde continues in discrete mode, place your finger over the chlorophyll optic (without touching it) and make sure that it jumps to a high number. Remove finger and wait for turbidity reading to decrease back to zero (24 sec.)

### III. CHLOROPHYLL

- A. Prepare 0.5 mg/l Rhodamine WT solution from the stock solution (if needed.)
  - a. Retrieve 100 mg/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.
  - d. Fill 1000-ml volumetric halfway with DI water.

- e. Using pipette bulb, 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. Remove calibration cup from sonde and rinse probes with DI water.
- C. Fill a clean, dry calibration cup 3/4 full with DI water. Be sure to use a tall calibration cup with a black base. Place probes down into DI water making sure temperature probe is immersed.
- D. Return to main menu. Select CALIBRATE, then OPTIC C - CHLOROPHYLL, then CHL UG/L, then TWO POINT. Enter zero (0) as the first standard.
- E. Press “3” to engage wipers. Note if wipers “park” 180° from the optical sensor. Check for air bubbles over optics. Repeat if necessary.
- F. After wipers have completed wiping cycle, allow readings to stabilize for at least 24 seconds. Record chlorophyll blank concentration. Press enter, and record calibrated chlorophyll blank concentration.
- G. Rinse a clean, empty calibration cup, with a black base, 3 times, and then fill it ¾ full with the 0.5 mg/l Rhodamine solution
- H. Using lab thermometer, note temperature of Rhodamine standard.
- I. Place probes down into standard making sure temperature probe is immersed.
- J. Using temperature reading obtained in step H, look up corresponding Chlorophyll value from Chlorophyll/Temperature chart in the folder. Enter this concentration (e.g. 113) as the second point in the calibration and press Enter.
- K. Press “3” to engage wipers again. Check for air bubbles over optics. Repeat if necessary.
- L. After wipers have completed wiping cycle, allow readings to stabilize for at least 24 seconds. Record chlorophyll concentration and temperature. Press Enter, and record calibrated chlorophyll concentration.

#### IV. TURBIDITY

- A. All turbidity calibrations must use the tall version of the calibration cup.
- B. Fill a clean, dry calibration cup 3/4 full with DI water. Be sure to use a calibration cup with a black base.
- C. Rinse probes with DI water and place sonde probes down into DI water, making sure that the temperature probe is submerged.
- D. Return to main menu. Select CALIBRATION, then TURBIDITY.
- E. Select 2 POINT. Enter the first standard as zero (0).
- F. Press “3” to engage wipers. Check for air bubbles over optics. Repeat if necessary.
- G. After wipers have completed wiping cycle, allow readings to stabilize. Record turbidity concentration. Press enter, and record calibrated turbidity concentration.
- H. Remove probes from DI water. Dry off Turbidity probe and temperature probe with a cotton swab or Kim-wipe. This will prevent the turbidity standard from becoming diluted.



- I. Gently fill a clean, dry calibration cup about 2/3 full with clean 123 NTU solution to minimize the amount of bubbles in the standard.
- J. Lower Turbidity probe down into calibration cup enough to immerse the temperature probe.
- K. Enter second standard as 123.
- L. Press “3” to engage wipers. Note if wipers “park” 180° from the optical sensor. Check for air bubbles over optics. Repeat if necessary.
- M. After wipers have completed wiping cycle, allow readings to stabilize. Record turbidity concentration. Press enter, and record calibrated turbidity concentration.

**V. SPECIFIC CONDUCTANCE**

- A. Attach open-ended calibration cup securely to meter and rinse probes 3 times with DI water.
- B. Rinse probes 3 times with conductance standard to be used.
- C. Set meter upright with probes facing up. Fill calibration cup with 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 meter gently or dislodging them with a cotton swab.
- D. Select CONDUCTIVITY, then SPECIFIC CONDUCTANCE from the CALIBRATION menu.
- E. Enter the conductance of the standard *in mS/cm*. Example: 2767  $\mu$ S = 2.767 mS.
- F. Press Enter when readings have stabilized. Record readings before and after calibration.
- G. Return to main menu.
- H. Select ADVANCED then CAL CONSTANTS. Record Conductivity Cell Constant.

**VI. pH**

- A. With calibration cup securely attached to meter, rinse probes 3 times with DI water.
- B. Rinse probes 3 times with pH 7 standard.
- C. Set meter upright with probes facing up. Fill calibration cup with standard until the standard level is above pH and temperature probes.
- D. Return to main menu. Select CALIBRATION then pH, then 2-POINT.
- E. Enter 7, and allow at least 60 seconds for meter to stabilize.
- F. When readings have stabilized press Enter, record pH before and after calibration, as well as the temperature and pH mV.
- G. Rinse probes 3 times with DI water.
- H. Rinse probes 3 times with pH 10 or pH 4 standard (depending on the expected pH of the waterway to be sampled)
- I. Fill calibration cup with standard until the standard level is above conductivity block and temperature probe.
- J. Enter appropriate buffer (10 or 4) at prompt, and allow at least 60 seconds for meter to achieve thermal equilibrium.
- K. When readings have stabilized press Enter, record pH before and after calibration, as well as the temperature and pH mV.
- L. Calculate pH slope by subtracting the pH 7 mV from pH 10 mV. Ensure that slope is within range.
- M. Remove pH standard, and rinse probes with DI water.
- N. Now is a good time to remove the small turbidity 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%, DOmg/l, DOchrg, Depth, pH, pH mV, Turb, Chl, Fluor, Batt. Return to main menu. Initiate data logging by selecting RUN, then *UNATTENDED SAMPLE*. Enter INTERVAL (15 minutes), START DATE, START TIME, DURATION (365 days), FILE and SITE. **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.
- B. Record File Name, Start Date/Time, Sampling Interval, Free Disk Space (in kb), and Battery Life (in days) in log book. Make sure stop date is 1 year after start date.
- C. If Battery life is less than 45 days, change batteries; If Free Disk space is less than 100 kb, then 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 already been successfully uploaded onto the server before deleting them.*
- D. Exit menu back to # prompt and disconnect sonde cable.
- E. Screw on waterproof connector cap.

## VIII. Dissolved Oxygen (Ideally performed day before deployment)

- A. Closely observe DO membrane to ensure that it is free of water, scratches, and nicks. Remove any water carefully with cotton swab. If scratch or nick is apparent, DO membrane must be replaced.
- B. Wipe dry the metal thermistor – a wet thermistor can indicate an artificially low temperature reading due to evaporation.
- C. Place probe guard onto instrument, being careful of the DO membrane, and exposed pH probe.
- D. Wrap moist towel around the probe-end of the instrument to create a saturated-air environment.
- E. Place instrument in a cooler that is cracked open to allow it to be in equilibrium with the atmosphere.
- F. Allow air to become water saturated and meter to come to thermal equilibrium (at least 30 minutes.)
- G. After enough time has elapsed, select *CALIBRATE* from the main menu, and then *DISSOLVED OXYGEN*.
- H. Next choose DO SAT%. Take current Barometric Pressure from a reliable barometer in the room. Log in Barometric Pressure in mm Hg and press <Enter>.
- I. Meter will automatically perform calibration. Record barometric pressure, temperature, meter DO before and after calibration, DO Sat% before and after calibration, and true DO value, as calculated from pressure/temperature chart. **Record DO charge.** If DO charge <25 or >75, DO probe needs to be serviced.
- J. Return to main menu. Select ADVANCED then CAL CONSTANTS. Record DO Gain.

## VIII. Dissolved Oxygen Check (performed the morning of the deployment)

- A. Verify DO calibration by connecting sonde cable to sonde, accessing menu and selecting VIEW FILES then QUICK VIEW. Note the most recent several samples, and check that the readings are stable.
- B. Record the temperature, DO (mg/L), DO %, DO charge
- C. Check the barometric pressure, and record the true DO from the temperature/pressure chart.

- D. If samples are consistent and accurate within 0.2 mg/L of true DO value according to chart, do not recalibrate meter.
- E. If samples are not within 0.2 mg/L of true DO, recalibrate meter according to **step VII-H**. Since the meter is already in a saturated air environment, you need not wait for equilibrium. Record changes in calibration log.
- F. If samples are greater than 0.5 mg/L of true DO, do not recalibrate and do not deploy instrument until DO issue is resolved.

## Post Calibration

### IX. Notes

- A. During Post Calibration, the idea is to preserve the condition of the meter after deployment. Thus it is important **not** to clean the sonde 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 sensors themselves.*
- B. Inspect each probe on the sonde. Using the selections available at the bottom of the Rhodamine calibration chart page, 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.
- C. Because most meters 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 the clean standards. New, clean standards are then prepared.

### X. Dissolved Oxygen (ideally performed the day after retrieving meter)

- A. If meter was wrapped in moist towel following retrieval, make sure membrane and thermistor are dry, keep towel on meter and allow meter to come to thermal equilibrium in a stable environment – usually overnight. Allow meter to continue to log data while coming to equilibrium. Connect sonde cable to sonde and access last several readings according to **step VII-H in the Calibration procedures**. Skip to step C.
- B. If there was a problem - meter malfunction, batteries died, etc. - you may run a post calibration by accessing menu, selecting RUN, then DISCREET SAMPLE using a sample interval of 120 sec.
- C. Check barometric pressure using reliable barometer.
- E. Record temperature, barometric pressure, DO (mg/l), DO Sat%, and DO Charge.
- F. Also record true D.O. as read from temperature and pressure chart. If the D.O. is more than 0.5 mg/L off from the chart D.O. reading, make a large note on the post calibration sheet.
- G. Use this opportunity to record the depth post-cal also, if applicable.
- H. Stop logging by selecting RUN, UNATTENDED SAMPLE, then STOP LOGGING.
- I. At this time, upload the data from the last deployment. In the main menu, select FILE, then QUICK UPLOAD.
- J. Select PC6000, and press enter. This will automatically upload the most recent deployment data onto the computer. It will be stored under the folder, Ecowatch.
- K. After uploading the latest data set from the YSI, remove the towel and probe guard from the meter.
- L. Remove the EDS “clean-sweep” or brush wiper from the turbidity probe, and replace with a small gray or white non-brushing wiper. Place the EDS brush wiper in a beaker with water and light soap to soak.
- M. The meter is now ready to complete the post-calibration process, or it can be stored in a calibration cup with DI until the post-calibration can be completed.

## XI. CHLOROPHYLL AND TURBIDITY

- A. From the Main Menu, select Report. Select only the following to be reported: Temp C, SpCond ms/cm, DO mg/l, pH, pH mV, Turbid NTU, Ch lug/l
- B. Do not rinse probes.
- C. Make sure to use the tall calibration cups.
- D. Fill a clean, dry calibration cup  $\frac{3}{4}$  full with DI water. Be sure to use a calibration cup with a black base.
- E. Place probes down into DI water being sure to submerge the temperature probe.
- F. Select RUN from the main menu. Select DISCREET SAMPLE.
- G. Change SAMPLE INTERVAL to 4 seconds.
- H. Select START SAMPLING. Wipers should activate. If not, press “3” to activate wipers manually. Observe if wipers park 180° from optic sensors. Note this in log book.
- I. Place and hold lab thermometer in DI water until temperature reading is stable. Record thermometer temperature in logbook.
- J. After wipers have completed cycle, record instrument temperature, chlorophyll zero and turbidity zero readings once they have stabilized.
- H. Remove probes from DI water and *carefully* dry tips of turbidity and chlorophyll probes including wiper with Kim-wipe or cotton swab. Do not clean off the optic sensors. *Note:* Turbidity standard is particularly fragile so try to minimize contamination by cleaning tip of turbidity probe. This should not affect reading *as long as the optical sensor is not cleaned.*
- I. Fill a clean black-based calibration cup  $\frac{2}{3}$  full with “dirty” 123 NTU solution.
- J. Lower probes down into calibration cup just enough to immerse the tips. There should be at least an inch between probe and bottom of the calibration cup. Also allow about 1.5 to 2 inches of space between the top of the calibration cup and the bottom of threading on the sonde.
- K. Press “3” to engage wipers.
- L. After wipers have completed wiping cycle, record turbidity reading when readings have stabilized.
- M. Fill a clean, dry calibration cup  $\frac{3}{4}$  full with the 0.5 mg/L Rhodamine solution (see section 2). Be sure to use a calibration cup with a black base. Place probes down into DI water making sure temperature probe is submerged.
- N. Press “3” to engage wipers.
- O. After wipers have completed wiping cycle, allow readings to stabilize. Record chlorophyll concentration and temperature.

## XII. Specific Conductance

- A. Attach open-ended calibration cup securely to meter.
- B. *Gently* rinse probes 3 times with conductance standard that was used to calibrate the meter. Take care not to dislodge fouling from conductance block, as the goal is to read conductance “as is.”
- C. Set meter upright with probes facing up. Fill calibration cup with “dirty” conductance standard until the standard level is above conductivity block and temperature probe. Pour standard gently down the side of calibration cup to prevent dislodging dirt or growth from probes. If any air bubbles are apparent in the conductivity block, remove them by shaking meter gently or dislodging them with a cotton swab.
- D. Run a DISCREET SAMPLE with SAMPLE INTERVAL of 4 seconds.

E. Record conductance when readings have stabilized.

XIII. pH

- A. With calibration cup securely attached to meter, **gently** rinse 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 meter upright with probes facing up. Gently pour standard down the inside of the calibration cup until the buffer level is above pH and temperature probes.
- D. Run a DISCREET SAMPLE with SAMPLE INTERVAL of 4 seconds.
- E. Allow at least 30 seconds for meter to stabilize.
- F. When readings have stabilized, record pH, pH mV and temperature.
- G. Gently rinse probes 3 times with DI water.
- H. Gently rinse probes 3 times with pH 10 or pH 4 buffer (use whichever buffer used to calibrate instrument.)
- I. Gently pour pH 10/pH 4 buffer down the inside of the calibration cup until the standard level is above pH and temperature probes.
- J. Run a DISCREET SAMPLE with SAMPLE INTERVAL of 4 seconds.
- K. Allow at least 60 seconds for meter to stabilize.
- L. When readings have stabilized, record pH, pH mV and temperature, and calculate pH slope by subtracting the pH 7 mV from pH 10 mV.

***Meter should now be cleaned and stored for next deployment.***

**CALIBRATION**

Date \_\_\_\_\_ Time \_\_\_\_\_  
 Location \_\_\_\_\_  
 Deployment site: \_\_\_\_\_ RESET? Y N  
 Initials \_\_\_\_\_ Zero Depth? Y N  
**Dissolved Oxygen** \_\_\_\_\_ Notes \_\_\_\_\_  
 Temperature \_\_\_\_\_ °C new membrane? Y N  
 Bar. Pressure \_\_\_\_\_ mm Hg Hi to Low? Y N  
 Chart D.O. \_\_\_\_\_ mg/L  
 Meter D.O. \_\_\_\_\_ mg/L  
 changed to \_\_\_\_\_ mg/L  
 D.O. Saturation \_\_\_\_\_ %  
 changed to \_\_\_\_\_ %  
 D.O. Charge \_\_\_\_\_ (Range 25 to 75)  
 D.O. Gain \_\_\_\_\_ (Range 0.8 - 1.7)

**Chlorophyll (2-point)**

Chlorophyll zero \_\_\_\_\_ → \_\_\_\_\_ µg/L  
 Temperature \_\_\_\_\_ °C  
 Rhodo WT equivalent \_\_\_\_\_ µg/L  
 Meter reads \_\_\_\_\_ → \_\_\_\_\_ µg/L  
 Wiper parks 180 deg. from sensor? YES NO

**Turbidity (2-point)**

Turb zero \_\_\_\_\_ → \_\_\_\_\_ NTU  
 Turb Std \_\_\_\_\_ NTU  
 Meter reads \_\_\_\_\_ NTU  
 changed to \_\_\_\_\_ NTU  
 Wiper parks 180 deg. from sensor? YES NO

**Specific Conductance**

Sp. Cond. Std. \_\_\_\_\_ µS/cm  
 Meter reads \_\_\_\_\_ µS/cm  
 changed to \_\_\_\_\_ µS/cm  
 Cond. Cell Const. \_\_\_\_\_ (Range 4.6 - 5.45)

**pH 7**

Temperature \_\_\_\_\_ °C  
 Meter pH reads \_\_\_\_\_  
 changed to \_\_\_\_\_  
 pH mV \_\_\_\_\_ mV (Range 0 ± 50)

**pH 10**

Temperature \_\_\_\_\_ °C  
 Meter pH \_\_\_\_\_  
 changed to \_\_\_\_\_  
 pH mV \_\_\_\_\_ mV (Range -180 ± 50 )  
 Slope (pH7 mV - pH10 mV) \_\_\_\_\_ (Range 165 - 180 )

**PROGRAMMING**

Parameters: (circle) Date Time Temp SpC Sal DO% DO DOch pH  
 Set time to: \_\_\_\_\_ : \_\_\_\_\_ EST Turb Chl Fluor Batt  
 Log to filename \_\_\_\_\_ Depth  
 Start Date / Time / interval \_\_\_\_\_ / \_\_\_\_\_ / \_\_\_\_\_ min  
 Started Logging YES NO  
 Free Disk Space \_\_\_\_\_ kilobytes (delete if < 100kb)  
 Battery Life \_\_\_\_\_ Days changed Y N  
 (change if batt life < 45 days)

**FIELD DATA**

Date \_\_\_\_\_ Time(s) \_\_\_\_\_  
 Initials \_\_\_\_\_  
 Add'l Samples? \_\_\_\_\_

**FIELD NOTES**

**DO Check**

Temp \_\_\_\_\_  
 B.P. \_\_\_\_\_  
 Chart \_\_\_\_\_  
 Meter \_\_\_\_\_  
 DO % \_\_\_\_\_  
 Charge \_\_\_\_\_  
 Re-Cal? Y N

**POST CALIBRATION**

Date \_\_\_\_\_ Time \_\_\_\_\_  
 Location \_\_\_\_\_  
 Initials \_\_\_\_\_ Depth (0) \_\_\_\_\_  
**Dissolved Oxygen** \_\_\_\_\_ Notes \_\_\_\_\_  
 Stopped Logging? YES NO Upload? YES NO  
 Temperature \_\_\_\_\_ °C Fouling Grade \_\_\_\_\_  
 Bar. Pressure \_\_\_\_\_ mm Hg  
 Chart D.O. \_\_\_\_\_ mg/L  
 Meter D.O. \_\_\_\_\_ mg/L  
 D.O. Saturation \_\_\_\_\_ %  
 D.O. Charge \_\_\_\_\_

**Temperature**

Thermometer temp \_\_\_\_\_ °C YSI temp: \_\_\_\_\_ °C

**Chlorophyll (2-point)**

Chlorophyll zero \_\_\_\_\_ µg/L Fouling Grade \_\_\_\_\_  
 Temperature \_\_\_\_\_ °C  
 Chlorophyll Std \_\_\_\_\_ µg/L  
 Meter reads \_\_\_\_\_ µg/L  
 Wiper parks 180 deg. from sensor? YES NO

**Turbidity (2-point)**

Turb zero \_\_\_\_\_ NTU Fouling Grade \_\_\_\_\_  
 Turb Std \_\_\_\_\_ NTU  
 Meter reads \_\_\_\_\_ NTU  
 Wiper parks 180 deg. from sensor? YES NO

**Specific Conductance**

Sp. Cond. Std. \_\_\_\_\_ µS/cm Fouling Grade \_\_\_\_\_  
 Meter reads \_\_\_\_\_ µS/cm

**pH 7**

Temperature \_\_\_\_\_ °C Fouling Grade \_\_\_\_\_  
 Meter pH \_\_\_\_\_  
 pH mV \_\_\_\_\_ mV

**pH 10**

Temperature \_\_\_\_\_ °C  
 Meter pH \_\_\_\_\_  
 pH mV \_\_\_\_\_ mV  
 Slope \_\_\_\_\_

**Battery** \_\_\_\_\_ changed YES NO

**DATA SET COMPARISON**

	old	new	Discrete
meter			
time			
Temp.			°C
Sp. Cond			µS/cm
Salinity			ppt
D.O.			mg/l
pH			
Turb.			NTU
Chloro			µg/L
total depth =	_____ m	_____ m	secchi = _____ m
sample depth =	_____ m		

**calibration notes**

## Appendix 6. YSI 6600 Calibration and Post-Calibration Procedures (DataFlow)

W. Nelson

Revised: 12/5/2003

### Calibration

#### 1. SET UP

- A. Remove waterproof cap from the 9-pin sonde connector and attach sonde cable from laptop to the sonde.
- B. Take a spare Hydrolab battery and attach it to the connector on the laptop.
- C. Launch Ecowatch and select SONDE icon from the TOOLBAR menu.
- D. Choose *COM 1* when prompted to select COM port.
- E. Type menu *@* at the *#* prompt and select *REPORT*
- F. Select **the following** parameters prior to calibration:
  - Time, Temp C, Sal ppt, Sp. Cond., DO Sat%, DO mg/l, DO charge, pH, pH mV, Turbidity NTU, Fluorescence, Chl ug/L.
- G. Press Esc until you are back to the main menu.

#### 2. Dissolved Oxygen

- A. Closely observe DO membrane to ensure that it is free of water, scratches, and nicks. Remove any water carefully with a cotton swab. If scratch or nick is apparent, DO membrane must be replaced.
- B. Wipe dry the metal thermistor - a wet thermistor can indicate an artificially low temperature reading due to evaporation.
- C. Place approximately 1/8 inch of DI water in the bottom of a calibration cup.
- D. Place the probe end of the sonde into the cup making sure that the DO probe or temperature probe do not come in contact with DI water.
- E. Engage only 1 or 2 threads of the calibration cup to insure the DO probe is vented to the atmosphere.
- F. Allow sonde to remain idle so air can become water saturated and meter comes to thermal equilibrium (at least 20 minutes).
- G. After enough time has elapsed, from the main menu, select *CALIBRATE* then *DISSOLVED OXYGEN*.
- H. Next choose *DO SAT%*. Take current Barometric Pressure from a reliable barometer in the room. Log in Barometric Pressure in mmHg and press <Enter>.
- I. Allow DO% to stabilize for at least 30 seconds and press <Enter>. Meter will automatically perform calibration. Record temperature, barometric pressure, chart DO value (obtained from pressure/temperature chart), meter DO before and after calibration, DO Sat% before and after calibration in the calibration log.
- J. Return to the main menu.



### 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) Rinse clean 1000-ml volumetric flask 3 times with DI.
  - 3) Fill 1000-ml volumetric flask halfway with DI water.
  - 4) Pipette exactly 5.0 ml of the stock solution into 1000 ml volumetric flask using a volumetric pipette.
  - 5) 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.
  - 6) Allow solution to reach ambient temperature using a warm water bath.
- B. Fill a clean calibration cup with **black top** attached 3/4 full with DI water. Place probes down into DI water allowing at least three inches between probes and the bottom of the calibration cup.
- C. Return to main menu. Select *CALIBRATE*, then *OPTIC C - CHLOROPHYLL*, then *CHL UG/L*, then *TWO POINT*. Enter zero (0) as the first standard. Press <Enter>.
- D. Press 3 to engage wipers.
- D. After wipers have completed wiping cycle, check optics for air bubbles. Repeat wiper cycle until air bubbles are gone. Allow readings to stabilize. Record chlorophyll blank concentration. Press <Enter>, and record calibrated chlorophyll blank concentration.
- E. Rinse calibration cup 3 times with Rhodamine solution, then fill cup 3/4 full with the 0.5 mg/l Rhodamine solution.
- G. Using lab thermometer, record temperature of Rhodamine standard.
- H. Dry probes with Kim-wipes 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. Press A3@ to engage wipers again. Check for air bubbles over optics. Repeat if necessary.
- K. After wipers have completed wiping cycle, allow readings to stabilize. Record chlorophyll concentration and temperature. Press <Enter>, and record calibrated chlorophyll concentration.
- L. Return to the calibration menu.

#### 4. TURBIDITY

- A. Fill a clean calibration cup 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 calibration menu select *TURBIDITY*, then *2 POINT*.
- D. Enter the first standard as zero (0). Press <Enter>.
- E. Press 3 to engage wipers.
- F. After wipers have completed wiping cycle, allow readings to stabilize. Record turbidity concentration. Press <Enter>, and record calibrated turbidity concentration.
- G. Remove probes from calibration cup and dry off all probes with a Kim-wipe. This will prevent the turbidity standard from becoming diluted.
- H. Fill a **clean, dry** calibration cup with **black top** attached 3/4 full with clean 100/123 NTU solution.
- 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 123. Press <Enter>.
- K. Press 3 to engage wipers.
- L. After wipers have completed wiping cycle, allow readings to stabilize. Record turbidity concentration. Press <Enter> and record calibrated turbidity concentration.
- M. Return to the calibration menu.

#### 5. Specific Conductance

- A. Attach open-ended calibration cup securely to sonde and rinse probes 3 times with DI water.
- B. Rinse probes 3 times with conductance standard to be used.
- C. Set meter upright with probes facing up. Fill calibration cup with standard until the standard level is above all of the probes. If any air bubbles are apparent in the conductivity block, remove them by shaking meter gently or dislodging them with a cotton swab.
- D. Select *CONDUCTIVITY*, then *SPECIFIC CONDUCTANCE* from the CALIBRATION menu.
- E. Enter the conductance of the standard **in mS/cm**. Ex: 24820 FS = 24.82 mS. Press <Enter>.
- F. When readings have stabilized press <Enter>. Record readings before and after calibration.
- G. Return to Calibration menu.

#### 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 standard.
- C. Set meter upright with probes facing up. Fill calibration cup with clean pH 7 standard.
- D. Select *PH*, then *2-POINT*.
- E. Enter 7 as the 1<sup>st</sup> point and press <Enter>. Allow at least 60 seconds for meter to stabilize.
- F. When readings have stabilized press <Enter> and record pH before and after calibration, as well as the temperature.
- G. Rinse probes 3 times with DI water. Then 3 times with pH 10 or pH 4 standard (depending on the expected pH of the waterway to be sampled).
- H. Next fill the calibration cup with 2<sup>nd</sup> standard to be used.

- H. Enter 2<sup>nd</sup> standard value and press <Enter>, allow at least 60 seconds for meter to stabilize.
- I. When readings have stabilized press <Enter>, record pH before and after calibration, as well as the temperature.

## DAILY CHECK

- A. Before each run: set up YSI to be checked the following morning. Rinse probes with DI and dry all the probes with a kim-wipe, specifically DO and Temp. probe. Set YSI into calibration cup and engage one or two threads. Allow sonde to remain idle so air can become water saturated and meter comes to thermal equilibrium
- B. **Next Morning**; Take a spare Hydrolab battery and attach it to the connector on the laptop.
- C. Attach sonde connector to sonde and launch *Ecowatch* as you would to calibrate.
- D. Type "menu" at the # prompt.
- E. **MAKE SURE THAT ONLY THE FOLLOWING PARAMETERS ARE CHECKED UNDER THE REPORT MENU:**
  - Time, Temp., Sp. Cond., Sal, DO%, DOmg/L, pH, Turb., Flur., Chl., and Battery.
- F. Select *Run* from the main menu, then *Discrete Sampling*, then *Start Sampling*.
- G. Allow readings to stabilize for at least 30 seconds then record Temperature, Barometric Pressure, Chart DO, DO mg/l, and DO% Saturation. Follow directions on "Range for Daily Check" table if DO is off.
- H. Remove sonde from calibration cup and fill cup  $\frac{3}{4}$  with DI.
- I. Place probes down into DI water allowing at least three inches between probes and the bottom of the calibration cup.
- J. Record Chlorophyll and Turbidity "0" once readings have stabilized. If "0" is off according to Range for Daily Check Table, re-calibrate using the procedures listed in the Calibration section.
- K. Attach a clean, dry open-ended calibration cup to YSI. Rinse calibration cup and probes three times with specific conductance standard that was used to calibrate. Place YSI in ring stand with probes facing up. Fill calibration cup with specific conductance standard and record specific conductance reading after it has stabilized. Re-calibrate if there is any changes according to the "Range for Daily Check" table or if sampling from a higher saline system to a lower saline system or vice versa.
- L. Rinse probes three times with DI then three times with pH 7 buffer.
- M. Pour pH 7 buffer into calibration cup, wait until readings stabilize, then record pH 7 reading.
- N. Repeat step L and M with pH 10 (or pH 4 buffer, which ever is used).
- O. Re-calibrate if pH is off by +/- 0.2 units.

## POST Calibration

- Set YSI up as you would for a Daily Check.
- Type menu at the # prompt and select *REPORT*
- Select **the following** parameters to be post calibrated:
  - **Time, Temp C, Sal ppt, Sp. Cond., DO Sat%, DO mg/l, DO charge, pH, pH mV, Turbidity NTU, Fluorescence, Chl ug/L.**

### 1) Dissolved Oxygen

- A. After enough time has elapsed select *Run* from the Main Menu, then *Discrete Sampling*.
- B. Set sample interval to 2 seconds, then select *Start sampling*.
- C. After readings have stabilized, record temperature, barometric pressure, chart DO, meter DO (mg/l), DO Sat%, and DO Charge.
- D. Remove sonde from calibration cup.

### 2) Chlorophyll and Turbidity

- A. Fill a 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. Press "3" to engage wipers. Be sure no air bubbles are covering optics. After wipers have completed cycle, allow readings to stabilize. Record instrument temperature and chlorophyll and turbidity "0" value.
- C. Rinse calibration cup 3 times with 0.5 mg/l Rhodamine WT solution (obtained from calibration procedure), then fill cup  $\frac{3}{4}$  full with the 0.5 mg/l Rhodamine solution.
- D. Wipe dry probes with a kim-wipe. Place probes down into Rhodamine standard allowing at least three inches between probes and the bottom of calibration cup. Record Chlorophyll value, temperature, and Rhodamine equivalent value after readings have stabilized.
- E. Remove sonde from calibration cup, rinse probes with DI and dry them with a kim-wipe. Fill a clean, dry **black top** calibration cup  $\frac{3}{4}$  full with 100/123 NTU standard. Press "3" to engage wipers and record "123 NTU" value after readings have stabilized.

### 3) Specific Conductance

- A. Attach open-ended calibration cup securely to sonde.
- B. Rinse probes 3 times with DI then 3 times with conductance standard used.
- C. Set meter upright with probes facing up. Fill calibration cup with 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 meter gently or dislodging them with a cotton swab.
- D. Record specific conductance when readings have stabilized.

### 4) pH

- A. With calibration cup securely attached to 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 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.
- E. When readings have stabilized, record pH and temperature.

- F. Rinse probes 3 times with DI water.
- G. Rinse probes 3 times with pH 10 buffer (or pH4, whichever was used)
- H. Pour pH standard into calibration cup until the standard level is above pH and temperature probes.
- I. Allow at least 60 seconds for meter to stabilize.
- J. When readings have stabilized, record pH and temperature.

Dataflow Calibration Log									
Date									
Time									
Calibration Type:									
Cal, Post Cal, Daily Check									
Project									
Set Time?									
Initials									
<b>DISSOLVED OXYGEN (mg/L)</b>									
Temperature: °C									
Bar. Pressure: mmHg									
Chart D.O.: mg/L									
Meter D.O.: mg/L									
-Adjusted to: mg/L									
D.O. Saturation : %									
-Adjusted to:									
D.O. Charge (range: 25-75)									
<b>CHLOROPHYLL (µg/L)</b>									
Chlorophyll zero: µg/L									
-Adjusted to: µg/L									
Temperature: °C									
Rhodo WT equivalent: µg/L									
Meter Reads: µg/L									
-Adjusted to: µg/L									
<b>TURBIDITY (NTU)</b>									
Turbidity zero:									
-Adjusted to:									
Turbidity standard:									
Meter Reads:									
-Adjusted to:									
<b>SPECIFIC CONDUCTANCE (mS/cm)</b>									
Sp. Cond. Std.: mS/cm									
Meter Reads: mS/cm									
-Adjusted to: mS/cm									
<b>pH 7</b>									
Temperature: °C									
Meter Reads:									
-Adjusted to:									
pH mV:									
<b>pH 10</b>									
Temperature: °C									
Meter Reads:									
-Adjusted to:									
pH mV:									
Notes:									

## Appendix 7. Continuous Monitoring and Water Quality Mapping Filtering Methods

### 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  $\mu\text{m}$ ) 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 graduate 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  $\text{MgCO}_3$ , as it settles rapidly. Add approximately 1 ml of  $\text{MgCO}_3$  suspension (1.0 g  $\text{MgCO}_3$  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. When filtering chlorophyll for core samples, after you fold the filter in half, fold in half again to make it  $\frac{1}{4}$  size so it will fit in the small zip-lock bag neatly.
- j) Be sure that foil square is marked with date, station, depth of sample, volume of sample filtered, and sample number. For core samples, be sure the baggie is labeled with the station number, date and volume filtered.
- 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 DHMH in the freezer.
- l) Record sample station number, date, volume filtered (L), depth (m), layer, start time, end time and field scientist sign-off on the chlorophyll volume sheet. Record the study code, submitter code, data category code and replicate number, if not already pre-filled in, on chlorophyll 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 "Chlorophyll, DHMH".

*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  $\mu$ 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.

*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 the freezer (large boats) or in a cooler on ice (small boats & land).
- 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).
- 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.
- f) Use this filtrate to fill up the tubes for the dissolved parameter analysis. See section C (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  $\mu\text{m}$ ). The VSS pads come in individually numbered petri dishes from CBL. Remove one pad from its individual petri dish and place on the filter screen. Record the pad number from the petri dish on the TSS/VSS foil label in the space marked “Pad #”.
- b) Filter 50 - 500 ml and filter through the filter pad leaving a noticeable color on the pad.
- c) Make sure 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.

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

- 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, and volume filtered, and VSS pad number.
- 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/VSS 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 pads that are pre-combusted (PC/PN & VSS) or units that are in contact with  $\text{MgCO}_3$  (CHLA).*

1. 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.
2. Total Dissolved Nitrogen & Phosphorus (TDN/TDP)
  - a) Rinse the TDN/P tube (30 ml borosilicate glass – tall skinny tube!) and cap three times with filtrate.
  - b) Flick all remaining water droplets out of the test tube and cap.
  - c) Rinse the 10 ml graduated cylinder three times with filtrate.
  - d) Fill the graduated cylinder with 10 ml of filtrate.
  - e) Carefully, pour the 10 ml of filtrate 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.

3. Nitrate, Nitrite, Ammonia, Orthophosphate & Silicate
  - a) Rinse the 4 like-numbered AA vials (4 ml polystyrene cups) and 4 caps three times with filtrate.
  - b) Fill the AA vials with filtrate up to ridge where the caps are seated.
  - c) Snap the caps on the vials. You should hear them snap twice to be fully seated.
  - d) Store 3 AA vials in the freezer. Store 1 AA vial in the refrigerator.
  - e) 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.
4. Dissolved Organic Carbon (DOC)
  - a) Rinse the DOC tube (30 ml Teflon) and cap three times with filtrate.

### C. Quality Control Samples

1. Clean Check

The clean check is a two step process. First, clean, dry pads are analyzed as if they had been in contact with actual samples. Second, deionized water is filtered through a second set of pads in place of sample water.

  - a) Place clean, dry pads in foils for appropriate parameters to be analyzed as if they had been used for real samples.
  - b) Performed the same as A – C above, however, only deionized (DI) water is used. The volume filtered should be consistent with other volumes filtered on the run the clean check is being performed on.
2. Fluorescence Blanks
  - a) 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  $\mu\text{m}$ ) on the filter frit. Always use clean forceps when handling the filter pads.
  - c) Agitate a 400 ml sample and filter volume through filtration unit. Keep the vacuum pressure below 10 inches of Hg (around 8" Hg is good).
  - d) Measure the fluorescence of the filtrate with a calibrated YSI 6600 EDS sonde.

## Appendix 8. Nutrient Analytical Services Laboratory / Chesapeake Biological Laboratory Method for Total Volatile Solids Analysis

### TOTAL VOLATILE SUSPENDED SOLIDS Revised 2/2004

Total volatile solids (TVS) is the volatilized material that is lost on ignition from Total Suspended Solids (TSS). It is calculated from the measurement of a total suspended solid (TSS) sample minus the measurement of the quantity remaining after combustion. Results are expressed in mg/L.

#### Methodology

APHA. 1975. Method 208 E (with modification). Total volatile and fixed residue at 550° C. in Standard Methods for the Examination of Water and Wastewater, 14<sup>th</sup> Edition. American Public Health Association. Washington, D.C. 1193pp.

#### Sample Collection and Handling

1. Combust Whatman 47 mm GF/F filters (0.7 µm pore size) in an oven set at 500° C for 90 minutes. This setting on CBL's oven has been determined to be 550° C.
2. Weigh filters (g) to 4 decimal places to obtain pre-weight and store individual pads in a numbered petri dish.
3. Follow sample filtration procedure for total suspended solid sample. Make note of pad number on foil pouch.

#### Procedure

1. Dry filters overnight at 103°-105° C. Allow to cool to room temperature in dessicator.
2. Weigh filters and record weights (in g). Calculate TSS.
3. Transfer filter to a porcelain crucible and combust at 500° C for 90 minutes. Allow to cool to room temperature in dessicator.
4. Weigh filter and record weights (in g). Calculate TVS.

#### Calculation of TVS

$$mgTVS / L = \frac{(W_{combust(g)} - W_{post(g)}) \times 1000}{V_L}$$

where:  $W_{combust}$  = dry weight of filter pad and sample after combustion (in grams).  
 $W_{post}$  = dry weight of filter pad after filtering (in grams).  
 $V_L$  = volume of water filtered (L)

## **Appendix 9. Maryland Department of Health and Mental Hygiene Method for Turbidity Analysis**

### **Turbidity EPA Method 180.1 (Nephelometric)**

#### **1.0 SCOPE AND APPLICATION**

- 1.1 This method is applicable to drinking, ground, waste and saline waters.
- 1.2 The applicable range is 0 to 4000 nephelometric turbidity units (NTU). Higher values may be determined with dilution of the sample.

#### **2.0 SUMMARY OF METHOD**

- 2.1 The method is based upon a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension. The higher the intensity of light scattered, the higher the turbidity. Readings in NTUs are made in a Nephelometer designed according to specifications outlined under Equipment and Supplies.
- 2.2 A set of commercially available polymer primary standards with a concentration range from 20 to 4000 NTU is used to calibrate the instrument once every two months. These standard solutions are identified as AMCO CLEAR, available from Advanced Polymer Systems and are EPA approved.
- 2.3 Another set of above polymer primary standards with a concentration range from 0.5 to 20 NTU is used as a daily calibration check.

#### **3.0 INTERFERENCES**

- 3.1 The presence of floating debris and coarse sediments which settle out rapidly will give low readings. Air bubbles will affect the results in a positive manner.
- 3.2 The presence of true color, that is, the color of water which is due to dissolved substances, which absorb light, will cause turbidity values to be low, although this effect is generally not significant with drinking waters.
- 3.3 Light absorbing materials such as activated carbon in significant concentrations can cause low readings.

#### **4.0 HEALTH AND SAFETY**

- 4.1 Good laboratory practices should be followed during inversion of sample, handling of silicone oil (may cause eye irritation; do not ingest) and reading of sample result.

#### **5.0 EQUIPMENT AND SUPPLIES**

- 5.1 Equipment

5.1.1 Hach Model 2100AN Laboratory Turbidimeter B The turbidimeter consists of a nephelometer with a tungsten-filament lamp for illuminating the sample. Detectors are in place to measure the 90° light scatter, the forward scattered light, the back scattered light and the light transmitted through the sample. The instrument microprocessor uses a mathematical calculation to ratio signals from each detector. The benefits of applying ratio on measurements include better linearity, calibration stability, wide measurement range, and the ability to measure turbidity in the presence of color.

## 5.2 Supplies

5.2.1 Sample cells, 30 ml capacity; Hach catalogue number 20849-00.

## 6.0 REAGENTS AND STANDARDS

### 6.1 Reagents

6.1.1 Distilled water with a turbidity reading of less than 0.07 NTU.

### 6.2 Standards

6.2.1 A set of Primary Standards consisting of turbidity values 0, 20, 200, 1000 and 4000 NTU is used to calibrate the instrument once every two months.

6.2.2 A set of standards with turbidity values 0, 0.5, 2.0, 5.0, 20, 50, 100, and 200 NTU is used for daily calibration of the instrument.

## 7.0 SAMPLE COLLECTION, PRESERVATION, AND STORAGE

7.1 Samples are collected in liter polyethylene cubitainers. Samples should be refrigerated or iced to 4°C until analysis to minimize microbiological decomposition of solids. The holding time is 48 hours when preserved at 4°C.

## 8.0 QUALITY CONTROL

8.1 AMCO CLEAR primary standards with concentrations ranging from 0.5 to 200 NTU are analyzed before each day's run of samples. The instrument calibration is considered valid when the each measured NTU value is within 90 B 110% of its true value. The daily calibration curve is considered acceptable when the coefficient of correlation of the calibration curve is equal to or greater than 0.9950.

8.2 Every tenth sample is analyzed in duplicate. The accepted value for the relative standard deviation (RSD) is 10 %.

8.3 A blank (distilled water) is run at the beginning and after every ten samples. The accepted value for the blank is less than 0.07 NTU.

8.4 A commercially available quality control sample is analyzed quarterly.

## 9.0 PROCEDURE

### 9.1 Sample Cell Preparation

#### 9.1.1 Use of Samples Cells

9.1.1.1 Samples cells should be clean and free of fingerprints; any water droplets on the outside surface should be wiped dry. A light coating of silicone oil applied to the outside surface and then wiped to attain an even film will minimize the effects of minor scratches or other imperfections in the glass. The oil coating also helps to eliminate static electricity on the sample cell, which tends to collect dust. Sample cells that are nicked or scratched extensively must be replaced. Because imperfections in the glass cause variations between sample cells, best accuracy will be obtained if the same cell is used when doing comparisons among samples or when calibrating the instrument. Also accuracy is increased if the sample cell is oriented the same way in the cell holder every time. An index mark appears on each 25 mm cell for this purpose; it should be aligned with the raised mark on the spill ring around the cell holder opening. All cells should be marked likewise.

9.1.1.2 The fill ring on the sample cell represents a volume of approximately 30 mL. It is recommended that the cell be filled to the mark every time to ensure that the volume is well beyond the minimum amount required.

### 9.2 Instrument Calibration

#### 9.2.1 Instrument Start-up

Leave the turbidimeter on 24 hours a day if the instrument is used regularly. Make sure Ratio, Sample and Signal Average keys are in ON mode displayed by a green light. Maintain Range key in auto mode. Select NTU from Units/Exit key.

#### 9.2.2 Calibration with Primary Standards (once every two months)

##### 9.2.2.1 Press Cal Zero

9.2.2.2 Insert 0 NTU standard, press Enter; wait as the display counts down, then continue entering the rest of the standards in increasing sequence.

9.2.2.3 Press Cal Zero again to store calibration information into memory.

### 9.3 Sample Analysis

9.3.1 Prepare the list of samples for turbidity on the sample run sheet starting with blank, the daily calibration standards of 0.5, 2.0, 5.0, 20, 50, 100, and 200 NTU, the distilled water, then followed by each sample number. Measure one replicate, one check standard and one blank for every ten samples.

9.3.2 Fill the clean and dry glass cell with distilled water. Insert the cell. If the reading is greater than 0.07 NTU, the cell should be cleaned with detergent and the process be

repeated. Distilled water should have an NTU value of less than 0.07. Press Enter & Print to send data to computer. Continue entering the daily calibration standards in the increasing sequence.

9.3.3 If readings of standards are not within 10% of the true values, and standards are less than one year old, the turbidimeter should be recalibrated.

9.3.4 Allow samples to reach room temperature to prevent fogging of the cell. Thoroughly mix the sample by gentle inversion. Do not shake. Quickly remove cap and pour approximately 20 mL of sample into the cell for rinse. Immediately fill cell with sample to volume line, wipe dry and insert into turbidimeter. Align the index mark on the cell with the raised mark on the spill ring around the cell holder opening. Be sure the cell has been pushed down completely and is held in place by the spring clip. Cover the sample with the light shield.

9.3.5 Read the turbidity of the sample from the digital display. Press Enter & then press Print to save the first stable reading at approximately 15 seconds. If the turbidity reading fluctuates up and down, take the cell out, invert to mix well and measure again. Observe the results in the display for accuracy. After every tenth sample, measure one standard with the concentration within the range of the sample readings.

9.3.6 After reading all samples, double click the blank area outside the table to go to Microsoft Excel. Enter all sample identifications according to the run sheet into the sample column. Display the daily calibration curve with r-square value. Save the date as the file name. Print out the results along with the daily calibration curve.

## **10.0 DATA ANALYSIS AND CALCULATIONS**

10.1 Multiply sample reading by the dilution factor to obtain the final reading.

10.2 Report results to tenths of an NTU when using the 0-20 range and report whole numbers when the value is above 20 NTU.

## **11.0 DATA AND RECORDS MANAGEMENT**

11.1 The detection limit for this method is 0.5 NTU. All sample concentrations below this value are recorded as less than 0.5 NTU (< 0.5 NTU).

11.2 All daily run sheets are kept in a binder labeled as "Turbidity". All quality control data are kept in a binder labeled as "Quality Control".

## **12.0 WASTE MANAGEMENT**

1.1 Samples and standards are poured down the drain while flushing with large amount of cold water.

### 13.0 REFERENCES

- 13.1 United States Environmental Protection Agency, Methods for Chemical Analysis of Water and Wastes. Method Number 180.1 Revision 2.0 August 1993
- 13.2 Hach Instruction Manual for Model 2100AN Laboratory Turbidimeter With Software Version 1. 1993
- 13.3 The ABC's of NTU's B A Primer on Turbidity B J. A. Spair. Available from Advance Polymer Systems B 3696 Haven Avenue, Redwood City, California 94063



## Appendix 10. Continuous Monitoring Parameters

C. Trumbauer, C. Heyer, M. Trice

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	
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 AB = Fixed Above Bottom VP = Vertical Profile	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	F01
Dissolved Oxygen Concentration	mg/l	DO	F01
pH	su	PH	F01
Turbidity	NTU	TURB_NTU	F01 for 6136 F02 for 6026
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.

## Appendix 11. Water Quality Mapping Parameters

W. Nelson, C. Heyer, M. Trice

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 for 6136 F02 for 6026
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.

## Appendix 12. Continuous Monitoring and Water Quality Mapping Error Codes

C. Trumbauer, W. Nelson, C. Heyer, M. Trice

Revised: 2/23/2004

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

Category	Code	Description	Immediate Data Impacts	Suggested Uses
Comments	CTS	Time Skip	Comment - No Impact on Data Value	Improper Time Recording By Sonde
Comments	CBF	Biofouling	Comment - No Impact on Data Value	
Comments	CWD	Instrument at Wrong Depth (Depth Value)	Comment - No Impact on Data Value	Continuous Monitoring Specific
Comments	CTF	Temperature Probe Failure	Comment - No Impact on Data Value	
Comments	CSW	Salinity Calibrated at the Wrong Level	Comment - No Impact on Data Value	
Comments	CLF	Flow Low	Comment - No Impact on Data Value	Water Quality Mapping Specific
Comments	CDB	Disturbed Bottom	Comment - No Impact on Data Value	Field Observation
Comments	CTC	Time Change	Comment - No Impact on Data Value	NA to Data Post 2003
Comments	CTW	Turbid Water	Comment - No Impact on Data Value	Field Observation
Comments	CFK	Fish Kill	Comment - No Impact on Data Value	Field Observation
Comments	CSC	Site Location Change	Comment - No Impact on Data Value	Continuous Monitoring Specific
Comments	CAS	Algal Sample Taken (Sample #)	Comment - No Impact on Data Value	Field Observation
Comments	CAB	Algal Bloom - No Sample Taken	Comment - No Impact on Data Value	Field Observation

### **Appendix 13. Continuous Monitoring Data Verification and Management Procedures**

*C. Trumbauer, C. Heyer, M. Trice*

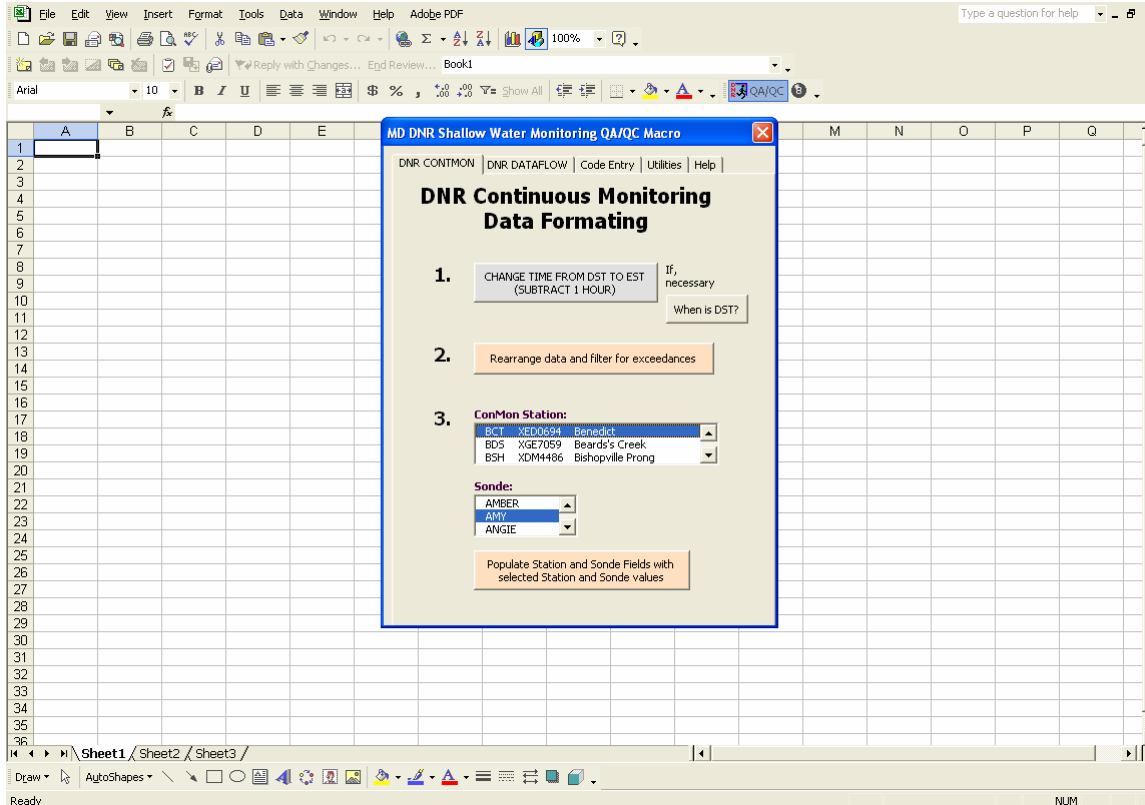
*Revised: 3/21/2006*

- 1) Open raw .DAT file in Ecowatch 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 .CDF format (e.g., STP0418.cdf).
  
- 3) Using Microsoft Excel, open the .CDF file, choosing comma delimited when prompted to identify the delimiter type.
  
- 4) 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.
  
- 5) Run the QA/QC macro by clicking the "REARRANGE CONTMON DATA" button on the "DNR CONTMON" tab of the macro dialog (Figure A13\_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 delete any overlapping data records resulting from the three-way *in situ* match-up. The overlapping record should be deleted from this deployment to ensure that the data are continuous from deployment to deployment.

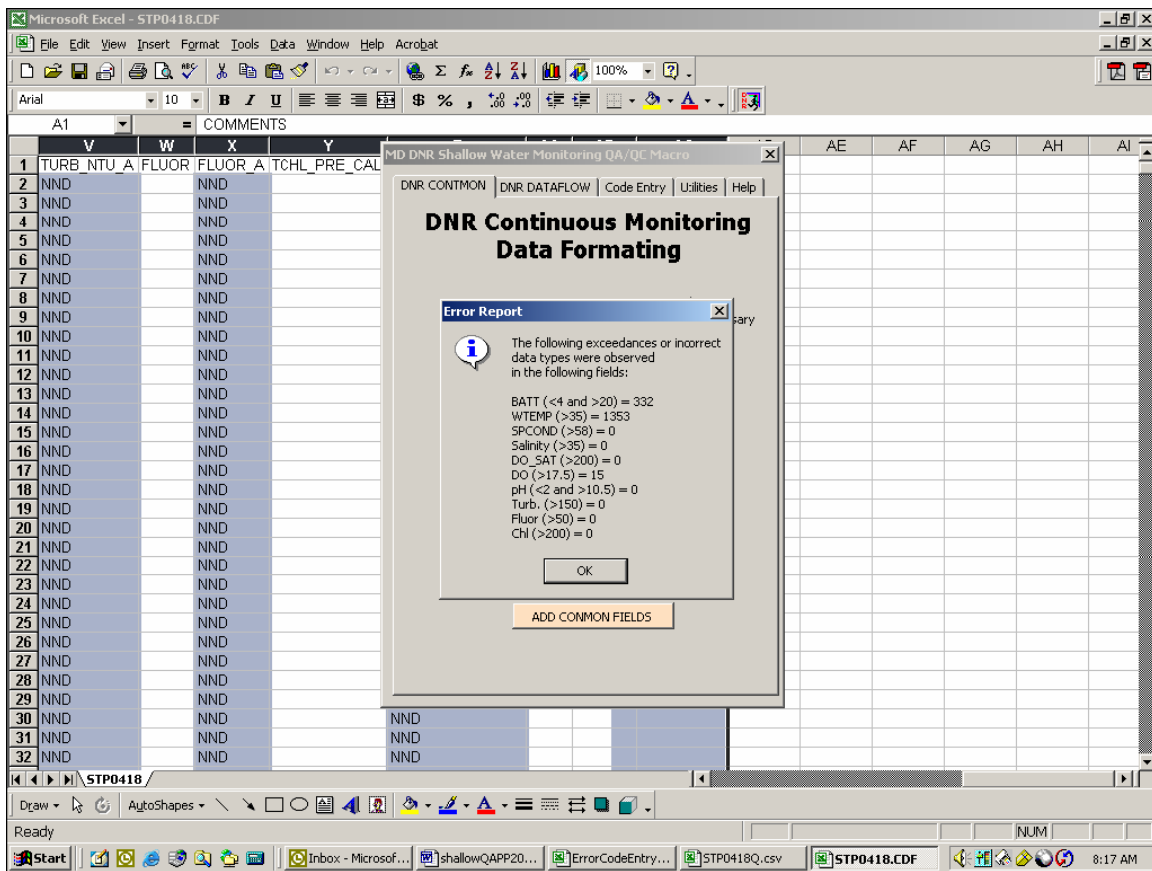


**Figure A13\_1. Screenshot of the QA/QC macro for continuous monitoring data formatting.**

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 A13\_1), and returns an overview summary of exceedances (Figure A13\_2). Tolerance levels are purposefully large to accommodate the diversity of data collected throughout Maryland’s Coastal and Chesapeake Bays.

**Table A13\_1. Tolerance levels 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 A13\_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:

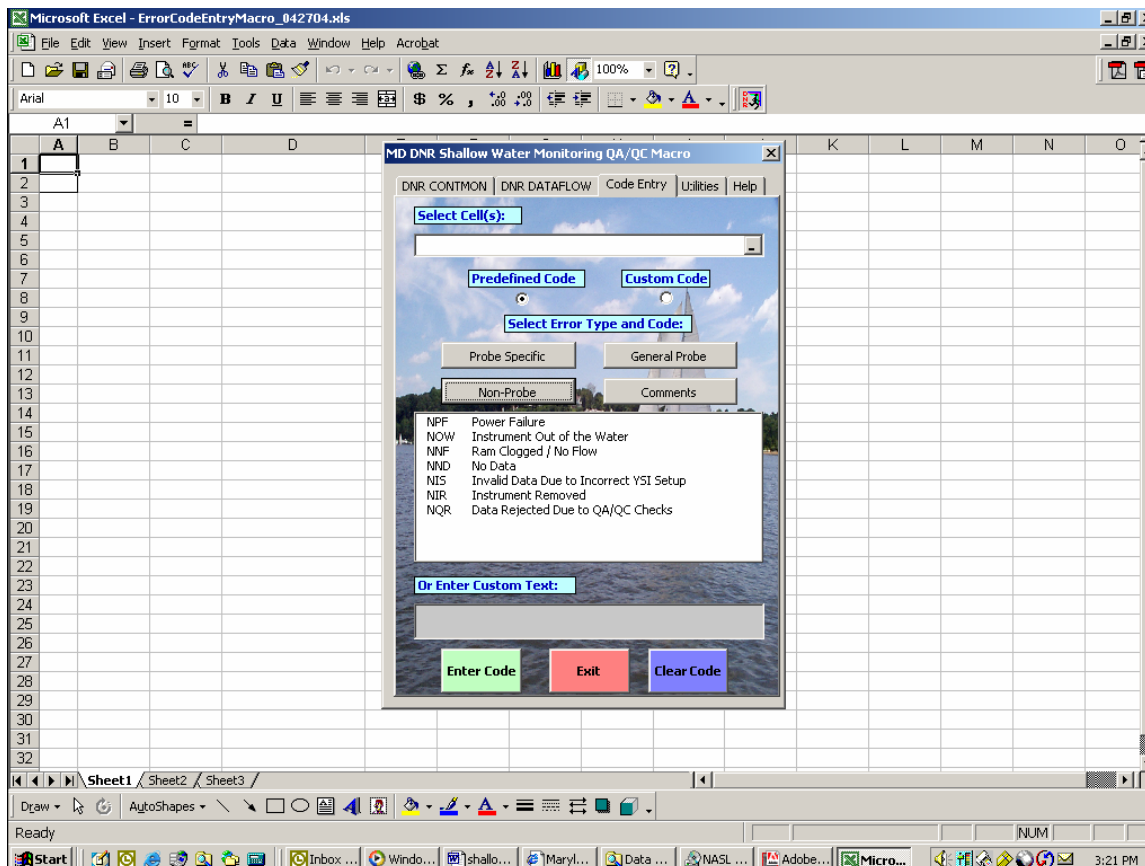
Sound data management practices dictate that data should never be deleted. As such, we employ a data management system in which all original data values are retained in the database, but erroneous data are masked with an error code (see Appendix 13 for list of error codes). Each parameter value field 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 A14\_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

A13\_3. Screenshot of QA/QC macro's code entry screen.

10) Using the procedures outlined above in Step 8 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.*

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., STP0418Q.csv).

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](http://www.eyesonthebay.net)) website to overwrite any existing provisional real-time data.

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

STP0418.dat (Raw data - no editing),  
STP0418.cdf (Exported file with travel time deleted), and  
STP0418Q.csv (Final QA/QC'd file with erroneous data masked)

## Appendix 14. Water Quality Mapping Data Verification and Management Procedures

W. Nelson, C. Heyer, M. Trice

Revised: 5/24/2004

- 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 "REARRANGE DATAFLOW DATA" button on the "DNR DATAFLOW" tab of the macro dialog (Figure A14\_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  
CHLA  
CHLA\_A  
COMMENTS

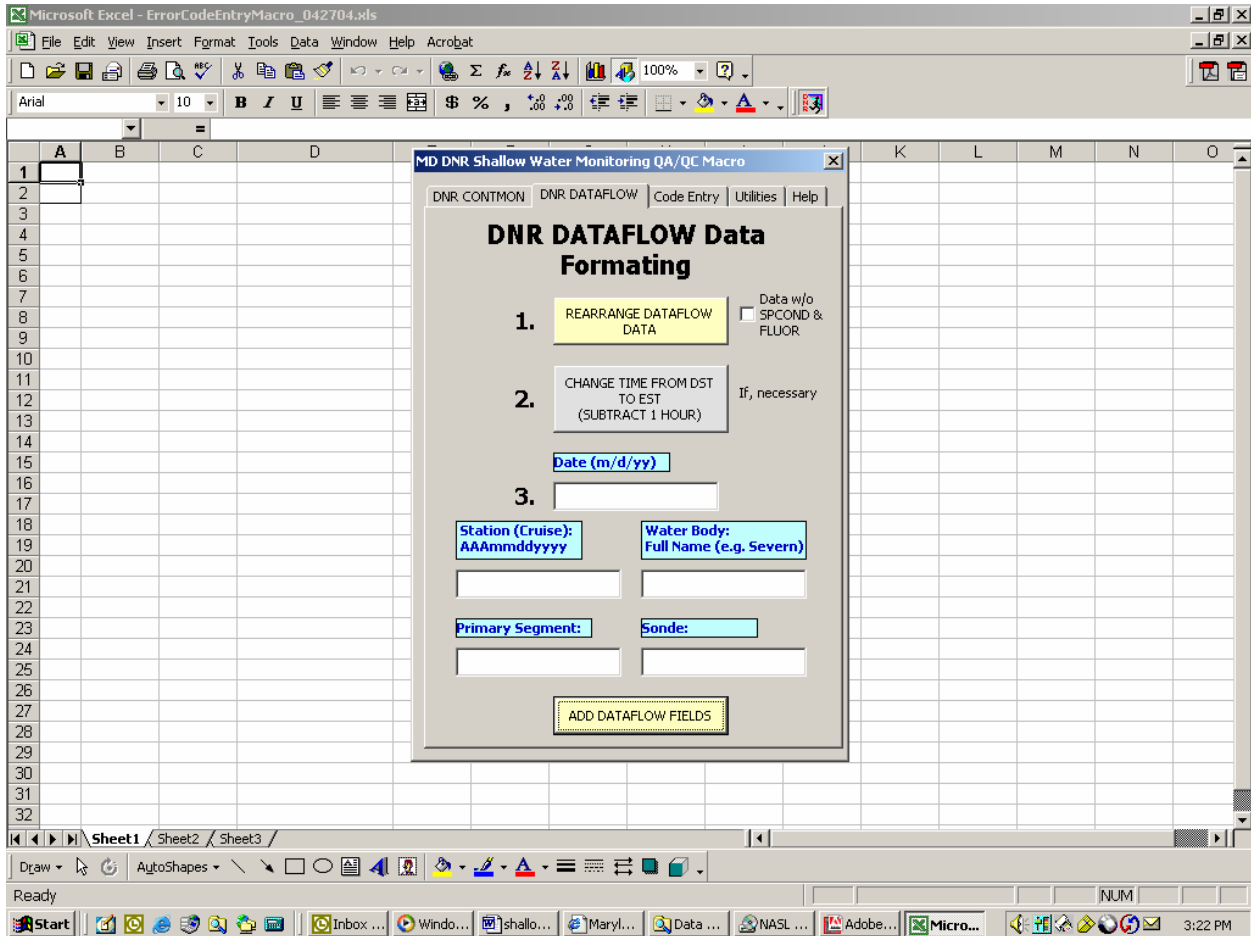


Figure A14\_1. Screenshot of the QA/QC macro for continuous monitoring data formatting.

- 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 A13\_1 in Appendix 13), and returns an overview summary of exceedances (Figure A13\_2 in Appendix 13). Tolerance levels are purposefully large to accommodate the diversity of data collected throughout Maryland’s Coastal and Chesapeake Bays.

Enter the Date, Station, Water Body, Primary Segment and Sonde information for the deployment being reviewed into the macro dialog box and click “ADD 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 13 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 A14\_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.
- 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)