Developing a New Chesapeake Bay Water Quality Indicator for Tracking Progress toward the EO's Water Quality Outcome

[09/17/2012 DRAFT—STILL SUBJECT TO REVIEW AND FURTHER CHANGES]

EPA needs to develop a combined indicator to measure progress towards the Chesapeake Bay Executive Order's water quality outcome, which is for 60% of segments attaining Bay water quality standards by 2025 via the implementation of pollution reduction actions for nitrogen, phosphorus and sediment. The 2009 baseline condition indicates that 89 of 92 segments of the Chesapeake Bay and its tidal tributaries and embayments are impaired (USEPA 2010). This new indicator could also replace the individual dissolved oxygen, water clarity and chlorophyll *a* indicators currently reported by the Chesapeake Bay Program Partnership.

There are a variety of unique combinations of criteria applied to each of the designated uses within each of the 92 segments which EPA and its four tidal water jurisdictional partners –DC, DE, MD, and VA—separately assess for water quality standards attainment (Figure 1). Each segment can have between 1 (i.e., Eastern Branch of the Elizabeth River which only has open water) and all 5 designated uses (i.e., Lower Rappahannock River which has migratory fish and spawning nursery, open-water, deep-water, deep-channel, and shallow-water bay grass designated uses) (Table 1).

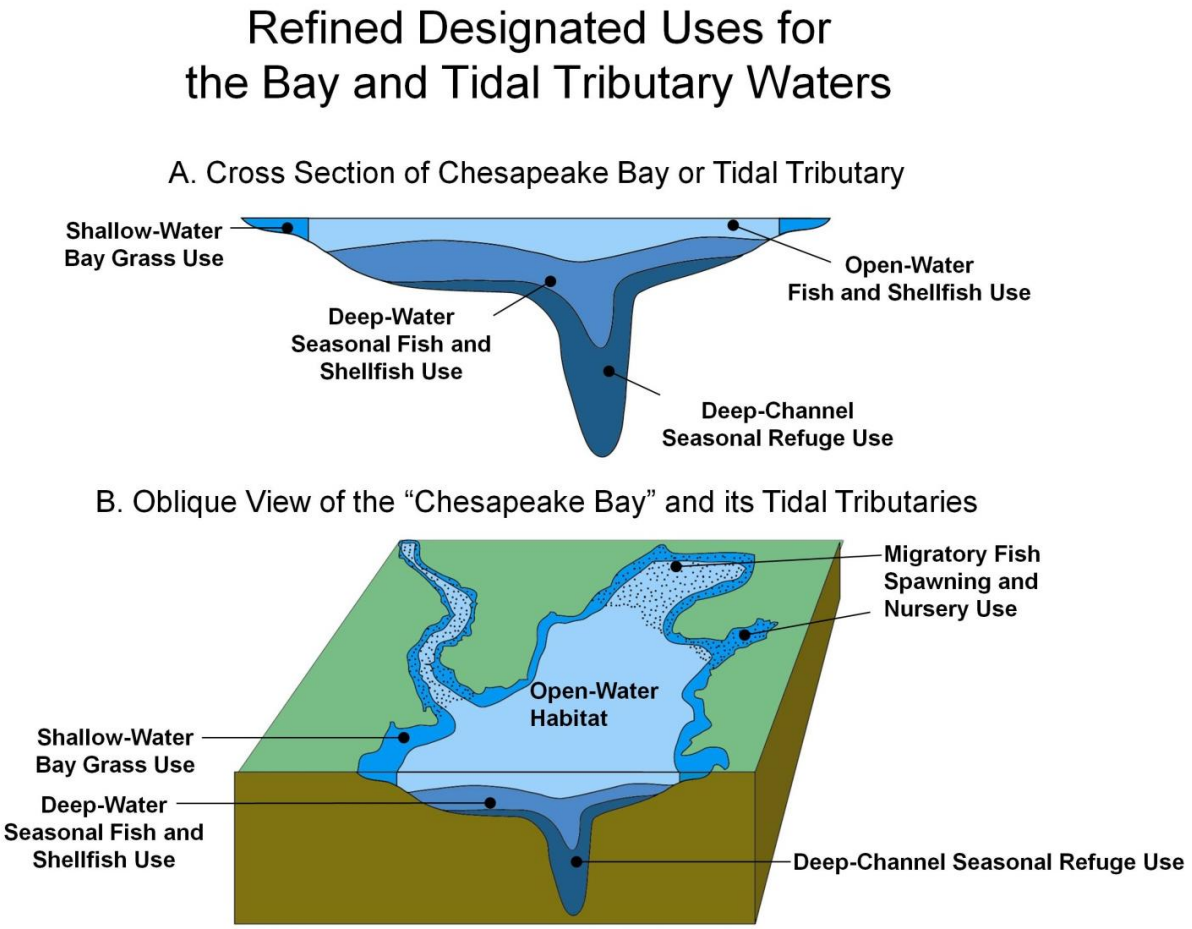

Figure 1. Conceptual illustration of the five Chesapeake Bay tidal water designated use zones.
Source: USEPA 2003

Table 1. Tidal water designated uses by Chesapeake Bay segment

Waterbody	CBP Segments & Split Segments	Jurisdiction	Migratory Spawning & Nursery	Open Water	Deep Water	Deep Channel	Shallow Water Bay grasses	Chlorophyll-a (applies to open water)
Anacostia River	ANATF_DC	DC	X	X			X	X
Anacostia River	ANATF_MD	MD	X	X			X	
Appomattox River	APPTF	VA	X	X			X	
Back River	BACOH	MD	X	X			X	
Big Annemessex River	BIGMH1	MD	X	X			X	
Big Annemessex River	BIGMH2	MD	X	X			X	
Bohemia River	BOHOH	MD	X	X			X	
Bush River	BSHOH	MD	X	X			X	
Northern Chesapeake Bay	CB1TF1	MD	X	X			X	
Northern Chesapeake Bay	CB1TF2	MD	X	X			X	
Upper Chesapeake Bay	CB2OH	MD	X	X			X	
Upper Central Chesapeake Bay	CB3MH	MD	X	X	X	X	X	
Middle Central Chesapeake Bay	CB4MH	MD	X	X	X	X	X	
Lower Central Chesapeake Bay	CB5MH_MD	MD		X	X	X	X	
Lower Central Chesapeake Bay	CB5MH_MD	MD		X	X	X	X	
Western Lower Chesapeake Bay	CB6PH	VA		X	X		X	
Eastern Lower Chesapeake Bay	CB7PH	VA		X	X		X	
Mouth of the Chesapeake Bay	CB8PH	VA		X			X	
Chickahominy River	CHKOH	VA	X	X			X	
Mouth of the Choptank River	CHOMH1	MD	X	X			X	
Lower Choptank River	CHOMH2	MD	X	X			X	
Middle Choptank River	CHOOH	MD	X	X			X	
Upper Choptank River	CHOTF	MD	X	X				
Lower Chester River	CHSMH	MD	X	X	X	X	X	
Middle Chester River	CHSOH	MD	X	X			X	
Upper Chester River	CHSTF	MD	X	X			X	
C&D Canal	C&DOH_MD	MD	X	X			X	
C&D Canal	C&DOH_DE	DE	X	X				
Corrotoman River	CRRMH	VA	X	X			X	
Eastern Bay	EASMH	MD		X	X	X	X	
Eastern Branch Elizabeth River	EBEMH	VA		X				
Mouth of the Elizabeth River	ELIPH	VA		X				
Elk River	ELKOH1	MD	X	X			X	

Elk River	ELKOH2	MD	X	X			X	
Fishing Bay	FSBMH	MD	X	X			X	
Gunpowder River	GUNOH1	MD	X	X			X	
Gunpowder River	GUNOH2	MD	X	X			X	
Honga River	HNGMH	MD		X			X	
Lower James River	JMSMH	VA	X	X			X	X
Middle James River	JMSOH	VA	X	X			X	X
Mouth of the James River	JMSPH	VA		X			X	X
Upper James River	JMSTF1	VA	X	X			X	X
Upper James River	JMSTF2	VA	X	X			X	X
Lafayette River	LAFMH	VA		X				
Little Choptank River	LCHMH	MD		X			X	
Lynnhaven River	LYNPH	VA		X			X	
Magothy River	MAGMH	MD	X	X	X		X	
Manokin River	MANMH1	MD	X	X			X	
Manokin River	MANMH2	MD	X	X			X	
Mattawoman Creek	MATTF	MD	X	X			X	
Middle River	MIDOH	MD	X	X			X	
Mobjack Bay	MOBPH	VA		X			X	
Lower Mattaponi River	MPNOH	VA	X	X				
Upper Mattaponi River	MPNTF	VA	X	X			X	
Lower Nanticoke River	NANMH	MD	X	X			X	
Middle Nanticoke River	NANOH	MD	X	X			X	
Upper Nanticoke River	NANTF_DE	DE	X	X				
Upper Nanticoke River	NANTF_MD	MD	X	X				
Northeast River	NORTF	MD	X	X			X	
Patapsco River	PATMH	MD	X	X	X	X	X	
Lower Patuxent River	PAXMH1	MD	X	X	X		X	
Lower Patuxent River	PAXMH2	MD	X	X	X		X	
Lower Patuxent River	PAXMH3	MD	X	X	X		X	
Lower Patuxent River	PAXMH4	MD	X	X	X		X	
Lower Patuxent River	PAXMH5	MD	X	X	X		X	
Lower Patuxent River	PAXMH6	MD	X	X	X		X	
Middle Patuxent River	PAXOH	MD	X	X			X	
Upper Patuxent River	PAXTF	MD	X	X			X	
Piankatank River	PIAMH	VA		X			X	
Piscataway Creek	PISTF	MD	X	X			X	
Lower Pamunkey River	PMKOH	VA	X	X				
Upper Pamunkey River	PMKTF	VA	X	X			X	

Lower Pocomoke River	POCMH_MD	MD	X	X			X	
Lower Pocomoke River	POCMH_VA	VA	X	X			X	
Middle Pocomoke River	POCOH_MD	MD	X	X				
Middle Pocomoke River	POCOH_VA	VA	X	X				
Upper Pocomoke River	POCTF	MD	X	X				
Lower Potomac River	POTMH_MD	MD	X	X	X	X	X	
Lower Potomac River	POTMH_VA	VA	X	X	X	X	X	
Middle Potomac River	POTOH1_MD	MD	X	X			X	
Middle Potomac River	POTOH2_MD	MD	X	X			X	
Middle Potomac River	POTOH3_MD	MD	X	X			X	
Middle Potomac River	POTOH_VA	VA	X	X			X	
Upper Potomac River	POTTF_MD	MD	X	X			X	
Upper Potomac River	POTTF_VA	VA	X	X			X	
Upper Potomac River	POTTF_DC	DC	X	X			X	X
Rhode River	RHDMH	MD	X	X			X	
Lower Rappahannock River	RPPMH	VA	X	X	X	X	X	
Middle Rappahannock River	RPPOH	VA	X	X			X	
Upper Rappahannock River	RPPTF	VA	X	X			X	
Sassafras River	SASOH1	MD	X	X			X	
Sassafras River	SASOH2	MD	X	X			X	
Southern Branch Elizabeth River	SBEMH	VA		X	X			
Severn River	SEVMH	MD	X	X	X		X	
South River	SOUMH	MD	X	X	X		X	
Tangier Sound	TANMH1_MD	MD		X			X	
Tangier Sound	TANMH2_MD	MD		X			X	
Tangier Sound	TAHMH_VA	VA		X			X	
Western Branch Elizabeth River	WBEMH	VA		X				
Western Branch Patuxent River	WBRTF	MD	X	X			X	
Wicomico River	WICMH	MD	X	X			X	
West River	WSTMH	MD	X	X			X	
Middle York River	YRKMH	VA	X	X			X	
Lower York River	YRKPH	VA		X	X		X	
TOTAL Number of Segments by Designated Use & Applicable Criteria			**83**	**104**	**23**	**10**	**90**	**7**

Note: This table contains additional split segments (in grey) beyond the 92 Chesapeake Bay segments for purposes of applying separate water clarity criteria application depths (0.5, 1, and 2 meters) within the same Bay segment for assessing water clarity/SAV criteria attainment only (USEPA 2004).

Source: USEPA 2010; Code of Maryland Title 26 Subtitle 08, Chapter 2, Section 3; Code of Virginia 9 62.1-44.13 3a; Delaware Administrative Code 7401; District of Columbia Municipal Regulations Title 21, Chapter 11.

There are two sets of decisions to be made in creating this water quality indicator: 1) how to address the fact that the CBP partnership has not fully developed/reached agreement on nor has EPA then published a full set of criteria assessment procedures for all the applicable dissolved oxygen criteria; and 2) whether to take an area-based approach versus the count of number of designated use segments approach to reporting the water quality indicator.

Criteria Assessment Options Resolution

We explored a series of options for analysis, and through previous FHTE meetings, we narrowed down to two options and a recommendation. For our two narrowed options, we defined percent of segments attaining on the basis of the count of the number attaining water quality standards. We conducted the analysis considering attainment for each segment by designated use (i.e., middle James River open-water) and applicable criteria (i.e., chlorophyll *a*).

The difference between the two options was directly related to the question posed earlier: how to address the fact that the CBP partnership has not fully developed/reached agreement on nor has EPA then published a full set of criteria assessment procedures for all the applicable dissolved oxygen criteria. Following further review, FHTE recommended that for those designated use criteria where a full suite of DO assessment procedures have not been agreed to by the partnership, the segment is considered to be in non-attainment. For example, for OW, DW, and Migratory Fish Spawning and Nursery, there is no published procedure in place for the assessment of the 7-day, 1-day means and instantaneous minimum, where applicable. Therefore, the OW, DW and Migratory Fish Spawning and Nursery designated uses are treated as not in attainment because we cannot assess attainment for all the applicable criteria. This approach is fully consistent with the states and the District's current listing approach for Chesapeake Bay segments.

COUNT APPROACH			
317 Designated Use Segments (making up the 92 CBP Segmentation Scheme)			
Designated Use	Total # DU Segments	# DU Segments in Attainment	% in Attainment
Migratory Fish Spawning and Nursery	83	0	0.00%
Open Water - DO	104	0	0.00%
Open Water CHLA (spring + summer)	7	0	0.00%
Deep Water - DO	10	1	10.00%
Deep Channel - DO	23	0	0.00%
Shallow-Water Bay Grasses - SAV/Water Clarity	90	27	30.00%
Baywide Percentage of WQS Attainment	**317**	**28**	**8.83%**

Please note that as the CBP partnership works through the remaining DO criteria assessment procedures and reaches agreement on how to assign the full array of Bay DO criteria, the percentage of designated use segment attaining will increase.

Accounting Options Resolution

We have been facing two set of choices for reporting the water quality indicator. The first choice was between using a cumulative volumetric- or area-based approach versus a total count approach for accounting for all the individual designated use segments attaining all

applicable criteria. If we decided to use the cumulative volumetric- or area based approach, we needed to make a second decision on whether to use volume or area.

We determined that strictly using a count of the number of segment, be they the original 92 segments or all the 317 designated use segments, would not be representative of the amount of Bay tidal waters achieving water quality standards. The shear size difference, whether measured as surface area or total volume, between the Magothy River segment and the middle central Chesapeake Bay is a several hundred fold. Weighting them equally by taking the count approach does not provide the public with an honest measure of how much of the Bay tidal waters are achieving water quality standards.

Then we considered taking a volumetric approach. This approach works well for dissolved oxygen criteria whose attainment is assessed on a volume-basis. However, in the case of the water clarity/SAV and chlorophyll a criteria, both are assessed on a surface area-basis. We were unable to determine a method for accounting for both volume and surface area within the same metric which would have accounted for the how much of the Bay tidal waters were achieving water quality standards.

Having narrowed down the choice for this approach to area, we were faced with more hurdles—how to account for the area for those segments with two or more designated uses with depth (e.g., open-water, deep-water, and deep-channel) and how to factor in the shallow-water uses which will have very small areas compared with open-water uses but are equally critically important habitats which need considered in the accounting.

The solution was using the surface area of each of the 92 segments times the number of applicable designated uses for that segment. This approach factors in the relative size of each segment, ensuring we report the best available measure of how much of the Bay tidal waters were achieving water quality standards. At the same time, this approach gives equal weight to achievement of the criteria protective of each designated use, preventing any need to weigh differently the importance of restoring dissolved oxygen versus bringing back underwater bay grasses.

AREA-BASED APPROACH			
317 Designated Use Segments (making up the 92 CBP Segmentation Scheme)			
Designated Use	Total Surface Areas (km^2)	Total Surface Areas IN ATTAINMENT (km^2)	% in Attainment
Migratory Fish Spawning and Nursery	5565101169.36	0.00	0.00%
Open Water - DO	11660174083.95	0.00	0.00%
Open Water CHLA (spring + summer)	620327627.29	0.00	0.00%
Deep Water - DO	6932558324.18	0.00	0.00%
Deep Channel - DO	4404190644.45	83660695.00	1.90%
Shallow-Water Bay Grasses - SAV/Water Clarity	11558645485.84	2616220341.04	22.63%
Baywide Percentage of WQS Attainment	40740997335.07	2699881036.04	6.63%

Finally, this approach also directly lends itself to a visual illustration of the indicator status in a single graphic—the relative shading or different color of each individual segment would reflect the percent of all applicable designated uses in attainment the applicable criteria—as well as a single percentage for all Bay tidal waters.

NOTE: The map below serves as an example of what a graphical illustration may look like and is meant purely for illustrative purposes.

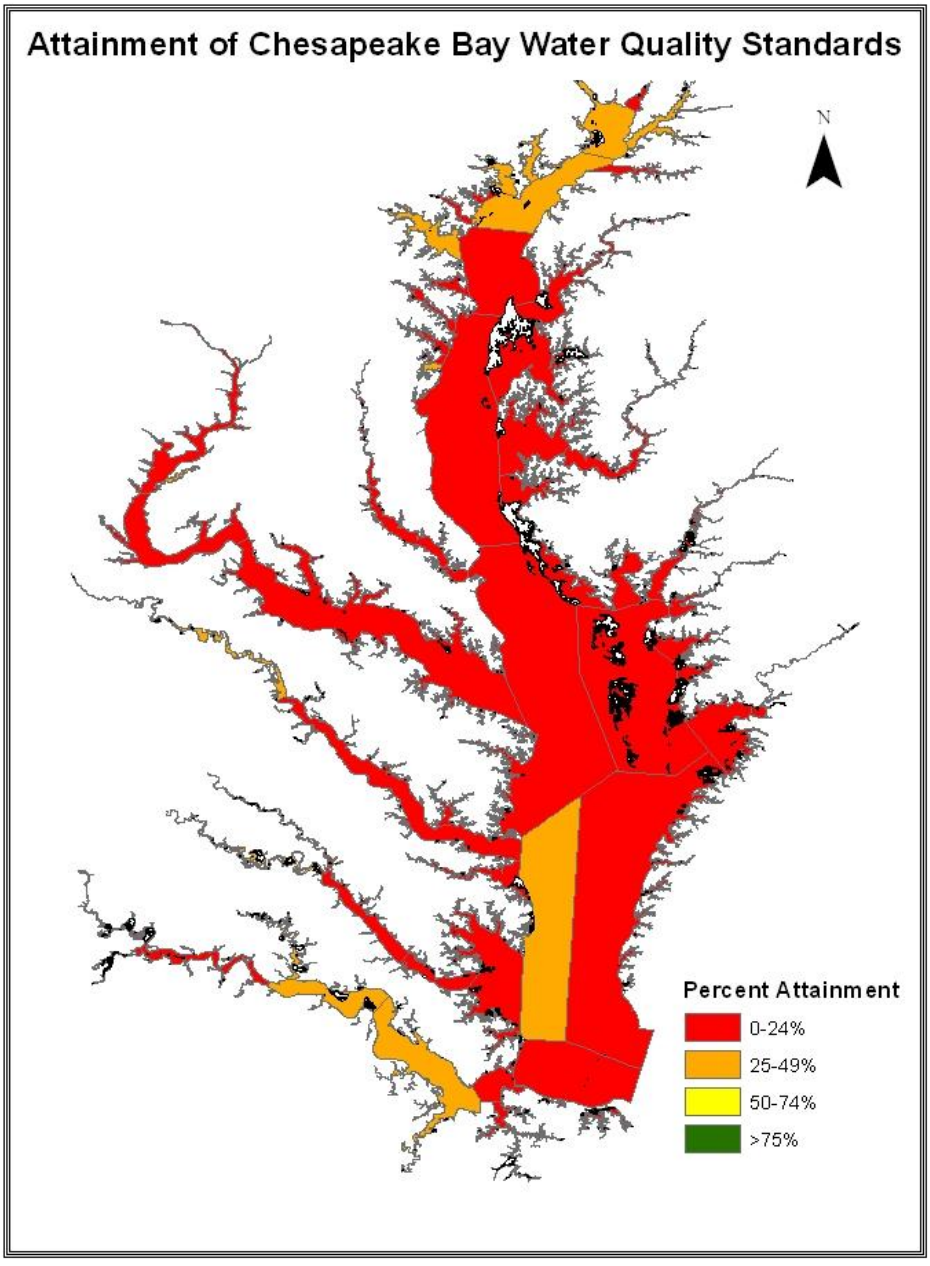

Figure 2. Visual illustration of the indicator status as a single percentage of attainment for all Bay tidal waters.

Recommended Water Quality Indicator

The recommended water quality indicator for reporting on progress towards the Executive Order's water quality outcome of "meet water quality standards for dissolved oxygen, clarity/underwater grasses and chlorophyll *a* in the Bay and tidal tributaries by implementing 100 percent of the pollution reduction actions for nitrogen, phosphorus and sediment no later than 2025, with 60 percent of segments attaining standards by 2025" is as follows:

- The indicator will be based on an accounting of attainment of all Bay water quality criteria—dissolved oxygen, clarity/underwater grasses, and chlorophyll *a*—applicable to the 317 designated use segments contained within the 92 Bay segments.

- The indicator will be reported annually as a baywide percentage based on the summation of the surface area of each of the 317 designated use segments determined to be in full attainment of its applicable criteria divided by the summation of the surface areas of all 317 designated use segments.

- For those designated use criteria where a full suite of dissolved oxygen assessment procedures have not been agreed to by the partnership and published by EPA, those respective designated use segments where these dissolved oxygen criteria apply will be considered to be in non-attainment.[1]

- The indicator will be graphically illustrated by shading or coloring each of the 92 Bay segments according to the percent of all applicable designated uses for that individual segment which are in attainment with the applicable criteria.

[1] By 2015, EPA and its jurisdictional partners are committed to working collaboratively on developing, agreeing to and then publishing criteria assessment procedures for the remaining dissolved oxygen criteria currently without approved assessment procedures.

References:

U.S. Environmental Protection Agency. 2003. *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries.* EPA 903-R-03-002. Region 3 Chesapeake Bay Program Office, Annapolis, MD.

U.S. Environmental Protection Agency. 2004. *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability.* EPA 903-R-03-004. Region 3 Chesapeake Bay Program Office, Annapolis, MD.

U.S. Environmental Protection Agency. 2010. *Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment*. Region 3 Chesapeake Bay Program Office, Annapolis, MD.