II. Virginia's Water Resources

A. Background Summary

Previous estimates indicated that the surface waters of Virginia were composed of approximately 49,350 miles of perennial streams and rivers, 149,982 acres of major reservoirs and lakes, 808,000 acres of freshwater wetlands, 236,900 acres of tidal salt marshes and coastal wetlands, 2,500 square miles of estuaries and 120 miles of Atlantic Ocean coastline, encompassing 440.75 square miles of near-shore oceanic waters. Figures cited in the 2012 305(b)/303(d) Integrated Water Quality Report (IR) listed 52,257 riverine miles, 2,684.5 square miles of estuary and 116,365 acres of reservoirs/lakes for assessment. Draft estimates based on the current status of the statewide 1:24,000 delineation of the new National Hydrological Dataset (NHD) suggest 102,121 perennial riverine miles, 2,834.5 square miles of estuaries and 121,148 reservoir/lake acres. These figures represent the agency's assessment units potentially associated with the Integrated Report and are still subject to change as regional office assessors evaluate waters for the 2014 IR. They do not include other surface water resources (*e.g.*, swamp/marsh features, etc.) that are not incorporated in the assessment.

As with the study of any geographic feature or natural resource, one of the first tasks necessary in the monitoring and assessment of water quality is to identify and describe the geographic locations and physical characteristics of the resources of interest. The identification (localization) and classification (description) of water bodies consist of two distinct processes involving different types of information. The first is related to describing the geographic location of the water body and the drainage basin with which is associated, while the other deals with the physical and chemical characteristics of the water body itself.

B. Identification (Localization) of Water Resources

Water resources almost always have a name of their own, which partially identifies them. Some water bodies, however, have more than one name that is used locally. The name of a single stream or river may also vary regionally, and it is not unusual for two or more streams, in the same or in different regions, to bear identical names. Consequently, the identification of an aquatic resource should also include its exact geographic location in addition to its name.

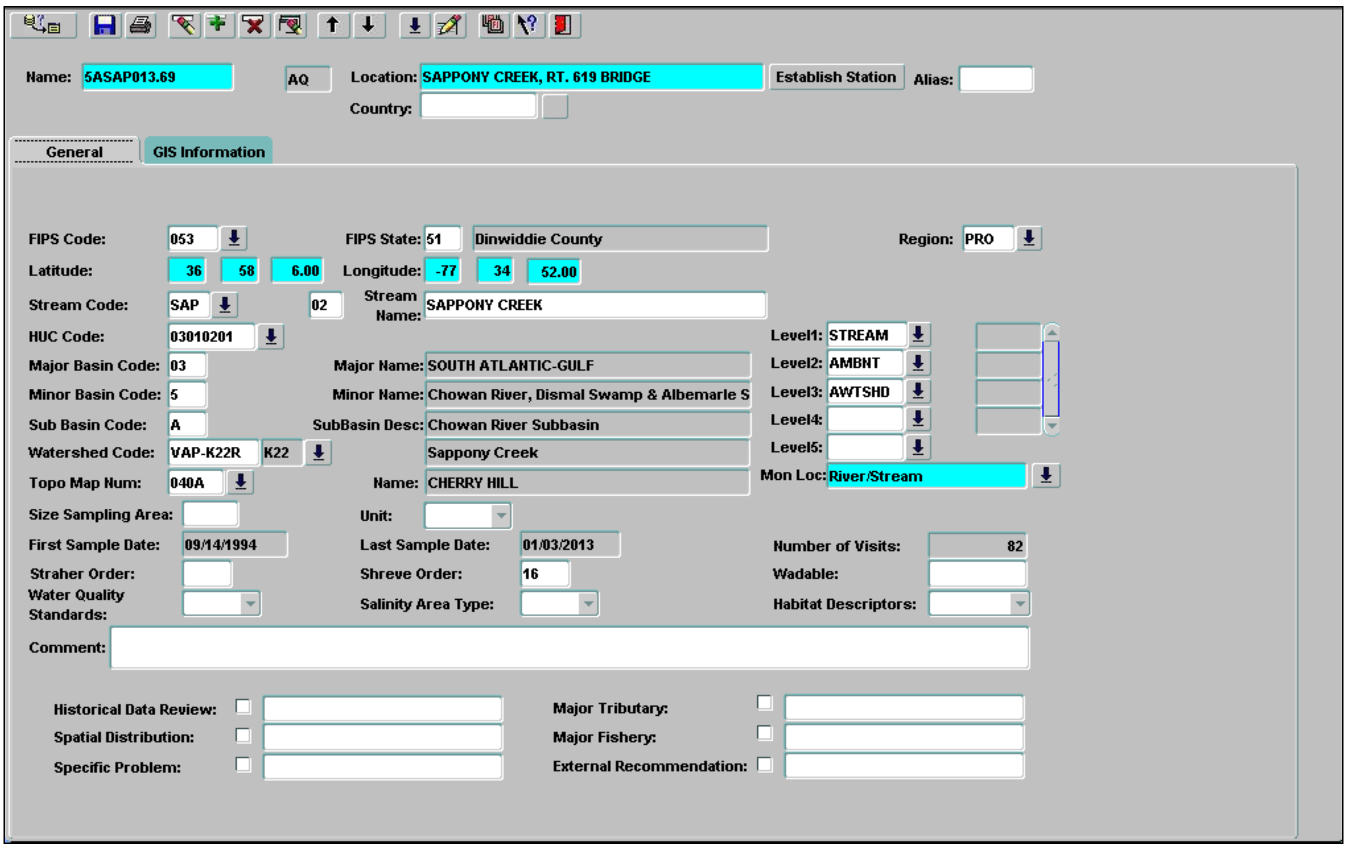
When one wishes to identify a physical point on the earth's surface, such as a water quality monitoring station, one of the most common ways to describe its location is by using its geographic coordinates, or latitude and longitude. On most conventional maps, latitudes and longitudes are expressed, respectively, as degrees, minutes and seconds north (N) or south (S) of the equator, and east (E) or west (W) of the prime (Greenwich) meridian. In modern electronic databases, however, with computer generated Geographic Information Systems (GIS), it is customary to represent geographic coordinates with decimal degrees. In such cases, north latitudes and east longitudes are represented by positive (+) decimal degrees, and south latitudes and west longitudes by negative (-) decimal degrees. This is sufficient to locate a single water quality sampling station on a map, or in the field with Geographical Positioning Systems (GPS), and is in fact used for this purpose on a daily basis.

Various systems of geographic coordinates have been developed through the years and in various regions of the earth. Consequently, it is important to specify the coordinate system being used, as well as to define the confirmed geographic coordinates of the location of interest. DEQ utilizes the coordinate system identified as the 1983 North American datum system (i.e., NAD '83) to express the locations of its monitoring sites and of other geographic points of interest. This coordinate system is the same as that utilized on USGS 7.5' topographic maps (1:24,000 scale) and by several web-based and/or computer software applications based on the same maps (e.g., TopoZone.com, DeLorme 3-D TopoQuads 2.0, or DeLorme Topo North America 9.0 software).

1. DEQ Conventions

In DEQ's 'Comprehensive Environmental Data System' (CEDS) database, location information is summarized in the 'Station List' screen, as illustrated in **Figure II-1** - "'Stations' screen from VA-DEQ's Comprehensive Environmental Data System." Geographic coordinates are presented in degrees, minutes and decimal seconds, and the degree value is preceded by a minus sign "–" to indicate south latitude or west longitude. This nomenclature facilitates the direct mathematical conversion of the coordinates into other forms, such as decimal degrees or degrees and decimal minutes, when desired.

Figure II-1. 'Stations' screen from VA-DEQ's Comprehensive Environmental Data System (CEDS)



On streams, rivers, and man-made reservoirs an additional identifier is often used to describe a specific point (monitoring station) on the reference line formed by the water body's centerline. By DEQ convention, this consists of a two-character basin/sub-basin code (*e.g.*, 5A), and a more specific three-character water body identification code (*e.g.*, SAP), followed by the number of "river miles" above the mouth of the stream or river on which the point is located (*e.g.*, 013.69). Within the Commonwealth of Virginia, the principal rivers and the tributaries that feed them are first identified by a numerical code for each major drainage basin. Larger stream systems may be subdivided into major segments or sub-basins that are identified by letter. **Figure II-2** Virginia's Major River Basins summarizes the major and minor river basin classification scheme currently in use by DEQ.

Following a VA-DEQ convention, rivers and streams within each major basin or sub-basin (including man-made reservoirs) are then identified using a three-letter code, based on the stream name. This is followed by

Figure II-2 Virginia's Major River Basins

Virginia's Major River Basins and Sub-Basins
(Updated with 2006 NWBD changes)

DEQ Basin Code	DEQ Sub-Basin Code	DEQ Basin Name	DEQ Sub-Basin Name	USGS Cataloging Unit/Sub-Basin Name	USGS 8-Digit Hydrologic Unit (Sub-Basin) Code	Local Virginia Watershed Codes (1995 DEQ/DCR/NRCS)
1-		Potomac/Shenandoah River Basin				A01 - A34, B01 - 58
	1A		Lower Potomac River Sub-Basin			A01 - A34
			1A	Middle Potomac-Catoctin	02070008	A01 - A11
			1A	Middle Potomac-Anacostia-Occoquan	02070010	A12 - A25
			1A	Lower Potomac	02070011	A26 - A34
	1B		Upper Potomac River / Shenandoah River Sub-Basin			B01 - B58
			1B	South Branch Potomac [1]	02070001	B01 - B03
			1B	Conococheague-Opequon [1]	02070004	B04 - B09
			1B	South Fork Shenandoah	02040005	B10 - B41
			1B	North Fork Shenandoah	02070006	B42 - B54
			1B	Shenandoah	02070007	B55 - B58
2-		James River Basin				I01 - I38, H01 - H39, G01 - G15, J01 - J17
	2A		Upper James River Sub-Basin			I01 - I38
			2A	Upper James	02080201	I01 - I28
			2A	Maury	02080202	I29 - I38
	2B		Middle James River Sub-Basin [2]			H01 - H39
			2B	Middle James-Buffalo	02080203	H01 - H22
			2B	Rivanna	02080204	H223 - H32
			2B	Middle James-Willis	02080205	H33 - H39
	2C		Lower James River Sub-Basin (tidal) [2]			G01 - G15
			2C	Lower James	02080206	G01 - G11
			2C	Hampton Roads	02080208	G12 - G15
	2D		Appomattox Sub-Basin (formerly included in 2B)			J01 - J17
			2D	Appomattox	02080207	J01 - J17
3-		Rappahannock River Basin				E01 - E26
	3-		Rappahannock River Basin (No DEQ Sub-Basins)			E01 - E26
			3-	Rapidan-Upper Rappahannock	02080103	E01 - E18
			3-	Lower Rappahannock	02080104	E19 - E26
4-		Roanoke River Basin				L01 - L82, M01 - M03
	4A		Roanoke River Sub-Basin			L01 - L82
			4A	Upper Roanoke	03010101	L01 - L29
			4A	Middle Roanoke	03010102	L30 - L41, L75 - L77
			4A	Upper Dan	03010103	L42 - L59
			4A	Lower Dan	03010104	L10 - L64, L73 - L74
			4A	Banister	03010105	L65 - L72
			4A	Roanoke Rapids	03010106	L78 - L82
	4B		Yadkin River Sub-Basin			M01 - M03
			4B	Upper Yadkin	03040101	M01 - M03

[1] The South Branch Potomac and the Conococheague-Opequon are included in the Potomac River Sub-Basin (1A) for regulatory purposes. They were included in Sub-Basin 1B by DCR/NRCS during the 1995 elaboration of the local watershed delineations.

[2] For regulatory (Water Quality Standards) purposes, that portion of the Lower James and its tributaries from Barrets Point (at mouth of the Chicahominy River) to the fall line in Richmond is included in the "Middle James" as "tidal freshwater".

Figure II-2 Virginia's Major River Basins (continued)

Virginia's Major River Basins and Sub-Basins (Updated with 2006 NWBD changes to 8-digit hydrologic units)						
DEQ Basin Code	**DEQ Sub-Basin Code**	**DEQ Basin Name**	**DEQ Sub-Basin Name**	**USGS Cataloging Unit/Sub-Basin Name**	**USGS 8-Digit Hydrologic Unit (Sub-Basin) Code**	**Local Virginia Watershed Codes** (1995 DEQ/DCR/NRCS)
5-		**Chowan River and Dismal Swamp Basin**				**K01 - K42**
	5A		**Chowan River Sub-Basin**			**K01 - K38**
			5A	**Nottoway**	**03010201**	**K14 - K30**
			5A	**Blackwater**	**03010202**	**K31 - K36**
			5A	**Chowan**	**03010203**	**K37 - K38**
			5A	**Meherrin**	**03010204**	**K01 - K13**
	5B		**Dismal Swamp Sub-Basin** (to Albemarle Sound)			**K39 - K42**
			5B	**Albemarle** (Back Bay, North Landing River, etc.)	**03010205**	**K39 - K42**
6-		**Tennessee and Big Sandy River Basins**				**Q01 - Q14, P01 - P24, O01 - O14**
	6A		**Big Sandy River Sub-Basin**			**Q01 - Q14**
			6A	**Tug**	**05070201**	**Q01 - Q03**
			6A	**Upper Levisa**	**05070202**	**Q04 - Q14**
	6B		**Clinch River / Powell River Sub-Basin**			**P01 - P24**
			6B	**Upper Clinch**	**06010205**	**P01 - P16**
			6B	**Powell**	**06010206**	**P17 - P24**
	6C		**Holston River Sub-Basin**			**O01 - O14**
			6C	**North Fork Holston**	**06010101**	**O09 - O14**
			6C	**South Fork Holston**	**06010102**	**O01 - O08**
7-		**Chesapeake Bay and Small Coastal Basins**				**C01 - C16, D01 - D07, R01**
	7A		**Chesapeake Bay - Mainstem**			
			7A	**Lower Chesapeake Bay**	**02080101**	**R01**
	7B		**Chesapeake Bay - Minor Tributaries and Embayments**			**C01 - C16**
			7B	**Great Wicomico-Piankatank**	**02080102**	**C01 - C06**
			7B	**Lynnhaven-Poquosin**	**02080108**	**C07- C08 (D07 [3])**
			7B	**Tangier**	**02080110**	**R01 [4]**
			7B	**Pocomoke-Western Lower Delmarva**	**02080111**	**C09 - C16**
	7C		**Coastal Delmarva**			**D01 - D07**
			7C	**Chincoteague**	**02040303**	**D01**
			7C	**Eastern Lower Delmarva**	**02040304**	**D02-D07 [3]**
	7D		**Atlantic Ocean south of Rudee Inlet**			**K42**
			7D	**Albemarle** (shoreline to 3 Km territorial limit)	**03010205**	**K42**
8-		**York River Basin**				**F01 - F27**
	8-		**York River Basin** (No DEQ Sub-Basins)			**F01 - F27**
			8-	**Mattaponi**	**02080105**	**F15 - F25**
			8-	**Pamunkey**	**02080106**	**F01 - F14**
			8-	**York**	**02080107**	**F26 - F27**
9-		**New River Basin**				
	9-		**New River Basin** (No DEQ Sub-Basins)			**N01 - N37**
			9-	**Upper New**	**05050001**	**N01 - N22**
			9-	**Middle New**	**05050002**	**N23 - N37**

[3] D07 (Rudee Inlet) was previously included in the USGS 8-digit HUC 02080108 (Lynnhaven-Poquosin), although the local watershed drains directly to the Atlantic Ocean! In the National Watershed Boundary Dataset (NWBD) it is included in 02040304 - Eastern Lower Delmarva.

[4] The Tangier Island region was not differentiated from the Chesapeake mainstem in the 1995 DCR/NRCS delineation. It was included in the new 8-digit HUC bearing its name in the 2006 NWBD delineation.

Note: The newly completed 'National Watershed Boundary Dataset' has established new nomenclature for 6- and 8-digit hydrological units. They are now referred to as '3rd Order Basins' (6-digit) and '4th Order Sub-Basins' (8-digit), respectively. See a five-digit numerical value (with two decimal places) that identifies the specific point on the stream as the number of miles upstream from the stream's mouth. This is defined to be "river-miles" above its discharge the following section on the 'National Watershed Boundary Dataset'. The names and codes for several Delmarva Peninsula Sub-Basins have also been changed.

a five-digit numerical value (with two decimal places) that identifies the specific point on the stream as the number of miles upstream from the stream's mouth. This is defined to be "river-miles" above its discharge point into a receiving water body, at which point the name of the larger water body would prevail. For example, a DEQ ambient water quality monitoring station is located at latitude 36^{o} 58' 06.00" N (36.9683 decimal degrees) and longitude -77^{o} 34' 52.00" W (-77.5811 decimal degrees). Its location is also specified by its station identification number, 5ASAP013.69, such that:

5A……	Chowan River Sub-basin of the Chowan & Dismal Swamp Basin, on
… SAP …	Sappony Creek,
……… 013.69	13.69 river miles above its confluence with Stony Creek (STO)

Such a 'Station Name' is highlighted in the first field of the Station screen illustrated in **Figure II-1**. A number of additional fields within this figure will be discussed in the text below. These waters subsequently join the Nottoway River and then the Blackwater River, where the two join to form the Chowan River as they flow into North Carolina, and ultimately into Albemarle Sound and the Atlantic Ocean.

2. USGS 8-Digit Hydrologic Units

A water quality sampling station, whether identified by its latitude and longitude or by its specific alphanumerical code, is a point on the earth's surface. The data collected there, however, are considered to be representative of a water body segment (and some portion of the geographic area that it drains). It is insufficient to identify a water body with a single pair of geographic coordinates because a water body possesses dimensions that, in many cases, are geographically extensive. For management purposes, a monitoring station's location must also be related to the specific watershed or drainage (hydrologic unit) that supplies its water, to the surrounding region and its associated characteristics (*e.g.*, geology, types of land use) that may affect the quality of its water, and to the larger drainage basin to which it contributes. Consequently, the functional concept and identification of hydrologic units is extremely important in the monitoring, assessment and regional management of surface waters.

After the Nottoway and Blackwater Rivers leave Virginia, additional sampling stations that monitor their waters in North Carolina may be identified using another State's system of identification. A separate numerical code, based on federal hydrologic units or drainage basins, has been standardized nationally and serves to unify nomenclature for water bodies that bridge state boundaries. The United States Geological Survey (USGS), of the Department of the Interior, considered numerous federal and state sources in producing its original hierarchical classification of hydrologic units based on regional, sub-regional, accounting and cataloging unit boundaries. Each local cataloging unit was identified by an eight-digit numerical code, composed of four two-digit couplets. For example, the USGS Hydrologic Unit Code 03010201 ('HUC Code' in **Figure II-2** - Virginia's Major River Basins) identifies:

03………	South Atlantic-Gulf Region
…01……	Chowan-Roanoke Sub-region
……02…	Albemarle-Chowan Accounting Unit [3]
………01	Nottoway Cataloging Unit [1]

[3] A more recent update of the USGS hydrological unit system (the National Watershed Boundary Dataset - NWBD) has changed the nomenclature used for 'Accounting Units' and 'Cataloging Units'… these levels of classification are now referred to as '3rd Order Basins' and '4th Order Sub-Basins', respectively. In addition, the names and 8-digit numerical codes of several hydrological units on the Delmarva Peninsula have been changed. Refer to the section below on the 'National Watershed Boundary Dataset.'

This is the same drainage basin, sub-basin and river (Nottoway) as that identified by the Virginia DEQ Station Name above. These eight-digit USGS cataloging unit codes are also recorded as water body identifications associated with all water quality monitoring stations and their data. A more recent national effort by the Natural Resources Conservation Service (NRCS) of the U.S. Department of Agriculture divided these USGS cataloging units into smaller watershed planning units of approximately 250,000 acres in average size. This would produce an eleven-digit level of hydrologic unit detail. This level of delineation, however, was never completed for Virginia (see below).

USGS regional, sub-regional, accounting and cataloging unit boundaries are commonly overlaid on maps of smaller, Commonwealth of Virginia hydrologic (or watershed) units, because they correspond to the geographic boundaries of major watersheds and drainage systems. Virginia contains portions of four major USGS regions (02 - Mid-Atlantic, 03 - South Atlantic-Gulf, 05 - Ohio, and 06 - Tennessee), eight sub-regions, eleven accounting units and forty-eight cataloging units. A comprehensive list of the USGS hydrological units found in Virginia, along with their names and other states included in the same unit, is presented above in **Figure II-3** - Comprehensive List of Virginia's USGS Hydrological Units.

3. NRCS/DCR Hydrologic Units - 1995

The USGS cataloging units (8-digit HUCs) are convenient and appropriate for describing the source, flow and destination of surface waters. However, they are generally too large to be useful for representative monitoring, for the assessment of local water quality problems, and for the planning and application of remedial measures or for the efficient evaluation of their results. Also, political subdivisions must be considered in addition to hydrologic unit boundaries when planning or making management decisions on a local or regional basis. The Commonwealth of Virginia consequently developed a system of classification for smaller hydrologic units within its jurisdiction during the early 1990's. The Department of Conservation and Recreation's Division of Soil and Water Conservation (DCR-DSWC) established a system of small watershed identification for Virginia in 1995, following several years of intensive collaboration with the Virginia Department of Environmental Quality and the federal Natural Resources Conservation Service (NRCS).[4] A Hydrological Atlas for the Commonwealth of Virginia (USDA-NRCS & VA-DCR, 1995) was published as a result of these efforts. The comprehensive list of "Virginia's DEQ/ DCR Designated Watersheds (1995 delineation)" [II-B-3.pdf], linked to this document, lists these 493 local Virginia watersheds (plus Chesapeake Bay) alphabetically by their three-character identification codes. The list also provides the complete name of each local watershed, the identification of the 8-digit HUC within which it falls, its total area, and the area within each associated political jurisdiction (county/city). A brief historical summary of the evolution of hydrologic unit geography in Virginia can be found on the Department of Conservation and Recreation (DCR) WebPages.

The 1995 delineation of local 14-digit watersheds satisfied Virginia's needs at that time, as well as meeting the NRCS guidelines for mapping and digitizing hydrologic units (HU):

1. HU delineation should be coordinated across state boundaries.
2. HUs of less than 3000 acres should not be delineated, unless necessary in VA's portion of a larger, interstate HU.

[4] The 1995 watershed delineations have more recently (2006) been supplanted by the delineation of 5th Order (10-digit) watersheds and 6th Order (12-digit) sub-watersheds following guidelines provided for the 'National Watershed Boundary Dataset' (NWBD). Refer to the descriptions of these watershed/sub-watershed delineations at the end of this section.

Figure II-3 - Comprehensive List of Virginia's 8-Digit USGS Hydrological Units

(Prior to the NWBD Revision – 2002-2006)

8-Digit USGS HUC	USGS Watershed Name (Accounting Unit / Cataloging Unit)	Other States Included	Virginia DCR/DEQ Watersheds Included (1995)
02 - Mid Atlantic Region			
0206 - Upper Chesapeake Subregion			
020600--	**Upper Chesapeake Accounting Unit**		
02060009	Pocomoke	VA DE, MD	C09
02060010	Chincoteague	VA DE, MD	D01
0207 - Potomac Subregion			
020700--	**Potomac Accounting Unit**		
02070001	South Branch Potomac	VA WV	B01-B03
02070004	Conococheague-Opequon	VA MD, PA, WV	B04-B09
02070005	South Fork Shenandoah	VA	B10-B41
02070006	North Fork Shenandoah	VA	B42-B54
02070007	Shenandoah	VA MD, WV	B55-B58
02070008	Middle Potomac - Catoctin	VA MD	A01-A11
02070010	Middle Potomac - Anacostia - Occoquan	VA MD, DC	A12-A25
02070011	Lower Potomac	VA MD, DC	A26-A34
0208 - Lower Chesapeake Subregion			
020801--	**Lower Chesapeake Accounting Unit**		
02080101	Lower Chesapeake Bay (Mainstem)	VA	R01
02080102	Great Wicomico - Piankatank	VA	C01-C06
02080103	Rapidan - Upper Rappahannock	VA	E01-E18
02080104	Lower Rappahannock	VA	E19-E26
02080105	Mattaponi	VA	F15-F25
02080106	Pamunkey	VA	F01-F14
02080107	York	VA	F26-F27
02080108	Lynnhaven - Poquoson	VA	C07-C08, D07
02080109	Western Lower Delmarva	VA	C10-C16
02080110	Eastern Lower Delmarva	VA	D02-D06
020802--	**James Accounting Unit**		
02080201	Upper James	VA WV	I01-I28
02080202	Maury	VA	I29-I38
02080203	Middle James - Buffalo	VA	H01-H22
02080204	Rivanna	VA	H23-H32
02080205	Middle James - Willis	VA	H33-H39
02080206	Lower James	VA	G01-G11
02080207	Appomattox	VA	J01-J17
02080208	Hampton Roads	VA	G12-G15

Note: In the more recent hydrological unit classification of the 'National Watershed Boundary Dataset' the Delaware Sub-Region (0204) has been extended southward along the Atlantic Coast to Rudee Inlet, in Virginia Beach. Several 8-digit HUCs on both sides of the Delmarva Peninsula have new codes and/or new names! HUC names or HUC codes that have undergone such changes in the newer classification are identified in red font. (Refer to **Figure II-2** for current identifications!)

Figure II-3 - Comprehensive List of Virginia's 8-Digit USGS Hydrological Units (continued)

8-Digit USGS HUC	USGS Watershed Name (Accounting Unit / Cataloging Unit)	Other States Included	Virginia DCR/DEQ Watersheds Included
03 - South Atlantic-Gulf Region			
0301 - Chowan-Roanoke Subregion			
030101--	**Roanoke Accounting Unit**		
03010101	Upper Roanoke	VA	L01-L29
03010102	Middle Roanoke	VA NC	L30-L41, L75-L77
03010103	Upper Dan	VA NC	L42-L59
03010104	Lower Dan	VA NC	L60-L64, L73-L74
03010105	Banister	VA	L65-L72
03010106	Roanoke Rapids	VA NC	L78-L82
030102--	**Albemarle-Chowan Accounting Unit**		
03010201	Nottoway	VA NC	K14-K30
03010202	Blackwater	VA NC	K31-K36
03010203	Chowan	VA NC	K37-K38
03010204	Meherrin	VA NC	K01-K13
03010205	Albemarle	VA NC	K39-K42
0304 - Pee Dee Subregion			
030401--	**Upper Pee Dee Accounting Unit**		
03040101	Upper Yadkin	VA NC	M01-M03
05 - Ohio Region			
0505 - Kanawa Subregion			
050500--	**Kanawha Accounting Unit**		
05050001	Upper New	VA NC, TN	N01-N22
05050002	Middle New	VA WV	N23-N37
0507 - Big Sandy-Guyandotte Subregion			
050702--	**Big Sandy Accounting Unit**		
05070201	Tug	VA KY, WV	Q01-Q03
05070202	Upper Levisa	VA KY	Q04-Q14
06 - Tennessee Region			
0601 - Upper Tennessee Subregion			
060101--	**French Broad-Holston Accounting Unit**		
06010101	North Fork Holston	VA TN	O09-O14
06010102	South Fork Holston	VA TN	O01-O08
060102--	**Upper Tennessee Accounting Unit**		
06010205	Upper Clinch	VA TN, KY	P01-P16
06010206	Powell	VA TN, KY	P17-P24

3. HU water feature breaks should be at physical features, particularly lake outlets, dams, and stream junctions.
4. HUs with non-contributing surface flow can be joined when their subsurface connection can be determined.
5. HUs should be sequentially coded, beginning upstream and proceeding downstream.

The HU boundaries defined by the 1995 system were coordinated, as far as possible, with the states of North Carolina, Tennessee, West Virginia, and Maryland. The newly defined boundaries were in better agreement with local and regional watershed geography than in the previous system, and their digitized form was more accurate. The new HU descriptions were more correct and more consistent in content than their predecessors and included in their names, by listing order, a ranking of the major water features appearing in any HU. The 1995 watershed designations, together with codes, names, maps and information on their areas, political jurisdictions, etc. are available in the Virginia Hydrological Unit Atlas (USDA-NCRS, et al., 1995).

The VIRGINIA HU (watershed) Code of K22 would thus complement the USGS hydrologic unit code above (03010201), which identifies the USGS 'Cataloging Unit'[5] of the sampling station (5ASAP013.69) on Sappony Creek. This code (K22) identified the "Sappony Creek" drainage, from its headwaters to its confluence with Stony Creek, approximately two miles upstream from the village of Stony Creek in western Sussex County. Virginia's major and minor river basins - as listed, described, and coded above, in **Figure II-2** - each has its own series of 8-digit hydrological units and associated smaller watersheds.

In DEQ's CEDS database additional modifiers are often added to the local watershed codes to identify the DEQ Regional Office responsible for monitoring a specific site (see **Figure II-4** - Local Watershed prefixes identifying VA-DEQ Regional Office responsibilities) and the general type of water body involved (*e.g.*, R = stream or river; L = lake or reservoir; E = estuary). For example, VAP-K22R in the 'Watershed Code' field of **Figure II-1** indicates that monitoring station 5ASAP013.69 is under the responsibility of DEQ's Piedmont Regional Office (VAP), is in watershed K22 (Sappony Creek), and is a stream station (R).

Figure II-4 - Local Watershed prefixes identifying VA-DEQ Regional Office responsibilities

VAC	SCRO – South Central Regional Office
VAN	NVRO - Northern Virginia Regional Office
VAP	PRO – Piedmont Regional Office
VAS	SWRO – Southwest Regional Office
VAT	TRO – Tidewater Regional Office
VAV	VRO – Valley Regional Office
VAW	WCRO – West Central Office

Note: The South Central Regional Office (SCRO) and the West Central Regional Office (WCRO) were more recently (2008) united to form a single Blue Ridge Regional Office (BRRO), but Watershed Codes in CEDS maintain the former regional office designations.

Thus, the Commonwealth of Virginia contains all, or part of, 493 local watershed units, plus its portion of the Chesapeake Bay mainstem. "Virginia Watershed Identifications" [II-B-3.pdf], as cited above, includes a comprehensive list of these 1995 watersheds, with their respective names, areas, and the political jurisdictions within which they fall. As indicated, with a few minor exceptions, the minimum size of a

[5] As previously pointed out, the term 'Cataloging Unit' has been replaced by the term 'Sub-Basin' in the more recent 'National Watershed Boundary Dataset' – see the discussion later in this chapter.

defined hydrologic unit was set at 3000 acres. In fact, the defined watershed units in Virginia vary in size from a minimum of 1228 acres (portion of K37 - Upper Chowan River/Buckhorn Creek - to North Carolina) to a maximum of 199,258 acres (G11 - James River / Pagan River / Warwick River / Chuckatuck Creek). Their average size is closer to 30,000 than to 3000 acres. (The Virginia portion of the Chesapeake Bay mainstem is considered to be a single hydrologic unit [02080101 = R01], and contains approximately 782,484 acres.) When land use practices are reasonably uniform within such smaller watershed units, the unit may be of adequate size for the implementation and evaluation of best management practices to maintain or improve water quality. Often, however, heterogeneity within such units may still inhibit the application of uniform management plans, and representative monitoring of water quality would also be needed on a more local scale. Consequently, management may be related to even smaller drainage basins within Virginia watershed units when needed and, when resources permit, monitoring may be relegated to more homogeneous stream segments within each watershed.

In addition, the National Hydrography Dataset (NHD - http://nhd.usgs.gov/) has provided computer-based files, which include the complete hydrography of most national drainage networks, for Geographic Information Systems (GIS). These files trace the course of all perennial streams in the nation, and contain coded identifiers for each geographically defined stream reach. These GIS files can be used to generate hydrographic layers to superpose over other geographic information layers for computer mapping.

4. The 'National Watershed Boundary Dataset' (NWBD) - 2006

National hydrologic unit standards have more recently been revised. In 2001, the NRCS, USGS, EPA, and other federal agencies teamed with the Subcommittee on Spatial Water Data (part of the Advisory Committee on Water Information [ACWI]) and the Federal Geographic Data Committee to develop the new *Federal Standards for Delineation of Hydrologic Unit Boundaries*. The new standards are for establishing seamless fifth and sixth order hydrologic units for all of the United States. The digital product resulting from the delineation and capture of these new units is the National Watershed Boundary Dataset (NWBD). There are several major differences between the new standards and those used to develop the earlier (1995) Virginia Hydrologic Unit System:

1. The new standards call for smaller fifth and sixth order units. Sixth order units of the 1995 product averaged 54,000+ acres in size. The new nomenclature and size requirements by order are summarized in **Figure II-5**, below.
2. Additional specific attributes to polygons and arcs are required in the final digital product of the NWBD. This includes unit modifiers (dam, karst, drainage ditches, etc.) and types (standard, frontal, water, etc.), unit names, line source, official unit codes at the fourth, fifth and sixth order, and the official codes of the fifth and sixth order units downstream (discharges to…).
3. Waterside delineations of frontal units are now defined to the toe of the shore face. This boundary has been set at a depth of 10 feet for Chesapeake Bay waters. For the Atlantic, this boundary has been set at a depth of 30 feet. Both are based on research regarding where wave action first affects the shoreline.
4. Unit coding for fifth and sixth order units has changed from requiring 11 and 14 digits to requiring 10 and 12 digits respectively as shown in **Figure II-5**, below.
5. Order names have been changed from those established in the 1970s to a new system as shown in **Figure II-5**.
6. Out to the three-nautical-mile territorial limit, the Atlantic Ocean is now partitioned into fifth and sixth order hydrologic units.

The Virginia Portion of the NWBD

As part of the NWBD development process in Virginia, proposed sixth order units have been delineated so as to preserve as much of the intent of the 1995 Virginia Hydrologic Unit boundaries as possible, to make the transition between the two systems less complicated. Occasionally, however, unit boundaries had to be revised so as to be in compliance with the new standards or, sometimes, just to fix previous flaws.

To uniquely identify NWBD units in Virginia without requiring the use of 10 digits, DCR developed a new 4-character internal coding scheme for the sixth order units of the NWBD. This 4-character code now replaces the 3-character code of the 1995 NRCS/DCR Virginia hydrologic unit system. The first two characters of the new code are based on the name of the predominant stream in the basin, or portion of the basin, where the unit is located (see the following table in **Figure II-6**). The two digits that follow these codes (*e.g.*, PL01 – PL74) are a sequential numbering scheme based on the drainage flow from upstream to downstream (see the table of **Figure II-7**, below).

Figure II-5. Table of New versus Old Hydrologic Unit System References

New Versus Old Hydrologic Unit System References					
Order	**New Digits**	**Old Digits**	**New Name**	**Old Name**	**Unit Size**
1	**2**	**2**	**Region**	**Region**	**Avg. 177,560 sq. miles**
2	**4**	**4**	**Sub-Region**	**Sub-Region**	**Avg. 16,800 sq. miles**
3	**6**	**6**	**Basin**	**Accounting Unit**	**Avg. 10,596 sq. miles**
4	**8**	**8**	**Sub-Basin**	**Cataloging Unit**	**Avg. 703 sq. miles**
5	**10**	**11**	**Watershed**		**Range: 40,000 - 250,000 acres**
6	**12**	**14**	**Sub-Watershed**		**Range: 10,000 - 40,000 acres**

Figure II-6. Table of Basin/Sub-basin Prefixes of the New Internal Sixth Order Unit Codes

Basin Prefixes of the New Internal Sixth Order Unit Codes		
AO - Atlantic Ocean	JL - James, Lower	RL - Roanoke, Lower
AS - Albemarle Sound Coastal	JA - James-Appomattox	RD - Roanoke-Dan
BS - Big Sandy	JR - James-Rivanna	TC - Tennessee-Clinch
CB - Chesapeake Bay	NE – New	TH - Tennessee-Holston
CU - Chowan, Upper	PU - Potomac, Upper	TP - Tennessee-Powell
CM - Chowan-Meherrin	PL – Potomac, Lower	YA - Yadkin
CL - Chowan, Lower	PS – Potomac-Shenandoah	YO – York
JU - James, Upper	RA - Rappahannock	
JM - James, Middle	RU - Roanoke, Upper	

Figure II-7. Internal Coding Changes for 5th and 6th Order Units

Internal Coding Changes for 5th and 6th Order Units			
1995 Units	5th Order NWBD Units (VAHU5)	6th Oorder NWBD Units (VAHU6)	Drainage
A01-A34	PL-A - PL-U	PL01-PL74	Potomac River, Lower
B01-B09	PU-A - PU-F	PU01-PU20	Potomac River, Upper
B10-B58	PS-A - PS-T	PS01-PS87	Potomac River - Shenandoah River
C01-C16 and R01	CB-A - CB-O	CB01-CB47	Chesapeake Bay / Chesapeake Bay Coastals
D01-D07	AO-A - AO-H	AO01-AO26	Atlantic Ocean Coastal
E01-E26	RA-A - RA-R	RA01-RA74	Rappahannock River
F01-F27	YO-A - YO-S	YO01-YO69	York River
G01-G15	JL-A - JL-L	JL01-JL59	James River, Lower (Tidal)
H01-H22, H33-H39	JM-A - JM-U	JM01-JM86	James River, Middle (Piedmont)
H23-H32	JR-A - JR-E	JR01-JR22	James River - Rivanna River
I01-I38	JU-A - JU-T	JU01-JU86	James River, Upper (Mountain)
J01-J17	JA-A - JA-J	JA01-JA45	James River - Appomattox River
K01-K13	CM-A - CM-H	CM01-CM32	Chowan River - Meherrin River
K14-K36	CU-A - CU-R	CU01-CU70	Chowan River, Upper
K37-K38	CL-A - CL-C	CL01-CL05	Chowan River, Lower
K39-K42	AS-A - AS-D	AS01-AS20	Albemarle Sound
L01-L41	RU-A - RU-V	RU01-RU94	Roanoe River, Upper
L42-L74	RD-A - RD-S	RD01-RD77	Roanoke River - Dan River
L75-L82	RL-A - RL-G	RL01-RL24	Roanoke River, Lower
M01-M03	YA-A - YA-B	YA01-YA07	Tadkin River - Ararat River
N01-N37	NE-A - NE-Y	NE01-NE88	New River
O01-O14	TH-A - TH-L	TH01-TH46	Tennessee - Holston River
P01-P16	TC-A - TC-H	TC01-TC35	Tennesse - Clinch River
P17-P24	TP-A - TP-D	TP01-TP19	Tennessee - Powell River
Q01-Q14	BS-A - BS-H	BS01-BS35	Big Sandy River

The final hydrologic unit product arising from compliance with the March 2002 NWBD standards contains 1,247 sixth order units and 315 fifth order units in Virginia, barring further final adjustments. A complete list of the new 5th Order watersheds and 6th Order sub-watersheds is provided in the table "Virginia's Integrated 5th & 6th Order Watersheds" [II-B-5-B.xls], which is linked to this document. This is a significant change from the 494 fourteen-digit units and 211 eleven-digit units of the 1995 product. There are also a number of improvements in the NWBD that arise from recapturing hydrologic units using new geographic information technologies, from past experiences developing and using hydrologic unit systems, and from the opportunities that arise from a true multi-state effort.

1. There is a more precise delineation and capture of hydrologic unit boundaries. Units of the NWBD were captured from heads-up digitizing on Digital Raster Graphics (DRGs) of the 7.5-minute topographic quadrangle maps and NOAA charts versus from the paper versions of those maps. The ability to zoom and pan made this process more precise, at least in regards to capturing line-work from these sources.
2. Line-work and labeling were coordinated with all surrounding states so as to make seamless and sequentially coded units across all state borders. This effort was attempted in 1995 but was only successful at the fifth order. The NWBD units will be seamless between all states at all orders. While this is in part due to this being a stated goal in the NWBD standards, it successfully occurred

in this version because all states were updating their fifth and sixth order units (to the NWBD) simultaneously.

3. The first two versions of sixth order hydrologic units developed for Virginia delineated units within the established fourth order units but, with one minor exception, did not affect the delineation of the fourth order units except to recapture them more precisely. Although the NWBD standards requested a continuance of that practice, the final product includes a few significant modifications and redefinitions of established second and fourth order units. These requested changes (line-work and coding), which affect multiple states, have not yet been officially endorsed. They are being requested to fix the more glaring problems created by imposing fifth and sixth order units from the new standards onto larger units developed many standards ago.

The new internal coding scheme of the Virginia NWBD, cross referenced to the previous 3-character coding scheme of the 1995 hydrologic unit system, is shown in the table of **Figure II-7**.

The changes made in performing improvement (3) above had to eventually occur if any hydrologic unit system (NWBD or some future version) was to be delineated correctly. The long history of use of the 1st through 4th order hydrologic unit coding, however, meant that many past unit recordings would no longer correlate to the new hydrologic unit system codes of the NWBD. It is important to note where these unit designation changes occurred.

The table of **Figure II-8**, below, lists the nomenclature for all 1st through 4th order hydrological units in Virginia and indicates in red those units that have had their references altered as a result of the above changes. A map of the newly completed 4^{th} order (8-digit) NWBD Sub-Basin Hydrological Unit Geography in Virginia [II-B-6.pdf] is linked to this document. Greater detail is discernible if the map is viewed at 200%.

Figure II-8. First through Forth Order Hydrological Units in Virginia

(This includes name and unit number changes resulting from the NWBD delineation.)

First Through Forth Order Hydrological Units in Virginia			
1st Order Region	**2nd Order Sub-Region**	**3rd Order Basin**	**4th Order Sub-Basin**
02 - Mid-Atlantic	0204 - Delaware	020403 - New Jersey to Virginia Coastal	02040303 - Chincoteague 02040304 - Eastern Lower Delmarva
	0207 - Potomac	020700 - Potomac	02070001 - South Branch 02070004 - Conococheague-Opequon 02070005 - South Fork Shenandoah 02070006 - North Fork Shenandoah 02070007 - Shenandoah 02070008 - Middle Potomac-Catoctin 02070010 - Middle Potomac-Anacostia-Occoquan 02070011 - Lower Potomac
	0208 - Lower Chesapeake	020801 - Lower Chesapeake	02080101 - Lower Chesapeake 02080102 - Great Wicomico-Piankatank 02080103 - Rapidan-Upper Rappahannock 02080104 - Lower Rappahannock 02080105 - Mattaponi 02080106 - Pamunkey 02080107 - York 02080108 - Lynnhaven-Poquoson 02080110 - Tangier 02080111 - Pokomoke-Western Lower Delmarva
		020802 - James	02080201 - Upper James 02080202 - Maury 02080203 - Middle James-Buffalo 02080204 - Rivanna 02080205 - Middle James-Willis 02080206 - Lower James 02080207 - Appomattox 02080208 - Hampton Roads
03 - South Atlantic-Gulf	0301 - Chowan-Roanoke	030101 - Roanoke	03010101 - Upper Roanoke 03010102 - Middle Roanoke 03010103 - Upper Dan 03010104 - Lower Dan 03010105 - Banister 03010106 - Roanoke Rapid
		030102 - Albemarle-Chowan	03010201 - Nottoway 03010202 - Blackwater 03010203 - Chowan 03010204 - Meherrin 03010205 - Albemarle
	0304 - Pee Dee	030401 - Upper Pee Dee	03040101 - Upper Yadkin
05 - Ohio	0505 - Kanawha	050500 - Kanawha	05050001 - Upper New 05050002 - Middle New
	0507 - Big Sandy	050702 - Big Sandy	05070201 - Tug 05070202 - Upper Levisa
06 - Tennessee	0601 - Upper Tennessee	060101 - French Broad-Holston	06010101 - North Fork Holston 06010102 - South Fork Holston

Note: It should be noted that hydrological unit names and codes indicated by red font in Figure II-8 represent changes from the previous hydrologic unit system! The Delaware Sub-Region (0204) has now been extended southward along the Atlantic Coast, south of Chesapeake Bay as far as Rudee Inlet in Virginia Beach City.

A map illustrating the boundaries of the 1247 newly delineated 6th order (12-digit) sub-watersheds, by DEQ Regional Office jurisdiction, is provided in "DEQ Assessment Regions by 6th Order NWBD Unit" [II-B-7b.pdf]. Greater detail can be viewed by expanding the map to 200 or 400%. The subdivision of the previous 494 14-digit watersheds into 1247 12-digit sub-watersheds has had significant effects on the design of DEQ's Watershed Monitoring Network and the subsequent assessment process. The results of these changes will be discussed later in this document (see Chapter III.B.1 - Watershed Station Network).

C. Classification (Description) of Water Resources

1. Physical Description

The initial description of a surface water body generally consists of its hierarchical classification into a successive series of ever more specific categories related to the type of water, the type of water body, its size, etc. Many of the descriptive characteristics used for this type of classification are already familiar to the general public:

Water type:	Freshwater, brackish water, saltwater, etc. Soft water, hard water Acid water, alkali water Cold water, warm water
Water body:	Wetland, stream, river, lake or reservoir Mountain stream, lowland stream, tidal stream Saltmarsh, tidal pool, estuary Bay, gulf, sea, ocean, etc.

Many of the commonly used terms listed above, however, are used in different ways in different geographical regions and by different agencies or organizations. In 1979, in an effort to standardize the nomenclature for classifying aquatic resources, the Fish and Wildlife Service (FWS) of the U.S. Department of the Interior published its "Classification of Wetlands and Deepwater Habitats of the United States" (Cowardin et al., 1979). This manual is currently available online from the Fish and Wildlife Service (142 pages, 17.03 Mb). The FWS classification is based on the geophysical, chemical and ecological characteristics of aquatic habitats, as reflected by plant communities, soils and frequency/duration of flooding. The primary objective was "to impose boundaries on natural ecosystems for the purposes of inventory, evaluation, and management." In this classification, aquatic habitats are divided into five major systems: Marine, Estuarine, Riverine, Lacustrine (lakes and reservoirs) and Palustrine (upland depressions). Each of these systems, with the exception of palustrine, is further divided into two or more subsystems based primarily upon the permanence and depth of the water. Each subsystem is subsequently subdivided into a series of classes and subclasses, based upon substrate type, flooding regime and/or plant community. In addition, a series of modifiers has been defined to further describe water regimes, water chemistry (salinity, pH, etc.), soils and other special characteristics of water bodies.

The U.S. Army Corps of Engineers has also produced a "Wetlands Delineation Manual" (USACOE, 1987 – Original, PDF Format) that provides technical guidance for the classification of wetlands, deepwater aquatic habitats and non-wetlands, primarily for juridical purposes. This manual is also available online at http://www.wetlands.com/regs/tlpge02e.htm ('1987 Wetland Delineation Manual' with February 1997 updates - 117 pages, PDF format). The purpose of the ACOE manual is "to provide users with guidelines and methods to determine whether an area is a wetland for purposes of Section 404 of the Act" (i.e., Clean Water Act). It does not attempt to classify wetlands by type. The ACOE manual includes most, but not all, wetlands identified in the FWS system. The primary difference between the two systems is that the FWS requires that a positive indicator of wetlands be present for any one of the three classification parameters of vegetation, soils and hydrology, while the ACOE system requires that a positive wetland indicator be present for all three. When necessary, the Commonwealth of Virginia uses the ACOE guidance to determine if an area falls within the jurisdiction of Section 404 of the Act, and the FWS system to further classify and describe specific aquatic resources.

Additional, more refined, classification of waterbodies is generally associated first with the size of the water body and, subsequently, its more detailed physical, chemical and biological characteristics. Classification of water bodies by size is often not as simple as it would seem. By convention, the overall sizes of various types of water bodies are expressed in different units. The linear extensions of streams and rivers, as well as of coastline, are expressed in miles (mi. or kilometers – Km.). The areas of fresh and saltwater wetlands, as well as lakes and reservoirs, are expressed in acres (ac. or hectares – ha.), and the area of bays and estuaries in square miles (mi^2 or square kilometers – Km^2). In many cases, such as for lakes and reservoirs or estuaries, additional measures of water depth or volume, as well as "turnover" or the rate of water replacement may be extremely informative. In addition, the flow or discharge rate (e.g., ft^3/sec) is considered an extremely important water quality variable in free-flowing streams and rivers.

(1) Wetlands

DEQ's classification of wetlands within the Commonwealth of Virginia follows the Cowardin system (Cowardin et al., 1979). Salt marshes include the extensive estuarine wetlands along the Chesapeake Bay and Delmarva Coast that are characterized by vegetation tolerant of brackish to salty water. Other tidal marshes include estuarine wetlands located along the freshwater portions of tidal rivers. Interdunal swales are topographic depressions among sand dunes on the Atlantic coast that contain palustrine emergent or scrub-shrub wetlands. Virginia's Atlantic white cedar swamps, red maple swamps, and cypress-tupelo swamps and its non-tidal flood-plain forests are freshwater, non-tidal (also called "palustrine") forested wetlands that have seasonally occurring standing water and flood-tolerant trees. 'Pocosins' are non-tidal, freshwater scrub-shrub wetlands that are slightly elevated above the surrounding landscape and have flat topography and poor natural drainage. Virginia's bogs, fens, and wet meadows are non-tidal, freshwater emergent wetlands that are often underlain by organic soils.

Recent surveys indicate that wetlands occupy approximately four percent of Virginia's land mass (Dahl, 1990). Based on the United States Fish and Wildlife Service National Wetlands Inventory mapping completed to date (fall 2006), vegetated palustrine wetlands cover approximately 1,075,443 acres of Virginia, and are by far the most abundant type of wetland in the state. Estuarine wetlands cover 190,996 acres, lacustrine wetlands 193 acres and riverine wetlands 380 acres (Hershner et al., 2000a, b). In addition, isolated wetlands, i.e. those wetlands occurring in depressions or fed by groundwater, with no surface water connection to other state waters, account for anywhere from 179,849 to 411,246 acres, depending on the method used to estimate these areas (Hershner et al., 2000b). Virginia is in the final stages of developing more accurate geographic information system (GIS) based estimates of the acreage of wetlands by watershed and wetland type.

Virginia includes five physiographic provinces: the Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateaus. Geologic features, landforms, and soils that directly affect the hydrology of wetlands characterize each province. Approximately 72 percent of the wetland area in Virginia, including all the estuarine wetlands and most of the large non-tidal wetlands, are in the Coastal Plain (Tiner and Finn, 1986). Extensive estuarine wetlands have developed in low-lying areas along the shores of the Chesapeake Bay and its tributaries and behind the barrier beaches of the Atlantic coast. Palustrine wetlands are distributed throughout the Commonwealth and are located primarily in bottomlands and in flood plains along stream channels, especially in headwater areas. Approximately 22 percent of the wetlands in Virginia are in the Piedmont, and the remaining six percent of the wetland areas are in the Appalachian Plateaus (Tinker and Finn, 1986; Harlow and LeCain, 1991).

(2) Streams

The majority of the Commonwealth's monitoring efforts focus upon the condition of its more than 49,000 miles (79,000 Km.) of free-flowing streams. This number will undoubtedly be adjusted upward once the agency completes the perennial stream layers revision statewide based on the new NHD. Within free-flowing streams and rivers, width, depth, slope, sinuosity, water velocity and total discharge rate (volume per unit time) are extremely important geo-morphological parameters. They have crucial effects upon the physical and chemical characteristics of the water, which in turn have ecological implications, and are necessary for calculating estimates of total material flow and the Total Maximum Daily Load (TMDL) necessary for management planning and the permitting of point-source dischargers. Ecologically and biologically, these stream parameters are important because they influence the water temperature, oxygen content, the quantity of suspended material that a stream can carry, and the size of substrate particles deposited within the streambed. DEQ uses a number of these characteristics to evaluate the "habitat condition" of the Commonwealth's streams and rivers.

All freshwater streams, as they progress downstream from their origin, grow in size, change in form, structure, velocity and substrate type, and evolve in other systematic ways. The "river continuum hypothesis", first presented by Vannote et al. (1980), relates the systematic physical and chemical changes experienced by flowing streams to the structure and function of ecosystems and the biological communities normally associated with each phase of stream evolution. Comparison of the observed structure and function of aquatic communities with those expected under "natural" unimpaired conditions is the first phase of biological assessment of stream water quality. The biological communities expected under natural conditions vary not only with the size and form of the stream, but also with the geographic "ecoregion" within which it is found. Consequently, both stream location and size are important parameters in their evaluation and should be recorded along with other monitoring data and their interpretations.

One method of classifying streams along their size gradient is with the "stream order" concept. One commonly used stream order classification system, utilized by the USGS, USEPA and many other federal and state agencies, is the Strahler stream order (Strahler, 1957). In the Strahler system first order streams are small, headwater streams that may flow from a single, readily identifiable source or from diffuse sources along its channel within a small, relatively restricted drainage basin.[6] Such streams remain first order until they are joined by a first order tributary, at which time they become a second order stream. Second order streams remain so until they are joined by a second order tributary. They then become third order streams, and so on until the final stream in a drainage system reaches the sea. Although streams of the same Strahler order may differ considerably in size, depending upon regional topography and drainage patterns, the identification of streams or stream segments by their order is very informative and should be included in the classification process whenever possible. In fact, the original EPA River Reach Files (RF3) included the Strahler Order of streams, along with their reach designations. The table "Distribution of Stream Miles by Strahler Order" [II-B-4.pdf], provided by EPA NHEER in Corvallis, OR, in 2001, provides a summary of the total known length (meters, kilometers and miles) of streams in Virginia known at that time, by Strahler Stream Order. These figures will be updated when the statewide revision based on the new NHD is completed (2013).
A second stream order system, the Shreve or "link" order (Shreve, 1967), is also useful for relating environmental variables to stream size. First order stream definitions are identical in the two systems, but second and higher order streams may differ drastically in their size and hydrology. A higher (>1) order stream in the Strahler system retains the same numerical value until joined by another stream of equal order, at which point its value increases by one (e.g., the union of two streams of the 4th order results in a

[6] For monitoring purposes, VA-DEQ provisionally defines "first order" streams based upon the blue line traces of USGS topographic maps reproduced at a scale of 1:24000 (7.5 minute Quads). Headwater streams that are represented by broken blue lines are denominated as "intermittent" (seasonal) streams and do not receive an order classification. Headwater streams represented by an unbroken blue line are considered perennial (permanent) "1st Order" streams until they join, or are joined by, another solid blue line. Perennial *versus* intermittent delineations may be amended, however, if field reconnaissance confirms that the original USGS topographic map delineation was in error.

stream of the 5th order). Depending upon the complexity of the hydrologic basins that the streams drain, the same Strahler order may be applied to streams of drastically different sizes. In the Shreve system, order number is determined by adding the orders of the joining streams (e.g., the union of a 4th order and a 5th order stream results in a stream of the 9th order). The Shreve order, consequently, is identical to the number of 1st order sources that drain through a specific stream segment, and is independent of drainage basin hydrology. The basins draining through any two stream segments of Shreve order "n" contain exactly the same number of primary or 1st order sources (n primary sources), the same number of stream junctions or "forks" (n–1 forks), and the same number of stream segments or "links" between successive forks or between forks and primary sources (2n-1 links). Streams of a specific Shreve order are therefore more uniform in size and the order number is independent of basin complexity. In addition, the Shreve order of the downstream "link" below any fork is a more informative measure of the change in stream size when two tributaries join, and of the potential reservoir of aquatic species (especially fish) that are available from the larger stream to colonize upstream habitats.

Each of these stream-ordering systems has its desirable characteristics. DEQ uses both to characterize stream and drainage basin size, as well as for identifying appropriate sites for establishing water quality monitoring stations. More details on stream order systems and their use by DEQ's ambient Water Quality Monitoring Program are discussed below in **Chapter III – Design and Implementation**, which documents current monitoring activities (see especially the discussion of the geographically-targeted Watershed Monitoring Network).

(3) Lakes

The Commonwealth of Virginia possesses only two natural lakes. Lake Drummond lies within the Great Dismal Swamp National Wildlife Refuge (Chowan River and Dismal Swamp Basin, in southeastern Virginia) and Mountain Lake is a privately owned lake located in the highlands of Pulaski County (New River Basin, in southwestern Virginia). The numerous other 'lakes" in the Commonwealth are actually all man-made reservoirs. The naming convention of using "lakes", however, is generally maintained in most discussions relating to the DEQ Water Quality Monitoring Program. Man-made reservoirs of significant size are almost always constructed along the channels of naturally free-flowing streams, but the size classification of lakes, as previously mentioned, is expressed in acres rather than in relation to the stream order of the parent body of water.

(4) Estuaries and Oceanic

Virginia possesses an estimated 2,500 square miles of estuaries, including Chesapeake Bay and its tidal tributaries, coastal Delmarva, and the Back Bay/North Landing River estuaries, plus 120 miles of Atlantic Ocean coastline. Estimates of estuarine area may change slightly once the new water body delineations of the National Hydrological Dataset are completed, probably later in 2013. The new delineations, at a scale of 1:24000 will be more precise than the previous, which were digitized at a scale of 1:100,000. Since the adoption of the NWBD 12-digit, 6th order sub-watershed delineation in 2006, Virginia's oceanic waters, out to the three-nautical-mile territorial limit, have been included in DEQ's area of responsibility. Eleven Atlantic Oceanic sub-watersheds, encompassing approximately 440.75 square statute miles, extend from Virginia's barrier beaches out to the Commonwealth's territorial limit, from the Maryland state line in the north to the North Carolina state line in the south. DEQ monitored these oceanic sub-watersheds for the first time in 2010, taking advantage of federal analytical resources from the National Coastal Condition Assessment survey and logistical support and human resources in the form of EPA's Oceanic Survey vessel the OSV Bold, her crew, and field crews from EPA Headquarters and EPA Region 3.

2. Water Body Classification for Water Quality Standards Application

Virginia's lakes, reservoirs and free-flowing streams have also been officially classified into categories based upon physical and chemical characteristics, suitability for specific fisheries, and other special standards. The most recent complete description of these classification criteria, as well as the classification of each water body, can be found in the Commonwealth of Virginia's Water Quality Standards (9 VAC 25-260-5 et seq. Virginia Water Quality Standards, Statutory Authority: § 62.1-44.15 3a of the Code of Virginia, WITH AMENDMENTS EFFECTIVE JANUARY 6, 2011), which may be accessed from the DEQ Office of Water Quality Standards' WebPages by clicking here. Parts I and II of the Water Quality Standards describe, respectively, surface water standards with general, statewide application and standards with more specific application. (Part III has been deleted from the current Standards.) (Parts IV and V, that described groundwater standards and water quality criteria for groundwater, were repealed from 9 VAC 25-260-5 et seq. and are now a separate regulation (9 VAC 25-280-10 et seq. Groundwater Regulation). Procedural requirements for variances, modification, amendment and cancellation of standards, analytical procedures, etc. are summarized in Part VI. Special standards are described in Part VII, and the identification of nutrient enriched waters is treated in Part VIII. Geographic descriptions of individual stream segments and their corresponding classifications, river basin by river basin, are presented in Part IX of Water Quality Standards.

It must be kept in mind that Water Quality Standards are periodically revised as additional information on pollutants and water quality monitoring data becomes available and is evaluated. Special standards may be developed for waters that naturally experience low pH (e.g., many wetlands and lowland streams) or low dissolved oxygen (e.g., wetlands and stratified deep-water bodies such as lakes and deep channels in estuaries). Revised criteria and standards may be developed for chemical contaminants as additional information on their toxicity or environmental effects becomes known, and new criteria and standards are often required for newly developed chemical products as they are introduced into the national market and, consequently, into the environment. DEQ is also in the process of developing water quality standards for nutrients in the Commonwealth's free-flowing streams. Standards for nitrogen, phosphorus, and chlorophyll, as well as for turbidity (water clarity), will vary among the types of water bodies and among the various physiographic/ecological regions of the state. Nutrient standards for Chesapeake Bay were approved in June 2005 and special nutrient standards for the estuarine portions of the James, Mattaponi and Pamunkey Rivers in January of 2006. The Virginia State Water Control Board, following the recommendations of DEQ's Academic Advisory Committee (AAC), adopted criteria for nutrients in "significant" lakes (those listed in 9 VAC 25-260-187) in 2006. Recommendations on nutrient criteria for free-running streams and rivers are still under development by the AAC.

In summary, the first level of physical/chemical classification is based upon the limits of normal variation in dissolved oxygen (DO), pH (acidity) and temperature of the waters. Numerical-classification criteria for these characteristics are described in 9 VAC 25-260-50 through 9 VAC 25-260-90 and are summarized in **Table II-9** - "Numerical Criteria for Dissolved Oxygen, pH and Maximum Temperature." The geographic boundaries between classes of water bodies (or their segments) that are described for regulatory purposes in the Virginia Water Quality Standards generally do not correspond to political jurisdictional boundaries. They also may not correspond exactly with the boundaries of USGS hydrological units or the more recently established local watersheds described above.

The Virginia Department of Game and Inland Fisheries - DGIF has designated a second level of surface water classification (DGIF trout waters: 9 VAC 25-260-370). The DGIF classification is based upon stream "aesthetics, productivity, resident fish population and stream structure" (see **Table II-10** - Department of

Game and Inland Fisheries Stream Classification). This classification in not regulatory in nature, and is not used during formal water quality assessment. Classes 'i' through 'iv' rate wild trout habitat; Classes 'v' through 'vii' rate cold water habitat not suitable for wild trout but adequate for year-round hold-over of stocked trout." A ninth class, "other", includes the remaining streams that are considered unsuitable for any type of trout fishery based upon summer temperatures, a significant population of warm water game fish, insufficient flow, or intolerable water quality. The State Water Control Board, in its own classification ("Numerical Criteria for Dissolved Oxygen, pH and Maximum Temperature") has superposed additional, simplified trout water classifications for Class V - Stockable trout waters and Class VI - Natural trout waters. These two broad WQS categories have aquatic life designated use classifications for regulatory (assessment) purposes. The finer divisions established by DGIF are considered descriptive in nature and are only used for informational considerations by DEQ.

Additional special standards may also be used to classify waters in relation to bacterial criteria for shellfish waters, because of their natural variations (in pH or DO, for example), because they require special standards to protect them, or because they have other special designations such as Public Water Supplies (PWS) or Nutrient Enriched Waters (NEW) (9 VAC 25-260-380).[7]

Procedures for the designation of uses of all state waters, including wetlands, are described in Part I of the Water Quality Standards (9 VAC 25-260-10). Designated uses include "recreational uses, e.g., swimming and boating; the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish."

In conjunction with the biennial 305(b) Water Quality Report and 303(d) TMDL Priority List, the Virginia Department of Conservation and Recreation (DCR) had also evaluated and classified local 14-digit watersheds (1995 delineation discussed above) based upon their risk potential for being impacted by Non-Point Sources (NPS) of pollution. Prior to the 2002 305(b) Report, DCR had produced an integrated ranking of Low, Moderate or High for the NPS Risk Potential within each of the 493 upland watersheds delineated in 1995. This ranking was based upon land use and the estimated nitrogen, phosphorus and sediment loadings contributed by forest, agricultural and urban areas. However, several changes in their NPS estimation procedures and the incorporation of two new components (i.e., known water quality impairments and the biological health of the water bodies) into their overall NPS Assessment and Prioritization prompted them to use a compound classification beginning with the 2002 Report (*e.g.*, see "Non-Point Source Pollution Risk Potential in Virginia Watersheds" [II-B-7a.xls]). The procedures used and the final classification of the 493 local upland watersheds were described in Chapter 3.6 and Table 3.6-3, respectively, of Virginia's 2002 - 2006 305(b) Water Quality Assessment Reports, copies of which may be requested from the DEQ WebPages (Click Here!). DCR's 2010 NPS characterization [II-B-7a2.xls] of the Commonwealth's 1247 NWBD sub-watersheds was included with the NPS Chapter of the most recent (2012) 305(b)/303(d) Integrated Report, but no new characterizations have been carried out since 2010.

Reorganization of state agencies and responsibilities initiated in 2012 as a result of significant declines in resource availability resulted in the transfer of various DCR functions to DEQ. Although specific methodologies for assessing the smaller, more numerous 6th Order 'sub-watersheds' of the new National Watershed Boundary Dataset (NWBD) had been developed for the 2010 Integrated Report, no updates

[7] The classification of waters as "Nutrient Enriched Waters" pursuant to Part VIII of the Water Quality Standards may be significantly altered once newly derived nutrient standards for estuaries, lakes and reservoirs, and streams have been established and adopted. A number of questions remain to be resolved relative to the issuance of permits for discharges to "nutrient enriched waters".

were available for inclusion in the 2012 Report. At present (May 2013) it is not clear which agency will ultimately assume the responsibility for future NPS characterizations and reporting, and it is doubtful whether this question will be resolved in time for inclusion in the Assessment Guidance Manual for the 2014 Integrated Report.

The more detailed physical, chemical and biological description of water bodies and their final classification in terms of water quality are among the primary objectives of the Office of Water Monitoring and Assessment and the Office of Wetlands and Stream Protection. The water quality assessment and water body classification processes are continuous. The results of these processes are published biennially, in even numbered years, in the form of the 305(b)/303(d) Integrated Water Quality Report to the U.S. Environmental Protection Agency and United States Congress.

Table II-9. Numerical Criteria for Dissolved Oxygen, pH and Maximum Temperature

CLASS	DESCRIPTION OF WATERS	DISSOLVED OXYGEN (mg/l)[4]		pH	Max. Temp. (°C)
		Min.	Daily Avg.		
I	Open Ocean	5.0	--	6.0-9.0	--
II	Estuarine Waters (Tidal Water-Coastal Zone to Fall Line)	4.0	5.0	6.0-9.0	--
III	Nontidal Waters (Coastal and Piedmont Zones)	4.0	5.0	6.0-9.0	32
IV	Mountainous Zones Waters	4.0	5.0	6.0-9.0	31
V	Stockable Trout Waters	5.0	6.0	6.0-9.0	21
VI	Natural Trout Waters	6.0	7.0	6.0-9.0	20
VII	Swamp Waters	--[1]	--[1]	3.7-8.0[1]	--[2]

[1] This classification recognizes that the natural quality of these waters may fluctuate outside of the values for D.O. and pH set forth above as water quality criteria in Class I through VI waters. The natural quality of these waters is the water quality found or expected in the absence of human-induced pollution. Water quality standards will not be considered violated when conditions are determined by the board to be natural and not due to human-induced sources. The board may develop site specific criteria for Class VII waters that reflect the natural quality of the waterbody when the evidence is sufficient to demonstrate that the site specific criteria rather than narrative criterion will fully protect aquatic life uses. Virginia Pollutant Discharge Elimination System limitations in Class VII waters shall not cause significant changes to the naturally occurring dissolved oxygen and pH fluctuations in these waters.

[2] Maximum temperature will be the same as that for Classes I through VI waters as appropriate.

[3] The water quality criteria in this section do not apply below the lowest flow averaged (arithmetic mean) over a period of seven consecutive days that can be statistically expected to occur once every 10 climatic years (a climatic year begins April 1 and ends March 31). See 9VAC25-260-310 and 9VAC25-260-380 through 9VAC25-260-540 for site specific adjustments to these criteria.

[4] For a thermally stratified man-made lake or reservoir in Class III, IV, V or VI waters that are listed in 9VAC25-260-187, these dissolved oxygen criteria apply only to the epilimnion of the water body. When these waters are not stratified, the dissolved oxygen criteria apply throughout the water column.

Table II-10 - Department of Game and Inland Fisheries Stream Classification

Department of Game and Inland Fisheries (DGIF) Stream Classification	
Class	**Description**
	Wild natural trout waters
Class i	Stream of outstanding natural beauty possessing wilderness or at least remote characteristics, an abundance of large deep pools, and excellent fish cover. Substrate is variable with an abundance of coarse gravel and rubble. Stream contains a good population of wild trout or has the potential for such. Would be considered an exceptional trout stream.
Class ii	Stream contains a good wild trout population or the potential for one but is lacking in aesthetic quality, productivity, and/or in some structural characteristic. Stream maintains good water quality and temperature, maintains at least a fair summer flow, and adjacent land is not extensively developed. Stream would be considered a good wild trout stream and would represent a major portion of Virginia's wild trout waters.
Class iii	Stream which contains a fair population of wild trout with carrying capacity depressed by natural factors or more commonly man-related land use practices. Land use activities may result in heavy siltation of the stream, destruction of banks and fish cover, water quality degradation, increased water temperature, etc. Most streams would be considered to be in the active state of degradation or recovery from degradation. Alteration in land use practices would generally improve carrying capacity of the stream.
Class iv	Stream which contains an adequately reproducing wild trout population but has severely reduced summer flow characteristics. Fish are trapped in isolated pools where they are highly susceptible to predators and fishermen. Such streams could quickly be over-exploited and, therefore, provide difficult management problems.
	Stockable trout streams
Class v	Stream does not contain an adequately reproducing wild trout population nor does it have the potential for such. However, water quality is adequate, water temperature is good, and invertebrate productivity is exceptional. Pools are abundant with good size and depth and fish cover is excellent. Stream would be good for stocked trout but may offer more potential for a fingerling stocking program.
Class vi	Stream does not contain a significant number of trout nor a significant population of warmwater gamefish. Water quality is adequate and water temperature good for summer carryover of stocked trout. Summer flow remains fair and adjacent land is not extensively developed. All streams in this class would be considered good trout stocking water.
Class vii	Stream does not contain a significant number of trout nor a significant population of warmwater gamefish. Water quality and temperature are adequate for trout survival but productivity is marginal as are structural characteristics. Streams in this class could be included in a stocking program but they would be considered marginal and generally would not be recommended for stocking.
Class viii	Stream does not contain a significant number of trout nor a significant population of warmwater gamefish. Water quality and temperature are adequate for trout but summer flows are very poor (less than 30% of channel). Streams in this class can provide good trout fishing during spring and early summer but would not be recommended for summer or fall stocking.
Other	Remaining streams would be considered unsuitable for any type of trout fishery. Streams would be considered unsuitable under any of the following conditions: (a) summer temperatures unsuitable for trout survival; (b) stream contains a significant population of warmwater gamefish; (c) insufficient flow; or (d) intolerable water quality.

DEQ's Office of Wetland and Stream Protection has received grants from the U. S. Environmental Protection Agency since 2005 for the development of a systematic methodology for characterizing the Commonwealth's wetlands. DEQ has collaborated with the Virginia Institute of Marine Science (VIMS) to develop wetland assessment protocols. The current set of protocols are designed to generate a nested data set in which descriptive data will be available for all identified wetlands in the state, and more extensive information will be available for selected subsets of wetlands. As currently designed, the assessment protocol is a three level approach to wetlands sampling. At the first level, a comprehensive coverage of all mapped non-tidal wetlands is achieved with a GIS-based analysis of remotely sensed information. These data will be summarized on the basis of small sub-watersheds. This data provides a first-order evaluation of the condition and functional capacity of wetlands based on their landscape. The second level assessment consists of a probabilistic (randomly selected) sub-sample of the watershed wetland population that involves a more sophisticated analysis of remotely sensed information with a site visit for verification and additional data collection. The third level assessment involves very detailed analysis of wetland performance of specific functions (habitat provision and water quality modification, in particular). This involves extensive sampling of a limited number of sites, specifically chosen to allow validation of the conceptual model of wetland function that underlies the Level 1 and Level 2 characterizations. Additional information on the DEQ Wetlands Programs is available on DEQ's Wetlands and Stream Protection WebPages, as well as in Chapter III of this strategy document (§ III-C-6 – "Wetlands Monitoring Program").

Additional information on the distribution, classification and characterization of Virginia's water resources is available from various other state and federal agencies. These include the Virginia Department of Conservation and Recreation, the Department of Game and Inland Fisheries, the Department of Forestry, The Marine Resources Commission, the Department of Transportation, the Chesapeake Bay Local Assistance Department, the Atlantic States Marine Fisheries Commission, the U.S. Geological Survey and the U.S. Environmental Protection Agency. A growing need to facilitate the characterization, assessment and management of the Commonwealth's aquatic resources is the development of an integrated statewide database and comprehensive catalog of aquatic resources, including geographical, geological, hydrological, and ecological descriptions as well as functional definitions of water body types. The VA-DEQ is striving to develop a geospatial application linking these various data sources in a common interface as resources permit.

3. Designated Uses, Use Criteria, and Attainment of Water Resources

Among the many ways to describe the various types of water resources within the Commonwealth, one of undeniable importance is the classification of each water body in terms of its attainment of water quality criteria, as defined in the Virginia Water Quality Standards - 9VAC25-260-10 - Designation of uses or, in the case of some aquatic life assessments, of its degree of degradation relative to natural (non-degraded) water bodies of the same type. Both federal and state clean water laws require DEQ to examine and report upon the condition of the state's waters on a regular basis (*i.e.,* the biennial 305(b) and 303(d) Reports). When degradation of a water resource is detected the geographic extent, cause(s), and source(s) of the degradation must be determined, whether it is caused directly by human activities, indirectly by anthropogenic sources of pollution, or is due to natural causes. This "assessment" of the state's waters is a very formal process that must follow federally (EPA) accepted methodologies.

These administrative processes, and the regulations that govern them, are defined and described in detail in numerous federal (EPA), state, and agency guidance documents. In brief and simplified terms, the EPA provides overall guidance on various physical, chemical and ecological/biological characteristics that have been determined to be sufficient for maintaining the nation's water resources in acceptable condition. These 'criteria', which may be presented in the form of direct physical measurements, chemical concentrations, or descriptions of ecosystem 'health', vary with the type of water resource and with the function(s) which it may serve. Each state has the subsequent responsibility of identifying the specific uses for which each of its water resources is to be designated, and for defining the proper Water Quality Standards (*e.g.*, the combination of criteria and designated uses appropriate for that water body or resource type). Water quality monitoring then provides the data, representative of each body of water (or monitoring site), to which the appropriate water quality criteria/standards are compared. If the water quality of a specific water body fails to satisfy the appropriate water quality standards, then the water body is assessed as being impaired. Impaired waters must be included on the state's 303(d) List of Impaired Waters and, unless mitigating circumstances permit its subsequent de-listing or the impairment is determined to be a natural occurrence, a Total Daily Maximum Load (TMDL) must be calculated for the listed water body. Virginia state law requires that the TMDL then be implemented within a reasonable time, and that measures be taken to return the listed water body to satisfactory condition.

(1) Designated Uses

The "designated uses" [8] for various types of water bodies within the Commonwealth of Virginia are specified in Part I of Virginia's Water Quality Standards (9 VAC 25-260 *et seq.* - Virginia Water Quality Standards - see the most recent updates here). In order to minimize misinterpretation of the pertinent legislation, much of the discussion in the following paragraphs is paraphrased or quoted directly from the Water Quality Standards. Direct quotes are italicized and brackets […] identify insertions.

9 VAC 25-260-10. Designation of uses

A. All State waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming [primary contact recreation[9]] *and boating* [secondary contact recreation[10]]*; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.*

B. In designating uses of a water body and the appropriate criteria [11] *for those uses, the board* [12] *shall take into consideration the water quality standard* [13] *of downstream waters and shall ensure that its water*

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[8] "Designated uses" means those uses specified in water quality standards for each water body or segment, whether or not they are being attained."

[9] *"Primary contact recreation" means any water-based form of recreation, the practice of which has a high probability for total body immersion or ingestion of water (examples include but are not limited to swimming, water skiing, canoeing and kayaking).*

[10] *"Secondary contact recreation" means a water-based form of recreation, the practice of which has a low probability for total body immersion or ingestion of waters (examples include but are not limited to wading, boating and fishing).*

[11] *"Criteria" means elements of the board's water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use.*

[12] *"Board" means State Water Control Board.*

quality standards provide for the attainment and maintenance of the water quality standards of downstream waters.

C.. The board may adopt subcategories of a use and set the appropriate criteria to reflect varying needs of such subcategories of uses, for instance, to differentiate between cold water (trout streams) and warm water fisheries.

D. At a minimum, uses are deemed attainable if they can be achieved by the imposition of effluent limits required under §§ 301(b) and 306 of the Clean Water Act and cost-effective and reasonable best management practices for nonpoint source control.

E. Prior to adding or removing any use, or establishing subcategories of a use, the board shall provide notice and an opportunity for a public hearing under the Administrative Process Act (§ 2.2-4000 et seq. of the Code of Virginia).

F. The board may adopt seasonal uses as an alternative to reclassifying a water body or segment thereof to uses requiring less stringent water quality criteria. If seasonal uses are adopted, water quality criteria should be adjusted to reflect the seasonal uses; however, such criteria shall not preclude the attainment and maintenance of a more protective use in another season.

G. The board may remove a designated use which is not an existing use, or establish subcategories of a use, if the board can demonstrate that attaining the designated use is not feasible because:

1. *Naturally occurring pollutant concentrations prevent the attainment of the use;*
2. *Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating state water conservation requirements to enable uses to be met;*
3. *Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place;*
4. *Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use;*
5. *Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or*
6. *Controls more stringent than those required by §§ 301(b) and 306 of the Clean Water Act would result in substantial and widespread economic and social impact.*

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[13] *"Water quality standards" means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§ 62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC § 1251 et seq.).*

H. The board may not remove designated uses if:

1. *They are existing uses* [14] *, unless a use requiring more stringent criteria is added; or*
2. *Such uses will be attained by implementing effluent limits required under §§ 301b and 306 of the Clean Water Act and by implementing cost-effective and reasonable best management practices for nonpoint source control.*

I. Where existing water quality standards specify designated uses less than those which are presently being attained, the board shall revise its standards to reflect the uses actually being attained.

J. The board must conduct a use attainability analysis [15] *whenever:*

The board designates or has designated uses that do not include the uses specified in § 101(a)(2) of the Clean Water Act, or
The board wishes to remove a designated use that is specified in § 101(a)(2) of the Clean Water Act or to adopt subcategories of uses specified in § 101(a)(2) of the Clean Water Act which require less stringent criteria.

K. The board is not required to conduct a use attainability analysis under this chapter whenever designating uses which include those specified in subsection A of this section.

(2) Criteria to Determine Degree of Use Support

The categories of criteria used to evaluate the attainment of designated uses for the biennial 305(b) / 303(d) Report are summarized in the 'Designated Use Matrix' below, extracted from the agency's current (2012) Assessment Guidance Manual for the Integrated 305(b)/303(d) Report). The specific constituent concentrations, levels, or narrative statements are identified in Virginia's Water Quality Standards and, as indicated earlier, may vary with resource type.

As currently defined, the 305(b) process assesses a total of up to six designated uses, as appropriate for a particular water body, based on the Water Quality Standards. Assessed designated uses may include wildlife use, aquatic life use, swimming use, fish consumption use, shellfish consumption use and drinking water use. Swimming use is assessed to represent both the primary and secondary water contact recreational uses. Drinking water use is based on attainment of public water supply criteria. Following are further details relating to the assessment of the six designated uses of Virginia's waters.

1. Wildlife Use: Support of wildlife use is determined by assessing Water Quality Toxic Standards for aquatic life (found in Virginia Water Quality Standards 9 VAC-25-260-140 B). These criteria were developed to protect aquatic life as well as wildlife.

2. Aquatic Life Use: Aquatic life use includes the propagation, growth, and protection of a balanced indigenous population of aquatic life (including game and marketable fish) which may be expected to

[14] *"Existing uses" means those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the water quality standards.*

[15] *"Use attainability analysis" means a structured scientific assessment of the factors affecting the attainment of the use which may include physical, chemical, biological, and economic factors as described in 9 VAC 25-260-10 G.*

inhabit the waters. Support of aquatic life use can be determined by the assessment of conventional parameters (dissolved oxygen, pH and temperature), toxic pollutants in the water column (relative to the acute and chronic WQS), toxic pollutant analysis of sediments, toxicity testing, nutrient analysis and/or the biological assessment of benthic communities. All available data relative to aquatic life use shall be considered to determine if the aquatic life use is being met. The maximum temperature will not be assessed for aquatic life in estuarine and open ocean waters, as no maximum temperature standard is applicable. (Note the more detailed discussion of "Development and Adoption of New Aquatic Life Uses and Criteria" for Chesapeake Bay and its tidal tributaries in the following section.)

Designated Use Matrix

DESIGNATED USE	USE DESCRIPTION/INDICATORS
Aquatic Life Use, Chesapeake Bay sub-uses	Description: The propagation, growth, and protection of a balanced indigenous population of aquatic life that may be expected to inhabit a waterbody
	Indicators: Dissolved oxygen, pH, temperature, chlorophyll a, nutrients, water column and sediment toxics, toxicity tests, benthics, submerged aquatic vegetation
Fish Consumption Use	Description: Game and marketable fish species that are safe for human health
	Indicators: VDH notices, fish tissue toxics, water column toxics
Shellfishing Use	Description: Marketable shellfish (clams, oysters, mussels) that are safe for human health
	Indicators: VDH notices
Recreation (Swimming) Use	Description: Swimming, boating, and other recreational activities
	Indicators: VDH notices, bacteria
Public Water Supply Use	Description: Drinking water safe for human health
	Indicators: VDH notices, water column toxics
Wildlife Use	Description: The propagation, growth, and protection of associated wildlife
	Indicators: Water column toxics

3. Fish Consumption Use: Fish consumption use includes the propagation, growth and protection of a balanced population of aquatic life including game and marketable fish. Support of this use is determined using two separate criteria.

First, support or lack thereof, is based on human health related advisories and/or restrictions issued by the Virginia Department of Health (VDH). Impairment for fish consumption results when the public is advised by VDH that fish consumption is prohibited for the general population or there is an "advisory" that certain fish species should not be consumed by the general population or sub-populations at greater risk, such as children and/or pregnant women.

Second, the assessment methodology used for fish consumption use is a comparison of fish tissue data to Water Quality Standards (WQS) criterion-based tissue values (TVs) and tissue screening values (TSVs) for toxic pollutants. Any single observation above the TV or TSV results in an assessment of the water as being fully supporting but having an observed effect. Two or more violations within or across species sampled of a particular TV, listed in the appropriate table of the Assessment Guidance Manual, results in an impaired assessment of the water for the fish consumption designated use.

4. Shellfishing Use: Shellfish use includes the propagation, growth and protection of a balanced population of aquatic life including marketable shellfish.

Support of this use is determined using the following criteria. The Division of Shellfish Sanitation (DSS) of the VDH bases support or lack thereof on a classification system designed for the harvesting and marketing of shellfish resources in accordance with Food and Drug Administration (FDA) guidelines. Four classifications are used to describe shellfish waters. They are approved, conditionally approved, restricted, and prohibited. ***Approved*** areas are waters from which shellfish may be taken for direct marketing at all times. ***Conditionally approved*** (seasonal condemnation) areas are waters where the quality may be affected by a seasonal population increase or sporadic use of a dock or harbor facility. ***Restricted*** (condemnations) areas are waters where a sanitary survey indicates a limited degree of pollution which makes it unsafe to market shellfish for immediate consumption. Shellfish harvested in these areas must be moved to an approved area for a certain length of time to allow for depuration before marketing. ***Prohibited*** (condemnations) areas are waters where the DSS sanitary survey indicates dangerous numbers of pathogenic microorganisms or other contaminants that impact the area. Shellfish cannot be harvested or relayed for purification from prohibited areas.

Shellfish waters where restrictions or prohibitions are due solely to a discharge outfall and not due to water quality violations will not be included in the 303(d) list. In these cases monitoring should not be conducted, as the shellfish designated use has been administratively removed through the issuance of a discharge permit. Additional information relative to shellfish use assessment can be found in Appendix C of the Assessment Guidance Manual.

5. Recreational Use: Recreational use assessment includes swimming and other primary and secondary water contact recreation uses such as water-skiing and pleasure boating.

Normally, support or lack thereof of this use is based on a comparison of *Escherichia coli* or *Enterococcus* spp. bacteria data to the instantaneous standard using the EPA percent assessment method.. However, if a special study designed to collect multiple bacteria data points within a one-month period is conducted, then these results should be compared to the geometric mean criterion described in the Water Quality Standards. Also, any VDH beach closures should be assessed according to Part V of the Water Quality Assessment Guidance Manual (see below).

6. Public Water Supply Use: Waters that are used for public drinking water supply are identified in the Water Quality Standards and are protected by additional health related standards that are applicable to these waters. Support or lack thereof of this use is based on VDH closures or advisories and/or a comparison of water column data to applicable public water supply criteria.

(3) Use Attainment Classification of Assessed Waters

The US Environmental Protection Agency (EPA) has defined specific categories for the classification of water resources, in relation to designated use attainment, based on the formal assessment methodologies utilized in the preparation of integrated 305(b)/303(d) Water Quality Assessment Reports. In some cases, the Commonwealth of Virginia has subdivided these categories into more specific classifications in order to facilitate the tracking of agency needs and the necessary follow-up actions required. This classification scheme is summarized below, and is discussed in more detail in the EPA's and DEQ's biennial assessment and reporting guidance documents.

FULLY SUPPORTING – Waters are supporting one or more designated uses

EPA Category 1: Attaining all associated designated uses and no designated use is threatened.

Va. Category 1A - waters are attaining all uses and a TMDL has been developed for one or more uses.

EPA Category 2: Some of the designated uses are met but there is insufficient data to determine if remaining designated uses are met.

Va. Category 2A - waters are attaining all of the uses for which they are monitored and there is insufficient data to document the attainment of all [other] uses.

Va. Category 2B - waters are of concern to the state but no Water Quality Standard exists for a specific pollutant, or the water exceeds a state screening value.

Va. Category 2C - waters are now attaining the use(s) for which they were originally 303(d) listed and the TMDL is EPA approved but other applicable use(s) were not monitored and assessed.

INDETERMINATE – Waters needing additional information

EPA Category 3: Insufficient data to determine whether any designated uses are met

Va. Category 3A - no data are available within the data window of the current assessment to determine if any designated use is attained and the water was not previously listed as impaired.

Va. Category 3B - some data exists but is insufficient to determine attainment of designated uses. Such waters will be a prioritized for follow up monitoring.

Va. Category 3C- data collected by a citizen monitoring or other organization indicating water quality problems may exist but the methodology and/or data quality has not been approved for a determination of attainment of designated uses. These waters are considered as having insufficient data with observed effects. Such waters will be a prioritized for follow up monitoring.

Va. Category 3D – data collected by a citizen monitoring or other organization indicate that designated uses are being attained but the methodology and/or data quality has not been approved for such a determination.

IMPAIRED – Waters are impaired or threatened but a TMDL is not needed.

EPA Category 4A: impaired or threatened for one or more designated uses but does not require a TMDL because the TMDL for specific pollutant(s) is complete and US EPA approved.

EPA Category 4B: impaired or threatened for one or more designated uses but does not require the development of a TMDL because other pollution control requirements (such as VPDES limits under a compliance schedule) are reasonably expected to result in attainment of the Water Quality Standard by the next reporting period or permit cycle.

EPA Category 4C: impaired or threatened for one or more designated uses but does not require a TMDL because the impairment is not caused by a pollutant and/or is determined to be caused by natural conditions.

Va. Category 4D – part(s) of a water quality standard is attained for a pollutant with a TMDL, but the remaining criteria for the standard were not assessed due to insufficient information. (Only to be applied to dissolved oxygen in tidal waters of the Chesapeake Bay).

IMPAIRED – Waters are impaired or threatened and require a TMDL

EPA Category 5: **Waters are impaired or threatened and a TMDL is needed.**

Va. Category 5A - the Water Quality Standard is not attained. The AU is impaired for one Or more designated uses by a pollutant(s) and requires a TMDL (303d list).

Va. Category 5B –the Water Quality Standard for shellfish use is not attained. One or more pollutants remain requiring TMDL development.

Va. Category 5C – the Water Quality Standard is not attained due to suspected natural conditions. The AU is impaired for one or more designated uses by a pollutant(s) and may require a TMDL (303d list). Standards for these waters may be re-evaluated due to the effects of natural conditions.

Va. Category 5D - the Water Quality Standard is not attained where TMDLs for a pollutant(s) have been developed but one or more pollutants remain requiring TMDL development.

Va. Category 5E – effluent limited waters are not expected to meet compliance schedules by next permit cycle or reporting period.

Va. Category 5F - the WQ Standard is attained for a pollutant(s) with a TMDL and 303(d) delisting approved but the water remains impaired for additional pollutant(s) requiring TMDL development.

EPA Category 5M – the Water Quality Standard is not attained for mercury primarily due to atmospheric deposition.

When sufficient data are available to assess a specific assessment unit (AU) of a water resource for a specific designated use, its use attainability is classified using the criteria defined in the tables of Designated Use Assessment Criteria linked below (Table 2 from the current 2012 Water Quality Assessment Guidance Manual). These designated use criteria are updated, as appropriate, for the assessment guidance manuals for each biennial integrated 305(b)/303(d) Report. More detailed tables, based on the individual designated uses, are included here to present a more concise unified overview of the assessment process:

Aquatic Life and Wildlife Core Indicators [II-D-1a.xls]
Fish & Shellfish Consumption Core Indicators [II-D-1b.xls]
Recreation Core Indicators [II-D-1c.xls] (swimming, boating, water-skiing, etc.)
Public Water Supply (Drinking Water) Core Indicators [II-D-1d.xls]

These linked tables may not be updated as frequently as those provided in the current Assessment Guidance Manual. The current editions of the Virginia "Water Quality Standards (9 VAC 25-260 et seq.)" and the Virginia "Groundwater Regulation (9 VAC 25-280-10 et seq.)", both available via the Featured Topics link on the DEQ Water Quality Standards WebPages, and the current DEQ Assessment Guidance Manual are always the best sources for the most up-to-date information on water quality criteria, water quality standards, and assessment methodologies.

(4) Assessment of Aquatic Life Use in Chesapeake Bay and its Tidal Tributaries

The following sections describe (1) Development and Adoption of New Aquatic Life Uses and Criteria and (2) Plans for future assessment refinements within the Chesapeake Bay drainage.

Development and Adoption of New Aquatic Life Uses and Criteria

The 'Chesapeake Bay 2000' agreement signed by the Governor of Virginia committed to, "correct the nutrient and sediment related problems in the Chesapeake Bay and its tidal tributaries sufficiently to remove the Bay and the tidal portions of its tributaries from the list of impaired waters under the Clean Water Act" by 2010. The first step in this process was to define appropriate regulatory criteria by which the Bay should be assessed. The U.S. Environmental Protection Agency (EPA) Region III developed a guidance document, titled "Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll *a* for the Chesapeake Bay and Its Tidal Tributaries" (U.S. EPA, 2003b). This document proposed nutrient and sediment enrichment criteria, expressed as dissolved oxygen, water clarity and chlorophyll-*a* criteria, applicable to the Chesapeake Bay and its tidal tributaries. This document formed the technical basis for DEQ's adoption of new sub-categories of aquatic life use in the Chesapeake Bay and its tidal tributaries.

Previous Chesapeake Bay Water Quality Standards in Virginia included an instantaneous and a daily average of 5.0 mg/L of dissolved oxygen throughout the Bay's waters, from the deep trench near the Bay's mouth to the shallows in other parts of the Bay. Normal conditions in some sections of the Bay, however, result in salinity and temperature stratification during the warmer months of the year and inhibit mixing. Consequently, deeper waters often could not naturally achieve the 5.0 mg/L standard. Other areas, such as prime migratory fish spawning areas, require more than 5.0 mg/l of dissolved oxygen to sustain life during the late winter to early summer time frame. In summary, the amount of oxygen needed in the Bay tidal waters depends upon the specific needs of the living aquatic resources, where they live, and the time of the year when they live there. In addition, Virginia did not have any regulatory criteria for evaluating water quality effects on submerged aquatic vegetation (SAV). SAV provides valuable habitat for other living resources, such as juvenile finfish and shellfish, as well as ecosystem functions such as nutrient/sediment reductions and shoreline stabilization.

Because of these factors, Virginia adopted five new tidal water aquatic life sub-uses, in order to reflect different aquatic living resource community needs in a variety of habitats within Chesapeake Bay. The new aquatic life designated use subcategories are described below. It should be noted that the overall State-wide Aquatic Life Use (ALU) of “propagation and growth of a balanced indigenous population of aquatic life, including game fish” still exists as a distinct designated use for waters in the Chesapeake Bay, and is assessed with other protocols including Benthic Index of Biological Integrity (B-IBI), ammonia criteria, toxicity bioassays, and sediment chemistry screening criteria. Furthermore, any non-attainment of these new subcategories of aquatic life use is considered a non-attainment of the Aquatic Life Use in general.

New Aquatic Life Use Subcategories

Designated Uses

Migratory Fish Spawning and Nursery (MSN) Designated Use - Waters in the Chesapeake Bay and its tidal tributaries that protect the survival, growth and propagation of the early life stages of a balanced, indigenous population of anadromous, semi-anadromous, catadromous and tidal-fresh resident fish species inhabiting spawning and nursery grounds. A generalized depiction of the spatial distribution of this designated use is illustrated in **Figure II-10** (below) and detailed geographic descriptions can be found in the “Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability - 2004 Addendum” (U.S. EPA, 2004b). The designated use extends from the upper limit of tidal waters to the downriver end of spawning and nursery habitats that have been determined through a composite of all targeted anadromous and semi-anadromous fish species’ spawning and nursery habitats. The designated use extends horizontally from the shoreline of the body of water to the opposite shoreline, and extends down through the water column to the bottom water-sediment interface. This use applies from February 1 through May 31 and is applied in addition to the open-water use.

Shallow-Water Submerged Aquatic Vegetation (SWSAV) Designated Use - Waters in the Chesapeake Bay and its tidal tributaries that support the survival, growth and propagation of submerged aquatic vegetation (rooted, underwater bay grasses). A generalized depiction of the spatial distribution of this designated use is illustrated in **Figure II-10** (below) and detailed geographic descriptions can be found in the technical support document cited above (U.S. EPA, 2004b). This use applies from April 1 through October 31 in tidal-fresh, oligohaline and mesohaline and from March 1 through November 30 in polyhaline Chesapeake Bay Program segments, and is applied in addition to the open-water use.

Open-Water (OW) Aquatic Life Designated Use - Waters in the Chesapeake Bay and its tidal tributaries that protect the survival, growth and propagation of a balanced, indigenous population of aquatic life inhabiting open-water habitats. A generalized depiction of the spatial distribution of this designated use is illustrated in **Figure II-10** (below) and detailed geographic descriptions can be found in the technical support document cited above (U.S. EPA, 2004b). This designated use applies year-round, but the vertical boundaries change seasonally. From October 1 through May 31 the open water aquatic life use extends horizontally from the shoreline at mean low water, to the opposite shoreline, and extends through the water column to the bottom water-sediment interface.

From June 1 through September 30, if a pycnocline (i.e. a physical inhibition of mixing) is present and presents a barrier to oxygen replenishment of deeper waters, this designated use extends downward only as far as the upper boundary of the pycnocline. If a pycnocline is present during this period, but other physical circulation patterns (such as influx of oxygen rich oceanic bottom waters) provide for oxygen replenishment of deeper waters, the open-water aquatic life designated use extends down into the bottom water-sediment interface. This designated use is applied in addition to the migratory fish spawning and nursery and shallow-water submerged aquatic vegetation uses.

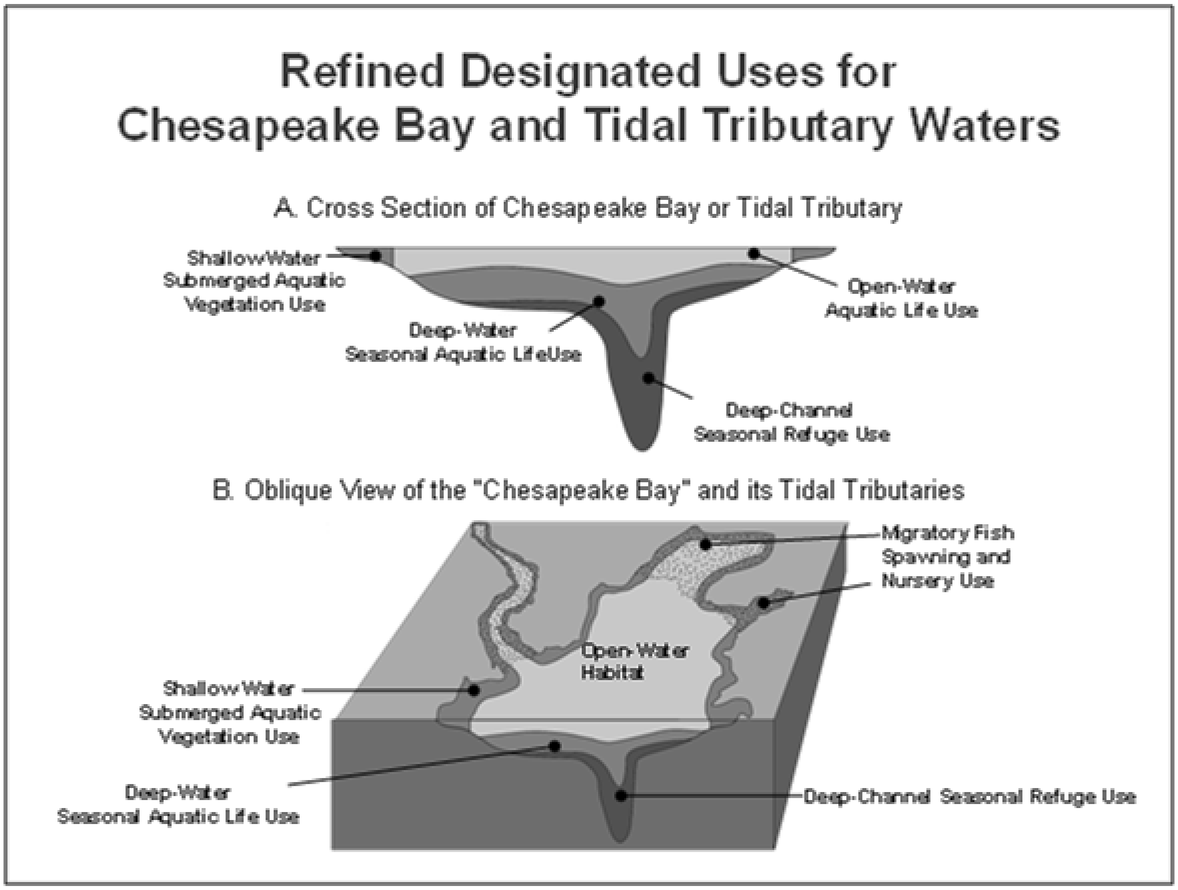


Figure II-10 - Refined Designated Uses for Chesapeake Bay and Tidal Tributary Waters

Deep-Water (DW) Aquatic Life Designated Use - Waters in the Chesapeake Bay and its tidal tributaries that protect the survival and growth of a balanced, indigenous population of aquatic life inhabiting deep-water habitats. A generalized depiction of the spatial distribution of this designated use is illustrated in **Figure II-10** (above) and detailed geographic descriptions can be found in the technical support document cited above (U.S. EPA, 2004b). This designated use applies to the tidally influenced waters located between the upper and lower boundaries of the pycnocline where, in combination with bottom bathymetry and water circulation patterns, a pycnocline is present and presents a barrier to oxygen replenishment of deeper waters. In some areas, the deep-water designated use extends from the upper boundary of the pycnocline down to the bottom water-sediment interface. This use applies from June 1 through September 30.

Deep-Channel (DC) Seasonal Refuge Designated Use - Waters in the Chesapeake Bay and its tidal tributaries that protect the survival of a balanced, indigenous population of benthic infauna and epifauna inhabiting deep-channel habitats. A generalized depiction of the spatial distribution of this designated use is illustrated in **Figure II-10** (above) and detailed geographic descriptions can be found in the technical support document cited above (U.S. EPA, 2004b). This designated use applies to the tidally influenced waters at depths greater than the lower boundary of the pycnocline in areas where, in combination with bottom bathymetry and water circulation patterns, the pycnocline presents a barrier to oxygen replenishment of deeper waters. This use applies from June 1 through September 30.

Applicable Criteria

Dissolved oxygen criteria to protect the described uses are summarized in the **Table II-11** - "Newly Defined Chesapeake Bay Dissolved Oxygen Criteria - 2006" (below). The methodology for assessing monitoring data against these criteria is very different from what has traditionally been used for regulatory assessment of dissolved oxygen criteria. It involves a spatial interpolation of fixed site monitoring results to create a 3-D picture of oxygen conditions in thousands of individual grid cells throughout the Bay. Each individual grid cell is then assessed against the criteria. In this way, the volume of water in attainment is calculated for each data collection cruise and a three dimensional "spatial" assessment is achieved. In order to account for naturally induced fluctuations between seasons and years, the individual spatial assessments of a three-year time period are aggregated, creating a "temporal" viewpoint. The final assessment involves examining the cumulative frequency distribution (CFD) of attainment from the aggregated data. In this way, a combined "space-time" assessment is achieved, which addresses the frequency and magnitude requirements for water quality assessments. More details of this procedure can be found in guidance manuals from EPA and DEQ (U.S. EPA, 2003b; U.S. EPA, 2004b; DEQ-WQA, 2005b).

Criteria specific to the Shallow Water Submerged Aquatic Vegetation use are shown in **Table II-12 -** "Summary of Chesapeake Bay Water Clarity Criteria for Application to Shallow-Water Bay Grass Designated Use Habitats" (below). There are dual criteria, one of "Water Clarity Acres" and one of "SAV Acres". The SAV Acres criterion is met by having actual aquatic vegetation present, as measured by annual aerial photography performed by the Virginia Institute of Marine Science. The Water Clarity Acres criterion is met by having sufficient water clarity present to support the potential for aquatic vegetation to grow (i.e. regardless of whether the submerged aquatic vegetation is actually present). This is because the water may be clear enough to support submerged aquatic vegetation but it may take several years for the areas to be re-populated with the grasses.

Numeric chlorophyll a criteria (Open-Water use) (**Table II-13**, below) apply only in the mainstem James River. It assessed in a similar fashion as dissolved oxygen, except that seasonal thresholds are used and only the water surface is assessed. A narrative standard applies to all other tidal waters from March 1 to September 30th.

Spatial Assessment Units

A general overview of the CBP segmentation scheme that is used for assessment of these new designated uses is shown in **Figure II-11** (below). Not every new designated use exists in each segment, or necessarily throughout the complete segment in which they do exist; details of where each designated use occurs within each of these CBP segments can be found in the Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability - 2004 Addendum (U.S. EPA, 2004b).

Dissolved Oxygen Criteria

Designated Use	Criteria Concentration/ Duration	Temporal Application
Migratory fish spawning and nursery	7-day mean ≥ 6 mg/l (tidal habitats with 0-0.5 ppt salinity)	February 1 - May 31
	Instantaneous minimum ≥ 5 mg/l	
Open-water [1]	30 day mean ≥ 5.5 mg/l (tidal habitats with 0-0.5 ppt salinity)	year-round
	30 day mean ≥ 5 mg/l (tidal habitats with >0.5 ppt salinity)	
	7 day mean ≥ 4 mg/l	
	Instantaneous minimum ≥ 3.2 mg/l at temperatures <29°C Instantaneous minimum ≥ 4.3 mg/l at temperatures ≥ 29°C	
Deep-water	30 day mean ≥ 3 mg/l	June 1 - September 30
	1 day mean ≥ 2.3 mg/l	
	Instantaneous minimum ≥ 1.7 mg/l	
Deep-channel	Instantaneous minimum ≥ 1 mg/l	June 1 - September 30

Table II-11 - Newly Defined Chesapeake Bay Dissolved Oxygen Criteria - 2006

[1] In applying this open-water instantaneous criterion to the Chesapeake Bay and its tidal tributaries where the existing water quality for dissolved oxygen exceeds an instantaneous minimum of 3.2 mg/l, that higher water quality for dissolved oxygen shall be provided anti degradation protection in accordance with 9 VAC 25-260-30 subsection A.2.

Submerged Aquatic Vegetation and Water Clarity Criteria

Designated Use	Chesapeake Bay Program Segment	SAV Acres[1]	Percent light-through-water[2]	Water Clarity Acres[1]	Temporal Application
Shallow-Water Submerged Aquatic Vegetation Use	CB5MH	7,633	22%	14,514	April 1 - October 31
	CB6PH	1,267	22%	3,168	March 1 - November 30
	CB7PH	15,107	22%	34,085	March 1 - November 30
	CB8PH	11	22%	28	March 1 - November 30
	POTTF	2,093	13%	5,233	April 1 - October 31
	POTOH	1,503	13%	3,758	April 1 - October 31
	POTMH	4,250	22%	10,625	April 1 - October 31
	RPPTF	66	13%	165	April 1 - October 31
	RPPOH	4	13%	10	April 1 - October 31
	RPPMH	1700	22%	5000	April 1 - October 31
	CRRMH	768	22%	1,920	April 1 - October 31
	PIAMH	3,479	22%	8,014	April 1 - October 31
	MPNTF	85	13%	213	April 1 - October 31
	MPNOH	-	-	-	-
	PMKTF	187	13%	468	April 1 - October 31
	PMKOH	-	-	-	-
	YRKMH	239	22%	598	April 1 - October 31
	YRKPH	2,793	22%	6,982	March 1 - November 30
	MOBPH	15,901	22%	33,990	March 1 - November 30
	JMSTF2	200	13%	500	April 1 - October 31
	JMSTF1	1000	13%	2500	April 1 - October 31
	APPTF	379	13%	948	April 1 - October 31
	JMSOH	15	13%	38	April 1 - October 31
	CHKOH	535	13%	1,338	April 1 - October 31
	JMSMH	200	22%	500	April 1 - October 31
	JMSPH	300	22%	750	March 1 - November 30
	LYNPH	107	22%	268	March 1 - November 30
	POCOH	-	-	-	-
	POCMH	4,066	22%	9,368	April 1 - October 31
	TANMH	13,579	22%	22,064	April 1 - October 31

Table II-12 – Summary of Chesapeake Bay Water Clarity Criteria for Application to Shallow-Water Bay Grass Designated Use Habitats.

1 = The assessment period for SAV and water clarity acres shall be the single best year in the most recent three consecutive years. A minimum of three years within the data assessment window are required when three consecutive years of data are not available.

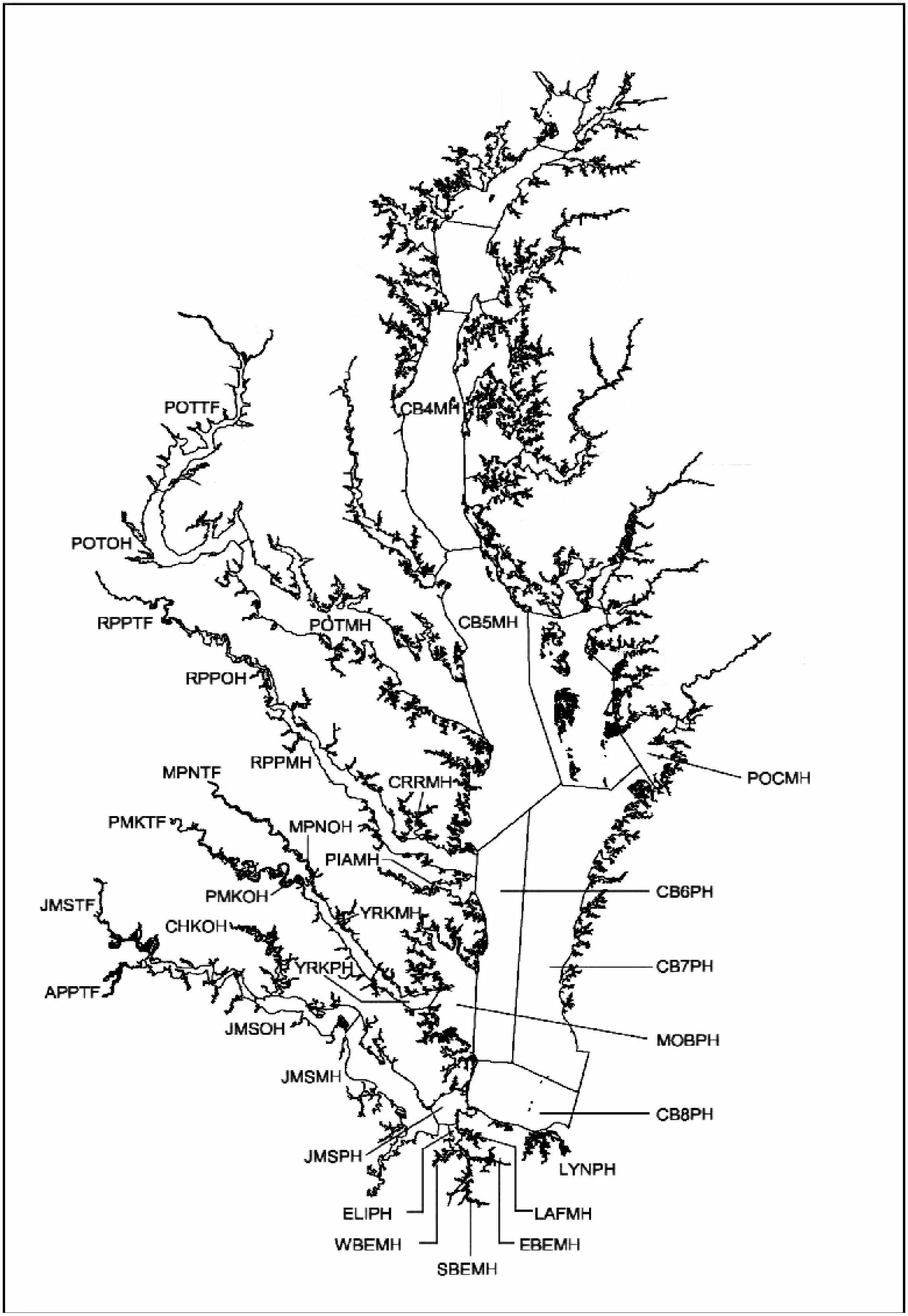
2 = Percent Light through Water = $100e^{(-KdZ)}$ where K_d is water column light attenuation coefficient and can be measured directly or converted from a measured secchi depth where K_d = 1.45/secchi depth. Z = depth at location of measurement of K_d.

Chlorophyll-a Criteria

Designated Use	**Chlorophyll *a* (µg/l)**	**Chesapeake Bay Program Segment**	**Temporal Application**
Open-Water	10	JMSTF2	March 1 - May 31
	15	JMSTF1	
	15	JMSOH	
	12	JMSMH	
	12	JMSPH	
	15	JMSTF2	July 1 - September 30
	23	JMSTF1	
	22	JMSOH	
	10	JMSMH	
	10	JMSPH	

Table II-13 - Numeric Chlorophyll-a Criteria (Open-Water use)

Figure II-11. Chesapeake Bay Dissolved Oxygen and Water Clarity Assessment Segmentation.



(5) Estuarine Bioassessments based on the CBP Benthic Index of Biological Integrity (B-IBI)

Assessments of benthic community health are performed in cooperation among environmental staff from offices of EPA Region III (Philadelphia, PA), the EPA Chesapeake Bay Program (Annapolis, MD), the Maryland Department of the Environment, the Maryland Department of Natural Resources, and the Virginia Department of Environmental Quality. The project examines Chesapeake Bay program benthic monitoring data collected during each five- or six-year assessment window with the goal of determining attainment of the MD and VA standards for Aquatic Life Use (ALUS). This assessment protocol is summarized in **Figure II-12**, below. More complete technical details are available in the report "2006 303(d) Assessment Methods for Chesapeake Bay Benthos" (Llanso, et al., 2005).

Protocol

The overall assessment decision protocol is conducted in three phases as shown in **Figure II-12** (below).

Phase I consists of the evaluation of the sample size available from the assessment segment during the five- or six-year assessment window. If the sample size requirement is not met, a statistical impairment assessment based on benthic community health is not carried out, but the data may still be useful as an adjunct to other available aquatic life use data. If the sample size satisfies the requirements of the statistical method ($N \geq 10$), a formal assessment of status (i.e. 'impaired' vs. 'supports aquatic life use') is determined utilizing the "percent degraded area" statistical methodology (Phase II).

Phase II consists of the aquatic life use impairment assessment based on a comparison of Benthic Index of Biotic Integrity (B-IBI) scores and can result in one of two possible outcomes: (1) the segment is not impaired for Aquatic Life use due to benthic community status (note that the segment may still be impaired for aquatic life use due to failure of the other aquatic life use subcategories), or (2) the segment fails to support aquatic life use due to benthic community status and is assessed as impaired.

Phase III consists of the identification of probable causes of benthic impairment of the waterbody segment based upon benthic stressor diagnostic analyses. It is a two step procedure that involves (1) Site Classification, and (2) Segment Characterization.

1. Site classification: The first step is to assign probable sources of benthic degradation to each individual "degraded" benthic sample. For the purpose of these diagnostic analyses, a sample is considered degraded if the B-IBI score is less than 2.7.

Site Classification - Step 1a: The application of a formal statistical linear discriminant function calculates the 'inclusion probability' of each degraded site belonging to a 'contaminant caused' group or an 'other causes' group, based upon its B-IBI score and associated metrics. If a site is assigned to the 'Contaminant' Group with a probability ≥ 0.9, this site is considered impacted by contaminated sediment and no further classification is required.

Site Classification - Step 1b: If a site is classified as degraded due to 'other causes' (i.e., not contaminant-related), an evaluation of the relative abundance (and/or biomass) of the benthos is examined. Scores for both abundance and biomass are considered to be bipolar for the Chesapeake Bay Benthic IBI. For either metric; a high score of 5, indicating desirable conditions, falls in the mid-range of the abundance/biomass distributions, while a low score of 1, indicating undesirable conditions, can result either from insufficient

Figure II-12. Estuarine Benthic Bioassessment Protocol (ALUS).

Overall Decision Protocol.

Phase I		Phase II		Phase III
Sample Size Evaluation		Impairment Assessment		Segment Characterization (Identify Probable Causes)
N < 10?	Yes →	Insufficient sample size to conduct statistical assessment Optional use of B-IBI scores and diagnostic analyses as adjunct to other available data		
↓ No				
N ≥ 10?	Yes →	Apply Degraded Area Statistical method		
		↓		
		Statistics indicate 'not impaired' for benthic aquatic life? Optional use of B-IBI scores and diagnostic analyses in conjunction with other available data		
		↓ No		
		Statistics indicate 'impaired' for benthic aquatic life	Yes →	Apply diagnostic analyses for assignment of suspected cause(s) of degradation

abundance/biomass or excessive abundance/biomass. The scoring thresholds for these two metrics vary with habitat type (salinity regime and substrate type). In this process, a site is classified as degraded by "low dissolved oxygen" if the abundance (and/or biomass) metric scores a 1 due to insufficient abundance (and/or biomass). Alternatively, if the abundance (and/or biomass) metric scores a 1 because of excessive abundance (and/or biomass) the site is classified as degraded by "eutrophication" without DO depression.

More detailed descriptions of the possible outcome scenarios from the 3 phases of this protocol are provided in the chapter on "Chesapeake Bay Program Assessment and Summary" of Virginia's most recent 305(b)/303(d) Integrated Report .

2. Segment classification: The assignment of probable causes of benthic degradation for the overall segment is accomplished using a simple 25% rule. If the total number of sites in a segment impacted by a single cause (i.e. sediment contaminants, low dissolved oxygen, or eutrophication) exceeds 25%, then that cause is assigned. If no causes exceed 25%, the cause is considered unknown. The cause(s) of benthic community degradation should be identified as suspected (as opposed to being verified) in the ADB database.

(4) Plans for future assessment refinements

Bay Assessment methodology has been revised since the initial 2006 Integrated Assessment Report, and more changes are anticipated as knowledge of the Chesapeake Bay increases and monitoring technology improves. To assure consistency throughout the multi-State Chesapeake Bay system, assessment issues are resolved through the Water Quality Criteria Assessment Workgroup (CAP) composed of staff from the offices of EPA Region III, EPA Chesapeake Bay Program, Maryland Department of the Environment, Maryland Department of Natural Resources and the Virginia Department of Environmental Quality. Full details of all refinements are described in USEPA, *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity, and* Chlorophyll a *for the Chesapeake Bay and Tidal Tributaries*, EPA 2007a (CBP/TRS 285-07, EPA 903-R-07-003), 2007b (CBP/TRS 288/07, EPA 903-R-07-005), 2008a (CBP/TRS 290-08, EPA 903-R-08-001), and 2010 (CBP/TRS 301-10, EPA 903-R-10-002) addenda. The following summarize the problems being currently addressed by CAP:

Assessment of Short-term Criteria

Currently, Bay waters are assessed using a combination of monthly/semi-monthly data collected by the Chesapeake Bay Program and more sporadic datasets collected by DEQ, citizen, and non-agency data collectors. These data are suited for the assessment of a number of parameters, but collectively they are considered insufficient for the assessment of all the dissolved oxygen criteria, which cover different durations. Currently, only two durations are assessed: 30-day mean (Open Water and Deep Water) and the Deep Channel instantaneous minimum. The remaining criteria have yet to be assessed due to a scarcity of the high-frequency datasets (continuous monitoring) that would allow for accurate estimation of 7-day and 1-day means. At present, the use of continuous monitoring is limited to shallow near-shore habitats (as opposed to deeper mid-channel habitats) in the major tributaries (as opposed to the Bay mainstem), and the datasets generated have only been assessed for pH. The Chesapeake Bay Program and state partners are working on methods to create segment-wide generalizations from continuous monitors that allow for the assessment of all DO criteria.

Refinements in statistical determination of attainment

Following interpolation, data are assessed for criteria exceedances using a reference curve to determine waterbody attainment. Assessments are based either upon (1) EPA-published reference curves or (2) use of a default 10% reference curve, if a published curve was not available for a specific aquatic life subcategory (e.g. deep water). It is possible that new reference curves developed by EPA will be adopted into Virginia's Water Quality Standards, and used in future assessments. Additionally, efforts may also be made to explicitly incorporate statistical measures of uncertainty into the assessment process in the future.

Assessment Evaluation Methodology

The methodologies utilized for the assessment of water quality vary with the type of parameter being considered, with the specific water resource type being assessed, and with the source(s) of the water quality data being evaluated. These considerations are discussed in detail in the agency's most recent biennial Water Quality Assessment Guidance Manual and are briefly summarized below.

Conventional Parameters: For conventional parameters (e.g., dissolved oxygen, pH, temperature, bacteria) with well-defined numerical criteria, the EPA-recommended fixed rate (percent) method is used. EPA has proposed a 10.5% violation threshold for differentiating between fully supporting or impaired waters for conventional pollutants. A violation rate that is greater than 10.5% and has at least two violations is considered impaired (see table of "Fixed Rate Assessment Guidelines below).

Fixed Rate Assessment Guidelines

Arithmetic Violation Rate (AR) of Total Samples Analyzed	Assessment
AR ≤ 10.5%	Meets use - Category 2A or 2B
AR > 10.5%	Fails to meet use (impaired) - Categories 4A, 5A, 5B, 5C or 5D

This assessment procedure is applied on each specific water quality parameter being evaluated. A **Category 1** classification is not obtained unless a specific Assessment Unit (AU) is determined to be unimpaired for all parameters assessed. Similarly, when the arithmetic rate of violation is used for assessment purposes the result is either 'supports' or 'fails to support' designated uses, and **Category 3** (Indeterminate) is not a potential outcome.

Monitoring Station Delineation and Siting Methodology: The specific processes for siting monitoring stations within the ambient and Chesapeake Bay monitoring programs, and the delineation of water body segments that they represent, are also described in the Assessment Guidance Manual. The specific strategies used for siting monitoring stations within the various components of the overall monitoring program are described more fully in **Chapter III - Design and Implementation** of this Water Quality Monitoring Strategy document.

Non-Agency Data: DEQ includes data from various sources outside the agency in its biennial assessments of water quality. All non-agency data must pass stringent quality assurance evaluations prior to being included in the assessment process. Such evaluations include ensuring that the procedures used are similar to DEQ or EPA recognized methods and that associated metadata, such as calibration and station location information, is correct. Major external sources of water quality data (physical, chemical and biological) include organized citizen's monitoring programs, other state and federal agencies, and county and municipal monitoring programs, among others.

Data is provided to DEQ on an annual or more frequent basis. Most of the submitted data is uploaded to the DEQ Citizen/Non-agency database [www.deq.virginia.gov/easi/]. This website acts as a central repository for submitted data to be viewable by the public and provide a segregated database to avoid mixing non-DEQ data with data stored in CEDS. Due to limited technical support to enhance the application, large datasets are not currently uploaded to the database. This data is stored electronically on agency computers and removable media for future use or to meet requests for data. Submitted data are kept for a minimum of seven years per agency policy.

Designated Use Evaluation Methodology:

Specific methodologies for the assessment of both Wildlife and Aquatic Life Use support are based on comparisons to acute aquatic life toxics pollutants identified in WQS 25-260-140B. Aquatic Life Use assessments also include the evaluation of both conventional parameters and aquatic community health in free-running freshwater and estuarine environments. Conventional parameters are generally assessed using numeric standards and the arithmetic violation rate procedure described above. The evaluation of aquatic community health is assessed by applying best professional judgment, a Stream Condition Index (SCI), and/or a Benthic Index of Biological Integrity (B-IBI). A weight of evidence approach is often utilized when two or more elements of the Sediment Quality Triad (SQT - sediment chemistry, sediment toxicity and benthic taxonomic diversity) are available and the number of samples fails to meet requirements for other assessment methodologies. Specific interpretation procedures for other data (DO and toxic contaminants) affecting the Chesapeake Bay Benthic IBI are detailed in the decision matrix of Table 4 in the Water Quality Assessment Guidance Manual. Considerations of the evaluation of naturally occurring conditions (without direct, indirect or accelerated anthropogenic impact) that affect aquatic life are also discussed in detail.

As mentioned above, the Interstate Chesapeake Bay Program has recently developed additional criteria for Aquatic Life Use to be applied in the Bay and its tidal tributaries. These criteria were evaluated by the agency's Office of Water Quality Standards, passed through the normal triennial review process, and for the most part have been adopted into the Commonwealth's Water Quality Standards. Although a few details remain to be resolved, initial guidance for their use attainment assessment was included in the 2006 Assessment Guidance Manual. These new criteria involve dissolved oxygen, area coverage by Submerged Aquatic Vegetation (SAV – rooted vascular plants) and water clarity, and chlorophyll-α. The recommended criteria vary by habitat type, season, and water body segment within the Bay drainage. Both the monitoring and assessment methodologies will be further refined for inclusion in future Assessment Guidance Manuals.

The support of the Fish Consumption Use is assessed based upon two types of information. These consist of (1) consumption advisories and restrictions (bans) issued by the Virginia Department of Health (VDH), under a Memorandum of Agreement between the two agencies, and (2) the comparison of fish tissue data to Water Quality Standards criterion-based tissue values (TVs) as listed in Appendix E in the Water Quality Assessment Guidance Manual.

Shellfishing Use support is based upon the determination of restrictions or condemnations of the harvesting and marketability of shellfish resources made by the VDH Division of Shellfish Sanitation (DSS) in the most recent condemnation list associated with the assessment reporting period. Shellfish use is classified as

Approved, Conditionally Approved, Restricted, or Prohibited based on specific conditions summarized in Part V of the Water Quality Assessment Guidance Manual:

Approved area:	Growing areas from which shellfish may be taken for direct marketing at all times.
Conditionally Approved:	Growing areas where the water quality may be affected by seasonal or sporadic use of boat docks or harbor facilities are considered conditionally approved. Normally, this would occur during the boating season (April 30 through October 31).
Restricted Area:	Growing areas where a sanitary survey indicates a limited degree of pollution which makes it unsafe to market shellfish for direct marketing. Shellfish from such areas may be marketed after purifying or relaying activities in accordance with certain VDH-DSS requirements.
Prohibited Area:	Growing areas where the sanitary survey indicates dangerous numbers pathogenic microorganisms or other contaminants that might reach that area. The harvesting of shellfish from these areas for direct marketing, relaying, or depuration is prohibited.

The support of Swimming and Secondary Contact Recreational Uses is assessed together, based primarily upon bacteriological data. In 2006, traditional water quality standards based upon fecal coliform bacteria were replaced with a freshwater standard based upon *Escherichia coli* and a saltwater standard based upon *Enterococci* concentrations in the water. Ambient waters are assessed using the simple arithmetic violation rate procedure applied to either (1) an independent (single grab sample) observation standard or (2) a geometric mean standard when multiple samples are collected within a single calendar month period. For public bathing areas, the frequency and duration of beach closures determined by the Virginia Department of Health are also used for assessment. All of these procedures are fully described in the Water Quality Assessment Guidance Manual.

Public Water Supply Use attainment is assessed according the Water Quality Standards criteria (9 VAC 25-260-140.B) for public water supply. Support of this use is based on specific methodologies described in the Water Quality Assessment Guidance Manual.

Additional Parameter Evaluation Methodologies:

Nutrient Screening Values: Since the last Strategy document, numerical nutrient standards have been developed for significant freshwater lakes (total phosphorus and chlorophyll-α) and the tidal James River (chlorophyll-α). Additionally, two regulations have been adopted which allow for the designation of "nutrient-enriched waters" and for the control of nutrient discharges from point sources into waters so designated. The procedure for assessing nutrient monitoring data under these regulations is described in the Water Quality Assessment Manual. Nutrient thresholds have not been adopted for other waters, but the agency's Academic Advisory Committee is developing a screening tool that will help establish nutrient criteria.

In the absence of approved numerical Water Quality Standards nutrient criteria, the assessment process will not designate a segment impaired based on nutrient data alone. However, these waters will be listed as fully supporting but having observed effects for aquatic life, where monitored nutrient screening values have been exceeded. It is recognized that other designated uses could be affected, but the aquatic life use is considered the primary use affected by nutrient enrichment. For “free flowing” streams, total phosphorus is assessed for the six-year period using a threshold of 200 µg/l. For the assessment of lakes, the total phosphorus threshold is 50 µg/l. In the absence of other monitored data related to aquatic life use, if at least two samples exceed the SV and these violations are >10.5% of the total samples, the water will be listed as fully supporting but having observed effects for aquatic life use. A single sample will not be assessed and a single violation will be considered not assessed. For phosphorus and chlorophyll-α evaluation, the primary concern is the impact on dissolved oxygen concentrations as it relates to aquatic life.

For fresh and tidal fresh waters in estuaries and lakes, chlorophyll-α is assessed for the six-year period. The threshold is 50 µg/l. In the absence of other monitored data related to aquatic life use, if at least two samples are available and violations are >10.5% of the total samples, the water will be listed as fully supporting but having observed effects for aquatic life use. A single sample will not be assessed and a single violation from a small dataset (2-9 samples) is considered fully supporting. Once again, it is recognized that other designated uses could be affected. However, for chlorophyll-α evaluation, the primary concern is increased algae production and the corresponding impact on dissolved oxygen concentrations.

DEQ is still in the process of developing quantitative nutrient-related criteria and Water Quality Standards in other waters, including rivers and streams. The methods that the agency has utilized and the schedule for completing this process are described in a Nutrient Criteria Development Plan, which is discussed elsewhere in this strategy document. Specific assessment methodologies for these parameters will be established once the individual criteria and standards have been defined.

Sediment Chemistry Screening Values (toxics): The methodology for assessment of sediment chemistry, relative to attainment of Aquatic Life Use support, varies with the water resource class being evaluated. For freshwater sediments above the fall line, the Consensus Based Probable Effects Concentrations (PEC; MacDonald et al. 2000) are applied. Estuarine sediment contaminant data collected during scheduled AWQM monitoring are compared to effects range-median (ER-M; National Oceanic and Atmospheric Administration, Long, et al., 1995) SVs for marine and estuarine sediment. If PEC or ER-M values are not available for a specific toxic contaminant, the Virginia 99th percentile value for that parameter (in sediment) is used. The PECs, ER-Ms and 99th Percentiles for specific toxic parameters, and the associated assessment methodologies are summarized in Appendix F of the Water Quality Assessment Guidance Manual.

Additional Toxics Evaluation:

For overall freshwater toxics evaluation, DEQ uses the Virginia Water Quality Standards for human health in surface waters, other than public water supplies (9 VAC 25-260-140.B). These same values are used to assess the fish consumption use in public water supplies as well as all other surface waters. (Please note, the criteria for human health in public water supplies are used only to assess the drinking water use in Public Water Supplies). For metals assessment, only dissolved metals data are used. In conformance with water quality management plans and VPDES permitting procedures, water column toxicant data in the six-year data window are assessed along with more recent data if they reflect current conditions. When assessing the aquatic life and wildlife use support for toxic contaminants, compliance is based on meeting the aquatic life acute Water Quality Standards found in 9 VAC 25-260-140 B. See Appendix E of the Water Quality Assessment Guidance Manual for additional information on fish tissue screening values.

The weight-of evidence approach adopted by DEQ for assessing estuarine toxics data (see EPA 903-R-00-010, June 1999) has been developed through a consensual process between partners of the Chesapeake Bay

Program (CBP) with oversight from the Bay Program's Scientific and Technical Advisory Committee (STAC). The CBP partners include the U.S. EPA Chesapeake Bay Program, the Bay jurisdictions, including Virginia, the private sector and several Virginia/Maryland academic institutions. It is suggested this approach be initiated only when a full suite of toxics related data are available. However, 'best professional judgment should still be used where a full set of toxics data is not available. Generally, this includes ambient water column chemical data with ambient water toxicity test data, and/or sediment chemical data with sediment toxicity test data. The inclusion of benthic-IBI data collected from the same stations is also important in this approach. If available, other relevant toxicological data such as fish tissue and fish histopathological information may be considered within this approach. More specific details of the assessment methodology are provided in Part VI, Section 6.4.2.3 of the Water Quality Assessment Guidance Manual.

Lake and Reservoir Evaluation Methodologies:

The Virginia DEQ monitors and assesses the water quality of all 'significant' lakes and reservoirs in the state. 'Significant' is defined to include all publicly accessible lakes and reservoirs greater than 100 acres in size and all those designated as public drinking water supplies. Assessment is based on (1) the violation rate of numerical water quality standards and/or, for any parameters for which DEQ does not have a Water Quality Standard, (2) a loss of designated use (fishable, swimmable, public water supply) documented by ancillary data (such as records of conditions preventing swimming and/or boating, recurrent fish kills, other QA/QC approved non-agency studies or reports, etc). Several interpretation and/or assessment issues are unique to lakes and reservoirs. The choice and application of specific criteria (especially for dissolved oxygen and trophic status during the summer season), and their appropriate methods of evaluation, depend upon the degree of stratification observed in the water body of interest. As discussed above, newly defined nutrient criteria for lakes and reservoirs were approved by the Virginia State Water Control Board in June 2006. The following describes how significant lakes are assessed.

The first step in the assessment process is to determine whether a lake is stratified. If a lake's temperature differential between surface and bottom waters during the summer months (June through September) is less than 4ºC, the lake is not thermally stratified and the entire water column is treated as a homogenous unit. Otherwise, its waters must be delineated into an epilimnion (warmer surface waters) and a hypolimnion (cooler bottom waters), which are generally separated by a thermocline (layer in which temperature rapidly changes). If these three strata cannot be clearly defined (because of shallow depth, unusual circulation patterns, etc.) the epilimnion is assumed to consist of the upper 1/3 of the water column and the hypolimnion of the bottom 2/3.

For all lakes, dissolved oxygen and pH are assessed by aggregating the two most recent years of data (a minimum of two consecutive monitoring years is required for assessment). Only the epilimnion is assessed if the lake is determined to be stratified; otherwise, the entire water column is assessed. If either parameter has a violation rate greater than 10.5%, the lake is assessed as impaired. Nutrients are implicated as a cause of impairment if 1) in the case of significant lakes, nutrient criteria are exceeded or 2) in the case of non-significant lakes, trophic state indices (see equations below) evaluation indicates eutrophication. Otherwise, the impairment is assumed to be of natural causes (assessment category "4C").

Specific nutrient criteria—total phosphorus and chlorophyll-α apply to significant lakes. Unlike for with DO and pH, each of the two monitoring years are assessed separately and only near-surface data (within one meter) are analyzed. The chlorophyll-α 90th percentile is compared to a lake-specific criterion. If a lake has been treated with algaecide, the median total phosphorus is compared to a lake-specific criterion.

If assessment for the two years conflicts, another year of monitoring data is required to determine aquatic life use support.

The following table summarizes the evaluation of trophic state indices, which are applicable to non-significant lakes:

Trophic State Index (TSI) Evaluation

Secchi Depth	TSI(SD) = 10(6 – ln SD / ln 2)
Chlorophyll-α	TSI(CA) = 10(6 – ((2.04 – 0.68 ln CA) / (ln 2)))
Total Phosphorus	TSI(TP) = 10(6 – ((ln (48/TP)) / ln 2)))

Where: SD = Secchi depth in meters
CA = μg Ca/l
TP = μg P/l

The following rules apply to assessment:

1. Do not calculate a chlorophyll-a TSI in lakes that are treated with algaecides.
2. The Chlorophyll-a TSI will normally be the preferred indicator in untreated lakes.
3. Assume that typical Virginia freshwater lakes and reservoirs are phosphorus limited.
4. Do not use the Secchi depth index in the assessment if it is much larger than the CA and TP indices in the same assessment unit (prevalence of inorganic matter).
5. The appropriate TSI should be calculated based on all summer sample data collected in the segment using the spreadsheet that has been developed for easier data processing.

For each monitoring station, if one or more of the TSI ≥ 60*, the lake/reservoir will be assessed as impaired partially due to one or more pollutants from anthropogenic sources. The assessment unit or entire lake/reservoir will be placed in category 5A for TMDL development.

Trophic Classification

Trophic State	*Carlson Trophic State Index*	*Assessment Category*
Hypereutrophic	80 – 100	5A
Eutrophic	60 – Less than 80	5A
Mesotrophic	40 – Less than 60	4C
Oligotrophic	0 – Less than 40	4C
Unknown	Insufficient Data	3A

Fish Kill Data

If there are documented chronic (more than 1) fish kills in the lake caused by low DO, the assessment unit or entire lake/reservoir will be assessed as impaired due to one or more pollutants from anthropogenic sources and will be placed in category 5A for TMDL development.

Lakes with Algaecide Applications

When the algae are killed from chemical applications they may settle to the bottom, taking phosphorous and particulate matter out of the epilimnion. Therefore, a lake subject to algaecide applications having a

TSI for TP greater than 60 [16] should be listed in category 5A for TMDL development if the land use or other information shows the probable presence of potential anthropogenic sources.

A list of the significant lakes and reservoirs statewide is included as Appendix G in the DEQ Assessment Guidance Manual.

Coastal Assessment:

Virginia has 120 miles of Atlantic Ocean coastline and approximately 2,500 square miles of estuaries. These resources have a prominent place in Virginia's history and culture. They are valued for their commercial fishing, wildlife, sporting, and recreational opportunities, as well as their commercial values in shipping and industry. In the 1970's adverse trends in water quality and living resources were noted and prompted creation of the Federal-Interstate Chesapeake Bay Program (CBP), which intensively monitors all tidal (estuarine) waters within the Chesapeake Bay drainage. This program has more recently been complemented by the Coastal 2000 Initiative / National Coastal Assessment Program, which was initiated in 2000 and has now evolved into one element (coastal) of the National Aquatic Resources Survey and DEQ's Estuarine Probabilistic Monitoring (ProbMon) Program. This ProbMon Program normally includes Atlantic coastal embayments and tidal tributaries to the Atlantic and to Albemarle Sound as well as minor tidal tributaries to Chesapeake Bay. At five-year intervals, when the rotating National Aquatic Resources Surveys (NARS) assess coastal waters, the Chesapeake Bay mainstem is also included in the sampling design. Following the delineation of Virginia's portion of the National Watershed Boundary Dataset (NWBD) in 2006, oceanic watersheds were defined from the shore out to the three-nautical-mile territorial limit, adding 440 square (statute) miles of oceanic waters to DEQ's responsibilities. In 2010, utilizing resources from the NARS program, DEQ General Funds, and logistical support from EPA National (Oceanic Survey Vessel – OSV Bold and crew) and EPA Region 3 headquarters (field team), DEQ was able to conduct its first survey to characterize these near-shore oceanic waters.

Estuarine Assessment

The assessment of coastal waters is conducted in the same manner as the estuarine assessments described above and in various sections of DEQ's Assessment Guidance Manual. Data from the Estuarine Probabilistic Monitoring Program permits an additional weight-of-evidence assessment methodology based upon the Sediment Quality Triad (SQT). The SQT consists of the evaluation of the structure and function of the benthic infauna community, the performance of toxicity tests on the sediment, and the results from chemical analysis of sediment samples. The specific methodology is described in detail in the Assessment Guidance Manual in the section on Estuarine Toxics Evaluation. The assessment is facilitated by the use of an Excel® Workbook that includes all the results from benthic, toxicological and chemical analyses at a specific site. An example of a completed "Weight-of-Evidence Assessment Workbook - Version 3.9" is provided here for station 7CASG000.06 (site VA11-002) D01-TRO [II-B-8.xls], the second estuarine probabilistic site (number 002) on Virginia's 2011 list, which was sampled in Assateague Channel, south of Thurf Marsh Islands, DCR/NRCS Watershed D01 (Chincoteague Bay/Little Mosquito Creek - Atlantic Coastal), NWBD sub-watershed AO03 – 020403030503 - Assateague Channel, by a field team from DEQ's Tidewater Regional Office on 17 August 2011. These Weight-of-Evidence Assessment Workbooks standardize the assessment procedure for the sediment quality triad across all sites, and serve as permanent records of the data used, the intermediate methodologies applied, and the final assessment result for each individual site.

[16] A TSI value of 60 was chosen based on review of approved lake TMDLs for DO impairments.

Near-Shore Oceanic Assessment

In August of 2010 DEQ conducted its first near-shore oceanic survey, collecting hydrographic profiles and sampling near-surface water, sediment, and benthic fauna at 50 probabilistic sites. Aquatic Life Use was characterized at these sites using the same weight-of-evidence procedures described for probabilistic sites in estuarine waters. At present, no Benthic Index of Biotic Integrity (B-IBI) has been validated for near-shore oceanic waters in the Mid-Atlantic coastal region. The fifty sites were also characterized using a Water Quality Index, a Sediment Quality Index, and estuarine Benthic Indices used in the National Aquatic Resource Survey's (NARS) National Coastal Condition Assessment (NCCA). These results were included in DEQ's 2012 305(b)/303(d) Integrated Water Quality Report.

303(d) Listing/De-listing and TMDL Priority Ranking

Part VII of the Assessment Guidance Manual describes the rules used for 303(d) listing/de-listing and TMDL priority ranking for the Commonwealth's waters, once they have been assessed. Five of the seven appendices to the main document provide additional information related to the assessment process:

APPENDIX A -	Clean Water Act References
APPENDIX B -	Regional Biologist Assessment Checklist
APPENDIX C -	Classification of Virginia's Shellfish Growing Areas
APPENDIX D -	Incorporating the *Proactive Approach* for Impaired Waters De-listing
APPENDIX E-1 -	Fish Tissue Values (TVs) P. 92
APPENDIX E-2 -	Fish Tissue Screening Values (TSVs) P. 94
APPENDIX F -	Consensus-Based and ER-M Sediment Screening Values P. 95
APPENDIX G -	Significant Lakes by DEQ Regional Offices

4. Watershed Monitoring and Assessment under the National Watershed Boundary Dataset (NWBD)

As mentioned elsewhere in this document, when the delineation of the 6th Order, 12-digit sub-watersheds of the National Watershed Boundary Dataset (NWBD) was completed in 2006, the effective number of hydrological units that DEQ was committed to monitoring increased from 494 (1995 delineation) to 1247 (2006 delineation), each delineation including the Chesapeake Bay mainstem as a single (super large) unit. In 2007, when the agency began adapting its Watershed Monitoring Network to the new hydrological unit system, DEQ formally stated its commitment to assess waters in all 1247 sub-watersheds by 2020. As a result of the process the agency had used in siting its watershed monitoring stations under the previous delineation (symmetrically sited, based on watershed hydrology and Shreve stream order - see Chapter III, Section B.1 – *Watershed Monitoring Network* – (2) siting), most of the smaller sub-watersheds in the NWBD delineation already contained a watershed station. Under the established schedule of six-year cycles, composed of three two-year station rotations, this would theoretically require the monitoring of approximately 416 HUs per year. Considering other monitoring required by the Trend Monitoring Network, two Probabilistic Monitoring Programs (free-running freshwater and estuarine), TMDL Monitoring, and other program-specific obligations, this was barely feasible with the resources available at that time (December 2006). Precipitous declines in available resources due to the 2007–2012 economic recession demanded a significant reduction in monitoring and a restructuring of the planned watershed-monitoring schedule.

Reexamination of the 1247 NWBD sub-watersheds revealed that the Chesapeake Bay mainstem and 11 Oceanic sub-watersheds contained no streams or traditional hydrologic structure and could be exempted from the established design of the Watershed Monitoring Network, although the commitment still exists to monitor and assess them. In addition, numerous sub-watersheds along terrestrial state boundaries were small fragments of larger HUs, many of which drained out-of-state. Eleven of these (see **Table II.C.4.1** below) contained no perennial waters that would support conventional ambient monitoring – a total of 2309.30 acres (3.6 sq. mi. or 0.0084% of the state's total area). Several of these will be shown to have perennial streams (0.04 to 2.47 mi or more) under the new 1:24,000 mapping delineation of the National Hydrography Dataset that is currently in progress.

12-Digit, 6th Order NWBD Sub-Watersheds without Perrenial Waters in Virginia			
VAHU6	**Basin/Sub-basin**	**Name**	**Area (Ac)**
CM28	5A - Chowan/Meherrin	Cypress Creek	221.22
JU16	2A - Upper James	North Fork Potts Creek-South Fork Potts Creek	148.56
PS87	1A - Upper Potomac/Shenandoah	Bullskin Run	508.13
PU05	1A - Upper Potomac	Thorn Creek-Whitehorn Creek	757.31
PU07	1A - Upper Potomac	Lost River-Cullers Run	35.43
RD68	4A - Roanoke/Dan	Hyco Lake-Cane Creek	36.58
RL15	4A - Lower Roanoke	Smith Creek-Newmans Creek	148.08
RL19	4A - Lower Roanoke	Sixpound Creek	5.25
RL24	4A - Lower Roanoke	Roanoke River/Roanoke Rapids Lake	98.94
TH46	6C - Tennessee/Holston	Big Creek	2.69
TP19	6B - Tennessee/Powell	Powell River-Gap Creek	347.11

Table II.C.4.1 - Sixth Order NWBD Sub-Watersheds without Perennial Waters in Virginia.
(Pale yellow highlights indicate watersheds of less than 5.0 square miles.)

In addition, 64 sub-watersheds or minor fragments[17] thereof (including those in the table above) contained less than 3200 acres (5.0 sq. mi.) of drainage area within Virginia. Such small watersheds were examined individually to determine their status and accessibility prior to deciding how to monitor them (or not). If such a small watershed had no public access, or could not be monitored safely, it might be left unmonitored or be monitored only biologically. If a watershed fragment drained into Virginia, it was either monitored directly (if accessible) or combined with the down-stream (receiving) watershed for assessment purposes. If a small watershed fragment drained out of state, it would only be monitored if the neighboring state assessed the receiving waters as impaired. Virginia waters, however, would only be assessed using Virginia Water Quality Standards and criteria.

In 2010, DEQ carried out a probabilistic survey of Virginia's 26 oceanic NWBD sub-watersheds (AO01 – AO26). Logistical and human resource support from EPA National and Region 3 Headquarters, and financial support from federal grants (Federal §106 Grant Supplement and National Aquatic Resource Survey / National Coastal Condition Assessment funds), united with DEQ general funds and agency field personnel, permitted sampling at 50 probabilistic sites during a four-day cruise on the EPA Oceanic Survey Vessel the (OSV) Bold. All 26 oceanic sub-watersheds were characterized for water quality (temperature, pH, salinity, dissolved oxygen, *Enterococci* bacteria, nutrients, chlorophyll, dissolved and total trace metals, and dissolved petrogenic PAHs), sediment quality (organic and metallic chemical contaminants, toxicity, total organic carbon and particle size), and benthic community structure and function. Five of the 26 oceanic sub-watersheds (see **Table II.C.4.2**, below) were monitored solely with probabilistic grab samples from the cruise and the data were not considered sufficient for formal assessment. They total

[17] Minor fragments in this case refer to small, non-contiguous portions of a watershed that are only connected to one another outside of Virginia.

117,112.98 acres (182.99 sq. mi or 0.43% of the state's surface area). The formal Weight-of-Evidence Aquatic Life Use assessment, which is based on the Sediment Quality Triad and is routinely applied to assess estuarine probabilistic sites, was not considered valid for oceanic sites because there was no verified benthic index available for evaluating oceanic benthic communities.

An additional fifteen terrestrial sub-watersheds (or fragments) had not yet been monitored and assessed in time for the 2012 Integrated Water Quality Report (see **Table II.C.4.3**, below). They total an area of 51,956.87 acres (81.18 sq. mi. or 0.19% of the state). The reasons for their not having been monitored are varied. Some are very small, or very remote, or difficult to access. Others have no safe access points from which monitoring can be accomplished.

Unassessed 12-Digit, 6th Order NWBD Oceanic Sub-Watersheds in Virginia			
VAHU6	Basin/Sub-basin	Name	Area (Ac)
AO07	7C - Atlantic Coastal (Delmarva)	Atlantic Ocean-020403030605	5,887.82
AO12	7C - Atlantic Coastal (Delmarva)	Atlantic Ocean-Metompkin Island	24,732.92
AO16	7C - Atlantic Coastal (Delmarva)	Atlantic Ocean-Parramore Island	26,544.00
AO17	7C - Atlantic Coastal (Delmarva)	Atlantic Ocean-020403040403	31,612.10
AO26	7D - Atlantic Coastal (Southeastern Coastal)	Atlantic Ocean-030102051706	28,336.14

Table II.C.4.2 - Five Oceanic NWBD Sub-Watersheds that were not formally assessed in the 2012 Integrated Report.

In spite of these difficulties, 1,216 (98.38%) of the state's 1236 NWBD sub-watersheds with perennial waters were monitored and assessed for at least one designated use in the 2002 through 2012 Water Quality Assessment Reports. This represents 99.38% of the state's surface area. The map of **Watersheds with Assessed Use(s) - (2002 - 2012)** [II-C-4-1.pdf], linked to this document, provides a visual summary of the NWBD sub-watersheds monitored and formally assessed in the six most recent 305(b)/303(d) Reports. To see more detail of the minor watershed fragments along the state's borders, it is best to view the map at a zoom level of 400%.

Unassessed 6th Order NWBD Sub-Watersheds as of the 2012 Integrated Water Quality Report			
VAHU6	**Basin/Sub-basin**	**Name**	**Area (Ac)**
AS08	5B - Dismal Swamp/Albemarle Sound	Dismal Swamp-Culpeper Island	1,137.47
AS11	5B - Dismal Swamp/Albemarle Sound	Northwest River-Tull Bay	832.26
CL01	5A - Lower Chowan	Jones Swamp[1]	25,346.96
CL05	5A - Lower Chowan	Duke Swamp	3,190.97
JU17	2A - Upper James	Potts Creek-Trout Branch	2,136.62
NE84	9- - New	East River	116.70
PU09	1A - Upper Potomac	Middle Fork Sleepy Creek	3,327.29
RD40	4A - Roanoke/Dan	Lower Hogans Creek	580.28
RL21	4A - Lower Roanoke	Roanoke River/Lake Gaston-Songbird Creek [2]	7,610.92
TC35	6B - Tennessee/Clinch	Panther Creek	207.44
TP15	6B - Tennessee/Powell	Mulberry Creek	822.24
TP16	6B - Tennessee/Powell	Powell River-Fourmile Creek	3,774.73
TP17	6B - Tennessee/Powell	Powell River-Cox Creek	820.80
YA01	4B - Yadkin	Headwaters Fisher River	886.47
YA02	4B - Yadkin	Little Fisher River	1,165.72

[1] This sub-watershed, entirely within Virginia, was monitored for field parameters, nutrients, and E. coli six times during 2012.
[2] This sub-watershed is also entirely within Virginia. Mill Creek in this watershed was sampled twice for benthic inverebrates in 2012!

Table II.C.4.3 - Sixth Order NWBD Sub-Watersheds that had not been monitored and assessed in time for the 2012 305(b)/303(d) Integrated Water Quality Report.
(Pale yellow highlights indicate watersheds of less than 5.0 square miles.)

Further Information:

The most updated additional details on the classification of the Commonwealth's water resources for assessment purposes are always available in the current Assessment Guidance Manual on the DEQ WebPages.

For additional information on the assessment process, contact:

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