CHESAPEAKE BAY TMDL EXECUTIVE SUMMARY

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has established the Chesapeake Bay Total Maximum Daily Load (TMDL), a historic and comprehensive “pollution diet” with rigorous accountability measures to initiate sweeping actions to restore clean water in the Chesapeake Bay and the region’s streams, creeks and rivers.

Despite extensive restoration efforts during the past 25 years, the TMDL was prompted by insufficient progress and continued poor water quality in the Chesapeake Bay and its tidal tributaries. The TMDL is required under the federal Clean Water Act and responds to consent decrees in Virginia and the District of Columbia from the late 1990s. It is also a keystone commitment of a federal strategy to meet President Barack Obama’s Executive Order to restore and protect the Bay.

The TMDL – the largest ever developed by EPA – identifies the necessary pollution reductions of nitrogen, phosphorus and sediment across Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia and the District of Columbia and sets pollution limits necessary to meet applicable water quality standards in the Bay and its tidal rivers and embayments. Specifically, the TMDL sets Bay watershed limits of 185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus and 6.45 billion pounds of sediment per year – a 25 percent reduction in nitrogen, 24 percent reduction in phosphorus and 20 percent reduction in sediment. These pollution limits are further divided by jurisdiction and major river basin based on state-of-the-art modeling tools, extensive monitoring data, peer-reviewed science and close interaction with jurisdiction partners.

The TMDL is designed to ensure that all pollution control measures needed to fully restore the Bay and its tidal rivers are in place by 2025, with at least 60 percent of the actions completed by 2017. The TMDL is supported by rigorous accountability measures to ensure cleanup commitments are met, including short-and long-term benchmarks, a tracking and accountability system for jurisdiction activities, and federal contingency actions that can be employed if necessary to spur progress.

Watershed Implementation Plans (WIPs), which detail how and when the six Bay states and the District of Columbia will meet pollution allocations, played a central role in shaping the TMDL. Most of the draft WIPs submitted by the jurisdictions in September 2010 did not sufficiently identify programs needed to reduce pollution or provide assurance the programs could be implemented. As a result, the draft TMDL issued September 24, 2010 contained moderate- to high-level backstop measures to tighten controls on federally permitted point sources of pollution.

A 45-day public comment period on the draft TMDL was held from September 24 to November 8, 2010. During that time, EPA held 18 public meetings in all seven Bay watershed jurisdictions, which were attended by about 2,500 citizens. EPA received more than 14,000 public comments and, where appropriate, incorporated responses to those comments in developing the final TMDL.

After states submitted the draft WIPs, EPA worked closely with each jurisdiction to revise and strengthen its plan. Because of this cooperative work and state leadership, the final WIPs were significantly improved. Examples of specific improvements include:

- Regulated point sources and non-regulated nonpoint sources of nitrogen, phosphorus, and sediment are fully considered and evaluated separately in terms of their relative contributions to water quality impairment of the Chesapeake Bay's tidal waters.
- Committing to more stringent nitrogen and phosphorus limits at wastewater treatment plants, including on the James River in Virginia. (Virginia, New York, Delaware)
- Pursuing state legislation to fund wastewater treatment plant upgrades, urban stormwater management and agricultural programs. (Maryland, Virginia, West Virginia)
- Implementing a progressive stormwater permit to reduce pollution. (District of Columbia)
- Dramatically increasing enforcement and compliance of state requirements for agriculture. (Pennsylvania)
- Committing state funding to develop and implement state-of-the-art-technologies for converting animal manure to energy for farms. (Pennsylvania)
- Considering implementation of mandatory programs for agriculture by 2013 if pollution reductions fall behind schedule. (Delaware, Maryland, Virginia)

These improvements enabled EPA to reduce and remove most federal backstops, leaving a few targeted backstops and a plan for enhanced oversight and contingency actions to ensure progress. As a result, the final TMDL is shaped in large part by the jurisdictions' plans to reduce pollution, which was a long-standing priority for EPA and why the agency always provided the jurisdictions with flexibility to determine how to reduce pollution in the most efficient, cost-effective and acceptable manner.

Now the focus shifts to the jurisdictions' implementation of the WIP policies and programs that will reduce pollution on-the-ground and in-the-water. EPA will conduct oversight of WIP implementation and jurisdictions' progress toward meeting two-year milestones. If progress is insufficient, EPA is committed to take appropriate contingency actions including targeted compliance and enforcement activities, expansion of requirements to obtain NPDES permit coverage for currently unregulated sources, revision of the TMDL allocations and additional controls on federally permitted sources of pollution, such as wastewater treatment plants, large animal agriculture operations and municipal stormwater systems.

In 2011, while the jurisdictions continue to implement their WIPs, they will begin development of Phase II WIPs, designed to engage local governments, watershed organizations, conservation districts, citizens and other key stakeholders in reducing water pollution.

TMDL BACKGROUND

The Clean Water Act (CWA) sets an overarching environmental goal that all waters of the United States be "fishable" and "swimmable." More specifically it requires states and the District of Columbia to establish appropriate uses for their waters and adopt water quality standards that are protective of those uses. The CWA also requires that every two years jurisdictions develop – with EPA approval – a list of waterways that are impaired by pollutants and do not meet water quality standards. For those waterways identified on the impaired list, a TMDL must be developed. A TMDL is essentially a “pollution diet” that identifies the maximum amount of a pollutant the waterway can receive and still meet water quality standards.

Most of the Chesapeake Bay and its tidal waters are listed as impaired because of excess nitrogen, phosphorus and sediment. These pollutants cause algae blooms that consume oxygen and create “dead zones” where fish and shellfish cannot survive, block sunlight that is needed for underwater Bay grasses, and smother aquatic life on the bottom. The high levels of nitrogen, phosphorus and sediment enter the water from agricultural operations, urban and suburban stormwater runoff, wastewater facilities, air pollution and other sources, including onsite septic systems. Despite some reductions in pollution during the past 25 years of restoration due to efforts by federal, state and local governments; non-governmental organizations; and stakeholders in the agriculture, urban/suburban stormwater, and wastewater sectors, there has been insufficient progress toward meeting the water quality goals for the Chesapeake Bay and its tidal waters.

More than 40,000 TMDLs have been completed across the United States, but the Chesapeake Bay TMDL will be the largest and most complex thus far – it is designed to achieve significant reductions in nitrogen, phosphorus and sediment pollution throughout a 64,000-square-mile watershed that includes the District of Columbia and large sections of six states. The TMDL is actually a combination of 92 smaller TMDLs for individual Chesapeake Bay tidal segments and includes pollution limits that are sufficient to meet state water quality standards for dissolved oxygen, water clarity, underwater Bay grasses and chlorophyll-*a*, an indicator of algae levels (Figure ES-1). It is important to note that the pollution controls employed to meet the TMDL will also have significant benefits for water quality in tens of thousands of streams, creeks, lakes and rivers throughout the region.

Since 2000, the seven jurisdictions in the Chesapeake Bay watershed (Delaware, District of Columbia, Maryland, New York, Pennsylvania, Virginia, and West Virginia), EPA and the Chesapeake Bay Commission, which are partners in the Chesapeake Bay Program, have been planning for a Chesapeake Bay TMDL.

Since September 2005, the seven jurisdictions have been actively involved in decision-making to develop the TMDL. During the October 2007 meeting of the Chesapeake Bay Program’s Principals’ Staff Committee, the Bay watershed jurisdictions and EPA agreed that EPA would establish the multi-state TMDL. Since 2008, EPA has sent official letters to the jurisdictions detailing all facets of the TMDL, including: nitrogen, phosphorus and sediment allocations; schedules for developing the TMDL and pollution reduction plans; EPA’s expectations and evaluation criteria for jurisdiction plans to meet the TMDL pollution limits; reasonable assurance for controlling nonpoint source pollution; and backstop actions that EPA could take to ensure progress.

The TMDL also resolves commitments made in a number of consent decrees, Memos of Understanding, the Chesapeake Bay Foundation settlement agreement of 2010, and settlement agreements dating back to the late 1990s that address certain tidal waters identified as impaired in the District of Columbia, Delaware, Maryland and Virginia.

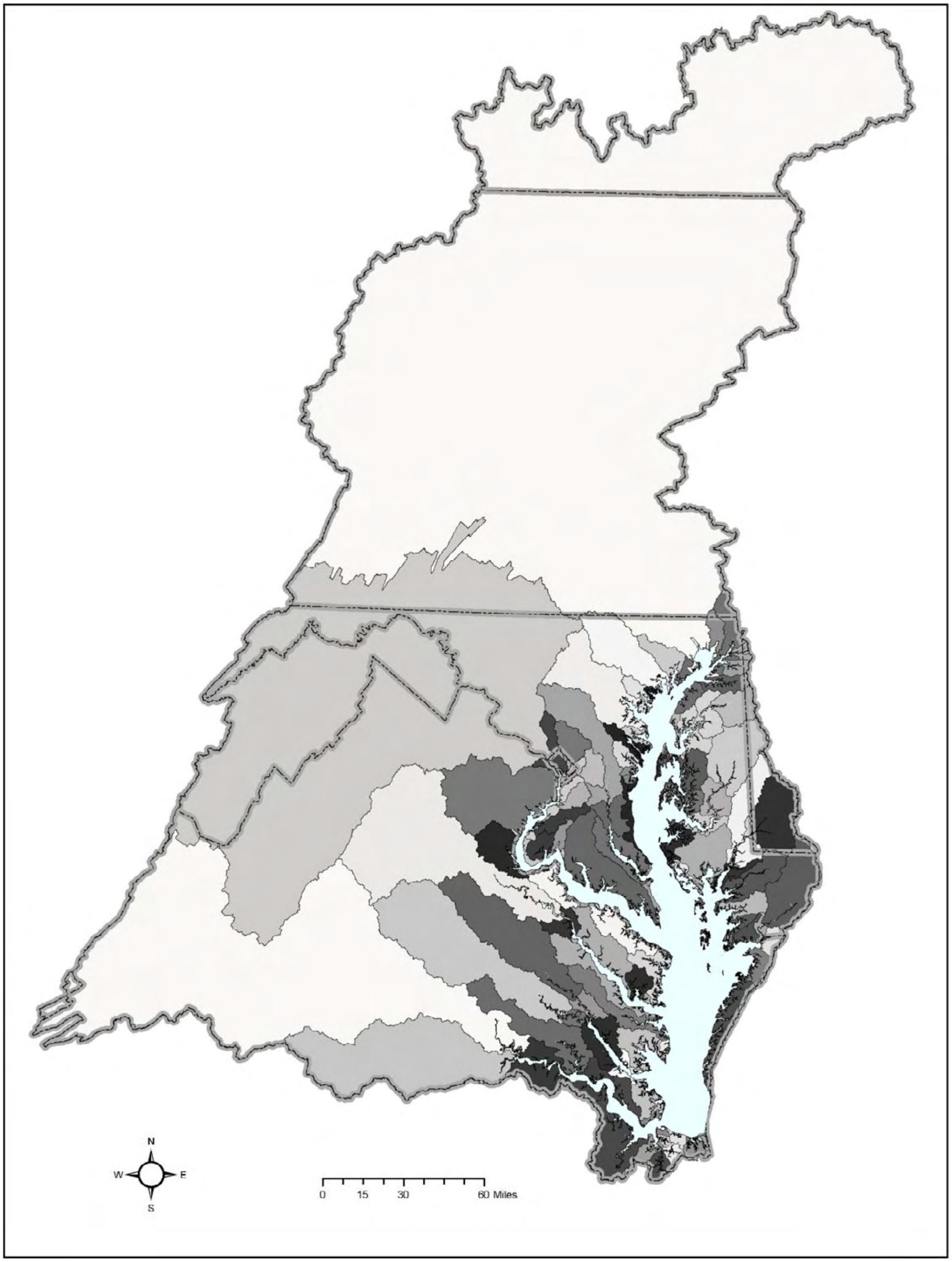

Figure ES-1. A nitrogen, phosphorus and sediment TMDL has been developed for each of the 92 Chesapeake Bay segment watersheds.

Additionally, President Obama issued Executive Order 13508 on May 12, 2009, which directed the federal government to lead a renewed effort to restore and protect the Chesapeake Bay and its watershed. The Chesapeake Bay TMDL is a keystone commitment in the strategy developed by 11 federal agencies to meet the President's Executive Order.

DEVELOPING THE CHESAPEAKE BAY TMDL

Development of the Chesapeake Bay TMDL required extensive knowledge of the stream flow characteristics of the watershed, sources of pollution, distribution and acreage of the various land uses, appropriate best management practices, the transport and fate of pollutants, precipitation data and many other factors. The TMDL is informed by a series of models, calibrated to decades of water quality and other data, and refined based on input from dozens of Chesapeake Bay scientists. Modeling is an approach that uses observed and simulated data to replicate what is occurring in the environment to make future predictions, and was a critical and valuable tool to develop the Chesapeake Bay TMDL.

The development of the TMDL consisted of several steps:

1. EPA provided the jurisdictions with loading allocations for nitrogen, phosphorus and sediment for the major river basins by jurisdiction.
2. Jurisdictions developed draft Phase I WIPs to achieve those basin-jurisdiction allocations. In those draft WIPs, jurisdictions made decisions on how to further sub-allocate the basin-jurisdiction loadings to various individual point sources and a number of point and nonpoint source pollution sectors.
3. EPA evaluated the draft WIPs and, where deficiencies existed, EPA provided backstop allocations in the draft TMDL that consisted of a hybrid of the jurisdiction WIP allocations modified by EPA allocations for some source sectors to fill gaps in the WIPs.
4. The draft TMDL was published for a 45-day public comment period and EPA held 18 public meetings in all six states and the District of Columbia. Public comments were received, reviewed and considered for the final TMDL.
5. Jurisdictions, working closely with EPA, revised and strengthened Phase I WIPs and submitted final versions to EPA.
6. EPA evaluated the final WIPs and used them along with public comments to develop the final TMDL.

Since nitrogen and phosphorus loadings from all parts of the Bay watershed have an impact on the impaired tidal segments of the Bay and its rivers, it was necessary for EPA to allocate the nitrogen and phosphorus loadings in an equitable manner to the states and basins. EPA used three basic guides to divide these loads.

- Allocated loads should protect living resources of the Bay and its tidal tributaries and should result in all segments of the Bay mainstem, tidal tributaries and embayments meeting water quality standards for dissolved oxygen, chlorophyll *a*, water clarity and underwater Bay grasses.
- Tributary basins that contribute the most to the Bay water quality problems must do the most to resolve those problems (on a pound-per-pound basis) (Figure ES-2).
- All tracked and reported reductions in nitrogen, phosphorus and sediment loads are credited toward achieving final assigned loads.

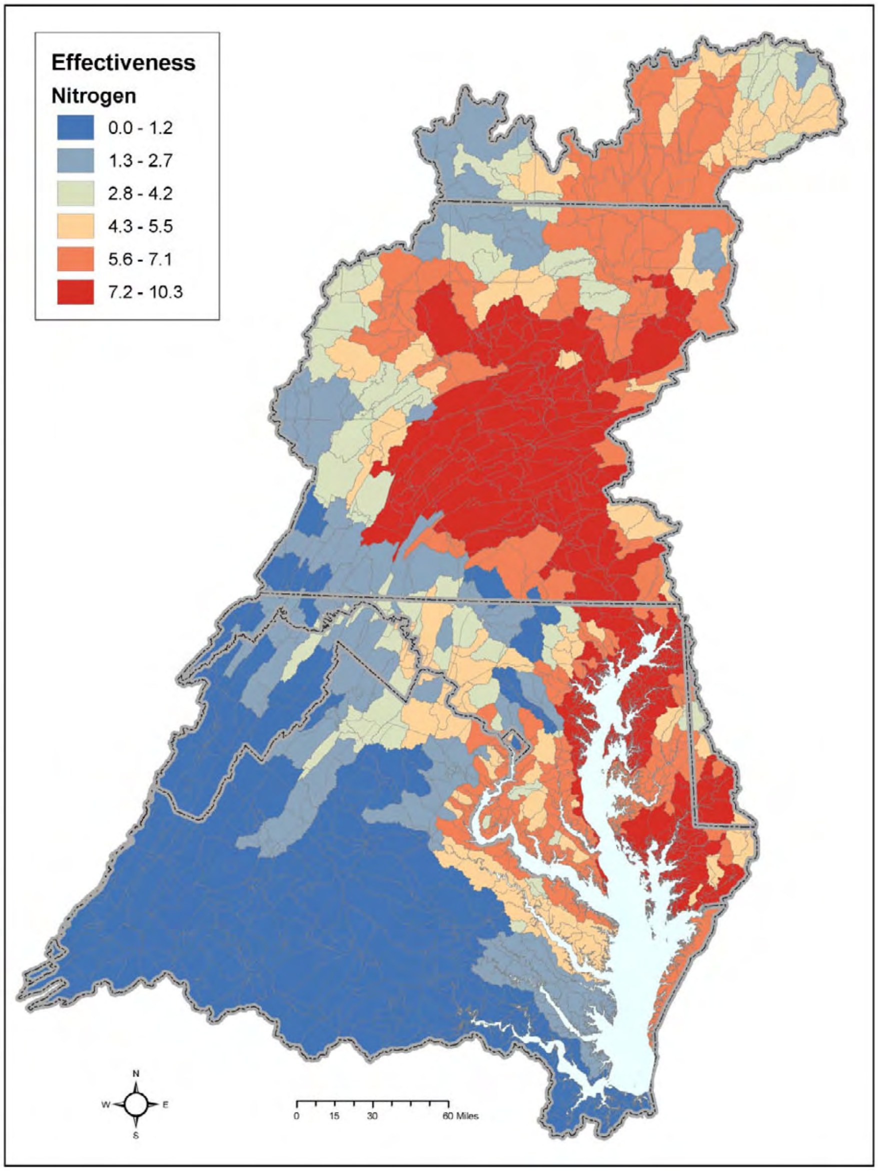

Figure ES-2. Sub-basins across the Chesapeake Bay watershed with the highest (red) to lowest (blue) pound for pound nitrogen pollutant loading effect on Chesapeake Bay water quality.

In addition, EPA has committed to reducing air deposition of nitrogen to the tidal waters of the Chesapeake Bay from 17.9 to 15.7 million pounds per year. The reductions will be achieved through implementation of federal air regulations during the coming years.

To ensure that these pollutant loadings will attain and maintain applicable water quality standards, the TMDL calculations were developed to account for critical environmental conditions a waterway would face and seasonal variation. An implicit margin of safety for nitrogen and phosphorus, and an explicit margin of safety for sediment, also are included in the TMDL.

Ultimately, the TMDL is designed to ensure that by 2025 all practices necessary to fully restore the Bay and its tidal waters are in place, with at least 60 percent of the actions taken by 2017.

The TMDL loadings to the basin-jurisdictions are provided in Table ES-1. These loadings were determined using the best peer-reviewed science and through extensive collaboration with the jurisdictions and are informed by the jurisdictions' Phase I WIPs.

Table ES-1. Chesapeake Bay TMDL watershed nitrogen, phosphorus and sediment final allocations by jurisdiction and by major river basin.

Jurisdiction	Basin	Nitrogen allocations (million lbs/year)	Phosphorus allocations (million lbs/year)	Sediment allocations (million lbs/year)
Pennsylvania	Susquehanna	68.90	2.49	1,741.17
	Potomac	4.72	0.42	221.11
	Eastern Shore	0.28	0.01	21.14
	Western Shore	0.02	0.00	0.37
	PA Total	**73.93**	**2.93**	**1,983.78**
Maryland	Susquehanna	1.09	0.05	62.84
	Eastern Shore	9.71	1.02	168.85
	Western Shore	9.04	0.51	199.82
	Patuxent	2.86	0.24	106.30
	Potomac	16.38	0.90	680.29
	MD Total	**39.09**	**2.72**	**1,218.10**
Virginia	Eastern Shore	1.31	0.14	11.31
	Potomac	17.77	1.41	829.53
	Rappahannock	5.84	0.90	700.04
	York	5.41	0.54	117.80
	James	23.09	2.37	920.23
	VA Total	**53.42**	**5.36**	**2,578.90**
District of Columbia	Potomac	2.32	0.12	11.16
	DC Total	**2.32**	**0.12**	**11.16**
New York	Susquehanna	8.77	0.57	292.96
	NY Total	**8.77**	**0.57**	**292.96**
Delaware	Eastern Shore	2.95	0.26	57.82
	DE Total	**2.95**	**0.26**	**57.82**
West Virginia	Potomac	5.43	0.58	294.24
	James	0.02	0.01	16.65
	WV Total	**5.45**	**0.59**	**310.88**
Total Basin/Jurisdiction Draft Allocation		**185.93**	**12.54**	**6,453.61**
Atmospheric Deposition Draft Allocation[a]		**15.7**	**N/A**	**N/A**
Total Basinwide Draft Allocation		**201.63**	**12.54**	**6,453.61**

[a] Cap on atmospheric deposition loads direct to Chesapeake Bay and tidal tributary surface waters to be achieved by federal air regulations through 2020.

ACCOUNTABILITY AND GOALS

The Chesapeake Bay TMDL is unique because of the extensive measures EPA and the jurisdictions have adopted to ensure accountability for reducing pollution and meeting deadlines for progress. The TMDL will be implemented using an accountability framework that includes WIPs, two-year milestones, EPA's tracking and assessment of restoration progress and, as necessary, specific federal contingency actions if the jurisdictions do not meet their commitments. This accountability framework is being established in part to provide demonstration of the reasonable assurance provisions of the Chesapeake Bay TMDL pursuant to both the Clean Water Act (CWA) and the Chesapeake Bay Executive Order, but is not part of the TMDL itself.

When EPA establishes or approves a TMDL that allocates pollutant loads to both point and nonpoint sources, it determines whether there is a "reasonable assurance" that the point and nonpoint source loadings will be achieved and applicable water quality standards will be attained. Reasonable assurance for the Chesapeake Bay TMDL is provided by the numerous federal, state and local regulatory and non-regulatory programs identified in the accountability framework that EPA believes will result in the necessary point and nonpoint source controls and pollutant reduction programs. The most prominent program is the CWA's National Pollutant Discharge Elimination System (NPDES) permit program that regulates point sources throughout the nation. Many nonpoint sources are not covered by a similar federal permit program; as a result, financial incentives, other voluntary programs and state-specific regulatory programs are used to achieve nonpoint source reductions. These federal tools are supplemented by a variety of state and local regulatory and voluntary programs and other commitments of the federal government set forth in the Executive Order strategy and identified in the accountability framework.

Beginning in 2012, jurisdictions (including the federal government) are expected to follow two-year milestones to track progress toward reaching the TMDL's goals. In addition, the milestones will demonstrate the effectiveness of the jurisdictions' WIPs by identifying specific near-term pollutant reduction controls and a schedule for implementation (see next section for further description of WIPs). EPA will review these two-year milestones and evaluate whether they are sufficient to achieve necessary pollution reductions and, through the use of a Bay TMDL Tracking and Accountability System, determine if milestones are met.

If a jurisdiction's plans are inadequate or its progress is insufficient, EPA is committed to take the appropriate contingency actions to ensure pollution reductions. These include expanding coverage of NPDES permits to sources that are currently unregulated, increasing oversight of state-issued NPDES permits, requiring additional pollution reductions from point sources such as wastewater treatment plants, increasing federal enforcement and compliance in the watershed, prohibiting new or expanded pollution discharges, redirecting EPA grants, and revising water quality standards to better protect local and downstream waters.

Watershed Implementation Plans

The cornerstone of the accountability framework is the jurisdictions' development of WIPs, which serve as roadmaps for how and when a jurisdiction plans to meet its pollutant allocations under the TMDL. In their Phase I WIPs, the jurisdictions were expected to subdivide the Bay TMDL allocations among pollutant sources; evaluate their current legal, regulatory, programmatic and financial tools available to implement the allocations; identify and rectify potential shortfalls in attaining the allocations; describe mechanisms to track and report implementation activities; provide alternative approaches; and outline a schedule for implementation.

EPA provided the jurisdictions with detailed expectations for WIPs in November 2009 and evaluation criteria in April 2010. To assist with WIP preparation, EPA provided considerable technical and financial assistance. EPA worked with the jurisdictions to evaluate various "what if" scenarios – combinations of practices and programs that could achieve their pollution allocations.

The two most important criteria for a WIP is that it achieves the basin-jurisdiction pollution allocations and meets EPA's expectations for providing reasonable assurance that reductions will be achieved and maintained, particularly for non-permitted sources like runoff from agricultural lands and currently unregulated stormwater from urban and suburban lands.

After the draft Phase I WIP submittals in September 2010, a team of EPA sector experts conducted an intense evaluation process, comparing the submissions with EPA expectations. The EPA evaluation concluded that the pollution controls identified in two of the seven jurisdictions' draft WIPs could meet nitrogen and phosphorus allocations and five of the seven jurisdictions' draft WIPs could meet sediment allocations. The EPA evaluation also concluded that none of the seven draft Phase I WIPs provided sufficient reasonable assurance that pollution controls identified could actually be implemented to achieve the nitrogen, phosphorus and sediment reduction targets by 2017 or 2025.

In response to its findings, EPA developed a draft TMDL that established allocations based on using the adequate portions of the jurisdictions' draft WIP allocations along with varying degrees of federal backstop allocations in all seven jurisdictions. Backstop allocations focused on areas where EPA has the federal authority to control pollution allocations through NPDES permits, including wastewater treatment plants, stormwater permits, and animal feeding operations.

Public Participation

The draft Chesapeake Bay TMDL was developed through a highly transparent and engaging process during the past two years. The outreach effort included hundreds of meetings with interested groups; two rounds of public meetings, stakeholder sessions and media interviews in all six states and the District of Columbia in fall of 2009 and 2010; a dedicated EPA website; a series of monthly interactive webinars; notices published in the Federal Register; and a close working relationship with Chesapeake Bay Program committees representing citizens, local governments and the scientific community.

The release of the draft Chesapeake Bay TMDL on September 24, 2010 began a 45-day public comment period that concluded on November 8, 2010. During the comment period EPA conducted 18 public meetings in all six states and the District of Columbia. More than 2,500 people participated in the public meetings. Seven of these meetings were also broadcast live online. During the six weeks that EPA officials traveled around the watershed, they also held dozens of meetings with stakeholders, including local governments, agriculture groups, homebuilder and developer associations, wastewater industry representatives and environmental organizations. EPA received more than 14,000 comments – most of which supported the TMDL – and the Agency's response to those comments is included as an appendix to the TMDL.

Final Watershed Implementation Plans and TMDL

Since submittal of the draft WIPs and release of the draft TMDL in September 2010, EPA worked closely with each jurisdiction to revise and strengthen its plan. Because of this cooperative work and state leadership, the final WIPs were significantly improved. Examples of specific improvements include:

- Committing to more stringent nitrogen and phosphorus limits at wastewater treatment plants, including on the James River in Virginia. (Virginia, New York, Delaware)
- Pursuing state legislation to fund wastewater treatment plant upgrades, urban stormwater management and agricultural programs. (Maryland, Virginia, West Virginia)
- Implementing a progressive stormwater permit to reduce pollution. (District of Columbia)
- Dramatically increasing enforcement and compliance of state requirements for agriculture. (Pennsylvania)
- Committing state funding to develop and implement state-of-the-art-technologies for converting animal manure to energy for farms. (Pennsylvania)
- Considering implementation of mandatory programs for agriculture by 2013 if pollution reductions fall behind schedule. (Delaware, Maryland, Virginia)

These improvements enabled EPA to reduce and remove most federal backstops, leaving a few targeted backstops and a plan for enhanced oversight and contingency actions to ensure progress.

Backstop Allocations, Adjustments, and Actions

Despite the significant improvement in the final WIPs, one of the jurisdictions did not meet all of its target allocations and two of the jurisdictions did not fully meet EPA's expectations for reasonable assurance for specific pollution sectors. To address these few remaining issues, EPA included in the final TMDL several targeted backstop allocations, adjustments and actions. As a result of the jurisdictions' significant improvements combined with EPA's backstops, EPA believes the jurisdictions are in a position to implement their WIPs and achieve the needed pollution reductions. This approach endorses jurisdictions' pollution reduction commitments, gives them the flexibility to do it their way first, and signals EPA's commitment to fully use its authorities as necessary to reduce pollution.

New York Wastewater – Backstop Allocation

- EPA closed the numeric gap between New York's WIP and its modified allocations by establishing a backstop that further reduces New York's wasteload allocation for wastewater. EPA is establishing an aggregate wasteload allocation for wastewater treatment plants.
- EPA calculated this backstop WLA using the nitrogen and phosphorus performance levels that New York committed to, but assumes that significant wastewater treatment plants (WWTPs) are at current flow rather than design flow.

- EPA understands that New York plans to renew and/or modify WWTP permits upon completion of its Phase II WIP, consistent with the applicable TMDL allocations at that time. New York is reviewing engineering reports from WWTPs and, in its Phase II WIP, will provide information to support individual WLAs for these plants.

Pennsylvania Urban Stormwater – Backstop Adjustment

- EPA transferred 50 percent of the stormwater load that is not currently subject to NPDES permits from the load allocation to the wasteload allocation. The TMDL allocation adjustment increases reasonable assurance that pollution allocations from urban stormwater discharges will be achieved and maintained by signaling that EPA is prepared to designate any of these discharges as requiring NPDES permits. Urban areas would only be subject to NPDES permit conditions protective of water quality as issued by Pennsylvania upon designation. EPA will consider this step if Pennsylvania does not demonstrate progress toward reductions in urban loads identified in the WIP. EPA may also pursue designation activities based on considerations other than TMDL and WIP implementation.
- EPA will maintain close oversight of general permits for the Pennsylvania stormwater sector (PAG-13 and PAG-2) and may object if permits are not protective of water quality standards and regulations. Upon review of Pennsylvania's Phase II WIP, EPA will revisit the wasteload allocations for wastewater treatment plants, including more stringent phosphorus limits, in the event that Pennsylvania does not reissue PAG-13 and PAG-2 general permits for Phase II MS4s and construction that are protective of water quality by achieving the load reductions called for in Pennsylvania's Phase I WIP.

West Virginia Agriculture – Backstop Adjustment

- EPA shifted 75 percent of West Virginia's animal feeding operation (AFO) load into the wasteload allocation and assumed full implementation of barnyard runoff control, waste management and mortality composting practices required under a CAFO permit on these AFOs. The shift signals that any of these operations could potentially be subject to state or federal permits as necessary to protect water quality. AFOs would only be subject to NPDES permit conditions as issued by West Virginia upon designation. EPA will consider this step if West Virginia does not achieve reductions in agricultural loads as identified in the WIP. EPA may also pursue designation activities based upon considerations other than TMDL and WIP implementation.
- Based upon West Virginia's ability to demonstrate near-term progress implementing the agricultural section of its WIP, including CAFO Program authorization and permit applications and issuance, EPA will assess in the Phase II WIP whether additional federal actions, such as establishing more stringent wasteload allocations for wastewater treatment plants, are necessary to ensure that TMDL allocations are achieved.

Enhanced Oversight and Contingencies

While final WIPs were significantly improved and the jurisdictions deserve credit for the efforts, EPA also has minor concerns with the assurance that pollution reductions can be achieved in certain pollution sectors in Pennsylvania, Virginia and West Virginia. EPA has informed these jurisdictions that it will consider future backstops if specific near-term progress is not demonstrated in the Phase II WIP.

Pennsylvania Agriculture

- Based on Pennsylvania's ability to demonstrate near-term progress implementing the agricultural section of its WIP, including EPA approval for its CAFO program and enhanced compliance assurance with state regulatory programs, EPA will assess in the Phase II WIP whether additional federal actions, such as shifting AFO loads from the load allocation to the wasteload allocation or establishing more stringent wasteload allocations for WWTPs, are necessary to ensure that TMDL allocations are achieved.

Pennsylvania Wastewater

- EPA established individual wasteload allocations for wastewater treatment plants in the TMDL to ensure that sufficient detail is provided to inform individual permits for sources within the wasteload allocation. Individual allocations do not commit wastewater plants to greater reductions than what the state has proposed in its WIP. Provisions of the TMDL allow, under certain circumstances, for modifications of allocations within a basin to support offsets and trading opportunities.
- EPA will assess Pennsylvania’s near-term urban stormwater and agriculture program progress and determine whether EPA should modify TMDL allocations to assume additional reductions from wastewater treatment plants.

Virginia Urban Stormwater

- If the statewide rule and/or the Phase II WIP do not provide additional assurance regarding how stormwater discharges outside of MS4 jurisdictions will achieve nitrogen, phosphorus, and sediment reductions proposed in the final Phase I WIP and assumed within the TMDL allocations, EPA may shift a greater portion of Virginia’s urban stormwater load from the load allocation to the wasteload allocation. This shift would signal that substantially more stormwater could potentially be subject to NPDES permits issued by the Commonwealth as necessary to protect water quality.

West Virginia Urban Stormwater

- If stormwater rules and/or the Phase II WIP do not provide additional assurance regarding how urban stormwater discharges outside of MS4 jurisdictions will achieve nitrogen, phosphorus, and sediment allocations proposed in the final Phase I WIP and assumed within the TMDL load allocations, EPA may shift a greater portion of West Virginia’s urban stormwater load from the load allocation to the wasteload allocation. The shift would signal that substantially more urban stormwater could potentially be subject to state permit coverage and/or federal Clean Water Act permit coverage as necessary to protect water quality.

West Virginia Wastewater

- EPA established individual wasteload allocations for significant wastewater treatment plants in the TMDL to ensure that sufficient detail is provided to inform individual permits for sources within the wastewater wasteload allocation. Individual allocations do not commit wastewater plants to greater reductions than what the state has proposed in its WIP. Provisions of this TMDL allow, under certain circumstances, for modifications of allocations within a basin to support offsets and trading opportunities.

- EPA will assess West Virginia's near-term agriculture program progress and determine whether additional federal actions consistent with EPA's December 29, 2009 letter, such as modifying TMDL allocations to assume additional reductions from wastewater treatment plants, are necessary to ensure that TMDL allocations are achieved.

Ongoing oversight of Chesapeake Bay jurisdictions

EPA will carefully review programs and permits in all jurisdictions. EPA's goal is for jurisdictions to successfully implement their WIPs, but EPA is prepared to take necessary actions in all jurisdictions for insufficient WIP implementation or pollution reductions. Federal actions can be taken at any time, although EPA will engage particularly during two-year milestones and refining the TMDL in 2012 and 2017. Actions include:

- Expanding coverage of NPDES permits to sources that are currently unregulated
- Increasing oversight of state-issued NPDES permits
- Requiring additional pollution reductions from federally regulated sources
- Increasing federal enforcement and compliance
- Prohibiting new or expanded pollution discharges
- Conditioning or redirecting EPA grants
- Revising water quality standards to better protect local and downstream waters
- Discounting nutrient and sediment reduction progress if jurisdiction cannot verify proper installation and management of controls

FINAL TMDL

As a result of the significantly improved WIPs and the removal and reduction of federal backstops, the final TMDL is shaped in large part by the jurisdictions' plans to reduce pollution. Jurisdiction-based solutions for reducing pollution was a long-standing priority for EPA and why the agency always provided the jurisdictions with flexibility to determine how to reduce pollution in the most efficient, cost-effective and acceptable manner.

Now, the focus shifts to jurisdictions' implementation of the WIP policies and programs designed to reduce pollution on-the-ground and in-the-water. EPA will conduct oversight of WIP implementation and jurisdictions' progress toward meeting two-year milestones. If progress is insufficient, EPA will utilize contingencies to place additional controls on federally permitted sources of pollution, such as wastewater treatment plants, large animal agriculture operations and municipal stormwater systems, as well as target compliance and enforcement activities.

Federal agencies will greatly contribute to restoration of the Chesapeake Bay watershed, particularly through implementation of the new federal strategy created under President Obama's Executive Order. Eleven federal agencies have committed to a comprehensive suite of actions and pursuit of critical environmental goals on the same 2025 timeline as the TMDL. Additionally, federal agencies will be establishing and meeting two-year milestones, with the specific charge of taking actions that directly support the jurisdictions in reducing pollution and restoring water quality.

The jurisdictions are expected to submit Phase II WIPs that provide local area pollution targets for implementation on a smaller scale; the timeframe for these Phase II WIPs will be determined in early 2011. Phase III WIPs in 2017 are expected to be designed to provide additional detail of restoration actions beyond 2017 and ensure that the 2025 goals are met.

Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment

December 29, 2010

U.S. Environmental Protection Agency
Region 3
Water Protection Division
Air Protection Division
Office of Regional Counsel
Philadelphia, Pennsylvania

U.S. Environmental Protection Agency
Region 3
Chesapeake Bay Program Office
Annapolis, Maryland

and

U.S. Environmental Protection Agency
Region 2
Division of Environmental Planning and Protection
New York, New York

in coordination with

U.S. Environmental Protection Agency
Office of Water
Office of Air and Radiation
Office of General Counsel
Office of the Administrator
Washington, D.C.

and in collaboration with

Delaware, the District of Columbia, Maryland, New York,
Pennsylvania, Virginia, and West Virginia

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The TMDL – the largest ever developed by EPA – identifies the necessary pollution reductions of nitrogen, phosphorus and sediment across Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia and the District of Columbia and sets pollution limits necessary to meet applicable water quality standards in the Bay and its tidal rivers and embayments. Specifically, the TMDL sets Bay watershed limits of 185.9 million pounds of nitrogen, 12.5 million pounds of phosphorus and 6.45 billion pounds of sediment per year – a 25 percent reduction in nitrogen, 24 percent reduction in phosphorus and 20 percent reduction in sediment. These pollution limits are further divided by jurisdiction and major river basin based on state-of-the-art modeling tools, extensive monitoring data, peer-reviewed science and close interaction with jurisdiction partners.

The TMDL is designed to ensure that all pollution control measures needed to fully restore the Bay and its tidal rivers are in place by 2025, with at least 60 percent of the actions completed by 2017. The TMDL is supported by rigorous accountability measures to ensure cleanup commitments are met, including short-and long-term benchmarks, a tracking and accountability system for jurisdiction activities, and federal contingency actions that can be employed if necessary to spur progress.

Watershed Implementation Plans (WIPs), which detail how and when the six Bay states and the District of Columbia will meet pollution allocations, played a central role in shaping the TMDL. Most of the draft WIPs submitted by the jurisdictions in September 2010 did not sufficiently identify programs needed to reduce pollution or provide assurance the programs could be implemented. As a result, the draft TMDL issued September 24, 2010 contained moderate- to high-level backstop measures to tighten controls on federally permitted point sources of pollution.

A 45-day public comment period on the draft TMDL was held from September 24 to November 8, 2010. During that time, EPA held 18 public meetings in all seven Bay watershed jurisdictions, which were attended by about 2,500 citizens. EPA received more than 14,000 public comments and, where appropriate, incorporated responses to those comments in developing the final TMDL.

After states submitted the draft WIPs, EPA worked closely with each jurisdiction to revise and strengthen its plan. Because of this cooperative work and state leadership, the final WIPs were significantly improved. Examples of specific improvements include:

- Regulated point sources and non-regulated nonpoint sources of nitrogen, phosphorus, and sediment are fully considered and evaluated separately in terms of their relative contributions to water quality impairment of the Chesapeake Bay's tidal waters.
- Committing to more stringent nitrogen and phosphorus limits at wastewater treatment plants, including on the James River in Virginia. (Virginia, New York, Delaware)
- Pursuing state legislation to fund wastewater treatment plant upgrades, urban stormwater management and agricultural programs. (Maryland, Virginia, West Virginia)
- Implementing a progressive stormwater permit to reduce pollution. (District of Columbia)
- Dramatically increasing enforcement and compliance of state requirements for agriculture. (Pennsylvania)
- Committing state funding to develop and implement state-of-the-art-technologies for converting animal manure to energy for farms. (Pennsylvania)
- Considering implementation of mandatory programs for agriculture by 2013 if pollution reductions fall behind schedule. (Delaware, Maryland, Virginia)

These improvements enabled EPA to reduce and remove most federal backstops, leaving a few targeted backstops and a plan for enhanced oversight and contingency actions to ensure progress. As a result, the final TMDL is shaped in large part by the jurisdictions' plans to reduce pollution, which was a long-standing priority for EPA and why the agency always provided the jurisdictions with flexibility to determine how to reduce pollution in the most efficient, cost-effective and acceptable manner.

Now the focus shifts to the jurisdictions' implementation of the WIP policies and programs that will reduce pollution on-the-ground and in-the-water. EPA will conduct oversight of WIP implementation and jurisdictions' progress toward meeting two-year milestones. If progress is insufficient, EPA is committed to take appropriate contingency actions including targeted compliance and enforcement activities, expansion of requirements to obtain NPDES permit coverage for currently unregulated sources, revision of the TMDL allocations and additional controls on federally permitted sources of pollution, such as wastewater treatment plants, large animal agriculture operations and municipal stormwater systems.

In 2011, while the jurisdictions continue to implement their WIPs, they will begin development of Phase II WIPs, designed to engage local governments, watershed organizations, conservation districts, citizens and other key stakeholders in reducing water pollution.

TMDL BACKGROUND

The Clean Water Act (CWA) sets an overarching environmental goal that all waters of the United States be "fishable" and "swimmable." More specifically it requires states and the District of Columbia to establish appropriate uses for their waters and adopt water quality standards that are protective of those uses. The CWA also requires that every two years jurisdictions develop – with EPA approval – a list of waterways that are impaired by pollutants and do not meet water quality standards. For those waterways identified on the impaired list, a TMDL must be developed. A TMDL is essentially a “pollution diet” that identifies the maximum amount of a pollutant the waterway can receive and still meet water quality standards.

Most of the Chesapeake Bay and its tidal waters are listed as impaired because of excess nitrogen, phosphorus and sediment. These pollutants cause algae blooms that consume oxygen and create “dead zones” where fish and shellfish cannot survive, block sunlight that is needed for underwater Bay grasses, and smother aquatic life on the bottom. The high levels of nitrogen, phosphorus and sediment enter the water from agricultural operations, urban and suburban stormwater runoff, wastewater facilities, air pollution and other sources, including onsite septic systems. Despite some reductions in pollution during the past 25 years of restoration due to efforts by federal, state and local governments; non-governmental organizations; and stakeholders in the agriculture, urban/suburban stormwater, and wastewater sectors, there has been insufficient progress toward meeting the water quality goals for the Chesapeake Bay and its tidal waters.

More than 40,000 TMDLs have been completed across the United States, but the Chesapeake Bay TMDL will be the largest and most complex thus far – it is designed to achieve significant reductions in nitrogen, phosphorus and sediment pollution throughout a 64,000-square-mile watershed that includes the District of Columbia and large sections of six states. The TMDL is actually a combination of 92 smaller TMDLs for individual Chesapeake Bay tidal segments and includes pollution limits that are sufficient to meet state water quality standards for dissolved oxygen, water clarity, underwater Bay grasses and chlorophyll-*a*, an indicator of algae levels (Figure ES-1). It is important to note that the pollution controls employed to meet the TMDL will also have significant benefits for water quality in tens of thousands of streams, creeks, lakes and rivers throughout the region.

Since 2000, the seven jurisdictions in the Chesapeake Bay watershed (Delaware, District of Columbia, Maryland, New York, Pennsylvania, Virginia, and West Virginia), EPA and the Chesapeake Bay Commission, which are partners in the Chesapeake Bay Program, have been planning for a Chesapeake Bay TMDL.

Since September 2005, the seven jurisdictions have been actively involved in decision-making to develop the TMDL. During the October 2007 meeting of the Chesapeake Bay Program’s Principals’ Staff Committee, the Bay watershed jurisdictions and EPA agreed that EPA would establish the multi-state TMDL. Since 2008, EPA has sent official letters to the jurisdictions detailing all facets of the TMDL, including: nitrogen, phosphorus and sediment allocations; schedules for developing the TMDL and pollution reduction plans; EPA’s expectations and evaluation criteria for jurisdiction plans to meet the TMDL pollution limits; reasonable assurance for controlling nonpoint source pollution; and backstop actions that EPA could take to ensure progress.

The TMDL also resolves commitments made in a number of consent decrees, Memos of Understanding, the Chesapeake Bay Foundation settlement agreement of 2010, and settlement agreements dating back to the late 1990s that address certain tidal waters identified as impaired in the District of Columbia, Delaware, Maryland and Virginia.

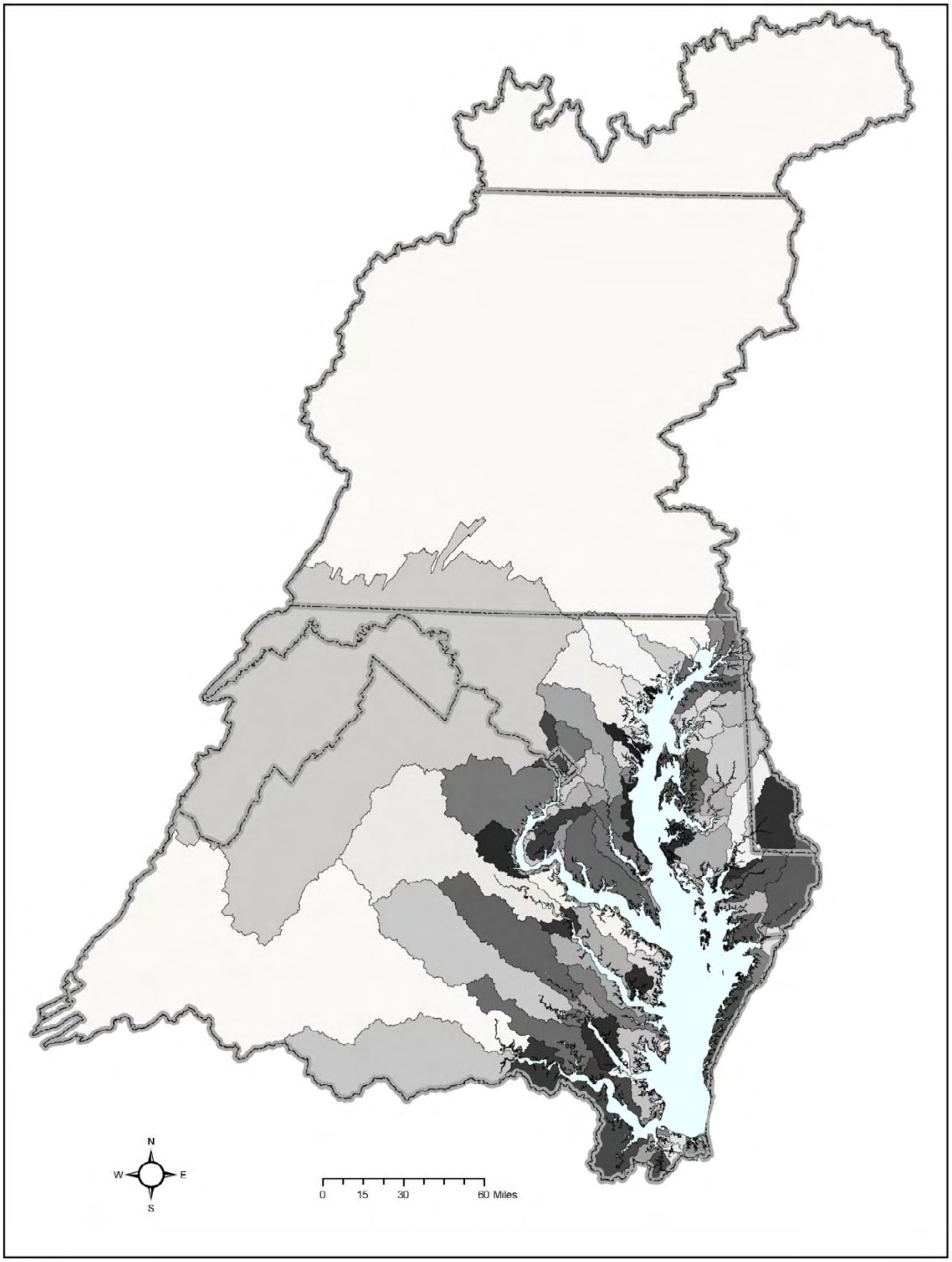

Figure ES-1. A nitrogen, phosphorus and sediment TMDL has been developed for each of the 92 Chesapeake Bay segment watersheds.

Additionally, President Obama issued Executive Order 13508 on May 12, 2009, which directed the federal government to lead a renewed effort to restore and protect the Chesapeake Bay and its watershed. The Chesapeake Bay TMDL is a keystone commitment in the strategy developed by 11 federal agencies to meet the President's Executive Order.

DEVELOPING THE CHESAPEAKE BAY TMDL

Development of the Chesapeake Bay TMDL required extensive knowledge of the stream flow characteristics of the watershed, sources of pollution, distribution and acreage of the various land uses, appropriate best management practices, the transport and fate of pollutants, precipitation data and many other factors. The TMDL is informed by a series of models, calibrated to decades of water quality and other data, and refined based on input from dozens of Chesapeake Bay scientists. Modeling is an approach that uses observed and simulated data to replicate what is occurring in the environment to make future predictions, and was a critical and valuable tool to develop the Chesapeake Bay TMDL.

The development of the TMDL consisted of several steps:

1. EPA provided the jurisdictions with loading allocations for nitrogen, phosphorus and sediment for the major river basins by jurisdiction.
2. Jurisdictions developed draft Phase I WIPs to achieve those basin-jurisdiction allocations. In those draft WIPs, jurisdictions made decisions on how to further sub-allocate the basin-jurisdiction loadings to various individual point sources and a number of point and nonpoint source pollution sectors.
3. EPA evaluated the draft WIPs and, where deficiencies existed, EPA provided backstop allocations in the draft TMDL that consisted of a hybrid of the jurisdiction WIP allocations modified by EPA allocations for some source sectors to fill gaps in the WIPs.
4. The draft TMDL was published for a 45-day public comment period and EPA held 18 public meetings in all six states and the District of Columbia. Public comments were received, reviewed and considered for the final TMDL.
5. Jurisdictions, working closely with EPA, revised and strengthened Phase I WIPs and submitted final versions to EPA.
6. EPA evaluated the final WIPs and used them along with public comments to develop the final TMDL.

Since nitrogen and phosphorus loadings from all parts of the Bay watershed have an impact on the impaired tidal segments of the Bay and its rivers, it was necessary for EPA to allocate the nitrogen and phosphorus loadings in an equitable manner to the states and basins. EPA used three basic guides to divide these loads.

- Allocated loads should protect living resources of the Bay and its tidal tributaries and should result in all segments of the Bay mainstem, tidal tributaries and embayments meeting water quality standards for dissolved oxygen, chlorophyll *a*, water clarity and underwater Bay grasses.
- Tributary basins that contribute the most to the Bay water quality problems must do the most to resolve those problems (on a pound-per-pound basis) (Figure ES-2).
- All tracked and reported reductions in nitrogen, phosphorus and sediment loads are credited toward achieving final assigned loads.

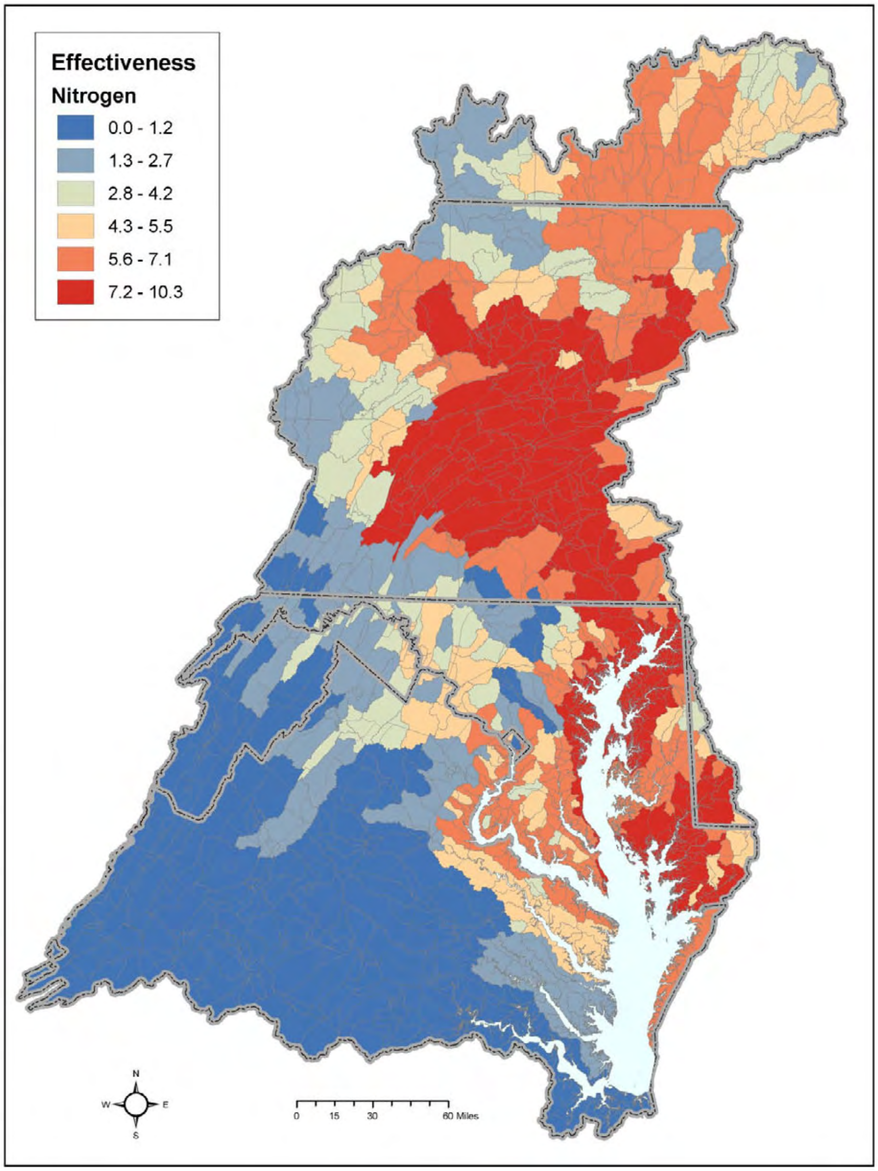

Figure ES-2. Sub-basins across the Chesapeake Bay watershed with the highest (red) to lowest (blue) pound for pound nitrogen pollutant loading effect on Chesapeake Bay water quality.

In addition, EPA has committed to reducing air deposition of nitrogen to the tidal waters of the Chesapeake Bay from 17.9 to 15.7 million pounds per year. The reductions will be achieved through implementation of federal air regulations during the coming years.

To ensure that these pollutant loadings will attain and maintain applicable water quality standards, the TMDL calculations were developed to account for critical environmental conditions a waterway would face and seasonal variation. An implicit margin of safety for nitrogen and phosphorus, and an explicit margin of safety for sediment, also are included in the TMDL.

Ultimately, the TMDL is designed to ensure that by 2025 all practices necessary to fully restore the Bay and its tidal waters are in place, with at least 60 percent of the actions taken by 2017.

The TMDL loadings to the basin-jurisdictions are provided in Table ES-1. These loadings were determined using the best peer-reviewed science and through extensive collaboration with the jurisdictions and are informed by the jurisdictions' Phase I WIPs.

Table ES-1. Chesapeake Bay TMDL watershed nitrogen, phosphorus and sediment final allocations by jurisdiction and by major river basin.

Jurisdiction	Basin	Nitrogen allocations (million lbs/year)	Phosphorus allocations (million lbs/year)	Sediment allocations (million lbs/year)
Pennsylvania	Susquehanna	68.90	2.49	1,741.17
	Potomac	4.72	0.42	221.11
	Eastern Shore	0.28	0.01	21.14
	Western Shore	0.02	0.00	0.37
	PA Total	**73.93**	**2.93**	**1,983.78**
Maryland	Susquehanna	1.09	0.05	62.84
	Eastern Shore	9.71	1.02	168.85
	Western Shore	9.04	0.51	199.82
	Patuxent	2.86	0.24	106.30
	Potomac	16.38	0.90	680.29
	MD Total	**39.09**	**2.72**	**1,218.10**
Virginia	Eastern Shore	1.31	0.14	11.31
	Potomac	17.77	1.41	829.53
	Rappahannock	5.84	0.90	700.04
	York	5.41	0.54	117.80
	James	23.09	2.37	920.23
	VA Total	**53.42**	**5.36**	**2,578.90**
District of Columbia	Potomac	2.32	0.12	11.16
	DC Total	**2.32**	**0.12**	**11.16**
New York	Susquehanna	8.77	0.57	292.96
	NY Total	**8.77**	**0.57**	**292.96**
Delaware	Eastern Shore	2.95	0.26	57.82
	DE Total	**2.95**	**0.26**	**57.82**
West Virginia	Potomac	5.43	0.58	294.24
	James	0.02	0.01	16.65
	WV Total	**5.45**	**0.59**	**310.88**
Total Basin/Jurisdiction Draft Allocation		**185.93**	**12.54**	**6,453.61**
Atmospheric Deposition Draft Allocation[a]		**15.7**	**N/A**	**N/A**
Total Basinwide Draft Allocation		**201.63**	**12.54**	**6,453.61**

[a] Cap on atmospheric deposition loads direct to Chesapeake Bay and tidal tributary surface waters to be achieved by federal air regulations through 2020.

ACCOUNTABILITY AND GOALS

The Chesapeake Bay TMDL is unique because of the extensive measures EPA and the jurisdictions have adopted to ensure accountability for reducing pollution and meeting deadlines for progress. The TMDL will be implemented using an accountability framework that includes WIPs, two-year milestones, EPA's tracking and assessment of restoration progress and, as necessary, specific federal contingency actions if the jurisdictions do not meet their commitments. This accountability framework is being established in part to provide demonstration of the reasonable assurance provisions of the Chesapeake Bay TMDL pursuant to both the Clean Water Act (CWA) and the Chesapeake Bay Executive Order, but is not part of the TMDL itself.

When EPA establishes or approves a TMDL that allocates pollutant loads to both point and nonpoint sources, it determines whether there is a "reasonable assurance" that the point and nonpoint source loadings will be achieved and applicable water quality standards will be attained. Reasonable assurance for the Chesapeake Bay TMDL is provided by the numerous federal, state and local regulatory and non-regulatory programs identified in the accountability framework that EPA believes will result in the necessary point and nonpoint source controls and pollutant reduction programs. The most prominent program is the CWA's National Pollutant Discharge Elimination System (NPDES) permit program that regulates point sources throughout the nation. Many nonpoint sources are not covered by a similar federal permit program; as a result, financial incentives, other voluntary programs and state-specific regulatory programs are used to achieve nonpoint source reductions. These federal tools are supplemented by a variety of state and local regulatory and voluntary programs and other commitments of the federal government set forth in the Executive Order strategy and identified in the accountability framework.

Beginning in 2012, jurisdictions (including the federal government) are expected to follow two-year milestones to track progress toward reaching the TMDL's goals. In addition, the milestones will demonstrate the effectiveness of the jurisdictions' WIPs by identifying specific near-term pollutant reduction controls and a schedule for implementation (see next section for further description of WIPs). EPA will review these two-year milestones and evaluate whether they are sufficient to achieve necessary pollution reductions and, through the use of a Bay TMDL Tracking and Accountability System, determine if milestones are met.

If a jurisdiction's plans are inadequate or its progress is insufficient, EPA is committed to take the appropriate contingency actions to ensure pollution reductions. These include expanding coverage of NPDES permits to sources that are currently unregulated, increasing oversight of state-issued NPDES permits, requiring additional pollution reductions from point sources such as wastewater treatment plants, increasing federal enforcement and compliance in the watershed, prohibiting new or expanded pollution discharges, redirecting EPA grants, and revising water quality standards to better protect local and downstream waters.

Watershed Implementation Plans

The cornerstone of the accountability framework is the jurisdictions' development of WIPs, which serve as roadmaps for how and when a jurisdiction plans to meet its pollutant allocations under the TMDL. In their Phase I WIPs, the jurisdictions were expected to subdivide the Bay TMDL allocations among pollutant sources; evaluate their current legal, regulatory, programmatic and financial tools available to implement the allocations; identify and rectify potential shortfalls in attaining the allocations; describe mechanisms to track and report implementation activities; provide alternative approaches; and outline a schedule for implementation.

EPA provided the jurisdictions with detailed expectations for WIPs in November 2009 and evaluation criteria in April 2010. To assist with WIP preparation, EPA provided considerable technical and financial assistance. EPA worked with the jurisdictions to evaluate various “what if” scenarios – combinations of practices and programs that could achieve their pollution allocations.

The two most important criteria for a WIP is that it achieves the basin-jurisdiction pollution allocations and meets EPA’s expectations for providing reasonable assurance that reductions will be achieved and maintained, particularly for non-permitted sources like runoff from agricultural lands and currently unregulated stormwater from urban and suburban lands.

After the draft Phase I WIP submittals in September 2010, a team of EPA sector experts conducted an intense evaluation process, comparing the submissions with EPA expectations. The EPA evaluation concluded that the pollution controls identified in two of the seven jurisdictions’ draft WIPs could meet nitrogen and phosphorus allocations and five of the seven jurisdictions’ draft WIPs could meet sediment allocations. The EPA evaluation also concluded that none of the seven draft Phase I WIPs provided sufficient reasonable assurance that pollution controls identified could actually be implemented to achieve the nitrogen, phosphorus and sediment reduction targets by 2017 or 2025.

In response to its findings, EPA developed a draft TMDL that established allocations based on using the adequate portions of the jurisdictions’ draft WIP allocations along with varying degrees of federal backstop allocations in all seven jurisdictions. Backstop allocations focused on areas where EPA has the federal authority to control pollution allocations through NPDES permits, including wastewater treatment plants, stormwater permits, and animal feeding operations.

Public Participation

The draft Chesapeake Bay TMDL was developed through a highly transparent and engaging process during the past two years. The outreach effort included hundreds of meetings with interested groups; two rounds of public meetings, stakeholder sessions and media interviews in all six states and the District of Columbia in fall of 2009 and 2010; a dedicated EPA website; a series of monthly interactive webinars; notices published in the Federal Register; and a close working relationship with Chesapeake Bay Program committees representing citizens, local governments and the scientific community.

The release of the draft Chesapeake Bay TMDL on September 24, 2010 began a 45-day public comment period that concluded on November 8, 2010. During the comment period EPA conducted 18 public meetings in all six states and the District of Columbia. More than 2,500 people participated in the public meetings. Seven of these meetings were also broadcast live online. During the six weeks that EPA officials traveled around the watershed, they also held dozens of meetings with stakeholders, including local governments, agriculture groups, homebuilder and developer associations, wastewater industry representatives and environmental organizations. EPA received more than 14,000 comments – most of which supported the TMDL – and the Agency's response to those comments is included as an appendix to the TMDL.

Final Watershed Implementation Plans and TMDL

Since submittal of the draft WIPs and release of the draft TMDL in September 2010, EPA worked closely with each jurisdiction to revise and strengthen its plan. Because of this cooperative work and state leadership, the final WIPs were significantly improved. Examples of specific improvements include:

- Committing to more stringent nitrogen and phosphorus limits at wastewater treatment plants, including on the James River in Virginia. (Virginia, New York, Delaware)
- Pursuing state legislation to fund wastewater treatment plant upgrades, urban stormwater management and agricultural programs. (Maryland, Virginia, West Virginia)
- Implementing a progressive stormwater permit to reduce pollution. (District of Columbia)
- Dramatically increasing enforcement and compliance of state requirements for agriculture. (Pennsylvania)
- Committing state funding to develop and implement state-of-the-art-technologies for converting animal manure to energy for farms. (Pennsylvania)
- Considering implementation of mandatory programs for agriculture by 2013 if pollution reductions fall behind schedule. (Delaware, Maryland, Virginia)

These improvements enabled EPA to reduce and remove most federal backstops, leaving a few targeted backstops and a plan for enhanced oversight and contingency actions to ensure progress.

Backstop Allocations, Adjustments, and Actions

Despite the significant improvement in the final WIPs, one of the jurisdictions did not meet all of its target allocations and two of the jurisdictions did not fully meet EPA's expectations for reasonable assurance for specific pollution sectors. To address these few remaining issues, EPA included in the final TMDL several targeted backstop allocations, adjustments and actions. As a result of the jurisdictions' significant improvements combined with EPA's backstops, EPA believes the jurisdictions are in a position to implement their WIPs and achieve the needed pollution reductions. This approach endorses jurisdictions' pollution reduction commitments, gives them the flexibility to do it their way first, and signals EPA's commitment to fully use its authorities as necessary to reduce pollution.

New York Wastewater – Backstop Allocation

- EPA closed the numeric gap between New York's WIP and its modified allocations by establishing a backstop that further reduces New York's wasteload allocation for wastewater. EPA is establishing an aggregate wasteload allocation for wastewater treatment plants.
- EPA calculated this backstop WLA using the nitrogen and phosphorus performance levels that New York committed to, but assumes that significant wastewater treatment plants (WWTPs) are at current flow rather than design flow.

- EPA understands that New York plans to renew and/or modify WWTP permits upon completion of its Phase II WIP, consistent with the applicable TMDL allocations at that time. New York is reviewing engineering reports from WWTPs and, in its Phase II WIP, will provide information to support individual WLAs for these plants.

Pennsylvania Urban Stormwater – Backstop Adjustment

- EPA transferred 50 percent of the stormwater load that is not currently subject to NPDES permits from the load allocation to the wasteload allocation. The TMDL allocation adjustment increases reasonable assurance that pollution allocations from urban stormwater discharges will be achieved and maintained by signaling that EPA is prepared to designate any of these discharges as requiring NPDES permits. Urban areas would only be subject to NPDES permit conditions protective of water quality as issued by Pennsylvania upon designation. EPA will consider this step if Pennsylvania does not demonstrate progress toward reductions in urban loads identified in the WIP. EPA may also pursue designation activities based on considerations other than TMDL and WIP implementation.
- EPA will maintain close oversight of general permits for the Pennsylvania stormwater sector (PAG-13 and PAG-2) and may object if permits are not protective of water quality standards and regulations. Upon review of Pennsylvania’s Phase II WIP, EPA will revisit the wasteload allocations for wastewater treatment plants, including more stringent phosphorus limits, in the event that Pennsylvania does not reissue PAG-13 and PAG-2 general permits for Phase II MS4s and construction that are protective of water quality by achieving the load reductions called for in Pennsylvania’s Phase I WIP.

West Virginia Agriculture – Backstop Adjustment

- EPA shifted 75 percent of West Virginia’s animal feeding operation (AFO) load into the wasteload allocation and assumed full implementation of barnyard runoff control, waste management and mortality composting practices required under a CAFO permit on these AFOs. The shift signals that any of these operations could potentially be subject to state or federal permits as necessary to protect water quality. AFOs would only be subject to NPDES permit conditions as issued by West Virginia upon designation. EPA will consider this step if West Virginia does not achieve reductions in agricultural loads as identified in the WIP. EPA may also pursue designation activities based upon considerations other than TMDL and WIP implementation.
- Based upon West Virginia's ability to demonstrate near-term progress implementing the agricultural section of its WIP, including CAFO Program authorization and permit applications and issuance, EPA will assess in the Phase II WIP whether additional federal actions, such as establishing more stringent wasteload allocations for wastewater treatment plants, are necessary to ensure that TMDL allocations are achieved.

Enhanced Oversight and Contingencies

While final WIPs were significantly improved and the jurisdictions deserve credit for the efforts, EPA also has minor concerns with the assurance that pollution reductions can be achieved in certain pollution sectors in Pennsylvania, Virginia and West Virginia. EPA has informed these jurisdictions that it will consider future backstops if specific near-term progress is not demonstrated in the Phase II WIP.

Pennsylvania Agriculture

- Based on Pennsylvania's ability to demonstrate near-term progress implementing the agricultural section of its WIP, including EPA approval for its CAFO program and enhanced compliance assurance with state regulatory programs, EPA will assess in the Phase II WIP whether additional federal actions, such as shifting AFO loads from the load allocation to the wasteload allocation or establishing more stringent wasteload allocations for WWTPs, are necessary to ensure that TMDL allocations are achieved.

Pennsylvania Wastewater

- EPA established individual wasteload allocations for wastewater treatment plants in the TMDL to ensure that sufficient detail is provided to inform individual permits for sources within the wasteload allocation. Individual allocations do not commit wastewater plants to greater reductions than what the state has proposed in its WIP. Provisions of the TMDL allow, under certain circumstances, for modifications of allocations within a basin to support offsets and trading opportunities.
- EPA will assess Pennsylvania’s near-term urban stormwater and agriculture program progress and determine whether EPA should modify TMDL allocations to assume additional reductions from wastewater treatment plants.

Virginia Urban Stormwater

- If the statewide rule and/or the Phase II WIP do not provide additional assurance regarding how stormwater discharges outside of MS4 jurisdictions will achieve nitrogen, phosphorus, and sediment reductions proposed in the final Phase I WIP and assumed within the TMDL allocations, EPA may shift a greater portion of Virginia’s urban stormwater load from the load allocation to the wasteload allocation. This shift would signal that substantially more stormwater could potentially be subject to NPDES permits issued by the Commonwealth as necessary to protect water quality.

West Virginia Urban Stormwater

- If stormwater rules and/or the Phase II WIP do not provide additional assurance regarding how urban stormwater discharges outside of MS4 jurisdictions will achieve nitrogen, phosphorus, and sediment allocations proposed in the final Phase I WIP and assumed within the TMDL load allocations, EPA may shift a greater portion of West Virginia’s urban stormwater load from the load allocation to the wasteload allocation. The shift would signal that substantially more urban stormwater could potentially be subject to state permit coverage and/or federal Clean Water Act permit coverage as necessary to protect water quality.

West Virginia Wastewater

- EPA established individual wasteload allocations for significant wastewater treatment plants in the TMDL to ensure that sufficient detail is provided to inform individual permits for sources within the wastewater wasteload allocation. Individual allocations do not commit wastewater plants to greater reductions than what the state has proposed in its WIP. Provisions of this TMDL allow, under certain circumstances, for modifications of allocations within a basin to support offsets and trading opportunities.

- EPA will assess West Virginia's near-term agriculture program progress and determine whether additional federal actions consistent with EPA's December 29, 2009 letter, such as modifying TMDL allocations to assume additional reductions from wastewater treatment plants, are necessary to ensure that TMDL allocations are achieved.

Ongoing oversight of Chesapeake Bay jurisdictions

EPA will carefully review programs and permits in all jurisdictions. EPA's goal is for jurisdictions to successfully implement their WIPs, but EPA is prepared to take necessary actions in all jurisdictions for insufficient WIP implementation or pollution reductions. Federal actions can be taken at any time, although EPA will engage particularly during two-year milestones and refining the TMDL in 2012 and 2017. Actions include:

- Expanding coverage of NPDES permits to sources that are currently unregulated
- Increasing oversight of state-issued NPDES permits
- Requiring additional pollution reductions from federally regulated sources
- Increasing federal enforcement and compliance
- Prohibiting new or expanded pollution discharges
- Conditioning or redirecting EPA grants
- Revising water quality standards to better protect local and downstream waters
- Discounting nutrient and sediment reduction progress if jurisdiction cannot verify proper installation and management of controls

FINAL TMDL

As a result of the significantly improved WIPs and the removal and reduction of federal backstops, the final TMDL is shaped in large part by the jurisdictions' plans to reduce pollution. Jurisdiction-based solutions for reducing pollution was a long-standing priority for EPA and why the agency always provided the jurisdictions with flexibility to determine how to reduce pollution in the most efficient, cost-effective and acceptable manner.

Now, the focus shifts to jurisdictions' implementation of the WIP policies and programs designed to reduce pollution on-the-ground and in-the-water. EPA will conduct oversight of WIP implementation and jurisdictions' progress toward meeting two-year milestones. If progress is insufficient, EPA will utilize contingencies to place additional controls on federally permitted sources of pollution, such as wastewater treatment plants, large animal agriculture operations and municipal stormwater systems, as well as target compliance and enforcement activities.

Federal agencies will greatly contribute to restoration of the Chesapeake Bay watershed, particularly through implementation of the new federal strategy created under President Obama's Executive Order. Eleven federal agencies have committed to a comprehensive suite of actions and pursuit of critical environmental goals on the same 2025 timeline as the TMDL. Additionally, federal agencies will be establishing and meeting two-year milestones, with the specific charge of taking actions that directly support the jurisdictions in reducing pollution and restoring water quality.

The jurisdictions are expected to submit Phase II WIPs that provide local area pollution targets for implementation on a smaller scale; the timeframe for these Phase II WIPs will be determined in early 2011. Phase III WIPs in 2017 are expected to be designed to provide additional detail of restoration actions beyond 2017 and ensure that the 2025 goals are met.

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Foreword

This document describes the technical, legal, and policy underpinnings of the Chesapeake Bay Total Maximum Daily Load (TMDL). While EPA Regions 2 and 3 are establishing this TMDL, it represents the product of decades of scientific research, monitoring, assessment, and model application, and years of focused dialogue and analysis among EPA, our six watershed state partners and the District of Columbia, and numerous stakeholders. This document has benefited from the input of thousands of professionals and citizens dedicated to the restoration of the Chesapeake Bay. In accordance with the Clean Water Act and Executive Order 13508 (signed by President Obama on May 12, 2009), the Chesapeake Bay TMDL provides a critical plan to restore and maintain the living resources of the Chesapeake Bay.

A TMDL is required by the Clean Water Act for waters that are on state lists identifying waters that are impaired – i.e., not attaining state adopted and EPA approved water quality standards. Most of the waters of the Chesapeake Bay and its tidal tributaries and embayments are on the three states' (Maryland, Virginia, and Delaware) and the District's lists of impaired waters because of excess nitrogen, phosphorus, and sediment pollution. The Chesapeake Bay TMDL identifies the loadings of nitrogen, phosphorus, and sediment that are necessary to achieve the applicable jurisdiction's water quality standards for the Bay and its tidal tributaries and embayments for dissolved oxygen, chlorophyll *a* (an indicator of algae), water clarity, and submerged aquatic vegetation (SAV, or underwater Bay grasses). For this reason, the Chesapeake Bay TMDL has been described as a pollution diet defining the pollutant loadings necessary to attain water quality standards and restore the aquatic life resources of the Chesapeake Bay.

The Chesapeake Bay receives waters from thousands of streams and rivers within seven jurisdictions in the mid-Atlantic region of the United States: Delaware, the District of Columbia, Maryland, New York, Pennsylvania, Virginia, and West Virginia. These waters drain to the Chesapeake Bay and, therefore, contribute pollutant loadings to the Bay. The Chesapeake Bay TMDL also establishes total maximum daily loads from these watersheds and jurisdictions for each of the 92 impaired segments that comprise the waters of the Chesapeake Bay and its tidal tributaries and embayments. Thus, the Chesapeake Bay TMDL is actually an assemblage of 276 TMDLs: individual TMDLs for each of the 3 pollutants— nitrogen, phosphorus, and sediment— for each of the 92 segments (3 x 92 = 276).

The purpose of the Chesapeake Bay TMDL is to identify the pollutant loading reductions needed to meet the applicable Bay water quality standards. The TMDL, thus, allocates loads to <u>all</u> pollutant source sectors in <u>all</u> parts of the Bay's 64,000 square mile watershed. Because of the watershed-wide nature of these loading reductions, the water quality benefits from these reductions will not be limited to the Bay and its tidal tributaries and embayments. In fact, the watershed's headwaters from the location the pollutant reductions are made to the point they enter the Bay or its tidal tributaries should benefit from some measure of improved water quality. The controls necessary to reduce nitrogen, phosphorus, and sediment also are likely to reduce other pollutants like bacteria and chemical contaminants.

While the Chesapeake Bay TMDL establishes the pollutant loadings for nitrogen, phosphorus, and sediment needed to restore and maintain a healthy Bay, the TMDL is essentially an information and planning tool that does not, by itself, implement the needed controls. Implementation mechanisms available under other provisions of the Clean Water Act, Clean Air Act, state laws, and federal and state regulations, and local ordinances, as well as appropriate levels of funding, are needed to achieve these loading targets. The Bay TMDL will be implemented using an accountability framework that includes the seven jurisdictions' Watershed Implementation Plans (WIPs), two-year milestones, EPA's tracking and assessment of restoration progress and, as necessary, specific federal actions if the Bay watershed jurisdictions do not meet their targets and commitments. Although not itself an element of the Chesapeake Bay TMDL, the accountability framework is being established pursuant to both section 117(g)(1) of the Clean Water Act and Executive Order 13508, in part, to demonstrate reasonable assurance that the Chesapeake Bay TMDL allocations for nitrogen, phosphorus, and sediment and the jurisdictions' water quality standards are met.

An executive summary provides an overview of the TMDL, highlighting its more important aspects. For more specific information, readers should consult the main document, which describes each aspect of the Chesapeake Bay TMDL in detail. Finally, for additional background and supportive material, the reader is referred to the references contained in the main document and numerous appendices.

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Acknowledgements

This document was developed through the collaborative efforts of the U.S. Environmental Protection Agency (EPA) and its seven Chesapeake Bay watershed partners—Delaware, the District of Columbia, Maryland, New York, Pennsylvania, Virginia, and West Virginia—principally through the Chesapeake Bay Program's (CBP) Water Quality Goal Implementation Team (WQGIT) (formerly the Water Quality Steering Committee), its principal workgroups, and the former Nutrient Subcommittee. The CBP's Principals' Staff Committee made decisions on behalf of the partnership and provided policy direction to the WQGIT. Advice, direction, and independent peer review were provided by the CBP's Scientific and Technical Advisory Committee (STAC), the Local Government Advisory Committee (LGAC), and the Citizen's Advisory Committee (CAC). Comments and recommendations gathered through the November–December 2009 public meetings/webinars, the monthly webinars scheduled during 2010, and the September—November 2010 public comment period were instrumental in ensuring that the published allocations provide the most benefits to local streams and rivers and still achieve the jurisdictions' Chesapeake Bay water quality standards.

The document resulted from the collaborative expertise, input, feedback, and formal comments of thousands of individuals from the multitude of CBP partnering agencies and institutions, local governments, nongovernmental organizations, businesses, many other involved stakeholders, and the general public. Their individual and collective contributions are hereby acknowledged.

Special acknowledgment is made to past and present members the following CBP committees: WQGIT, Principals' Staff Committee, Management Board, STAC, LGAC, CAC, Agriculture Workgroup, Forestry Workgroup, Sediment Workgroup, Urban and Suburban Stormwater Workgroup, Wastewater Treatment Workgroup, Watershed Technical Workgroup, TMDL Workgroup (formerly Reevaluation Technical Workgroup), the former Nutrient Subcommittee, Scientific and Technical Analysis and Reporting Team, Criteria Assessment Procedures Workgroup, Modeling Workgroup, Nontidal Water Quality Workgroup, Tidal Monitoring and Analysis Workgroup, Analytical Methods and Quality Assurance Workgroup, and former Monitoring and Analysis Subcommittee. Appendix A provides a detailed member listing of these committees, teams, and workgroups who were instrumental in completing the Chesapeake Bay total maximum daily load (TMDL).

Special acknowledgement is also made to the following individuals (in alphabetical order) for their contributions to the development of the Bay TMDL, support of the development of the jurisdictions' Phase I Watershed Implementation Plans (WIPs), evaluation of the draft and final Phase I WIPs, supporting public and stakeholder outreach, responding to thousands of public comments, and publication of this document: Greg Allen, EPA Region 3 CBP Office; Katherine Antos, EPA Region 3 CBP Office; Cheryl Atkinson, EPA Region 3 Water Protection Division (WPD); Seth Ausubel, EPA Region 2 Division of Environmental Planning and Protection; Michael Barnes, Chesapeake Research Consortium/CBP Office; Greg Barranco, EPA Region 3 CBP Office; Richard Batiuk, EPA Region 3 CBP Office; Benita Best-Wong, EPA Office of Water; Carin Bisland, EPA Region 3 CBP Office; Ross Brennan, EPA Office of Water; Kevin Bricke, EPA Region 2 Division of Environmental Planning and Protection; Chris Brosch, University of Maryland/CBP Office; Brian Burch, EPA Region 3 CBP Office; Jon Capacasa, EPA Region 3 WPD; Ann Carkhuff, EPA Region 3 WPD; Peter Claggett, U.S. Geological

Survey (USGS)/CBP Office; Jeff Corbin, EPA Region 3 Office of the Regional Administrator; James Curtin, EPA Office of General Counsel; Thomas Damm, EPA Region 3 WPD; Christopher Day, EPA Region 3 Office of Regional Counsel; Kevin DeBell, EPA Region 3 CBP Office; Robin Dennis, NOAA/EPA Office of Research and Development; Helene Drago, EPA Region 3 WPD; Mark Dubin, University of Maryland/CBP Office; Jim Edward, EPA Region 3 CBP Office; Judith Enck, EPA Region 2 Regional Administrator; Leo Essenthier, EPA Region 3 WPD; Barbara Finazzo, EPA Region 2 Division of Environmental Planning and Protection; Katie Foreman, University of Maryland/CBP Office; Kristin Foringer, Chesapeake Research Consortium/CBP Office; Debra Forman, EPA Region 3 WPD; J. Charles Fox, EPA Office of the Administrator; Michael Fritz, EPA Region 3 CBP Office; Elizabeth Gaige, EPA Region 3 WPD; Angie Garcia, EPA Region 3 WPD; Shawn Garvin, EPA Region 3 Regional Administrator; Kelly Gable, EPA Region 3 Office of Regional Counsel; Patricia Gleason, EPA Region 3 WPD; Peter Gold, EPA Region 3 WPD; Aaron Gorka, Chesapeake Research Consortium/CBP Office; Michelle Gugger, EPA Region 3 WPD; Michael Haire, EPA Office of Water; Denise Hakowski, EPA Region 3 WPD; Suzanne Hall-Trevena, EPA Region 3 WPD; James Hanlon, EPA Office of Water; Rachel Herbert, EPA Office of Water; Sara Hilbrich, EPA Office of Water; Amie Howe, EPA Region 3 Office of State and Congressional Relations; Nan Ides, EPA Region 3 WPD; Fred Irani, USGS/CBP Office; Ruth Izraeli, EPA Region 2 Division of Environmental Planning and Protection; Jackie Johnson, Interstate Commission on the Potomac River Basin/CBP Office; Jeni Keisman, University of Maryland/CBP Office; Victoria Kilbert, Chesapeake Research Consortium/CBP Office; Robert Koroncai, EPA Region 3 WPD; Caitlin Kovelove, EPA Office of Water; Amelia Letnes, EPA Office of Water; Mary Letzkus, EPA Region 3 WPD; Lewis Linker, EPA Region 3 CBP Office; Felix Locicero, EPA Region 2 Division of Environmental Planning and Protection; Travis Loop, EPA Region 3 CBP Office; Michael Mallonee, Interstate Commission on the Potomac River Basin/CBP Office; Lori Mackey, EPA Region 3 CBP Office; David McGuigan, EPA Region 3 WPD; Evelyn MacKnight, EPA Region 3 WPD; Mike Mason, EPA Office of Water; Larry Merrill, EPA Region 3 WPD; Linda Miller, EPA Region 3 Office of State and Congressional Relations; Jenny Molloy, EPA Region 3 CBP Office/WPD; Francis Mulhern EPA Region 3 WPD; Elizabeth Ottinger, EPA Region 3 WPD; Andrew Parker, Tetra Tech; Reggie Parrish, EPA Region 3 CBP Office; Jeffrey Potent, EPA Office of Water; Lucinda Power, EPA Region 3 CBP Office; Andrew Prugar, EPA Office of Environmental Information; Teresa Rafi, Tetra Tech; Pravin Rana, EPA Office of Water; Sucharith Ravi, University of Maryland/CBP Office; Bill Richardson, EPA Region 3 WPD; Robert Rose, EPA Office of Water; Jennifer Sincock, EPA Region 3 WPD; Mike Shapiro, EPA Office of Water; Gary Shenk, EPA Region 3 CBP Office; Kelly Shenk, EPA Region 3 CBP Office; Rachel Streusand, Chesapeake Research Consortium/CBP Office; Jeff Strong, Tetra Tech; Fred Suffian, EPA Region 3 WPD; Gwen Supplee, EPA Region 3 WPD; Jeff Sweeney, University of Maryland/CBP Office; Nita Sylvester, EPA Region 3 CBP Office; Peter Tango, U.S. Geological Survey/CBP Office; Renee Thompson, USGS/CBP Office; Brian Trulear, EPA Region 3 WPD; Randy Waite, EPA Office of Air and Radiation; Tom Wall, EPA Office of Water; Ping Wang, University of Maryland/CBP Office; Howard Weinberg, University of Maryland/CBP Office; Steve Whitlock EPA Office of Water; Julie Winters, EPA Region 3 CBP Office; John Wolf, USGS/CBP Office; Robert Wood, EPA Region 3 CBP Office; Jing Wu, University of Maryland/CBP Office; Guido Yactayo, University of Maryland/CBP Office; Ning Zhou, Virginia Polytechnical and State University/CBP Office; Kyle Zieba, EPA Region 3 WPD; and Hank Zygmunt, EPA Region 3 WPD.

Special acknowledgement of the policy direction and guidance provided by Lisa Jackson, EPA Administrator; Robert Perciasepe, EPA Deputy Administrator; and Robert Sussman, Counselor to the Administrator.

Members of the Chesapeake Bay Program's Water Quality Goal Implementation Team gather in Lancaster, Pennsylvania, in April 2009 to discuss development of the Chesapeake Bay TMDL.

SECTION 1. INTRODUCTION

This document establishes total maximum daily loads (TMDLs) for nitrogen, phosphorus, and sediment for the Chesapeake Bay and its tidal tributaries and embayments as required by section 303(d) of the Clean Water Act (CWA) and its implementing regulations at Title 40 of the *Code of Federal Regulations* (CFR) section 130.7. This TMDL represents the culmination of decades of collaboration among many partners and stakeholders and is the result of an analysis of water quality pollution and its solution on an unprecedented geographic, scientific, programmatic, and political scale. While all TMDLs are unique, this TMDL is distinguished by the magnitude of the watershed it addresses and the wealth of science synthesized, data developed, and analyses conducted over the course of the past decades that support its conclusions.

In an effort to keep the Chesapeake Bay TMDL (Bay TMDL) document as clear and succinct as possible, discussion of the technical analyses and modeling that support the pollutant allocations are reasonably summarized in nature with links provided to the more detailed technical support documentation. Because of the large size of the watershed and the many individual sources, load allocations (LAs) and wasteload allocations (WLAs) summarized in Section 9 are presented in greater detail in supporting appendices.

This document is organized into 11 sections as follows:

- Section 1: Clean Water Act and regulatory, statutory, and historical background of the Chesapeake Bay TMDL
- Section 2: Description of the Chesapeake Bay watershed, the Bay, and its impaired segments
- Section 3: The jurisdictions’ Chesapeake Bay water quality standards
- Section 4: The major sources of nutrients and sediment in the Bay, its watershed, and its airshed
- Section 5: The modeling tools used to develop the WLAs and LAs
- Section 6: How the TMDL was developed, including the allocation methodology and related considerations
- Section 7: Discussion of reasonable assurance, Bay TMDL implementation, and the Bay TMDL accountability framework
- Section 8: The evaluation of jurisdictions’ Watershed Implementation Plans
- Section 9: The individual nitrogen, phosphorus, and sediment TMDLs for each of the 92 Bay tidal segments
- Section 10: Adaptive management approach to Bay TMDL implementation
- Section 11: Documentation of public participation, comments, and responses

This document also contains three additional sections providing: a list of references (Section 12), a glossary (Section 13), and a list of abbreviations (Section 14) and 24 Appendices.

Additional supporting information that is not part of this document or its appendices, can be found as follows:

- Technical documentation for each of the Chesapeake Bay TMDL models and supporting tools—Bay airshed, land change, Scenario Builder, SPARROW, Bay watershed, Bay water quality and sediment transport, oyster filter feeder, and menhaden filter feeder—are provided via URL links in Section 5.
- Access to each of the jurisdictions' final Phase I Watershed Implementation Plans (WIPs) is provided via URL in Section 7. The WIPs are part of the accountability framework meant to implement the Bay TMDL, but they are not an element of the Bay TMDL itself. EPA reviewed the Phase I WIPs as part of the information used to inform its allocation decisions.
- Publicly accessible agreements, documents, reports, papers, meeting summaries, correspondence, and data sets developed during the decades and more recent years leading up to the Chesapeake Bay TMDL, which were instrumental in setting the scientific, programmatic, policy, and legal foundation on which the Bay TMDL is built, are listed in Appendix B with electronic access to all through the provided URLs.

1.1 TMDLS AND THE CWA

Section 303(c) of the 1972 Clean Water Act (CWA) requires states, including the District of Columbia, (collectively referred to as jurisdictions) to establish water quality standards (WQS) that identify each waterbody's designated uses and the criteria needed to support those uses. The CWA establishes a rebuttable presumption that all waters can attain beneficial aquatic life uses, i.e., fishable and recreational (i.e., swimmable) uses.

Section 303(d) of the CWA requires states, including the District of Columbia, to develop lists of impaired waters that fail to meet WQS set by jurisdictions even after implementing technology-based and other pollution controls. EPA's regulations for implementing CWA section 303(d) are codified in the Water Quality Planning and Management Regulations at 40 CFR Part 130. The law requires that jurisdictions establish priority rankings and develop TMDLs for waters on the lists of impaired waters (40 CFR 130.7).

A TMDL specifies the maximum amount of a pollutant that a waterbody can receive and still meet applicable WQS. A mathematical definition of a TMDL is written as the sum of the individual wasteload allocations (WLAs) for point sources, the load allocation (LAs) for nonpoint sources and natural background, and a margin of safety (MOS)[CWA section 303(d)(1)(C)]:

$$\mathrm{TMDL} = \Sigma WLA + \Sigma LA + MOS$$

where

WLA = wasteload allocation, or the portion of the TMDL allocated to existing and/or future point sources.

LA = load allocation, or the portion of the TMDL attributed to existing and/or future nonpoint sources and natural background.

MOS = margin of safety, or the portion of the TMDL that accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality, such as uncertainty about the relationship between pollutant loads and receiving water quality, which can be provided implicitly by applying conservative analytical assumptions or explicitly by reserving a portion of loading capacity.

The process of calculating and documenting a TMDL involves a number of tasks and—especially for a large, complex, and multijurisdictional waterbody with multiple impairments—can require substantial effort and resources. Major tasks involved in the TMDL development process include the following:

- Characterizing the impaired waterbody and its watershed
- Identifying and inventorying the relevant pollutant source sectors
- Applying the appropriate WQS
- Calculating the loading capacity using appropriate modeling analyses to link pollutant loads to water quality
- Identifying the required source allocations

The Bay TMDL report presents the results of numerous analyses and model simulations designed to calculate the Bay and its tidal tributaries and embayments' pollutant loading capacity and documents the informational elements described above. Because the Chesapeake Bay watershed is so large, and the analysis required for developing the Bay TMDL so extensive, the Chesapeake Bay TMDL and its supporting documentation consists of this report and additional supporting materials in the numerous appendices referenced throughout the report. The Bay TMDL is also supported by an extensive list of significant documents (Appendix B).

1.2 HISTORY OF THE CHESAPEAKE BAY TMDL

The Chesapeake Bay watershed has been inhabited for thousands of years, but the population started to increase significantly with the arrival of European settlers in the 1600s. Settlers began clearing forests for timber and to make room for expanding agricultural activities, increasing soil erosion and nutrient delivery to the Bay and its tributaries (Curtin et al. 2001; Rountree et al. 2007). As early as 1900, the oyster population began to decline. Throughout the 20th century, urban development and agricultural activities increased throughout the watershed. In the late 1970s, Maryland Senator Charles Mathias sponsored a congressionally funded, 5-year study to analyze the rapid loss of aquatic life that was affecting the Bay. That study identified excess nitrogen and phosphorus pollution as the main source of the Bay's degradation (USEPA 1982, 1983a, 1983b, 1983c, 1983d).

1.2.1 Regulatory and Management Initiatives

In response to the Bay's decline, various regulatory and management initiatives have been undertaken aimed at Bay restoration, ranging from cooperative agreements among surrounding jurisdictions to new regulatory programs and policies. Through the years, the agreements and alliances have become more formalized and inclusive to address the multitude of factors contributing to the deterioration in Chesapeake Bay water quality. The following paragraphs outline the major policy, legislative, and programmatic events that have led to the development of the Bay TMDL, including the management agreements and statutory and regulatory requirements that form the underpinning of the Bay TMDL.

1983 Chesapeake Bay Agreement

In 1983 the governors of Maryland, Virginia, and Pennsylvania; the mayor of the District of Columbia; the chairman of the Chesapeake Bay Commission; and EPA's Administrator signed the first Chesapeake Bay Agreement. In that agreement, the signatories acknowledged the decline in living resources of the Chesapeake Bay and agreed to establish the Chesapeake Executive Council (CEC) to "assess and oversee the implementation of coordinated plans to improve and protect the water quality and living resources of the Chesapeake Bay estuarine systems" (Chesapeake Bay Partnership 1983).

1987 Chesapeake Bay Agreement

Faced with the need to take a more comprehensive and coordinated approach to restoring water quality and living resources of the Chesapeake Bay, the signatories to the 1983 agreement entered into the 1987 Chesapeake Bay Agreement (CEC 1987). The 1987 Chesapeake Bay Agreement set priority goals and commitments, of which a key goal was to "reduce and control point and nonpoint sources of pollution to attain the water quality condition necessary to support the living resources of the Bay." To achieve that goal, signatories to the 1987 Bay Agreement committed to reduce the controllable nitrogen and phosphorus loads delivered to the mainstem of the Chesapeake Bay by 40 percent by 2000 and to develop a Bay-wide implementation strategy to achieve those reductions (CEC 1987).

CWA Section 117 and the Chesapeake Bay Program (CBP)

In the 1987 amendments to the CWA, Congress—in section 117—authorized the formation and funding of the Chesapeake Bay Program (CBP) within EPA Region 3. Congress directed the CBP to collect and disseminate information related to the environmental quality of the Bay, to "coordinate state and federal efforts to improve Bay water quality, to evaluate sediment impacts on the Bay, and to determine the impact of natural and human-induced environmental changes on the living resources of the Bay."[1]

1991 Reevaluation

A 1991 reevaluation of progress made toward achievement of the 1987 Bay Agreement's 40 percent nutrient reduction goal led to a detailed quantification of the original narrative goal. Each major river basin by jurisdiction received a "tributary nutrient load allocation" as a "40% controllable load reduction" for both nitrogen and phosphorus as the principal outcome of the reevaluation (Secretary Robert Perciasepe 1992). The 1991 reevaluation also introduced several concepts still applicable in the Bay TMDL: tributary strategies (WIPs), limit of technology (everything by everyone everywhere or E3 scenario), recognition of air deposition (air load allocation to tidal surface waters), and geographic-based allocations (relative effectiveness-based allocation methodology).

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[1] Clean Water Act section 117 (33 United States Code [U.S.C.] 1267).

1992 Amendments to the Chesapeake Bay Agreement

The 1991 reevaluation led to several amendments to the 1987 Chesapeake Bay Agreement in 1992, including an increased focus on the importance of the tributaries in the Bay's restoration. The parties to the 1987 Chesapeake Bay Agreement were to begin by 1993 to develop and implement tributary-specific strategies to meet mainstem nutrient reduction goals, to improve water quality, and to restore living resources to the mainstem and tributaries (CEC 1992). The amendments also established a goal of expanding the distribution of submerged aquatic vegetation (SAV) as an initial measure of progress toward the water quality and living resource goals of the 1987 Agreement.

1997 Reevaluation

In 1997 the CBP conducted a year-long evaluation to assess what progress had been made toward the goal set in the 1987 Chesapeake Bay Agreement of a 40 percent reduction by 2000 in nitrogen and phosphorus delivered to the Bay (CEC 1997). The 1997 reevaluation found that between 1985 and 1996 phosphorus loads delivered to the Bay declined by 6 million pounds annually, and nitrogen loads delivered to the Bay declined by 29 million pounds annually. By 1996 phosphorus loads from wastewater dischargers had been reduced by 51 percent in the participating jurisdictions as a result of implementing effluent standards, upgrading wastewater treatment plants, and banning phosphate laundry detergents. Wastewater nitrogen loads were reduced by 15 percent by implementing biological nutrient removal at some major municipal wastewater treatment facilities and by upgrading certain industrial wastewater treatment facilities. Implementation of nutrient reduction best management practices (BMPs) reduced nonpoint source loadings of nitrogen and phosphorus to the Bay by 7 and 9 percent, respectively. There was no clear trend in Bay dissolved oxygen (DO) levels, however. Although progress was made, the 1997 reevaluation report stated, "we must accelerate our efforts to close the gap on the year 2000 goal, maintain those reduced loading levels into the future and if necessary adjust the nutrient goals to help us achieve the water quality improvements needed to sustain living resources in the Bay" (CBP 1997).

1999 Integration of Cooperative and Statutory Programs

In September 1999, senior water quality program managers representing the Bay watershed jurisdictions and EPA outlined the *Process for Integrating the Cooperative and Statutory Programs of the Chesapeake Bay and its Tributaries—Continuing the Watershed Partnership to Restore the Chesapeake Bay* (CBP 1999). That consensus document laid the groundwork for the water quality goals and commitments within the Chesapeake 2000 Agreement. A decade in advance, it set the partnership on a course that culminated in the Bay TMDL.

Chesapeake 2000 Agreement

In June 2000 the governors of Maryland, Virginia, and Pennsylvania; the mayor of the District of Columbia; the Administrator of EPA; and the chairman of the Chesapeake Bay Commission signed the Chesapeake 2000 Agreement (CEC 2000). To meet the goal of "achieving and maintaining the water quality necessary to support the aquatic living resources of the Bay and its tributaries and to protect human health," the signatories committed to specific actions, including:

"Continue to achieve and maintain the 40 percent nutrient reduction goal agreed to in 1987.

By 2010, correct 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. In order to achieve this:

1. By 2001, define the water quality conditions necessary to protect aquatic living resources and then assign load reductions for nitrogen and phosphorus to each major tributary;
2. By 2001, using a process parallel to that established for nutrients, determine the sediment load reductions necessary to achieve the water quality conditions that protect aquatic living resources, and assign load reductions for sediment to each major tributary;
3. By 2002, complete a public process to develop and begin implementation of revised Tributary Strategies to achieve and maintain the assigned loading goals;
4. By 2003, jurisdictions with tidal waters use their best efforts to adopt new or revised WQS consistent with the defined water quality conditions. Once adopted by the jurisdictions, EPA will expeditiously review the new or revised standards, which are used as the basis for removing the Bay and its tidal rivers from the list of impaired waters; and
5. By 2003, work with the Susquehanna River Basin Commission and others to adopt and begin implementing strategies that prevent the loss of the sediment retention capabilities of the lower Susquehanna River dams."

2000 Six-Jurisdiction Memorandum of Understanding

In the fall of 2000, EPA, Delaware, the District of Columbia, Maryland, New York, Pennsylvania, and Virginia signed a Memorandum of Understanding (MOU) (Chesapeake Bay Watershed Partners 2000), with West Virginia joining as a signatory in June 2002, agreeing to the following:

- Work cooperatively to achieve the nutrient and sediment reduction targets necessary to achieve the goals of a clean Chesapeake Bay by 2010, thereby allowing the Chesapeake Bay and its tidal tributaries to be removed from the list of impaired waters.
- Provide for an inclusive, open and comprehensive public participation process.
- Collaborate on the development and use of innovative measures such as effluent trading, cooperative implementation mechanisms, and expanded interstate agreements to achieve the necessary reductions.

The signatories also agreed to report annually on progress toward achieving the goals of the agreement.

2003 Nutrient and Sediment Cap Load Allocations

In 2003 EPA and its seven watershed jurisdictional partners established nitrogen, phosphorus, and sediment cap loads based on Bay water quality model projections of attainment of the then EPA-proposed dissolved oxygen water quality criteria under long-term average hydrologic conditions (Secretary Tayloe Murphy 2003). Reaching those cap loads was expected to eliminate the summer no-oxygen conditions in the deep waters of the Bay and excessive algal blooms throughout the Bay, tidal tributaries and embayments (USEPA 2003c).

EPA and its watershed jurisdiction partners allocated the nitrogen and phosphorus cap loads among the major river basins by jurisdiction. Those jurisdictions with the highest impact on Bay water quality were assigned the highest nutrient reductions, while jurisdictions without tidal waters received less stringent reductions because they would not realize a direct benefit from the improved water quality conditions in the Bay (USEPA 2003c). Sediment allocations were based on the phosphorus-equivalent allocations to each major river basin by jurisdiction (USEPA 2003c).

Although not original signatories of the Chesapeake 2000 Agreement, New York, Delaware, and West Virginia signed on as partners in implementing the cap loads; thus, all seven Bay watershed jurisdictions were assigned allocations (Chesapeake Bay Watershed Partners 2000; USEPA 2003c). The final total basinwide cap loads agreed to by EPA and the seven watershed jurisdictions were 175 million pounds of nitrogen per year and 12.8 million pounds of phosphorus per year delivered to the tidal waters of the Bay (USEPA 2003c). The basinwide upland sediment cap load was 4.15 million tons per year (USEPA 2003c).

2004–2006 Tributary Strategies

To achieve the nitrogen, phosphorus, and sediment cap loads, the seven watershed jurisdictions developed what became known as the Chesapeake Bay Tributary Strategies (Table 1-1) (Secretary Tayloe Murphy 2003). The tributary strategies outlined river basin-specific implementation activities to reduce nitrogen, phosphorus, and sediment pollutant loads from point and nonpoint sources sufficient to remove the Chesapeake Bay and its tidal tributaries and embayments from the Bay jurisdictions' respective impaired waters lists. Many of the policies and procedures used in developing the Chesapeake Bay TMDL originated with the development of the 2003 nutrient and sediment cap loads and subsequent development of tributary strategies.

Table 1-1. URLs for accessing the seven Chesapeake Bay watershed jurisdictions' tributary strategies

Jurisdiction	Tributary strategy URL link
Delaware	http://www.chesapeakebay.net/watershedimplementationplantools.aspx?menuitem=52044
District of Columbia	http://www.chesapeakebay.net/watershedimplementationplantools.aspx?menuitem=52044
Maryland	http://www.dnr.state.md.us/bay/tribstrat/implementation_plan.html
New York	http://www.dec.ny.gov/docs/water_pdf/cbaystratfinal.pdf
Pennsylvania	http://www.chesapeakebay.net/watershedimplementationplantools.aspx?menuitem=52044
Virginia	http://www.chesapeakebay.net/watershedimplementationplantools.aspx?menuitem=52044
West Virginia	http://www.wvca.us/bay/files/bay_documents/8_9657_WV_Potomac_Tributary_Strategy_FINAL_from_web.pdf

2004–2005 Jurisdiction Adoption of Chesapeake Bay Water Quality Standards

In continued efforts to coordinate activities to address nitrogen, phosphorus, and sediment-based pollution in the Bay, the tidal jurisdictions of Maryland, Virginia, Delaware, and the District of Columbia adopted into their respective WQS regulations the EPA-published Chesapeake Bay water quality criteria for dissolved oxygen, water clarity, SAV, and chlorophyll *a*, along with criteria attainment assessment procedures and refined tidal water designated uses (for details, see Section 3) (USEPA 2003a, 2003d). EPA approved those four jurisdictions' WQS regulations modifications pursuant to CWA section 303(c).

2007 Reevaluation

Secretary Tayloe Murphy's 2003 memorandum summarized the comprehensive set of agreements made by Bay watershed partners with regard to cap loads for nitrogen, phosphorus, and sediment; new Bay-wide and local SAV restoration goals; and a commitment to reevaluate the allocations in 2007 (Secretary Tayloe Murphy 2003). The initiation of that reevaluation at a partnership sponsored workshop in September 2005 laid the institutional groundwork for the collaborative work on the Bay TMDL (Chesapeake Bay Reevaluation Steering Committee 2005).

EPA and the seven watershed jurisdictions reevaluated the nutrient and sediment cap loads in 2007, in response to the four Bay jurisdictions revising their WQS regulations for the Chesapeake Bay, its tidal tributaries and embayments in 2004-2005 (Secretary Tayloe Murphy 2003). The 2007 reevaluation found that sufficient progress had not been made toward improving water quality to a level that indicated the mainstem Chesapeake Bay and its tidal tributaries and embayments were no longer impaired by nitrogen, phosphorus, and sediment pollution (Chesapeake Bay Reevaluation Steering Committee 2005).

1.2.2 Partnership Commitment to Develop the Chesapeake Bay TMDL

Throughout the Bay TMDL development process, EPA has worked in close and open partnership with all seven watershed jurisdictions, sharing decision making with the jurisdictions via the CBP structure described in Section 1.3. While EPA established the Bay TMDL, the seven watershed jurisdictions were essential partners in the initiative, providing critical input and participating in deliberations and making key decisions affecting the development process. The seven Bay watershed jurisdictions and EPA had been building the foundation for the Chesapeake Bay TMDL since signing the Chesapeake 2000 Agreement, which laid out the steps necessary to put in place an appropriate framework for a future Bay TMDL, including consistent jurisdictional Chesapeake Bay WQS (CEC 2000).

From the September 2005 reevaluation workshop to the publication of the Bay TMDL in December 2010, the seven watershed jurisdictions were actively involved in developing the Bay TMDL through participation in the CBP's Principals' Staff Committee (PSC), Water Quality Goal Implementation Team (WQGIT), and other decision-making committees, teams, and technical workgroups (see Section 1.3.1). The full records of the meetings and conference calls of those committees, teams, and workgroups are accessible via the Internet—see Appendix C.

At the October 1, 2007 meeting of the PSC, the seven watershed jurisdictions and EPA reached consensus that EPA would establish the Bay TMDL on behalf of the seven jurisdictions with a target date of 2025 when all necessary pollution control measures would be in place (CBP PSC 2007). Consensus within the Principals' Staff Committee means that all parties present have either agreed on this as a course of action and/or that no party objected to it. Table 1-2 summarizes that and the other Bay TMDL-relevant consensus agreements reached by the partners during that meeting.

Table 1-2. Summary of Chesapeake Bay TMDL relevant actions agreed to by the CBP's Principals' Staff Committee during its October 1, 2007, meeting

- The Bay watershed TMDLs will be developed jointly between the six Bay watershed states, the District, and EPA and then established by EPA.
- The Water Quality Steering Committee (WQSC) will draft nutrient and sediment cap load allocations by tributary basin by jurisdiction, and the PSC will formally adopt these allocations.
- The watershed states and the District would have responsibility for further assigning loads — WLAs and LAs—to sources consistent with EPA regulations and guidance.
- These state/District suballocations (WLA/LA) would become part of the overall Bay watershed TMDLs report.
- The final publication would contain all the required documentation supporting the EPA Bay watershed TMDLs in a single, integrated publication with extensive appendices.
- EPA will provide the technical resources/analyses required to support development of the Bay watershed TMDLs through the CBP Office staff and EPA-funded contractor support.
- The Bay watershed TMDLs must be completed and established by EPA no later than May 1, 2011.
- The CBP partners will engage stakeholders and the public in a more extensive structured dialogue about the tributary strategy implementation challenges before us.
- The CBP partners will focus on getting the programs in place by 2010 that we believe are required to achieve our water quality goals.
- The CBP partnership's public announcement of initiation of work on the Bay watershed TMDLs will occur following the states' submission and EPA approval of the 2008 303(d) lists in the spring 2008 time frame.
- Eight principles will guide the reevaluation efforts by the WQSC and its workgroups (see Attachment A for more detailed version):
    - Shared urgency to restore the Bay;
    - Clear communication and common message;
    - Focus and accelerate implementation (do no harm);
    - Engage the public about the implementation challenge;
    - Legal obligations will be met;
    - Improving and applying the latest science;
    - Flexibility of the sub-allocations within the major basins; and
    - Keep healthy waters healthy.
- The WQSC will proceed forward with the responsibility for carrying out the necessary preparation work following these eight guiding principles.
- The state/EPA Reevaluation Technical Workgroup (RTWG) will be reconvened and operate under the direction of the WQSC.
- The RTWG was charged with responsibility for resolving the existing technical issues in light of the desire to accelerate implementation at all scales. The WQSC will convene a parallel Implementation Workgroup and charge this group with the responsibility for ensuring that the reevaluation and TMDL development process results in acceleration of ongoing tributary strategy implementation.

Source: CBP PSC 2007

1.2.3 President's Chesapeake Bay Executive Order

On May 12, 2009, President Barack Obama issued the Chesapeake Bay Protection and Restoration Executive Order 13508, which calls for the federal government to lead a renewed effort to restore and protect the Chesapeake Bay and its watershed. Critical among its directives were:

- Establish a Federal Leadership Committee to oversee the development and coordination of reporting, data management and other activities by agencies involved in Bay restoration.
- Require involved agencies to prepare and submit reports with recommendations on a wide range of Bay issues (EPA-HQ-OW-2009-0761; FRL-8978-8).
- Require the Federal Leadership Committee to develop a *Strategy for Protecting and Restoring the Chesapeake Bay* by May 2010 (http://executiveorder.chesapeakebay.net/).
- Require the Federal Leadership Committee to publish an annual *Chesapeake Bay Action Plan* describing how federal funding proposed in the President's budget will be used to protect and restore the Chesapeake Bay during the upcoming fiscal year.
- Require federal agencies to consult extensively with Bay watershed jurisdictions in preparing their reports.

Pursuant to the Executive Order, on May 12, 2010, the Federal Leadership Committee—led by the EPA Administrator and secretaries from the Departments of Agriculture, Commerce, Defense, Homeland Security, Interior, Transportation, and others—issued its coordinated strategy for restoring the Chesapeake Bay (FLCCB 2010). That strategy sets measurable goals for improving environmental conditions in the Bay for the following:

- Clean water
- Habitat
- Fish and wildlife
- Land and public access

Other supporting strategies address citizen stewardship, climate change, science, and implementation and accountability. A key element of the approach for meeting water quality goals was the development of this TMDL for the Chesapeake Bay (FLCCB 2010).

Parallel to the issuance of the Executive Order, the jurisdictions and the federal government committed to implement all necessary measures for restoring water quality in the Bay by 2025 and to meet specific milestones every 2 years (FRL-8955-4; Clean Water Act section 303(d): Preliminary Notice of Total Maximum Daily Load (TMDL) Development for the Chesapeake Bay). To that end, EPA is developing an accountability framework to guide the overall restoration effort and to link it to implementation of the Chesapeake Bay TMDL. The accountability framework, which is discussed in more detail in Section 7, includes four elements:

- Watershed Implementation Plans (WIPs)
- Two-year milestones to demonstrate restoration progress
- EPA's commitment to track and assess progress

- Federal actions if the Bay watershed jurisdictions fail to meet expectations such as developing sufficient WIPs, effectively implementing their WIPs, and/or fulfilling their 2-year milestones

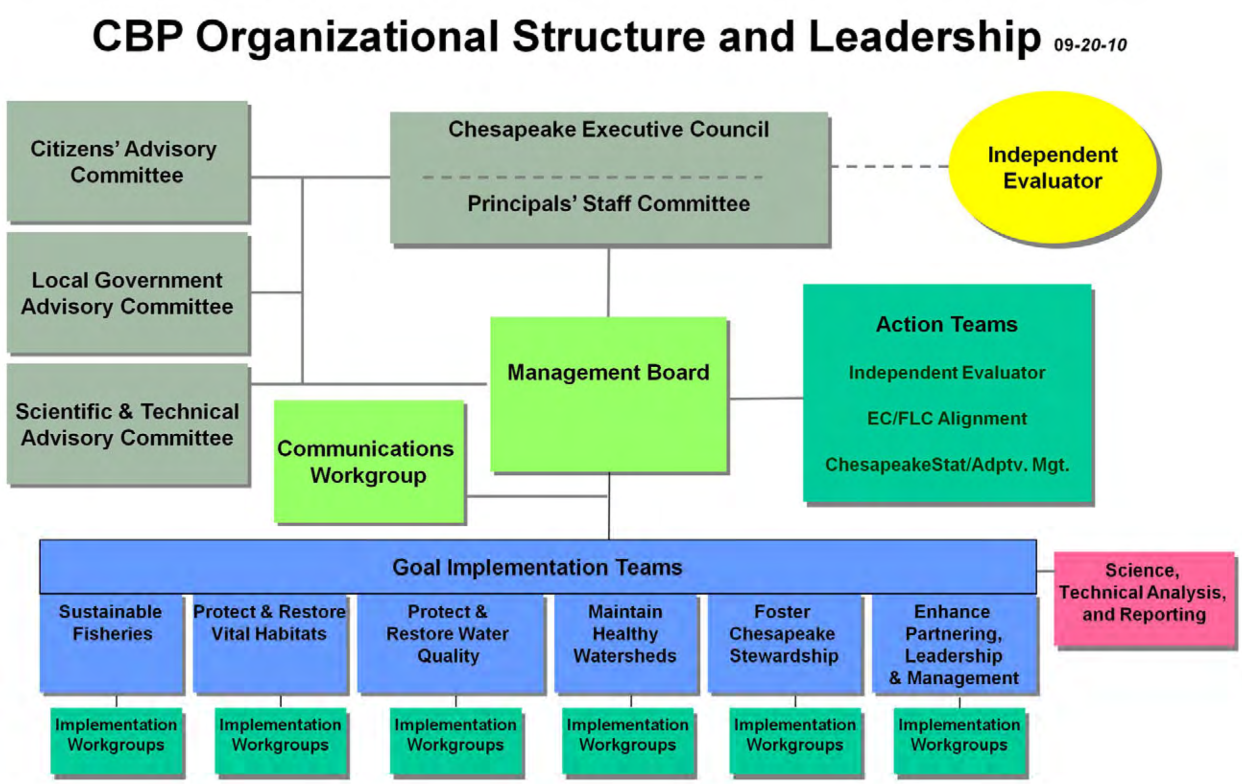
1.3 BAY TMDL PROCESS, PARTNER COORDINATION AND RESPONSIBILITIES

EPA Region 3 is the lead federal office responsible for developing the Chesapeake Bay TMDL, with the Water Protection Division (WPD) having the lead responsibility within the Regional Office. In developing this TMDL, WPD coordinated efforts with the Chesapeake Bay Program Office, Air Protection Division, Office of Regional Counsel, Office of State and Congressional Relations, Office of Public Affairs, and Office of the Regional Administrator (all within EPA Region 3), EPA Region 2 (Division of Environmental Planning and Restoration and Office of the Regional Administrator), and EPA Headquarters (Office of Water, Office of General Counsel, Office of Air and Radiation, and Office of the Administrator). Throughout the Bay TMDL development process, EPA worked in close and open partnership with all seven watershed jurisdictions, numerous federal agency partners, and a diverse array of other partners and stakeholders through the CBP partnership. This section describes the different elements of the CBP organizational structure and provides additional descriptions of the roles and responsibilities of the various entities and stakeholders involved in developing the Chesapeake Bay TMDL.

1.3.1 CBP Partnership and Organizational Structure

The CBP is a unique regional partnership that includes Maryland, Pennsylvania, Virginia, the District of Columbia, the Chesapeake Bay Commission, EPA, federal agencies, and participating advisory groups. The headwater states of Delaware, New York, and West Virginia participate as full partners on issues related to water quality. Each of the CBP partners agrees to use its own resources to implement projects and activities that advance Bay and watershed restoration.

The partnership defines its collective actions through formal, voluntary agreements and provides general policy direction through consensus documents, typically called directives. The CBP works through a series of Goal Implementation Teams with oversight provided by the CBP’s Management Board. Extensive documentation of the CBP structure and governance is provided in *Chesapeake Bay Program Governance—Managing the Partnership for a Restored and Protected Watershed and Bay* (CBP 2009). Figure 1-1 shows the CBP organizational chart.



Source: CBP 2009

Figure 1-1. CBP's organizational structure.

Chesapeake Executive Council

The top executive of each of the signatories of the Chesapeake 2000 Agreement (state governors, the District of Columbia mayor, EPA Administrator, and Chesapeake Bay Commission Chair), form the Chesapeake Executive Council (CEC), which meets annually to set basinwide policies and the future directions for the CBP. Delaware, New York, and West Virginia participate in CEC meetings and have full input status on all water quality-related matters. Principals' Staff Committee (PSC) members serve as advisors to their respective CEC members. The CEC has played a pivotal role in developing the Bay TMDL by signing the Chesapeake 2000 Agreement and subsequent directives and by setting the partnership on a well-defined, 10-year path directly supporting development of the Bay TMDL (CEC 2000, 2003, 2005).

Federal Leadership Committee

To bring the full weight of the federal government to address the Chesapeake's challenges, President Obama issued Executive Order 13508 on Chesapeake Bay Protection and Restoration and established the Federal Leadership Committee, which is chaired by the Administrator of the U.S. Environmental Protection Agency and includes senior representatives from the departments of Agriculture, Commerce, Defense, Homeland Security, Interior, and Transportation.

Principals' Staff Committee

The Principals' Staff Committee (PSC) provided policy and programmatic direction to the Management Board on the development and adoption of the Chesapeake Bay nutrient and sediment targets and allocations for the Bay TMDL (Figure 1-1). The PSC is composed of cabinet-level representatives from each of the seven watershed jurisdictions, EPA Region 3's Regional Administrator, senior federal agency executives, the Chesapeake Bay Commission executive director, and the director of the CBP Office. The Regional Administrator of EPA Region 3 currently chairs the PSC. The Citizens, Local Governments, and the Scientific and Technical advisory committees all advise the PSC.

Management Board

PSC members provided policy and program direction to the Management Board which, in turn, provided strategic planning, priority setting, and operational guidance and direction to the Water Quality Goal Implementation Team (WQGIT) during the development of the Bay TMDL (Figure 1-1). The Management Board is composed of senior policy representatives from the seven watershed jurisdictions, the Chesapeake Bay Commission, the nine core federal agency partners,[2] and the chairs of the Citizens, Local Governments, and the Scientific and Technical advisory committees. The Management Board directs and coordinates the efforts of the six Goal Implementation Teams and Action Teams. The director of the CBP Office chairs the Management Board, and the CBP Office provides for the staff to support the work of all the Goal Implementation Teams and workgroups. Staffing for the three advisory committees is supported by EPA through cooperative agreements with nonprofit organizations.

Water Quality Goal Implementation Team

The WQGIT's purpose is to support efforts to reduce and cap the nitrogen, phosphorus, and sediment loads entering the Bay and to ensure that such reductions are maintained over time. It is composed of the members of the former Water Quality Steering Committee and the former Nutrient Subcommittee. The WQGIT provided advice and guidance to EPA related to the draft target loads and allocations before they were brought to the PSC. The WQGIT consists of senior water program managers from each of the seven Bay watershed jurisdictions, EPA Headquarters and Regions 2 and 3, the Chesapeake Bay Commission, the Susquehanna River Basin Commission, and the Interstate Commission on the Potomac River Basin. The WQGIT provided technical direction to the Watershed Technical, Agriculture, Forestry, Wastewater Treatment, Sediment, and Urban Stormwater workgroups.

Watershed Technical Workgroup

The Watershed Technical Workgroup was created to provide a forum for communication among the Bay watershed jurisdictions and other CBP participants on technical issues originally related to tributary strategy development, tracking and reporting. Members of the Watershed Technical Workgroup include technical staff and mid-level managers from the seven watershed jurisdictions, EPA, and point source and environmental stakeholder groups. For the Chesapeake

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[2] The Natural Resources Conservation Service, U.S. Forest Service, National Oceanic and Atmospheric Administration, U.S. Geological Survey, National Park Service, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Department of Defense, and EPA.

Bay TMDL, the workgroup provided review and oversight in regards to application of the Bay Watershed Model.

Pollutant Source Workgroups

The Agricultural Workgroup coordinated and evaluated agricultural nutrient and sediment reduction measures throughout the jurisdictions and resolved issues related to tracking, reporting, and crediting conservation practices.

The Forestry Workgroup provided information on the effectiveness of different riparian forest buffer restoration and other forest management practices.

The Wastewater Treatment Workgroup provided a formal means of communication among federal agencies, state agencies/jurisdictions, and wastewater treatment facility owner/operators.

The Sediment Workgroup provided technical and policy-related assistance to the CBP partners in setting the sediment allocations.

The Urban Stormwater Workgroup provided input related to all aspects of stormwater nutrient and sediment loads and management practices.

Science, Technical Analysis, and Reporting Team—Criteria Assessment Protocols Workgroup

The Criteria Assessment Protocols Workgroup had the lead responsibility for ensuring coordinated assessment of all Chesapeake Bay, tidal tributary and embayment waters related to the four Bay jurisdictions' listing and delisting under CWA section 303(d). The workgroup also had the lead in developing, reviewing, and recommending to the WQGIT amendments to the original 2003 Chesapeake Bay water quality criteria published by EPA.

Science, Technical Analysis, and Reporting Team—Modeling Workgroup

The Modeling Workgroup, formerly the Modeling Subcommittee and now under the Science, Technical Analysis, and Reporting (STAR) team, oversaw the development, calibration, verification, and management application of the suite of computer-based Bay models that supported the development of the Bay TMDL. The models allowed managers to estimate the pollutant load reductions needed to achieve WQS and to assess the potential of different management scenarios to achieve the needed pollutant load reductions.

Scientific and Technical Advisory Committee

The Scientific and Technical Advisory Committee (STAC) is composed of scientists representing a diverse range of disciplines from federal agencies and academic institutions in the seven watershed jurisdictions. STAC provides scientific and technical guidance and independent scientific peer review to the CBP on measures to restore and protect the Chesapeake Bay. STAC activities related to the Bay TMDL included independent scientific peer reviews of all the Bay models (watershed, land change, estuarine water quality, estuarine sediment transport, estuarine filter feeder), Bay criteria assessment procedures, and land use data, and reviewing and commenting on the draft Bay TMDL.

Local Governments Advisory Committee

The Local Governments Advisory Committee (LGAC) is a body of locally elected officials appointed by the governors of Maryland, Pennsylvania, Virginia, and the mayor of the District of Columbia. The LGAC was established to promote the role of local governments in Bay restoration efforts and develop strategies that ultimately broaden local government participation in the CBP. The LGAC was directly involved in developing the Bay TMDL in the following ways: ensured the direct involvement of local elected officials in the decision-making processes, helped establish the local Watershed Implementation Plan (WIP) pilots in 2010 (before development of the Phase II WIPs starting in 2011), and helped inform the thousands of local governments across the watershed about the Bay TMDL.

Citizen's Advisory Committee

The Citizens Advisory Committee (CAC) provides advice to the CEC, the PSC, the Management Board, and all the Goal Implementation Teams as needed in implementing the Chesapeake Bay Agreement. The CAC directly assisted the Bay TMDL development process by providing detailed recommendations on how to engage the nongovernmental components of the larger Bay watershed community and placing a strong focus on ensuring full accountability during the development and throughout the long-term implementation of the Bay TMDL.

Appendix A provides the membership lists of all the above described committees, teams, and workgroups at the time of publication of the Bay TMDL, fully acknowledging their individual and collective contributions.

1.4 LEGAL FRAMEWORK FOR THE CHESAPEAKE BAY TMDL

1.4.1 What is a TMDL?

As discussed more fully in Section 1.1, a TMDL specifies the maximum amount of a pollutant that a waterbody can receive and still meet applicable WQS. Allocations to point sources are called wasteload allocations or WLAs, while allocations to nonpoint sources are called load allocations or LAs. A TMDL is the sum of the WLAs (for point sources), LAs (for nonpoint sources and natural background) (40 CFR 130.2), and a margin of safety (CWA section 303(d)(1)(C)). Section 303(d) requires that TMDLs be established for impaired waterbodies "at a level necessary to implement the applicable [WQS]."[3]

TMDLs are "primarily informational tools" that "serve as a link in an implementation chain that includes federally regulated point source controls, state or local plans for point and nonpoint source pollutant reduction, and assessment of the impact of such measures on water quality, all to the end of attaining water quality goals for the nation's waters."[4] Recognizing a TMDL's role as a vital link in the implementation chain, federal regulations require that effluent limits in NPDES permits be "consistent with the assumptions and requirements of any available WLA" in an approved TMDL.[5]

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[3] 33 U.S.C. 1313(d)(1)(C).
[4] Pronsolino v. Nastri, 291 F.3d 1123, 1129 (9th Cir. 2002).
[5] 40 CFR 122.44(d)(1)(vii)(B).

In addition, before EPA establishes or approves a TMDL that allocates pollutant loads to both point and nonpoint sources, it determines whether there is reasonable assurance that the nonpoint source LAs will, in fact, be achieved and WQS will be attained (USEPA 1991b). If the reductions embodied in LAs are not fully achieved, the collective reductions from point and nonpoint sources will not result in attainment of the WQS.

The Bay TMDL will be implemented using an accountability framework that includes the jurisdictions' WIPs, 2-year milestones, EPA's tracking and assessment of restoration progress and, as necessary, specific federal actions if the Bay jurisdictions do not meet their commitments. The accountability framework is being established, in part, to demonstrate that the Bay TMDL is supported by reasonable assurance. The accountability framework is also being established pursuant to CWA section 117(g)(1). Section 117(g) of the CWA directs the EPA Administrator to "ensure that management plans are developed and implementation is begun...to achieve and maintain...the nutrient goals of the Chesapeake Bay Agreement for the quantity of nitrogen and phosphorus entering the Chesapeake Bay and its watershed, [and] the water quality requirements necessary to restore living resources in the Chesapeake Bay ecosystem."[6] In addition, Executive Order 13508 directs EPA and other federal agencies to build a new accountability framework that guides local, state, and federal water quality restoration efforts. The accountability framework is designed to help ensure that the Bay's nitrogen, phosphorus, and sediment goals, as embodied in the Chesapeake Bay TMDL, are met. While the accountability framework informs the TMDL, section 303(d) does not require that EPA "approve" the framework *per se*, or the jurisdictions' WIPs that constitute part of that framework.

1.4.2 Why is EPA establishing this TMDL?

In 1998, data showed the mainstem and tidal tributary waters of the Chesapeake Bay to be impaired for aquatic life resources. EPA determined that the mainstem and tidal tributary waters of the Chesapeake Bay must be placed on Virginia's section 303(d) list. EPA therefore added the mainstem of the Chesapeake Bay to Virginia's final section 303(d) list. As described in Section 2, each tidal river, tributary, embayment, and other tidal waterbody that is part of the Chesapeake Bay TMDL is included on a jurisdiction's section 303(d) list.

EPA established the Chesapeake Bay TMDL pursuant to a number of existing authorities, including the CWA and its implementing regulations, judicial consent decrees requiring EPA to address certain impaired Chesapeake Bay and tidal tributary and embayment waters, a settlement agreement resolving litigation brought by the Chesapeake Bay Foundation, the 2000 Chesapeake Agreement, and Executive Order 13508. In establishing the Bay TMDL, EPA acted pursuant to the consensus direction of the Chesapeake Executive Council's PSC and in partnership with each of the seven Chesapeake Bay watershed jurisdictions.

The CWA provides EPA with ample authority to establish the Chesapeake Bay TMDL. CWA section 117(g)(1) provides that "[t]he Administrator, in coordination with other members of the [CEC], shall ensure that management plans are developed and implementation is begun by signatories to the Chesapeake Bay Agreement to achieve and maintain [among other things] the

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[6] Clean Water Act section 117(g)(1)(A)-(B), 33 U.S.C. 1267(g)(1)(A)-(B).

nutrient goals of the Chesapeake Bay Agreement for the quantity of nitrogen and phosphorus entering the Chesapeake Bay and its watershed [and] the water quality requirements necessary to restore living resources in the Chesapeake Bay ecosystem." Because it establishes the Bay and tidal tributaries' nutrient and sediment loading and allocation targets, the Chesapeake Bay TMDL is itself such a "management plan." In addition, the Bay TMDL's loading and allocation targets both inform and are informed by a larger set of federal and state management plans being developed for the Bay, including the Bay watershed jurisdictions' WIPs and the May 2010 *Strategy for Protecting and Restoring the Chesapeake Bay* (FLCCB 2010).

CWA section 303(d) requires jurisdictions to establish and submit TMDLs to EPA for review. Under certain circumstances, EPA also has the authority to establish TMDLs. The circumstances of this TMDL do not necessarily identify the outer bounds of EPA's authority. However, where – as here – impaired waters have been identified on jurisdictions' section 303(d) lists for many years, where the jurisdictions in question decided not to establish their own TMDLs for those waters, where EPA is establishing a TMDL for those waters at the direction of, and in cooperation with, the jurisdictions in question, and where those waters are part of an interrelated and interstate water system like the Chesapeake Bay that is impaired by pollutant loadings from sources in seven different jurisdictions, CWA section 303(d) authorizes EPA to establish that TMDL[7].

On May 12, 2009, President Barack Obama signed Executive Order 13508—*Chesapeake Bay Protection and Restoration*. The Executive Order's overarching goal is "to protect and restore the health, heritage, natural resources, and social and economic value of the Nation's largest estuarine ecosystem and the natural sustainability of its watershed." The Executive Order says the federal government "should lead this effort" and acknowledges that progress in restoring the Bay "will depend on the support of state and local governments." To that end, the Executive Order directs the lead federal agencies, including EPA, to work in close collaboration with their state partners. To protect and restore the Chesapeake Bay and its tidal tributaries, the President directed EPA to "make full use of its authorities under the [CWA]." In establishing the Bay TMDL, EPA is doing no more—or less—than making full use of its CWA authorities to lead a collaborative and effective federal and state effort to meet the Bay's nutrient and sediment goals.

A number of consent decrees, memoranda of understanding (MOUs), and settlement agreements provide additional support for EPA's decision to establish the Chesapeake Bay TMDL addressing certain waters identified as impaired on the Maryland, Virginia, and the District of Columbia's 1998 section 303(d) lists and on the Delaware 1996 section 303(d) list. EPA established the Chesapeake Bay TMDL consistent with those consent decrees, MOUs, and settlement agreements, described below.

Virginia–EPA Consent Decree

The American Canoe Association, Inc., and the American Littoral Society filed a complaint against EPA for failing to comply with the CWA, including section 303(d), regarding the TMDL program in the Commonwealth of Virginia. A consent decree signed in 1999 resolved the litigation.[8] The consent decree includes a 12-year schedule for developing TMDLs for impaired

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[7] *Dioxin/Organochlorine Center v. Clarke*, 57 F.3d 1517 (9th Cir. 1995); *Scott v. City of Hammond*, 741 F.2d 992 (7th Cir. 1984); *American Canoe Assn. v EPA*, 54 F.Supp.2d 621 (E.D.Va. 1999).

[8] *American Canoe Association v. EPA*, 98cv979 (June 11, 1999).

segments identified on Virginia's 1998 section 303(d) list. The consent decree requires EPA to establish TMDLs for those waters, by May 1, 2011, if Virginia fails to do so according to the established schedule. Virginia has requested that EPA establish TMDLs for the nutrient- and sediment-impaired tidal portions of the Chesapeake Bay and its tributaries and embayments in accordance with the Virginia consent decree schedule (CBP PSC 2007). Table 1-3 provides a list of the Virginia consent decree waters that were addressed by the Chesapeake Bay TMDLs for nitrogen, phosphorus, and sediment.

Table 1-3. Virginia consent decree (CD) waters impaired for dissolved oxygen (DO) and/or nutrients addressed by the Chesapeake Bay TMDL

Waterbody Name	CD Segment ID	Chesapeake Bay Segment ID	CD Impairment
Bailey Bay, Bailey Creek – Tidal	VAP-G03E	JMSTF1	DO
Broad Creek	VAT-G15E	ELIPH, WBEMH,SBEMH, EBEMH	DO
Chesapeake Bay Mainstem	Narrative [a]	CB5MH, CB6PH, CB7PH	Nutrients
Chesapeake Bay Mainstem	VACB-R01E	CB5MH, CB6PH, CB7PH	DO
Elizabeth River – Tidal	Narrative [b]	ELIPH, WBEMH,SBEMH, EBEMH	Nutrients
Hungars Creek	VAT-C14R	CB7PH	DO
James River – Tidal	Narrative [c]	JMSTF2, JMSTF1, JMSOH, JMSMH, JMSPH	Nutrients
King Creek	VAT-F27E	YRKPH	DO
Mattaponi River – Tidal	Narrative [d]	MPNTF, MPNOH	Nutrients
Messongo Creek	VAT-C10E	POCMH	DO
North Branch Onancock Creek	VAT-C11E	CB7PH	DO
Pagan River	VAT-G11E	JMSMH	DO
Pamunkey River – Tidal	Narrative [e]	PMKTF, PMKOH	Nutrients
Queen Creek	VAT-F26E	YRKMH	DO
Rappahannock River	Narrative [f]	RPPMH	Nutrients
Rappahannock River	VAP-E25E	RPPMH	Nutrients
Rappahannock River	VAP-E25E	RPPMH	DO
Rappahannock River	VAP-E26E	RPPMH	Nutrients
Rappahannock River	VAP-E26E	RPPMH	DO
Thalia Creek	VAT-C08E	LYNPH	DO
Williams Creek	VAN-A30E	POTMH	DO
York River	Narrative [g]	YRKMH, YRKPH	Nutrients
York River	VAT-F27E	YRKPH	DO

Source: *American Canoe Association v. EPA*, 98cv979 (June 11, 1999).
Notes:
a = Chesapeake Bay Mainstem (VACB-R01E) impaired for nutrients
b = Elizabeth River (VAT-G15E) impaired for DO, nutrients
c = James River (VAP-G01E, VAP-G03E, VAP-G02E, VAP-G04E, VAP-G11E, and VAP-G15E) impaired for nutrients
d = Mattaponi River (VAP-F24E and VAP-F25E) impaired for nutrients
e = Pamunkey River (VAP-F13E and VAP-F14E) impaired for DO, nutrients
f = Rappahannock River (VAP-E24E) impaired for DO
g = York River (VAT-F26E) impaired for nutrients

District of Columbia–EPA Consent Decree

In 1998 Kingman Park Civic Association and others filed a similar suit against EPA.[9] The lawsuit was settled through the entry of a consent decree requiring EPA to, among other things, establish TMDLs for the District of Columbia's portions of the tidal Potomac and tidal Anacostia rivers if not established by the District of Columbia by a certain date.

The impairment of the District of Columbia's portion of the upper tidal Potomac River by low pH is directly related to the Chesapeake Bay water quality impairments because the low pH is a result of excess nutrients causing algal blooms in the tidal river. Establishing a tidal Potomac River pH TMDL is directly linked to establishing the Chesapeake Bay TMDL because of their common impairing pollutants (nitrogen and phosphorus) and the hydrologic connection between the District's portion of the tidal Potomac River and the Chesapeake Bay. EPA and the Kingman Park plaintiffs jointly sought, and received on February 12, 2008, a formal extension of the District of Columbia TMDL Consent Decree so that EPA could complete the Potomac River pH TMDL on the same schedule as the Chesapeake Bay TMDL.[10] The District of Columbia requested that EPA establish the pH TMDL for the District's portion of the tidal Potomac River (CBP PSC 2007). Table 1-4 provides a list of the District's consent decree waters that were addressed by the Chesapeake Bay TMDLs for nitrogen, phosphorus, and sediment.

In addition, Anacostia Riverkeeper and Friends of the Earth filed suit against EPA challenging more than 300 TMDLs for the District of Columbia, including the Anacostia River TMDLs, because the TMDLs were not expressed as daily loads. On May 25, 2010, the District Court for the District of Columbia ordered the vacatur of the District of Columbia's TMDL for pH for the Washington Ship Channel, with a stay of vacatur until May 31, 2011.[11] With publication of the Bay TMDL, the Washington Ship Channel pH impairment has been addressed and the pH TMDL for the Ship Channel approved by EPA on December 15, 2004 has been superseded.

Table 1-4. District of Columbia consent decree (CD) waters impaired for pH addressed by the Chesapeake Bay TMDL

Waterbody Name	CD Segment ID	Chesapeake Bay Segment ID	CD Impairment
Washington Ship Channel	DCPWC04E_00	POTTF_DC	pH
Middle Potomac River	DCPMS00E	POTTF_DC	pH

Source: *Kingman Park Civic Association v EPA*, 98cv00758 (June 13, 2000).

Delaware–EPA Consent Decree

In 1996 the American Littoral Society and the Sierra Club filed a suit against EPA to ensure that TMDLs were developed for waters on Delaware's 1996 section 303(d) list, one of which is a tidal Bay segment (Upper Nanticoke River). The parties entered into a consent decree resolving the lawsuit.[12] The consent decree required EPA to establish TMDLs if Delaware failed to do so within the 10-year TMDL development schedule. Although Delaware established TMDLs for the

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[9] *Kingman Park Civic Association v EPA*, 98cv00758 (June 13, 2000).

[10] *Kingman Park Civic Association v. EPA*, 98cv00758 (Order February 12, 2008).

[11] *Anacostia Riverkeeper et al v. Jackson*, 1:2009cv00098 (D.DC)(Mem. and Order May 25, 2010)

[12] *American Littoral Society, et al. v EPA, et al.*, 96cv591 (D.Del. 1997).

one listed tidal Bay segment (DE DNREC 1998), the TMDLs were established to meet prior WQS and are insufficient to attain Chesapeake Bay WQS.

Maryland–EPA MOU

In 1998 Maryland and EPA Region 3 entered into an MOU that, among other things, established a 10-year schedule for addressing waters on Maryland's 1998 section 303(d) list, with completion by 2008 (MDE 1998). Because of funding constraints, the complexity of some TMDLs, and limited staff resources, Maryland determined that it would not be able to address all 1998 listed waters by 2008. Further, the Chesapeake 2000 Agreement established a goal of meeting water quality standards in the Chesapeake Bay by 2010 (CEC 2000). Many of the waters on Maryland's 1998 section 303(d) list were open waters of the Bay or tidal tributaries and embayments to the Bay. Maryland determined that developing TMDLs for those tidal waters before the deadline established by the MOU, as would be required under the schedule established in 1998, "would undermine the spirit of the agreement" because of a lack of integration between the CBP partnership and Maryland efforts (MDE 2004). Therefore, Maryland decided to postpone development of TMDLs for Maryland's listed Chesapeake Bay and its tidal tributary and embayment waters until the two programs could coordinate efforts.

In September 2004, Maryland and EPA Region 3 entered into a revised MOU that extended the schedule for TMDL development to 13 years (by 2011) (MDE 2004). Although neither Maryland nor EPA is under a consent decree for establishing TMDLs for Maryland waters, the state has requested that EPA develop the TMDLs for the Maryland portion of the Chesapeake Bay and tidal tributaries and embayments impaired by excess nitrogen, phosphorus, and sediment as recognized in the MOU between Maryland and EPA (CBP PSC 2007).

Chesapeake Bay Foundation Settlement Agreement

In January 2009, the Chesapeake Bay Foundation and others filed suit against EPA in U.S. District Court for the District of Columbia (1:09-cv-00005-CKK) alleging, among other things, that EPA had failed to carry out nondiscretionary duties under CWA section 117(g) designed to restore and preserve the Chesapeake Bay. In May 2010, EPA signed a settlement agreement with the plaintiffs promising to take a number of actions to restore and preserve the Bay. In particular, EPA promised that by December 31, 2010, it would establish a TMDL for those segments of the Chesapeake Bay impaired by nitrogen, phosphorus, and sediment. EPA is establishing this TMDL, in part, to meet that commitment.

SECTION 2. WATERSHED AND IMPAIRMENT DESCRIPTION

This section provides a general description of the watershed and the impairments addressed in the Chesapeake Bay TMDL. Section 2.1 provides a description of the basic history, geography, land uses, and recent development patterns and trends. Section 2.2 presents the scope of the Bay TMDL including the parameters of concern, the specific impairment listings addressed, and the Bay TMDL segmentation.

2.1 GENERAL WATERSHED SETTING

The Chesapeake Bay watershed includes parts of six states—Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia—and the entire District of Columbia (collectively, the jurisdictions). The Chesapeake Bay proper is approximately 200 miles long, stretching from Havre de Grace, Maryland, to Norfolk, Virginia. It varies in width from about 3.4 miles near Aberdeen, Maryland, to 35 miles near the mouth of the Potomac River. The easternmost boundary of the Chesapeake Bay with the Atlantic Ocean is represented by a line between Cape Charles and Cape Henry. Including its tidal tributaries and embayments, the Chesapeake Bay encompasses approximately 11,684 miles of shoreline, a length longer than the entire West Coast of the United States.

About half of the Bay’s water volume consists of saltwater from the Atlantic Ocean. The other half is freshwater that drains into the Bay from its 64,000-square-mile watershed (Figure 2-1). Ninety percent of the freshwater is delivered from five major rivers: the Susquehanna (which is responsible for about 50 percent), Potomac, James, Rappahannock, and York rivers. In all, the watershed contains more than 10,000 streams and rivers that eventually flow into the Bay.

Runoff from the Bay’s enormous watershed flows into an estuary with a surface area of 4,500 square miles resulting in a land-to-water ratio of 14 to 1. That large ratio is one of the key factors in explaining why the drainage area has such a significant influence on water quality in the Bay.

Although the Chesapeake Bay is entirely within the Atlantic Coastal Plain, its watershed includes parts of the Piedmont and Appalachian provinces. The waters that flow into the Bay have different chemical characteristics, depending on the geology from which they originate (Figure 2-2).

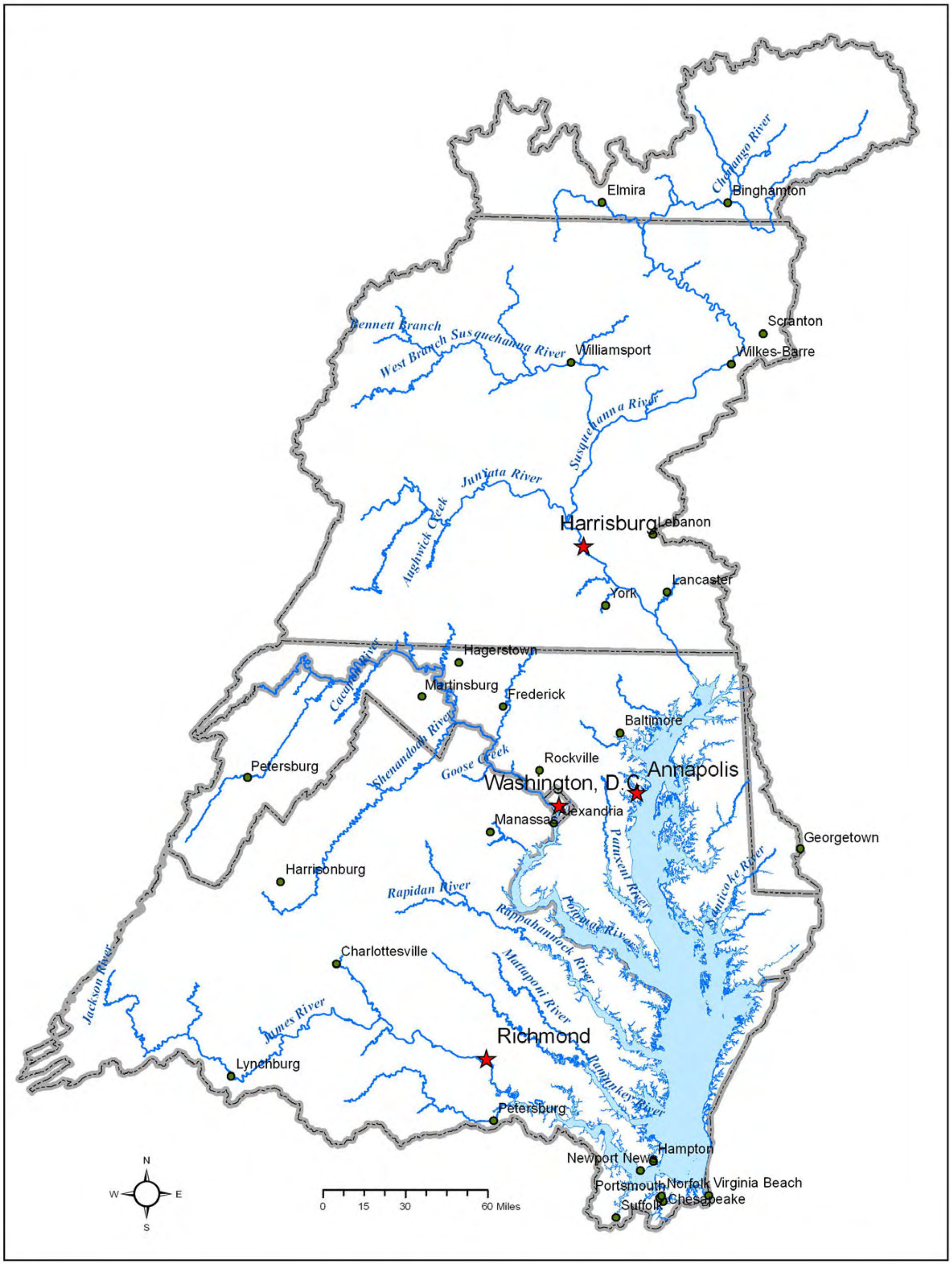
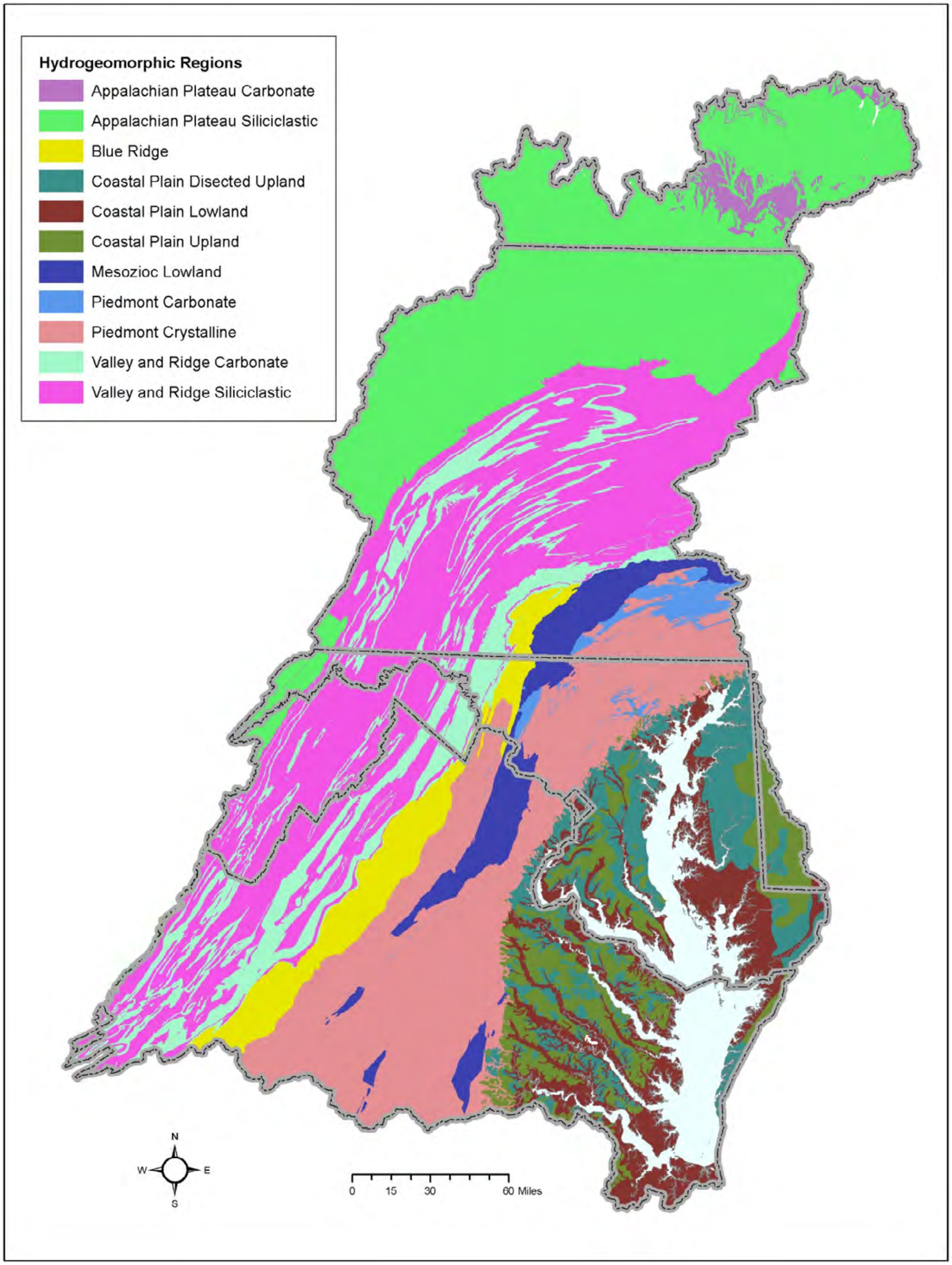


Figure 2-1. The Chesapeake Bay watershed with major rivers and cities.



Source: USGS WRIR 00-424

Figure 2-2. Hydrogeomorphic regions of the Chesapeake Bay watershed.

The Atlantic Coastal Plain is a flat, lowland area with a maximum elevation of about 300 feet. It is supported by a bed of crystalline rock, covered with southeasterly dipping wedge-shaped layers of relatively unconsolidated sand, clay, and gravel. Water passing through the loosely compacted mixture dissolves many of the minerals. The most soluble elements are iron, calcium, and magnesium. The coastal plain extends from the edge of the continental shelf, to the east, to a fall line that ranges from 15 to 90 miles west of the Chesapeake Bay. The fall line, which is the location where free flowing streams enter tidal waters, forms the boundary between the Piedmont Plateau and the coastal plain. Waterfalls and rapids clearly mark this line, which is close to Interstate 95. At the fall line, the elevation rises to 1,100 feet.

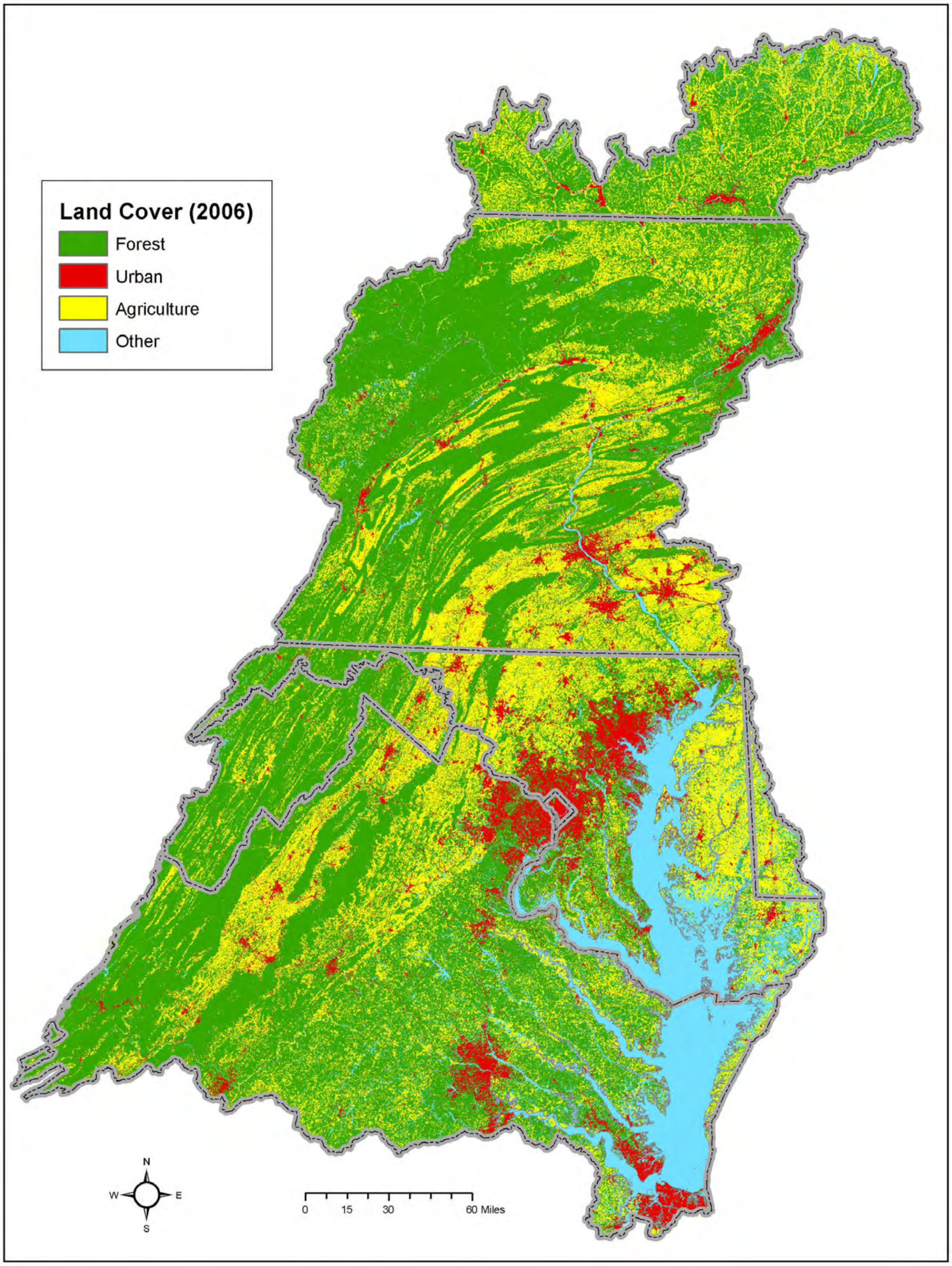
The Piedmont Plateau extends from the fall line in the east to the Appalachian Mountains in the west. The area is divided into two geologically distinct regions by Parrs Ridge, which traverses Carroll, Howard, and Montgomery counties in Maryland and adjacent counties in Pennsylvania. Several types of dense, crystalline rock—including slates, schists, marble, and granite—compose the eastern side of the Piedmont Plateau. That variety results in a very diverse topography. Rocks of the Piedmont tend to be impermeable, and water from the eastern side is low in calcium and magnesium salts. The western side of the Piedmont consists of sandstones, shales, and siltstones, layered over by limestone. The limestone bedrock contributes calcium and magnesium to its water, making it hard. Waters from the western side of Parrs Ridge flow into the Potomac River, one of the Chesapeake Bay's largest tributaries.

The Appalachian Province covers the western and northern part of the watershed and is rich in coal and natural gas deposits. Sandstone, siltstone, shale, and limestone form the bedrock. Water from that province flows to the Chesapeake Bay mainly via the Susquehanna River.

Earliest evidence of human inhabitants in the Bay watershed is of hunter-gatherers as long as 10,000 years ago. Native Americans began cultivating crops and settling in villages throughout the area around 1,000 years ago. European settlement less than 500 hundred years ago began a period of transformation of forests into farmland, while today many of those lands are undergoing retransformations into urban and suburban lands.

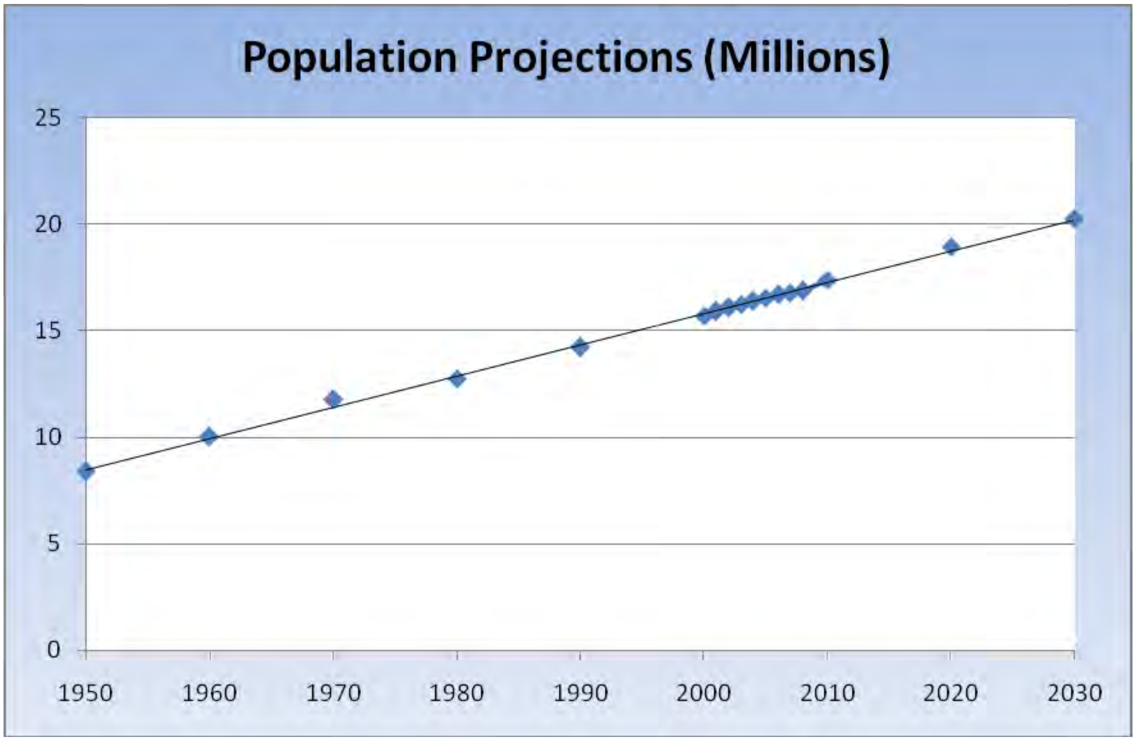
Over the past hundreds of years, forest clearing and urban development have resulted in the following land use breakdown in the watershed: 69 percent wooded/open, 22 percent agriculture, 7 percent developed, and 2 percent open water and extractive (Figure 2-3).

From 1950 through 2008, the Bay watershed's population doubled, increasing from 8.3 million to 16.8 million. The 8-year period from 2000 to 2008 witnessed population growth of approximately 7 percent from 15.7 million. Today, nearly 17 million people live in the watershed. According to census data, the watershed's population is growing by about 157,000 per year. Projections through 2030 are for the population to reach approximately 20 million (Figure 2-4).



Source: Irani and Claggett 2010

Figure 2-3. Chesapeake Bay watershed land cover.



Source: CBP Office Bay Barometer 2009

Figure 2-4. Reported and projected human population growth in the Chesapeake Bay watershed 1950–2030.

2.2 CHESAPEAKE BAY TMDL SCOPE

The Chesapeake Bay TMDL is the largest, most complex TMDL in the country, covering a 64,000-square-mile area across seven jurisdictions. EPA established a federal TMDL for the tidal segments of the Chesapeake Bay and its tidal tributaries and embayments that are impaired for aquatic life uses due to excessive loads of nutrients (nitrogen and phosphorus) and sediment and listed on the four tidal Bay jurisdictions' respective CWA 2008 section 303(d) lists of impaired waters. The Bay TMDL also allocates loadings of nitrogen, phosphorus, and sediment to sources contributing those pollutants in all seven jurisdictions in the Bay watershed—Delaware, the District of Columbia, Maryland, New York, Pennsylvania, Virginia, and West Virginia.

As described more fully in Section 2.2.1 below, the Chesapeake Bay TMDL addresses only the restoration of aquatic life uses for the Bay and its tidal tributaries and embayments that are impaired from excess nitrogen, phosphorus, and sediment pollution. If Bay segments are impaired for other pollutants, EPA expects that the Bay watershed jurisdictions will develop separate TMDLs to address those pollutants.

Thousands of previously approved TMDLs have been established to protect local waters across the Chesapeake Bay watershed. While many addressed other pollutants, some addressed nitrogen, phosphorus, and/or sediment. For watersheds and waterbodies where both local TMDLs and Chesapeake Bay TMDLs have already been developed or established for nitrogen, phosphorus, and sediment, the more stringent of the TMDLs will apply. In some cases, the reductions required to meet local conditions shown in existing TMDLs may be more stringent than those needed to meet Bay requirements, and vice versa.

2.2.1 Pollutants of Concern

The pollutants of concern for this TMDL are nutrients—nitrogen and phosphorus—and sediment. Excessive nitrogen and phosphorus in the Chesapeake Bay and its tidal tributaries promote a number of undesirable water quality conditions such as excessive algal growth, low DO, and reduced water clarity (Smith et al. 1992; Kemp et al. 2005). The effect of nitrogen and phosphorus loads on water quality and living resources can vary considerably by season and region.

Sediment suspended in the water column reduces the amount of light available to support healthy and extensive SAV or underwater Bay grass communities (Dennison et al. 1993; Kemp et al. 2004). The relative contribution of suspended sediment and algae that causes poor light conditions varies with location in the Bay tidal waters (Gallegos 2001).

Sediment also can contain other pollutants. For example, certain bacteria (e.g., *Escherichia coli*) often cling to sediment. By reducing sediment, reductions in phosphorus delivered to the Bay (and possibly other pollutants such as *E. coli*) also will occur. However, EPA is not providing allocations for *E. coli* or other additional pollutants in this TMDL.

If Bay segments are impaired for other pollutants, EPA expects that the Bay watershed jurisdictions will develop separate TMDLs to address those pollutants. Because of the actions taken to achieve the Chesapeake Bay TMDL, direct benefits to local water quality conditions in surface waters throughout the Chesapeake Bay watershed also will occur.

2.2.2 Chesapeake Bay Program Segmentation Scheme

For 27 years, the CBP partners have used various versions of a basic segmentation scheme to organize the collection, analysis, and presentation of environmental data relating to the Chesapeake Bay. The *Chesapeake Bay Program Segmentation Scheme: Revisions, Decisions and Rationales* provides documentation of the spatial segmentation scheme of the Chesapeake Bay and its tidal tributaries and the later revisions and changes over almost thirty years (USEPA 1983b, 2004b, 2005, 2008a).

Segmentation is the compartmentalization of the estuary into subunits on the basis of selection criteria (USEPA 2008a). Generally, segments reflect certain unique physical, chemical or biological characteristics of a portion of a waterbody (e.g., salinity, influence of pollutant sources, etc.). The 92-segment scheme used in the Chesapeake Bay was derived from the 2004 published 78-segment scheme with additional jurisdictional boundary lines imposed to create 89 segments (USEPA 2004b, 2008a). The scheme includes only the split segments[1] agreed to by the CBP partnership for the tidal James and Potomac rivers for a total of 92 segments (Figure 2-5) (Table 2-1) (USEPA 2008a). The 92 individual watersheds that drain directly into one of the 92 Chesapeake Bay segments are referred to in this document as Bay segment watersheds (Figure 2-6).

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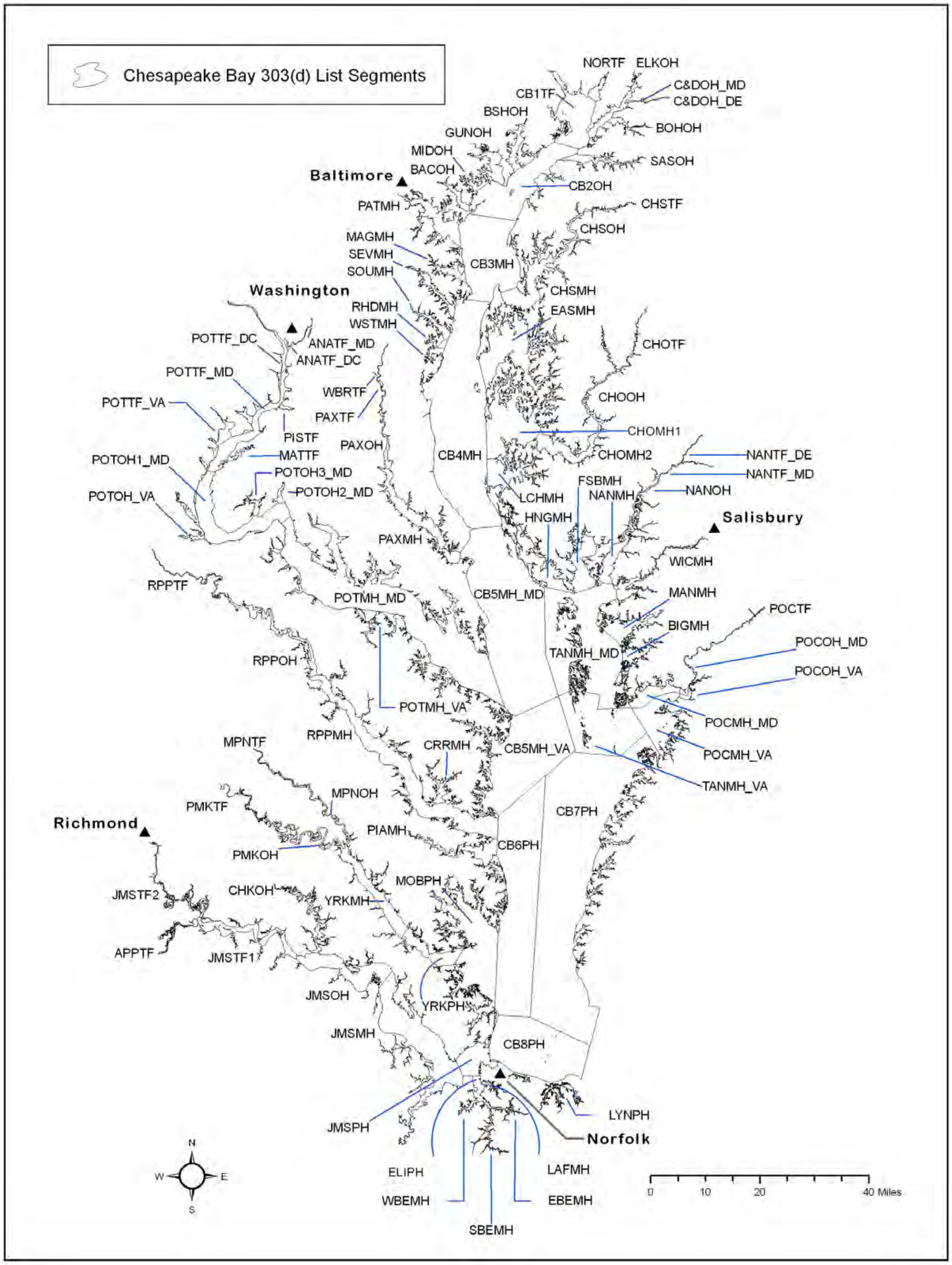
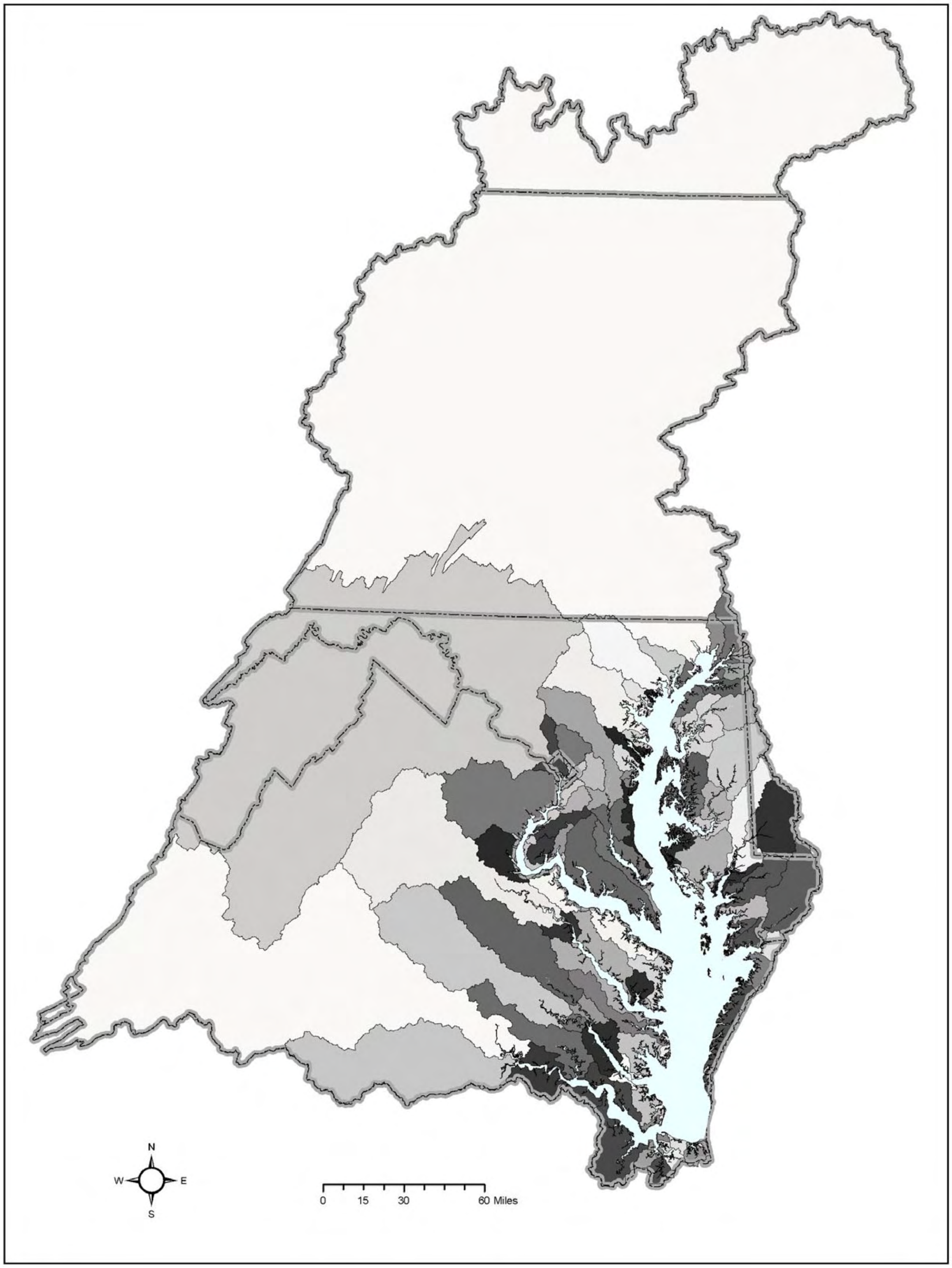
[1] A split segment refers to when an established tidal Bay segment was fully bisected for purposes of applying different water quality criteria specific to two different portions of the same segment—in the case of the James River, or different assessments of attainment of the same applicable criteria separately from the main river segment—in the case of the Potomac River.



Source: USEPA 2008a

Figure 2-5. The 92 Chesapeake Bay segments.



Source: USEPA 2008a

Figure 2-6. The 92 Chesapeake Bay segment watersheds.

Table 2-1 lists the eight major river basins draining to the Chesapeake Bay and their associated Bay segments with information related to each Bay segment's 2008 section 303(d) list status and whether the Bay segment is addressed by a consent decree or MOU. The 303(d) Integrated Report listing categories are as follows:

- Category 1—attaining all WQS
- Category 2—attaining some WQS
- Category 3—insufficient information to determine if WQS are attained
- Category 4—impaired or threatened waters that do not need or already have completed a TMDL
    - 4a—TMDL has been completed
    - 4b—Other pollution control requirements are reasonably expected to result in the attainment of the WQS in the near future
    - 4c—Impairment is not caused by a pollutant
- Category 5—impaired or threatened water that requires a TMDL

Most Bay segments are listed as category 5 (impaired for most/all designated uses); exceptions are noted in Table 2-1.

Table 2-1. The Chesapeake Bay 303(d) tidal segments with consent decree (CD)/ memorandum of understanding (MOU) and 303(d) listing status by major river basin and jurisdiction

Major river basin	Jurisdiction	Chesapeake Bay 303(d) segment	Segment ID	CD/MOU	2008 list status[a]
Eastern Shore	MD	Big Annemessex River	BIGMH	--	5
	MD	Bohemia River	BOHOH	MD MOU	4a for TN and TP
	DE	C&D Canal, DE	C&DOH_DE	--	5
	MD	C&D Canal, MD	C&DOH_MD	MD MOU	5
	MD	Eastern Bay	EASMH	MD MOU	5
	VA	Eastern Lower Chesapeake Bay	CB7PH	VA CD	5
	MD	Elk River	ELKOH	MD MOU	5
	MD	Fishing Bay	FSBMH	MD MOU	4a for TN and TP
	MD	Honga River	HNGMH	MD MOU	5
	MD	Little Choptank River	LCHMH	MD MOU	5
	MD	Lower Chester River	CHSMH	MD MOU	5
	MD	Lower Choptank River	CHOMH2	MD MOU	5
	MD	Lower Nanticoke River	NANMH	--	5
	MD	Lower Pocomoke River, MD	POCMH_MD	MD MOU	5
	VA	Lower Pocomoke River, VA	POCMH_VA	VA CD	5
	MD	Manokin River	MANMH	MD MOU	4a for TN and TP
	MD	Middle Chester River	CHSOH	MD MOU	4a for TN and TP

Major river basin	**Jurisdiction**	**Chesapeake Bay 303(d) segment**	**Segment ID**	**CD/MOU**	**2008 list status**[a]
	MD	Middle Choptank River	CHOOH	MD MOU	5
	MD	Middle Nanticoke River	NANOH	MD MOU	5
	MD	Middle Pocomoke River, MD	POCOH_MD	MD MOU	5
	VA	Middle Pocomoke River, VA	POCOH_VA	--	5
	MD	Mouth of Choptank River	CHOMH1	MD MOU	5
	MD	Northeast River	NORTF	MD MOU	4a for TN and TP
	MD	Sassafras River	SASOH	MD MOU	4a for TP
	MD	Tangier Sound, MD	TANMH_MD	MD MOU	5
	VA	Tangier Sound, VA	TANMH_VA	--	5
	MD	Upper Chester River	CHSTF	MD MOU	4a for TN and TP
	MD	Upper Choptank River	CHOTF	MD MOU	5
	DE	Upper Nanticoke River, DE	NANTF_DE	DE CD finished	5
	MD	Upper Nanticoke River, MD	NANTF_MD	MD MOU	5
	MD	Upper Pocomoke River	POCTF	MD MOU	5
	MD	Wicomico River	WICMH	MD MOU	5
James	VA	Appomattox River	APPTF	--	5
	VA	Chickahominy River	CHKOH	--	5
	VA	Eastern Branch Elizabeth River	EBEMH	VA CD	5
	VA	Lafayette River	LAFMH	--	5
	VA	Lower James River	JMSMH	VA CD	5
	VA	Lynnhaven River	LYNPH	VA CD	5
	VA	Middle James River	JMSOH	VA CD	5
	VA	Mouth of Chesapeake Bay	CB8PH	--	5
	VA	Mouth of James River	JMSPH	VA CD	5
	VA	Mouth to mid-Elizabeth River	ELIPH	VA CD	5
	VA	Southern Branch Elizabeth River	SBEMH	VA CD	5
	VA	Upper James River - Lower	JMSTF1	VA CD	5
	VA	Upper James River - Upper	JMSTF2	VA CD	5
	VA	Western Branch Elizabeth River	WBEMH	VA CD	5
Patuxent	MD	Lower Patuxent River	PAXMH	MD MOU	5
	MD	Middle Patuxent River	PAXOH	MD MOU	5
	MD	Upper Patuxent River	PAXTF	MD MOU	5

Major river basin	Jurisdiction	Chesapeake Bay 303(d) segment	Segment ID	CD/MOU	2008 list status[a]
	MD	Western Branch Patuxent River	WBRTF	MD MOU	BOD TMDL completed for DO impairments; 4a for BOD
Potomac	DC	Anacostia River, DC	ANATF_DC	DC CD	3 for DO; 4a for BOD, TN, TP and TSS
	MD	Anacostia River, MD	ANATF_MD	MD MOU	4a for BOD, TN, TP and TSS
	VA	Lower Central Chesapeake Bay, VA [b]	CB5MH_VA [b]	VA CD	5
	MD	Lower Potomac River, MD	POTMH_MD	MD MOU	5
	VA	Lower Potomac River, VA	POTMH_VA	VA CD	5
	MD	Mattawoman Creek	MATTF	MD MOU	5
	MD	Middle Potomac River, MD - Mainstem	POTOH1_MD	MD MOU	5
	MD	Middle Potomac River, MD - Nanjemoy Creek	POTOH2_MD	MD MOU	5
	MD	Middle Potomac River, MD - Port Tobacco River	POTOH2_MD	MD MOU	4a for TN and TP
	VA	Middle Potomac River, VA	POTOH_VA	--	3 for DO in Migratory Spawning and Nursery (MSN); 2 for SAV and DO in open water
	MD	Piscataway Creek	PISTF	MD MOU	5
	DC	Upper Potomac River, DC	POTTF_DC	DC CD	3 for DO, 5 for pH
	MD	Upper Potomac River, MD	POTTF_MD	MD MOU	5
	VA	Upper Potomac River, VA	POTTF_VA	--	3 for DO in Migratory Spawning and Nursery; 2 for SAV and DO in open water
Rappa-hannock	VA	Corrotoman River	CRRMH	--	5
	VA	Lower Rappahannock River	RPPMH	VA CD	5

Major river basin	Jurisdiction	Chesapeake Bay 303(d) segment	Segment ID	CD/MOU	2008 list status[a]
	VA	Middle Rappahannock River	RPPOH	--	3 for DO in Migratory Spawning and Nursery; 2 for SAV and DO in open water
	VA	Upper Rappahannock River	RPPTF	--	5
	VA	Western Lower Chesapeake Bay[b]	CB6PH[b]	VA CD	5
Susquehanna	MD	Northern Chesapeake Bay[b]	CB1TF[b]	MD MOU	5
Western Shore	MD	Back River	BACOH	MD MOU	4a for TN and TP
	MD	Bush River	BSHOH	MD MOU	5
	MD	Gunpowder River	GUNOH	MD MOU	5
	MD	Lower Central Chesapeake Bay, MD[b]	CB5MH_MD[b]	MD MOU	5
	MD	Magothy River	MAGMH	MD MOU	5
	MD	Middle Central Chesapeake Bay[b]	CB4MH[b]	MD MOU	5
	MD	Middle River	MIDOH	MD MOU	5
	MD	Patapsco River	PATMH	MD MOU	5
	MD	Rhode River	RHDMH	MD MOU	5
	MD	Severn River	SEVMH	MD MOU	5
	MD	South River	SOUMH	MD MOU	5
	MD	Upper Central Chesapeake Bay[b]	CB3MH[b]	MD MOU	5
	MD	Upper Chesapeake Bay[b]	CB2OH[b]	MD MOU	5
	MD	West River	WSTMH	MD MOU	5
York	VA	Lower Mattaponi River	MPNOH	VA CD	5
	VA	Lower Pamunkey River	PMKOH	VA CD	5
	VA	Lower York River	YRKPH	VA CD	5
	VA	Middle York River	YRKMH	VA CD	5
	VA	Mobjack Bay	MOBPH	--	5
	VA	Piankatank River	PIAMH	--	5
	VA	Upper Mattaponi River	MPNTF	VA CD	5
	VA	Upper Pamunkey River	PMKTF	VA CD	5

Sources: American Canoe Association v. EPA; American Littoral Society, et al. v. EPA, et al.; DC DOH 1998; DC DOE 2008; DE DNREC 1996; DE DNREC 2008; Kingman Park Civic Association, et al. vs. EPA; MDE 1998, 2004, 2008; USEPA 2008 a; VA DEQ 1998; VA DEQ 2008

a. BOD = biological oxygen demand; DO = dissolved oxygen; TN = total nitrogen; TP = total phosphorus; TSS = total suspended solids

b. More than one river basin flows into this tidal segment

2.2.3 Jurisdictions' 2008 303(d) Listings

The Chesapeake Bay TMDL is based on the most recent EPA-approved tidal Bay jurisdictions' section 303(d) lists, which are the 2008 303(d) listings.[2] Those section 303(d) lists identify 89 of the 92 Chesapeake Bay segments as impaired on either Category 4a (impaired, TMDL has been developed) or Category 5 (impaired, needs TMDL) because of various factors, including low DO levels, insufficient SAV, excess chlorophyll *a*, biological/nutrient indicators, total nitrogen, total phosphorus, total suspended solids (TSS), biological oxygen demand (BOD), and pH (caused by excessive nitrogen and phosphorus fueling algal blooms) (DC DOE 2008; DE DNREC 2008; MDE 2008; VADEQ 2008).

Three Chesapeake Bay segments are not listed in Category 4a or 5 on Virginia's 2008 integrated report:

- Upper Potomac River (POTTF_VA)
- Middle Potomac River (POTOH_VA)
- Middle Rappahannock River (RPPOH)

Those three segments are listed as either Category 2 (some uses met, other uses have insufficient information to determine impairment) or Category 3 (insufficient information to determine if impaired) (VA DEQ 2008). Because their listing status raises a reasonable possibility that they are impaired, and because those segments are tidally interconnected with other impaired Bay segments, it is appropriate that they also be addressed by the Chesapeake Bay TMDL.

The first segment, Virginia's Upper Potomac River (POTTF_VA), encompasses a series of small tidal embayments that are tidally interconnected with Maryland's Upper Potomac River (POTTF_MD) segment and the District of Columbia's Upper Potomac River (POTTF_DC) segment (USEPA 2008a), both of which are listed as Category 5 of Maryland's and the District of Columbia's respective 2008 integrated reports (DCDOE 2008; MDE 2008). Loads originating in the watershed that drains directly to Virginia's Upper Potomac River segment influence the water quality in the two adjacent Maryland and District of Columbia impaired tidal segments and other down-tide segments.

The second segment, Virginia's Middle Potomac River (POTOH_VA), also encompasses a series of small tidal embayments that are tidally interconnected with Maryland's Middle Potomac River (POTOH_MD) segment (USEPA 2008a), which is listed as Category 5 on Maryland's 2008 integrated report (MDE 2008). Loads originating in the watershed that drains directly to Virginia's Middle Potomac River segment influence the water quality in the adjacent Maryland impaired tidal segment and other down-tide impaired segments.

The third segment, Virginia's Middle Rappahannock River (RPPOH), is tidally interconnected with both the Lower Rappahannock River (RPPMH) and the Upper Rappahannock River (RPPTF) segments (USEPA 2008a), both of which are listed as Category 5 on Virginia's 2008 integrated report (VADEQ 2008). Loads originating in the watershed that drains directly to

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[2] At the time EPA applied the Bay models for development of the allocations starting in 2009, the 2008 section 303(d) lists were the most recent approved lists. Although EPA subsequently received 2010 section 303(d) lists for approval from all tidal jurisdictions, EPA used the approved 2008 lists in establishing the Bay TMDL to have a consistent basis for the TMDL.

Virginia's Middle Rappahannock River segment influence the water quality in the adjacent Virginia impaired tidal segments and other down-tide segments.

As detailed in Section 9, TMDLs have been completed as part of the Chesapeake Bay TMDL for all 92 Chesapeake Bay segments listed in Table 2-1 (see Section 9). These include TMDLs for the above described three Virginia Bay segments because they flow into impaired tidal Bay segments, and reductions in nitrogen, phosphorus, and sediment loadings from their respective watersheds, therefore, are necessary to achieve the Bay jurisdictions' Chesapeake Bay WQS.

2.2.4 2008 303(d) Listing Segments Compared to Consent Decree and MOU Segments

To ensure that EPA established TMDLs for all necessary Bay segments—all 2008 listed segments, all Virginia, Delaware, and the District of Columbia TMDL consent decree segments, and all Maryland MOU segments—EPA compared the 2008 listed segments with those included on those consent decrees and MOUs (Table 2-1). In total, 77 segments are addressed by the Virginia and District of Columbia consent decrees and the Maryland MOU: 22 segments are on the Virginia TMDL consent decree; 2 segments are on the Delaware TMDL consent decree; 2 segments are on the District of Columbia TMDL consent decree; and 51 segments are on the Maryland TMDL MOU (Table 2-2). The evaluation found that all segments of the Virginia consent decree, Delaware consent decree, the District of Columbia consent decree, and Maryland MOU are included in the list of 92 Chesapeake Bay segments for which nitrogen, phosphorus, and sediment TMDLs have been established under the Bay TMDL.

Table 2-2. Comparison of consent decree/MOU segments with total number of Bay segments

Jurisdiction	Consent decree or MOU segments	Chesapeake Bay segments
Virginia	22	35
District of Columbia	2	2
Maryland	51	53
Delaware	2[a]	2
Total	77	92

Source: Adapted from Table 2-1.

a. Two consent decrees affect one Bay segment in Delaware, but TMDLs have already been established for both waterbodies.

SECTION 3. CHESAPEAKE BAY WATER QUALITY STANDARDS

WQS consist of four basic elements: designated uses, water quality criteria, an antidegradation policy (to maintain and protect existing uses and high-quality waters), and general policies (addressing implementation issues such as low flows, variances, and mixing zones). Designated uses are a jurisdiction's goals and expectations for each of the individual surface waters (e.g., coldwater fisheries, public water supply, and primary contact recreation). EPA's WQS regulation defines designated uses as the "uses specified in WQS for each waterbody or segment, whether or not they are being attained" (40 CFR 131.3). Water quality criteria may be numeric or narrative, and represent a quality of water that supports a particular use. When water quality criteria are met, water quality is expected to protect its designated use. Numeric water quality criteria are generally chemical-specific and reflect specific levels of pollutants that, if found in the waterbody, do not impair its designated uses (e.g., physical or chemical characteristics like temperature, minimum concentration of DO, and the maximum concentrations of toxic pollutants).

Starting in 1986, EPA and its CBP partners embarked on a process to synthesize scientific evidence on the water quality requirements of hundreds of aquatic species and biological communities inhabiting Chesapeake Bay and its tidal tributaries and embayments. The 1987 Chesapeake Bay Agreement included a commitment to "develop and adopt guidelines for the protection of water quality and habitat conditions necessary to support the living resources found in the Chesapeake Bay system, and to use these guidelines in the implementation of water quality and habitat quality programs" (CEC 1987). The CBP partnership initially published two syntheses of the available scientific findings supporting establishment of habitat requirements for 31 target species (CBP 1987; Funderburk et al. 1991). Those efforts spawned development and publication of synthesis documents focused on DO requirements (Jordan et al. 1992) and underwater Bay grasses habitat requirements (Batiuk et al. 1992, 2000). On the basis of that work, in part, EPA published as guidance the Chesapeake Bay water quality criteria (USEPA 2003a) and the Chesapeake Bay refined aquatic life designated uses and attainability (USEPA 2003d) documents.

Guided by those efforts, Delaware, the District of Columbia, Maryland, and Virginia adopted jurisdiction-specific Chesapeake Bay WQS regulations in 2004–2005 consistent with the EPA published guidance. EPA then reviewed and approved the four tidal Bay jurisdictions' WQS submissions pursuant to CWA section 303(c).

Since 2005, Delaware, Maryland, Virginia, and the District of Columbia each has proposed and adopted very specific amendments to its respective Chesapeake Bay WQS regulations. Each jurisdiction's process for amending its existing Chesapeake Bay WQS regulations requires full public notice, public review and comment, and response to public comments before submission to EPA Region 3 for final EPA review and approval.

3.1 CHESAPEAKE BAY WATER QUALITY CRITERIA AND DESIGNATED USES

The above described DO, underwater Bay grasses, and Bay habitat requirements documents (Batiuk et al. 1992, 2000; CBP 1987; Funderburk et al. 1991; Jordan et al. 1991), supplemented by additional scientific research findings, provided the basis for developing the applicable water quality criteria guidance for the Chesapeake Bay. The criteria assessment guidance is documented within EPA's Bay criteria (USEPA 2003a), designated uses/attainability (USEPA 2003d), and Bay segmentation (USEPA 2004b) documents and the subsequent seven addenda (USEPA 2004a, 2004e, 2005, 2007a, 2007b, 2008a, 2010a). EPA Region 3 published those documents as guidance in accordance with CWA sections 117(b) and 303 to derive water quality criteria specifically for addressing the critical nutrient and sediment enrichment parameters necessary to protect designated aquatic life uses in the Bay (Table 3-1). These criteria serve as surrogate numeric criteria for nitrogen, phosphorus, and sediment.

Table 3-1. Chesapeake Bay water quality criteria and designated use related documentation and addenda

Document title	Month/year published	Document content and description
Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries. EPA 903-R-03-002. [USEPA 2003a]	April 2003	Original Chesapeake Bay water quality criteria document.
Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability. EPA 903-R-03-004. [USEPA 2003d]	October 2003	Original Chesapeake Bay tidal waters designated uses document.
Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries—2004 Addendum. EPA 903-R-03-002. [USEPA 2004a]	October 2004	Addresses endangered species protection, assessment of DO criteria, derivation of site-specific DO criteria, pycnocline boundary delineation methodology, and updated water clarity criteria/SAV restoration acreage assessment procedures.
Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability—2004 Addendum. EPA 903-R-04-006. [USEPA 2004e]	October 2004	Addresses refinements to Bay tidal waters designated use boundaries, segmentation boundaries, and Potomac River jurisdictional boundaries; documents SAV no-grow zones, restoration goal, and shallow-water acreages.
Chesapeake Bay Program Analytical Segmentation Scheme: Revisions, Decisions and Rationales 1983–2003. EPA 903-R-04-008. CBP/TRS 268-04. [USEPA 2004b]	October 2004	Details documentation on the history of the segmentation schemes and provides coordinates, georeferences, and narrative descriptions of the 2003 segmentation scheme.

Document title	Month/year published	Document content and description
Chesapeake Bay Program Analytical Segmentation Scheme: Revisions, Decisions and Rationales 1983–2003: 2005 Addendum. EPA 903-R-05-004. CBP/TRS 278-06. [USEPA 2005]	December 2005	Addresses methods used to subdivide the segments by jurisdiction and provides coordinates, georeferences, and narrative descriptions for those subdivided segments.
Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries—2007 Addendum. EPA 903-R-07-003. CBP/TRS 285-07. [USEPA 2007a]	July 2007	Addresses refinements to the Bay water quality DO, water clarity/SAV, and chlorophyll a criteria assessment methodologies and documents the framework for Bay tidal waters 303(d) list decision making.
Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries—2007 Chlorophyll Criteria Addendum. EPA 903-R-07-005. CBP/TRS 288/07. [USEPA 2007b]	November 2007	Publishes a set of numerical chlorophyll a criteria for Chesapeake Bay and the supporting criteria assessment procedures.
Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries—2008 Technical Support for Criteria Assessment Protocols Addendum. EPA 903-R-08-001. CBP/TRS 290-08. [USEPA 2008a]	September 2008	Addresses refinements to the Bay water quality DO, water clarity/SAV and chlorophyll a criteria assessment methodologies and documents the 2008 92-segment scheme for Bay tidal waters.
Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries—2010 Technical Support for Criteria Assessment Protocols Addendum. EPA 903-R-10-002. CBP/TRS 301-10. [USEPA 2010a]	May 2010	Addresses refinements to procedures for defining designated uses, procedures for deriving biologically based reference curves for DO criteria assessment and chlorophyll a criteria assessment procedures.

Before adoption into each Bay jurisdiction's WQS regulations, each set of criteria, criteria assessment procedures, designated uses, and proposed WQS were subject to extensive scientific, programmatic, and public review.

The original 2003 water quality criteria, assessment procedures, and designated uses all went through independent scientific peer reviews sponsored by the CBP's STAC and public review. The CBP's Water Quality Steering Committee's water quality criteria and designated use teams then reviewed and approved them. Finally, the CBP's Water Quality Steering Committee reviewed and approved them for EPA publication on behalf of the partnership.

Since the publication of the original Chesapeake Bay water quality criteria document (USEPA 2003a), Chesapeake Bay designated uses and attainability document (USEPA 2003d), and Chesapeake Bay segmentation document (USEPA 2004b), EPA has published enhancements to the criteria assessment procedures, designated use boundaries, and Bay segmentation scheme. Specifically, EPA has published five addenda—USEPA 2004a, 2007a, 2007b, 2008a, 2010a—to the original 2003 Bay criteria document (USEPA 2003a), one addendum—USEPA 2004e—to the original 2003 Bay designated use/attainability document (USEPA 2003d), and one addendum—USEPA 2005—to the original Bay segmentation document (USEPA 2004b) (see Table 3-1).

Those revisions have undergone independent scientific peer reviews, sponsored by the CBP's STAC, before review and approval by the CBP's Criteria Assessment Protocols Workgroup and then the Water Quality Steering Committee/Water Quality Implementation Team for EPA publication on behalf of the partnership. Examples include the cumulative frequency distribution approach (STAC 2006) and the biological reference curves (STAC 2009).

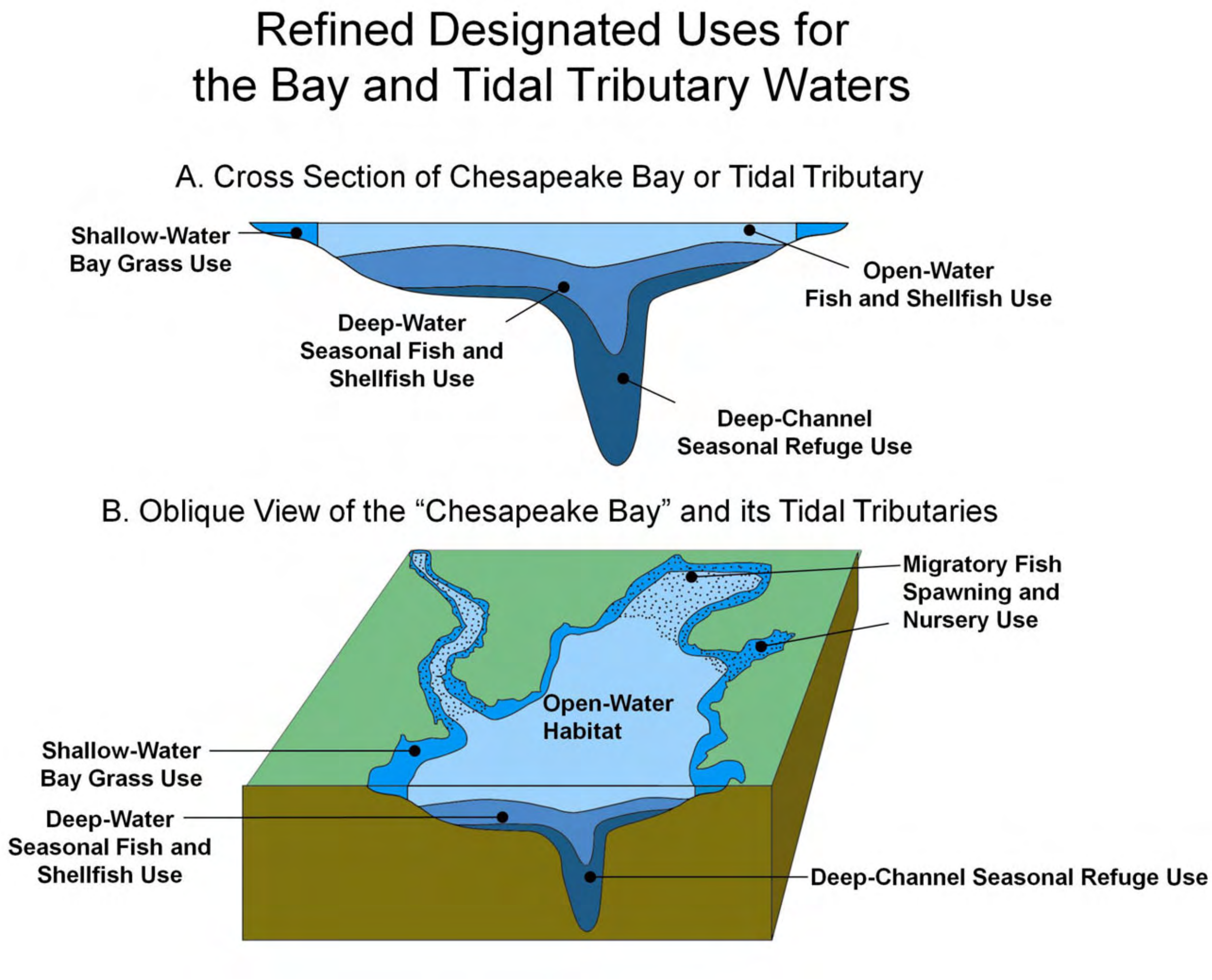
3.1.1 Tidal Water Designated Uses

EPA and its seven watershed jurisdiction partners agreed on five refined aquatic life designated uses reflecting the habitats of an array of recreationally, commercially, and ecologically important species and biological communities (USEPA 2003d, 2004e, 2010a). The five tidal Bay designated uses are applied, where appropriate, consistently across Delaware, the District of Columbia, Maryland, and Virginia's portions of the Chesapeake Bay and its tidal tributary and embayment waters. The vertical and horizontal breadth and temporal application of the designated use boundaries are based on a combination of natural factors, historical records, physical features, hydrology, bathymetry, and other scientific considerations (USEPA 2003d, 2004e, 2010a). Table 3-2 outlines the Chesapeake Bay tidal water designated uses, which are illustrated in Figure 3-1.

Table 3-2. Five Chesapeake Bay tidal waters designated uses

Tidal water designated use	Chesapeake Bay habitats and communities protected
Migratory fish spawning and nursery	Migratory and resident tidal freshwater finfish during the late winter/spring spawning and nursery season in tidal freshwater to low-salinity habitats.
Shallow-water Bay grass	Underwater Bay grasses and fish and crab species that depend on the shallow-water habitat provided by underwater Bay grass beds.
Open-water fish and shellfish	Diverse populations of sport fish, including striped bass, bluefish, mackerel and sea trout, as well as important bait fish such as menhaden and silversides in surface water habitats within tidal creeks, rivers, embayments, and the mainstem Chesapeake Bay year-round.
Deep-water seasonal fish and shellfish	Animals inhabiting the deeper transitional water column and bottom habitats between the well-mixed surface waters and the very deep channels during the summer months (e.g., bottom-feeding fish, crabs and oysters, as well as other important species, including the Bay anchovy).
Deep-channel seasonal refuge	Bottom-sediment-dwelling worms and small clams that serve as food for bottom-feeding fish and crabs in the very deep channels in summer.

Sources: USEPA 2003d, 2004e



Source: USEPA 2003d

Figure 3-1. Conceptual illustration of the five Chesapeake Bay tidal water designated use zones.

Table 3-3 lists the designated uses for each of the 92 Chesapeake Bay segments pursuant to Delaware, the District of Columbia, Maryland, and Virginia's existing WQS regulations. Amended based on USEPA 2010a, Table 3-3 was originally published as Table V-1 on pages 51–53 of the *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries 2007 Addendum* (USEPA 2007a), which is an updated version of Table IV-3 originally published on pages 62–63 of the 2003 *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability* (USEPA 2003d). The absence of an X in the shallow-water Bay grass designated use column indicates that the Bay segment has been entirely delineated as an SAV no-grow zone and, therefore, the shallow-water Bay grass designated use does not apply to that Bay segment (USEPA 2004e).

Table 3-3. Current tidal water designated uses by Chesapeake Bay segment

CB segment name	CB segment	Juris.	Migratory fish spawning & nursery Feb. 1– May 31	Open water fish & shellfish Year-round	Deep water seasonal fish & shellfish June 1– Sept. 30	Deep channel seasonal refuge June 1– Sept. 30	Shallow water Bay grasses SAV growing season
Northern Chesapeake Bay	CB1TF	MD	X	X			X
Upper Chesapeake Bay	CB2OH	MD	X	X			X
Upper Central Chesapeake Bay	CB3MH	MD	X	X	X	X	X
Middle Central Chesapeake Bay	CB4MH	MD	X	X	X	X	X
Lower Central Chesapeake Bay , MD	CB5MH_MD	MD		X	X	X	X
Lower Central Chesapeake Bay, VA	CB5MH_VA	VA		X	X	X	X
Western Lower Chesapeake Bay	CB6PH	VA		X	X		X
Eastern Lower Chesapeake Bay	CB7PH	VA		X	X		X
Mouth of the Chesapeake Bay	CB8PH	VA		X			X
Bush River	BSHOH	MD	X	X			X
Gunpowder River	GUNOH	MD	X	X			X
Middle River	MIDOH	MD	X	X			X
Back River	BACOH	MD	X	X			X
Patapsco River	PATMH	MD	X	X	X		X
Magothy River	MAGMH	MD	X	X	X		X
Severn River	SEVMH	MD	X	X	X		X
South River	SOUMH	MD	X	X	X		X
Rhode River	RHDMH	MD	X	X			X
West River	WSTMH	MD	X	X			X
Upper Patuxent River	PAXTF	MD	X	X			X
Western Branch Patuxent River	WBRTF	MD	X	X			X
Middle Patuxent River	PAXOH	MD	X	X			X
Lower Patuxent River	PAXMH	MD	X	X	X		X
Upper Potomac River, DC	POTTF_DC	DC	X	X			X
Upper Potomac River, MD	POTTF_MD	MD	X	X			X
Upper Potomac River, VA	POTTF_VA	VA	X	X			X
Anacostia River, DC	ANATF_DC	DC	X	X			X
Anacostia River, MD	ANATF_MD	MD	X	X			X
Piscataway Creek	PISTF	MD	X	X			X
Mattawoman Creek	MATTF	MD	X	X			X

CB segment name	CB segment	Juris.	Migratory fish spawning & nursery	Open water fish & shellfish	Deep water seasonal fish & shellfish	Deep channel seasonal refuge	Shallow water Bay grasses
			Feb. 1– May 31	Year-round	June 1– Sept. 30	June 1– Sept. 30	SAV growing season
Middle Potomac River, MD-Mainstem	POTOH1_MD	MD	X	X			X
Middle Potomac River, MD-Nanjemoy Creek	POTOH2_MD	MD	X	X			X
Middle Potomac River, MD-Port Tobacco River	POTOH3_MD	MD	X	X			X
Middle Potomac River, VA	POTOH_VA	VA	X	X			X
Lower Potomac River, MD	POTMH_MD	MD	X	X	X	X	X
Lower Potomac River, VA	POTMH_VA	VA	X	X	X	X	X
Upper Rappahannock River	RPPTF	VA	X	X			X
Middle Rappahannock River	RPPOH	VA	X	X			X
Lower Rappahannock River	RPPMH	VA	X	X	X	X	X
Corrotoman River	CRRMH	VA	X	X			X
Piankatank River	PIAMH	VA		X			X
Upper Mattaponi River	MPNTF	VA	X	X			X
Lower Mattaponi River	MPNOH	VA	X	X			
Upper Pamunkey River	PMKTF	VA	X	X			X
Lower Pamunkey River	PMKOH	VA	X	X			
Middle York River	YRKMH	VA	X	X			X
Lower York River	YRKPH	VA		X	X		X
Mobjack Bay	MOBPH	VA		X			X
Upper James River-Lower	JMSTF1	VA	X	X			X
Upper James River-Upper	JMSTF2	VA	X	X			X
Appomattox River	APPTF	VA	X	X			X
Middle James River	JMSOH	VA	X	X			X
Chickahominy River	CHKOH	VA	X	X			X
Lower James River	JMSMH	VA	X	X			X
Mouth of the James River	JMSPH	VA		X			X
Western Branch Elizabeth River	WBEMH	VA		X			
Southern Branch Elizabeth River	SBEMH	VA		X			
Eastern Branch Elizabeth River	EBEMH	VA		X			
Lafayette River	LAFMH	VA		X			
Mouth of the Elizabeth River	ELIPH	VA		X	X	X	

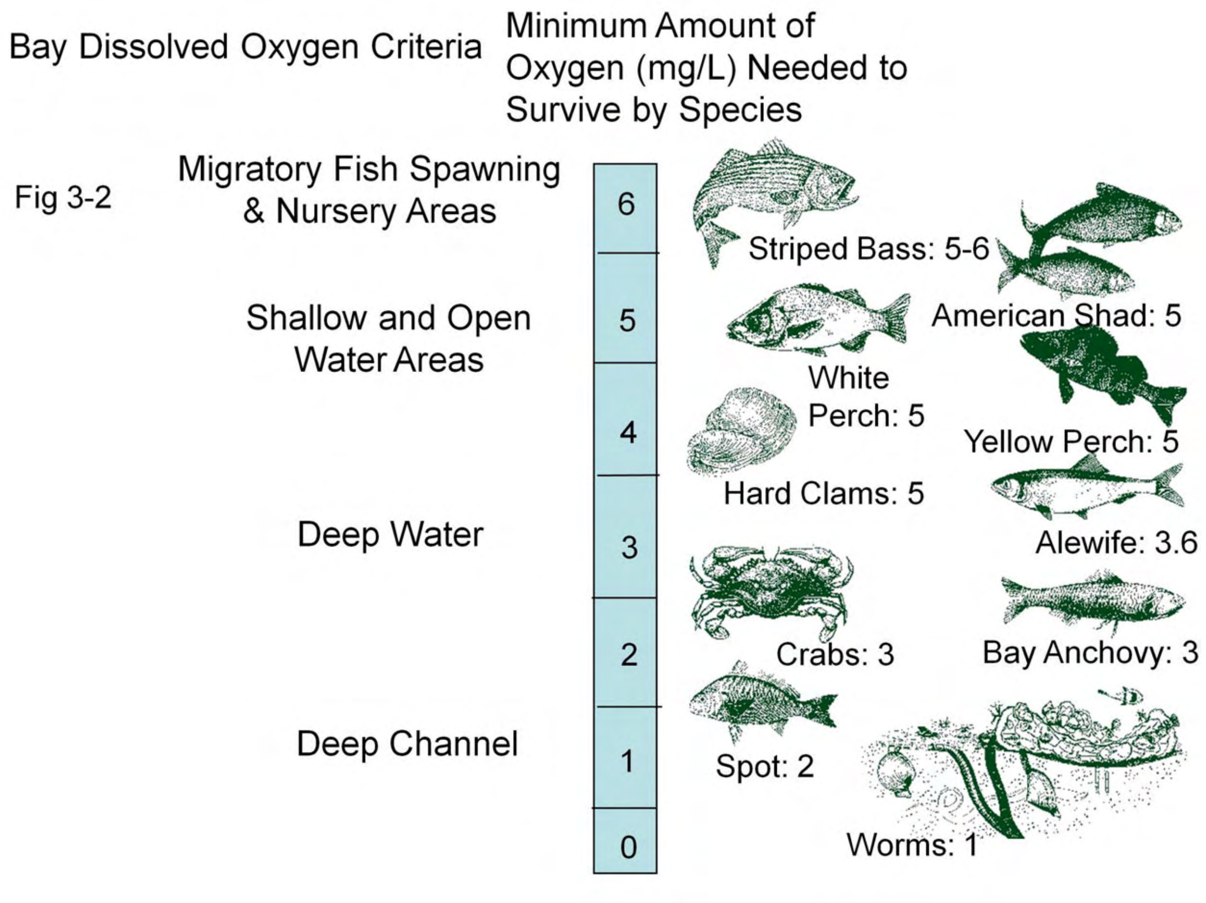
CB segment name	**CB segment**	**Juris.**	**Migratory fish spawning & nursery**	**Open water fish & shellfish**	**Deep water seasonal fish & shellfish**	**Deep channel seasonal refuge**	**Shallow water Bay grasses**
			Feb. 1– May 31	Year-round	June 1– Sept. 30	June 1– Sept. 30	SAV growing season
Lynnhaven River	LYNPH	VA		X			X
Northeast River	NORTF	MD	X	X			X
C&D Canal, DE	C&DOH_DE	DE	X	X			X
C&D Canal, MD	C&DOH_MD	MD	X	X			X
Bohemia River	BOHOH	MD	X	X			X
Elk River	ELKOH	MD	X	X			X
Sassafras River	SASOH	MD	X	X			X
Upper Chester River	CHSTF	MD	X	X			X
Middle Chester River	CHSOH	MD	X	X			X
Lower Chester River	CHSMH	MD	X	X	X	X	X
Eastern Bay	EASMH	MD		X	X	X	X
Upper Choptank River	CHOTF	MD	X	X			
Middle Choptank River	CHOOH	MD	X	X			X
Lower Choptank River	CHOMH2	MD	X	X			X
Mouth of the Choptank River	CHOMH1	MD	X	X			X
Little Choptank River	LCHMH	MD		X			X
Honga River	HNGMH	MD		X			X
Fishing Bay	FSBMH	MD	X	X			X
Upper Nanticoke River, MD	NANTF_MD	MD	X	X			
Upper Nanticoke River, DE	NANTF_DE	DE	X	X			X
Middle Nanticoke River	NANOH	MD	X	X			X
Lower Nanticoke River	NANMH	MD	X	X			X
Wicomico River	WICMH	MD	X	X			X
Manokin River	MANMH	MD	X	X			X
Big Annemessex River	BIGMH	MD	X	X			X
Upper Pocomoke River	POCTF	MD	X	X			
Middle Pocomoke River, MD	POCOH_MD	MD	X	X			
Middle Pocomoke River, VA	POCOH_VA	VA	X	X			
Lower Pocomoke River, MD	POCMH_MD	MD	X	X			X
Lower Pocomoke River, VA	POCMH_VA	VA	X	X			X
Tangier Sound, MD	TANMH_MD	MD		X			X
Tangier Sound, VA	TANMH_VA	VA		X			X

Sources: USEPA 2003d, 2004e, 2007a, 2010a

3.1.2 Dissolved Oxygen Criteria

Oxygen is one of the most essential environmental constituents supporting life. In the Chesapeake Bay’s deeper waters, there is a natural tendency toward reduced DO conditions because of the Bay’s physical morphology and estuarine circulation. The Chesapeake Bay’s highly productive shallow waters, coupled with strong density stratification (preventing reaeration); long residence times (weeks to months); low tidal energy; and tendency to retain, recycle, and regenerate nutrients from the surrounding watershed all set the stage for low DO conditions.

Against that backdrop, EPA worked closely with its seven watershed partners and the larger Bay scientific community to derive and publish a set of DO criteria to protect specific aquatic life communities and reflect the Chesapeake Bay’s natural processes that define distinct habitats (Figure 3-2) (USEPA 2003a; Batiuk et al. 2009). Working with the National Marine Fisheries Service, EPA also ensured that the DO criteria were protective of the shortnose sturgeon, a species listed as endangered by the Endangered Species Act (NMFS 2003; USEPA 2003b).



Source: USEPA 2003a

Figure 3-2. Dissolved oxygen concentrations (mg/L) required by different Chesapeake Bay species and biological communities.

Criteria for the migratory fish spawning and nursery, shallow-water Bay grass and open-water fish and shellfish designated uses were set at levels to prevent impairment of growth and to protect the reproduction and survival of all organisms living in the open-water column habitats (Table 3-4) (USEPA 2003a). Criteria for deep-water seasonal fish and shellfish designated use habitats, during seasons when the water column is significantly stratified, were set at levels to protect juvenile and adult fish, shellfish, and the recruitment success of the Bay anchovy. Criteria for deep-channel seasonal refuge designated use habitats in summer were set to protect the survival of bottom sediment-dwelling worms and clams.

Table 3-4. Current Chesapeake Bay DO criteria

Designated use	Criteria concentration/duration	Protection provided	Temporal application
Migratory fish spawning and nursery use	7-day mean ≥ 6 mg/L (tidal habitats with 0–0.5 ppt salinity)	Survival and growth of larval/juvenile tidal-fresh resident fish; protective of threatened/endangered species	February 1–May 31
	Instantaneous minimum ≥ 5 mg/L	Survival and growth of larval/juvenile migratory fish; protective of threatened/endangered species	
	Open-water fish and shellfish designated use criteria apply		June 1–January 31
Shallow-water Bay grass use	Open-water fish and shellfish designated use criteria apply		Year-round
Open-water fish and shellfish use	30-day mean ≥ 5.5 mg/L (tidal habitats with 0–0.5 ppt salinity)	Growth of tidal-fresh juvenile and adult fish; protective of threatened/endangered species	Year-round
	30-day mean ≥ 5 mg/L (tidal habitats with >0.5 ppt salinity)	Growth of larval, juvenile, and adult fish and shellfish; protective of threatened/endangered species	
	7-day mean ≥ 4 mg/L	Survival of open-water fish larvae	
	Instantaneous minimum ≥ 3.2 mg/L	Survival of threatened/endangered sturgeon species[a]	
Deep-water seasonal fish and shellfish use	30-day mean ≥ 3 mg/L	Survival and recruitment of Bay anchovy eggs and larvae	June 1–September 30
	1-day mean ≥ 2.3 mg/L	Survival of open-water juvenile and adult fish	
	Instantaneous minimum ≥ 1.7 mg/L	Survival of Bay anchovy eggs and larvae	
	Open-water fish and shellfish designated use criteria apply		October 1–May 31
Deep-channel seasonal refuge use	Instantaneous minimum ≥ 1 mg/L	Survival of bottom-dwelling worms and clams	June 1–September 30
	Open-water fish and shellfish designated use criteria apply		October 1–May 31

Source: USEPA 2003a

Notes: mg/L = milligrams per liter; ppt = parts per thousand salinity

[a] At temperatures considered stressful to shortnose sturgeon (> 29 degrees Celsius), DO concentrations above an instantaneous minimum of 4.3 mg/L will protect survival of this listed sturgeon species.

3.1.3 Chlorophyll a Criteria

EPA's 2003 Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries (USEPA 2003a) describes the applicable narrative criteria for chlorophyll a:

"Concentrations of chlorophyll *a* in free-floating microscopic aquatic plants (algae) shall not exceed levels that result in ecologically undesirable consequences—such as reduced water clarity, low dissolved oxygen, food supply imbalances, proliferation of species deemed potentially harmful to aquatic life or humans or aesthetically objectionable conditions—or otherwise render tidal waters unsuitable for designated uses."

In 2007 EPA published numeric chlorophyll *a* criteria guidance protective of open-water designated use impairment by harmful algal blooms and provided recommended reference chlorophyll *a* concentrations for historic chlorophyll *a* levels, and DO and water clarity impairments (USEPA 2007b).

Delaware, the District of Columbia, Maryland, and Virginia all adopted EPA's narrative chlorophyll *a* criteria. Additionally, the District of Columbia and Virginia adopted numeric chlorophyll *a* criteria for certain tidal waters as detailed in Sections 3.2.2 and 3.2.7, respectively.

3.1.4 Water Clarity/Underwater Bay Grasses Criteria

Underwater bay grass beds create rich animal habitats that support the growth of diverse fish and invertebrate populations. Underwater bay grasses, also referred to as submerged aquatic vegetation (SAV), help improve tidal water quality by retaining nitrogen and phosphorus as plant material, stabilizing bottom sediment (preventing their resuspension) and reducing shoreline erosion. The health and survival of such underwater plant communities in the Chesapeake Bay and its tidal tributaries and embayments depend on suitable environmental conditions (Dennison et al. 1993; Kemp et al. 2004).

The loss of SAV from the shallow waters of the Chesapeake Bay, which was first noted in the early 1960s, is a widespread, well-documented problem (Orth and Moore 1983; Orth et al. 2010b). The primary causes of the decline of SAV are nutrient over-enrichment, increased suspended sediment in the water, and associated reductions in light availability (Kemp et al. 2004). To restore the critical habitats and food sources, enough light must penetrate the shallow waters to support the survival, growth, and repropagation of diverse, healthy, SAV communities (Dennison et al. 1993).

EPA, working closely with its seven watershed partners and the larger Bay scientific community, derived and published Chesapeake Bay water clarity criteria to establish the minimum level of light penetration required to support the survival, growth, and continued propagation of SAV (USEPA 2003a). Chesapeake Bay-specific water clarity criteria were derived for low and higher salinity habitats using a worldwide literature synthesis, an evaluation of Chesapeake Bay-specific field study findings, and application model simulations and diagnostic tools (Table 3-5).

The water clarity criteria, applied only during the SAV growing seasons, are presented in terms of the percent ambient light at the water surface extending through the water column and the equivalent Secchi depth by application depth (Table 3-5). The recommended percent light-through-water criteria can be directly measured using a Secchi disk or a light meter. A specific application depth is required to apply and determine attainment of the water clarity criteria (Table 3-6).

SAV restoration acreage goals and water clarity application depths were developed based on historic and recent data on the distribution of SAV (USEPA 2003d). Detailed analyses using that data—including historical aerial photographs—were undertaken to map the distribution and depth of historical SAV beds in the Chesapeake Bay and its tidal tributaries and embayments. The analyses led to the adoption of the single best year method that considers historical SAV distributions from the 1930s through the early 1970s and more recent distributions since 1978 to the present mapped through annual SAV aerial surveys of the Bay's shallow-water habitats. Using that method, the EPA and its watershed partners established a Bay-wide SAV restoration goal of 185,000 acres and Bay segment-specific acreage goals (Table 3-6) (USEPA 2003d).

Table 3-5. Summary of Chesapeake Bay water clarity criteria for application to shallow-water Bay grass designated use habitats

Salinity regime[b]	Water clarity criteria (percent light-through-water)	Water clarity criteria as Secchi depth[a]								Temporal application
		Water clarity criteria application depths (meters)								
		0.25	0.5	0.75	1.0	1.25	1.5	1.75	2.0	
		Secchi depth for above criteria application depth (meters)								
Tidal-fresh	13%	0.2	0.4	0.5	0.7	0.9	1.1	1.2	1.4	April 1–Oct 31
Oligohaline	13%	0.2	0.4	0.5	0.7	0.9	1.1	1.2	1.4	April 1–Oct 31
Mesohaline	22%	0.2	0.5	0.7	1.0	1.2	1.4	1.7	1.9	April 1–Oct 31
Polyhaline	22%	0.2	0.5	0.7	1.0	1.2	1.4	1.7	1.9	March 1–May 31 Sept 1–Nov 30

Source: USEPA 2003a

a. Based on application of the Equation IV-1 published in USEPA 2003a, PLW = 100exp(-K_dZ), where the appropriate percent light through water (PLW) criterion value and the selected application depth (see Table 3-6) are inserted and the equation is solved for K_d. The generated K_d value is then converted to Secchi depth (in meters) using the conversion factor K_d = 1.45/Secchi depth.

b. Tidal fresh = 0-0.5 ppt salinity; oligohaline = >0.5-5 ppt salinity; mesohaline = >5-18 ppt salinity; polyhaline = >18 ppt salinity

Table 3-6. Chesapeake Bay SAV restoration acreage goals and application depths

Segment description	State	Segment designator	SAV acreage restoration goal (acres)	Application depth (meters)
Northern Chesapeake Bay	MD	CB1TF2	12,149	2.0
Northern Chesapeake Bay	MD	CB1TF1	754	1.0
Upper Chesapeake Bay	MD	CB2OH	705	0.5
Upper Central Chesapeake Bay	MD	CB3MH	1,370	0.5
Middle Central Chesapeake Bay	MD	CB4MH	2,533	2.0
Lower Central Chesapeake Bay	MD	CB5MH_MD	8,270	2.0
Lower Central Chesapeake Bay	VA	CB5MH_VA	7,633	2.0
Western Lower Chesapeake Bay	VA	CB6PH	1,267	1.0

Segment description	State	Segment designator	SAV acreage restoration goal (acres)	Application depth (meters)
Eastern Lower Chesapeake Bay	VA	CB7PH	15,107	2.0
Mouth of Chesapeake Bay	VA	CB8PH	11	0.5
Bush River	MD	BSHOH	350	0.5
Gunpowder River-Upper	MD	GUNOH2	572	2.0
Gunpowder River-Lower	MD	GUNOH1	1,860	0.5
Middle River	MD	MIDOH	879	2.0
Back River	MD	BACOH	30	0.5
Patapsco River	MD	PATMH	389	1.0
Magothy	MD	MAGMH	579	1.0
Severn River	MD	SEVMH	455	1.0
South River	MD	SOUMH	479	1.0
Rhode River	MD	RHDMH	60	0.5
West River	MD	WSTMH	238	0.5
Upper Patuxent River	MD	PAXTF	205	0.5
Middle Patuxent River	MD	PAXOH	115	0.5
Lower Patuxent River	MD	PAXMH1	1,459	2.0
Lower Patuxent River	MD	PAXMH2	172	0.5
Lower Patuxent River	MD	PAXMH4	1	0.5
Lower Patuxent River	MD	PAXMH5	2	0.5
Upper Potomac River	MD	POTTF_MD	2,142	2.0
Piscataway Creek	MD	PISTF	789	2.0
Mattawoman Creek	MD	MATTF	792	1.0
Middle Potomac River	MD	POTOH1	1,387	2.0
Middle Potomac River	MD	POTOH2	262	1.0
Middle Potomac River	MD	POTOH3	1,153	1.0
Lower Potomac River	MD	POTMH_MD	7,088	1.0
Upper Potomac River	VA	POTTF_VA	2,093	2.0
Middle Potomac River	VA	POTOH_VA	1,503	2.0
Lower Potomac River	VA	POTMH_VA	4,250	1.0
Upper Rappahannock River	VA	RPPTF	66	0.5
Middle Rappahannock River	VA	RPPOH	4	0.5
Lower Rappahannock River	VA	RPPMH	1,700	1.0
Corrotoman River	VA	CRRMH	768	1.0
Piankatank River	VA	PIAMH	3,479	2.0
Upper Mattaponi River	VA	MPNTF	85	0.5
Upper Pamunkey River	VA	PMKTF	187	0.5
Middle York River	VA	YRKMH	239	0.5
Lower York River	VA	YRKPH	2,793	1.0
Mobjack Bay	VA	MOBPH	15,901	2.0
Upper James River-Upper	VA	JMSTF2	200	0.5
Upper James River-Lower	VA	JMSTF1	1,000	0.5
Appomattox River	VA	APPTF	379	0.5
Middle James River	VA	JMSOH	15	0.5

Segment description	State	Segment designator	SAV acreage restoration goal (acres)	Application depth (meters)
Chickahominy River	VA	CHKOH	535	0.5
Lower James River	VA	JMSMH	200	0.5
Mouth of the James River	VA	JMSPH	300	1.0
Lynnhaven River	VA	LYNPH	107	0.5
Northeast River	MD	NORTF	89	0.5
Chesapeake & Delaware Canal	MD	C&DOH_MD	7	0.5
Bohemia River	MD	BOHOH	354	0.5
Elk River	MD	ELKOH1	1,844	2.0
Elk River	MD	ELKOH2	190	0.5
Sassafras River	MD	SASOH1	1,073	2.0
Sassafras River	MD	SASOH2	95	0.5
Upper Chester River	MD	CHSTF	1	0.5
Middle Chester River	MD	CHSOH	77	0.5
Lower Chester River	MD	CHSMH	2,928	1.0
Eastern Bay	MD	EASMH	6,209	2.0
Middle Choptank River	MD	CHOOH	72	0.5
Lower Choptank River	MD	CHOMH2	1,621	1.0
Mouth of Choptank River	MD	CHOMH1	8,184	2.0
Little Choptank River	MD	LCHMH	4,076	2.0
Honga River	MD	HNGMH	7,761	2.0
Fishing Bay	MD	FSBMH	197	0.5
Middle Nanticoke River	MD	NANOH	12	0.5
Lower Nanticoke River	MD	NANMH	3	0.5
Wicomico River	MD	WICMH	3	0.5
Manokin River	MD	MANMH1	4,294	2.0
Manokin River	MD	MANMH2	59	0.5
Big Annemessex River	MD	BIGMH1	2,021	2.0
Big Annemessex River	MD	BIGMH2	22	0.5
Lower Pocomoke River	MD	POCMH_MD	877	1.0
Lower Pocomoke River	VA	POCMH_VA	4,066	1.0
Tangier Sound	MD	TANMH1_MD	24,683	2.0
Tangier Sound	MD	TANMH2_MD	74	0.5
Tangier Sound	VA	TAHMH_VA	13,579	2.0

Sources: USEPA 2003d, 2004e; Code of Maryland Title 26 Subtitle 08, Chapter 2, Section 3; Code of Virginia 9 62.1-44.15 3a; VAC 25-260-185; 7 Delaware Code section 6010; 7 Delaware Administrative Code 7401; District of Columbia Municipal Regulations Title 21, Chapter 11.

Notes: This table contains additional split segments beyond the 92 Chesapeake Bay segments listed in Table 3-3 strictly for purposes of applying separate water clarity criteria application depths within the same Bay segment (USEPA 2004e). If a Bay segment was listed in Table 3-3, but it is not listed here, that entire Bay segment has been delineated as a SAV no-grow zone and the shallow-water bay grass does not apply (USEPA 2004e).

3.2 JURISDICTIONS' CURRENT CHESAPEAKE BAY WATER QUALITY STANDARDS REGULATIONS

Delaware, the District of Columbia, Maryland, and Virginia each has adopted WQS consistent with EPA's published Chesapeake Bay water quality criteria, assessment procedures, and tidal water designated uses in its respective WQS regulations (Table 3-7). In some cases, a jurisdiction also adopted jurisdiction-specific designated uses or criteria or both; those cases are briefly described below.

Table 3-7. Links for accessing the current waters quality standards (WQS) regulations for Delaware, the District of Columbia, Maryland, and Virginia

Jurisdiction	WQS regulations URL address
Delaware	7 Delaware Code Section 6010; 7 Delaware Administrative Code 7401 <http://www.epa.gov/waterscience/standards/wqslibrary/de/de_3_wqs.pdf>
District of Columbia	DC Municipal Regulations Title 21, Chapter 11 <http://www.epa.gov/waterscience/standards/wqslibrary/dc/dc_3_register.pdf>
Maryland	Code of Maryland Title 26 Subtitle 08, Chapter 2 <http://www.epa.gov/waterscience/standards/wqslibrary/dsd.state.md/md-ch2-quality-20051130.pdf.us/comar/subtitle_chapters/26_Chapters.htm>
Virginia	Code of Virginia 9 62.1-44.15 3a; VAC 25-260 Virginia WQSs <http://www.deq.virginia.gov/wqs/> OR <http://epa.gov/waterscience/standards/wqslibrary/va/va_3_wqs.pdf>

3.2.1 Delaware

Delaware has adopted all the EPA-published Chesapeake Bay criteria, assessment procedures, designated use documents, and subsequent addenda listed in Table 3-1 by reference into its WQS regulations. The EPA-published Chesapeake Bay criteria, assessment procedures, and designated use documents and subsequent addenda apply to the tidal Nanticoke River and Broad Creek in Delaware, both of which are subject to this Chesapeake Bay TMDL (see Table 2-1). Delaware has also adopted EPA's narrative chlorophyll *a* water quality criteria.

3.2.2 District of Columbia

The District of Columbia has adopted all the EPA-published Chesapeake Bay criteria, assessment procedures, designated use documents, and subsequent addenda listed in Table 3-1 by reference into its WQS regulations. Table 3-8 summarizes the District of Columbia's designated uses for its surface waters. The District of Columbia has adopted EPA's narrative chlorophyll *a* water quality criteria but also adopted the numeric chlorophyll *a* water quality criteria shown in Table 3-9 with respect to the District of Columbia's tidal Class C waters (those designated for the protection and propagation of fish, shellfish, and wildlife). Those numeric chlorophyll *a* criteria are subject to this Chesapeake Bay TMDL (see Table 2-1).

Table 3-8. District of Columbia designated uses for surface waters

Class of water	Description
A	Primary contact recreation
B	Secondary contact recreation and aesthetic enjoyment
C	Protection and propagation of fish, shellfish, and wildlife
D	Protection of human health related to consumption of fish and shellfish
E	Navigation

Source: District of Columbia Municipal Regulations Title 21, Chapter 11

Table 3-9. Numeric criteria for the District of Columbia's tidally influenced waters

Constituent	Numeric criteria	Temporal application	Designated use
Dissolved oxygen	7-day mean ≥ 6.0 mg/L Instantaneous minimum ≥ 5.0 mg/L	February 1–May 31	C
	30-day mean ≥ 5.5 mg/L	June 1–January 31	
	7-day mean ≥ 4.0 mg/L Instantaneous minimum ≥ 3.2 mg/L (At temperatures > 29 °C, in tidally influenced waters, an instantaneous minimum DO concentration of 4.3 mg/L will apply)		
Secchi depth	0.8 m (seasonal segment average)	April 1–October 31	C
Chlorophyll *a*	25 µg/L (season segment average)	July 1–September 30	C

Source: District of Columbia Municipal Regulations Title 21, Chapter 11
Note: µg/L = micrograms per liter

3.2.3 Maryland

Maryland has adopted into its WQS regulations all the EPA-published Chesapeake Bay criteria, assessment procedures, and designated uses documents, and subsequent addenda listed in Table 3-1. These WQS apply to all Chesapeake Bay, tidal tributary and embayment waters of Maryland, all of which are subject to this Chesapeake Bay TMDL (see Table 2-1). Maryland has also adopted EPA's narrative chlorophyll *a* water quality criteria.

Several tidal Bay segment-specific applications of DO criteria are unique to Maryland. In the middle-central Chesapeake Bay segment (CB4MH), restoration variances[1] of 7 and 2 percent apply to the application of the deep-water and deep-channel designated use DO criteria, respectively. In the Patapsco River segment (PATMH), a restoration variance of 7 percent applies to the application of the deep-water designated use DO criteria. In the lower Chester River segment (CSHMH), a restoration variance of 14 percent applies to the application of the deep-channel designated use DO criterion (COMAR 26.08.02.03-3(c)(8)(e)(vi). These restoration variances are consistent with EPA-published guidance (USEPA 2003d) and were

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[1] A restoration variance is the percentage of allowable exceedance of a WQS based on water quality modeling incorporating the best available data and assumptions. The restoration variances are temporary and will be reviewed at a minimum every 3 years, as required by the CWA and EPA regulations. The variances could be modified on the basis of new data or assumptions incorporated into the water quality model. COMAR 26.08.02.03-3(C)(8)(h).

approved by EPA on August 29, 2005 in the case of the two mainstem Bay and Patapsco River segments and December 27, 2010 in the case of the lower Chester River segment.

In the tidal upper and middle Pocomoke River segments (POCTF, POCOH_MD), because of the seasonal lower DO concentration from the natural oxygen-depleting processes present in the extensive surrounding tidal wetlands, Maryland adopted a site-specific criterion of greater than or equal to 4 mg/L 30-day mean DO, consistent with the EPA-published criterion (USEPA 2004a), and approved by EPA on December 27, 2010.

3.2.4 Virginia

Virginia has adopted into its WQS regulations all the EPA-published Bay criteria, assessment procedures, designated uses documents, and subsequent addenda listed in Table 3-1. These WQS apply to all Chesapeake Bay, tidal tributary and embayment waters of Virginia, all of which are subject to this Chesapeake Bay TMDL. The narrative chlorophyll *a* criteria guidance published by EPA (USEPA 2003a) was adopted by Virginia for application to Virginia's Bay tidal waters. Virginia also adopted the segment-specific numeric chlorophyll *a* criteria for the tidal James River listed in Table 3-10 into its WQS regulations. The criteria are based on various scientific lines of evidence published in the original EPA 2003 Bay criteria document (USEPA 2003a) with additional river-specific considerations (VADEQ 2004). EPA approved Virginia's WQS regulations on June 27, 2005 and approved additional amendments on December 28, 2010.

Table 3-10. Segment-specific chlorophyll *a* criteria for Virginia's tidal James River waters

Designated use	Chlorophyll *a* criterion (µg/L)	Chesapeake Bay segment	Temporal application
Open-Water	10	Upper James River-Upper (JMSTF2)	March 1–May 31
	15	Upper James River-Lower (JMSTF1)	
	15	Middle James River (JMSOH)	
	12	Lower James River (JMSMH)	
	12	Mouth of the James River (JMSPH)	
	15	Upper James River-Upper (JMSTF2)	July 1–September 30
	23	Upper James River-Lower (JMSTF1)	
	22	Middle James River (JMSOH)	
	10	Lower James River (JMSMH)	
	10	Mouth of the James River (JMSPH)	

Source: Code of Virginia 9 section 62.1-44.15 3a; VAC 25-260
Note: µg/L = micrograms per liter

Virginia has additional site-specific DO and chlorophyll *a* criteria. In the tidal Mattaponi (MPNTF, MPNOH) and Pamunkey (PMKTF, PMKOH) river segments, because of the seasonal lower DO concentration from the natural oxygen-depleting processes present in the surrounding extensive tidal wetlands, Virginia adopted a site-specific criterion of greater than or equal to 4 mg/L 30-day mean DO (9 VAC 25-260-185), consistent with the EPA-published criterion (USEPA 2004a) and approved by EPA on June 27, 2005.

3.3 ASSESSING ATTAINMENT OF CHESAPEAKE BAY WATER QUALITY STANDARDS

The Bay criteria assessment approach is designed to protect the living resources as defined by the designated uses (USEPA 2003a). The criteria levels themselves were largely based on scientific studies performed in laboratory settings or under controlled field conditions. The criteria establish the level of a given habitat condition that living resources need for survival. They do not account for many other environmental factors that could affect survival.

For all four tidal jurisdictions, attainment of each jurisdiction’s Chesapeake Bay WQS is determined by applying the same set of assessment procedures published in the original 2003 Chesapeake Bay criteria document (USEPA 2003a) and subsequent published addenda (USEPA 2004a, 2007a, 2007b, 2008a, 2010a) (see Table 3-1). Those consistent sets of criteria assessment procedures were formally adopted into each jurisdiction’s WQS regulations by reference.

3.3.1 Defining Total Exceedances

Criteria attainment for DO, water clarity, and chlorophyll *a* is assessed in terms of the spatial and temporal extent of criterion exceedances—what volume or surface area of the Bay segment exceeds a given criterion and for how much time during the assessment period (USEPA 2003a, 2004a). The allowable frequency with which criteria can be violated without a loss of the designated use is also considered. For each listing cycle, assessments are based on monitoring data collected over a 3-year period in each spatial assessment unit. Spatial assessment units are defined by Chesapeake Bay segments and applicable designated uses. Such assessment of the criteria as further described below is designed to provide reliable protection for the associated refined aquatic life use.

The spatial exceedances of criteria are determined using a grid cell-based data interpolation software application that enables estimation of water quality values for the entire Bay using monitored data at specific points (USEPA 2003a, 2007a). The interpolated data are compared to water quality criteria on a cell by cell basis, and the percent of surface area or volume exceeding the criterion in each spatial assessment unit is calculated. The percent spatial exceedances for each assessment unit are then compiled for each monitoring event conducted during the 3-year monitoring period.

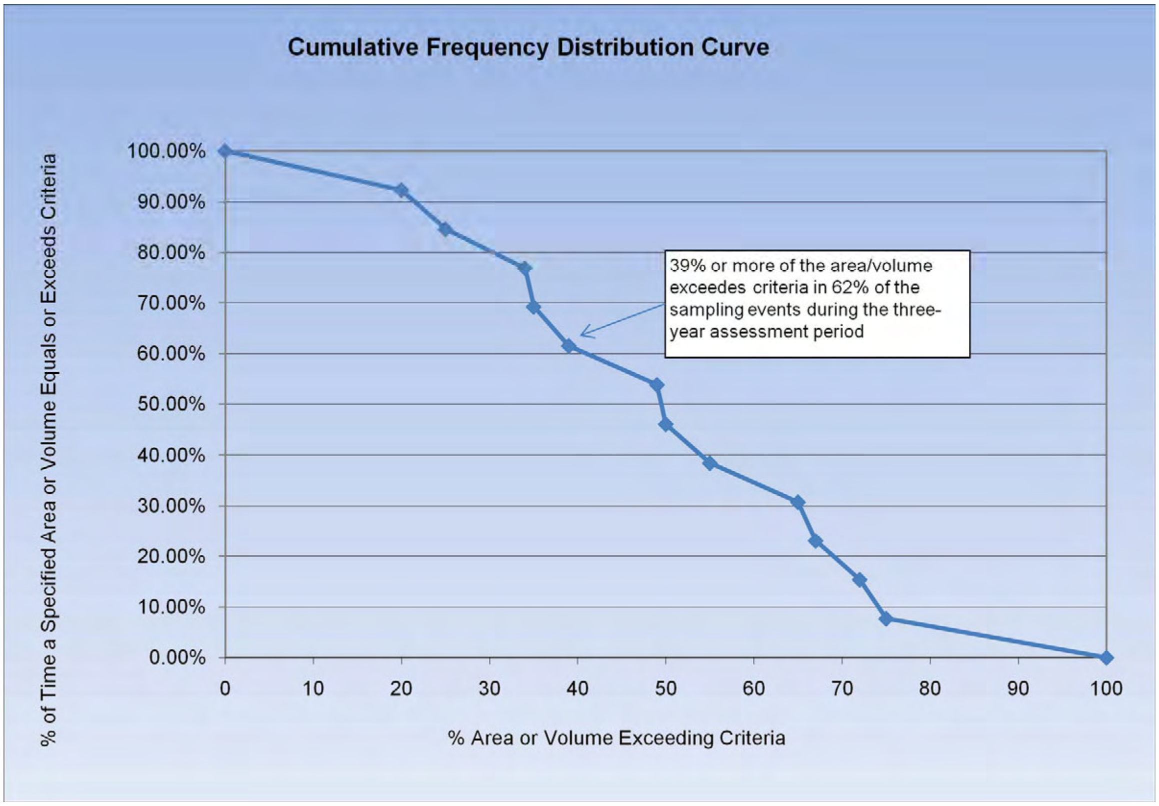
The temporal extent of exceedances is determined by calculating the probability that an observed percent exceedance will be equaled or exceeded. To calculate that probability, the percent of spatial exceedances are sorted and ranked, and a cumulative probability is calculated for each spatial exceedance value (USEPA 2003a). An example is shown in Table 3-11.

The spatial and temporal exceedances can be graphically illustrated by plotting the cumulative frequency distribution (CFD) curve, which is a plot of the temporal exceedance values on the Y-axis versus the spatial exceedance values (in area or volume) on the X-axis (Figure 3-3) (USEPA 2003a, 2007a; STAC 2006).

Table 3-11. Estimated percent spatial criteria exceedances and associated cumulative probabilities

Period of data	Percent area/volume exceeding criteria (spatial)	Rank	Cumulative probability [rank / (n + 1)] (temporal)
	100		0.00%
June 1998	75	1	7.69%
March 1998	72	2	15.38%
May 1999	67	3	23.08%
May 1998	65	4	30.77%
April 1998	55	5	38.46%
June 2000	50	6	46.15%
March 1999	49	7	53.85%
April 2000	39	8	61.54%
May 2000	35	9	69.23%
Apr 1999	34	10	76.92%
June 1999	25	11	84.62%
March 2000	20	12	92.31%

Source: USEPA 2003a



Source: USEPA 2003a

Figure 3-3. Example cumulative frequency distribution (CFD) curve.

3.3.2 Defining Allowable Exceedances

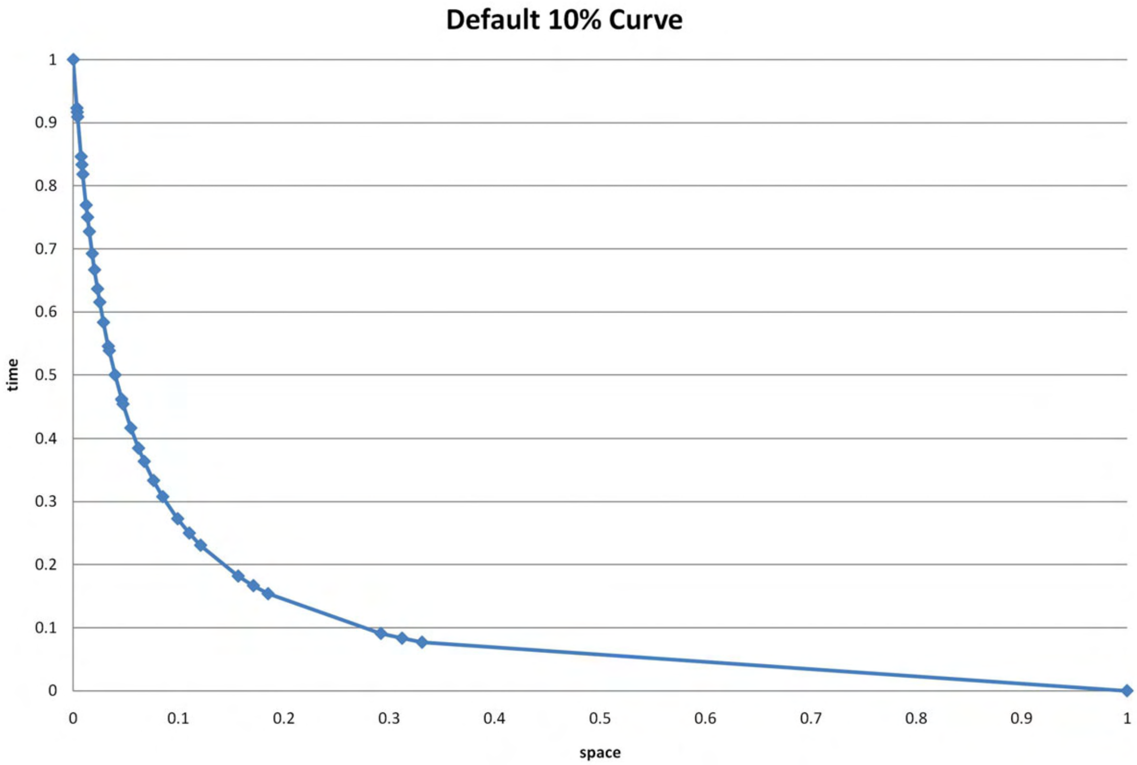
EPA developed reference curves for each water quality criterion (DO, water clarity, and chlorophyll *a*) to provide a scientifically based, direct measure of the time and space during which a particular criterion can be allowably exceeded – i.e., without resulting in harm to the designated uses(s) (USEPA 2003a). Those allowable exceedances are defined to be those that last a short enough time or cover a small enough volume/surface area to have no adverse effects on the designated use. It is assumed that the designated uses can be attained even with some limited level of criteria exceedances and, thus, the reference curves define those criteria exceedances deemed to be allowable—chronic in time but over small volumes/surface areas, or infrequent occurrences over large volumes/surface areas. Exceedances that occur over large areas of space and time would be expected to have significant detrimental effects on biological communities, which would imply nonattainment of designated uses.

For assessment purposes, EPA developed two types of reference curves: a biological reference curve and a 10 percent default reference curve for use when a biological reference curve is unavailable.

Biological reference curves are CFDs developed for a given criterion in areas for which monitoring data are available and in which healthy aquatic communities exist (USEPA 2003a). They represent the range of conditions that can reasonably be expected in a healthy community. As a result, the biological reference curve can be used to provide an understanding of what level of criteria exceedances are allowable without losing support of the designated use. Given the Bay’s nutrient-enriched status, however, appropriate reference sites are limited. Biological reference curves have been published for and are used to assess allowable exceedances for the deep-water DO criteria (USEPA 2010a) and the water clarity criteria (USEPA 2003a).

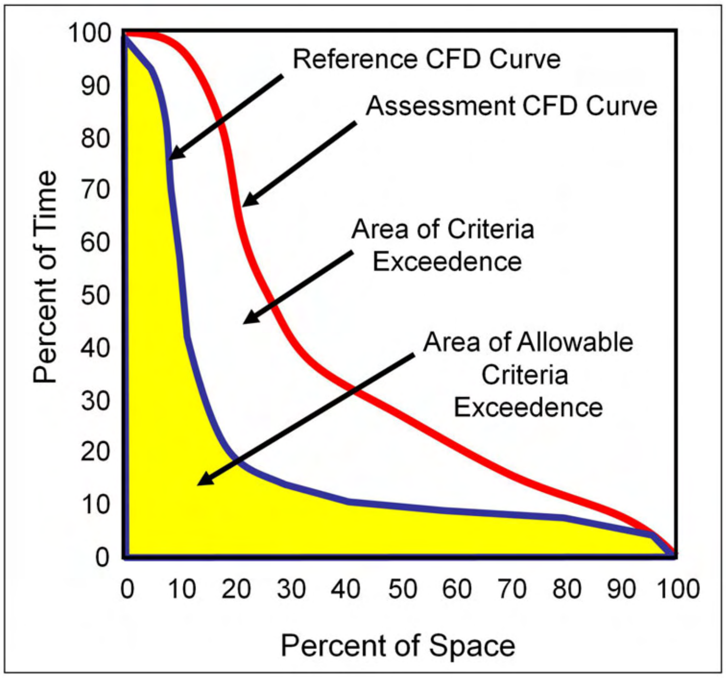
In some cases, developing a biologically based reference curve is not possible because of a lack of data describing the health of the relevant species or biological communities and lack of appropriate reference sites. In those cases, EPA used a 10 percent default reference curve (USEPA 2007a). The 10 percent default reference curve is defined as a hyperbolic curve that encompasses no more than 10 percent of the area of the CFD graph (percent of space multiplied by percent of time) (USEPA 2007a, page 13, Figure II-4 and Equation 1) (Figure 3-4).

Once the CFD curve for a spatial assessment unit is developed from monitoring data (also referred to as the assessment curve), it is compared to the appropriate reference curve. The area on the graph above the reference curve (blue line) and below the assessment curve (red line) is considered a non-allowable exceedance. The area below the reference curve (yellow) is considered an allowable exceedance (Figure 3-5).



Source: USEPA 2007a

Figure 3-4. Default reference curve used in the attainment assessment of Chesapeake Bay water quality criteria for which biologically based reference curves have not yet been derived.



Source: USEPA 2003a

Figure 3-5. Example reference and assessment curves showing allowable and non-allowable exceedances.

3.3.3 Assessing Criteria Attainment

Dissolved Oxygen Criteria Assessment

EPA published DO criteria protective of migratory fish spawning and nursery, open-water fish and shellfish, deep-water seasonal fish and shellfish, and deep-channel seasonal refuge designated use habitats. DO criteria were established for the Chesapeake Bay that varied in space and time to provide levels of protection for different key species and communities (Table 3-4). The criteria also were designed around several lengths of time to reflect the varying oxygen tolerances for different life stages (e.g., larval, juvenile, adult) and effects (e.g., mortality, growth, behavior) (USEPA 2003a).

The DO criteria include multiple components, including the target DO concentration, the duration of time over which the concentration is averaged, the designated use area where the criterion applies, the protection provided, and the time of year when the criterion applies (USEPA 2003a, 2003d). The four tidal Bay jurisdictions adopted these DO criteria into their respective WQS regulations.

Assessing DO criteria attainment is challenging because of the complexity of both the criteria and the Bay itself. To fully assess all the criteria components, data needed to be collected at a spatial intensity that adequately represents the four designated use habitats of Chesapeake Bay tidal waters at different times of the year (USEPA 2003c, 2004e). Similarly, data were collected during all the applicable seasons and at frequencies sufficient to address the various criteria duration components.

The different DO criteria apply to different designated use areas and multiple criteria apply to the same designated use area. The DO criteria components also apply over different periods to protect species during critical life stages or during particularly stressful times of the year. To fully assess each DO component in each designated use habitat over the appropriate periods will require an extensive monitoring program and a detailed assessment methodology. The CBP conducts extensive water quality and living resource monitoring throughout the Bay tidal waters (CBP 1989a, 1989b; MRAT 2009). The existing Bay water quality monitoring was not sufficient to cover all the criteria components, however, and some details in the assessment methodology remain unresolved (USEPA 2007a; MRAT 2009).

The DO criteria include 30-day, 7-day, and 1-day means along with an instantaneous minimum. The CBP partners have the capacity (data, published assessment methodology) to assess only the 30-day mean open-water and deep-water DO criteria and, in the case of the deep-channel use, the instantaneous minimum DO criteria (USEPA 2003a, 2004a, 2007a, 2008a, 2010a). The remaining DO criteria were not assessed because the existing water quality monitoring programs and the published assessment methodologies are not yet adequate for full assessment.

Evaluation of the Chesapeake Bay Water Quality and Sediment Transport Model’s outputs have provided clear evidence that the 30-day mean open-water and deep-water and the instantaneous minimum deep-channel DO criteria are the criteria driving determination of nutrient loadings supporting attainment all the open-water (30-day mean, 7-day mean, instantaneous minimum), deep-water (30-day mean, 1-day and instantaneous minimum), and deep-channel (instantaneous minimum) DO criteria.

For both open-water and deep–water designated uses, the 30-day mean criteria had the highest nonattainment in all three scenarios illustrated in Figure 3-6. The 30-day mean open-water and deep-water criteria are, therefore, protective of the other non-assessed DO criteria (open-water 7-day and instantaneous minimum, deep-water 1-day mean and instantaneous minimum) on average for the mainstem Bay segments. The deep–channel designated use has only one DO criterion, and it is currently assessed using monitoring data. The deep-channel criterion is also more protective, based on the levels of nonattainment recorded in Figure 3-6, than the deep-water and open-water criteria. The analyses documented in Appendix D provide clear evidence the 30-day mean open-water, 30-day mean deep-water DO criteria, and the deep-channel instantaneous minimum criterion are the most protective criteria across all Bay segments and designated uses.

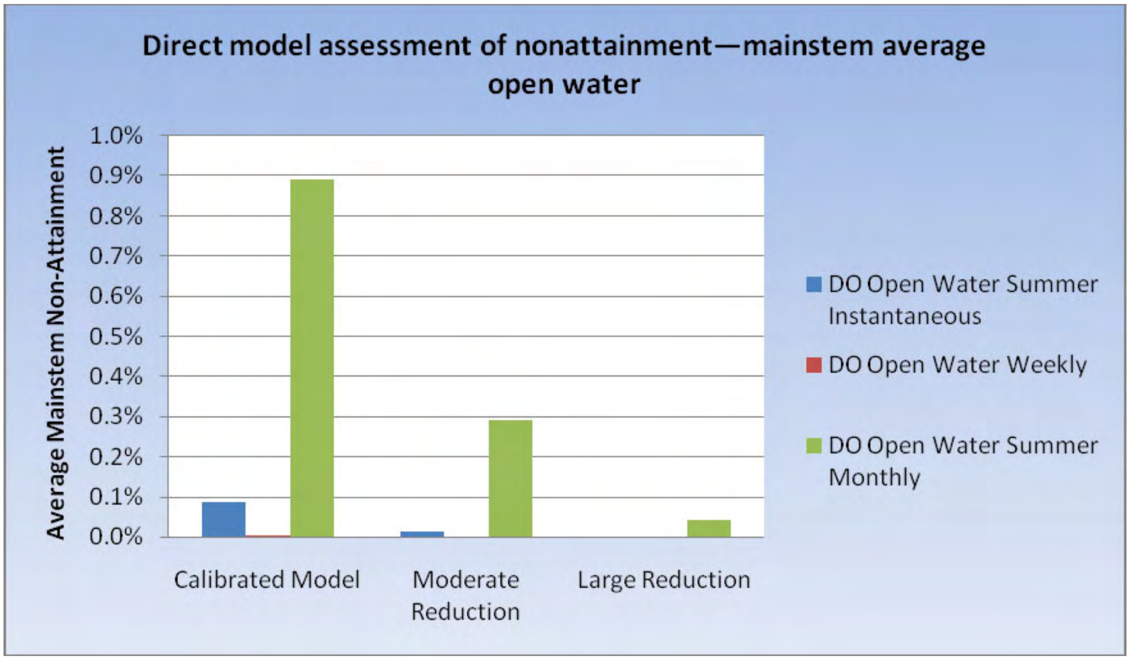
Chlorophyll *a* Criteria Assessment

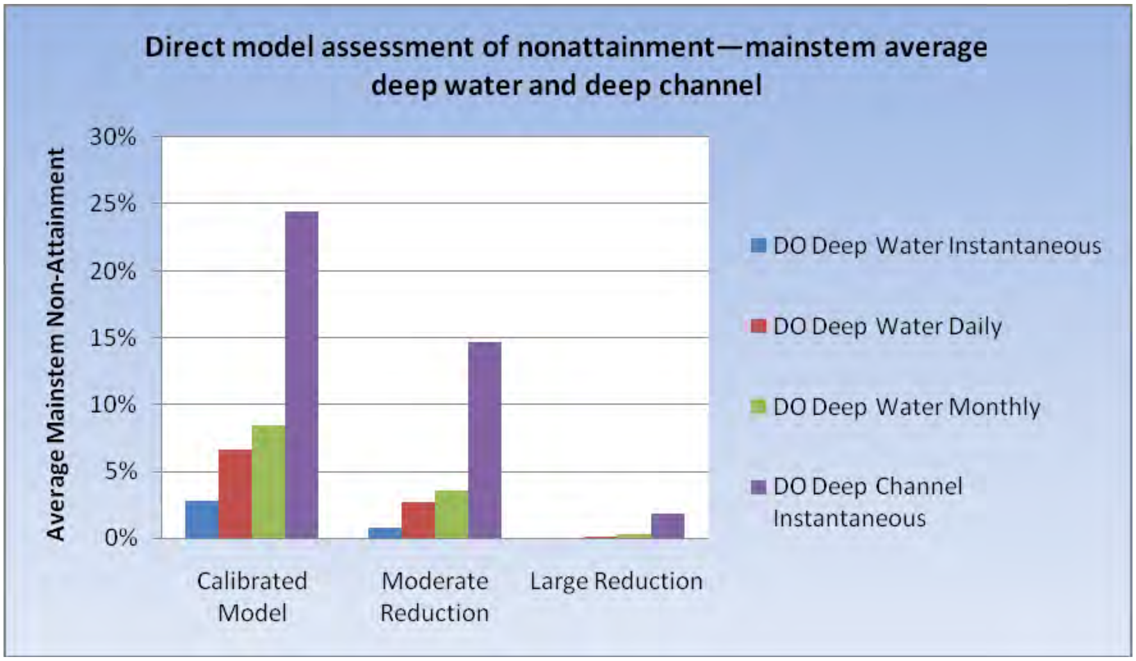
The procedures described in USEPA 2007b, and further refined in USEPA 2010a, apply to assessing Virginia's tidal James River and the District of Columbia's tidal waters numeric chlorophyll *a* criteria.

To assess attainment of the Virginia and the District of Columbia's adopted numerical chlorophyll *a* concentration-based criteria, it was necessary to establish a reference curve for use in the CFD criteria assessment (USEPA 2003a, 2007a). In the case of the numerical chlorophyll *a* criteria where a biologically based reference curve is not available (USEPA 2007b), EPA recommends—and Virginia and the District of Columbia adopted—using the 10 percent default reference curve originally described in USEPA 2007a and illustrated in Figure 3-4.

The jurisdiction-adopted, concentration-based chlorophyll *a* criteria values are threshold concentrations that should be exceeded infrequently (< 10 percent) because a low number of naturally occurring exceedances occur even in a healthy phytoplankton population (USEPA 2007b). The assessment of chlorophyll *a* criteria attainment, therefore, uses the CFD-based assessment method described earlier that applies the 10 percent default reference curve. Such concentration-based Chesapeake Bay chlorophyll *a* criteria apply only to those seasons and salinity-based habitats for which they were defined to protect against applicable human health and aquatic life impairments (USEPA 2007b). Each season—Spring (March 1–May 31) and Summer (July 1–September 30)—was assessed separately to evaluate chlorophyll *a* criteria attainment.

The chlorophyll *a* criteria are based on seasonal means of observed chlorophyll data. The observed data are first transformed by taking the natural logarithm and then interpolated spatially to equally spaced points (representing interpolator cells) within the designated use area for each monitoring cruise. The interpolated value of each cell is averaged in time across the entire season, and then the spatial violation rate is calculated as the fraction of interpolator cells in a designated use area that fails the appropriate criterion (USEPA 2010a).





Source: Appendix D

Figure 3-6. Direct model assessment of open water (a), and deep water and deep channel (b) criteria.

SAV/Water Clarity Criteria Assessment

Water clarity criteria and SAV restoration acreages are used to define attainment of the shallow-water Bay grass designated use in the Chesapeake Bay, its tidal tributaries and embayments (USEPA 2003a, 2003d). EPA published three measures for assessing attainment of the shallow-water SAV designated use for a Chesapeake Bay segment (USEPA 2007a):

1. Measure SAV acreage in the Bay segment from overflight data mapping analysis and compare with the SAV restoration goal acreage for that Bay segment (USEPA 2003d).
2. Measure water clarity acreage on the basis of routine water quality mapping using data from the Chesapeake Bay shallow-water monitoring program and, combined with measured acres of SAV, compare with the calculated water clarity acres for that segment (USEPA 2007a).
3. Measure water clarity criteria attainment on the basis of the CFD assessment methodology, again, using shallow-water monitoring program data (USEPA 2003a, 2003d, 2007a, 2008a).

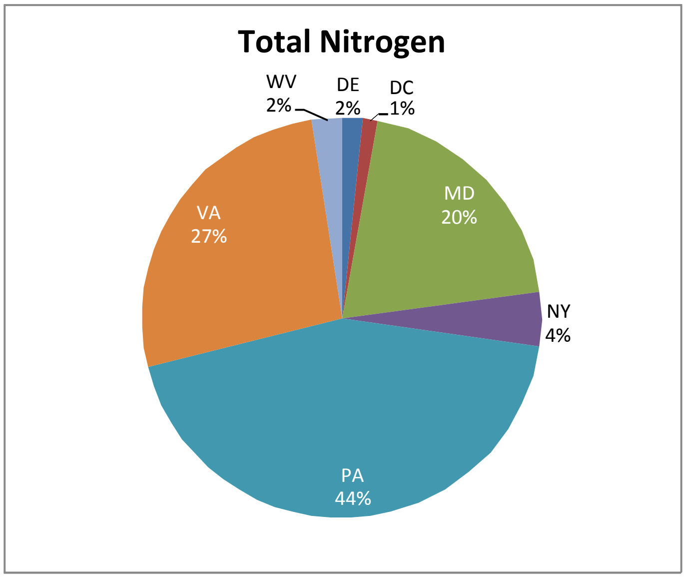
Without sufficient shallow-water monitoring data to determine the available water clarity acres (measurement 2 above) or to assess water clarity criteria attainment using the CFD-based procedure (measurement 3 above), EPA recommends that the jurisdictions assess shallow-water Bay grass designated use attainment using the acres of mapped SAV (measurement 1 above) (USEPA 2003a, 2003d, 2007a, 2008a).

SECTION 4. SOURCES OF NITROGEN, PHOSPHORUS AND SEDIMENT TO THE CHESAPEAKE BAY

Nitrogen, phosphorus, and sediment loads originate from many sources in the Bay watershed. Point sources of nitrogen, phosphorus, and sediment include municipal wastewater facilities, industrial discharge facilities, CSOs, SSOs, NPDES permitted stormwater (MS4s and construction and industrial sites), and CAFOs. Nonpoint sources include agricultural lands (AFOs, cropland, hay land, and pasture), atmospheric deposition, forest lands, on-site treatment systems, nonregulated stormwater runoff, streambanks and tidal shorelines, tidal resuspension, the ocean, wildlife, and natural background. Unless otherwise specified, the loading estimates presented in this section are based on results of the Phase 5.3 Chesapeake Bay Watershed Model (Bay Watershed Model). For a description of the Bay Watershed Model, see Section 5.8. Estimates of existing loading conditions are based on the 2009 scenario run through the Bay Watershed Model.

4.1 JURISDICTION LOADING CONTRIBUTIONS

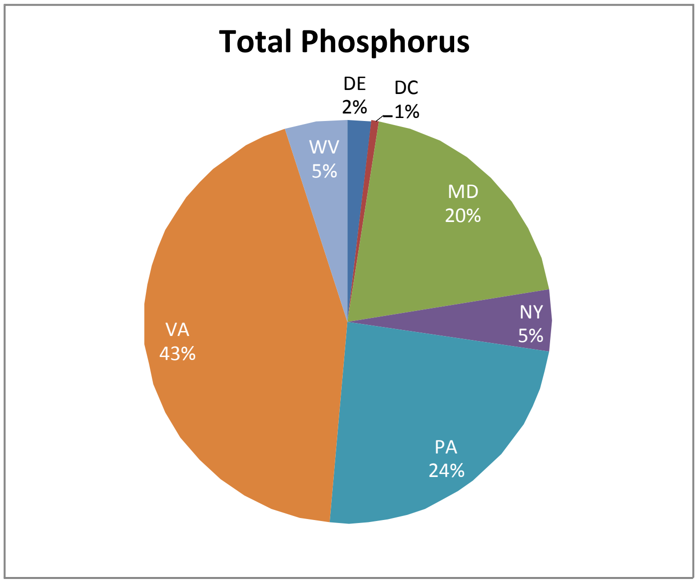
Analysis of 2009 monitoring data and estimated modeling results shows that Pennsylvania provided the largest proportion of nitrogen loads delivered to the Bay (44 percent), followed by Virginia (27 percent), Maryland (20 percent), New York (4 percent), Delaware (2 percent) and West Virginia (2 percent), and the District of Columbia (1 percent) (Figure 4-1). Delivered loads are the amount of a pollutant delivered to the tidal waters of the Chesapeake Bay or its tributaries from an upstream point. Delivered loads differ from edge-of-stream loads becauese of in-stream processes in free-flowing rivers that naturally remove nitrogen and phosphorus from the system.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-1. Modeled estimated total nitrogen loads delivered to the Chesapeake Bay by jurisdiction in 2009.

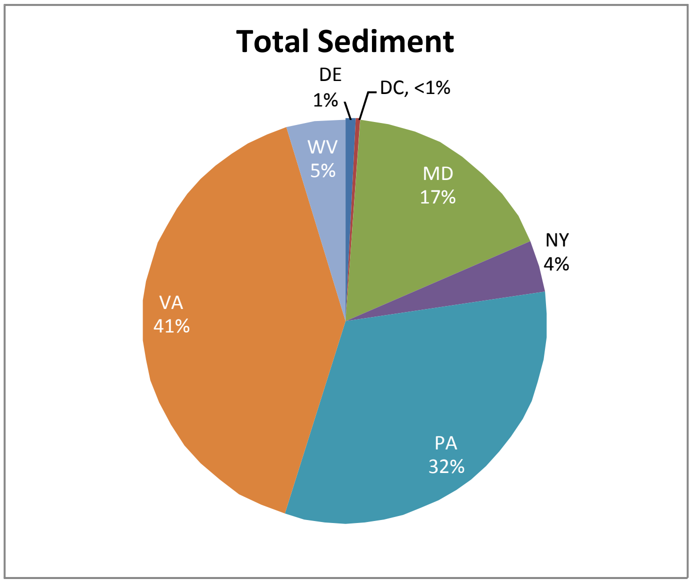
The model estimated phosphorus loads delivered to the Bay were dominated by Virginia (43 percent), followed by Pennsylvania (24 percent), Maryland (20 percent), New York (5 percent), West Virginia (5 percent), Delaware (2 percent), and the District of Columbia (1 percent) (Figure 4-2).



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-2. Model estimated total phosphorus loads delivered to the Chesapeake Bay by jurisdiction in 2009.

Similar to the phosphorus loads, 2009 model estimated sediment loads delivered to the Bay are dominated by Virginia (41 percent), followed by Pennsylvania (32 percent), Maryland (17 percent), West Virginia (5 percent), New York (4 percent), Delaware (1 percent), and the District of Columbia (< 1 percent) (Figure 4-3).

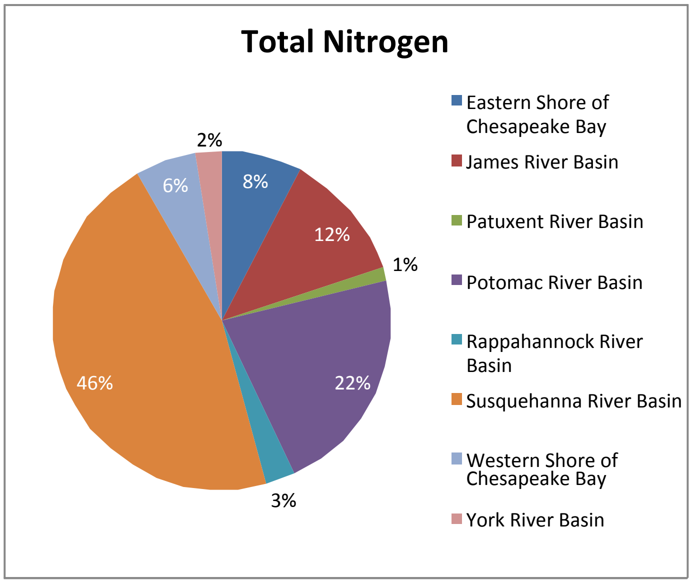


Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-3. Model estimated total sediment loads delivered to the Chesapeake Bay by jurisdiction in 2009.

4.2 MAJOR RIVER BASIN CONTRIBUTIONS

The major river basins' model-estimated contributions of total nitrogen loads delivered to the Bay in 2009 are illustrated in Figure 4-4. The Susquehanna River basin, draining parts of New York, Pennsylvania, and Maryland, is estimated to be responsible for almost half of the nitrogen loads delivered to the Bay (46 percent). The next major contributor, at 22 percent, is the Potomac River Basin, draining the entire District of Columbia and parts of Maryland, Pennsylvania, Virginia, and West Virginia. The James River Basin (draining parts of Virginia and West Virginia) contributes 12 percent of the nitrogen loads to the Bay; the Eastern Shore Basin (draining parts of Delaware, Maryland, and Virginia) contibutes 8 percent of the nitrogen loads to the Bay; and the Western Shore Basin (draining parts of Maryland) is estimated to be responsible for 6 percent of the nitrogen loading to the Bay. Smaller portions, 3 percent, 2 percent, and 1 percent are contributed by the Rappahannock (Virginia), the York (Virginia) and the Patuxent (Maryland) river basins, respectively (Figure 4-4).

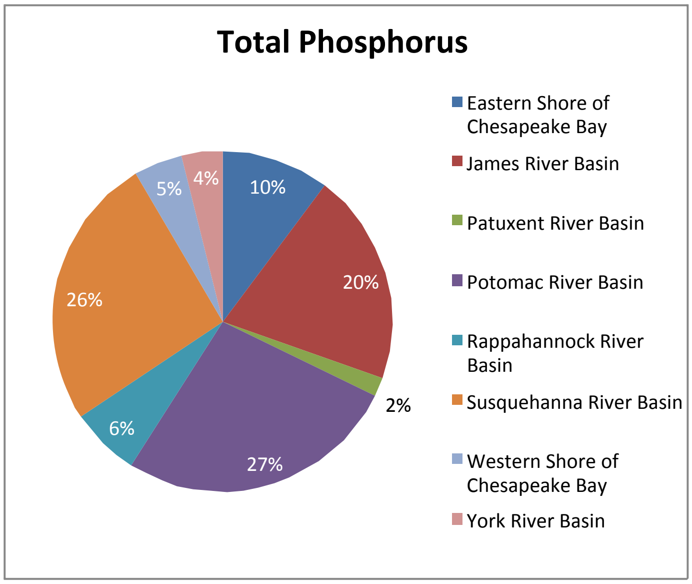


Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-4. Model estimated total nitrogen loads delivered to the Chesapeake Bay by major tributary in 2009.

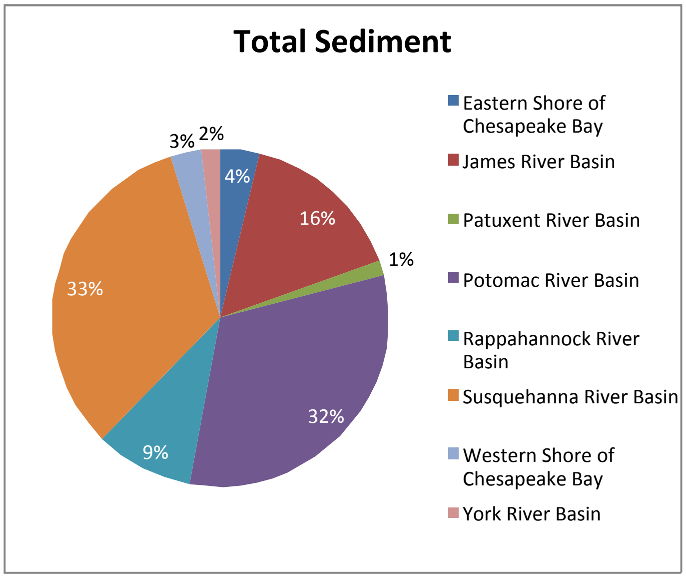
The major river basins' model estimated contributions to total phosphorus loads to the Bay in 2009 are illustrated in Figure 4-5. Three river basins—the Potomac (27 percent), the Susquehanna (26 percent), and the James (20 percent)—are estimated to account for about three-quarters of the total phosphorus loading to the Bay. The Eastern Shore contributes 10 percent of the total phosphorus load, while the balance is provided by the Rappahannock (6 percent), the Western Shore (5 percent), the York (4 percent), and the Patuxent (2 percent) river basins (Figure 4-5).

The major river basins' model estimated contributions to total sediment loads to the Bay in 2009 are illustrated in Figure 4-6. The Susquehanna (33 percent) and Potomac (32 percent) river basins are estimated to contribute the majority of the total sediment loads delivered to the Chesapeake Bay, followed by the James (16 percent) and the Rappahannock (9 percent) river basins. The Eastern Shore (4 percent), Western Shore (3 percent), York (2 percent) and Patuxent (1 percent) river basins each contribute relatively small total sediment loads (Figure 4-6).



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-5. Model estimated total phosphorus loads delivered to the Chesapeake Bay by major tributary in 2009.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-6. Model estimated total sediment loads delivered to the Chesapeake Bay by major tributary in 2009.

4.3 POLLUTANT SOURCE SECTOR CONTRIBUTIONS

Table 4-1 and Table 4-2 provide model estimates of major pollutant sources of nitrogen and phosphorus, respectively, delivered to the Bay by each jurisdiction and by each major pollutant source sector. Nontidal deposition refers to atmospheric deposition direct to nontidal surface waters (e.g., streams, rivers). Table 4-3 provides estimates of major sediment sources by jurisdiction and by major pollutant source sector and represents the portion of sediment that is from land-based sources. Stream erosion is also a significant source of watershed sediment delivered to the Bay. Sufficient data do not exist to accurately quantify the portion of the total sediment load specifically from stream erosion.

Table 4-1. Percentage of total nitrogen delivered to the Bay from each jurisdiction by pollutant source sector

Jurisdiction	Agriculture	Forest	Stormwater runoff	Point source	Septic	Nontidal deposition
Delaware	3%	1%	1%	0%	2%	1%
District of Columbia	0%	0%	1%	5%	0%	0%
Maryland	16%	14%	28%	27%	36%	27%
New York	4%	7%	3%	3%	5%	5%
Pennsylvania	55%	46%	33%	25%	30%	42%
Virginia	20%	27%	33%	39%	24%	25%
West Virginia	3%	4%	2%	1%	2%	1%
Total	100%	100%	100%	100%	100%	100%

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario
Note: Nontidal deposition refers to atmospheric deposition direct to nontidal surface waters.

Table 4-2. Percentage of total phosphorus delivered to the Bay from each jurisdiction by pollutant source sector

Jurisdiction	Agriculture	Forest	Stormwater runoff	Point source	Septic	Nontidal deposition
Delaware	4%	1%	1%	0%	0%	0%
District of Columbia	0%	0%	1%	2%	0%	0%
Maryland	19%	14%	28%	21%	0%	27%
New York	5%	7%	3%	5%	0%	5%
Pennsylvania	24%	25%	16%	28%	0%	27%
Virginia	42%	45%	50%	42%	0%	38%
West Virginia	6%	7%	2%	3%	0%	2%
Total	100%	100%	100%	100%	100%	100%

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario
Note: Nontidal deposition refers to atmospheric deposition direct to nontidal surface waters. Although the percentage contribution of phosphorus from nontidal deposition is provided here, the overall amount of phosphorus contributed from nontidal deposition is considered to be insignificant.

Table 4-3. Percentage of sediment delivered to the Bay from each jurisdiction by pollutant source sector

Jurisdiction	Agriculture	Forest	Stormwater runoff	Point source	Septic	Nontidal deposition
Delaware	1%	0%	1%	0%	--	--
District of Columbia	0%	0%	1%	27%	--	--
Maryland	15%	13%	32%	11%	--	--
New York	3%	8%	4%	3%	--	--
Pennsylvania	35%	34%	21%	23%	--	--
Virginia	41%	40%	39%	35%	--	--
West Virginia	5%	5%	3%	1%	--	--
Total	100%	100%	100%	100%	--	--

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario
Note: Only land-based sources of sediment were included in this table. Septic sources discharge to groundwater and nontidal deposition refers to atmospheric deposition direct to nontidal surface waters.

The following sections provide additional details regarding the major pollutant source sectors, including descriptions of the extent/magnitude of the pollutant source, geographic distribution, and long-term trends relevant to the source sector. The significance of the source sector in terms of loading to the Bay relative to other sources is also discussed.

4.4 REGULATED POINT SOURCES

Point sources are defined as any “discernable, confined, and discrete conveyance, including...any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, or vessel or other floating craft, from which pollutants are or may be discharged” [CWA section 502(14), 40 CFR 122.2]. That definition does not include agricultural stormwater discharges or return flows from irrigated agriculture, which are exempt from the definition of point source under the CWA. The NPDES program, under CWA sections 318, 402, and 405, requires permits for the discharge of pollutants from point sources.

Two issues that directly affect modeling of the regulated point sources in the Bay watershed are the size of facility flows and permitted discharge limits. For purposes of the Chesapeake Bay TMDL analysis and modeling, regulated point sources in the Chesapeake Bay watershed have been evaluated under the following categories[1]:

- Municipal wastewater facilities
- Industrial wastewater facilities
- CSOs
- NPDES permitted stormwater (MS4s, industrial, and construction)
- NPDES permitted CAFOs

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[1] The universe of regulated point sources may change over time due to such actions as designation, compliance evaluation, or new permitting activities.

The remainder of this section outlines the distinctions between significant and nonsignificant municipal and industrial wastewater discharge facilities in the Bay watershed, explains how the facilities were addressed in modeling, discusses the effect of the basinwide nitrogen and phosphorus permitting approach on point source modeling for the TMDL, and provides a summary of model-estimated loads associated with each of the regulated point source categories of nitrogen, phosphorus, and sediment to the Bay. Appendix Q includes the regulated point sources accounted for in the Bay TMDL.

4.4.1 Significant and Nonsignificant Municipal and Industrial Facilities

Municipal and industrial wastewater discharge facilities are categorized as significant or nonsignificant primarily on the basis of permitted or existing flow characteristics and comparable loads in the case of industrial discharge facilities. The Bay jurisdictions define significant facilities as outlined in Table 4-4.

Table 4-4. Jurisdiction-specific definitions of significant municipal and industrial wastewater discharge facilities

Jurisdiction	Municipal wastewater facilities (million gallons per day)	Industrial wastewater facilities (estimated loads, pounds per year)
Delaware	Design flow ≥ 0.4	≥ 3,800 total phosphorus or ≥ 27,000 total nitrogen
District of Columbia	Blue Plains WWTP	
Maryland	Design flow ≥ 0.5	
New York	Design flow ≥ 0.4	
Pennsylvania	Existing flow ≥ 0.4	
Virginia	Design flow ≥ 0.5[a] Design flow ≥ 0.1[b] New facilities ≥ 0.04[c]	
West Virginia	Design flow ≥ 0.4	

Source: USEPA 2010b
Notes: a. Above the fall line/tidal line; b. Below the fall line/tidal line; c. Also includes expansion of flows ≥ 0.04 mgd.

Jurisdictions also may identify specific facilities as significant in their WIPs (USEPA 2009c). Facilities not meeting the above criteria, and not otherwise identified in the jurisdictions' WIPs, are considered nonsignificant facilities. Table 4-5 provides a jurisdictional breakdown of municipal and industrial discharging facilities in the Chesapeake Bay watershed.

For the TMDL, facilities were represented using various flow and discharge concentrations depending on their status as significant or nonsignificant. Significant facilities received individual WLAs, except for New York and the Virginia James River Basin, which received an aggregate WLA. The New York WLA for wastewater is discussed further in Section 8.4.4, and the James River Basin WLA is discussed further in Appendix X. Nonsignificant facilities were generally included in the aggregate WLAs by Bay segment watershed (USEPA 2009c) and are discussed further in Section 8.3.3.

Table 4-5. Significant and nonsignificant municipal and industrial wastewater discharging facilities by jurisdiction as of December 2010

Jurisdiction	Significant facility			Nonsignificant facility			Total Facilities
	Municipal	Industrial	Total	Municipal	Industrial	Total	
DC[a]	1	0	1	1	9	10	11
DE	3	1	4	1	1	2	6
MD	75	12	87	163	477	640	727
NY	26	2	28	26	45	71	99
PA	183	30	213	1246	409	1655	1868
VA	101	24	125	1618	639	2257	2382
WV[b]	13	7	20	125	23	148	168
Total	**402**	**76**	**478**	3180	1603	4783	5261

Source: Facilities identified in the final phase 1 WIPs
Notes:
a. Blue Plains WWTP serves DC and parts of MD and VA, but is only counted once.
b. Multiple facilities (4) share one NPDES permit in West Virginia.

4.4.2 Basinwide NPDES Permitting Approach

In 2004 EPA and the Bay watershed jurisdictions agreed to take a consistent approach to permitting all the significant municipal and industrial wastewater discharging facilities contributing nitrogen and phosphorus to the Chesapeake Bay watershed (USEPA 2004d). As part of that approach and on the basis of the jurisdictions’ revised Chesapeake Bay WQS, permits are to be reissued with nitrogen and phosphorus limits that are sufficient to achieve Bay WQS and that are consistent with the jurisdictions’ tributary strategies. The basinwide permitting approach also contains additional specific provisions for permitting of nitrogen and phosphorus in the Bay watershed, including the following:

- Annual load limits—Unless such expressions would be impracticable, EPA’s regulations require NPDES permits for non-publicly owned treatment works to express effluent limits as maximum daily and average monthly limits [40 CFR 122.45(d)(1)] and require NPDES permits for POTWs to express effluent limits as average weekly and average monthly limits [40 CFR 122.45(d)(2)]. In the case of the Chesapeake Bay permitting for nitrogen and phosphorus, EPA has determined that because of the long hydraulic durations in the Bay, and the fact that the control of annual loading levels of nitrogen and phosphorus from wastewater treatment plants is much more relevant and appropriate in terms of the effect of nitrogen and phosphorus on Bay water quality criteria than daily maximums or weekly or monthly averages, expression of nitrogen and phosphorus effluent limits in short periods is impracticable and that, therefore, such effluent limits may be expressed as an annual load (USEPA 2004c).
- Compliance Schedules—Compliance schedules that are consistent with jurisdiction tributary strategies may be incorporated into permits, where such compliance schedules are needed, appropriate, and allowable under jurisdiction WQS and federal NPDES requirements (USEPA 2004d).
- Watershed permits/trading—Watershed permits, which may accommodate nitrogen and phosphorus trading, may be used if such an approach would ensure protection of applicable

jurisdiction WQS and would be consistent with existing EPA policy regarding trading (USEPA 2004d).

In 2005 the seven Bay jurisdictions began implementing the new permitting approach. As of June 2010, the permits for the significant nitrogen and phosphorus sources have been issued with nitrogen and phosphorus limits consistent with the Tributary Strategy allocations (described in Section 1.2.1) (some of which may include compliance schedules) to 64 percent of the significant wastewater treatment facilities (305 out of the total 478), accounting for 74 percent of the total design flow, 76 percent of the total nitrogen loads and 91 percent of the total phosphorus loads from significant facilities (Table 4-6).

By the end of 2011, EPA expects all 478 significant wastewater treatment facilities in the Bay watershed to have annual nitrogen and phosphorus load limits in place in their permits (some of which may have compliance schedules as well).

Table 4-6. Nitrogen and phosphorus permit tracking summary under the Basinwide NPDES Wastewater Permitting Approach, through December 2010

Jurisdiction	Significant facility NPDES	Permits drafted	Permits issued	Design flow of facilities permits issued	Percent of design flow for permits issued/significant facilities
DC[a]	1	1	1	152.5	100%
DE	4	4	4	3.3	100%
MD	87	72	51	357.7	42%
NY	28	1	1	20.0	22%
PA	213	141	103	434.1	67%
VA	125	125	125	1,253.5	100%
WV[b]	20	16	16	27.737	100%
Total	478	364	305	2,259.7	74%

Source: USEPA Region 3, Region 2, Facilities identified in the final Phase 1 WIPs
Notes:
Some industrial design flows are not available or not comparable and not listed in the database. Some permits may contain compliance schedules.
a. Blue Plains WWTP serves DC and parts of MD and VA, but is only counted once.
b. Multiple facilities (4) share one NPDES permit in West Virginia.

4.5 REGULATED POINT SOURCE LOAD SUMMARIES

This section presents load estimates for each major point source sector.

4.5.1 Municipal Wastewater Discharging Facilities

A municipal wastewater facility is defined as a facility discharging treated wastewater from municipal or quasi-municipal sewer systems. EPA identified 3,582 NPDES permitted facilities as discharging municipal wastewater into the Chesapeake Bay watershed. Table 4-7 provides a summary of municipal wastewater facilities by jurisdiction; a complete list is available in Appendix Q.

Table 4-8 and Table 4-9 summarize modeled 2009 municipal wastewater loading estimates by jurisdiction and major river basin, respectively, for total nitrogen and phosphorus loads delivered to the Chesapeake Bay. Modeled sediment loads for those facilities are not presented because wastewater discharging facilities represent a *de minimis* source of sediment (i.e., less than 0.5 percent of the 2009 total sediment load). In 2009 municipal wastewater treatment facilities contributed an estimated 17 percent of the total nitrogen and 16 percent of the total phosphorus loads delivered to Chesapeake Bay.

Table 4-7. Municipal wastewater facilities by jurisdiction

Jurisdiction	Significant	Nonsignificant
DC	1	1
DE	3	1
MD	75	163
NY	26	26
PA	183	1246
VA	101	1618
WV	13	125
Total	402	3180

Source: EPA Region 3, EPA Region 2

Note: Blue Plains wastewater treatment plant serves DC and portions of Maryland and Virginia but is counted once in this table as a DC plant.

Table 4-8. Model estimated 2009 municipal wastewater loads by jurisdiction delivered to Chesapeake Bay

Jurisdiction	Flow (mgd)	Total nitrogen delivered (lb/yr)	Total phosphorus delivered (lb/yr)
DC	140	2,387,918	20,456
DE	2	42,529	4,984
MD	563	11,928,717	568,905
NY	62	1,360,684	159,096
PA	335	9,391,741	740,397
VA	585	16,926,806	1,047,998
WV	13	188,137	62,674
Total	1,698	42,226,535	2,604,509

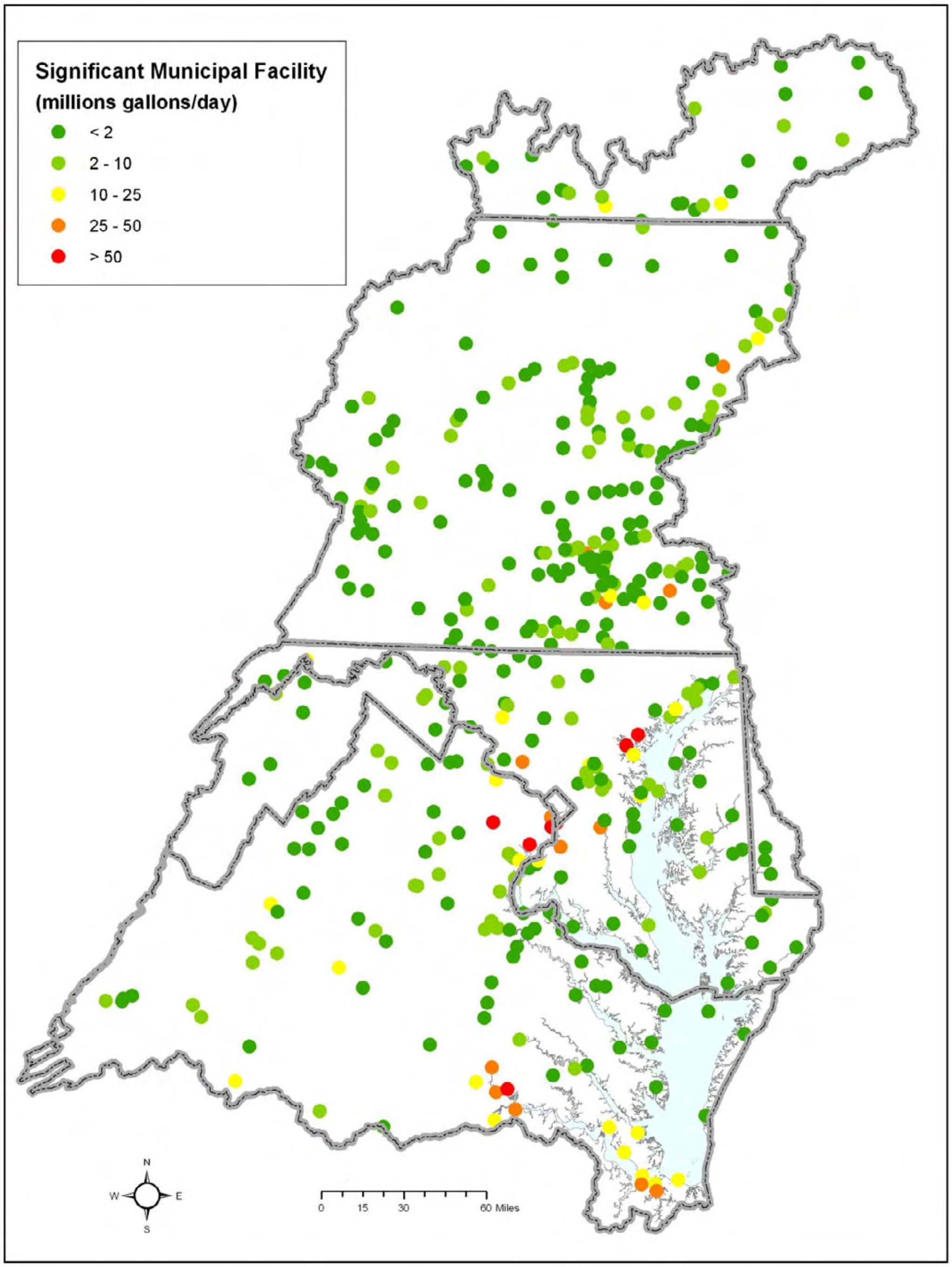
Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Table 4-9. Model estimated 2009 municipal wastewater loads by major river basin delivered to Chesapeake Bay

Basin	Flow (mgd)	Total nitrogen delivered (lbs/yr)	Total phosphorus delivered (lbs/yr)
Susquehanna River	383	10,556,831	835,426
MD Eastern Shore	25	696,872	70,540
MD Western Shore	254	7,279,406	331,362
Patuxent River	58	640,507	61,948
Potomac River	635	9,475,644	412,464
Rappahannock River	23	376,453	46,463
York River	20	691,550	45,012
James River	299	12,494,335	798,615
VA Eastern Shore	< 1	14,937	2,679
Total	1,698	42,226,535	2,604,509

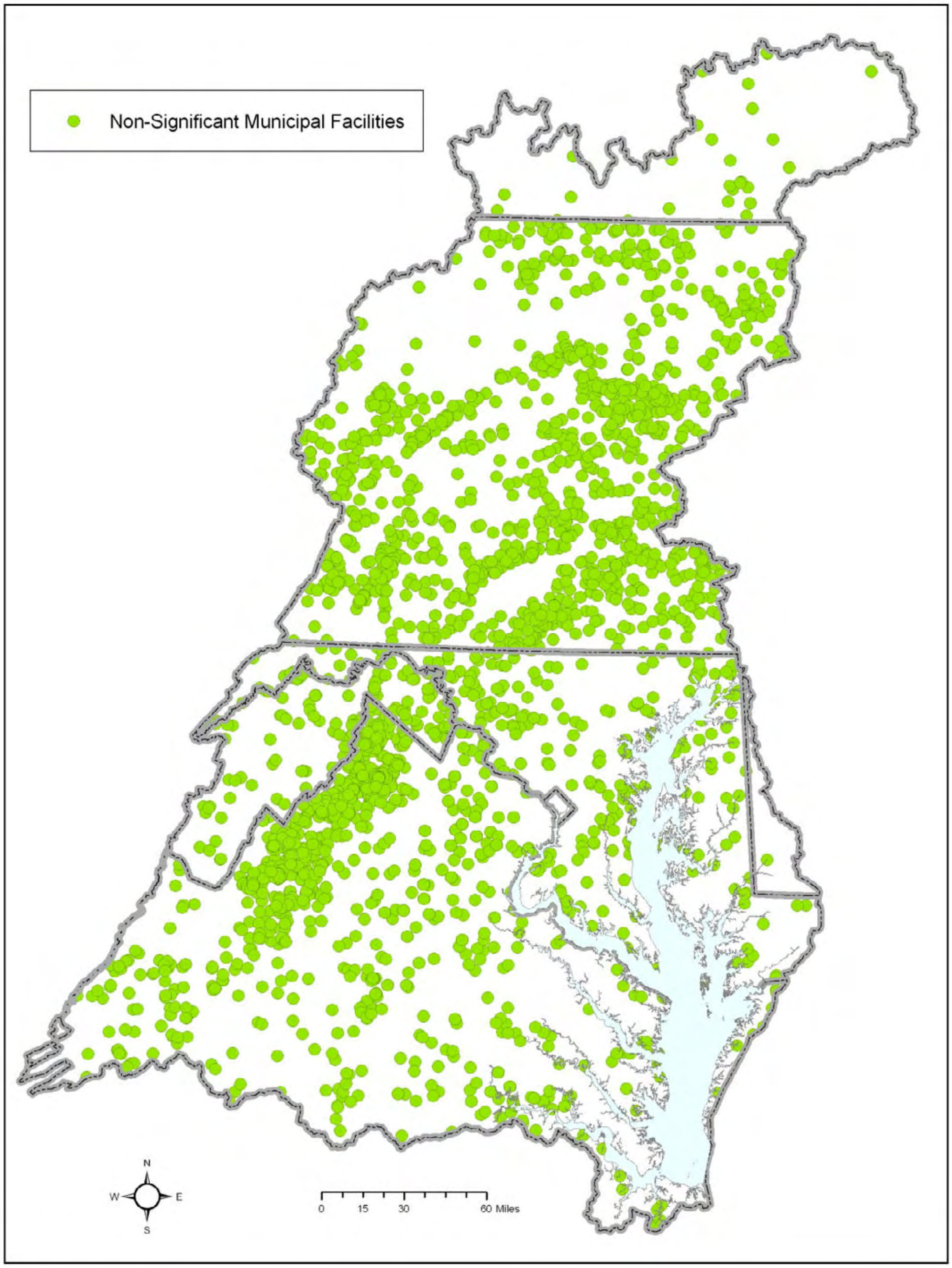
Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-7 and Figure 4-8 illustrate the prevalence and locations of significant and nonsignificant municipal wastewater discharge facilities, respectively, across the watershed.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-7. Significant wastewater treatment facilities in the Chesapeake Bay watershed.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-8. Nonsignificant municipal wastewater treatment facilities in the Chesapeake Bay watershed.

Data related to municipal and industrial facilities are in the Bay Watershed Model point source database maintained by the CBP and include information for the 478 significant industrial, municipal, and federal facilities discharging directly to the surface waters in the watershed. The wastewater data used to calibrate the Bay Watershed Model cover the 1984 to 2005 time frame and are updated annually as data become available. Data are largely supplied by the seven watershed jurisdictions but are also obtained from NPDES permit databases, including EPA's Permit Compliance System (PCS) and jurisdiction discharge monitoring reports (DMRs). For each facility outfall, the database includes monthly flow and monthly average concentrations for total nitrogen, ammonia, nitrate and nitrite, total organic nitrogen, total phosphorus, orthophosphate, total organic phosphorus, total suspended solids, biological oxygen demand, and DO.

Because the Bay jurisdictions are required to submit monthly concentration and flow data to EPA for only significant dischargers, the Bay Watershed Model point source database does not include comprehensive information useful for characterizing the nonsignificant facilities (especially nonsignificant industrials) for the Bay TMDL. For nonsignificant municipal facilities, all Bay jurisdictions conducted a one-time data collection in 2008 for the nitrogen and phosphorus discharge data, and estimates are based on any available data sources and default values recommended in *Chesapeake Bay Watershed Model Application and Calculation of Nutrient and Sediment Loadings – Appendix F: Phase IV Chesapeake Bay Watershed Model Point Source Load* (CBP 1998). EPA supplemented this information by querying the Integrated Compliance Information System database (ICIS) for jurisdictions that have migrated to ICIS as of 2009 (District of Columbia, Maryland, Pennsylvania, and New York), querying the PCS database for jurisdictions that have not yet migrated to ICIS (Delaware, Virginia and West Virginia), and obtaining Maryland and Virginia facility information directly from Maryland Department of the Environment (MDE) and Virginia Department of Environmental Quality (VADEQ), respectively.

For more information regarding the data used to represent municipal wastewater discharge facilities and how they were incorporated into modeling for the TMDL, see Section 7 of the Bay Watershed Model documentation at
http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169

Appendix Q provides facility-specific information including NPDES ID, location, and more for all wastewater dischargers accounted for in the Bay TMDL.

4.5.2 Industrial Discharge Facilities

Industrial discharge facilities are facilities discharging process water, cooling water, and other contaminated waters from industrial or commercial sources. EPA identified 1,679 NPDES permitted facilities discharging industrial wastewaters in the Chesapeake Bay watershed (Table 4-10, Appendix Q), with 76 significant facilities (Figure 4-9) and 1,603 nonsignificant facilities (Figure 4-10). In 2009 industrial wastewater discharging facilities contributed an estimated 7.3 million pounds of the total nitrogen and 1.27 million pounds of the total phosphorus loads delivered to Chesapeake Bay (Table 4-11 and Table 4-12) an estimated 3 percent and 8 percent, respectively, of all nitrogen and phosphorus loads delivered to the Chesapeake Bay.

Table 4-12 summarizes modeled wastewater nitrogen and phosphorus loading estimates using 2009 loading conditions. Modeled sediment loads for industrial or commercial facilities are not presented because their wastewater discharges represent a *de minimis* source of sediment (i.e., less than 0.5 percent of the 2009 total sediment load).

Table 4-10. Industrial wastewater facilities

Jurisdiction	Significant	Nonsignificant
DC	0	9
DE	1	1
MD	12	477
NY	2	45
PA	30	409
VA	24	639
WV	7	23
Total	76	1,603

Source: USEPA Region 3, Region 2

Table 4-11. 2009 Load estimates of industrial facility discharges

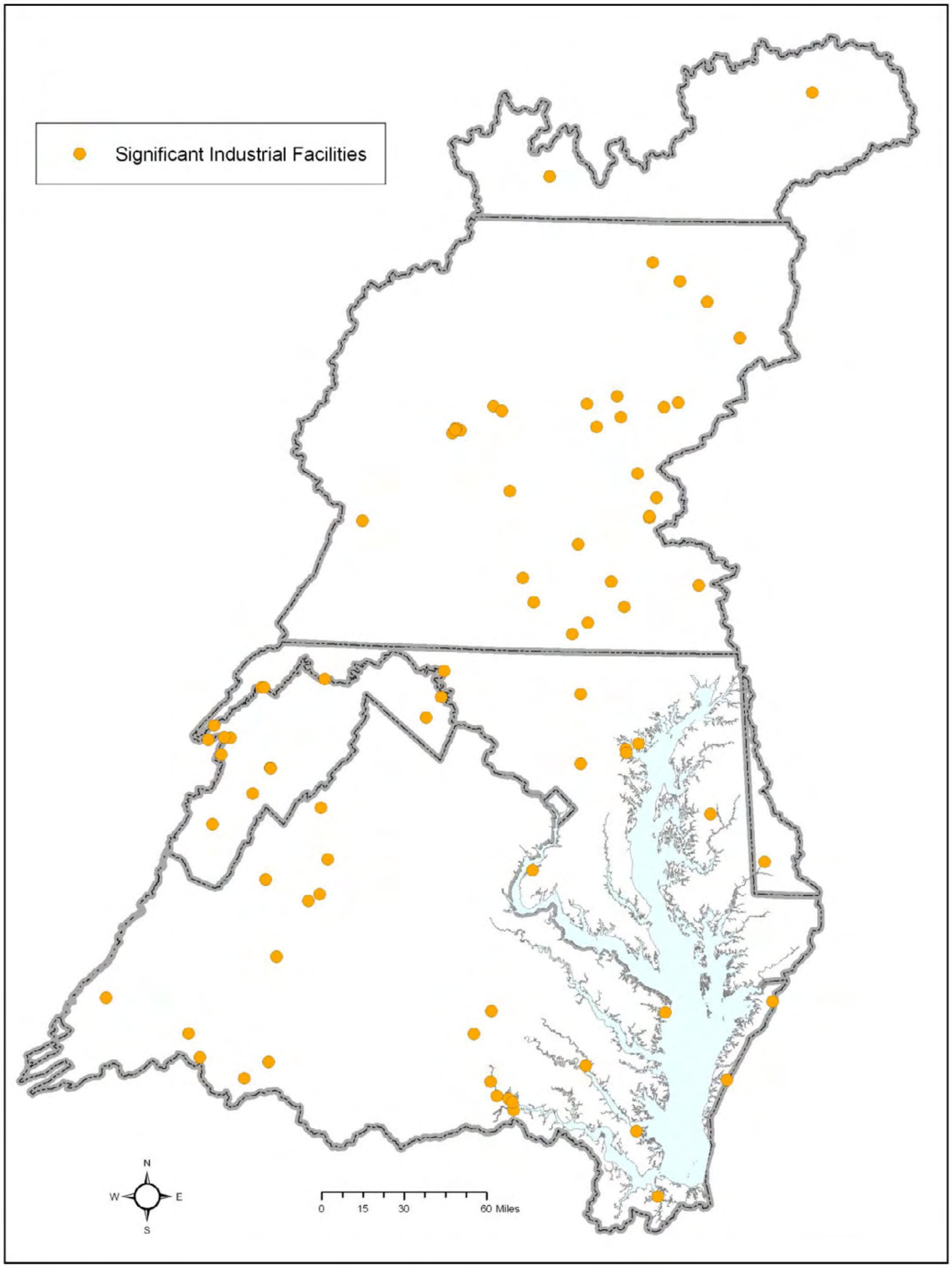
Jurisdiction	Flow (mgd)	Total nitrogen delivered (lbs/yr)	Total phosphorus delivered (lbs/yr)
DC	13	183,490	20,433
DE	< 1	95,438	71
MD	48	1,989,243	267,093
NY	7	126,897	19,971
PA	179	2,010,639	260,140
VA	160	2,883,828	649,266
WV	14	55,213	53,592
Total	422	7,344,748	1,270,566

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Table 4-12. 2009 Flow, total nitrogen, and total phosphorus load estimates of industrial wastewater facility discharges by major river basin

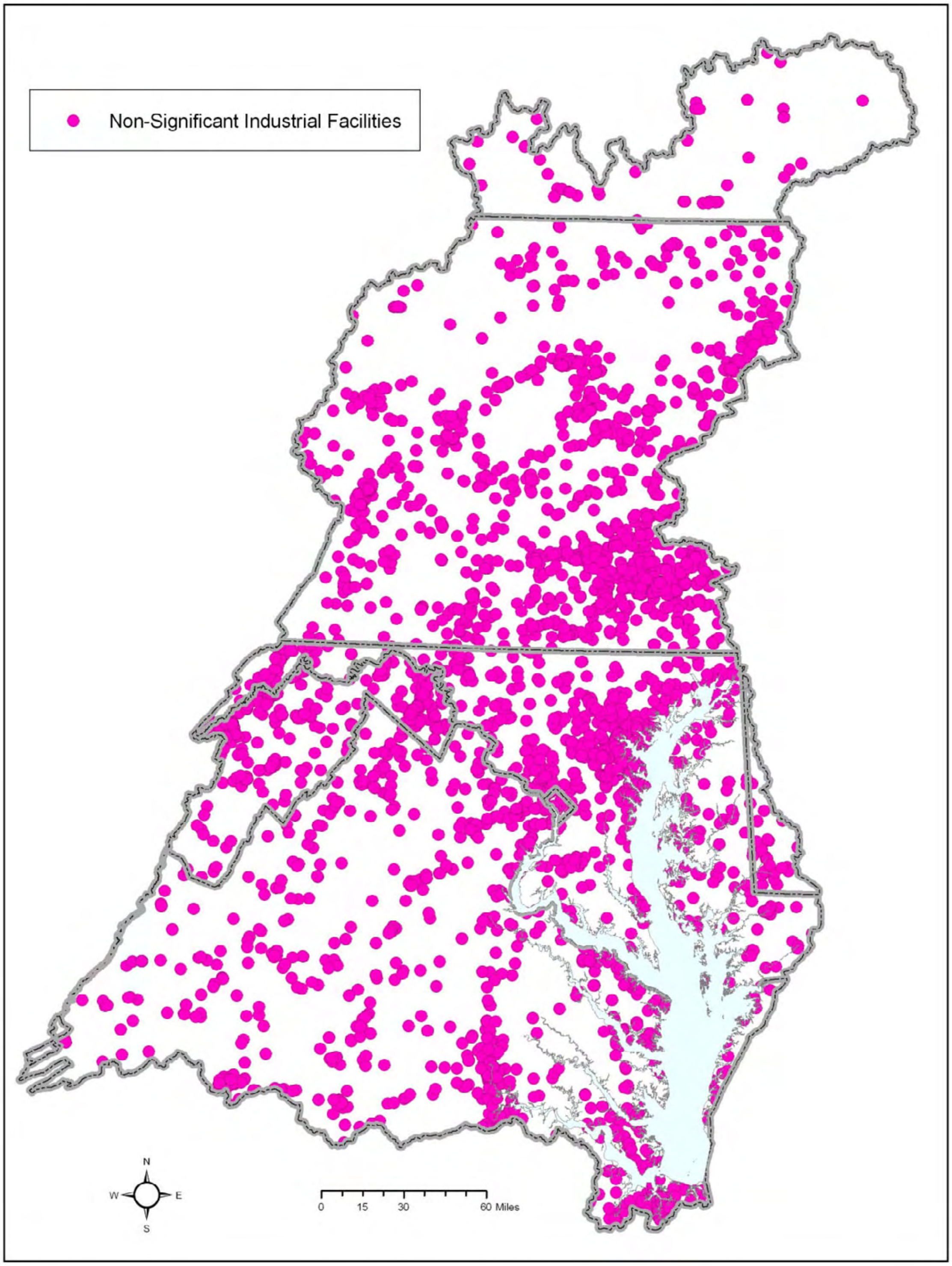
Basin	Flow (mgd)	Total nitrogen delivered (lbs/yr)	Total phosphorus delivered (lbs/yr)
Susquehanna River	184	2,171,197	281,922
MD Eastern Shore	5	302,210	45,626
MD Western Shore	21	1,369,383	105,100
Patuxent River	3	50,615	38,689
Potomac River	71	779,885	420,997
Rappahannock River	5	78,006	36,039
York River	81	478,892	81,675
James River	51	1,979,297	259,331
VA Eastern Shore	1	135,211	1,160
Total	422	7,344,697	1,270,539

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-9. Significant industrial wastewater discharge facilities in the Chesapeake Bay watershed.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario.

Figure 4-10. Nonsignificant industrial wastewater discharge facilities in the Chesapeake Bay watershed.

Discharge Monitoring Report (DMR) data from the population of industrial facilities were used to derive loadings where available. The majority of nonsignificant industrial facilities do not have DMR data for nitrogen and phosphorus. However, the default values from typical pollutant concentrations (Tetra Tech 1999) were used to estimate the loads where DMR data are not available, except for power plants and other facilities with high flows.

Industrial facilities, such as power plants, petroleum refineries, and steel mills, that were not on the significant facility list were considered as high-flow, nonsignificant facilities in the evaluation. Nitrogen and phosphorus loads resulting from the use of flue gas desulfurization units, effluent from coal ash ponds and biocide applications at high-flow facilities were estimated from available databases. Data sets queried include EPA's PCS and ICIS permit systems, 316(b) cooling water intake structure regulation data, U.S. Department of Energy's Energy Information Administration data, and EPA's eGrid database.

Thirty-two power plants were identified as being in the Chesapeake Bay watershed. Eight of those facilities use cooling towers as part of their cooling system. Of the 32 facilities, 18 use coal as a fuel source; 7 use a flue gas desulfurization, and 13 use ash ponds. Eighty-nine other high-flow industrial sites were identified in the watershed and represent a variety of industrial activities.

Pollutant loads were estimated for the eight facilities that use cooling towers. The PCS and ICIS databases were queried for blowdown flows, and cooling tower chemical vendors were consulted to estimate water quality conditions in the towers. Facility use rates were then obtained from EPA's eGrid database to characterize utilization routines and variability in blowdown events. Similarly, flue gas desulfurization and ash pond loads were estimated using data obtained from the PCS and ICIS databases.

4.5.3 Combined Sewer Overflows

Combined sewer systems (CSS) are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. Normally, the systems transport wastewater to a treatment plant, where it is treated and discharged to surface waters. However, during heavy rainfall or snowmelt, flow volumes in a CSS can exceed the capacity of the sewer system or treatment plant. To avoid situations where excess flows overwhelm the sewer network or the treatment capacity of the treatment system, CSSs are designed to overflow during times of high volume, discharging untreated excess wastewater directly to nearby streams, rivers, or other waterbodies.

Such overflows, called combined sewer overflows (CSOs), contain stormwater and untreated human and industrial waste, toxic materials, and debris. There are 64 CSO communities in the Chesapeake Bay watershed (Table 4-13 and Figure 4-11).

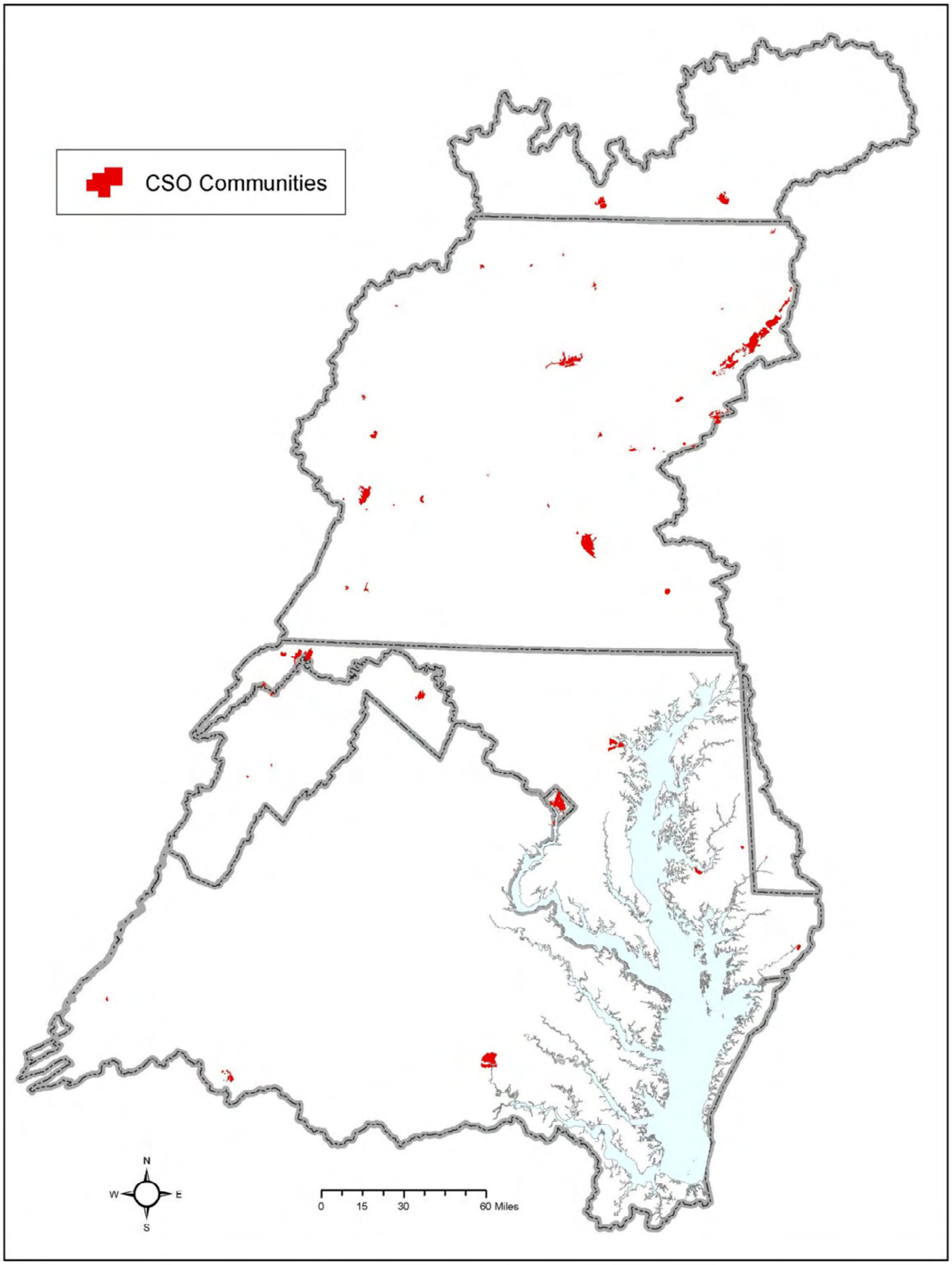
Table 4-13. Combined sewer system communities in the Bay watershed

Jurisdiction	River basin	NPDES ID	Facility name
DC	Potomac	DC0021199	Washington, District of Columbia
DE	Eastern Shore	DE0020265	Seaford Waste Treatment Plant
MD	Eastern Shore	MD0020249	Federalsburg WWTP
MD	Eastern Shore	MD0021571	City of Salisbury WWTP
MD	Potomac	MD0021598	Cumberland WWTP
MD	Patapsco	MD0021601	Patapsco WWTP
MD	Eastern Shore	MD0021636	Cambridge WWTP
MD	Eastern Shore	MD0022764	Snow Hill Water & Sewer Department
MD	Potomac	MD0067384	Westernport CSO
MD	Potomac	MD0067407	Allegany County CSO
MD	Potomac	MD0067423	Frostburg CSO
MD	Potomac	MD0067547	Lavale Sanitary Commission CSO
NY	Susquehanna	NY0023981	Johnson City (V) Overflows
NY	Susquehanna	NY0024406	Binghamton (C) CSO
NY	Susquehanna	NY0035742	Chemung Co Elmira SD STP
PA	Susquehanna	PA0020940	Tunkhannock Boro Municipal Authority
PA	Susquehanna	PA0021237	Newport Boro STP
PA	Susquehanna	PA0021539	Williamsburg Municipal Authority
PA	Susquehanna	PA0021571	Marysville Borough WWTP
PA	Susquehanna	PA0021687	Wellsboro WWTP
PA	Susquehanna	PA0021814	Mansfield Boro WWTP
PA	Susquehanna	PA0022209	Bedford WWTP
PA	Susquehanna	PA0023248	Berwick Area Joint Sewer Authority WWTP
PA	Susquehanna	PA0023558	Ashland WWTP
PA	Susquehanna	PA0023736	Tri-Boro Municipal Authority WWTP
PA	Susquehanna	PA0024341	Canton Boro Auth. WWTP
PA	Susquehanna	PA0024406	Mount Carmel WWTF
PA	Susquehanna	PA0026107	Wyoming Valley Sanitary Authority WWTP
PA	Susquehanna	PA0026191	Huntingdon Borough WWTP
PA	Susquehanna	PA0026310	Clearfield Mun. Auth. WWTP
PA	Susquehanna	PA0026361	Lower Lackawanna Valley Sanitary Authority WWTP
PA	Susquehanna	PA0026492	Scranton Sewer Authority WWTP
PA	Susquehanna	PA0026557	Sunbury City Municipal Authority WWTP
PA	Susquehanna	PA0026743	Lancaster City WWTP
PA	Susquehanna	PA0026921	Greater Hazelton Joint Sewer Authority WWTP
PA	Susquehanna	PA0027014	Altoona City Auth. - Easterly WWTP
PA	Susquehanna	PA0027022	Altoona City Auth. - Westerly WWTF
PA	Susquehanna	PA0027049	Williamsport Sanitary Authority – West Plant
PA	Susquehanna	PA0027057	Williamsport Sanitary Authority – Central Plant
PA	Susquehanna	PA0027065	LRBSA - Archbald WWTP
PA	Susquehanna	PA0027081	LRBSA - Clinton WWTP
PA	Susquehanna	PA0027090	LRBSA - Throop WWTP
PA	Susquehanna	PA0027197	Harrisburg Advanced WWTF
PA	Susquehanna	PA0027324	Shamokin Coal Twp Joint Sewer Authority
PA	Susquehanna	PA0028631	Mid-Cameron Authority

Jurisdiction	River basin	NPDES ID	Facility name
PA	Susquehanna	PA0028673	Gallitzin Borough Sewer and Disposal Authority
PA	Susquehanna	PA0036820	Galeton Borough Authority WWTP
PA	Susquehanna	PA0037711	Everett Area WWTP
PA	Susquehanna	PA0038920	Burnham Borough Authority WWTP
PA	Susquehanna	PA0043273	Hollidaysburg STP
PA	Susquehanna	PA0046159	Houtzdale Boro Municipal Sewer Authority
PA	Susquehanna	PA0070041	Mahanoy City Sewer Authority WTP
PA	Susquehanna	PA0070386	Shenandoah Municipal Sewer Authority WWTP
PA	Susquehanna	PAG062202	Lackawanna River Basin Sewer Authority.
PA	Susquehanna	PAG063501	Steelton Boro Authority
VA	James	VA0063177	Richmond
VA	James	VA0024970	Lynchburg
VA	James	VA0025542	Covington Sewage Treatment Plant
VA	Potomac	VA0087068	Alexandria
WV	Potomac	WV0020150	City of Moorefield
WV	Potomac	WV0021792	City of Petersburg
WV	Potomac	WV0023167	City of Martinsburg
WV	Potomac	WV0024392	City of Keyser
WV	Potomac	WV0105279	City of Piedmont

CSOs are considered point sources and are assigned WLAs in this TMDL. EPA's *CSO Control Policy* is the national framework for implementing controls on CSOs through the NPDES permitting program. The policy resulted from negotiations among EPA, municipal organizations, environmental groups, and state agencies. It provides guidance to municipalities and state and federal permitting authorities on how to meet the CWA's pollution control goals as flexibly and cost-effectively as possible. The CSO policy was published in the *Federal Register* (FR) (59 FR 18688, April 19, 1994). CSO communities are required to develop Long-Term Control Plans (LTCPs), detailing steps necessary to achieve full compliance with the CWA.

EPA relied on various sources of information to characterize the prevalence of CSOs in the Bay watershed and to quantify their loads for the Bay TMDL. There are 64 CSO communities in the Bay watershed (Table 4-13). Overflow volume and pollutant loading from CSO communities are heavily dependent on the service area or catchment area of the combined system. Service area data obtained from the communities were used to calculate the loading from each community during high-flow events. Precipitation data observations were also obtained from weather monitoring stations proximate to each community to derive runoff volumes. Estimates of overflows and associated pollutant loads from CSO communities were then developed using various sources of water quality data including monitoring data and literature values.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-11. CSO communities in the Chesapeake Bay watershed.

For four of the largest CSO communities in the watershed—Alexandria, Virginia; Lynchburg, Virginia; Richmond, Virginia; and the District of Columbia—EPA relied heavily on readily available and relatively detailed LTCPs to characterize overflows. In addition, EPA ran simulations of existing sewer models for those communities to support developing overflow and water quality estimates. EPA used the District of Columbia's CSS model to develop loading estimates for the CSOs. For the Alexandria, Richmond, and Lynchburg CSSs, various versions of EPA's Storm Water Management Model (SWMM) were used to estimate overflows. CSO discharge monitoring data were available for the Alexandria and Richmond CSSs, but no samples were available from Lynchburg because the LTCP calls for complete separation of this system (i.e., separation of the storm sewers from sanitary sewers).

Information related to loading from the other 60 CSO communities in the watershed includes spatial data collected as a result of a direct survey of the communities to support the TMDL, limited water quality and overflow data from some of the CSO communities in the watershed, and representative water quality concentrations available in the literature. For further information regarding the data used to estimated CSO loads, see Section 7 of the Chesapeake Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

To avoid the difficulty of measuring LTCP implementation progress with weather-dominated CSO loading estimates, EPA used the 10-year average CSO loads for 1991–2000, which correlates with the hydrologic period selected for the TMDL (see Section 6.1.1). The loads from that 10-year period were used as the baseline to assess CSO progress and WLAs. Any CSO implementation progress will be tracked and input in the model as a reduction factor to represent a reduction achieved from the baseline. Thus, any reduction will be from management actions only and not from climate variation. The CSS land use will be changed to urban area for stormwater simulation in the model if there is CSS separation in the implementation plan and the separation acreage is reported with the reduction factor for implementation progress tracking.

4.5.4 Sanitary Sewer Overflows

Properly designed, operated, and maintained sanitary sewer systems are meant to collect and transport all the sewage that flows into them to a WWTP. SSOs are illegal discharges of raw sewage from municipal sanitary sewer systems. Frequent SSOs are indicative of problems with a community's collection system and can be due to multiple factors:

- Infiltration and inflow contributes to SSOs when rainfall or snowmelt infiltrates through the ground into leaky sanitary sewers or when excess water flows in through roof drains connected to sewers, broken pipes, or badly connected sewer service lines. Poor service connections between sewer lines and building service lines can contribute as much as 60 percent of SSOs in some areas.
- Undersized systems contribute to SSOs when sewers and pumps are too small to carry sewage from newly developed subdivisions or commercial areas.
- Pipe failures contribute to SSOs as a result of blocked, broken, or cracked pipes; tree roots growing into the sewer; sections of pipe settling or shifting so that pipe joints no longer match; and sediment and other material building up causing pipes to break or collapse.
- Equipment failures contribute to SSOs because of pump failures or power failures.

SSOs represent a source of nitrogen and phosphorus to the Chesapeake Bay; however, information available to characterize their contribution to the overall nitrogen and phosphorus loads delivered to the Bay is limited largely because of their illegality and infrequency. Although the Bay Watershed Model does not specifically account for SSOs, the nitrogen and phosphorus load contributions from SSOs are part of the background conditions incorporated into the Phase 5.3 watershed model and, therefore, such loads are accounted for in the data used for calibration of the Bay Watershed Model. Because SSOs are illegal, however, the Chesapeake Bay TMDL assumes full removal of SSOs and makes no allocation to them.

4.5.5 NPDES Permitted Stormwater

Urban and suburban stormwater discharges contain nitrogen, phosphorus, and sediment from sources such as pet wastes, lawn fertilizers, construction activity, impervious surfaces, and air contaminants. The in-stream bank and bed scouring caused by increased volumes and durations of stormwater discharges contribute additional sediment and nitrogen and phosphorus loads to the Bay and its tributaries. Those nitrogen, phosphorus, and sediment loads affect local water quality, habitats, and the Bay downstream and represent a significant proportion of nitrogen, phosphorus, and sediment loads to Bay. The CBP estimates that in 2009 stormwater from urban and suburban development contributed to 16 percent of the sediment loadings, 15 percent of the phosphorus loadings, and 8 percent of the nitrogen loadings to the Bay (Bay Watershed Model 2009 Scenario).

Under the federal stormwater regulatory program, three broad categories of stormwater discharges are regulated (see 40 CFR 122.26, CFR 122.30-37):

- Stormwater discharges from medium and large Municipal Separate Storm Sewer Systems (MS4s) and small MS4s in Census Bureau defined urbanized areas
- Stormwater discharges associated with construction activity 1 acre and larger
- Stormwater discharges associated with specified categories of industrial activity

In addition, EPA established a process for designating and requiring NPDES permit coverage for additional stormwater discharges, implementing section 402(p)(2)(E). This *residual designation authority* (RDA) of section 402(p)(2)(E) is in 40 CFR 122.26(a)(9)(i)(C) and (D). EPA retains additional authority in CWA section 402(p)(5) and (6) to designate additional point sources of stormwater.

EPA’s intent in creating the MS4 Stormwater Program was to regulate stormwater discharges by requiring the municipalities to develop management programs to control stormwater discharging via the MS4, i.e., stormwater collected by the MS4 from throughout its service area.

CWA section 402(p) establishes the framework for EPA to address stormwater discharges. In Phase I, EPA established NPDES permit requirements for stormwater discharges associated with

- Industrial activity, including construction activity disturbing 5 acres or greater, including sites smaller than 5 acres if they are associated with a common plan of development or sale that is at least 5 acres in size
- Discharges from MS4s serving populations of 100,000 or more

In Phase II, EPA established permit requirements for stormwater discharges from

- Construction activity disturbing 1 to 5 acres, including sites smaller than 1 acre if they are associated with a common plan of development or sale that is at least 1 acre in size
- Small MS4s serving populations of fewer than 100,000 in urbanized areas

With respect to Phase II MS4s, EPA considers stormwater discharges from within the geographic boundary of the urbanized area (and designated areas) served by small MS4s to be regulated (64 FR 68722, 68751-52 and 68804, Appendix 2, December 8, 1999). The reason for regulating small MS4s in urbanized areas was based on the correlation between the degree of development/ urbanization and adverse water quality impacts from stormwater discharged from such areas.

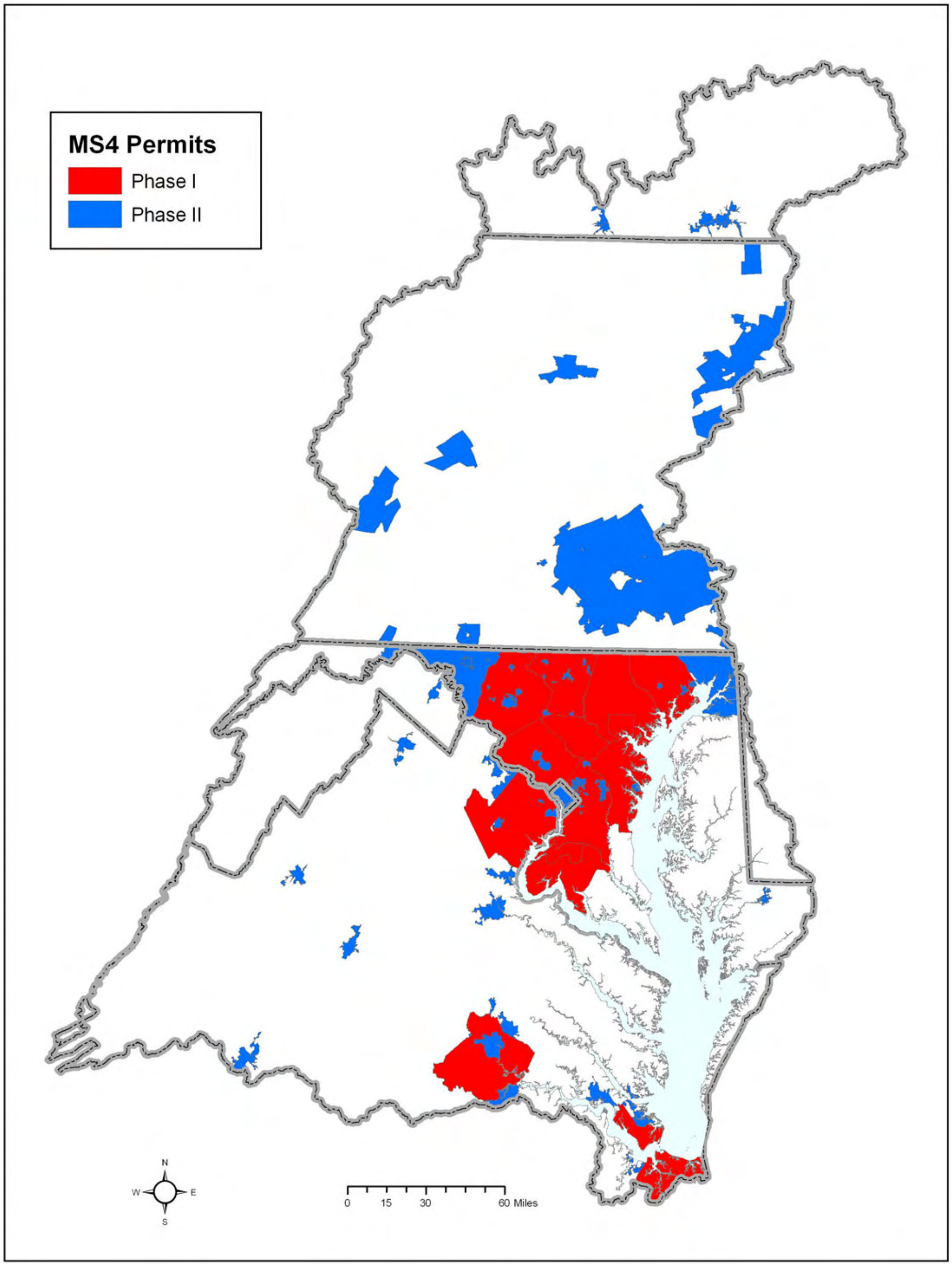
EPA can and has designated additional stormwater discharges, such as those from impervious surfaces above a certain size threshold, using its residual designation authority under 40 CFR 122.26(a)(9)(i)(C) and (D). At the discretion of the NPDES permitting authority, stormwater dischargers that require NPDES permits can either obtain individual permits or, with the exception of medium and large MS4s, obtain coverage under general permits (see 40 CFR 122.28). Also, EPA has additional authority in CWA section 402(p)(5) and (6) to designate additional point sources of stormwater.

Figure 4-12 shows the locations of Phase I and II MS4s in the Bay watershed.

Unless stormwater discharges are identified in EPA’s Phase I or Phase II regulations or are designated pursuant to CWA section 402(p)(2)(E) or 402(p)(6), the discharges are not regulated under CWA section 402. As explained in EPA guidance, “stormwater discharges that are regulated under Phase I or Phase II of the NPDES stormwater program are point sources that must be included in the WLA portion of a TMDL” (USEPA 2002). Appendix Q includes the stormwater permits subject to this Bay TMDL.

It is estimated that existing NPDES MS4 areas contributed approximately 7,027,362 lbs total nitrogen, 900,868 lbs total phosphorus, and 287,295 tons of sediment annually in 2009. That compares to the total load delivered annually to the Bay of 251,040,081 lbs total nitrogen, 16,619,332 lbs total phosphorus and 4,000,118 tons sediment by all sources (Bay Watershed Model 2009 Scenario).

The contribution from industrial stormwater discharges subject to NPDES permits has been estimated on the basis of data submitted by jurisdictions in their Phase I WIPs, including the number of industrial stormwater permits per county and the number of urban acres regulated by industrial stormwater permits. For the Bay TMDL, the permitted industrial stormwater load is subtracted from the MS4 load when applicable. Table 4-14 provides an accounting of the current individual and general stormwater NPDES permits issued within the Chesapeake Bay watershed.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-12. Phase I and II MS4s in the Chesapeake Bay watershed.

Table 4-14. NPDES stormwater permittees by jurisdiction and in the Chesapeake Bay watershed, summer 2009

Jurisdiction		NPDES Stormwater permit type					
		MS4 Phase I	MS4 Phase II	Industrial	Construction	Total	% Permittees in the Bay
DC	Baywide	1	0	60	212	273	1.6%
	Districtwide	1	0	60	212	273	
DE	Baywide	1	0	48	NA*	49	0.3%
	Statewide	14	3	337	1,375	1,729	
MD	Baywide	11	82	1,578	8,300	9,971	57.6%
	Statewide	11	82	1,578	8,332	10,003	
NY	Baywide	0	34	122	470	626	3.6%
	Statewide	1	502	1,393	7,251	9,147	
PA	Baywide	0	206	1,238	906	2,350	13.6%
	Statewide	2	727	2,494	2,399	5,622	
VA	Baywide	11	75	975	2,252	3,313	19.2%
	Statewide	11	90	1,432	2,851	4,384	
WV	Baywide	0	3	113	651	767	4.4%
	Statewide	0	45	933	2,488	3,466	
Total	Bay	23	400	4,086	12,791	17,300	100%
	States	40	1,449	8,227	24,908	34,624	

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario
Note: Numbers of permittees are not static, and especially for categories like construction are fluctuating regularly.
* Not including Delaware

Data used to characterize loads from regulated stormwater activities and to represent these sources in the model are available from the jurisdictions' NPDES programs and from EPA Region 3's NPDES permitting, the permitting authority in the District of Columbia and for federal facilities in Delaware. Details related to how loads for MS4s and NPDES-permitted construction and industrial stormwater activities were derived for the Bay TMDL are in Section 7 of the Phase 5 Chesapeake Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

4.5.6 Concentrated Animal Feeding Operations

The NPDES program regulates the discharge of pollutants from point sources to waters of the United States. Concentrated Animal Feeding Operations (CAFOs) are included in the definition of point sources in CWA section 502(14). To be considered a CAFO, a facility must first be defined as an AFO.

AFOs are agricultural operations where animals are kept and raised in confined situations. AFOs generally congregate animals, feed, manure, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures. Such operations are defined as AFOs if animals are confined for 45 or more days per year in facilities where vegetation and other growth are not present during the normal growing season [40 CFR 122.42(b)(1)].

AFOs that meet the regulatory definition of a CAFO or that are designated as a CAFO are regulated under the NPDES permitting program and are required to seek NPDES permit coverage if they discharge or propose to discharge. The NPDES regulations define AFOs as CAFOs based primarily on the number of animals confined (Table 4-15) (for example, a large dairy CAFO confines 700 or more dairy cattle) [40 CFR 122.23(b)(2), (4), and (6)]. An AFO that is not defined as a CAFO may be designated as a CAFO if it meets certain conditions [40 CFR 122.23(c)].

Table 4-15. Federal numeric thresholds for small, medium, and large CAFOs

Animal sector	Size thresholds (number of animals)		
	Large CAFOs	**Medium CAFOs**	**Small CAFOs**
Cattle or cow/calf pairs	1,000 or more	300–999	less than 300
Mature dairy cattle	700 or more	200–699	less than 200
Veal calves	1,000 or more	300–999	less than 300
Swine (weighing over 55 pounds)	2,500 or more	750–2,499	less than 750
Swine (weighing less than 55 pounds)	10,000 or more	3,000–9,999	less than 3,000
Horses	500 or more	150–499	less than 150
Sheep or lambs	10,000 or more	3,000–9,999	less than 3,000
Turkeys	55,000 or more	16,500–54,999	less than 16,500
Laying hens or broilers (liquid manure handling systems)	30,000 or more	9,000–29,999	less than 9,000
Chickens other than laying hens (other than a liquid manure handling systems)	125,000 or more	37,500–124,999	less than 37,500
Laying hens (other than a liquid manure handling systems)	82,000 or more	25,000–81,999	less than 25,000
Ducks (other than a liquid manure handling systems)	30,000 or more	10,000–29,999	less than 10,000
Ducks (liquid manure handling systems)	5,000 or more	1,500–4,999	less than 1,500

Source: 40 CFR 122.23(b)

Under federal regulations, NPDES permits for CAFOs require CAFOs to implement the terms of a site-specific nutrient management plan (NMP) that includes a number of critical minimum elements [40 CFR 122.42(e)(1)]. Those requirements limit nitrogen and phosphorus loads from the production area as well as from the land application area, where manure, litter and process wastewater must be applied in accordance with site-specific practices to ensure that nitrogen and phosphorus in the manure will be used appropriately. NPDES permits for all CAFOs must include technology-based effluent limits in accordance with 40 CFR 122.44. Permitted Large CAFOs that land-apply manure, litter or process wastewater must comply with technology-based effluent limitations for land application per the effluent limitations guidelines (ELGs) at 40 CFR 412 (C) and (D). Unpermitted Large CAFOs may not have any discharges except for agricultural stormwater discharges from the land application area.

Agricultural stormwater discharges are the precipitation-related discharges from CAFO land application areas where the CAFO land applies manure, litter or process wastewater in accordance with nutrient management practices “that ensure appropriate agricultural utilization of the nutrients in the manure, litter or process wastewater” applied to the land—i.e., for permitted CAFOs, the terms of an NMP concerning land application [40 CFR 122.23(e)(1)]. State technical standards are used in calculating the technology-based effluent limits in NPDES permits of Large CAFOs. Requirements for land application areas at small and medium CAFOs are based on the best professional judgment of the permit writer, and may also incorporate state technical standards. The agricultural stormwater exemption does not apply to a CAFO’s production area. As a nonpoint source, an agricultural stormwater discharge is not subject to NPDES permitting requirements or water quality-based effluent limitations (WQBELs).

Any permit issued to a CAFO of any size must include a requirement to implement an NMP that contains, at a minimum, BMPs that meet the requirements specified in 40 CFR 122.42(e)(1). These include the following:

- Ensuring adequate storage of manure, litter, and process wastewater, including procedures to ensure proper operation and maintenance of the storage facility.
- Managing mortalities to ensure that they are not disposed of in a liquid manure, stormwater, or process wastewater storage or treatment system that is not specifically designed to treat animal mortalities.
- Ensuring that clean water is diverted, as appropriate, from the production area.
- Preventing direct contact of confined animals with waters of the United States.
- Ensuring that chemicals and other contaminants handled on-site are not disposed of in any manure, litter, process wastewater, or stormwater storage or treatment system unless specifically designed to treat such chemicals and other contaminants.
- Identifying appropriate site-specific conservation practices to control runoff of pollutants to waters of the United States.
- Identifying protocols for appropriate testing of manure, litter, process wastewater, and soil.
- Establishing protocols to land apply manure, litter, or process wastewater in accordance with site-specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients in the manure, litter or process wastewater.
- Identifying specific records that will be maintained to document the implementation and management of the minimum elements described above.

EPA and the jurisdictions have estimated the number of state or federal permitted CAFOs in the Chesapeake Bay watershed, in part, on the basis of the jurisdictions’ respective final Phase I WIPs (Table 4-16).

Table 4-16. Estimated number of state or federal permitted CAFOs

Jurisdiction	# State or federal permitted CAFOs
Delaware[a]	165
Maryland[a]	365
New York	65
Pennsylvania	325
Virginia	30
West Virginia	30
Total	980

Sources: State data submitted to EPA for the Senate Environment and Public Works Committee Hearing on the Chesapeake Bay on April 20, 2009, and EPA Office of Wastewater Management's latest NPDES CAFO Rule Implementation Status quarterly national CAFO number update. http://www.epa.gov/npdes/pubs/tracksum1Q10.pdf.
Note:
a. The numbers of CAFOs in Maryland and Delaware with permits are estimated according to the number of Notices of Intent (NOIs) received as a result of the EPA February 2009 permit application deadline. The NOIs are being reviewed for permit requirement completeness.

4.6 NONPOINT SOURCES

The term *nonpoint source* means any source of water pollution that does not meet the legal definition of point source (see Section 4.5). Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification. For purposes of the Chesapeake Bay TMDL analysis and modeling, nonpoint sources in the Chesapeake Bay watershed have been evaluated under the following categories:

- Agriculture (manure, biosolids, chemical fertilizer)
- Atmospheric deposition
- Forest lands
- On-site wastewater treatment systems (OSWTSs)
- Nonregulated stormwater runoff
- Oceanic inputs
- Streambank and tidal shoreline erosion
- Tidal resuspension
- Wildlife

For the Bay TMDL, Scenario Builder was used to provide the land use-based scenario inputs to the Bay Watershed Model including forest lands, OSWTSs , nonregulated stormwater runoff, oceanic inputs, streambank and tidal shoreline erosion, tidal resuspension, and wildlife (see Section 5.7). Data sources for agriculture and atmospheric deposition in the Chesapeake Bay watershed are included in the relevant sections below. Scenario Builder provides estimates of nitrogen and phosphorus loads to the land and the area of soil available to be eroded. Loads are input to the Bay Watershed Model to generate modeled estimates of loads delivered to the Bay. Additional information related to Scenario Builder and its application in Bay TMDL development (USEPA 2010d) is at http://archive.chesapeakebay.net/pubs/SB_V22_Final_12_31_2010.pdf.

4.6.1 Agriculture

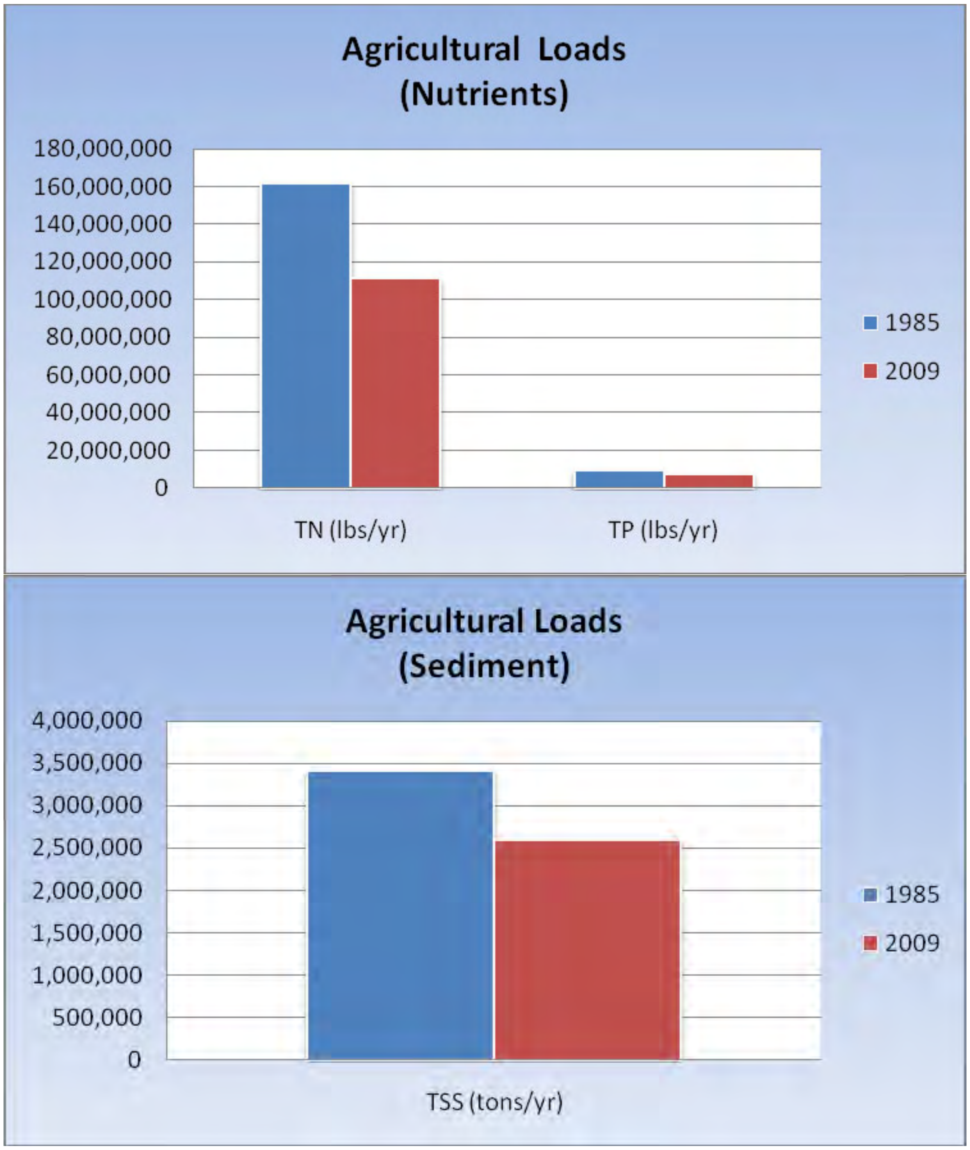
Agricultural lands account for 22 percent of the watershed, making agriculture one of the largest land uses in the area, second only to forested and open wooded areas (69 percent). The Bay watershed has more than 87,000 farm operations and 6.5 million acres of cropland. However, the District of Columbia does not include any agricultural lands.

Farms in the Chesapeake Bay watershed produce more than 50 named commodities. The area's primary crops are pasture, hay, corn, wheat, soybeans, vegetables, and fruits. The eastern part of the region is home to a rapidly expanding nursery and greenhouse industry.

Animal operations account for more than 60 percent of the region's annual farm product sales. In the watershed, the six major types of animal operations are dairy cows, beef cattle, pigs, egg production, broilers, and turkeys. The three major animal production regions in the watershed, according to livestock concentration, are the lower Susquehanna River in Pennsylvania, the Shenandoah Valley in Virginia and West Virginia, and the Delmarva Peninsula in Delaware, Maryland, and Virginia. The Delmarva Peninsula is considered to be one of the country's top poultry producing regions and, according to the 2002 Census, three Bay counties are among the top 20 poultry producing counties in the nation (for either poultry/eggs, broilers, or layers): Sussex County, Delaware; Lancaster County, Pennsylvania; and Wicomico County, Maryland. In addition, at least one Bay county is among the top 20 counties for production of the following farm commodities: turkeys; cattle and calves; milk and other cow dairy products; hogs and pigs; horses and ponies; corn for silage; snap beans; apples; short rotation woody crops; and nursery, greenhouse, floriculture, and sod.

Agriculture is the largest single source of nitrogen, phosphorus, and sediment loading to the Bay through applying fertilizers, tilling croplands, and applying animal manure. Agricultural activities are responsible for approximately 44 percent of nitrogen and phosphorus loads delivered to the Bay and about 65 percent of sediment loads delivered to the Bay (Bay Watershed Model 2009 Scenario). Figure 4-13 compares modeled loads from agricultural lands for 1985 and 2009.

Data sources used to estimate nitrogen, phosphorus, and sediment from agriculture-related sources include information related to livestock production and manure generation, crop production and nutrient management, fertilizer use and application, and implementation of BMPs. EPA in cooperation with the Chesapeake Bay Program's Agricultural Nutrient and Sediment Reduction Workgroup and Modeling Subcommittee relied on the many sources of information to characterize loads related to agriculture that are summarized in Section 2 of the Scenario Builder documentation *Estimates of County-Level Nitrogen and Phosphorus Data for Use in Modeling Pollutant Reduction*(USEPA 2010d). Examples of data sources are the U.S. Department of Agriculture (USDA) Agricultural Census; USDA, state, and university nutrient management standards and handbooks; peer-reviewed journal articles; agricultural conservation data from state agricultural and environmental agencies; county agencies, and nongovernmental organizations; and extensive input from members of the Chesapeake Bay Program's Agricultural Nutrient and Sediment Reduction Workgroup.



Source: Phase 5.3 Chesapeake Bay Watershed Model 1985 and 2009 Scenarios

Figure 4-13. 1985 and 2009 modeled total nitrogen, phosphorus, and sediment loads from agricultural lands across the Chesapeake Bay watershed.

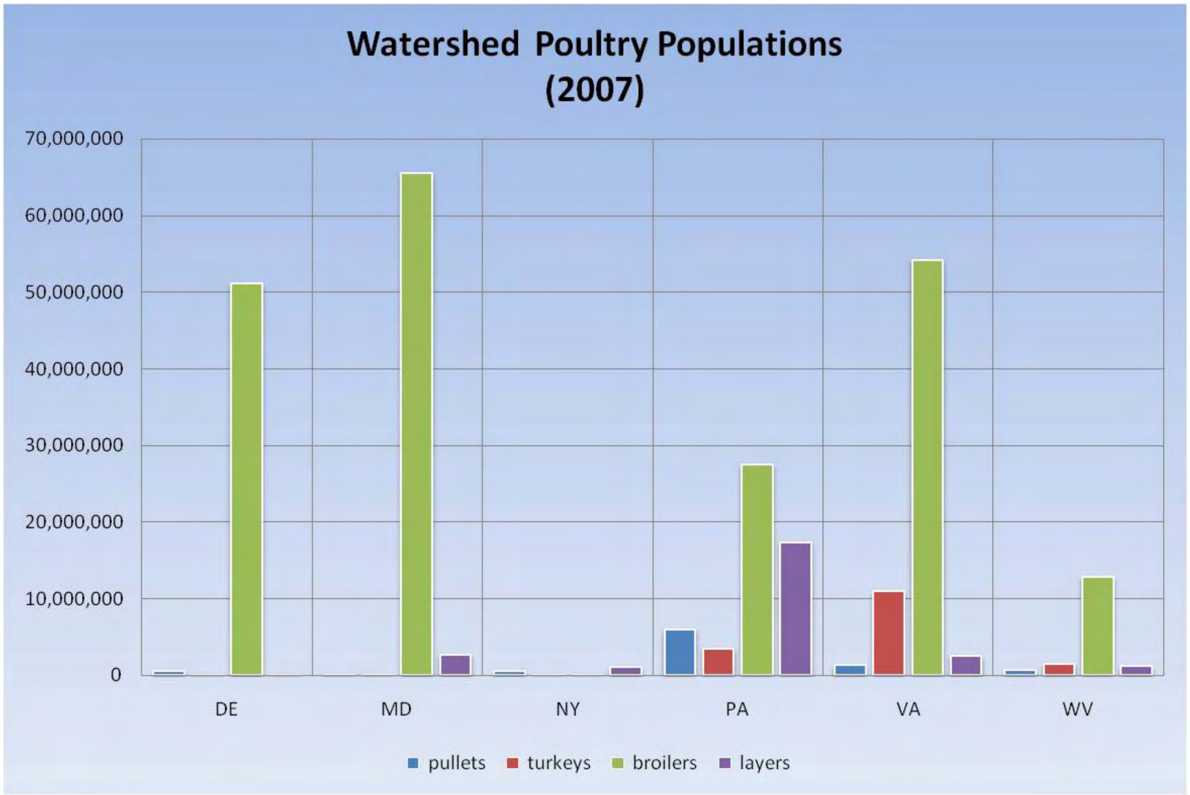
Manure

Animal populations vary across the Bay watershed by animal type and management. Pastures exist in the watershed for dairy and beef heifers, goats, hogs, and in some places even chickens and turkeys. Animal feed BMPs are recognized by the Chesapeake Bay watershed model, and managing manure from production areas can include a suite of BMPs for storage and handling. Land application of manure is an important nitrogen and phosphorus recycling process in agriculture. Because manure is so extensively used as a resource of nitrogen and phosphorus, it is considered as important as inorganic fertilizer and is an important source of nonpoint source pollution. Figure 4-14 and Figure 4-15 provide historical population data of poultry and non-poultry animals in the watershed, respectively.

Annual manure production is calculated as a daily excreted amount per animal equivalent unit (1 animal equivalent unit equals 1,000 lbs live animal weight). Animal units are estimated for counties on the basis of USDA Agricultural Census data. The total amount of manure produced is then distributed among the applicable land uses, which include pasture, AFO, and other row crop land uses. The percentage of time animals spend in pasture (based on state recommendations) is used to estimate the percentage of total manure produced on pasture lands. For example, 50 percent pasture time equates to 50 percent of the total manure production occurring on pasture lands. Manure produced that is associated with time spent confined is considered to be generated on AFO acres. A fraction of that amount, (15–21 percent depending on animal type) is assumed to remain on the AFO acres (i.e., not captured by storage and handling activities), while the rest is redistributed by land application to pasture and row crop lands. The model simulates AFO acres similarly to urban impervious areas.

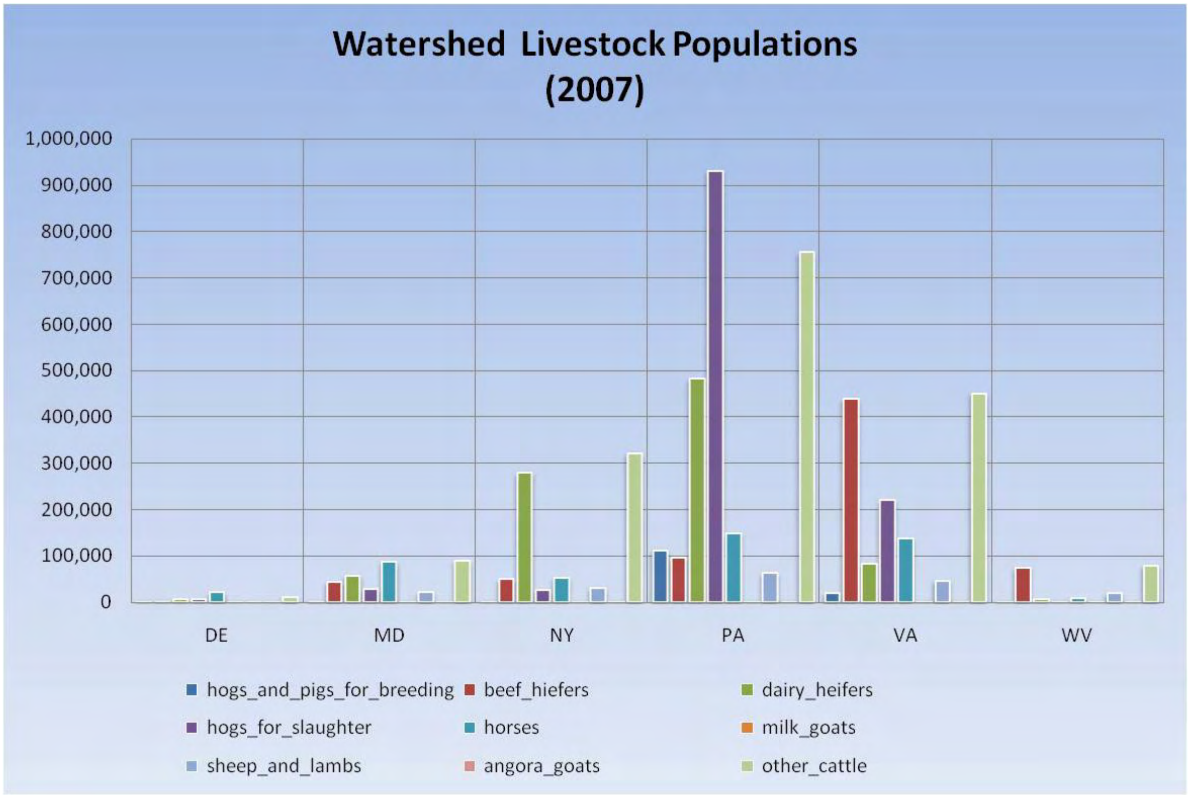
Biosolids

Applying biosolids, the nutrient-rich organic materials resulting from treating sewage sludge, as fertilizer to croplands represents another source of nutrients to the Bay. Biosolids typically contain plant nutrients (nitrogen, phosphorus, and potassium), although the amount of nutrients available from biosolids are normally lower than the amounts from most commercial fertilizers (Huddleston and Ronayne 1990). Nitrogen and phosphorus are the most prevalent nutrients found in sewage sludge.



Source: 2007 Agriculture Census

Figure 4-14. 2007 Chesapeake Bay watershed poultry populations by jurisdiction.



Source: 2007 Agriculture Census

Figure 4-15. 2007 Chesapeake Bay watershed livestock populations by jurisdiction.

Regulations governing use, disposal and application of sewage sludge are in EPA's Sewage Sludge Use or Disposal Regulation (Part 503), which provides a framework for permitting sewage sludge use or disposal. No jurisdictions in EPA Region 3 have applied for program authorization of the federal Part 503. Although all Bay jurisdictions have their own sewage sludge programs in place, only Virginia routinely submits to EPA information regarding land application of biosolids. As a result, information available to characterize biosolids as a source and to represent it in the model is limited.

For model characterization, jurisdiction-specific data on biosolids application were used. Land uses receiving biosolids include crops and pasture/hay, with different monthly proportions based on seasonal growing patterns. Modeled application rates are the same as manure because biosolids are applied to land in the same fashion as manure.

For additional information related to representation of biosolids in the Bay TMDL, see the Phase 5.3 Chesapeake Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169

Chemical Fertilizer

Chemical fertilizer application practices across the watershed can be estimated through commercial sales information. Fertilizer sales data are prepared by the Association of American Plant Food Control Officials on the basis of fertilizer consumption information submitted by state fertilizer control offices. The consumption data include total fertilizer sales or shipments for farm and non-farm use. Liming materials, peat, potting soils, soil amendments, soil additives, and soil conditioners are excluded. Materials used for the manufacture or blending of reported fertilizer grades or for use in other fertilizers are excluded to avoid duplicate reporting. A review of commercial fertilizer sales records (from 1982 to 2007) showed that in all states, the sales are increasing. The increase can be attributed to both yield increases and increasing application. Removing the yield increases resulted in persistent increasing trends in chemical fertilizer nutrient application (except in Maryland where the trend is flat).

Model estimates of commercial fertilizer loads have been derived by back-calculating load from agricultural lands and determining the proportion of nutrient species applied from commercial fertilizer, manure, and atmospheric deposition.

As phosphorus-based nutrient management plans increase, the reliance on nitrogen fertilizer is expected to increase because less manure will be legally permitted to be applied to agricultural lands. Therefore chemical fertilizers are and will remain a significant potential source of nitrogen and phosphorus to the Bay.

4.6.2 Atmospheric Deposition

Air sources contribute about one-third of the total nitrogen loads delivered to the Chesapeake Bay by depositing directly onto the tidal surface waters of Chesapeake Bay and onto the surrounding Bay watershed. Direct deposition to the Bay’s tidal surface waters is estimated to be 6 to 8 percent of the total (air and non-air) nitrogen load delivered to the Bay. The nitrogen deposited onto the land surface of the Bay’s watershed and subsequently transported to the Bay is estimated to account for 25 to 28 percent of the total nitrogen loadings delivered to the Bay.

Atmospheric loads of nitrogen are from chemical species of oxidized nitrogen, also called NOx, and from reduced forms of nitrogen deposition, also called ammonia (NH_4^+). Oxidized forms of nitrogen deposition originate from conditions of high heat and pressure and are formed from inert diatomic atmospheric nitrogen (N_2). The principle sources of NOx are industrial-sized boilers such as electric power plants and the internal combustion engines in cars, trucks, locomotives, airplanes, and the like.

Reduced nitrogen, or ammonia, is responsible for approximately one-third of the total nitrogen atmospheric emissions that eventually end up as loads to the Bay. Ammonia sources are predominately agricultural, and ammonia is released into the air by volatilization of ammonia from manures and emissions from ammonia based fertilizers. Minor sources include mobile sources, slip ammonia released as a by-product of emission controls on NOx at power plants, and industrial processes.

Two types of atmospheric deposition—wet and dry—are input to the Bay Watershed and Bay Water Quality Models daily. Wet deposition occurs during precipitation events and contributes to nitrogen loads only during days of rain or snow. Dry deposition occurs continuously and is input at a constant rate daily in Bay Watershed and Bay Water Quality Models.

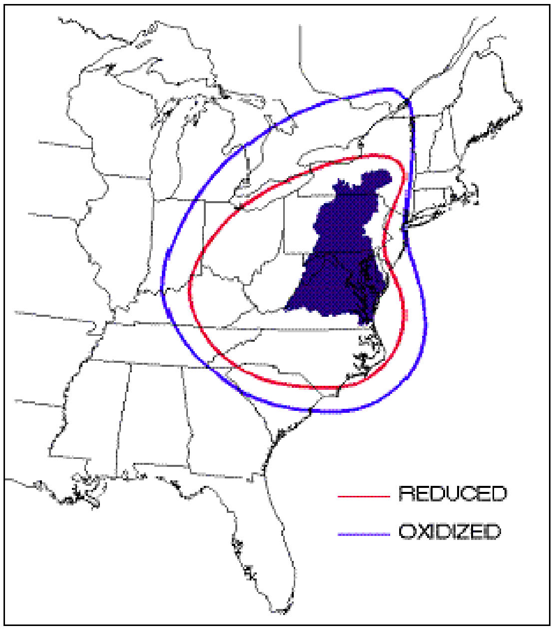
Because the Bay Watershed and Bay Water Quality Models are mass balance models, all sources of nitrogen and phosphorus inputs to the tidal Bay must be accounted for. Given atmospheric deposition of phosphorus and organic forms of nutrients are minor inputs, the Bay Watershed and Bay Water Quality Models account for estimated loads of phosphorus and organic nutrients to open surface waters only, on the assumption that all phosphorus and organic nutrients are derived from aeolian or wind processes, which result in no net change in organic nitrogen on terrestrial or land surfaces but result in a net gain when deposited directly on water surfaces.

Organic nitrogen is simulated only as wet deposition as dissolved organic nitrogen because the magnitude of dry deposition of organic nitrogen is not well characterized in the literature. Therefore, the limited dry deposition of organic nitrogen simulated by the Bay Airshed Model is lumped into the oxidized nitrogen atmospheric dry deposition.

Atmospheric deposition monitoring in the Chesapeake watershed is through National Atmospheric Deposition Program (NADP) and AirMon stations throughout the watershed. Measured deposition at these discrete stations is used to extrapolate to all the land and waters of the Chesapeake watershed through a wet deposition regression model developed by Grimm and Lynch (2000, 2005; Lynch and Grimm 2003). Dry deposition data are estimated through the Community Multiscale Air Quality Model (CMAQ) (Dennis et al. 2007; Hameedi et al. 2007) (for more details, see Section 5.4).

Chesapeake Bay Airshed

The Bay's NOx airshed—the area where emission sources that contribute the most airborne nitrates to the Bay originate—is about 570,000 square miles, or nine times the size of the Bay's watershed (Figure 4-16). Close to 50 percent of the nitrate deposition to the Bay is from air emission sources in Bay watershed jurisdictions. Another 25 percent of the atmospheric deposition load to the Chesapeake watershed is from the remaining area in the airshed. The remaining 25 percent of deposition is from the area outside the Bay airshed. The ammonia airshed is similar to the NOx airshed, but slightly smaller.

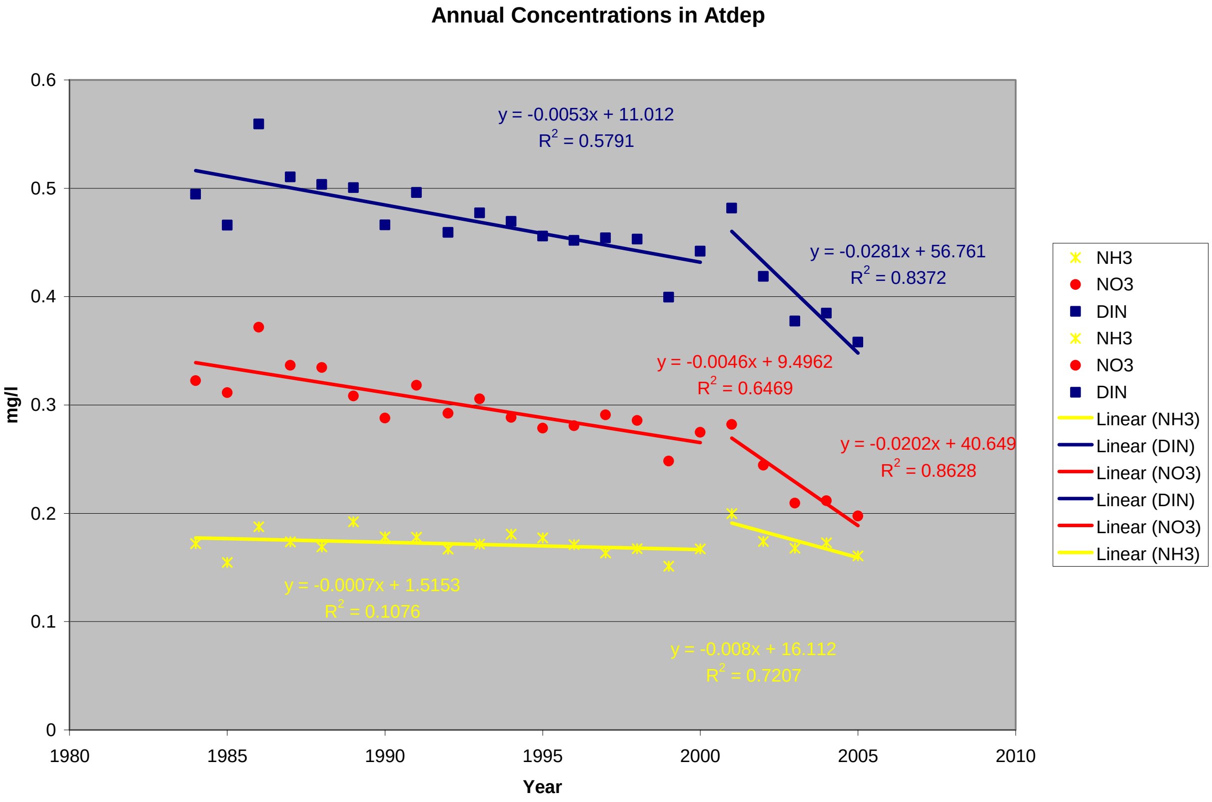


Source: Dr. Robin Dennis, EPA/ORD/NERL/AMAD/AEIB

Figure 4-16. Principle area of NO_X emissions (outlined in blue) that contribute nitrogen deposition to the Chesapeake Bay and its watershed (solid blue fill) (the Bay airshed).

Atmospheric Deposition Emissions Sources and Trends

Between 1985 and 2005, the simulation period of the Bay Watershed Model, atmospheric deposition loads of nitrate (NOx) in the Chesapeake watershed have decreased by about 30 percent (Figure 4-17). Considerable variability exists across the watershed, however, with the greatest reductions occurring in the northern and western portions (Grimm and Lynch 2000, 2005; Lynch and Grimm 2003). Figure 4-17 shows the trend of estimated average nitrate and ammonia deposition concentrations in the Phase 5 Model from 1984 to 2005. The average annual concentration from 1984 to 2005 was used as an adjustment to smooth out the high- and low-rainfall years, which bring different amounts of deposition load to the watershed depending on the volume of precipitation. Much of the reduction has been from point source air emission reductions, particularly from electric generating units (EGUs) such as electric power plants. Reductions from mobile sources, such as cars and trucks, are another large contributor to the downward trend.



Source: Phase 5.3 Chesapeake Bay Watershed Model.

Figure 4-17. Trend of estimated average nitrate and ammonia deposition concentrations in the Phase 5 Model domain from 1984 to 2005.

Table 4-17 shows the estimated portion of deposited NOx loads on the Chesapeake watershed from four sectors including EGUs, mobile sources, industry, and all other sources. From 1990 to 2020, considerable reductions have been made in the power sector. In addition, both on road and off-road mobile sources have ongoing fleet turnover and replacement, which is putting cleaner spark and diesel engines in service, and that is expected to continue beyond 2030. Table 4-17 shows that in 1990, EGUs are the dominant source of NOx; in 2020, mobile sources will be the dominant sources of NOx with EGUs the least contributor of NOx. However Figure 4-17 shows that all sources will be decreasing their NOx emissions, and the total deposition load in 2020 will be less than the 1990 load.

Average ammonia loads over the Phase 5 Chesapeake Bay Watershed Model domain have followed the trend in overall manure loads in the watershed and have remained steady over the 1985 to 2000 simulation period (Figure 4-17). Ammonia deposition is very site-specific and strongly influenced by local emissions. Local and regional trends in manure, such as the rise of poultry animal units in the Eastern Shore and Shenandoah basins and reduction of dairy farms in the northern portions of the watershed in the late 1980s, affect regional ammonia deposition in the Chesapeake watershed.

Table 4-17. Estimated portion of deposited NOx loads on the Chesapeake watershed from four source sectors—EGUs, mobile sources, industry, and all other sources in 1990 and 2020

Source sector	1990	2020
Power plants (EGUs)	40%	17%
Mobile sources (on-road)	30%	32%
Industry	8%	20%
Other (off-road-construction; residential, commercial)	21%	31%

Source: Dr. Robin Dennis, EPA/ORD/NERL/AMAD/AEIB

4.6.3 Forest Lands

Forested areas represent a significant portion of the Chesapeake Bay watershed (see Figure 2-3), as approximately 70 percent of the watershed is composed of forested and open wooded areas. This land use contributes the lowest loading rate per acre of all the land uses, however. Compared with other major pollutant source sectors in 2009, forest lands in the Bay watershed contributed an estimated 20 percent (49 million pounds per year) of total nitrogen, 15 percent (2.4 million pounds per year) of total phosphorus, and 18 percent (730,000 tons per year) of sediment of the total delivered loads to the Bay from the watershed (Bay Watershed Model 2009 Scenario).

Forest land differs from most land uses in that a significant portion of the loads that come off the land do not originate in the forests. Most of the nitrogen loads come from atmospheric deposition of nitrogen (Campbell 1982; Langland et al. 1995; Ritter and Chirnside 1984; Stevenson et al. 1987; Nixon 1997; Castro et al. 1997; Goodale et al. 2002; Pan et al. 2005; Aber et al. 1989; 2003; Stoddard 1994). Sediment and phosphorus loads originate from poorly managed forest harvesting with unprotected stream crossings and unhealthy forest biota (Riekerk et al. 1988; Clark et al. 2000).

The Bay Watershed Model differentiates between harvested and un-harvested forest lands as distinct land uses. Un-harvested forest lands contributed 1.63 lbs of nitrogen, 0.08 lb of phosphorus, and 0.02 ton of sediment per acre, which is the lowest loading rate of any land use. In contrast, harvested forest contributes 10.30 lbs of nitrogen, 0.47 lb of phosphorus, and 0.19 ton of sediment per acre. The loads from harvested forest can be greatly reduced by using forest harvesting BMPs. The loads are estimated through model calibration, which estimates loading rate per area on the basis of monitoring stations in forested areas.

For additional information related to the representation of forest lands, see the Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

4.6.4 On-site Wastewater Treatment Systems

Onsite Wastewater Treatment Systems (OSWTS), commonly referred to as septic systems, have the potential to deliver nitrogen and phosphorus to surface waters directly because of system failure and malfunction and indirectly through groundwater. Septic systems treat human waste using a collection system that discharges liquid waste into the soil through a series of distribution lines that compose the drain field. In properly functioning (normal) systems, phosphates are adsorbed, or gathered onto the soil surface, and retained by the soil as the effluent percolates through the soil to the shallow, groundwater table. Therefore, functioning systems do not contribute nitrogen and phosphorus loads to surface waters directly. A septic system failure occurs when there is a discharge of waste to the soil surface where it is available for washoff. As a result, failing septic systems can contribute high nitrogen and phosphorus loads to surface waters. Short-circuited systems (those close to streams) and direct discharges to streams also contribute significant nitrogen and phosphorus loads.

OSWTSs represented an estimated 6 percent of the total nitrogen load from the Chesapeake watershed in 2009 (Bay Watershed Model 2009 Scenario). Information on the watershed loads from OSWTSs is generally sparse. Detailed descriptions of data procedures, source information, and assumptions used in estimating those loads are in Palace et al. (1998).

For the Chesapeake Bay Watershed Model, the number of OSWTSs in each modeling segment was estimated by calculating the number of households outside areas served by public sewer. One septic system was assumed to exist for each household. Digital maps of 2009 sewer service areas were provided by 257 of the 403 major wastewater treatment plants in the watershed contacted during a 2009 survey sponsored by EPA. Digital data were also provided by the Maryland Department of Planning for all of Maryland, Fairfax County, and the Washington Council of Governments. In 2008 the CBP Office contacted some local jurisdictions and collected sewer service area data for all three Delaware counties, Albemarle, Arlington, Henrico, Loudoun, and Rockingham counties in Virginia and for James City, Newport News City, Virginia Beach, and Richmond in Virginia. Data were also collected for Perry, Dauphin, Lancaster, Lycoming, and Cumberland counties in Pennsylvania, and for Broome County in New York. For those major wastewater treatment plants that did not provide data and were not included in data supplied by county or state agencies, the extent of their sewer service area was estimated on the basis of population density.

EPA simulated the extent of existing sewer service areas using a thresholded and log-transformed raster data set of year 2000 population density. A population density raster was created using a dasymetric mapping technique with 2000 Census Block Group data and a secondary road density raster map (Claggett and Bisland 2004). A logarithmic transformation was used to normalize the population density data in the surface raster. The standard deviations in the data range were examined to find the optimal threshold for representing sewer service areas in Maryland because statewide maps of existing sewer service areas were provided by the Maryland Department of Planning. A threshold of 1.5 standard deviations from the mean (> –0.4177) was chosen and used to reclassify the surface raster into a binary grid. A low-pass filter (ignoring no data) was then used to smooth the data, and the output was converted from a floating point to an integer grid. The resulting integer grid was used to represent potential sewer service areas for wastewater treatment plants that did not submit digital data. Households in the Bay watershed were mapped using a similar dasymetric mapping technique and 2000 Census household data. The resulting raster data set of households was overlaid on the sewer service area map to estimate the number of households outside sewer service areas. The data were scaled from the year 2000 to the year 2009 using published annual county-level population estimates adjusted for changes in average household size. In addition, the data were scaled back through time using county-level population estimates and spatially distributed raster data sets representing 1990 and 2000 Census Block Group data on the total number of households.

Using that methodology, the number of OSWTSs is estimated and the nitrate loads exported to the river from OSWTSs are simulated. Phosphorus loads are assumed to be entirely attenuated by the OSWTSs. Standard engineering assumptions of per capita nitrogen waste and standard attenuation of nitrogen in the septic systems are applied. Overall, the assumption of a load of 4.0 kg/person-year is used at the edge of the OSWTS field, all in the form of nitrate.

Using an average water flow of 75 gallons/person-day for a septic tank (Salvato 1982), a mean value of 3,940 grams of nitrogen/person-year for groundwater septic flow, 4,240 grams/person-year for surface flow of septic effluent, and typical surface/subsurface splits as reported by Maizel et al. (1995), a total nitrogen concentration of about 39 mg/L at the edge of the septic field was calculated. This concentration compares favorably with Salvato (1982) who calculated OSWTS total nitrogen concentrations of 36 mg/L. It is assumed that attenuation of the nitrate loads between the septic system field and the edge-of-river nitrate loads represented in the Bay Watershed Model is due to: (1) attenuation in anaerobic saturated soils with sufficient organic carbon (Robertson et al. 1991; Robertson and Cherry 1992); (2) attenuation by plant uptake (Brown and Thomas 1978); or (3) attenuation in low-order streams before the simulated river reach. Overall, the total attenuation is assumed to be 60 percent (Palace et al. 1998) that is applied to all OSWTS in the Bay watershed except for MD where the zone specific attenuation rates developed by MDE were used. MDE assumes an 80 percent delivery rate (or 20 percent attenuation) in critical areas; a 50 percent delivery rate within 1,000 feet from any perennial surface water; and a 30 percent delivery rate from distances greater than 1,000 feet from any perennial surface water (http://www.mde.state.md.us/assets/document/NutrientCap_Trading_Policy.pdf).

Additional information related to how the number of OSWTSs is estimated and how they are represented in the model is available in the Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169

4.6.5 Nonregulated Stormwater Runoff

The sources of nitrogen, phosphorus and sediment from nonregulated stormwater are generally the same as those from regulated stormwater. Sources include residential and commercial application of fertilizer, land disturbance and poorly vegetated surfaces, atmospheric deposition of nutrients, pet wastes, and developed properties. Together with regulated stormwater, the nitrogen, phosphorus, and sediment loads affect local water quality and habitats and represent a significant proportion of nitrogen, phosphorus, and sediment loads to the Bay. The CBP estimates that, in 2009, urban and suburban development and runoff contributed to 16 percent of the sediment loadings, 15 percent of the phosphorus loadings, and 8 percent of the nitrogen loadings to the Bay (Bay Watershed Model 2009 Scenario).

The regulated sources of stormwater are discussed in the point sources section above (4.5.5). For the purposes of the TMDL, urban and suburban runoff occurring outside the NPDES regulatory purview is considered nonpoint source loading and is a component of the LA. However, note that CWA section 402(p) provides the authority to regulate many of those discharges. If any of the discharges are designated for regulation, they would then be considered part of the WLA. As discussed in Section 8 some of the unregulated sources of stormwater are being shifted from the LA portion to the WLA portion of the TMDL as potential regulated sources to further increase the reasonable assurance that the TMDL reductions will be achieved. Some jurisdictions might have state stormwater regulatory programs and, therefore, could have little to no nonregulated stormwater sources.

For additional details related to how the non-regulated stormwater runoff loads were estimated in the Bay Watershed Model, see Section 7 in the Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

4.6.6 Oceanic Inputs

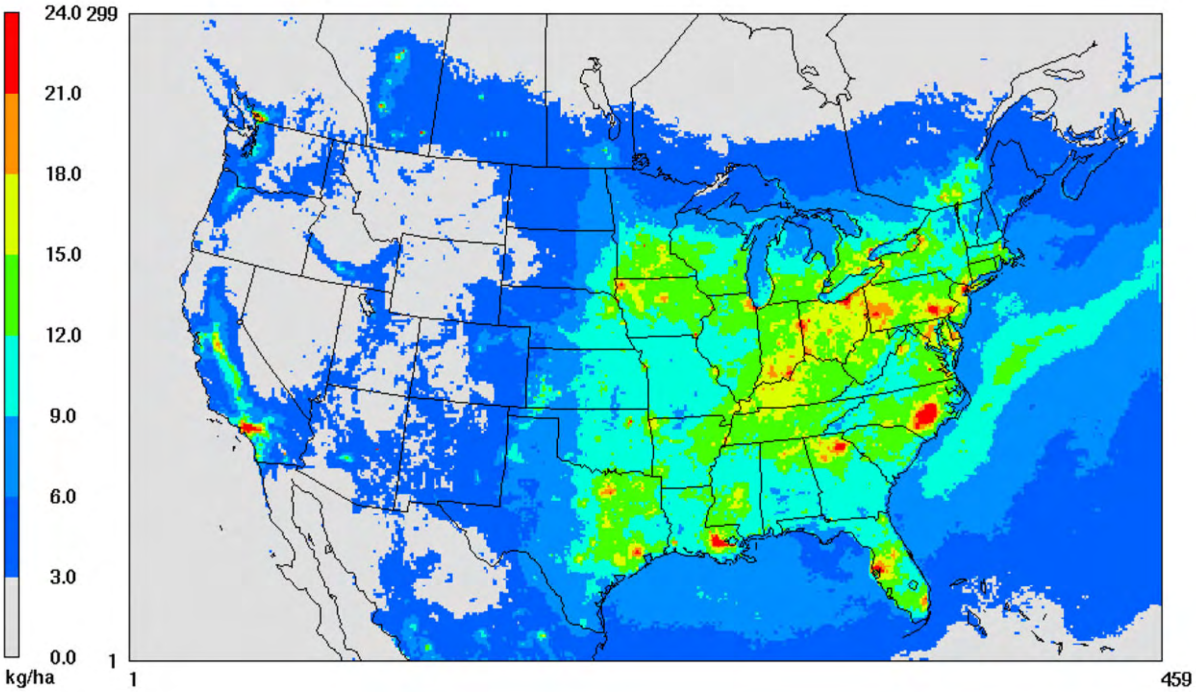
The Chesapeake Bay is an estuary and, by definition, a mixture of fresh and salt water. The relative proportion of ocean water in any region of the Bay can be roughly estimated by its salinity because salt is a perfectly conservative tracer. The salinity of full strength seawater just outside the Chesapeake Bay mouth is about 35 parts per thousand (ppt). At mid-Bay around the where Potomac River enters the mainstem Bay, the salinity drops to about 15 ppt, or a mixture of about half seawater (43 percent) and at the Bay Bridge between Annapolis and Kent Island, Maryland, salinity drops to about 6 ppt or 20 percent seawater. While nitrogen, phosphorus and sediment concentrations are relatively low in ocean water, the large volume of seawater entering the Bay brings considerable nitrogen, phosphorus, and sediment loads to the Bay.

Ocean input loads of nitrogen, phosphorus, and sediment to the Chesapeake Bay are determined by calibration to the three Bay water quality monitoring stations at the mouth of the Chesapeake Bay by using the Curvilinear-grid Hydrodynamic Three-Dimensional model (CH3D Hydrodynamic Model), which has a model grid and domain that extends about 10 km beyond the mouth of the Bay. Ocean boundary concentrations are set monthly in the Chesapeake Bay Water Quality and Sediment Transport Model (Bay Water Quality Model) to best represent the nitrogen, phosphorus, and total suspended solids concentrations of the monitoring stations at the Chesapeake Bay month on an incoming tide.

A previous study of ocean boundary loads found that when accounting for all input loads to the Chesapeake Bay, including atmospheric deposition to tidal waters and ocean inputs, the ocean inputs were significant and accounted for about one-third of the total nitrogen and about half the total phosphorus loads to the Bay (Thomann et al. 1994). Ocean sediment inputs are predominantly sand and have little influence on light attenuation beyond the Bay mouth and lower mainstem Bay.

Several nutrient budgets of the ocean waters off the Chesapeake, also called the Middle Atlantic Bight, have been made (Fennel et al. 2006; Howarth et al. 1995; Howarth 1998). Howarth (1998) estimates that for the northeast coast of the United States, which includes the discharge of all watersheds from Maine to Virginia draining to the Atlantic, the watershed inputs of nitrogen to coastal waters are 0.27 teragram (10^{12} grams) from rivers and estuaries. Estimated inputs from direct atmospheric deposition to coastal waters are 0.21 teragram, and inputs from deep ocean upwelling are 1.54 teragrams for a total input to the coastal ocean of 2.02 teragrams.

The direct atmospheric deposition loads are roughly equivalent to the watershed loads in the northeast United States. The estimated distribution of 2001 atmospheric deposition loads to North America and adjacent coastal ocean is shown in Figure 4-18. Using the Community Multi-scale Air Quality (CMAQ) Model estimates of atmospheric deposition loads to the coastal ocean under different air scenarios provides a means of adjusting the ocean boundary loads to changes in atmospheric deposition. Appendix L describes how the ocean boundary loads were adjusted to reflect projected changes in nitrogen atmospheric deposition to the coastal ocean and, therefore, coastal ocean nitrogen loads delivered to Chesapeake Bay.



Source: Dr. Robin Dennis, EPA/ORD/NERL/AMAD/AEIB

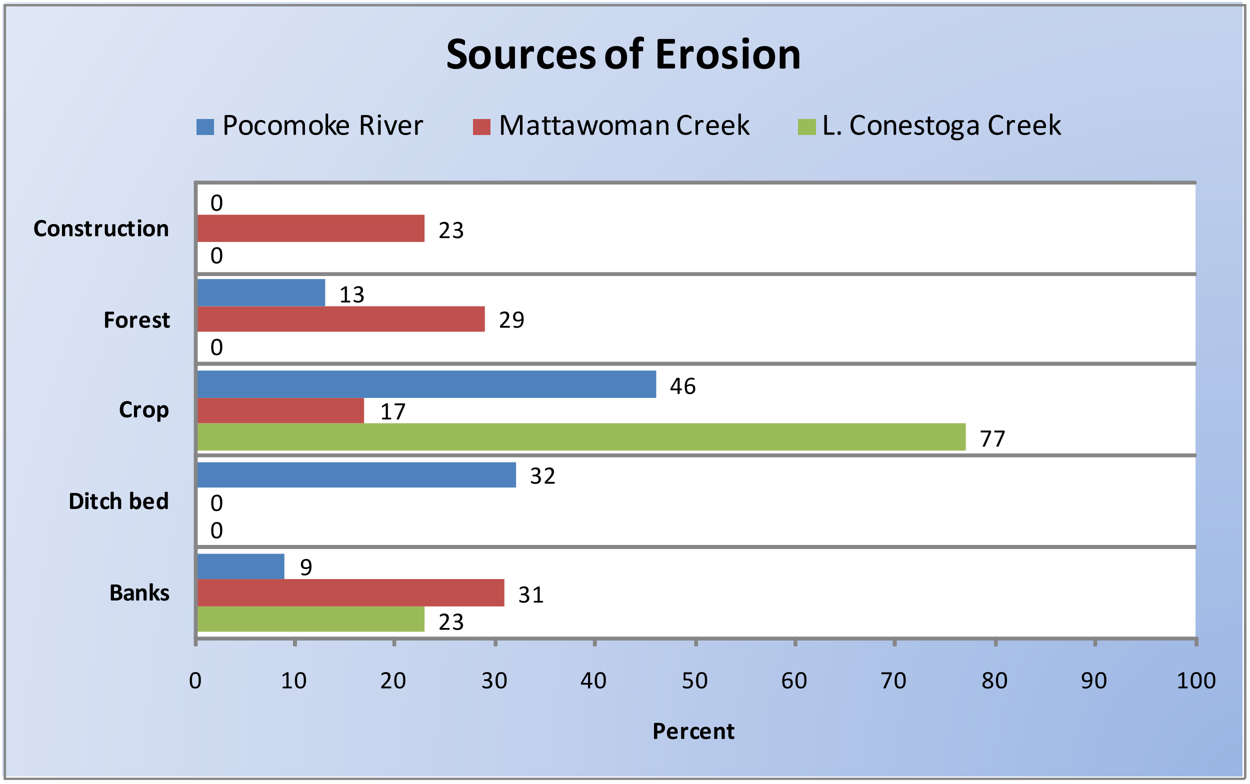
Figure 4-18. Estimated 2001 annual total deposition of nitrogen (kg/ha) to North America and adjacent coastal ocean.

4.6.7 Streambank and Tidal Shoreline Erosion

Steambank Erosion

Streambank erosion is erosion from the reworking of streams and rivers, either as flow rates change as in the case of increased imperviousness in a watershed (Center for Watershed Protection 2003), because of long-term changes in the landscape (Walter and Merritts 2008; Trimble 1999), or as a natural process of river channel dynamics (Leopold et al. 1995).

In the Chesapeake Bay watershed, the relative amounts of streambank erosion and erosion from the land is difficult to quantify (Gellis et al. 2009) because the water quality monitoring stations measure the total suspended sediment in the free-flowing rivers, which is composed of sediment from both sources. The Bay Watershed Model has estimates of land erosion derived from RUSLE estimates made in the National Resource Inventory (http://www.nrcs.usda.gov/technical/NRI/), which could be used to quantify that source of sediment relative to the scour and erosion simulated in the rivers, but both sources of information are thought to be too crude to estimate the splits in erosion loads on a segment basis. However, on a watershed-wide basis, both sources of information estimate that 70 percent of the sediment delivered to the Bay comes from erosion from land and 30 percent comes from bank erosion. That is consistent with other estimates from research and field studies that find a wide variance of the portions of delivered erosion from land surfaces and bank erosion but could be generalized to about one-third of the erosion as coming from bank erosion (Figure 4-19).



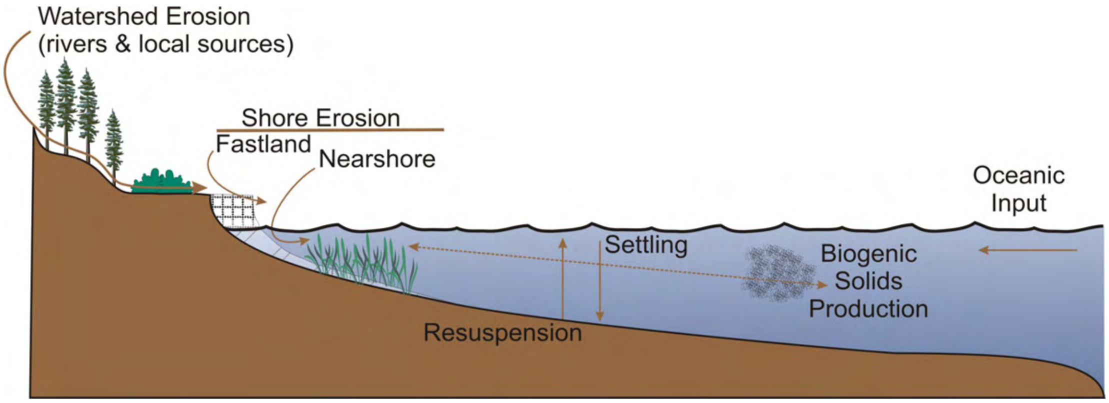
Source: Gellis et al. 2009

Figure 4-19. Relative estimates of sources of erosion from land sources (crop, forest, or construction) or bank sources banks and ditch beds).

Because sediment monitoring stations in the watershed collect all the sediment loads passing the station, including both land erosion and bank erosion sources, the stream bank load is accounted for, ultimately, both in the Chesapeake Bay watershed monitoring network and in the Bay Watershed Model, at least as part of the total combination of sediment from land and riverine sources. In the same way, streambank loads are also accounted for in tracking sediment load reductions from stream restoration actions and through reductions of nitrogen, phosphorus, and sediment tracked in the jurisdictions' WIPs.

Tidal Shoreline Erosion

Tidal shoreline erosion is a combination of the erosion of fastland (or shoreline) and nearshore erosion. Figure 4-20 illustrates the tidal shoreline erosion process. Fastland and nearshore is subtidal and usually unseen. Subtidal erosion can be accelerated when shoreline protection activities such as stone revetment, a facing of stone placed on a bank or bluff to protect a slope, are used. That practice typically cuts off fastland erosion, but the reflected wave energy continues subtidal erosion until the wave energy no longer scours the bottom to the depth of a meter or more.



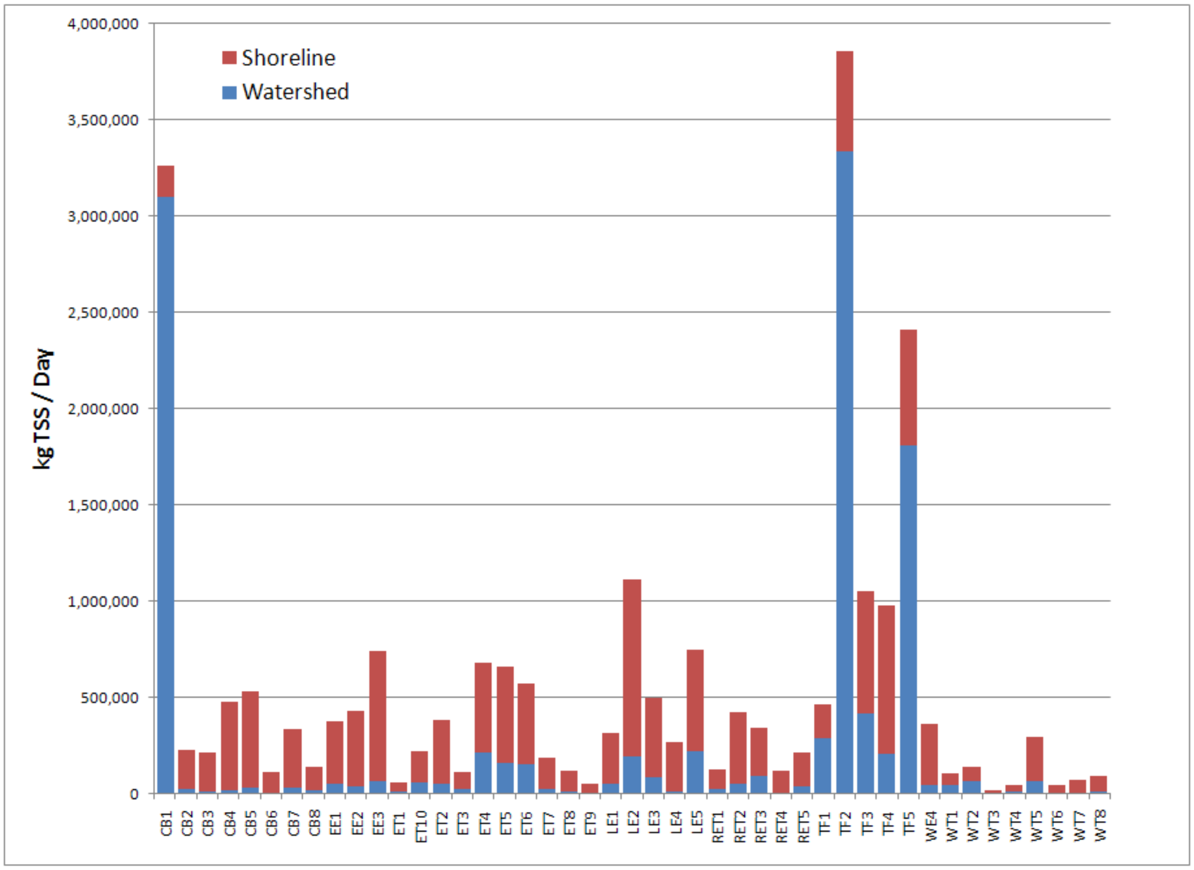
Source: CBP Sediment Workgroup

Figure 4-20. Sources of total suspended solids in the Chesapeake including the two components of shoreline erosions, fastland and nearshore erosion.

Estimates of shoreline erosion were provided for the Bay Water Quality Model. Estimates of the shore recession rate, the elevation of the fastland, and the subtidal erosion rate were used to develop the shoreline erosion estimates. Figure 4-21 demonstrates considerable variation in the sediment load delivered by sediment erosion from segment to segment.

4.6.8 Tidal Resuspension

The bottom of the Chesapeake Bay is covered by sediment that has been either carried into the estuary by rivers draining the Bay's extensive watershed; eroded from the Bay's lengthy shoreline; transported up-estuary from the Atlantic Ocean, through the mouth of the Bay; introduced from the atmosphere; or generated by primary productivity (Langland and Cronin 2003). Tidal resuspension is generated by episodic wave or current energy that scours the bottom sediment and resuspends the surficial sediment layers.



Source: Chesapeake Bay Water Quality and Sediment Transport Model.

Figure 4-21. Estimated tidal sediment inputs for 1990 from the Chesapeake Bay watershed and from shore erosion. Shoreline sediment inputs (here labeled bank load) are estimated to be about equal to watershed inputs (here labeled as nonpoint source).

In the Bay Water Quality Model, a wave resuspension model simulates such episodic events. In some regions of the Bay, resuspended sediment can be one of the most detrimental sediment loads to SAV restoration as shown in results of sediment scoping scenarios run on the Bay Water Quality Model (Table 4-18). The Bay Water Quality Model was run to compare the base scenario of the 2010 Tributary Strategy against model scenarios that individually eliminated watershed loads of total suspended sediment, fall line loads of total suspended sediment, shore erosion loads, sediment resuspension loads, and ocean sediment loads. The model scenarios were run to determine which sediment source was most important. In most of the mainstem Bay, sediment resuspension loads were relatively more detrimental to SAV growth than were other sediment sources.

4.6.9 Wildlife

Wildlife sources are rarely, if ever, considered in nitrogen and phosphorus TMDLs because wildlife only cycle nitrogen and phosphorus that already exist in the system. To the extent that wildlife increases the availability of nitrogen and phosphorus for runoff, wildlife nitrogen and phosphorus loads are inherently represented in land use sources. As a specific example, the loads

Table 4-18. Chesapeake Bay Water Quality and Sediment Transport Model -simulated SAV acres under a range of sediment scoping scenarios compared with the 2010 Tributary Strategy scenario

CBSEG	SAV acre	No watershed loads % increase over base	SAV acre	No fall line loads % increase over base	SAV acre	No shore erosion loads % increase over base	SAV acre	No resuspension loads % increase over base	SAV acres	No ocean sed loads % increase over base
CB1TF	11,253	23%	11,001	20%	9,751	6%	10,344	13%	9,173	0%
CB2OH	212	63%	192	47%	177	36%	269	107%	138	6%
CB3MH	609	44%	539	28%	478	13%	704	67%	450	7%
CB4MH	1,150	30%	1,039	18%	1,096	24%	1,671	89%	980	11%
CB5MH	9,432	9%	9,086	5%	10,341	20%	14,055	63%	9,177	6%
CB6PH	825	21%	695	2%	701	3%	980	44%	728	7%
CB7PH	14,236	4%	13,798	1%	13,959	2%	14,582	7%	14,162	4%
CB8PH	6	25%	5	17%	5	5%	6	29%	5	18%

a. The percentages are the percentage increase in simulated SAV acres over the 2010 Tributary Strategy scenario SAV acres.

from the wooded land incorporate nitrogen and phosphorus loads that are cycled through wildlife. The overall loads from the watershed and each land use type are calibrated to observed data and literature load estimates, which also include loads cycled through wildlife. As a result, no explicit allocation to wildlife is necessary or appropriate in the Bay TMDL.

4.6.10 Natural Background

The Bay Airshed Model, Watershed Model, and Bay Water Quality Model all include the loads from natural background conditions because all the Bay models are mass balance models and are calibrated to observed conditions. For example, the atmospheric deposition loads are monitored principally at the NADP sites. The deposition measured at those sites includes NOx from natural sources, which includes lightning, forest fires, and bacterial processes such as nitrification, which oxidizes ammonia (NH_3) to NO_2 or NO_3. Those sources compose about 1 percent of the NOx deposition in the Chesapeake region (USEPA 2010i). Natural background sources of ammonia are easily volatilized from land and water surfaces and are generated from the decay (ammonification) of natural sources of organic nitrogen. Those are likewise a relatively small portion, relative to anthropogenic sources, of the atmospheric loads estimated by the NADP sites.

Natural loads of nitrogen, phosphorus, and sediment from forested land are also part of the monitored load at the free-flowing stream, river, and river input monitoring stations throughout the Chesapeake Bay watershed. Because the loads are part of the total loads to which the Chesapeake Bay Program’s mass balance models are calibrated, the natural nitrogen, phosphorus, and sediment loads in the system, while small, are fully accounted for in the Bay TMDL assessment.

The natural background loads can best be estimated by simulating the All Forest scenario, which includes no point source, manure, or fertilizer loads. Atmospheric deposition loads in that scenario are set at estimated pristine levels. The scenario yields delivered nitrogen, phosphorus, and sediment loads that are more than an order of magnitude less than current conditions (see Appendix J).

SECTION 5. CHESAPEAKE BAY MONITORING AND MODELING FRAMEWORKS

For purposes of developing the Chesapeake Bay TMDL, data and scenario results from extensive monitoring networks and a series of linked environmental models simulating the nitrogen, phosphorus, and sediment pollutant load sources and the associated water quality and biological responses have been applied to support decision making by EPA and its partner Bay watershed jurisdictions. The suite of models were developed, calibrated, and verified using long-term Bay, watershed, airshed, and land-cover monitoring network observations and published technical and scientific findings.

The suite of Bay and watershed monitoring networks and the Bay modeling framework provide the most accurate and reliable representations of the complex Bay water quality processes currently available. Quality assured monitoring data collected over multiple decades from hundreds of stations provides the most direct measures of Bay and watershed water quality conditions and biological responses. The linked Bay models are valuable tools in synthesizing an enormous amount of data and scientific findings, projecting possible outcomes to a range of management actions, and assessing pollutant load reductions needed to restore Bay water quality. Although models have some inherent uncertainty, the amount of data and resources taken to develop, calibrate, and verify the accuracy of each of the Bay models, minimized the uncertainly of the suite of Bay models.

5.1 TECHNICAL MONITORING AND MODELING REQUIREMENTS

The combined Chesapeake Bay monitoring networks and modeling frameworks effectively address all the factors necessary for developing a scientifically sound and reliable TMDL that meets the TMDL regulatory requirements. The factors addressed in and through the various monitoring networks and linked models include the following:

- Regulated point sources and non-regulated nonpoint sources of nitrogen, phosphorus, and sediment are fully considered and evaluated separately in terms of their relative contributions to water quality impairment of the Chesapeake Bay’s tidal waters.
- Water quality impairments in the Chesapeake Bay and its tidal tributaries and embayments are temporally and spatially variable and are directly linked to nitrogen, phosphorus, and sediment pollutant loadings.
- Time-variable aspects of land-based best management practices that have a large effect on nitrogen, phosphorus, and sediment loadings and resulting water quality in the Bay are fully simulated.
- All sources of data are gathered using documented methodologies fully consistent across the Bay watershed and the Bay’s tidal shorelines and waters helping to ensure equitable allocation of the resultant load reduction responsibility across the seven watershed jurisdictions and multiple pollutant source sectors.
- The Bay modeling framework takes advantage of decades of atmospheric deposition, streamflow, precipitation, water quality, biological resource, and land cover monitoring

data generated through the Bay-wide tidal and basinwide watershed monitoring networks as well as tracking and reporting of the implementation of pollution load reduction best management practices, conservation practices, and technologies for model calibration and verification.

- A wide variety of hydrological conditions, across the decadal-scale model hydrologic periods, have been characterized through decades of Bay watershed and tidal water monitoring to provide reliable simulations in support of management decisions.
- The combined monitoring networks and linked Bay models provide the ability to simulate and assess the critical spatial and temporal variability of the Bay water quality criteria parameters—dissolved oxygen, water clarity, underwater Bay grass acreage, and chlorophyll *a*—as adopted into the four Bay jurisdictions' WQS regulations.

The primary regulatory factor that must be addressed by the combined monitoring networks and linked models is whether the Bay TMDL allocation scenario will attain and maintain the applicable jurisdictions' WQS. To make that assessment, the Bay models must be able to relate the nitrogen, phosphorus, and sediment pollutant loadings from all sources and across all tidal waters to achievement of the four Bay jurisdictions' Chesapeake Bay WQS. A determination that a particular scenario achieves compliance with the applicable water quality criteria within each segment for each of the jurisdictions' WQS requires evaluating the water quality impacts of pollutant loadings on multiple parameters across all seasons over a minimum of 3 years within a 10-year hydrologic period (USEPA 2003a, 2007a). As a result, the full suite of Bay models must provide a time-variable analysis. In addition, to support a determination of reasonable assurance, the Bay modeling framework must also be useful in developing and evaluating action plans for implementation, and confirming those combined implementation actions will yield achievement of Chesapeake Bay WQS (USEPA 2008b, 2009c, 2009d).

5.2 BAY MONITORING FRAMEWORK OVERVIEW

In August 1984, the Chesapeake Bay tidal monitoring program was created to achieve three objectives: characterize the baseline water quality conditions; detect trends in water quality indicators; and increase the understanding of ecosystem process and factors affecting Bay water quality and living resources (MD OEP 1987). The long-term Chesapeake Bay and watershed monitoring networks have accomplished many more objectives in the past 26 years, including the following:

- Classifying status and tracking trends in tidal Bay and Bay watershed water quality and living resources response to management actions and other anthropogenic and natural factors
- Supporting a scientific basis for targeting a dual nitrogen/phosphorus load reduction strategy for Bay water quality and habitat health recovery
- Identifying eutrophication as the primary cause of the SAV decline
- Providing sufficient and diverse data supporting scientifically based and peer-reviewed estuarine water quality criteria development to guide restoration targeting and water quality assessments (e.g., CWA section 303(d) listing/delisting decisions)

- Supporting geographic and pollutant source specific targeted implementation for the most cost effective, reduction efficient management actions
- Supporting decision makers' needs for the Bay TMDL process with high-quality data underlying the Chesapeake Bay watershed and tidal water quality, sediment transport, biological resource, and filter feeder models' development, calibration, verification and management application

5.2.1 Partnership's Chesapeake Bay Tidal Monitoring Network

Undergoing adaptive changes over the almost three decades as the partnership's management needs and requests have significantly evolved over time (CBP 1989a, 1989b; USEPA 2003a; MRAT 2009), the Chesapeake Bay tidal monitoring network includes the following:

- Tidal water quality monitoring for 26 parameters at over 150 stations distributed over the 92 Chesapeake Bay tidal segments across Delaware, the District of Columbia, Maryland, and Virginia
- Shallow-water monitoring addressing a select set of segments on a rotational basis
- Benthic infaunal community monitoring at fixed and random stations across the tidal waters
- Annual aerial and ground surveys of underwater Bay grasses
- Decadal records of phytoplankton and zooplankton monitoring
- Fisheries independent population monitoring programs and surveys

Each component of the tidal monitoring network has been designed to support the four Bay jurisdictions' tidal water Bay section 303(d) listing decision makings, addressing DO, water clarity, SAV, and chlorophyll *a* criteria attainment assessments and benthic infaunal community-based impairment decisions (USEPA 2003a, 2004a, 2007a, 2007b, 2008a, 2010a).

The Bay tidal monitoring network is funded, operated, and maintained through a longstanding state-federal-university partnership that produced the fundamental monitoring data supporting Bay TMDL development. This data is also utilized in public reporting on the health of the Bay, its tidal rivers, and supporting ecosystem; assessment of achieving the Bay jurisdictions' Chesapeake Bay WQS regulations; evaluation of the effectiveness of actions to reduce nitrogen, phosphorus, and sediment pollution loadings from the surrounding watershed; developing, calibrating, verifying and applying models; and generating and reporting water quality and living resource indicators.

Chesapeake Bay Water Quality Monitoring

The long-term Chesapeake Bay water quality monitoring program uses a fixed station strategy with sites distributed along the mid-channel waters of the Bay, its tidal tributaries and embayments. The exact number of stations has varied over the 26-year history of the program. A set of 162 stations that have been sampled consistently for the majority of those years is illustrated in Figure 5-1. One or more stations are in each of the 92 Bay segments. Over the 26-year history of the program, sampling frequency has ranged from 20 times per year to the present 14 cruises annually. Synoptic sampling of all the tidal waters takes 1–2 weeks with the available funding, field staff, and sampling vessel resources.

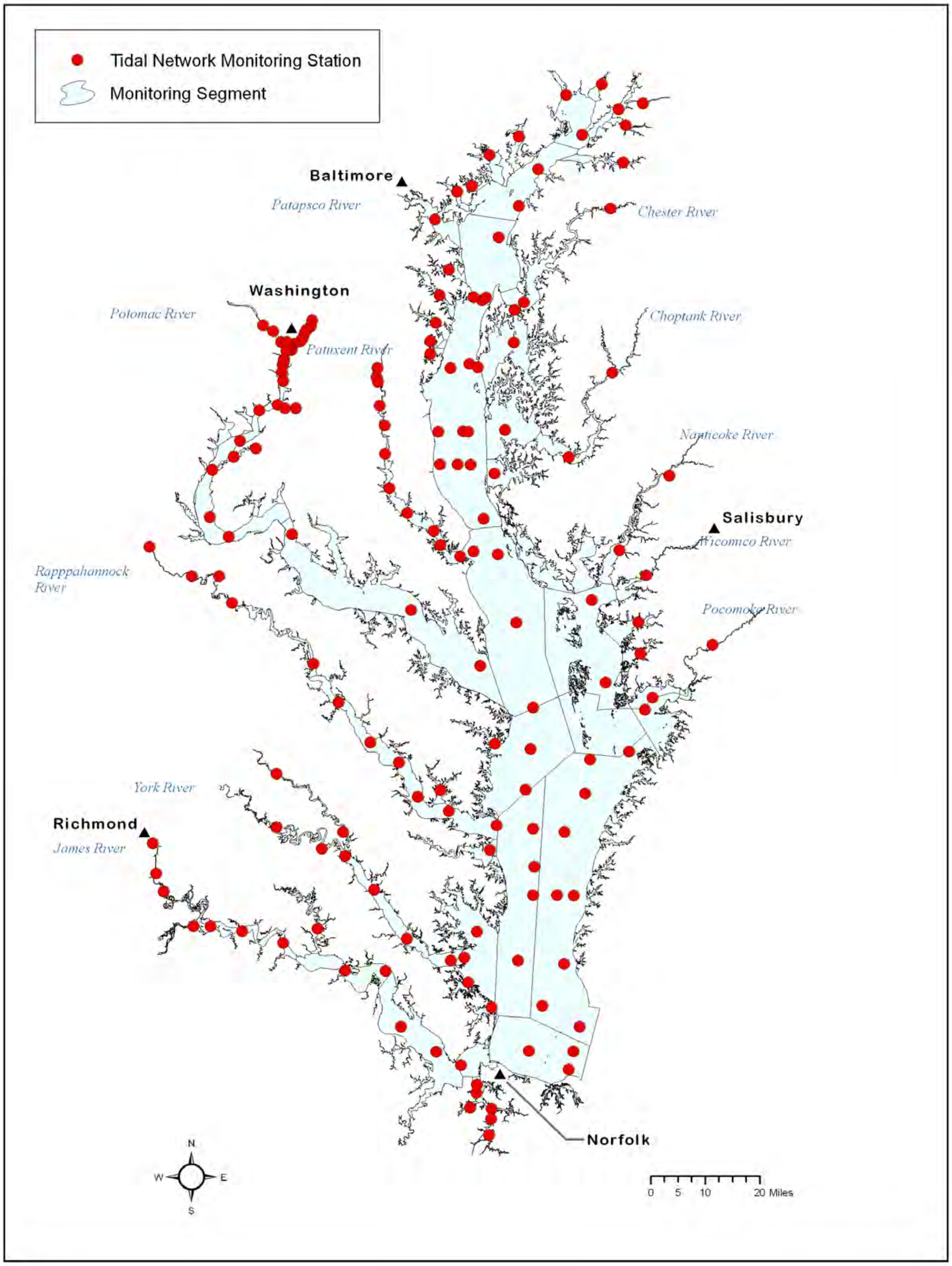


Figure 5-1. Tidal Chesapeake Bay water quality monitoring network stations.

The tidal water quality monitoring program is designed to represent the complexities of the estuary. Every 2–4 weeks, a three-dimensional view is obtained by sampling various depths from the surface to the bottom of the water column at each station, with each of the 92 Bay segments having one or more sampling sites. Sites are sampled at least once each month. Standardized sampling and analytical methods are used to detect low levels of nutrients, chlorophyll *a* and particulates; these methods were approved by EPA in 1986 and are still used today (USEPA 1996).

At each station, vertical profiles of in-situ water quality measurements are made using instrumentation and standard operating procedures approved by the Chesapeake Bay Program's Analytical Methods and Quality Assurance Workgroup (see Section 5.2.3). Measurements are collected at 0.5 m, 1.0 m, 2.0 m, and 3.0 m, and at a maximum of 2-meter intervals from 1.0 m below the surface to 1.0 m above the bottom. Water temperature, DO, conductivity, and pH are recorded at each depth. Photosynthetic Active Radiation (PAR) measurements are made, and Secchi depth measurements are recorded using a Secchi disc.

At stations where stratification provides a pycnocline, as determined by the partnership's approached protocol (USEPA 2004a) discrete samples are collected at 0.5 m below the surface, at 1.5 m above the upper pycnocline, at 1.5 m below the lower pycnocline and at 1.0 m above the bottom. At stations with no identifiable pycnocline as determined by the protocol, discrete samples are collected at 0.5 m below the surface and 1.0 m above the bottom, and at the physical profiling depths which are above one-third and two-thirds the distance between the surface- and bottom-sampling depths. Each of the discrete sample depths corresponds to an in-situ water quality measured profiling depth.

Chesapeake Bay Shallow-Water Monitoring

For shallow-water tidal habitats, monitoring consists of high-speed, spatially detailed water quality mapping (data collected every 4 seconds) called DATAFLOW, and high-frequency (15-minute measurement intervals) continuous monitoring at fixed sites (CONMON) (USEPA 2007a; MD DNR 2009; VIMS 2009). Both DATAFLOW and CONMON record high-resolution measurements of water temperature, DO concentration, DO saturation, pH, salinity (derived from conductivity), turbidity (used to estimate total suspended solids or TSS), and fluorescence (used to estimate chlorophyll *a*).

CONMON measurements are collected March to November. All sondes (i.e. data measurement devices) are either at constant depth of approximately 1 m below the surface or at a fixed depth from the bottom (0.3 m–0.5 m) depending on depth conditions. In addition to the suite of measurements collected by the CONMON meter, LI-COR sensors measure the light penetration at the site on each visit. A Secchi depth measurement is also collected. As a part of standardized operating procedures to ensure data quality, each CONMON site is serviced biweekly unless water quality readings demonstrate that weekly intervals should be maintained. During each site visit, instruments in the water are calibrated against replacement instruments and a third instrument. Discrete water samples are collected for chlorophyll *a*, turbidity, and TSS calibration. Analyses for a suite of nutrient parameters are also conducted on the discrete water sample. Upon swapping out instruments, the instrument removed from the field is returned to the lab for cleaning and lab calibration before being redeployed.

DATAFLOW is conducted on a subset of the 92 Bay segments each year with monthly measurements from April to October. Measurements are made while traveling in a boat at speeds up to 25 knots. The DATAFLOW system is compact, can fit on a small boat, and allows sampling in shallow water every 45 seconds with the ability to map an entire small tidal tributary or embayment in a day or less. This program complements the long-term fixed-station monitoring by providing data in nearshore, shallow-water habitats critical to SAV where water quality behaves differently from those measured in the mid-channel.

DATAFLOW calibration data are collected at multiple sites to either coordinate with long-term or CONMON monitoring stations, and large signal areas to insure coverage of the data gradient with the calibration. Discrete grab water samples are collected for chlorophyll. In addition, measurements of physical parameters (water temperature, DO, conductivity, pH) and Secchi depth are made, and on PAR to calculate water column light attenuation (Kd). There is extensive quality assurance/quality control (QA/QC) on the data set upon returning from the field.

To date, 65 of the 92 Chesapeake Bay segments have 1 to 3 years of shallow-water monitoring data available for assessment (Figure 5-2).

Chesapeake Bay Benthos Monitoring

The current Bay-wide benthic monitoring program, initiated in Maryland in 1984 and in Virginia in 1985, now consists of fixed and random site components (Weisberg et al. 1997; Dauer and Llansó 2003; Llansó et al 2003). The fixed site monitoring program has 53 stations traditionally sampled annually in spring and summer to monitor changes over time (trends). All fixed sites in Maryland and Virginia are sampled using three replicate bottom grabs. The probability-based, random strata sampling was initiated in Maryland in 1994. Since 1996, the probability-based sampling program has become the standardized approach in Virginia as well, providing for a Bay-wide regulatory assessment estimating impaired habitat conditions. The impairment assessment relies on approximately 200 sites sampled between July 15 and September 30 each year (Figure 5-3).

Chesapeake Bay Submerged Aquatic Vegetation Aerial and Ground Surveys

Consistent annual SAV aerial surveys commenced in 1984 and have been completed every year (except 1988) to the present providing detailed mapping of SAV bed coverage, acreage, estimated density, and, in combination with ground survey, species identification (Orth et al. 2010a; VIMS 2009) (Figure 5-4). In 2001 the program increased efficiency and accuracy by scanning aerial photography from digital negatives and orthorectifying (i.e., geometrically correcting) the images using image processing software. SAV beds are categorized visually according to density on the basis of percent cover estimates. SAV beds are generally photographed May through October—lower Bay SAV in May and June, and low salinity and freshwater areas August through October (Figure 5-5) (Orth et al. 2010a; VIMS 2010).

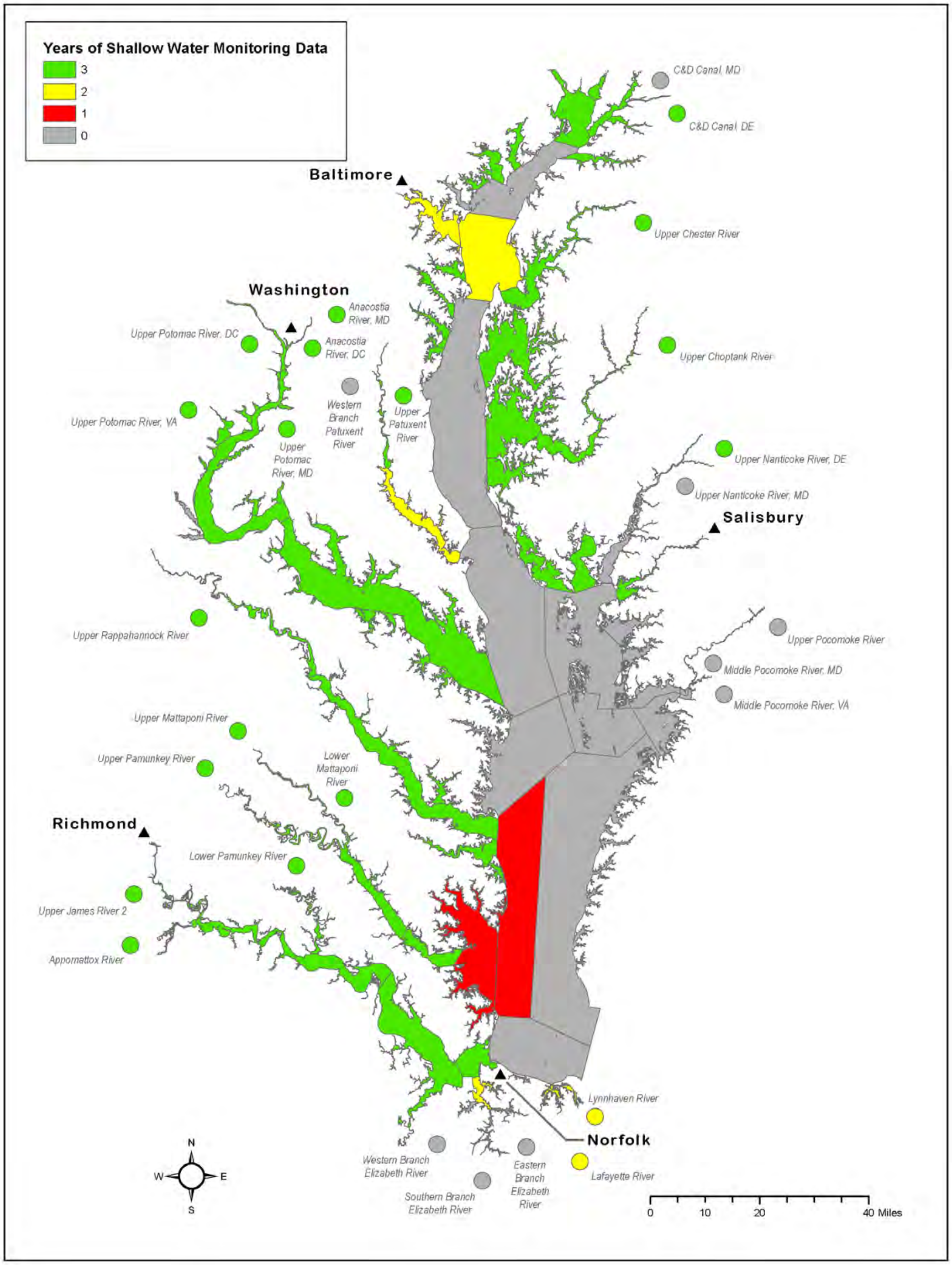
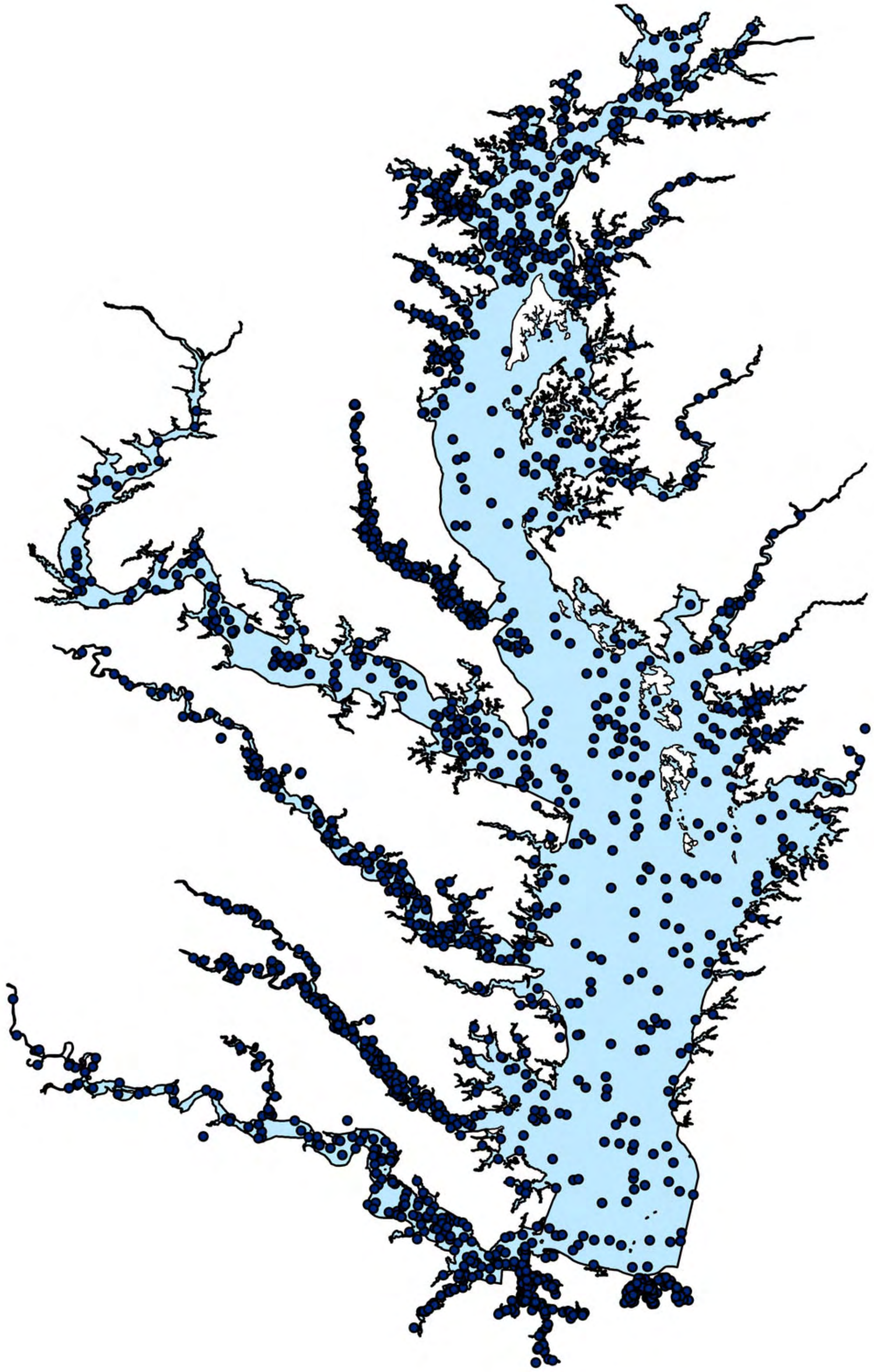
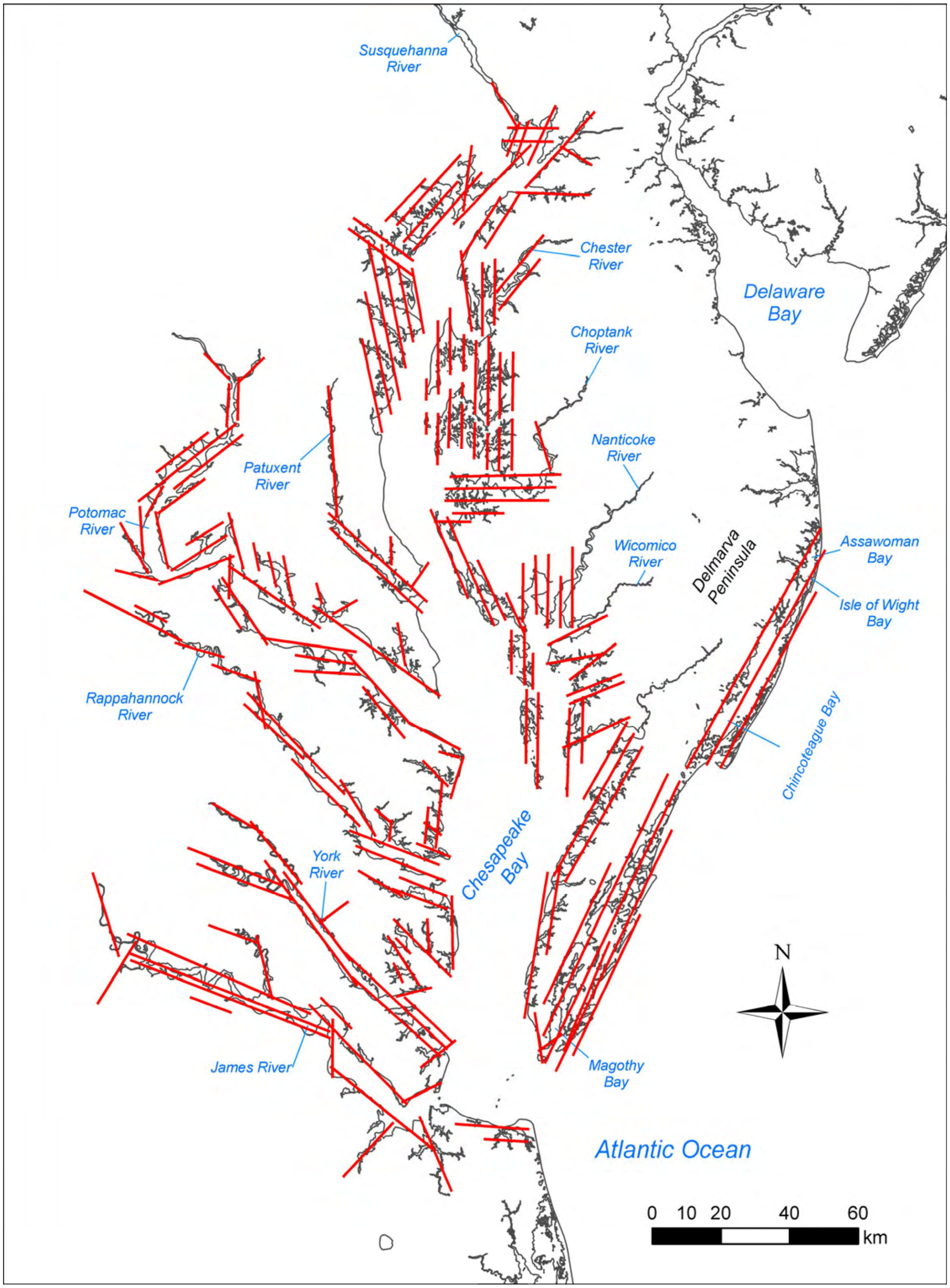


Figure 5-2. Shallow-water monitoring illustrating segment completion and latest rotation for Maryland.



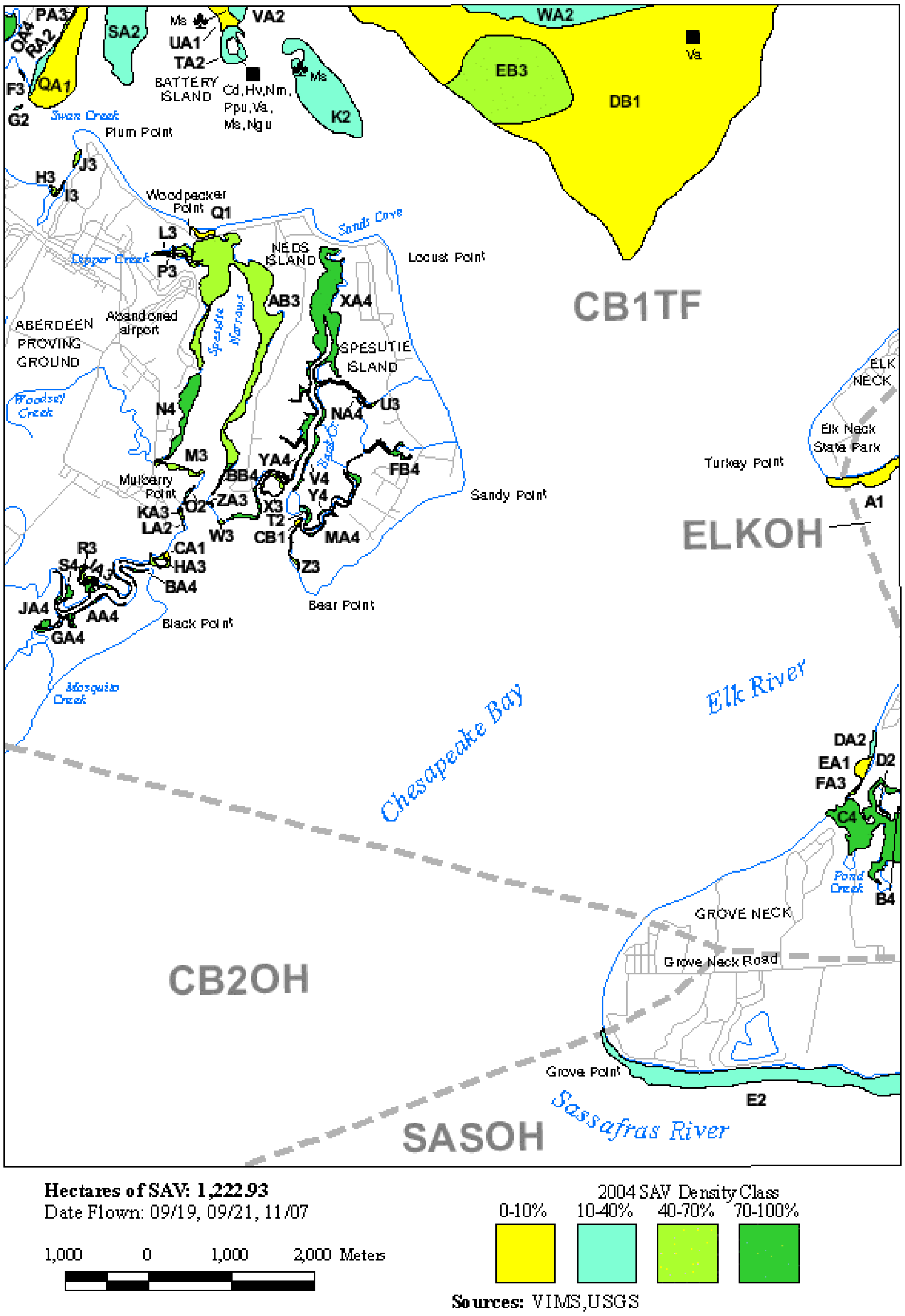
Source: Dauer and Llansó 2003

Figure 5-3. 2003-2008 Chesapeake Bay stratified random benthic sampling sites used to estimate habitat impairment through benthic community condition assessment.



Source: http://www.vims.edu/bio/sav

Figure 5-4. Flightlines for the annual Chesapeake Bay SAV Aerial Survey.



Source: http://www.vims.edu/bio/sav

Figure 5-5. Illustration of mapped SAV beds, individual bed coding, bed density estimates, and species identification (from ground surveys).

Chesapeake Bay Phytoplankton Monitoring Program

The Chesapeake Bay Monitoring Network has included a Phytoplankton Monitoring Program since its start in 1984. Phytoplankton samples for species enumeration, and water samples for laboratory measurements of phytoplankton primary production are collected at fixed monitoring stations in the mainstem and tidal tributaries of the bay (Marshall et al. 2006; Lacouture 2006).

Monitoring has been performed concurrently with water quality monitoring at as many as 32 stations, however, 27 stations are currently active. Staff from Old Dominion University performed monitoring for the Virginia Department of Environmental Quality and by staff from Morgan State University Estuarine Research Center (formerly the Academy of Natural Sciences Benedict Estuarine Research Center) for the Maryland Department of the Environment/Maryland Department of Natural Resources. Monitoring data are available at http://www.chesapeakebay.net/. Virginia data after 1999 is also available at http://www.chesapeakebay.odu.edu/.

Chesapeake Bay Zooplankton Monitoring Program

The Chesapeake Bay Monitoring Network included a Zooplankton Monitoring Program from 1984-2002 (Buchanan 1993; Carpenter et al. 2006). Mesozooplankton and microzooplankton samples for species enumeration were collected at up to 36 fixed monitoring stations in the main stem and tidal tributaries of the bay. Microzooplankton sampling was conducted in Virginia only from 1993-2002 and gelatinous zooplankton occurred only in Maryland. Monitoring usually occurred concurrently with water quality monitoring. Staff from Old Dominion University performed monitoring for the Virginia Department of Environmental Quality and by staff from Versar, Inc and Morgan State University Estuarine Research Center (formerly the Academy of Natural Sciences Benedict Estuarine Research Center) for the Maryland Department of the Environment/Maryland Department of Natural Resources. Monitoring funding was briefly reinstated to count archive samples in 2005. Monitoring data is available at http://www.chesapeakebay.net/. Virginia data collected between 1999 and 2002 is also available at http://www.chesapeakebay.odu.edu/.

Chesapeake Bay Fisheries Monitoring Programs

There are a series of federal, state, and Baywide fisheries monitoring programs and surveys briefly described below.

- **Commercial Landings:** The NOAA National Marine Fisheries Service maintains a database of domestic fishery landings of fish and shellfish beginning with data from 1880, with Chesapeake Bay specific commercial landings data by years, states, and species; by years, states, species, and fishing gears. More information and online data can be found at: http://www.st.nmfs.gov/st1/commercial/.
- **The Blue Crab Winter Dredge Survey**: The survey serves as the only Baywide fishery-independent survey of the blue crab population, provides abundance and relative exploitation estimates, as well as recruitment and female spawning potential indices initiated in 1988 by the Maryland Department of Natural Resources and University of Maryland Chesapeake Biological Laboratory, with the Virginia Institute of Marine Science joining the following year. Data can be obtained from http://www.dnr.state.md.us/fisheries/crab/winter_dredge.html.
- **Maryland Surveys**: The Maryland Department of Natural Resources conducts a series of fisheries surveys including: Potomac River Shad Survey, Maryland American Eel Populations Surveys, Maryland Striped Bass Gill Net Seine Survey, Maryland Upper Bay Trawl Survey, Maryland Shoal Water Trawl Survey, Calvert Cliffs Pot Survey, Maryland Annual Oyster Spat Index and Disease Survey, and the Maryland Oyster Stock Assessment Program. For more information see http://www.dnr.state.md.us/FISHERIES/.

- **Virginia Surveys:** The Virginia Institute of Marine Science conducts a series of fisheries surveys including: Virginia Shad and Herring Gill Net Survey, Virginia American Eel Young of Year Survey, Virginia Striped Bass Monitoring and Tagging Survey, Virginia Shark Long Line Survey, Virginia Striped Bass Young of Year Beach Seine Survey, Virginia Blue Crab Megalopae Monitoring Program, Virginia Juvenile Fish and Blue Crab Trawl Survey, Virginia Spring and Fall Oyster Bar Survey, and the Virginia Oyster Spat Survey. For more information see http://www.vims.edu/research/departments/fisheries/programs/.

5.2.2 Partnership's Watershed Monitoring Network

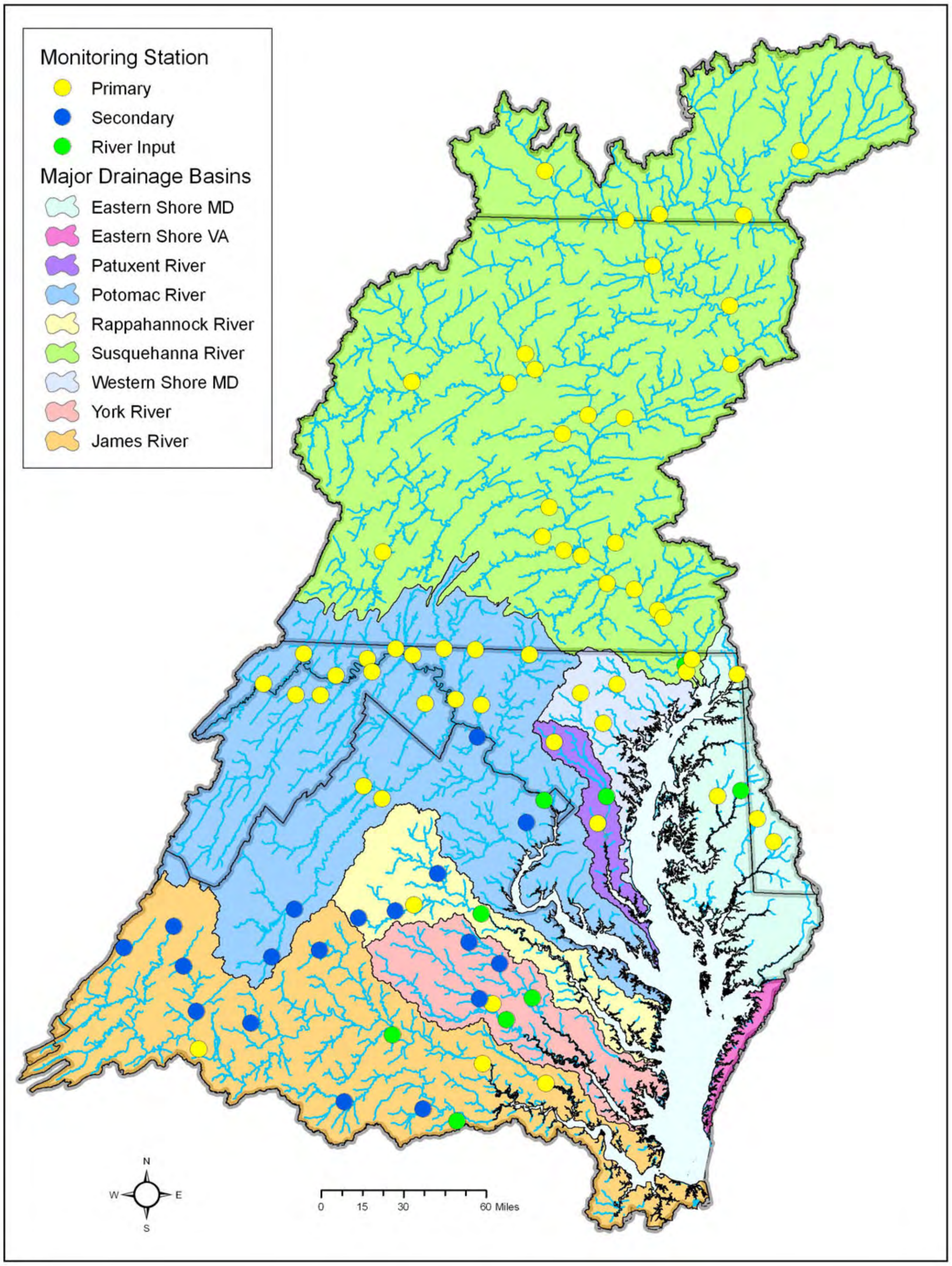
The Chesapeake Bay watershed monitoring network is a network of 85 streamflow gauges and water-quality sampling sites operated across the Bay watershed (CBP 2004a; MRAT 2009) (Figure 5-6). The network is an essential component to reporting, tracking, and modeling stream flow as well as nitrogen, phosphorus, and sediment concentrations and loads across the Chesapeake Bay watershed as it provides the only consistent, coordinated monitoring effort across all seven Chesapeake Bay watershed jurisdictions. Data from the watershed monitoring network sites have been used to develop, calibrate, and verify the Phase 5.3 Chesapeake Bay Watershed Model (USEPA 2010j).

The CBP partnership designed the watershed streamflow and water-quality sampling network in 2004 and signed a MOU in September 2004 to implement the network (Chesapeake Bay Watershed Partners 2004). The watershed monitoring network has undergone multiple scientific reviews since its inception (e.g., STAC 2005a, 2005b; MRAT 2009). After a 2009 review of the monitoring network, the original objectives of the network were modified to reflect a balance between the long-term monitoring goals of CBP partners and the increased need for tracking changes that could result from management actions (restoration) and other changes occurring in the watershed. The new objectives, as adopted by the partnership through the CBP's Management Board (MRAT 2009), are as follows:

1. Measure and assess the status and trends of nitrogen, phosphorus, and sediment concentrations and loads in major tributaries and subwatersheds and selected tributary strategy basins
2. Provide data suitable for the assessment of factors affecting nitrogen, phosphorus, and sediment status and trends from major pollutant source sectors
3. Measure and assess the effects of targeted management and land-use change
4. Improve calibration and verification of the partners' watershed models
5. Support spatial and topical prioritization of pollutant reduction, restoration, and preservation actions

As of 2010, the watershed monitoring network has 85 sites consisting of 67 sites fully implemented (primary) and another 18 sites partially implemented (secondary) (CBP 2010a) (Figure 5-6). All primary sites have the following: (1) continuous U.S. Geological Survey (USGS) streamflow gaging; (2) 20 water chemistry samples collected annually over a range of stream flow conditions (12 base flow and 8 storm flow); (3) nitrogen, phosphorus, and sediment parameter analyses; and (4) collection techniques that ensure representative samples (CBP 2008).

At secondary sites, all the requirements for primary sites are met except storm sampling (Figure 5-6). More than 30 of the primary sites are in locations where monitoring has been coordinated for decades, allowing for trend analysis at the locations. Trend analysis has recently become possible on the remaining sites as they accumulate the minimum of 5 continuous years of data.



Source: CBP 2010a

Figure 5-6. Chesapeake Bay watershed monitoring network.

The Chesapeake Bay watershed monitoring network is designed to measure the discharge of nitrogen, phosphorus, and sediment loads from 85 sites in watersheds larger than 1,000 square kilometers. Routine samples are collected monthly with additional storm-event samples to obtain a range of discharges and loadings. The seven jurisdictions, the Susquehanna River Basin Commission, and USGS all use the same set of standardized CBP protocols that are based on USGS sampling methods and EPA-approved analytical methods (CBP 2008).

5.2.3 Data Quality and Access

The EPA Chesapeake Bay Program Office operates the quality assurance (QA) program that covers all internal and external Chesapeake Bay Program activities that involve the collection, evaluation, and/or use of environmental data on behalf of the partnership. The QA program meets the requirements of EPA Order CIO 2105.0 for EPA programs, i.e., the American National Standard ANSI/ASQC E4-1994. The QA program also satisfies the requirements of the *EPA Information Quality Guidelines*, which describe how EPA organizations meet the Data Quality Act[1] (USEPA 2002b). The CBP Office *Quality Assurance Program Management Plan* describes the QA systems and is reviewed regularly and approved by EPA Region 3 (USEPA 2010k).

The CBP partnership has maintained a research-quality monitoring program for Chesapeake Bay tidal waters since the late 1980s when standardized sampling, analytical, and data management procedures were developed and coordinated with the then Maryland Office of Environmental Programs and the Virginia State Water Control Board. River Input Monitoring Program was then initiated at the major fall lines to measure nutrient and sediment loadings from the watershed's nine largest rivers and integrated into the QA program. Coordinated water quality monitoring was later expanded upstream into the free flowing rivers and streams across the Bay watershed, with seven watershed jurisdictions using comparable protocols (Chesapeake Watershed Partners 2004; CBP 2008).

Each of the partnership's monitoring programs produces a continuous record of high-quality data. As each of the monitoring programs is designed, in part, to detect trends in water quality constituents, therefore, trend analyses require very reproducible data over time collected at the lowest possible limits of detection. Changes in methods, laboratories, instruments, sampling sites, and such, can affect the results, so changes are carefully evaluated and approved to preserve the reproducibility of the data sets over time. Data comparability among watershed jurisdictions is reviewed every 3 months through the Chesapeake Bay Coordinated Split Sample Program (USEPA 1991a). The CBP Office evaluates the accuracy of laboratory data every 3 months by reviewing results of performance evaluation samples, e.g., CBP Blind Audit Samples[2] and USGS Standard Reference Samples.[3]

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[1] Section 515(a) of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554; H.R. 5658.

[2] See http://nasl.cbl.umces.edu/.

[3] See http://bqs.usgs.gov/srs/.

Online Chesapeake Bay Monitoring Networks data submission, data access, and quality assurance resources:

Chesapeake Bay Program Data Hub
http://www.chesapeakebay.net/dataandtools.aspx?menuitem=14872

CBP Water Quality Database
http://www.chesapeakebay.net/data_waterquality.aspx

CBP Map of Mainstem and Tributary Stations
http://archive.chesapeakebay.net/pubs/maps/2004-149.pdf

CBP Online Water Quality Data Dictionary
http://archive.chesapeakebay.net/data/data_dict.cfm?DB_CODE=CBP_WQDB

Guide to Using CBP Water Quality Data
http://archive.chesapeakebay.net/pubs/wqusers.pdf

CBP Recommended Guidelines for Sampling and Analysis
http://www.chesapeakebay.net/committee/analyticalmethodsworkgroup_agencies,institutions,andprojects.aspx?menuitem=16701

CBP Blind Audit Sample Program
http://nasl.cbl.umces.edu/

USGS Standard Reference Samples
http://bqs.usgs.gov/srs

CBPO Quality Assurance Program
http://www.chesapeakebay.net/qualityassurance_wq.aspx

CBP Analytical Methods and Quality Assurance Workgroup
http://www.chesapeakebay.net/committee_analyticalmethodsworkgroup_info.aspx

CBP Data and Information Tracking System
http://archive.chesapeakebay.net/pubs/DAITS_9_21_10.pdf

All federally funded organizations performing field sampling, laboratory analysis and/or data analysis as part of the Chesapeake Bay tidal and watershed monitoring networks have EPA-approved QA plans and standard operating procedures that conform to the CBP Recommended Guidelines for Sampling and Analysis (USEPA 1996). These guidelines, updated periodically, reviewed and approved by the CBP Analytical Methods and Quality Assurance Workgroup, and then posted on-line, specify sampling and analytical methods, precision and accuracy checks and tolerances, and documentation requirements. The QA documents for individual partner organizations responsible for components of the larger tidal and watershed water quality monitoring networks are on the CBP partnership website at http://www.chesapeakebay.net/qualityassurance_wq.aspx.

The CBP Office conducts routine audits of field and laboratory operations to ensure that the procedures are carried out according to their approved QA plans. Several organizations conduct their own internal field audits or require the use of accredited environmental laboratories.

Partners involved in water quality monitoring are required to submit Quality Assurance Project Plans. Cooperators undergo annual field visits, laboratories cooperative with annual on-site inspections and participate in quarterly multi-laboratory split sample evaluations to assure comparability among laboratories. The split samples are surface samples from a location in the mainstem Chesapeake Bay. Since 1987, within programs of routinely collected data, QA data are submitted for chemically analyzed parameters in the form of field split samples, lab duplicates, and lab-spiked samples. Further blind audits are conducted semi-annually.

The Analytical Methods and Quality Assurance Workgroup[4] has been part of the CBP organizational structure since 1988. The workgroup, composed of field sampling team and laboratory managers provides technical peer reviews of data collection and reporting activities to ensure consistency among the sampling and analytical organizations (Figure 5-7). The Workgroup reviews blind audit and coordinated split sample results and identifies potential causes of observed differences. Special studies or corrective actions might be necessary to ensure inter-laboratory agreement. If differences are found to affect subsequent data analyses, the associated bias is quantified and documented in Data and Information Tracking System (DAITS). DAITS is a registry of technical investigations regarding the quality and use of water quality data sets.

5.2.4 Data Submission and Quality Assurance

Water quality data are submitted electronically to the CBP Office by the participating data providers (Figure 5-7) according to data submission requirements specified in the federal grant/cooperative agreement assistance award provisions (USEPA 2010b). Agencies collecting data as part of the Chesapeake Bay tidal water quality monitoring program submit data to the Chesapeake Information Management System (CIMS) within 60 days of the end of the month in which the sample was collected. Watershed streamflow and water quality monitoring data are submitted once per year. The Data Upload and Quality Assurance Tool (DUQAT) is an automated online tool available to data submitters who manage the processing of their data before it is included in the database. DUQUAT proceeds through more than 150 format and QA checks, provides a report on errors and outliers and, after formal acceptance by the submitter and CBP data manager, loads the data into the CIMS Water Quality Database. The final report from the QA-checks is archived and available for future reference. The *CIMS Data Upload & Quality Assurance Tool User's Guide*[5] gives directions on how to use the tool and shows the correct table formats (Lane 2004). The database for the Chesapeake Bay watershed monitoring network is being developed and data submittals from the participating partners will be required to pass through a modified version of DUQAT before acceptance into the database.

After a water quality data submission has passed through DUQAT, and within 24 hours after acceptance, the data are added to the Water Quality Database and made available to the public on the CBP Data Hub.[6] The Data Hub interface provides access to several types of data related to the Chesapeake Bay. It provides links to CBP water quality, living resources (benthic, phytoplankton, zooplankton), and wastewater treatment and discharging facilities databases, and external links to partner data sets and databases available on the Data Hub. A data download tool is available for each CBP database that allows for queries based upon user-defined inputs such as geographic region and date range. Each query results in a downloadable, tab- or comma-delimited text file that can be imported to any program (e.g., SAS, Excel, and Access) for further analysis. About 12,000 sampling events comprising 8,000,000 data records are housed in the Water Quality Database from 1984 to present that are available to the public (scientists, data analysts, and private citizens).

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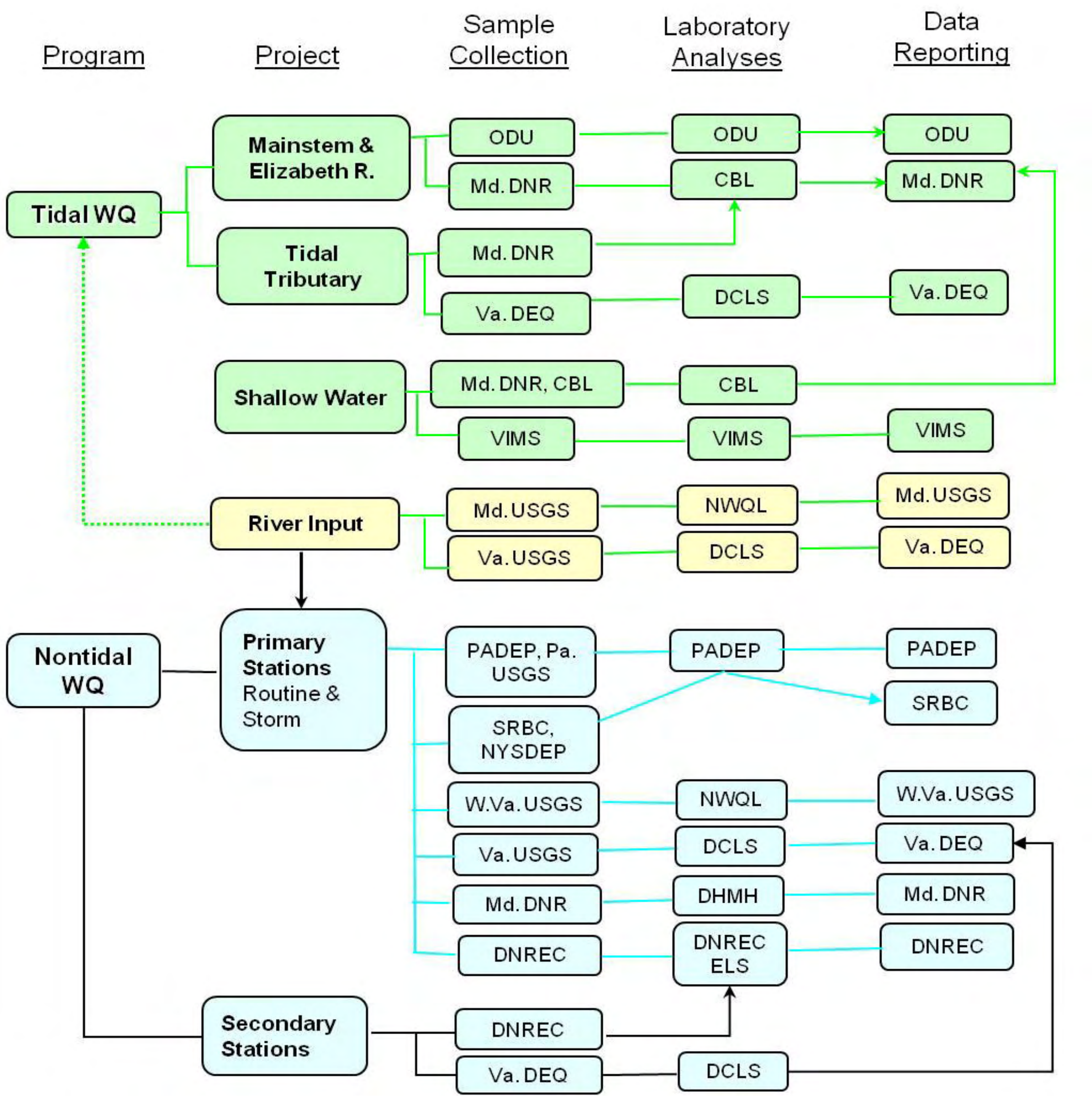
[4] See http://www.chesapeakebay.net/committee_analyticalmethodsworkgroup_info.aspx.

[5] See http://archive.chesapeakebay.net/pubs/DUQATUsersGuide.pdf.

[6] See http://www.chesapeakebay.net/dataandtools.aspx?menuitem=14872.



Source: Chesapeake Bay Program Office

Figure 5-7. Chesapeake Bay tidal and watershed water quality monitoring networks' participants arrayed by their role in sample collection, laboratory analysis, and/or data reporting.

Laboratory Abbreviations:
CBL – University of Maryland Chesapeake Biological Laboratory
DCLS – Virginia Department of Consolidated Laboratory Services
DHMH – Maryland Department of Health and Mental Hygiene
DNREC – Delaware Department of Natural Resources and Environmental Quality
DNREC ESL – Delaware Natural Resources Environmental Laboratory Services
Md. DNR – Maryland Department of Natural Resources
NWQL – National Water Quality Laboratory
NYSDEP – New York State Department of Environmental Conservation
ODU – Old Dominion University Water Quality Laboratory
PADEP – Pennsylvania Department of Environmental Protection
SRBC – Susquehanna River Basin Commission
USGS – United States Geological Survey (Md., Pa., Va. & W.Va. Water Science Centers)
Va. DEQ – Virginia Department of Environmental Quality
VIMS – Virginia Institute of Marine Science

All required data submissions from the monitoring programs described must meet the data requirements set forth in the *Chesapeake Bay Program Guidance and Policies for Data, Information and Document Outputs Submission* (USEPA 2010b). All living resources data deliverables are sent in a format compliant with Appendix E of the 2000 Users Guide to Living Resources Data when submitted to the CBP (USEPA 2000).

Database documentation and metadata links for the various sampling programs are available for viewing and download. A map of mainstem and tributary monitoring stations[7] is available and helps users query for data in a specific geographic region of the watershed. The *Guide to Using CBP Water Quality Monitoring Data* describes the Chesapeake Bay tidal water quality monitoring program in general and provides detailed information about the existing database (CBP 2010b). The *Water Quality Database Design and Data Dictionary* is a resource that defines the development of the database and provides a detailed description of the tables and data in the database (CBP 2004b). The online version of the Water Quality Data Dictionary provides the up-to-date CIMS and CBP codes used in the Water Quality Database.

5.2.5 Monitoring Applications in Chesapeake Bay TMDL Development

Data collected through the Chesapeake Bay tidal and watershed monitoring networks over the last three decades, described above, have been applied in numerous ways, supporting the development of the Bay TMDL:

- Used to develop the original Chesapeake Bay segmentation scheme and its subsequent refinements (USEPA 1983b, 2004b, 2005)
- Used in derivation of the DO, water clarity, SAV restoration acreage, and chlorophyll *a* criteria published by EPA on behalf of the partnership (USEPA 2003a)
- Used in the delineation of the spatial boundaries of the five Chesapeake Bay tidal water designated uses (USEPA 2003d, 2004e, 2010a)
- Used in the original development and ongoing refinement of the Chesapeake Bay water quality criteria assessment procedures (USEPA 2003a, 2004a, 2007a, 2007b, 2008a, 2010a)
- Used by four Bay jurisdictions to assess achievement of their respective Chesapeake Bay WQS regulations and development of their section 303(d) lists (USEPA 2007a)
- Used in the development, calibration, verification and management application of the Phase 5.3 Chesapeake Bay Watershed Model and Chesapeake Bay Water Quality Model (Cerco and Noel 2004; Cerco et al. 2010; USEPA 2010j)

5.3 MODELING FRAMEWORK OVERVIEW

Since the early 1980s, the CBP partnership has developed and applied multiple generations of linked environmental models to help evaluate the response of Chesapeake Bay water quality to a multitude of pollutant control management scenarios and programmatic approaches (Figure 5-8).

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[7] See http://archive.chesapeakebay.net/pubs/maps/2004-149.pdf.

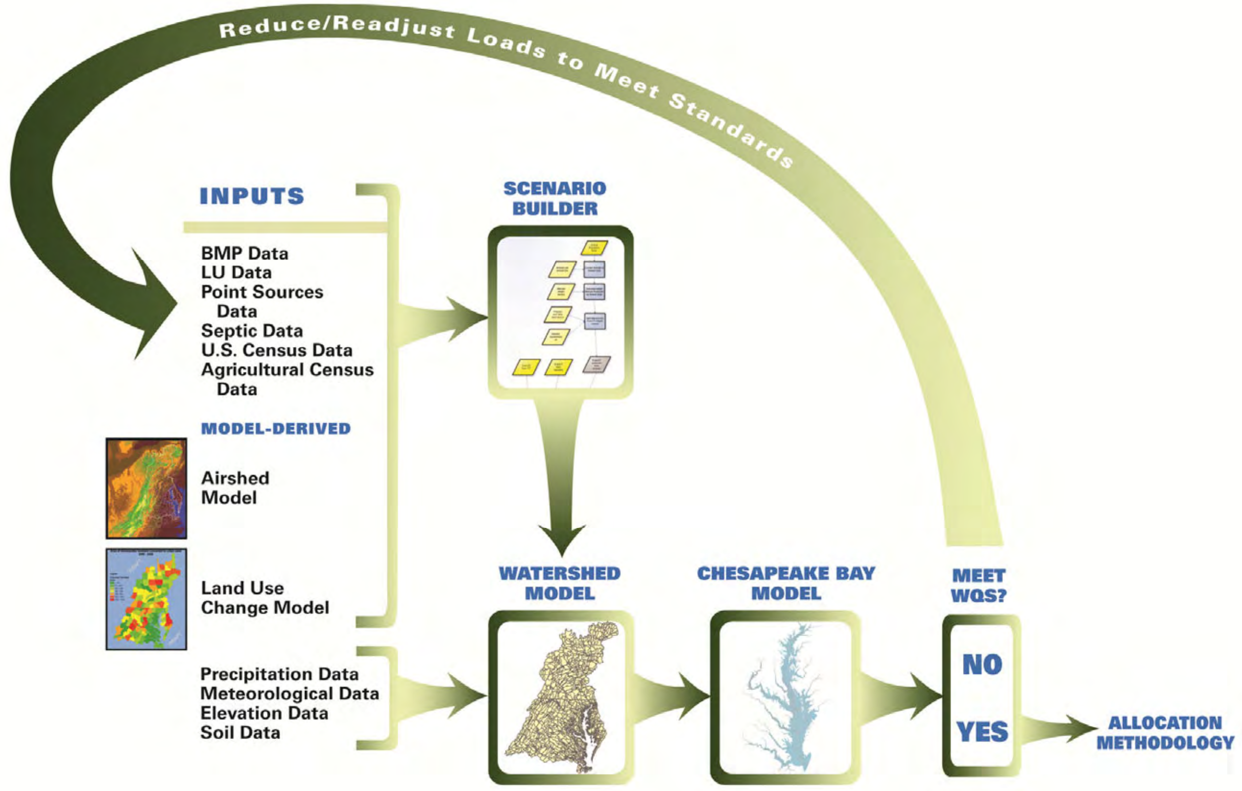


Figure 5-8. Chesapeake Bay TMDL modeling framework.

The fourth and fifth generations of some of these environmental models have been applied to support development of the Chesapeake Bay TMDL.

The Chesapeake Bay models are state-of-the-science and played a pivotal role in the development of the Bay TMDL. However, these models are just one of the tools in the TMDL analysis that also includes monitoring and environmental research. The models produce estimates, not perfect forecasts. Hence, they reduce, but do not eliminate, uncertainty in environmental decision making. Used properly, the suite of Bay models provide best estimates for developing nitrogen, phosphorus, and sediment reductions that are most protective of the environment. Ultimately, the Chesapeake Bay TMDL was based on the overall corroboration of the suite of Chesapeake Bay models, the Bay tidal and watershed monitoring networks, and environmental research.

The two major components of the Chesapeake Bay TMDL modeling framework are the Phase 5.3 Chesapeake Bay Watershed Model (Bay Watershed Model) and the Chesapeake Bay Water Quality and Sediment Transport Model (Bay Water Quality Model). Several other models and tools were used to provide critical inputs or to facilitate parameterizing (i.e., selecting the model components and their attributes that best describe the relevant characteristics of the watershed) the Bay Watershed Model to run various management scenarios (Table 5-1).

The models used to develop the Chesapeake Bay TMDL simulate the same 10-year hydrologic period from 1991 to 2000. The models are linked together so that the output of one simulation provides input data for another model (Figure 5-8). For example, the nitrogen outputs from the

Chesapeake Bay Airshed Model affect the nitrogen input from atmospheric deposition to the Bay Watershed Model. The Bay Watershed Model, in turn, transports the total nitrogen, phosphorus, and sediment loads, including the contributions from atmospheric deposition, to the Bay Water Quality Model. The Bay Water Quality Model, in turn, simulates the effects of the nitrogen, phosphorus, and sediment loads generated by the Bay Watershed Model and the effects of direct atmospheric deposition to tidal surface waters on Bay water quality (e.g., DO, water clarity, chlorophyll *a*), exchange of nitrogen, phosphorus, and oxygen with bottom sediment, and living resources (e.g., underwater Bay grasses, algae, microscopic animals, bottom sediment dwelling worms and clams, oysters, and menhaden).

Table 5-1. Modeling tools supporting development of the Chesapeake Bay TMDL

Model	Function
Chesapeake Bay Airshed Model	Provides estimates of wet and dry atmospheric deposition to the Bay watershed and Bay water quality models
Chesapeake Bay Land Change Model, Version 4	Provides annual time series of land uses to the Bay Watershed Model as well as projects land uses out to 2030
Chesapeake Bay Spatially Referenced Regressions on Watershed Attributes (SPARROW) Model	Provides a general calibration check on the Bay Watershed Model's land use and riverine loads
Chesapeake Bay Scenario Builder	Facilitates the creation of input decks for Bay Watershed Model management scenarios
Phase 5.3 Chesapeake Bay Community Watershed Model	Simulates loading and transport of nitrogen, phosphorus, and sediment from pollutant sources throughout the Bay watershed Provides estimates of watershed nitrogen, phosphorus, and sediment loads resulting from various management scenarios
Chesapeake Bay Water Quality/Sediment Transport Model	Simulates estuarine hydrodynamics, water quality, sediment transport, and key living resources such as algae, microscopic animals, bottom sediment dwelling worms and clams, underwater grasses, and oyster and menhaden filter feeding Predicts Bay water quality resulting from various management scenarios Ensures allocated loads under the Bay TMDL will meet jurisdictions' Bay water quality standards
Chesapeake Bay Criteria Assessment Program	Assesses attainment of the jurisdictions' Bay water quality standards using a unique combination of Bay Water Quality Model management scenario outputs and Bay water quality monitoring data
Chesapeake Bay Climate Change Simulation	Uses aspects of downscaled data from a suite of Global Climate Models, the Bay Watershed Model, and the Bay Water Quality Model to simulate climate change effects in the Chesapeake Bay and its watershed

The following sections provide additional details about each of the Bay models and other decision support tools used in development of the Chesapeake Bay TMDL and the linkages between the various models and tools. For each model/tool, the sections provide a general description of the model and how it was used in developing the Chesapeake Bay TMDL. Links to more detailed, online documentation are provided. Appendix B contains a more extensive list of Bay model related documentation, reports, independent scientific peer reviews, and model scenario inputs and outputs all with links for on-line access.

5.4 CHESAPEAKE BAY AIRSHED MODEL

The Chesapeake Bay Airshed Model (Bay Airshed Model) provides estimates of nitrogen deposition resulting from changes in emissions from utility, mobile, and industrial sources because of management actions or growth.

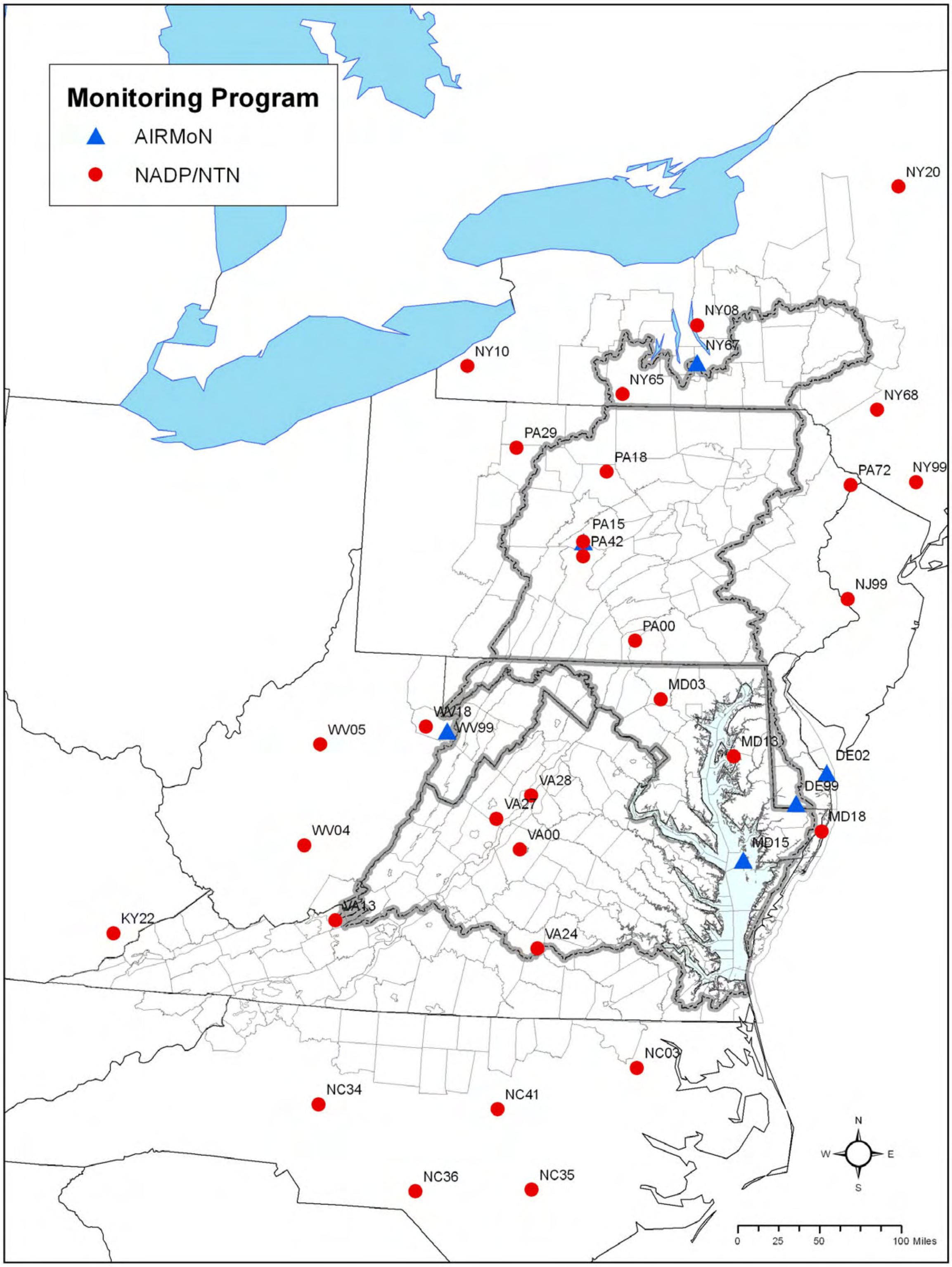
The Bay Airshed Model was used to provide inputs of nitrogen from wet and dry deposition to the Bay Watershed Model and to the Bay Water Quality Model. The Bay Airshed Model is linked to the Bay Watershed Model through atmospheric deposition to land surfaces and free flowing streams and rivers and to the Bay Water Quality Model through direct atmospheric deposition to the tidal surface waters of Chesapeake Bay (USEPA 2010j).

The Bay Airshed Model combines a wet deposition regression model (Figure 5-9) (Grimm and Lynch 2000; 2005), and a continental-scale air quality model of North America called the Community Multiscale Air Quality Model (CMAQ) for estimates of dry deposition (Figure 5-10) (Dennis et al. 2007; Hameedi et al. 2007). Wet deposition occurs during precipitation events and contributes to the loads only during days of rain or snow. Dry deposition occurs continuously and is input at a constant rate every day.

The CMAQ scenarios include the management actions required by the Clean Air Act (CAA) in 2010, 2020, and 2030. The future year scenarios reflect emissions reductions from national control programs for both stationary and mobile sources, including the Clean Air Transport Rule (Replacement for the Clean Air Interstate Rule), the Tier-2 Vehicle Rule, the Nonroad Engine Rule, the Heavy-Duty Diesel Engine Rule, and the Locomotive/Marine Engine Rule (see Section 6.4.1 and Appendix L for more details).

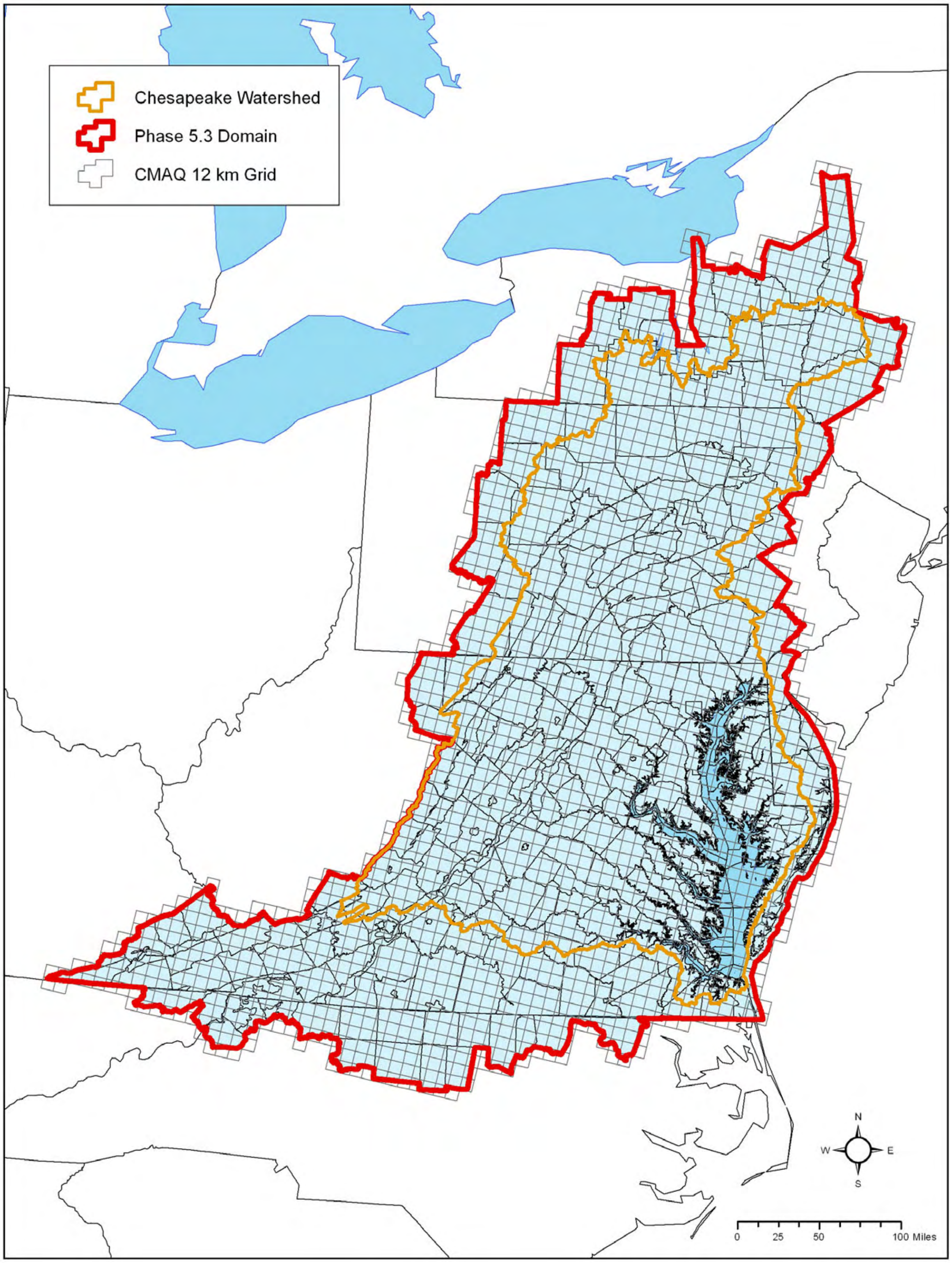
The CMAQ provides monthly constants for dry deposition. It requires a variety of input files that contain information pertaining to the entire North American continent. Those include hourly emissions estimates and meteorological data in every grid cell and a set of pollutant concentrations to initialize the model and to specify concentrations along the modeling domain boundaries. The initial and boundary concentrations were obtained from output of a global chemistry model.

The CMAQ simulation period is for one year, 2002, characterized as an average deposition year. The 2002 CMAQ simulation year was used to provide the monthly dry deposition estimate for each year of Bay model simulation from 1985 to 2010.



Source: Grimm and Lynch 2005

Figure 5-9. Atmospheric deposition monitoring stations used in the Chesapeake Bay airshed nitrogen wet deposition regression model.



Source: USEPA 2010j

Figure 5-10. The Community Multiscale Air Quality Model's 12 km grid over the Phase 5.3 Chesapeake Bay Watershed Model county segmentation.

The wet deposition regression model provides hourly wet deposition loads to each land-segment on the basis of each land-segment's rainfall. The regression model uses 29 National Atmospheric Deposition Program monitoring stations and 6 AIRMoN stations to form a regression of wetfall deposition across the entire Phase 5 Chesapeake Bay Watershed Model domain over the entire simulation period (see Appendix L).

To account for wet deposition of nitrogen, EPA both developed a specific TMDL load allocation (LA) for the direct nitrogen atmospheric deposition onto the tidal surface waters of Chesapeake Bay and accounted for air deposition of nitrogen to the Bay watershed in the LAs of the watershed-based sources. The Bay TMDL air load allocation reflects the modeled atmospheric nitrogen deposition to the tidal surface waters of the Bay, taking into account the reduction in air emissions expected from sources regulated under existing or planned federal CAA authorized programs (see Section 6.4.1 and Appendix L).

Detailed information related to the Bay Airshed Model and its application in development of the Chesapeake Bay TMDL is available in Section 5 of the Phase 5.3 Chesapeake Bay Watershed Model Report (USEPA 2010j) at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

5.5 CHESAPEAKE BAY LAND CHANGE MODEL

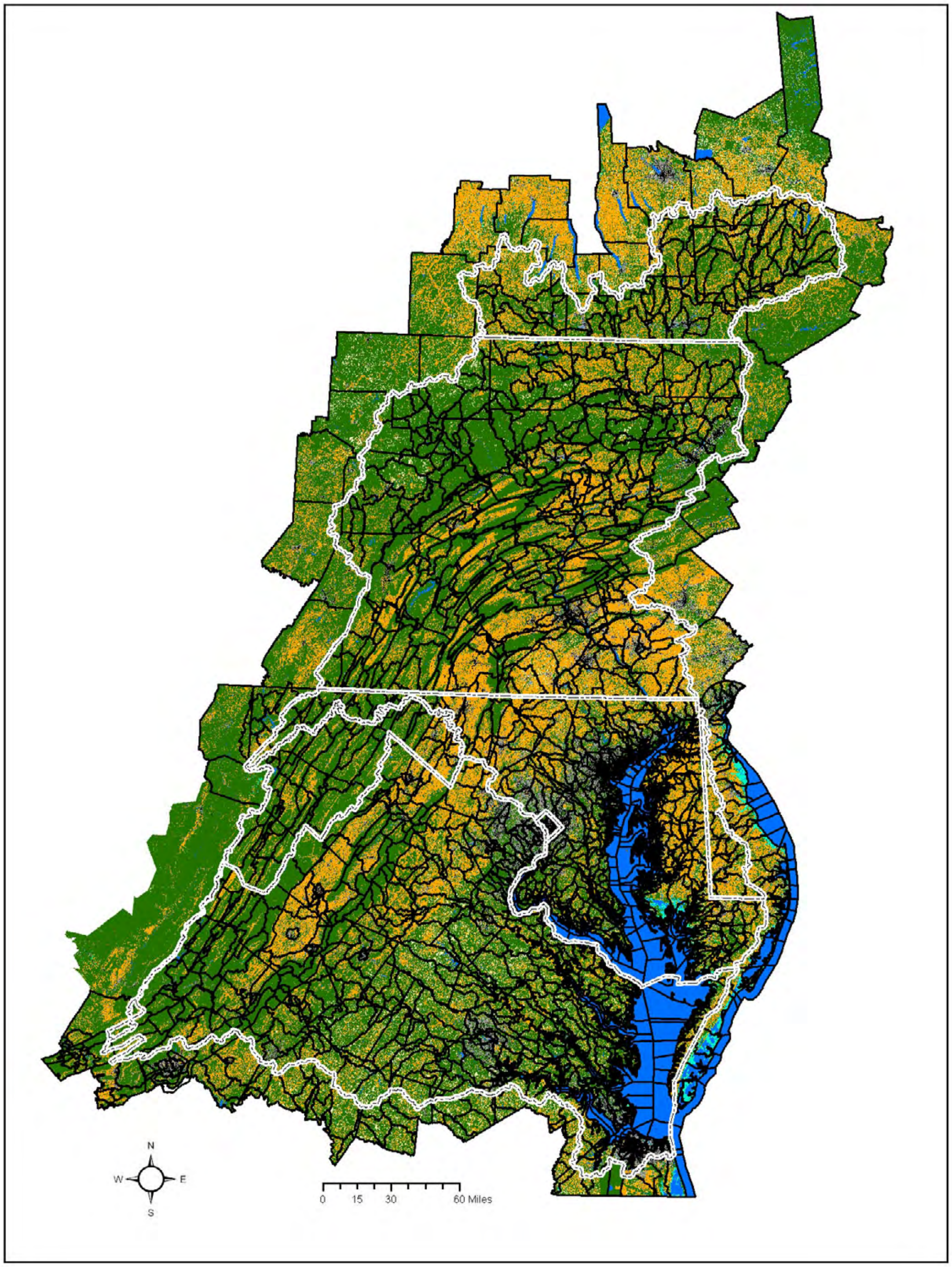
The Phase 5.3 Chesapeake Bay Watershed Model makes use of annually changing land use profiles derived from the Chesapeake Bay Land Change Model.

5.5.1 Motivations for Developing Future Land Use Estimates

A major challenge facing water resource managers today is how to maintain progress restoring the Chesapeake Bay in the face of continued population and urban development. The Chesapeake Bay Land Change Model (Bay Land Change Model) was developed to help address this management challenge. In conjunction with the Bay Watershed Model, the Bay Land Change Model can be used to assess potential future changes in nitrogen, phosphorus, and sediment loads to the Bay.

5.5.2 Scale of Chesapeake Bay Land Change Model Future Land Use Estimates

To meet the data requirements of Bay Watershed Model, the Bay Land Change Model forecasts change at the Bay Watershed Model segment scale. Version 4 of the Bay Land Change Model includes more than 2,000 modeling segments (e.g., polygons) in the Bay watershed and intersecting counties (Figure 5-11). The segments were created on the basis of an intersection of county boundaries, major topographic divides, and a 1:250,000 scale river reach drainage area network. Because the modeling segments are within counties, all data generated at the modeling segment scale can also be provided at the county scale for local review and comment.



Source: Irani and Claggett 2010

Figure 5-11. 2006 Land cover conditions in the Chesapeake Bay watershed and intersecting counties.

5.5.3 Components of Chesapeake Bay Land Change Model Future Land Use Estimates

In support of the CBP management concerns, researchers from USGS, EPA, Shippensburg University, and a private consultant developed the Chesapeake Bay Land Change Model, which combines the strengths of a growth allocation model or GAMe (Reilly 2003), with those of a cellular automata model, SLEUTH (slope, land use, excluded land, urban extent, transportation, and hillshade) (Clarke et al. 1997; Jantz et al. 2003). GAMe projects future urban developed area at the Bay Watershed Model segment scale by fitting total housing unit trends over the 1990s to a Gompertz (exponential S-shaped) Curve that is then used to extrapolate housing trends to the year 2030. County population projections converted to county scale estimates of total housing demand are used to constrain the modeling segment scale forecasts generated using the Gompertz Curve. After the model segment scale forecasts of housing demand are adjusted to match the county scale housing demand totals, they are converted to an estimate of future urban developed area using segment-specific ratios of urban developed land cover area to total housing units.

The proportions of structural development growth occurring on farmland, forest land, sewer, septic, and within existing developed boundaries are determined uniquely for each Bay Watershed Model segment using the SLEUTH growth model, a stochastic cellular automata model customized for application in the Chesapeake Bay watershed by Goetz and Jantz (2006). SLEUTH extrapolates historic rates and patterns of urban developed growth into the future using satellite derived imagery of 1990 and 2000 impervious cover. SLEUTH was calibrated separately in 15 different county clusters in the Bay watershed. Counties were clustered according to shared characteristics of urban developed growth, commuting patterns, and state and ecoregion boundaries. SLEUTH uses a Monte Carlo method to generate multiple simulations of future growth, which are combined to create a probability map of future urban development. The output from SLEUTH is a 30-m resolution probability raster data set that indicates the probability of urban developed growth in the year 2030 with values ranging from 0 to 100 percent.

The patterns of probable growth can vary for each cluster of counties by the coefficients used to calibrate SLEUTH in each cluster. The patterns and levels of probable urban development can also vary within a county by local factors of attraction and repulsion. The factors are represented in a 30-m resolution raster data set referred to as an exclusion layer. Local areas off limits to development can include public lands, conservation easements, rurally zoned lands, steep slopes (greater than 21 percent grade), emergent wetlands, and open water. For the Bay watershed, an exclusion layer was created in a GIS using information on public and protected lands, generalized zoning, and land cover. Values greater than 50 are relatively repulsive to growth with 100 being completely excluded. Values less than 50 are relatively attractive to growth (e.g., areas zoned for moderate or high density growth). The midpoint, 50, is neutral.

The probability output from SLEUTH is overlaid onto a raster land cover data set to determine the relative proportions of land cover classes and sewer areas affected by future growth. For example, if a cell with a 50 percent probability of becoming developed by 2030 overlays a forest cell in the land cover map, 50 percent of that cell is considered forest loss. For each modeling segment, the total acreage of all land cover classes converted to urban developed are summed and divided by the total of urban developed acreage forecasted in the modeling segment. That process generates relative proportions of future growth by land cover class for each modeling segment. Multiplying those proportions by the acreage of forecasted growth (generated by GAMe) determines how much acreage to subtract or add in future years to the Phase 5.3 Bay Watershed Model 2002 baseline land use classes.

The Bay Land Change Model also includes a Sewer Model to estimate the population on sewer and septic in the years 2000 and 2030. Where local data were not available, a population density raster data set derived from year 2000 Census Block Group data and detailed road vector files were used to represent probable sewered areas in the year 2000. The approach captures 81 percent of Maryland's mapped residential sewered areas on the basis of a one-to-one cell comparison. That approach also compares favorably with survey data in Virginia representing households with sewer service in the 2001 to 2005 period.

Modeled sewered areas in the year 2000 were expanded along existing roads by 300 m to 2,000 m to represent possible expansion of the sewer network through the year 2030. Forecasted population values for each watershed modeling segment were derived by converting the housing demand forecasts into estimates of future population. Future populations on sewer and septic were estimated by overlaying the SLEUTH probability map onto the modeled sewer service areas for 2030 to derive proportions of growth on sewer and septic, which were then multiplied by the forecasted population in each modeling segment. The proportions of growth on sewer and septic were kept constant for all interim year forecasts between 2000 and 2030. The percent change in population within each sewer service area was used to estimate the percent change in flow for all wastewater treatment plants in or close to each service area.

More detailed information on the Chesapeake Bay Land Change Model and its application in the Chesapeake Bay TMDL is available in Section 4 of the Phase 5.3 Chesapeake Bay Watershed Model Report (USEPA 2010j) at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

5.6 CHESAPEAKE BAY SPARROW MODEL

The USGS developed a set of spatially referenced regression models to provide additional spatial detail on nutrient sources and transport processes in the Bay watershed. The SPARROW (SPAtially Referenced Regression On Watershed Attributes) model integrates monitoring data with landscape information and uses statistical methods to relate water-quality monitoring data to upstream sources and watershed characteristics that affect the fate and transport of constituents to streams, estuaries, and other receiving waterbodies (Preston et al. 2009). SPARROW is watershed based and designed for use in predicting long-term average values such as concentrations and delivered loads to downstream receiving

For additional information on Chesapeake Bay SPARROW modeling, see the following resources:

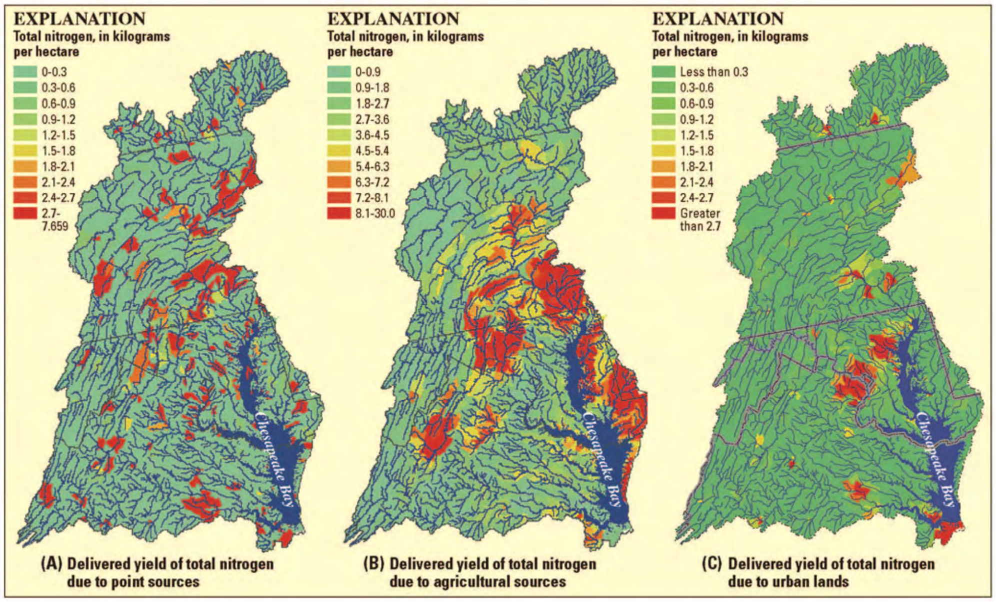
SPARROW fact sheet
http://pubs.usgs.gov/fs/2009/3019/

National SPARROW home page
http://water.usgs.gov/nawqa/sparrow/

Chesapeake Bay Specific
http://md.water.usgs.gov/publications/wrir-99-4054/html/index.htm
http://md.water.usgs.gov/publications/ofr-2004-1433/
http://chesapeake.usgs.gov/coast/restorationmapper.html

waters. Statistical methods are used to explain in-stream measurements of water quality in relation to upstream sources and watershed properties (e.g., soil characteristics, precipitation, and land cover).

Among its outputs, the SPARROW model can be used to quantify incremental yield or edge-of-field loading, which is the amount (load per area) of total nitrogen, phosphorus, or sediment generated in each reach basin independent of upstream load (Figure 5-12). The Chesapeake Bay SPARROW models provide loading information for three separate periods, the late 1980s, the early 1990s, and the late 1990s (Brakebill et al. 2010; Brakebill and Preston 2004, 2007; Preston and Brakebill 1999). For the Chesapeake Bay watershed modeling and TMDL development effort, EPA used the results of the SPARROW model as a data source for estimating average edge-of-field targets when developing and calibrating the Phase 5.3 Chesapeake Bay Watershed Model (USEPA 2010j).



Source: Brakebill and Preston 2007

Figure 5-12. An example of the Chesapeake Bay SPARROW Model output showing delivered yields of total nitrogen in the Chesapeake Bay watershed.

5.7 CHESAPEAKE BAY SCENARIO BUILDER

Scenario Builder is a standalone data pre-processor for the Phase 5.3 Chesapeake Bay Watershed Model. It is designed to track the land use-related nutrient processes for the multiple land use-related sources in the Bay watershed and to facilitate parameterization of those sources for watershed model scenarios to be run through the Bay Watershed Model (Figure 5-13). Scenario Builder generates information that is used to simulate loads related to animal production areas, manure storage, application of manure and fertilizers, septic inputs, plant growth/uptake, and best management practice (BMP) implementation. Scenario Builder can handle data at a variety of levels, including land-river segment, river segment, land segment, county, state and basin, tributary strategy basin, or state and can vary by the BMP in question. Scenario Builder is designed so that users may select an area of one or more counties, the livestock types, and the number of animals, along with a land use using the 25 Watershed Model-HSPF categories and then be able to alter the crop mix that is nested in each of the agricultural land uses along with BMPs.

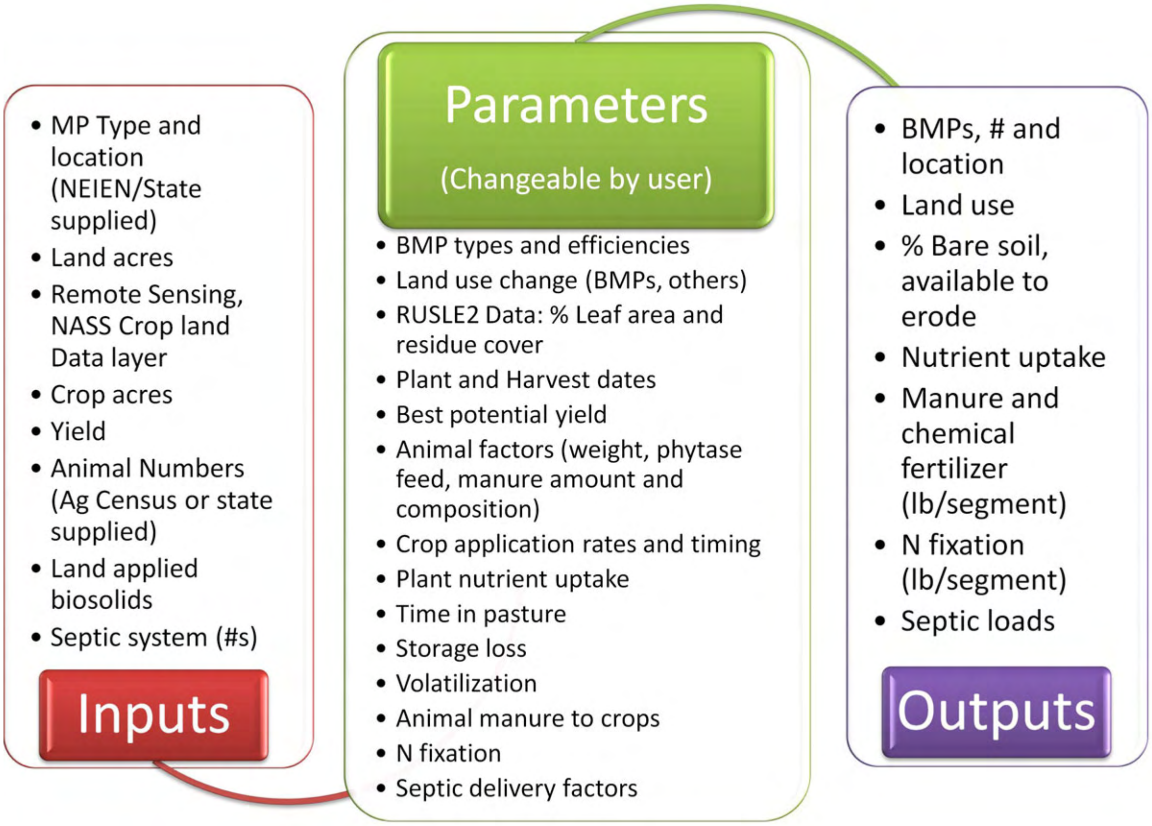


Figure 5-13. Scenario Builder conceptual process.

Scenario Builder estimates the amount of nitrogen and phosphorus load that will be generated by a given land use in the presence of agricultural and other land-based activities and estimates the area of soil available to be eroded. Loads are input to the Bay Watershed Model to generate modeled estimates of loads delivered to the Bay. Additional information related to Scenario Builder and its application in Bay TMDL development (USEPA 2010d) is at http://archive.chesapeakebay.net/pubs/SB_V22_Final_12_31_2010.pdf.

For the Bay TMDL, Scenario Builder was used to provide the land use-based scenario inputs to the Phase 5.3 Chesapeake Bay Watershed Model. The seven watershed jurisdictions will continue using it when implementing their Watershed Implementation Plans to build model scenarios of their actual and future implementation practices that will, in turn, be run through the Bay Watershed Model to track implementation status and project future implementation rates.

5.8 PHASE 5.3 CHESAPEAKE BAY WATERSHED MODEL

The Phase 5.3 Chesapeake Bay Watershed Model is an application of the Hydrologic Simulation Program-Fortran (HSPF) (Bicknell et al. 2005). The segmentation scheme divides the Chesapeake Bay watershed into approximately 1,000 segments/subbasins, with the average size about 64 square miles. About 280 monitoring stations throughout the Chesapeake Bay watershed were used for calibration of hydrology, while approximately 200 monitoring stations were used to calibrate water quality, depending on the constituent being calibrated. There are 530 river-segments with simulated reaches that drain to a simulated downstream reach. There are 62 river-segments with simulated reaches that drain directly to the Chesapeake Bay and 379 river-segments adjacent to tidal waters that are without a simulated reach (Figure 5-14).

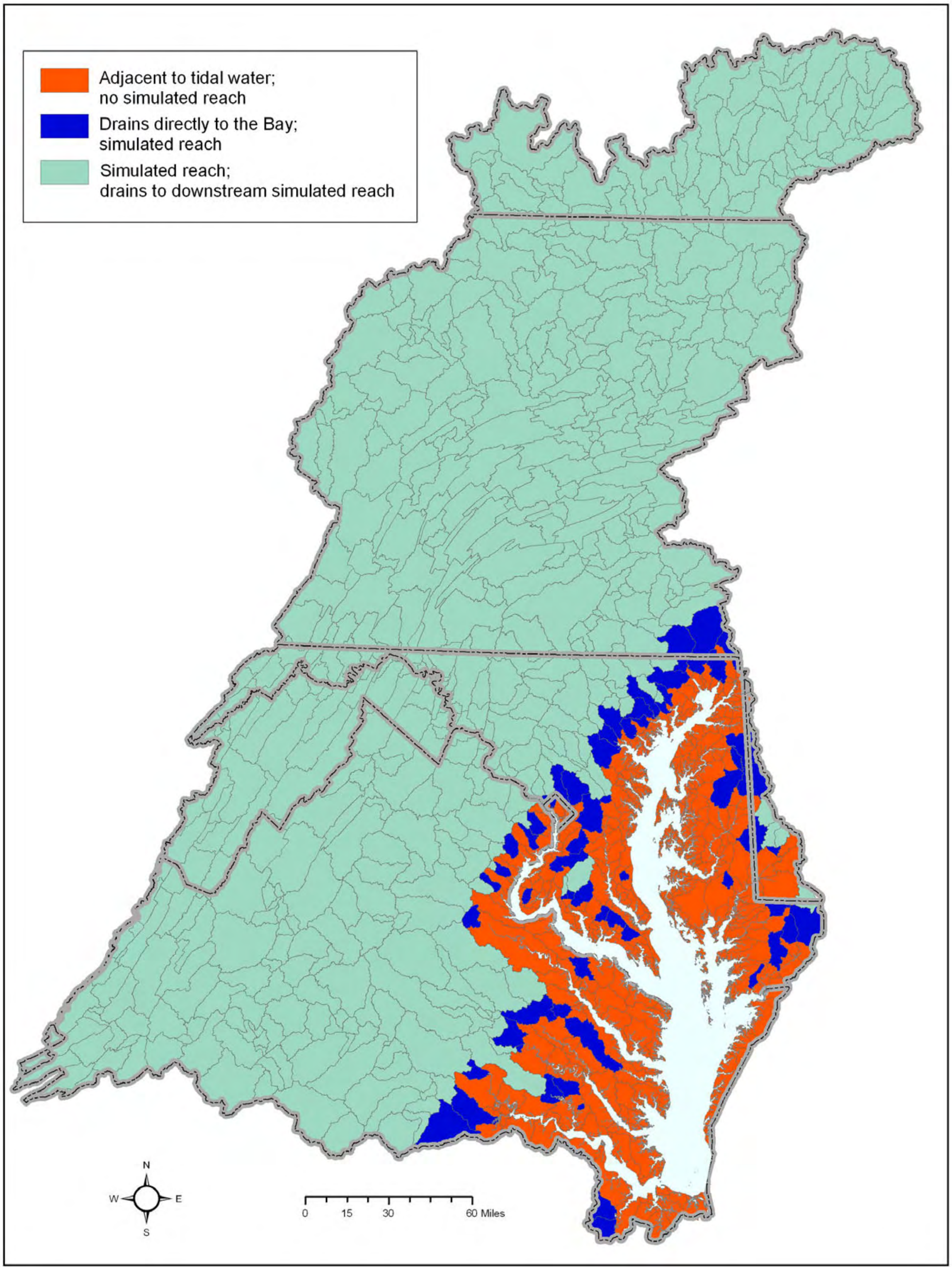
The Bay Watershed Model simulation period covers 21 years from 1984 to 2005 to take advantage of more recent and expanded monitoring data and information. The expansion of the model period to a 21-year period resulted in a more representative and improved land use inventory for use in model calibration. While the Phase 4.3 Bay Watershed Model and all previous Bay watershed model versions had a constant land use, the Phase 5.3 Bay Watershed Model allows a time series of land use input data to change annually over the 1984 to 2005 simulation period (USEPA 2010j).

As a community model, the Phase 5.3 Bay Watershed Model has open source model code, pre-processors, post-processors, and input data that are freely available to the public (USEPA 2010j). Input data include precipitation information, municipal and industrial wastewater treatment and discharging facilities, atmospheric deposition, and land use (USEPA 2010j). By offering the Bay Watershed Model as a community model, end users—typically TMDL model developers and watershed researchers and implementation plan developers—can use the model independently as is or as a starting point for more detailed, small-scale models (USEPA 2010j). The Phase 5.3 Chesapeake Bay Watershed Model can be downloaded from this ftp site: ftp://ftp.chesapeakebay.net/Modeling/phase5/community/ or the Chesapeake Community Modeling Program's website at http://ches.communitymodeling.org/models/CBPhase5/datalibrary.php.

The Bay Watershed Model simulates the 21-year period (1984–2005) on a one-hour time step (USEPA 2010j). Nutrient inputs from manure, fertilizers, and atmospheric deposition are based on an annual time series using a mass balance of U.S. Census of Agriculture animal populations and crops, records of fertilizer sales, and other data sources. BMPs are incorporated on an annual time step and nutrient and sediment reduction efficiencies are varied by the size of storms. Municipal and industrial wastewater treatment and discharging facilities and onsite wastewater treatment systems' nitrogen, phosphorus, and sediment contributions are also included in the Bay Watershed Model. The following sections provide additional details regarding the underlying data used to develop and calibrate the Bay Watershed Model.

5.8.1 Bay Watershed Model Segmentation

In many HSPF applications, the river segmentation and the land segmentation is the same. Each river segment will have a set of land uses that drain to it and it only. In the Phase 5.3 Chesapeake Bay Watershed Model, the segmentation schemes are separate (USEPA 2010j). Land segments are generally county-based because a simulation of a representative acre of each land use type



Source: USEPA 2010j

Figure 5-14. Segmentation and reach simulation of the Phase 5.3 Chesapeake Bay Watershed Model.

exists in each county. Some counties in mountainous regions where the rainfall patterns varied significantly have been broken out into several land segments. The segments that result from the intersection of the two segmentation schemes are known as land-river segments (Martucci et al. 2006).

5.8.2 Bay Watershed Model Setup

Detailed information related to how the Bay Watershed Model was set up to support development of the Bay TMDL is available in the Phase 5.3 Chesapeake Bay Watershed Model Report (USEPA 2010j). In addition, information related to model representation of land use-related nutrient generating sources is available in the Scenario Builder documentation (USEPA 2010d). The following paragraphs provide a general description of critical data components underlying the Bay Watershed Model.

Meteorological Data

Meteorological data are critical inputs to the Bay Watershed Model because precipitation is a primary driver of nitrogen, phosphorus, and sediment loadings to the Bay. Approximately 500 daily data and 200 hourly data precipitation monitoring stations were used in development and calibration of the Phase 5.3 Chesapeake Bay Watershed Model (USEPA 2010j). Precipitation is derived from an hourly output regression model of these stations developed by USGS. Meteorological parameters included in the simulation are hourly temperature, solar radiation, wind speed, daily dew point, cloud cover, and potential evapotranspiration. Those parameters were collected from the seven primary meteorological stations in the Chesapeake Bay watershed (USEPA 2010j).

Withdrawals

Water withdrawals are represented in the Bay Watershed Model as daily amounts from jurisdictions’ reported data of monthly or annual withdrawals. Water withdrawals include irrigation use and thermoelectric use, among others. The Bay Watershed Model also takes into account the seasonal cycle of irrigation use. Consumptive uses are modeled as 100 percent removal of the water from the appropriate stream segment, and any resulting wastewater is treated as a separately modeled point source discharge (USEPA 2010j).

Soils and Sediment

Soil characteristics were obtained from the Natural Resources Conservation Service’s Interpretation Records and the National Resources Institute. Sediment delivery from each land use is based on National Resources Institute’s estimates of annual edge-of-field sediment loads, as determined by the Revised Universal Soil Loss Equation (USEPA 2010j).

Land uses

The Phase 5.3 Chesapeake Bay Watershed Model simulates 24 land uses, including 11 types of cropland, 2 types of woodland, 3 types of pasture, 5 types of developed land, and provisions for other special land uses such as surface mines and AFOs (Table 5-2) (USEPA 2010j). Nitrogen and phosphorus in the major pervious land uses of woodland, cropland, hay, pasture, and developed pervious are simulated using the AGCHEM modules in HSPF that fully simulate forest or crop nutrient cycling, including uptake by plants. The minor pervious land uses, which are harvested forest, land under construction, nurseries, surface mines, and degraded riparian pasture, are simulated through PQUAL, which represents nutrient export through concentration coefficients. Impervious land uses are simulated through the IQUAL modules, which use accumulation and wash-off coefficients to simulate nutrient and sediment export.

The final Phase 5.3 land use is available as a sub-county tabular database for the years 1985, 1987, 1992, 1997, 2002, and 2005 at ftp://ftp.chesapeakebay.net/Modeling/phase5/Phase%205.3%20Calibration/Model%20Input/land_use.zip. The Phase 5.3 model input decks including the land use files above are also linked with a brief explanation from the Phase 5 Model page at http://www.chesapeakebay.net/model_phase5.aspx. The Bay Watershed Model uses a continuous time series of land use interpolated from those years.

The principal databases used to develop the Phase 5.3 Bay Watershed Model, 30-meter land use coverage were the following:

- USGS Chesapeake Bay Land Cover 1984, 1992, 2001 and 2006 Data Series (CBLCD)
- County level U.S. Census of Agriculture 1982, 1987, 1992, 1997, 2002, and 2007 data
- 2001 Impervious Surface Land Cover data developed by the University of Maryland's Regional Earth Science Applications Center (RESAC) (Goetz et al. 2004)
- Ancillary data from the jurisdictions were used to develop the extractive land use cover, including spatial and tabular permitting information
- Construction land use is a percentage of impervious change

Table 5-2 provides a summary of the land use types modeled by the Phase 5.3 Bay Watershed Model, the specific land uses, and a basic description of their derivation. Additional detail is available in Section 4 of the Phase 5.3 Chesapeake Bay Watershed Model report (USEPA 2010j) at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

Table 5-2. Phase 5.3 Chesapeake Bay Watershed Model land uses

Land use type	Land use	Description	Source
Agricultural	Pasture	Based on pastureland areas from the agricultural census	USDA Agricultural Census
	Degraded riparian pasture	Unfenced riparian areas where livestock have stream access; represents a portion of the pasture use	A unique area designated by each state as the acres of planned riparian pasture fencing in their Tributary Strategies
	Nutrient management pasture	Pasture that is part of a farm plan where crop nutrient management is practiced. Nutrient management pasture is pasture that receives manures that are excess on a farm after all crop nutrient needs are satisfied.	Derived from the pasture land use and state nutrient management BMP tracking data

Land use type	Land use	Description	Source
	Alfalfa hay	Alfalfa is a separate hay category because it is a nitrogen-fixing, leguminous crop and receives different nutrient applications than other hay crops	USDA Agricultural Census
	Hay-unfertilized	(Wild hay) + (cropland idle) + (cropland in cultivated summer fallow)	USDA Agricultural Census
	Hay-fertilized	(Hay-alfalfa, other tame, small grain, wild grass, silage, green chop, act) – (wild hay) – (alfalfa) + (cropland on which all crops failed)	USDA Agricultural Census
	Conventional tillage with manure	Wheat, barley, buckwheat, sunflower, corn, sorghum, soybeans and dry beans	USDA Agricultural Census
	Conventional tillage without manure	(Cotton) + (tobacco) + (land used for vegetables) + (potatoes, excluding sweet potatoes) + (sweet potatoes) + (berries) + (nursery acres in the open) + (land in orchards)	USDA Agricultural Census
	Conservation tillage without manure	Crops typically grown for direct human consumption (such as cotton, tobacco, vegetables, potatoes and berries) and field nurseries	USDA Agricultural Census
	Nursery	Container nurseries, which typically have a high density of plants (10–100 plants per square meter) and high rates of nutrient applications	USDA Agricultural Census
	Animal Feeding Operations	Percentage of pastureland, based on animal populations from the agricultural census	Derived from the USDA Agricultural Census count of farms and the type and numbers of animals
Woodland	Forest, woodlots, and wooded	Includes woodlands, woodlots, wetlands and usually any wooded area of 30 meters by 30 meters remotely sensed by spectral analysis. Predominant land use in watershed.	Largely derived from the land area the was not developed, not in the USDA Agricultural Census, and not water of lakes and rivers
	Harvested forest	Estimated at 1% of forest, woodlots, and wooded land use	Derived from the forest, woodlots, and wooded land use
Developed	High-density pervious	High-Intensity Pervious Developed (Hp) lands are immediately adjacent to High-Intensity Impervious Developed lands and include mostly small landscaped areas and lands adjacent to developed structures and major roadways. No portions of these lands are impervious	Derived from satellite data and density of road network

Land use type	Land use	Description	Source
	High-density impervious	High-Intensity Impervious Developed (Hi) lands contain more than 50% impervious surfaces per quarter-acre (on average) and generally represent impervious surfaces associated with large structures and major roads and include mostly commercial, industrial, and high-density residential land uses, interstates, and other major roads.	Derived from satellite data and density of road network
	Low-density pervious	Low Intensity Pervious Developed (Lp) lands are generally associated with Low-Intensity Impervious Developed lands and include residential lawns, golf courses, cemeteries, ball fields, developed parks, and other developed open spaces. Any impervious surfaces associated with these land uses are captured in either the low-intensity or high-intensity impervious developed classes depending on the size of the structure or road.	Derived from satellite data and density of road network
	Low-density impervious	Low-Intensity Impervious Developed (Li) lands contain less than 50% impervious surfaces per quarter-acre (on average) and generally represent impervious surfaces associated with small structures and minor roads and include mostly low to medium density residential areas and some sidewalks and driveways.	Derived from satellite data and density of road network
	MS4	Developed land coincident with an area requiring Municipal Separate Storm Sewer System (MS4) permits.	Derived from state regulatory data
Minor Land uses	Bare-construction	Based on the difference between the RESAC impervious land estimates of 1990 and 2000. Impervious land, which increased over the 10-year period, was assumed to have transitioned from a bare-construction land use	Derived from a combination of impervious area and construction permits
	Extractive-Active and Abandoned Mines	Mines, gravel pits and areas affected by mine-related activities. In Virginia, acres are based on permit information; all others are based on RESAC data	State permitting data
	Open Water	Nontidal waters, acreage constant throughout model period	Satellite-derived estimate

Source: USEPA 2010j

Agricultural Land Uses

Satellite-derived estimates of cropland and pasture have higher uncertainty in the prediction of the extent of these land cover classes compared to the USDA Agricultural Census data in certain land-river segments, so census data were used to inform and modify the extent of these land uses. County-level total agricultural land use information from the USDA Agricultural Census data were interpolated to the base years of 1990 and 2000. Agricultural land use was distributed to the model segments by the ratio of census agricultural classes for each county, and other land uses were distributed in the remaining model segment area in proportion to their acreage in the county. Annual changes in land use were linearly extrapolated or interpolated from the 1990 and 2000 base years and years covered in the USDA Agricultural Census (1982, 1987, 1992, 1997, 2002, and 2007), resulting in annual sub-county data sets of land use.

The total agricultural area was split into different agricultural land uses, by the average ratio of crops in the USDA agricultural census. Crops were aggregated by similar surface cover characteristics and fertilizer application rates to yield categories with similar nutrient-loading properties.

State agricultural engineers provided fertilizer and manure application timing and rates, crop rotation information, and field operation timing information. Manure application is represented in a time-varying mass balance of manure nutrients, according to animal population and predominant manure handling practices (USEPA 2010j).

Animal waste areas are defined by manure acres, which allows for the simulation of high nutrient content runoff, and are based on the population of different animal types. The manure acres in a given area change based on the number of animals of each type (beef and dairy cattle, swine, laying hens, broilers and turkeys) and the implementation of animal waste management systems. Nutrient export is simulated as a concentration applied to the runoff from the manure acres (USEPA 2010j).

Urban Land Uses

For urban land representation, high- and low-density development and the proportion of impervious and pervious area were mapped for 1990 and 2000 (USEPA 2010j).

Other Land Uses

Other land uses represented in the model include construction, which typically has high sediment loading capacity; extractive-active and abandoned mines; and open non-tidal water.

Future Land Use Estimations

The Chesapeake Bay Land Change Model was developed to help assess potential future changes in nutrient and sediment loads to the Bay resulting from land use changes (see Section 5.5 and Section 10.1).

5.8.3 Pollutant Source Representation

The Bay Watershed Model represents various sources of nitrogen, phosphorus, and sediment on the basis of the characteristics of the source and information available for characterizing the source. Point sources such as permitted wastewater and industrial dischargers that generally discharge continuously are represented directly in the Bay Watershed Model using locational data, flow, and discharge characteristics. Other sources, such as septic systems or agricultural activities, are represented in the model through the underlying land use coverage and assumptions related to nitrogen, phosphorus, and sediment production from associated land uses. Those sources can be thought of as land use-related sources because the simulation of their loading characteristics is driven by the land use categories with which they are associated. Several such land use-related sources are subject to National Pollutant Discharge Elimination System (NPDES) permits. An example of such a land use-related source is an municipal separate storm sewer system (MS4) area, which is subject to an NPDES permit and must receive a WLA in the TMDL, but loadings are derived as a function of the modeled land use loading rates for associated land uses (e.g., urban pervious land). The following paragraphs summarize the Bay Watershed Model's representation of the major sources of nitrogen, phosphorus, and sediment to the Bay. Additional minor land use sources are also detailed in the Phase 5.3 Chesapeake Bay Watershed Model Report (USEPA 2010j).

Municipal and Industrial Discharges

Municipal and industrial discharges are considered direct inputs to the river reaches. In the Bay Watershed Model, the river segments are simulated as a completely mixed reactor, and all the wastewater discharged loads within a reach are summed for each of the river segments and input as a daily load (USEPA 2010j).

Concentrated Animal Feeding Operations (CAFOs)

CAFOs are represented in the model as part of the AFO land use, which represents the production area of livestock operations. The loading is calculated on the basis of animal counts; manure nutrients production rate modified by feed considerations; time spent in pasture out of the production area; volatilization factors; and loss coefficients, which are dependent on storage facility type. The full description of the CAFO and AFO land use loads is available in the Scenario Builder documentation (USEPA 2010d) at http://archive.chesapeakebay.net/pubs/SB_V22_Final_12_31_2010.pdf.

Combined Sewer Overflows (CSOs)

CSO loads are not directly simulated by the Bay Watershed Model. CSO loads for the TMDL were developed using estimations of daily CSO flows and nutrient concentrations for the CSO communities in the watershed. For details related to how the CSO loads were calculated, see Section 7 of the Phase 5.3 Chesapeake Bay Watershed Model Report (USEPA 2010j) at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

MS4s

The estimated MS4 areas were provided by each of the jurisdictions and represent the current understanding of MS4 areas. While the best and final definition of an MS4 is delineated sewersheds (drainage area served by a sewer system), most jurisdictions could provide only municipal boundaries as an estimated MS4 area. There might be additional developed land, however, outside the municipal boundaries that also drains to the MS4 area that can be shown by GIS data. The Phase 5.3 Bay Watershed Model uses the GIS data and topographic information to delineate the sewershed, which includes all land in the municipal boundaries and developed land outside the municipal boundaries that drains to the MS4 (USEPA 2010j).

Septic Loads

Septic system loads are calculated on the basis of U.S. Census Bureau estimates of the number of systems in the watershed and standard assumptions regarding nitrogen waste generation and attenuation. The model simulates nitrate discharges directly to stream and river reaches (USEPA 2010j).

5.8.4 Calibration

The Phase 5.3 Bay Watershed Model segments are defined such that segment outlets are in proximity to in-stream flow gauging and water quality monitoring stations to increase the accuracy of model calibration. Calibration involved comparing available streamflow and water quality data for the years 1985 to 2005 to watershed model calibration output for the same period.

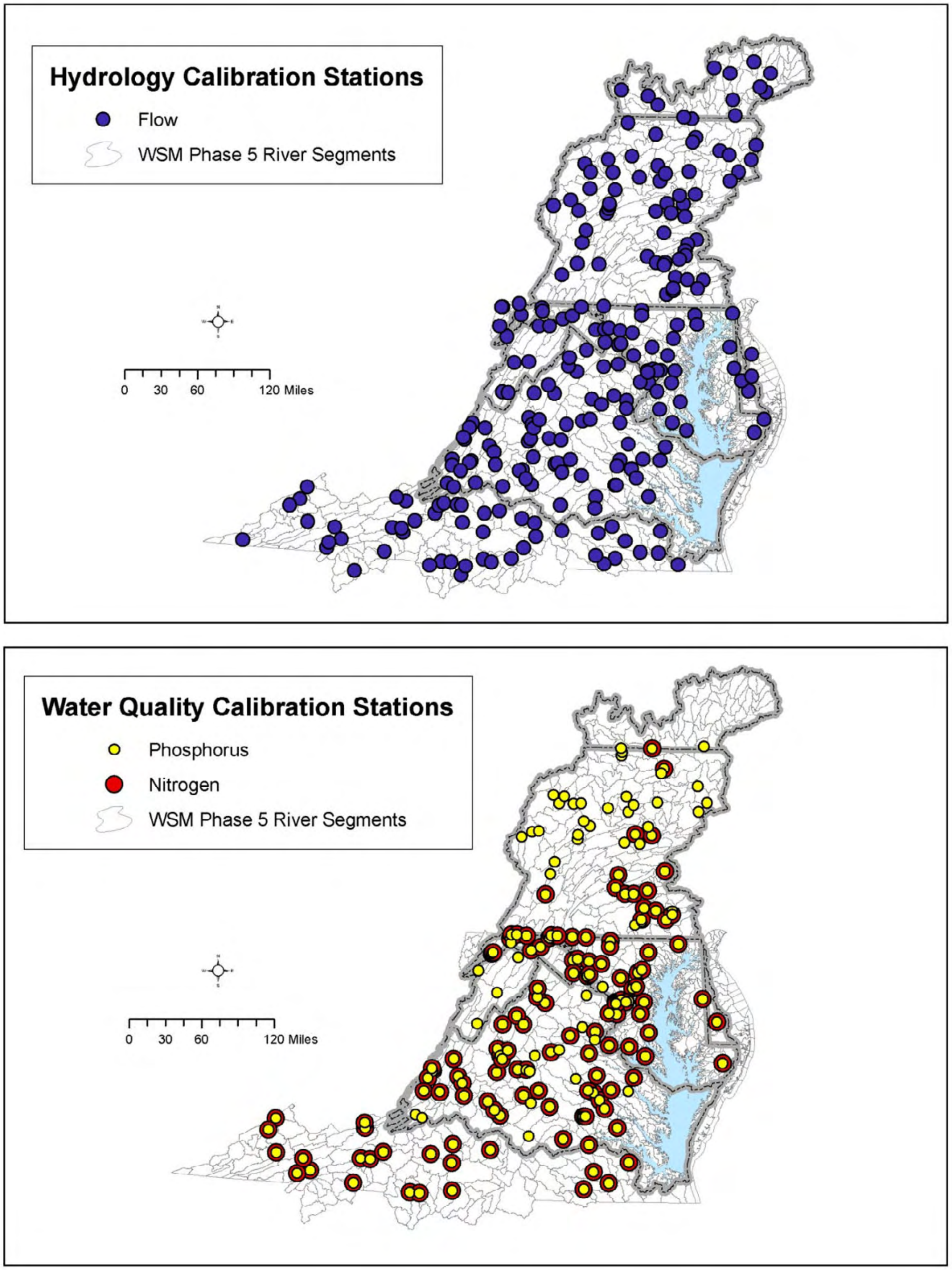
To calibrate the model output, various water quality parameters such as simulated streamflows, TSS (sediment), total phosphorus, organic phosphorus, particulate phosphorus, phosphate, total nitrogen, nitrate, total ammonia, and organic nitrogen concentrations and loads, temperature, and DO were compared to the observed data from the in-stream monitoring sites (Figure 5-15). Through the application of an automated calibration process, model parameters were adjusted to optimize the representation of observed in-stream conditions (USEPA 2010j).

The calibrated Bay Watershed Model was run for a 21-year hydrologic period (1985–2005) to simulate loads for various evaluation scenarios. Those loads were linked to the Bay Water Quality Model to test whether a given scenario met the Bay jurisdictions’ WQS in the Bay. Modeled loads are reported as the average annual load over the modeled period.

5.9 CHESAPEAKE BAY WATER QUALITY AND SEDIMENT TRANSPORT MODEL

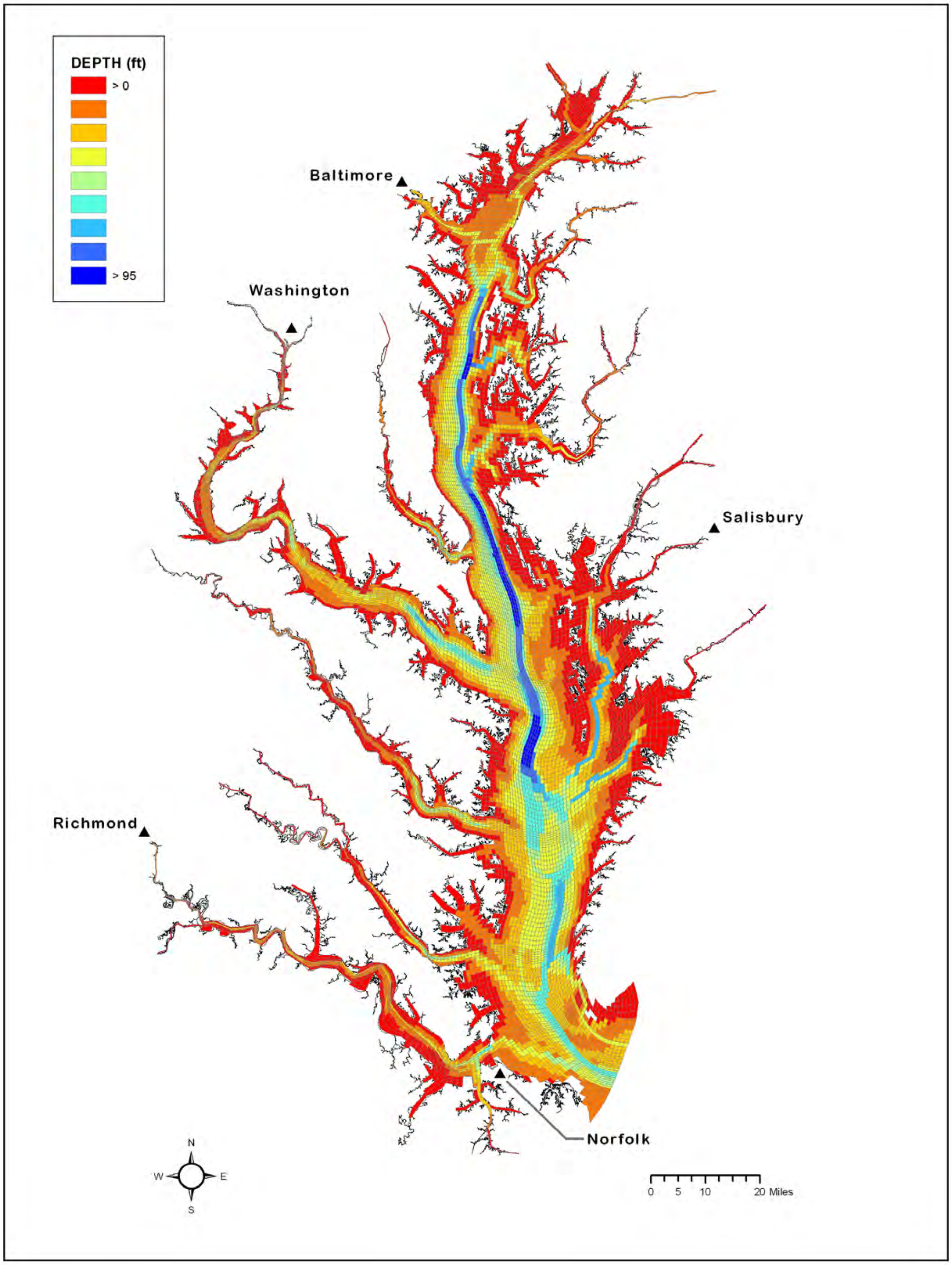
The Bay Watershed Model was linked to the Chesapeake Bay Water Quality and Sediment Transport Model (Bay Water Quality Model), which in turn was used to evaluate the impacts on Bay water quality conditions in response to changes in nitrogen, phosphorus, and sediment loading levels.

The Bay Water Quality Model combines a three-dimensional hydrologic transport model (CH3D) with a eutrophication model (CE-QUAL-ICM) to predict water quality conditions in the Bay resulting from changes in loads from the contributing area (Figure 5-16). The hydrodynamic model computes intra-tidal transport using a three-dimensional grid framework of 57,000 cells (Cerco et al. 2010). The sediment transport model computes continuous three-dimensional velocities, surface elevation, vertical viscosity and diffusivity, temperature, salinity, and density using time increments of 5 minutes.



Source: USEPA 2010j

Figure 5-15. Phase 5.3 Chesapeake Bay Watershed Model hydrology (upper panel) and water quality (lower panel) monitoring calibration stations overlaid on the Phase 5.3 Bay Watershed Model's river segments.



Source: Cerco et al. 2010

Figure 5-16. The detailed 57,000 cell grid of the Chesapeake Bay Water Quality and Sediment Transport Model.

The hydrodynamic model was calibrated for the period 1991–2000 and verified against the large amount of observed tidal elevations, currents, and densities available for the Bay.

Computed flows, surface elevations, and vertical diffusivities from the hydrodynamic model were output at 2-hour intervals for use in the water quality model. Boundary conditions were specified at all river inflows, lateral flows, and at the mouth of the Bay.

The eutrophication (water quality) model computes algal biomass, nutrient cycling, and DO, as well as numerous additional constituents and processes using a 15-minute time step (Cerco and Cole 1993; Cerco 2000; Cerco et al. 2002; Cerco and Noel 2004). In addition, the eutrophication model incorporates a predictive sediment diagenesis[8] component, which simulates the chemical and biological processes undergone at the sediment-water interface after sediment are deposited (Di Toro 2001; Cerco and Cole 1994).

Loads to the system include distributed or nonpoint source loads, point source loads, atmospheric loads, bank loads, and wetlands loads. Nonpoint source loads enter the tidal system at tributary fall lines and as runoff below the fall lines. Point source loads are from industries and municipal wastewater treatment plants. Atmospheric loads are deposited directly to the Bay tidal surface waters. Atmospheric loads to the watershed are incorporated in the distributed loads. Bank loads originate with shoreline erosion. Wetland loads are materials created in and exported from wetlands and include exported wetland oxygen demand.

Detailed documentation on the Chesapeake Bay Water Quality and Sediment Transport Model (Cerco and Noel 2004; Cerco et al. 2010) is at http://www.chesapeakebay.net/content/publications/cbp_26167.pdf.

5.9.1 Nonpoint Source Loads

Nonpoint source loads to the Bay Water Quality Model are from the Phase 5.3 Bay Watershed Model. Loads are provided daily, routed to surface cells on the model grid. Routing is based on local watershed characteristics and on drainage area contributing to the cell adjacent to the land (USEPA 2010j).

5.9.2 Point Source Loads

Wastewater discharged loads to the Bay Water Quality Model were based on reports provided by state and local agencies which, depending on the source, were specified annually or monthly. In the model, loads from individual sources were summed into loads to model surface cells and were provided monthly (USEPA 2010j).

5.9.3 Atmospheric Loads

The EPA CBP Office computed the daily atmospheric loads to each Water Quality Model surface cell (USEPA 2010j). Wet deposition loads of ammonium and nitrate were derived from National Atmospheric Deposition Program observations. Dry deposition load was derived from

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[8] Predictive sediment diagenesis is a predictive model of how organic material and nutrients in sediment on the Bay floor are processed.

the CMAQ. Deposition loads of organic and inorganic phosphorus were specified on a uniform, constant, areal basis derived from published values.

5.9.4 Bank Loads

Bank loads are the solids, carbon, nitrogen, and phosphorus loads contributed to the water column through shoreline erosion. Although erosion is episodic, bank loads can be estimated only as long-term averages by areal surveys. The volume of eroded material is commonly quantified from comparison of topographic maps or aerial photos separated by time scales of years. Consequently, the erosion estimates are averaged over periods of years, but bank loads are input into the Bay Water Quality Model as episodic events as determined by a wave energy submodel. Bank loads were estimated for shoreline and sub-tidal erosion for much of the Chesapeake Bay shoreline on a scale of about every 10 kilometers of shoreline.

5.9.5 Wetlands

Wetlands loads are the sources (or sinks) of oxygen and oxygen-demanding material, such as carbon, that is associated with wetlands that fringe the shore of the Bay and tributaries. These loads are invoked primarily as an aid in calibrating tidal tributary dissolved oxygen concentrations. Loads to each cell were computed by multiplying the amount of adjacent wetlands area by the amount of areal carbon export or oxygen consumption. A uniform carbon export of 0.3 grams carbon per meters^2 per day was employed, leading to a uniform oxygen demand of 2 gram oxygen per meters^2 per day. Segments receiving the largest carbon loads and subject to the greatest oxygen consumption include the mid-portion of the Bay, Tangier Sound, several Eastern Shore tidal tributaries, the tidal middle and lower James River, the tidal fresh York River, and the tidal York River mouth.

5.9.6 Model Setup

Within the Bay Water Quality Model, 90 of the 92 Chesapeake Bay segments are fully represented within the 57,000 model cells and fully simulated. Two Bay segments—the Western Branch Patuxent River and the Chesapeake and Delaware Canal—were either not included in the modeled Chesapeake Bay segments or not fully simulated in the Chesapeake Bay Water Quality and Sediment Transport Model. Bay TMDLs were developed for both of these Bay segments using information from the Phase 5.3 Bay Watershed Model, Bay Water Quality Model results from adjoining tidal Bay segments, and other documented sources (see Section 9).

The Western Branch Patuxent River (WBRTF) segment in Maryland (see Table 2-1 and Figure 2-5) was not simulated in the Bay Water Quality Model because of the lack of quality data on the tidal river's bathymetry (Cerco et al. 2010). In June 2000, the Maryland Department of Environment published a BOD TMDL for this tidal river segment to address DO impairments (MDE 2000). Therefore, WBRTF is listed on Category 4a for a BOD TMDL on Maryland's 2008 Integrated Report (see Table 2-1) (MDE 2008). A TMDL for segment WBRTF has been developed on the basis of: (1) Maryland Department of Environment's original BOD TMDL and loading information from the surrounding Phase 5.3 watershed model segments that drain directly into the Western Branch Patuxent River segment; and (2) outputs from the down-tide

Patuxent River segments (PAXTF, PAXOH, PAXMH), which are also listed as impaired (see Table 2-1 and Section 9) (MDE 2008).

The Delaware portion of the Chesapeake and Delaware Canal (C&DOH_DE) is simulated in the Bay Water Quality Model as a boundary condition[9] for the Delaware Bay using constant flow and load (Cerco et al. 2010). The segment is listed as impaired (see Table 2-1) (DE DNREC 2008). A Chesapeake Bay TMDL for segment C&DOH_DE was developed using a combination of loading information from the surrounding Phase 5.3 Bay Watershed Model segments that drain directly into this Bay segment and outputs from the down-tide Chesapeake Bay segments (C&DOH_MD, ELKOH, and CB1TF), which also are listed as impaired (see Table 2-1 and Section 9) (MDE 2008).

5.10 CHESAPEAKE BAY CRITERIA ASSESSMENT PROGRAM

Output from the Bay Water Quality Model is used to modify historical water quality monitoring observations from the period 1991–2000 for the purposes of determining Chesapeake Bay WQS attainment under various pollutant load reduction scenarios (for more details on this process, see Section 6.2.2). To perform the necessary procedures on the large amount of data required from both the Bay Water Quality Model and the Chesapeake Bay Water Quality Monitoring Program database, a set of FORTRAN modules was developed. These post-processing modules read output from the Bay Water Quality Model (hourly values for DO; daily values for chlorophyll *a*), perform regression analyses, and apply those regressions to the appropriate historical monitoring data set. Additional FORTRAN modules then perform the same standardized, automated criteria assessment procedures that are used to assess more recent monitoring data for the Bay jurisdictions' section 303(d) listing reports.

The source code for this suite of FORTRAN modules is maintained by the EPA CBP Office's Modeling and Monitoring teams on behalf of the partnership and is accessible at ftp://ftp.chesapeakebay.net/Monitoring/CriteriaAssessment/.

The process by which historical monitoring data are scenario-modified using output from the Bay Water Quality Model is summarized in Section 6.2.2. For a detailed description of the Chesapeake Bay water quality criteria assessment procedures used for generating 303(d) listings, see EPA's *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries–2008 Technical Support for Criteria Assessment Protocols Addendum* (USEPA 2008a) and EPA's *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries: 2010 Technical Support for Criteria Assessment Protocols Addendum* (USEPA 2010a).

5.11 CLIMATE CHANGE SIMULATION

The potential effects of future climate change were accounted for in the current Bay TMDL allocations based on a preliminary assessment of climate change impacts on the Chesapeake Bay.

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[9] Boundary conditions refer to the definition or statement of conditions or phenomena at the boundaries of a model; water levels, flows, and concentrations that are specified at the boundaries of the area being modeled.

Because of well known limitations in the current suite of Bay models to fully simulate the effects of climate change as listed below, EPA and its partners are committed to a more comprehensive assessment in 2017. Effects of climate change already observed in the mid-Atlantic region have been factored in the Bay TMDL through the application of recent records of precipitation, streamflow, and Chesapeake Bay water column temperatures which reflect changes in the regional climate over the past several decades.

A preliminary assessment of climate change impacts on the Chesapeake Bay was conducted, in parallel, using an earlier version of the Phase 5 Bay Watershed Model and tools developed for EPA's BASINS 4 system including the Climate Assessment Tool (see Appendix E for details). Flows and associated nutrient and sediment loads were assessed in all river basins of the Chesapeake Bay with three key climate change scenarios reflecting the range of potential changes in temperature and precipitation in the year 2030. The three key scenarios came from a larger set of 42 climate change scenarios that were evaluated from seven Global Climate Models, two scenarios from the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios storylines, and three assumptions about precipitation intensity in the largest events. The 42 climate change scenarios were run on the Phase 5 Watershed Model of the Monocacy River watershed, a subbasin of the Potomac River basin in the Piedmont region, using a 2030 estimated land use based on a sophisticated land use model containing socioeconomic estimates of development throughout the watershed.

The results provide an indication of likely precipitation and flow patterns under future potential climate conditions (Linker et al. 2007, 2008) (see Appendix E). Projected temperature increases tend to increase evapotranspiration in the Bay watershed, effectively offsetting increases in precipitation. The preliminary analysis indicated overall decreases in annual stream flow, nitrogen and phosphorus loads. The higher intensity precipitation events yielded estimated increases in annual sediment loads. These preliminary findings support the nitrogen and phosphorus allocations within the Bay TMDL and application of an implicit margin of safety for these two pollutants, recognizing these loads might not increase, even decrease. These same preliminary findings support EPA's decision for an explicit sediment allocation margin of safety, recognizing the potential for increased sediment loads.

EPA and its partners are committed to conducting a more complete analysis of climate change effects on TMDL nitrogen, phosphorus, and sediment loads, which is to be made during the mid-course assessment of Chesapeake Bay TMDL progress in 2017 as called for in Section 203 of the Chesapeake Executive Order 13508 (May 12, 2009) (please see Section 10.5 for more details).

To carry out a more complete analysis of climate change effects, changes will be needed to the current suite of Bay models and tools including:

- Applying the results from the next generation of global climate change models to develop the best available estimates of the effects of climate change on the mid-Atlantic region
- Developing a better means for down-scaling the results from the applicable global climate change models to match the finer segmentation of the Phase 5.3 Chesapeake Bay Watershed Model

- Developing the means to better understand and fully simulate the interactions between increased evapotranspiration and high intensity precipitation events within the Chesapeake Bay Watershed Model
- Building the capacity to simulate the effects of change in tidal water column temperatures on all the existing temperature dependent rates and processes currently simulated with the hydrodynamic, estuarine water quality, sediment transport, living resources and filter feeder component models of the Chesapeake Bay Water Quality and Sediment Transport Model
- Reevaluate the temperature dependent effects on key species and communities (e.g., eelgrass) to ensure the latest scientific understanding has been factored into the suite of Bay models

SECTION 6. ESTABLISHING THE ALLOCATIONS FOR THE BASIN-JURISDICTIONS

The process that informed EPA's decisions establishing the Chesapeake Bay TMDL involved many stakeholders, most notably, the Bay jurisdiction partners. A four-step process was used for the development of the TMDL. Those steps were

1. EPA defined 19 major river basin and jurisdictional loading allocations—July 1, 2010, for nitrogen and phosphorus; August 13, 2010, for sediment. The methodology that EPA used in defining those allocations is described in detail in this section.
2. Each jurisdiction developed a Phase I Watershed Implementation Plan (WIP) that described how it would achieve the target allocations for nitrogen, phosphorus, and sediment assigned to the jurisdictions and basins in step 1.
3. EPA evaluated the jurisdictions' suballocations and final Phase I WIPs to determine whether they met the jurisdiction-wide and major river basin allocations, included adequate detail to ensure that NPDES permits are consistent with the assumptions and requirements of the WLAs, and provided sufficient reasonable assurance that nonpoint source reductions could be achieved and maintained through credible and enforceable or otherwise binding strategies in jurisdictions that are signatories to the Chesapeake Bay Agreement, and similarly effective strategies in non-signatory jurisdictions. That evaluation and its results are described in detail in Section 8.

On the basis of the results of its evaluation, EPA established an allocation scenario for the final Chesapeake Bay TMDL, including allocations for each of the 92 Bay segments, using suballocations provided in the final Phase I WIPs, alternative EPA backstop allocations, or a combination of the two. Tables showing the 92 Bay segment-specific and sector-specific allocations of the Chesapeake Bay TMDL are in Section 9.

This section describes the method used to derive the basin-jurisdiction allocations described in Step 1 above. The following subsections discuss the specific approaches adopted to address specific technical aspects of the Chesapeake Bay TMDL:

- 6.1-Establishing the overall model parameters
- 6.2-Establishing the nitrogen and phosphorus model parameters
- 6.3-Methodology for establishing the basin-jurisdiction allocations for nitrogen and phosphorus
- 6.4-Establishing the Basin-jurisdiction allocations for nitrogen and phosphorus
- 6.5-Establishing the sediment model parameters
- 6.6-Establishing the basin-jurisdiction allocations for sediment
- 6.7-Basin-jurisdiction allocations to achieve the Bay WQS
- 6.8-Attainment of the District of Columbia pH WQS

The Chesapeake Bay Program partners initiated discussions related to the technical aspects of the Chesapeake Bay TMDL starting at the September 2005 Reevaluation Workshop sponsored by what would become the partnership's Water Quality Steering Committee (Chesapeake Bay Reevaluation Steering Committee 2005). Over the next 5 years, EPA and its partners, in particular members of the Water Quality Steering Committee (2005–2008) and then the Water Quality Goal Implementation Team (WQGIT) (2009–present) systematically evaluated and agreed on approaches to address multiple technical aspects related to developing the Bay TMDL.

EPA, together with its seven watershed jurisdictional partners, developed and applied approaches and methodologies to address a number of factors in developing the Bay TMDL. A multitude of policy, programmatic, and technical issues were addressed through this collaborative process.

6.1 Establishing the Overall Model Parameters

The first step in the process was to establish the key parameters for the models used in developing the TMDL. The model parameters discussed below are those that are common to developing TMDLs that ensure attainment for all three water quality criteria: DO, chlorophyll *a* and submerged aquatic vegetation (SAV)/water clarity. Those key parameters are: (1) the hydrologic period, or the period that is representative of typical conditions for the waterbody; (2) the seasonal variation in water quality conditions and the factors (e.g., temperature, precipitation and wind) that directly affect those conditions; and (3) the development of daily loads for the TMDL.

6.1.1 Hydrologic Period

The hydrologic period for modeling purposes is the period that represents the long-term hydrologic conditions for the waterbody. This is important so that the Bay models can simulate local long-term conditions for each area of the Bay watershed and the Bay's tidal waters so that no one area is modeled with a particularly high or low loading, an unrepresentative mix of point and nonpoint sources or extremely high or low river flow. The selection of a representative hydrologic averaging period ensures that the balance between high and low river flows and the resultant point and nonpoint source loadings across the Bay watershed and Bay tidal waters are appropriate. The hydrologic period also provides the temporal boundaries on the model scenario runs from which the critical period is determined (see Section 6.2.1).

To identify the appropriate hydrologic period, EPA analyzed decades of historical stream flow data. It is important when determining representative hydrology to be able to compare various management scenarios through the suite of Bay models. In the course of evaluating options for the TMDL, EPA and its jurisdictional partners ran numerous modeling scenarios through the Bay Watershed and the Bay Water Quality Sediment Transport models with varying levels of management actions (e.g., land use, BMPs, wastewater treatment technologies) held constant against an actual record of rainfall and meteorology to examine how those management actions perform over a realistic distribution of simulated meteorological conditions.

Because of the long history of monitoring throughout the Chesapeake Bay watershed, the CBP partners were in the position of selecting a period for model application representative of typical hydrologic conditions of the 21 contiguous model simulation years—1985 to 2005. Two extreme conditions occurred during the 21-year model simulation period for the Chesapeake Bay models: Tropical Storm Juan in November 1985, and the Susquehanna *Big Melt* of January 1996. In the

Chesapeake Bay region, Tropical Storm Juan was a 100-year storm primarily affecting the Potomac and James River basins. No significant effect on SAV or DO conditions was reported in the aftermath of Tropical Storm Juan. In the case of the Susquehanna Big Melt in January 1996, a warm front brought rain to the winter snow pack in the Susquehanna River basin and caused an ice dam to form in the lower reaches of the river. No significant effects on SAV or DO were reported from that 1996 extreme event, likely because of the time of year when it occurred (late winter).

From the 21-year period, EPA selected a contiguous 10-year hydrologic period because a 10-year period provides enough contrast in different hydrologic regimes to better examine and understand water quality response to management actions over a wide range of wet and dry years. Further, a 10-year period is long enough to be representative of the long-term flow (Appendix F). Finally, a 10-year period is within today's capability of computational resources, particularly for the Chesapeake Bay Water Quality Sediment Transport Model (Bay Water Quality Model), which required high levels of parallel processing for each management scenario. The annualized Bay TMDL allocations are expressed as an average annual load over the 10-year hydrologic period.

EPA then determined which 10-year period to use by examining the statistics of long-term flow relative to each 10-year period at nine USGS gauging stations measuring the discharge of the major rivers flowing to the Bay (Appendix F). All the contiguous 10-year hydrologic periods from 1985 to 2005 appeared to be suitable because quantifiable assessments showed that all the contiguous 10-year periods had relatively similar distributions of river flow.

EPA selected the 10-year hydrologic assessment period from 1991 to 2000 from the 21-year flow record for the following reasons:

- It is one of the 10-year periods that is closest to an integrated metric of long-term flow.
- Each basin has statistics for this period that were particularly representative of the long-term flow.
- It overlaps several years with the previous 2003 tributary strategy allocation assessment period (1985–1994), which facilitated comparisons between the two assessments.
- It incorporates more recent years than the previous 2003 tributary strategy allocation assessment period (1985–1994).
- It overlaps with the Bay Water Quality Transport Model calibration period (1993–2000), which is important for the accuracy of the model predictions.
- It encompasses the 3-year critical period (1993–1995) for the Chesapeake Bay TMDL as explained in Section 6.2.1 below.

More detailed documentation on the determination of the hydrologic period is provided in Appendix F.

6.1.2 Seasonal Variation

A TMDL analysis must consider the seasonal variations within the watershed (CWA 303(d)(1)(C); 40 CFR 130.7). The Chesapeake Bay TMDL inherently considers all seasons through the use of a continuous 10-year simulation period that captures seasonal precipitation on a year-to-year basis throughout the entire watershed. Furthermore, the critical periods selected for this TMDL, being a minimum of 3 consecutive years provide further assurance that the seasonality of the Bay loading and other dynamics are properly addressed in this TMDL. In this way, the TMDL simulations ensure attainment of WQS during all seasons.

Seasonal Variation in the Jurisdictions' Bay Water Quality Standards

In the case of the Chesapeake Bay TMDL, the Chesapeake Bay WQS adopted by the four tidal Bay jurisdictions are biologically based and designed to be protective of Chesapeake living resources, including full consideration of their unique seasonal-based conditions (see Section 3) (USEPA 2003a, 2003c). To assess the degree of WQS achievement using the Bay Water Quality Model, an overlay of the time and space dimensions are simulated to develop an assessment that is protective of living resources with consideration of all critical periods within the applicable seasonal period (USEPA 2007a).

The same approach of considering the time and space of the critical conditions is applied in the assessment of the WQS achievement with observed monitoring data. Ultimately, the time and space of water quality exceedances are assessed against a reference curve derived from healthy living resource communities to determine the degree of WQS achievement (USEPA 2007a).

Model Simulation Supporting Seasonal Variation

The suite of Chesapeake Bay Program models being used to establish the Chesapeake Bay TMDL—Bay Airshed, Bay Watershed, Bay Water Quality, Bay Sediment Transport, Bay filter feeders—all simulate the 10-year period and account for all storm events, high flows/low flows, and resultant nitrogen, phosphorus, and sediment loads across all four seasons. The full suite of Chesapeake Bay models operate on at least an hourly time-step and often at finer time-steps for the Bay Airshed Model and the Bay Water Quality Model (see Sections 5.4 and 5.9, respectively). Therefore, through proper operation of the suite of Bay models, the Chesapeake Bay TMDL considers all seasons and within season variations through the use of a continuous 10-year simulation period (see Section 6.1.1).

Seasonal Variations Known and Addressed through Annual Loads

A key aspect of Chesapeake Bay nitrogen and phosphorus dynamics is that annual loads are the most important determinant of Chesapeake Bay water quality response (USEPA 2004c). Chesapeake Bay physical and biological processes can be viewed as integrating variations in nitrogen, phosphorus, and sediment loads over time. The integration of nitrogen, phosphorus, and sediment loads over time allows for an analysis of loads in the Chesapeake Bay that is minimally influenced by short-term temporal fluctuations. Bay water quality responds to overall loads on a seasonal to annual scale, while showing little response to daily or monthly variations within an annual load.

Numerous Chesapeake Bay studies show that annually based wastewater treatment of nitrogen and phosphorus reductions are sufficient to protect Chesapeake Bay water quality (Linker 2003, 2005). The seasonal aspects of the jurisdictions' Chesapeake Bay WQS are due to the presence and special seasonal needs of the living resources being protected (e.g., spawning), but annual nitrogen, phosphorus, and sediment load reductions are most important to achieve and maintain the seasonal water quality criteria, some of which protect multiple season designated uses—open-water, shallow-water bay grass, and migratory spawning and nursery (USEPA 2003a, 2003d).

6.1.3 Daily Loads

Consistent with the D.C. Circuit Court of Appeals decision in *Friends of the Earth, Inc. v. EPA*, in addition to the annual loading expressions of the pollutants in this TMDL, EPA is also expressing its Chesapeake Bay TMDL in terms of daily time increments (446 F.3d 140 [D.C. Cir. 2006]). Specifically, the Chesapeake Bay TMDL has developed a maximum daily load based on annual and seasonal loads for nitrogen, phosphorus, and sediment for each of the 92 Chesapeake Bay segments. EPA also recognizes that it may be appropriate and necessary to identify non-daily allocations in TMDL development despite the need to also identify daily loads. In an effort to fully understand the physical and chemical dynamics of a waterbody, TMDLs can be developed using methodologies that result in the development of pollutant allocations expressed in monthly, seasonal, or annual periods consistent with the applicable WQS. TMDLs can be developed applying accepted and reasonable methodologies to calculate the most appropriate averaging period for allocations on the basis of factors such as available data, watershed and waterbody characteristics, pollutant loading considerations, applicable WQS, and the TMDL development methodology. Consistent with that policy, the Chesapeake Bay TMDL was developed and is expressed in annual loads. In addition, EPA calculated daily loads to reflect a statistical expression of an annually-based maximum daily load and a seasonally-based maximum daily load. Appendix R of this TMDL includes detailed nitrogen, phosphorus, and sediment annually based maximum daily allocations to achieve applicable WQS. The spreadsheet lists total nitrogen, phosphorus, and sediment loads as delivered to the Chesapeake Bay's tidal waters. Daily load allocations are shown for each of the 92 segments and by sources for WLAs including agriculture (CAFOs), stormwater (MS4s), wastewater (CSO) and wastewater (significant and nonsignificant by NPDES permit); and for LAs including agriculture, forest, nontidal atmospheric deposition, onsite treatment systems, and urban sources.

Approach for Expressing the Maximum Daily Loads

The methodology applied to calculate the expression of the maximum daily loads and associated wasteload and load allocations in the Chesapeake Bay TMDL is consistent with the approach contained in EPA's published guidance, *Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA, et al., No. 05-5015, (April 25, 2006) and Implications for NPDES Permits*, dated November 15, 2006 (USEPA 2006). Additionally, the analytical approach selected in the Bay TMDL is similar to the wide range of technically sound approaches and the guiding principles and assumption described in the technical document *Options for the Expression of Daily Loads in TMDLs* (USEPA 2007c).

Computing the Daily Maximum Loads and the Seasonal Daily Maximum Loads

Annually based maximum daily loads are derived for each of the 92 tidal segments and for each of the three pollutants—nitrogen, phosphorus, and sediment—as a direct product of the Chesapeake Bay TMDL and associated modeling. That modeling output serves as the starting point for the annually-based maximum daily load expression and the seasonally-based maximum daily load expression. Those daily maximum loads are a function of the 10-year continuous simulation produced by the paired Bay Watershed-Bay Water Quality models. The modeling approach allows for the daily maximum load expression to be taken directly from the output of the TMDL itself, assuring a degree of consistency between the daily maximum load calculation and the annual loads necessary to meet applicable WQS included in the final TMDL. That is, the methodology uses the annual allocations derived through the modeling/TMDL analysis, and converts those annual loads to daily maximum loadings.

Both the Chesapeake Bay TMDL annually-based maximum daily load and seasonally based maximum daily load represents the 95th percentile of the distribution to protect against the presence of anomalous outliers. That expression implies a 5 percent probability that an annually-based daily or seasonal-based daily maximum load will exceed the specified value under the TMDL condition. However, during such unlikely events, compliance with the annual loading will assure that applicable WQS will be achieved.

On the basis of probability analysis, a loading that will be achieved 100 percent of the time cannot be calculated. So some percentage probability of attainment must be chosen that is less than 100 percent but high enough that there is comfort that the loading will be achieved. A 95 percent probability is often determined by EPA to be appropriate in environmental matters (like WQS and NPDES permitting) and has also been chosen in this application. The EPA guidance mentioned above provides for much discretion in selecting the percent probability to use in the daily calculation. Because the calculation is for a daily maximum value, it is EPA’s professional opinion that, with regard to the Chesapeake Bay TMDL, a 95 percent probability is most appropriate. The steps employed to compute the annually or seasonally based maximum daily load for each segment were as follows:

1. Calculate the annual average loading for each of the 92 Bay segments; that would be the annual loading under the TMDL/allocation condition. Annual allocations are in Section 9 and Appendix Q.
2. Calculate the 95th percentile of the daily loads delivered to each of the 92 Bay segments (using the same loading condition as step 1).
3. Calculate the Annual/Daily Maximum ratio (ADM) for each of the 92 Bay segments by dividing the annual average load by the 95th percentile calculated in Step 2.
4. Calculate a Baywide ADM by computing a load-weighted average of all 92 Bay segments ADM ratios. Table 6-1 provides the annual Baywide ADM.
5. Divide all the annual TMDLs, WLAs, and LAs in each of the 92 Bay segments in the TMDL by the Baywide ADM. Those are the calculated annual-based daily maximum loads found in Appendix R.
6. Using the approach described in steps 1–5 above, calculate a Baywide ADM for each season for each of the 92 Bay segments. Table 6-1 provides the Seasonal Baywide ADM.
7. Divide all the annual TMDLs in each of the 92 tidal segments in the TMDL by Seasonal ADM to calculate the seasonally-based maximum daily load.

Table 6-1. ADM for calculating daily maximum loads

	Winter	Spring	Summer	Fall	All year
Total Nitrogen	123.7	80.9	337.1	210.9	123.6
Total Phosphorus	95.8	60.1	260.7	141.2	98.2
Total Suspended Solids	96.5	58.0	384.7	158.1	100.3

It should be noted that a statistical expression of a daily load is just that, an expression of the probability that a specific maximum daily load will occur in a given segment for a specific pollutant. The magnitude of the TMDL allocations was established to assure the attainment of all applicable WQS in each of the 92 tidal Bay segments. EPA has provided annually based maximum daily load expressions in Appendix R. Seasonally based maximum daily loads can be calculated by dividing the annual allocations by the seasonal ADMs in Table 6-1. That seasonal expression reflects a temporally variable target because the various pollutant sources (point and nonpoint) vary significantly by month and by season. The annually based daily maximum loads represent the infrequent, maximum inputs into the Chesapeake Bay. The annually based maximum daily load and the seasonally based maximum daily load provide a range of conditions that are acceptable on a daily basis and that will meet overall TMDL allocations and the applicable WQS.

The Expression of Daily Loads and NPDES Permits

NPDES permit regulations require that effluent limits in permits be expressed as monthly average and either weekly average or daily maximum, unless impracticable. As reflected in EPA's March 3, 2004 Memorandum *Annual Permit Limits for Nitrogen and Phosphorus for Permits Designed to Protect Chesapeake Bay and its tidal tributaries from excess nitrogen and phosphorus loadings under the National Pollutant Discharge Elimination System* and EPA's December 29, 2004 letters to each Chesapeake Bay watershed jurisdiction, which enclosed the *NPDES Permitting Approach for the Discharges of Nitrogen and Phosphorus in the Chesapeake Bay Watershed* it is EPA's best professional judgment that, when developing NPDES permit limits consistent with this TMDL, jurisdictions should consider expressing permit effluent limits for nitrogen and phosphorus as annual loads, instead of expressing the limits as monthly, weekly, or daily limits (USEPA 2004c, 2004d). After consideration of complex modeling of the effect of nitrogen and phosphorus loading to the Bay from individual point source discharges, EPA concluded that the Chesapeake Bay and its tidal tributaries in effect integrate variable point source monthly loads over time, so that as long as a particular annual total load of nitrogen and phosphorus is met, constant or variable intra-annual load variation from individual point sources has no effect on water quality of the main Bay. EPA recommends that because of the characteristics of nitrogen and phosphorus loading and its effect on the water quality of the Bay, the derivation of appropriate daily, weekly, or monthly permit limits is impracticable, and the permit limits expressed in annual loads is appropriate. To protect local water quality, or for other appropriate reasons, the NPDES permitting authority may also express the effluent limits in monthly or daily terms.

6.2 Establishing the Nitrogen and Phosphorus Related Model Parameters

6.2.1 Critical Conditions

TMDLs are required to identify the loadings necessary to achieve applicable WQS. The allowable loading is often dependent on key environmental factors, most notably wind, rainfall, streamflow, temperature, and sunlight. Because those environmental factors can be highly variable, EPA regulations require that in establishing the TMDL, the critical conditions (mostly environmental conditions as listed above) be identified and employed as the design conditions of the TMDL [40 CFR 130.7(c)(1)].

When TMDLs are developed using supporting watershed models, such as the Chesapeake Bay TMDL, selecting a critical period for model simulation is essential for capturing important ranges of loading/waterbody conditions and providing the necessary information for calculating appropriate TMDL allocations that will meet applicable WQS. Because the WQS applicable to this TMDL are assessed over 3-year periods, the critical period is defined as the 3-year period within the previously selected 1991–2000 hydrologic period (see Section 6.1.1) that meets the above description (USEPA 2003a). Critical conditions for sediment and SAV are discussed in Section 6.5.1 below.

Critical Conditions for DO

In the Chesapeake Bay, EPA has found that as flow and nitrogen and phosphorus loads increase, DO and water clarity levels decrease (Officer 1984). Therefore, EPA bases the critical period for evaluation of the DO and water clarity WQS on identifying high-flow periods. Those periods were identified using statistical analysis of flow data as described below and in detail in Appendix G.

For the Bay TMDL, EPA conducted an extensive analysis of streamflow of the major tributaries of the Chesapeake Bay as the primary parameter representing critical conditions. In that analysis, it was observed that high streamflow most strongly correlated with the worst DO conditions in the Bay. That is logical because most of the nitrogen and phosphorus loading contributing to low DO in the Bay comes from nonpoint sources, whose source loads are driven by rainfall and correlate well to rainfall and higher streamflows. Additionally, higher freshwater flows generally increase water column stratification, preventing the low-DO bottom waters from being reaerated.

Because future rainfall conditions cannot be predicted, EPA analyzed rainfall from past decades to derive a critical rainfall/streamflow condition that would be used to develop the allowable loadings in the TMDL. The initial analysis concluded that the years 1996–1998 represented the highest streamflow period for the Chesapeake Bay drainage during the 1991–2000 hydrology period. However, it was later discovered that this 3-year period represented an extreme high-flow condition that was inappropriate for the development of the TMDL—the high-flow period would generally occur once every 20 years (Appendix G). After further analysis, EPA selected the second highest flow period of 1993–1995 as the critical period. The 1993–1995 critical period experienced streamflows that historically occurred about once every 10 years, which is much more typical of the return frequency for hydrological conditions employed in developing TMDLs (Appendix G). Thus, while the modeling for the Bay TMDL consists of the entire hydrologic period of 1991–2000, EPA used the water quality conditions during the 1993–1995 critical period to determine attainment with the Bay jurisdictions' DO WQS.

Critical Conditions for Chlorophyll *a*

Algae, measured as chlorophyll *a*, responds to a multitude of different environmental factors, parameters, and conditions including the following:

- Nitrogen and phosphorus loads
- Water column temperature
- pH conditions
- Local nitrogen and phosphorus conditions (e.g., fluxes of nitrogen and phosphorus from the bottom sediment)
- River flow influences on dilution of existing algae populations
- River flow, bathymetry, and other factors influencing residence time
- Local weather conditions (e.g., wind, percentage of sunlight)
- Other conditions and parameters not well understood within the current state of the science

Some of those same factors influence DO conditions, while others are unique to algae. As documented in Appendix G, using the same methodology as was used to determine the DO critical period for the entire Chesapeake Bay, EPA conducted a flow analysis to support the selection of a critical period for the tidal James River, which has numeric chlorophyll *a* criteria. EPA based that analysis on the correlation between flow and violations of the numeric chlorophyll *a* water quality criteria. The analysis showed no strong correlation between streamflow and chlorophyll *a* conditions (Appendix G). As a result, EPA assessed numeric chlorophyll *a* attainment using all eight of the 3-year criteria assessment periods (e.g., 1991–1993, 1992–1994) that occur within the hydrologic period of 1991–2000.

6.2.2 Assessment Procedures for DO and Chlorophyll a Standards

The Bay Water Quality Model is used to predict water quality conditions for the various loading scenarios explored. It is necessary to compare these model results with the applicable WQS to determine compliance with the standards. This section describes the process by which model results are compared to WQS to determine attainment.

In general, to determine management scenarios that achieved WQS, EPA ran model scenarios representing different nitrogen, phosphorus, and sediment loading conditions using the Bay Watershed Model. EPA then used the resultant model simulated nitrogen, phosphorus, and sediment loadings as input into the Bay Water Quality Model to evaluate the response of critical water quality parameters: specifically DO, SAV, water clarity, and chlorophyll *a*.

To determine whether the different loading scenarios met the Bay DO and chlorophyll *a* WQS, EPA compared the Bay Water Quality Model's simulated tidal water quality response for each variable to the corresponding observed monitoring values collected during the same 1991-2000 hydrological period. In other words, the Bay Water Quality Model was used primarily to estimate the *change* in water quality that would result from various loading scenarios. The model-simulated change in water quality is then applied to the actual observed calibration monitoring data. In its simplest terms, the following steps were taken to apply the modeling results to predict Bay DO and chlorophyll *a* WQS attainment:

1. Using the 1991 to 2000 hydrologic period, calibrate the Bay Water Quality Model to Bay water quality monitoring data.
2. Run a model simulation for a given loading scenario (usually a management scenario resulting in lower loads relative to the calibration scenario) through the Phase 5.3 Chesapeake Bay Watershed Model (Bay Watershed Model) and Bay Water Quality Model.
3. Determine the model simulated change in water quality from the calibration scenario to the given loading scenario.
4. Apply the change in water quality as predicted by the Bay Water Quality Model to the actual historical water quality monitoring data used for calibration and evaluate attainment on the basis of that scenario-modified data set.
5. If WQS are met, use the allocations for the TMDL. If WQS are not met, reduce and readjust loads to meet WQS.

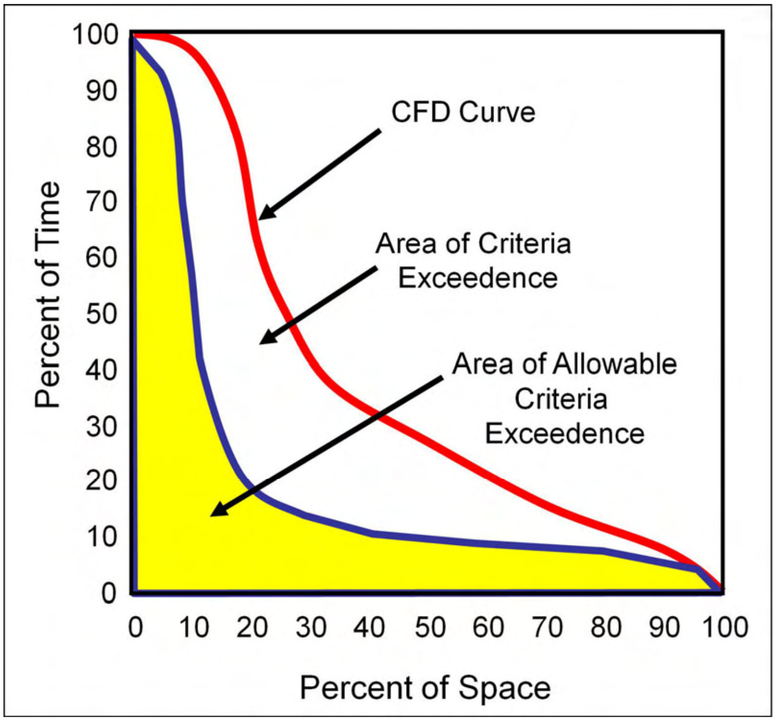
For a full discussion of the procedure, see Appendix H and the original report titled *A Comparison of Chesapeake Bay Estuary Model Calibration With 1985–1994 Observed Data and Method of Application to Water Quality Criteria* (Linker et al. 2002).

6.2.3 Addressing Reduced Sensitivity to Load Reductions at Low Nonattainment Percentages

Mathematical models, including the models used in the Chesapeake Bay TMDL, are not perfect representations of the real world. For that reason, it is important to use professional judgment in the interpretation of those model results. One example of that is, for some segments, the Bay Water Quality Model showed persistent nonattainment at consistently low levels even after the loadings were lowered. After careful analysis, EPA concluded that the low (1 percent) modeled nonattainment levels were more an artifact of the modeling and assessment process, than a representation of actual nonattainment. For that reason, EPA concluded that modeled nonattainment of 1 percent or less was, in fact, attainment with the applicable WQS. The subsection below describes the analysis that EPA conducted to arrive at this conclusion.

The Chesapeake Bay water quality criteria that the jurisdictions adopted into their respective WQS regulations provide for allowable exceedances of each set of DO, water clarity, SAV, and chlorophyll *a* criteria defined through application of a biological or default reference curve (USEPA 2003a). Figure 6-1 depicts that concept in yellow as allowable exceedance of the criterion concentration.

To compare model results with the WQS, EPA analyzes the Bay Water Quality Model results for each scenario and for each modeled segment to determine the percent of time and space that the modeled waster quality results exceed the allowable concentration. For any modeled result where the exceedance in space and time (shown in Figure 6-1 as the area below the red line) exceeds the allowable exceedance (shown in Figure 6-1 as the area below the blue line that is shaded yellow), that segment is considered in nonattainment. The amount of nonattainment is shown in the figure as the area in white between the red line and the blue line and is displayed in model results as percent of nonattainment for that segment. The amount of nonattainment is reported to the whole number percent.



Source: USEPA 2003a

Figure 6-1. Graphic comparison of allowable exceedance compared to actual exceedance.

Dissolved Oxygen

Figure 6-2 displays Bay Water Quality Model results showing percent nonattainment of the 30-day mean open-water DO criterion for various basinwide loading levels of the Maryland portion of the lower central Chesapeake Bay segment CB5MH_MD.

As can be seen in Figure 6-2, there is a notable improvement in the percent nonattainment as the loads are reduced until approximately 1 percent nonattainment. At a loading level of 191 million pounds per year TN, the 1 percent nonattainment is persistent through consecutive reductions in loading levels and remains consistent until a loading level of 170 million pounds per year TN is reached. While this is one of the more extreme examples of persistent levels of 1 percent nonattainment, this general observation of persistent nonattainment at 1 percent is fairly common to the Bay Water Quality Model DO results (Appendix I).

Clear evidence of small, yet persistent percentage of model projected DO WQS nonattainment over a wide range of reduced nitrogen and phosphorus loads across a wide range of segments and designated uses, all of which are responding to nitrogen and phosphorus load reductions, is documented in Appendix I. Because of those widespread observations, supported by independent validation, and for purposes of developing the Chesapeake Bay TMDL, EPA determined that nonattainment percentages projected by the Bay Water Quality Model rounded to 1 percent would be considered in attainment for a segment's designated use. For a more detailed discussion, see Appendix I.

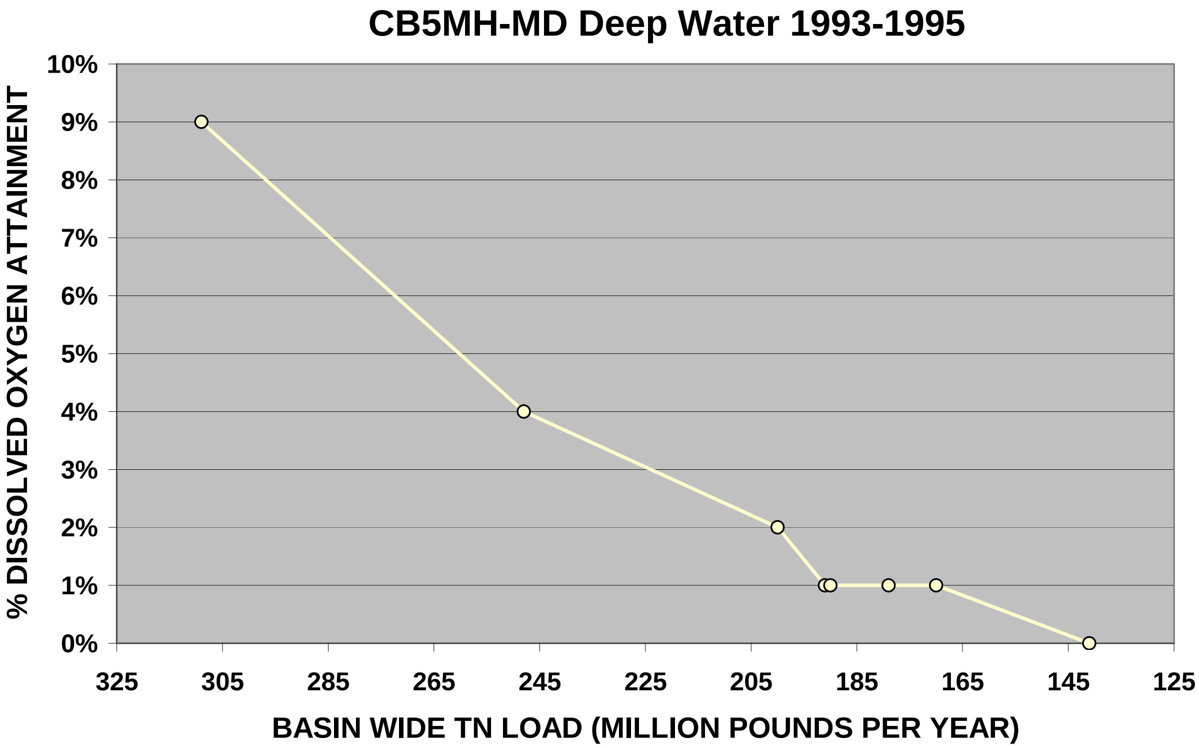


Figure 6-2. Example of DO criteria nonattainment results from a wide range of nitrogen and phosphorus load reduction model scenarios.

Chlorophyll *a*

In the case of assessment of the numeric chlorophyll *a* WQS in the tidal James River in Virginia, there was limited evidence of a reduced sensitivity when approaching the criteria values as compared with the suite of DO WQS as described above for across multiple designated uses and segments. However, as illustrated in Figure 6-3, there is a clear pattern of diminishing response to lowered loadings of nitrogen and phosphorus as the graph approaches 1 percent nonattainment. On the basis of that analysis, combined with the pattern that was even more pronounced with DO, it is EPA's professional judgment that modeled levels of 1 percent nonattainment of the numeric chlorophyll *a* WQS is considered in attainment. In developing the James River Basin allocations under the Bay TMDL, the vast majority of the spring and summer season 3-year periods came into full attainment at the established nitrogen and phosphorus allocations of 23.5 million pounds of nitrogen per year and 2.35 million pounds of phosphorus per year (Appendix O). EPA considered 1 percent nonattainment of the applicable segment and season-specific chlorophyll *a* criteria in attainment for only a limited number of segment/season/3-year period combinations given the evidence, though limited, of reduced sensitivity when approaching full attainment of the criteria values (Appendix I).

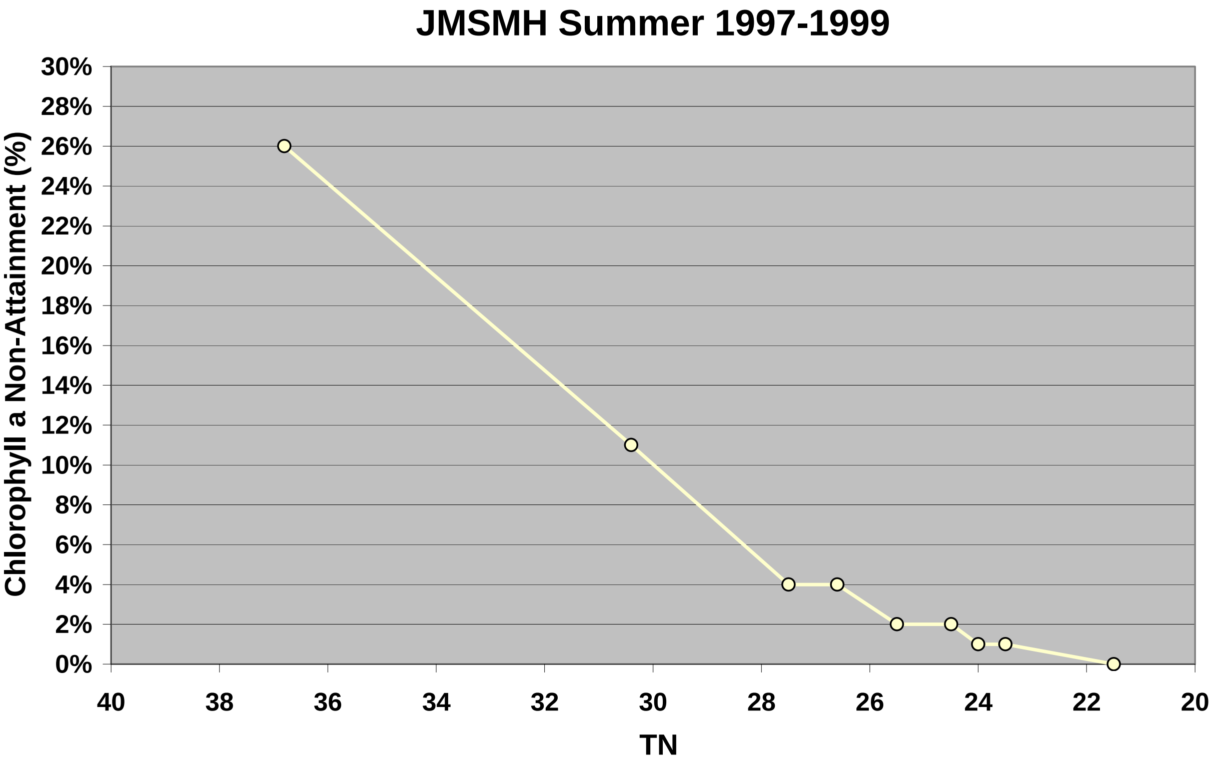


Figure 6-3. Example of a James River segment's spring chlorophyll *a* WQS nonattainment results from a wide range of TN loading Chesapeake Bay Water Quality Model scenarios.

6.2.4 Margin of Safety

Under EPA's regulations, a TMDL is mathematically expressed as

$$\text{TMDL} = \sum WLA + \sum LA + MOS$$

where

- TMDL is the total maximum daily load for the water segment
- WLA is the wasteload allocation, or the load allocated to point sources
- LA is the load allocation, or the load allocated to nonpoint sources
- MOS is the margin of safety to account for any uncertainties in the supporting data and the model

The margin of safety (MOS) is the portion of the TMDL equation that accounts for any lack of knowledge concerning the relationship between LAs and WLAs and water quality [CWA 303(d)(1)(c) and 40 CFR 130.7(c)(1)]. For example, knowledge is incomplete regarding the exact nature and magnitude of pollutant loads from various sources and the specific impacts of those pollutants on the chemical and biological quality of complex, natural waterbodies. The MOS is intended to account for such uncertainties in a manner that is conservative from the standpoint of environmental protection. On the basis of EPA guidance, the MOS can be achieved through two approaches (USEPA 1999): (1) implicitly incorporate the MOS by using conservative model assumptions to develop allocations; or (2) explicitly specify a portion of the

TMDL as the MOS and use the remainder for allocations. Table 6-2 describes different approaches that can be taken under the explicit and implicit MOS options.

Table 6-2. Different approaches available under the explicit and implicit MOS types

Type of MOS	Available approaches
Explicit	• Set numeric targets at more conservative levels than analytical results indicate. • Add a safety factor to pollutant loading estimates. • Do not allocate a portion of available loading capacity; reserve for MOS.
Implicit	• Use conservative assumptions in derivation of numeric targets. • Use conservative assumptions when developing numeric model applications. • Use conservative assumptions when analyzing prospective feasibility of practices and restoration activities.

Source: USEPA 1999

Implicit Margin of Safety for Nitrogen and Phosphorus

The Chesapeake Bay TMDL analysis is built on a foundation of more than two decades of modeling and assessment in the Chesapeake Bay and decades of Bay tidal waters and watershed monitoring data. The Bay Airshed, Watershed, and Water Quality models are state-of-the-science models, with several key models in their fourth or fifth generation of management applications since the early and mid-1980s. The use of those sophisticated models to develop the Bay TMDL, combined with application of specific conservative assumptions, significantly increases EPA’s confidence that the model’s predictions of standards attainment are correct and, thereby, supports the use of an implicit MOS for the Chesapeake TMDL.

The Chesapeake Bay TMDL for nitrogen and phosphorus applies an implicit MOS in derivation of the DO and chlorophyll *a*-based nitrogen and phosphorus allocations through the use of numerous conservative assumptions in the modeling framework. The principal set of conservative assumptions used in the determining the actual allocations is as follows.

The basinwide allowable nitrogen and phosphorus loads were determined on the basis of achieving a select set of deep-water and deep-channel DO standards in the mainstem Bay and adjoining embayments—upper (CB3), middle (CB4MH) and lower (CB5MH) central Chesapeake Bay, and lower Potomac River (POTMH_MD). The Bay TMDL calls for nitrogen load reductions upwards of 50 million pounds greater than that necessary to achieve the applicable DO WQS in those four Bay segments compared with many of the remaining 88 Bay segments.

The open-water and deep-water standards adopted by the jurisdictions have DO WQS that apply to a 30-day mean and an instantaneous maximum. The open-water standards also have a 7-day mean and the deep water use has a 1-day mean. Last, the deep channel use has only a deep-channel instantaneous minimum. The Bay TMDL assessed attainment of each of those standards. But, as described in Appendix D and summarized in Section 3.3.3, the 30-day mean was clearly the most restrictive of the standards for the open-water and deep-water use classifications. For that reason, the allocations were based on 30-day mean for open-water and deep-water and instantaneous standards for deep channel. Because the allocations to achieve those standards are significantly more restrictive than the allocations needed to achieve the other DO standards for the Bay segments, there is an implicit MOS in achieving many of the Bay DO standards.

The DO standards apply year-round. Yet, at the allocated loadings, for the non-summer months of the year, the standards will be readily achieved. Further, as described above, most of the Bay and tributary tidal waters will readily achieve the applicable WQS at the allocated loads because of the conservative assumption described above. So from an aggregate viewpoint, the expected water quality at the allocated loads will readily attain the applicable WQS most of the time and will marginally attain the applicable WQS only about once in 10 years, and only for a small fraction of the summer months, and only for a very small portion of the volume of the Bay and tidal tributary waters.

An assumption of the model is the concentration of nitrogen, phosphorus, and sediment from the ocean waters entering the Bay. This is called a boundary condition. With improvement in pollutant controls, it is expected that the coastal ocean concentration of the pollutants will go down. EPA has conservatively estimated this reduction in coastal ocean water pollutant levels but only for reductions in atmospheric deposition (see Appendix L). EPA has not adjusted this boundary condition for expected land-based reductions. Such significant reductions can be expected from Long Island Sound, Delaware River, and other mid-Atlantic estuaries that all contribute nitrogen and phosphorus loads to Chesapeake Bay via the ocean boundary. Thus the boundary condition in the model for the concentration and, therefore the loading, of nitrogen, phosphorus, and sediment is higher than the concentration likely to exist with the application of coastal, land-based controls.

In addition to the above, the extensive development and refinement of the Bay models provides for excellent confidence in the modeling accuracy and conversely speaks to the need for a minimal (implicit) MOS. The following are some, but not all, of the model attributes that are in Section 5 that demonstrate the robust science behind the modeling network in support of the bay TMDL:

- The models are based on decades of data (1985–2005) used to develop, calibrate, and validate the models.
- A substantial increase in the number of stations was used to calibrate the watershed model to available data.
- The models are in some cases in their fifth generation of refinement, because of extensive input from baywide and national experts in the field.
- The modeling grid for both the Bay Watershed and Bay Water Quality and Sediment Transport models has been refined up to ten times the previous number of modeling segments.

The individual reasons cited above may not be sufficient to singly merit the conclusion that an implicit MOS is appropriate for the nitrogen and phosphorus allocations, but together those reasons provide ample support, in EPA's professional judgment, that an implicit MOS is adequate.

6.3 Methodology for Establishing the Basin-Jurisdiction Allocations for Nitrogen and Phosphorus

An early step in the process of developing the Bay TMDL, especially for nitrogen and phosphorus, is to determine the allowable loading from jurisdictions and major basins draining to the Bay. As a result, an equitable approach must be employed to apportion the allowable loading among the jurisdictions. This subsection describes the process EPA ultimately selected for this Bay TMDL.

Nitrogen and phosphorus from sources further upstream within the Chesapeake Bay watershed affect the condition of local receiving waters and affect tidal water quality conditions far downstream, hundreds of miles away in some cases. For example, the middle part of the mainstem Chesapeake Bay is affected by nitrogen and phosphorus from all parts of the Bay watershed. A key objective of the nitrogen and phosphorus allocation methodology was to find a process, based on an equitable distribution of loads for which the basinwide load for nitrogen and phosphorus could be distributed among the basin-jurisdictions. This section describes the specific processes involved in allocating the nitrogen and phosphorus loads necessary to meet the jurisdictions' Chesapeake Bay DO and chlorophyll *a* WQS. While many alternative processes were explored (Appendix K), only the process determined to be appropriate by EPA and agreed upon by five of the seven Bay watershed jurisdictional partners are described here.

Principles and Guidelines

The nitrogen and phosphorus basin-jurisdiction allocation methodology was developed to be consistent with the following guidelines adopted by the partnership:

- The allocated loads should protect the living resources of the Bay and its tidal tributaries and result in all segments of the Bay mainstem, tidal tributaries, and embayments meeting WQS for DO, chlorophyll *a*, and water clarity.
- Major river basins that contribute the most to the Bay water quality problems must do the most to resolve those problems (on a pound-per-pound basis).
- All tracked and reported reductions in nitrogen and phosphorus loads are credited toward achieving final assigned loads.

A number of critical concepts are important in understanding the major river basin by jurisdiction nitrogen and phosphorus allocation methodology. They include the following:

- Accounting for the geographic and source loading influence of individual major river basins on tidal water quality termed relative effectiveness
- Determining the controllable load
- Relating controllable load with relative effectiveness to determine the allocations of the basinwide loads to the basin-jurisdictions

The following subsections further describe the above concepts and how they directly affect the Chesapeake Bay TMDL.

6.3.1 Accounting for Relative Effectiveness of the Major River Basins on Tidal Water Quality

Relative effectiveness accounts for the role of geography on nitrogen and phosphorus load changes and, in turn, Bay water quality. Because of various factors such as in-stream transport and nitrogen and phosphorus cycling in the watershed, a given management measure on water quality in the Bay, varies depending on the location of its implementation within the watershed (USEPA 2003b). For example, the same control applied in Williamsport, Pennsylvania, will have less of an effect on Bay DO than one applied in Baltimore, Maryland.

A relative effectiveness assessment evaluates the effects of both estuarine transport (location of discharge/runoff loading to the Bay) and riverine transport (location of the discharge/runoff loading in the watershed). EPA determined the relative effectiveness of each contributing river basin in the overall Bay watershed on DO in several mainstem Bay segments and the lower Potomac River by using the Bay Water Quality Model to run a series of isolation runs and using the Bay Watershed Model to estimate attenuation of load through the watershed.

From the relative estuarine effectiveness analysis, several things are apparent. Northern, major river basins have a greater relative influence than southern major river basins on the central Bay and the lower Potomac River DO levels because of the general circulation patterns of the Chesapeake Bay (up the Eastern Shore, down the Western Shore). Nitrogen and phosphorus from the most southern river basins of the James and York rivers have relatively less influence on mainstem Bay water quality because of their proximity to the mouth of the Bay. Because these southern river basins are on the western shore, the counterclockwise circulation of the lower Bay also tends to transport nitrogen and phosphorus loads from those larger southern river basins out of the Bay mouth. That same counterclockwise circulation tends to sweep loads from the lower Eastern Shore northward.

River basins whose loads discharge directly to the mainstem Bay, like the Susquehanna, tend to have more effect on the mainstem Bay segments than basins with long riverine estuaries (e.g., the Patuxent, Potomac, and Rappahannock rivers). The long riverine estuaries, with longer water residence times, allow nitrogen and phosphorus attenuation (burial and denitrification) before the waters reaching the mainstem Chesapeake Bay. The size of a river basin is uncorrelated to its relative influence, although larger river basins, with larger loads, have a greater absolute effect. The upper tier of relative effect on the three mainstem segments includes the largest river basin (Susquehanna) and the smallest (Eastern Shore Virginia). Their high degree of impact is because they both discharge directly into the Bay, without intervening river estuaries to attenuate loads, and they are both up-current relative to the general Bay circulation pattern.

The estuarine effectiveness is estimated by running a series of Bay Water Quality Model scenarios holding one major river basin at E3 loads and all other major river basins at calibration levels. After considering several metrics to assess the DO benefit from progressive reductions in nitrogen and phosphorus loadings, EPA chose a 25th percentile. The advantage of this metric was that it was based on DO values at the more critical lower end of the range (25th percentile) yet, unlike a percent nonattainment metric, it could also be used for segments that were in attainment under some loading scenarios. For each scenario, the increase in the 25th percentile DO concentration during the summer criteria assessment period in the critical segments CB3MH, CB4MH, and CB5MH for deep-channel and CB3MH, CB4MH, CB5MH, and POTMH for deep-water was recorded. The 25th percentile was selected as the appropriate metric as indicative of a change in low DO. The riverine effectiveness is calculated as the fraction of load produced in the watershed that is delivered to the estuary. It is estimated as an output of the watershed model. For more details on this method, see Appendix K.

Absolute estuarine effectiveness accounts for the role of both total loads and geography on pollutant load changes to the Bay. The absolute estuarine effectiveness of a contributing river basin, measured separately both above and below the fall line, is the change in 25th percentile DO concentration that results from a single basin changing from calibration conditions to E3. For example, if the 25th percentile DO in the deep water of the lower Potomac River segment POTMH moves from 5 to 5.3 mg/L from a change in loads from calibration to E3 in the Potomac above fall line basin, the absolute estuarine effectiveness is 0.3 mg/L. Comparing the absolute estuarine effectiveness among basins helps to identify which major river basins have the greatest effect on WQS.

Relative estuarine effectiveness is defined as absolute estuarine effectiveness divided by the total load reduction, delivered to tidal waters, necessary to gain that water quality response. For example, if the load reduction in the Potomac above fall line basin was 30 million pounds of pollutant to get a 0.3 mg/L change in DO concentration, the relative estuarine effectiveness is 0.01 mg/L per million pounds. The higher the relative estuarine effectiveness, the less reduction required to achieve the change in status. The relative estuarine effectiveness calculation is an attempt to isolate the effect of geography by normalizing the load on a per-pound basis. Comparing the relative estuarine effectiveness among the major river basins shows the resulting gain in attainment from performing equal pound reductions among the major river basins.

Riverine attenuation also has an effect on overall effectiveness. Loads are naturally attenuated or reduced as they travel through long free-flowing river systems, making edge-of-stream loads in headwater regions less effective on a pound-for-pound basis than edge-of-stream loads that take place nearer tidal waters in the same river basin. The watershed model calculates delivery factors as the fraction of edge-of-stream loads that are delivered to tidal waters. The units of riverine attenuation are delivered pound per edge-of-stream pound.

Multiplying the estuarine relative effectiveness (measured as DO increase per delivered pound reduction) by the riverine delivery factor (measured as delivered pound per edge-of-stream pound) gives the overall relative effectiveness in DO concentration increase per edge-of-stream pound. The relative estuarine effectiveness is the same for nitrogen or phosphorus, while the riverine delivery is different, so the overall relative effectiveness is calculated separately for nitrogen and phosphorus. Table 6-3 gives the overall relative effectiveness for nitrogen and phosphorus for the watershed jurisdictions by major river basin for above and below the fall line.

The relative effectiveness numbers are separate for WWTPs and all other sources. The distinction is made because of the following:

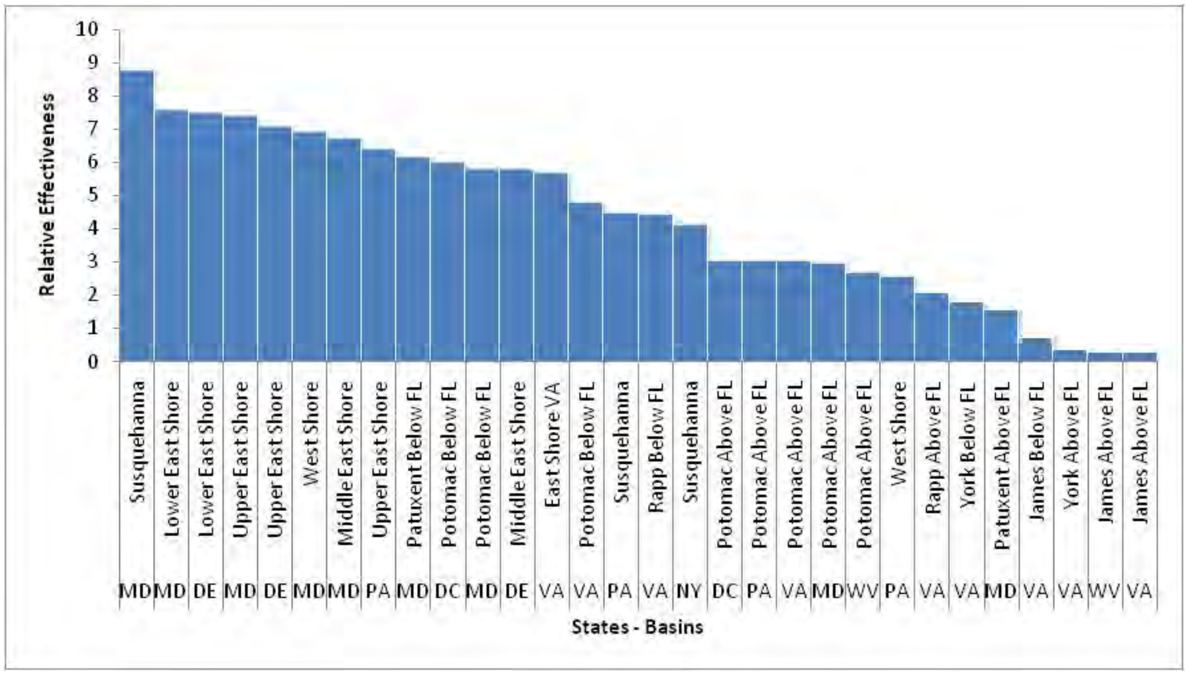
1. There is a wide disparity in the percent loading from WWTPs when comparing one basin to another.
2. On the basis of information in Appendix K, it is EPA's professional judgment that WWTPs can achieve a much higher percent of controllable load than that for other sources.

The difference in relative effectiveness is because of the geographic location of the sources. For example, in the Maryland western shore basin, the majority of the wastewater treatment load is discharged directly to tidal waters, whereas a significant fraction of all other sources are upstream, including areas that are above reservoirs with very low delivery factors.

Table 6-3. Relative effectiveness (measured as DO concentration per edge-of-stream pound reduced) for nitrogen and phosphorus for watershed jurisdictions by major river basin and above and below the fall line

Jurisdiction	Basin	WWTP nitrogen	All other nitrogen	WWTP phosphorus	All other phosphorus
District of Columbia	Potomac above Fall Line	6.09	6.09	3.08	3.08
District of Columbia	Potomac below Fall Line	6.17	5.15	6.17	5.62
Delaware	Lower East Shore	7.93	7.30	7.97	7.46
Delaware	Middle East Shore	4.13	4.74	5.51	5.83
Delaware	Upper East Shore	6.75	6.75	7.10	7.10
Maryland	Lower East Shore	7.88	7.37	7.89	7.55
Maryland	Middle East Shore	6.91	6.49	6.92	6.71
Maryland	Patuxent above Fall Line	1.89	1.25	1.66	1.58
Maryland	Patuxent below Fall Line	6.38	6.20	6.38	6.10
Maryland	Potomac above Fall Line	3.32	3.25	2.99	2.99
Maryland	Potomac below Fall Line	6.17	4.86	6.12	5.75
Maryland	Susquehanna	9.39	8.68	9.11	8.77
Maryland	Upper East Shore	7.49	7.27	7.49	7.40
Maryland	West Shore	7.83	4.98	7.68	6.13
New York	Susquehanna	5.60	4.58	4.25	4.11
Pennsylvania	Potomac above Fall Line	2.10	1.98	3.08	3.08
Pennsylvania	Susquehanna	6.99	6.44	4.38	4.58
Pennsylvania	Upper East Shore	5.50	5.95	6.12	6.47
Pennsylvania	West Shore	2.23	2.23	2.61	2.61
Virginia	East Shore VA	5.72	5.72	5.72	5.72
Virginia	James above Fall Line	0.23	0.25	0.33	0.31
Virginia	James below Fall Line	0.79	0.61	0.79	0.70
Virginia	Potomac above Fall Line	1.45	1.97	3.08	3.08
Virginia	Potomac below Fall Line	5.54	3.54	5.49	4.62
Virginia	Rappahannock above Fall Line	1.05	0.83	2.10	2.10
Virginia	Rappahannock below Fall Line	4.48	4.41	4.48	4.47
Virginia	York above Fall Line	0.37	0.31	0.43	0.40
Virginia	York below Fall Line	1.85	1.77	1.85	1.82
West Virginia	James above Fall Line	0.06	0.06	0.34	0.34
West Virginia	Potomac above Fall Line	1.34	1.72	2.12	2.89

Figure 6-4 illustrates the relative effectiveness scores for nitrogen of the major river basins provided in Table 6-3 in descending order.



Source: Table 6-3

Figure 6-4. Relative effectiveness for nitrogen for the watershed jurisdictions and major rivers basins, above and below the fall line, in descending order.

Figure 6-5 and Figure 6-6 provide additional graphical illustration of the relative effectiveness concept for all the basins in the watershed related to nitrogen and phosphorus loading, respectively. The figures illustrate that, on a per-pound basis, a large disparity exists among basin loads on the effect of DO concentrations in the Bay. Generally, the northern and eastern river basins have a greater effect on water quality than do other basins.

6.3.2 Determining Controllable Load

Modeling in support of developing the Chesapeake Bay TMDL employs two theoretical scenarios that help to illustrate the load reductions in the context of a controllable load.

The No Action scenario is indicative of a theoretical worst case loading situation in which no controls exist to mitigate nitrogen, phosphorus, and sediment loads from any sources. It is specifically designed to support equity among basin-jurisdiction allocations in that the levels of all control technologies, BMPs, and program implementation are completely removed.

The E3 scenario—everything by everyone everywhere—represents a best-case possible situation, where a certain set of possible BMPs and available control technologies are applied to land, given the human and animal populations, and wastewater treatment facilities are represented at highest technologically achievable levels of treatment regardless of costs. Again, it considers equity among the allocations in that the levels of control technologies, BMPs, and program implementation are the same across the entire watershed.

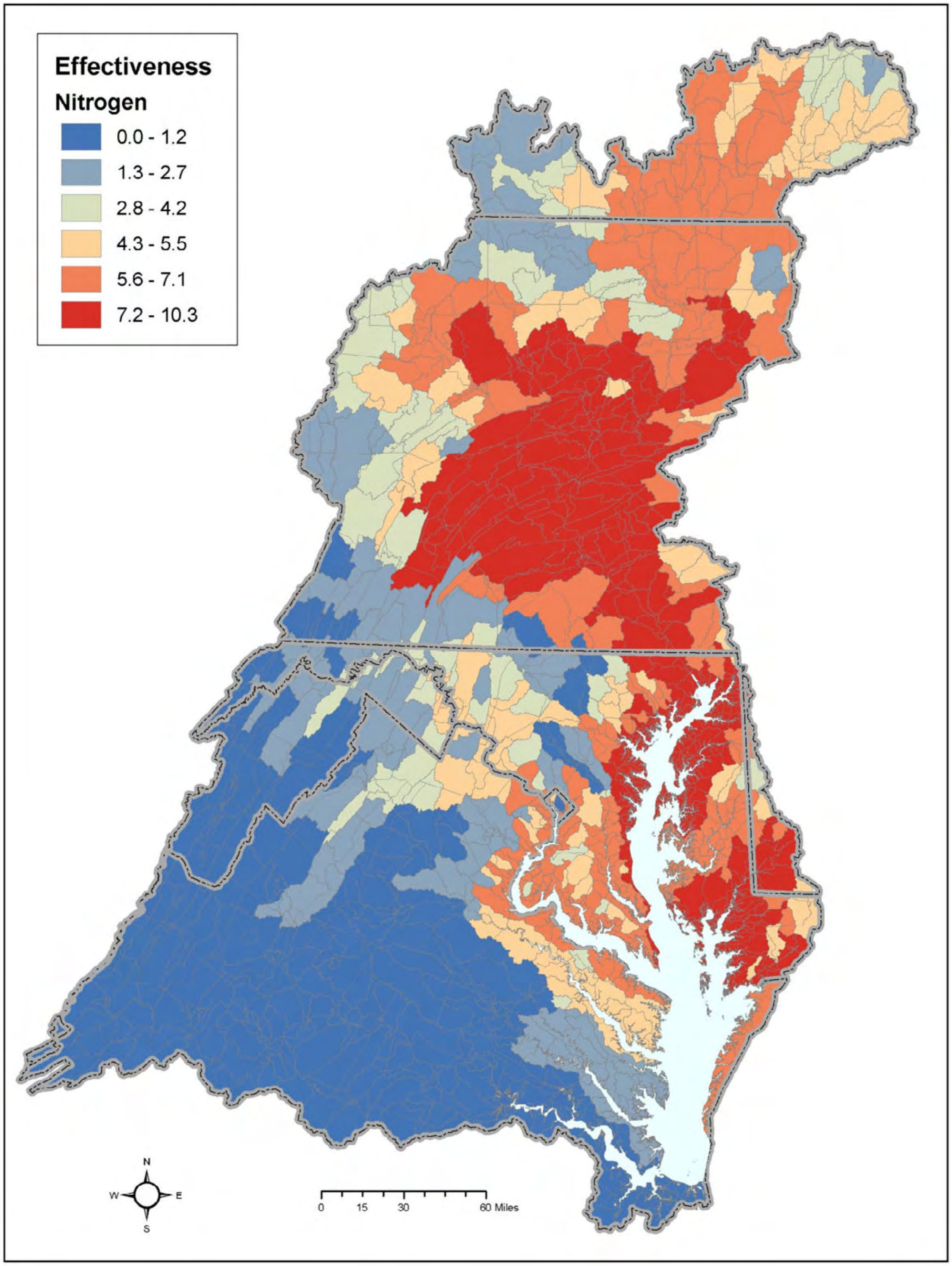


Figure 6-5. Relative effectiveness illustrated geographically by subbasins across the Chesapeake Bay watershed for nitrogen.

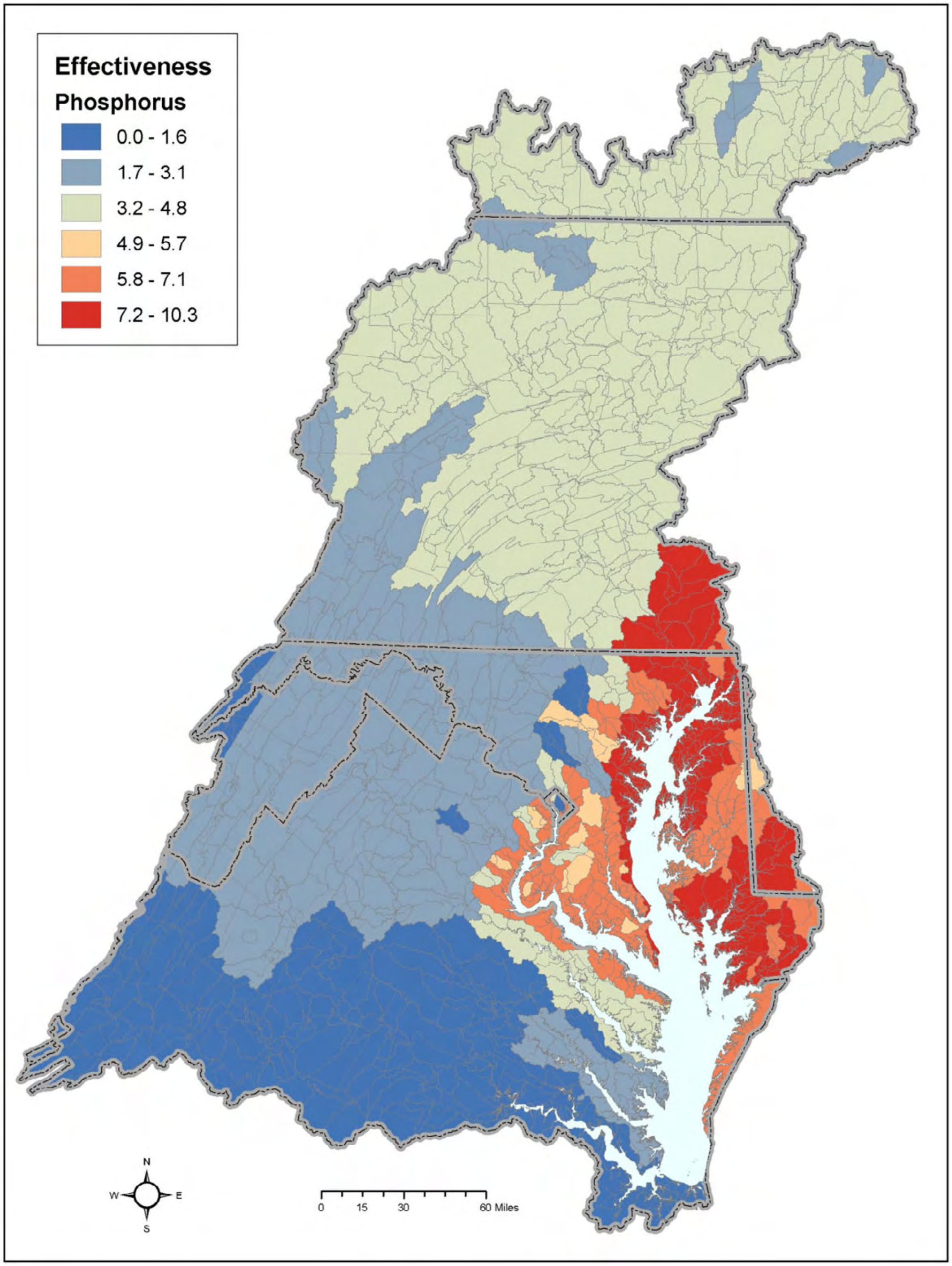


Figure 6-6. Relative effectiveness for illustrated geographically by subbasins across the Chesapeake Bay watershed for phosphorus.

The gap between the No Action scenario and the E3 scenario represents the maximum theoretical controllable load reduction that is achievable by fully implementing the control technologies included in E3 scenario. Those and other key reference scenarios are defined and documented in detail in Appendix J.

Each scenario can be run with any given year's land-use representation. The year 2010 was selected as the base year because it represents conditions at the time the Bay TMDL is developed. Thus, the 2010 No Action scenario represents loads resulting from the mix of land uses and point sources present in 2010 with no effective controls on loading, while the 2010 E3 scenario represents the highest technically feasible treatment that could be applied to the mix of all land use-based sources and permitted point sources in 2010 (Table 6-4).

Basinwide, anthropogenic, controllable loads are determined by subtracting the basinwide E3 load from the basinwide No Action load. Calculated *percentage of E3* is used as a comparative tool for assessing the relative level of effort between various loading reduction scenarios.

Table 6-4. Pollutant sources as defined for the No Action and E3 model scenarios

Model source	**Scenario**	
	No Action	**E3 = Everyone Everything Everywhere**
Land uses	No BMPs applied to the land	All possible BMPs applied to land given current human and animal population and land use
Wastewater Dischargers	Significant municipal WWTPs Flow = design flows TN = 18 mg/L TP = 3 mg/L BOD = 30 mg/L DO = 4.5 mg/L TSS = 15 mg/L	Significant municipal WWTPs Flow = design flows TN = 3 mg/L TP = 0.1 mg/L BOD = 3 mg/L DO = 6 mg/L TSS = 5 mg/L
	Non-significant municipal WWTPs Flow = existing flows TN = 18 mg/L TP = 3 mg/L BOD = 30 mg/L DO = 4.5 mg/L TSS = 15 mg/L	Non-significant municipal WWTPs Flow = existing flows TN = 8 mg/L TP = 2 mg TP/l BOD = 5 mg/L DO = 5 mg/L TSS = 8 mg/L
CSOs	Flow = 2003 base condition flow TN = 2003 load estimate TP = 2003 load estimate BOD = 2003 load estimate DO = 2003 load estimate TSS = 2003 load estimate	Full storage and treatment of CSOs
Atmospheric deposition	1985 Air Scenario	2030 Air Scenario, max reductions

Source: Appendix J
Note: BOD = biological oxygen demand; DO = dissolved oxygen; TN = total nitrogen; TP = total phosphorus; TSS = total suspended solids

6.3.3 Relating Relative Impact to Needed Controls (Allocations)

To apply the allocation methodology, loads from each major river basin were divided into two categories—wastewater and all other sources (Figure 6-7). The rationale for such separate accounting is the higher likelihood of achieving greater load reductions for the wastewater sector than for other source sectors (Appendix K). In addition there was a wide disparity between basin and jurisdictions on the fraction of the load coming from the wastewater sector as opposed to other sectors. Therefore, that disparity is addressed by separate accounting for the wastewater sector from the other sectors in the allocation methodology. Wastewater loads included all major and minor municipal, industrial and CSO discharges. Then lines were drawn for each of the two source categories such that the addition of the two lines would equal the basinwide nitrogen and phosphorus loading targets for nitrogen and phosphorus.

Using the general methodology described above, the CBP partners considered many different combinations of wastewater and other sources controls and slopes of the lines on the allocation graph (Appendix K). After discussing the options at length, the following graph specifications were generally accepted by the partners and determined to be appropriate by EPA.

The wastewater line was set first and would be a hockey stick shape with load reductions increasing with relative effectiveness until a maximum percent controllable load was reached.

For nitrogen

- The maximum percent controllable load was 90 percent, corresponding to an effluent concentration of 4.5 mg/L.
- The minimum percent controllable load was 67 percent, corresponding to an effluent concentration of 8 mg/L.

For phosphorus

- The maximum percent controllable load was 96 percent, corresponding to an effluent concentration of 0.22 mg/L.
- The minimum percent controllable load was 85 percent, corresponding to an effluent concentration of 0.54 mg/L.

For both the nitrogen and phosphorus wastewater lines

- Any relative effectiveness that was at least half of the maximum relative effectiveness value was given maximum percent controllable.
- The minimum controllable load value was assigned to a relative effectiveness of zero, and all values of relative effectiveness between zero and half of the maximum value were assigned interpolated percentages (Figure 6-7).

The other sources line was set at a level that was necessary to achieve the basinwide load needed for achieving the DO standards in the middle mainstem Bay and lower tidal Potomac River segments. That line was set at a slope such that there was a 20 percent overall difference from highest controllable load to lowest, ranging from 56 percent of controllable loads for basins with low relative effectiveness to 76 percent of controllable loads for basins with high relative effectiveness for nitrogen (Figure 6-7). The slope was chosen as the most supported by the jurisdiction partners after exploring many options. The slope provides a balance of enough relief of controls for the less effectiveness basins yet still requires significant controls for all basins.

For each category—wastewater and all other sources—loads are aggregated by major basin and reductions are assigned according to the process detailed above. The graph in Figure 6-7 illustrates the methodology for the total nitrogen target load of 190 million lbs per year.

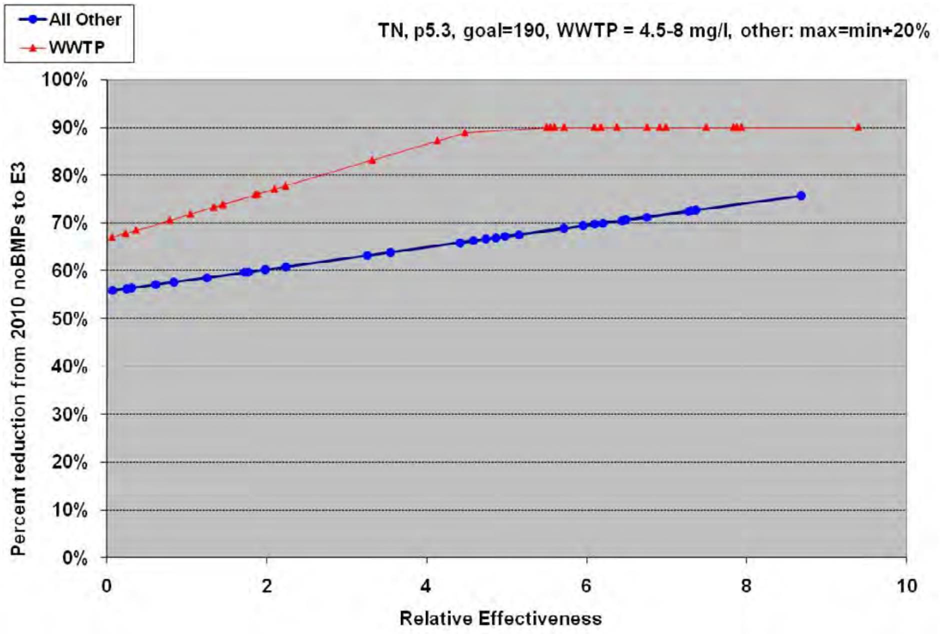


Figure 6-7. Allocation methodology example showing the *hockey stick* and straight line reductions approaches, respectively, to wastewater (red line) and all other sources (blue line) for nitrogen.

6.4 Establishing the Basin-Jurisdiction Allocations for Nitrogen and Phosphorus

This subsection describes the application of all the processes described earlier in this section. EPA identified the nitrogen and phosphorus allocations to the basin-jurisdictions in a letter on July 1, 2010, from the EPA Region 3 Administrator to the seven watershed jurisdictions (USEPA 2010f). The allocations to the seven watershed jurisdictions were derived to achieve Chesapeake Bay WQS recently adopted by the four Bay jurisdictions.

The Bay jurisdictions' WQS are described in Section 3.3. The allocations in the letter cited above are the allocations on which the jurisdictions based their draft and final Phase I WIPs. The full process for establishing the nitrogen and phosphorus basin-jurisdiction allocations is described below:

- Established the atmospheric deposition allocations on the basis of addressing the requirements of the CAA to meet existing national air quality standards out through 2020.
- Set the basinwide nitrogen and phosphorus loads on the basis of attaining the applicable DO criteria in those Bay segments (middle Chesapeake Bay mainstem and the lower tidal Potomac River) and designated uses (deep-water and deep-channel) whose water quality

conditions are influenced by major river basins and jurisdictions throughout the Bay watershed.

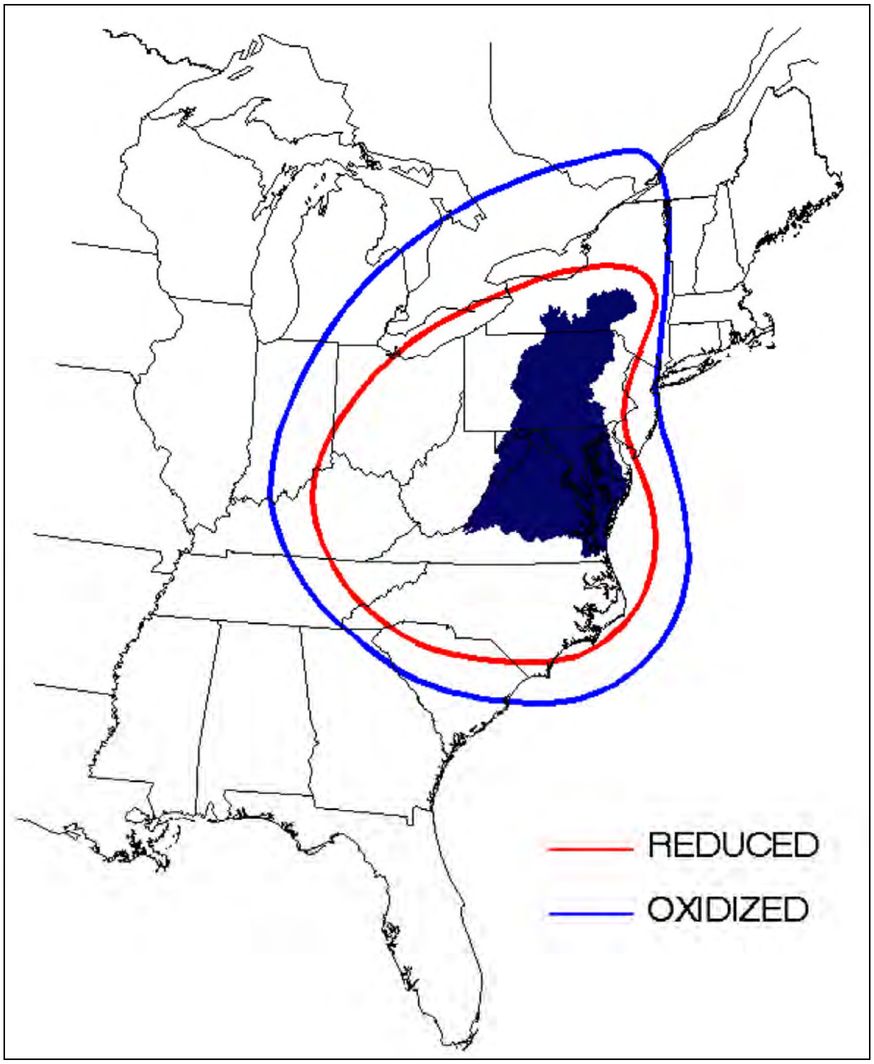
- Distributed the basinwide nitrogen and phosphorus loads by major river basin and jurisdiction following the methodology developed by the partnership (see Section 6.2).
- Made certain discretionary adjustments to the allocations to New York and West Virginia.
- Allowed for individual jurisdictions to exchange nitrogen and phosphorus loads within and between their major river basins using specific exchange ratios, as long as the exchanges still resulted in attainment of all WQS.
- Identified those individual Bay segments still not attaining their applicable DO/chlorophyll *a* WQS at the allocated basinwide nitrogen and phosphorus loads and addressed the remaining nonattainment segments.
- Derived the final basin-jurisdiction nitrogen and phosphorus allocations to achieve the applicable WQS for DO and chlorophyll *a* in all 92 Bay segments.

Individual jurisdictions further suballocated their major river basin-jurisdiction allocated loads within their Phase I WIPs down to their respective Bay segment watersheds in their jurisdiction. After in-depth review of the final Phase I WIPs and the public comments, EPA made final determinations on the allocations as described in Section 8.

6.4.1 Setting the Atmospheric Nitrogen Deposition Allocation

Atmospheric deposition of nitrogen is the major source of nitrogen to the Chesapeake Bay watershed, greater than the other sources of fertilizer, manures, or point sources. For that reason, it is necessary to allocate an allowable loading of nitrogen from air deposition in the Chesapeake Bay TMDL. The nitrogen loadings come from many jurisdictions outside the Chesapeake Bay watershed. Figure 6-8 shows the approximate delineation of the Bay airshed. Seventy-five percent of the nitrogen air deposition loads to the Chesapeake watershed originate from sources within the Bay airshed, with twenty-five percent originating from sources beyond the airshed, and in the largest sense, the source of atmospheric loads to the Chesapeake Bay watershed are global. That is reflected in the Bay Airshed Model, which has a domain of all North America (with boundary conditions to quantify global nitrogen sources). About 50 percent of the oxidized nitrogen (NOx) atmospheric deposition loads to the Chesapeake watershed and tidal Bay come from the seven Bay watershed jurisdictions. For more detailed discussion, see Appendix L.

By including air deposition in the Bay TMDLs LAs, the Bay TMDL accounts for the emission reductions that will be achieved by seven watershed jurisdictions and other states in the larger Bay airshed. If air deposition and expected reductions in nitrogen loading to the Bay were not included in the LAs, other sources would have to reduce nitrogen discharges/runoff even further to meet the nitrogen loading cap. Because CAA regulations and programs will achieve significant decreases in air deposition of nitrogen by 2020, EPA believes the TMDL inclusion of air allocations (and reductions) is based on both the best available information with a strong reasonable assurance that those reductions will occur. The TMDL developed for the Chesapeake Bay will reflect the expected decreases in nitrogen deposition and the 2-year federal milestones will track the progress of CAA regulations and programs.



Source: Dr. Robin Dennis, USEPA/ORD/NERL/AMAD/AEIB

Figure 6-8. Principal areas of nitrogen oxide (blue line) and ammonia (red line) emissions that contribute to nitrogen deposition to the Chesapeake Bay and its watershed (dark blue fill).

In determining the allowable loading from air deposition, EPA separated the nitrogen atmospheric deposition into two discreet parcels: (1) atmospheric deposition occurring on the land and nontidal waters in the Bay watershed, which is subsequently transported to the Bay; and (2) atmospheric deposition occurring directly onto the Bay tidal surface waters.

The deposition on the land becomes part of the allocated load to the jurisdictions because the atmospheric nitrogen deposited on the land becomes mixed with the nitrogen loadings from the land-based sources and, therefore, becomes indistinguishable from land-based sources. Furthermore, once the nitrogen is deposited on the land, it would be managed and controlled along with other sources of nitrogen that are present on that parcel of land. In contrast, the atmospheric nitrogen deposited directly to tidal surface waters is a direct loading with no land-based management controls and, therefore, needs to be linked directly back to the air sources and air emission controls. For more detailed discussion, see Appendix L.

EPA included an explicit basinwide nitrogen atmospheric deposition allocation in the Bay TMDL and determined it to be 15.7 million pounds per year of nitrogen atmospheric deposition loads direct to Chesapeake Bay tidal tributary and embayment waters (Appendix L) (see Section 9.1). Activities associated with implementation of CAA regulations by EPA and the jurisdictions through 2020 will ensure achievement of that allocation and are already accounted for within the jurisdictions' major river basin nitrogen allocations. Any additional nitrogen reductions realized through more stringent air pollution controls at the jurisdictional level, beyond minimum federal requirements to meet air quality standards, may be credited to the individual jurisdictions through future revisions to the jurisdictions' WIPs, 2-year milestones, and the Chesapeake Bay TMDL tracking and accounting framework (Appendix L).

In determining the amount of air controls to be used as a basis for the Bay TMDL air allocation, EPA relied on current laws and regulations under the CAA. Those requirements, together with national air modeling analysis, provided the resulting allocated air load from direct deposition to the tidal surface waters of the Bay and its tidal tributaries (Appendix L).

The air allocation scenario represents emission reductions from regulations implemented through the CAA authority to meet National Ambient Air Quality Standards for criteria pollutants in 2020. The air allocation scenario includes the following:

- The Clean Air Interstate Rule (CAIR) with second phase and the Clean Air Mercury Rule (CAMR)
- The Regional Haze Rule and guidelines for Best Available Retrofit Technology (BART)
- The On-Road Light Duty Tier 2 Rule
- The Clean Heavy Duty Truck and Bus Rule
- The Clean Air Non-Road Diesel Tier 4 Rule
- The Locomotive and Marine Diesel Rule
- The Non-road Large and Small Spark-Ignition Engines Programs
- The Hospital/Medical Waste Incinerator Regulations

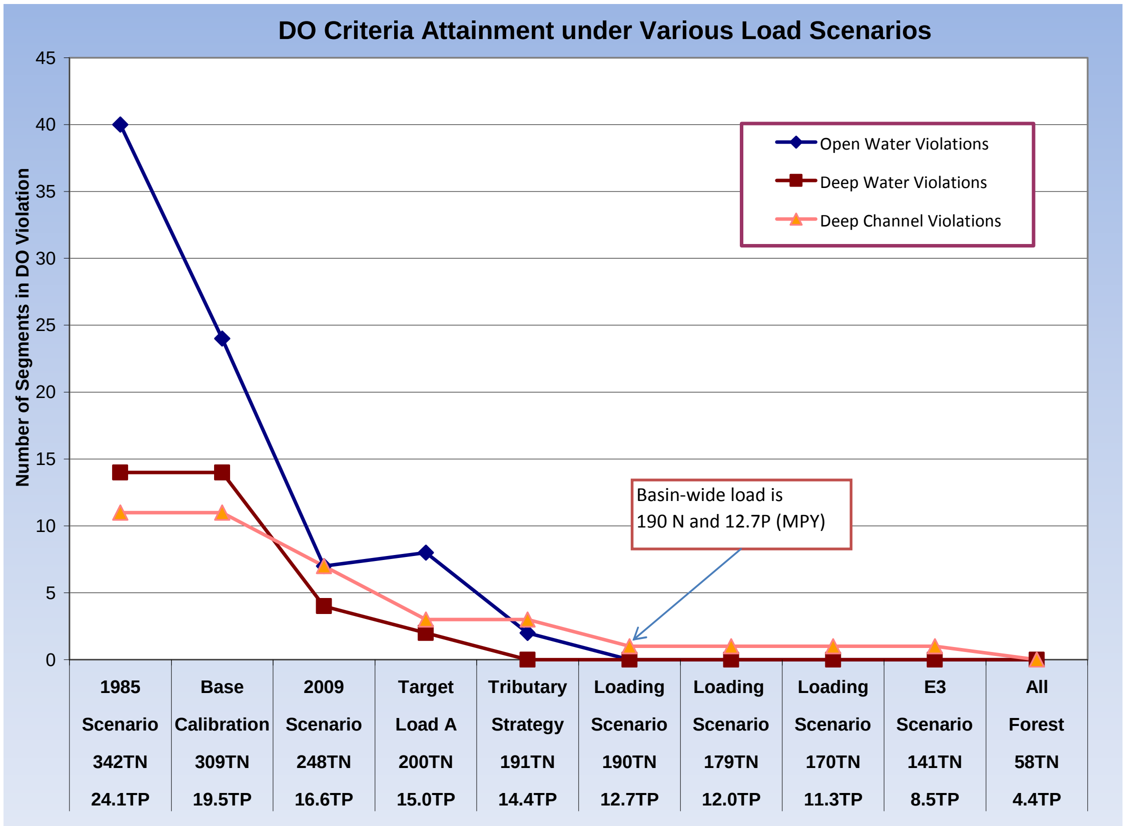
The controls described above were modeled using the Community Multiscale Air Quality (CMAQ) national model, which enabled quantification of deposition direct to the Chesapeake Bay tidal waters to be determined. Information on the CMAQ modeling analysis is at http://www.epa.gov/cair/technical.html. That approach is the basis for the previously mentioned 15.7 million pounds per year as the allocation in the Bay TMDL for air deposition directly to the tidal waters. Appendix L provides a more detailed description of the process for establishing the atmospheric deposition allocations for nitrogen.

6.4.2 Determining the Basinwide Nitrogen and Phosphorus Target Load Based on Dissolved Oxygen

With the air allocated loads being set at 15.7 million pounds per year, the next step in the process was to determine the basinwide nitrogen and phosphorus loadings that would cause the mainstem Bay and major tidal river segments—all influenced by nitrogen and phosphorus loads from multiple jurisdictions—to achieve all the applicable DO WQS. Numerical chlorophyll *a* WQS were not used for this basinwide loading determination because they apply to only the tidal James River and the District of Columbia's tidal waters of the Potomac and the Anacostia rivers and, therefore, are not affected by the other basins in the watershed. The principal Bay segments that were most important for determining the basinwide nitrogen and phosphorus loads were the middle mainstem Bay segments CB3MH, CB4MH, and CB5MH (Maryland and Virginia) and the lower tidal Potomac River segment POTMH_MD because their water quality conditions are influenced by all river basins through the Bay watershed. Therefore, achieving attainment in those segments will necessitate nitrogen and phosphorus reductions from all basins.

The process used for determining the load that will achieve the DO WQS in these segments was to progressively lower the nitrogen and phosphorus loadings simulated in the Bay Water Quality Model and then assess DO WQS attainment for each loading scenario. Numerous iterations of different load scenarios were run until the appropriate nitrogen and phosphorus loadings to achieve WQS could be determined (Appendix M).

Figure 6-9 shows the numerous water quality model runs that were performed at various loading levels and the resulting DO standards attainment results. The water quality measure on the vertical axis is the number of Bay segments that were not attaining the applicable Bay DO WQS. As can be expected, as loadings are lowered throughout the Bay watershed, the number of DO



Note: This graph expands some of the 92 TMDL segments into separate jurisdiction-segments so that the total numbers of open-water, deep-water, and deep-channel designated use segments are 98, 14, and 11, respectively

Figure 6-9. Chesapeake Bay water quality model simulated DO criteria attainment under various TN and TP loading scenarios.

WQS non-attaining segments was reduced. At the loading of 190 million pounds per year of nitrogen and 12.7 million pounds per year of phosphorus, and after considering other lines of evidence beyond the Bay Water Quality and Sediment Transport Model, as presented in Appendix N, only one Bay segment was in nonattainment for DO—lower Chester River. For the lower Chester River segment, nonattainment persisted even to extremely low loading levels. Therefore, Maryland adopted, and EPA approved a restoration variance for that segment. The final allocations for the Bay will attain that restoration variance for DO. It should be noted that the critical segments of CB3MH, CB4MH, and CB5MH for deep-channel and CB3MH, CB4MH, CB5MH, and POTMH for deep-water were among the last segments to come into attainment. Watershed-wide reductions will be needed to attain WQS in these segments. Therefore, EPA determined that basinwide nitrogen loadings of 190 million pounds per year and phosphorus loadings of 12.7 million pounds per year were sufficient to attain the main Bay DO standards; as a result, EPA distributed those loadings among the major river basins and jurisdictions in the Chesapeake Bay watershed.

6.4.3 Allocating Nitrogen and Phosphorus Loads to Jurisdictions within the Bay Watershed

After more than 2 years of discussion and exploration by EPA and the jurisdictions of many different approaches to allocating allowable loads to each of the jurisdictions and major basins, a consensus could not be reached for an approach for allocating loads to all jurisdictions. With the exception of New York and West Virginia, all the watershed jurisdictions agreed to the method described above for allocating loadings to the major river basins and jurisdictions. EPA then chose to use that method as described above to distribute the loadings based on the equity and near consensus of the jurisdictions. Using that method, EPA calculated the relative effectiveness of each of the major river basins in the Bay watershed and plotted as dots on the lines in Figures 6-10 (for phosphorus) and 6-11 (for nitrogen) to determine the basin-jurisdiction allocation represented by each of the points. On the vertical axis is the percent of controllable load (represented in the graph as No Action Minus E3 load) that would correspond to the allocated load for each basin-jurisdiction. For example, 100 percent represents a loading such that all sources would have all control technologies and practices approved by the partnership installed (E3). The horizontal axis represents the relative effectiveness of each of the basin-jurisdictions, a measure of the impact that a pound of nitrogen and phosphorus has on the DO concentrations in the Chesapeake Bay. EPA first constructed the wastewater (WWTP) line (red line in Figures 6-10 and 6-11) on the basis of the removal efficiencies of established treatment technologies.

EPA then constructed the other sources line (blue line in Figures 6-10 and 6-11) by having a difference of 20 percent of controllable load when comparing facilities/lands in the basin-jurisdiction with the highest relative effectiveness with the facilities/lands in the basin-jurisdiction with the lowest relative effectiveness. As can be seen in Figure 6-10 and Figure 6-11, facilities/lands in those basin-jurisdictions that have the highest effectiveness (or impact on the Bay) on a per-pound basis must install the most controls (the basin-jurisdictions on the right of the graph). While it is too cluttered to show each of the basin-jurisdictions on these graphs, see Table 6-3 to identify the relative effectiveness for each basin and then find that point on these graphs. Because the dots represent the various basin-jurisdictions in the watershed, the percent of controllable load can be converted to the actual allocated load to achieve the Bay DO WQS.

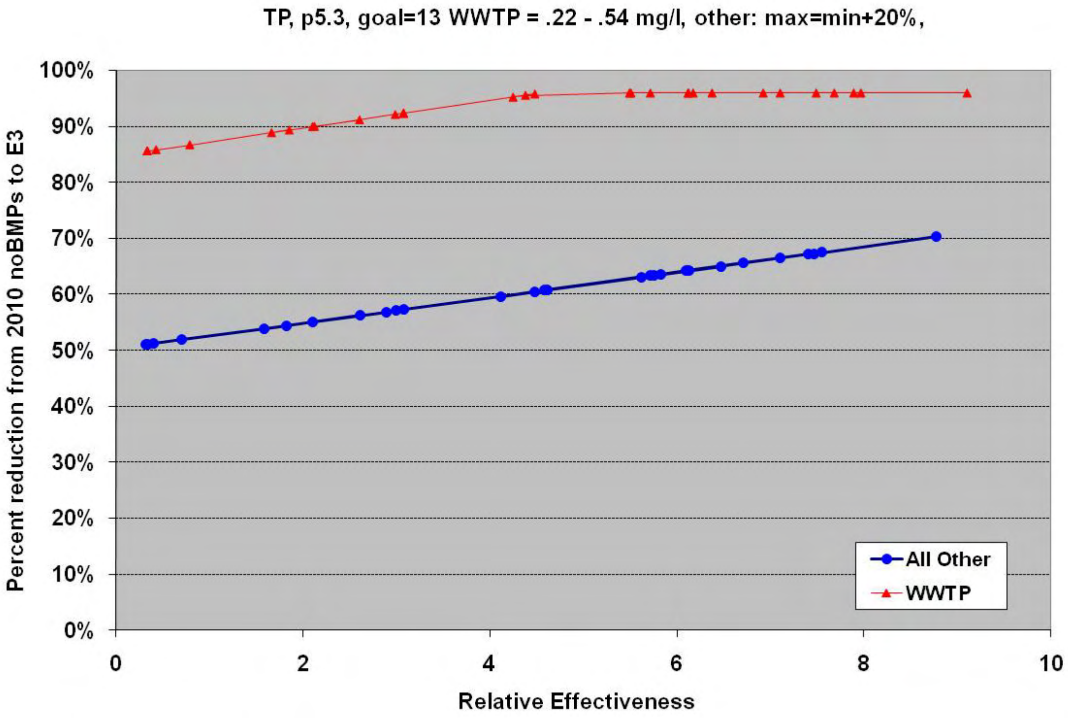


Figure 6-10. Example allocation methodology application for phosphorus.

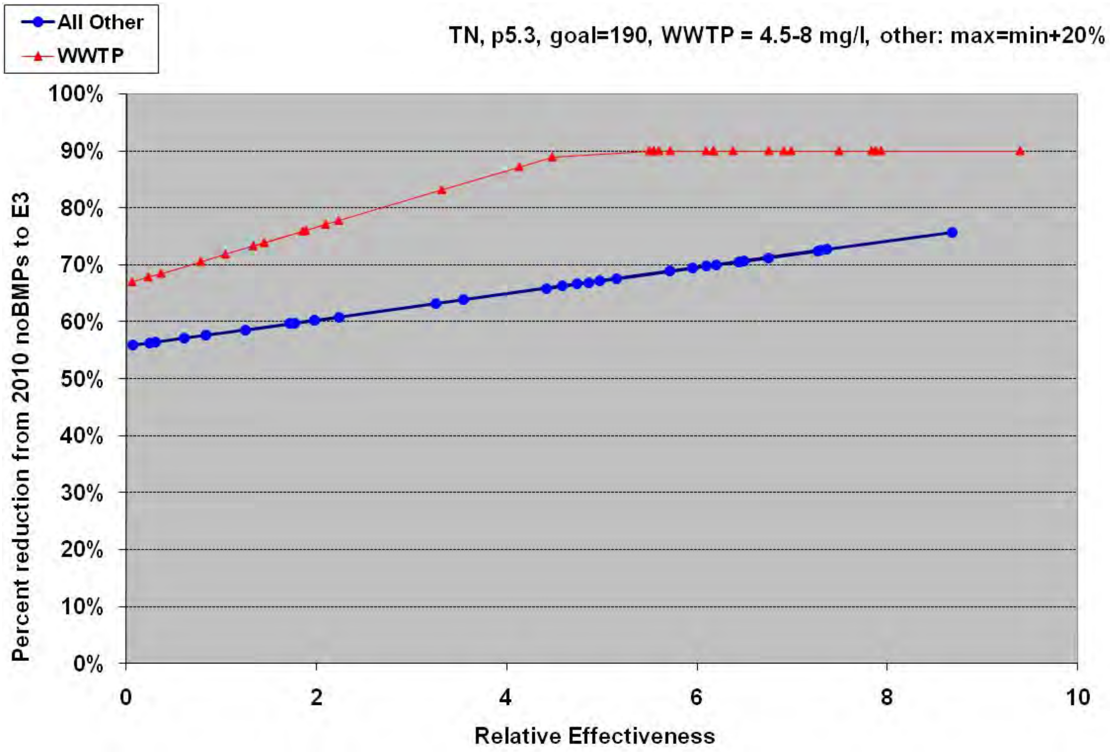


Figure 6-11. Example allocation methodology application for nitrogen.

Finally, EPA added the allocated load for wastewater (WWTP) to the allocated load for other sources to determine the total allocated load for each basin-jurisdiction. It must be noted that although the graph separates wastewater and other sources, this does not necessarily require the jurisdictions to use that separate wastewater or other sources loading in their WIPs for suballocating the loads.

6.4.4 Resolving Dissolved Oxygen and Chlorophyll a Nonattaining Bay Segments

After determining the target basinwide nitrogen and phosphorus allocations and distributing those loads to the major basins and jurisdictions using the methodology illustrated above, EPA identified seven designated-use segments for which the Bay Water Quality Model was predicting nonattainment of the applicable Bay DO WQS (see Table 6-5). Those seven segments out of attainment for the open-water designated use represent less than 1 percent of the total volume of open-water habitats in entire Chesapeake Bay.

The Bay Water Quality Model also predicted nonattainment for numeric chlorophyll *a*. All five Bay segments of the tidal James River in Virginia and the two Bay segments in the District of Columbia (tidal Potomac and Anacostia rivers). On the basis of Bay Water Quality Model runs at the basinwide nitrogen and phosphorus loading of 190 million pounds per year nitrogen and 12.7 million pounds per year phosphorus allocated by major river by jurisdiction the Bay Water Quality Model predicted those seven segments to be in nonattainment of each jurisdiction’s respective numeric chlorophyll *a* WQS. This section explores the process by which EPA examined Bay Water Quality Model results showing persistent nonattainment at reduced loading levels and other evidence to make determinations regarding the loadings that would be sufficient to attain the respective WQS for each of the Bay segments.

Dissolved Oxygen Nonattaining Segments

EPA examined the reasons of persistent nonattainment in these segments. Upon further review of the model results for the non-attaining segments, along with other lines of evidence (including water quality monitoring) and application of best professional judgment, EPA determined that 190 million pounds per year TN and 12.7 million pounds per year TP allocated by major river by jurisdiction would be sufficient for these segments to attain the respective DO criteria (see Appendix N). It was generally found that predicted nonattainment in a Bay segment resulted from two or more of the following factors:

1. Less-than-expected change in DO concentrations from the calibration scenario to a given reduced nitrogen and phosphorus load scenario
2. Poor agreement between model-simulated and historically observed DO concentrations for a particular location and historical period
3. A limited number of unusually or very low DO concentrations that the Bay Water Quality Model predicted were very difficult to bring into attainment of the open-water DO criteria even with dramatically reduced loads

Table 6-5. Chesapeake Bay designated use segments showing percent nonattainment of the applicable Bay DO WQS under the basinwide nitrogen and phosphorus target loadings (million pounds per year)

CBSEG	309TN, 19.5TP, 8950TSS '93-'95	248TN, 16.6TP, 8110TSS '93-'95	200TN, 15TP, 6390TSS '93-'95	191TN 14.4TP, 6462 TSS '93-'95	190TN, 13TP, 6123TSS '93-'95	190TN 12.7TP, 6030TSS '93-'95	179TN 12.0TP, 5510TSS '93-'95	170TN 11.3TP, 5650TSS '93-'95	141TN 8.5TP, 5060TSS '93-'95	All Forest '93-'95
Open Water Summer Monthly										
GUNOH	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
MANMH	1%	5%	5%	5%	5%	5%	5%	5%	5%	0%
ANATF_MD	39%	19%	18%	12%	12%	12%	11%	11%	0%	0%
PMKTF	11%	5%	5%	5%	5%	5%	5%	2%	1%	1%
WBEMH	11%	15%	8%	8%	8%	8%	8%	8%	0%	0%
WICMH	11%	11%	15%	5%	5%	5%	5%	5%	5%	4%
Deep Water										
MAGMH	35%	35%	16%	16%	16%	3%	3%	1%	1%	0%

Source: Appendix M

Notes: GUNOH-Gunpowder River, MANMH-Manokin River, ANATF_MD-Anacostia River, Maryland, PMKTF-Upper Pamunkey River, WBEMH-Western Branch Elizabeth River, WICMH-Wicomico River, and MAGMH-Magothy River.

TN - total nitrogen, TP - total phosphorus, and TSS – total suspended solids.

The majority of those segments are in small and relatively narrow regions of the Bay's smallest tidal tributaries. Such conditions constrain the Bay Water Quality Model's ability to effectively integrate multiple drivers of DO concentrations. As a result, the Bay Water Quality Model's ability to simulate the water quality changes in response to dramatically reduced loads was also limited. In such cases, additional lines of evidence were used to determine whether a segment could be expected to achieve the applicable WQS under the reduced nitrogen and phosphorus loads (Appendix N).

EPA evaluated each Bay segment to determine: (1) whether violations of the DO criteria were isolated or widespread; (2) whether nearby Bay segments also exhibited persistent or widespread hypoxia or both; and (3) whether the Bay Water Quality Model predicted sufficient improvements in DO concentrations to achieve DO WQS in nearby deeper, wider segments. Results of the evaluations, documented in detail in Appendix N, are summarized as follows.

Following the comprehensive evaluation of the modeling results, application of the factors described above, and inclusion of alternative lines of evidence, all seven segments were determined to be in attainment of applicable WQS.

Results of the segment-specific evaluations, documented in detail in Appendix N, are summarized as follows.

Gunpowder River (GUNOH)

Monitored DO concentrations over the 10-year period of 1991–2000 were almost universally well above the 30-day mean open-water criterion of 5 mg/L. A single instance of moderate hypoxia, combined with poor model agreement and an almost complete lack of response by the Bay Water Quality Model to load reductions in the monitored location for the relevant month, resulted in persistent nonattainment across all reduced loading scenarios for the month in question. In contrast, nearby Bay segments—Bush River (BSHOH), Middle River (MIDOH), and upper Chesapeake Bay (CB2OH)—all attained their respective DO WQS when loads were reduced to the target basinwide allocation of 190 million pounds per year TN and 12.7 million pounds per year TP (Appendix N). Given those factors, including the poor predictive performance of the model in the Gunpowder River and 10 years of observed attainment of the DO criteria at relatively high nutrient loadings, EPA finds with a reasonable degree of certainty that target loadings of 190 million pounds per year TN and 12.7 million pounds per year TP will be sufficient for the Gunpowder River segment to attain the DO WQS.

Manokin (MANMH), Maryland Anacostia (ANATF_MD), West Branch Elizabeth (WBEMH), Pamunkey (PMKTF), and Wicomoco (WICMH) Rivers

Similar to the Gunpowder River segment, few violations of the open-water DO criteria occurred in these five Bay segments, and Bay Water Quality Model simulations did not match well with historically observed water quality conditions. The Bay Water Quality Model often failed to simulate hypoxia for these locations under observed loads; thus, it was also unable to estimate improved DO concentrations when nitrogen and phosphorus loads were reduced. Nearby deeper, wider regions generally attained DO WQS at or before the target basinwide loadings. For more discussion and data, see Appendix N. Given those factors, observed historic attainment with existing criteria at current high nutrient loadings and limited predictive capacity of the model for those unique segments, EPA finds with a reasonable degree of certainty that target loadings of 190 million pounds per year TN and 12.7 million pounds per year TP will be sufficient for these Bay segments to attain the DO WQS.

Magothy River (MAGMH)

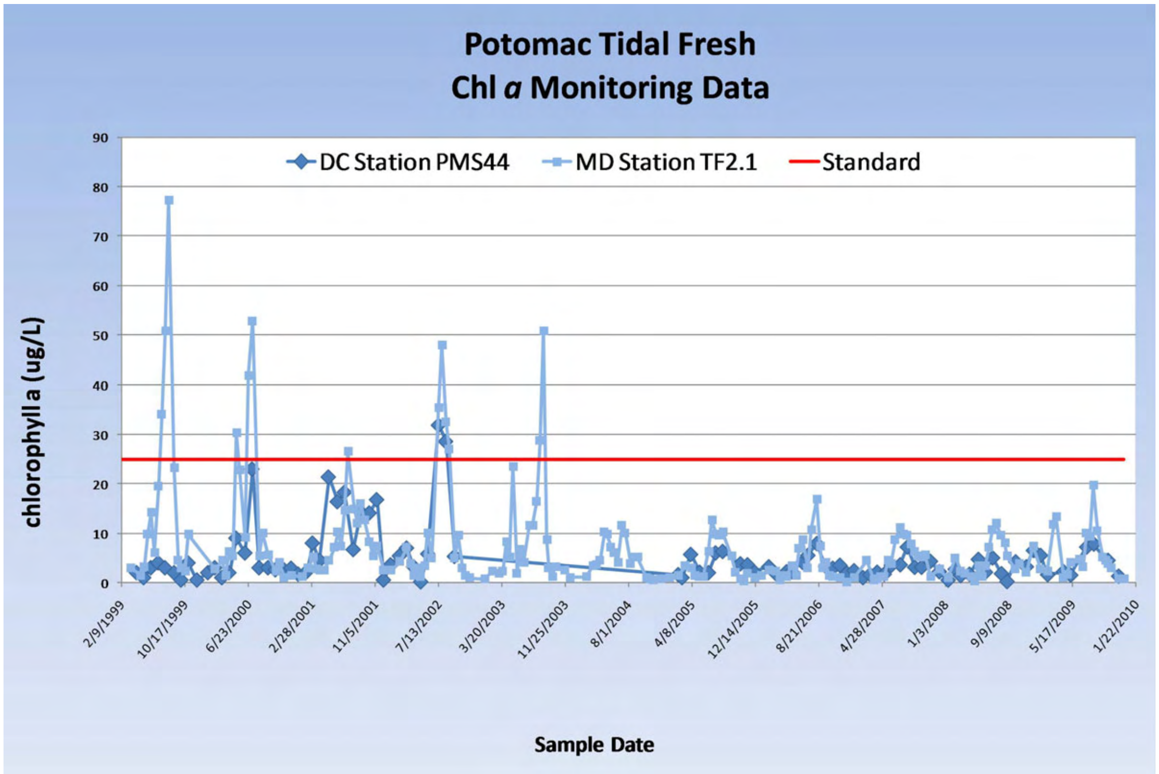
Summer hypoxic conditions were not uncommon in the Magothy River from 1991 to 2000, particularly when episodes of water column stratification prevented mixing of the bottom waters with more oxygenated surface waters. Maryland adopted (and EPA approved) an episodic deep-water designated use applicable to MAGMH to account for periods of water column stratification (USEPA 2010a). However, some violations of the deep-water DO 30-day mean criterion of 3.0 mg/L persisted even when nitrogen and phosphorus loads were reduced to the target basinwide allocation (Appendix N). Because of the small, embayment nature of the Magothy River, the Bay Water Quality Model was unable to reliably simulate observed conditions in MAGMH or consistently estimate a response of sufficiently improved DO in response to load reductions. However, the deep-water region of the adjacent mainstem segment CB3MH attained its DO WQS well before the target basinwide nitrogen and phosphorus LAs (Appendix N). Given the poor simulation of MAGMH conditions by the Bay Water Quality Model, the significant load reductions already required of the Magothy River basin at the target basinwide LAs, the considerable influence of the mainstem Chesapeake Bay on MAGMH water quality conditions, and the predicted attainment of CB3MH deep-water well before the target basinwide loading, EPA determined that MAGMH can reasonably be expected to attain its DO WQS at the target loadings of 190 million pounds per year TN and 12.7 million pounds per year TP.

Chlorophyll *a* Nonattaining Segments

Potomac and Anacostia Rivers in DC

The Bay Water Quality Model projected that the District of Columbia’s portions of the Potomac and Anacostia River segments would be in nonattainment of the applicable numeric chlorophyll *a* WQS at the basinwide nitrogen and phosphorus target loads allocated to those two river basins. However, through diagnostic analysis of the modeled chlorophyll *a* simulations for the Potomac and Anacostia rivers in the District of Columbia, EPA determined that the Bay Water Quality Model does not reliably simulate measured chlorophyll *a* levels. Therefore, other lines of evidence (i.e., monitoring data) were weighed more heavily by EPA in the attainment determination (Appendix N). Through further investigation, EPA analyzed recent chlorophyll *a* data for the two segments. The actual monitoring data show that the Potomac River segment is attaining the District’s chlorophyll *a* WQS and has been attaining that standard for at least the past 7 years (Figure 6-12). Applying a similar assessment of recent water quality monitoring data to the Anacostia River segment, a 4 percent level of nonattainment was determined (Appendix N).

Because those two segments are at, or near, attainment of the current chlorophyll *a* WQS on the basis of analysis of recent monitoring data and that additional nitrogen and phosphorus loading reductions will occur as a result of the current allocations, EPA has concluded that both of the Bay segments will be in full attainment with the chlorophyll *a* WQS under these nitrogen and phosphorus allocations (Appendix N). Additionally, a TMDL for biochemical oxygen demand



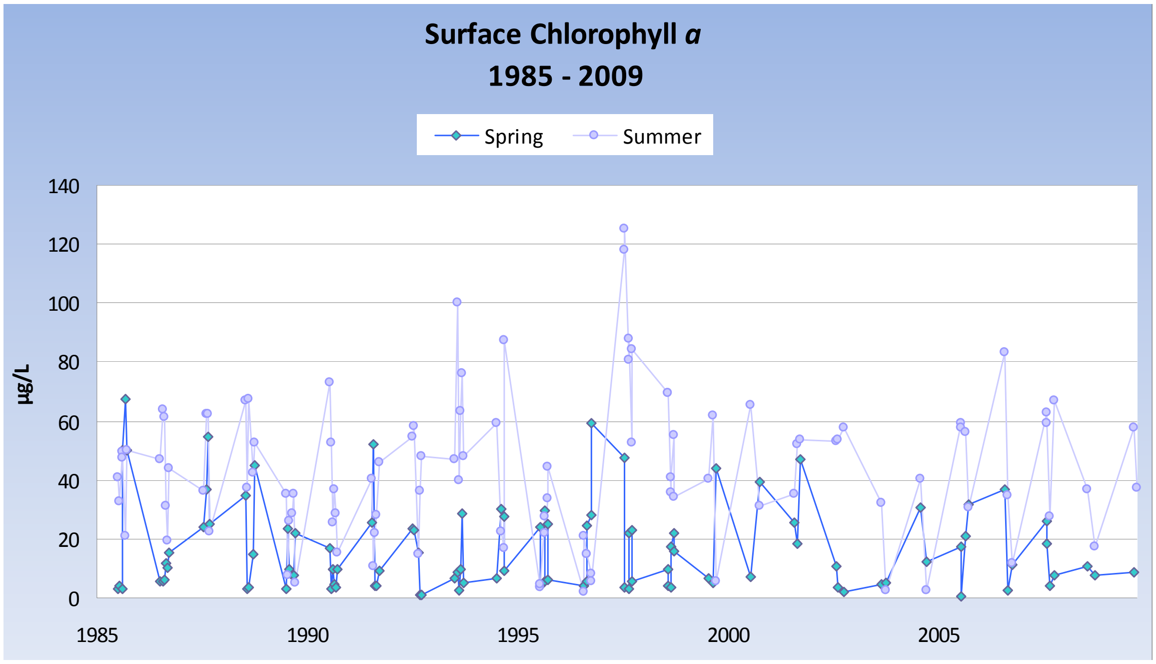
Source: http://www.chesapeakebay.net
Note: The DC station PMS44 is on the tidal Potomac River at the Woodrow Wilson Memorial Bridge (50 meters upstream of the draw span). The MD station TF2.1 is on the tidal Potomac River at Buoy *77* off the mouth of Piscataway Creek.

Figure 6-12. Potomac River chlorophyll a monitoring data compared with the District's summer seasonal mean chlorophyll *a* water quality criteria.

and nitrogen and phosphorus was approved by EPA in 2008 for the *Anacostia River Basin Watershed in Montgomery and Prince Georges Counties, Maryland and the District of Columbia* (MDE and DC DOE 2008). That TMDL for the Anacostia River requires significant reductions that, when implemented, will result in attainment of the chlorophyll *a* WQS.

James River in Virginia

Similar to the EPA analysis of attainment of the District of Columbia's chlorophyll *a* criteria using upper tidal Potomac and Anacostia rivers chlorophyll *a* monitoring data, EPA also assessed attainment using chlorophyll *a* monitoring data for the tidal James River. In contrast to the District's tidal Anacostia and Potomac River segments, EPA found that the past and current monitoring data for most of the tidal James River segments showed significant nonattainment of Virginia's chlorophyll *a* WQS. More recently, the *Virginian-Pilot* on August 12, 2010, reported on algal blooms in the southern Bay region including the James River. An example of the comparative analysis of the monitored data for the James as compared to Virginia's segment-season specific chlorophyll *a* criteria is shown in Figure 6-13. EPA, therefore, has concluded that nutrient controls beyond the present controls are needed in the James and EPA continued to rely on the model results in assessing conditions and determining the appropriate allocations of nitrogen and phosphorus.



Source: http://www.chesapeakebay.net

Figure 6-13. Tidal James River monitoring data for chlorophyll *a* at station TF5.5 (in the upper tidal James River near Hopewell, Virginia) compared to Virginia's James River segment-season specific chlorophyll *a* criteria.

In general, the Bay Water Quality Model is well-calibrated to the tidal James River and effectively simulates average seasonal conditions in the five tidal segments of the river. The Bay Water Quality Model also consistently estimates improved chlorophyll *a* conditions with increasing nitrogen and phosphorus load reductions. At the same time, however, the model does not simulate individual algal bloom events, which are highly variable and caused by numerous factors, some of which are still not well understood by the scientific community (Appendix O). The chlorophyll *a* WQS adopted in Virginia's regulation to protect the tidal James River were set at numerical limits for spring and summer seasonal averaged conditions, not for addressing individual algal bloom events lasting hours to days. Therefore, EPA's determination of nitrogen and phosphorus loadings required to attain chlorophyll *a* WQS in the tidal James River was based on those years and Bay (James River) segments for which the Bay Water Quality Model reliably simulated the water quality monitoring-based chlorophyll *a* calibration data. EPA used that approach to determine the James River basin allocation of 23.5 million pounds per year TN and 2.35 million pounds per year TP.

However, since the Bay Water Quality Model does not accurately simulate short-frequency, individual bloom events, some segment and season-specific nonattainment remains at the target James River allocation. Nonattainment of the summer chlorophyll *a* WQS persisted in the lower tidal fresh James segment (JMSTFL) for the summer periods of 1995–2000 and in the James River mouth segment (JMSPH) for the 1997–2000 summer periods (Appendix O). The Bay Water Quality Model results for those nonattainment areas were not used to establish the allocations for the James River.

Figure 6-14 shows the number of segments and 3-year periods (segment-periods) in nonattainment of Virginia's James River chlorophyll *a* WQS (out of the simulation period of 1991–2000) for the various load scenarios simulated, using those model results where the model is reliably simulating the calibration data. From the graph, it can be seen that the James River does not fully attain the chlorophyll *a* WQS until a loading of 23.5 million pounds per year of nitrogen and 2.35 million pounds per year of phosphorus was achieved. EPA set the necessary load allocations for nitrogen and phosphorus at those levels.

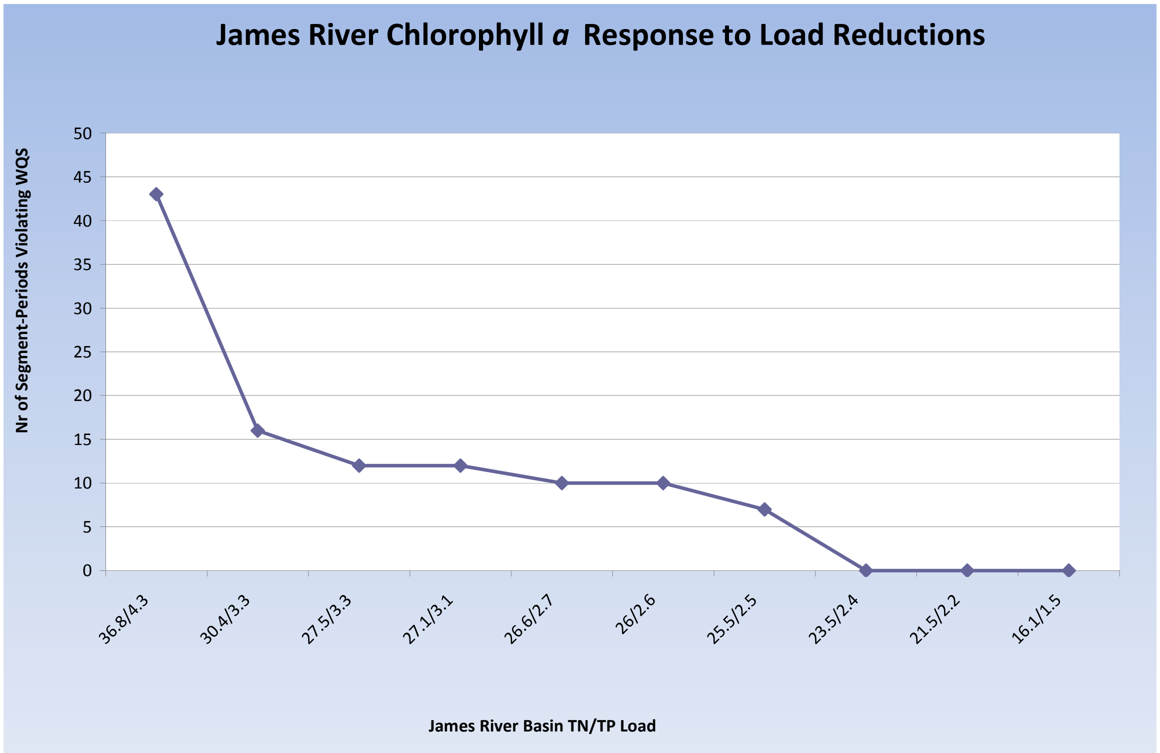


Figure 6-14. James River nonattainment of the chlorophyll *a* WQS at various load scenarios.

6.4.5 Allocation Considerations for the Headwater Jurisdictions (New York and West Virginia)

The methodology described above for distributing the basinwide loading was accepted by all jurisdictions except New York and West Virginia. From an additional Bay Water Quality Model run, EPA determined that small amounts of additional loadings of nitrogen and phosphorus in excess of the 190 million pounds per year TN and 12.7 million pounds per year TP could be allocated and still attain applicable WQS. In the July 1, 2010, letter to the jurisdictions, EPA used its discretionary authority to allocate to New York an additional 750,000 pounds per year of nitrogen (above the allocation calculated for New York using the method used to distribute the basinwide loads of 190 million pounds per year of nitrogen and 12.7 million pounds per year of phosphorus) (USEPA 2010g). With the final TMDL, EPA provided an additional 250,000 pounds per year of nitrogen and 100,000 pounds per year of phosphorus to New York's allocation. In addition, EPA used its discretionary authority to allocate to West Virginia an additional 200,000 pounds per year of phosphorus (above the level allocated to West Virginia using the allocation methodology to distribute the basinwide load of 190 million pounds per year of nitrogen and 12.7 million pounds per year of phosphorus) (USEPA 2010g). EPA, through model analysis, confirmed that those loadings will achieve WQS in the Chesapeake Bay. EPA provided the additional allocations for several reasons, including the following:

- Following the principles and guidelines as expressed in Section 6.3, tributary basins that contribute the most to the Bay water quality problems must do the most to resolve those problems (on a pound-per-pound basis). The headwater jurisdictions of New York and West Virginia contribute small portions of the overall nitrogen and phosphorus delivered to the Bay (5 percent or less) and, therefore, are provided some relief in their allocations.
- The water quality of the Susquehanna River leaving New York appears to be of better quality than that of downstream waters.
- The allocation methodology accommodates to some extent future growth by providing WLAs for wastewater treatment facilities at design flow rather than actual flow, thereby reserving a load for expansion of the facility. Therefore, New York considered the methodology to be biased against Bay watershed jurisdictions that are growing relatively slowly, like New York.
- A cleaner Bay provides greater benefit (in terms of commercial and recreational benefits of a cleaner bay) to the tidal jurisdictions than to the nontidal jurisdictions such as New York and West Virginia.

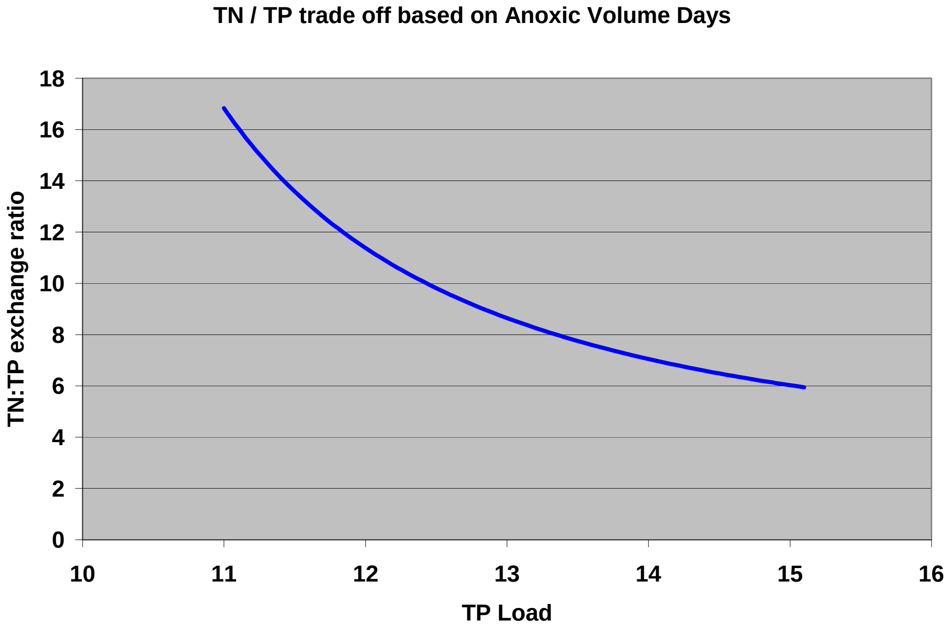
6.4.6 Nitrogen-to-Phosphorus Exchanges

On the basis of recent science regarding the relationship between nitrogen and phosphorus, EPA permitted the jurisdictions to propose the exchange of nitrogen and phosphorus loads within major river basins at a 1:5 ratio for reducing existing allocated phosphorus loads in exchange for increased nitrogen loads; and a 15:1 ratio for reductions in existing allocated nitrogen loads in exchange for increased phosphorus loads. For example, in jurisdiction allocations, for every 1 pound of phosphorus reduced, 5 pounds of nitrogen can be added and for every 15 pounds of nitrogen reduced, 1 pound of phosphorus can be added. This section documents the technical basis for those exchange rates.

Two scientific papers published in recent years specifically address tradeoffs between nitrogen and phosphorus. While those two analyses were completed with earlier versions of the Bay Watershed Model and the Bay Water Quality Model, the results are still meaningful if used to put bounds on the exchanges on a Bay-wide scale.

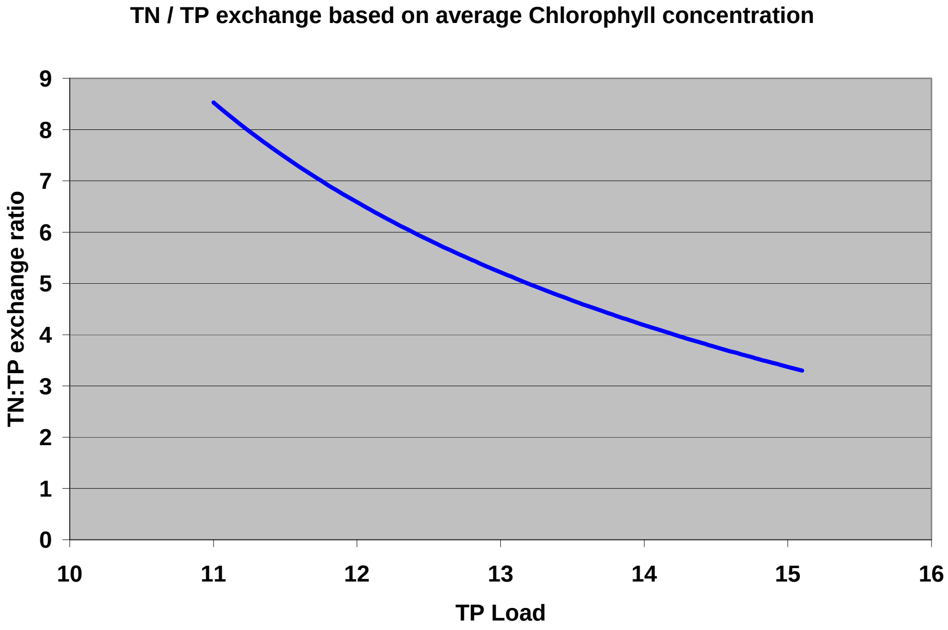
Wang et al. (2006) published response surface plots for chlorophyll *a* concentrations and anoxic volume days using a matrix of nitrogen and phosphorus load reduction scenarios. The response surface plots were generated by applying equations predicting overall chlorophyll *a* concentrations and anoxic volume days as quadratic functions of the nitrogen and phosphorus fraction of 2000 loading levels. Applying the Bay Watershed Model generated values in these same equations to assess the area around the allocation levels of 187.4 million pounds TN and 12.52 million pounds TP, one can use the derivatives of the original published equations to determine estimated TN:TP exchange relationships.

Figure 6-15 illustrates the TN:TP exchange ratio for different levels of TP based on the Anoxic Volume Days metric. At the allocation level of 12.52 million pounds of TP, the calculated exchange ratio is about 9:1, but the ratio has a good deal of variability. Considering that those are earlier versions of the Bay Watershed and Bay Water Quality models applied to the current reduction percentages, the local exchange ratio can vary depending on the location of the basin within the Bay. Given the degree of variability in this graph, EPA adopted a conservative approach. Figure 6-16 is the same analysis, except it uses chlorophyll *a* concentration in place of Anoxic Volume Days. The exchange ratios are lower, putting a greater importance on TP overall.



Source: Wang et al. 2006

Figure 6-15. TN:TP exchanges based on anoxic volume days and varying TP loads.



Source: Wang and Linker 2009.

Figure 6-16. TN: TP exchanges based on chlorophyll *a* concentrations and varying TP loads.

Wang and Linker (2009) documented an application of the earlier Bay models to the deep-water designated use of the upper central Chesapeake Bay segment CB4MH and determined a TN:TP exchange ratio of roughly 5:1 for that region of the mainstem Bay.

Further, the stoichiometric Redfield ratio for algal cell is well established at 16:1 TN:TP. This is the number of nitrogen and phosphorus atoms that approximates the nitrogen needed to make algal proteins and the phosphorus needed to make algal nucleic acids. On a weight basis, which is how one measures nitrogen and phosphorus loads delivered to the Bay, the TN/TP ratio equates to 10:1 TN:TP.

Taking both of those analyses, the two published papers, and EPA's desire to be conservative on these exchanges into account, an asymmetrical exchange ratio of 5:1 TN:TP when allowing more nitrogen loads and lowering the phosphorus load, and a ratio of 15:1 TN:TP when allowing more phosphorus loads and lowering the nitrogen load are applied. All applications of these TN:TP exchanges are confirmed to not affect the attainment of the jurisdictions' Bay WQS through follow-up Bay Water Quality Model scenarios.

Basin-Jurisdiction Nitrogen and Phosphorus Allocations

After performing all the analyses described above, EPA determined the basin-jurisdiction allocations for nitrogen and phosphorus needed to attain the WQS for DO and chlorophyll *a*. EPA sent a letter to the jurisdictions on July 1, 2010, to inform the jurisdictions of the allocations (USEPA 2010g). The table of those allocations are in Section 6.7. The jurisdictions used the allocations to develop their Phase I WIPs that further suballocate the nitrogen and phosphorus loadings to finer geographic scales and to individual sources or aggregate source sectors.

6.5 Establishing the Sediment-Related Model Parameters

In the sampling of particulate material in the streams and rivers of the Chesapeake Bay watershed as well as within the tidal waters, almost all of the measurements are for total suspended solids (TSS). This parameter includes sand, silt, and clay particles of sediment but also includes particulate organics. The Bay Watershed Model is calibrated to the observed TSS values. Since TSS is predominantly sediment, total suspended solids and sediment are often used interchangeably. Throughout the document, most of the references to allocations use the term sediment as that is the pollutant that needs to be reduced, but the formal allocation tables use the term TSS as that's the parameter output from the Bay models and its the parameter causing the aquatic life impairment (e.g., reducing light from reaching SAV).

6.5.1 Critical Conditions for Water Clarity and SAV

Submerged aquatic vegetation or SAV responds negatively to the same suite of environmental factors that result in low to no DO conditions—high-flow periods yielding elevated loads of nitrogen, phosphorus, and sediment (Dennison et al. 1993; Kemp 2004). High levels of nitrogen and phosphorus within the estuarine water column results in high level of algae, which block sunlight from reaching the SAV leaves. The same high concentrations of nitrogen and phosphorus also fuel the growth of epiphytes or microscopic plants on the surface of the SAV leaves, also directly blocking sunlight. Sediment suspended in the water column reduces the amount of sunlight reaching the SAV leaves. Because the critical period for both DO and water clarity/SAV are based on high-flow periods, EPA determined that the same critical period used for DO was appropriate for water clarity/SAV. Therefore, the critical period selected for assessment of the jurisdictions' SAV/water clarity WQS was 1993–1995. Detailed technical documentation is provided in Appendix G.

6.5.2 Assessment Procedures for the Clarity and SAV Standards

The Chesapeake Bay SAV restoration acreage in the jurisdictions' WQS are based on achieving SAV acreage goals set forth in state WQS that were based on the highest SAV acreage ever observed over a 40-year to more than 70-year historical record depending on the records available for each basin (USEPA 2003a; 2003d). Bay-wide, the SAV restoration goal is 185,000 acres.

The linked SAV and water clarity WQS are unique in some respects. Rather than covering the entire Bay as the DO WQS does, the SAV-water clarity WQS applies in only a narrow ribbon of shallow water habitat along the shoreline in depths of 2 meters or less. That presents certain challenges for the Chesapeake Bay model simulation and monitoring systems, both of which have long been more oriented toward the open waters of the Chesapeake Bay and its tidal tributaries and embayments. Scientific understanding of the transport, dynamics, and fate of sediment in the shallow waters of the Chesapeake Bay and understanding and simulating all the factors influencing SAV growth continues to develop. Appendix P provides more details of the Chesapeake Bay Water Quality and Sediment Transport Model-based combined SAV-water clarity attainment assessment procedures used in developing the sediment allocations.

The combined SAV/water clarity WQS can be achieved in one of three ways (see Section 3.3.3). First, as SAV acreage is the primary WQS, the WQS can be achieved by the number of SAV acres measured by way of aerial surveys—the method that is primarily used in CWA section 303(d) assessments. Second, the WQS can be achieved by the number of water clarity acres (divided by a factor of 2.5) added to the measured acres of SAV. Third, water clarity criteria attainment can be measured on the basis of the cumulative frequency distribution (CFD) assessment methodology using shallow-water monitoring data.

Although SAV responds to nitrogen, phosphorus, and sediment loads, DO and chlorophyll *a* primarily respond only to nitrogen and phosphorus loads. Because of that hierarchy of WQS response, EPA developed the strategy to achieve WQS by first setting the nitrogen and phosphorus allocation for achieving all the DO and chlorophyll *a* WQS in all 92 segments, and then making any additional sediment reductions where needed to achieve the SAV/water clarity WQS. That strategy is augmented by management actions in the watershed to reduce nitrogen, phosphorus, and sediment loads.

Just as the SAV resource is responsive to nitrogen, phosphorus, and sediment loads, many management actions in the watershed that reduce nitrogen and phosphorus also reduce sediment loads. Examples include conservation tillage, farm plans, riparian buffers, and other key practices. The estimated ancillary sediment reductions resulting from implementation actions necessary to achieve the nitrogen and phosphorus reductions needed to achieve the allocations are estimated to be about 40 percent less than 1985 sediment loads and 25 percent less than current (2009) load estimates. The sediment reductions associated with the nitrogen and phosphorus controls necessary to achieve the basin-jurisdiction target loads provided on July 1, 2010, are provided in Table 6-6.

Table 6-6. Tributary strategy scenario and nitrogen and phosphorus-based allocation scenario's total suspended solids loads (millions of pounds) by watershed jurisdiction

Jurisdiction	Tributary strategy	Allocation scenario
Maryland	1,195	1,118
Pennsylvania	2,004	1,891
Virginia	2,644	2,434
District of Columbia	10	10
New York	310	291
West Virginia	248	240
Delaware	55	55
Total	6,467	6,040

Using the Bay Water Quality Model, the SAV/water clarity WQS were assessed by starting with measured area of SAV in each Bay segment from the 1993–1995 critical period. On the basis of regressions of SAV versus load, the estimated SAV area, resulting from a particular nitrogen and phosphorus or sediment load reduction, was estimated as described in Appendix P. Then the estimated water clarity acres from the Bay Water Quality Model were added after adjustment by a factor of 2.5 to convert to the water clarity acres to water clarity equivalent SAV acres (Appendix P). Finally the water clarity equivalent SAV acres were added to the regression-estimated SAV acres and compared to the Bay segment-specific SAV WQS.

Note that when assessing attainment using monitoring data, only the SAV acres measurement is generally used because the number of Bay segments assessed with shallow-water clarity data are still limited. When projecting attainment using the Bay Water Quality model, the extrapolated measured SAV acres are added to the model-projected water clarity equivalent SAV acres to determine total SAV acres (Appendix P).

6.5.3 Addressing Reduced Sensitivity to Load Reductions at Low Nonattainment Percentages

Water Clarity

Only one segment displayed a small, yet persistent percentage of model projected water clarity/SAV criteria nonattainment over a range of reduced nitrogen and phosphorus loads—the Appomattox River segment (APPTF) in Virginia's James River Basin. In the case of that segment, while historical records document observed SAV acres in the 1950s, no observed SAV has been mapped since the early 1970s. That tidal fresh segment (salinities from 0 to 0.5 ppt) did not exhibit a positive response (increased water clarity, increased SAV acreage) to model simulated reductions in nitrogen, phosphorus, and sediment as observed in most other Bay tidal fresh segments. For the reasons unique to that Bay segment, EPA would consider it to be in full attainment of its shallow-water bay grass designated use if a 1 percent nonattainment level is achieved.

6.5.4 Explicit Margin of Safety for Sediment

In a TMDL, where there is uncertainty, an explicit MOS may be appropriate. In the Bay TMDL, EPA determined that an explicit MOS is appropriate for sediment because the Bay Water Quality Model was overly optimistic in its simulation of SAV acreages and water clarity attainment in the shallows. Specifically, the Bay Water Quality Model projected that widespread attainment of the SAV/water clarity standards would result at the current (2009) basinwide loading levels of about 8 billion pounds per year. In contrast, however, recent data from the Baywide SAV aerial survey and shallow-water quality monitoring data showed that most Bay segments were not attaining the SAV restoration acreages goals or water clarity criteria. That discrepancy justified the need for an explicit MOS to ensure that the sediment allocations would achieve the Bay jurisdictions' SAV/water clarity WQS.

EPA acknowledges that the science supporting the estuarine modeling simulation of the transport and resuspension for sediment is not as strong as that for nitrogen and phosphorus.[1] It is important to note, however, that many of the conservative assumptions identified in the implicit MOS discussion for nitrogen and phosphorus in Section 6.2.4 also apply to the MOS for sediment. In addition to the conservative assumptions in the modeling and allocation methods, EPA applied an explicit MOS in establishing the sediment allocations.

Since the SAV/water clarity modeling methodology was overly optimistic, and because reducing phosphorus often has the co-benefit of reducing sediment, EPA established sediment allocations on the basis of sediment loads that EPA estimated would result from implementing the phosphorus controls. The basin-jurisdiction sediment allocations initially were expressed as an allocation range reflecting the application of an explicit MOS in order to provide the jurisdictions with some flexibility in preparing their WIPs (USEPA 2010h). That initial allocation range was from 6.1 billion pounds per year to 6.7 billion pounds per year. Using 8 billion pounds per year of sediment as the estimate of the load needed to generally attain at the Baywide SAV/water clarity standards, that allocation range provides a Baywide range for MOS of about 16 to 24 percent.

In the final TMDL, EPA used a singular allocation to the basin-jurisdictions for sediment as opposed to a range. The method used to interpret the WIPs to derive that allocation is described in Section 8. The final Baywide sediment allocation is about 6.5 million pounds per year. So that allocated load yields a Baywide explicit MOS of 19 percent. Of course, the explicit MOS for each of the Bay segments would be expected to be somewhat higher or lower than the Baywide MOS. It is EPA's professional opinion that an explicit Baywide MOS of 19 percent—which is beyond the conservative assumptions identified in the Section 6.2.4 above on the implicit MOS for nitrogen and phosphorus—is appropriate for establishing the sediment allocations.

6.6 Establishing the Basin-Jurisdiction Allocations for Sediment

The methodology used for allocating sediment loads to major river basins and jurisdictions for sediment was much different than the methodology used for nitrogen and phosphorus. Because sediment has a localized water quality effect, the immediate subbasin (e.g., the Chester River) is

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[1] Copies of the Chesapeake Bay Water Quality Sediment Transport Model Review Panel's (convened by the CBP's Scientific and Technical Advisory Committee) reports are at http://www.chesapeakebay.net/committee_msc_projects.aspx?menuitem=16525#peer.

usually the dominant controlling influence on water clarity and SAV growth. Therefore, a methodology is not needed to further suballocate the loading to contributing jurisdictions or neighboring basins. On August 13, 2010, the EPA Region 3 Administrator sent a letter to the jurisdictions identifying the sediment allocations (USEPA 2010g).

6.6.1 Methodology for Determining Sediment Allocations

To identify the sediment loads needed to achieve the SAV/water clarity WQS, the following key steps were taken:

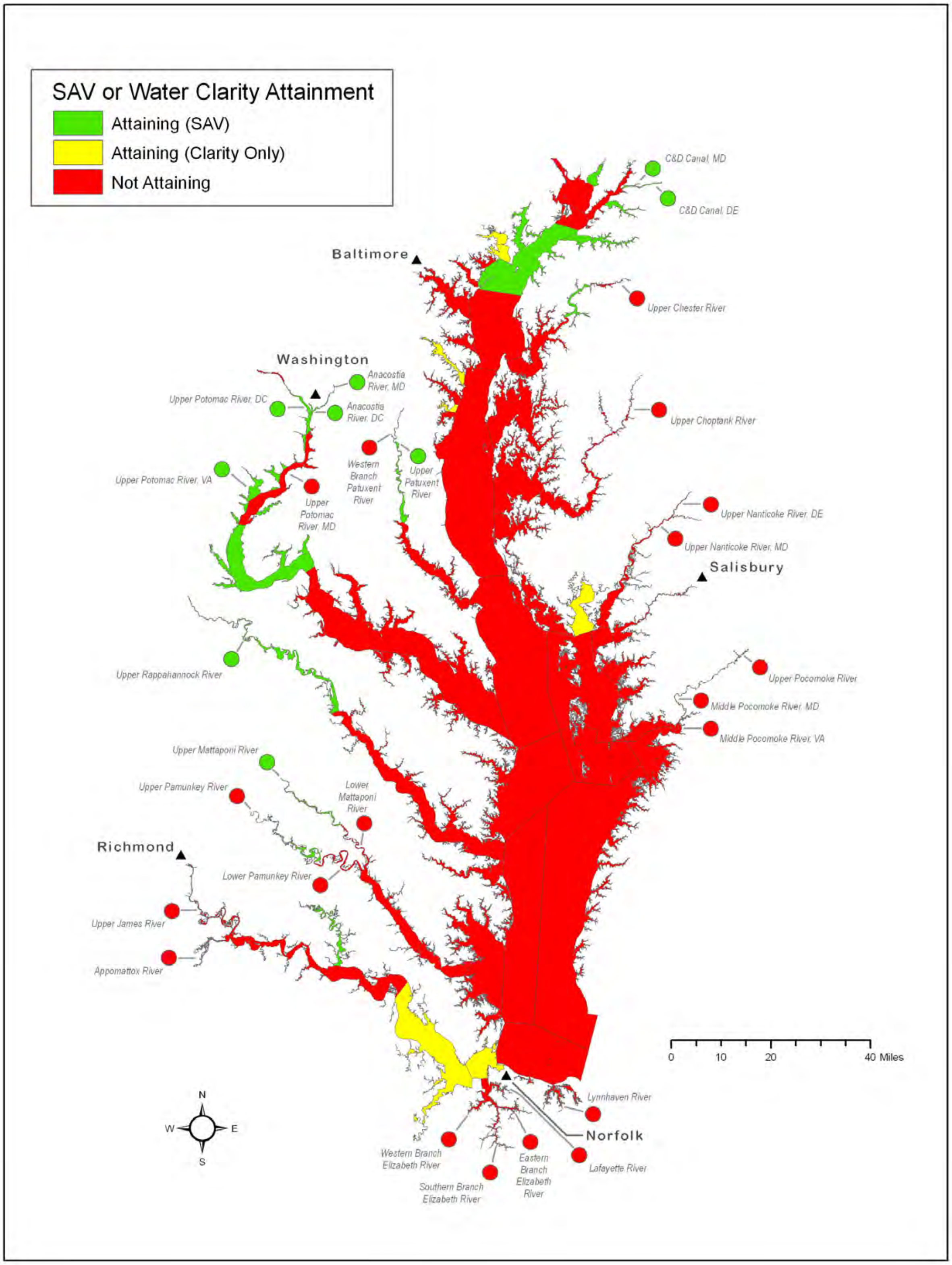
- Determine the sediment loading for each Bay segment that would be expected from installing the controls needed to meet the phosphorus allocations but have the co-benefit of reducing sediment (as described above).
- Using the Bay Water Quality Model, determine the number of acres in each segment that would attain the clarity standards for that segment and divide that number by 2.5 to determine the SAV equivalent acres.
- Add the SAV equivalent acres determined above to the expected SAV acreage on the basis of observed acres to determine the total SAV acreage expected under that nitrogen, phosphorus, and sediment loading scenario.
- Compare the expected SAV acres to the SAV goal for that segment to determine attainment with the WQS.
- For the non-attaining segments, go back to step 1.

Of the 92 tidal Bay segments assessed by Maryland, Virginia, Delaware, and the District of Columbia, 26 achieve the respective jurisdiction’s SAV/water clarity WQS according to available monitoring data (Appendix P). Twenty segments have mapped SAV acreages meeting the segment-specific SAV restoration acreage in the jurisdiction’s WQS (single best year of the past 3 years). Of the 12 water clarity acre assessments that were performed, an additional 6 segments were found to attain the jurisdiction’s water clarity criteria on the basis of an analysis of shallow-water monitoring data (Figure 6-17).

However, the Bay Water Quality Model projected widespread attainment at existing loading levels, yet the existing SAV water quality data show SAV/water clarity WQS nonattainment in 66 of 92 segments with only 46 percent of the Bay-wide restoration acreage achieved (Appendix P). The existing state of scientific understanding has resulted in the Bay Water Quality Model being optimistic in its simulation of SAV acreage in the Bay under current (2009) pollutant loads.

6.6.2 Addressing Water Clarity/SAV Nonattaining Segments

After applying the sediment loads described above, four segments were initially found to be in nonattainment of the SAV-water clarity WQS. Those segments are the Mattawoman Creek (MATTF), the Gunpowder River (GUNOH), the Appomattox River (APPTF), and the Virginia’s portion of the lower Potomac River (POTMH_VA). A detailed assessment of those nonattaining segments are in Appendix N, but a brief review is provided below.



Sources: DC DOE 2008; DE DNREC 2008; MDE 2008; VA DEQ 2008; Appendix Q.

Figure 6-17. Chesapeake Bay SAV/Water Clarity WQS attainment from monitoring data assessment.

Mattawoman Creek (MATTF)—Recent aerial surveys have shown a remarkable recovery of the acreage of SAVs in the Mattawoman Creek. In fact, for the years 2006–2009 the acres of observed SAV was higher than the SAV goal. Furthermore, with the implementation of the allocations in this TMDL, further nitrogen, phosphorus, and sediment reductions are expected, which will likely encourage additional SAV growth. So from the observed SAV line of evidence, EPA concludes that the allocated sediment load to Mattawoman Creek will attain the SAV goals.

Gunpowder River (GUNOH)—Similar to the Mattawoman Creek, substantial regrowth of SAV has occurred in the Gunpowder River since 2000. While the SAV goal is not being exceeded consistently, there have been several recent years where the goal is essentially met. On the basis of observed SAV information, combined with the fact that the TMDL allocations will result in additional nitrogen, phosphorous, and sediment reductions, EPA concludes that the allocated sediment load to the Gunpowder River will attain the SAV goals.

Appomattox River (APPTF)

No reported SAV acres are in the Appomattox River in the recent record. Therefore, attainment in this segment will need to be based on attainment for the clarity WQS alone. On the basis of modeling results at the allocation levels, the clarity levels barely attain applicable WQS. So an overall sediment allocations for the James may not be specific enough to assure attainment of the SAV standards in the Appomattox River. Therefore, while the basin-jurisdiction allocation for sediment for the James has been established, it is important to closely track the regrowth of SAV in the segment and use that information to provide needed updates to the assessment for the segment.

Virginia's portion of the lower Potomac River (POTMH_VA)

This segment covers the embayments on the Virginia side of the lower tidal Potomac River. The embayments are well isolated from the Potomac River and, therefore, respond primarily to the inputs from the subwatershed and not the Potomac itself. Recent SAV observations for the segment are much improved over the past but still far short of the WQS. Therefore, attainment determinations for the segment rely largely on the clarity attainment. As a reminder, the predicted SAV levels can be calculated as a combination of the measured SAV levels plus acres of clarity attainment (divided by 2.5). If one uses the critical period 1993–1995 SAV observed acreage and combines this acreage with the expected clarity attainment at the allocation loadings, the segment does not attain the SAV goal at the sediment allocation level. Furthermore, at much higher levels of controls (lower loadings), beyond the sediment allocation, the calculated nonattainment for this segment persists. There is simply not enough shallow water habitat in the segment to attain the standard on the basis of water clarity alone. On the other hand, all neighboring Bay segments in the tidal Potomac River are expected to achieve the SAV standards with the implementation of the sediment allocations. Therefore, having limited basis for which to establish a sediment allocation, and in consideration that neighboring Bay segments are expected to attain the SAV standards, EPA retained the sediment allocations for the Potomac basin. However, EPA considers it important, similar to the Appomattox River, to closely track the regrowth of SAV in this segment and use that information to provide needed updates to the assessment for this segment.

6.7 Basin-Jurisdiction Allocations to Achieve the Bay WQS

On the basis of all the methods and analyses described above, EPA identified allocations for the major basins within each jurisdiction called the basin-jurisdiction allocations. Those allocations were the beginning point for developing the Bay TMDL and are provided below.

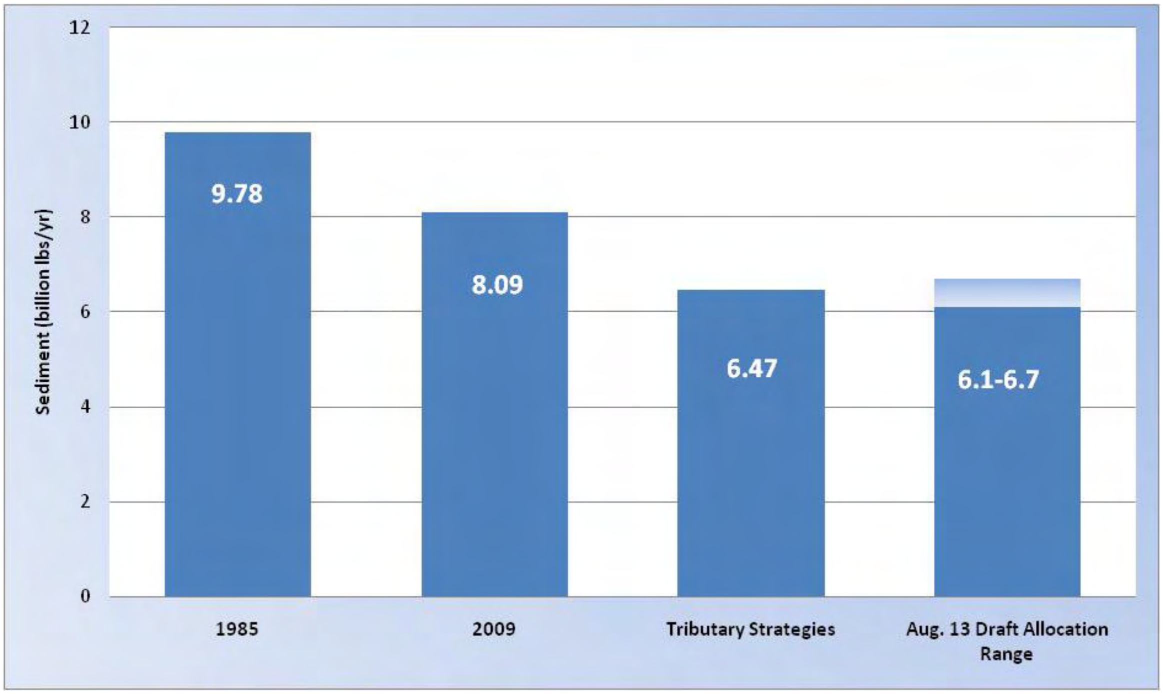
6.7.1 Basin-Jurisdiction Allocations Tables

Throughout 2009 up until the summer of 2010, EPA and its watershed jurisdictional partners worked together to develop the major river basin/jurisdiction allocations. From those collaborative efforts, EPA shared an initial set of major river basin/jurisdiction nitrogen and phosphorus target loads on November 3, 2009, on the basis of decisions at the October 23, 2009, PSC meeting (USEPA 2009b). Then, after a 2-day PSC meeting on April 29-30, 2010, EPA shared in a letter to the partners an updated Bay TMDL schedule and further outlined a long-term commitment to an adaptive management approach to the Bay TMDL (USEPA 2010f).

The basin-jurisdiction allocations were based on attaining the adopted (but proposed at the time) amendments to the jurisdictions’ Bay WQS. On July 1, 2010, EPA shared the nitrogen and phosphorus allocations (USEPA 2010g) and the sediment allocations on August 13, 2010 (USEPA 2010h). Those were the allocations that jurisdictions used to develop their Phase I WIPs that further suballocate the nitrogen, phosphorus, and sediment loadings to finer geographic scales and to individual sources or aggregate source sectors and EPA used to evaluate those WIPs. By initially expressing the sediment allocations as a range, EPA allowed the jurisdictions some flexibility in developing their Phase I WIPs while assuring with confirmation Water Quality Model runs that all the WQS would be met (Figure 6-18) (USEPA 2010h). The allocations were calculated as delivered loads (the loading that actually reaches tidal waters) and as annual loads. The loads are provided in Tables 6-7 and 6-8. The allocations were further refined through the jurisdictions’ WIPs by exchanges of loadings for some basins in Maryland and exchanges of nitrogen to phosphorus or phosphorus to nitrogen within a basin. Those adjusted allocations are provided in Section 8.

6.7.2 Correction of the West Virginia Sediment Allocation

The allocation for sediment for West Virginia, listed in Tables 6-7 and 6-8, was corrected subsequent to the distribution of the sediment allocation letter to the jurisdictions on August 13. 2010. Recall that the sediment range of allowable loads was based on the expected sediment loading that would result as a co-benefit to reducing phosphorus. So the sediment range was highly dependent on the phosphorus allocation. The reason the sediment allocation for West Virginia needed to be corrected was that the previous sediment allocation in the EPA letter of August 13, 2010, was not based on the supplemental phosphorus load that was provided to West Virginia. When the full phosphorus allocation for West Virginia is considered, the updated sediment load range for West Virginia was 309–340 million of pounds per year. For the Potomac River in West Virginia, the updated sediment load range is 294–324 million pounds per year**.** The sediment allocation range for the James River Basin in West Virginia remains unchanged.



Source: USEPA 2010h

Figure 6-18. Model simulated sediment loads by scenario compared with the range of sediment allocations (billions of pounds per year as total suspended sediment).

6.8 Attainment of the District of Columbia pH Water Quality Standard

After the development of the nitrogen, phosphorus and sediment allocations to achieve the Bay DO, chlorophyll *a*, SAV/water clarity WQS, EPA conducted an analysis to explore whether these allocations were sufficient to remedy the pH impairment in the District of Columbia portion of the Potomac River Estuary. The upper Potomac River Estuary from Key Bridge to Haines Point has been on the District of Columbia's 303(d) list of impaired waters for pH from 1998 to present. EPA believes that the high pH levels are indirectly caused by the relationship between high nitrogen and phosphorus levels and algal growth. Readily available nitrogen and phosphorus in surface waters supports the growth of algae, which can become prolific when nitrogen and phosphorus levels are high. During photosynthesis, algae use carbon dioxide, resulting in high pH conditions (Sawyer et al. 1994). In water, carbon dioxide gas dissolves to form soluble carbon dioxide, which reacts with water to form undissociated carbonic acid. Carbonic acid then dissociates and equilibrates as bicarbonate and carbonate. Generally, as carbon dioxide is used up in photosynthesis, pH rises because of the removal of carbonic acid (Horne and Goldman 1994). It is expected that the high pH levels in this segment of the tidal Potomac River are due to primary productivity (algal growth). Algal growth is fueled by excess nitrogen and phosphorus inputs. On the basis of a reasonable degree of scientific certainty, as further explained below, EPA finds that the reduced nitrogen and phosphorus loads resulting from implementation of the Chesapeake Bay TMDL will also result in decreased algae levels and, thus, meet the District of Columbia pH numeric WQS.

Table 6-7. Chesapeake Bay watershed nitrogen and phosphorus and sediment allocations by major river basin by jurisdiction to achieve the Chesapeake Bay WQS

Basin	Jurisdiction	Nitrogen allocations (million lbs/year)	Phosphorus allocations (million lbs/year)	Sediment allocations (million lbs/year)
Susquehanna	New York	8.48 [b]	0.62 [b]	293–322
	Pennsylvania	71.74	2.31	1,660–1,826
	Maryland	1.08	0.05	60–66
	Total	81.31 [b]	2.98 [b]	2,013–2,214
Eastern Shore	Delaware	2.95	0.26	58–64
	Maryland	9.71	1.09	166–182
	Pennsylvania	0.28	0.01	21–23
	Virginia	1.21	0.16	11–12
	Total	14.15	1.53	256–281
Western Shore	Maryland	9.74	0.46	155–170
	Pennsylvania	0.02	0.001	0.37–0.41
	Total	9.76	0.46	155–171
Patuxent	Maryland	2.85	0.21	82–90
	Total	2.85	0.21	82–90
Potomac	Pennsylvania	4.72	0.42	221–243
	Maryland	15.70	0.90	654–719
	District of Columbia	2.32	0.12	10–11
	Virginia	17.46	1.47	810–891
	West Virginia	4.67	0.74	294–324 [c]
	Total	44.88	3.66	1,989–2,188 [c]
Rappahannock	Virginia	5.84	0.90	681–750
	Total	5.84	0.90	681–750
York	Virginia	5.41	0.54	107–118
	Total	5.41	0.54	107–118
James	Virginia	23.48	2.34	837–920
	West Virginia	0.02	0.01	15–17
	Total	23.50	2.35	852–937
Total Basin/Jurisdiction Allocation		187.69	12.62	6,135–6,749
Atmospheric Deposition Allocation[a]		15.70	--	--
Total Basinwide Allocation		203.39	12.62	6,135–6,749

a. Cap on atmospheric deposition loads direct to Chesapeake Bay and tidal tributary surface waters to be achieved by federal air regulations through 2020.
b. This allocation to New York does include the additional (beyond the draft) allocation of 250,000 pounds per year of nitrogen and 100,000 pounds per year of phosphorus that EPA added to the New York allocation (see Section 6.4.5)
c. This allocation includes a correction of the sediment allocations to West Virginia to account for the increase in phosphorus allocation provided to West Virginia (see Section 6.7.2)

To support that assumption, continuous monitoring data from the District of Columbia’s Department of the Environment long-term monitoring station at the Roosevelt Island Bridge were evaluated. This location falls within the impaired tidal Potomac River segment (POTTF_DC) and is the only location for which continuous data are available for trend analysis. Plots of pH vs. chlorophyll *a* for the period of record indicate a distinct relationship between the two parameters; increased chlorophyll *a* levels are associated with increased levels of pH. That relationship is particularly apparent for April through June of 2010 (Figure 6-19).

Table 6-8. Chesapeake Bay watershed nitrogen and phosphorus and sediment allocations by jurisdiction by major river basin to achieve the Chesapeake Bay WQS

Jurisdiction	Basin	Nitrogen allocations (million lbs/year)	Phosphorus allocations (million lbs/year)	Sediment allocations (million lbs/year)
Pennsylvania	Susquehanna	71.74	2.31	1,660-1,826
	Potomac	4.72	0.42	221-243
	Eastern Shore	0.28	0.01	21-23
	Western Shore	0.02	0.001	0.37-0.41
	PA Total	76.77	2.74	1,903-2,093
Maryland	Susquehanna	1.08	0.05	60-66
	Eastern Shore	9.71	1.09	166-182
	Western Shore	9.74	0.46	155-170
	Patuxent	2.85	0.21	82-90
	Potomac	15.70	0.90	654-719
	MD Total	39.09	2.72	1,116-1,228
Virginia	Eastern Shore	1.21	0.16	11-12
	Potomac	17.46	1.47	810-891
	Rappahannock	5.84	0.90	681-750
	York	5.41	0.54	107-118
	James	23.48	2.34	837-920
	VA Total	53.40	5.41	2,446-2,691
District of Columbia	Potomac	2.32	0.12	10-11
	DC Total	2.32	0.12	10-11
New York	Susquehanna	8.48 [b]	0.62 [b]	293-322
	NY Total	8.48 [b]	0.62 [b]	293-322
Delaware	Eastern Shore	2.95	0.26	58-64
	DE Total	2.95	0.26	58-64
West Virginia	Potomac	4.67	0.74	294-324 [c]
	James	0.02	0.01	15-17
	WV Total	4.68	0.75	309–341 [c]
Total Basin/Jurisdiction Allocation		187.69	12.62	6,135-6,749
Atmospheric Deposition Allocation[a]		15.70	--	--
Total Basinwide Allocation		203.39	12.62	6,135-6,749

a. Cap on atmospheric deposition loads direct to Chesapeake Bay and tidal tributary surface waters to be achieved by federal air regulations through 2020.
b. This allocation to New York does include the additional (beyond the draft) allocation of 250,000 pounds per year of nitrogen and 100,000 pounds per year of phosphorus that EPA added to the New York allocation (see Section 6.4.5)
c. This allocation includes a correction of the sediment allocations to West Virginia to account for the increase in phosphorus allocation provided to West Virginia (see Section 6.7.2)

For the most recent 2-year period (September 2008 to November 2010), pH levels at that location have regularly exceeded the maximum criterion level of 8.5; however, they never exceeded 9.0.[2] Those pH levels are similar to those observed at other tidal Potomac River Estuary monitoring stations.

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[2] In 9VAC25-260-50, Virginia requires that estuarine waters fall within the acceptable pH range of 6.0 to 9.0.

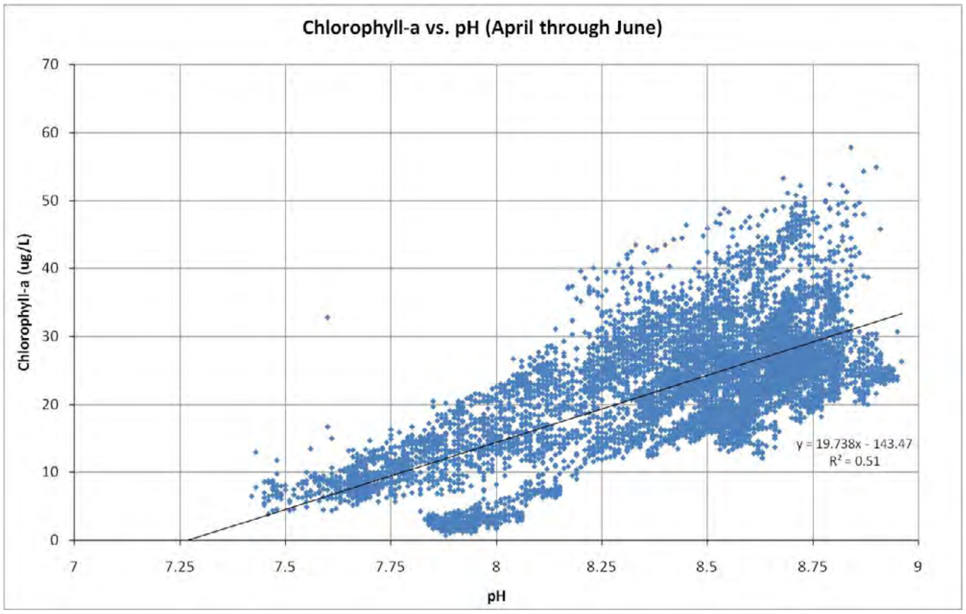

Figure 6-19. District of Columbia's Roosevelt Island station pH versus chlorophyll *a* monitoring data regression.

It is also important to note that no known wastewater discharges are expected to contribute to high pH levels along this stretch of the Potomac. Only one nonsignificant industrial facility discharges to the tidal Potomac River above this location, the Washington Aqueduct. Flow from the facility is relatively small (13.2 million gallons per day) when compared to the flow rate of the Potomac (about 7 billion gallons per day) in the vicinity. Permit limits for the facility require that pH is between 6.0 and 8.5. Examination of discharge monitoring report (DMR) data from May 2003 to May 2010 for the facility indicates one pH violation on August 31, 2003, for pH of 9.22 at Outfall 004. No other outfalls had violations between May 2003 and February 2006, and pH ranged from 6.5 to 8.0 during that time. A second violation, failure to report DMR data, occurred in May 2010.[3] A second facility, Walter Reed Army Medical Center, discharges approximately 0.09 million gallons per day to the tidal Potomac River via Rock Creek. Because of its upstream location, discharge characteristics (process water from heating and cooling system and rooftop runoff), and small size, it is not a source of high pH waters. Because the next segment upstream is the POTTF_MD, and it is not impaired for pH, no further upstream discharge facilities were evaluated.

Flow and pH data for the most recent 2-year period show that high flows generally do not correspond to pH exceedances. That evidence strongly suggests that nonpoint sources are not a direct cause of the pH exceedances. For those reasons, it is EPA's best professional judgment that pH exceedances are caused by the high nitrogen and phosphorus and resultant algae growth and that the reductions expected to result from implementing the Chesapeake Bay TMDL will also ensure attainment of the pH criterion in this segment of the Potomac.

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[3] EPA reviewed DMR records from both PCS and ICIS. Actual data were available from the PCS review (2003 to early 2006), whereas the ICIS review (2006 to May 2010) provided information regarding whether a violation occurred and the type of violation.

The Washington Ship Channel is another waterbody segment in the District that was listed as impaired on the District of Columbia's 1998 303(d) list and was part of EPA's Consent Decree. In 2004 the District established, and EPA approved, a TMDL to address the pH impairment that requires phosphorus reductions expressed in annual loads. Since the 2004 Washington Ship Channel TMDL, the District's final 2008 303(d) list and its draft 2010 303(d) both indicate that the Washington Ship Channel's aquatic life use is no longer impaired due to pH. It is EPA's best professional judgment that this supports the conclusion that implementing the Chesapeake Bay TMDL's nitrogen and phosphorus reductions will address the District of Columbia's pH impairments and that implementing the Chesapeake Bay TMDL will continue to protect the Washington Ship Channel from pH impairment. The Chesapeake Bay TMDL supersedes the Washington Ship Channel's 2004 pH TMDL.

SECTION 7. REASONABLE ASSURANCE AND ACCOUNTABILITY FRAMEWORK

When the U.S. Environmental Protection Agency (EPA) establishes or approves a total maximum daily load (TMDL) that allocates pollutant loads to both point and nonpoint sources, it determines whether there is reasonable assurance that the load allocations (LAs) will be achieved and water quality standards (WQS) will be attained. EPA does that to be sure that the wasteload allocations (WLAs) and LAs established in the TMDL are not based on overly generous assumptions regarding the amount of nonpoint source pollutant reductions that will occur.

This is necessary because the WLAs for point sources are determined, in part, on the basis of the expected contributions to be made by nonpoint sources to the total pollutant reductions necessary to achieve WQS. If the reductions embodied in LAs are not fully achieved because of a failure to fully implement needed nonpoint source pollution controls, or that the reduction potential of the proposed best management practices (BMPs) was overestimated, the collective reductions from all sources will not result in attainment of WQS. As a result, EPA evaluates whether a TMDL provides reasonable assurance that nonpoint source controls will achieve expected load reductions.

For the Chesapeake Bay TMDL, numerous elements combine to provide that reasonable assurance, of which the primary mechanism is the Accountability Framework described in Section 7.2. Section 8 also describes EPA actions designed to provide additional assurance that the Bay TMDL’s allocations are achieved.

7.1 REASONABLE ASSURANCE

The Clean Water Act (CWA) section 303(d) requires that a TMDL be “established at a level necessary to implement the applicable water quality standard.” Federal regulations define a TMDL as “the sum of the individual WLAs for point sources and LAs for nonpoint sources and natural background” [40 CFR 130.2(i)]. Documenting adequate reasonable assurance increases the probability that regulatory and voluntary mechanisms will be applied such that the pollution reduction levels specified in the TMDL are achieved and, therefore, applicable WQS are attained.

When a TMDL is developed for waters impaired by point sources only, the existence of the National Pollutant Discharge Elimination System (NPDES) regulatory program and the issuance of an NPDES permit provide the reasonable assurance that the WLAs in the TMDL will be achieved. That is because federal regulations implementing the CWA require that effluent limits in permits be consistent with “the assumptions and requirements of any available [WLA]” in an approved TMDL [40 CFR 122.44(d)(1)(vii)(B)].

Where a TMDL is developed for waters impaired by both point and nonpoint sources, in EPA’s best professional judgment, determinations of reasonable assurance that the TMDL’s LAs will be achieved could include whether practices capable of reducing the specified pollutant load: (1) exist; (2) are technically feasible at a level required to meet allocations; and (3) have a high likelihood of implementation. Where there is a demonstration that nonpoint source load reductions can and will be achieved, a TMDL writer can determine that reasonable assurance exists and, on the basis of that reasonable assurance, allocate greater loadings to point sources. Without a demonstration of reasonable assurance that relied-upon nonpoint source reductions will occur, the Bay TMDL would have to assign commensurate reductions to the point sources.

7.1.1 Overview of the Accountability Framework

For the Chesapeake Bay TMDL, reasonable assurance that nonpoint source load reductions will be achieved is based, in large part, on the new accountability framework EPA is developing for this TMDL, including the Bay jurisdictions' watershed implementation plans (WIPs). This framework incorporates an adaptive management approach that documents implementation actions, assesses progress, and determines the need for alternative management measures based on the feedback of the accountability framework. As discussed below and in the *Strategy for Protecting and Restoring the Chesapeake Bay Watershed* (FLCCB 2010), the goal for installing all controls necessary to achieve the Bay's DO, water clarity, SAV, and chlorophyll *a* criteria is 2025. EPA therefore is making its evaluation of reasonable assurance according to that time horizon. EPA has provided an interim goal that 60 percent of the reductions to achieve applicable WQS occur by no later than 2017. This interim goal ensures that the large portions of necessary reductions, or the more difficult restoration actions, are not left until the later years of the restoration schedule.

Since 2008, EPA Region 3 has communicated its heightened expectations for reasonable assurance in the Chesapeake Bay watershed and its basis for expecting the jurisdictions' WIPs to assist in the demonstration of that reasonable assurance. EPA's September 11, 2008, and November 4, 2009, letters and its April 2, 2010, *Guide for EPA's Evaluation of Phase I Watershed Implementation Plans* provide extensive information on what EPA expects the jurisdictions to include in their WIPs to help demonstrate reasonable assurance (USEPA 2008b, 2009c, 2010e), including that the jurisdictions

- Develop WIPs that identify how point and nonpoint sources will reduce nitrogen, phosphorus, and sediment loads sufficient to meet WQS for DO, chlorophyll *a*, SAV, and water clarity in the tidal waters of the Chesapeake Bay and its tidal tributaries
- Commit to set and meet specific 2-year milestones for implementing practices to achieve load reductions

EPA also has stated its intention to take additional federal actions, as determined to be appropriate to ensure implementation of the Bay TMDL, as described in Section 7.2.4 below. One of those potential federal actions is the modification or replacement of the TMDL. Another is the use of EPA's discretionary authority to increase oversight of NPDES permits proposed and issued by the Bay watershed jurisdictions. As discussed in EPA's December 29, 2009, letter, pursuant to EPA-jurisdiction NPDES program agreements, EPA can expand its oversight review of draft permits in the Bay watershed and can object to permits that do not meet CWA requirements, including NPDES effluent limits that are inconsistent with the Bay TMDL's WLAs (USEPA 2009d). EPA also could use its discretionary residual designation authority to increase the number of sources, operations, or communities regulated under the NPDES permit program.

As part of EPA's demonstration of reasonable assurance, EPA evaluated the jurisdictions' final Phase I WIPs to determine whether the jurisdictions both met their target allocations and provided sufficient reasonable assurance. Section 8 describes the results of EPA's evaluation of the jurisdictions' final Phase I WIPs. Section 8 also describes EPA actions designed to provide additional reasonable assurance that applicable WQS in the Chesapeake Bay watershed will be attained and maintained.

In addition to the new Bay-specific accountability framework, reasonable assurance for the Chesapeake Bay TMDL is based on the existence and implementation of numerous existing federal, state, and local programs that provide for both point and nonpoint source controls. While not all these programs provide funding or apply to all sources, together they contribute to EPA's determination that reasonable assurance exists for the Chesapeake Bay TMDL.

7.1.2 Federal Strategy

President Obama signed Executive Order 13508 on May 12, 2009. That order directs federal agencies to "define environmental goals for the Chesapeake Bay and describe milestones for making progress toward attainment of these goals." The federal agencies fulfilled this order by drafting the *Strategy for Protecting and Restoring the Chesapeake Bay Watershed*, which focused on achieving four essential priorities to restore and maintain a healthy Chesapeake ecosystem: restore clean water; recover habitat; sustain fish and wildlife; and conserve land and increase public access (FLCCB 2010). The *Federal Strategy* articulates 12 key environmental outcomes that will be achieved through federal actions and ongoing state activities. The commitments and actions described in the Federal Strategy and annual federal action plans are a unique and powerful tool to achieve the Bay's water quality goals and provide additional support for reasonable assurance in this TMDL.

The Bay TMDL, along with the jurisdictions' WIPs, are key elements of the strategy because together they provide a set of numeric pollutant reduction targets and implementation plans to guide and assist achievement of the goal to restore clean water. Under the Federal Strategy, EPA is also creating a system to track and report TMDL/WIP reduction goals and 2-year milestones for federal and state agencies (see Section 7.2.3). The tracking system provides additional reasonable assurance that the TMDL's allocations will be met by clearly charting ongoing progress and, if there are shortfalls, informing EPA, the seven Bay watershed jurisdictions, and other stakeholders, including the public, about the need for additional state and federal actions.

USGS, NOAA, and other federal agencies will work with EPA and the jurisdictions to improve the water quality monitoring and tracking of management actions and restoration activities. Part of that effort includes expanding and improving the NOAA Chesapeake Bay Interpretive Buoy System and improving the monitoring of tidal river and upland stream conditions. Many other federal agencies will undertake actions to conserve land, sustain fish and wildlife, and recover habitat.

The strategy also outlines specific tools to promote transparency and accountability in the implementation and coordination of the activities. Those tools include federal 2-year milestones where the federal agencies identify and track their actions toward meeting water quality milestones and other strategy outcomes. Other tools outlined in the strategy include an annual federal action plan, an annual progress report and providing for an independent evaluation of both federal and state progress on meeting the goals set forth in section 206 of the Executive Order.

7.1.3 Funding

The CWA authorizes EPA to provide funding to the Bay watershed jurisdictions through various sources, including but not limited to Chesapeake Bay Implementation grants, Nonpoint Source Control grants, CWA section 106 grants for water pollution control programs, the Clean Water State Revolving Loan Fund, the American Recovery and Reinvestment Act, and various grant programs targeting Chesapeake Bay restoration. The funding will help the jurisdictions meet their pollutant reduction targets.

In addition, significant U.S. Department of Agriculture (USDA) funds and cost share programs are available through the Farm Bill, which recently were increased through the Chesapeake Bay Watershed Initiative. USDA administers the funds and target priority watersheds in the Chesapeake Bay. The Federal Strategy describes how USDA is working with producers to apply new, more effective conservation practices on the highest priority watersheds in the Chesapeake Bay basin. Along with an increase in federal cost share dollars, USDA is bringing an unprecedented focus on targeted efforts in the watersheds that contribute the greatest reductions in nitrogen, phosphorus, and sediment. That will substantially help the jurisdictions to meet their respective LAs in the TMDL, to implement their WIPs, and to achieve their 2-year milestones (FLCCB 2010 pp. 34–45). USDA also is leading efforts to accelerate development of new conservation technologies and is contributing to the system of accountability for tracking and reporting conservation practices. Finally, USDA is working to streamline conservation planning and is sponsoring a number of showcase projects to test and monitor the benefits of a focused outreach on a number of small watersheds (30,000–40,000 acres).

7.1.4 Air Emission Reductions.

The reasonable assurance for the reductions in loadings from air deposition is based on the air emission reductions that will occur by regulation under the Clean Air Act (CAA) through 2020. These reductions are discussed in more detail in Section 6.4.1 and Appendix L.

While the federal Bay strategy and associated activities are not a federal TMDL implementation plan and are not directly part of the TMDL, the additional resources, accountability, oversight, and coordination provided by EPA and other federal agencies add to the reasonable assurance that the TMDL allocations will be implemented. Those combined elements, together with the accountability framework described in greater detail below, collectively provide reasonable assurance that the Chesapeake Bay TMDL nitrogen, phosphorus, and sediment allocations will be achieved.

7.2 ACCOUNTABILITY FRAMEWORK

The Chesapeake Bay Protection and Restoration Executive Order 13508 directs EPA and other federal agencies to build a new accountability framework that guides water quality restoration of the Chesapeake Bay. In addition to the federal components described above as set forth in the Federal Strategy, the Chesapeake Bay TMDL accountability framework has four elements:

- The Bay jurisdictions' development of WIPs;
- The Bay jurisdictions' development of 2-year milestones to demonstrate restoration progress;
- EPA's commitment to track and assess the jurisdictions' progress, by way of developing and implementing a Chesapeake Bay TMDL Tracking and Accountability System (BayTAS); and
- EPA's commitment to take appropriate federal actions if the jurisdictions fail to develop sufficient WIPs, effectively implement their WIPs, or fulfill their 2-year milestones.

The accountability framework, including the jurisdictions' WIPs and 2-year milestones, will help ensure implementation of the Chesapeake Bay TMDL but is not itself an approvable part of the TMDL. In its September 11, 2008, letter to the CBP's PSC (USEPA 2008b), EPA outlined the following expectations for each of the Bay watershed jurisdictions as part of the Bay TMDL accountability framework:

1. Identify the controls needed to achieve the allocations identified in the Bay TMDL through revised tributary strategies.
2. Identify the current state and local capacity to achieve the needed controls (i.e., an assessment of current funding programs for point source permitting/treatment upgrades and nonpoint source controls, programmatic capacity, regulations, legislative authorities).
3. Identify the gaps in current programs that must be filled to achieve the needed controls (i.e., additional incentives, state or local regulatory programs, market-based tools, technical or financial assistance, new legislative authorities).
4. A commitment from each jurisdiction to work to systematically fill the identified gaps. As part of this commitment, the jurisdictions would agree to meet specific, iterative, and short-term (1-2 year) milestones demonstrating increased levels of implementation or nitrogen, phosphorus, and sediment load reduction.
5. A commitment to continue efforts underway to expand monitoring, tracking, and reporting directed to assessing the effectiveness of implementation actions and to use the data to drive adaptive decision making and redirect management actions.
6. Agreement that if the jurisdictions do not meet the commitments, additional measures might be necessary.

Letters sent by EPA to the jurisdictions on November 4, 2009, and December 29, 2009, further developed this accountability framework (USEPA 2009c, 2009d). In his July 1, 2010, and August 13, 2010, letters to the jurisdictions setting out the draft nitrogen, phosphorus, and sediment allocations, Regional Administrator Shawn Garvin further communicated key aspects of the accountability framework (USEPA 2010g, 2010h).

7.2.1 Watershed Implementation Plans

A major element of EPA's demonstration of reasonable assurance for the Chesapeake Bay TMDL is the development of WIPs by each of the seven Bay watershed jurisdictions. The WIPs have informed, and will continue to inform, EPA's development of the Bay TMDL and its setting of WLAs and LAs. In essence, the WIPs are the roadmap for how the jurisdictions, in partnership with federal and local governments, will achieve and maintain the Chesapeake Bay TMDL nitrogen, phosphorus, and sediment allocations.

EPA's November 4, 2009, letter outlined expectations for the WIPs, including that they address the eight elements summarized in Table 7-1 below.

Table 7-1. Eight elements of the jurisdictions' Watershed Implementation Plans

Element	Description
1. Interim and Final Nitrogen, Phosphorus, and Sediment Target Loads	WIPs are expected to subdivide interim and final target loads by pollutant source sector within each of the 92 areas draining to section 303(d) tidal water segments and identify the amount and location of loads from individual or aggregate point sources and nonpoint source sectors.
2. Current Loading Baseline and Program Capacity	WIPs are expected to include evaluation of current legal, regulatory, programmatic, financial, staffing, and technical capacity to deliver the target loads established in the TMDL.
3. Account for Growth	WIPs are expected to describe procedures for estimating additional loads due to growth and to provide EPA with information to inform additional pollutant load reductions that are at least sufficient to offset the growth and development that is anticipated in the watershed between 2011 and 2025.
4. Gap Analysis	WIPs are expected to identify gaps between current capacity (Element 2) and the capacity needed to fully attain the interim and final nitrogen, phosphorus, and sediment target loads for each of the 92 drainage areas for impaired segments of the Bay TMDL (Element 1).
5. Commitment and Strategy to Fill Gaps	WIPs are expected to include a proposed strategy to systematically fill the gaps identified in Element 4.
6. Tracking and Reporting Protocols	WIPs are expected to describe efforts underway or planned to improve transparent and consistent monitoring, tracking, reporting, and assessment of the effectiveness of implementation actions.
7. Contingencies for Slow or Incomplete Implementation	If the proposed strategies outlined in Element 5 are not implemented, WIPs are expected to provide for alternative measures resulting in equivalent reductions and an indication of what such contingencies might entail.
8. Appendix with Detailed Targets and Schedule	WIPs are expected to include detailed interim and final load targets for each tidal Bay segment drainage area, source sector, and local area (after November 2011) in an appendix, with a reduction schedule comprising the 2-year target loads at the scale of each major basin within a jurisdiction. The 2-year target loads allow EPA to assess whether future 2-year milestones are on schedule to meet interim and final water quality goals.

Source: USEPA 2009c

Three Phases of Watershed Implementation Plans

The jurisdictions are expected to develop WIPs over three Phases. Draft Phase I WIPs were developed and submitted to EPA on or around September 1, 2010. EPA used them to support the development of specific allocations in the draft Bay TMDL. Draft Phase I WIPs for each of the seven Chesapeake watershed jurisdictions are at www.epa.gov/chesapeakebaytmdl.

The jurisdictions submitted their final Phase I WIPs to EPA on November 29, 2010 (December 3, 2010 for Maryland; December 17, 2010 for New York; Pennsylvania amended December 23, 2010), for consideration in the final Bay TMDL. After working with local partners, the jurisdictions are expected to submit their Phase II WIPs describing actions and controls to be implemented by 2017 to achieve applicable WQS; deadlines for the submission of draft and final Phase II WIPs to EPA are currently June 1, 2011 and November 1, 2011, respectively, but these dates will be revisited in early 2011. Finally, the jurisdictions are expected to submit to EPA by 2017, their Phase III WIPs describing refined actions and controls to be implemented between 2018 and 2025 to achieve applicable WQS.

With submission of the Phase II WIP, the jurisdictions are expected to subdivide the allocations provided in the Bay TMDL at an increasingly finer scale (Table 7-2). During Phases II and III of the WIP process, EPA will consider whether modifications to the Chesapeake Bay TMDL are necessary and appropriate on the basis of developments or changes in the jurisdictions' WIPs.

Table 7-2. Comparison of elements within the Chesapeake Bay TMDL and Phase I, II, and III WIPs

Element	Bay TMDL	Phase I WIP	Phase II WIP	Phase III WIP
Individual or Aggregate WLAs and LAs to Tidal Jurisdictions	✓			
Gross WLAs and LAs for Non-Tidal Jurisdictions if those Jurisdictions Submit WIPs that meet EPA Expectations	✓			
WLAs for individual significant point sources, or, where appropriate, aggregate point sources		✓	✓	✓
LAs for nonpoint source sectors		✓	✓	✓
Proposed actions and, to the extent possible, specific controls to achieve point source and nonpoint source target loads		✓	✓	✓
Point source and nonpoint source loads by local area			✓	✓
Specific controls and practices to be implemented by 2017		To the extent possible	✓	
Refined point source and nonpoint source loads				✓
Specific controls and practices to be implemented by 2025				✓

Source: USEPA 2009c

Evaluation of Phase I Watershed Implementation Plans

EPA provided the jurisdictions with a *Guide for EPA's Evaluation of Phase I Watershed Implementation Plans* in April 2010 detailing how it would evaluate the adequacy of the jurisdictions' WIPs (USEPA 2010e). EPA also provided continuous feedback and technical support to each jurisdiction on elements of its final Phase I WIP that the jurisdiction submitted informally to EPA.

Upon receiving the jurisdictions' final Phase I WIPs, EPA evaluated the WIPs to determine whether they met EPA's expectations as described in the April 2010 guide and in EPA's November 4, 2009, letter (USEPA 2009c, 2010e). EPA's WIP evaluation process involved a systematic review of the contents of the eight elements of each jurisdiction's final Phase I WIP (see Section 8).

The final Phase I WIPs were to include the Bay jurisdictions' proposed allocations to sources and sectors and a demonstration of reasonable assurance that those proposed allocations will be achieved and maintained. The Chesapeake Bay TMDL incorporates the jurisdictions' proposed allocations where they enable the jurisdictions to meet the overall loadings necessary to meet applicable WQS and where the jurisdictions provided sufficient reasonable assurance.

Where the proposed allocations provided by a jurisdiction in its final Phase I WIP did not meet the overall loadings necessary to meet applicable WQS or where the jurisdiction provided an insufficient demonstration of reasonable assurance, EPA established alternative WLAs and LAs and provided additional reasonable assurance as appropriate. (see Section 7.2.4 and Section 8) (USEPA 2009d).

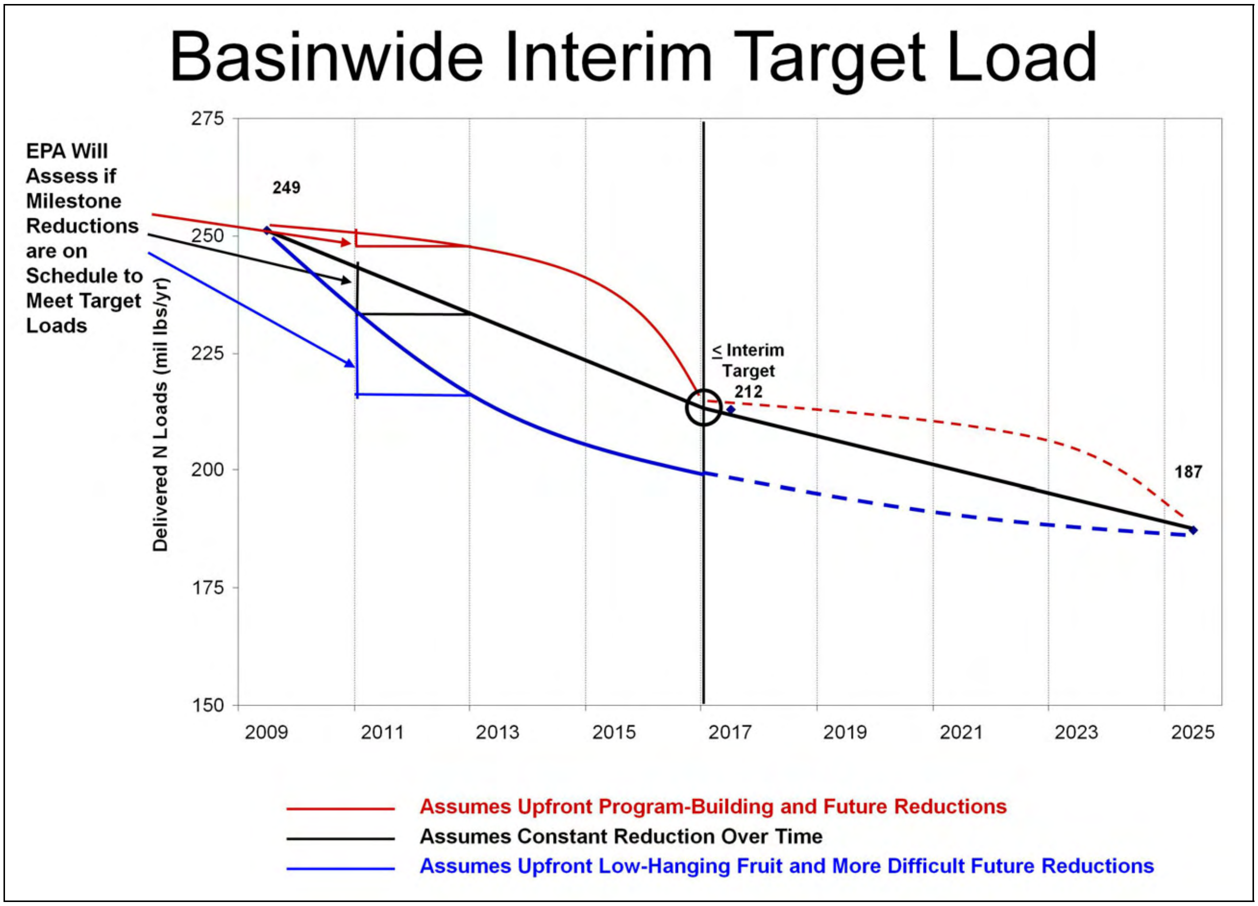
7.2.2 Two-Year Milestones

EPA will measure the jurisdictions' progress toward reaching the TMDL's ultimate nitrogen, phosphorus, and sediment reduction goals against 2-year milestones by which the jurisdictions are expected to identify and commit to implement specific pollutant-reduction controls and actions in each of their successive 2-year milestone periods (USEPA 2009c). The federal government also will be providing 2-year milestones.

Before the start of each milestone period, EPA will evaluate whether the 2-year commitments are sufficient to achieve necessary reductions identified in the jurisdictions' WIPs for the associated 2-year milestone period and whether the jurisdictions have fulfilled their previous milestone commitments. As discussed in Section 7.1, an independent evaluation will be made of progress toward achieving the water quality restoration goal in accordance with section 206 of the Executive Order.

When assessing 2-year milestone commitments, EPA will evaluate whether proposed actions, controls, and practices would result in estimated loads at the jurisdiction scale that meet the jurisdiction's 2-year milestone targets (USEPA 2009c). If EPA determines that a jurisdiction would not achieve the milestone loads identified, EPA may identify which source sectors, basins, and local areas would not achieve reductions on schedule to meet that jurisdiction's interim and final target loads. EPA will then be in a position to decide what appropriate action to take (see Section 7.2.4) (USEPA 2009d).

At the end of a milestone period, EPA expects that model-estimated nitrogen, phosphorus, and sediment loads resulting from reported implementation would be at or below target loads at the jurisdiction scale (Figure 7-1). Note that the 2009 load represented in Figure 7-1 includes nitrogen delivered to the Bay from atmospheric deposition on the watershed. EPA estimates that delivered nitrogen loads will be reduced by 3.4 million pounds by 2025 through implementation of rules and standards under the CAA. The graph in Figure 7-1 does not include the 17.4 million pounds of atmospheric nitrogen deposited directly to tidal waters of the Bay, of which approximately 1.7 million pounds per year will be reduced by 2025 through implementation of rules and standards under the CAA.



Source: USEPA 2009c

Figure 7-1. Relationship between WIPs and 2-year milestones.

In comparison to past Bay restoration efforts, the WIPs and 2-year milestones are expected to provide greater specificity regarding source sector and geographic load reduction, more rigorous assurances that load reductions will be achieved, and more detailed and transparent reporting to the public (USEPA 2008b, 2009c, 2010f).

7.2.3 Chesapeake Bay TMDL Tracking and Accountability System

To determine whether sufficient progress is being made toward meeting the TMDL allocations and interim milestones, EPA will rely on the jurisdictions to monitor, verify, and report their progress. EPA will use the reported tracking data and the Phase 5.3 Chesapeake Bay Watershed Model along with Chesapeake Bay tidal and watershed water quality monitoring data (including contributions from other federal agencies including NOAA, USGS, USACE, and USDA) to assess the jurisdictions' progress.

While the jurisdictions will continue to report annually to EPA on BMP and other pollution control implementations within their respective jurisdiction, existing tracking and reporting mechanisms must be enhanced to fully measure progress toward meeting the TMDL allocations. As EPA stated in its December 29, 2009, letter, where jurisdictions do not provide verification that reported practices and controls have been properly installed and maintained, EPA may not fully or partially credit these actions in its assessment of annual progress and 2-year milestones (USEPA 2009d).

EPA will track the jurisdictions' progress toward achieving the gap-filling strategies proposed in their WIPs through their 2-year milestone commitments using a transparent Chesapeake Bay TMDL Tracking and Accountability System (BayTAS). EPA is designing BayTAS in consultation with the jurisdictions.

BayTAS is a Web-based system that uses data from EPA and the jurisdictions to

- Track the WLAs and LAs established in the TMDL. Tracking entails storing the loadings values and managing changes in status that may occur to the loadings in the future;
- Enable users to determine progress toward the final TMDL allocations, using progress run data from the Chesapeake Bay Watershed Model;
- Track progress relative to the milestones identified by jurisdictions in their WIPs; and
- Record the baseline nitrogen and phosphorus and sediment control practices reported in the Bay jurisdictions' WIPs and track progress against those baselines.

Executive Order 13508 called for developing such a tracking and accountability system. In addition, implementation of the system is a commitment of EPA under the May 12, 2010, Settlement Agreement between Chesapeake Bay Foundation and EPA, under which EPA committed to begin implementation of a tracking system 30 days after establishment of the final TMDL.

Version 1.0 of BayTAS (and future upgrades) will provide EPA, the Bay watershed jurisdictions, and the public with information about LAs and WLAs established in the Chesapeake Bay TMDL, and the jurisdictions' respective progress toward implementing the strategies outlined in their Phase I WIPs.

EPA expects to refine and adjust BayTAS as the jurisdictions submit their Phase II and Phase III WIPs. As it is refined, BayTAS is expected to enable higher levels of monitoring of jurisdiction pollution-control programs than currently exist, including tracking the implementation of WLAs in NPDES permits; LAs for nonpoint sources; offsets of new or increased loadings of nitrogen, phosphorus, and sediment; and pollutant trades.

One critical system that will facilitate the exchange of information between the jurisdictions and the Bay Watershed Model is the National Environmental Information Exchange Network (NEIEN).[1] NEIEN is a partnership among the jurisdictions and EPA that facilitates exchange of environmental information. Partners in the NEIEN share data efficiently and securely over the Internet.

The jurisdictions have received EPA resources to develop NEIEN schema for reporting nitrogen, phosphorus, and sediment controls on sources other than wastewater treatment plants and began to submit annual implementation data to the Chesapeake Bay Program using the NEIEN format after October 2010 (USEPA 2010b). As the WIP development and evaluation process proceeds, EPA expects that the data-sharing relationships and practices among the jurisdictions and EPA will rely heavily on NEIEN to support the BayTAS. In fact, BMPs may be incorporated into BayTAS only if they are reported through NEIEN.

BayTAS data also will come from different EPA and national systems. Basic facility/permit information will come from EPA's Permit Compliance System (PCS) or the Integrated Compliance Information System (ICIS); DMR data and other information for NPDES permits will be submitted by the jurisdictions as part of an existing grant agreement; BMP implementation status information will come from the National Environmental Information Exchange Network (NEIEN); and the status of loadings information will come from the Chesapeake Bay Watershed Model. As other processes are implemented, BayTAS may incorporate information from additional data sources.

Once BayTAS Version 1.0 becomes operational 30 days from establishment of the TMDL, data flow into BayTAS will be electronic (e.g., via NEIEN) or loaded by the BayTAS operation and maintenance team. This will eliminate the jurisdictions' data entry and other operational requirements for maintaining the system. As noted above, Bay jurisdictions are expected to review information in BayTAS to ensure accuracy and for other needs and to advise the BayTAS team on design over the lifecycle of the system.

7.2.4 Federal EPA Actions

In its December 29, 2009, letter to the jurisdictions, EPA listed various federal actions that EPA may take if a jurisdiction fails to demonstrate progress toward meeting required nitrogen, phosphorus, and sediment load reductions (USEPA 2009d). EPA may take action if a jurisdiction fails to do the following:

- Develop and submit Phase I, II, and III WIPs consistent with the expectations and schedule described in EPA's letter of November 4, 2009, and the amended schedule described in EPA's letter of June 11, 2010
- Develop 2-year milestones consistent with the expectations, load reductions, and schedule described in EPA's letter of November 4, 2009, and the amended schedule described in EPA's letter of June 11, 2010

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[1] http://www.epa.gov/Networkg/info/index.html.

- Achieve each successive set of 2-year milestones and their respective target loads by having appropriate controls in place pursuant to the strategies identified in the jurisdiction's WIP and 2-year milestones
- Develop and propose sufficiently protective NPDES permits consistent with the CWA and the Chesapeake Bay TMDL WLAs
- Develop appropriate mechanisms to ensure that nonpoint source LAs are achieved

Following is the list of potential actions EPA may take to ensure that jurisdictions develop and implement appropriate WIPs, attain appropriate 2-year milestones of progress, and provide timely and complete information to an effective accountability system for monitoring pollutant reductions:

- Expand NPDES permit coverage to unregulated sources: For example, using residual designation authority to increase the number of sources, operations or communities regulated under the NPDES permit program
- NPDES program agreements: Expanding EPA oversight review of draft permits (significant and nonsignificant) in the Bay watershed and objecting to inadequate permits that do not meet the requirements of the CWA (including NPDES effluent limits that are not consistent with the Chesapeake Bay TMDL WLAs)
- Require net improvement offsets: For new or increased loadings, requiring net improvement offsets that do more than merely replace the anticipated new or increased loadings
- Establish finer-scale WLAs and LAs in the Chesapeake Bay TMDL: Establishing more specific allocations in the final December 2010 Chesapeake Bay TMDL than those proposed by the jurisdictions in their Phase I WIPs
- Require additional reductions of loadings from point sources: Revising the final December 2010 Chesapeake Bay TMDL to reallocate additional load reductions from nonpoint to point sources of nitrogen, phosphorus, and sediment pollution, such as wastewater treatment plants
- Increase and target federal enforcement and compliance assurance in the watershed: That could include both air and water sources of nitrogen, phosphorus, and sediment
- Condition or redirect EPA grants: Conditioning or redirecting federal grants; incorporating criteria into future Requests for Proposals based on demonstrated progress in meeting WIPs or in an effort to yield higher nitrogen, phosphorus, or sediment load reductions
- Federal promulgation of local nutrient WQS: Initiating promulgation of federal standards where the jurisdiction's WQS do not contain criteria that protect designated uses locally or downstream

SECTION 8. WATERSHED IMPLEMENTATION PLAN EVALUATION AND RESULTANT ALLOCATIONS

This section describes the process by which EPA established final basinwide and basin-jurisdiction allocations to replace the target allocations described in Section 6. This section specifically describes the methodology that EPA used to evaluate the jurisdictions' final Phase I WIPs, the results of EPA's evaluation of the final Phase I WIPs, the process EPA used to develop the final allocations, and the resultant final allocations. Segment-specific and sector-specific allocations are provided in Section 9. Links to each jurisdiction's final Phase I WIP are at www.epa.gov/chesapeakebaytmdl.

The overall process of developing the Chesapeake Bay TMDL had four steps:

1. EPA defined 19 major river basin and jurisdictional target allocations, which EPA communicated to the jurisdictions on July 1, 2010 (for nitrogen and phosphorus) and August 13, 2010 (for sediment). The methodology that EPA used in setting these target allocations is described in detail in Section 6.
2. Each jurisdiction developed a Phase I WIP that described how it would achieve the target allocations for nitrogen, phosphorus, and sediment that were assigned in Step 1.
    a. Using data submitted by the jurisdictions as input decks, or spreadsheets that EPA processed through Chesapeake Bay Program's Scenario Builder and the Phase 5.3 Chesapeake Bay Watershed Model, each jurisdiction developed suballocations to assign to individual, significant wastewater treatment plant (WWTP) point sources; aggregate nonsignificant WWTPs, urban stormwater, and CAFO point sources; and nonpoint source sectors draining to each of the 92 segments of the Chesapeake Bay and its tidal tributaries.
    b. Each jurisdiction also developed implementation strategies to achieve the suballocations, as EPA requested in its letters of September 11, 2008, November 4, 2009, and December 29, 2009, as well as the *Guide for EPA's Evaluation of Phase I Watershed Implementation Plans* issued April 2, 2010. Those expectations are further described in Section 7.
    c. The jurisdiction's proposed suballocations and implementation strategies formed the basis of its final Phase I WIP, which the jurisdiction delivered to EPA on November 29, 2010 (December 3, 2010, for Maryland; December 17, 2010, for New York; Pennsylvania amended December 23, 2010).
3. EPA evaluated each jurisdiction's proposed suballocations and implementation strategies in its final Phase I WIP to determine whether the WIP met the jurisdiction-wide and major river basin allocations, included adequate detail to ensure that NPDES permits will be developed that are consistent with the assumptions and requirements of the WLAs, and met EPA's expectations of providing reasonable assurance that nonpoint source reductions would be achieved and maintained through credible and enforceable or otherwise binding strategies in jurisdictions that are signatories to the Chesapeake Bay Agreement, and

similarly effective strategies in non-signatory jurisdictions. That evaluation and its results are described in detail here in Section 8.

4. On the basis of the results of EPA's evaluation of all seven Bay jurisdictions' final Phase I WIPs and refinements EPA made thereto, and supplemented by more than 14,000 comments from the public during a formal public review of the draft TMDL, EPA established an allocation scenario for the final Chesapeake Bay TMDL. This allocation scenario includes allocations at the jurisdiction-wide and basin-wide levels, as well as allocations for each of the 92 Bay segments. Tables showing the segment-specific and sector-specific allocations of the Chesapeake Bay TMDL are in Section 9.

EPA is establishing in this Chesapeake Bay TMDL final allocations that are based on the jurisdictions' final Phase I WIPs wherever possible and supplemented by public comments. Overall, the final Phase I WIPs were significantly improved from the draft Phase I WIPs, with most jurisdictions meeting their target allocations and meeting EPA's expectations of reasonable assurance that those target allocations would be met. These improved Phase I WIPs are a direct result of the cooperative work and leadership by the jurisdictions, each of which worked closely with EPA over the past few months to strengthen its WIP. As a result of these improvements in the jurisdictions' final Phase I WIPs, EPA significantly reduced the backstop allocations that had been proposed in the draft TMDL for most of the jurisdictions, and, in some cases, completely removed the backstops. As explained in detail in Section 8.4 below, only New York, Pennsylvania, and West Virginia received allocations that differed from those proposed in their final Phase I WIPs.

Six of the seven jurisdictions met their jurisdiction-wide target allocations for nitrogen, phosphorus, and sediment. In the one jurisdiction that did not fully meet its target allocations (New York), the final TMDL established a backstop allocation in the form of additional reductions from wastewater treatment loads beyond those proposed by New York in its final Phase I WIP to meet the jurisdiction-wide and basinwide TMDL allocations.

In addition, five of the seven jurisdictions met EPA's expectations of reasonable assurance in their final Phase I WIPs that they would achieve the load reductions proposed in their final Phase I WIPs. In jurisdictions that did not meet EPA's expectations that the necessary reductions for a particular source sector would be achieved (Pennsylvania urban stormwater, West Virginia agriculture), the final TMDL established backstop adjustments to the sector allocations that shifted a portion of the proposed LA to the WLA in that particular sector. This allocation adjustment recognizes the jurisdictions' already substantial pollutant reduction commitments and signals that future regulatory and/or permitting actions may need to be implemented to achieve the necessary load reductions. This allocation adjustment also provides an additional measure of reasonable assurance that these reductions will be achieved, yet does so in a manner that affords the jurisdictions an appropriate measure of flexibility to decide exactly how the final allocations will be achieved.

EPA will track progress and take any additional federal actions that are necessary to ensure that these reductions are achieved and maintained. To further ensure that the Bay TMDL is supported by reasonable assurance, EPA is committing to enhanced oversight actions in those jurisdictions whose final Phase I WIP did not fully meet EPA's expectations. As a result of this enhanced oversight, EPA will evaluate, on an ongoing basis, the need for appropriate future backstop actions and is committed to taking actions consistent with its December 29, 2009, letter as necessary; such necessity may be demonstrated if, for example, the jurisdictions do not demonstrate sufficient progress in the wastewater, urban stormwater, or agriculture sectors in their Phase II WIPs (USEPA 2010d). EPA also is committed to maintaining its ongoing oversight in all seven of the Chesapeake Bay jurisdictions as authorized under the CWA, and, in conjunction with its accountability and tracking system and the series of two-year milestones, is committed to taking additional appropriate federal action consistent with its December 29, 2009, letter to ensure that the jurisdictions successfully implement their TMDL allocations and final Phase I WIPs.

8.1 WIP EVALUATION METHODOLOGY

A team of EPA source sector experts, together with the EPA staff assigned to each of the seven watershed jurisdictions, conducted a rigorous, systematic quantitative and qualitative evaluation of each jurisdiction's final Phase I WIP and accompanying input deck. EPA evaluated each final Phase I WIP on the basis of how well the jurisdiction's final Phase I WIP was designed to achieve WQS and meet the TMDL's target allocations. EPA evaluated the final Phase I WIP in light of the expectations articulated in EPA's November 4, 2009 letter and April 2, 2010, *Guide for Evaluation of Phase I Watershed Implementation Plans* (USEPA 2009c, 2010e). EPA also considered whether the jurisdiction addressed key areas for improvement that EPA identified as a result of its review of the jurisdiction's draft Phase I WIP.

In conducting the evaluations, EPA addressed two primary questions:

(1) Whether the jurisdiction met its target allocations for nitrogen, phosphorus, and sediment—both jurisdiction-wide and in each of the major river basins—to ensure attainment of each of the Chesapeake Bay WQS in all 92 segments of the Bay and its tidal tributaries; and

(2) Whether the jurisdiction met EPA's expectations for reasonable assurance that it would implement the necessary nitrogen, phosphorus, and sediment reductions, including documentation that nonpoint source controls would be achieved and maintained and permitting programs would result in point source reductions, with emphasis on having practices in place by 2017 to achieve at least 60 percent of the necessary reductions as compared to 2009 loads.

8.1.1 Quantitative Evaluation of the Final Phase I WIPs

To evaluate the first (quantitative) question and determine whether a jurisdiction met each of its nitrogen and phosphorus target allocations, EPA processed the jurisdiction's input deck by running it through Scenario Builder and the Chesapeake Bay Watershed Model, assuming that other jurisdictions met their target allocations. If the jurisdiction's WIP exceeded any of the target allocations, EPA considered the degree to which it did so and whether adjusting nitrogen and phosphorus allocations using approved ratios as discussed in Section 6 would decrease the exceedances.

EPA determined each jurisdiction's allocation for sediment on the basis of whether and to what extent the jurisdiction met the target allocation range for sediment provided on August 13, 2010 and any modifications that EPA approved as still meeting applicable WQS. EPA ran the BMPs assumed within the nitrogen and phosphorus backstop allocations through Scenario Builder and the Chesapeake Bay Program Watershed Model. EPA then compared the sediment outputs from that scenario run to the target allocation range for sediment that it communicated to the jurisdictions. Where the reductions proposed in a jurisdiction's WIP surpassed what was needed to meet the target allocation (i.e., came in under the low end of the target range), EPA assigned that jurisdiction the low end of the target allocation range. Where the reductions proposed in a jurisdiction's WIP were insufficient to meet its target allocation (i.e., came in above the high end of the target range), EPA assigned that jurisdiction the high end of the target allocation range. Where a jurisdiction met its target allocation (i.e., fell within the target range), EPA assigned that jurisdiction the allocation that resulted from the practices proposed in its final Phase I WIP.

8.1.2 Qualitative Evaluation of the Final Phase I WIPs

To evaluate the second (qualitative) question and determine whether a jurisdiction met EPA's expectations for reasonable assurance through enforceable or otherwise binding commitments or similarly effective strategies to implement necessary controls, EPA evaluated each major pollutant source sector (agriculture, urban stormwater, and wastewater) on a number of criteria, including those factors set out in the April 2, 2010, *Guide for Evaluation of Phase I Watershed Implementation Plans* (USEPA 2010e). EPA determined that a jurisdiction met EPA's expectations for reasonable assurance if it provided, among other things: a schedule for potential actions, evidence of or commitment to clear permit conditions, a discussion of compliance, no major discrepancies between the type and extent of practices in the WIP narrative and the input deck, contingencies for high risk or highly improbable actions, and proposals for obtaining additional resources. .

After evaluating the two key questions, EPA conducted a jurisdiction-by-jurisdiction analysis to determine whether and, if so, to what degree, to backstop or adjust the allocations proposed by the jurisdiction in its final Phase I WIP. In developing the adjusted or backstop allocations, EPA fully considered the following:

- Whether a jurisdiction met, or to what degree it missed, its target allocations for nitrogen, phosphorus, and sediment.
- Whether and to what extent the jurisdiction met EPA's expectations for reasonable assurance.
- Whether the proposed WLAs in the jurisdiction's final Phase I WIP were consistent with EPA's definition of point source loads and could be achieved through implementation of a permitting program.
- Whether, if necessary, EPA could ensure achievement of the point source reductions through appropriate federal actions under the CWA and other federal authorities, including enhanced program oversight, permit objections, compliance assurance, enforcement actions, and other federal actions as described in EPA's December 29, 2009 letter.

Where EPA determined that a jurisdiction did not meet its target allocations, EPA applied a *backstop allocation*—a change to the allocation to close the numeric gap, such as assigning the jurisdiction a more stringent WWTP allocation reflecting an assumption that future WWTP effluent limits for nitrogen and/or phosphorus would be made more stringent to meet the TMDL's overall allocation for that jurisdiction.

Where EPA determined that a jurisdiction met its allocation target but did not meet EPA's expectations for reasonable assurance, EPA applied a *backstop adjustment* or *allocation adjustment*—a change to a sector-specific allocation to provide additional assurance that the allocation would be achieved, such as shifting some of a specific sector's loadings from the LA category to the WLA category. This signaled that, depending on the success of the jurisdiction's WIP implementation and the nature of the choices the jurisdiction makes in adapting its implementation strategies, additional future regulatory controls may have to be applied to sources in that sector to attain the sector's overall allocation.

If EPA had determined that a jurisdiction neither met its target allocation nor met EPA's expectations for reasonable assurance, EPA would have applied both backstops.

After applying all backstops that EPA determined were necessary, EPA ran the combination of specific practices and allocations through the Chesapeake Bay Program's Scenario Builder and the Phase 5.3 Chesapeake Bay Watershed Model to ensure that the allocations provided in the final Chesapeake Bay TMDL would result in the attainment of WQS.

8.2 WIP EVALUATION RESULTS

Overall, the jurisdictions submitted significantly-improved final Phase I WIPs; most jurisdictions met each of their target allocations jurisdiction-wide and met EPA's expectations for reasonable assurance that they would meet those target allocations. Six of the seven jurisdictions met or came very close to their jurisdiction-wide target allocations for nitrogen, phosphorus, and sediment—only New York did not meet each of its jurisdiction-wide target allocations. In addition, five of the seven jurisdictions met EPA's expectations for reasonable assurance in their final Phase I WIPs that they would achieve the load reductions proposed in their WIPs. Only Pennsylvania urban stormwater and West Virginia agriculture did not meet EPA's expectations for providing reasonable assurance that the sector-specific target allocations would be achieved. These are significant improvements from the draft Phase I WIPs, where six of the seven draft WIPs did not meet their jurisdiction-wide target allocations for all three pollutants and none of the seven draft WIPs fully met EPA's expectations for reasonable assurance that they would meet their respective target allocations.

8.2.1 Target Allocation Attainment

Each jurisdiction's final Phase I WIP, with the exception of New York, met its jurisdiction-wide nitrogen, phosphorus, and sediment target allocations. EPA established backstop allocations for WWTP allocations in New York to close the numeric gap between New York's final Phase I WIP and its target allocations.

The results of EPA's analysis of whether each jurisdiction met its jurisdiction-wide and basin-wide target allocations for each pollutant after allowing for any EPA-approved exchanges are shown in Tables 8-1 and 8-2, below. Table 8-1 shows whether and to what degree each jurisdiction met its jurisdiction-wide target allocations for nitrogen, phosphorus, and sediment.

Table 8-1. Comparison between nitrogen, phosphorus, and sediment jurisdiction-wide allocations and final Phase I Watershed Implementation Plans, in millions of pounds per year

	Total nitrogen (TN)			Total phosphorus (TP)			Total suspended solids (TSS)*			
	Target allocation	**Final Phase I WIP**	**Final Phase I WIP % off target**	**Target allocation**	**Final Phase I WIP**	**Final Phase I WIP % off target**	**Target allocation - low**	**Target allocation - high**	**Final Phase I WIP**	**Final Phase I WIP % off target[a]**
DC	2.32	2.32	0%	0.12	0.12	0%	10.14	11.16	11.16	0%
DE	2.95	2.86	-3%	0.26	0.23	-12%	57.82	63.61	42.89	-33%
MD[b]	39.09 (39.09)	39.09	0%	2.72 (2.72)	2.72	0%	1,116.16	1,218.11 (1,227.78)	1,218.11	0%
NY[c]	8.77 (8.23)	9.25	5%	0.57 (0.52)	0.57	2%	292.96	322.26	277.66	-14%
PA	73.93 (76.77)	75.56	2%	2.93 (2.74)	2.98	2%	1,902.51	2,092.76	1,979.65	-5%
VA[d]	53.42 (53.40)	54.43	2%	5.36 (5.41)	5.48	2%	2,446.14	2,690.75	2,617.22	-3%
WV[e]	5.45 (4.68)	5.45	0%	0.59 (0.75)	0.59	-1%	309.37 (240.68)	340.30 (264.75)	302.12	-11%
Total	185.93 (187.45)	188.96	2%	12.54 (12.52)	12.70	1%	6,135.10 (6066.42)	6,738.94 (6673.06)	6448.80	-4%

* As discussed in Section 6, the metric for sediment is Total Suspended Solids.

a. Calculated on the basis of the high end of the target sediment allocation range.

b. Maryland target allocations were modified to allow for exchanges of TN, TP, and TSS both within and across basins. Runs of the Chesapeake Bay Water Quality and Sediment Transport Model confirmed that these exchanges still attained applicable WQS. The original target allocations are in parentheses. The final allocations proposed in Maryland's final Phase I WIP are derived using the method outlined in Appendix A of Maryland's final Phase I WIP rather than an input deck that was run through the Chesapeake Bay Program Watershed Model.

c. New York's nitrogen and phosphorus target allocations were modified to provide New York with additional loads of TN (1,000,000 lbs) and TP (100,000 lbs) based on concerns with the equity of New York's July 1 target allocations (see Section 6.4.5). Target nitrogen and phosphorus allocations were further modified to allow for trading of TN and TP within state basins. The original target allocations are in parentheses.

d. Virginia target allocations were modified to allow for trading TN and TP within state basins. The original target allocations are in parentheses.

e. West Virginia Potomac basin target allocations for nitrogen and phosphorus were revised to allow for trading between TN and TP, and the sediment target allocation range was adjusted based on the 200,000 lb increase in the July 1st phosphorus allocation (see Section 6.4.5). The original target allocations are in parentheses.

f. Where input decks in West Virginia, Virginia, and Pennsylvania did not meet all target allocations, EPA and the jurisdiction came to an agreement on how to close the gap. See Section 8.4 for details regarding these agreements.

g. In New York, EPA closed the gap via an adjustment to nitrogen and phosphorus allocations using approved ratios as discussed in Section 6 and via a backstop allocation for the wastewater sector as described in Section 8.4.4.

Note: Any discrepancy is due to the rounding of figures.

Table 8-2. Comparison between the nitrogen, phosphorus, and sediment basin-jurisdiction allocations and final Phase I Watershed Implementation Plans, in million pounds per year

		Total nitrogen (TN)			Total phosphorus (TP)			Total suspended solids (TSS)*			
Major river basin	Juris-diction	Target allocation	Final Phase I WIP	Final Phase I WIP % off target	Target ALLOCATION	Final Phase I WIP	Final Phase I WIP % off target	Target allocation - low end	Target allocation - high end	Final Phase I WIP	Final Phase I WIP % off target[a]
Potomac	DC	2.32	2.32	0%	0.12	0.12	0%	10.14	11.16	11.16	0%
Eastern Shore	DE	2.95	2.86	-3%	0.26	0.23	-12%	57.82	63.61	42.89	-33%
Eastern Shore	MD[b]	9.71	9.71	0%	1.02 (1.09)	1.02	0%	165.88	168.85 (182.47)	168.85	0%
Patuxent	MD[b]	2.86 (2.85)	2.86	0%	0.24 (0.21)	0.24	0%	81.93	106.30 (90.12)	106.30	0%
Potomac	MD[b]	16.38 (15.70)	16.38	0%	0.90	0.90	0%	653.61	680.29 (718.97)	680.29	0%
Susquehanna	MD[b]	1.09 (1.08)	1.09	0%	0.05	0.05	0%	59.85	62.84 (65.83)	62.84	0%
Western Shore	MD[b]	9.04 (9.74)	9.04	0%	0.51 (0.46)	0.51	0%	154.90	199.82 (170.38)	199.82	0%
Susquehanna	NY[c]	8.77 (8.23)	9.25	5%	0.57 (0.52)	0.57	2%[g]	292.96	322.26	277.66	-14%
Eastern Shore	PA	0.28	0.28	-1%[g]	0.01	0.01	-13%[g]	21.14	23.25	19.11	-18%
Potomac	PA	4.72	4.17	-12%	0.42	0.35	-17%	221.11	243.22	219.12	-10%
Susquehanna	PA	68.90 (71.74)	71.10	3%	2.49 (2.31)	2.62	5%	1659.89	1,825.88	1,741.17	-5%
Western Shore	PA	0.02	0.002	-92%	0.001	0.0002	-76%	0.37	0.41	0.26	-37%
Eastern Shore	VA[d]	1.31 (1.21)	1.35	3%	0.14 (0.16)	0.14	0%	10.91	12.00	11.31	-6%
James	VA[d]	23.09 (23.48)	23.09	0%	2.37 (2.34)	2.43	3%	836.57	920.23	948.49	3%
Potomac	VA[d]	17.77 (17.46)	18.24	3%	1.41 (1.47)	1.41	0%	810.07	891.08	829.53	-7%
Rappahannock	VA	5.84	6.15	5%	0.90	0.94	5%	681.49	749.64	700.04	-7%
York	VA	5.41	5.61	4%	0.54	0.56	4%	107.09	117.80	127.86	9%
James	WV	0.02 (0.02)	0.03	50%	0.01 (0.01)	0.01	18%[g]	15.13	16.65	29.35	76%

		Total nitrogen (TN)			**Total phosphorus (TP)**			**Total suspended solids (TSS)***			
Major river basin	**Juris-diction**	**Target allocation**	**Final Phase I WIP**	**Final Phase I WIP % off target**	**Target ALLOCATION**	**Final Phase I WIP**	**Final Phase I WIP % off target**	**Target allocation - low end**	**Target allocation - high end**	**Final Phase I WIP**	**Final Phase I WIP % off target[a]**
Potomac	WV[e]	5.43 (4.67)	5.43	0%	0.58 (0.74)	0.58	-1%	294.24 (225.55)	323.66 (248.11)	272.77	-16%
TOTAL	ALL	185.93 (187.45)	188.96	2%	12.55 (12.52)	12.70	1%	6,135.10 (6,066.42)	6,738.94 (6,673.06)	6,448.80	-4%

* As discussed in Section 6, the metric for sediment is Total Suspended Solids.

a. Calculated on the basis of the high end of the target sediment allocation range.

b. Maryland target allocations were modified to allow for exchanges of TN, TP, and TSS both within and across basins. Runs of the Chesapeake Bay Water Quality and Sediment Transport Model confirmed that these exchanges still attained applicable WQS. The original target allocations are in parentheses. The final allocations proposed in Maryland's final Phase I WIP are derived using the method outlined in Appendix A of Maryland's final Phase I WIP rather than an input deck that was run through the Chesapeake Bay Program Watershed Model.

c. New York's nitrogen and phosphorus target allocations were modified to provide New York with additional loads of TN (1,000,000 lbs) and TP (100,000 lbs) based on concerns with the equity of New York's July 1 target allocations (see Section 6.4.5). Target nitrogen and phosphorus allocations were further modified to allow for trading of TN and TP within state basins. The original target allocations are in parentheses.

d. Virginia target allocations were modified to allow for trading TN and TP within state basins. The original target allocations are in parentheses.

e. West Virginia Potomac basin target allocations for nitrogen and phosphorus were revised to allow for trading between TN and TP, and the sediment target allocation range was adjusted based on the 200,000 lb increase in the July 1st phosphorus allocation (see Section 6.4.5). The original target allocations are in parentheses.

f. Where input decks in West Virginia, Virginia, and Pennsylvania did not meet all target allocations, EPA and the jurisdiction came to an agreement on how to close the gap. See Section 8.4 for details regarding these agreements.

g. In New York, EPA closed the gap via an adjustment to nitrogen and phosphorus allocations using approved ratios as discussed in Section 6 and via a backstop allocation for the wastewater sector as described in Section 8.4.4.

Note: Any discrepancy is due to the rounding of figures.

Table 8-2 shows whether and to what degree each jurisdiction met its basinwide target allocations for nitrogen, phosphorus, and sediment.

These tables show the initial target allocations communicated to the jurisdictions on July 1, 2010 (for nitrogen and phosphorus) and August 13, 2010 (for sediment), which are in parentheses. These tables also show the jurisdictions' adjusted target allocations, which incorporate corrections to allocations for some of the headwater jurisdictions, backstop allocations and adjustments made by EPA, and intra-basin and inter-basin nutrient exchanges requested by the some of the jurisdictions. The combination of these corrections, backstop allocations and adjustments, and nutrient exchanges resulted in all jurisdictions meeting their nitrogen, phosphorus, and sediment target allocations. Further specific information about the corrections, backstop allocations and adjustments, and nutrient exchanges is provided in the footnotes to the tables.

8.2.2 Reasonable Assurance

EPA determined that each of the jurisdictions' final Phase I WIPs provided reasonable assurance that met EPA's expectations in each major source sector, with the exception of Pennsylvania urban stormwater and West Virginia agriculture. The jurisdictions' final Phase I WIPs showed many noteworthy improvements regarding reasonable assurance, including the following:

- Commitments to upgrade WWTPs
- Expanded septic system improvements
- Increased accountability for urban stormwater programs
- New enforcement and compliance initiatives for agriculture
- Agreements to extend regulatory coverage for traditional nonpoint sources if needed

Overall, these are significant improvements from the jurisdictions' draft Phase I WIPs, none of which provided reasonable assurance that fully met EPA's expectations.

EPA determined that various levels of EPA oversight and additional potential actions are appropriate for the various jurisdictions as a result of EPA's evaluation of both key aspects of the jurisdictions' final Phase I WIPs as discussed above. All seven jurisdictions will receive an ongoing level of oversight for all sectors that may justify federal actions to address shortfalls. In addition to that ongoing oversight, New York, Pennsylvania, Virginia, and West Virginia will receive an enhanced level of oversight and potential federal actions for certain sectors. Lastly, in addition to those levels of oversight and potential federal actions, New York, Pennsylvania, and West Virginia received in the final TMDL backstop allocations (New York) or backstop adjustments (Pennsylvania urban stormwater and West Virginia agriculture). Further details regarding EPA's assessment of the reasonable assurance provided by each jurisdiction's final Phase I WIP are provided in Section 8.4 below.

8.3 ALLOCATION METHODOLOGY

EPA determined each jurisdiction's wasteload and load allocations on the basis of whether the jurisdiction met each of its respective target allocations and whether it met EPA's expectations for reasonable assurance that those allocations would be achieved. EPA relied on the portion(s) of the jurisdiction's final Phase I WIP that met expectations and supplemented any gaps in the allocations and reasonable assurance with allocation adjustments and determinations of reasonable assurance to achieve the necessary reductions.

8.3.1 Backstop Allocation Methodology

EPA established backstop allocations where EPA determined that the final Phase I WIP did not achieve the jurisdiction's basin target allocation for one or more pollutants or where the final Phase I WIP did not meet EPA's expectations for reasonable assurance that the LA reductions would be achieved by the nonpoint sources.

Another enhanced action that EPA took in the nontidal jurisdictions of Pennsylvania and West Virginia was to establish finer-scale individual allocations or aggregate allocations. EPA stated in its November 4 and December 29, 2009, letters to the jurisdictions that it might do so by establishing individual source and aggregate source sector, rather than gross basin-jurisdiction, WLAs and LAs for the nontidal jurisdictions if their Phase I WIPs did not meet EPA's expectations for reasonable assurance (USEPA 2009c, 2009d). With the exception of WWTPs in New York and the James River in Virginia, EPA is establishing individual WLAs for the significant municipal and industrial wastewater discharging facilities and sector-specific aggregate WLAs for urban stormwater, CAFOs, and nonsignificant municipal and industrial wastewater discharging facilities. EPA is establishing the finer-scale allocations to better inform permit writers as they issue and renew NPDES permits consistent with the assumptions and requirements of the Chesapeake Bay TMDL WLAs. Those allocations for the nontidal jurisdictions are at the same scale as those made to the tidal jurisdictions of Delaware, Maryland, Virginia, and the District of Columbia.

As explained more fully in Appendix X, EPA is issuing with this final TMDL an aggregate WLA for the significant facilities in the Virginia portion of the James River basin. EPA also is establishing an aggregate WLA for WWTPs in New York to allow time for the New York State Department of Environmental Conservation to review engineering reports from WWTPs and determine the load reductions expected from each facility. New York has committed to provide information to support individual WLAs for these WWTPs in its Phase II WIPs. EPA understands that New York plans to renew and/or modify WWTP permits after completing its Phase II WIPs, consistent with the applicable TMDL allocations at that time.

8.3.2 Backstop Adjustment (Allocation Shift) Methodology

After evaluating the final Phase I WIPs for reasonable assurance, EPA found that the final Phase I WIPs did not fully meet EPA's expectations for reasonable assurance for the urban stormwater sector in Pennsylvania and the agriculture sector in West Virginia. As a result, EPA applied a backstop adjustment to those sectors by shifting a portion of the allocations for those sectors from the LA to the WLA for the respective jurisdiction.

For Pennsylvania urban stormwater, as detailed in Section 8.4.5 below, EPA shifted to the WLA 50 percent of the loading from currently unregulated urban stormwater sources that the WIP included in the LA. Therefore, the Pennsylvania urban stormwater WLAs include both unregulated and NPDES regulated sources. For urban stormwater sources already covered by

NPDES permits, EPA has broad authority to ensure that the necessary controls are included to implement the Bay TMDL.

For West Virginia agriculture, as detailed in Section 8.4.7 below, EPA shifted to the WLA 75 percent of currently unregulated AFOs that the WIP included in the LA. The same rationale described above also applies to EPA's adjustment of allocations in the AFO/CAFO sector. For those CAFO facilities already under NPDES permit coverage, EPA has broad authority to ensure that the necessary controls are included to implement the Bay TMDL.

For both AFOs and urban stormwater point sources, the allocation shift signals that substantially more of these discharges and operations could potentially be subject to NPDES permits as necessary to protect water quality. These conditions could include additional nitrogen, phosphorus, and sediment controls. These sources would only be subject to NPDES permits as issued by the delegated permitting authority or EPA upon designation. It is important to note, however, that EPA may also pursue designation activities based upon considerations other than TMDL and WIP implementation.

EPA has adjusted these allocations on the basis of two assumptions: (1) a percentage of loading from currently unregulated sources may have to be controlled under the NPDES permit program through appropriate designation, rulemaking, and permit issuances; and (2) the aggregate projected load reductions under the adjusted WLA (based on assumed NPDES effluent controls consistent with the WLA) will result in reductions sufficient to meet the jurisdiction's allocations.

In establishing allocations that shift from the LA to the WLA some urban stormwater and AFO/CAFO sources not currently regulated by the NPDES permit program but that could become NPDES-regulated facilities either through residual designation authority or other mechanisms, EPA has acted consistent with EPA guidance, *Establishing Total Maximum Daily Loads (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs*, dated November 22, 2002 (USEPA 2002a) and as revised November 12, 2010. EPA has authority to designate certain nonregulated urban stormwater sources for regulation under the NPDES program. See section 402(p)(2)(E) and (6) and 40 CFR 122.26(a)(9)(i)(C)(D). EPA also has authority to designate AFOs as CAFOs as set forth in 40 CFR 122.23(c).

The inclusion of currently unregulated sources in the WLA does not, by itself, constitute a designation or regulatory action to include such sources in the NPDES program; the source would have to be designated for the source to come under the NPDES program, and the shift in allocations in this TMDL is not an exercise of that designation authority. Instead, it reflects the possibility that such designation may be necessary in the future if the jurisdictions do not otherwise achieve their allocation targets. The TMDL is a watershed pollution budget, not a regulatory determination to change a source's legal status. As with any NPDES permitting or rulemaking decision, applying new controls or designations must be consistent with applicable procedural and substantive requirements, including a recognition of state permitting primacy in jurisdictions authorized to administer the NPDES program.

Furthermore, EPA's residual designation would not be intended to change the NPDES-permitting authorized agency. That is, if EPA were to residually designate an AFO as a CAFO in an NPDES-delegated state, that CAFO would apply for a state CAFO permit, not a federal CAFO permit, as would any other state facility so long as EPA does not take over the permit or the permitting program.

Some jurisdictions, as described in the jurisdiction-specific subsections below, included in their final Phase I WIPs the shift of a portion or all of the loading of current AFO or urban stormwater facilities not currently regulated under the NPDES permit program from the LA to an aggregate WLA. Jurisdictions did this primarily to provide additional reasonable assurance that the implementation of practices and reductions in pollutants would occur. By doing this, the jurisdiction indicated that it is prepared to implement the necessary pollutant reductions in those sectors. Like EPA's backstop adjustment, the WIP's inclusion of currently unregulated sources in the WLA by itself does not constitute a designation or regulatory action to include such sources in the NPDES program. The jurisdiction's WIP informs the TMDL, which is a watershed plan, not a regulatory determination to change a source's legal status. As with any NPDES permitting or rulemaking decision, applying new controls or designations must be consistent with applicable procedural and substantive requirements.

EPA believes these load-shifting allocation adjustments, whether done by the jurisdictions or by EPA, are a reasonable way of supplementing reasonable assurance that the allocation targets will be met. These allocations signal that EPA and the jurisdictions will be tracking load reductions in these sectors with a heightened degree of scrutiny and are prepared to take action to increase the extent to which these loads are regulated as necessary. EPA is committed to ensure and track implementation of actions necessary to reduce these sector loads by 2025 consistent with Executive Order 13508 (FLCCB 2010). Additional assurance that these adjusted sector allocations will be met is provided by the public commitments EPA has made in the Federal Strategy and elsewhere, including the May 2010 settlement agreement resolving the Chesapeake Bay Foundation lawsuit.

8.3.3 Assumptions Supporting the Allocations

EPA regulations require that NPDES permits be consistent with assumptions and requirements of WLAs. See 40 CFR 122.44(d)(1)(vii)(B). This section summarizes the assumptions that are incorporated into the Chesapeake Bay TMDL allocations.

EPA established WLAs and LAs based in part upon the overall assumption that certain nitrogen, phosphorus, and sediment controls are implemented on a certain percentage of available land. Over time, implementing nitrogen, phosphorus, and sediment controls could involve a combination of (a) different practices; (b) implementation in different locations; or (c) implementation at different implementation rates so long as an equivalent or greater reduction occurs within the portion of the watershed draining to a particular tidal segment of the Chesapeake Bay.

Appendix V includes the percent of available land or sources on which nitrogen, phosphorus, and sediment controls are implemented (percent implementation) that is assumed within the WLAs and LAs for sources other than WWTPs. The Appendix does not include a table for Maryland because final allocations proposed in Maryland's final Phase I WIP are derived using the method outlined in Appendix A of Maryland's WIP rather than an input deck that was run through the Phase 5.3 Chesapeake Bay Watershed Model.

EPA will continue to track and assess the jurisdictions' annual progress toward meeting the commitments outlined in their respective final Phase I WIPs and 2-year milestone commitments. As outlined in its December 29, 2009, letter to the jurisdictions, EPA may take additional federal actions beyond those listed above as appropriate and consistent with applicable laws and regulations, including the following: conditioning federal grants; promulgating nutrient WQS; objecting to NPDES permits; and discounting pollutant reduction practices that do not meet EPA verification expectations to ensure that the jurisdictions achieve the nitrogen, phosphorus, and sediment reductions identified in their final Phase I WIPs and needed to meet the TMDL allocations (USEPA 2009d) (see Section 7.2.4). In correspondence directed individually to each jurisdiction providing detailed feedback on EPA's evaluation of the final Phase I WIPs (see Appendix B), EPA communicated its intent to consider taking additional federal actions as necessary if EPA determines that the respective jurisdiction's Phase II WIP and 2-year milestones do not meet EPA's expectations for providing reasonable assurance that implementation will occur as described in their plans.

Nonpoint Sources

The jurisdictions' final Phase I WIPs provided the starting point for EPA's consideration and development of final allocations. EPA assumed for purposes of its evaluation that jurisdictions would implement the practices that will result in the same or greater nitrogen, phosphorus, and sediment controls as provided in their final Phase I WIP scenario input decks and as evaluated by the Chesapeake Bay Scenario Builder and Watershed Model. In the few jurisdictions where final Phase I WIP input decks did not meet the target allocations for each major basin, EPA either applied a backstop allocation to close the numeric gap (New York) or reached agreement with the respective jurisdictions on further nonpoint source reductions to achieve allocations both statewide and in each basin (Pennsylvania, Virginia, West Virginia). Details regarding these backstop allocations and nonpoint source adjustments are provided in Section 8.4.

EPA will assess jurisdictions' progress toward meeting LAs through ongoing program oversight, the Phase II and Phase III WIPs, and the 2-year milestones. EPA also will consider whether to take appropriate federal actions, as detailed in its letter of December 29, 2009 to the jurisdictions, to ensure that adequate progress is made toward achieving and maintaining the nonpoint source load reductions.

Point Sources—Agriculture

In all jurisdictions, the CAFO WLA includes AFO production areas that are currently or potentially regulated under jurisdictions' CAFO programs. The CAFO WLA assumes that these production areas have 100 percent implementation of waste management, barnyard runoff control, and mortality composting practices and that such practices are required as conditions of CAFO permits. These practices are assumed to result in an approximately 80 percent decrease in nutrient loads from production areas compared to a pre-BMP condition. The draft TMDL assumed that all animals within the WLA receive feed management except cattle on small dairies not currently subject to CAFO permits. By comparison, the CAFO WLA in the final TMDL assumes feed management at rates and nutrient reduction levels proposed by the jurisdictions in their final Phase I WIPs. Many of the final Phase I WIPs reflected higher rates of feed management than did the draft WIPs.

Jurisdictions can meet the WLA assumptions by (a) applying a different set of practices that are shown to result in equivalent nitrogen, phosphorus, and sediment reductions, or (b) applying a more aggressive performance standard on a smaller percentage of AFO production areas that will result in the nitrogen, phosphorus, and sediment reductions called for within the WLA.

Point Sources—Urban Stormwater

The Chesapeake Bay TMDL allocations for urban stormwater are based on load reductions proposed by jurisdictions in their final WIPs compared to a 2009 baseline. In the draft TMDL, EPA assumed additional urban stormwater retrofits in the five jurisdictions that received a proposed urban stormwater backstop allocation. In contrast, in the final TMDL, EPA is establishing a backstop adjustment for urban stormwater only in one jurisdiction—Pennsylvania. Further, EPA is not adjusting the urban stormwater load reductions that Pennsylvania proposed in its final Phase I WIP. Specifically, EPA is not assuming additional retrofits. Rather, EPA is establishing a backstop adjustment in Pennsylvania that shifts 50 percent of the unregulated urban stormwater load to the WLA.

Table 8-3 summarizes the per-acre, edge-of-stream nitrogen, phosphorus, and sediment percent reductions compared to 2009 based on urban stormwater WLAs by jurisdiction. EPA can also provide information by county to those jurisdictions that wish to use it in developing permits. NPDES permits issued to these jurisdictions and other regulatory mechanisms should achieve these reductions, over multiple permit cycles as necessary but by no later than 2025—the date by which the Chesapeake Executive Council has committed to have all practices in place necessary to meet water quality goals in the Bay. Jurisdictions have the option of interpreting these allocations as specific measurable requirements, e.g., performance standards or management practices, or of putting the allocations in permits and requiring MS4 operators to develop an implementation plan to achieve the allocation.

Table 8-3. Percent reductions in edge-of-stream loads to achieve urban stormwater WLAs

Jurisdiction	Per-acre edge-of-stream % changes in urban stormwater load from a 2009 baseline*		
	Nitrogen	Phosphorus	Sediment
District of Columbia	6.6%	29.6%	29.6%
Delaware	14.3%	18.3%	23.7%
Maryland**	16.9%	35.7%	37.5%
New York	11.4%	0.0%	0.0%
Pennsylvania	28.9%	17.7%	7.0%
Virginia	16.4%	20.8%	32.5%
West Virginia	0%	0%	0%

* Edge-of-stream reductions assumed within the urban stormwater WLAs result from differences in BMP implementation rates between 2009 and the final WIP submission.

** Maryland’s assumed reductions are calculated as the difference between 2009 edge-of-stream loads and Maryland’s final edge-of-stream target loads for urban stormwater WLAs. Maryland derived its final loads using the method outlined in Appendix A of Maryland's WIP.

Appendix V includes the percent implementation for nitrogen, phosphorus, and sediment controls that are assumed on urban land uses in 2009 and as proposed in the final Phase I WIP input decks. With the exception of Maryland, edge-of-stream reductions assumed within urban stormwater WLAs are the direct result of the differences in implementation rates between 2009 and the final Phase I WIP submission. However, jurisdictions can meet the WLAs by (a) applying a different set of practices or performance standards that would result in equivalent nitrogen, phosphorus, and sediment reductions, or (b) applying a more aggressive suite of practices or performance standards to a smaller percentage of urban lands or urban stormwater discharges, so long as the total nitrogen, phosphorus, and sediment reduction from urban discharges within the WLA are equal to or greater than the reductions assumed within Table 8-3.

Point Sources—Wastewater

Federal regulations require that water quality based effluent limits in permits ensure (a) attainment of applicable WQS; and (b) consistency with assumptions and requirements of the TMDL WLAs [40 CFR 122.44(d)(1)(vii)(B)]. Therefore, permits are written with effluent limits necessary to meet applicable WQS and/or consistent with the assumptions and requirements of applicable WLAs. Where authorized and appropriate, such effluent limits may contain a compliance schedule that requires compliance as soon as possible. In the instances where implementation of the final TMDL WLAs for wastewater facilities is staged (e.g., in the James River), permits are written with effluent limits necessary to meet applicable WQS and/or consistent with the assumptions and requirements of applicable WLAs. In those instances as well, where authorized and appropriate, such effluent limits may contain a compliance schedule that requires compliance as soon as possible. The TMDL assumes that all controls will be in place to meet WLAs by 2025. Therefore, any facilities with compliance schedules longer than one year must include interim dates and milestones in their permit fact sheets with the time between milestones not more that one year [40 CFR 122.47(a)(3)].

The WLAs for WWTPs are based on the loads summarized in Table 9-4 for the significant WWTPs in the Chesapeake Bay watershed. Additional information on edge-of-stream discharges from these facilities is provided in Appendices Q and R.

Appendices Q and R also include the WLAs and information on edge-of-stream discharges for facilities that have been aggregated in the final TMDL. For facilities with discharges that are part of an aggregate WLA or are covered by a general permit, the TMDL assumes that the permit contains language to require the establishment of individual schedules for each facility to come into compliance with their individual or aggregate WLAs. Also, for facilities included within an aggregate WLA, the TMDL assumes that permitting authorities will provide justification in the permit fact sheet that the limits assigned to the individual facility are included as part of the aggregate TMDL WLAs. Due to lack of specific information, some nonsignificant discharges covered under an aggregate WLA may be based on default assumptions regarding flow and concentrations. These facilities should provide, at a minimum, nitrogen, phosphorus, and/or TSS monitoring data with their next NPDES permit renewal application. Renewed NPDES permits for these discharges will require monitoring to verify existing loads and to either (1) verify that these loads do not contribute to any exceedance of the WLAs—individual or aggregate (determination of no reasonable potential to contribute to an exceedance of local WQS and/or Bay TMDL WLA); or (2) incorporate an effluent limit consistent with the local WQS and/or Bay

TMDL WLA (where monitoring data shows reasonable potential to contribute to an exceedance of local WQS and/or Bay TMDL WLA).

Table 8-4. EPA backstop allocations, adjustments, and actions based on assessment of final Phase I WIPs

		No Backstop Allocation		Backstop Allocations, Adjustments, and/or Actions	
		Ongoing Oversight and Actions	**Enhanced Oversight and Actions**	**Backstop Adjustments and Actions**	**Backstop Allocations and Actions**
DC	Stormwater	🟦			
	Wastewater	🟦			
DE	Agriculture	🟦			
	Stormwater	🟦			
	Wastewater	🟦			
MD	Agriculture	🟦			
	Stormwater	🟦			
	Wastewater	🟦			
NY	Agriculture	🟦			
	Stormwater	🟦			
	Wastewater				Reduce wastewater WLA to meet statewide allocation
PA	Agriculture		Possible future backstop adjustments		
	Stormwater			Shift 50% stormwater from LA to WLA	
	Wastewater		Individual allocations; Possible future backstop allocations		
VA	Agriculture	🟦			
	Stormwater		Possible future backstop adjustments		
	Wastewater	🟦			
WV	Agriculture			Shift 75% AFOs from LA to WLA	
	Stormwater		Possible future backstop adjustments		
	Wastewater		Individual allocations; Possible future backstop allocations		

8.4 ALLOCATIONS BY JURISDICTION

On the basis of EPA's evaluations of the three major pollution source sectors combined with EPA's evaluations of whether the jurisdictions met their respective nitrogen, phosphorus, and sediment target allocations as illustrated in Tables 8-1 and 8-2, EPA assigned final allocations according to the assumptions detailed below for each of the seven watershed jurisdictions. Because EPA determined that many of the jurisdictions' final Phase I WIPs met all target allocations and/or met EPA's expectations for reasonable assurance, EPA reduced or eliminated many of the backstop allocations that it had included for those jurisdictions in the September 24, 2010, draft Chesapeake Bay TMDL, where warranted. The allocations for each jurisdiction, and the assumptions and rationale underlying those allocations, are described below.

8.4.1 Delaware

Delaware developed a final Phase I WIP input deck with nitrogen, phosphorus, and sediment controls that achieved jurisdiction-wide allocations when run through the Watershed Model. Delaware's final Phase I WIP also met EPA's expectations for reasonable assurance. As a result, EPA based Delaware's final allocations entirely on Delaware's final Phase I WIP. Delaware's final Phase I WIP shifts the urban stormwater load into the WLA, provides stronger agricultural contingencies to enhance reasonable assurance that reduction targets will be met, and improves WWTP performance levels to meet nitrogen allocations.

Delaware Allocations

Delaware meets its nitrogen, phosphorus, and sediment allocations in the final TMDL, based on EPA's quantitative and qualitative evaluation of Delaware's final Phase I WIP. Delaware's WIP input deck resulted in jurisdiction-wide loads that are 3 percent under nitrogen, 12 percent under phosphorus, and 33 percent under sediment target allocations. Delaware has agreed to apply the spare pounds back to the nonpoint source agriculture allocation and to refine the implementation measures in its Phase II WIP. Delaware's Bay TMDL jurisdiction-wide allocations are nitrogen 2.95 million pounds per year (mpy); phosphorus 0.26 mpy; and sediment 57.82 mpy.

Delaware Agriculture

Delaware's final Phase I WIP showed significant improvements from its draft Phase I WIP in the agriculture sector, including a strong contingency that "Delaware commits to review and evaluate the pace and progress of agriculture BMP implementation at the end of 2013. If needed, Delaware will enact new policy measures and explore mandatory BMP compliance options in a timely manner to ensure that water quality commitments will be met." Delaware's final Phase I WIP also includes greater detail on funding coordination and the implementation of agriculture BMPs. These improvements bolster reasonable assurance that agriculture allocations will be met.

EPA will maintain ongoing oversight of Delaware's agriculture sector to ensure these allocations are achieved and maintained. Specifically, EPA will use its national review of CAFO State Technical Standards in 2011 and beyond as an opportunity to identify any deficiencies in the State Technical Standards for protecting water quality. Through its review of State Technical Standards, EPA also will evaluate whether Delaware's phosphorus management program is sufficient to address phosphorus imbalances and water quality concerns. If deficiencies are identified that are not addressed or the permit does not include other conditions to achieve nitrogen and phosphorus reductions identified in the WIP, EPA may object to permits on the basis that they are not protective of water quality.

Delaware Urban Stormwater

Delaware's final Phase I WIP also showed significant improvements in the urban stormwater sector. The WIP used BMPs that address both urban stormwater quality and quantity. The WIP also describes proposed regulatory revisions that, once adopted, will require redevelopment to reduce effective imperviousness by 50 percent and will increase required treatment volume for new development to the level of annualized runoff from the 1-year frequency storm event (about 2.7 inches of rainfall). The initial goal of these regulatory provisions would be to use runoff reduction practices so that effective imperviousness is 0 percent. Delaware's final Phase I WIP further provided detailed strategies to restrict turfgrass fertilizer and documented a variety of funding sources to implement proposed strategies.

As in the draft Phase I WIP, Delaware has shifted the entire urban stormwater load into the WLA. This shift enhances reasonable assurance that nitrogen, phosphorus, and sediment allocations from urban discharges will be achieved and maintained by signaling that many more discharges could potentially be subject to NPDES permits as necessary to protect water quality.

EPA will maintain ongoing oversight of Delaware's urban stormwater sector. In particular, EPA will monitor Delaware's progress in revising its urban stormwater regulations for new development and redevelopment to be consistent with the final Phase I WIP commitments. EPA also will monitor Delaware's efforts to develop a system for tracking inspections and compliance information. Finally, EPA will review the timeline and content of proposed regulations to limit turfgrass fertilizer use and the application of regulatory tools as a contingency should voluntary programs not result in fertilizer reductions on 95 percent of available urban lands.

Delaware Wastewater

Delaware's final Phase I WIP showed key improvements in the wastewater sector. Most notably, Delaware lowered effluent limits at 3 significant WWTPs to 4 mg/L TN at design flow to meet the nitrogen allocations and committed to hire additional staff for the on-site treatment systems and WWTP programs to manage permits consistent with the Chesapeake Bay TMDL. Delaware also confirmed that all nonsignificant WWTPs are included within the WLA.

EPA will maintain ongoing oversight of Delaware's wastewater program to ensure that the actions detailed in the final Phase I WIP occur and achieve the expected pollutant reductions. EPA also will review NPDES permit conditions to ensure that they are consistent with the assumptions and requirements of the Bay TMDL WLAs.

Delaware Conclusion

EPA applauds Delaware for its improvements in its Phase I WIP. The TMDL allocations in Delaware are based solely on the final Phase I WIP because Delaware met its target allocations and met EPA's expectations for providing reasonable assurance by identifying practices and implementation strategies to attain applicable WQS. EPA will assess progress through ongoing permit and program oversight and 2-year milestones, and believes that Delaware will succeed.

Although EPA does not anticipate that additional federal actions will be necessary, EPA is prepared to object to permits, target enforcement, condition grants, or adopt other federal actions as detailed in its December 29, 2010 letter, as necessary and appropriate, to support Delaware's ambitious restoration commitment.

8.4.2 District of Columbia

The District of Columbia developed a final Phase I WIP that met the interim allocation target of achieving a 60 percent reduction by 2017, and that met the nitrogen, phosphorus, and sediment target allocations by 2025. The District's final Phase I WIP also met EPA's expectations for providing reasonable assurance that those target allocations would be met, although it is contingent in part upon the issuance of a final MS4 permit with performance standards for new development, redevelopment, and retrofits that are similar to those included in the draft permit issued earlier in 2010. As a result, EPA based the District's final allocations entirely on the District's final Phase I WIP.

District of Columbia Allocations

The District of Columbia meets its nitrogen, phosphorus, and sediment allocations in the final TMDL, based on EPA's quantitative and qualitative evaluation of the District's final Phase I WIP. The District's input deck resulted in loads that are 0 percent over for nitrogen, phosphorus and sediment allocations. The District of Columbia's Bay TMDL jurisdiction-wide allocations are nitrogen 2.32 mpy; phosphorus 0.12 mpy; and sediment 11.16 mpy.

District of Columbia Urban Stormwater

The District of Columbia's final Phase I WIP showed significant improvements in urban stormwater from its draft Phase I WIP. For example, the District's final WIP incorporates a new urban stormwater volume standard (1.2-inch retention) that is consistent with the District's draft MS4 permit. EPA anticipates that the final MS4 permit will include detailed information on permit conditions, with timelines for implementation, tracking, inspections, and reporting. The District's final Phase I WIP also includes a more detailed list of GSA properties and provides a detailed discussion of the District's enforcement authority regarding federal properties. The WIP also describes a plan for engaging federal facilities in the Phase II WIP, including tracking of federal 2-year milestones.

EPA will maintain ongoing oversight of the District's urban stormwater sector and will continue to work with DDOE to finalize the DC MS4 permit. EPA will assure specific permit conditions and fact sheet language to reflect TMDL expectations (e.g., implementation action timelines, inspection schedule, verification, and tracking). Once the DC MS4 permit is finalized, EPA will continue to work with the District to implement the MS4 permit consistent with meeting 2-year milestones and reporting for the TMDL.

District of Columbia Wastewater

The District of Columbia's final Phase I WIP also showed significant improvement in the wastewater sector. Not only does the final Phase I WIP include a complete list of non-significant facilities, but EPA and DC agreed upon the inclusion of a growth reserve in the final TMDL. Although the final Phase I WIP and input deck do acknowledge the growth reserve, the final

WLA for Blue Plains is separate and provides loading sufficient for and consistent with the permit limits in the 2010 NPDES permit. If additional capacity is needed beyond the permitted loads, the District has committed to work with other jurisdictions as necessary to adjust the Blue Plains Inter-jurisdictional Municipal Agreement.

EPA will maintain ongoing oversight of the District's wastewater program and will implement the TMDL WLAs through the permits that EPA issues, renews and modifies in the District of Columbia. EPA also will continue to work closely with the District to assure that loads from both significant and nonsignificant sources are consistent with the aggregate WLA. Specifically, the final Phase I WIP proposes that the WLA for Blue Plains be developed based on the annual average flows for outfall 001. However, WLAs for the combined sewer system (CSS) and its associated WWTP in the District of Columbia are based on the limits in the NPDES permit issued by EPA for Blue Plains and the Long Term Control Plan (LTCP) for the CSS system in the District of Columbia. The WLAs assume full implementation of the Blue Plains LTCP.

District of Columbia Conclusion

EPA applauds the District of Columbia for its improvements in its Phase I WIP. EPA believes that the District of Columbia will achieve and maintain its TMDL allocations based on its final Phase I WIP. EPA commits to issue permits and target enforcement actions to implement TMDL allocations. EPA also will encourage and work with its sister federal agencies to lead by example in reducing nitrogen, phosphorus, and sediment loads into the Potomac and Anacostia rivers.

8.4.3 Maryland

Maryland developed a final Phase I WIP input deck with nitrogen, phosphorus, and sediment controls that more than met the interim target allocations by achieving a 70 percent reduction by 2017, and met the nitrogen, phosphorus, and sediment target allocations by 2020. Maryland's final Phase I WIP also met EPA's expectations for providing reasonable assurance that these allocations will be met. As a result, EPA based Maryland's final allocations entirely on Maryland's final Phase I WIP.

Maryland Allocations

Maryland meets its nitrogen, phosphorus, and sediment allocations for each basin in the final TMDL, based on EPA's quantitative and qualitative evaluation of Maryland's final Phase I WIP. Maryland submitted proposed modifications to its nitrogen, phosphorus, and sediment allocations in each of its five basins. EPA used the Chesapeake Bay Water Quality Model to confirm that these modifications would still attain applicable WQS. Maryland's final Phase I WIP input deck resulted in jurisdiction-wide loads that are 0 percent over modified nitrogen, phosphorus, and sediment allocations. Maryland's Bay TMDL jurisdiction-wide allocations are nitrogen 39.09 mpy; phosphorus 2.72 mpy; and sediment 1218.10 mpy.

Maryland Agriculture

Maryland's final Phase I WIP showed significant improvements from its draft Phase I WIP in the agriculture sector, including a strong contingency statement that significantly bolsters EPA's reasonable assurance that Maryland will meet its agriculture targets by committing to explore new policy measures and mandatory BMP compliance options. For example, these could include a regulatory change that cover crops be planted on the highest risk acres. The Maryland final Phase I WIP also provides more detail on phosphorus management, strengthens contingencies, improves coordination with USDA, develops a plan for increasing staff levels, and selects a subset of strategies to implement by 2017.

EPA will maintain ongoing oversight of Maryland's agriculture sector. EPA will use its national review of CAFO State Technical Standards in 2011 as an opportunity to identify any deficiencies in the State Technical Standards for protecting water quality. Through its review of State Technical Standards, EPA also will evaluate whether Maryland's phosphorus management program is sufficient to address phosphorous imbalances and water quality concerns. If deficiencies are identified that are not addressed by Maryland or a CAFO permit does not include other conditions to achieve nitrogen and phosphorus reductions identified in the final Phase I WIP, EPA may object to permits if they are not protective of water quality.

Maryland Urban Stormwater

Maryland's final Phase I WIP also showed significant improvement in its commitment to urban stormwater management. In the final Phase I WIP, Maryland committed to several actions to ensure reductions, including limits on lawn fertilizer use, use of natural filters such as riparian buffers and stream restoration, and an increase in watershed restoration requirements for MS4s by requiring additional nitrogen, phosphorus, and sediment reductions. The WIP also included a contingency plan whereby if local utilities or other systems of charges are not underway in 2012, Maryland will seek legislation requiring development of local stormwater utilities via a statewide system of fees. The final Phase I WIP also included descriptions of the policy, financing, and tracking mechanisms for implementing urban stormwater retrofit programs.

Maryland also included in its final Phase I WIP specific activities and milestones for urban stormwater program implementation, including the following:

- Renewal of Phase I MS4 permits to require nutrient and sediment reductions equivalent to urban stormwater treatment on 30 percent of the impervious surface that does not have adequate urban stormwater controls.
- Renewal of Phase II MS4 permits to require nutrient and sediment reductions equivalent to urban stormwater treatment on 20 percent of the impervious surface that does not have adequate urban stormwater controls.
- Renewal of State Highway Administration Phase I and Phase II MS4 permits to require nutrient and sediment reductions equivalent to urban stormwater treatment on 30 percent of the impervious surface that does not have adequate controls.
- Regulation of fertilizer applications on 220,000 acres of commercially managed lawns.

While EPA is satisfied overall with Maryland's demonstration of reasonable assurance, EPA will closely track the nitrogen, phosphorus, and sediment reductions expected to result from these urban stormwater retrofits. EPA will maintain ongoing oversight of Maryland's urban stormwater sector and will assess how well Maryland is able to track and quantify outcomes from the retrofits projected in its final Phase I WIP.

Maryland Wastewater

Maryland's final Phase I WIP also showed significant improvement in the wastewater sector. Maryland committed to identify options to structure the Bay Restoration Fund (BRF) fee in order to fully fund Enhanced Nutrient Removal (ENR) upgrades at 67 public major wastewater treatment plants. Options include fees based on consumption, income, or other criteria; and, in 2012, to propose an amendment to the BRF statute to change the BRF fee in order to provide funding needed to complete the upgrades.. Maryland's final Phase I WIP also included a contingency that if the BRF statute is not amended, "All funding for ENR projects will be reduced from 100 percent grant to provide partial grant funds for each remaining project. Local governments would be responsible for the balance of the necessary funding. State low interest loan funds would be available to assist."

EPA will maintain ongoing oversight of Maryland's wastewater sector to ensure that the actions detailed in the final Phase I WIP occur and achieve the expected pollutant reductions.

Maryland Conclusion

EPA applauds Maryland for following up a strong draft with an even stronger final Phase I WIP. Maryland clarifies how its existing programs will implement nitrogen, phosphorus, and sediment reductions ahead of schedule. Both Maryland and EPA are committed to carefully review progress and adopt contingency actions as necessary to achieve and maintain the nitrogen, phosphorus, and sediment reductions.

8.4.4 New York

New York developed a final Phase I WIP input deck with nitrogen, phosphorus, and sediment controls that achieved additional reductions from the agricultural and wastewater sectors and achieved jurisdiction-wide allocations for sediment, but did not meet allocations for nitrogen or phosphorus. In response to New York's concerns regarding the fairness of how EPA distributed the Baywide allocations to jurisdictions, EPA increased New York's nitrogen and phosphorus allocations by a total of 1,000,000 pounds and 100,000 pounds, respectively, and approved New York's exchange of some phosphorus for nitrogen (see Section 6.4.5). New York still did not meet its target allocations for nitrogen and phosphorus, however, despite these increased allocations and nutrient exchanges. As described below, EPA closed the gap with an aggregate WLA backstop allocation that further reduced New York's wastewater load.

New York Allocations

New York meets its modified nitrogen, phosphorus, and sediment allocations in the final TMDL, based on a combination of EPA's quantitative and qualitative evaluation of New York's final Phase I WIP, EPA's increase of New York's nitrogen and phosphorus allocations, EPA's approval of New York's exchange of some phosphorus for nitrogen, and EPA's establishment of a backstop allocation for wastewater as described in detail below. New York's final Phase I WIP input deck resulted in loads that are 14 percent under its sediment allocation and 5 percent and 2 percent over its modified nitrogen and phosphorus allocations, respectively. EPA closed the gaps between New York's WIP and its nitrogen and phosphorus allocations with an aggregate WLA backstop allocation that further reduced New York's wastewater load. New York's jurisdiction-wide allocations are nitrogen 8.77 mpy; phosphorus 0.57 mpy; and sediment 292.96 mpy.

New York Agriculture

New York's final Phase I WIP showed significantly more details in the agriculture section to demonstrate reasonable assurance that WIP commitments would be achieved than it did in its draft. New York's final Phase I WIP is built on the strength of New York's Agricultural Environmental Management (AEM) and CAFO programs. For example, AEM captures 95 percent of dairies in the watershed and farms must participate in AEM to get Farm Bill funding, CAFO permits are required at dairies with as few as 200 animal units, and every field covered by a nutrient management plan is tested for phosphorus. The WIP also includes a regulatory requirement for pasture fencing as a contingency action, and outlines specific steps to implement advanced technologies to process dairy manure. New York's final Phase I WIP also describes in-depth strategies that support New York's BMP implementation rates. These strategies are based on analyses of historic rates and cost of practices, realistic estimates of state and federal funding, and the type of agriculture practiced in New York. These strategies met EPA's expectations for reasonable assurance that New York will implement the commitments in its final Phase I WIP.

EPA will maintain ongoing oversight of New York's agriculture sector. EPA will use its national review of CAFO State Technical Standards in 2011 and beyond as an opportunity to identify any deficiencies in the State Technical Standards for protecting water quality. If deficiencies are identified that are not addressed by the state or the permit does not include other conditions to achieve nitrogen and phosphorus reductions identified in the final Phase I WIP, EPA may object to permits if they are not protective of water quality.

New York Urban Stormwater

New York's final Phase I WIP showed improvement in the urban stormwater sector by better documenting the strengths of its current program. New York volunteered to shift 50 percent of its urban stormwater load from the LA to the WLA. This change enhances reasonable assurance that nitrogen, phosphorus, and sediment allocations will be achieved and maintained by signaling that substantially more urban stormwater could potentially be subject to NPDES permits issued by New York as necessary to protect water quality. The final Phase I WIP also documented a variety of funding sources to implement proposed strategies, and committed to BMPs that address urban stormwater quality and quantity. In addition, the New York construction general permit imposes volume-based post-construction controls on a significant portion of all construction projects state-wide. New York also finalized legislation limiting the residential use of fertilizer.

EPA will maintain ongoing oversight of New York's urban stormwater sector. EPA will monitor New York's progress in implementing its urban stormwater program and issuing permits that achieve the nitrogen, phosphorus, and sediment reductions that New York committed to in its final Phase I WIP. EPA also will provide oversight of the urban stormwater permitting program.

New York Wastewater

In the wastewater sector, New York's final Phase I WIP included a commitment to improve WWTP performance to BNR equivalent performance levels for nitrogen (8 mg/L) and to 0.5 mg/L for phosphorus at design flow. Despite increasing New York's nitrogen and phosphorus allocations, however, New York's WIP did not reduce loads enough to meet the modified allocations. As a result, EPA applied backstop allocations and actions that further reduce New York's WLA for wastewater to close the numeric gap.

EPA established an aggregate WLA for WWTPs that is calculated using the nitrogen and phosphorus performance levels to which New York committed and that assumed that significant WWTPs are at current flow rather than design flow. As discussed in Section 8.3, EPA allowed for an aggregate WLA for WWTPs in New York to provide time for the New York State Department of Environmental Conservation to review engineering reports from WWTPs and determine the load reductions expected from each facility. New York has committed to provide information to support individual WLAs for these WWTPs in its Phase II WIP. EPA understands that New York plans to renew and/or modify WWTP permits after completing its Phase II WIP, consistent with the applicable TMDL allocations at that time.

New York Conclusion

EPA values New York's continued commitment to protect its local waters and restore the Chesapeake Bay through strong agricultural and urban stormwater programs as well as commitments to reduce WWTP discharges. EPA has made adjustments to New York's allocations based on concerns with equity (USEPA 2010f). EPA is confident that New York will achieve its agricultural and urban stormwater allocations. EPA applied a backstop allocation to further reduce wastewater loads to enable New York to meet its statewide nitrogen and phosphorus allocations.

8.4.5 Pennsylvania

Pennsylvania developed a final Phase I WIP input deck with nitrogen, phosphorus, and sediment controls that met its sediment allocations and came within two percent of jurisdiction-wide nitrogen and phosphorus allocations after allowing for nitrogen to phosphorus exchanges. Pennsylvania's final Phase I WIP resulted in loads below nitrogen, phosphorus, and sediment allocations in the Potomac, Eastern, and Western Shore Basins. EPA will place the spare allocation for these basins back into the agriculture nonpoint source sector. In contrast, after allowing for nitrogen to phosphorus exchanges at EPA-approved ratios to modify the Pennsylvania Susquehanna basin nitrogen and phosphorus allocations, the Commonwealth's final Phase I WIP input deck remained 2 percent over its nitrogen allocation and 2 percent over its phosphorus allocation. EPA and the Commonwealth have reached agreement on further reductions from agricultural and urban stormwater nonpoint sources proportional to the amount of load that they contribute to the Bay to achieve allocations in the Susquehanna in the final TMDL. These further reductions are supported by contingencies included in the final Phase I WIP and EPA's commitment to track progress and take any necessary federal actions to ensure all pollutant reductions are achieved and maintained.

Pennsylvania's final Phase I WIP demonstrated substantially more reasonable assurance that it could achieve and maintain agricultural allocations due to several key improvements. However, as described below, Pennsylvania did not meet EPA's expectations for reasonable assurance that urban stormwater allocations will be achieved and maintained. As described below, EPA closed this reasonable assurance gap with a backstop adjustment for Pennsylvania's urban stormwater load that transfers 50 percent of the urban stormwater load not currently subject to NPDES permits from the LA to the WLA.

Pennsylvania Allocations

Pennsylvania met its nitrogen, phosphorus, and sediment allocations in each basin in the final TMDL, based on a combination of EPA's quantitative and qualitative evaluation of Pennsylvania's final Phase I WIP, EPA's commitment to enhanced oversight and actions for Pennsylvania agriculture, EPA's approval of nitrogen and phosphorus exchanges, and EPA's establishment of a backstop adjustment for urban stormwater as described in detail below. After adjusting for EPA-approved nitrogen and phosphorus exchanges, Pennsylvania's WIP input deck resulted in statewide loads that are 2 percent over for nitrogen and phosphorus, and 5 percent under for sediment allocations. EPA and the Commonwealth have reached agreement on further reductions from agriculture and urban stormwater nonpoint sources proportional to the amount of load that they contribute to the Bay to achieve allocations in the Susquehanna and, therefore, statewide. These further reductions are supported by the contingencies included in the WIP and EPA's commitment to track progress and take any necessary federal actions to ensure these reductions are achieved and maintained. Pennsylvania's final allocations are nitrogen 73.93 mpy; phosphorus 2.93 mpy; and sediment 1983.78 mpy.

Pennsylvania Agriculture

Pennsylvania's final Phase I WIP showed significant improvement from the draft Phase I WIP in the agriculture sector. The WIP included detailed strategies for increasing compliance with agricultural regulations and for advancing manure technologies, and aligned Pennsylvania's technical workforce to support WIP priorities. The Pennsylvania final Phase I WIP detailed a specific approach for tracking agricultural conservation by working with EPA, the National Association of Conservation Districts, and other Bay jurisdictions' agricultural agencies to develop verification protocols for crediting non-cost-shared practices in the Chesapeake Bay Watershed Model.

EPA wants Pennsylvania to succeed in achieving these reductions from the agriculture sector. To support the Commonwealth's efforts, EPA will use its national review of CAFO State Technical Standards in 2011 and beyond as an opportunity to identify any deficiencies in the State Technical Standards for protecting water quality. EPA also will evaluate whether Pennsylvania's approach to managing phosphorus is sufficient to address phosphorus imbalances and water quality concerns. EPA will continue to engage Pennsylvania about the ways to phase out the practice of winter spreading of manure, which continues to be allowed in Pennsylvania despite being banned in other jurisdictions. If Pennsylvania does not adequately address these matters or the permit does not include other conditions to achieve the nitrogen and phosphorus reductions identified in its final Phase I WIP, EPA may object to permits if they are not protective of water quality.

EPA also is committed to enhanced oversight and actions for Pennsylvania's agriculture sector. Upon review of the Phase II WIP, EPA will revisit the WLAs for agriculture and WWTPs in the event that Pennsylvania does not make significant progress in the following areas: receiving EPA approval for its CAFO program, demonstrating enhanced compliance assurance with agricultural state regulatory programs, developing more targeted contingency actions, and advancing manure technologies. Specifically, EPA may consider

- More stringent phosphorus limits on WWTPs.

- Shifting a greater portion of Pennsylvania's AFO load from the LA to the WLA. EPA would assume full implementation of practices required under a CAFO permit for AFOs included in the WLA. The shift to the WLA would signal that any of these AFOs could potentially be subject to NPDES permits as necessary to protect water quality. AFOs would only be subject to NPDES permit conditions issued by Pennsylvania upon designation. EPA will consider this step if Pennsylvania does not achieve reductions in agricultural loads as identified in the final Phase I WIP. EPA may also pursue designation activities based upon considerations other than TMDL and WIP implementation.

Pennsylvania Urban Stormwater

Pennsylvania's final Phase I WIP also showed improvement in the urban stormwater sector. It provided a strong description of Chapter 102 regulations and what Pennsylvania can enforce and regulate to achieve no net change in urban stormwater runoff. The Commonwealth requires a *no net increase* provision to maintain existing hydrology or demonstrate that at least 20 percent of a previously disturbed site has the hydrologic conditions of meadow or better. The WIP also included a commitment from PADEP to add a statewide program to reduce the application of fertilizer on non-agricultural lands.

Despite these improvements, the WIP's urban stormwater discussion continues to have weaknesses. Pennsylvania's final WIP lacked clear strategies to achieve the almost 40 percent reduction in urban loads that the Commonwealth included in its WIP input deck. For example, PADEP continues to assert that the scope of the MS4 program is limited to the conveyance system only, and Pennsylvania's small MS4 permit program does not include construction and post-construction requirements. Further, the requirement for an MS4 to have a TMDL Implementation Plan does not include the Chesapeake Bay TMDL, and there is no supporting documentation to quantify how local TMDL implementation plans will meet Bay targets. In addition, Pennsylvania is assuming high compliance levels, but has not demonstrated a high level of compliance assurance activities nor enhanced the field resources available to support an enforcement presence. Recent EPA activities in this area have illustrated a high level of noncompliance with existing permits.

As a result of the reasonable assurance weaknesses in the urban stormwater sector, EPA applied backstop adjustments and actions to this sector. Specifically, EPA transferred 50 percent of the urban stormwater load that is not currently subject to NPDES permits from the LA to the WLA. This TMDL allocation adjustment increased reasonable assurance that nitrogen, phosphorus, and sediment allocations from urban stormwater discharges will be achieved and maintained by signaling that EPA is prepared to designate any of these discharges as requiring NPDES permits. Urban areas would only be subject to NPDES permit conditions protective of water quality as issued by the Commonwealth upon designation. EPA will consider this step if Pennsylvania does not demonstrate progress toward reductions in urban loads identified in its final Phase I WIP. EPA may also pursue designation activities based on considerations other than TMDL and WIP implementation.

EPA will maintain close oversight of general permits for the Pennsylvania urban stormwater sector (PAG-13, PAG-2) and may object as needed if permits are not protective of WQS and regulations. Upon review of Pennsylvania's Phase II WIP, EPA will revisit the WLAs for WWTPs, including more stringent phosphorus limits, in the event that Pennsylvania does not reissue PAG-13 and PAG-2 general permits for Phase II MS4s and construction activities that are protective of water quality by achieving the load reductions called for in Pennsylvania's final Phase I WIP.

Pennsylvania Wastewater

Pennsylvania's final Phase I WIP showed a number of key improvements in the wastewater sector. For example, the WIP provided language on a process for granting 25 lb/yr credit to POTWs for each septic system retired and incorporated into a treatment facility and provided additional language on implementation schedules for significant WWTP upgrades. In addition, the final Phase I WIP and input decks included permit numbers for additional non-significant facilities covered under the PAG-04 and PAG-05 general permits.

EPA committed to enhanced oversight and actions for the Pennsylvania wastewater sector, and established individual WLAs for WWTPs in the TMDL to ensure that sufficient detail is provided to inform individual permits for sources within the WLA. Provisions of this TMDL allow (under certain circumstances, see Section 10) for modifications of allocations within a basin to support offsets and trading opportunities. Further, as described above, EPA will assess Pennsylvania's near-term urban stormwater and agricultural program progress and determine whether EPA should modify TMDL allocations to assume additional reductions from WWTPs.

Pennsylvania Conclusion

Pennsylvania's final Phase I WIP articulated a strategy to achieve its TMDL allocations. Pennsylvania's final Phase I WIP contained significantly more detail than the draft Phase I WIP and, with the incorporation of EPA's backstop adjustment and enhanced oversight, met EPA's expectations for reasonable assurance that agricultural reductions can be achieved and maintained. EPA is committed to enhanced oversight to ensure that necessary program enhancements and load reductions are achieved in all sectors and that permits are consistent with TMDL WLAs. Further, EPA applied a backstop adjustment for urban stormwater to signal that substantially more urban stormwater discharges may need to be designated for coverage under the NPDES program and receive NPDES permits from Pennsylvania that EPA deems are protective of water quality.

8.4.6 Virginia

As described below, Virginia's final Phase I WIP showed significant improvements from its draft Phase I WIP, including a commitment to implement aggressive, additional WWTP upgrades, a more accountable urban stormwater program, and expanded mandatory agriculture programs if voluntary programs are not successful. EPA is committing to ongoing oversight of the agriculture and wastewater sectors and enhanced oversight of Virginia's urban stormwater sector to ensure that WLAs and LAs are achieved and maintained.

Virginia Allocations

Virginia met its nitrogen, phosphorus, and sediment allocations for each basin in the final TMDL, based on a combination of EPA's quantitative and qualitative evaluation of Virginia's final Phase I WIP, EPA's approval of Virginia's exchange of some phosphorus for nitrogen, and EPA's commitment to enhanced oversight and actions for Virginia urban stormwater. After adjusting for EPA-approved nitrogen and phosphorus exchanges, Virginia's WIP input deck resulted in statewide loads that were 2 percent over for nitrogen and phosphorus, and 3 percent under for sediment. Some individual basins, however, were as much as 5 percent over their nitrogen and phosphorus target allocations, or 9 percent over their sediment target allocations. EPA and the Commonwealth have reached agreement on further reductions from agricultural, urban stormwater, and on-site septic system nonpoint sources proportional to the amount of load that they contribute to the Bay to achieve allocations both jurisdiction-wide and in each basin in the final TMDL. These further reductions are supported by the contingencies included in Virginia's final Phase I WIP and EPA's commitment to track progress and take any necessary federal actions to ensure these reductions are achieved and maintained. Virginia's jurisdiction-allocations are nitrogen 53.42 mpy; phosphorus 5.36 mpy; and sediment 2578.90 mpy.

Virginia Agriculture

Virginia's final Phase I WIP showed a number of improvements in the agriculture sector. For example, Virginia shifted the entire AFO load into the WLA and assumed full implementation of barnyard runoff control, waste management, and mortality composting practices that would be required under a CAFO permit. This change enhanced reasonable assurance that nitrogen, phosphorus, and sediment allocations from animal operations will be achieved and maintained by signaling that any of these facilities could potentially be subject to NPDES permits as necessary to protect water quality. Virginia also committed to evaluating all small AFOs to determine whether they discharge or propose to discharge and should be permitted. Virginia's final Phase I WIP also provided more detail on the type of practices that are likely to be included in Resource Management Plans and mechanisms for promoting these Plans to producers. Virginia committed to pursue state legislation for mandatory actions or programs in the event that the 2-year milestone agricultural reduction targets are not met, and provided assurance that sufficient funding will be available through the 2013 milestone period.

EPA will maintain ongoing oversight of Virginia's agriculture program and will closely track compliance with the agricultural milestone targets to ensure that appropriate contingency actions are pursued as necessary. EPA will use its national review of CAFO State Technical Standards in 2011 and beyond to identify any deficiencies in the State Technical Standards for protecting water quality. Through its review of CAFO State Technical Standards, EPA also will evaluate whether Virginia's phosphorus management program is sufficient to address phosphorus. If deficiencies are identified that are not addressed by the Commonwealth or the permit does not include other conditions to achieve nutrient reductions identified in the WIP, EPA may object to permits if they are not protective of water quality.

Virginia Urban Stormwater

Virginia's final Phase I WIP also showed improvement in the urban stormwater sector. Virginia revised its WIP target loads to include much more achievable, yet still aggressive, load reductions from the urban sector, committed to implement a Bay-wide and possibly statewide regulatory program to limit fertilizer application on urban lands, and committed to finalize a urban stormwater rule in 2011 that would improve new development and redevelopment performance standards. Virginia also requested individual WLAs for Phase I MS4s to more explicitly demonstrate the amount of urban runoff load that each permitted jurisdiction is expected to achieve.

EPA committed to enhanced oversight and actions regarding Virginia's urban stormwater program. Specifically, if the statewide rule and/or the Phase II WIP do not provide additional assurance regarding how urban stormwater discharges outside of MS4 jurisdictions will achieve nitrogen, phosphorus, and sediment reductions proposed in the final Phase I WIP and assumed within the TMDL allocations, EPA may shift a greater portion of Virginia's urban stormwater load from the LA to the WLA. This shift would signal that substantially more urban stormwater could potentially be subject to NPDES permits issued by the Commonwealth as necessary to protect water quality.

As in other Bay jurisdictions, EPA committed to ongoing oversight and actions. This includes potentially objecting to proposed urban stormwater regulations, MS4 permits, construction general permits, and industrial stormwater permits that are not consistent with the Bay TMDL allocations and do not require conditions to reduce nitrogen, phosphorus, and sediment loads to the degree identified in the final Phase I WIP.

Virginia Wastewater

Virginia's final Phase I WIP showed strong improvement in the wastewater sector. Virginia committed to require WWTP upgrades in the James River Basin sufficient to achieve 100 percent of reductions needed to meet DO-based allocations and 60 percent of reductions needed to meet chlorophyll-*a* based allocations by 2017. Virginia has committed to additional WWTP upgrades to achieve 100 percent of the reductions needed to meet the chlorophyll-*a* based WLAs for WWTPs by 2023, as outlined in the Staged Implementation Approach for Wastewater Treatment Facilities in the Virginia James River Basin, which is found in Appendix X.

EPA will maintain ongoing oversight of Virginia's wastewater program. EPA will review NPDES permit conditions to ensure that they are consistent with the assumptions and requirements of the Bay TMDL WLA. If VADEQ and EPA cannot come to agreement on the language of the Watershed General Permit related to combined sewer systems (CSS) by the time that EPA reviews the Commonwealth's Phase II WIP, EPA may reopen WLAs to ensure that they are reasonable and that compliance can be achieved.

Virginia Conclusion

Due to substantial improvements between the draft and final Phase I WIP, Virginia now demonstrates that it can achieve and maintain nitrogen, phosphorus, and sediment allocations for all source sectors. As a result, EPA has removed all backstop allocations for Virginia that it had proposed in the draft TMDL. EPA commits to careful oversight to ensure that the valuable commitments detailed in the final Phase I WIP are implemented on schedule, and that permits and programs within the Commonwealth are consistent with assumptions and requirements of the TMDL WLAs. EPA also will carefully assess the Phase II WIP to determine whether EPA should establish a backstop adjustment for urban stormwater that shifts substantially more of the unregulated load to the WLA.

8.4.7 West Virginia

West Virginia developed a final Phase I WIP input deck with nitrogen, phosphorus, and sediment controls that met its statewide target allocations when run through the Chesapeake Bay Watershed Model after adjusting for EPA-approved nitrogen and phosphorus exchanges.

West Virginia's final Phase I WIP did not fully meet EPA's expectations for reasonable assurance that agriculture allocations will be achieved, however. EPA closed the reasonable assurance gap with a backstop adjustment for West Virginia's agriculture load that transferred 75 percent of West Virginia's AFO load into the WLA and assumed full implementation of barnyard runoff control, waste management, and mortality composting practices. EPA also committed to enhanced oversight of Virginia's urban stormwater and wastewater sectors to ensure that they achieve and maintain their allocations.

EPA based West Virginia's final allocations on a combination of West Virginia's final Phase I WIP with the above backstop adjustment for animal agriculture and enhanced oversight actions for urban stormwater and wastewater as described below.

West Virginia Allocations

West Virginia met its nitrogen, phosphorus, and sediment allocations for each basin in the final TMDL, based on a combination of EPA's quantitative and qualitative evaluation of West Virginia's final Phase I WIP, EPA's commitment to enhanced oversight and actions for West Virginia urban stormwater and wastewater, and EPA's establishment of a backstop adjustment for West Virginia agriculture as described in detail below. After adjusting for EPA-approved nitrogen and phosphorus exchanges, West Virginia's input deck resulted in statewide loads that are 0 percent under nitrogen, 1 percent under phosphorus and 11 percent under sediment allocations.

West Virginia agreed that any *spare allocations* in the Potomac River Basin would go to a LA reserve. Results from the final Phase I WIP input deck exceed nitrogen, phosphorus, and sediment allocations by 51 percent, 18 percent and 76 percent in the West Virginia portion of the James River basin, however. These exceedances are in large part due to an increasing portion of loads in West Virginia reaching the tidal portions of the James River as downstream loads decrease. EPA and West Virginia have reached agreement to fill these gaps by assuming additional reductions from all nonpoint sources proportional to the amount of loads they discharge to the Bay. West Virginia has committed to explore additional opportunities for reducing loads in this basin. EPA will track progress and consider whether to adopt additional federal actions to ensure that reductions are achieved and maintained. Furthermore, EPA will consider the effect of delivery factors when evaluating options for allocating basinwide loads to the major basins and jurisdictions in 2011. West Virginia's jurisdiction-wide allocations are nitrogen 5.45 mpy; phosphorus 0.59 mpy; and sediment 310.88 mpy.

West Virginia Agriculture

West Virginia's final Phase I WIP included some improvements. For example, it focused on effective nutrient-reducing practices such as poultry litter transport, targeted Nutrient Management Plans in high nitrogen-loading counties, and stream fencing. West Virginia also has increased coordination efforts with USDA to support proposed agriculture strategies and implementation.

West Virginia's final Phase I WIP contained a number of weaknesses in the agriculture sector, however. The WIP lacked detailed strategies for how West Virginia will implement nitrogen, phosphorus, and sediment controls on agricultural lands at levels necessary to meet TMDL allocations. The WIP also lacked strong contingencies such as new policies, programs, or mandates in the event that voluntary approaches are not sufficient to meet reduction goals. West Virginia's recently approved CAFO program has not yet had an opportunity to demonstrate a successful track record for AFO outreach and permitting.

To address these reasonable assurance weaknesses, EPA applied backstop adjustments and actions to this sector. Specifically, EPA shifted 75 percent of West Virginia's AFO load into the WLA and assumed full implementation of barnyard runoff control, waste management, and mortality composting practices required under a CAFO permit on these AFOs. This adjustment increased reasonable assurance that nitrogen, phosphorus, and sediment allocations for the agriculture sector will be achieved and maintained by signaling that EPA is prepared to designate any of these AFOs as requiring NPDES permits. The shift signaled that any of these operations could potentially be subject to NPDES permits as necessary to protect water quality. AFOs would only be subject to NPDES permit conditions as issued by West Virginia upon designation. EPA will consider this step if West Virginia does not achieve reductions in agricultural loads as identified in the WIP. EPA also may pursue designation activities based upon considerations other than TMDL and WIP implementation. Based upon EPA's review of the state technical standards, the number of permit applications and permits issued under the new CAFO program, and progress towards developing programs to reduce agricultural loads, EPA will assess in the Phase II WIP whether more stringent WLAs for WWTPs are necessary to ensure that TMDL allocations are achieved.

In addition, EPA committed to ongoing oversight and actions consistent with other Bay jurisdictions. EPA will use its national review of CAFO State Technical Standards in 2011 and beyond as an opportunity to identify any deficiencies in the State Technical Standards for protecting water quality. Through its review of CAFO State Technical Standards, EPA also will evaluate whether West Virginia's phosphorus management program is sufficient to address phosphorus imbalances and water quality concerns. If deficiencies are identified that are not addressed by the state or a permit does not include other conditions to achieve nutrient reductions identified in the WIP, EPA may object to permits if they are not protective of water quality.

West Virginia Urban Stormwater

West Virginia's final Phase I WIP showed some improvement in the urban stormwater sector. For example, West Virginia clarified contingencies in its final Phase I WIP, including mechanisms to regulate urban stormwater discharges from new development and redevelopment outside of regulated MS4 areas and implementation of retrofits to reduce pollutant loads from existing discharges.

The WIP still has weaknesses in its demonstration of reasonable assurance that urban stormwater allocations will be achieved and maintained, however. As a result, EPA committed to enhanced oversight and actions of West Virginia's urban stormwater program to ensure implementation. If urban stormwater rules and/or the Phase II WIP do not provide additional assurance regarding how urban stormwater discharges outside of MS4 jurisdictions will achieve nitrogen, phosphorus, and sediment reductions proposed in the final WIP and assumed within the TMDL LAs, EPA may shift a greater portion of West Virginia's urban stormwater load from the LA to the WLA. The shift would signal that substantially more urban stormwater could potentially be subject to NPDES permits issued by West Virginia as necessary to protect water quality. EPA will also monitor any increased discharges above the current baseline, as no reductions from permitted urban stormwater are expected. Finally, as in other Bay jurisdictions, EPA commits to ongoing oversight to ensure that programs and permits are consistent with WIP commitments. If they are not, EPA is prepared to take other federal actions as identified in its December 29, 2009 letter to ensure that TMDL allocations are achieved and maintained.

West Virginia Wastewater

West Virginia's final Phase I WIP showed improvement in the wastewater sector. For example, it included a commitment for the West Virginia legislature in 2011 to consider mechanisms to enhance financial assistance for POTWs to facilitate prompt compliance with NPDES permit requirements resulting from the Chesapeake Bay TMDL. West Virginia also provided additional information on compliance schedules and limits in the Permit Compliance System, and committed to reevaluate certain wastewater dischargers in its Phase II WIP to determine whether it will be necessary to reallocate loads.

Despite these improvements, however, the WIP does not fully meet EPA's expectations for reasonable assurance. As a result, EPA committed to enhanced oversight and actions for the West Virginia wastewater sector and, consistent with West Virginia's input deck, established individual WLAs for significant WWTPs in the TMDL to ensure that sufficient detail is provided to inform individual permits for sources within the wastewater WLA. Provisions of this TMDL allow (under certain circumstances, see Section 10) for modifications of allocations within a basin to support offsets and trading opportunities. Further, as described above, EPA will assess West Virginia's near-term agriculture program progress and determine whether additional federal actions consistent with EPA's December 29, 2009 letter, such as modifying TMDL allocations to assume additional reductions from WWTPs, are necessary to ensure that TMDL allocations are achieved.

West Virginia Conclusion

In summary, West Virginia's final Phase I WIP did not meet EPA's expectations for reasonable assurance for the agriculture sector. However, it did include an input deck with nitrogen, phosphorus, and sediment controls that, if implemented, would achieve statewide allocations. EPA wants West Virginia to successfully implement its final Phase I WIP. To fill the remaining reasonable assurance gap, EPA applied a backstop adjustment that shifted a portion of unregulated AFO production area loads into the WLA as a signal that substantially more operations may be subject to NPDES permits to protect water quality. Consistent with its December 29, 2009 letter, EPA is also prepared to take other federal actions as detailed in its December 29, 2010 letter as necessary to ensure that West Virginia succeeds in achieving the load reductions identified in its final Phase I WIP.

8.5 ALLOCATION SUMMARY CHART

The final allocations for nitrogen, phosphorus, and sediment listed above also are presented in Table 8-5 at both the jurisdiction and major river basin scales for each of the jurisdictions. These allocations are further sub-allocated to the 92 Bay segment watersheds by individual and aggregate WLAs and LAs in Section 9.

Table 8-5. Chesapeake Bay watershed nitrogen, phosphorus, and sediment allocations by jurisdiction and by major river basin, in millions of pounds per year

Jurisdiction	Major river basin	Nitrogen allocations (million lbs/year)	Phosphorus allocations (million lbs/year)	Sediment allocations (million lbs/year)
Pennsylvania	Susquehanna	68.90	2.49	1,741.17
	Potomac	4.72	0.42	221.11
	Eastern Shore	0.28	0.01	21.14
	Western Shore	0.02	0.00	0.37
	PA Total	**73.93**	**2.93**	**1,983.78**
Maryland	Susquehanna	1.09	0.05	62.84
	Eastern Shore	9.71	1.02	168.85
	Western Shore	9.04	0.51	199.82
	Patuxent	2.86	0.24	106.30
	Potomac	16.38	0.90	680.29
	MD Total	**39.09**	**2.72**	**1,218.10**
Virginia	Eastern Shore	1.31	0.14	11.31
	Potomac	17.77	1.41	829.53
	Rappahannock	5.84	0.90	700.04
	York	5.41	0.54	117.80
	James	23.09	2.37	920.23
	VA Total	**53.42**	**5.36**	**2,578.90**
District of Columbia	Potomac	2.32	0.12	11.16
	DC Total	**2.32**	**0.12**	**11.16**
New York	Susquehanna	8.77	0.57	292.96
	NY Total	**8.77**	**0.57**	**292.96**
Delaware	Eastern Shore	2.95	0.26	57.82
	DE Total	**2.95**	**0.26**	**57.82**
West Virginia	Potomac	5.43	0.58	294.24
	James	0.02	0.01	16.65
	WV Total	**5.45**	**0.59**	**310.88**
Preliminary Baywide Allocation		**185.93**	**12.54**	**6,453.61**
Atmospheric Deposition Allocation[a]		**15.7**	**N/A**	**N/A**
Total Baywide Allocation		**201.63**	**12.54**	**6,453.61**

[a] Cap on atmospheric deposition loads direct to Chesapeake Bay and tidal tributary surface waters to be achieved by federal air regulations through 2020.

Note: These basin-jurisdiction allocations have been modified from the original allocations established by EPA earlier this summer for the following reasons:

1. New York's allocations for nitrogen and phosphorus have been adjusted;
2. West Virginia's allocation for sediment has been corrected;
3. Maryland's allocations have been adjusted for some jurisdiction-requested basin exchanges;
4. Sever al other jurisdictions requested nutrient exchanges in their final Phase I WIPs

SECTION 9. CHESAPEAKE BAY TMDLS

This section presents the segment-specific and sector-specific Chesapeake Bay TMDL allocations for nitrogen, phosphorus, and sediment that resulted from EPA's evaluation of the jurisdictions' final Phase I WIPs as described in Section 8.

The MOS is implicit for the nitrogen and phosphorus allocations, having been built into the suite of decision-making tools, procedures and assumptions described in the previous sections (see Section 6.2.4). In the case of the sediment allocations, the explicit MOS is built directly into the allocations themselves (see Section 6.5.4). Natural background loads are included in the LAs presented in this section and the referenced appendices.

9.1 BAY SEGMENT ANNUAL AND DAILY ALLOCATIONS TO MEET WQS

Tables 9-1, 9-2, and 9-3 provide the annual total nitrogen, total phosphorus, and total suspended solids (sediment) allocations, respectively, for the watershed areas draining to each of the 92 Chesapeake Bay segments necessary to meet their applicable WQS. Those allocations are calculated as delivered loads (the loading that actually reaches tidal waters) and as annual loads. These tables are structured by major basin from north to south with western shore first and eastern shore second. The Bay and tidal tributary segments themselves are listed in geographic order from the head of tide down river from north to south. Each of the 92 segments is displayed as white rows while contributing portions of some of the 92 segments are displayed as gray rows. Table 9-4 provides the individual WLAs (annual) for total nitrogen, total phosphorus, and total suspended solids (sediment) for each of the 478 significant permitted dischargers. All WLAs listed in Table 9-4 are calculated as edge-of-stream loads (the loading that reaches a simulated stream segment from a point in that stream's watershed). More detailed LAs and WLAs are provided in Appendix Q for annual TMDLs and in Appendix R for daily TMDLs.

Table 9-1. Chesapeake Bay TMDL total nitrogen (TN) annual allocations[a] (pounds per year) by Chesapeake Bay segment[b] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TN WLA (lbs/yr)	TN Land Based LA (lbs/yr)	TN AtDep[c] LA (lbs/yr)	TN TMDL (lbs/yr)	TN 2009 Existing (lbs/yr)
CB1TF	NY	Northern Chesapeake Bay	1,305,533	7,466,415		8,771,948	10,947,653
CB1TF	PA	Northern Chesapeake Bay	13,938,796	54,965,400		68,904,197	101,652,996
CB1TF	MD	Northern Chesapeake Bay	292,953	1,173,509		1,466,462	1,943,851
CB1TF		Northern Chesapeake Bay	15,537,282	63,605,325	337,488	79,480,095	114,544,499
BSHOH	MD	Bush River	445,589	282,015	68,092	795,696	930,895
GUNOH	PA	Gunpowder River	90	19,866		19,957	30,135
GUNOH	MD	Gunpowder River	255,714	792,403		1,048,117	1,305,958
GUNOH		Gunpowder River	255,804	812,269	73,337	1,141,411	1,336,092
MIDOH	MD	Middle River	31,639	26,896	32,551	91,085	147,687
BACOH	MD	Back River	1,700,239	23,108	25,010	1,748,357	2,233,080
PATMH	MD	Patapsco River	3,475,456	606,149	213,246	4,294,851	7,602,511
MAGMH	MD	Magothy River	48,270	91,496	45,831	185,597	236,865
SEVMH	MD	Severn River	244,630	114,992	64,618	424,239	445,316
SOUMH	MD	South River	49,303	98,704	37,585	185,591	219,201
RHDMH	MD	Rhode River	14,888	20,632	13,683	49,203	53,329
WSTMH	MD	West River	5,292	22,517	18,626	46,435	39,366
WBRTF	MD	Western Branch Patuxent River	97,386	116,500	360	214,246	239,170
PAXTF	MD	Upper Patuxent River	1,110,871	685,570	12,074	1,808,516	1,768,198
PAXOH	MD	Middle Patuxent River	11,563	267,180	28,352	307,095	359,289
PAXMH	MD	Lower Patuxent River	27,816	456,617	148,769	633,203	627,161
ANATF_MD	MD	Anacostia River, MD	294,029	149,357		443,386	507,448
ANATF_MD	DC	Anacostia River, MD	11,055	970		12,026	13,640
ANATF_MD		Anacostia River, MD	305,084	150,327	1,124	456,535	521,088
ANATF_DC	MD	Anacostia River, DC	39,160	6,780		45,940	54,823
ANATF_DC	DC	Anacostia River, DC	41,153	17,652		58,805	131,992
ANATF_DC		Anacostia River, DC	80,313	24,432	7,248	111,993	186,815
POTTF_MD	PA	Upper Potomac River, MD	342,541	4,378,072		4,720,613	6,228,235
POTTF_MD	MD	Upper Potomac River, MD	2,634,386	9,009,270		11,643,656	13,520,999
POTTF_MD	DC	Upper Potomac River, MD	15,397	3,038		18,435	202,365
POTTF_MD	VA	Upper Potomac River, MD	2,189,118	9,815,634		12,004,752	13,761,560

Table 9-1. Chesapeake Bay TMDL total nitrogen (TN) annual allocations[a] (pounds per year) by Chesapeake Bay segment[b] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TN WLA (lbs/yr)	TN Land Based LA (lbs/yr)	TN AtDep[c] LA (lbs/yr)	TN TMDL (lbs/yr)	TN 2009 Existing (lbs/yr)
POTTF_MD	WV	Upper Potomac River, MD	472,895	4,961,651		5,434,546	5,909,347
POTTF_MD		Upper Potomac River, MD	5,654,338	28,167,664	164,918	33,986,920	39,622,506
POTTF_DC	MD	Upper Potomac River, DC	2,102,951	48,466		2,151,417	2,340,588
POTTF_DC	DC	Upper Potomac River, DC	2,205,248	23,829		2,229,078	2,507,384
POTTF_DC	VA	Upper Potomac River, DC	692,389	12,535		704,924	880,860
POTTF_DC		Upper Potomac River, DC	5,000,589	84,831	34,413	5,119,832	5,728,832
POTTF_VA	VA	Upper Potomac River, VA	2,912,791	487,502	74,213	3,474,506	3,634,235
PISTF	MD	Piscataway Creek	426,385	88,969	6,263	521,617	463,644
MATTF	MD	Mattawoman Creek	44,833	124,244	8,762	177,840	198,150
POTOH1_MD	MD	Middle Potomac River, MD Mainstem	2,259	46,281		48,540	55,152
POTOH1_MD	VA	Middle Potomac River, MD Mainstem	5,603	24,015		29,617	33,122
POTOH1_MD		Middle Potomac River, MD Mainstem	7,862	70,296	309,297	387,455	88,274
POTOH2_MD	MD	Middle Potomac River, MD Nangemoy Creek	41,351	81,080	13,562	135,993	136,802
POTOH3_MD	MD	Middle Potomac River, MD Port Tobacco River	6,165	102,258	19,613	128,036	121,907
POTOH_VA	VA	Middle Potomac River, VA	144,881	366,024	36,719	547,624	569,992
POTMH_MD	MD	Lower Potomac River, MD	200,139	933,683		1,133,822	1,370,808
POTMH_MD	VA	Lower Potomac River, MD	168	57,574		57,742	78,506
POTMH_MD		Lower Potomac River, MD	200,307	991,257	1,047,100	2,238,664	1,449,314
POTMH_VA	VA	Lower Potomac River, VA	127,796	877,532	81,362	1,086,690	1,280,940
RPPTF	VA	Upper Rappahannock River	713,032	3,427,258	52,969	4,193,259	4,724,938
RPPOH	VA	Middle Rappahannock River	438	203,619	28,473	232,530	273,194
RPPMH	VA	Lower Rappahannock River	56,873	961,971	522,040	1,540,883	1,353,400
CRRMH	VA	Corrotoman River	21,563	135,107	37,232	193,902	177,281
MPNTF	VA	Upper Mattaponi River	55,429	971,640	19,845	1,046,913	1,268,961
MPNOH	VA	Lower Mattaponi River	11,425	125,500	15,545	152,470	172,806
PMKTF	VA	Upper Pamunkey River	313,111	1,602,061	22,674	1,937,846	2,137,617
PMKOH	VA	Lower Pamunkey River	301,581	64,773	16,059	382,413	311,629
PIAMH	VA	Piankatank River	32,045	313,841	72,763	418,650	394,383

Table 9-1. Chesapeake Bay TMDL total nitrogen (TN) annual allocations[a] (pounds per year) by Chesapeake Bay segment[b] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TN WLA (lbs/yr)	TN Land Based LA (lbs/yr)	TN AtDep[c] LA (lbs/yr)	TN TMDL (lbs/yr)	TN 2009 Existing (lbs/yr)
YRKMH	VA	Middle York River	15,026	333,648	164,516	513,189	428,617
YRKPH	VA	Lower York River	61,648	107,505	119,007	288,160	165,661
MOBPH	VA	Mobjack Bay	712,032	351,903	366,485	1,430,420	1,518,048
JMSTF2	WV	Upper James River Upper	376	17,325		17,701	23,854
JMSTF2	VA	Upper James River Upper	5,013,858	8,298,038		13,311,896	15,313,468
JMSTF2		Upper James River Upper	5,014,234	8,315,363	178,108	13,507,705	15,337,322
JMSTF1	VA	Upper James River Lower	2,551,063	531,401	30,245	3,112,709	3,440,277
APPTF	VA	Appomattox River	421,341	1,392,078	26,741	1,840,160	2,169,402
CHKOH	VA	Chickahominy River	46,371	300,704	37,675	384,750	407,317
JMSOH	VA	Middle James River	278,731	275,044	207,608	761,382	730,672
JMSMH	VA	Lower James River	480,063	733,761	590,001	1,803,824	1,960,753
JMSPH	VA	Mouth of James River	1,022,650	7,286	116,792	1,146,728	3,346,988
ELIPH	VA	Mouth to mid Elizabeth River	418,811	10,120	52,778	481,709	1,233,036
WBEMH	VA	Western Branch Elizabeth River	119,709	29,560	14,005	163,274	161,521
SBEMH	VA	Southern Branch Elizabeth River	246,851	76,507	18,868	342,226	416,080
EBEMH	VA	Eastern Branch Elizabeth River	162,243	9,662	14,810	186,716	263,580
LAFMH	VA	Lafayette River	70,367	1,941	7,274	79,582	71,296
LYNPH	VA	Lynnhaven River	409,349	25,873	5,728	440,951	1,850,029
NORTF	PA	Northeast River	1,324	33,132		34,456	55,984
NORTF	MD	Northeast River	55,341	177,361		232,702	253,404
NORTF		Northeast River	56,665	210,493	31,564	298,723	309,388
ELKOH	PA	Elk River	39,372	210,104		249,476	385,703
ELKOH	DE	Elk River	2,193	8,312		10,506	12,615
ELKOH	MD	Elk River	92,717	277,145		369,863	470,335
ELKOH		Elk River	134,283	495,562	83,506	713,351	868,653
C&DOH_DE	DE	C&D Canal, DE	5,787	14,830		20,617	29,732
C&DOH_DE	MD	C&D Canal, DE	1	105		106	193
C&DOH_DE		C&D Canal, DE	5,788	14,935	18,818	39,540	29,925
C&DOH_MD	DE	C&D Canal, MD	15,427	38,028		53,455	72,814
C&DOH_MD	MD	C&D Canal, MD	10,954	37,855		48,808	59,686

Table 9-1. Chesapeake Bay TMDL total nitrogen (TN) annual allocations[a] (pounds per year) by Chesapeake Bay segment[b] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TN WLA (lbs/yr)	TN Land Based LA (lbs/yr)	TN AtDep[c] LA (lbs/yr)	TN TMDL (lbs/yr)	TN 2009 Existing (lbs/yr)
C&DOH_MD		C&D Canal, MD	26,381	75,882	10,602	112,865	132,501
BOHOH	DE	Bohemia River	5,059	31,069		36,128	56,121
BOHOH	MD	Bohemia River	4,676	127,984		132,660	182,321
BOHOH		Bohemia River	9,735	159,053	34,514	203,302	238,442
SASOH	DE	Sassafras River	266	25,867		26,133	42,936
SASOH	MD	Sassafras River	6,320	253,244		259,563	398,175
SASOH		Sassafras River	6,585	279,111	65,635	351,331	441,111
CHSTF	DE	Upper Chester River	1,973	108,560		110,534	162,575
CHSTF	MD	Upper Chester River	8,590	419,379		427,969	576,551
CHSTF		Upper Chester River	10,563	527,939	13,240	551,742	739,126
CHSOH	MD	Middle Chester River	24,337	491,394	39,045	554,776	802,555
CHSMH	MD	Lower Chester River	48,244	426,553	214,655	689,453	633,424
EASMH	MD	Eastern Bay	33,621	553,829	309,901	897,352	795,200
CHOTF	DE	Upper Choptank River	5,477	247,037		252,514	376,251
CHOTF	MD	Upper Choptank River	38,113	1,117,792		1,155,905	1,479,532
CHOTF		Upper Choptank River	43,590	1,364,829	33,376	1,441,796	1,855,784
CHOOH	MD	Middle Choptank River	56,463	475,043	59,131	590,637	653,485
CHOMH2	MD	Mouth of Choptank River	112,961	239,223	130,585	482,769	385,997
CHOMH1	MD	Lower Choptank River	8,904	282,914	257,748	549,565	380,753
LCHMH	MD	Little Choptank River	1,454	179,887	102,495	283,836	225,829
HNGMH	MD	Honga River	494	46,750	96,162	143,406	59,280
FSBMH	MD	Fishing Bay	12,125	617,858	81,039	711,023	792,951
NANTF_DE	DE	Upper Nanticoke, DE	320,160	1,689,986		2,010,146	2,773,808
NANTF_DE	MD	Upper Nanticoke, DE	210	16,295		16,506	25,772
NANTF_DE		Upper Nanticoke, DE	320,371	1,706,282	33,839	2,060,492	2,799,580
NANTF_MD	DE	Upper Nanticoke, MD	0	231		231	355
NANTF_MD	MD	Upper Nanticoke, MD	6,883	50,104		56,986	67,870
NANTF_MD		Upper Nanticoke, MD	6,883	50,335	39,790	97,007	68,226
NANOH	DE	Middle Nanticoke River	6,253	322,431		328,684	475,395
NANOH	MD	Middle Nanticoke River	56,861	605,179		662,040	838,869

Table 9-1. Chesapeake Bay TMDL total nitrogen (TN) annual allocations[a] (pounds per year) by Chesapeake Bay segment[b] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TN WLA (lbs/yr)	TN Land Based LA (lbs/yr)	TN AtDep[c] LA (lbs/yr)	TN TMDL (lbs/yr)	TN 2009 Existing (lbs/yr)
NANOH		Middle Nanticoke River	63,114	927,610	39,025	1,029,748	1,314,264
NANMH	MD	Lower Nanticoke River	2,120	111,021	66,561	179,702	127,980
WICMH	DE	Wicomico River	1,926	6,610		8,536	12,256
WICMH	MD	Wicomico River	147,286	500,869		648,154	902,542
WICMH		Wicomico River	149,212	507,479	81,392	738,082	914,798
MANMH	MD	Manokin River	42,169	211,375	88,913	342,457	249,077
BIGMH	MD	Big Annemessex River	2,677	71,365	71,912	145,954	80,947
POCTF	DE	Upper Pocomoke River	1,603	91,833		93,436	132,227
POCTF	MD	Upper Pocomoke River	39,327	767,616		806,943	887,951
POCTF		Upper Pocomoke River	40,931	859,449	20,328	920,708	1,020,178
POCOH_MD	MD	Middle Pocomoke River, MD	2,353	61,218	44,935	108,506	72,356
POCOH_VA	MD	Middle Pocomoke River, VA	770	58,791		59,560	69,459
POCOH_VA	VA	Middle Pocomoke River, VA	3,176	131,816		134,992	185,664
POCOH_VA		Middle Pocomoke River, VA	3,946	190,607	7,659	202,212	255,123
POCMH_MD	MD	Lower Pocomoke River, MD	1,317	92,217	124,041	217,575	99,014
POCMH_VA	VA	Lower Pocomoke River, VA	36,905	203,748	157,367	398,020	510,169
TANMH_MD	MD	Tangier Sound, MD	14,635	86,546	612,332	713,512	120,118
TANMH_VA	VA	Tangier Sound, VA	0	5,583	307,485	313,068	5,823
CB2OH	MD	Upper Chesapeake Bay	22,867	252,884	434,345	710,096	404,690
CB3MH	MD	Upper Central Chesapeake Bay	113,726	72,325	529,188	715,239	193,692
CB4MH	MD	Middle Central Chesapeake Bay	69,854	232,568	1,188,056	1,490,477	393,898
CB5MH_MD	MD	Lower Central Chesapeake Bay, MD	74,462	86,384	957,593	1,118,439	208,367
CB5MH_VA	VA	Lower Central Chesapeake Bay, VA	65,831	312,716	594,229	972,776	483,600
CB6PH	VA	Western Lower Chesapeake Bay	80	26,860	707,095	734,034	32,282
CB7PH	VA	Eastern Lower Chesapeake Bay	52,274	874,208	1,739,897	2,666,379	1,301,326
CB8PH	VA	Mouth of Chesapeake Bay	135,685	24,511	609,543	769,739	162,895
All	All	All	53,358,309	132,563,059	15,700,000	201,621,368	249,262,775

a. MOS is implicit for nitrogen (see Section 6.2.4)

b. Each of the 92 segments is displayed as white rows while contributing portions of some of the 92 segments are displayed as gray rows.

c. AtDep means atmospheric deposition only for direct deposition to tidal waters.

Note: Any differences between this table and Table 8-5 are due to rounding.

Table 9-2. Chesapeake Bay TMDL total phosphorus (TP) annual allocations[a] (pounds per year) by Chesapeake Bay segment[b] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TP WLA (lbs/yr)	TP Land Based LA (lbs/yr)	TP TMDL (lbs/yr)	TP 2009 Existing (lbs/yr)
CB1TF	NY	Northern Chesapeake Bay	101,576	464,126	565,702	801,589
CB1TF	PA	Northern Chesapeake Bay	1,207,756	1,287,074	2,494,830	3,409,157
CB1TF	MD	Northern Chesapeake Bay	23,108	47,626	70,734	82,274
CB1TF		Northern Chesapeake Bay	1,332,440	1,798,827	3,131,267	4,293,020
BSHOH	MD	Bush River	33,173	9,155	42,328	63,813
GUNOH	PA	Gunpowder River	18	983	1,001	1,062
GUNOH	MD	Gunpowder River	17,669	20,713	38,382	58,656
GUNOH		Gunpowder River	17,686	21,697	39,383	59,719
MIDOH	MD	Middle River	3,392	440	3,832	11,819
BACOH	MD	Back River	95,781	788	96,569	75,530
PATMH	MD	Patapsco River	212,595	14,772	227,366	397,260
MAGMH	MD	Magothy River	5,910	1,772	7,682	20,754
SEVMH	MD	Severn River	23,149	3,499	26,647	50,568
SOUMH	MD	South River	6,620	5,232	11,852	19,690
RHDMH	MD	Rhode River	1,339	1,962	3,301	4,354
WSTMH	MD	West River	960	2,123	3,083	4,227
WBRTF	MD	Western Branch Patuxent River	15,001	6,353	21,354	26,163
PAXTF	MD	Upper Patuxent River	98,055	41,553	139,607	150,585
PAXOH	MD	Middle Patuxent River	3,081	20,573	23,654	31,358
PAXMH	MD	Lower Patuxent River	16,584	30,632	47,216	63,861
ANATF_MD	MD	Anacostia River, MD	33,237	7,208	40,445	61,485
ANATF_MD	DC	Anacostia River, MD	1,433	95	1,528	2,705
ANATF_MD		Anacostia River, MD	34,669	7,303	41,973	64,190
ANATF_DC	MD	Anacostia River, DC	6,384	357	6,741	10,799
ANATF_DC	DC	Anacostia River, DC	6,845	2,283	9,129	27,387
ANATF_DC		Anacostia River, DC	13,229	2,641	15,870	38,186
POTTF_MD	PA	Upper Potomac River, MD	59,991	361,850	421,841	537,617
POTTF_MD	MD	Upper Potomac River, MD	194,657	379,011	573,668	696,408
POTTF_MD	DC	Upper Potomac River, MD	619	65	685	21,433

Table 9-2. Chesapeake Bay TMDL total phosphorus (TP) annual allocations[a] (pounds per year) by Chesapeake Bay segment[b] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TP WLA (lbs/yr)	TP Land Based LA (lbs/yr)	TP TMDL (lbs/yr)	TP 2009 Existing (lbs/yr)
POTTF_MD	VA	Upper Potomac River, MD	208,723	780,655	989,378	1,591,680
POTTF_MD	WV	Upper Potomac River, MD	63,734	519,726	583,459	819,300
POTTF_MD		Upper Potomac River, MD	527,724	2,041,307	2,569,031	3,666,438
POTTF_DC	MD	Upper Potomac River, DC	99,835	1,511	101,347	46,383
POTTF_DC	DC	Upper Potomac River, DC	107,806	1,801	109,607	34,853
POTTF_DC	VA	Upper Potomac River, DC	36,476	397	36,873	30,368
POTTF_DC		Upper Potomac River, DC	244,117	3,710	247,827	111,604
POTTF_VA	VA	Upper Potomac River, VA	201,920	32,105	234,026	193,977
PISTF	MD	Piscataway Creek	26,339	5,481	31,820	25,394
MATTF	MD	Mattawoman Creek	8,741	6,889	15,630	20,655
POTOH1_MD	MD	Middle Potomac River, MD Mainstem	592	3,603	4,195	4,415
POTOH1_MD	VA	Middle Potomac River, MD Mainstem	1,033	1,722	2,755	3,077
POTOH1_MD		Middle Potomac River, MD Mainstem	1,624	5,325	6,950	7,492
POTOH2_MD	MD	Middle Potomac River, MD Nangemoy Creek	4,809	5,234	10,043	11,413
POTOH3_MD	MD	Middle Potomac River, MD Port Tobacco River	1,116	8,243	9,358	9,972
POTOH_VA	VA	Middle Potomac River, VA	14,012	23,931	37,943	38,482
POTMH_MD	MD	Lower Potomac River, MD	22,450	88,603	111,053	125,786
POTMH_MD	VA	Lower Potomac River, MD	29	5,270	5,300	7,079
POTMH_MD		Lower Potomac River, MD	22,479	93,873	116,352	132,864
POTMH_VA	VA	Lower Potomac River, VA	14,146	84,514	98,660	135,581
RPPTF	VA	Upper Rappahannock River	99,695	630,035	729,730	875,321
RPPOH	VA	Middle Rappahannock River	51	19,923	19,974	23,141
RPPMH	VA	Lower Rappahannock River	7,522	94,953	102,475	130,960
CRRMH	VA	Corrotoman River	2,406	11,569	13,975	16,049
MPNTF	VA	Upper Mattaponi River	12,270	72,110	84,380	102,834
MPNOH	VA	Lower Mattaponi River	787	11,291	12,078	15,988
PMKTF	VA	Upper Pamunkey River	35,785	133,955	169,740	201,331
PMKOH	VA	Lower Pamunkey River	59,373	5,525	64,898	61,342
PIAMH	VA	Piankatank River	5,207	38,034	43,241	49,451
YRKMH	VA	Middle York River	2,736	28,149	30,885	39,514

Table 9-2. Chesapeake Bay TMDL total phosphorus (TP) annual allocations[a] (pounds per year) by Chesapeake Bay segment[b] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TP WLA (lbs/yr)	TP Land Based LA (lbs/yr)	TP TMDL (lbs/yr)	TP 2009 Existing (lbs/yr)
YRKPH	VA	Lower York River	7,994	7,734	15,727	16,751
MOBPH	VA	Mobjack Bay	85,291	27,892	113,183	127,487
JMSTF2	WV	Upper James River Upper	107	9,645	9,752	13,917
JMSTF2	VA	Upper James River Upper	496,605	999,919	1,496,524	1,973,287
JMSTF2		Upper James River Upper	496,712	1,009,564	1,506,276	1,987,204
JMSTF1	VA	Upper James River Lower	103,556	46,904	150,460	131,562
APPTF	VA	Appomattox River	46,961	130,326	177,287	241,572
CHKOH	VA	Chickahominy River	19,822	47,781	67,603	79,799
JMSOH	VA	Middle James River	19,360	19,766	39,125	74,626
JMSMH	VA	Lower James River	70,805	70,647	141,451	187,692
JMSPH	VA	Mouth of James River	82,383	330	82,712	194,769
ELIPH	VA	Mouth to mid Elizabeth River	23,109	579	23,689	63,685
WBEMH	VA	Western Branch Elizabeth River	20,931	2,153	23,083	25,012
SBEMH	VA	Southern Branch Elizabeth River	44,856	5,994	50,850	68,406
EBEMH	VA	Eastern Branch Elizabeth River	32,418	637	33,055	45,115
LAFMH	VA	Lafayette River	11,703	128	11,831	13,403
LYNPH	VA	Lynnhaven River	43,629	1,816	45,445	123,014
NORTF	PA	Northeast River	141	1,439	1,580	2,214
NORTF	MD	Northeast River	5,334	6,600	11,934	13,211
NORTF		Northeast River	5,475	8,039	13,515	15,425
ELKOH	PA	Elk River	4,606	7,752	12,357	17,281
ELKOH	DE	Elk River	317	441	758	911
ELKOH	MD	Elk River	9,506	15,600	25,106	30,123
ELKOH		Elk River	14,428	23,793	38,221	48,315
C&DOH_DE	DE	C&D Canal, DE	897	1,855	2,752	3,379
C&DOH_DE	MD	C&D Canal, DE	0	13	13	37
C&DOH_DE		C&D Canal, DE	897	1,867	2,765	3,415
C&DOH_MD	DE	C&D Canal, MD	2,323	3,601	5,924	7,212
C&DOH_MD	MD	C&D Canal, MD	1,742	3,413	5,155	6,496
C&DOH_MD		C&D Canal, MD	4,065	7,013	11,079	13,708

Table 9-2. Chesapeake Bay TMDL total phosphorus (TP) annual allocations[a] (pounds per year) by Chesapeake Bay segment[b] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TP WLA (lbs/yr)	TP Land Based LA (lbs/yr)	TP TMDL (lbs/yr)	TP 2009 Existing (lbs/yr)
BOHOH	DE	Bohemia River	807	4,134	4,941	6,017
BOHOH	MD	Bohemia River	735	13,191	13,927	20,230
BOHOH		Bohemia River	1,543	17,326	18,868	26,246
SASOH	DE	Sassafras River	42	3,629	3,671	4,469
SASOH	MD	Sassafras River	1,675	28,505	30,180	36,981
SASOH		Sassafras River	1,716	32,134	33,851	41,450
CHSTF	DE	Upper Chester River	304	12,791	13,095	16,298
CHSTF	MD	Upper Chester River	1,467	45,823	47,290	52,108
CHSTF		Upper Chester River	1,771	58,614	60,385	68,407
CHSOH	MD	Middle Chester River	4,798	54,074	58,872	67,837
CHSMH	MD	Lower Chester River	5,961	44,742	50,703	52,278
EASMH	MD	Eastern Bay	2,630	61,927	64,557	71,988
CHOTF	DE	Upper Choptank River	1,101	31,531	32,631	41,664
CHOTF	MD	Upper Choptank River	5,779	116,838	122,617	147,321
CHOTF		Upper Choptank River	6,880	148,368	155,248	188,985
CHOOH	MD	Middle Choptank River	5,145	55,704	60,850	63,666
CHOMH2	MD	Mouth of Choptank River	9,873	28,001	37,874	41,658
CHOMH1	MD	Lower Choptank River	1,683	33,233	34,915	40,931
LCHMH	MD	Little Choptank River	229	19,780	20,008	22,960
HNGMH	MD	Honga River	75	4,314	4,389	6,603
FSBMH	MD	Fishing Bay	1,440	67,261	68,701	78,173
NANTF_DE	DE	Upper Nanticoke, DE	25,589	128,715	154,304	181,200
NANTF_DE	MD	Upper Nanticoke, DE	48	1,752	1,800	2,901
NANTF_DE		Upper Nanticoke, DE	25,637	130,467	156,104	184,100
NANTF_MD	DE	Upper Nanticoke, MD	0	18	18	22
NANTF_MD	MD	Upper Nanticoke, MD	1,147	6,057	7,204	7,011
NANTF_MD		Upper Nanticoke, MD	1,147	6,076	7,223	7,033
NANOH	DE	Middle Nanticoke River	983	33,399	34,382	42,964
NANOH	MD	Middle Nanticoke River	7,398	67,078	74,475	84,307
NANOH		Middle Nanticoke River	8,381	100,477	108,858	127,271

Table 9-2. Chesapeake Bay TMDL total phosphorus (TP) annual allocations[a] (pounds per year) by Chesapeake Bay segment[b] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TP WLA (lbs/yr)	TP Land Based LA (lbs/yr)	TP TMDL (lbs/yr)	TP 2009 Existing (lbs/yr)
NANMH	MD	Lower Nanticoke River	238	9,550	9,788	11,165
WICMH	DE	Wicomico River	295	496	792	969
WICMH	MD	Wicomico River	13,499	45,386	58,884	85,428
WICMH		Wicomico River	13,794	45,882	59,676	86,397
MANMH	MD	Manokin River	6,225	22,502	28,727	25,686
BIGMH	MD	Big Annemessex River	405	7,462	7,867	8,318
POCTF	DE	Upper Pocomoke River	326	8,212	8,538	10,255
POCTF	MD	Upper Pocomoke River	4,437	84,571	89,007	95,447
POCTF		Upper Pocomoke River	4,763	92,783	97,546	105,702
POCOH_MD	MD	Middle Pocomoke River, MD	991	6,981	7,972	8,174
POCOH_VA	MD	Middle Pocomoke River, VA	234	7,255	7,490	7,781
POCOH_VA	VA	Middle Pocomoke River, VA	547	14,959	15,506	20,922
POCOH_VA		Middle Pocomoke River, VA	782	22,214	22,996	28,703
POCMH_MD	MD	Lower Pocomoke River, MD	194	10,453	10,646	11,173
POCMH_VA	VA	Lower Pocomoke River, VA	2,587	21,905	24,493	31,873
TANMH_MD	MD	Tangier Sound, MD	1,353	6,051	7,405	8,275
TANMH_VA	VA	Tangier Sound, VA	0	492	492	527
CB2OH	MD	Upper Chesapeake Bay	3,063	25,092	28,155	34,772
CB3MH	MD	Upper Central Chesapeake Bay	9,263	6,948	16,211	23,949
CB4MH	MD	Middle Central Chesapeake Bay	7,487	14,191	21,678	35,651
CB5MH_MD	MD	Lower Central Chesapeake Bay, MD	5,766	6,977	12,744	28,818
CB5MH_VA	VA	Lower Central Chesapeake Bay, VA	6,100	29,609	35,710	45,025
CB6PH	VA	Western Lower Chesapeake Bay	7	2,277	2,284	2,773
CB7PH	VA	Eastern Lower Chesapeake Bay	5,565	96,646	102,211	140,064
CB8PH	VA	Mouth of Chesapeake Bay	23,848	1,161	25,009	30,461
All	All	All	4,512,260	8,030,114	12,542,374	16,462,955

a. MOS is implicit for phosphorus (see Section 6.2.4)

b. Each of the 92 segments is displayed as white rows while contributing portions of some of the 92 segments are displayed as gray rows.

Note: Any differences between this table and Table 8-5 are due to rounding.

Table 9-3. Chesapeake Bay TMDL sediment (TSS)[a] annual allocations[b] (pounds per year) by Chesapeake Bay segment[c] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TSS WLA (lbs/yr)	TSS LA (lbs/yr)	TSS TMDL (lbs/yr)	TSS 2009 Existing (lbs/yr)
CB1TF	NY	Northern Chesapeake Bay	42,014,121	250,946,605	292,960,727	337,266,496
CB1TF	PA	Northern Chesapeake Bay	152,686,225	1,588,480,781	1,741,167,006	2,286,387,566
CB1TF	MD	Northern Chesapeake Bay	5,949,689	64,361,278	70,310,967	81,125,570
CB1TF		Northern Chesapeake Bay	200,650,035	1,903,788,665	2,104,438,699	2,704,779,632
BSHOH	MD	Bush River	13,196,649	15,973,700	29,170,349	35,527,626
GUNOH	PA	Gunpowder River	3,892	368,273	372,165	765,816
GUNOH	MD	Gunpowder River	9,239,345	38,001,024	47,240,369	58,189,414
GUNOH		Gunpowder River	9,243,237	38,369,297	47,612,534	58,955,230
MIDOH	MD	Middle River	509,743	236,484	746,227	1,576,785
BACOH	MD	Back River	15,955,266	410,195	16,365,461	9,421,900
PATMH	MD	Patapsco River	56,849,993	31,375,105	88,225,098	113,667,512
MAGMH	MD	Magothy River	901,450	535,226	1,436,676	2,101,536
SEVMH	MD	Severn River	2,991,739	935,655	3,927,394	3,716,445
SOUMH	MD	South River	1,090,181	1,071,766	2,161,947	3,022,869
RHDMH	MD	Rhode River	172,442	474,811	647,253	739,818
WSTMH	MD	West River	118,448	634,597	753,044	998,390
WBRTF	MD	Western Branch Patuxent River	9,492,711	10,104,173	19,596,885	23,382,999
PAXTF	MD	Upper Patuxent River	27,928,151	40,733,517	68,661,668	67,673,319
PAXOH	MD	Middle Patuxent River	501,122	7,721,654	8,222,777	10,784,126
PAXMH	MD	Lower Patuxent River	853,761	8,070,930	8,924,690	12,133,210
ANATF_MD	MD	Anacostia River, MD	47,005,706	22,921,343	69,927,049	111,245,825
ANATF_MD	DC	Anacostia River, MD	317,718	21,960	339,678	609,892
ANATF_MD		Anacostia River, MD	47,323,423	22,943,303	70,266,727	111,855,717
ANATF_DC	MD	Anacostia River, DC	790,954	90,167	881,121	1,620,633
ANATF_DC	DC	Anacostia River, DC	1,616,149	511,485	2,127,634	4,743,620
ANATF_DC		Anacostia River, DC	2,407,104	601,651	3,008,755	6,364,253
POTTF_MD	PA	Upper Potomac River, MD	7,119,122	213,989,662	221,108,783	309,605,976
POTTF_MD	MD	Upper Potomac River, MD	65,621,675	430,700,804	496,322,479	549,338,715
POTTF_MD	DC	Upper Potomac River, MD	446,556	47,439	493,995	18,182,239
POTTF_MD	VA	Upper Potomac River, MD	52,111,881	645,079,928	697,191,809	955,858,637

Table 9-3. Chesapeake Bay TMDL sediment (TSS) [a] annual allocations[b] (pounds per year) by Chesapeake Bay segment[c] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TSS WLA (lbs/yr)	TSS LA (lbs/yr)	TSS TMDL (lbs/yr)	TSS 2009 Existing (lbs/yr)
POTTF_MD	WV	Upper Potomac River, MD	4,251,816	289,983,789	294,235,605	349,862,416
POTTF_MD		Upper Potomac River, MD	129,551,049	1,579,801,621	1,709,352,671	2,182,847,983
POTTF_DC	MD	Upper Potomac River, DC	26,116,504	6,077,446	32,193,949	25,474,106
POTTF_DC	DC	Upper Potomac River, DC	6,290,046	1,906,768	8,196,814	8,467,385
POTTF_DC	VA	Upper Potomac River, DC	7,990,096	348,443	8,338,540	6,385,015
POTTF_DC		Upper Potomac River, DC	40,396,647	8,332,657	48,729,304	40,326,507
POTTF_VA	VA	Upper Potomac River, VA	73,817,620	23,707,878	97,525,497	101,055,750
PISTF	MD	Piscataway Creek	4,420,894	3,164,315	7,585,209	6,198,882
MATTF	MD	Mattawoman Creek	2,164,085	3,781,157	5,945,242	6,897,769
POTOH1_MD	MD	Middle Potomac River, MD Mainstem	141,182	1,503,199	1,644,382	1,928,927
POTOH1_MD	VA	Middle Potomac River, MD Mainstem	126,225	192,470	318,695	374,540
POTOH1_MD		Middle Potomac River, MD Mainstem	267,408	1,695,669	1,963,077	2,303,467
POTOH2_MD	MD	Middle Potomac River, MD Nangemoy Creek	517,854	1,777,500	2,295,354	2,662,195
POTOH3_MD	MD	Middle Potomac River, MD Port Tobacco River	173,198	2,851,267	3,024,465	3,509,912
POTOH_VA	VA	Middle Potomac River, VA	6,193,677	7,882,449	14,076,126	17,280,595
POTMH_MD	MD	Lower Potomac River, MD	7,436,553	53,034,527	60,471,080	72,595,650
POTMH_MD	VA	Lower Potomac River, MD	9,492	490,435	499,928	682,793
POTMH_MD		Lower Potomac River, MD	7,446,045	53,524,962	60,971,007	73,278,444
POTMH_VA	VA	Lower Potomac River, VA	604,405	6,899,027	7,503,432	10,266,702
RPPTF	VA	Upper Rappahannock River	21,344,146	624,671,576	646,015,721	709,235,879
RPPOH	VA	Middle Rappahannock River	7,877	9,936,097	9,943,973	1,225,958
RPPMH	VA	Lower Rappahannock River	904,914	37,705,787	38,610,700	38,050,038
CRRMH	VA	Corrotoman River	32,486	1,064,500	1,096,986	1,275,873
MPNTF	VA	Upper Mattaponi River	1,092,098	13,603,734	14,695,833	22,576,525
MPNOH	VA	Lower Mattaponi River	59,447	1,105,563	1,165,010	1,604,598
PMKTF	VA	Upper Pamunkey River	6,026,107	47,032,619	53,058,726	84,819,341
PMKOH	VA	Lower Pamunkey River	13,086,736	674,771	13,761,507	1,518,896
PIAMH	VA	Piankatank River	803,391	9,372,914	10,176,305	13,746,640
YRKMH	VA	Middle York River	290,754	10,716,330	11,007,084	4,087,532
YRKPH	VA	Lower York River	514,729	968,271	1,483,000	2,101,402

Table 9-3. Chesapeake Bay TMDL sediment (TSS) [a] annual allocations[b] (pounds per year) by Chesapeake Bay segment[c] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TSS WLA (lbs/yr)	TSS LA (lbs/yr)	TSS TMDL (lbs/yr)	TSS 2009 Existing (lbs/yr)
MOBPH	VA	Mobjack Bay	8,727,001	3,433,596	12,160,596	14,112,361
JMSTF2	WV	Upper James River Upper	35,199	16,609,948	16,645,148	28,519,899
JMSTF2	VA	Upper James River Upper	67,286,234	612,850,612	680,136,846	1,059,920,428
JMSTF2		Upper James River Upper	67,321,434	629,460,560	696,781,994	1,088,440,327
JMSTF1	VA	Upper James River Lower	15,607,897	24,690,254	40,298,151	9,015,473
APPTF	VA	Appomattox River	26,032,004	62,293,157	88,325,161	106,140,533
CHKOH	VA	Chickahominy River	939,747	18,584,599	19,524,346	4,841,974
JMSOH	VA	Middle James River	2,999,553	20,449,110	23,448,664	6,690,974
JMSMH	VA	Lower James River	7,332,882	27,529,658	34,862,540	25,514,847
JMSPH	VA	Mouth of James River	11,502,783	34,350	11,537,133	6,505,447
ELIPH	VA	Mouth to mid Elizabeth River	4,694,148	52,510	4,746,658	3,056,281
WBEMH	VA	Western Branch Elizabeth River	2,006,272	147,738	2,154,010	2,636,798
SBEMH	VA	Southern Branch Elizabeth River	3,556,563	375,463	3,932,026	4,741,119
EBEMH	VA	Eastern Branch Elizabeth River	3,356,476	24,188	3,380,664	4,406,458
LAFMH	VA	Lafayette River	1,977,709	12,922	1,990,631	2,336,093
LYNPH	VA	Lynnhaven River	7,233,702	174,719	7,408,420	7,882,520
NORTF	PA	Northeast River	52,337	2,078,118	2,130,456	3,258,381
NORTF	MD	Northeast River	3,822,591	10,695,417	14,518,008	16,472,012
NORTF		Northeast River	3,874,928	12,773,535	16,648,463	19,730,393
ELKOH	PA	Elk River	950,124	18,055,981	19,006,105	28,398,346
ELKOH	DE	Elk River	31,854	64,385	96,239	106,497
ELKOH	MD	Elk River	1,639,790	7,052,756	8,692,546	9,998,038
ELKOH		Elk River	2,621,768	25,173,121	27,794,890	38,502,881
C&DOH_DE	DE	C&D Canal, DE	140,066	414,748	554,814	626,615
C&DOH_DE	MD	C&D Canal, DE	14	4,012	4,026	4,677
C&DOH_DE		C&D Canal, DE	140,079	418,760	558,840	631,292
C&DOH_MD	DE	C&D Canal, MD	336,975	825,087	1,162,062	1,291,350
C&DOH_MD	MD	C&D Canal, MD	107,601	969,513	1,077,114	1,258,787
C&DOH_MD		C&D Canal, MD	444,576	1,794,600	2,239,176	2,550,137
BOHOH	DE	Bohemia River	65,521	514,661	580,182	624,140

Table 9-3. Chesapeake Bay TMDL sediment (TSS) [a] annual allocations[b] (pounds per year) by Chesapeake Bay segment[c] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TSS WLA (lbs/yr)	TSS LA (lbs/yr)	TSS TMDL (lbs/yr)	TSS 2009 Existing (lbs/yr)
BOHOH	MD	Bohemia River	64,402	3,167,619	3,232,020	3,777,673
BOHOH		Bohemia River	129,923	3,682,279	3,812,203	4,401,813
SASOH	DE	Sassafras River	5,525	642,671	648,196	684,780
SASOH	MD	Sassafras River	286,930	8,289,784	8,576,714	10,011,983
SASOH		Sassafras River	292,455	8,932,455	9,224,910	10,696,763
CHSTF	DE	Upper Chester River	93,984	2,860,897	2,954,881	3,357,254
CHSTF	MD	Upper Chester River	137,542	12,094,797	12,232,339	13,409,995
CHSTF		Upper Chester River	231,526	14,955,694	15,187,220	16,767,249
CHSOH	MD	Middle Chester River	298,598	9,332,711	9,631,310	10,775,054
CHSMH	MD	Lower Chester River	528,519	12,292,064	12,820,583	14,312,931
EASMH	MD	Eastern Bay	576,343	9,815,207	10,391,551	11,324,723
CHOTF	DE	Upper Choptank River	361,498	6,182,065	6,543,563	7,462,694
CHOTF	MD	Upper Choptank River	1,261,836	17,937,463	19,199,299	20,356,821
CHOTF		Upper Choptank River	1,623,334	24,119,528	25,742,862	27,819,515
CHOOH	MD	Middle Choptank River	558,079	4,015,407	4,573,486	4,510,268
CHOMH2	MD	Mouth of Choptank River	966,759	2,978,930	3,945,688	3,789,712
CHOMH1	MD	Lower Choptank River	386,256	4,567,610	4,953,867	5,815,588
LCHMH	MD	Little Choptank River	98,483	3,097,933	3,196,416	3,487,049
HNGMH	MD	Honga River	10,644	531,405	542,049	646,232
FSBMH	MD	Fishing Bay	81,663	4,576,273	4,657,936	5,111,822
NANTF_DE	DE	Upper Nanticoke, DE	10,827,397	27,256,751	38,084,149	42,177,643
NANTF_DE	MD	Upper Nanticoke, DE	5,894	104,157	110,051	128,452
NANTF_DE		Upper Nanticoke, DE	10,833,291	27,360,908	38,194,199	42,306,095
NANTF_MD	DE	Upper Nanticoke, MD	0	680	680	721
NANTF_MD	MD	Upper Nanticoke, MD	28,289	495,823	524,111	557,353
NANTF_MD		Upper Nanticoke, MD	28,289	496,502	524,791	558,073
NANOH	DE	Middle Nanticoke River	361,062	6,223,525	6,584,587	7,739,104
NANOH	MD	Middle Nanticoke River	817,307	6,910,025	7,727,332	8,184,073
NANOH		Middle Nanticoke River	1,178,369	13,133,549	14,311,918	15,923,178
NANMH	MD	Lower Nanticoke River	40,737	743,265	784,002	827,854

Table 9-3. Chesapeake Bay TMDL sediment (TSS) [a] annual allocations[b] (pounds per year) by Chesapeake Bay segment[c] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TSS WLA (lbs/yr)	TSS LA (lbs/yr)	TSS TMDL (lbs/yr)	TSS 2009 Existing (lbs/yr)
WICMH	DE	Wicomico River	104,196	39,998	144,195	174,874
WICMH	MD	Wicomico River	1,664,605	4,687,746	6,352,351	7,198,430
WICMH		Wicomico River	1,768,802	4,727,744	6,496,545	7,373,305
MANMH	MD	Manokin River	333,932	1,216,362	1,550,294	1,492,064
BIGMH	MD	Big Annemessex River	28,574	602,203	630,777	666,385
POCTF	DE	Upper Pocomoke River	62,520	406,956	469,476	532,895
POCTF	MD	Upper Pocomoke River	481,873	10,323,430	10,805,303	11,359,483
POCTF		Upper Pocomoke River	544,393	10,730,387	11,274,779	11,892,378
POCOH_MD	MD	Middle Pocomoke River, MD	196,894	588,961	785,855	797,483
POCOH_VA	MD	Middle Pocomoke River, VA	46,287	636,117	682,405	718,647
POCOH_VA	VA	Middle Pocomoke River, VA	12,493	653,177	665,670	977,918
POCOH_VA		Middle Pocomoke River, VA	58,780	1,289,295	1,348,075	1,696,564
POCMH_MD	MD	Lower Pocomoke River, MD	55,660	1,264,202	1,319,862	1,370,010
POCMH_VA	VA	Lower Pocomoke River, VA	65,386	1,102,827	1,168,213	1,610,806
TANMH_MD	MD	Tangier Sound, MD	189,923	415,636	605,560	679,354
TANMH_VA	VA	Tangier Sound, VA	18	416,465	416,483	19,960
CB2OH	MD	Upper Chesapeake Bay	383,801	7,474,139	7,857,940	9,344,169
CB3MH	MD	Upper Central Chesapeake Bay	1,022,587	1,957,395	2,979,982	2,646,201
CB4MH	MD	Middle Central Chesapeake Bay	1,058,853	3,258,291	4,317,144	5,413,881
CB5MH_MD	MD	Lower Central Chesapeake Bay, MD	631,522	1,513,513	2,145,035	2,042,464
CB5MH_VA	VA	Lower Central Chesapeake Bay, VA	446,801	3,626,293	4,073,093	5,353,666
CB6PH	VA	Western Lower Chesapeake Bay	453	294,130	294,582	387,639
CB7PH	VA	Eastern Lower Chesapeake Bay	518,824	8,538,667	9,057,491	13,772,993
CB8PH	VA	Mouth of Chesapeake Bay	2,787,517	64,200	2,851,717	3,580,118
All	All	All	898,226,531	5,555,386,665	6,453,613,196	8,090,521,521

a. Upon review and after consideration of public comments, EPA has determined that Total Suspended Solids (TSS) is a more appropriate expression of the sediment load than Total Sediment (TSED), which was used in the draft TMDL. As a result, the allocation tables in the draft TMDL that were expressed as TSED have been changed such that they now are expressed as TSS.

b. MOS is implicit and explicit for TSS (see Section 6.5.4)

c. Each of the 92 segments is displayed as white rows while contributing portions of some of the 92 segments are displayed as gray rows.

Note: Any differences between this table and Table 8-5 are due to rounding.

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
BLUE PLAINS	DC0021199	DC**	POTTF_DC	4,689,000	203,854	8,198,328
INVISTA (DUPONT-SEAFORD)	DE0000035	DE	NANTF_DE	171,818	0	749,208
LAUREL	DE0020125	DE	NANTF_DE	8,528	2,132	31,978
BRIDGEVILLE	DE0020249	DE	NANTF_DE	9,746	2,436	36,547
SEAFORD	DE0020265	DE	NANTF_DE	24,364	6,091	48,729
COX CREEK	MD_COXCRK	MD	PATMH	231,101	3,614	193,606
HART MILLER	MD_HARTMI	MD	MIDOH	0	0	0
MASONVILLE DMCF	MD_MASNV	MD	PATMH	231,101	3,614	193,606
W R GRACE	MD0000311	MD	PATMH	310,721	1,782	334,037
MD & VA MILK PRODUCERS	MD0000469	MD	PAXTF	5,431	543	42,150
ISG SPARROWS POINT (BETHLEHEM STEEL CORP)	MD0001201	MD	PATMH	131,420	25,400	85,863
CONGOLEUM	MD0001384	MD	PATMH	4,005	160	19,324
NEWPAGE	MD0001422	MD	POTTF_MD	12,733	597	124,473
ERACHEM	MD0001775	MD	PATMH	13,809	58	8,352
NSWC-INDIAN HEAD	MD0003158	MD	MATTF	1,777	727	41,937
WINEBRENNER WWTP	MD0003221	MD	POTTF_MD	12,182	914	91,367
CRISFIELD	MD0020001	MD	TANMH_MD	12,182	914	91,367
CHESTERTOWN	MD0020010	MD	CHSMH	18,273	1,371	137,050
INDIAN HEAD	MD0020052	MD	MATTF	6,091	457	45,683
BOONSBORO	MD0020231	MD	POTTF_MD	6,100	484	48,424
FEDERALSBURG	MD0020249	MD	NANOH	9,137	685	68,525
EMMITSBURG	MD0020257	MD	POTTF_MD	9,137	685	68,525
EASTON	MD0020273	MD	CHOOH	48,729	3,655	365,467
CHESAPEAKE BEACH	MD0020281	MD	CB4MH	18,273	1,371	137,050
DENTON	MD0020494	MD	CHOTF	9,746	731	73,093
LA PLATA	MD0020524	MD	POTOH2_MD	18,273	1,371	137,050
DELMAR	MD0020532	MD	WICMH	10,355	777	77,662
PERRYVILLE	MD0020613	MD	CB1TF	20,101	1,508	150,755
PRINCESS ANNE	MD0020656	MD	MANMH	11,512	1,151	115,122

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
TANEYTOWN	MD0020672	MD	POTTF_MD	13,400	1,005	100,503
ELKTON	MD0020681	MD	ELKOH	37,156	2,787	278,669
CENTREVILLE	MD0020834	MD	CHSMH	6,091	457	45,683
BELTSVILLE USDA EAST	MD0020842	MD	ANATF_MD	7,553	566	56,647
FORT DETRICK	MD0020877	MD	POTTF_MD	24,364	1,827	182,734
NSWC-INDIAN HEAD	MD0020885	MD	POTTF_MD	6,091	457	45,683
BRUNSWICK	MD0020958	MD	POTTF_MD	17,055	1,279	127,914
DAMASCUS	MD0020982	MD	POTTF_MD	18,273	1,371	137,050
THURMONT	MD0021121	MD	POTTF_MD	12,182	914	91,367
ABERDEEN PROVING GROUNDS-EDGEWOOD	MD0021229	MD	BSHOH	36,547	2,741	274,100
ABERDEEN PROVING GROUNDS-ABERDEEN	MD0021237	MD	CB1TF	34,110	2,558	255,827
SENECA CREEK	MD0021491	MD	POTTF_MD	316,738	21,380	2,375,537
FREEDOM DISTRICT	MD0021512	MD	PATMH	42,638	3,198	319,784
PISCATAWAY	MD0021539	MD	PISTF	365,467	16,446	2,741,004
BACK RIVER*	MD0021555	MD	BACOH	1,583,691	79,185	11,877,684
BACK RIVER*	MD0021555	MD	PATMH	609,112	30,456	4,568,340
ABERDEEN	MD0021563	MD	CB1TF	48,729	3,655	365,467
SALISBURY	MD0021571	MD	WICMH	103,549	7,766	776,618
CUMBERLAND	MD0021598	MD	POTTF_MD	182,734	13,705	1,370,502
PATAPSCO	MD0021601	MD	PATMH	889,304	66,698	6,669,776
FREDERICK	MD0021610	MD	POTTF_MD	97,458	7,309	730,934
BOWIE	MD0021628	MD	PAXTF	40,201	3,015	301,510
CAMBRIDGE	MD0021636	MD	CHOMH2	98,676	7,401	740,071
BROADNECK	MD0021644	MD	CB3MH	73,093	5,482	548,201
PATUXENT	MD0021652	MD	PAXTF	91,367	6,853	685,251
COX CREEK	MD0021661	MD	PATMH	182,734	13,705	1,370,502
MARLAY TAYLOR (PINE HILL RUN)	MD0021679	MD	CB5MH_MD	73,093	5,482	548,201
UPPER POTOMAC RIVER COMMISSION	MD0021687	MD	POTTF_MD	79,109	30,401	1,982,660
FORT MEADE	MD0021717	MD	PAXTF	54,820	4,112	411,151

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
PARKWAY	MD0021725	MD	PAXTF	91,367	6,853	685,251
WESTERN BRANCH	MD0021741	MD	PAXTF	372,777	27,958	2,795,824
HAVRE DE GRACE	MD0021750	MD	CB1TF	27,715	2,079	207,859
HAGERSTOWN	MD0021776	MD	POTTF_MD	97,458	7,309	730,934
ANNAPOLIS	MD0021814	MD	SEVMH	158,369	11,878	1,187,768
BALLENGER CREEK	MD0021822	MD	POTTF_MD	219,280	16,446	1,644,602
WESTMINSTER	MD0021831	MD	POTTF_MD	60,911	4,568	456,834
MATTAWOMAN	MD0021865	MD	POTTF_MD	243,645	10,964	1,827,336
HAMPSTEAD	MD0022446	MD	GUNOH	10,964	822	82,230
MOUNT AIRY	MD0022527	MD	PATMH	14,619	1,096	109,640
JOPPATOWNE	MD0022535	MD	GUNOH	11,573	868	86,798
POCOMOKE CITY	MD0022551	MD	POCTF	17,908	1,343	134,309
HURLOCK	MD0022730	MD	NANOH	20,101	1,508	150,755
SNOW HILL	MD0022764	MD	POCTF	6,091	457	45,683
MARLBORO MEADOWS	MD0022781	MD	PAXTF	0	0	0
POOLESVILLE	MD0023001	MD	POTTF_MD	9,137	685	68,525
KENT ISLAND	MD0023485	MD	CB3MH	36,547	2,741	274,100
US NAVAL ACADEMY	MD0023523	MD	SEVMH	12,182	914	91,367
TALBOT COUNTY REGION II	MD0023604	MD	EASMH	8,040	603	60,302
MARYLAND CORRECTIONAL INSTITUTE	MD0023957	MD	POTTF_MD	19,492	1,462	146,187
BROADWATER	MD0024350	MD	CB4MH	24,364	1,827	182,734
LEONARDTOWN	MD0024767	MD	POTMH_MD	8,284	621	62,129
NORTHEAST RIVER	MD0052027	MD	NORTF	24,364	1,827	182,734
FRUITLAND	MD0052990	MD	WICMH	9,746	731	73,093
LITTLE PATUXENT	MD0055174	MD	PAXTF	304,556	22,842	2,284,170
SOD RUN	MD0056545	MD	BSHOH	243,645	18,273	1,827,336
SWAN POINT	MD0057525	MD	POTMH_MD	7,309	548	54,820
PINEY ORCHARD	MD0059145	MD	PAXTF	14,619	1,096	109,640
GEORGES CREEK	MD0060071	MD	POTTF_MD	7,309	548	54,820
MAYO LARGE COMMUNAL	MD0061794	MD	RHDMH	9,989	749	74,921
MARYLAND CITY	MD0062596	MD	PAXTF	30,456	2,284	228,417

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
DORSEY RUN	MD0063207	MD	PAXTF	24,364	1,827	182,734
CONOCOCHEAGUE	MD0063509	MD	POTTF_MD	49,947	3,746	374,604
CELANESE	MD0063878	MD	POTTF_MD	24,364	1,827	182,734
ALLEN FAMILY FOODS	MD0067857	MD	CHOTF	4,500	370	62,091
WISE FOODS INC	PA0007498	PA	CB1TF	19,957	898	14,375
EMPIRE KOSHER POULTRY-MIFFLINT	PA0007552	PA	CB1TF	21,928	740	53,602
POPE & TALBOT WIS INC.	PA0007919	PA	CB1TF	40,569	1,941	45,318
GOLD MILLS DYEHOUSE	PA0008231	PA	CB1TF	5,723	198	48,729
APPLETON PAPER SPRINGMILL	PA0008265	PA	CB1TF	61,666	7,367	117,924
MERCK & COMPANY	PA0008419	PA	CB1TF	44,497	11,748	289,937
PPL MONTOUR LLC	PA0008443	PA	CB1TF	72,749	1,200	191,748
NATIONAL GYPSUM COMPANY-MILTON PLANT	PA0008591	PA	CB1TF	2,213	106	7,553
P-H GLATFELTER COMPANY	PA0008869	PA	CB1TF	117,588	6,821	701,697
PROCTOR & GAMBLE PAPER PRODUCTS	PA0008885	PA	CB1TF	100,360	5,441	188,094
OSRAM SYLVANIA PRODUCTS, INC.	PA0009024	PA	CB1TF	600,515	1,577	26,801
CONSOLIDATED RAIL CORPORATION-ENOLA	PA0009229	PA	CB1TF	2,539	93	12,182
HEINZ PET FOODS	PA0009270	PA	CB1TF	30,639	1,449	16,349
MOTTS INC	PA0009326	PA	CB1TF	18,645	729	25,339
USFW-LAMAR NATIONAL FISH HATCHERY	PA0009857	PA	CB1TF	60,138	1,919	147,356
PAPETTI'S ACQUISTION INC (QUAKER STATE FARMS)	PA0009911	PA	CB1TF	8,104	532	7,188
PENNSYLVANIA FISH & BOAT COMMISSION-BENNER SPRINGS	PA0010553	PA	CB1TF	110,347	2,285	224,543
PENNSYLVANIA FISH & BOAT COMMISSION-PLEASANT GAP	PA0010561	PA	CB1TF	55,049	1,591	134,200
BLOSSBURG	PA0020036	PA	CB1TF	7,306	974	9,746
MOUNT UNION BOROUGH	PA0020214	PA	CB1TF	17,351	2,314	23,146
ROARING SPRING BOROUGH	PA0020249	PA	CB1TF	12,785	1,705	17,055

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
MILTON MUNICIPAL AUTHORITY	PA0020273	PA	CB1TF	80,040	8,329	83,326
LITITZ SEWAGE AUTHORITY	PA0020320	PA	CB1TF	70,319	9,376	93,802
KULPMONT-MARION HEIGHTS JT MUN	PA0020338	PA	CB1TF	9,132	1,218	12,182
BELLEFONTE BOROUGH	PA0020486	PA	CB1TF	58,812	7,842	78,453
MCCONNELLSBURG STP	PA0020508	PA	POTTF_MD	10,959	1,461	14,619
NORTHUMBERLAND BOROUGH	PA0020567	PA	CB1TF	20,548	2,740	27,410
MIDDLEBURG MUN AUTH	PA0020583	PA	CB1TF	8,219	1,096	10,964
WAYNESBORO BOROUGH	PA0020621	PA	POTTF_MD	29,223	3,896	38,983
MIDDLETOWN	PA0020664	PA	CB1TF	40,182	5,358	53,601
MONTGOMERY BOROUGH	PA0020699	PA	CB1TF	15,525	2,070	20,710
WHITE DEER TOWNSHIP	PA0020800	PA	CB1TF	10,959	1,461	14,619
GLEN ROCK SEW AUTH	PA0020818	PA	CB1TF	10,959	1,461	14,619
DOVER TOWNSHIP SEWER AUTHORITY	PA0020826	PA	CB1TF	146,117	19,482	194,914
FRANKLIN COUNTY AUTHORITY-GREENCASTLE	PA0020834	PA	POTTF_MD	17,351	2,314	19,491
MECHANICSBURG BOROUGH MUNICIPAL	PA0020885	PA	CB1TF	38,565	5,065	50,678
MANHEIM BOROUGH AUTHORITY	PA0020893	PA	CB1TF	21,847	2,776	27,775
PINE GROVE BOROUGH AUTHORITY	PA0020915	PA	CB1TF	27,397	3,653	36,546
NEW OXFORD MUNICIPAL FACILITY	PA0020923	PA	CB1TF	35,057	4,354	43,563
MOUNT JOY	PA0021067	PA	CB1TF	27,945	3,726	37,277
LITTLESTOWN BOROUGH	PA0021229	PA	POTTF_MD	18,265	2,435	24,364
NEWPORT BORO MUN AUTH	PA0021237	PA	CB1TF	7,306	974	9,746
DUNCANNON BORO	PA0021245	PA	CB1TF	13,516	1,802	18,030
WILLIAMSBURG BOROUGH	PA0021539	PA	CB1TF	9,132	1,218	12,182
GETTYSBURG MUNICIPAL AUTHORITY	PA0021563	PA	POTTF_MD	44,748	5,966	59,692
MARYSVILLE MUNICIPAL AUTHORITY	PA0021571	PA	CB1TF	22,831	3,044	30,455
DOVER BORO	PA0021644	PA	CB1TF	7,306	974	9,746
WELLSBORO MUNICIPAL AUTHORITY	PA0021687	PA	CB1TF	46,029	4,871	48,729
MARIETTA-DONEGAL JOINT AUTHORITY	PA0021717	PA	CB1TF	13,698	1,826	18,273
ANNVILLE TOWNSHIP	PA0021806	PA	CB1TF	13,698	1,826	18,273

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
MANSFIELD BOROUGH	PA0021814	PA	CB1TF	23,744	3,166	31,675
ADAMSTOWN BORO AUTH OF LANCAST	PA0021865	PA	CB1TF	10,959	1,461	14,619
WESTFIELD BORO	PA0021881	PA	CB1TF	8,402	1,120	11,208
NEW HOLLAND BOROUGH AUTHORITY	PA0021890	PA	CB1TF	24,475	3,263	32,648
BEDFORD BOROUGH MUNICIPAL AUTHORITY	PA0022209	PA	CB1TF	27,397	3,653	36,546
MILLERSBURG BOROUGH AUTHORITY	PA0022535	PA	CB1TF	18,265	2,435	24,364
ELIZABETHTOWN BOROUGH	PA0023108	PA	CB1TF	82,191	10,959	109,639
HASTINGS AREA SA	PA0023141	PA	CB1TF	10,959	1,461	14,619
MT. HOLLY SPRINGS BOROUGH AUTHORITY	PA0023183	PA	CB1TF	10,959	1,461	14,619
BERWICK MUNICIPAL AUTHORITY	PA0023248	PA	CB1TF	92,198	8,913	89,173
TWIN BOROUGHS SANITARY AUTHORITY	PA0023264	PA	CB1TF	16,438	2,192	21,928
WRIGHTSVILLE BORO MUN AUTH	PA0023442	PA	CB1TF	7,306	974	9,746
DANVILLE MUNICIPAL AUTHORITY	PA0023531	PA	CB1TF	66,118	8,816	88,199
ASHLAND MUNICIPAL AUTHORITY	PA0023558	PA	CB1TF	23,744	3,166	31,674
TRI-BORO MUNICIPAL AUTHORITY	PA0023736	PA	CB1TF	9,132	1,218	12,182
NORTHEASTERN YORK COUNTRY	PA0023744	PA	CB1TF	46,535	4,627	41,419
HIGHSPIRE	PA0024040	PA	CB1TF	36,529	4,871	48,729
CUMBERLAND TWP AUTH (NORTH PLANT)	PA0024139	PA	POTTF_MD	9,132	1,218	12,182
CUMBERLAND TWP MUN AUTH	PA0024147	PA	POTTF_MD	11,872	1,583	15,837
PENNFIELD FARMS INC (BC NATURAL CHICKEN LLC)	PA0024228	PA	CB1TF	18,982	766	14,619
PALMYRA BOROUGH AUTHORITY	PA0024287	PA	CB1TF	25,936	3,458	34,597
MUNCY BOROUGH MUNICIPAL AUTHORITY	PA0024325	PA	CB1TF	25,570	3,409	34,110
NORTH MIDDLETON AUTH	PA0024384	PA	CB1TF	22,020	2,253	22,537
MT. CARMEL MUNICIPAL SEWAGE AUTHORITY	PA0024406	PA	CB1TF	41,095	5,479	54,816
DILLSBURG BOROUGH AUTHORITY	PA0024431	PA	CB1TF	31,345	3,726	37,277

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
UNION TWP STP	PA0024708	PA	CB1TF	11,872	1,583	15,837
CURWENSVILLE MUNICIPAL AUTHORITY	PA0024759	PA	CB1TF	13,698	1,826	18,273
UPPER ALLEN TOWNSHIP	PA0024902	PA	CB1TF	20,091	2,679	26,801
SAXTON BORO MUN AUTH	PA0025381	PA	CB1TF	7,306	974	9,746
LOCK HAVEN	PA0025933	PA	CB1TF	90,192	9,132	91,366
CHAMBERSBURG BOROUGH	PA0026051	PA	POTTF_MD	124,199	16,560	165,677
CARLISLE BOROUGH	PA0026077	PA	CB1TF	134,277	17,047	170,550
WYOMING VALLEY	PA0026107	PA	CB1TF	584,467	77,929	779,657
COLUMBIA	PA0026123	PA	CB1TF	36,529	4,871	48,729
HUNTINGDON BOROUGH	PA0026191	PA	CB1TF	73,058	9,741	97,457
UNIVERSITY AREA JOINT AUTHORITY	PA0026239	PA	CB1TF	164,381	21,918	219,279
YORK CITY	PA0026263	PA	CB1TF	474,880	63,317	633,471
LEWISTOWN BOROUGH	PA0026280	PA	CB1TF	51,470	6,863	68,659
CLEARFIELD	PA0026310	PA	CB1TF	82,191	10,959	109,639
LOWER LACKAWANNA VALLEY	PA0026361	PA	CB1TF	109,588	14,612	146,186
LEMOYNE BOROUGH MUNICIPAL AUTHORITY	PA0026441	PA	CB1TF	46,270	5,784	50,873
DERRY TOWNSHIP MUNICIPAL AUTHORITY	PA0026484	PA	CB1TF	91,668	12,225	122,309
SCRANTON SEWER AUTHORITY	PA0026492	PA	CB1TF	365,292	48,706	487,286
SUNBURY CITY MUNICIPAL AUTHORITY	PA0026557	PA	CB1TF	76,711	10,228	102,330
MILLERSVILLE BOROUGH	PA0026620	PA	CB1TF	33,790	4,505	45,074
NEW CUMBERLAND BOROUGH AUTHORITY	PA0026654	PA	CB1TF	22,831	3,044	30,455
TYRONE BOROUGH SEWER AUTHORITY	PA0026727	PA	CB1TF	166,231	21,918	219,279
SWATARA TOWNSHIP	PA0026735	PA	CB1TF	115,367	15,342	153,495
LANCASTER CITY	PA0026743	PA	CB1TF	620,248	77,318	77,318
SPRINGETTSBURY TOWNSHIP	PA0026808	PA	CB1TF	273,969	36,529	365,464
HANOVER BOROUGH	PA0026875	PA	CB1TF	83,441	10,959	109,639
GREATER HAZELTON	PA0026921	PA	CB1TF	216,739	27,092	216,842
ALTOONA CITY AUTHORITY-EAST	PA0027014	PA	CB1TF	146,117	19,482	194,914

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
ALTOONA CITY AUTHORITY-WEST	PA0027022	PA	CB1TF	164,381	21,918	219,279
WILLIAMSPORT SANITARY AUTHORITY-WEST	PA0027049	PA	CB1TF	77,547	9,564	95,508
WILLIAMSPORT SANITARY AUTHORITY-CENTRAL	PA0027057	PA	CB1TF	153,423	20,456	204,660
LACKAWANNA RIVER BASIN SEWER AUTHORITY	PA0027065	PA	CB1TF	109,587	14,612	146,186
LACKAWANNA RIVER BASIN SEWER AUTHORITY	PA0027081	PA	CB1TF	12,786	1,705	17,055
LACKAWANNA RIVER BASIN SEWER AUTHORITY	PA0027090	PA	CB1TF	127,852	17,047	170,550
BLOOMSBURG MUNICIPAL AUTHORITY	PA0027171	PA	CB1TF	78,855	10,447	104,523
LOWER ALLEN TOWNSHIP AUTHORITY	PA0027189	PA	CB1TF	114,354	15,221	152,277
HARRISBURG SEWERAGE AUTHORITY	PA0027197	PA	CB1TF	688,575	91,810	918,533
LEBANON CITY AUTHORITY	PA0027316	PA	CB1TF	146,117	19,482	194,914
SHAMOKIN-COAL TOWNSHIP JOINT SANITARY AUTHORITY	PA0027324	PA	CB1TF	127,852	17,047	170,550
EPHRATA BOROUGH WWTP	PA0027405	PA	CB1TF	79,049	9,881	92,584
PINE CREEK MUNICIPAL AUTHORITY	PA0027553	PA	CB1TF	23,744	3,166	31,674
BROWN TOWNSHIP MUNICIPAL AUTHORITY	PA0028088	PA	CB1TF	10,959	1,461	14,619
FT INDIANTOWN GAP	PA0028142	PA	CB1TF	24,353	3,044	24,364
TROY BORO	PA0028266	PA	CB1TF	7,306	974	9,746
MARTINSBURG	PA0028347	PA	CB1TF	12,785	1,705	17,055
MIFFLINBURG BOROUGH MUNICIPAL	PA0028461	PA	CB1TF	25,570	3,409	34,110
CLARKS SUMMIT-SOUTH ABINGTON JOINT AUTHORITY	PA0028576	PA	CB1TF	45,662	6,088	60,911
EMPORIUM BOROUGH (MID-CAMERON AUTHORITY)	PA0028631	PA	CB1TF	17,100	2,140	24,364
JERSEY SHORE BOROUGH	PA0028665	PA	CB1TF	19,178	2,557	25,582
GALLITZIN BORO	PA0028673	PA	CB1TF	7,306	974	9,746

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
KELLY TOWNSHIP MUNICIPAL AUTHORITY	PA0028681	PA	CB1TF	68,492	9,132	91,366
RALPHO TWP MUN AUTH	PA0028738	PA	CB1TF	13,132	1,751	17,518
QUARRYVILLE STP	PA0028886	PA	CB1TF	7,306	974	9,746
GREENFIELD TWP MUN AUTH	PA0029106	PA	CB1TF	14,612	1,948	19,491
SOUTH MOUNTAIN RESTORATION CEN	PA0029297	PA	POTTF_MD	9,132	1,218	12,182
PA DEPT OF PUBLIC WELFARE	PA0029432	PA	CB1TF	10,959	1,461	9,624
DALLAS SCI	PA0030139	PA	CB1TF	9,741	1,218	10,964
FRANKLIN COUNTY GENERAL AUTH (SOUTH PATROL RD)	PA0030597	PA	POTTF_MD	9,132	1,218	12,182
SHIPPENSBURG BOROUGH AUTHORITY	PA0030643	PA	CB1TF	60,273	8,036	80,402
GRANVILLE TWP	PA0032051	PA	CB1TF	15,196	1,899	12,182
DCNR-BALD EAGLE STATE PARK	PA0032492	PA	CB1TF	8,219	1,096	10,964
LOGAN TOWNSHIP-GREENWOOD AREA	PA0032557	PA	CB1TF	12,785	1,705	17,055
DUNCANSVILLE	PA0032883	PA	CB1TF	22,228	2,963	29,651
TOWANDA MUNICIPAL AUTHORITY	PA0034576	PA	CB1TF	21,187	2,825	28,263
TYSON FOODS	PA0035092	PA	CB1TF	27,397	559	36,547
FARMER'S PRIDE INC	PA0035157	PA	CB1TF	16,438	1,370	21,928
STEWARTSTOWN BOROUGH	PA0036269	PA	CB1TF	13,516	1,802	18,030
GALETON BORO AUTH	PA0036820	PA	CB1TF	9,132	1,218	12,182
PFBC HUNTSDALE	PA0037141	PA	CB1TF	53,512	2,804	336,230
PENN TOWNSHIP	PA0037150	PA	CB1TF	81,811	10,228	102,330
EVERETT BORO AREA MA	PA0037711	PA	CB1TF	15,890	2,119	21,197
MOSHANNON VALLEY JOINT SANITARY AUTHORITY	PA0037966	PA	CB1TF	31,634	4,218	42,199
DEFENSE DISTRIBUTION DEPOT SUSQUEHANNA	PA0038385	PA	CB1TF	9,132	1,218	12,182
EAST PENNSBORO SOUTH TREATMENT PLANT	PA0038415	PA	CB1TF	67,579	9,011	90,148
SUSQUEHANNA AQUACULTURE INC	PA0038598	PA	CB1TF	54,007	3,530	161,293
BURNHAM BOROUGH	PA0038920	PA	CB1TF	11,689	1,559	15,593

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
PENNSYLVANIA FISH & BOAT COMMISSION-BELLEFONTE	PA0040835	PA	CB1TF	78,988	2,636	74,799
LANCASTER AREA SEWER AUTHORITY	PA0042269	PA	CB1TF	273,969	36,529	365,464
TREMONT MUNICIPAL AUTHORITY	PA0042951	PA	CB1TF	9,132	1,218	12,182
NEW FREEDOM WTP	PA0043257	PA	CB1TF	42,009	5,601	56,038
HOLLIDAYSBURG REGIONAL	PA0043273	PA	CB1TF	109,587	14,612	146,186
LYKENS BOROUGH	PA0043575	PA	CB1TF	7,488	998	9,989
VALLEY JOINT SEW AUTH	PA0043681	PA	CB1TF	41,095	5,479	54,820
WESTERN CLINTON COUNTY MUNICIPAL AUTHORITY	PA0043893	PA	CB1TF	16,438	2,192	21,928
PENNSYLVANIA FISH & BOAT COMMISSION-UPPER SPRING	PA0044032	PA	CB1TF	7,000	50	14,034
SOUTH MIDDLETON TOWNSHIP MUNICIPAL AUTHORITY	PA0044113	PA	CB1TF	29,322	3,653	36,546
LEWISBURG AREA JOINT SANITARY AUTHORITY/COLLEGE P	PA0044661	PA	CB1TF	44,200	5,893	58,962
HANOVER FOODS CORP	PA0044741	PA	CB1TF	26,385	979	15,666
MOUNTAINTOP AREA	PA0045985	PA	CB1TF	75,981	10,131	101,355
PORTER TOWER JOINT MUNICIPAL AUTHORITY	PA0046272	PA	CB1TF	7,854	1,047	10,477
ST. JOHNS	PA0046388	PA	CB1TF	40,182	5,357	53,601
REPUBLIC SERVICES OF PA LLC	PA0046680	PA	CB1TF	40,803	131	12,182
CAN-DO INC	PA0060046	PA	CB1TF	18,265	2,435	24,364
SHICKSHINNY BORO SA	PA0060135	PA	CB1TF	8,219	1,096	10,964
MONTROSE MA	PA0060801	PA	CB1TF	14,977	1,997	19,979
ABINGTON TWP SUPERVISORS	PA0061034	PA	CB1TF	9,132	1,218	12,182
LITTLE WASHINGTON WW CO	PA0061590	PA	CB1TF	24,073	3,210	32,112
SCHUYLKILL CO MA	PA0062201	PA	CB1TF	10,959	1,461	14,619
FRACKVILLE AREA MA	PA0062219	PA	CB1TF	25,570	3,409	34,110
KBM REGIONAL AUTH (NEW)	PA0064025	PA	CB1TF	13,637	1,705	17,055
MAHANOY CITY	PA0070041	PA	CB1TF	25,205	3,361	33,623

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
SHENANDOAH MUNICIPAL SEWAGE AUTHORITY	PA0070386	PA	CB1TF	36,529	4,871	48,729
CAERNARVON TWP STP	PA0070424	PA	CB1TF	12,785	1,705	17,055
WASHINGTON TOWNSHIP MUNICIPAL	PA0080225	PA	POTTF_MD	35,433	4,724	47,267
HAMPDEN TOWNSHIP SEWER AUTHORITY	PA0080314	PA	CB1TF	101,997	12,359	117,436
NORTHERN LANCASTER CO AUTH	PA0080438	PA	CB1TF	8,219	1,096	10,964
ANTRIM TOWNSHIP	PA0080519	PA	POTTF_MD	21,918	2,922	29,237
NORTHERN LEBANON CO AUTH	PA0080748	PA	CB1TF	7,306	974	9,746
ST THOMAS TWP MUN AUTH	PA0081001	PA	POTTF_MD	7,306	974	9,746
SALISBURY TWP	PA0081574	PA	CB1TF	13,150	1,643	14,131
EASTERN YORK COUNTY SEWER AUTH	PA0081591	PA	CB1TF	10,959	1,461	14,619
FAIRVIEW TOWNSHIP	PA0081868	PA	CB1TF	13,333	1,778	17,786
WEST EARL SEW AUTH	PA0081949	PA	CB1TF	8,219	1,096	10,964
DERRY TWP MUN AUTH - SOUTHWEST	PA0082392	PA	CB1TF	10,959	1,461	14,619
FAIRVIEW TOWNSHIP	PA0082589	PA	CB1TF	9,132	1,218	12,182
NEWBERRY TOWNSHIP	PA0083011	PA	CB1TF	23,744	3,166	31,674
SILVER SPRING TOWNSHIP	PA0083593	PA	CB1TF	21,918	2,922	29,237
NORTHWESTERN LANCASTER CNTY AUTH	PA0084026	PA	CB1TF	14,612	1,827	15,837
CONEWAGO TWP SEW AUTH	PA0084425	PA	CB1TF	9,132	1,218	12,182
WEST HANOVER	PA0085511	PA	CB1TF	16,496	1,900	1,900
SPRINGFIELD TWP SEW AUTH - HOL	PA0086860	PA	CB1TF	12,785	1,704	17,055
EPHRATA BORO AUTH #2	PA0087181	PA	CB1TF	54,550	6,818	56,038
CHESTNUT RIDGE AREA JMA	PA0087661	PA	CB1TF	12,877	1,717	17,177
NEW MORGAN STP	PA0088048	PA	CB1TF	9,132	1,218	12,182
LOWER PAXTON WET WEATHER STP	PA0088633	PA	CB1TF	45,662	6,088	60,911
FREEDOM TOWNSHIP WATER&SEWER AUTHORITY	PA0110361	PA	CB1TF	10,959	1,461	14,619
PATTON BORO STP	PA0110469	PA	CB1TF	9,863	1,315	13,157
FURMAN FOODS	PA0110540	PA	CB1TF	45,450	1,624	5,847

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
EASTERN SNYDER COUNTY REGIONAL AUTH	PA0110582	PA	CB1TF	51,141	6,819	68,220
MID-CENTRE COUNTY AUTH	PA0110965	PA	CB1TF	18,265	2,435	24,364
TAYLOR PACKING CO INC	PA0111759	PA	CB1TF	14,612	1,218	19,492
PENNSYLVANIA FISH & BOAT COMMISSION-TYPLERSVILLE	PA0112127	PA	CB1TF	63,339	2,382	316,738
ELKLAND MUNICIPAL AUTHORITY	PA0113298	PA	CB1TF	10,277	1,285	13,400
GREGG TOWNSHIP	PA0114821	PA	CB1TF	23,013	3,068	30,699
HUGHESVILLE-WOLF TWP JOINT SEW	PA0114961	PA	CB1TF	12,329	1,644	16,446
WEST BRANCH SA	PA0205869	PA	CB1TF	16,438	2,192	21,928
LYCOMING CO WATER & SEWER AUTH	PA0209228	PA	CB1TF	27,397	3,653	36,546
NORTH CODORUS TWP	PA0247391	PA	CB1TF	13,394	1,674	13,400
PILGRIM'S PRIDE - ALMA	VA0001961	VA	POTTF_MD	18,273	914	61,028
DUPONT-WAYNESBORO	VA0002160	VA	POTTF_MD	78,941	1,009	88,330
MERCK & COMPANY INC.-STONEWALL PLANT-ELKTON	VA0002178	VA	POTTF_MD	43,835	4,384	2,168,100
PILGRIMS PRIDE-HINTON	VA0002313	VA	POTTF_MD	27,410	1,371	66,649
GIANT REFINERY-YORKTOWN	VA0003018	VA	MOBPH	167,128	17,689	160,600
SMURFIT STONE	VA0003115	VA	PMKOH	259,177	56,038	13,030,500
OMEGA PROTEIN INC	VA0003867	VA	CB5MH_VA	21,213	1,591	352,836
TYSON FOODS, INC.-TEMPERANCEVILLE	VA0004049	VA	POCMH_VA	22,842	1,142	60,955
STRASBURG	VA0020311	VA	POTTF_MD	11,939	895	89,539
VINT HILL FARMS STATION WWTP	VA0020460	VA	POTTF_VA	11,573	868	86,798
BERRYVILLE	VA0020532	VA	POTTF_MD	8,528	640	63,957
KILMARNOCK	VA0020788	VA	CB5MH_VA	6,091	457	45,683
NAVAL SURFACE WARFARE CENTER-DAHLGREN	VA0021067	VA	POTMH_VA	6,578	658	65,784
GORDONSVILLE	VA0021105	VA	PMKTF	17,177	1,145	85,885
WARRENTON	VA0021172	VA	RPPTF	30,456	2,284	228,417
ONANCOCK	VA0021253	VA	CB7PH	9,137	685	68,525
CAPE CHARLES	VA0021288	VA	CB7PH	6,091	457	45,683

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
ORANGE	VA0021385	VA	RPPTF	36,547	2,741	274,100
WEYERS CAVE STP	VA0022349	VA	POTTF_MD	6,091	457	45,683
PURCELLVILLE	VA0022802	VA	POTTF_MD	18,273	1,371	137,050
NEW MARKET STP	VA0022853	VA	POTTF_MD	6,091	457	45,683
HAYNESVILLE CORRECTIONAL CENTER	VA0023469	VA	RPPMH	2,802	210	21,014
DALE CITY #8	VA0024678	VA	POTTF_VA	42,029	2,522	420,287
DALE CITY #1	VA0024724	VA	POTTF_VA	42,029	2,522	420,287
MASSANUTTEN PUBLIC SERVICE STP	VA0024732	VA	POTTF_MD	18,273	1,371	137,050
ASHLAND	VA0024899	VA	PMKTF	36,547	2,436	182,734
UPPER OCCOQUAN SEWAGE AUTHORITY	VA0024988	VA	POTTF_VA	1,315,682	16,446	4,933,807
H.L. MOONEY	VA0025101	VA	POTTF_VA	219,280	13,157	2,192,803
FREDERICKSBURG	VA0025127	VA	RPPTF	54,820	4,112	411,151
ARLINGTON	VA0025143	VA	POTTF_VA	365,467	21,928	3,654,672
WAYNESBORO	VA0025151	VA	POTTF_MD	48,729	3,655	365,467
ALEXANDRIA	VA0025160	VA	POTTF_VA	500,690	29,932	4,988,627
FISHERSVILLE	VA0025291	VA	POTTF_MD	48,729	3,655	365,467
NOMAN M. COLE JR. POLLUTION CONTROL PLANT	VA0025364	VA	POTTF_VA	612,158	36,729	6,121,576
MASSAPONAX	VA0025658	VA	RPPTF	97,458	7,309	730,934
ROUND HILL WWTP	VA0026212	VA	POTTF_MD	9,137	685	68,525
URBANNA	VA0026263	VA	RPPMH	1,218	91	9,137
COLONIAL BEACH	VA0026409	VA	POTMH_VA	18,273	1,827	182,734
MT JACKSON STP	VA0026441	VA	POTTF_MD	8,528	640	63,957
WOODSTOCK	VA0026468	VA	POTTF_MD	24,364	1,827	182,734
DAHLGREN (DAHLGREN SANITARY DISTRICT)	VA0026514	VA	POTMH_VA	9,137	914	91,367
WARSAW	VA0026891	VA	RPPMH	3,655	274	27,410
SHORE HOSPITAL	VA0027537	VA	CB7PH	1,218	91	9,137
QUANTICO-MAINSIDE	VA0028363	VA	POTOH_VA	20,101	1,206	201,007
STONEY CREEK STP	VA0028380	VA	POTTF_MD	7,309	548	54,820

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
MATHEWS COURTHOUSE	VA0028819	VA	MOBPH	1,827	122	9,137
DOSWELL	VA0029521	VA	PMKTF	18,273	1,218	91,367
MARSHALL WWTP	VA0031763	VA	RPPTF	7,797	585	58,475
FORT A.P. HILL (WILCOX CAMP SITE)	VA0032034	VA	RPPTF	6,457	484	48,424
HARRISONBURG-ROCKINGHAM (NORTH RIVER REGIONAL)	VA0060640	VA	POTTF_MD	253,391	19,004	1,900,429
REEDVILLE	VA0060712	VA	CB5MH_VA	2,436	183	18,273
AQUIA	VA0060968	VA	POTOH_VA	73,093	4,386	730,934
CULPEPER	VA0061590	VA	RPPTF	73,093	5,482	548,201
LURAY	VA0062642	VA	POTTF_MD	19,492	1,462	146,187
FRONT ROYAL	VA0062812	VA	POTTF_MD	48,729	3,655	365,467
MIDDLE RIVER	VA0064793	VA	POTTF_MD	82,839	6,213	621,294
FWSA OPEQUON	VA0065552	VA	POTTF_MD	121,851	11,512	1,151,222
STUARTS DRAFT	VA0066877	VA	POTTF_MD	48,729	3,655	365,467
TANGIER ISLAND	VA0067423	VA	POCMH_VA	1,218	91	9,137
FMC	VA0068110	VA	RPPTF	65,784	4,934	493,381
PURKINS CORNER STP	VA0070106	VA	POTMH_VA	1,096	110	10,964
TAPPAHANNOCK	VA0071471	VA	RPPMH	9,746	731	73,093
MONTROSS - WESTMORELAND	VA0072729	VA	RPPMH	1,584	119	11,878
COORS SHENANDOAH BREWERY	VA0073245	VA	POTTF_MD	54,820	4,112	184,690
CAROLINE COUNTY REGIONAL	VA0073504	VA	MPNTF	9,137	609	45,683
PARKINS MILL	VA0075191	VA	POTTF_MD	60,911	4,568	456,834
WEST POINT	VA0075434	VA	MPNOH	10,964	731	54,820
LITTLE FALLS RUN	VA0076392	VA	RPPTF	97,458	7,309	730,934
REMINGTON REGIONAL	VA0076805	VA	RPPTF	30,456	2,284	228,417
GEORGE'S CHICKEN INC	VA0077402	VA	POTTF_MD	31,065	1,553	104,390
BEAR ISLAND PAPER CO.	VA0077763	VA	PMKTF	47,328	10,233	383,741
SOUTH WALES STP	VA0080527	VA	RPPTF	10,964	822	82,230
HRSD-YORK	VA0081311	VA	MOBPH	274,100	18,273	1,370,502
WILDERNESS SHORES	VA0083411	VA	RPPTF	15,228	1,142	114,209
OAKLAND PARK STP	VA0086789	VA	POTOH_VA	1,706	128	12,791

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
PARHAM LANDING WWTP	VA0088331	VA	PMKOH	36,547	2,436	182,734
HAYMOUNT STP	VA0089125	VA	RPPTF	11,695	877	87,712
HOPYARD FARMS STP	VA0089338	VA	RPPTF	6,091	457	45,683
TOTOPOTOMOY	VA0089915	VA	PMKTF	182,734	12,182	913,668
MOUNTAIN RUN STP	VA0090212	VA	RPPTF	0	0	0
SIL MRRS	VA0090263	VA	POTTF_MD	23,390	1,754	175,424
NORTH FORK REGIONAL WWTP	VA0090328	VA	POTTF_MD	9,137	685	68,525
RAPIDAN STP	VA0090948	VA	RPPTF	7,309	548	54,820
BROAD RUN WRF	VA0091383	VA	POTTF_MD	134,005	3,350	1,005,035
FAIRVIEW BEACH	VA0092134	VA	POTOH_VA	1,827	183	18,273
LEESBURG	VA0092282	VA	POTTF_MD	121,822	9,137	913,668
PILGRIM'S PRIDE	WV0005495	WV	POTTF_MD	13,096	1,310	13,096
VIRGINIA ELECTRIC & POWER	WV0005525	WV	POTTF_MD	0	0	0
LEETOWN SCIENCE CENTER	WV0005649	WV	POTTF_MD	18,273	1,827	18,273
MOOREFIELD	WV0020150	WV	POTTF_MD	9,137	914	9,137
ROMNEY	WV0020699	WV	POTTF_MD	7,614	761	7,614
PETERSBURG	WV0021792	WV	POTTF_MD	20,558	2,056	20,558
CHARLES TOWN	WV0022349	WV	POTTF_MD	26,649	2,665	26,649
MARTINSBURG	WV0023167	WV	POTTF_MD	45,683	4,568	45,683
KEYSER	WV0024392	WV	POTTF_MD	36,547	3,655	36,547
SHEPHERDSTOWN	WV0024775	WV	POTTF_MD	6,091	609	6,091
WARM SPRINGS PSD	WV0027707	WV	POTTF_MD	26,496	2,650	26,496
FORT ASHBY PSD	WV0041521	WV	POTTF_MD	7,614	761	7,614
HESTER INDUSTRIES, INC.	WV0047236	WV	POTTF_MD	7,614	761	7,614
BERKELEY COUNTY PSSD***	WV0082759	WV	POTTF_MD	89,844	8,984	89,844
REEDS CREEK HATCHERY	WV0111821	WV	POTTF_MD	26,298	2,630	26,298
SPRING RUN HATCHERY	WV0112500	WV	POTTF_MD	65,480	6,548	65,480
THE CONSERVATION FUND FRESHWATER INST	WV0116149	WV	POTTF_MD	15,380	1,538	15,380

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
NY Significant WWTP Aggregate	**Including 28 NPDES listed below**	NY	CB1TF	1,545,956	104,612	3,185,071
KRAFT FOODS, INC.	NY0004189	NY	CB1TF			
KRAFT FOODS GLOBAL	NY0004308	NY	CB1TF			
ADDISON (V)	NY0020320	NY	CB1TF			
HAMILTON (V)	NY0020672	NY	CB1TF			
GREENE (V) WWTP	NY0021407	NY	CB1TF			
NORWICH	NY0021423	NY	CB1TF			
BATH (V)	NY0021431	NY	CB1TF			
SHERBURNE (V) WWTP	NY0021466	NY	CB1TF			
ALFRED (V)	NY0022357	NY	CB1TF			
OWEGO (T) #1	NY0022730	NY	CB1TF			
CANISTEO (V) STP	NY0023248	NY	CB1TF			
COOPERSTOWN	NY0023591	NY	CB1TF			
HORNELL (C)	NY0023647	NY	CB1TF			
ERWIN (T)	NY0023906	NY	CB1TF			
BINGHAMTON-JOHNSON CITY JOINT BOROUGH	NY0024414	NY	CB1TF			
PAINTED POST (V)	NY0025712	NY	CB1TF			
CORNING (C)	NY0025721	NY	CB1TF			
OWEGO #2	NY0025798	NY	CB1TF			
CORTLAND (C)	NY0027561	NY	CB1TF			
ENDICOTT (V)	NY0027669	NY	CB1TF			
OWEGO (V)	NY0029262	NY	CB1TF			
SIDNEY (V)	NY0029271	NY	CB1TF			
WAVERLY (V)	NY0031089	NY	CB1TF			
ONEONTA (C)	NY0031151	NY	CB1TF			
RICHFIELD SPRINGS (V)	NY0031411	NY	CB1TF			
ELMIRA / CHEMUNG CO. SD #2	NY0035742	NY	CB1TF			
LAKE STREET/CHEMUNG COUNTY SD #1	NY0036986	NY	CB1TF			
CHENANGO NORTHGATE WWTP	NY0213781	NY	CB1TF			

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
VA James River Significant PS Aggregate	**Including 39 NPDES listed below**	VA		8,968,864	545,558	79,804,603
R.J. REYNOLDS (BROWN & WILLIAMSON)	VA0002780	VA	JMSTF2			
GEORGIA PACIFIC CORPORATION	VA0003026	VA	JMSTF2			
JH MILES	VA0003263	VA	JMSPH			
WESTVACO CORPORATION-COVINGTON HALL	VA0003646	VA	JMSTF2			
BWXT	VA0003697	VA	JMSTF2			
TYSON FOODS, INC.	VA0004031	VA	CHKOH			
DOMINION VIRGINIA POWER-CHESTERFIELD	VA0004146	VA	JMSTF2			
DUPONT-SPRUANCE	VA0004669	VA	JMSTF2			
LEES COMMERCIAL CARPET	VA0004677	VA	JMSTF2			
HONEYWELL	VA0005291	VA	JMSTF1			
GREIF BROS CORP-RIVERVILLE	VA0006408	VA	JMSTF2			
CREWE STP	VA0020303	VA	APPTF			
DOC Powhatan CC	VA0020699	VA	JMSTF2			
BUENA VISTA	VA0020991	VA	JMSTF2			
CLIFTON FORGE	VA0022772	VA	JMSTF2			
LAKE MONTICELLO STP	VA0024945	VA	JMSTF2			
LYNCHBURG	VA0024970	VA	JMSTF2			
FALLING CREEK	VA0024996	VA	JMSTF2			
SOUTH CENTRAL	VA0025437	VA	APPTF			
MOORES CREEK-RIVANNA AUTHORITY	VA0025518	VA	JMSTF2			
COVINGTON	VA0025542	VA	JMSTF2			
PHILLIP MORRIS-PARK 500	VA0026557	VA	JMSTF1			
LOW MOOR	VA0027979	VA	JMSTF2			
AMHERST TOWN STP	VA0031321	VA	JMSTF2			
PROCTORS CREEK	VA0060194	VA	JMSTF2			
RICHMOND	VA0063177	VA	JMSTF2			
HENRICO COUNTY	VA0063690	VA	JMSTF2			

Table 9-4. Edge of Stream (EOS) WLAs (Annual) for the 478 significant permitted dischargers to meet TMDLs to attain the Chesapeake Bay WQS

Permit Name	NPDES ID	Jurisdiction	Segment ID	TN EOS WLA (lbs/yr)	TP EOS WLA (lbs/yr)	TSS EOS WLA (lbs/yr)
HOPEWELL	VA0066630	VA	JMSTF1			
HRSD-ARMY BASE	VA0081230	VA	JMSPH			
HRSD-BOAT HARBOR	VA0081256	VA	JMSPH			
HRSD-CHESAPEAKE/ELIZABETH	VA0081264	VA	LYNPH			
HRSD-JAMES RIVER	VA0081272	VA	JMSMH			
HRSD-VIP	VA0081281	VA	ELIPH			
HRSD-NANSEMOND	VA0081299	VA	JMSPH			
HRSD-WILLIAMSBURG	VA0081302	VA	JMSOH			
FARMVILLE	VA0083135	VA	APPTF			
LEXINGTON-ROCKBRIDGE REGIONAL STP	VA0088161	VA	JMSTF2			
CHICKAHOMINY	VA0088480	VA	CHKOH			
ALLEGHANY CO. LOWER JACKSON	VA0090671	VA	JMSTF2			

* Back River WWTP discharges into two segments BACOH and PATMH

** Blue Plains treats wastewater from DC, MD and VA, but is listed once in this table as a plant located in DC

*** BERKELEY COUNTY PSSD WV0082759 includes four facilities under the same permit.

Note: Gray shading indicates significant permitted dischargers that are part of a larger aggregate WLA.

SECTION 10. IMPLEMENTATION AND ADAPTIVE MANAGEMENT

10.1 FUTURE GROWTH

As an assumption of the Chesapeake Bay TMDL, EPA expects Chesapeake Bay jurisdictions to account for and manage new or increased loadings of nitrogen, phosphorus, and sediment.

10.1.1 Designating Target Loads for New or Increased Sources

Where the TMDL does not provide a specific allocation to accommodate new or increased loadings of nitrogen, phosphorus, or sediment, a jurisdiction may accommodate such new or increased loadings only through a mechanism allowing for quantifiable and accountable offsets of the new or increased load in an amount necessary to implement the TMDL and applicable WQS in the Chesapeake Bay and its tidal tributaries. Therefore, the Chesapeake Bay TMDL assumes, and EPA expects, that the jurisdictions will accommodate new or increased loadings of nitrogen, phosphorus, or sediment that do not have a specific allocation in the TMDL with appropriate offsets supported by credible and transparent offset programs subject to EPA oversight.

10.1.2 Offset Programs

EPA expects that new or increased loadings of nitrogen, phosphorus, and sediment in the Chesapeake Bay watershed that are not specifically accounted for in the TMDL’s WLA or LA will be offset by loading reductions and credits generated by other sources under programs that are consistent with the definitions and common elements described in Appendix S. These definitions and common elements are important to ensure that offsets are achieved through reliable pollution controls and that the goals of the Chesapeake Bay TMDL are met.

EPA expects the jurisdictions to develop offset programs that are credible, transparent, consistent with the definitions and common elements set out in Appendix S, and subject to EPA and public oversight. Any such offsets are expected to account for the entire delivered nitrogen, phosphorus, or sediment load after accounting for location of the sources, delivery factors affecting pollutant fate and transport, equivalency of pollutants, and the certainty of any such reductions. In addition, such offsets may not cause an exceedance of local WQS or local TMDLs. The offsets are to be in addition to reductions already needed to meet the allocations in the TMDL and must be consistent with applicable federal and state laws and regulations.

For nonpoint sources, this assumption and expectation is based on the fact that any new or increased nonpoint source loadings not accounted for in the TMDL’s LA will have to be offset by appropriate reductions from other sources if the TMDL’s pollutant loading cap and applicable WQS are to be met. For permitted point sources, the assumption and expectation also is based on the statutory and regulatory requirements that effluent limits for any such discharges be derived from and comply with all applicable WQS and be consistent with the assumptions and requirements of any available WLAs [CWA sections 301(b)(1)(C), 303(d); 40 CFR 122.44(d)(1)(vii)(A) & (B)].

In addition, CWA section 117(g) authorizes EPA to ensure that management plans are developed and implementation is begun to achieve and maintain the Bay's nutrient goals. If jurisdictions authorize new or increased loadings without a specific TMDL allocation, an offset is a necessary component of any management plan designed to meet those goals. Accordingly, the Bay TMDL assumes that new point source dischargers, without an allocation in the TMDL (or in other words, with a zero allocation), will find offsets large enough to compensate for their entire loading. The TMDL similarly assumes that point source dischargers that increase pollution loading will find offsets large enough to compensate for the entire increase in their loading and to meet their Water Quality Based Effluent Limit (WQBEL) consistent with the WLA in the TMDL. In the case of new or increased loading from sources other than permitted point source dischargers, jurisdictions are expected to estimate loadings and ensure offsets that fully compensate for this estimated increase in pollutant load.

Although EPA assumes that there can legitimately be some flexibility in the design and content of Bay jurisdiction offset programs, EPA encourages and expects that the jurisdictions will generally develop and implement programs for offsetting new and increased loadings consistent with the definitions and common elements described in detail in Appendix S. EPA also encourages and expects jurisdictions with existing trading programs that address new or increased loadings (such as several jurisdictions have), to ensure that their programs address new or increased loads consistent with the definitions and common elements in Appendix S.

10.1.3 Additional Offset Program Features

The jurisdictions also may consider using the following features to build their offset programs for new or increased loadings of nitrogen, phosphorus, and sediment:

Net Improvement Offsets: For purposes of the Bay TMDL, this means an offset at a ratio greater than merely accounting for the entire new or increased load. The jurisdiction's offset program would need to provide the authority and procedures for invoking such a provision. This tool might be considered as a means to accelerate load reductions where a jurisdiction is not on a schedule to ensure that nitrogen, phosphorus, and sediment controls are in place by 2017 and 2025 to meet interim and final target loads, respectively. This may be determined based on an EPA evaluation of a jurisdiction's progress on its WIP and 2-year milestones, as discussed in EPA's December 29, 2009 letter (USEPA 2009d). Net improvement offsets also might be considered, in the case of permitted point sources, to offset new or increased loads from nonpoint sources or from point sources not expected to be permitted.

Aggregated Programmatic Credits: For purposes of the Bay TMDL, this means defining a programmatic solution for over-control of nitrogen, phosphorus or sediment beyond the basic WIP strategies to achieve the TMDL allocation. In essence, it is an aggregation of credits from reductions by a class or subclass of sources where such reductions have been achieved by the jurisdiction or another duly authorized body. The jurisdiction may consider making such credits available to offset new or increased loadings. In some circumstances, such class reductions also could be applied as a reallocation of loadings under the TMDL. Such reallocation may require modification of the TMDL.

Reserve-Offset Hybrid: For purposes of the Bay TMDL, this applies where a jurisdiction reserves a portion of its allocations for future growth and, once that allocation is depleted, uses an offset program as described herein.

10.1.4 EPA's Oversight Role of Jurisdictions' Offset Programs

EPA encourages jurisdictions to consult with EPA throughout the development of their offset programs to facilitate alignment with the CWA and the Bay TMDL. EPA has various oversight responsibilities under the CWA, MOUs for authorization of jurisdictions' NPDES programs, and the TMDL/Executive Order 13508, including approval of revisions to WQS, review of NPDES permits, and provisions for reviewing and making recommendations regarding revisions to a jurisdiction's water quality management plans through the continuing planning process.

EPA intends to maintain regular oversight of jurisdictions' offset programs through periodic audits and evaluations. EPA will report its findings to the respective jurisdiction. EPA's first such review of jurisdictional offset and trading programs will take place in calendar year 2011. EPA expects that the findings of this evaluation will inform offset and trading provisions included in the jurisdictions' Phase II WIPs. Such oversight generally will be conducted on a programmatic basis, not an individual offset basis. EPA reserves its authority, however, to review any individual offset (including an NPDES permit containing an offset) and to comment on, object to, or issue the permit as needed if EPA determines that the offset is not consistent with the Clean Water Act or EPA's regulations. When questions or concerns arise, EPA will use its oversight authorities to ensure that offset programs are fully consistent with the CWA and its implementing regulations. EPA recognizes the value of implementing a strategy for offsets that, wherever possible, is consistent among the jurisdictions to increase credibility, scalability, and broader regional implementation such as interstate trading.

10.2 WATER QUALITY TRADING

EPA recognizes that a number of Bay jurisdictions already are implementing water quality trading programs. EPA supports implementation of the Bay TMDL through such programs, as long as they are established and implemented in a manner consistent with the CWA, its implementing regulations, and EPA's 2003 *Water Quality Trading Policy*[1] (USEPA 2003e) and 2007 *Water Quality Trading Toolkit for NPDES Permit Writers*[2] (USEPA 2007d). An assumption of this TMDL is that trades may occur between sources contributing pollutant loadings to the same or different Bay segments, provided such trades do not cause or contribute to an exceedance of WQS in either receiving segment or anywhere else in the Bay watershed. EPA does not support any trading activity that would delay or weaken implementation of the Bay TMDL, that is inconsistent with the assumptions and requirements of the TMDL, or that would cause the combined point source and nonpoint source loadings covered by a trade to exceed the applicable loading cap established by the TMDL.

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[1] See http://www.epa.gov/owow/watershed/trading/finalpolicy2003.pdf.

[2] See http://www.epa.gov/owow/watershed/trading/WQTToolkit.html.

In Section 10.1, EPA explains how Bay jurisdictions may accommodate new or increased loadings of nitrogen, phosphorus, and sediment either through a specific TMDL allocation or by offsetting those loadings with quantifiable and accountable reductions necessary to implement applicable WQS in the Bay and its tidal tributaries. In Appendix S, EPA discusses a number of definitions and common elements that EPA encourages and expects the jurisdictions to include and implement in their offset programs. EPA believes the definitions and common elements in Appendix S also constitute important components of trading programs in the Chesapeake Bay watershed. EPA anticipates using these Appendix S definitions and elements in reviewing jurisdictions' trading programs.

10.3 FUTURE MODIFICATIONS TO THE CHESAPEAKE BAY TMDL

EPA has established the Chesapeake Bay TMDL, including its component WLAs, LAs, and margin of safety, based on the Bay and tidal tributaries' applicable WQS and the totality of the information available to it concerning Bay Watershed water quality and hydrology, present and anticipated pollutant sources and loadings, and jurisdiction-submitted implementation plans. In establishing the TMDL and making determinations about reasonable assurance, EPA has also relied on facts and assumptions regarding its own ability to ensure and successfully track TMDL implementation through the two-year milestone process and the application, if necessary, of appropriate federal actions. As a result, EPA believes this TMDL is an appropriate and effective framework for the point source and nonpoint source-focused implementation activities that the jurisdictions, EPA, and the other Bay watershed stakeholders must take to meet the Bay's nitrogen, phosphorus, and sediment reduction goals.

EPA recognizes, however, that neither the world at large nor the Bay watershed is static. In a dynamic environment like the Bay watershed, during the next 15 years change is inevitable. It may be possible to accommodate some of those changes within the existing TMDL framework without the need to revise it in whole, or in part. For example, EPA's permitting regulations at 122.44(d)(1)(vii)(B) require that permit WQBELs be "consistent with the assumptions and requirements of any available wasteload allocation for the discharge" contained in the TMDL. As the EPA Environmental Appeals Board has recognized, "WLAs are not permit limits *per se*; rather they still require translation into permit limits." *In re City of Moscow*, NPDES Appeal No. 00-10 (July 27, 2001). In providing such translation, the EAB said that "[w]hile the governing regulations require consistency, they do not require that the permit limitations that will finally be adopted in a final NPDES permit be identical to any of the WLAs that may be provided in a TMDL." Id. Accordingly, depending on the facts of a particular situation, it may be possible for the jurisdictions to write a permit limit that is consistent with (but not identical to) a given WLA without revising that WLA (either increasing or decreasing a specific WLA), provided the permit limit is consistent with the operative "assumptions " (e.g., about the applicable WQS, ambient water quality conditions, the sum of the delivered point source loads, hydrology, implementation strategies , the sufficiency of reasonable assurance) that informed the decision to establish that particular WLA.

There might, however, be circumstances in which the permit authority is not comfortable with, or the CWA would not allow, the degree to which a permit limit might deviate from a WLA in the TMDL such that one or more WLAs and LAs in the Bay TMDL would need to be revised. Or, fundamental assumptions like the nature and stringency of the applicable WQS or a jurisdiction's legal authority might change. In these cases, it might be appropriate for EPA to revise the Bay TMDL (or portions of it). EPA would consider a request by the jurisdictions to propose such a revision to the TMDL following appropriate notice and comment. Alternatively, a jurisdiction could propose to revise a portion(s) of the Bay TMDL that applies within its boundaries (including, but not limited to specific WLAs and LAs) and submit those revisions to EPA for approval. If EPA approved any such jurisdiction-submitted revisions, those revisions would replace their respective parts in the EPA-established Bay TMDL framework. In approving any such jurisdiction-submitted revisions (or in making its own revisions) EPA would ensure that the revisions themselves met all the statutory and regulatory requirements for TMDL approval and did not result in any component of the original TMDL not meeting applicable WQS.

Based on possible updates to the model and on jurisdictions' WIPs, EPA will consider revising the Chesapeake Bay TMDL, if appropriate, in 2012 and 2017. EPA will also consider revising the TMDL based on other new or additional information provided by the jurisdictions. All revision requests from jurisdictions should be coordinated with EPA to fit within EPA's planned revision time frame.

10.4 FEDERAL FACILITIES AND LANDS

Federal lands account for approximately 5.3 percent of the Chesapeake Bay watershed. The federal sector is like other sectors in that EPA expects federal land owners to be responsible for achieving LAs and WLAs through actions, programs, and policies that will reduce the release of nitrogen, phosphorous, and sediment (CWA section 313, 33 U.S.C. 1323).

EPA expects federal agencies with property in the watershed to provide leadership and work with the seven Bay watershed jurisdictions in implementing their Phase I WIPs. Federal agencies have provided information on the spatial boundaries and land use types for facilities in the watershed. EPA used that information to model current pollutant loads from federal facilities and has provided the estimated loads to the jurisdictions. The Federal Strategy also requires federal agencies with property in the Bay watershed to work with the jurisdictions in developing their WIPs by identifying pollutant reductions from point and nonpoint sources associated with federal lands and committing to actions, programs, policies, and resources necessary to reduce nitrogen, phosphorus, and sediment by specific dates.

In their final Phase I WIPs, jurisdictions have established load reduction goals for sectors contributing nitrogen, phosphorus, and sediment loads to the Chesapeake Bay. The TMDL allocations are based almost wholly upon these load reductions; federal lands and installations are expected to contribute to these load reductions. In the Phase II WIPs, the jurisdictions are expected to further distribute LA and WLA allocations among local level target areas such as counties. These more local targets also could include federal facilities. EPA also expects that federal agencies will cooperate with Bay jurisdictions and provide them with information on federal agency actions, programs, policies, and resources necessary to achieve federal facility-specific load reduction targets in jurisdictions' Phase II WIPs.

Like the Bay jurisdictions, federal agencies are expected to create 2-year milestones detailing specific implementation actions to achieve federal lands' and facilities' share of load reductions.

These federal milestones also should support the implementation of jurisdictions' WIPs and two-year milestones through commitments to comply with permit conditions and provide coordination, funding, and technical assistance, as appropriate. The milestones will be the basis for tracking progress and providing transparency on federal sector performance related to agency TMDL responsibilities in the watershed.

Federal facility-specific target loads are expected to be included in the jurisdictions' Phase II WIPs in 2011 via one of two approaches: (a) jurisdictions could establish explicit load reduction expectations for federal facilities as part of the Phase II WIP process; or (b) on the basis of broad load reduction goals established by the jurisdiction, individual federal facilities/installations could develop Federal Facility Implementation Plans (FFIPs), which would explain to the jurisdiction how the facility would achieve needed load reductions in nitrogen, phosphorus, and sediment. The FFIPs would be expected to address, at a minimum, the following in targeting and achieving load reductions:

- Assess properties to determine the feasibility of installing urban retrofit practices and implementing nonstructural control measures that reduce volume and improve quality of stormwater runoff.
- Align cost-effective, urban stormwater retrofits and erosion repairs with the Bay TMDL allocations and jurisdictions' 2-year milestones.
- Assess and implement appropriate nonstructural practices to control stormwater discharges from developed areas and to reduce, prevent, or control erosion from unpaved roads, trails, and ditches.
- Consider the full spectrum of nitrogen, phosphorus, and sediment sources at a facility or installation to assess the ideal approach to achieve the needed nitrogen, phosphorus, and sediment reduction.

In addition, section 501 of Executive Order 13508 and the subsequent Executive Order Federal Strategy (FLCCB 2010) direct each federal agency with land, facilities or installation management responsibilities affecting 10 or more acres in the Bay watershed to implement section 502 guidance on federal land management. Pursuant to section 502 of the Executive Order, EPA issued on May 12, 2010, the Guidance for Federal Land Management in the Chesapeake Bay Watershed (EPA May 12, 2010), EPA 841-R-10-002 (section 502 guidance). EPA's objective in developing the section 502 guidance was to provide information and data on appropriate, proven, and cost-effective tools and practices for implementation on federal lands and at federal facilities.

The section 502 guidance includes chapters addressing agriculture, urban and suburban areas (including turf), forestry, riparian area management, decentralized wastewater treatment systems, and hydromodification. Each chapter contains one or more implementation measures that provide the framework for the chapter. They are intended to convey the actions that will help ensure that the broad goals of the Chesapeake Bay Executive Order are achieved. Each chapter also includes information on practices that can be used to achieve the goals; information on the effectiveness and costs of the practices; where relevant, cost savings or other economic/societal benefits (in addition to the pollutant reduction benefits) that derive from the implementation goals or practices; and copious references to other documents that provide additional information. Federal agencies are expected to incorporate the section 502 guidance as part of their overall strategy to meet the loading reductions that the jurisdictions in their Phase II WIPs assign to them.

In addition, the Executive Order Federal Strategy calls for federal agencies to adopt an agency-specific policy to ensure implementation of the stormwater requirements in section 438 of the Energy Independence and Security Act (EISA) for new development and redevelopment activities consistent with guidance developed by EPA. Section 438 of EISA requires federal agencies to maintain or restore the predevelopment hydrology (the runoff volume, rate, temperature, and duration of flow that typically existed on the site before human-induced land disturbance occurred) of any project with a footprint that exceeds 5,000 square feet. The agency-specific policy should include mechanisms for producing an annual internal agency action plan and progress report. Implementation of the agency-specific policy is to begin in 2011. The results of each federal agency's actions to comply with section 438 of EISA will be published as part of the annual progress report issued under the direction of the Executive Order discussed above.

10.5 FACTORING IN EFFECTS FROM CONTINUED CLIMATE CHANGE

EPA accounted for the potential effects of future climate change in the current Bay TMDL allocations based on a preliminary assessment of climate change impacts on the Chesapeake Bay (see Section 5.11 and Appendix E). There are well-known limitations in the current suite of Bay models to fully simulate the effects of climate change as cited in Section 5.11.

EPA and its partners are committed to conducting a more complete analysis of climate change effects on nitrogen, phosphorus, and sediment loads and allocations in time for the mid-course assessment of Chesapeake Bay TMDL progress in 2017 as called for in Section 203 of the Chesapeake Executive Order 13508 (May 12, 2009), accessible at http://executiveorder.chesapeakebay.net/EO/file.axd?file=2009%2f8%2fChesapeake+Executive+Order.pdf. To do that will require building the capacity to quantify the impacts of climate change at the scale of the Bay TMDL—92 Bay segments and their surrounding watersheds at the scale of the Phase II Watershed Implementation Plans' target loads—and incorporate that information into the full suite of Bay models and other decision support tools.

EPA has committed to take an adaptive management approach to the Bay TMDL and incorporate new scientific understanding of the effects of climate change into the Bay TMDL, in this case during the mid-course assessment.

10.6 SEDIMENT BEHIND THE SUSQUEHANNA RIVER DAMS

The dams along the lower Susquehanna River are a significant factor influencing nitrogen, phosphorus, and sediment loads to the Bay because they retain large quantities of sediment and phosphorus, and some nitrogen, in their reservoirs (Appendix T). The three major dams along the lower Susquehanna River are the Safe Harbor Dam, Holtwood Dam, and Conowingo Dam. In developing the TMDL, EPA considered the impact of these dams on the pollutant loads to the Bay and how those loads will change when the dams no longer function to trap nitrogen, phosphorus, and sediment.

The Bay TMDL incorporates the current sediment-trapping capacity of the Conowingo Dam at 55 percent, with nitrogen and phosphorus trapping capacity at 2 percent and 40 percent, respectively. That allows the sediment, nitrogen, and phosphorus allocations to the jurisdictions to reflect the actual input to the Bay. If future monitoring shows a change in trapping capacity in the Conowingo Dam, the 2-year milestone delivered load reductions could be adjusted accordingly. The adjusted loads may be compared to the 2-year milestone commitments to ensure that each jurisdiction is meeting its obligations. For example, if there were a reduction in the sediment-trapping capacity in the reservoir, an upland jurisdiction might need to increase its sediment-reduction efforts to meet the allocations it has been assigned in the Bay TMDL. The jurisdictions' sediment allocation would not necessarily change, but the jurisdictions might need to increase the level of effort in reducing sediment to account for the loss of trapping capacity in the reservoir. Changes in the sediment-trapping capacity are not expected to alter the amount of sediment that the Bay is able to assimilate and, therefore, are not expected to change the allocations in this Bay TMDL.

For the purposes of the Chesapeake Bay TMDL, EPA and the partners assumed the current trapping efficiencies will continue. If future monitoring shows that trapping efficiencies are reduced, Pennsylvania, New York, and Maryland's respective 2-year milestone delivered loads could be adjusted accordingly. Therefore it is imperative that those jurisdictions work together to develop an implementation strategy for addressing the sediment, nitrogen, and phosphorus behind the Conowingo Dam through their respective WIPs, so that they are prepared if the trapping efficiencies decrease.

10.7 FILTER FEEDERS

Filter feeders play an important role in the uptake of nitrogen and phosphorus from the Chesapeake Bay and have the potential significantly improve water quality if present in large numbers (Appendix U). The organisms of interest for their ability to improve water quality are the native Eastern oyster, *Crassostrea virginica*, and menhaden fish, *Brevoortia tyrannus*. Each market-sized oyster contains about 0.5 gram of nitrogen and 0.16 gram of phosphorus. Menhaden fish are another filter feeding organism in the Chesapeake Bay. The Chesapeake Bay TMDL incorporates the effects of filter feeders.

EPA is basing the TMDL on the current assimilative capacity of filter feeders at existing populations built into the calibration of the oyster filter feeding submodel of the Chesapeake Bay Water Quality and Sediment Transport Model. Potential future population changes are not accounted for in the Bay TMDL. If future monitoring data indicate an increase in the filter feeder population, the appropriate jurisdiction's 2-year milestone delivered load reductions can be adjusted accordingly. Similarly if reductions in future filter feeder populations are observed that result in reduced nutrient assimilation, the 2-year milestone delivered load reductions can be adjusted to account for the change. The adjusted loads will be compared to the 2-year milestone commitments to ensure that each jurisdiction is meeting its obligations.

SECTION 11. PUBLIC PARTICIPATION

EPA and the Bay jurisdictions have benefitted from a comprehensive effort to exchange information with key stakeholders and the broader public on the Chesapeake Bay TMDL.

The Bay TMDL has been the subject of public discussion and close interaction between EPA and the seven watershed jurisdictions since 2005. Activities to further public involvement in the Bay TMDL will continue in 2011 and beyond as the TMDL is implemented.

The concentrated outreach period of 2009 and 2010 leading up to the establishment of the TMDL is of particular focus in this section. That 2-year effort featured hundreds of meetings with interested groups; two extensive rounds of public meetings, stakeholder sessions, and media interviews throughout the watershed; a dedicated EPA website; a series of monthly interactive webinars accessed online by more than 2,500 people; three notices published in the *Federal Register*; and a close working relationship with Chesapeake Bay Program committees representing citizens, local governments, and the scientific community.

The states and the District of Columbia have also involved stakeholders and the broader public in the development of their Watershed Implementation Plans, which informed the Bay TMDL.

11.1 Stakeholder and Local Government Outreach and Involvement

EPA has made a concerted effort over the past years to involve a variety of stakeholders, including local governments, in the development of the Chesapeake Bay TMDL. This subsection describes some of the more significant aspects of that effort.

11.1.1 Open Collaboration with Stakeholders

EPA has taken extra efforts to reach out to groups and sectors that will be particularly affected by the Bay TMDL. Since 2008, EPA principals involved in developing the Bay TMDL have attended nearly 400 meetings with a wide range of groups throughout the watershed to give and receive information about the TMDL. A list of those meetings is provided in Appendix C.

During the course of months-long outreach campaigns in the fall of 2009 and 2010, EPA teams conducted nearly 100 separate meetings and briefings with key stakeholder groups to share sector-specific information and address sector-focused questions. Those groups included farmers and producers, homebuilders and developers, municipal wastewater authorities, local elected officials, conservation groups, and environmental advocacy organizations. The outreach generated key insights and perspectives.

11.1.2 Outreach to Local Governments and Elected Officials

EPA and the watershed jurisdictions have made a special effort to involve local governments in the Bay TMDL process to better understand how the TMDL can best be tailored to local scales for implementation. EPA and the jurisdictions will have more targeted discussions with local officials starting in 2011 as the Phase II Watershed Implementation Plans from the states and the

District offer a finer scale commitment to meeting the pollution reduction allocations. EPA has and is willing to use the scientific ability in the TMDL to identify pollution sources and impacts on a relatively local level.

11.1.3 Local Pilots

EPA provided $300,000 in technical assistance for a series of pilot projects to help the jurisdictions engage local partners as part of their Watershed Implementation plan Process. Local governments, conservation districts, watershed groups and others were eligible for a share of the assistance. The projects are demonstrating how local needs, priorities, and existing restoration efforts can be incorporated in the implementation plans. EPA awarded funds to the following communities and watersheds:

District of Columbia
Maryland: Anne Arundel and Caroline counties
New York: Chemung River watershed
Pennsylvania: Conewago Creek watershed
Virginia: Prince William County and Rivanna River basin
West Virginia: Berkeley, Jefferson, and Morgan counties

Information on the pilot projects is at http://www.epa.gov/reg3wapd/pdf/pdf_chesbay/WIPPilotProjectSummary_82010.pdf.

11.2 Public Outreach

EPA's extensive outreach efforts included public meetings, webinars, and a dedicated website that facilitated a continuing dialogue between EPA, the seven watershed jurisdictions, and key stakeholders on the Chesapeake Bay TMDL for nitrogen, phosphorus, and sediment.

11.2.1 Public Meetings

Two rounds of public meetings in each of the watershed jurisdictions were a centerpiece of EPA's outreach efforts.

November–December 2009 Public Meetings

EPA and its jurisdiction partners sponsored 16 public meetings in the fall of 2009 to share information on the forthcoming Bay TMDL. A number of the public meetings were broadcast to a live, online audience via webinar. More than 2,000 people participated in the meetings, including 1,815 in person and 263 online via webinar at six of the locations. There was also a kickoff public meeting in Richmond, Virginia, in October 2009 that drew a combined live and online audience of more than 400 people.

The 2009 public meetings were held in

Martinsburg, West Virginia, November 4*
Moorefield, West Virginia, November 5
Washington, D.C., November 16*
Ashley, Pennsylvania, November 17
Williamsport, Pennsylvania, November 18

State College, Pennsylvania, November 19
Lancaster, Pennsylvania, November 23*
Binghamton, New York, December 1*
Baltimore, Maryland, December 8*
Laurel, Delaware, December 10*
Wye Mills, Maryland, December 11
Falls Church, Virginia, December 14
Chesapeake, Virginia, December 15
Williamsburg, Virginia, December 15
Penn Laird, Virginia, December 16
Fredericksburg, Virginia, December 17

* Meeting also was broadcast online via webinar. The largest live audiences were in Penn Laird, Virginia (205), and Lancaster, Pennsylvania (196).

September-November 2010 Public Meetings

The draft Chesapeake Bay TMDL was issued on September 24, 2010, commencing a 45-day public comment period. During that comment period, a total of 18 public meetings were held in all seven watershed jurisdictions. As in 2009, one of the meetings in each jurisdiction was broadcast online via webinar to a broader audience. The times, specific locations, directions, and parking information were posted on the Bay TMDL website: http://www.epa.gov/chesapeakebaytmdl.

EPA and the respective jurisdictions each made presentations during the public meetings. Those presentations were posted on the Bay TMDL website as they happened. They can be found on the site as part of a summary of the 2010 public meetings.

Nearly 2,800 people participated in the meetings, including 2,311 in person (estimated based on sign-in sheets and headcounts) and 477 online via webinar.

The meetings and attendance figures were as follows:

Washington, D.C., September 29* (29 in person, 74 online)
Harrisonburg, Virginia, October 4 (330)
Annandale, Virginia, October 5 (135)
Richmond, Virginia, October 6 (250)
Webinar, October 7 (9 in person, 160 online)
Hampton, Virginia, October 7 (165)
Georgetown, Delaware, October 11* (90 in person, 16 online)
Easton, Maryland, October 12 (111)
Annapolis, Maryland, October 13 (200)
Hagerstown, Maryland, October 14* (60 in person, 65 online)
Lancaster, Pennsylvania, October 18 (200)
State College, Pennsylvania, October 19 (101)
Williamsport, Pennsylvania, October 20* (80 in person, 101 online)
Ashley, Pennsylvania, October 21 (40)
Elmira, New York, October 26 (120)
Binghamton, New York, October 27* (120 in person, 42 online)

Martinsburg, West Virginia, November 3 (100)
Romney, West Virginia, November 4* (171 in person, 19 online)

* Meeting also broadcast online via webinar. Webinar registration links were available on the Bay TMDL website listed above.

11.2.2 Webinars to Expand Audiences

EPA Region 3 was one of the first regional offices to acquire capacity to host large webinars. The system was obtained specifically to broadcast a representative number of the 2009 fall public meetings to online audiences, thus expanding the ability for the public to hear and participate in the meetings. Webinars were broadcast about monthly and were incorporated in a number of the fall 2010 public meetings—one in each jurisdiction.

Monthly Webinars

EPA sponsored monthly webinars in 2010 to keep the public up to date on Bay TMDL developments. The seven webinars drew a collective audience of 2,587 participants. The regularly scheduled webinars represent one of EPA's Open Government flagship initiatives for public outreach. A substantial portion of each webinar was reserved for informal questions and answers.

The monthly webinars were advertised widely using stakeholder and jurisdiction lists of hundreds of people and organizations that have expressed an interest in the Bay TMDL. The registration links for the webinars were published prominently on the Bay TMDL website.

The monthly webinars were held on

February 25, 2010	TMDL Update 1	529 participants
March 25, 2010	TMDL Update 2	379 participants
May 17, 2010	TMDL Update 3	294 participants
June 7, 2010	TMDL Update 4	288 participants
July 8, 2010	TMDL Update 5	383 participants
August 9, 2010	TMDL Update 6	385 participants
September 28, 2010	TMDL Update 7	329 participants

Webinars Tailored to Specific Stakeholder Communities

In addition to the monthly webinars, EPA sponsored two webinars to review detailed modeling and other technical information with representatives of the agriculture and development communities.

The webinars were held on

March 22, 2010	Webinar for the Agriculture Community	218 participants
May 6, 2010	Webinar for the Development Community	84 participants

11.2.3 Chesapeake Bay TMDL Website

EPA established a website for the Chesapeake Bay TMDL in August 2009. The address is http://www.epa.gov/chesapeakebaytmdl.

The site continues to include the latest news and information on the Bay TMDL, along with fact sheets, questions and answers, presentations, and other features. The site has consistently been one of the most popular in EPA Region 3 according to access numbers.

In addition, the Chesapeake Bay Program partnership's website (www.chesapeakebay.net) has contained detailed information involving Bay TMDL proceedings, including scientific data, PowerPoint presentations, and other items used in the process.

11.2.4 Public Notices

Federal Register Notices

EPA has issued two notices in the *Federal Register* regarding the Chesapeake Bay TMDL to ensure that the public has full advance notification of major events. The notices include a September 17, 2009, announcement (USEPA 2009a) of the public meetings and a September 22, 2010 announcement (USEPA 2010c) of the public review and comment period. EPA issued a third notice to announce establishment of the final Chesapeake Bay TMDL.

Newspaper Notices

EPA has issued notices in regional and local newspapers regarding the Chesapeake Bay TMDL to ensure that the public throughout the watershed has full advance notification of major events.

11.3 Responses to Public Comments

The Draft Chesapeake Bay TMDL was available for public comment from September 24, 2010, to November 8, 2010. Comments were accepted electronically via Docket ID No. EPA-R03-OW-2010-0736 at www.regulations.gov, by mail, and by hand delivery. A link to review and comment on the Bay TMDL was provided through the Bay TMDL website.

EPA received more than 14,000 comments on the Bay TMDL, including more than 700 detailed comment letters. More than 90 percent of the comments, including many similar submissions, were in favor of the TMDL. Comments came from many different sources, including individual citizens, industry, local government, environmental organizations, and academia.

A team of EPA specialists reviewed and responded to all written comments submitted during the public comment period and the comments were considered, as appropriate, in the establishment of the final Bay TMDL. Responses to the comments are included in Appendix W in the final Bay TMDL document.

11.4 Interaction with States, D.C. on Watershed Implementation Plans

EPA provided considerable assistance to the six watershed states and the District of Columbia in the development of their draft and final WIPs. In addition to financial and technical assistance, EPA held numerous meetings and conference calls with each of the jurisdictions to provide input and guidance and to reiterate expectations for the WIPs. A listing of those conference calls and meetings are included in Appendix C in this document.

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SECTION 13. GLOSSARY

Airshed. A geographic area delineating the relative location of air emission sources contributing to the atmospheric deposition to a down-wind watershed.

Allocations. Best estimates of current and future pollutant loads (both nonpoint and point sources) entering a water body. Pollutant load estimates can range from reasonably accurate measurements to gross estimates and the techniques used for predicting specific loads.

Ammonia. An inorganic nitrogen compound. In water, ammonia levels in excess of the recommended limits may harm aquatic life.

Assimilative Capacity. The capacity of a natural body of water to receive wastewaters or toxic materials without deleterious effects and without damage to aquatic life or humans who consume the water.

Bay Segment. Subunits of the Chesapeake Bay estuary that were derived on the basis of specific selection criteria related to factors such as jurisdictional boundaries and other water quality, physical, geographic, and habitat related characteristics. The Chesapeake Bay and its tidal tributaries and embayments are divided into 92 segments.

Best Management Practices. Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources.

Bloom. A proliferation of algae or higher aquatic plants (or both) in a body of water; often related to pollution, especially when pollutants accelerate growth. Blooms are often the result of excessive levels of nutrients—generally nitrogen and phosphorus—in water.

Boundary Conditions. The definition or statement of conditions or phenomena at the boundaries of a model; water levels, flows, and concentrations that are specified at the boundaries of the area being modeled.

Chlorophyll *a*. A photosynthetic pigment that is found in green plants. The concentration of chlorophyll *a* is used as an indicator of water quality.

Critical Condition. Critical conditions are represented by the combination of loading, waterbody conditions, and other environmental conditions that result in impairment and violation of water quality standards. Critical conditions for an individual TMDL typically depend on applicable water quality standards, characteristics of the observed impairments, source type and behavior, pollutant, and waterbody type.

Critical Period. A period during which hydrologic, temperature, environmental, flow, and other such environmental conditions result in a waterbody being most sensitive to an identified impairment (e.g., summer low flow, winter high flow).

Delist. To remove an impaired waterbody from the Section 303(d) Impaired Waters List.

Delivered Load. The amount of a pollutant delivered to the tidal waters of the Chesapeake Bay or its tidal tributaries from an upstream point of discharge/runoff after accounting for permanent reductions in pollutant loads due to natural in-stream processes in nontidal rivers.

Edge-of-Stream Load. The amount of a pollutant reaching a simulated stream segment from a point in that stream's watershed.

Effluent. Wastewater, either treated or untreated, that flows out of a treatment plant, sewer, or industrial outfall. Generally refers to wastes or waters containing pollutants discharged into surface waters.

Eutrophication. The slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. During the later stages of eutrophication the water body is choked by abundant plant life due to higher levels of nutritive compounds such as nitrogen and phosphorus. Human activities can accelerate the process.

Existing Flow. The average flow volume discharged from a facility based on monitored data.

Facility Design Flow. The maximum flow volume for which a facility is designed and permitted to operate at.

Failing Septic System. Septic systems in which the drain field has failed such that effluent that is supposed to percolate into the soil, rises to the surface and pools on the surface where it can run into streams or rivers.

Impaired Waters. Waters with chronic or recurring monitored violations of the applicable numeric or narrative water quality standards.

Load Allocation. The portion of the TMDL allocated to existing or future nonpoint sources and natural background.

Loading Capacity. The greatest pollutant loading a waterbody can receive without exceeding water quality standards.

Mainstem Bay. The Chesapeake Bay, from Havre de Grace, Maryland to the Virginia Capes, without the tidal tributaries and embayments included.

Margin of Safety. An accounting of uncertainty about the relationship between pollutant loads and receiving water quality. The margin of safety can be provided implicitly through analytical assumptions or explicitly by reserving a portion of loading capacity.

Mesohaline. Salinity regime with >5-18 parts per thousand salinity.

Mixing Zone. A limited area or volume of a receiving water body where the initial dilution occurs and a permitted or authorized discharge occurs. Mixing zones are supposed to dilute or reduce pollutant concentrations below applicable water quality standards such that the applicable criteria in the standards are met at the edge of the mixing zone.

Model. A system of mathematical expressions that describe and represent the physical world or some aspect therein. In the Bay TMDL, models are used to describe both hydrologic and water quality processes as well as estimate the load of a specific pollutant to a water body and make predictions about how the load would change as remediation methods (e.g. scenarios) are implemented.

National Pollutant Discharge Elimination System (NPDES) permit program is authorized by the Clean Water Act and works to control water pollution by regulating point sources that discharge pollutants into waters of the United States. Industrial, municipal, and other facilities must obtain permits for any discharge into waters of the United States. In most cases, the NPDES permit program is administered by authorized states or EPA.

Nonpoint Source. Any source of water pollution that does not meet the legal definition of *point source*. Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification.

Nonsignificant Discharge Facility. A municipal or industrial wastewater discharge facility that is not defined as *a significant discharge facility* by the jurisdiction in which it is permitted. In general but not always, nonsignificant municipal facilities have design flows less than 0.4 million gallons per day (Virginia and Maryland thresholds are slightly different). Nonsignificant industrial facilities discharge less than 3,800 pounds per year total phosphorus and less than 27,000 pounds per year total nitrogen.

Oligohaline. Salinity regime with >0.5-5 parts per thousand salinity.

Point Source. Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel or other floating craft from which pollutants are or may be discharged.

Pollutant Source Sector. Category of related sources of nutrient and sediment loads identified for purposes of quantifying load allocations. Examples include agriculture, wastewater, forest, urban runoff.

Polyhaline. Salinity regime with 0-0.5 parts per thousand salinity.

Pycnocline. The depth in the water column where there is an abrupt change in density, temperature, and salinity. A pycnocline often forms in the Chesapeake Bay and its tidal tributaries when the lighter, warmer, and fresher water coming downstream from the spring rains overlays the denser, colder, and saltier water of the salt wedge bringing water upstream from the ocean.

Residence Time. Length of time that a pollutant remains with a section of a stream or river. Residence time is determined by streamflow and volume of the body in question.

Riparian. Referring to the areas adjacent to rivers and streams with a differing density, diversity, and productivity of plant and animal species relative to nearby uplands.

Runoff. That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface-water. It can carry pollutants from the air and land into receiving waters.

Section 303(d). A section of the Clean Water Act that requires periodic identification of waters that do not or are not expected to meet applicable water quality standards and the establishment of TMDLs for such waters.

Sediment. Soil, sand, and minerals washed from the land into water, usually after rain or snow melt.

Segment Watershed. Watershed area draining into one of the 92 Chesapeake Bay segments.

Significant Discharge Facility. A municipal or industrial wastewater facility defined as such by the jurisdiction in which it is permitted. Significant facilities are distinguished from nonsignificant facilities on the basis of flow for municipals and loads for industrials. In general but not always, significant municipal facilities have flows larger than 0.4 million gallons per day, and significant industrial facilities discharge loads larger than 3,800 pounds per year of total phosphorus and 27,000 pounds per year of total nitrogen.

Simulation Period. A period used to run the model scenario simulation, selected to ensure that the simulated rainfall, meteorological, and environmental time series used to drive the watershed simulation such that it accurately simulates the critical conditions.

Suspended Solids. Small particles of solid pollutants that float on the surface of, or are suspended in, sewage or other liquids. They resist removal by conventional means.

Tidal Fresh. Salinity regime with 0-0.5 parts per thousand salinity.

Total Maximum Daily Load. Specifies the maximum amount of a pollutant that a waterbody can receive and still meet applicable water quality standards. It is the sum of the allocations for point sources (called wasteloads) and allocations for nonpoint sources (called loads) and natural background with a margin of safety (CWA section 303(d)(1)(c)). The TMDL can be described by the following equation:

$$\text{TMDL} = LC = \Sigma WLA + \Sigma LA + MOS$$

Turbidity. A measure of the cloudy condition in water due to suspended solids or organic matter.

Wasteload Allocation. The portion of the TMDL allocated to existing, potential or future point sources.

Water Clarity Acre. An acre of shallow-water bay grass designated-use bottom habitat, located anywhere between the 2-meter depth contour and the adjacent shoreline inclusively, which has been observed to achieve the applicable salinity-regime-specific water clarity criteria.

Watershed. An area of land from which all water drains to a common point.

SECTION 14. ABBREVIATIONS

µg/L	microgram per liter
ADM	annual/daily maximum ratio
AEU	animal equivalent units
AFO	animal feeding operation
ASMFC	Atlantic States Marine Fisheries Commission
BART	best available retrofit technology
BayTAS	Chesapeake Bay TMDL Tracking and Accountability System
BMP	best management practice
BOD	biological oxygen demand
CAA	Clean Air Act
CAC	Citizen's Advisory Committee
CAFO	concentrated animal feeding operation
CAMR	Clean Air Mercury Rule
CBLCD	Chesapeake Bay land cover data
CBP	Chesapeake Bay Program
CEC	Chesapeake Executive Council
CFD	cumulative frequency distribution
CFR	*Code of Federal Regulations*
CIMS	Chesapeake Information Management System
CMAQ	Community Multi-scale Air Quality model
COE	U.S. Army Corps of Engineers
COMAR	Code of Maryland
CONMON	continuous monitoring
CSO	combined sewer overflow
CSS	combined sewer system
CWA	Clean Water Act
DAITS	Data and Information Tracking System
DC	District of Columbia
DC WASA	District of Columbia Water and Sewer Authority
DE	Delaware
DE DNREC	Delaware Department of Natural Resources and Environmental Control
DMR	discharge monitoring report
DO	dissolved oxygen
DUQAT	Data Upload and Quality Assurance Tool
E3	everything by everyone everywhere
EGU	electric generating unit
EISA	Energy Independence and Security Act
ELG	effluent limit guidelines
EO	Executive Order
EPA	U.S. Environmental Protection Agency
FFIP	federal facility implementation plan
FR	*Federal Register*
GIS	geographic information system
ICIS	Integrated Compliance Information System

Kd	light attenuation coefficient
LA	load allocation
lbs	pounds
LC	loading capacity
LGAC	Local Governments Advisory Committee
Ln	natural log
LOESS	locally weighted scatter plot smoother
LTCP	Long-Term Control Plan
m	meter
MAWP	Mid-Atlantic Water Program
MD	Maryland
MDE	Maryland Department of the Environment
mgd	million gallons per day
mg/L	milligrams per liter
MOS	margin of safety
MOU	memorandum of understanding
MRAT	Monitoring Realignment Action Team
MS4	Municipal Separate Storm Sewer System
NADP	National Atmospheric Deposition Program
NAS	National Agricultural Statistics
NEIEN	National Environmental Information Exchange Network
NH_3	ammonia
NH_4+	ammonium
NMFS	National Marine Fisheries Service
NMP	nutrient management plan
NO_2	nitrite
NO_3	nitrate
NOI	notice of intent
NOx	nitrogen oxides
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NY	New York
OSWTS	on-site wastewater treatment system
PA	Pennsylvania
PA DEP	Pennsylvania Department of Environmental Protection
PAR	photosynthetically active radiation
PCS	Permit Compliance System
PLW	percent light through water
POTW	publicly owned treatment works
PSC	Principals’ Staff Committee
ppt	parts per thousand (salinity)
QA	quality assurance
QA/QC	quality assurance/quality control
RDA	Residual Designation Authority
RESAC	University of Maryland’s Regional Earth Science Applications Center

SAV	submerged aquatic vegetation
SCR	selective catalytic reduction
SIP	state implementation plan
SNCR	selective non-catalytic reduction
SPARROW	Spatially Referenced Regressions on Watershed Attributes
SSO	sanitary sewer overflow
STAC	Scientific and Technical Advisory Committee
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
USC	Upper Susquehanna Coalition
U.S.C.	*United States Code*
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VA	Virginia
VA DEQ	Virginia Department of Environmental Quality
VA DCR	Virginia Department of Conservation and Recreation
WIP	watershed implementation plan
WLA	wasteload allocation
WQBELs	water quality-based effluent limits
WQGIT	Water Quality Group Implementation Team
WQS	water quality standards
WV	West Virginia
WV DEP	West Virginia Department of Environmental Protection
WWTP	wastewater treatment plant
yr	year
z	depth

Appendix A.
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The Chesapeake Bay TMDL resulted from the collaborative expertise, input, and feedback of many individuals. Advice, technical information and guidance was provided by the multitude of Chesapeake Bay Program partnering agencies and institutions, local governments, nongovernmental organizations, businesses, many other involved stakeholders, and the general public. Their individual and collective contributions are acknowledged here.

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Tetra Tech, Inc.

Many dedicated people at Tetra Tech, Inc. provided assistance to EPA and the jurisdictions in developing the Chesapeake Bay TMDL and the Phase I WIPs including but not limited to the following: Clint Boschen, Kimberly Brewer, Krista Carlson, Jim Collins, Melissa DeSantis, Mustafa Faizullabhoy, Martin Hurd, Lisa Koehler, Jessica Koenig, Jon Ludwig, Kelly Meadows, Jennifer McDonnell, Elsa Mittelholtz, Aileen Molloy, Andrew Parker, Teresa Rafi, Vladislav Royzman, Mark Sievers, Jeff Strong, Barry Tonning, and Peter Von Lowe.

Appendix B.
Index of Documents Supporting the Chesapeake Bay TMDL

This index of documents (with URL links for direct electronic access) includes materials EPA and its seven watershed jurisdictional partners relied upon during development of the Chesapeake Bay TMDL. These documents include but are not limited to data, analyses, computer programs, computer model code, scientific/technical references used or cited in the main Bay TMDL document, correspondence, agreements, directives, strategies, plans, independent peer reviews, workshop proceedings, and other supporting materials. Access to advance briefing materials, presentations, issue papers, and summaries of relevant partnership meetings and conference calls related to development of the Bay TMDL are fully cataloged in Appendix C.

The listed documents are organized by subcategories by date of publication to assist the reader in locating documents of interest. For each listed document, full reference citation (in the case of a formal publication) and URL address for direct web-based electronic access to the document are provided. In the case of reference to data, the data repository and the URL address for direct electric access to the data are provided. Some of the individual documents are listed in multiple categories to aid the readers to get access the correct documents.

The ultimate objective of this appendix is to ensure direct public access to the full array of data, documentation, models, tools, and computer programming that supported development of the Chesapeake Bay TMDL.

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Appendix C.
Record of Chesapeake Bay TMDL Related Chesapeake Bay Program Committee, Team and Workgroup and Partner/Stakeholder Meetings

This appendix presents the dates of Chesapeake Bay Program (CBP) committee, team, and workgroup meetings since 2005 where the Chesapeake Bay TMDL or a directly related topic was on the agenda (Table C-1). A URL is provided to access the Chesapeake Bay Program website’s calendar of events and each meeting’s respective agenda, advance briefing materials, presentations or meeting summary.

This appendix also documents the record of Chesapeake Bay Program committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (Table C-2). The abbreviations used in Table C-2 are explained in Tables C-3 (EPA staff names) and C-4 (organizations).

Table C-1. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda

Date	Group	URL
January 10, 2005	Executive Council	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5851&DefaultView=all&RequestDate=01/17/2005
January 11, 2005	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5937&DefaultView=all&RequestDate=01/17/2005
January 12, 2005	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5858&DefaultView=all&RequestDate=01/17/2005
January 25, 2005	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5802&DefaultView=all&RequestDate=01/17/2005
February 15, 2005	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5749&DefaultView=all&RequestDate=02/17/2005
February 17, 2005	Implementation Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5507&DefaultView=all&RequestDate=02/17/2005
February 22, 2005	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5755&DefaultView=all&RequestDate=02/17/2005
February 23, 2005	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5721&DefaultView=all&RequestDate=02/17/2005
April 4, 2005	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5932&DefaultView=all&RequestDate=04/17/2005
April 5, 2005	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5933&DefaultView=all&RequestDate=04/17/2005
April 28, 2005	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5803&DefaultView=all&RequestDate=04/17/2005
May 3, 2005	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5934&DefaultView=all&RequestDate=05/17/2005
May 5, 2005	Water-Quality Criteria Assessment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6366&DefaultView=all&RequestDate=05/17/2005
June 7, 2005	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5935&DefaultView=all&RequestDate=06/17/2005
June 21, 2005	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5756&DefaultView=all&RequestDate=06/17/2005
June 22, 2005	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6371&DefaultView=all&RequestDate=06/17/2005
July 12, 2005	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5976&DefaultView=all&RequestDate=07/17/2005
July 13, 2005	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5977&DefaultView=all&RequestDate=07/17/2005
July 14, 2005	Water-Quality Criteria Assessment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6363&DefaultView=all&RequestDate=07/17/2005
July 21, 2005	Implementation Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5512&DefaultView=all&RequestDate=07/17/2005
July 21, 2005	Water-Quality Criteria Assessment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6393&DefaultView=all&RequestDate=07/17/2005
July 28, 2005	Water-Quality Criteria Assessment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6480&DefaultView=all&RequestDate=07/17/2005
August 3, 2005	Water-Quality Criteria Assessment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6483&DefaultView=all&RequestDate=08/17/2005
August 18, 2005	Water-Quality Criteria Assessment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6527&DefaultView=all&RequestDate=08/17/2005
August 24, 2005	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5728&DefaultView=all&RequestDate=08/17/2005

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
September 13-14, 2005	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/MeetInfo/Sept05Mins.pdf
September 28, 2005	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5729&DefaultView=all&RequestDate=09/17/2005
October 3, 2005	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6619&DefaultView=all&RequestDate=10/17/2005
October 11, 2005	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5980&DefaultView=all&RequestDate=10/17/2005
October 13, 2005	Agricultural Nutrient Reduction Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5672&DefaultView=all&RequestDate=10/17/2005
October 26, 2005	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5730&DefaultView=all&RequestDate=10/17/2005
October 27, 2005	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5806&DefaultView=all&RequestDate=10/17/2005
November 21, 2005	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6844&DefaultView=all&RequestDate=11/17/2005
December 7, 2005	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=5950&DefaultView=all&RequestDate=12/17/2005
December 13-14, 2005	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/MeetInfo/Dec05Mins.pdf
December 19, 2005	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6845&DefaultView=all&RequestDate=12/17/2005
December 21, 2005	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6957&DefaultView=all&RequestDate=12/17/2005
January 9, 2006	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6934&DefaultView=all&RequestDate=01/17/2006
January 19, 2006	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6832&DefaultView=all&RequestDate=01/17/2006
January 23, 2006	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6935&DefaultView=all&RequestDate=01/17/2006
January 24-25, 2006	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6940&DefaultView=all&RequestDate=01/17/2006
February 23, 2006	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6985&DefaultView=all&RequestDate=02/21/2006
February 27, 2006	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6936&DefaultView=all&RequestDate=02/17/2006
March 14-15, 2006	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/MeetInfo/Mar06Mins.pdf
March 20, 2006	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6937&DefaultView=all&RequestDate=03/17/2006
April 4-5, 2006	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7065&DefaultView=all&RequestDate=4/17/2006
April 17, 2006	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6938&DefaultView=all&RequestDate=04/01/2006

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
April 25, 2006	Water Quality Assessment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7293&DefaultView=all&RequestDate=04/21/2006
April 27, 2006	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6986&DefaultView=all&RequestDate=04/21/2006
May 16, 2006	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7072&DefaultView=all&RequestDate=05/21/2006
May 22, 2006	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7290&DefaultView=all&RequestDate=05/21/2006
May 24, 2006	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6848&DefaultView=all&RequestDate=05/21/2006
June 7-8, 2006	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7081&DefaultView=all&RequestDate=06/21/2006
June 29, 2006	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6987&DefaultView=all&RequestDate=06/21/2006
July 18-19, 2006	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7066&DefaultView=all&RequestDate=07/21/2006
July 27, 2006	Water Quality Assessment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7453&DefaultView=all&RequestDate=07/21/2006
August 21, 2006	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7455&DefaultView=all&RequestDate=08/21/2006
August 28, 2006	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7569&DefaultView=all&RequestDate=08/21/2006
August 30, 2006	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7450&DefaultView=all&RequestDate=08/01/2006
September 6, 2006	Tributary Strategy Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7460&DefaultView=all&RequestDate=09/01/2006
September 18, 2006	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7456&DefaultView=all&RequestDate=09/01/2006
September 27, 2006	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6896&DefaultView=all&RequestDate=09/01/2006
October 2, 2006	Tributary Strategy Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6776&DefaultView=all&RequestDate=10/01/2006
October 16, 2006	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7457&DefaultView=all&RequestDate=10/01/2006
October 17-18, 2006	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7067&DefaultView=all&RequestDate=10/01/2006
October 26, 2006	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6988&DefaultView=all&RequestDate=10/21/2006
November 2, 2006	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6777&DefaultView=all&RequestDate=11/01/2006
November 6, 2006	Tributary Strategy Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6777&DefaultView=all&RequestDate=11/01/2006
November 14-15, 2006	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7684&DefaultView=all&RequestDate=11/01/2006
December 12, 2006	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6989&DefaultView=all&RequestDate=12/01/2006
December 13, 2006	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=6763&DefaultView=all&RequestDate=12/21/2006
January 9-10, 2007	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7849&DefaultView=all&RequestDate=01/01/2007

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
January 16, 2007	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8083&DefaultView=all&RequestDate=01/01/2007
March 1, 2007	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8045&DefaultView=all&RequestDate=03/01/2007
March 5, 2007	Tributary Strategy Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7819&DefaultView=all&RequestDate=03/01/2007
March 6-7, 2007	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/MeetInfo/March07Minutes.pdf
March 8, 2007	Agricultural Nutrient Reduction Workshop	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7896&DefaultView=all&RequestDate=03/11/2007
March 26, 2007	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8087&DefaultView=all&RequestDate=03/01/2007
March 30, 2007	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8269&DefaultView=all&RequestDate=03/18/2007
April 3-4, 2007	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8028&DefaultView=all&RequestDate=04/18/2007
June 4, 2007	Tributary Strategy Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=7823&DefaultView=all&RequestDate=06/18/2007
June 6, 2007	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8255&DefaultView=all&RequestDate=06/18/2007
June 12-13, 2007	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/MeetInfo/Jun07Minutes.pdf
June 20-21, 2007	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8501&DefaultView=all&RequestDate=06/18/2007
July 10-11, 2007	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8678&DefaultView=all&RequestDate=07/18/2007
July 23, 2007	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8823&DefaultView=all&RequestDate=07/18/2007
July 24, 2007	Wastewater Treatment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8813&DefaultView=all&RequestDate=07/18/2007
August 6, 2007	Tributary Strategy Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8816&DefaultView=all&RequestDate=08/18/2007
August 27, 2007	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8824&DefaultView=all&RequestDate=08/18/2007
September 11, 2007	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/meetings
September 17, 2007	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8825&DefaultView=all&RequestDate=09/18/2007
October 1, 2007	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9029&DefaultView=all&RequestDate=10/18/2007
October 9, 2007	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9034&DefaultView=all&RequestDate=10/18/2007

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
October 15, 2007	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8030&DefaultView=all&RequestDate=10/18/2007
October 15, 2007	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8826&DefaultView=all&RequestDate=10/18/2007
October 25, 2007	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9098&DefaultView=all&RequestDate=10/18/2007
November 16, 2007	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9194&DefaultView=all&RequestDate=11/18/2007
November 19, 2007	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8827&DefaultView=all&RequestDate=11/18/2007
December 11-12, 2007	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/December2007quarterly.html
December 17, 2007	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9246&DefaultView=all&RequestDate=12/18/2007
December 17, 2007	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=8829&DefaultView=all&RequestDate=12/18/2007
December 18, 2007	Tributary Strategy Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9212&DefaultView=all&RequestDate=12/18/2007
January 8, 2008	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9046&DefaultView=all&RequestDate=01/18/2008
January 10, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9301&DefaultView=all&RequestDate=01/18/2008
January 22, 2008	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9043&DefaultView=all&RequestDate=01/18/2008
January 23, 2008	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9159&DefaultView=all&RequestDate=01/18/2008
January 24, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9302&DefaultView=all&RequestDate=01/18/2008
January 31, 2008	Wastewater Treatment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9296&DefaultView=all&RequestDate=01/18/2008
February 7, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9356&DefaultView=all&RequestDate=02/18/2008
February 28, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9369&DefaultView=all&RequestDate=02/18/2008
March 5, 2008	Wastewater Treatment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9374&DefaultView=all&RequestDate=03/18/2008
March 13, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9370&DefaultView=all&RequestDate=03/18/2008
March 17, 2008	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9377&DefaultView=all&RequestDate=03/18/2008

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
March 19, 2008	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9413&DefaultView=all&RequestDate=03/18/2008
March 25-26, 2008	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/march2008quarterly.html
March 26, 2008	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9161&DefaultView=all&RequestDate=03/18/2008
March 27, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9422&DefaultView=all&RequestDate=03/18/2008
April 8, 2008	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9414&DefaultView=all&RequestDate=04/18/2008
April 10, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9471&DefaultView=all&RequestDate=04/18/2008
April 22-23, 2008	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9376&DefaultView=all&RequestDate=04/18/2008
April 28-29, 2008	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9316&DefaultView=all&RequestDate=04/18/2008
May 19, 2008	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9486&DefaultView=all&RequestDate=05/20/2008
May 27, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9537&DefaultView=all&RequestDate=05/20/2008
June 2, 2008	Tributary Strategy Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9155&DefaultView=all&RequestDate=06/20/2008
June 3, 2008	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/june2008quarterly.html
June 5, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9538&DefaultView=all&RequestDate=06/20/2008
June 18-19, 2008	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9553&DefaultView=all&RequestDate=06/20/2008
June 19, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9539&DefaultView=all&RequestDate=06/20/2008
June 24, 2008	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9233&DefaultView=all&RequestDate=06/20/2008
July 2, 2008	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9048&DefaultView=all&RequestDate=07/20/2008
July 3, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9540&DefaultView=all&RequestDate=07/20/2008
July 14, 2008	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9639&DefaultView=all&RequestDate=07/20/2008
July 17, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9541&DefaultView=all&RequestDate=07/20/2008

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
July 21, 2008	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9534&DefaultView=all&RequestDate=07/20/2008
July 23, 2008	Reasonable Assurance Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9734&DefaultView=all&RequestDate=07/20/2008
August 4, 2008	Watershed Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9725&DefaultView=all&RequestDate=08/20/2008
August 6, 2008	Reasonable Assurance Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9735&DefaultView=all&RequestDate=08/20/2008
August 14, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9543&DefaultView=all&RequestDate=08/20/2008
August 19, 2008	Agricultural Nutrient Reduction Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9619&DefaultView=all&RequestDate=08/20/2008
August 19, 2008	Reasonable Assurance Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9736&DefaultView=all&RequestDate=08/20/2008
August 21-22, 2008	Citizens Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9299&DefaultView=all&RequestDate=08/20/2008
September 8-9, 2008	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9721&DefaultView=all&RequestDate=09/20/2008
September 12, 2008	Reasonable Assurance Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9733&DefaultView=all&RequestDate=09/20/2008
September 16-17, 2008	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/september2008quarterly.html
September 18, 2008	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9728&DefaultView=all&RequestDate=09/20/2008
September 22, 2008	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9784&DefaultView=all&RequestDate=09/20/2008
September 25, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9546&DefaultView=all&RequestDate=09/20/2008
September 29, 2008	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9536&DefaultView=all&RequestDate=09/20/2008
October 6, 2008	Tributary Strategy Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9157&DefaultView=all&RequestDate=10/20/2008
October 9, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9547&DefaultView=all&RequestDate=10/20/2008
October 20, 2008	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9780&DefaultView=all&RequestDate=10/20/2008
October 20, 2008	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9773&DefaultView=all&RequestDate=10/20/2008

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
October 22, 2008	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9168&DefaultView=all&RequestDate=10/20/2008
October 23, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9548&DefaultView=all&RequestDate=10/20/2008
October 30, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9775&DefaultView=all&RequestDate=10/20/2008
October 31, 2008	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9865&DefaultView=all&RequestDate=10/20/2008
November 6-7, 2008	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9795&DefaultView=all&RequestDate=11/20/2008
November 19, 2008	Agricultural Nutrient Reduction Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9922&DefaultView=all&RequestDate=11/20/2008
November 20, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9777&DefaultView=all&RequestDate=11/28/2008
November 20, 2008	Chesapeake Executive Council	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9923&DefaultView=all&RequestDate=11/20/2008
November 21, 2008	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9800&DefaultView=all&RequestDate=11/28/2008
November 26, 2008	Wastewater Treatment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9916&DefaultView=all&RequestDate=11/28/2008
December 4, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9778&DefaultView=all&RequestDate=12/28/2008
December 8, 2008	Tributary Strategy Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9158&DefaultView=all&RequestDate=12/28/2008
December 9-10, 2008	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/december08quarterly.html
December 11, 2008	Agricultural Nutrient Reduction Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9226&DefaultView=all&RequestDate=12/28/2008
December 11, 2008	Watershed Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9981&DefaultView=all&RequestDate=12/28/2008
December 15, 2008	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9774&DefaultView=all&RequestDate=12/28/2008
December 18, 2008	Chesapeake Action Plan Partners Meeting	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9211&DefaultView=all&RequestDate=12/19/2008
December 18, 2008	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9779&DefaultView=all&RequestDate=12/28/2008
January 6-7, 2009	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9964&DefaultView=all&RequestDate=01/28/2009
January 8, 2009	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9895&DefaultView=all&RequestDate=01/28/2009

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
January 12, 2009	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9901&DefaultView=all&RequestDate=01/28/2009
January 13, 2009	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9980&DefaultView=all&RequestDate=01/28/2009
January 13, 2009	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10020&DefaultView=all&RequestDate=01/28/2009
January 14, 2009	Wastewater Treatment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10091&DefaultView=all&RequestDate=01/28/2009
January 15, 2009	Agricultural Nutrient Reduction Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9983&DefaultView=all&RequestDate=01/11/2009
January 22, 2009	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9896&DefaultView=all&RequestDate=01/28/2009
January 26, 2009	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9903&DefaultView=all&RequestDate=01/28/2009
February 2, 2009	Watershed Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9913&DefaultView=all&RequestDate=02/28/2009
February 5, 2009	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9897&DefaultView=all&RequestDate=02/28/2009
February 9, 2009	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9904&DefaultView=all&RequestDate=02/28/2009
February 17, 2009	Agricultural Nutrient Reduction Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9984&DefaultView=all&RequestDate=02/28/2009
February 17, 2009	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10119&DefaultView=all&RequestDate=02/28/2009
February 18, 2009	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10149&DefaultView=all&RequestDate=02/28/2009
February 19-20, 2009	Citizens Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9867&DefaultView=all&RequestDate=02/28/2009
February 23, 2009	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9920&DefaultView=all&RequestDate=02/28/2009
February 24, 2009	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9955&DefaultView=all&RequestDate=02/28/2009
February 25, 2009	Nutrient Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9817&DefaultView=all&RequestDate=02/28/2009
February 26, 2009	Local Government Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9872&DefaultView=all&RequestDate=02/28/2009
March 9, 2009	Water Quality Steering Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9921&DefaultView=all&RequestDate=03/30/2009

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
March 10-11, 2009	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/march09quarterly.html
March 16, 2009	Water Quality Criteria Assessment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10153&DefaultView=all&RequestDate=03/30/2009
April 6, 2009	Watershed Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9914&DefaultView=all&RequestDate=04/30/2009
April 6, 2009	Water Quality Steering	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10096&DefaultView=all&RequestDate=04/30/2009
April 7-8, 2009	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9965&DefaultView=all&RequestDate=04/30/2009
April 15-16, 2009	Water Quality Steering	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10097&DefaultView=all&RequestDate=04/30/2009
April 16-17, 2009	Citizens Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9868&DefaultView=all&RequestDate=04/30/2009
April 20-21, 2009	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10103&DefaultView=all&RequestDate=04/30/2009
April 23-24, 2009	Local Government Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9991&DefaultView=all&RequestDate=04/30/2009
April 24, 2009	Water Quality Criteria Assessment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10238&DefaultView=all&RequestDate=04/11/2009
May 18, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10241&DefaultView=all&RequestDate=05/30/2009
June 1, 2009	Watershed Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9915&DefaultView=all&RequestDate=06/30/2009
June 9, 2009	Wastewater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10305&DefaultView=all&RequestDate=06/30/2009
June 9, 2009	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10319&DefaultView=all&RequestDate=06/11/2009
June 16, 2009	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/june09quarterly.html
June 22, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10242&DefaultView=all&RequestDate=06/30/2009
June 23, 2009	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10335&DefaultView=all&RequestDate=06/30/2009
July 6, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10345&DefaultView=all&RequestDate=07/30/2009
July 8, 2009	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9966&DefaultView=all&RequestDate=07/30/2009
July 20, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10243&DefaultView=all&RequestDate=07/30/2009
July 22, 2009	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10348&DefaultView=all&RequestDate=07/30/2009

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
August 24, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10403&DefaultView=all&RequestDate=08/30/2009
September 3, 2009	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10406&DefaultView=all&RequestDate=09/30/2009
September 8-9, 2009	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/sept09quarterly.html
September 9, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10244&DefaultView=all&RequestDate=09/30/2009
September 10, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10402&DefaultView=all&RequestDate=08/30/2009
September 14, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10458&DefaultView=all&RequestDate=09/30/2009
September 15, 2009	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10408&DefaultView=all&RequestDate=09/30/2009
September 17-18, 2009	Citizens Advisory Committee/Local Government Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?eventdetails=9874
September 19, 2009	Watershed Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10193&DefaultView=all&RequestDate=08/30/2009
September 21, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10412&DefaultView=all&RequestDate=09/30/2009
September 29-30, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10404&DefaultView=all&RequestDate=09/30/2009
October 5, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10491&DefaultView=all&RequestDate=10/31/2009
October 6-7, 2009	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9967&DefaultView=all&RequestDate=10/31/2009
October 8, 2009	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10476&DefaultView=all&RequestDate=10/31/2009
October 9, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10492&DefaultView=all&RequestDate=10/31/2009
October 19, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10245&DefaultView=all&RequestDate=10/31/2009
October 22, 2009	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10526&DefaultView=all&RequestDate=10/26/2009
October 23, 2009	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10431&DefaultView=all&RequestDate=10/26/2009
October 27, 2009	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9959&DefaultView=all&RequestDate=10/26/2009

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
November 2, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10527&DefaultView=all&RequestDate=11/26/2009
November 5-6, 2009	Citizens Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9871&DefaultView=all&RequestDate=11/26/2009
November 18, 2009	Wastewater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10547&DefaultView=all&RequestDate=11/26/2009
November 20, 2009	CAP-TMDL Tech call	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10554&DefaultView=all&RequestDate=11/26/2009
November 30, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10558&DefaultView=all&RequestDate=11/26/2009
December 8-9, 2009	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/dec09quarterly.html
December 14, 2009	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10572&DefaultView=all&RequestDate=12/26/2009
December 15, 2009	Nonpoint BMP Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10573&DefaultView=all&RequestDate=12/26/2009
December 18, 2009	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10537&DefaultView=all&RequestDate=12/26/2009
December 18, 2009	Urban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=9962&DefaultView=all&RequestDate=12/26/2009
January 11, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10248&DefaultView=all&RequestDate=01/26/2010
February 1, 2010	Watershed Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10589&DefaultView=all&RequestDate=02/26/2010
February 5, 2010	Local Government Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?eventdetails=10636
February 12, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10249&DefaultView=all&RequestDate=02/26/2010
February 17, 2010	Reevaluation Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10113&DefaultView=all&RequestDate=02/28/2009
March 11, 2010	Citizens Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10555&DefaultView=all&RequestDate=03/26/2010
March 15, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10251&DefaultView=all&RequestDate=03/26/2010
March 23, 2010	Management Board	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10619&DefaultView=all&RequestDate=03/26/2010
March 29, 2010	Agriculture Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10714&DefaultView=all&RequestDate=03/26/2010
March 29, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10679&DefaultView=all&RequestDate=03/26/2010
March 31-April 1, 2010	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10657&DefaultView=all&RequestDate=04/26/2010

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
April 5-6, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10559&DefaultView=all&RequestDate=04/26/2010
April 7, 2010	Forestry Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10715&DefaultView=all&RequestDate=04/26/2010
April 8, 2010	Citizens Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10556&DefaultView=all&RequestDate=04/26/2010
April 12, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10736&DefaultView=all&RequestDate=04/26/2010
April 19, 2010	Management Board	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10620&DefaultView=all&RequestDate=04/26/2010
April 19, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10738&DefaultView=all&RequestDate=04/26/2010
April 21, 2010	Watershed Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10590&DefaultView=all&RequestDate=04/26/2010
April 22, 2010	Wastewater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10746&DefaultView=all&RequestDate=04/26/2010
April 22-24, 2010	Local Government Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?eventdetails=10637
April 26, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10737&DefaultView=all&RequestDate=04/26/2010
April 27, 2010	Agriculture Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10747&DefaultView=all&RequestDate=04/26/2010
April 28, 2010	Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10775&DefaultView=all&RequestDate=04/26/2010
April 29-30, 2010	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10740&DefaultView=all&RequestDate=04/26/2010
May 3, 2010	Watershed Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10609&DefaultView=all&RequestDate=05/26/2010
May 5, 2010	Forestry Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10778&DefaultView=all&RequestDate=05/26/2010
May 10, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10776&DefaultView=all&RequestDate=05/26/2010
May 17, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10252&DefaultView=all&RequestDate=05/26/2010
May 21, 2010	CB Atmospheric Deposition Meeting	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10859&DefaultView=all&RequestDate=05/26/2010
May 24, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10851&DefaultView=all&RequestDate=05/26/2010
May 26, 2010	Urban/Suburban Stormwater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10858&DefaultView=all&RequestDate=05/26/2010
May 27, 2010	Agriculture Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10862&DefaultView=all&RequestDate=05/26/2010
June 1, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10850&DefaultView=all&RequestDate=06/26/2010

Table C-2. Record of CBP Office committee, team, and workgroup meetings/conference calls where the Chesapeake Bay TMDL or a directly related topic was on the meeting/conference call agenda (continued)

Date	Group	URL
June 7, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10852&DefaultView=all&RequestDate=06/26/2010
June 8-9, 2010	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/june10quarterly.html
June 17, 2010	Management Board	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10866&DefaultView=all&RequestDate=06/26/2010
June 21, 2010	Wastewater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10879&DefaultView=all&RequestDate=06/26/2010
July 6, 2010	Water Quality GIT	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10933&DefaultView=all&RequestDate=07/26/2010
July 12, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10929&DefaultView=all&RequestDate=07/26/2010
July 13, 2010	Modeling Subcommittee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10658&DefaultView=all&RequestDate=07/26/2010
July 15-16, 2010	Citizen Advisory Meeting	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10562&DefaultView=all&RequestDate=07/26/2010
July 20, 2010	Management Board	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10929&DefaultView=all&RequestDate=07/26/2010
July 21, 2010	Wastewater Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10941&DefaultView=all&RequestDate=07/26/2010
July 22, 2010	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10939&DefaultView=all&RequestDate=07/26/2010
August 5-6, 2010	Local Government Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?eventdetails=10861
August 16, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10936&DefaultView=all&RequestDate=08/20/2010
September 13, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10937&DefaultView=all&RequestDate=09/20/2010
October 13, 2010	Sediment Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=11023&DefaultView=all&RequestDate=10/20/2010
October 21, 2010	Principals' Staff Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=11035&DefaultView=all&RequestDate=10/20/2010
October 25, 2010	Water Quality Goal Implementation Team	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10254&DefaultView=all&RequestDate=10/20/2010
November 4, 2010	Point Source Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=11080&DefaultView=all&RequestDate=11/20/2010
November 18-19, 2010	Citizens Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=10557&DefaultView=all&RequestDate=11/20/2010
December 3, 2010	Local Government Advisory Committee	http://archive.chesapeakebay.net/calendar.cfm?eventdetails=10986
December 1, 2010	Watershed Technical Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=11111&DefaultView=all&RequestDate=12/20/2010
December 9, 2010	Analytical Methods and Quality Assurance Workgroup	http://archive.chesapeakebay.net/calendar.cfm?EventDetails=11113&DefaultView=all&RequestDate=12/20/2010
December 14-15, 2010	Scientific and Technical Advisory Committee	http://www.chesapeake.org/stac/dec10quarterly.html

Table C-3. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting

Date	Meeting	Location	EPA/CBPO staff
January 9, 2008	VA DEQ	Richmond, VA	RB
January 10, 2008	DE DNREC	Dover, DE	RB
January 15, 2008	WVDEP, WVDA, WVCA	Charleston, WV	RB
January 18, 2008	PA DEP	Harrisburg, PA	RB
January 23, 2008	CBP STAC	Annapolis, MD	RB, LL
February 21, 2008	CBP CAC	Annapolis, MD	RB
March 10, 2008	Bay Funders Network	Washington, D.C.	RB
March 19, 2008	CBP PSC	Annapolis, MD	RB
March 21, 2008	Chesapeake Bay Foundation	Annapolis, MD	RB
March 28, 2008	MDE	Baltimore, MD	RB, JS
April 10, 2008	CBP RTWG	Annapolis, MD	RB, JS
April 11, 2008	PA DEP	Williamsport, PA	RB, BK
April 22-23, 2008	CBP WQSC	Fairfield, PA	BK, RB, JS, etc.
May 3, 2008	CBP STAC	Annapolis, MD	RB
June 6, 2008	EPA HQs briefing with Ben Grumbles	Washington, D.C.	BK, JS, JC, DW, etc.
June 16, 2008	Chesapeake Bay Foundation	Annapolis, MD	DE, BK, RB, JS
June 19, 2008	CBP PSC	Montross, VA	RB
August 19, 2008	Reasonable Assurance Action Team	Annapolis, MD	CD, JS
August 21, 2008	CBP LGAC	Annandale, VA	RB
August 26, 2008	Congressional Staff Bay Briefing and Boat Tour	Edgewater, MD	RB
September 17, 2008	CBP STAC	Ashburn, VA	JS
September 18, 2008	CBP USWG	Annapolis, MD	JS, AD, RP, KA
September 29, 2008	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
October 7, 2008	PA Public Television	State College, PA	RB
October 17, 2008	Society of Environmental Journalists	Roanoke, VA	RB
October 20, 2008	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
October 24, 2008	MDE and MDNR	Baltimore, MD	BK, RB, KA, JS
October 30, 2009	CBP RTWG	Rockville, MD	RB, JS
November 6-7, 2008	CBP WQSC	Shepherdstown, WV	BK, RB, KA, JS, etc.
November 18, 2008	Harrisburg Homebuilders	Harrisburg, PA	BK
November 19, 2008	Susquehanna River Basin Commission	Harrisburg, PA	RB

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
November 20, 2008	CBP Executive Council	Washington, D.C.	RB
December 15, 2008	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
January 6, 2009	VA DEQ, DCR	Richmond, VA	RB, BK
January 6, 2009	CBP Modeling Subcommittee	Annapolis, MD	LL, JS
January 12, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
January 23, 2009	PA Chamber of Commerce	Harrisburg, PA	BK
January 26, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
February 4, 2009	NYSDEC	Albany, NY	RB, BK
February 7, 2009	MD Tributary Teams Annual Meeting	Baltimore, MD	RB
February 9, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
February 11, 2009	Metropolitan Washington Council of Governments	Washington, D.C.	BK, RB, JS
February 11, 2009	DC DOE	Washington, D.C.	BK, RB, JS
February 13, 2009	PA DEP	Harrisburg, PA	BK
February 19, 2009	Chesapeake Bay Foundation	Philadelphia, PA	RB, BK, CD
February 20, 2009	CBP CAC	Annapolis, MD	RB
February 23, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
February 26, 2009	CBP LGAC	Annapolis, MD	RB
February 27, 2009	DE DNREC	Dover, DE	BK, RB, JS
March 5, 2009	PA Chesapeake Bay Advisory Committee	Harrisburg, PA	BK
March 9, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
March 12, 2009	WV DEP	Charleston, WV	RB
March 18, 2009	MDNR	Annapolis, MD	RB
March 23, 2009	Senator Brubaker (PA)	Harrisburg, PA	BK
March 24, 2009	CBP LGAC	Washington, D.C.	RB
April 1, 2009	VA Environmental Forum	Lexington, VA	BK
April 6, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
April 7, 2009	CBP Modeling Subcommittee	Annapolis, MD	LL, JS
April 14-15, 2009	CBP WQSC	Lancaster, PA	BK, RB, KA, JS, etc.
April 20, 2009	CBP PSC	Montross, VA	BK, RB, KA, etc.
April 30, 2009	Bay TMDL/Stormwater Webinar	Charlottesville, VA	AD, JS
May 8, 2009	Chesapeake Bay Commission	Washington, D.C.	BK

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
May 12, 2009	CBP Executive Council	Mount Vernon, VA	BK, RB, etc.
May 13, 2009	TMDL/NPS/WQS States Meeting	Martinsburg, WV	JS
May 15, 2009	Bay Funders Network	Washington, D.C.	RB
May 18, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
May 20, 2009	Senator Brubaker (PA)	Lancaster, PA	BK
May 21, 2009	NPDES States Meeting	Gettysburg, PA	JS
May 28-29, 2009	CBP STAC	Annapolis, MD	RB
June 1, 2009	Bay Executive Order Meeting	Arlington, VA	BK
June 9, 2009	Harrisburg Chamber of Commerce	Harrisburg, PA	BK
June 16, 2009	CBP STAC	Annapolis, MD	RB
June 22, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
July 1, 2009	WEF 2009 Nutrient Removal Conference	Washington, D.C.	BK
July 6, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
July 7, 2009	Municipal Water Quality Meeting	Washington, D.C.	BK
July 9, 2009	PA DEP - Executive Order	Harrisburg, PA	BK
July 9, 2009	Metropolitan Washington Council of Governments Water Resources Technical Committee	Washington, D.C.	KA
July 10, 2009	PA Transportation and Agricultural Group (Legacy Sediments)	Lancaster, PA	BK, JS
July 20, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
July 22, 2009	CBP PSC	Washington, D.C.	BK, RB, KA
August 4, 2009	USDA NRCS	Annapolis, MD	BK, RB, KA, JS, SH
August 4, 2009	Environmental Defense Fund	Annapolis, MD	BK, RB, KA, JS, SH
August 4, 2009	CBP LGAC webinar	Annapolis, MD	BK, RB
August 6, 2009	Hampton Roads Planning District Commission	Chesapeake, VA	KA
August 10, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
August 11, 2009	Chesapeake Bay Commission	Annapolis, MD	BK
August 12, 2009	Maryland Association of Counties	Ocean City, MD	BK
August 20, 2009	Lancaster Chamber of Commerce	Lancaster, PA	JS
August 24, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
August 25, 2009	Congressional Staff Bay Briefing and Boat Tour	Mason Neck, VA	RB
August 27, 2009	VA House of Delegates Natural Resources Committee - Chesapeake Bay Subcommittee	Gloucester, VA	RB

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
August 27, 2009	U.S. Department of Defense Chesapeake Quality Management Board	Aberdeen Proving Ground, MD	KA
September 3, 2009	PA Chesapeake Bay Advisory Committee	Harrisburg, PA	BK
September 8-9, 2009	CBP STAC	Annapolis, MD	RB
September 9, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
September 9, 2009	Chesapeake Bay Commission	Williamsburg, VA	BK
September 10, 2009	Metropolitan Washington Council of Governments Water Resources Technical Committee	Washington, D.C.	RB
September 14, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
September 17-18, 2009	CBP LGAC & CAC	Lancaster, PA	KA, RB
September 21, 2009	CBP WQSC	Conference Call	BK, RB, KA, JS, etc.
September 23, 2009	Susquehanna River Basin Commission Water Quality Advisory Committee	Harrisburg, PA	RB
September 29-30, 2009	CBP WQSC	Lancaster, PA	BK, RB, KA, etc.
October 2, 2009	Bay TMDL Public Meeting & Webinar	Richmond, VA	BK, RB
October 5, 2009	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
October 5, 2009	Mid-Atlantic Regional Air Management Association, Inc.	Towson, MD	RB
October 9, 2009	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
October 9-10, 2009	Chesapeake Watershed Forum	Shepherdstown, WV	BK
October 16, 2009	Pennsylvania State Senate/House members	Harrisburg, PA	RB
October 19, 2009	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
October 21, 2009	Lancaster County Agriculture Forum	Bird-in-Hand, PA	JS, KZ
October 22, 2009	Regulatory Update: Water Pollution Controls	Richmond, VA	RP
October 23, 2009	CBP PSC	Washington, D.C.	BK, RB, KA
October 27, 2009	USGS Chesapeake Bay Science Workshop	Shepherdstown, WV	RB
October 28, 2009	Anne Arundel County, MD	Annapolis, MD	RB, KS
November 2, 2009	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
November 2, 2009	National TMDL Conference	Washington, D.C.	JS
November 4, 2009	WV Region 9, local officials for planning, stormwater, wastewater, and economic development	Martinsburg, WV	BK, RB, JS, etc.
November 4, 2009	Eastern Panhandle Home Builders Association	Martinsburg, WV	BK, RB, JS, etc.
November 4, 2009	Bay TMDL Public Meeting & Webinar	Martinsburg, WV	BK, RB, JS, etc.

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
November 5, 2009	WV environmental and watershed groups at Freshwater Institute	Shepherdstown, WV	BK, RB, JS, etc.
November 5, 2009	Planning and utility directors at USDA offices	Martinsburg, WV	BK, RB, JS, etc.
November 5, 2009	Agricultural representatives at the WV Department of Agriculture	Moorefield, WV	BK, RB, JS, etc.
November 5, 2009	Bay TMDL Public Meeting	Moorefield, WV	BK, RB, JS
November 6, 2009	CBP CAC	Washington, D.C.	RB
November 16, 2009	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
November 16, 2009	Bay TMDL Public Meeting & Webinar	Washington, D.C.	BK, KA, JS
November 17, 2009	Bay TMDL Public Meeting	Wilkes-Barre, PA	BK, RB, JS
November 18, 2009	Pennsylvania Builders Association	Lemoyne, PA	BK, RB, JS
November 18, 2009	Environmental/conservation groups at Chesapeake Bay Foundation office	Harrisburg, PA	BK, RB, JS
November 18, 2009	Pennsylvania Municipal Authority Association	Wormleysburg, PA	BK, RB, JS
November 18, 2009	Bay TMDL Public Meeting	Williamsport, PA	BK, RB, JS
November 19, 2009	Lycoming County officials	Williamsport, PA	BK, RB, JS
November 19, 2009	NRCS State Technical Committee meeting	State College, PA	BK, RB, JS
November 19, 2009	Bay TMDL Public Meeting	State College, PA	BK, RB, JS
November 23, 2009	MDE, DNR, MDA, MDP Meeting on Bay TMDL and WIPs for Counties and Conservation Districts	Baltimore, MD	KA
November 23, 2009	Lancaster County government officials	Lancaster, PA	BK, RB, JS, SH
November 23, 2009	Bay TMDL Public Meeting & Webinar	Lancaster, PA	BK, RB, JS
November 30, 2009	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
December 1, 2009	Bay TMDL Public Meeting & Webinar	Binghamton, NY	BK, KA, TD
December 1, 2009	NY wastewater treatment operators	Binghamton, NY	BK, KA, TD
December 2, 2009	Rappahannock River Basin Comm.	Richmond, VA	RB
December 2, 2009	Upper Susquehanna Coalition	Owego, NY	BK, KA, TD
December 4, 2009	Water Resources Planning in MD: Hosted by CBF, MACo, MD Municipal League	Annapolis, MD	KA
December 4, 2009	CBP LGAC	Annapolis, MD	RB
December 8, 2009	CBP STAC	Annapolis, MD	RB
December 8, 2009	PA Chesapeake Bay Advisory Committee	Harrisburg, PA	BK
December 8, 2009	Bay TMDL Public Meeting & Webinar	Baltimore, MD	BK, RB, JS
December 9, 2009	Rappahannock River Symposium	Fredericksburg, VA	BK

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
December 10, 2009	Delaware and Maryland Homebuilders	Grasonville, MD	BK, KA, JS
December 10, 2009	Seaford, DE local officials and wastewater treatment plant operators	Seaford, DE	BK, KA, JS
December 10, 2009	Delaware and Maryland agricultural representatives at Delaware Poultry Industry office	Georgetown, DE	BK, KA, JS, HZ
December 10, 2009	Bay TMDL Public Meeting & Webinar	Laurel, DE	BK, KA, JS
December 11, 2009	Maryland and Delaware environmental/watershed/conservation groups	Annapolis, MD	BK, RB, JS, HZ
December 11, 2009	Bay TMDL Public Meeting	Wye Mills, MD	BK, RB, JS
December 14, 2009	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
December 14, 2009	Virginia environmental/watershed/conservation groups at CBF office	Richmond, VA	BK, RB, TD
December 14, 2009	Prince William County staff, planning commissioners, Board members, nonprofit conservation groups, Northern Virginia Industry	Prince William, VA	BK, RB, TD
December 14, 2009	Bay TMDL Public Meeting	Falls Church, VA	BK, RB, TD
December 15, 2009	Bay TMDL Public Meeting	Chesapeake, VA	BK, RB, TD
December 15, 2009	Virginia Farm Bureau and other agricultural organizations	Williamsburg, VA	BK, RB, TD
December 15, 2009	Bay TMDL Public Meeting	Williamsburg, VA	BK, RB, TD
December 16, 2009	National Academy of Sciences	Washington, D.C.	BK, RB, TD
December 16, 2009	Waste Solutions Forum steering committee meeting	Harrisonburg, VA	BK, RB, TD
December 16, 2009	Bay TMDL Public Meeting	Penn Laird, VA	BK, RB, TD
December 16, 2009	Region 3 State Nonpoint Source Managers Meeting	Frederick, MD	KA
December 17, 2009	Homebuilders Association of Virginia	Richmond, VA	BK, RB, TD
December 17, 2009	VA Watershed Implementation Plan stakeholder group	Richmond, VA	BK, RB, TD
December 17, 2009	Rivanna River Basin Commission - Local government officials and environmental groups	Charlottesville, VA	BK, RB, TD
December 17, 2009	Bay TMDL Public Meeting	Fredericksburg, VA	BK, RB, TD
December 18, 2009	George Washington Regional Commission	Fredericksburg, VA	RB, TD
December 18, 2009	VAMWA	Fredericksburg, VA	RB, TD
January 7, 2010	Maryland Association of Counties	Cambridge, MD	KA
January 8, 2010	World Resources Institute	Washington, D.C.	RB, PG
January 10-12, 2010	Choose Clean Water Conference	Washington, D.C.	BK, RB
January 11, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
January 12, 2010	VA General Assembly Joint Commission on Administrative Rules	Richmond, VA	RB

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
January 20, 2010	VA House of Delegates Natural Resources, Chesapeake Bay, and Agriculture Committee/Senate Natural Resources, Conservation and Agriculture Committee	Richmond, VA	RB
January 20, 2010	Symposium on Integrated Modeling and Analysis to Support the Management and Restoration of Large Aquatic Ecosystems	Washington, D.C.	MH, LL, GS
January 29, 2010	American Academy of Environmental Engineering	Washington, D.C.	RB
February 2, 2010	CBP Modeling Subcommittee	Annapolis, MD	LL
February 5, 2010	CBP LGAC	Annapolis, MD	JL
February 9, 2010	MDE Meeting on Bay TMDL and WIPs	Baltimore, MD	KA
February 12, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
February 18, 2010	Virginia Polytechnic Institute and State University	Blacksburg, VA	RB
February 19, 2010	Waste Solutions Forum steering committee meeting	Charlottesville, VA	RB
February 22, 2010	University of Maryland	College Park, MD	RB
February 23, 2010	Chesapeake Bay Commission	Annapolis, MD	BK, RB
February 24, 2010	MDE and MDNR meeting on WIP	Baltimore, MD	MF
February 25, 2010	Bay TMDL Monthly Webinar	Webinar	RB, BK, TD
March 1, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
March 3, 2010	Maryland Association of Counties	Annapolis, MD	KA
March 3, 2010	Conewago Watershed Advisory Team Meeting webinar	Webinar	KA
March 4, 2010	Pennsylvania General Assembly Legislators Retreat	Bedford Springs, PA	RB
March 4, 2010	WIP Pilots with Anne Arundel and Caroline Counties	Annapolis, MD	MF
March 6, 2010	Public engagement with Tributary Teams	Annapolis, MD	MF and JL
March 9, 2010	PA Senate Ag & Rural Affairs and Environmental Resources & Energy Committees	Harrisburg, PA	BK
March 9-10, 2010	CBP STAC	Annapolis, MD	RB, LL, GS
March 11, 2010	CBP CAC	Annapolis, MD	RB
March 12, 2010	Metropolitan Council of Governments	Washington, D.C.	KA
March 13, 2010	State of Our Watersheds Conference	Baltimore, MD	JL
March 15, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
March 17, 2010	PA Senate Ag & Rural Affairs and Environmental Resources & Energy Committees	Harrisburg, PA	BK, JC
March 22, 2010	Bay TMDL Webinar for the Agricultural Community	Washington, D.C.	RB, BK, etc

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
March 25, 2010	WIP Pilot with Anne Arundel County	Annapolis, MD	MF
March 25, 2010	Bay TMDL Monthly Webinar	Webinar	RB, BK, TD
March 25, 2010	PA Association of Environmental Professionals - Eastern & Central Divisions	Fort Washington, PA	BK
March 29, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
March 29 -30, 2010	Farm Pilot Project Coordination (FPPC) Regional Summit	Annapolis, MD	MD
March 31, 2010	PA WIP Stakeholder meeting	Harrisburg, PA	SH, BK
March 31 - April 1, 2010	CBP Modeling Subcommittee	Annapolis, MD	LL, GS, etc
April 5-6, 2010	CBP WQGIT	Gettysburg, PA	BK, RB, JS, etc.
April 7, 2010	WIP Pilot with Anne Arundel County	Annapolis, MD	MF
April 7, 2010	VA Environmental Forum	Lexington, VA	BK
April 9, 2010	USDA/EPA Chesapeake Bay Models Meeting	Annapolis, MD	BK, LL, GS, etc
April 9, 2010	Draft Chesapeake Bay Federal Land Management Guidance Document (Section 502 Guidance)	Webinar	KA
April 12, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
April 19, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
April 23, 2010	CBP LGAC	Washington, D.C.	JS
April 26, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
April 27, 2010	WIP Pilot with Anne Arundel County	Annapolis, MD	MF
May 3-5, 2010	American Planning Association (Virginia Chapter) Conference	Norfolk	KA
May 3, 2010	PA Chesapeake Bay Advisory Committee	Harrisburg, PA	SH
May 6, 2010	American Planning Association (DE/MD Chapter) Conference	Dover, DE	KA
May 6, 2010	Bay TMDL Webinar for the Homebuilders/Developers Community	Annapolis, MD	BK, RB, etc.
May 6, 2010	PA Chesapeake Bay WIP Urban/Suburban/Rural Workgroup	Harrisburg, PA	SH
May 7, 2010	Choose Clean Water Coalition Roundtable	Washington, D.C.	JeffC
May 10, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
May 10, 2010	PA Chesapeake Bay WIP Agriculture Workgroup	Harrisburg, PA	SH
May 11, 2010	PA Water Resources Advisory Committee	Harrisburg, PA	SH
May 11-13, 2010	Region 3 NPS/TMDL/WQM/WQS/NPDES Annual Meeting	Gettysburg, PA	JS
May 12, 2010	Positive Growth Alliance - DE congressional meeting	Conference Call	BK, JM
May 13, 2010	WIP Pilot with Caroline County	Denton, MD	MF
May 13, 2010	LGAC/STAC Stormwater Meeting	Washington, D.C.	BK

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
May 13, 2010	PA Chesapeake Bay WIP Management Team	Harrisburg, PA	SH
May 13, 2010	ASIWPCA Watershed Ad Hoc Committee	Conference Call	BK
May 14, 2010	Western Maryland Local Government Exchange	Hagerstown, MD	KA or MF
May 17, 2010	Bay TMDL Webinar	Webinar	BK, RB, etc.
May 17, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
May 24, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
May 25, 2010	USDA/EPA meeting on Nutrient Trading Tool/Comet-VR and Chesapeake Bay Watershed Model	Washington, D.C.	RB
May 25, 2010	PA Chesapeake Bay WIP Management Team	Harrisburg, PA	SH
June 1, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
June 2, 2010	VA Association of Counties Environmental Policy Committee	Charlottesville, VA	RB or KA
June 3, 2010	CBP Executive Council	Baltimore, MD	SG
June 7, 2010	Bay TMDL Webinar	Webinar	BK, RB, etc.
June 7, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
June 8-9, 2010	CBP STAC	Kent Island, MD	RB
June 10, 2010	WIP Pilot with Anne Arundel County	Annapolis, MD	MF
June 10, 2010	Rappahannock Nutrient Cooperative Business Advisory Council	Fredericksburg, VA	KA
June 10, 2010	LEAD Maryland Panel	Solomons, MD	MF
June 11, 2010	Tidal States Call with MDNR, MDE, VADEQ, VADCR, and DC DoE	Conference Call	BK, RB
June 14, 2010	CBP WQGIT: co-regulators only	Conference Call	BK, RB, KA, JS, etc.
June 15, 2010	EPA Region 3 State/Interstate Water Directors Meeting	Stauton, VA	RB, MM, TD
June 15, 2010	VA Stakeholders Advisory Group	Richmond, VA	KA, Jeff C
June 15, 2010	MD Public Meeting on WIP	Hagerstown, MD	MF
June 16, 2010	Center for Watershed Protection Watershed Treatment Model	Webinar	Staff
June 16, 2010	Tri-County Council for Southern Maryland	Waldorf, MD	KA
June 17, 2010	Beyond Water Quality in the Chesapeake Bay: Lowering Barriers to Achieving Multiple Environmental Goals,	Washington, D.C.	KA
June 17, 2010	CBP Management Board	Annapolis, MD	RB
June 18, 2010	MD Public Meeting on WIP	Baltimore, MD	MF
June 21, 2010	TMDL Seminar for USDA Undersecretary	Washington, D.C.	BK
June 23, 2010	MD Public Meeting on WIP	Denton, MD	MF
July 6, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
July 8, 2010	Bay TMDL Webinar	Webinar	BK, RB, etc.
July 9, 2010	WIP Pilot with Anne Arundel County	Annapolis, MD	MF
July 12, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
July 12, 2010	NYSDEC, NYSDA, USDA, USC meeting on WIP	NY	RI
July 13, 2010	CBP Modeling Subcommittee	Annapolis, MD	LL
July 14, 2010	PA DEP meeting on WIP	Harrisburg, PA	KS, SH
July 19, 2010	USDA Leadership Conference	Washington, D.C.	RB
July 20, 2010	CBP Management Board	Annapolis, MD	BK
July 20, 2010	MDE and MDNR meeting on WIP	Baltimore, MD	MF, KA,
July 20, 2010	Virginia Legislature - House Agriculture, Natural Resrouces and Chesapeake Committee	Richmond, VA	JeffC
July 21, 2010	Industry Coffee with EPA HQs	Washington, D.C.	BK
July 26, 2010	CBP WQGIT: co-regulators only	Conference Call	BK, RB, KA, JS, etc.
July 29, 2010	WIP Pilot discussion with Anne Arundel County	Annapolis, MD	MF
July 30, 2010	Metropolitan Washington Council of Governments Water Resources Technical Committee	Washington, D.C.	JE
July 30, 2010	WIP Pilot with Caroline County	Denton, MD	MF
August 4, 2010	PA DEP meeting on WIP	Harrisburg, PA	SH
August 5, 2010	PA DEP meeting on WIP	Harrisburg, PA	SH
August 9, 2010	CBP WQGIT: co-regulators only	Conference Call	BK, RB, KA, JS, etc.
August 10, 2010	MDE meeting on stormwater/WIP	Conference Call	MF, JM
August 11, 2010	PA DEP meeting on WIP	Harrisburg, PA	SH
August 11, 2010	VA DEQ/DCR WIP discussion	Richmond, VA	JeffC, KA, AC, MD, JM, etc.
August 11, 2010	Patuxent River Commission, Tributary Team for the Patuxent River	Annapolis, MD	MF
August 16, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
August 18, 2010	MDE and MDNR meeting on WIP	Annapolis, MD	KA, MF. KS
August 19, 2010	Bay TMDL Webinar	Webinar	BK, RB, etc.
August 19, 2010	DE DNREC meeting on WIP	Annapolis, MD	KA, KS, MD
August 23, 2010	CBP WQGIT: co-regulators only	Conference Call	BK, RB, KA, JS, etc.
August 24, 2010	VA DCR and DEQ meeting on WIP	Richmond, VA	KA, MD
August 25, 2010	Annual Army Chesapeake Bay Meeting	Fort A.P. Hill, VA	GS

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
August 26, 2010	MDE, DNR, MDA meeting on input decks/WIP	Annapolis, MD	MF, MD
August 26, 2010	WIP Pilot discussion with Anne Arundel County	Annapolis, MD	MF
August 26, 2010	Congressional Staff Bay Briefing and Boat Tour	Annapolis, MD	RB, JE, TL, JeffC
September 8, 2010	National Academy of Sciences - Independent Evaluator Panel	Washington, D.C.	JeffC, RB, JW
September 13, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
September 14-15, 2010	CBP STAC	Annapolis, MD	RB, RW
September 15, 2010	Council on Environmental Quality/Chesapeake Bay Federal Leadship Committee	Washington, D.C.	RB, JE, CB
September 15, 2010	Sierra Club "Healling Our Waters" Public Forum	Hampton, VA	JeffC
September 16, 2010	WIP Pilots with Caroline County	Denton, MD	MF
September 18, 2010	Virginia Environmental Assembly	Virginia Beach, VA	JeffC
September 20, 2010	EPA conference call with WV to discuss high-level comments on draft WIP	Conference Call	RW, LE, KA, etc.
September 21, 2010	EPA meeting with MD to discuss high-level comments on draft WIP	Annapolis, MD	JE, MF
September 21, 2010	EPA conference call with PA to discuss high-level comments on draft WIP	Conference Call	BK, JC, KA, GwenS
September 21, 2010	EPA conference call with DE to discuss high-level comments on draft WIP	Conference Call	SG, JC, KA
September 22, 2010	CBP Management Board	Annapolis, MD	JE, RW, CB, JeffC
September 22, 2010	Virginia Water Environment Association	Hampton, VA	JeffC
September 23, 2010	EPA conference call with VA to discuss high-level comments on draft WIP	Conference Call	JeffC, AC, KA
September 23, 2010	EPA conference call with DC to discuss high-level comments on draft WIP	Conference Call	JC, RP, KA
September 23, 2010	Congressional Briefings for Environmental and Agriculture Committees	Washington, D.C.	JeffC
September 24, 2010	Bay TMDL Briefing for Environmental/Fishing Community	Conference Call	JeffC
September 24, 2010	CBP Advisory Committees	Conference Call	JE
September 28, 2010	Bay TMDL Webinar	Webinar	BK, RB, etc.
September 28, 2010	PA WIP Management Stakeholder Team meeting	Harrisburg, PA	BK, SH, GwenS
September 29, 2010	Bay TMDL Public Meeting & Webinar	Washington, D.C.	BK, RB, JS, LM, PG, SH, JimC, TL, GwenS
September 29, 2010	Metropolitan Washington Council of Governments	Washington, D.C.	BK, RB, LM, JS, RP, TL
September 30, 2010	EPA Federal Advisory Committee on Agriculture	Washington, D.C.	RB

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
September 30, 2010	EPA meeting with DE to discuss detailed comments on draft WIP	Dover, DE	SG, KA, PG, KS, MD
September 30, 2010	PA Agriculture Stakeholder Workgroup meeting	Harrisburg, PA	SH, GwenS, MD, KS
September 30, 2010	EPA conference call with WV to discuss detailed comments on draft WIP	Conference Call	LE, KA, JM, BT, EM
October 4, 2010	EPA meeting with MD to discuss detailed comments on draft WIP	Annapolis, MD	JE, MF, KA, etc.
October 4, 2010	Virginia agriculture stakeholders	Harrisonburg, VA	RB, BK, LM, PG, TL, JeffC
October 4, 2010	Virginia environmental groups/stakeholders	Harrisonburg, VA	RB, BK, LM, PG, TL, JeffC
October 4, 2010	Bay TMDL Public Meeting	Harrisonburg, VA	RB, BK, LM, PG, TL, JeffC
October 5, 2010	PA WIP Point Source Stakeholder Workgroup Meeting	Harrisburg, PA	SH, GwenS
October 5, 2010	Virginia environmental groups/stakeholders	Fairfax, VA	RB, BK, LM, PG, TL, JeffC
October 5, 2010	Virginia local government stakeholders	Fairfax, VA	RB, BK, LM, PG, TL, JeffC
October 5, 2010	Virginia developers and homebuilders	Fairfax, VA	RB, BK, LM, PG, TL, JeffC
October 5, 2010	Bay TMDL Public Meeting	Annandale, VA	RB, BK, LM, PG, TL, JeffC
October 6, 2010	Virginia wastewater treatment operators	Richmond, VA	RB, BK, LM, GwenS, GB, JeffC
October 6, 2010	Virginia developers and homebuilders	Richmond, VA	RB, BK, LM, GwenS, GB, JeffC
October 6, 2010	Virginia State Legislators	Richmond, VA	RB, BK, LM, GwenS, GB, JeffC
October 6, 2010	Bay TMDL Public Meeting	Richmond, VA	RB, BK, LM, GS, GB, JeffC
October 7, 2010	EPA meeting with PA to discuss detailed comments on draft WIP	Harrisburg, PA	KA, SH, KS, MD, JM, etc.
October 7, 2010	EPA meeting with VA to discuss detailed comments on draft WIP		AC, JeffC
October 7, 2010	Virginia environmental groups/stakeholders	Richmond, VA	RB, BK, LM, GwenS, GB, JeffC

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
October 7, 2010	Hampton Roads Planning District Commission	Chesapeake, VA	RB, BK, LM, GwenS, GB, JeffC
October 7, 2010	Bay TMDL Public Meeting & Webinar	Webinar	RB, BK, LM, GwenS, GB, JeffC
October 7, 2010	Bay TMDL Public Meeting	Hampton, VA	RB, BK, LM, GwenS, GB, JeffC
October 11, 2010	Delaware agriculture stakeholders	Georgetown, DE	RB, BK, LM, GwenS, TL
October 11, 2010	Delaware local government stakeholders	Seaford, DE	RB, BK, LM, GwenS, TL
October 11, 2010	Delaware developers and homebuilders	Seaford, DE	RB, BK, LM, GwenS, TL
October 11, 2010	Bay TMDL Public Meeting & Webinar	Georgetown, DE	RB, BK, LM, GwenS, TL
October 12, 2010	PA WIP Stormwater Stakeholder Meeting	Harrisburg, PA	SH, JM, EM
October 12, 2010	Maryland environmental groups/stakeholders	Easton, MD	RB, BK, LM, GwenS, TL
October 12, 2010	Bay TMDL Public Meeting	Easton, MD	RB, BK, LM, GwenS, TL
October 12, 2010	Chesapeake Bay Stormwater Listening Session	Richmond, VA	RH, JM, KW
October 13, 2010	EPA Call with NY to discuss detailed comments on draft WIP	Conference Call	RI, KA
October 13, 2010	Maryland developers and homebuilders	Annapolis, MD	RB, BK, LM, JS
October 13, 2010	Maryland State Legislators	Annapolis, MD	RB, BK, LM, JS, CF
October 13, 2010	Bay TMDL Public Meeting	Annapolis, MD	RB, BK, LM, JS, TL
October 14, 2010	EPA conference call with PA to discuss stormwater - WIP	Conference Call	JC, KA, SH, JM, EM
October 14, 2010	EPA conference call with MD, DC, and VA to discuss Blue Plains	Conference Call	RP, MF, BT
October 14, 2010	Maryland local government stakeholders	Annapolis, MD	RB, BK, LM, JS
October 14, 2010	Maryland agriculture stakeholders	Frederick, MD	RB, BK, LM, JS, TL
October 14, 2010	Bay TMDL Public Meeting & Webinar	Hagerstown, MD	RB, BK, LM, JS, TL
October 14, 2010	Chesapeake Bay Stormwater Listening Session	Washington, D.C.	RH, JM, KW
October 15, 2010	EPA weekly call with VA to discuss WIP	Conference Call	JeffC, AC, KA, KD, NZ, JeffS
October 18, 2010	EPA call with WV to discuss offsets/growth/trading in WIP	Conference Call	RW, KevinD
October 18, 2010	Pennsylvania local government stakeholders	Lancaster, PA	RB, BK, SH, TD
October 18, 2010	Pennsylvania agriculture stakeholders	Lancaster, PA	RB, BK, SH, TD
October 18, 2010	Bay TMDL Public Meeting	Lancaster, PA	RB, BK, SH, TD
October 18, 2010	Pennsylvania legislative delegation	Harrisburg, PA	RB, BK, SH, TD, JC
October 18, 2010	Chesapeake-Bay Focused EMS conference for Federal Facilities	Greenbelt, MD	Staff

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
October 19, 2010	Pennsylvania Municipal Authority Association	Harrisburg, PA	RB, BK, SH, TD, LM
October 19, 2010	Pennsylvania environmental groups/stakeholders	Harrisburg, PA	RB, BK, SH, TD, LM
October 19, 2010	Bay TMDL Public Meeting & Webinar	State College, PA	RB, BK, SH, TD, LM
October 19, 2010	Pennsylvania agriculture stakeholders	State College, PA	RB, BK, SH, TD, LM
October 19, 2010	Chesapeake Bay Stormwater Listening Session	Baltimore, MD	RH, JM, KW
October 20, 2010	EPA conference call with MD to discuss stormwater - WIP	Conference Call	MF, JM
October 20, 2010	EPA meeting with DC to discuss detailed comments on draft WIP	Washington, D.C.	RP, JM, BT
October 20, 2010	EPA conference call with NY to discuss agriculture - WIP	Conference Call	RI, KS, MD, KA
October 20, 2010	Richmond, VA Mayor's Office	Richmond, VA	JeffC
October 20, 2010	Pennsylvania Builders Association	Williamsport, PA	RB, BK, SH, TD, LM
October 20, 2010	Lycoming County officials	Williamsport, PA	RB, BK, SH, TD, LM
October 20, 2010	Bay TMDL Public Meeting	Williamsport, PA	RB, BK, SH, TD, LM
October 21, 2010	Bay TMDL Public Meeting	Ashley, PA	RB, BK, SH, TD, LM
October 21, 2010	Chesapeake Bay Stormwater Listening Session	Salisbury, MD	RH, JM, KW
October 21, 2010	CBP PSC	Baltimore, MD	JE, RW, CB, GS
October 22, 2010	EPA weekly call with VA to discuss WIP	Conference Call	JeffC, AC, KA
October 25, 2010	EPA conference call with NY to discuss wastewater - WIP	Conference Call	RI, BT, KA
October 25, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
October 26, 2010	EPA call with MD to discuss trading/offsets/growth	Conference Call	RW, KevinD, MF
October 26, 2010	EPA meeting with VA to discuss agriculture - WIP	Richmond, VA	JeffC, AC, KS, MD
October 26, 2010	OMB/CEQ TMDL Briefing	Washington, D.C.	CF, KA, JE
October 26, 2010	Bay Model Briefing for Senators Warner and Webb staff	Washington, D.C.	JeffC, GS, LK
October 26, 2010	New York wastewater treatment operators	Elmira, NY	RB, BK, PG, DS
October 26, 2010	Bay TMDL Public Meeting	Elmira, NY	RB, BK, PG, DS
October 26, 2010	Chesapeake Bay Stormwater Listening Session	Lancaster, PA	RH, JM, KW
October 27, 2010	Virginia Water Commission	Richmond, VA	JeffC
October 27, 2010	Chemung County Stormwater Coalition	Horseheads, NY	RB, BK, PG, DS
October 27, 2010	Upper Susquehanna Coalition	Apalachin, NY	RB, BK, PG, DS
October 27, 2010	New York Farm Bureau	Apalachin, NY	RB, BK, PG, DS
October 27, 2010	Bay TMDL Public Meeting & Webinar	Binghamton, NY	RB, BK, PG, DS
October 29, 2010	EPA meeting with VA to discuss detailed comments on draft WIP	Annapolis, MD	JeffC, AC, KA, etc.
November 1, 2010	Sierra Club TMDL/WIP Forum	Virginia Beach, VA	JeffC

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
November 1, 2010	EPA conference call with NY to discuss stormwater - WIP	Conference Call	RI, JM, KA
November 2, 2010	EPA conference call with PA on non-cost share BMPs	Conference Call	SH, KS, KA, MD
November 3, 2010	EPA "closure" meeting with PA on final WIP	Harrisburg, PA	JC, KA, SH, KS
November 3, 2010	EPA conference call with DE to discuss trading/offsets/growth - WIP	Conference Call	RW, KevinD, PG
November 3, 2010	EPA "closure" conference call with DC to discuss final WIP	Conference Call	JC, RP, KA
November 3, 2010	West Virginia environmental groups/stakeholders	Shepherdstown, WV	RB, BK, JS, JG, GB
November 3, 2010	West Virginia developers and homebuilders	Martinsburg, WV	RB, BK, JS, JG, GB
November 3, 2010	West Virginia local government stakeholders	Martinsburg, WV	RB, BK, JS, JG, GB
November 3, 2010	Bay TMDL Public Meeting	Martinsburg, WV	RB, BK, JS, JG, GB
November 4, 2010	Chesapeake Bay Commission	Montross, VA	JeffC
November 4, 2010	EPA weekly conference call with VA to discuss final WIP	Conference Call	JeffC, AC, KA, KS
November 4, 2010	West Virginia agriculture stakeholders	Romney, WV	RB, BK, JS, JG, GB, RW
November 4, 2010	West Virginia local government stakeholders	Romney, WV	RB, BK, JS, JG, GB, RW
November 4, 2010	West Virginia developers and homebuilders	Romney, WV	RB, BK, JS, JG, GB, RW
November 4, 2010	Bay TMDL Public Meeting & Webinar	Romney, WV	RB, BK, JS, JG, GB, RW
November 5, 2010	EPA "closure" conference call with WV to discuss final WIP	Conference Call	RW, LE, KA
November 8, 2010	Virginia Association of Counties Annual Conference	Hot Springs, VA	JeffC
November 8, 2010	EPA "closure" meeting with MD to discuss final WIP	Annapolis, MD	JE, MF, KA, etc.
November 8, 2010	EPA conference call with PA on non-cost share BMPs	Conference Call	KS, MD, SH, JS
November 9, 2010	PA Chesapeake Bay WIP Urban/Suburban/Rural Workgroup	Harrisburg, PA	SH, LP, LO; JS called in
November 9, 2010	PA Chesapeake Bay WIP Agriculture Workgroup	Harrisburg, PA	SH, LP, MD
November 10, 2010	EPA weekly conference call with VA to discuss final WIP	Conference Call	JeffC, AC, KA
November 10, 2010	EPA "closure" meeting with DE to discuss final WIP	Dover, DE	SG, PG, KA
November 10, 2010	EPA "closure" conference call with NY to discuss final WIP	Conference Call	RI, KA, etc.
November 10, 2010	EPA conference call with PA on non-cost share BMPs	Conference Call	KS, MD, SH, JS
November 12-13, 2010	2010 Watershed Forum	Shepherdstown, WV	Staff
November 16, 2010	CBP WQGIT	Conference Call	BK, RB, KA, JS, etc.
November 16, 2010	PA Chesapeake Bay WIP Wastewater workgroup	Harrisburg, PA	SH, BT, NZ, LP all called in
November 18, 2010	CBP CAC	Washington, D.C.	RB, JE
November 18, 2010	EPA conference call with PA on non-cost share BMPs	Conference Call	KS
November 19, 2010	EPA "closure" meeting with VA to discuss final WIP	Washington, D.C.	JeffC, KA, AC, RW, KS

Table C-4. Record of CBP committee/workgroup and stakeholder meetings since 2008 where the Chesapeake Bay TMDL was a principal topic of the meeting (continued)

Date	Meeting	Location	EPA/CBPO staff
November 23, 2010	EPA conference call with PA on non-cost share BMPs	Conference Call	MD
November 24, 2010	EPA discussion with PA on closing the gap	conference call	SH, MD, KA, CB
December 3, 2010	CBP LGAC	Annapolis, MD	RB, CB
December 14, 2010	CBP STAC	Annapolis, MD	RB, RW

Table C-5. EPA staff name abbreviations key

EPA staff abbreviation	Name
AC	Ann Carkcuff
AD	Andrew Dinsmore
BK	Bob Koroncai
BT	Brian Trulear
CB	Carin Bisland
CD	Chris Day
CF	Chuck Fox
DE	Diana Esher
DM	Dave McGuigan
DS	David Sternberg
DW	Don Welsh
EM	Evelyn MacKnight
GB	Greg Barranco
GS	Gary Shenk
GwenS	Gwen Supplee
HZ	Hank Zygmunt
JC	Jon Capacasa
JE	Jim Edward
JeffC	Jeff Corbin
JeffS	Jeff Sweeney
JimC	Jim Curtin
JG	Jessica Greathouse
JL	Jeff Lape
JM	Jenny Molloy

EPA staff abbreviation	Name
JS	Jennifer Sincock
JW	Julie Winters
KA	Katherine Antos
KD	Kevin DeBell
KS	Kelly Shenk
KW	Kevin Weiss
KZ	Kyle Zieba
LK	LaRonda Koffi
LL	Lewis Linker
LM	Linda Miller
LO	Liz Ottinger
LP	Lucinda Power
MD	Mark Dubin
MF	Mike Fritz
MH	Mike Haire
PG	Peter Gold
RB	Rich Batiuk
RH	Rachel Herbert
RI	Ruth Izraeli
RP	Reggie Parrish
RW	Rob Wood
SG	Shawn Garvin
SH	Suzanne Hall Trevena
TD	Thomas Damm
TL	Travis Loop

Table C-4. Organization abbreviations key

Abbreviations	Organization
ASWIPCA	Association of States Interstate Water Pollution Control Administrators
CAC	Citizens Advisory Committee
CBP	Chesapeake Bay Program
DC DOE	District of Columbia Department of Environment
DE DNREC	Delaware Department of Natural Resources and Environmental Control
EPA	Environmental Protection Agency
HQ	Headquarters
LGAC	Local Government Advisory Committee
MDA	Maryland Department of Agriculture
MDE	Maryland Department of Environment
MDNR	Maryland Department of Natural Resources
MDP	Maryland Department of Planning
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
NYSDA	New York State Department of Agriculture
NYSDEC	New York State Department of Environmental Conservation
PA DEP	Pennsylvania Department of Environmental Protection
PSC	Principles' Staff Committee
RTWG	Re-evaluation Technical Workgroup
STAC	Scientific and Technical Advisory Committee
USC	Upper Susquehanna Coalition
USDA	United States Department of Agriculture
USGS	United States Geological Survey
USWG	Urban Stormwater Workgroup
VA DCR	Virginia Department of Conservation and Recreation
VA DEQ	Virginia Department of Environmental Quality
VAMWA	Virginia Municipal Wastewater Authorities
WEF	Water Environmental Federation
WQGIT	Water Quality Goal Implementation Team
WQM	Water Quality Monitoring
WQS	Water Quality Standards
WQSC	Water Quality Steering Committee
WVCA	West Virginia Conservation Agency
WVDA	West Virginia Department of Agriculture
WVDEP	West Virginia Department of Environmental Protection

Appendix D.
Evaluation of the Most Protective Bay Dissolved Oxygen Criteria

As outlined in the criteria assessment documentation in Section 3.4.3 and shown in Table D-1, seven different dissolved oxygen criteria are to be assessed to determine attainment of the open-water, deep-water, and deep-channel designated uses (USEPA 2003). Using the available monitoring data, only one temporal averaging period can be assessed for each designated-use type (USEPA 2003, 2007). Because the monitoring data are not available to assess all seven criteria or an assessment protocol has not been developed by the Chesapeake Bay Program partners and published by EPA, it raises the question of whether the three assessed criteria are more or less protective of all four Chesapeake Bay designated uses than the four criteria that are not able to be assessed.

Table D-1. Chesapeake Bay dissolved oxygen criteria assessed with observed data for developing the jurisdictions' the 303(d) lists and criteria that are not evaluated because of insufficient data/lack of published assessment protocols

Designated use	Instantaneous	1-day mean	7-day mean	30-day mean
Open water	Insufficient Data	No Criterion	Insufficient Data	Assessed
Deep water	Insufficient Data	Insufficient Data	No Criterion	Assessed
Deep channel	Assessed	No Criterion	No Criterion	No Criterion

Because of insufficient monitoring data or lack of published assessment protocols or both, it is difficult to comprehensively evaluate the protectiveness of the assessed criteria strictly on the basis of monitoring data, because the unassessed criteria cannot be directly evaluated. A multi-partner effort is underway to develop criteria assessment protocols based on the available monitoring data, but those protocols will not be complete, peer reviewed, and published until 2011 at the earliest.

The full set of seven dissolved oxygen criteria can be assessed through direct evaluation of the Chesapeake Bay Water Quality and Sediment Transport Model (Bay Water Quality Model) output. The assessments will not agree precisely with the 303(d) or Bay TMDL-related criteria assessment because neither of those criteria assessments uses model outputs directly (see Section 6.2.4). However, assuming that the temporal variability of dissolved oxygen in the Chesapeake Bay is reasonably well-characterized in the Bay Water Quality model, the relative protectiveness of different criteria evaluated directly using Bay Water Quality Model output would approximate the relative protectiveness of three dissolved oxygen criteria evaluated using monitoring data.

All seven dissolved oxygen criteria were assessed using the direct outputs from a series of Bay Water Quality Model scenarios. That work was completed in November 2008 using the Phase 5.1 version of the Chesapeake Bay Watershed Model. The Bay Water Quality Model has not been modified since completion of the work described here. Because the analysis is focused on evaluating temporal variability of dissolved oxygen in the Bay Water Quality Model outputs and uses only the Bay Watershed Model for generation of different loading scenario input decks, the findings are still relevant even with use of the Phase 5.3 Bay Watershed Model in developing the Bay TMDL.

Figures D-1 and D-2 show the average dissolved oxygen criteria nonattainment of eight mainstem Chesapeake Bay segments for three scenarios for the 1996–1998 period. The moderate reduction scenario approximates 2009 loads and the large reduction scenario approximates the Bay TMDL cap loads.

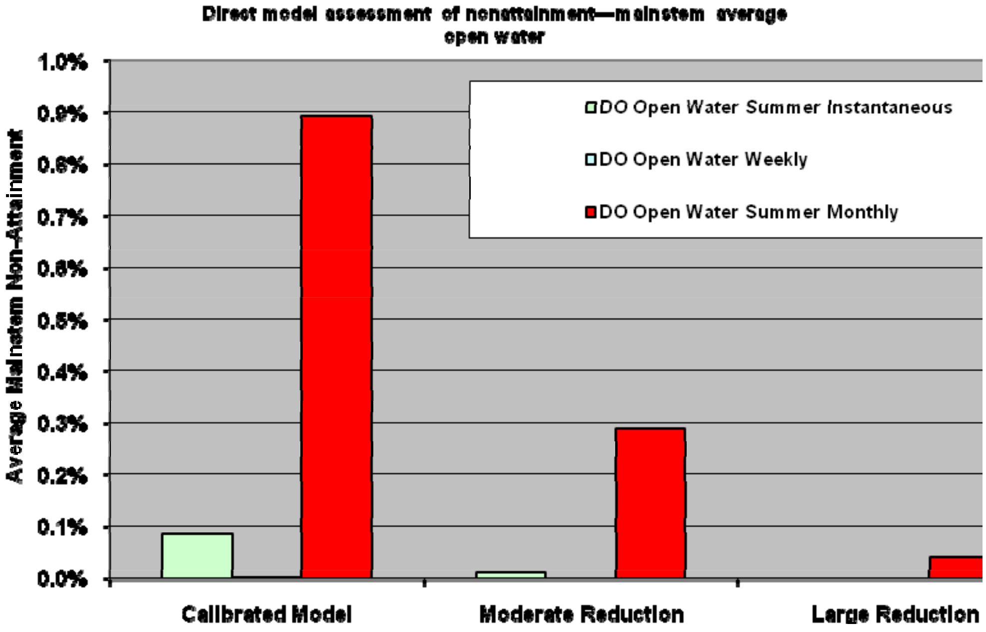


Figure D-1. Direct model assessment of open-water dissolved oxygen criteria nonattainment for the eight mainstem Chesapeake Bay segments.

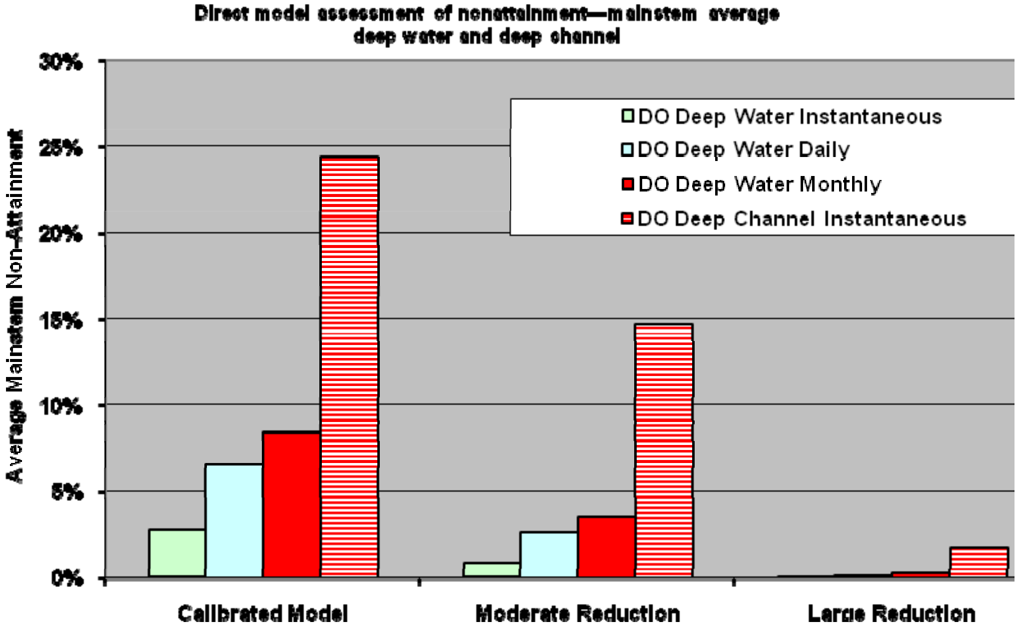


Figure D-2. Direct model assessment of deep-water and deep-channel dissolved oxygen criteria nonattainment for the eight mainstem Chesapeake Bay segments.

For both open-water and deep-water designated uses, the 30-day mean criteria had the highest nonattainment in all three scenarios (Figures D-1 and D-2). The 30-day mean open-water and deep-water criteria are, therefore, protective of the other two sets of non-assessed dissolved oxygen criteria (open-water 7-day and instantaneous minimum, deep-water 1-day mean and instantaneous minimum) on average for the eight mainstem Bay segments. Only one dissolved oxygen criterion applies to the deep-channel designated use, and it is assessed using monitoring data. The deep-channel criterion is also more protective, on the basis of the levels of nonattainment recorded in Figures D-1 and D-2, than all the other six open-water and deep-water criteria.

Looking at the results of criteria assessment of the individual designated uses strengthens those findings considerably. Using the criteria nonattainment percentages for the moderate reduction scenario and the 1996–1998 assessment period, the 30-day mean, 7-day mean, and instantaneous minimum criteria are compared across 53 of the 92 Bay segments with the open-water designated use. During the 1996–1998 assessment period, those 53 segments did not attain all three open-water criteria. In all 53 segments, the 30-day mean open-water criterion had the highest nonattainment percentage compared to the 7-day mean and 1-day mean open-water criteria (Table D-2). In the 16 Bay segments that did not attain all three deep-water criteria during the same 3-year period, the 30-day mean deep-water criterion had the highest nonattainment percentage in all 16 segments compared with the deep-water 1-day mean and instantaneous minimum criteria (Table D-3).

Because this is a direct assessment of the Bay Water Quality Model output using inputs from the Phase 5.1 Bay Watershed Model and because the water quality criteria and assessment protocols that existed in 2008, the nonattainment values will not match with nonattainment in other parts of this document.

EPA used direct assessment of Bay Water Quality Model outputs to document that the three dissolved oxygen criteria that are assessed by Maryland, Virginia, Delaware, and the District of Columbia using Bay water quality monitoring data—open-water 30-day mean, deep-water 30-day mean, and deep-channel instantaneous minimum—are the most restrictive and, therefore, most protective criteria. Those three criteria, applied during the summer period, are protective of the other four dissolved oxygen criteria across all four designated uses, across a range of nutrient reduction scenarios, and in all areas of the Chesapeake Bay and its tidal tributaries and embayments.

Table D-2. Comparison of open-water dissolved oxygen 30-day mean, 7-day mean, and instantaneous criteria for the moderate reduction scenario and the 1996–1998 assessment period across Bay segments for identification of the most protection criterion

Ches Bay segment	30-day mean	7-day mean	Instantaneous minimum	Most protective criterion
BI2MH	3.56%	0.43%	0.00%	30-day mean
C11TF	0.02%	0.00%	0.00%	30-day mean
CB1TF	0.03%	0.00%	0.00%	30-day mean
CB2OH	1.48%	0.00%	0.10%	30-day mean
CB5MH	0.01%	0.00%	0.00%	30-day mean
CB6PH	0.24%	0.00%	0.00%	30-day mean
CB7PH	0.57%	0.00%	0.00%	30-day mean
CDDOH	24.87%	20.59%	19.19%	30-day mean
CHOMH1	7.24%	1.96%	2.53%	30-day mean
CHOMH2	34.10%	28.45%	25.47%	30-day mean
CHOOH	28.04%	24.18%	23.20%	30-day mean
CHOTF	20.32%	14.31%	13.96%	30-day mean
CHSMH	0.65%	0.00%	0.12%	30-day mean
CHSOH	46.68%	36.62%	34.53%	30-day mean
CHSTF	63.24%	60.63%	57.21%	30-day mean
CMDOH	48.35%	41.64%	37.15%	30-day mean
CNDOH	35.86%	30.44%	27.75%	30-day mean
CRRMH	0.25%	0.00%	0.00%	30-day mean
DCATF	2.67%	0.09%	0.29%	30-day mean
EBEMH	1.19%	0.00%	0.00%	30-day mean
EL1OH	9.96%	3.44%	4.14%	30-day mean
ELIPH	27.51%	16.54%	13.56%	30-day mean
ELKOH	9.13%	2.93%	3.77%	30-day mean
FSBMH	8.13%	2.35%	2.83%	30-day mean
HNGMH	1.09%	0.00%	0.13%	30-day mean
JMSPH	1.07%	0.00%	0.00%	30-day mean
JMSTF	0.22%	0.00%	0.13%	30-day mean
JMSTFL	0.27%	0.00%	0.17%	30-day mean
LCHMH	10.24%	6.17%	7.01%	30-day mean
MA1MH	0.55%	0.00%	0.00%	30-day mean
MAGMH	3.74%	0.00%	0.00%	30-day mean
MANMH	0.48%	0.00%	0.00%	30-day mean
MD5MH	0.01%	0.00%	0.00%	30-day mean
MOBPH	1.26%	0.00%	0.02%	30-day mean
NANMH	5.70%	3.09%	3.95%	30-day mean
NANOH	0.04%	0.00%	0.00%	30-day mean
PAXOH	10.68%	0.49%	0.03%	30-day mean
PAXTF	0.95%	0.00%	0.00%	30-day mean
PIAMH	1.93%	0.00%	0.00%	30-day mean
PO1OH	3.83%	0.00%	0.04%	30-day mean
POCMH	1.14%	0.03%	0.41%	30-day mean
POTOH	3.55%	0.00%	0.03%	30-day mean
SA1OH	10.46%	1.28%	1.36%	30-day mean
SA2OH	8.85%	1.54%	2.19%	30-day mean
SASOH	9.95%	1.27%	1.81%	30-day mean

Ches Bay segment	30-day mean	7-day mean	Instantaneous minimum	Most protective criterion
SEVMH	4.38%	0.77%	1.54%	30-day mean
TA1MH	11.93%	6.99%	7.39%	30-day mean
TA2MH	1.20%	0.00%	0.00%	30-day mean
TAMMH	11.34%	6.50%	7.00%	30-day mean
TANMH	12.85%	6.76%	6.66%	30-day mean
TAVMH	15.43%	7.17%	5.76%	30-day mean
VPCMH	1.62%	0.08%	0.59%	30-day mean
YRKMH	7.42%	2.89%	3.19%	30-day mean

Table D-3. Comparison of deep–water dissolved oxygen 30-day mean, 1-day mean and instantaneous criteria for the moderate reduction scenario and the 1996–1998 assessment period across Bay segments for identification of the most protection criterion.

Ches Bay segment	30-day mean	1-day mean	Instantaneous minimum	Most protective criterion
CB3MH	1.86%	0.60%	0.29%	30-day mean
CB4MH	11.45%	10.21%	3.00%	30-day mean
CB5MH	2.22%	1.55%	0.01%	30-day mean
CB7PH	2.21%	0.99%	0.77%	30-day mean
CHSMH	14.31%	12.37%	6.60%	30-day mean
EASMH	18.11%	16.84%	9.91%	30-day mean
MD5MH	6.08%	5.52%	0.01%	30-day mean
PA1MH	0.11%	0.00%	0.00%	30-day mean
PA2MH	8.11%	7.82%	3.44%	30-day mean
PATMH	29.12%	27.75%	19.75%	30-day mean
PAXMH	0.63%	0.00%	0.10%	30-day mean
POMMH	0.08%	0.00%	0.00%	30-day mean
POMMH	0.08%	0.00%	0.00%	30-day mean
POTMH	0.08%	0.00%	0.00%	30-day mean
RPPMH	0.01%	0.00%	0.00%	30-day mean
SBEMH	42.50%	35.44%	22.34%	30-day mean

References

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

USEPA (U.S. Environmental Protection Agency). 2007. *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll* a *for the Chesapeake Bay and Its Tidal Tributaries–2007 Addendum*. EPA 903-R-07-003. CBP/TRS 285-07. U.S. Environmental Protection Agency Region 3 Chesapeake Bay Program Office, Annapolis, MD.

Appendix E.
Summary of Initial Climate Change Impacts on the Chesapeake Bay Watershed Flows and Loads

The potential effects of climate change have not been explicitly accounted for in the current Chesapeake Bay TMDL allocations, beyond application of a 10-year hydrologic period, because of known limitations in the current suite of Chesapeake Bay models to fully simulate the effects of climate change. A preliminary assessment of climate change impacts on the Chesapeake Bay was conducted, in parallel, using an earlier version of the Phase 5 Chesapeake Bay Watershed Model and tools developed for EPA's BASINS 4 system including the Climate Assessment Tool (CAT). Flows and associated nutrient and sediment loads were assessed in all river basins of the Chesapeake Bay with three key climate change scenarios reflecting the range of potential changes in temperature and precipitation in the year 2030. The three key scenarios came from a larger set of 42 climate change scenarios that were evaluated from 7 Global Climate Models (GCMs), 2 scenarios from the Intergovernmental Panel on Climate Change SRES (Special Report on Emissions Scenarios) storylines, and 3 assumptions about precipitation intensity in the largest events. The 42 climate change scenarios were run on the Phase 5 Watershed Model of the Monocacy River watershed, a subbasin of the Potomac River watershed in the Piedmont region, using a 2030 estimated land use based on a sophisticated land use model containing socioeconomic estimates of development throughout the watershed. The results provide an indication of likely precipitation and flow patterns under future potential climate conditions.

Downscaling of GCM temperature and precipitation data sets were provided by the Consortium for Atlantic Regional Assessment (http://www.cara.psu.edu/). Weather data reflecting each climate change scenario were created by modifying a 16-year period of historical data of precipitation and temperature from 1984 to 2000. The climate change simulation provided for low, medium, and high climate change effects projected out to 2030.

The Susquehanna River Basin covers almost half the Chesapeake watershed and has a major influence on flows and loads to the Chesapeake. The Susquehanna River responses were examined with an annual average time series of flows and loads reported as a percent difference of the 2030 climate scenarios to the 2000 Base Scenario. Generally flows were seen to decrease in the climate change scenarios despite the higher climate change precipitation inputs. Decreased flows were due to the increased estimates in temperature which, in turn, increased the simulated evapotranspiration in the Susquehanna River watershed.

In the Chesapeake Bay watershed, the 2030 estimated temperatures are about 1.5 degrees Celsius higher over the current temperatures. That estimate is relatively consistent in the different GCMs and has a high degree of certainty. Estimated precipitation increases among the seven global climate models are about 2 percent over current conditions, especially at higher rainfall events, and that is estimated with a moderate degree of certainty. How the temperature and precipitation increases affect flow and associated nutrient and sediment loads in the watershed depends on the hydrologic balance between precipitation and evapotranspiration.

Temperature increases tend to increase evapotranspiration in watersheds, and that can offset increases in precipitation. That seems to be the case in the Chesapeake Bay watershed. Current estimates of the medians of the different scenarios run have an annual average flow, nitrogen, and phosphorus load decrease of –6.0 percent, –1.6 percent, and –2.1 percent, respectively. Because sediment loads increase with higher rainfall events, the median of the nine scenario estimates for sediment is for an increase of 4.9 percent. Figures E-1 through E-4 show annual average time series of flow, nitrogen, phosphorus, and sediment loads, respectively, for the three climate change scenarios compared to the 2000 Base Scenario.

For all three scenarios, flow is decreased in the high-flow winter period, although for two of the scenarios, summer flows are higher (Figure E-1). That could be because of the *flash 30%* and *flash 10%* precipitation conditions used in the scenarios as summer precipitation is characterized by short-term, high-precipitation thunderstorm events.

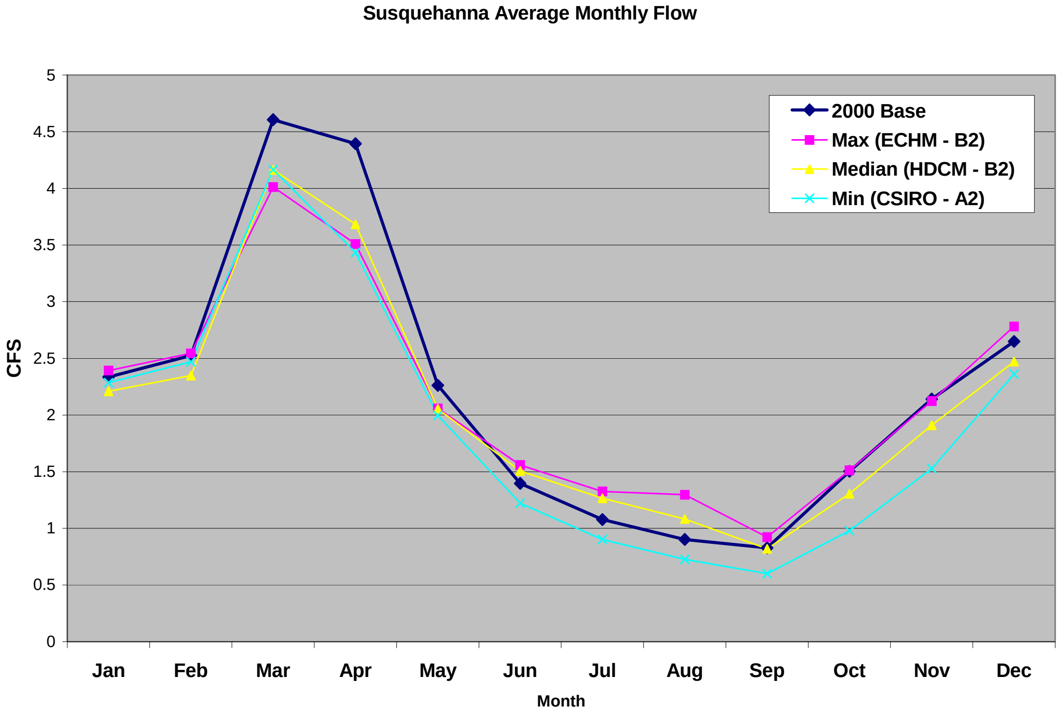


Figure E-1. Average annual time series of flow (cubic feet per second or CFS) for the 2000 Base Scenario and the maximum, median, and minimum climate change scenarios.

Total nitrogen loads follow the overall flow conditions, and they are generally depressed in the winter high-load period of nitrogen (Figure E-2).

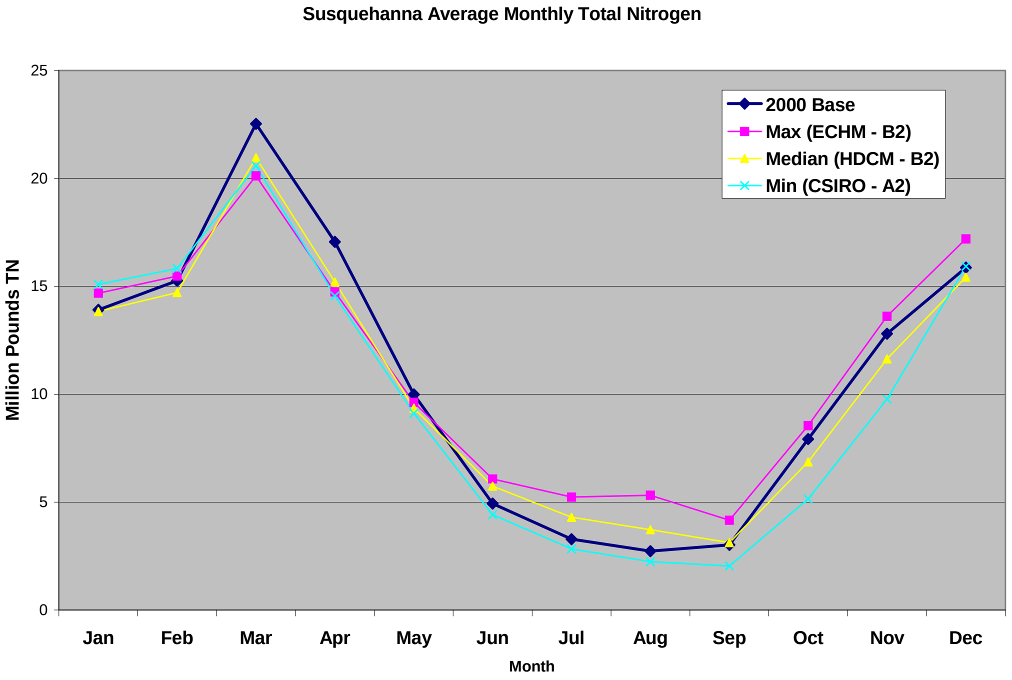


Figure E-2. Average annual time series of total nitrogen loads (millions of pounds per year) for the 2000 Base Scenario and the maximum, median, and minimum climate change scenarios.

The total phosphorus time series is similar to total nitrogen but is somewhat more responsive to episodic high flows in the two flash 10% and flash 30% precipitation conditions (Figure E-3).

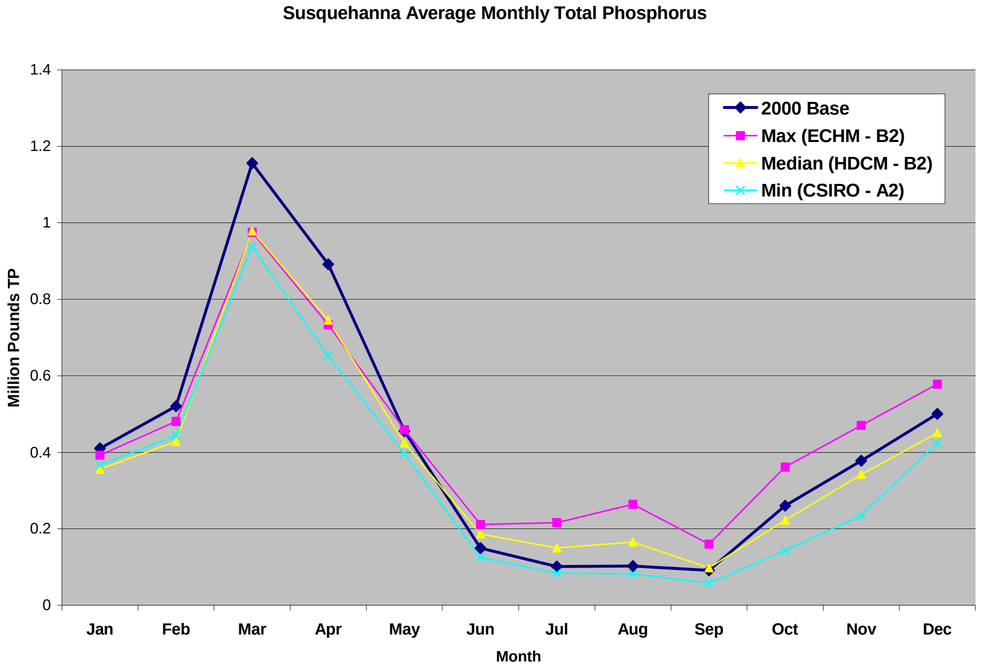


Figure E-3. Average annual time series of total phosphorus loads (millions of pounds per year) for the 2000 Base Scenario and the maximum, median, and minimum climate change scenarios.

In the Chesapeake Bay watershed, the concentration of total suspended solids (TSS) can increase three orders of magnitude from low-flow to extreme high-flow conditions, particularly in the larger rivers. Combined with higher flows, the higher TSS concentrations generate estimates of TSS loads under the flash 10% and flash 30% conditions that are episodic and flashy in nature (Figure E-4).

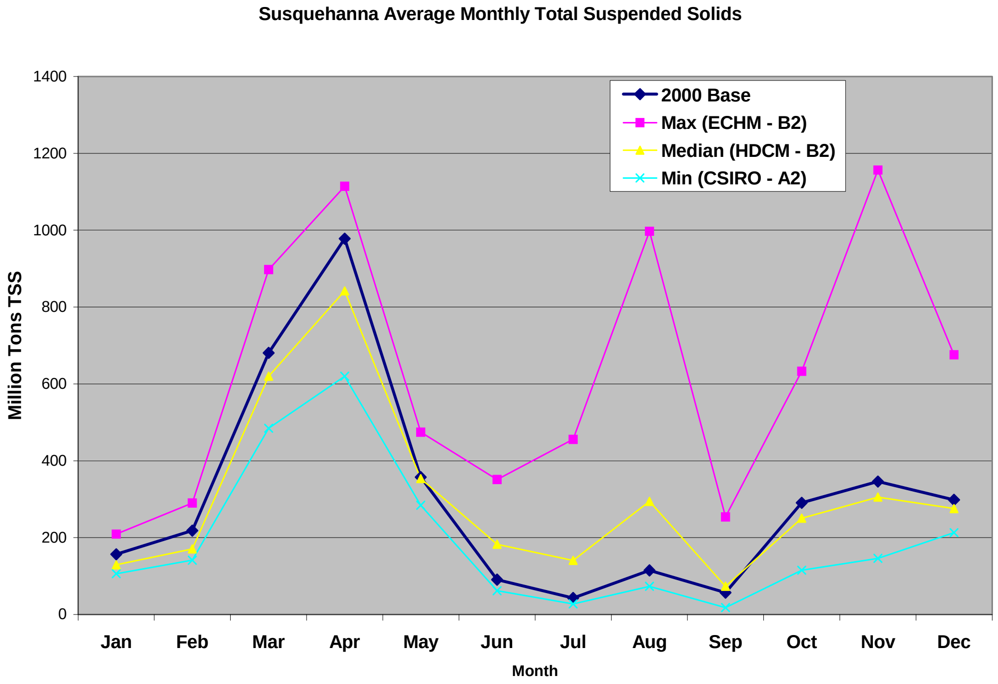


Figure E-4. Average annual time series of total suspended solids loads (millions of tons per year) of the 2000 Base Scenario and the maximum, median, and minimum climate change scenarios

Overall, the model simulation-based findings show the potential range of response of flows and loads to climate change, at least over a relatively short planning horizon of 20 years. If the historic and model trends hold true with respect to precipitation trends increasing in the larger events, and if estimated increases in evapotranspiration with higher temperature outweigh estimated 2030 increases in precipitation, the flow and nutrient loads in the Chesapeake Bay should experience relative declines on an annual average basis. However, the increased precipitation and its related flows could increase sediment loads.

Appendix F.
Determination of the Hydrologic Period for Model Application

Section 6.1.1 defined the hydrologic period for application of the suite of Chesapeake Bay models and reported that the 10-year period 1991–2000 was selected on the basis of a number of criteria. This appendix documents the analyses behind the selection of the hydrologic averaging period.

The hydrologic period for modeling purposes represents a typical or representative long-term hydrologic condition for the waterbody. The hydrologic period is used for expressing average annual loads from various sources. It is not to be confused with the critical period, which defines a period of high stress (see Sections 6.2.1 and 6.4.1 and Appendix G). It is important that the selected hydrologic period is representative of the long-term hydrology in each area of the Chesapeake Bay watershed so that no one area is modeled with a particularly high or low loading or an unrepresentative mix of point and nonpoint sources. The selection of a representative hydrologic averaging period ensures that the balance between point and nonpoint source loading and the balance between different geographic areas are appropriate.

Because of the long history of stream flow and water quality monitoring in the Chesapeake Bay watershed, the Chesapeake Bay Program partners were in the position of selecting a period for model application representative of typical hydrologic conditions from among the 21 contiguous model simulation years—1985 to 2005. The partners first selected 10 years as the appropriate number of years for the hydrologic period and then selected the best contiguous 10-year period.

Methods

Monitored stream/river flow was used exclusively as the indicator of hydrology. Three other criteria were investigated and evaluated by the Chesapeake Bay Program's Water Quality Goal Implementation Team but were not used.

1. Rainfall: Stream/river flow was judged to be a better overall indicator than rainfall as flow integrates the effects of evapotranspiration and snowpack effects of temperature. Flow is also more tractable to work with because the nine river input monitoring stations characterize flows and pollutant loads from 80 percent of the Chesapeake Bay watershed, whereas approximately 500 rainfall stations are across the entire Chesapeake Bay watershed.
2. Water quality: Observed water quality was considered as an ancillary criterion but was eventually rejected. Observed water quality is dependent, in part, on management actions taken throughout the Bay watershed. The Chesapeake Bay Program's Water Quality Goal Implementation Team decided that the criteria for selecting the hydrologic period should be independent of management actions.
3. Modeled loads: The EPA Chesapeake Bay Program Office performed an analysis of modeled loads to investigate the change in the fraction of load by major river basin and pollutant loading source sectors for different hydrologic averaging periods. This criterion was also rejected by the Water Quality Goal Implementation Team because it incorporated the effects from management actions and not just hydrology.

The objective of selecting a hydrologic period is to ensure that the period has flow statistics that were representative of the long-term flow statistics and that the representativeness held across different areas of the Bay watershed. Flow statistics for periods of different length and starting years were considered. To judge the overall representativeness, several statistics were calculated.

1. Mean flow anomaly: This statistic is the absolute value of the difference between the mean flow value for any given period and the long-term mean, divided by the long-term mean. If the mean flow value for a candidate period were equal to the long-term mean, the value of this indicator would be zero. If the mean flow value for a candidate period were either zero or twice the long-term mean, the value would be one.
2. Standard deviation anomaly: Similar to the mean anomaly, this statistic is the absolute value of the difference between the standard deviation of a candidate period and the long-term standard deviation divided by the long-term standard deviation.
3. Kolmogorov-Smirnov (K-S) test statistic: The K-S test is a common nonparametric method of comparing two distributions. The cumulative frequency distributions of two populations are plotted together, and the maximum distance between the two distributions on the probability axis is used at the test statistic, commonly known as *D*. From that test statistic, P values are generally calculated and hypothesis tests run. In the analyses for selecting the hydrologic period, a candidate period distribution is compared to a long-term distribution. For this work, the Water Quality Goal Implementation Team decided to use the D statistic. The D is monotonically related to the P value in this case because the number of observations was constant across analyses and the distribution of the D values was more suited to this work. The D statistic was calculated for the daily flow for an estimate of the agreement in short-term events and for the annual flow for an estimate of the agreement in inter-annual variability.

The nine river input stations compose the set of farthest-downstream, well-monitored flow stations on significant rivers flowing to the Chesapeake Bay, measuring river flow close to the point where the free-flowing river enters the Bay's tidally influenced waters. The analysis used a 30-year flow period that was common to all nine stations and also a long-term flow that used different flow period lengths for each major river basin (Table F-1). In both analyses, only years without missing data were used. At the time of this analysis, the last full year record of flow data was 2006, so the 30-year analysis used all data from 1977 to 2006.

Table F-1. The nine major Chesapeake Bay river flow gage stations used in the determination of the Chesapeake Bay TMDL hydrologic period

Gage ID	Flow gage station description	Full years in the 30-year record*	Full years in long-term record
1668000	Rappahannock River near Fredericksburg, VA	30	99
1646502	Potomac River (Adjusted) near Washington, DC	30	77
2037500	James River near Richmond, VA	30	72
1674500	Mattaponi River near Beulahville, VA	28	64
1673000	Pamunkey River near Hanover, VA	30	65
1491000	Choptank River near Greensboro, MD	30	60
1578310	Susquehanna River at Conowingo, MD	30	40
2041650	Appomattox River at Matoaca, VA	30	37
1594440	Patuxtent River near Bowie, MD	29	29

* The 30-year record is 1977-2006.

Selecting the Number of Years

Ten years was selected as an appropriate length of time as the following analysis showed that most of the 12 possible 10-year contiguous periods are statistically similar to the long-term flow record.

To reduce the dimensionality of the analysis, the Water Quality Goal Implementation Team recommended using a statistic that combined the mean and standard deviation of a given candidate period compared to the same statistics for the 30-year period. The combined statistic allows depiction of a single statistic rather than multiple statistics for easier interpretation. The combination statistic was simply the average of the mean flow anomaly and the standard deviation anomaly described above. The flow and standard deviation anomalies were calculated separately for each of the nine river stations and then averaged. Lower values of the combined statistic correspond to more representative periods.

Because the hydrologic period had to be within the Chesapeake Bay model simulation period of 1985–2005, only periods that fell within that 21-year window were considered. The combined statistic was calculated for each instance of each window length that occurred within the modeling period. For example, the statistic was calculated for two 20-year periods, 1985–2004 and 1986–2006 and for 16 6-year periods, 1985–1990, 1986–1991, ... 2000–2005. For each candidate hydrologic period length, the minimum, maximum, and average values of the combined statistic were tabulated and are plotted in Figure F-1.

Figure F-1 illustrates that when using 10 or more contiguous years, all possible candidate periods are score relatively well using the combined metric. With fewer than 10 years, there is a mix of periods that score well and periods that score poorly. A 10-year period was chosen by the Water Quality Goal Implementation Team as a robust choice for the length of the hydrologic period.

Selecting the Ten-Year Period

There are 12 possible 10-year contiguous periods from 1985 to 2005. Although the above analysis suggests that any of the periods might be acceptable, a more detailed analysis showed that some regional differences and overall statistical differences exist between the candidates. As with selecting the number of years, a combined statistic reduced the dimensionality to make the analysis more tractable. For the analysis, the Water Quality Goal Implementation Team agreed on developing a statistic that combined mean anomaly, standard deviation anomaly, and the D statistic for daily and annual flow. Those four statistics were normalized by the average value of each statistical type individually and then averaged so that the overall score for all 10-year periods centered around one. The averages were plotted separately for each of the nine major river basins.

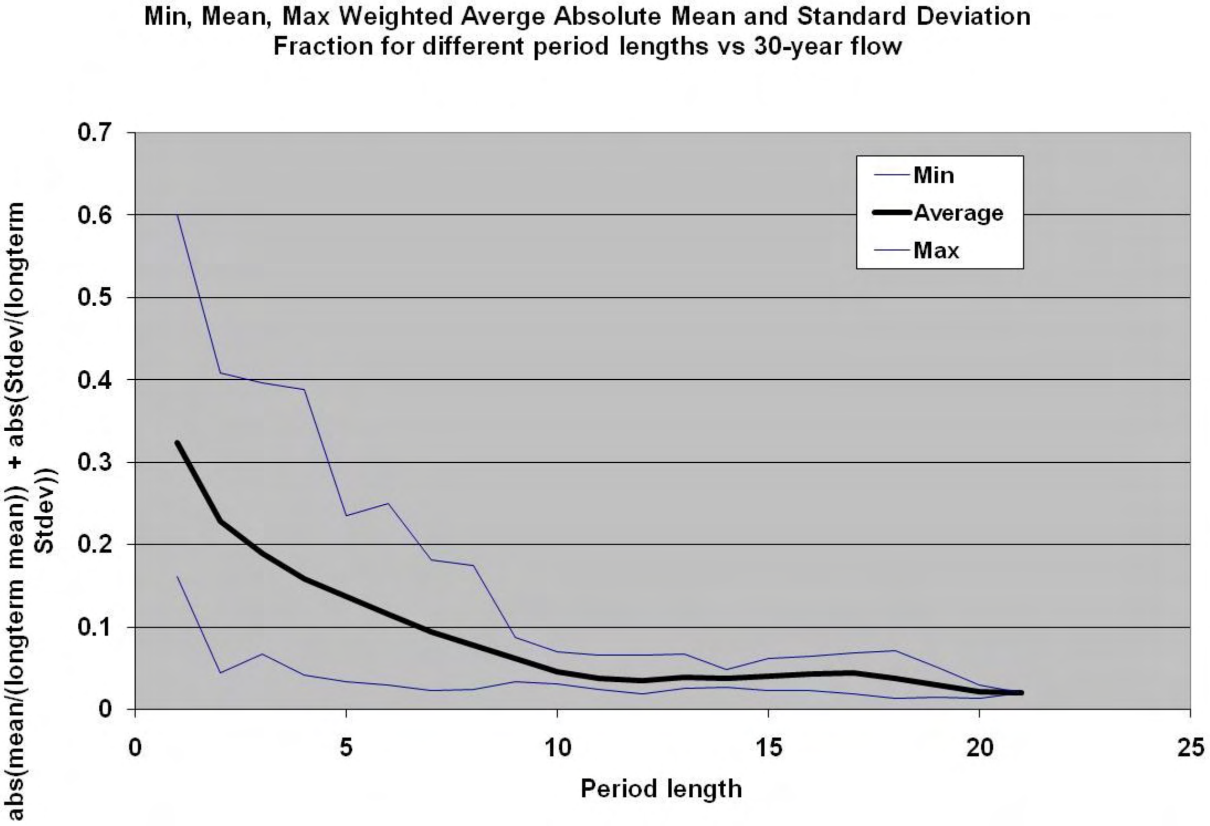
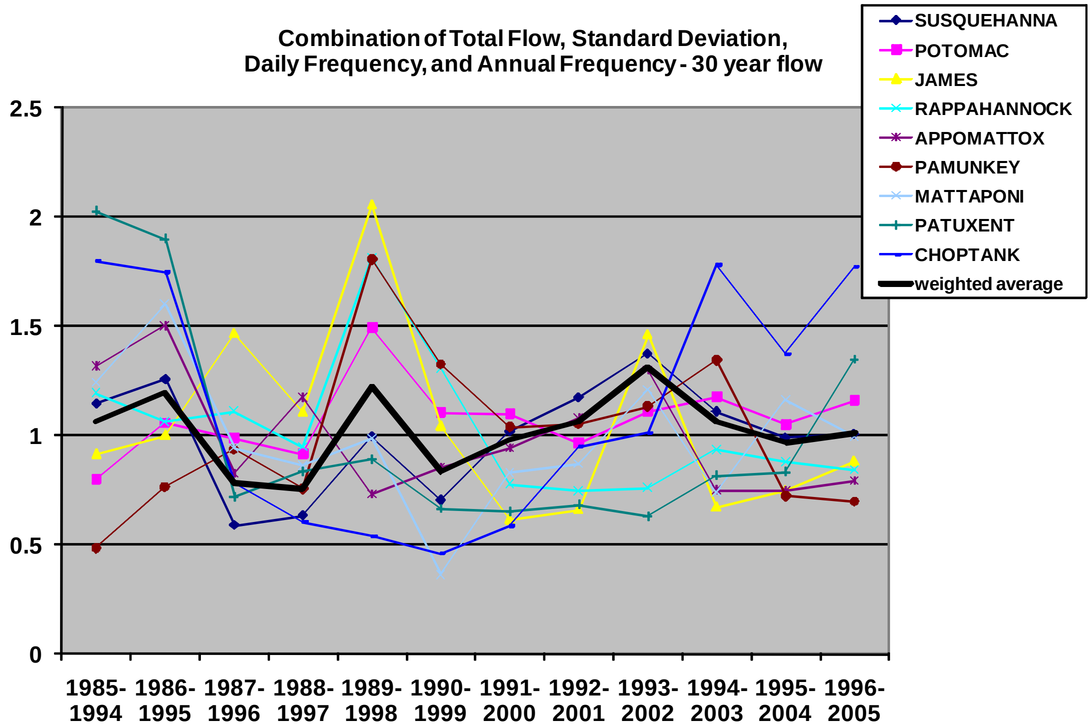


Figure F-1. Range of values of the combined flow statistic for different period lengths.

For example, the mean anomaly in the James River Basin for 1985–1994 was divided by the average mean anomaly of all twelve 10-year periods in the James River Basin. The standard deviation anomaly and D statistics for 1985–1994 were divided by the average of their counterparts for all twelve 10-year periods. The four values were averaged to get an overall score for 1985–1994 in the James River Basin. That process was repeated for each basin and for the flow-weighted average of all nine major river basins for each candidate period. Both the 30-year flow and the long-term flow were considered. The results are shown in Figure F-2.

In Figure F-2, the statistics are all compared to the average, so the average value is one. Lower values reflect better statistical fit to the long-term data set, so values below one are the better candidates for a representative hydrologic period. The thick black line in Figure F-2 is the flow-weighted average of the values for the individual major river basins and, therefore, the best overall indication of statistical fit.

Another consideration is the size of the spread around the flow-weighted average. A tighter distribution means that the good statistical fit holds across all major river basins and is not an unrepresentative hydrologic period for any major river basin. The candidate periods 1987–1996, 1988–1997, 1990–1999, and 1991–2000 are all better than average in terms of the statistical fit (Figure F-2). However, the first three candidate periods—1987–1996, 1988–1997, and 1990–1999—all have individual major river basins that are not good statistical fits. The period 1991–2000 has the tightest overall grouping meaning that it is representative across all major river basins (Figure F-2).



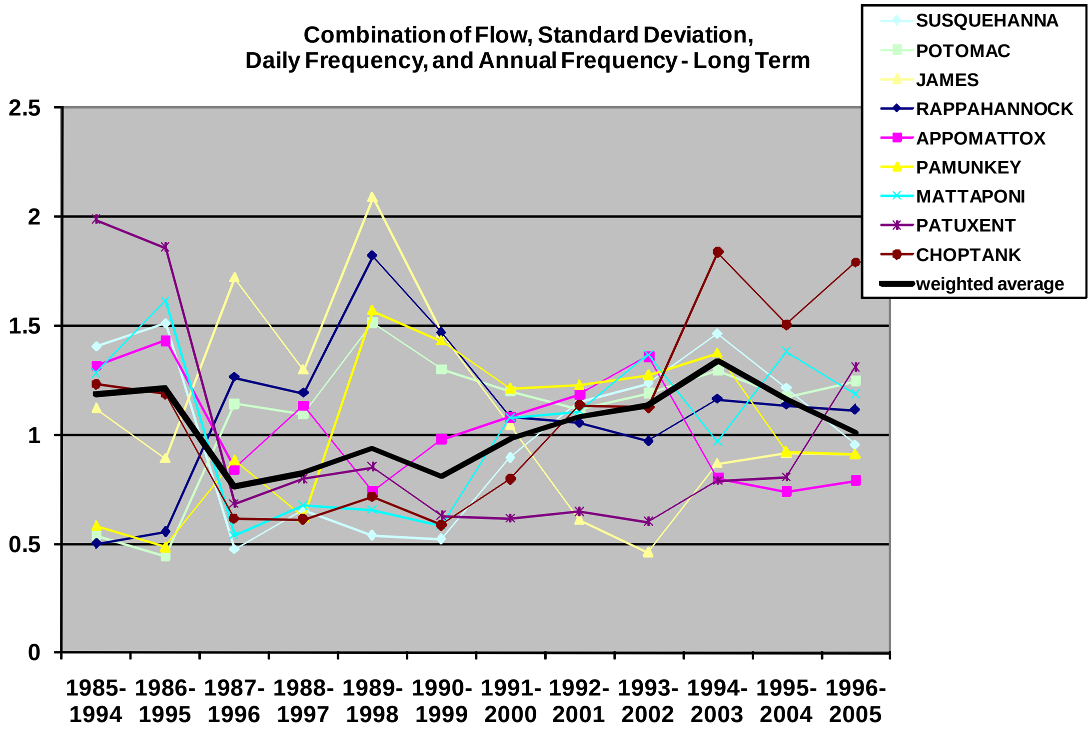


Figure F-2. The combined statistic for the candidate 10-year periods by the nine major river basins for the 30-year flow record (a) and the available long term flow record (b).

The 10-year hydrologic assessment period from 1991 to 2000 was selected by the Water Quality Goal Team for the following reasons:

- It was one of the 10-year periods within the 1985–2005 Chesapeake Bay model simulation period that was closest to an integrated metric of long-term flow.
- Each of the nine major river basins had statistics that were particularly representative of the long-term flow for both the 30-year flow record and available long-term flow record.
- It overlaps several years with the previous 2003 tributary strategy allocation assessment period (1985–1994) facilitating comparisons between the two assessments.
- It incorporates more recent years than previous 2003 assessment period (1985–1994).
- It encompasses the complete decade of 1991–2000, which is a straightforward span of time to communicate to the public,
- It overlaps with the Chesapeake Bay Water Quality Model calibration period (1993–2000), which is important for the accuracy of the model predictions.
- The 10-year period encompasses the 3-year critical period (1993–1995) for the Chesapeake Bay TMDL as explained in Section 6.2.1 and documented in Appendix G.

Appendix G.
Determination of Critical Conditions for the Chesapeake Bay TMDL

Introduction

The Chesapeake Bay TMDL must be developed to attain applicable water quality standards. Critical conditions for stream flow pollutant loading and water quality parameters must be taken into account. All approvable TMDLs must be established in a manner that reflects *Critical Conditions*. Critical conditions are represented by the combination of loading, waterbody conditions, and other environmental conditions that result in impairment and violation of water quality standards. Critical conditions for an individual TMDL typically depend on applicable water quality standards, characteristics of the observed impairments, source type and behavior, pollutant, and waterbody type. In establishing the Chesapeake Bay TMDL, it was necessary to define a *Critical Period*, a period during which hydrologic, temperature, environmental, flow, and other such conditions result in a waterbody experiencing critical conditions with respect to an identified impairment (e.g., summer low flow, winter high flow). The approach chosen in the Chesapeake Bay TMDL was to select a 3-year period as the critical period.

The Chesapeake Bay Program's Water Quality Goal Implementation Team decided that the critical period would be selected from the previously selected hydrologic period 1991–2000 because that time frame is representative of long-term hydrology, is within the model calibration period, and would facilitate modeling operations (see Sections 6.2.1 and 6.5.1 and Appendix F). A 3-year period was selected to coincide with the Chesapeake Bay water quality criteria assessment period (USEPA 2003).

The Water Quality Goal Implementation Team also agreed that the critical period should be representative of an approximate 10-year return period. The return period is defined as the average period of time expected to elapse between occurrences of events at a certain site. A 10-year event is an event of such size that over a long period, the average time between events of equal or greater magnitude is 10 years. The team believed that 10 years was a good balance between guarding against extreme events (greater than 10-year return frequency) and ensuring attainment during more frequent critical events (occurring within less than a 10-year period). The selection of a 10-year return period was also based on the commonly applied 10-year return period for application of the 7Q10 low flow conditions. Finally, the 10-year return period is also consistent with the critical periods selected for other TMDLs developed and published by the Chesapeake Bay watershed jurisdictions.

The following sections discuss the process for determining the critical period on the basis of determining the return period for each of the 3-year time frames within the selected 1991–2000 hydrologic period using various methods. A critical period was selected for assessing achievement of the jurisdictions' Chesapeake Bay dissolved oxygen (DO) and water clarity/submerged aquatic vegetation (SAV) water quality standards. As described below, there was no basis for selecting a specific 3-year critical period for assessment of achievement of the jurisdictions' numerical chlorophyll *a* water quality standard.

Approaches Used in Previous TMDLs to Select the Critical Period

To determine if there is a consistent approach to establishing a critical period among the Chesapeake Bay watershed jurisdictions, each jurisdiction's water quality standards were reviewed, the seven watershed jurisdictions were polled, and previously completed TMDLs were referenced.

Generally, the jurisdictions' water quality standards do not address a method for establishing the critical hydrologic period. Further, EPA does not have specific guidance or regulations on how to determine critical period. EPA only requires that critical conditions and seasonal variations are considered [40 CFR 130.7(c)(1)]. EPA Region 3 has not required any specific method for determining critical conditions and seasonal variations as long as the critical condition captures the *worst case* scenario or the most vulnerable environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards.

In polling the jurisdictions regarding their approaches to determining the hydrology critical period, all jurisdictions reported that the determination is dependent on the pollutant, the water quality standards, the TMDL endpoint, and the amount of flow data available. All jurisdictions reported that the critical period was determined using a representative data set capturing a range of high, low, and average flows. Maryland, the District of Columbia, and Virginia reported selecting the critical period by using a dry year, an average year, and a wet year. Maryland also indicated that in some TMDLs, time-variable models use the worst condition in the calibration period. Although, nutrient TMDLs with steady-state models use 7Q10 flows as the critical period. Delaware reported using the 7Q10 for free-flowing streams and using the monthly or seasonally average as the critical condition for the calibration period for tidal streams. Pennsylvania reported recently beginning to use the growing season average as the critical period for nutrient TMDLs. West Virginia watershed TMDLs use representative precipitation-induced flow data over a 6-year period with high, low, and average conditions.

A review of TMDLs completed for tidal influenced streams and estuaries along the Atlantic and Gulf Coasts revealed that there is no consistent method for determining the critical period. That review was not intended to be exhaustive but to reveal general patterns of methodology across the country. Most TMDLs used a critical period that was protective during low flows, rather than high flows, the condition of interest for the Chesapeake Bay TMDL.

The most commonly identified method for establishing the critical period was the use of 7Q10 flows. The *Louisiana Standard Operating Procedures for Louisiana TMDL Technical Procedures* (LDEQ 2009) specifically outlines the summer critical conditions as 7Q10 or 0.1 cubic feet per second (cfs), whichever is greater, or for tidal streams one-third of the average or typical flow averaged over one tidal cycle. Similarly, winter critical conditions are 7Q10 of 1 cfs, whichever is greater, or for tidal streams one-third of the average or typical flow averaged over one tidal cycle.

Other examples of using 7Q10 flows include the following:

- **Total Maximum Daily Load Analysis for Nanticoke River and Broad Creek, Delaware (DNREC 1998).** The model for this DO, total nitrogen, and total phosphorus TMDL was developed and calibrated using hydrologic and hydrodynamic from 1992, a dry year. Hydrodynamic Model was run using 7Q10 flows, water quality model was run using 1992 pollutant loads.

- **Organic Enrichment/Dissolved Oxygen TMDL Rabbit Creek and Dog River, Alabama (ADEM 2005).** The hydrology of the LSPC model was calibrated for the period of record, October 1, 1996, through September 30, 2000. For the purposes of this TMDL the 2000-year was used as the critical low-flow period. 2000 was a relatively dry year and was one of the periods over which the models were calibrated, lending confidence to the simulations. The period of the model simulation was from 2000 to 2001. This period was selected on the basis of the availability and relevance of the observed data to the current conditions in the watershed. The model was calibrated for the year 2000, which represented both high- and low-flow periods. In 2000 flows were very low and near critical 7Q10 conditions, while in 2001 flows were higher.
- **TMDL Bayou Sara/Norton Creek – Mobile River Basin Organic Enrichment/DO (ADEM 1996).** Summer (May–November) TMDL critical conditions and MOS were established as 7Q10 flows and 30 degrees Celsius (°C). The winter (December–April) TMDL critical conditions and MOS were established as 7Q2 and 20 °C.
- **Total Maximum Daily Load Cooper River, Wando River, Charleston Harbor System, South Carolina (SCDHEC 2002).** Critical conditions for this DO TMDL were determined in the model by setting water quality parameters to represent 75/25 percentiles. The average spring and neap tidal conditions were evaluated with freshwater inflow set to approximate a 7Q10 recurrence, and algal processes were turned off. The model was calibrated to a 3-day period and validated on a 2-day period in 1993. The seasonal critical period was considered to be the low-flow, high-temperature conditions associated with summer and early fall.
- **Total Maximum Daily Load Ashley River, South Carolina (SCDEHC 2003).** The recommended critical flow period includes setting uncontrolled freshwater inflows to 7Q10 flows and selecting the seaward tidal boundary to represent a full lunar month including both spring and neap tides. Those conditions approach worst-case conditions for the impact of point sources on river DO levels. The wasteloads determined for the critical conditions are considered to be protective of the river DO standard when river flow is equal to or greater than 7Q10 because higher flows would provide greater dilution. Higher river flows are expected during wet weather, so the wasteloads should be protective under those conditions.

Another common method for determining the critical period was selecting a 3-year time span on the basis of precipitation, selected to include a wet year, a dry year, and a normal year. Some examples of this approach include the following:

- **Total Maximum Daily Load Analysis for Indian River, Indian River Bay and Rehoboth Bay, Delaware (DNREC 1998).** This is a nitrogen and phosphorus TMDL. The baseline period was established as 1988 through 1990. The hydrologic condition of the year 1988 was considered to represent a dry year, 1989 a wet year, and 1990 a normal year. No indication of the full data set from which the baseline period was established was given.
- **Total Maximum Daily Loads of Nitrogen and Phosphorus for Baltimore Harbor in Anne Arundel, Baltimore, Carroll, and Howard Counties and Baltimore City, Maryland (MDE 2006).** The baseline conditions scenario represents the observed

conditions of the Harbor and its tributaries 1995–1997. Simulating the system for 3 years accounts for various loading and hydrologic conditions, which represent possible critical conditions and seasonal variations of the system. For example, the 1995–1997 period includes an average year (1995), a wet year (1996) and a dry year (1997).

- **Total Maximum Daily Load Organic Enrichment/Dissolved Oxygen Threemile Creek, Alabama (ADEM 2006).** The hydrology of the LSPC model was calibrated for the period of record, October 1, 1996, through September 30, 2000. The period of the model simulation was from 2000 to 2001. That period was selected on the basis of the availability and relevance of the observed data to the current conditions in the watershed. The model was calibrated for the year 2000, which represented both high and low-flow periods. The model was simulated from May 2000 through April 2001 to account for both summer (May–November) and winter (December–April) conditions. In the natural conditions model, two critical periods were selected to establish seasonal TMDLs. A period during June 2000 was simulated under natural conditions, which resulted in a minimum DO concentration of 1.91 milligrams per liter (mg/L) at a 5-foot depth. That June event defines critical conditions in Threemile Creek during the summer season. A period during April of 2001, the model simulated natural condition is 2.26 mg/L at a 5-foot depth and defines the winter critical period. A low-flow period with high temperatures for both summer and winter seasons was used to represent the worst-case conditions.
- **Total Maximum Daily Loads of Nutrients/Biochemical Oxygen Demand for the Anacostia River Basin, Montgomery and Prince George's Counties, Maryland and the District of Columbia. (MDE and DC DOE 2008).** The critical condition and seasonality was accounted for in the TMDL analysis by the choice of simulation period, 1995–1997. That 3-year period represents a relatively dry year (1995), a wet year (1996), and an average year (1997), based on precipitation data, and accounts for various hydrological conditions including the critical condition.

Two TMDLs used the period of the worst hypoxia as the critical period. DO exceedances for Long Island Sound were dominated by point sources. Further details regarding the TMDLs follow:

- **A Total Maximum Daily Load Analysis to Achieve Water Quality Standards for Dissolved Oxygen in Long Island Sound (NYSDEC and CTDEP 2000)**. Annual surveys from 1986 to 1998 and a review of historical data indicated that the 1988–1989 modeling time frame was the most severe period of hypoxia on record. As a result, model simulations of reduced nitrogen inputs were used to predict water quality conditions that would result during the same physical conditions that exist during the 1988–1989 period. The use of 1988–1989 worst-case scenario was considered an implicit margin of safety.
- **Total Maximum Daily Load for Nitrogen in the Peconic Estuary Program Study Area Including Waterbodies Currently Impaired Due to Low Dissolved Oxygen: the Lower Peconic River and Tidal Tributaries; Western Flanders Bay and Lower Sawmill Creek; and Meetinghouse Creek, Terrys Creek and Tributaries (Peconic Estuary Program 2007)**. The Environmental Fluid Dynamics Code (EFDC) model was calibrated using an 8-year period from October 1, 1988, to September 30, 1996 and validated using the 6-year period from October 1, 196, through September 30, 2002. Model calibration and verification included all seasons of the year, as well as extreme wet and dry years.

> Monitoring data indicated that the October 2000 to September 2002 time frame was the most severe period of hypoxia on record from 1988 to 2002. October 1, 2000, to September 30, 2002, was selected as the critical period for the TMDL model runs.

In some cases, the data set either does not contain a critical year or several years are included to capture a range of temperature and flow concentrations. The *TMDLs for The Little Assawoman Bay and Tributaries and Ponds of the Indian River, Indian River Bay, and Rehoboth Bay* (DNREC 2004) is an example of the former. There was no *worst* year for DO, nitrogen and phosphorus during the 3-year period in question, so the average over the three summers was used as the critical (design) condition. The *TMDL for Nutrients in the Lower Charles River Basin, Massachusetts* (MassDEP and USEPA 2007) is an example of the latter. A continuous, 5-year simulation was run. The 1998–2002 period was selected because it represented some of the lowest summer flows throughout the 23-year period of record. Low flows at or near the 7Q10 flow value were observed during three of the summers during the selected critical period.

Two of the TMDLs reviewed had limited data sets, so the critical period was chosen on the basis of the period with the most data available. Examples of this approach follow:

- **Total Maximum Daily Loads of Nitrogen and Phosphorus for the Upper and Middle Chester River, Kent and Queen Anne's Counties, Maryland (MDE 2006).** The models were calibrated to the period of 1997–1999, which was the most recent period for which all of the needed data were available and consistent with the Chesapeake Bay Program modeling efforts of the Tributary Strategies. Only the output from 1997 was used to investigate different nutrient loading scenarios and calculate the annual average and growing season TMDLs for the Upper and Middle Chester rivers because in 1999, the region experienced extreme weather conditions (prolonged drought followed by Hurricane Floyd) resulting in atypically high flows and loads. On the basis of the flow gauge, it was determined that the flow in 1997 was representative of the average annual flow and loads. The timeframe selected includes representative wet and dry periods, accounting for seasonality and critical conditions.
- **Total Maximum Daily Load for Dissolved Oxygen in Mill Creek, Northampton County, Virginia (VADEQ 2009).** The observations show that the instantaneous DO levels fell below the water quality criterion of 4 mg/L minimum repeatedly throughout the period of 1997–2003. Because the nutrients data in the watershed were not available, an interactive approach of calibration of watershed and in-stream water quality model was conducted using all available in-stream monitoring data. The water quality model was calibrated in Mill Creek using the observation data. A 6-year model simulation (1998–2003) was conducted. Seasonal variations involved changes in surface runoff, stream flow, and water quality condition as a result of hydrologic and climatologic patterns. Those were accounted for by using this long-term simulation to estimate the current load and reduction targets.

Initial Analysis by Malcolm Pirnie

The consulting firm Malcolm Pirnie, representing the stakeholders from the Maryland Association of Municipal Wastewater Agencies, Inc. (MAMWA) and the Virginia Association of Municipal Wastewater Agencies, Inc. (VAMWA) conducted an independent analysis of the inflows to the Chesapeake Bay to determine whether the initially selected critical period of 1996–1998 might represent a hydrologic condition with a longer return period than 10 years (Malcolm Pirnie 2009).

Malcolm Pirnie analyzed the flows from the Potomac and Susquehanna rivers, which together contribute most of the flow to the Chesapeake Bay, for the period 1967 through 2009. The average daily inflow from January through May was calculated for each year and for each 3-year period within the 42-year period of record. January through May was selected as the period of interest because studies have indicated that the magnitude and extent of hypoxia in the Chesapeake Bay is largely controlled by freshwater and nutrient inputs during the preceding winter and spring months (freshet).

Results indicated that 1996–1998 had the highest average January through May inflow over the entire period of record and would result in a return period of 40 years. The year 1996 had January through May inflows in the 93rd percentile and 1998 had flows in the 98th percentile. High flows in 1996 were attributed to rainfall on winter snowpack in January 1996, resulting in an event know as the *Big Melt*.

On the basis of those results, Malcolm Pirnie indicated that the critical condition would be too extreme if 1996–1998 were selected as the critical period. Malcolm Pirnie recommended using 1993–1995 or 1994–1996 as the critical period because they represent return flows much closer to a 10-year return period.

Replication of Malcolm Pirnie Results

To confirm the results of the Malcolm Pirnie analysis, Tetra Tech staff replicated the approach used in the Malcolm Pirnie flow analysis. The analysis was repeated using both the flow data presented in the Malcolm Pirnie technical memo (Malcolm Pirnie 2009) and the raw flow data from the U.S. Geological Survey (USGS). Although the replicated 3-year averages based on the flows in the technical memo did not match exactly what was presented in the technical memo, the minor discrepancies did not affect the percentile calculations. Similarly, the 3-year running averages using the raw USGS data resulted in minor discrepancies from the Malcolm Pirnie results. Despite the small differences, Tetra Tech’s replication yielded the same results as the Malcolm Pirnie technical memo (Malcolm Pirnie 2009).

Analysis to Support Critical Period Selection

Additional analyses were performed to further explore the options for the selection of the critical period.

Preliminary analysis included an exploration of the results of including the nine major rivers in the flow analysis and expanding the combinations of different monthly flow durations beyond January to May to include other monthly duration combinations from September through July. Data were analyzed for 1978 through 2009 because the Patuxent flow gage did not begin until 1977. Refer to Table G-1 for the gages used in the analysis and the period for which data was available. Running 3-year average flows were calculated for 25 different month combinations for the entire period of evaluation. The probability of each 3-year flow average was determined using the Weibull Plotting Position. The return period is the inverse of the probability. That method differed from the approach in the Malcolm Pirnie analysis (Malcolm Pirnie 2009), which used percentile ranks. A regression was also performed on the 3-year flow averages to determine if there was a correlation with the DO percent exceedances. The percent DO exceedances were provided by EPA's Chesapeake Bay Program Office (CBPO) and represent volume exceedances. The analysis was run with and without the use of tributary multipliers, which the CBPO developed because flows from different tributaries do not affect conditions in the Bay equally. Those factors are the estuarine delivery factors presented in the Section 6.3.1. The CBPO multipliers were translated to a 0.0 to 1.0 scale and are included in Table G-2. Without the multipliers, the Susquehanna and Potomac rivers contribute approximately 80 percent of the flow to the Bay. With the multipliers, the two rivers contribute approximately 95 percent of the effective load.

Table G-1. Flow gages and period of available data

Gage ID	Description	Start	End
1668000	Rappahannock River near Fredericksburg, VA	9/19/1907	8/25/2009
1646502	Potomac River (Adjusted) near Washington, DC	3/1/1930	7/31/2009
2037500	James River near Richmond, VA	10/1/1934	8/25/2009
1674500	Mattaponi River near Beulahville, VA	9/19/1941	8/25/2009
1673000	Pamunkey River near Hanover, VA	10/1/1941	8/25/2009
1491000	Choptank River near Greensboro, MD	1/1/1948	8/25/2009
1578310	Susquehanna River at Conowingo, MD	10/1/1967	8/25/2009
2041650	Appomattox River at Matoaca, VA	10/1/1969	8/25/2009
1594440	Patuxtent River near Bowie, MD	6/27/1977	8/25/2009

Table G-2. Chesapeake Bay tributaries flow multiplier ratios

Major river basin	Multiplier	Adjusted ratio
Appomattox	0.533111028	0.017
Choptank	6.929861533	0.217
James	0.533111028	0.017
Mattaponi	0.798423188	0.025
Pamunkey	0.798423188	0.025
Patuxent	3.093385849	0.097
Potomac	6.188243619	0.193
Rappahannock	2.809613056	0.088
Susquehanna	10.3187158	0.322
		1.000

Source: EPA Chesapeake Bay Program Office

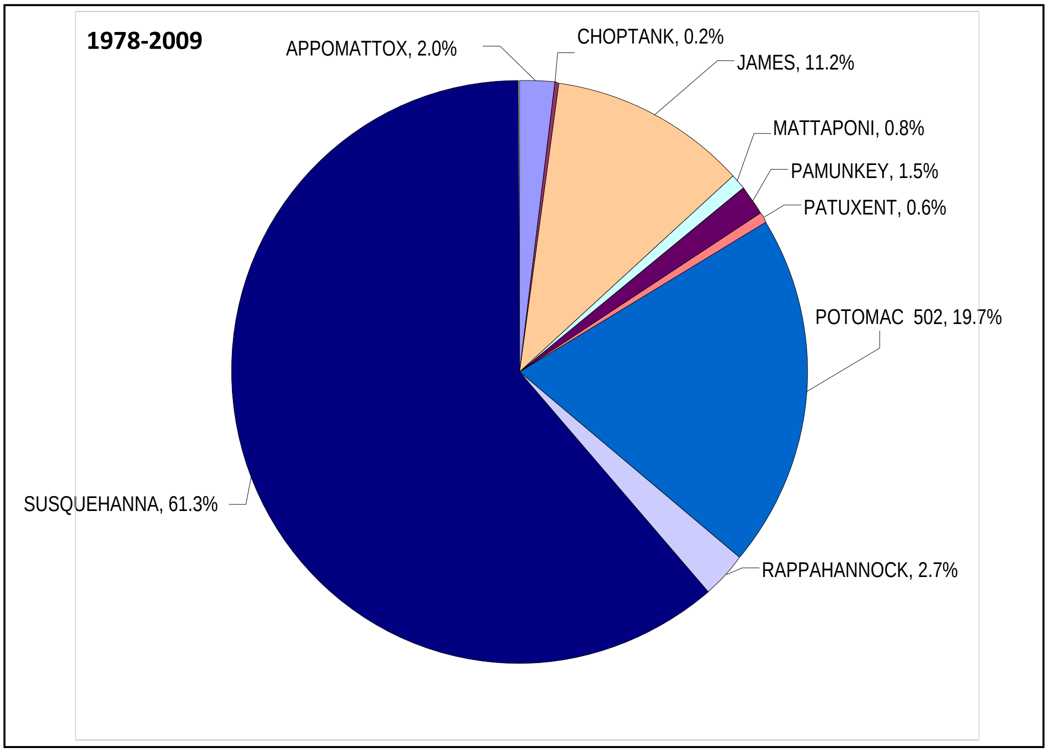


Figure G-1. Tributary flow contributions without multiplier ratios.

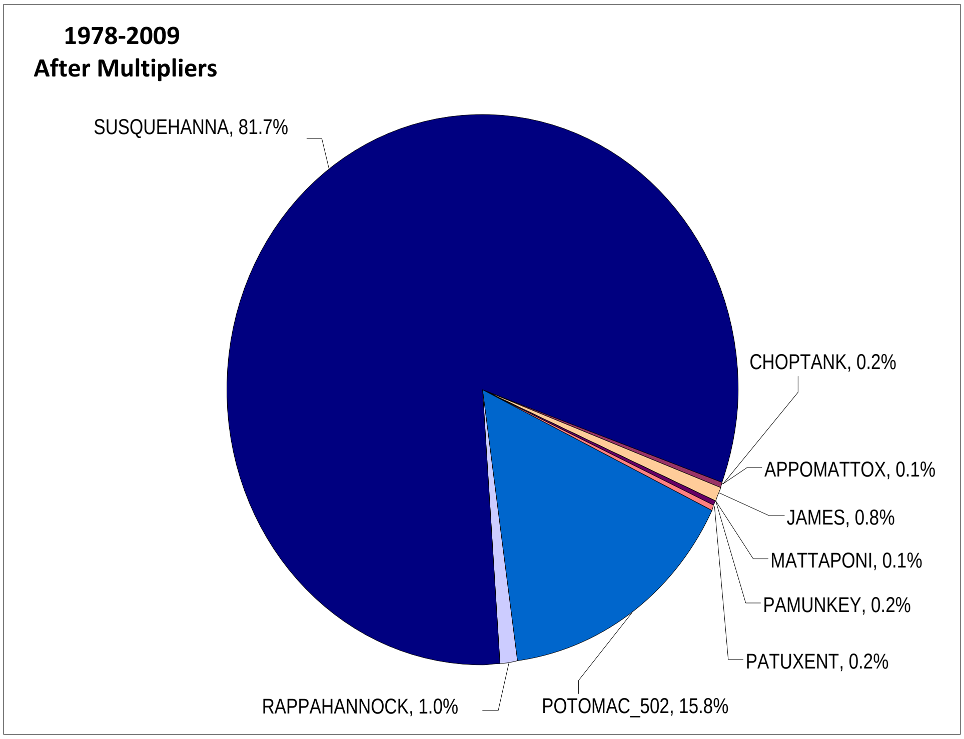


Figure G-2. Tributary flow contributions with the multiplier ratios.

Results of the analysis, as shown in Tables G-3 and G-4, indicate that the monthly span should be extended beyond the January through May period suggested in the Malcolm Pirnie analysis (Malcolm Pirnie 2009) because the 3-year flow averages with the highest correlation to DO exceedances generally included longer monthly spans. The 3-year average flow with the highest correlation to DO exceedances was September through June. Findings also suggest that 1996–1998 had closer to a 15-year return period for months when flow was more closely correlated with DO exceedances. The other possible critical periods 1992–1994 and 1993–1995 had generally lower than 10-year return periods and return periods greater than 10 years when flow was not strongly correlated with DO exceedances. Return periods greater than 6 years are highlighted in Tables G-3 and G-4, and only 3-year average flows with at least one monthly interval with a 6-year or greater return period are shown. There were no 3-year average flows with return periods greater than 6 years for any of the years between 1978 and 1991.

Table G-3. Return periods and R^2 correlation between various monthly durations and DO percent exceedances without the Tributary Multiplier Ratio.

% DO Exceedences --->		25.87%	25.92%	24.26%	27.84%	26.05%	31.11%	27.24%
Interval	R2	1992-1994	1993-1995	1994-1996	1996-1998	1997-1999	2003-2005	2004-2006
		Return Period						
SEP-JUNE	0.54	4.43	6.20	3.44	15.50	2.58	31.00	7.75
NOV-JUNE	0.53	6.20	7.75	5.17	31.00	2.07	15.50	4.43
SEP-JULY	0.53	4.43	5.17	3.44	15.50	2.58	31.00	10.33
NOV-JULY	0.52	6.20	7.75	4.43	15.50	2.07	31.00	5.17
DEC-JUNE	0.52	7.75	6.20	4.43	31.00	2.38	15.50	3.88
SEP-MAY	0.51	4.43	6.20	3.88	15.50	3.10	31.00	7.75
DEC-JULY	0.51	6.20	7.75	4.43	31.00	2.21	15.50	3.88
OCT-JUNE	0.50	5.17	6.20	4.43	15.50	2.38	31.00	7.75
OCT-JULY	0.49	5.17	6.20	4.43	15.50	2.21	31.00	7.75
NOV-MAY	0.48	6.20	7.75	5.17	31.00	3.10	15.50	4.43
SEP-APR	0.48	4.43	5.17	3.44	15.50	3.10	31.00	10.33
OCT-MAY	0.46	5.17	7.75	4.43	31.00	2.82	10.33	6.20
DEC-MAY	0.46	10.33	7.75	5.17	31.00	2.82	6.20	3.88
JAN-JUNE	0.44	10.33	6.20	4.43	31.00	2.58	5.17	2.21
JAN-JULY	0.44	6.20	5.17	4.43	31.00	2.21	7.75	2.82
NOV-APR	0.44	7.75	10.33	4.43	31.00	3.10	15.50	5.17
OCT-APR	0.42	5.17	7.75	3.44	31.00	3.10	15.50	6.20
SEP-MAR	0.42	2.82	3.44	3.88	15.50	4.43	31.00	10.33
DEC-APR	0.40	10.33	15.50	5.17	31.00	3.10	6.20	4.43
NOV-MAR	0.39	3.10	3.44	6.20	31.00	4.43	15.50	7.75
JAN-MAY	0.37	10.33	7.75	6.20	31.00	3.10	4.43	2.21
OCT-MAR	0.36	2.82	3.44	4.43	31.00	3.88	10.33	7.75
DEC-MAR	0.36	3.44	5.17	7.75	31.00	4.43	10.33	6.20
JAN-APR	0.32	31.00	15.50	6.20	10.33	3.44	3.88	2.38
JAN-MAR	0.26	5.17	6.20	10.33	31.00	7.75	3.88	2.58

Table G-4. Return periods and R^2 correlation between various monthly durations and DO percent exceedances with the Tributary Multiplier Ratio

% DO Exceedences --->		25.87%	25.92%	24.26%	27.84%	26.05%	31.11%	27.24%
Interval	R2	1992-1994	1993-1995	1994-1996	1996-1998	1997-1999	2003-2005	2004-2006
		Return Period						
SEP-JUNE	0.53	4.43	5.17	3.44	7.75	2.21	31.00	15.50
NOV-JUNE	0.53	5.17	6.20	4.43	15.50	1.94	31.00	7.75
DEC-JUNE	0.52	6.20	7.75	3.88	15.50	1.94	31.00	4.43
SEP-JULY	0.52	3.88	5.17	3.44	10.33	2.07	31.00	15.50
NOV-JULY	0.52	5.17	6.20	4.43	15.50	1.94	31.00	10.33
DEC-JULY	0.51	5.17	6.20	3.88	15.50	1.94	31.00	7.75
OCT-JUNE	0.49	5.17	6.20	3.88	15.50	2.07	31.00	7.75
SEP-MAY	0.49	4.43	5.17	3.88	7.75	2.58	31.00	15.50
OCT-JULY	0.48	5.17	6.20	3.88	15.50	1.94	31.00	10.33
NOV-MAY	0.46	6.20	7.75	4.43	31.00	2.38	15.50	5.17
SEP-APR	0.46	4.43	5.17	3.44	6.20	2.82	31.00	15.50
JAN-JULY	0.46	10.33	5.17	4.43	31.00	1.55	15.50	3.88
JAN-JUNE	0.46	10.33	6.20	4.43	31.00	1.82	5.17	2.82
DEC-MAY	0.45	7.75	10.33	5.17	31.00	2.21	6.20	4.43
OCT-MAY	0.44	5.17	6.20	3.88	15.50	2.21	10.33	7.75
NOV-APR	0.42	7.75	10.33	3.88	15.50	2.58	31.00	6.20
SEP-MAR	0.41	2.07	3.10	3.88	10.33	4.43	15.50	31.00
OCT-APR	0.41	5.17	6.20	3.44	10.33	2.58	31.00	7.75
DEC-APR	0.40	15.50	31.00	4.43	10.33	2.58	7.75	5.17
NOV-MAR	0.38	2.58	3.10	5.17	31.00	3.44	15.50	10.33
JAN-MAY	0.37	15.50	7.75	6.20	31.00	2.38	5.17	2.82
DEC-MAR	0.37	2.58	3.44	6.20	31.00	3.88	15.50	10.33
OCT-MAR	0.35	2.38	3.10	4.43	31.00	3.44	10.33	15.50
JAN-APR	0.32	31.00	15.50	6.20	10.33	2.58	5.17	3.44
JAN-MAR	0.28	2.58	3.88	10.33	31.00	7.75	6.20	2.82

Analysis of Critical Period Using the Log Pearson III Method

After determining the return period using the Weibull Plotting Position method, a second method, the Log Pearson III Method (U.S. Interagency Advisory Committee on Water Data 1982; Ponce 1989), was used to determine whether the return period changed significantly depending on the method of calculation. The Log Pearson III method provides a smooth fit through the plotting position data and in essence smoothens out the predicted values. That analysis was conducted over the same 1978 through 2009 period and focused on monthly spans with the highest correlation between flow and DO exceedances. Results in Table G-5 and Table G-6 show that there are some changes in the return periods, but the conclusion in terms of candidate years remains the same. This method of determining the return period was used in subsequent analyses.

Table G-5. Log Pearson III method for determining return period, without Tributary Multiplier Ratio.

Without Multiplier

% DO Exceedences	25.87%	25.92%	24.26%	27.84%	31.11%	27.24%
Year	1992-1994	1993-1995	1994-1996	1996-1998	2003-2005	2004-2006
Sep-June	4.38	4.90	3.77	17.99	34.80	12.37
Nov-June	7.45	7.90	5.46	20.71	19.09	5.36
Sep-July	4.16	4.79	4.05	16.77	36.03	14.15
Nov-July	6.79	7.53	6.02	18.95	20.33	6.59
Dec-June	9.19	9.11	6.68	19.70	15.89	4.24
Sep-May	4.90	5.74	3.80	17.77	23.83	11.69
Dec-July	8.39	8.66	7.26	18.14	17.24	4.97
Oct-June	5.44	6.15	4.60	19.99	21.57	7.16
Flow (Sep-June) (cfs)	81,791	83,254	80,099	95,684	101,516	92,106
Flow (Nov-June) (cfs)	97,725	98,368	94,810	108,161	107,300	94,664
Flow (Sep-July) (cfs)	76,755	78,432	76,487	89,677	96,200	88,110
Flow (Nov-July) (cfs)	89,756	90,753	88,724	99,399	100,142	89,485
Flow (Dec-June) (cfs)	104,233	104,117	100,461	111,988	109,418	95,653
Flow (Sep-May) (cfs)	86,706	88,203	83,278	100,501	103,783	96,146
Flow (Dec-July) (cfs)	94,451	94,829	92,906	101,658	101,107	89,709
Flow (Oct-June) (cfs)	88,780	89,746	87,057	101,106	101,688	91,140

Table G-6. Log Pearson III method for determining return period, with Tributary Multiplier Ratio.

With Multiplier

% DO Exceedences	25.87%	25.92%	24.26%	27.84%	31.11%	27.24%
Year	1992-1994	1993-1995	1994-1996	1996-1998	2003-2005	2004-2006
Sep-June	4.39	5.17	3.87	13.21	35.52	18.76
Nov-June	7.47	8.19	5.70	16.84	19.21	8.52
Sep-July	4.19	4.83	4.04	12.21	36.18	21.53
Nov-July	6.85	7.48	5.98	16.06	21.37	10.34
Dec-June	9.17	9.27	6.76	16.02	17.64	6.88
Sep-May	4.92	6.32	4.08	13.12	24.42	17.15
Dec-July	8.38	8.39	7.08	14.58	18.76	8.73
Oct-June	5.40	6.41	4.67	16.09	22.11	10.74
Flow (Sep-June) (cfs)	19,682	20,141	19,338	22,251	24,445	23,100
Flow (Nov-June) (cfs)	23,429	23,668	22,837	25,294	25,648	23,779
Flow (Sep-July) (cfs)	18,494	18,892	18,400	20,891	23,136	22,147
Flow (Nov-July) (cfs)	21,550	21,739	21,292	23,285	23,910	22,535
Flow (Dec-June) (cfs)	24,860	24,893	24,069	26,006	26,242	24,110
Flow (Sep-May) (cfs)	20,897	21,462	20,265	23,415	25,103	24,122
Flow (Dec-July) (cfs)	22,568	22,569	22,178	23,659	24,214	22,671
Flow (Oct-June) (cfs)	21,337	21,662	20,998	23,689	24,436	22,921

Analysis of Critical Period Using Expanded Flow Data

Given some concern that the 30-year period from 1978 through 2009 was of insufficient length to fully capture the return period over the full period of flow data and was artificially lowering the most extreme return period to 30 years, an extended analysis was performed for the years 1930 through 2009 but only included the Potomac and Susquehanna rivers. The Potomac and Susquehanna rivers account for almost 80 percent of the total flow to the Chesapeake Bay, and if the CBPO allocation multipliers are used, those two rivers account for almost 95 percent of the total inflow to the Chesapeake Bay. Hence, those two flow gages were considered sufficient for analysis purposes. The two USGS flow gages are described in Table G-1.

The Susquehanna River at Conowingo gage flow data runs from October 1, 1967, to the present. The period before October 1, 1967, was patched using data from the Susquehanna River at Harrisburg gage (01570500 – October 1, 1890, to August 25, 2009) using a simple drainage area ratio method. The daily freshwater inflow from the Potomac and Susquehanna rivers were weighed using the adjusted tributary multipliers provided by the CBPO (Table G-7).

Table G-7. Adjusted tributary flow multiplier ratios

Gage	Multiplier	Adjusted ratio
Potomac	6.188	0.375
Susquehanna	10.317	0.625

Source: EPA Chesapeake Bay Program Office

The analysis using the extended period followed the same procedure as previous analyses except that the data were extended back to 1930, only the weighted flow data based on multipliers were used, and the Log Pearson III method was used to determine the return period. Table G-8 lists the return periods for each of the monthly intervals for the extended period, with return periods greater than 6 years highlighted.

Table G-8. Extended period (1930–2009) return periods

% DO Exceedences	24.97%	25.87%	25.92%	24.26%	22.58%	27.84%	31.11%	27.24%
Year	1991-1993	1992-1994	1993-1995	1994-1996	1995-1997	1996-1998	2003-2005	2004-2006
jan-july	2.69	11.80	8.95	8.72	1.77	16.28	11.76	4.37
jan-june	3.05	13.72	9.84	8.14	1.69	17.59	9.71	3.03
jan-may	4.61	24.98	19.13	10.56	1.69	25.43	7.20	2.73
jan-apr	7.48	39.45	34.34	10.82	1.81	16.67	7.48	3.59
jan-mar	2.18	3.24	4.32	13.91	4.28	46.60	5.51	4.33
dec-july	3.03	9.20	9.15	7.92	2.69	15.66	20.18	9.88
dec-june	3.35	9.90	9.98	7.52	2.62	17.02	19.14	7.95
dec-may	4.76	16.77	17.73	9.20	2.76	23.09	16.70	8.14
dec-apr	6.96	20.14	23.89	9.10	3.01	16.01	16.48	9.99
dec-mar	2.68	3.49	5.42	9.87	7.27	31.16	13.94	13.66
nov-july	1.66	2.08	3.29	2.63	3.11	2.75	1.35	1.31
nov-june	3.39	8.92	9.67	7.10	3.18	20.60	25.44	10.69
nov-may	4.68	13.11	15.60	8.48	3.43	28.01	21.32	11.48
nov-apr	6.51	16.24	19.83	8.46	3.78	19.26	21.02	15.07
nov-mar	2.84	3.43	5.51	8.90	8.28	34.04	17.98	17.83
oct-july	3.64	6.50	7.38	6.27	3.71	18.35	32.07	18.23
oct-june	4.12	6.98	8.03	5.91	3.72	19.90	31.72	15.37
oct-may	5.69	9.02	10.95	7.06	4.09	25.80	26.88	16.45
oct-apr	7.66	10.82	14.96	7.08	4.40	18.91	26.38	19.62
oct-mar	3.42	2.92	4.50	7.25	8.82	29.23	20.77	22.25
sep-july	3.39	5.40	6.73	5.06	4.18	17.56	69.44	38.08
sep-june	3.86	5.81	7.27	4.87	4.26	18.29	62.21	30.68
sep-may	4.93	7.51	9.31	5.64	4.62	21.90	56.34	34.77
sep-apr	6.60	8.70	11.93	5.68	4.90	17.28	52.38	40.22
sep-mar	3.25	2.74	4.31	5.78	9.16	23.34	40.15	43.20

The monthly intervals with high correlations with DO exceedances are September – June, November–June, December–June, September–July, and December–July. Table G-9 highlights the return periods for the monthly intervals with high correlations with DO exceedances.

Table G-9. Return periods for monthly intervals highly correlated to Chesapeake Bay DO criteria exceedances

Interval	1992–1994	1993–1995	1994–1996	1996–1998
September–June	5.81	7.27	4.87	18.29
November–June	8.92	9.67	7.10	20.60
December–June	9.90	9.98	7.52	17.02
September – July	5.40	6.73	5.06	17.56
December – July	9.20	9.15	7.92	15.66

Analysis of Critical Period using De-Trended Flow Data

As previously noted, initial analysis of the 3-year average flows from 1978 through 2009 did not reveal any 3-year periods before 1992 with return periods greater than 6 years for the monthly intervals included in the analysis. This indicates a potential increasing trend in flow volume over the last several decades. De-trending removes any flow trends over time and allows for an equal comparison of current and historic flows. It can remove the effects of urbanization and other impacts, which are apparent in the flow data.

The first step in de-trending was to determine if there is a significant trend in the flow data. The slope of the trend line is 0.1878. The Kendall Tau ranking correlation coefficient was used to determine if this is a statistically significant trend. The Tau value can range between –1 and 1, with a positive number indicating an increasing trend and a negative number indicating a decreasing trend. The flow data from 1930 through 2009 had a positive Tau value. A p-value < 0.05 indicates a statistically significant trend. The time-series flow data had a p-value of 0.0042, which is statistically significant. Figure G-3 shows the trend line in the raw data.

After establishing that a statistically significant increasing trend exists in the flow data, a de-trended time-series was developed. Two different methods were used to fit a trend line through the time-series data—Linear Least Squares Regression, and the Locally Weighted Scatter Plot Smoothing (LOWESS) (Helsel and Hirsch 2002; NIST and SEMATECH 2006).

The linear regression trend line was estimated by fitting the time-series data using a trend line of the form $y = mx + c$ (where m is the slope, c is the intercept, y being the dependent variable, i.e., flow, and x the independent variable time). The LOWESS fit is determined by specifying a smoothening parameter, which defines the subset of data that will be used for the local fit. The LOESS technique performs a weighted least square regression fit (on a subset of points) in a moving range around the x value (time), where the values in the moving range are weighted according to their distance from this x value. For that analysis, a smoothening parameter of 0.33 was found to fit the data trend reasonably well. Details of the LOWESS computation are at: http://www.itl.nist.gov/div898/handbook/pmd/section1/dep/dep144.htm.

The residuals were then calculated for each method (i.e., the difference between the observed and predicted values along the trend line). Finally, the residuals were added to the last point in the time series (the maximum value) to generate a de-trended time series. To confirm that no trend exists in the resulting de-trended time series using the linear regression approach, the linear slope was calculated. The slope was zero, indicating that there was no remaining trend. For the de-trended time-series using the LOWESS regression, the presence of no trend in the time-series was confirmed using a p-value. The p-value of the de-trended data was 1.2376, indicating a statistically insignificant trend (p-value < 0.05 is significant). Figure G-4 plots the de-trended data.

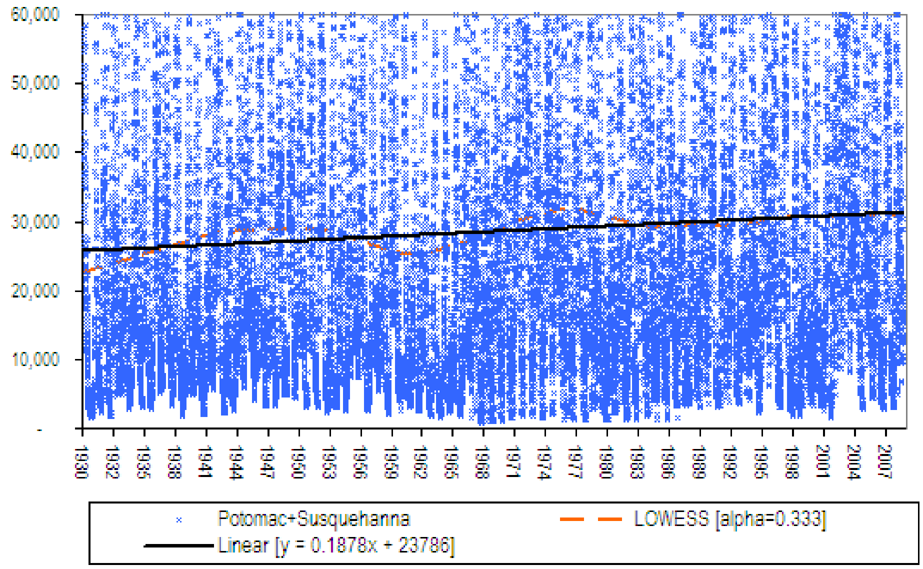


Figure G-3. Raw flow data with trend line.

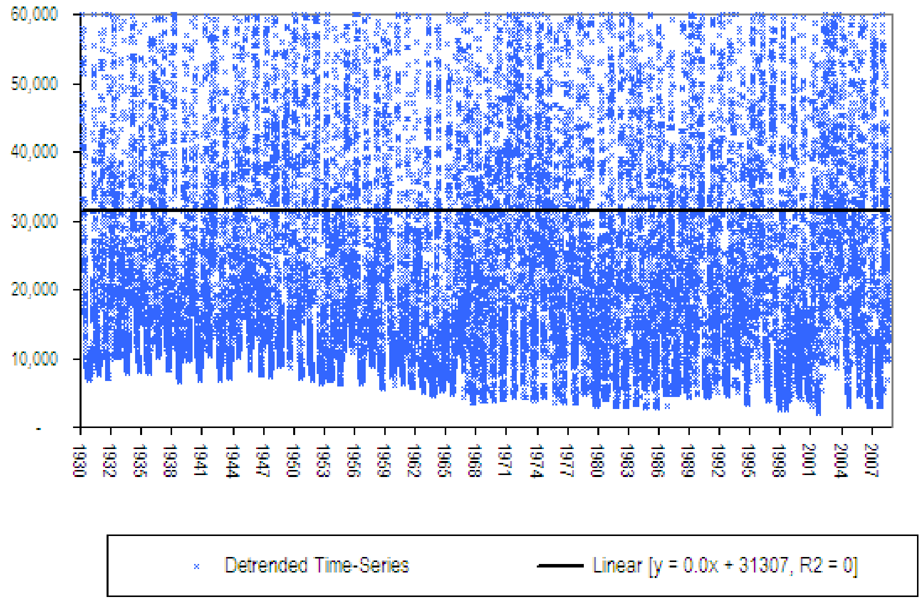


Figure G-4. De-trended data with slope of zero.

Linear Regression to Determine Return Period

Using the linear regression de-trended data yielded revised return periods, which are in Table G-10. Table G-11 highlights return periods for the monthly spans with the highest correlation to DO exceedances.

Table G-10. De-trending analysis results using linear regression

% DO Exceedences	25.87%	25.92%	24.26%	22.58%	27.84%	31.11%	27.24%
Year	1992-1994	1993-1995	1994-1996	1995-1997	1996-1998	2003-2005	2004-2006
jan-july	7.53	5.51	5.14	1.41	9.02	6.05	2.49
jan-june	8.57	6.62	4.89	1.39	9.82	5.28	1.97
jan-may	16.31	11.91	6.84	1.41	15.37	3.88	1.85
jan-apr	26.99	22.35	7.73	1.54	10.27	4.50	2.46
jan-mar	2.67	3.36	9.85	3.28	34.34	3.92	3.10
dec-july	6.52	6.34	4.95	1.95	9.54	11.75	5.74
dec-june	7.38	7.36	4.83	1.95	10.73	11.13	4.48
dec-may	11.05	11.80	6.33	2.06	15.37	9.18	4.57
dec-apr	16.93	19.29	6.92	2.28	11.43	10.39	6.93
dec-mar	2.83	4.30	8.35	5.44	26.43	9.67	9.45
nov-july	2.80	4.80	3.61	4.36	3.69	1.46	1.41
nov-june	6.35	7.03	4.60	2.29	14.35	15.47	6.38
nov-may	9.00	10.18	5.63	2.44	19.11	13.24	6.80
nov-apr	12.56	16.41	6.16	2.77	15.06	14.98	9.32
nov-mar	2.75	4.30	7.17	6.40	29.15	13.42	13.06
oct-july	4.31	4.71	4.05	2.48	12.57	19.18	9.92
oct-june	4.64	5.26	3.96	2.58	13.94	18.36	8.54
oct-may	6.42	7.83	4.53	2.79	18.18	16.63	9.13
oct-apr	8.37	10.70	4.77	3.12	14.50	18.16	13.31
oct-mar	2.29	3.42	5.25	6.88	23.92	15.97	16.78
sep-july	3.75	4.39	3.45	2.81	11.30	40.03	21.57
sep-june	4.00	4.73	3.31	2.87	13.01	42.41	18.94
sep-may	4.91	6.67	3.79	3.13	16.03	37.44	20.99
sep-apr	6.53	8.84	4.01	3.48	12.77	39.63	29.60
sep-mar	2.14	3.23	4.29	7.21	19.30	32.86	34.85

Table G-11. Return periods for monthly intervals highly correlated to Chesapeake Bay DO criteria exceedances using linear regression de-trended flow data.

Interval	**1992–1994**	**1993–1995**	**1994–1996**	**1996–1998**
September–June	4.00	4.73	3.31	13.01
November–June	6.35	7.03	4.60	14.35
December–June	7.38	7.36	4.83	10.73
September–July	3.75	4.39	3.45	11.30
December–July	6.52	6.34	4.95	9.54

LOWESS Polynomial Regression

Using LOWESS regression to de-trend the data, the 3-year return periods were recalculated (Tables G-12 and G-13).

Table G-12. De-trending analysis results using LOWESS polynomial regression

% DO Exceedences	24.97%	25.87%	25.92%	24.26%	22.58%	27.84%	31.11%	27.24%
Year	1991-1993	1992-1994	1993-1995	1994-1996	1995-1997	1996-1998	2003-2005	2004-2006
jan-july	2.25	11.24	8.10	7.33	1.42	11.81	7.30	2.60
jan-june	2.57	13.21	9.07	6.67	1.40	13.47	6.26	1.98
jan-may	3.88	23.61	17.29	8.59	1.44	18.30	4.16	1.88
jan-apr	6.54	38.98	32.42	9.11	1.58	12.20	4.73	2.53
jan-mar	1.98	3.00	3.95	13.24	3.61	44.48	4.14	3.21
dec-july	2.61	9.21	8.92	7.01	2.06	12.92	15.91	7.02
dec-june	2.99	9.92	9.82	6.55	2.05	14.52	14.78	4.95
dec-may	4.23	17.41	18.11	8.19	2.15	19.58	11.04	4.92
dec-apr	6.39	21.35	25.19	8.30	2.44	13.25	12.00	7.63
dec-mar	2.39	3.18	4.99	9.93	6.51	35.53	11.54	11.12
nov-july	1.73	2.15	3.58	2.65	3.13	2.67	1.30	1.31
nov-june	3.02	8.93	9.61	6.16	2.47	18.92	19.92	7.68
nov-may	4.13	14.14	16.91	7.59	2.62	28.85	17.34	7.96
nov-apr	5.91	17.53	22.63	7.72	3.00	17.97	17.60	10.73
nov-mar	2.47	3.08	4.99	8.85	7.67	44.25	16.87	16.58
oct-july	3.16	6.30	7.20	5.28	2.81	18.23	31.63	14.98
oct-june	3.63	6.83	7.95	4.91	2.85	20.09	30.32	11.10
oct-may	4.95	9.06	11.49	5.97	3.06	28.12	23.30	11.96
oct-apr	7.36	11.36	16.16	6.17	3.45	17.97	22.69	16.49
oct-mar	3.10	2.57	4.14	6.83	8.28	33.96	19.30	20.54
sep-july	3.00	4.97	6.38	4.44	3.18	16.66	81.73	36.71
sep-june	3.32	5.35	7.02	4.21	3.24	18.26	82.60	29.70
sep-may	4.46	7.18	9.27	4.63	3.51	22.56	73.13	34.38
sep-apr	6.09	8.59	12.46	4.76	4.01	16.11	59.30	40.07
sep-mar	2.92	2.37	3.87	5.01	8.65	25.51	44.82	48.49

Table G-13. Return periods for monthly intervals highly correlated to Chesapeake Bay DO criteria exceedances using LOWESS polynomial regression de-trended flow data

Interval	1992–1994	1993–1995	1994–1996	1996–1998
September–June	5.35	7.02	4.21	18.26
November–June	8.93	9.61	6.16	18.92
December–June	9.92	9.82	6.55	14.52
September–July	4.97	6.38	4.44	16.66
December–July	9.21	8.92	7.01	12.92

Summary of Analyses

No strict guidance exists on determining the critical period; however, the general approach is to determine the critical period for TMDLs on the basis of data availability, capturing the worst conditions in the period of record, capturing a range of flows, or 7Q10 flow. The availability of many decades of flow and water quality monitoring data in the Chesapeake Bay watershed allowed the opportunity to select a critical period from a group of candidate periods, so there is some freedom to follow a very rational approach to the selection of the period. It is EPA's best professional judgment that a 10-year return period captures a good balance between guarding against extreme events and ensuring attainment during more frequent critical events.

The analyses presented here take into account two methods of calculating probability, two methods of giving weight to more effective basins, two periods to calculate long-term probability, and two de-trending methods. All methods are more or less relevant and are considered as a group to determine the critical period most indicative of a 10-year return period. Of the candidate periods, 1996–1998 and 1993–1995 are closest to the 10-year return period. Table G-14 below summarizes the results from the two candidate periods.

Table G-14. Summary of results for 1993–1995 and 1996–1998 periods

	All tributaries (1978–2009)		Potomac + Susquehanna (1930–2009)		
	Without multiplier	With multiplier	With multiplier	With multiplier	With multiplier
	No de-trending	No de-trending	No De-trending	De-trended (Linear regression)	De-trended (LOWESS)
Year	1993–1995				
Median (High r^2)	7.53	7.48	7.27	6.34	8.92
Mean (High r^2)	6.84	6.99	7.39	5.97	8.35
Median (All monthly spans)			9.31	6.62	9.07
Mean (All monthly spans)			11.28	8.05	11.26
Overall range 1993–1995	**5.97–11.28**				
Year	1996-1998				
Median (High r^2)	18.95	16.02	17.56	11.3	16.66
Mean (High r^2)	18.82	14.87	15.24	11.78	16.26
Median (All monthly spans)			19.26	14.35	18.26
Mean (All monthly spans)			21.63	15.57	21.05
Overall range 1996–1998	**11.30–21.63**				

Using the above table to compare 1993–1995 and 1996–1998, it is clear that in all methods of determining the return period, the 1996–1998 period has a return period of greater than 10 years. The period 1993–1995 is generally evaluated to be slightly below a 10-year return period, but the overall range incorporates the 10-year period. The Water Quality Goal Implementation Team selected 1993–1995 as the most appropriate critical period for assessment of the jurisdictions' DO water quality standards because it was the most consistent with existing Chesapeake Bay watershed jurisdictions' practices.

Critical Period for Water Clarity/SAV Standards Assessment

SAV responds negatively to the same suite of environmental factors that result in low to no DO conditions—high-flow periods yielding elevated loads of nitrogen, phosphorus, and sediments (Dennison et al. 1993; Kemp 2004). High levels of nitrogen and phosphorus within the estuarine water column results in high level of algae, which block sunlight from reaching the SAV leaves. The same high concentrations of nitrogen and phosphorus also fuel the growth of epiphytes or microscopic plants on the surface of the SAV leaves, also directly blocking sunlight. Sediment in the form of total suspended solids further reduces that amount of sunlight reaching the SAV leaves. Therefore, the critical period of 1993–1995 that was selected for assessing the jurisdictions' DO water quality standards was also selected as the same critical period for assessing the water clarity/SAV water quality standards.

Critical Period for Chlorophyll a Standards Assessment

Algae, measured as chlorophyll *a*, responds to a multitude of different environmental factors, parameters, and conditions including the following:

- Nitrogen and phosphorus loads
- Water column temperature

- pH conditions
- Local nutrient conditions (e.g., fluxes of nutrients from the bottom sediments)
- River flow influences on dilution of existing algae populations
- River flow, bathymetry, and other factors influencing residence time
- Local weather conditions (e.g., wind, percentage of sunlight)
- Other conditions and parameters not well understood in the current state of the science

Some of those same factors influence DO conditions, while others are unique to algae. As documented below, by applying the same methodology used to determine the critical period for DO (and water clarity/SAV) water quality standards assessment, a specific 3-year critical period appropriate for assessing the chlorophyll *a* water quality standards was not supported by the analyses.

Using the same methodology as was used to determine the DO critical period for the entire Chesapeake Bay, a flow analysis was conducted to support the selection of a critical period for the James River on the basis of the correlation between flow and chlorophyll *a* violations.

Flow from USGS Gage 02037500 – James River near Richmond, Virginia, was analyzed for the period 1935–2009. De-trending was unnecessary because no trend was detected from the flow time series. The average annual flows and running 3-year average flows were calculated for the James River. The 3-year averages were used to determine the corresponding exceedance probabilities and return period for the flows. The exceedance probability was determined using both the Weibull Plotting Position and the Log Pearson III Method. The return period is defined as the inverse of the exceedance probability. Table G-15 summarizes the flow and return period using both the Weibull Plotting Position and Log Pearson III Method. Although the analysis includes all years between 1935 and 2009, only the years 1985 through 2006 are shown below, because those are the years with available data on water quality criteria violations.

To determine whether a correlation exists between 3-year mean annual flows and the percent violations for chlorophyll *a*, two methods were used: the R-squared value and Kendall's Tau. Chlorophyll *a* violations were tested for both the spring and summer by individual segments and for the James River as a whole for the years 1985–2006. Table G-16 summarizes the results of the analyses. Generally, a strong correlation does not exist between the percent chlorophyll *a* violations and the 3-year average flow. The two exceptions were JMSTFL – Spring and JMSTFU – Summer, which had statistically significant correlations but were shown to have an inverse relationship between flow and chlorophyll *a* violations. Because the James River did not exhibit a correlation between high flow and chlorophyll *a* violations, a critical period was not selected on the basis of those factors..

Within the selected 1991-2000 hydrologic period, the return periods for the three year assessment periods were generally four years or less for the James River, well below the 10-year return frequency selected by the Water Quality Goal Implementation Team (Table G-15). The exceptions were 1994-1996 with about an 8 year return period and 1996-1998 with a 15 year return period. These return periods were derived using both the the Weibull Plotting Position and the Log Pearson III Method. This evaluation of return periods also did not support selection of a critical period for the James River.

Table G-15. James River 3-year flow averages and return period

Assessment Period	James River flow (cfs)	Flow rank	Weibull return period (yr)	Log Pearson III return period (yr)
1985-1987	7,057	36	2.08	2.37
1986-1988	5,780	53	1.42	1.36
1987-1989	7,386	28	2.68	2.88
1988-1990	7,073	35	2.14	2.39
1989-1991	8,018	19	3.95	4.36
1990-1992	7,270	30	2.50	2.67
1991-1993	7,502	25	3.00	3.08
1992-1994	8,011	21	3.57	4.34
1993-1995	8,012	20	3.75	4.34
1994-1996	8,836	10	7.50	8.24
1995-1997	8,225	17	4.41	4.93
1996-1998	9,526	5	15.00	14.56
1997-1999	7,211	31	2.42	2.57
1998-2000	6,645	41	1.83	1.92
1999-2001	4,240	72	1.04	1.03
2000-2002	3,975	74	1.01	1.02
2001-2003	7,277	29	2.59	2.69
2002-2004	9,235	7	10.71	10.99
2003-2005	10,320	3	25.00	30.50
2004-2006	7,701	22	3.41	3.48

Because a specific 3-year critical period appropriate for assessment of the chlorophyll *a* water quality standards in the tidal James River was not supported by these analyses—e.g., no critical period was selected—EPA determined the need to evaluate all eight 3-year periods in the 1991–2000 hydrologic period to assess attainment of the chlorophyll *a* water quality standards in the tidal James River.

Table G-16. Correlation analyses for flow and chlorophyll *a* violations

Segment	p-value	Kendall Tau	Level of significance	R^2
Spring-Whole James	0.4180	– 0.14	> 0.01	0.008
Summer-Whole James	0.4966	– 0.12	> 0.01	0.061
Spring-JMSMH	0.7188	0.06	> 0.01	0.029
Spring-JMSOH	0.0250	– 0.37	>0.01	0.274
Spring-JMSPH	0.9204	0.02	>0.01	0.084
Spring-JMSTFL	**0.0058**	**– 0.45**	**<0.01**	**0.519**
Spring-JMSTFU	0.1616	– 0.23	>0.01	0.117
Summer-JMSMH	0.6242	0.08	>0.01	0.027
Summer-JMSOH	0.5824	0.09	>0.01	0.004
Summer-JMSPH	0.6242	0.08	>0.01	0.015
Summer-JMSTFL	0.0644	– 0.31	>0.01	0.219
Summer-JMSTFU	**0.0001**	**– 0.63**	**<0.01**	**0.519**

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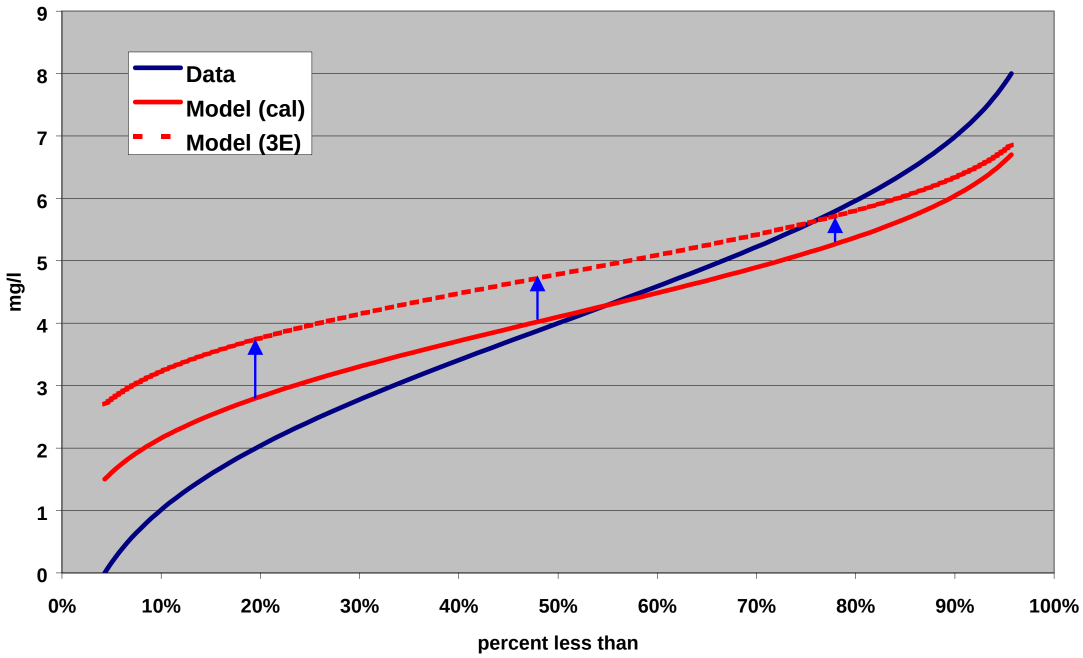
Appendix H.
Criteria Assessment Procedures using Model Scenario Output with Bay Monitoring Data

Scenarios representing different nutrient and sediment loading conditions were run using the Chesapeake Bay Phase 5.3 Watershed Model (Bay Watershed Model) and the resultant model scenario output was used as input into the Chesapeake Bay Water Quality and Sediment Transport Model (Bay Water Quality Model) to evaluate the response of critical water quality parameters, specifically dissolved oxygen, water clarity, underwater bay grasses, and chlorophyll *a*. To determine whether the loading scenarios met the applicable Bay jurisdictions' Chesapeake Bay water quality standards, the Bay Water Quality Model's simulated water quality response for each variable was used to increase/decrease the corresponding observed monitoring values collected during the same 1991–2000 hydrological period. In other words, the Bay Water Quality model was used to estimate the change in Bay water quality that would result from various loading scenarios. The model-simulated change in water quality was then used to adjust the actual Chesapeake Bay water quality monitoring data. Figure H-1 provides an example of the relationship between the calibration (cal) and scenario (E3) Bay Water Quality Model outputs described above, as well as their relationship to hypothetical monitoring observations (Data) over the same 10-year period.



Source: Linker et al. 2002

Figure H-1. Frequency distribution of hypothetical observed data (blue), model calibration (solid red) and model scenario (dashed) for a designated use.

In the simplest terms, the following steps were taken to apply the Bay Water Quality Model outputs to predict Bay water quality:

1. Calibrate the Bay Water Quality Model to actual monitoring data.
2. Run a Bay Water Quality Model simulation for a given *loading scenario* (usually a management scenario resulting in lower loads relative to the calibration scenario) through the Bay Watershed and Bay Water Quality models.
3. Determine the simulated change in water quality from the calibration scenario to the given loading scenario.
4. Apply the change in water quality as predicted by the Bay Water Quality Model to the actual historical water quality monitoring data, and evaluate attainment based on this *scenario modified* data set.

In following those steps, the scenario assessment process uses both model simulated outputs and observed water quality monitoring data.

For a more detailed description of the model calibration process (Step 1 above), and the process of constructing management scenarios to simulate reduced loads to the Bay Water Quality Model (step 2 above), see Sections 5 and 6, respectively. More detailed descriptions of Steps 3 and 4 are summarized below.

To determine the expected effect of reduced pollutant loads on a water quality parameter such as dissolved oxygen or chlorophyll *a* (Step 3 above), the simulated parameter concentrations from the Bay Water Quality Model's calibration scenario are compared to the parameter concentrations from a given load reduction scenario. This is accomplished by relating each month's worth of values from the calibration scenario for a given location to the same month's worth of values from the load reduction scenario at the same location. The resulting *linear regression* equation represents the degree of change (in dissolved oxygen or chlorophyll *a* concentration) from the calibration scenario to the load reduction scenario. In Figure H-2, a dissolved oxygen concentration of 2 milligrams per liter (mg/L) (x axis) in the calibration scenario becomes 3.6 mg/L (y axis) in the load reduction scenario.

Regressions are generated for all Bay Water Quality Model cells that match up with the long-term Chesapeake Bay mainstem and tidal tributary water quality monitoring stations and vertical sampling locations through the water column. The regressions are generated using all Bay Water Quality Model simulated values (hourly for dissolved oxygen; daily for chlorophyll *a*) for the month when the historical monitoring observation occurred. The result is a unique linear regression equation for each monitoring location and month (Figure H-3).

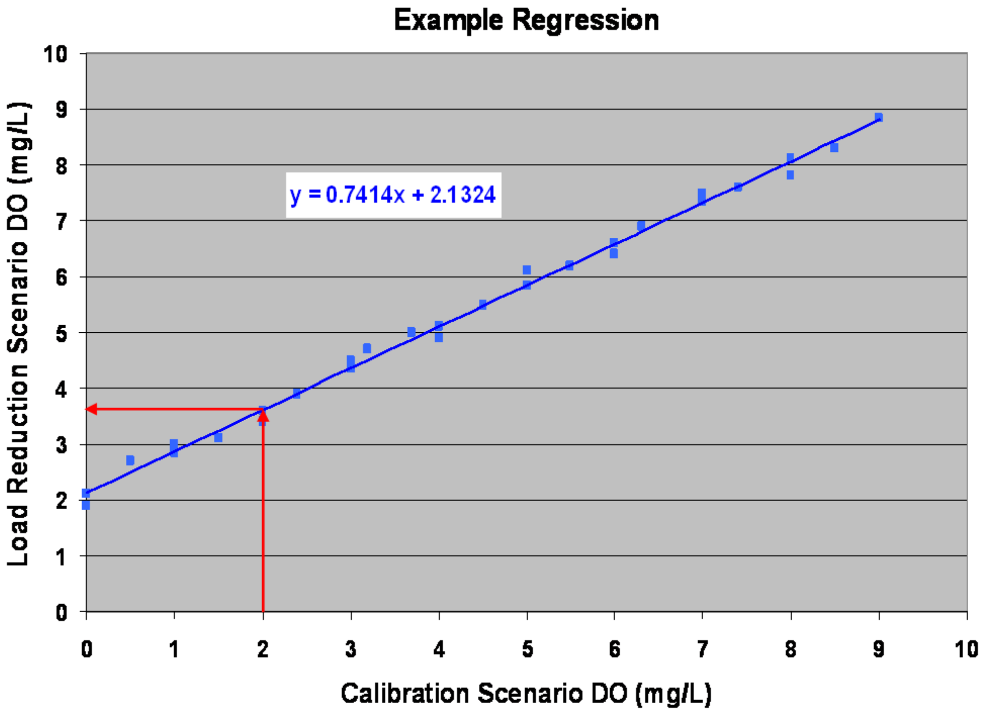


Figure H-2. Hypothetical example of a linear regression between model calibration (x axis) and scenario (y axis) data.

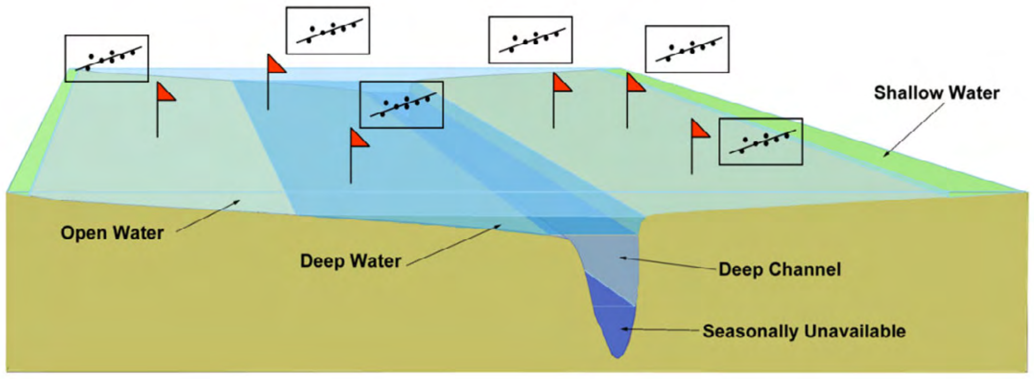
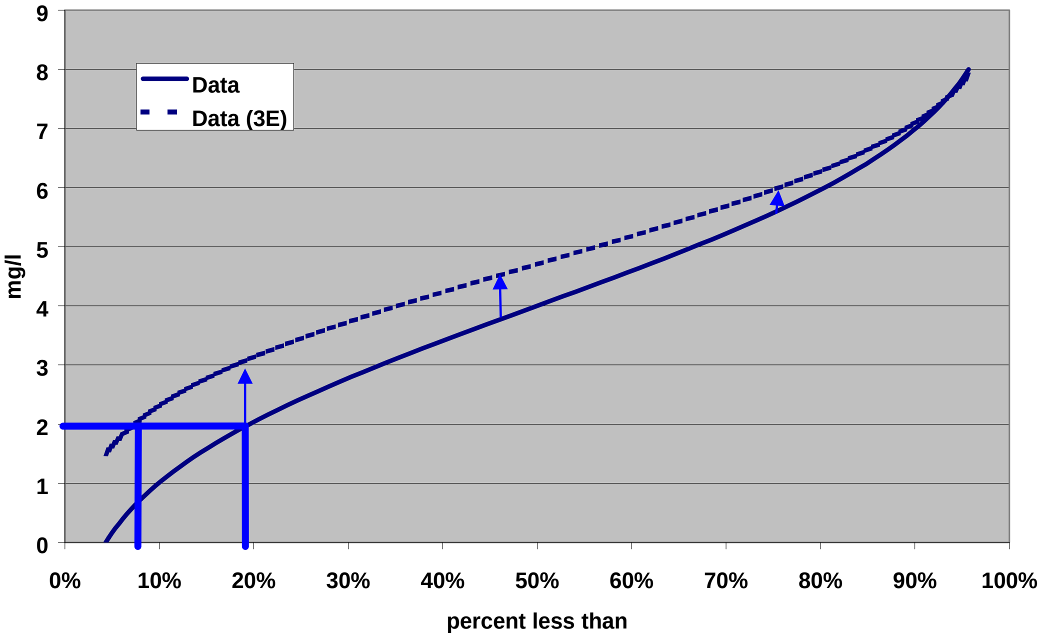


Figure H-3. Individual regression equation generated for each monitoring station location and month.

Once the relationship between the calibration and a given loading scenario is established, that relationship is used to generate a *scenario-modified* value for each observation in the historical monitoring data set spanning 1991–2000 (step 4 above). Those scenario-modified values represent an estimate of the concentration that would have been observed under the conditions of nutrient and sediment management represented by the scenario. In that manner, each observed concentration for dissolved oxygen or chlorophyll *a* in the 1991–2000 data set is replaced with a scenario-modified' concentration for the same sampling location and date.

Figure H-4 illustrates the modification of hypothetical historical monitoring data using a regression generated with the described procedure. The result is shown on a frequency plot so that changes in the prediction of attainment can be seen. The perpendicular blue lines in the lower-left portion of the graph illustrate the predicted change in dissolved oxygen from the hypothetical historical monitoring data (solid line) to the E3 scenario (dashed line). In this case, the incidence of dissolved oxygen concentrations less than 2.0 mg/L is predicted to decrease from 20 percent to 10 percent.

For a full discussion of this procedure, see *A Comparison of Chesapeake Bay Estuary Model Calibration With 1985-1994 Observed Data and Method of Application to Water Quality Criteria* (Linker et al. 2002).



Source: Linker et al. 2002

Figure H-4. Frequency distribution of hypothetical summer DO concentrations, as observed (solid blue line) and as simulated using a regression equation generated from water quality model scenarios.

Reference

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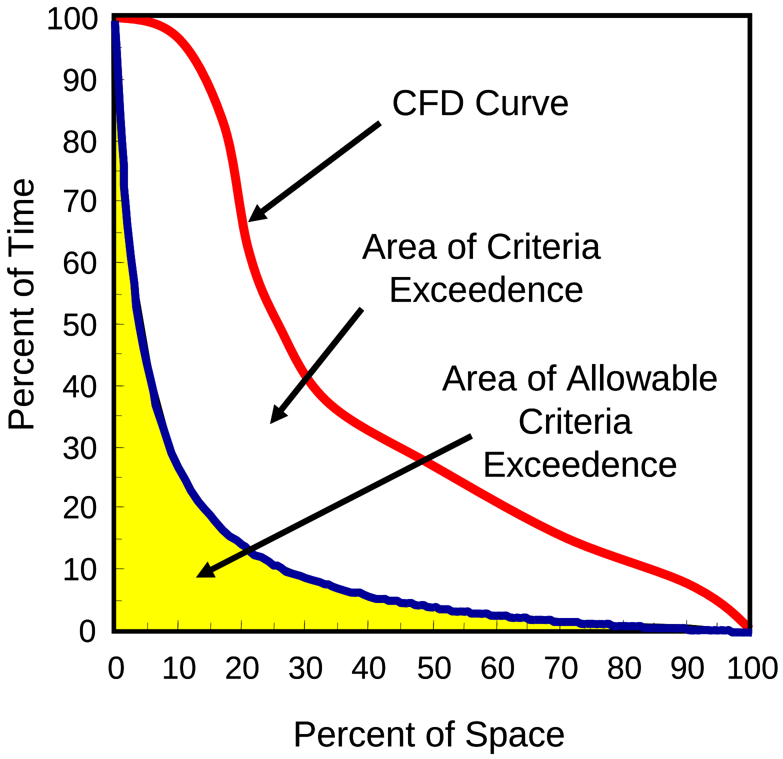
Appendix I.
Documentation of the Reduced Sensitivity to Load Reductions at Low Nonattainment Percentages

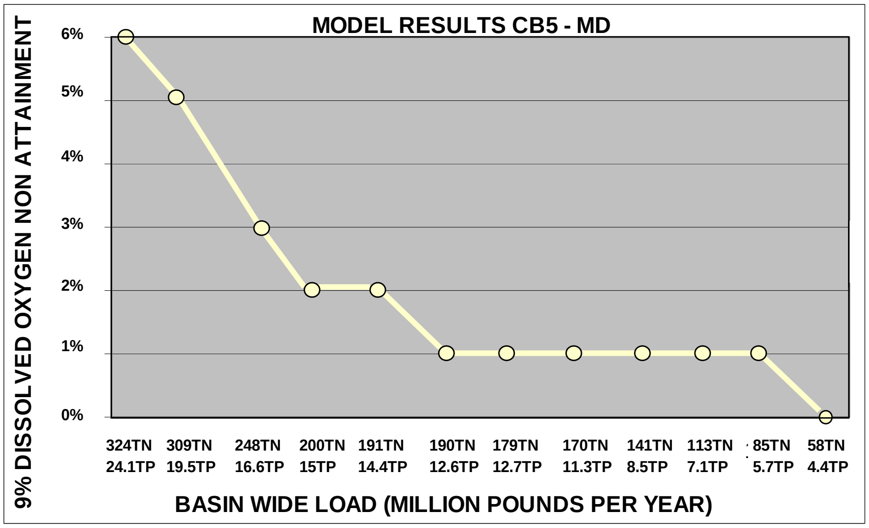
The Chesapeake Bay water quality criteria adopted by the four Bay jurisdictions into their respective water quality standards (WQS) regulations provide for allowable exceedances of each set of dissolved oxygen (DO), water clarity and chlorophyll a criteria defined through application of a biological or default reference curve (USEPA 2003). Figure I-1 depicts this concept in yellow as allowable exceedance of the criterion concentration. To compare the Chesapeake Bay Water Quality Model results with the Bay jurisdictions WQS, the model results for each scenario and for each modeled segment are analyzed to determine the percent of time and space that the modeled DO results exceed the allowable concentration. For any modeled result where the exceedance in space and time (shown in Figure I-1 as the red line) exceeds the allowable exceedance (shown in Figure I-1 as the yellow area), that segment is considered in nonattainment. That amount of nonattainment is shown in the figure as the area in white between the red line and the yellow area and is typically displayed in model results as percent of nonattainment for that segment. The amount of nonattainment is reported to the whole number percent. The yellow area below the blue reference curve reflects the amount of *allowable* criteria exceedance. The area between the blue reference curve and the red cumulative frequency distribution (CFD) curve is the amount of *unallowable* criteria exceedance, defined here as the *red area*.



Source: USEPA 2003

Figure I-1. Illustration of the application of a reference curve to the cumulative frequency distribution curve to assess Chesapeake Bay water quality criteria attainment.

Figure I-2 below displays Chesapeake Bay Water Quality Model results showing percent nonattainment of the 30-day mean open-water DO criterion of the Maryland portion of the lower central Chesapeake Bay segment CB5MH_MD for various basinwide nitrogen and phosphorus loading levels.



Source: Appendix M

Figure I-2. Example of DO criteria nonattainment results from a wide range of total nitrogen (TN) and total phosphorus (TP) loading Chesapeake Bay Water Quality Model scenarios.

As can be seen in Figure I-2, there is a notable improvement in the percent DO criterion nonattainment as the loads are reduced until approximately 1 percent nonattainment. At and below a basinwide loading level of 190 million pounds per year total nitrogen (TN) and 12.7 million pounds per year total phosphorus (TP), the 1 percent nonattainment is persistent through consecutive reductions in loading levels and remains consistent until a loading level of 58 million pounds per year TN and 4.4 million pounds per year of TP is reached. While this is one of the more extreme examples of persistent levels of 1 percent nonattainment over a wider range of reduced nitrogen and phosphorus loads, this general observation of persistent nonattainment at 1 percent is fairly common to the Bay Water Quality Model DO results as described and documented below.

Clear evidence of small, yet persistent percentage of model projected DO criteria nonattainment over a wide range of reduced nitrogen and phosphorus loads across a wide range of segments and designated uses, all of which are responding to nitrogen and phosphorus load reductions, is documented within this appendix. Given that this has been observed in a wide variety of different segments across all three designated uses—open-water, deep-water, and deep-channel—nonattainment percentages projected by the Bay Water Quality Model rounded to 1 percent were considered to be in attainment for a segment's designated use for purposes of developing the Chesapeake Bay TMDL.

A separate validation of the findings described above was undertaken to confirm that 1 percent was the correct percentage below which the designated use-segment could be considered in attainment and is provided in this appendix.

Reporting of Criteria Nonattainment Percentages

Chesapeake Bay modeling results for DO, chlorophyll *a*, and water clarity criteria nonattainment percentages are rounded to whole numbers. This is a common scientific practice and principle for conveying data to the public and is fully consistent with how many others report modeling output.

Documenting Attainment for 1 Percent Nonattainment Criteria Values

The Chesapeake Bay water quality criteria adopted by Maryland, Virginia, Delaware, and the District of Columbia into their respective WQS regulations already provides for *allowable* exceedances of each set of DO, water clarity and chlorophyll *a* criteria defined through application of a biological or default reference curve (USEPA 2003). What is being addressed here is how to address 1 percent nonattainment DO, water clarity, and chlorophyll *a* criteria values assessed using the CFD-based criteria assessment procedures in the face of clear evidence: (1) for persistence over large simulated load reductions across numerous segments and designated uses; and (2) reduced sensitivity to load reductions at and below the 1 percent nonattainment level.

Evaluation of Residual 1.499 Percent or Less DO Criteria Nonattainment Values

There is clear evidence for a *residual* of 1 percent DO criteria nonattainment across a large span of model-simulated load reductions across a number of tidal Bay segments and designated uses (Table I-1). Within the Bay TMDL document and supporting appendices, the reported criteria attainment values already account for the allowable exceedances documented in each Bay jurisdiction’s respective Chesapeake Bay WQS regulations. These reported criteria attainment values also account for any restoration variances adopted by the Bay jurisdictions into their WQS regulations. All the values that are colored green denote full attainment of the respective criteria, DO in this case.

For illustration purposes only, as observed in the DO *stoplight plot* spreadsheet dated May 24, 2010, shared with members of the Chesapeake Bay Program’s Water Quality Goal Implementation Team, 21 designated use-segments have the recorded model scenario-transformed monitoring data nonattainment values between 0.0 percent and 1.5 percent across a range of model scenarios. (Note that all the values reported in Table I-1 would round to 0 percent or 1 percent.) Those model scenarios had loading levels that spanned 9 to 151 million pounds of nitrogen and comparable ranges of phosphorus loading levels (Table I-1).

Table I-1. The range of DO criteria nonattainment percentages across different model simulated nitrogen load ranges for 21 Chesapeake Bay segments-designated uses

Chesapeake Bay segment	Designated use	Criteria nonattainment range[a] (%)	Model simulated nitrogen load range (million pounds/yr)
CB7	Open-water	0.5-0.0	200-141
CHOMH1	Open-water	0.1-0.0	254-179
CSHMH	Open-water	0.8-0.1	342-309
DCATF	Open-water	1.2-0.1	191-179
PAXTF	Open-water	1.0-0.6	190-179
DCPTF	Open-water	0.6-0.2	309-254
MAGMH	Open-water	1.3-0.3	342-191
MOBPH	Open-water	1.0-0.0	342-200
PIAMH	Open-water	0.1-0.1	191-179
TANMH	Open-water	1.5-0.1	342-309
YRKMH	Open-water	1.0-0.4	191-170
CB3MH	Deep-water	0.6-0.0	254-179
CB5MH	Deep-water	1.5-0.0	254-141
CHSMH	Deep-water	0.5-0.4	170-141
EASMH	Deep-water	0.8-0.2	200-170
MD5MH	Deep-water	1.5-0.1	191-141
MAGMH	Deep-water	0.5-0.5	170-141
PATMH	Deep-water	1.1-0.1	200-190
VA5MH	Deep-water	0.7-0.0	254-179
CB3MH	Deep-channel	0.2-0.1	200-190
EASMH	Deep-channel	1.3-0.0	190-170

Source: The DO criteria attainment detailed stoplight spreadsheet dated May 24, 2010 presented to the Chesapeake Bay Program's Water Quality Goal Implementation Team during the Team's May 24, 2010, conference call.
Note:
a. Each 0.0% value in this column is colored in red in the original May 24, 2010 stoplight plot spreadsheet, denoting a very low percentage of nonattainment was recorded below 0.1%.

Small, yet persistent percentage of DO criteria nonattainment are observed across a wide range of segments and designated uses, all of which are responding to nutrient load reductions. There is not comparable evidence of persistent percentages of DO criteria nonattainment above 1 percent across a wide range of segments and designated uses for segments responding to nutrient load reductions. Several open-water segments exist where the same percentage nonattainment persists across a wide set of nutrient loading reductions—e.g., Gunpowder River (GUNOH) at 5 percent from 342 TN to 85 TN, Wicomico River (WICMH) at 5 percent from 191 TN to 85 TN, several segments in Pocomoke River at 5 percent from 179 TN to 85 TN (see Appendix M). However, all those segments have been identified as having poor local responses to load reductions in the Bay Water Quality Model scenarios on the basis of poor linear regressions. Other lines of evidence, separate from the model-generated outputs were used to determine attainment and develop the respective Bay segment TMDL (see Appendix N). The cause for the persistent percentages (poor linear regressions) is different from the small, yet persistent percentages (reduced sensitivity when approaching water quality criteria attainment) being addressed in this appendix.

Analysis of DO Criteria Attainment Sensitivity to Simulated Load Reductions

A separate validation of the findings described above was undertaken to confirm that 1 percent was the correct percentage below which the designated use-segment could be considered in attainment. This analysis involves plotting the change in unallowable DO criterion exceedance or *red area* under the reference curve (see Figure I-1) per loading unit against the starting red area. The change in red area between two scenarios is divided by the change in load. For this analysis, the changes in nitrogen (N) and phosphorus (P) loads are combined into a single measure, load units, enabling the calculation of change in red area per change in load:

$$\text{load units} = (N + 10 \times P) / 2) \qquad \text{Equation I-1}$$

This single measure, when plotted against starting red area, allows a direct comparison of sensitivity of the analysis system[1] to nitrogen and phosphorus load changes across different levels of nonattainment. To get a true sensitivity, calculations involving scenarios that attained the applicable DO criteria were not included. Twelve scenarios were used with eight 3-year periods for a total of 96 possible sensitivity assessments per designated-use segment, decreased by the number of assessments that attained the applicable DO criterion.

This analysis was not amenable to tidal tributary segments as the nitrogen and phosphorus loadings are basinwide and not specific to an individual tidal tributary. Further, some of the existing scenarios used for this analysis have varying levels of nitrogen and phosphorus load reductions between different tributaries.

The CB7PH open-water segment provides a clear example of a decrease in sensitivity to nitrogen and phosphorus load reductions as criteria nonattainment approaches zero. The highest sensitivity to load reductions is with the highest red area, but there is still considerable sensitivity to nitrogen and phosphorus load reductions through approximately 0.2 percent (Figure I-3). Another example is the CB2OH open-water segment, where a sharp drop off occurs in sensitivity to nitrogen and phosphorus load reductions near 1 percent (Figure I-4).

A counter-example is the CB5MH open-water segment, where the sensitivity to load reductions is relatively constant throughout the model-simulated range of load reductions (Figure I-5).

A large number of segments could be analyzed (see Table I-1), but it is most appropriate to focus on those designated-use segments most important to the Bay TMDL—those requiring significant basinwide nutrient reductions to come in attainment with the respective DO criterion. Those designated use-segments are CB3MH, CB4MH, and CB5MH for deep-water and deep-channel and POTMH for deep-channel.

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[1] The analysis system referred to here is the combination of the Chesapeake Bay Water Quality and Sediment Transport Model, the procedures for using differences in Bay model scenarios outputs to transform Bay water quality monitoring data, and the EPA-published Bay criteria assessment procedures.

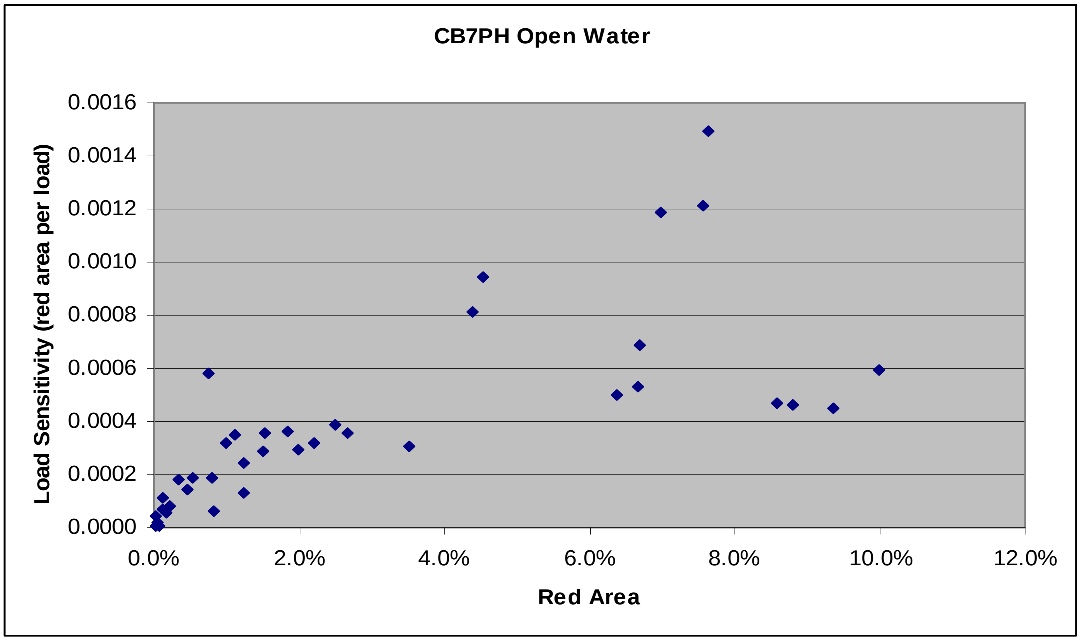


Figure I-3. Load sensitivity (unallowable DO criteria exceedances per load unit) vs. red area (unallowable DO criteria exceedances) for designated use-segment CB7PH open-water.

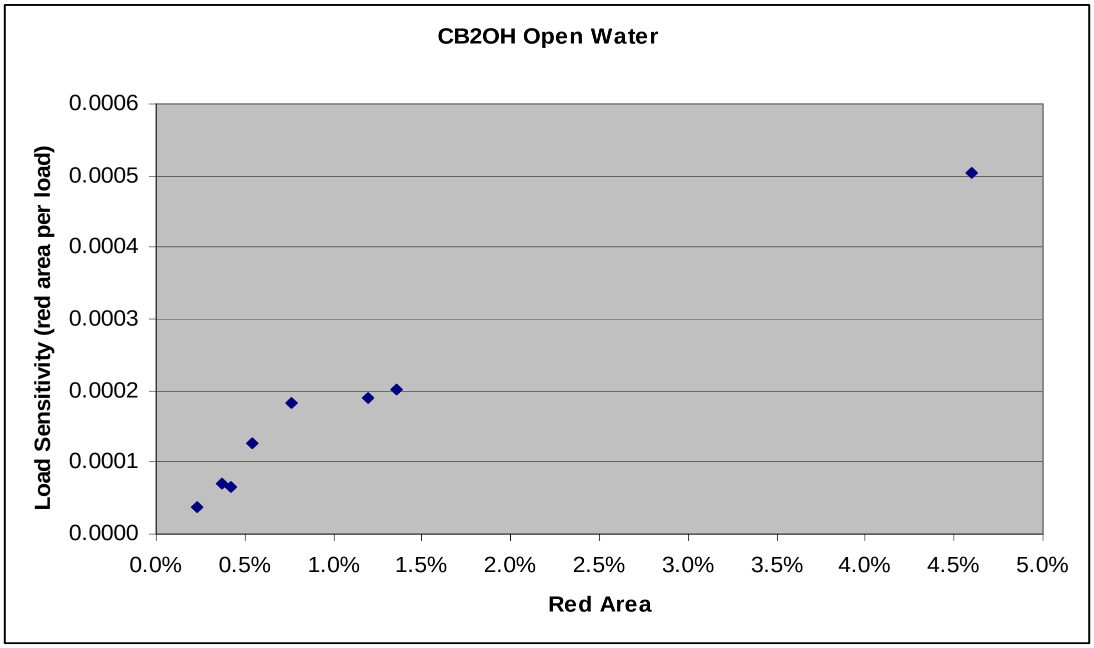


Figure I-4. Load sensitivity (unallowable DO criteria exceedances per load unit) vs. red area (unallowable DO criteria exceedances) for designated use-segment CB2OH open-water.

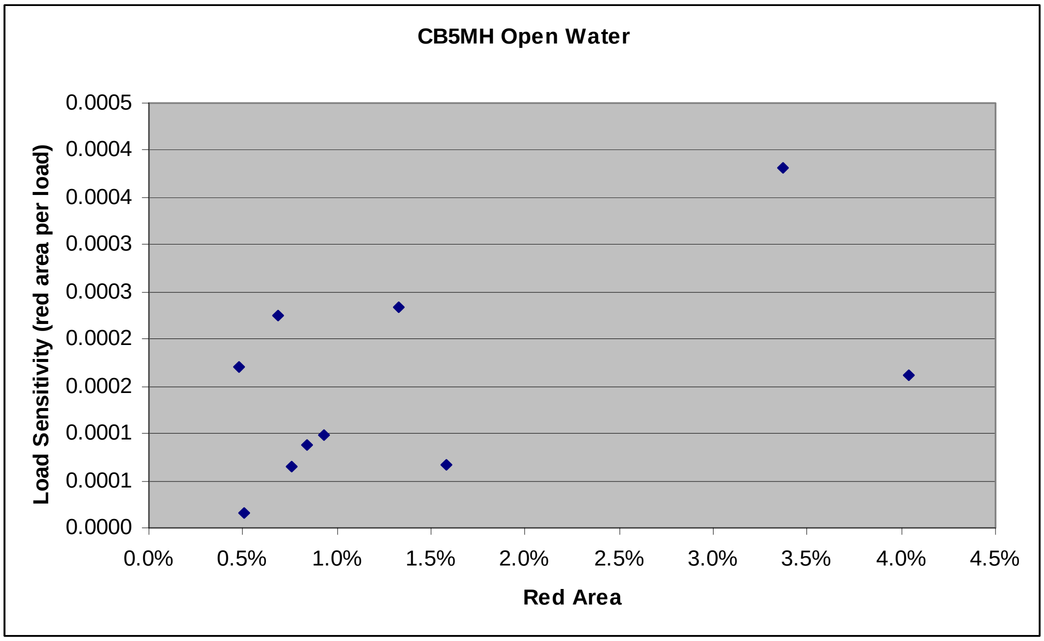


Figure I-5. Load sensitivity (unallowable DO criteria exceedances per load unit) vs. red area (unallowable DO criteria exceedances) for designated use-segment CB5MH open-water.

The CB3MH deep-water segment has consistently reducing sensitivity to nitrogen and phosphorus load reductions and no high sensitivity examples above 1 percent red area (Figure I-6). The CB4MH deep-water designated use-segment shows relatively consistent sensitivity across a wide range of red area (Figure I-7). The CB5MH deep-water designated use-segment (Figure I-8) and the POTMH deep-water designated use-segment (Figure I-9) are relatively constant across wide ranges but have a clear reduction in sensitivity to load reductions around 1 percent.

The deep-channel designated use-segment plots are similar to the deep-water designated use-segment plots. The CB3MH deep-channel designated use-segment also shows a consistent range of sensitivity throughout multiple ranges of red area but has low sensitivity to further load reductions at 1–1.5 percent red area (Figure I-10). The CB4MH deep-channel designated use-segment shows a clear drop off in sensitivity to load reductions at 1 percent (Figures I-11 and I-12). The CB5MH deep-channel designated use-segment has no basis to make the judgment because no red area values are less than 15 percent (Figure I-13).

Although there is some discretion involved in the judgment of exactly when sensitivity to further load reductions becomes low, there is a general decrease in sensitivity when the red area is low. One percent is a relatively consistent level at which sensitivity decreases significantly across many of the principal designated use-segments used for decision making in the Chesapeake Bay TMDL (Table I-2). At the nonattainment values of 1 percent (or less), there is a significant drop off in the sensitivity—further reduction in DO criteria nonattainment—of these designated use-segments to further load reductions. The analysis system is not sensitive to the effects of further load reductions at the 1 percent or less nonattainment level. This finding is fully consistent with findings from the parallel analysis summarized in Table I-1 for a wider array of designated use-segments.

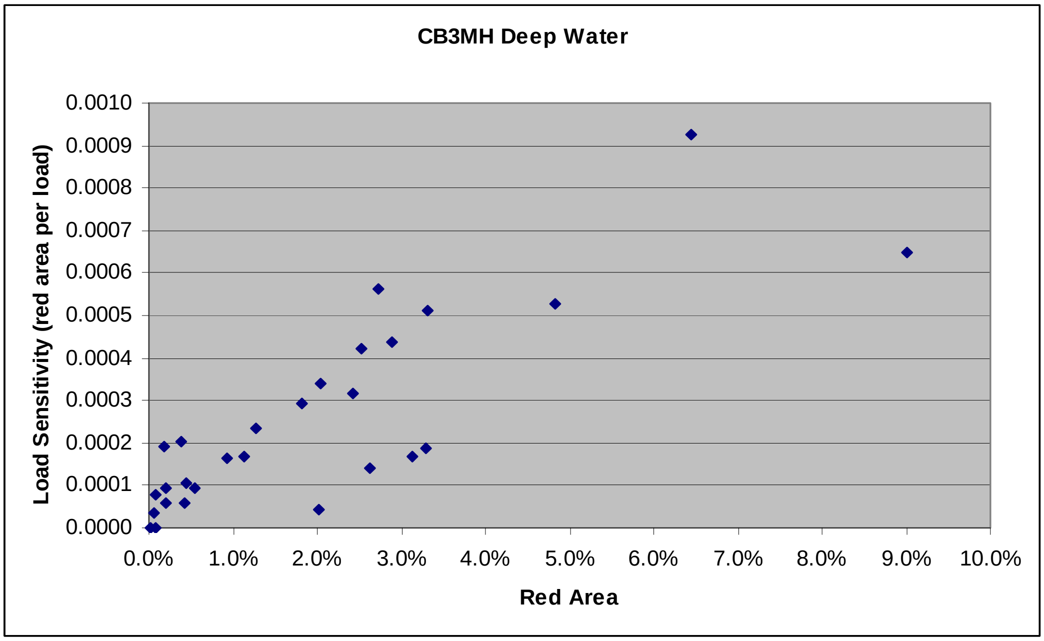


Figure I-6. Load sensitivity (unallowable DO criteria exceedances per load unit) vs. red area (unallowable DO criteria exceedances) for designated use-segment CB3MH deep-water.

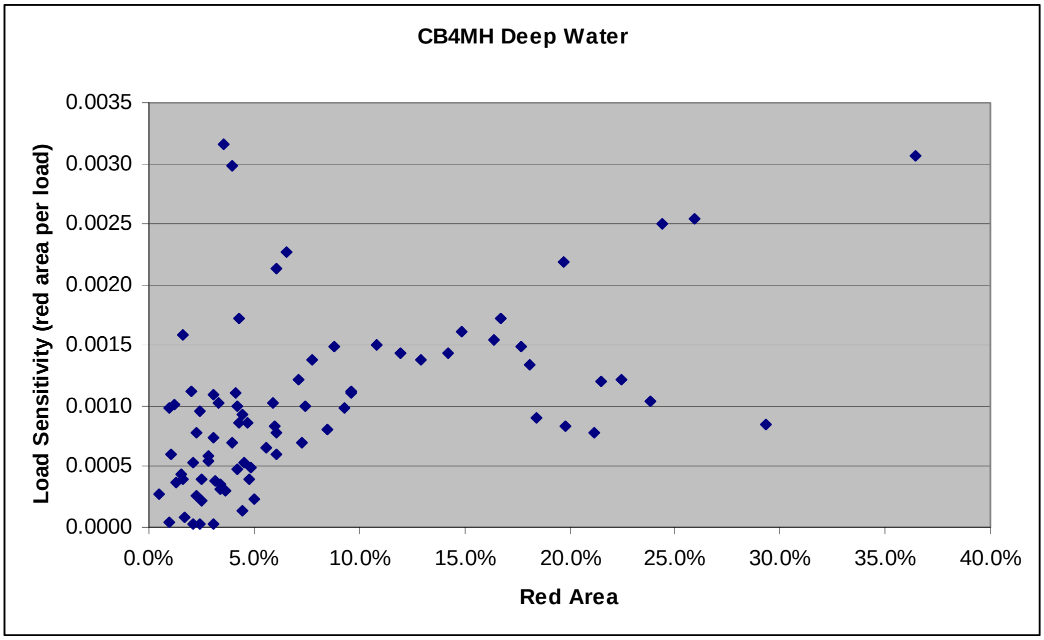


Figure I-7. Load sensitivity (unallowable DO criteria exceedances per load unit) vs. red area (unallowable DO criteria exceedances) for designated use-segment CB4MH deep-water.

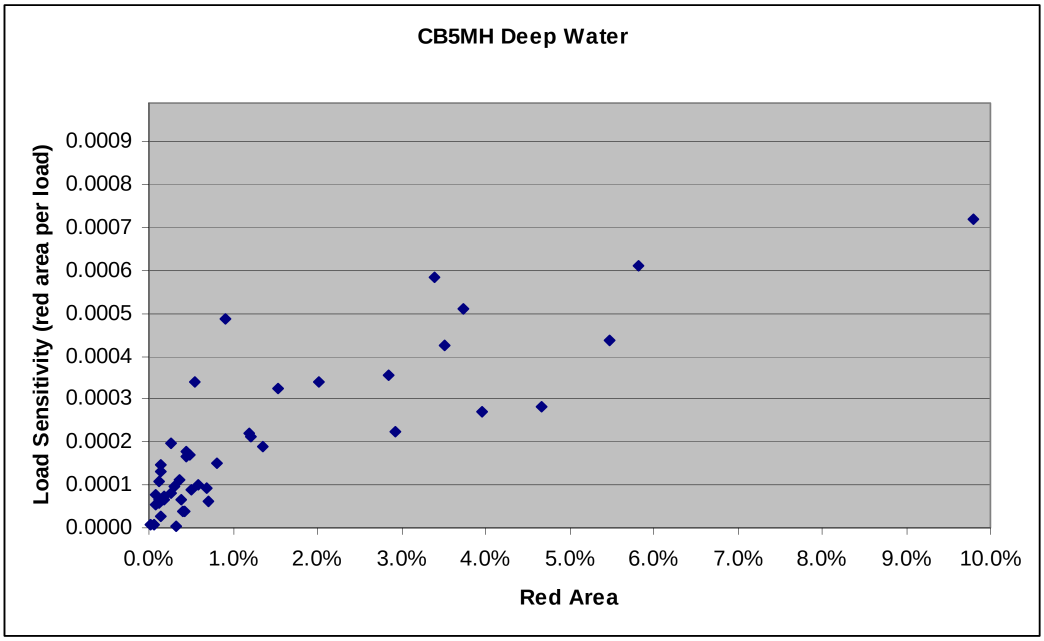


Figure I-8. Load sensitivity (unallowable DO criteria exceedances per load unit) vs. red area (unallowable DO criteria exceedances) for designated use-segment CB5MH deep-water.

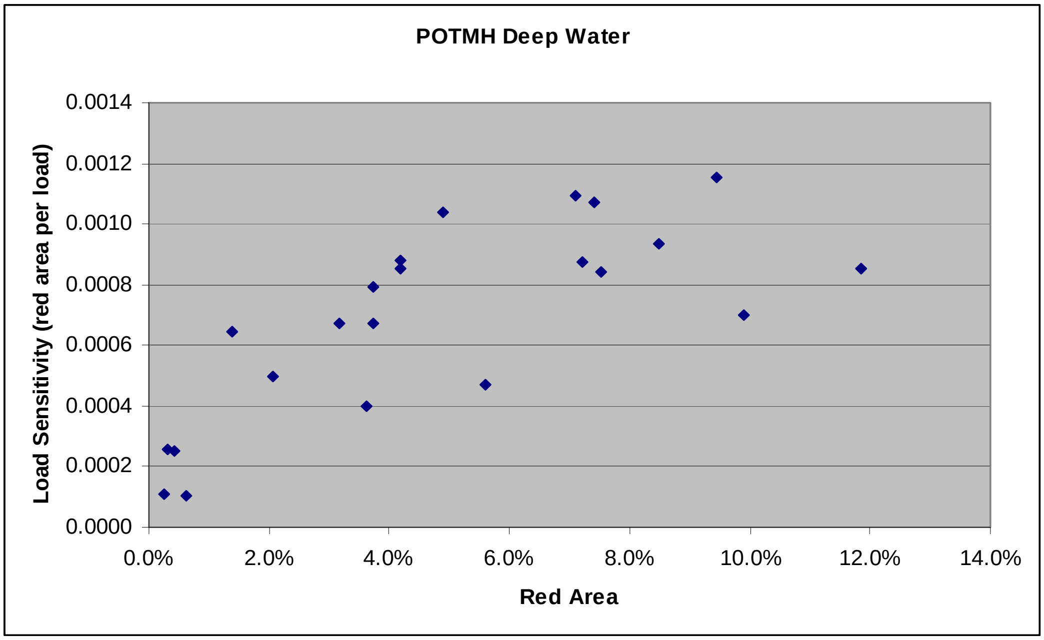


Figure I-9. Load sensitivity (unallowable DO criteria exceedances per load unit) vs. red area (unallowable DO criteria exceedances) for designated use-segment POTMH deep-water.

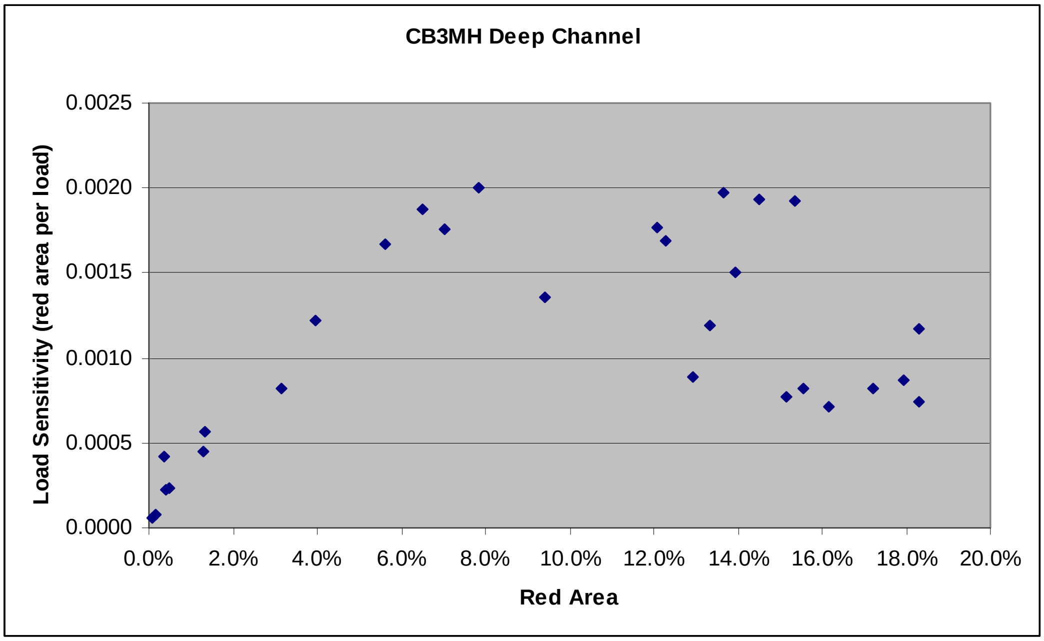


Figure I-10. Load sensitivity (unallowable DO criteria exceedances per load unit) vs. red area (unallowable DO criteria exceedances) for designated use-segment CB3MH deep-channel.

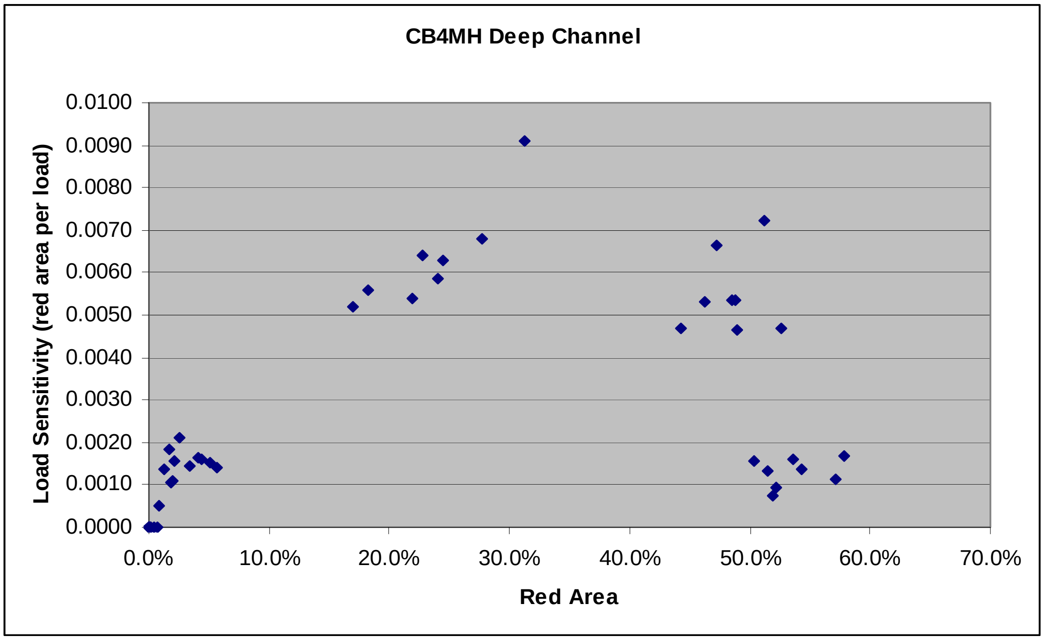


Figure I-11. Load sensitivity (unallowable DO criteria exceedances per load unit) vs. red area (unallowable DO criteria exceedances) for designated use-segment CB4MH deep-channel.

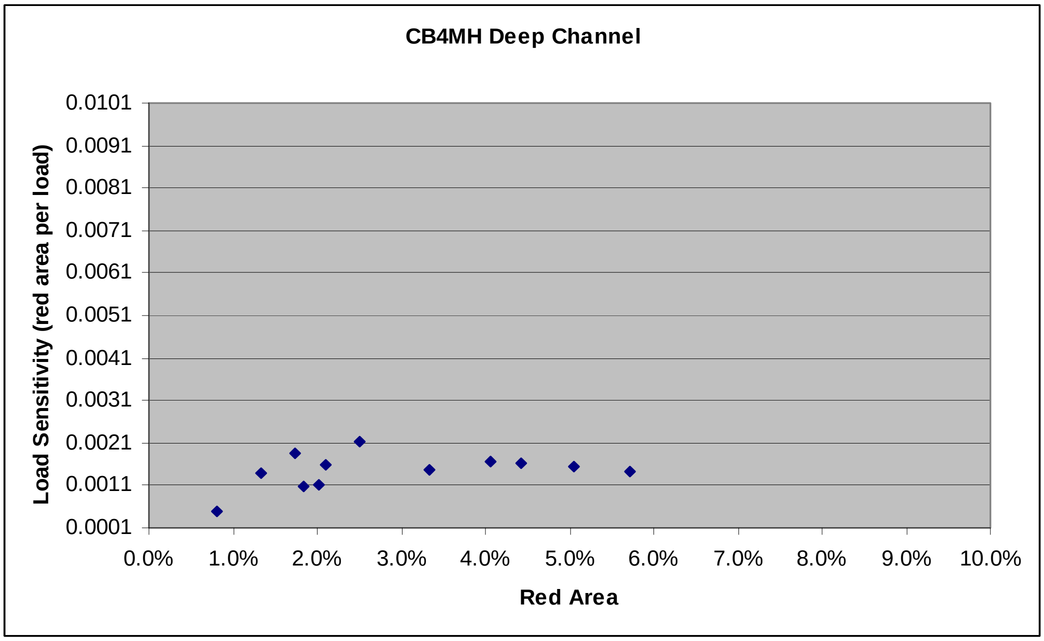


Figure I-12. Expanded view of the Figure I-11 focusing down on the 0-10% red area for segment CB4MH deep-channel to illustrate the drop off in sensitivity at the 1-1.5% of red area.

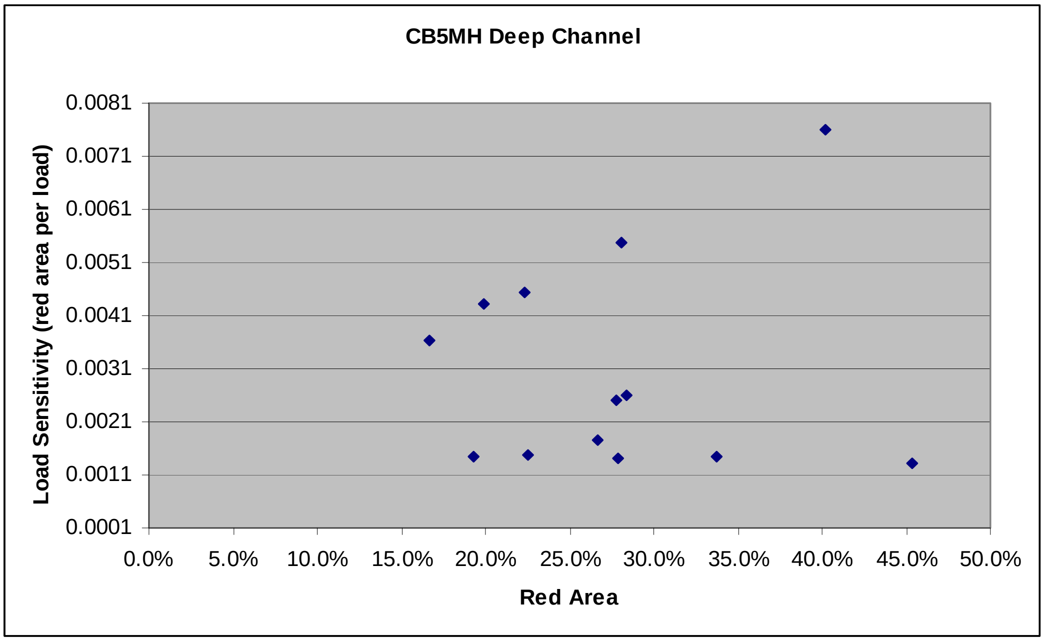


Figure I-13. Load sensitivity (unallowable DO criteria exceedances per load unit) vs. red area (unallowable DO criteria exceedances) for designated use-segment CB5MH deep-channel.

Table I-2. Summary of findings from the analysis of red area with low sensitivity to load reductions for the Chesapeake Bay designated use

Chesapeake Bay segment	Designated use	Red area with low sensitivity to load reductions (%)
CB3MH	Deep-water	0.2
CB4MH	Deep-water	0
CB5MH	Deep-water	1
POTMH	Deep-water	1
CB3MH	Deep-channel	1-1.5
CB4MH	Deep-channel	1
CB5MH	Deep-channel	N/A

Sources: Figures I-6 through I-13 in this appendix

Water Clarity Criteria

Only one segment displayed a small, yet persistent percentage of model projected water clarity/submerged aquatic vegetation (SAV) criteria nonattainment over a range of reduced nitrogen and phosphorus loads—the Appomattox River segment (APPTF) in Virginia's James River Basin. In the case of that segment, no observed SAV has been mapped since the early 1970s, but historical acreages were observed back in the 1950s. That tidal fresh segment (salinities from 0 to 0.5 ppt) was one of the very few tidal fresh segments that did not exhibit a positive response (increased water clarity, increased SAV acreage) to model simulated reductions in nitrogen, phosphorus, and sediment. For the reasons unique to this segment, EPA considered 1 percent nonattainment of the water clarity/SAV criteria in attainment for the Bay segment's shallow water bay grass designated use for purposes of developing the Bay TMDL.

Chlorophyll a Criteria

In the case of assessment of the chlorophyll *a* criteria in the tidal James River in Virginia, there was very limited evidence of a reduced sensitivity when approaching the criteria values as compared with the suite of DO criteria as described above for across multiple designated uses and segments. As illustrated in Figure I-14, there is a clear, positive response to reduced nitrogen and phosphorus loads, with a stepwise flattening of the response approaching full attainment. In developing the James River basin allocations under the Bay TMDL, the vast majority of the spring and summer season 3-year periods came into full attainment at the established nitrogen and phosphorus allocations of 23.5 million pounds of nitrogen per year and 2.35 million pounds of phosphorus per year (see Section 6.2.3 and Appendix O). EPA considered 1 percent nonattainment of the applicable segment and season-specific chlorophyll *a* criteria in attainment for only a limited number of segment/season/3-year period combinations given the evidence, though limited, of reduced sensitivity when approaching full attainment of the criteria values.

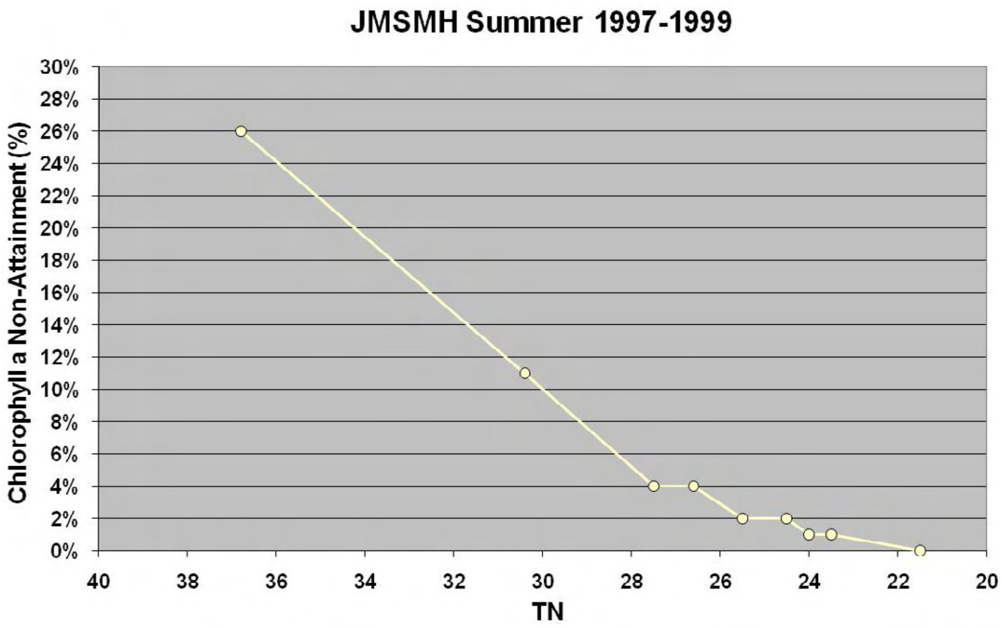


Figure I-14. Example of the middle James River segment's summer chlorophyll *a* criteria nonattainment results from a wide range of TN and TP loading Chesapeake Bay Water Quality Model scenarios.

Application in Development of the Bay TMDL

DO Criteria

Because such findings have been observed in a wide variety of different segments across all three designated uses—open-water, deep-water, and deep-channel—and confirmed through an independent analysis, DO criteria nonattainment percentages rounded to 1 percent were considered in attainment for that Bay segment's designated use for purposes of developing the Bay TMDL. For those designated use-segments for which a jurisdiction has adopted a restoration variance that sets attainment at a percentage of the non-allowable criteria exceedances, the 1 percent nonattainment described above does not apply to assessment of the restoration variance percentage. For example, Maryland's designated use-segment CB4MH deep water has a restoration variance of 7 percent. Chesapeake Bay Water Quality Model-based criteria attainment assessment results showing 8 percent nonattainment would still be considered in nonattainment.

Chlorophyll a and Water Clarity/SAV Criteria

In the case of the chlorophyll *a* criteria assessments, EPA considered nonattainment percentages rounded to 1 percent in attainment only for a select set of segment/season/3-year period combinations given the more limited evidence of reduced sensitivity when approaching full attainment of the criteria values compared with DO. Only one Bay segment had unique circumstances that supported EPA's considering water clarity/SAV criteria nonattainment percentages rounded to 1 percent to be in attainment.

References

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

Appendix J
Key Chesapeake Bay TMDL Reference and Management Modeling Scenarios: Definitions and Descriptions

1985 Scenario

The 1985 scenario uses the estimated 1985 land uses, NPS loadings, animal numbers, atmospheric deposition, and point source loads. This scenario estimates the highest loads of nitrogen, phosphorus, and sediment to the Bay in recent time (using a constant 1991-2000 hydrology). The Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus, and sediment loads for this scenario are listed in Tables J-2, J-4, and J-6, respectively.

2009 Scenario

The 2009 scenario uses the estimated 2009 land uses, NPS loadings, animal numbers, atmospheric deposition, and point source loads as well as the best management practices tracked and reported by the seven watershed jurisdictions through 2009. The 2009 year was chosen as the baseline for the TMDL, as it was the most recent year for which complete implementation data (BMPs, waster loads, etc.) was available during the Bay TMDL development process. Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus and sediment loads for this scenario are listed in Tables J-2, J-4, and J-6, respectively.

Tributary Strategy Scenario

The Tributary Strategy scenario estimates the nitrogen, phosphorus, and sediment loads through model simulations of full implementation of the seven jurisdictions’ 2004-2005 tributary strategies throughout the Chesapeake Bay watershed. This scenario included an accounting for all the tributary strategy BMPs on a 2010 land use, and the 2010 estimated permitted loads for all the significant and non-significant wastewater dischargers, as described in Table J-1. Adjustments to the jurisdictions’ tributary strategies developed in 2004 and 2005 to reflect changes in State laws or policies (e.g., permitting of significant wastewater discharge facilities) since development of the initial set of jurisdictional tributary strategies were also included in this scenario’s input decks. Atmospheric deposition inputs were from the Community Multi-scale Air Quality Model’s 12 km grid with an estimated 2010 deposition and included simulations of the State Implementation Plans to reach the 2010 Air Quality Standards. Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus, and sediment loads for this scenario are listed in Tables J-2, J-4, and J-6, respectively.

Table J-1. Wastewater discharge facilities and combined sewer overflows (CSO) assumptions for the Tributary Strategy, Everything by Everyone Everywhere (E3) and the 2010 No Action scenarios

Scenario		Tributary Strategy	E3	2010 No Action
Definition		Latest jurisdiction tributary strategy	Level of Technology Everywhere Tier 4 Level	No management action. Secondary Treatment at the same level everywhere with tributary strategy flows
Concentration	Significant Municipal Plants	Latest jurisdiction tributary strategy BOD=5 mg/l, DO=5 mg/l and TSS=5 mg/l	TN=3 and TP=0.1 BOD=3 mg/l, DO=6 mg/l and TSS=5 mg/l	TN=18 mg/l and TP =3 mg/l BOD=30 mg/l, DO=4.5 mg/l and TSS=15 mg/l
	Significant Industrial Plants	Latest jurisdiction tributary strategy BOD=5 mg/l, DO=5 mg/l and TSS=5 mg/l	TN=3 and TP=0.1 or tributary strategy level if less for industrial facilities BOD=3 mg/l, DO=6 mg/l and TSS=5 mg/l	Highest Loads on record, or tributary strategy loads if greater BOD=30 mg/l, DO=4.5 mg/l and TSS=15 mg/l
	Non-significant Municipal Plants	2006 data or more recently submitted non-significant facility data BOD=30 mg/l, DO=4.5 mg/l and TSS=25 or 45 mg/l	TN=8 mg/L and TP=2 mg/L for municipal plants Current level adjusted by the same rates used for sig industrial plants BOD =5 mg/l, DO=5 mg/l and TSS= 8 mg/l	TN=18 mg/l and TP =3 mg/l BOD=30 mg/l, DO=4.5 mg/l and TSS=15 mg/l
	Non-significant Industrial Plants	Tetra Tech estimated non-significant industrial data BOD=30 mg/l, DO=4.5 mg/l and TSS=25 or 45 mg/l	Tetra Tech estimated non-significant industrial data adjusted by the percentage of equivalent reduction from No-Action (18 mg/l TN, 3mg/l TP) to E3 (3 mg/l TN, 0.1 mg/l TP) BOD =5 mg/l, DO=5 mg/l and TSS= 8 mg/l	Tetra Tech estimated non-significant industrial data. BOD=30 mg/l, DO=4.5 mg/l and TSS=25 or 45 mg/l
Flow		Tributary strategy flows for significant facilities. 2006 data or more recently submitted data for non-significant facilities	Same as tributary strategy scenario	Same as tributary strategy scenario
CSO		Long Term Control Plan--full implementation	100% CSO overflow reduction	2003 Estimates

Notes: E3 - everyone, everything, everywhere, TN - total nitrogen, TP - total phosphorus, BOD - biological oxygen demand, DO - dissolved oxygen, TSS - total suspended solids, CSO- combined sewer overflow

1985 No Action Scenario

The No Action scenario estimates nitrogen, phosphorus, and sediment loads under the conditions of minimal to no pollution reduction controls on sources and nonpoint sources using a 1985 land use and human and agricultural animal populations. Major widespread management practices that would not already be in place such as nutrient management and conservation tillage were eliminated in this scenario. Wastewater treatment/discharging facilities were set at primary treatment with no nutrient removal and with no phosphate detergent ban. Atmospheric deposition loads were set to 1985 levels of emissions and controls. Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus and sediment loads for this scenario are listed in Tables J-2, J-4, and J-6, respectively.

The No Action scenario is used with the E3 scenario to define “controllable” loads, the difference between No Action and E3 loads. No Action and E3 scenario conditions can be determined for historic years (beginning 1985), current year, or projected future (through 2030) by changing the underlying land use, associated pollutant loadings and population estimates. All past practices, programs, and treatment upgrades that currently exist are credited toward the needed reductions from the No Action “baseline”.

1985 No Action Wastewater Treatment/Discharging Facilities

- No Action Significant municipal wastewater treatment facilities
  - Flow = Tributary Strategy flows where most are at design flows
  - Nitrogen effluent concentration = 18 mg/l TN
  - Phosphorus effluent concentration = 6 mg/l TP
  - BOD = 30 mg/l, DO = 4.5 mg/l and TSS = 15 mg/l
- No Action Significant industrial dischargers
  - Flow = Tributary Strategy flows where most are at design flows
  - Highest Loads on record or Tributary Strategy loads if greater
  - BOD = 30 mg/l, DO = 4.5 mg/l and TSS = 15 mg/l
- No Action Nonsignificant municipal wastewater treatment facilities
  - Flow = Tributary Strategy flows
  - Nitrogen effluent concentration = 18 mg/l TN
  - Phosphorus effluent concentration = 6 mg/l TP
  - BOD = 30 mg/l, DO = 4.5 mg/l and TSS = 15 mg/l

1985 No Action Combined Sewer Overflows

- Flow = current base condition flow
- Nitrogen effluent concentration = 18 mg/l TN
- Phosphorus effluent concentration = 6 mg/l TP
- BOD = 200 mg/l, DO = 4.5 mg/l and TSS = 45 mg/l.

1985 No Action On-site Waste Treatment Systems

There are no nitrogen and phosphorus control practices and programs in the No Action scenario throughout the Chesapeake Bay watershed for on-site waste treatment systems.

1985 No Action Atmospheric Deposition

The 2020 CMAQ Scenario is used for atmospheric deposition in both the E3 and No-Action scenarios in determining the “controllable” load (see Appendix L). This approach allows for the agreed to Bay TMDL air reductions to be already considered in the nitrogen load reductions needed to achieve the Bay water quality standards.

1985 No Action Urban Practices

There are no nitrogen, phosphorus, and sediment control practices and programs in the No Action scenario throughout the Chesapeake Bay watershed for the urban sector.

1985 No Action Agricultural Practices

There are no nitrogen, phosphorus, and sediment control practices and programs in the No Action scenario throughout the Chesapeake Bay watershed for agricultural lands and operations.

1985 No Action Forestry Practices

There are no nitrogen, phosphorus, and sediment control practices and programs in the No Action scenario throughout the Chesapeake Bay watershed on forest lands where there could be environmental impacts from timber harvesting and dirt and gravel roads.

2010 No Action Scenario

This scenario estimates nutrient and sediment loads under the conditions of minimal to no pollution reduction controls on point sources and nonpoint sources using a 2010 land use and population. Major widespread management practices such as nutrient management and conservation tillage were eliminated in this scenario. Wastewater treatment facilities were set at primary treatment (no nutrient removal) with no phosphate detergent ban. Atmospheric deposition loads were set to 1985 levels of emissions and controls. See the above description of the 1985 No Action Scenario for further details. Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus, and sediment loads for this scenario are listed in Tables J-2, J-4, and J-6, respectively.

Everyone, Everything, Everywhere (E3) Scenario

The E3 Scenario is an estimate of the application of management actions to the fullest possible extent practicable (this is not Limit of Technology). The E3 scenario is a “what-if” scenario of watershed conditions with the theoretical maximum practicable levels of managed controls on all pollutant load sources. There are no cost and few physical limitations to implementing BMPs for point and nonpoint sources in the E3 scenario. This scenario is used with the No Action scenario to define “controllable” loads, the difference between No Action and E3 loads. Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus, and sediment loads for this scenario are listed in Tables J-2, J-4, and J-6, respectively.

“Controllable” loads are considered when allocating the target loads needed to meet water quality standards to different regions of the Chesapeake Bay watershed. Target cap allocations also take into consideration the relative impacts of load reductions from regions throughout the watershed on water quality standards. Differences between No Action and E3 scenario loads provide equity among regions of the Chesapeake Bay watershed in that the assumptions for point source controls and nonpoint source practice and program implementation levels for each scenario are spatially universal. Differences among regions occur because of more “inherent” differences in, for example, animal and human populations, the number and types of point source facilities, agricultural land uses and areas, urban land areas, atmospheric deposition, etc.

Generally, E3 implementation levels and their associated reductions in nitrogen, phosphorus, and sediment could not be achieved for many practices, programs, and control technologies when considering physical limitations and required participation levels. E3 includes most technologies, practices and programs that have been reported by jurisdictions as part of annual model assessments, Tributary Strategies, and two-year milestones.

For most non-point source BMPs, it was assumed that the load from every available acre of the relevant land area was being controlled by a suite of existing or innovative practices. In addition, management programs converted land uses from those with high yielding nitrogen, phosphorus, and sediment loads to those with lower. E3 does not include the entire suite of practices, but rather, fully implements only those practices that have been estimated to produce greater reductions than alternative practices that could be applied to the same land base.

The current definition of E3 includes a greater number of types of practices than historic E3 scenarios. E3 load reductions could be exceeded through greater effectiveness of practices and technologies in the future because of, for example, employment of new technologies and greater efforts on operation and maintenance. For point sources, nutrient control technologies are assumed to apply to all dischargers.

E3 Wastewater Discharging Facilities

- E3 Significant municipal wastewater treatment facilities
    - Flow = Tributary Strategy flows where most are at design flows
    - Nitrogen effluent concentration = 3 mg/l TN
    - Phosphorus effluent concentration = 0.1 mg/l TP
    - BOD = 3 mg/l, DO = 6 mg/l and TSS = 5 mg/l
- E3 Significant industrial dischargers
    - Flow = Tributary Strategy flows where most are at design flows
    - Nitrogen effluent concentration = 3 mg/l TN or Tributary Strategy concentration if less
    - Phosphorus effluent concentration = 0.1 mg/l TP or Tributary Strategy concentration if less
    - BOD = 3 mg/l, DO = 6 mg/l and TSS = 5 mg/l

- E3 Non-significant municipal wastewater treatment facilities
  - Flow = Design or 2006 flow if design is not available
  - Nitrogen effluent concentration = 8 mg/l TN or Tributary Strategy concentration if less
  - Phosphorus effluent concentration = 2 mg/l TP or Tributary Strategy concentration if less
  - BOD = 5 mg/l, DO = 5 mg/l and TSS = 8 mg/l
- E3 Nonsignificant industrial wastewater treatment facilities
  - Applies the percentage of equivalent reduction from No Action (18 mg/l TN, 3mg/l TP) to E3 (3 mg/l TN, 0.1 mg/l TP) to the 2010 load estimates.

E3 Combined Sewer Overflows

- 100% overflow reduction through storage and treatment, separation or other practices. Storage and treatment is assumed in current model scenarios.

E3 On-site Wastewater Treatment Systems

- E3 Septic system connections
  - 10% of septic systems retired and connected to wastewater treatment facilities.
- E3 Septic denitrification and maintenance
  - Remaining septic systems after connections employ denitrification technologies and are maintained through regular pumping to achieve a 55% TN load reduction at the edge-of-septic-field.
  - Septic systems are maintained by a responsible management entity or in perpetuity through a maintenance contract.

E3 Atmospheric Deposition

- E3 atmospheric deposition uses the Chesapeake Bay Program’s air scenario that shows the maximum reductions in deposition – a projection to 2020 called the Maximum Feasible Scenario (see Appendix L).
- The Chesapeake Bay Program’s Water Quality Goal Implementation Team decided to use the same atmospheric deposition for both the E3 and No Action scenarios in the allocation methodology.
- The 2020 Maximum Feasible Scenario represents incremental improvements and control options (beyond 2020 CAIR) that might be available to states for application by 2020 to meet a more stringent ozone standard, stricter than 0.08 ppm – such as the proposed 0.070 ppm ozone standard of January 2010.
- Emissions projections for the 2020 E3 scenario assume the following:
  - National/regional and available State Implementation Plans (SIP) for NOx reductions – with lower ozone season nested emission caps in OTC states; targeting use of maximum controls for coal fired power plants in or near non-attainment areas.
  - Electric Generating Units (EGU):
    - CAIR second phase in place, in coordination with earlier NOx SIP call.

    - NOx Budget Trading Program (NBP).
    - Regional Haze Rule and guidelines for Best Available retrofit Technology (BART) for reducing regional haze.
    - Clean Air Mercury Rule (CAMR) in place.
  - Non-EGU point sources:
    - New supplemental controls, such as low NOx burners, plus increased control measure efficiencies on planned controls and step up of controls to maximum efficiency measures, e.g., replacing SNCRs (Selective Non-Catalytic Reduction) with SCRs (Selective Catalytic Reduction) control technology.
    - Solid Waste Rules – Hospital/Medical Waste Incinerator Regulations
  - On-Road mobile sources:
    - On-Road Light Duty Mobile Sources – Tier 2 vehicle emissions standards and the Gasoline Sulfur Program which affects SUV's, pickups and vans which are subject to same national emission standards as cars.
    - On-Road Heavy Duty Diesel Rule – Tier 4: New emission standards on diesel engines starting with the 2010 model year for NOx, plus increased penetration of diesel retrofits and continuous inspection and maintenance using remote onboard diagnostic systems.
  - Clean Air Non-Road Diesel Rule:
    - Off-road diesel engine vehicle rule, reduced NOx emissions from marine vessels in coastal shipping lanes, and locomotive diesels (phased in by 2014) require controls on new engines.
    - Off-road large spark ignition engine rules affect recreational vehicles (marine and land based).
  - Area (nonpoint area) sources: switching to natural gas and low sulfur fuel.

- E3 Agricultural Ammonia Emissions Reductions
  - Assumes rapid incorporation of fertilizers in soils at the time of application, litter treatment, bio-filters on housing ventilation systems, and covers on animal waste storage or treatment facilities.
  - The overall benefit of reduced emissions from confined animal housing and waste storage as well as lower emissions from fertilized soils is a 15% reduction of ammonia deposition.

E3 Urban Practices

- E3 Forest conservation & urban growth reduction
  - All projected loss of forest from development is retained or planted in forest.

- E3 Riparian forest buffers on urban
  - 10% of pervious riparian areas without natural vegetation (forests and wetlands) associated with urban lands are buffered as forest for each modeled hydrologic segment in the Chesapeake Bay watershed.
  - The area of un-buffered riparian land is determined using the best available data: 1) 1:24K National Hydrography Dataset; and 2) 2001 land cover.

- E3 Tree planting on urban
  - Forest conservation and urban riparian forest buffers account for tree plantings in the urban sector.
- E3 Stormwater Management
  - Regions with karst topography (low permeability) and Coastal Plain Lowlands (high groundwater)
    - 50% of areas – impervious cover reduction.
    - 30% of area – filtering practices designed to reduce TN by 40%, TP by 60% and SED by 80% from a pre-BMP condition.
    - 20% of area – infiltration practices designed to reduce TN by 85%, TP by 85% and sediment by 95% from a pre-BMP condition.
  - Ultra-urban regions – defined as high- and medium-intensity land cover
    - 50% of areas – impervious cover reductions, e.g. cisterns and collections systems to capture rainwater for reuse.
    - 30% of area – filtering practices, e.g., sand filters, bio-retention, and dry wells.
    - 20% of area – infiltration practices, e.g., infiltration trenches and basins.
  - Other urban/suburban regions
    - 10% of areas – impervious cover reduction.
    - 30% of area – filtering practices, e.g. sand filters, bio-retention.
    - 60% of area – infiltration practices.
- E3 Erosion & sediment controls
  - Controls of the runoff from all bare-construction land use areas are assumed to be at a level so that the construction loads are equal to the nutrient and sediment edge-of-stream loads from pervious urban under E3 conditions.
- E3 Nutrient management on urban
  - All pervious urban acres are under nutrient management.
- E3 Controls on extractive (active and abandoned mines)
  - Controls of the runoff from all extractive land use areas are assumed to be to a degree so that the loads are equal to the nutrient and sediment edge-of-stream loads from pervious urban under E3 conditions.

E3 Agricultural Practices

- E3 Conservation tillage
  - All row crops are conservation-tilled.
- E3 Enhanced nutrient management applications
  - All cropland is under enhanced nutrient management – the hybrid of reduced application rate and decision agriculture.
  - Long-term, adaptive management approach with continuous improvement.

- E3 Riparian forest buffers on agriculture
  - Riparian areas without natural vegetation (forests and wetlands) associated with agricultural lands are buffered as forest.
  - This equates to 15% of cropland and 10% of pasture land including the pasture stream corridor for each modeled hydrologic segment in the Chesapeake Bay watershed.
  - The area of un-buffered riparian land is determined using the best available data: 1) 1:24K National Hydrography Dataset; and 2) 2001 land cover.
  - Current implementation of riparian grass buffers is considered converted to riparian forest buffers.
- E3 Wetland restoration
  - 5% of available agricultural acres in crops and grazed for each modeled hydrologic segment in the Chesapeake Bay watershed.
- E3 Carbon sequestration / alternative crops
  - 5% of the available row crop acres for each modeled hydrologic segment in the Chesapeake Bay watershed.
  - Program is replacement of row crops with long-term grasses that serve as a carbon bank.
- E3 Agricultural land retirement
  - Retirement of highly erodible land is considered in the E3 practices of riparian forest buffers, wetland restoration, and carbon sequestration practices which typically have equal or greater environmental benefits.
- E3 Tree planting on agriculture
  - Tree planting is considered in the E3 practice of riparian forest buffers which typically have equal or greater environmental benefits.
- E3 Conservation Plans (non-nutrient management)
  - Conservation Plans are fully implemented on all agricultural land (row crops, hay, alfalfa, and pasture).
- E3 Cover crops and commodity cover crops
  - Early-planting rye cover crops with drilled seeding on all relevant row crops.
  - The watershed-wide average of 81% of row crops are not associated with small-grain production is applied to each modeled hydrologic segment in the Chesapeake Bay watershed.
  - Early-planting wheat commodity cover crops with drilled seeding on remaining row crops (associated with small-grain production).
    - The watershed-wide average of 19% of row crops associated with small-grain production is applied to each modeled hydrologic segment in the Chesapeake Bay watershed.
- E3 Pasture Management
  - Stream Access Control with Fencing – Exclusion fencing is assumed to protect the stream corridor area designated as the degraded landuse and the area between the

stream bank and fence is converted to (and is part of) the agricultural forest buffer determination.

  - Prescribed grazing – All upland pasture area is assumed to be under prescribed grazing.
  - Dairy Precision Feeding and Forage Management (also listed under E3 Dairy Precision Feeding) – All dairy heifers have reduced nutrient concentrations in excreted manure of TN = 24% and TP = 28% from a pre-feed management condition.
    - Management approaches may include increased productivity and use of on-farm grass forage.
  - Horse pasture management benefits are the same as those for fencing and prescribed grazing practices for livestock in general.

- E3 Animal waste management/runoff control
  - Controls of runoff of manure nutrients from the production area of animal feeding operations is assumed to be at a level so that loads are equal to the nutrient and sediment edge-of-stream loads associated with hay that does not receive fertilizer applications.
  - Other practices typically associated with animal waste management and runoff control, that may affect runoff from the production area, are addressed separately in the E3 scenario. These include Poultry and Swine Phytase, Dairy Precision Feeding, Manure Transport, and Ammonia Emissions Reductions.
- E3 Poultry phytase
  - The phosphorus content in the manure of all poultry is reduced by 32% from a pre-feed management condition.
- E3 Swine phytase
  - The phosphorus content in excreted manure of all swine is reduced from a pre-feed management condition by 17%.
- E3 Dairy Precision Feeding
  - All dairy heifers have reduced nutrient concentrations in excreted manure of TN = 24% and TP = 28% from a pre-feed management condition.
- E3 Ammonia emissions reductions
  - Also under E3 Atmospheric Deposition – Agricultural Ammonia Emissions Reductions
  - Assumes rapid incorporation of fertilizers in soils at the time of application, litter treatment, bio-filters on housing ventilation systems, and covers on animal waste storage or treatment facilities.
  - The overall benefit of reduced emissions from confined animal housing and waste storage as well as lower emissions from fertilized soils is a 15% reduction of ammonia deposition.
- E3 Nursery Management
  - All nursery operations are managed through a number of practices to protect water quality including properly addressing nutrient management and incorporating erosion and sedimentation controls.

  - Controls are to a degree so that runoff from nursery areas is equal to the nitrogen, phosphorus, and sediment edge-of-stream loads from hay that does not receive fertilizer applications.

E3 Forest Harvest Practices

- E3 Forest harvesting practices
  - Controls of runoff from the disturbed area of timber harvest operations is assumed to be at a level so that the nitrogen, phosphorus, and sediment loads are equal to edge-of-stream loads associated with the forest/woody landuse.
  - It's assumed these BMPs, designed to minimize the environmental impacts from timber harvesting (such as road building and cutting/thinning operations), are properly installed on all harvested lands with no measurable increase in nitrogen, phosphorus, and sediment discharge.

All Forest with Current Air Scenario

This scenario uses an all forest land use and estimated atmospheric deposition loads for the 1991 – 2000 period, and represents estimated loads with maximum reductions on the land including the elimination of fertilizer, point source, and manure loads. However, this scenario has loads greater than a pristine scenario which would have reduced input atmospheric deposition loads by about an order of magnitude. Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus and sediment loads for this scenario are listed in Tables J-3, J-5, and J-7, respectively.

Base Calibration Scenario

The Base Calibration Scenario is used in data correction procedures and represents the calibration of the time series of land uses, loads, and hydrology over the ten year simulation period (1991-2001) used for TMDL scenarios. Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus and sediment loads for this scenario are listed in Tables J-2, J-4, and J-6, respectively.

Allocation Scenario

The Allocation Scenario characterizes the nitrogen, phosphorus and sediment loads necessary to achieve the Bay jurisdictions' Chesapeake Bay water quality standards. This scenario, ultimately replaced by the final Bay TMDL allocations listed in Section 9, is provided for documentation purposes. The Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus and sediment loads for this scenario are listed in Table J-8.

190/12.7 Loading Scenario

This scenario of 190 million pounds nitrogen and 12.7 million pounds phosphorus delivered to the Bay is one of several scoping scenarios that were run to explore the region of nutrient loads that were close to achieving all water quality standards in the Chesapeake. Phase 5.3 Chesapeake

Bay Watershed Model simulated nitrogen, phosphorus, and sediment loads for this scenario are listed in Tables J-3, J-5, and J-7, respectively.

179/12 Loading Scenario

This scenario of 179 million pounds nitrogen and 12 million pounds phosphorus delivered to the Bay is one of several scoping scenarios that were run to explore the region of nutrient loads that were close to achieving all water quality standards in the Chesapeake Bay. Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus and sediment loads for this scenario are listed in Tables J-3, J-5 and J-7, respectively.

170/11.3 Loading Scenario

This scenario of 170 million pounds nitrogen and 11.3 million pounds phosphorus delivered to the Bay is one of several scoping scenarios that were run to explore the region of nutrient loads that were close to achieving all water quality standards in the Chesapeake Bay. Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus, and sediment loads for this scenario are listed in Tables J-3, J-5, and J-7, respectively.

James Level of Effort Potomac Scenario

This scenario was one of several scoping scenarios examining achievement of the tidal James River's chlorophyll *a* water quality standards. The 190/12.7 Loading Scenario was used as a base for this scenario and all other basins but the James River basin received the nitrogen and phosphorus loadings that were allocated as part of the 190/12.7 Loading Scenario. In the James River basin, the nitrogen and phosphorus loads were equivalent to the same level of effort as Virginia's portion of the Potomac for the 190/12.7 Loading Scenario. Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus, and sediment loads for this scenario are listed in Tables J-3, J-5, and J-7, respectively.

James ½ Level of Effort Potomac Scenario

This scenario was one of several scoping scenarios examining achievement of the tidal James River's chlorophyll *a* water quality standards. The 190/12.7 Loading Scenario was used as a base for this scenario and all other basins but the James received the nitrogen and phosphorus loadings that were allocated as part of the 190/12.7 Loading Scenario. In the James River basin, the nitrogen and phosphorus loads are equivalent to the level of effort ***half way*** between Virginia's portion of the Potomac River basin and the James River basin for the 190/12.7 Loading Scenario. Phase 5.3 Chesapeake Bay Watershed Model simulated nitrogen, phosphorus and sediment loads for this scenario are listed in Tables J-3, J-5 and J-7, respectively.

Please note that in some cases the scenario loads reported in this Appendix may differ slightly from loads reported in other documentation, such as in the stoplight plots in Appendix M. This is because the scenario loads in this Appendix have the latest updated input load information but the stoplight plots in Appendix M contain scenarios that were dated and in some cases corrected with new information. For example, the scoping scenarios of the 190/12.7 Loading Scenario, 179/12 Loading Scenario, and 170/11 Loading Scenario were developed with appropriate factors of an early Tributary Strategy Scenario which has been updated since the stoplight assessments were run.

Table J-2. Delivered Total Nitrogen Loads (millions lbs/year) by State Basin and Scenario

Scenario		1985	Base Calibration	2009	2010 No-Action	Tributary Strategy	2010 E3
Eastern Shore (EAS)							
	DE	4.59	4.77	4.15	4.98	3.16	2.22
	MD	16.55	16.35	12.42	17.70	9.84	7.18
	PA	0.57	0.54	0.44	0.49	0.31	0.20
	VA	2.15	2.20	2.00	2.41	1.03	0.79
James River Basin (JAM)							
	VA	42.47	36.82	31.52	49.11	27.51	16.45
	WV	0.02	0.02	0.02	0.02	0.02	0.02
Potomac River Basin (POT)							
	DC	6.22	5.41	2.86	9.78	2.26	1.47
	MD	29.56	26.96	18.77	32.96	16.10	11.42
	PA	7.23	6.95	6.23	6.69	4.24	3.50
	VA	30.14	28.36	20.31	33.53	16.38	13.31
	WV	8.08	7.79	5.91	6.37	4.78	3.61
Rappahannock River Basin (RAP)							
	VA	8.92	8.35	6.94	9.33	5.62	4.39
Susquehanna River Basin (SUS)							
	MD	2.29	2.02	1.54	1.75	1.26	0.87
	NY	16.87	15.02	10.95	11.03	9.56	6.39
	PA	127.49	118.86	101.65	119.29	71.09	56.89
Western Shore (WES)							
	MD	27.00	17.75	14.00	36.64	9.84	5.99
	PA	0.04	0.04	0.03	0.04	0.01	0.01
Patuxent River Basin (PAT)							
	MD	4.16	3.86	3.09	6.01	2.78	2.03
York River Basin (YOR)							
	VA	7.60	7.37	6.44	8.49	5.09	3.83
Totals(millions lbs/year)							
State	DC	6.22	5.41	2.86	9.78	2.26	1.47
	DE	4.59	4.77	4.15	4.98	3.16	2.22
	MD	79.56	66.95	49.81	95.05	39.82	27.49
	NY	16.87	15.02	10.95	11.03	9.56	6.39
	PA	135.34	126.39	108.35	126.51	75.66	60.59
	VA	91.27	83.10	67.21	102.86	55.65	38.78
	WV	8.11	7.81	5.93	6.39	4.80	3.63
Basin	EAS	23.85	23.85	19.01	25.58	14.34	10.39
	JAM	42.49	36.84	31.54	49.12	27.53	16.47
	POT	81.23	75.47	54.07	89.33	43.76	33.31
	RAP	8.92	8.35	6.94	9.33	5.62	4.39
	SUS	146.65	135.90	114.14	132.07	81.92	64.15
	WES	27.04	17.79	14.03	36.68	9.85	6.00
	PAT	4.16	3.86	3.09	6.01	2.78	2.03
	YOR	7.60	7.37	6.44	8.49	5.09	3.83
Chesapeake Bay Total(millions lbs/year)							
Total		341.95	309.44	249.26	356.61	190.90	140.57

Table J-3. Delivered Total Nitrogen Loads (millions lbs/year) by State Basin and Scenario

		190/12.7	179/12	170/11.3	James L.O.E.	James L.O.E.	All Forest
					1/2 Potomac	Potomac	
Eastern Shore							
	DE	3.14	2.85	2.57	3.14	3.14	0.58
	MD	9.76	8.88	8.00	9.76	9.76	2.65
	PA	0.31	0.28	0.25	0.31	0.31	0.09
	VA	1.02	0.93	0.84	1.02	1.02	0.22
James River Basin							
	VA	26.55	25.99	25.43	23.47	21.51	7.26
	WV	0.02	0.02	0.02	0.02	0.02	0.01
Potomac River Basin							
	DC	2.31	2.21	2.10	2.31	2.31	0.06
	MD	16.48	15.72	14.96	16.48	16.48	4.66
	PA	4.34	4.14	3.94	4.34	4.34	1.03
	VA	16.77	16.00	15.23	16.77	16.77	5.22
	WV	4.89	4.67	4.44	4.89	4.89	1.84
Rappahannock River Basin							
	VA	5.87	5.54	5.22	5.87	5.87	2.20
Susquehanna River Basin							
	MD	1.25	1.17	1.09	1.25	1.25	0.50
	NY	9.44	8.85	8.27	9.44	9.44	2.88
	PA	70.20	65.87	61.54	70.20	70.20	23.52
Western Shore							
	MD	9.45	9.08	8.71	9.45	9.45	2.29
	PA	0.01	0.01	0.01	0.01	0.01	0.00
Patuxent River Basin							
	MD	2.77	2.63	2.49	2.77	2.77	0.88
York River Basin							
	VA	5.37	5.10	4.83	5.37	5.37	1.85
Totals(millions lbs/year)							
State	DC	2.31	2.21	2.10	2.31	2.31	0.06
	DE	3.14	2.85	2.57	3.14	3.14	0.58
	MD	39.70	37.48	35.26	39.70	39.70	10.98
	NY	9.44	8.85	8.27	9.44	9.44	2.88
	PA	74.86	70.30	65.74	74.86	74.86	24.63
	VA	55.58	53.56	51.54	52.51	50.55	16.74
	WV	4.91	4.69	4.46	4.91	4.91	1.85
Basin	EAS	14.23	12.94	11.66	14.23	14.23	3.54
	JAM	26.57	26.01	25.45	23.49	21.53	7.27
	POT	44.79	42.73	40.67	44.79	44.79	12.80
	RAP	5.87	5.54	5.22	5.87	5.87	2.20
	SUS	80.88	75.89	70.90	80.88	80.88	26.90
	WES	9.46	9.09	8.72	9.46	9.46	2.30
	PAT	2.77	2.63	2.49	2.77	2.77	0.88
	YOR	5.37	5.10	4.83	5.37	5.37	1.85
Chesapeake Bay Total(millions lbs/year)							
		189.94	179.94	169.95	186.86	184.90	57.72

Table J-4. Delivered Total Phosphorus Loads (millions lbs/year) by State Basin and Scenario

		1985	Base	2009	2010	Tributary	2010 E3
			Calibration		No-Action	Strategy	
Eastern Shore							
	DE	0.37	0.38	0.32	0.45	0.27	0.19
	MD	1.70	1.59	1.17	2.00	1.04	0.83
	PA	0.02	0.02	0.02	0.02	0.01	0.01
	VA	0.26	0.25	0.19	0.30	0.13	0.12
James River Basin							
	VA	6.47	4.32	3.25	7.52	3.28	1.55
	WV	0.01	0.01	0.01	0.01	0.01	0.01
Potomac River Basin							
	DC	0.10	0.10	0.09	1.58	0.11	0.05
	MD	1.48	1.24	1.01	3.56	1.03	0.63
	PA	0.57	0.54	0.54	0.61	0.38	0.33
	VA	2.18	2.09	2.01	4.97	1.70	0.98
	WV	0.85	0.91	0.82	0.92	0.54	0.37
Rappahannock River Basin							
	VA	1.29	1.24	1.08	1.65	0.94	0.60
Susquehanna River Basin							
	MD	0.09	0.07	0.06	0.07	0.06	0.04
	NY	1.07	0.98	0.80	0.97	0.65	0.43
	PA	4.48	3.79	3.41	5.25	2.65	1.76
Western Shore							
	MD	1.62	0.87	0.77	3.63	0.68	0.25
	PA	0.00	0.00	0.00	0.00	0.00	0.00
Patuxent River Basin							
	MD	0.48	0.36	0.29	0.83	0.29	0.13
York River Basin							
	VA	1.02	0.76	0.62	1.16	0.59	0.35
Totals(millions lbs/year)							
State	DC	0.10	0.10	0.09	1.58	0.11	0.05
	DE	0.37	0.38	0.32	0.45	0.27	0.19
	MD	5.37	4.13	3.31	10.10	3.10	1.88
	NY	1.07	0.98	0.80	0.97	0.65	0.43
	PA	5.07	4.36	3.97	5.89	3.04	2.10
	VA	11.24	8.67	7.15	15.60	6.64	3.60
	WV	0.86	0.93	0.83	0.93	0.55	0.38
Basin	EAS	2.36	2.23	1.70	2.77	1.45	1.15
	JAM	6.49	4.34	3.26	7.53	3.29	1.55
	POT	5.19	4.90	4.46	11.64	3.76	2.36
	RAP	1.29	1.24	1.08	1.65	0.94	0.60
	SUS	5.64	4.84	4.27	6.29	3.36	2.24
	WES	1.62	0.87	0.77	3.63	0.68	0.25
	PAT	0.48	0.36	0.29	0.83	0.29	0.13
	YOR	1.02	0.76	0.62	1.16	0.59	0.35
Chesapeake Bay Total(millions lbs/year)							
		24.10	19.54	16.46	35.51	14.36	8.63

Table J-5. Delivered Total Phosphorus Loads (millions lbs/year) by State Basin and Scenario

		190/12.7	179/12	170/11.3	James L.O.E. 1/2 Potomac	James L.O.E. Potomac	All Forest
Eastern Shore(EAS)							
	DE	0.29	0.27	0.25	0.29	0.29	0.05
	MD	1.10	1.02	0.94	1.10	1.10	0.22
	PA	0.01	0.01	0.01	0.01	0.01	0.00
	VA	0.14	0.13	0.12	0.14	0.14	0.02
James River Basin(JAM)							
	VA	2.67	2.57	2.47	2.34	2.21	0.90
	WV	0.01	0.01	0.01	0.01	0.01	0.01
Potomac River Basin(POT)							
	DC	0.10	0.09	0.09	0.10	0.10	0.00
	MD	0.95	0.90	0.85	0.95	0.95	0.25
	PA	0.35	0.33	0.31	0.35	0.35	0.13
	VA	1.56	1.48	1.39	1.56	1.56	0.40
	WV	0.50	0.47	0.45	0.50	0.50	0.27
Rappahannock River Basin(RAP)							
	VA	0.91	0.85	0.78	0.91	0.91	0.30
Susquehanna River Basin(SUS)							
	MD	0.05	0.05	0.04	0.05	0.05	0.01
	NY	0.56	0.53	0.51	0.56	0.56	0.31
	PA	2.28	2.17	2.06	2.28	2.28	1.04
Western Shore(WES)							
	MD	0.45	0.42	0.40	0.45	0.45	0.15
	PA	0.00	0.00	0.00	0.00	0.00	0.00
Patuxent River Basin(PAT)							
	MD	0.21	0.20	0.18	0.21	0.21	0.07
York River Basin(YOR)							
	VA	0.54	0.51	0.48	0.54	0.54	0.21
Totals(millions lbs/year)							
State	DC	0.10	0.09	0.09	0.10	0.10	0.00
	DE	0.29	0.27	0.25	0.29	0.29	0.05
	MD	2.75	2.58	2.41	2.75	2.75	0.71
	NY	0.56	0.53	0.51	0.56	0.56	0.31
	PA	2.64	2.52	2.39	2.64	2.64	1.17
	VA	5.82	5.53	5.24	5.48	5.36	1.84
	WV	0.51	0.48	0.45	0.51	0.51	0.28
Basin	EAS	1.53	1.42	1.31	1.53	1.53	0.30
	JAM	2.68	2.58	2.47	2.35	2.22	0.91
	POT	3.46	3.27	3.09	3.46	3.46	1.06
	RAP	0.91	0.85	0.78	0.91	0.91	0.30
	SUS	2.89	2.75	2.62	2.89	2.89	1.36
	WES	0.45	0.42	0.40	0.45	0.45	0.15
	PAT	0.21	0.20	0.18	0.21	0.21	0.07
	YOR	0.54	0.51	0.48	0.54	0.54	0.21
Chesapeake Bay Total(millions lbs/year)							
		12.67	12.00	11.33	12.33	12.20	4.36

Table J-6. Delivered Total Suspended Solids Loads (millions lbs/year) by State Basin and Scenario

		1985	Base Calibration	2009	2010 No-Action	Tributary Strategy	2010 E3
Eastern Shore							
	DE	76.68	76.96	64.78	93.67	54.75	31.13
	MD	260.20	243.41	185.80	294.98	156.99	126.05
	PA	38.73	37.04	31.66	40.47	20.12	19.52
	VA	22.16	20.21	16.38	21.99	10.30	8.83
James River Basin							
	VA	1562.90	1473.21	1247.04	1506.04	1004.70	691.16
	WV	29.45	28.81	28.52	28.59	18.21	14.62
Potomac River Basin							
	DC	22.54	29.86	32.00	100.95	10.31	4.12
	MD	923.43	866.58	781.47	1036.36	665.62	471.50
	PA	323.32	303.02	309.61	391.39	226.28	225.46
	VA	1296.91	1204.65	1092.77	1346.84	823.32	607.61
	WV	426.22	384.14	349.86	418.46	230.02	166.15
Rappahannock River Basin							
	VA	890.56	840.71	754.27	852.79	688.86	634.32
Susquehanna River Basin							
	MD	106.49	96.35	73.29	100.82	63.55	53.72
	NY	400.98	336.60	337.27	344.28	310.74	212.05
	PA	2718.95	2386.77	2286.39	2899.89	1756.33	1589.07
Western Shore							
	MD	311.80	266.86	239.00	325.15	204.99	105.10
	PA	0.93	0.89	0.77	1.11	0.49	0.56
Patuxent River Basin							
	MD	182.30	171.33	114.46	158.87	103.34	60.57
York River Basin							
	VA	208.88	179.78	145.18	201.47	114.12	83.19
Totals(millions lbs/year)							
State	DC	22.54	29.86	32.00	100.95	10.31	4.12
	DE	76.68	76.96	64.78	93.67	54.75	31.13
	MD	1784.21	1644.53	1394.02	1916.18	1194.48	816.94
	NY	400.98	336.60	337.27	344.28	310.74	212.05
	PA	3081.93	2727.72	2628.42	3332.86	2003.23	1834.60
	VA	3981.40	3718.57	3255.65	3929.11	2641.31	2025.11
	WV	455.67	412.96	378.38	447.04	248.23	180.77
Basin	EAS	397.76	377.62	298.62	451.11	242.17	185.53
	JAM	1592.34	1502.02	1275.56	1534.62	1022.91	705.78
	POT	2992.42	2788.26	2565.72	3293.99	1955.55	1474.84
	RAP	890.56	840.71	754.27	852.79	688.86	634.32
	SUS	3226.43	2819.72	2696.94	3345.00	2130.62	1854.84
	WES	312.73	267.75	239.76	326.26	205.48	105.65
	PAT	182.30	171.33	114.46	158.87	103.34	60.57
	YOR	208.88	179.78	145.18	201.47	114.12	83.19
Chesapeake Bay Total(millions lbs/year)							
		9803.41	8947.19	8090.52	10164.10	6463.06	5104.72

Table J-7. Delivered Total Suspended Solids Loads (millions lbs/year) by State Basin and Scenario

		190/12.7	**179/12**	**170/11.3**	**James L.O.E.**	**James L.O.E.**	**All Forest**
					1/2 Potomac	**Potomac**	
Eastern Shore(EAS)							
	DE	59.35	53.25	47.15	59.35	59.35	43.17
	MD	170.16	152.68	135.20	170.16	170.16	51.17
	PA	21.81	19.57	17.33	21.81	21.81	7.11
	VA	11.17	10.02	8.87	11.17	11.17	2.63
James River Basin(JAM)							
	VA	893.92	875.04	856.15	833.04	809.93	388.49
	WV	16.20	15.86	15.52	15.10	14.68	11.68
Potomac River Basin(POT)							
	DC	9.73	9.36	9.00	9.73	9.73	2.44
	MD	627.64	604.39	581.13	627.64	627.64	263.33
	PA	213.37	205.46	197.56	213.37	213.37	99.70
	VA	776.35	747.58	718.82	776.35	776.35	274.89
	WV	216.90	208.86	200.83	216.90	216.90	120.38
Rappahannock River Basin(RAP)							
	VA	678.31	657.13	635.96	678.31	678.31	506.66
Susquehanna River Basin(SUS)							
	MD	59.65	58.51	57.37	59.65	59.65	24.85
	NY	291.65	286.08	280.51	291.65	291.65	186.12
	PA	1648.48	1616.97	1585.46	1648.48	1648.48	1044.88
Western Shore(WES)							
	MD	150.73	144.46	138.20	150.73	150.73	84.11
	PA	0.36	0.35	0.33	0.36	0.36	0.06
Patuxent River Basin(PAT)							
	MD	81.84	78.75	75.67	81.84	81.84	64.89
York River Basin(YOR)							
	VA	105.98	101.56	97.13	105.98	105.98	61.29
Totals(millions lbs/year)							
State	DC	9.73	9.36	9.00	9.73	9.73	2.44
	DE	59.35	53.25	47.15	59.35	59.35	43.17
	MD	1090.01	1038.79	987.56	1090.01	1090.01	488.34
	NY	291.65	286.08	280.51	291.65	291.65	186.12
	PA	1884.03	1842.36	1800.68	1884.03	1884.03	1151.75
	VA	2465.72	2391.33	2316.94	2404.84	2381.73	1233.96
	WV	233.10	224.72	216.34	231.99	231.58	132.06
Basin	EAS	262.48	235.52	208.55	262.48	262.48	104.08
	JAM	910.12	890.90	871.67	848.14	824.61	400.16
	POT	1843.98	1775.66	1707.35	1843.98	1843.98	760.74
	RAP	678.31	657.13	635.96	678.31	678.31	506.66
	SUS	1999.78	1961.56	1923.33	1999.78	1999.78	1255.85
	WES	151.09	144.81	138.53	151.09	151.09	84.17
	PAT	81.84	78.75	75.67	81.84	81.84	64.89
	YOR	105.98	101.56	97.13	105.98	105.98	61.29
Chesapeake Bay Total(millions lbs/year)							
		6033.58	5845.89	5658.19	5971.60	5948.07	3237.84

Table J-8. Delivered Total Allocation Scenario Loads (millions lbs/year) by State Basin

		Allocation Scenario	Allocation Scenario	Allocation Scenario
		(Nitrogen)	**(Phosphorus)**	**(TSS) (range)**
Eastern Shore(EAS)				
	DE	2.95	0.26	58-64
	MD	9.71	1.09	166-182
	PA	0.28	0.01	21-23
	VA	1.21	0.16	11-12
James River Basin(JAM)				
	VA	23.48	2.34	837-920
	WV	0.02	0.01	15-17
Potomac River Basin(POT)				
	DC	2.32	0.12	10-11
	MD	15.70	0.90	654-719
	PA	4.72	0.42	221-243
	VA	17.46	1.47	810-891
	WV	4.67	0.74	226-248
Rappahannock River Basin(RAP)				
	VA	5.84	0.90	681-750
Susquehanna River Basin(SUS)				
	MD	1.08	0.05	60-66
	NY	8.23	0.52	293-322
	PA	71.74	2.31	1660-1826
Western Shore(WES)				
	MD	9.74	0.46	155-170
	PA	0.02	0.001	0.37-0.41
Patuxent River Basin(PAT)				
	MD	2.85	0.21	82-90
York River Basin(YOR)				
	VA	5.41	0.54	107-118
Totals(millions lbs/year)				
State	DC	2.32	0.12	10-11
	DE	2.95	0.26	58-64
	MD	39.09	2.72	1,116-1,228
	NY	8.23	0.52	293-322
	PA	76.77	2.74	1,903-2,093
	VA	53.40	5.41	2,446-2,691
	WV	4.68	0.75	241-265
Basin	EAS	14.15	1.53	256 -281
	JAM	23.50	2.35	852-937
	POT	44.88	3.66	1,920-2,113
	RAP	5.84	0.90	681-750
	SUS	81.06	2.88	2,013-2,214
	WES	9.76	0.46	155-171
	PAT	2.85	0.21	82-90
	YOR	5.41	0.54	107-118
Bay Total(millions lbs/yr)				
		187.44	12.52	6,066-6,673

Appendix K.
Allocation Methodology to Relate Relative Impact to Needed Controls

Introduction

The nutrient allocation procedures agreed to by five of the seven Bay watershed partners and followed by EPA are described in Section 6.4 of the main document. The reader should be familiar with Section 6.4 before reading this appendix. The goal of this appendix is to expand the options that were considered before selecting the final procedures and to provide rationale for the final decisions. Unless otherwise noted, the information presented in this appendix is based on the Phase 5.3 Chesapeake Bay Watershed Model and is the same information that was used to inform the decisions in the spring and summer of 2009 using the Phase 5.2 Chesapeake Bay Watershed Model, which had known limitations. Many of the values given in this appendix will be different from the final version as these decisions were not revisited with Phase 5.3 Bay Watershed Model.

Relative Effectiveness Options

Section 6.3.1 of the main document is a discussion of the relative effectiveness of major basins in improving dissolved oxygen in the critical areas of the tidal waters of the Chesapeake.

Relative effectiveness is a combination of riverine effectiveness, also known as a delivery factor, which is expressed as

- pounds of reduction reaching tidal waters/pounds of reduction to the local river and estuarine effectiveness, which is expressed as
- improvement in dissolved oxygen/pounds of reduction reaching tidal waters Multiplying the two together gives
- improvement in dissolved oxygen/pounds of reduction to the local river

Riverine Effectiveness Options

No options were considered in calculating riverine delivery factors. The principles of calculating delivery factors in the Chesapeake Bay Program watershed models are long-standing and have been approved several times by Chesapeake Bay Program workgroups and subcommittees. These principles were also reviewed in the Chesapeake Bay Program’s Scientific and Technical Advisory Committee sponsored independent scientific peer reviews of the Phase 5 Chesapeake Bay Watershed Model in 2007 and 2009. Nitrogen delivery factors are calculated for each river segment. Nitrogen levels are lowered naturally in river systems through denitrification, providing a long-run removal of nitrogen. Phosphorus and sediment do not undergo a similar process to denitrification and do not have long-run removal mechanisms other than delivery through the river system and burial. Burial is offset by scour, both of which are episodic in nature. That does not hold true in reservoir systems, where burial is much more significant and is not offset by scour to a great degree. Because of the lack of spatially and temporally detailed phosphorus and sediment data that would be needed to precisely calibrate scour and burial on the segment scale, the calculation of delivery factors for phosphorus and sediment is closed around reservoirs rather than segment by segment. That is, all segments upstream of a reservoir or an entrance to the tidal system and downstream of other reservoirs receive the same riverine delivery factor.

Geographic Grouping of Estuarine Effectiveness

The estuarine effectiveness is calculated by comparing the dissolved oxygen simulated in the Bay of the calibration run to the dissolved oxygen simulated in the Bay when a given watershed area has reduced loads relative to the calibration loads. The effectiveness for that given area is then calculated by dividing the improvement in dissolved oxygen by the reduction delivered loads. A choice has to be made regarding the geographic areas to test.

Each area along the estuary would theoretically have a different estuarine effectiveness, but there are limitations to what can be effectively calculated. If the area tested has a low total load and, therefore, a small change in going to a reduced load, the estuarine model might not be able to resolve the change in dissolved oxygen. Tested areas must be aggregated up to a reasonably large load to be able to record the change. Also, the estuarine model takes a few days to complete a run, and it would be time-prohibitive to make 100 or so more runs.

There is no difference in estuarine effectiveness between loads in the same nontidal watershed. Loads from areas just west of Washington, DC, would have the same estuarine effectiveness as loads from West Virginia because they enter the tidal waters at the same point, although they would have different overall effectiveness scores because of the differences in their riverine effectiveness. Therefore, the head of tide of large river systems is a natural place to define a discrete watershed. The estuarine portion of major river systems like the Potomac and Rappahannock would have significantly different effects on the critical area for dissolved oxygen and also have large enough loads to resolve these differences, so those areas are another reasonable place to lump geographically. The Eastern Shore is not amenable to simple rules like this because there are no large nontidal river systems connected to large estuarine river systems. There are, however significant differences in estuarine effectiveness between the northernmost and southernmost portions of the Eastern Shore. The Eastern Shore was therefore divided in to four sections.

The final geographic breakout, as a balance between the desire to calculate a different effectiveness where a distinction exists and the limiting factors of computer run time and the ability of the estuarine model to resolve the oxygen effect of small differences in loading are

Susquehanna
West Shore
Patuxent Above Fall Line
Patuxent Below Fall Line
Potomac Above Fall Line
Potomac Below Fall Line
Rapp Above Fall Line
Rapp Below Fall Line
York Above Fall Line
York Below Fall Line
James Above Fall Line
James Below Fall Line
Upper East Shore
Middle East Shore
Lower East Shore
East Shore VA

To be clear, the allocation calculations are split between those geographic areas within jurisdictions, resulting in 30 different spatial units. The allocations, however, are expressed on the jurisdiction and major river basin scale. That is, there is a calculation of Maryland Potomac above and below the fall line, but the allocation is expressed only as Maryland Potomac.

Choice of the Critical Designated Uses and Segments for Calculating Relative Effectiveness

To estimate the estuarine effectiveness, the change in dissolved oxygen must be calculated for a relevant area of the Chesapeake Bay. The most persistent areas of dissolved oxygen violations are in the mainstem of the Chesapeake Bay from roughly the Bay Bridge between Annapolis and Kent Island, Maryland, south to the mouth of the Potomac River and also the lower tidal Potomac River. The deep-water and deep-channel designated uses are impaired at a higher rate than the open-water designates use and also better integrators of baywide rather than local loads.

The deep-water and deep-channel designated uses of CB3MH, CB4MH, and CB5MH and the deep-water designated use of POTMH_MD were selected as the most appropriate grouping to use in calculating estuarine relative effectiveness for the following reasons:

1. These segments and designated uses had high levels of impairment
2. They are centrally located
3. They represent a large group of segments and a large volume of the Bay
4. Deep-water and deep-channel designated uses are good geographic integrators

Further tests of other combinations showed that the estuarine effectiveness was not particularly sensitive to the addition or subtraction of any given designated use.

Metric for Relative Effectiveness

To estimate the change in dissolved oxygen an appropriate metric of dissolved oxygen must be calculated that is sensitive to load changes across a wide array of segments, designated uses, and impairment levels and is relevant to the assessment of dissolved oxygen criteria. Three metrics were investigated:

1. Percent nonattainment.
2. Average dissolved oxygen during the summer assessment period
3. 25th percentile (quartile) of dissolved oxygen during the summer assessment period

Three criteria were applied in determining which of these make the best metric

1. Relevance to attainment of dissolved oxygen standards
2. Broad applicability to designated uses and water quality segments
3. Linearity of response—does the first pound have the same effect as the last?

Percent nonattainment is clearly the most relevant metric to standards attainment, although other measures of dissolved oxygen are certainly also relevant. The quartile is more relevant than the average in that EPA is estimating increases in the lower values of oxygen.

Percent nonattainment is applicable only to areas that are not in attainment in the calibration and do not come into attainment when simulating a reduction in any single basin, which is a considerable limitation. Average dissolved oxygen is not an appropriate measure for many open-water segments. An impaired open-water segment might have average dissolved oxygen near saturation but experience large swings between super saturation and low oxygen. A load reduction might not change the average but improve the water quality by reducing the variability of oxygen levels and the frequency of low values. The quartile is applicable to all segments and all designated uses.

Linearity of response is a crucial component. If a metric responded much more to the first pound of reduction than to the last, smaller basins would be estimated to have a greater pound-for-pound influence than larger basins. To determine the linearity of the response to the three candidate metrics, a run was made with the Susquehanna at half the level of reduction normally used to calculate estuarine effectiveness. In general, across multiple segments and designated uses, the response for all three metrics was mostly linear. There was not a significant difference between the metrics on this count.

The average was judged to be not suitable because of its limited applicability. The percent nonattainment was judged to be slightly more relevant than the quartile, but the quartile was selected as the appropriate metric because of its universal applicability.

Level of Effort Options

Section 6.3 of the main document describes the expression of level of effort as between the two extreme scenarios of No Action scenario and E3. Selection of those two scenarios is an expression of the third principle under Section 6.3 that all previous reductions are credited toward achieving the allocations.

Atmospheric Deposition

The atmospheric deposition options and rationale for choosing the air allocation is documented in Section 6.4.1. The method of incorporation is to hold atmospheric deposition constant through the bookend scenarios of No Action and E3, and through all the prospective management scenarios unless specific actions are called for in state plans that go beyond the federal levels. One example of states going beyond the federal level is that the E3 has atmospheric deposition set to a level that incorporates reduced agricultural emissions and other possible state actions. That allows the jurisdictions to be responsible strictly for the reductions that they can control and not for federal actions on atmospheric deposition.

Scenario Options

The E3 scenario was selected as the appropriate lower end of loading rather than other candidate scenarios such as the Current Programs, Maximum Feasible, or All Forest. Current Programs could be used as the lower end and an assessment made of how far efforts had to increase beyond current programs, but doing so would violate the expression of equity described above because jurisdictions that had already achieved significant reductions would have to do proportionately more than jurisdictions that have not. Maximum Feasible would be a similar expression as E3 and would meet the equity provision, but it was judged to be much more subjective and, therefore, inferior to E3 as a metric. The All Forest scenario would be an expression of anthropogenic, rather than controllable loads. The All Forest was used in the 2003 goal setting. Basing the allocation method on E3 recognizes that various sources have different possible levels of reduction. An allocation based on anthropogenic load could require levels of reduction beyond E3. For example, if an allocation required all loads to go 60 percent of the way toward All

Forest, certain theoretical land uses that can achieve only a 50 percent reduction at E3 would not be able to achieve the allocations, while wastewater treatment plants would be able to achieve a much larger than 60 percent reduction from No Action. Those distortions would increase at smaller scales as sources become more dominant locally.

The No Action scenario was chosen as the upper end to follow the principle of accounting for previous reductions. Using a starting point that incorporated management practices or higher levels of treatment would give a disadvantage to jurisdictions that had implemented the actions.

Allocation Method Options

Section 6.3.1 describes the method used to relate relative effectiveness to reduction effort. With that basic outline there is an infinite number of ways to define the allocation and still meet water quality standards. The major decisions to be made are the number of lines that represent different source categories and the shapes of those lines. The options were discussed in the Chesapeake Bay Program's Water Quality Goal Implementation Team (WQGIT) and the Principals' Staff Committee, and agreement was reached between EPA and five of the seven jurisdictional partners.

Number of Allocation Lines

During the allocation process, the WQGIT recognized that different source categories had different abilities to make progress toward an E3 level of implementation. Figure K-1 is a plot of implementation progress through 2009 plotted on the same vertical axis as the allocation charts, percent of E3 from No Action.

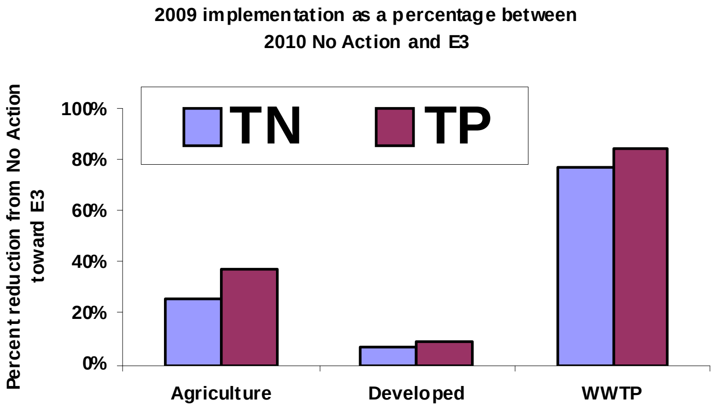


Figure K-1. 2009 implementation by sector.

The 2009 implementation represents the choices that the jurisdictions have made to date, presumably taking into account the same types of criteria that will be used to make decisions on restoration spending in the future.

There is a clear separation between the sources in that jurisdictions have chosen to set wastewater treatment plants at a level closer to E3, relative to No Action, than either agriculture or developed land. There is also a separation between agriculture and developed land, but it is not as large as the separation between wastewater treatment plants and all other sources. With that information, the decision was made to use two lines, one for wastewater treatment plants and one or all other sources.

Shape of the Allocation Lines

Several allocation line shapes were discussed with the three main shapes being

1. Straight: This is the most straightforward expression of the allocation principle stated under section 6.3 that areas with a greater pound for pound effect on water quality should do more.
2. Hockey Stick: It was recognized that a natural maximum existed for some sources, particularly with waste water treatment where a given technology could reach a concentration that could be expressed as a percentage from No Action to E3. A hockey stick line has a maximum for watershed areas in the range of relative effectiveness and slopes down for lower levels of relative effectiveness.
3. Z-curve: Similar to the hockey stick but also recognizing that a natural minimum also might exist. Again, related to wastewater treatment plants, a given technology producing a known concentration can be seen as a minimum technology that should be implemented.

As reported in more detail in Section 6.3.3 the wastewater line was set first in a hockey stick shape such that the upper 50 percent of the relative effectiveness values were at a maximum attainment percentage, according to a given concentration and the rest sloped off to a minimum value also based on a concentration. The straight line for all other sources was set such that a zero relative effectiveness would have a 20 percent lower value on the percent controllable axis than the area with the maximum relative effectiveness value. The intercept for all other sources was set such that the water quality standards were attained. Figure K-2, which is also Figure 6-7 in the main document, is the implementation of this method for nitrogen.

To make the above decision, the partnership was presented with several options for constructing the lines. Basin-jurisdiction loads were calculated for each option.

Table K-1 is a sample of options that were explored using the Phase 5.2 Chesapeake Bay Watershed Model. Several more options were generated before the final decision was made.

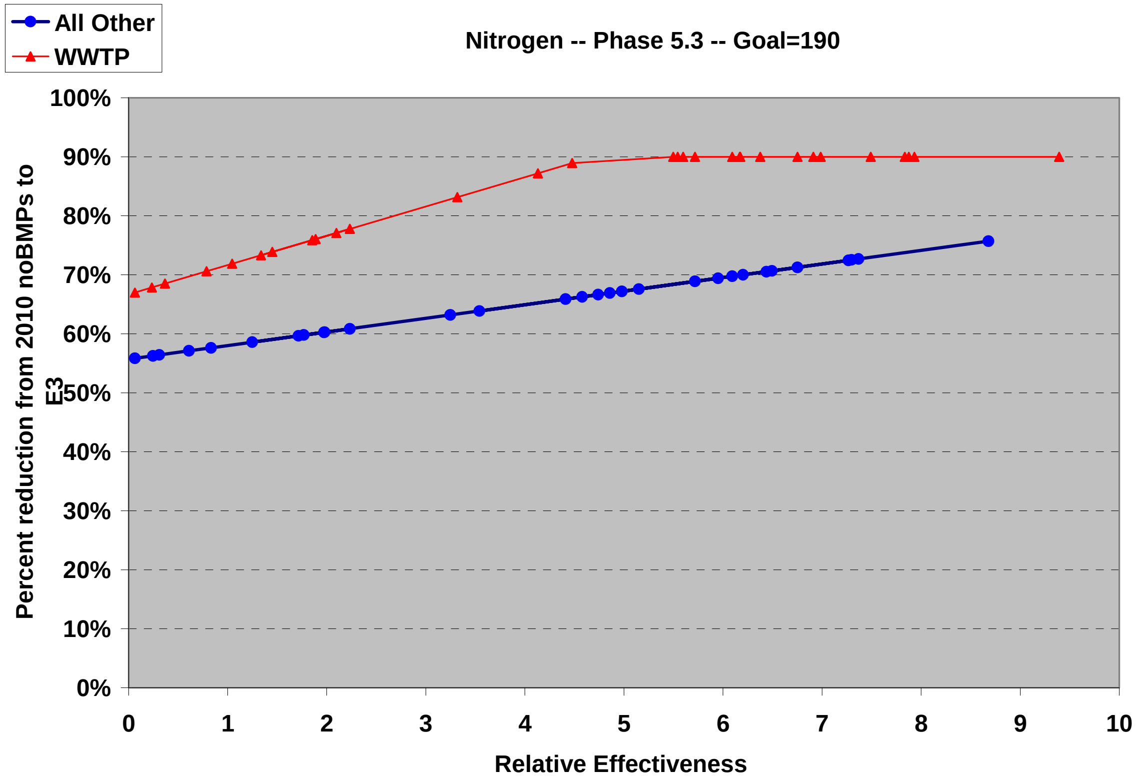


Figure K-2. Allocation methodology example showing the hockey stick and straight line reductions approaches, respectively, to wastewater (red line) and all other sources (blue line).

Table K-1: Initial options presented to the Chesapeake Bay Program’s Water Quality Goal Implementation Team on September 30, 2009

Lines	2	2	2	2	2				
WWTP rule	3-8 mg/l	3-8 mg/l	3-8 mg/l HS	3-8 mg/l HS	3-8 mg/l Z				
Other Load Rule	20%	10%	20%	10%	20%				
DO goal	200	200	200	200	200	**Largest Difference**	2010 Noact	E3 load	TS load
DC Potm	2.82	2.82	2.37	2.37	2.37	16%	9.68	1.53	2.12
DE Esh	5.12	5.21	5.25	5.34	5.21	4%	9.28	3.45	6.43
MD Esh	12.54	12.76	12.81	13.03	12.70	4%	23.94	8.25	13.84
MD Patux	3.26	3.25	3.15	3.13	3.27	4%	6.57	2.15	3.17
MD Potm	14.73	14.52	14.10	13.89	14.29	6%	30.31	9.65	14.66
MD Susq	0.81	0.83	0.83	0.85	0.82	4%	1.35	0.61	0.97
MD Wsh	10.18	10.15	10.15	10.11	10.12	1%	36.50	6.15	9.49
NY Susq	10.54	10.41	10.54	10.41	10.55	1%	16.36	7.78	8.68
PA Potm	4.76	4.58	4.83	4.65	4.83	5%	7.08	3.12	4.31
PA Susq	67.96	68.59	68.81	69.44	68.37	2%	121.19	49.23	68.86
VA Esh	1.60	1.59	1.61	1.61	1.60	1%	3.25	0.88	1.67
VA James	28.84	28.14	28.49	27.78	29.58	6%	52.63	15.80	28.85
VA Potm	16.85	16.47	16.09	15.72	16.50	7%	33.05	10.72	15.81
VA Rap	6.54	6.37	6.49	6.32	6.60	4%	10.61	4.33	6.49
VA York	6.55	6.32	6.53	6.30	6.72	6%	10.54	4.05	6.48
WV Potm	5.65	5.44	5.71	5.50	5.73	5%	8.32	3.76	5.69
Total	**198.77**	**197.46**	**197.76**	**196.45**	**199.27**	1%	**380.66**	**131.45**	**197.53**

Calculation of Equivalent Allocation Options

For any given level of water quality, an infinite number of lines can be drawn on the allocation plots like Figure K-2. To calculate an equivalent line to an existing line, it is necessary to meet the condition of

$$\sum (DeliveredLoad) \times (EstuarineDelivery) = C$$

or the sum of all delivered loads for each state/basin/fall-line combination times its estuarine delivery factor must equal a constant for the family of lines that meets the same water quality.

Expanding the delivered load term to create an equation between relative effectiveness and delivered load gives

$$\sum \left(E3_i + (NoBMP_i - E3_i)(1 - mX_i - b)\right) EstuarineDelivery_i = C$$

where

X_i	is the relative effectiveness
$E3_i$ and $NoBMP_i$	are the loads for that state/basin/fall-line/sector for the two scenarios
m and b	are the slope and intercept of the line and the only unknowns

Given a slope or an intercept, the above equation can be solved numerically for the other parameter of the line. This equation was implemented in MS Excel for multiple lines with enforced maximum and minimum to accommodate the decisions above.

Appendix L.
Setting the Chesapeake Bay Atmospheric Nitrogen Deposition Allocations

Atmospheric Deposition Nitrogen Inputs Compared to Other Nitrogen Sources

Atmospheric deposition of nitrogen is the highest nitrogen input load in the Chesapeake watershed (Figure L-1). Other nutrient input loads are fertilizer, manures, point sources, and septic systems. Over the 1985 to 2005 Chesapeake Bay model simulation period, the Chesapeake watershed average atmospheric deposition loads of nitrogen have been declining, particularly those of oxidized nitrogen.

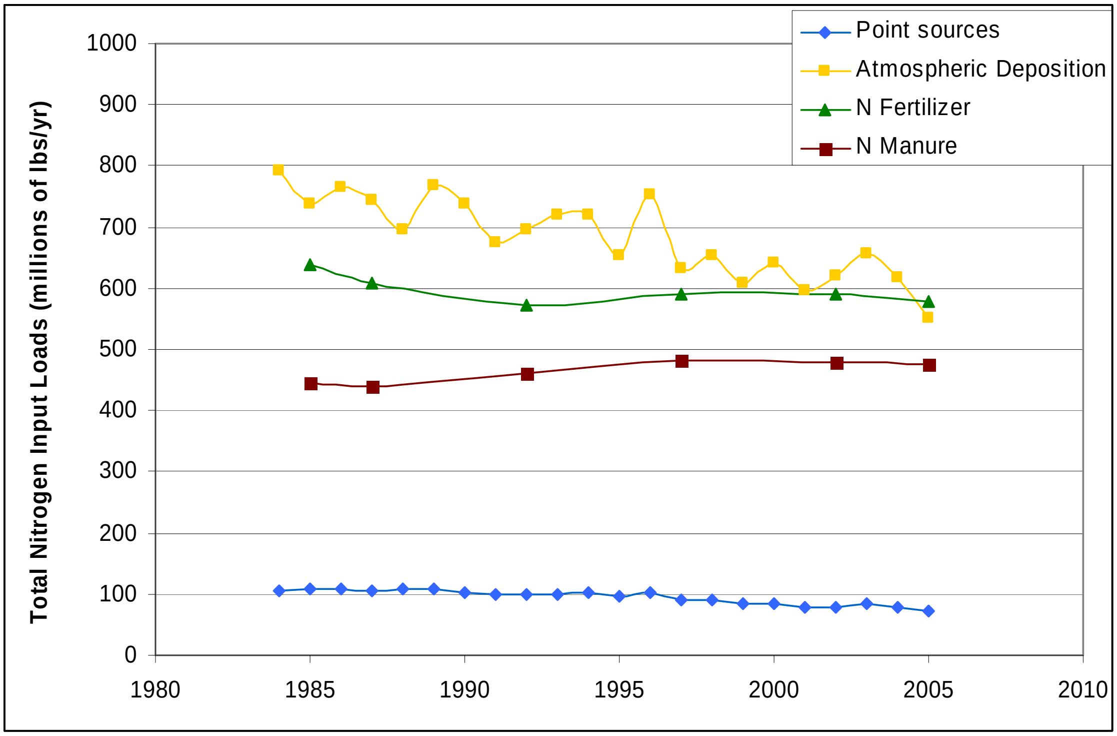


Figure L-1. 20-year (1985–2005) time series of atmospheric, fertilizer, manure, and wastewater treatment plant nitrogen input loads to the Chesapeake Bay Water Quality and Sediment Transport Model.

Atmospheric Deposition Inputs

Atmospheric loads of nitrogen are from chemical species of oxidized nitrogen, also called NOx, and from reduced forms of nitrogen deposition, also called ammonia (NH3). Oxidized forms of nitrogen deposition originate from conditions of high heat and pressure and are formed from eutrophically inert diatomic atmospheric nitrogen. The principle sources of NOx are air emissions from industrial-sized boilers such as electric power plants and internal combustion engines in cars, trucks, locomotives, airplanes, and the like.

Reduced nitrogen, or ammonia, is responsible for approximately one-third of the total nitrogen emissions that eventually end up as loads to the Bay. Ammonia sources are predominately agricultural, and ammonia is released into the air by volatilization of ammonia from manures and emissions from ammonia based fertilizers. Minor sources include mobile sources, slip ammonia released as a by-product of emission controls on NOx at power plants and industrial processes.

Two types of deposition are differentiated and both are tracked through the Chesapeake models and atmospheric deposition monitoring networks as input daily. The first is wet deposition, which occurs during precipitation events and contributes only to nitrogen loads during days of rain or snow. The other is dry deposition, which occurs continuously and is input at a constant rate daily into the Bay Watershed and Bay Water Quality models.

Because the Bay Watershed and Bay Water Quality models are mass balance models, all sources of nutrient inputs to the tidal Bay have to be accounted for including phosphorus and organic forms of nutrients. For phosphorus and organic nutrients, the models estimate loads to open water only, on the assumption that all phosphorus and organic nutrients are derived from aeolian or wind processes that result in no net change in organic nitrogen on terrestrial surfaces but result in a net gain when deposited on water surfaces.

Organic nitrogen is represented as wet fall only, i.e., dissolved organic nitrogen (DON). The magnitude of dry fall organic nitrogen is not well characterized in the literature, but the latest Community Multiscale Air Quality (CMAQ) model simulations with updated chemical mechanisms do include peroxyacyl nitrates **(**PAN, $CH_3COOONO_2$) and an organic nitrate group (NTR). The NTR represents several organic nitrates that are produced from ozone photochemistry. Both of these species are relatively small in magnitude and both are biologically labile. Therefore, the dryfall PAN and NTR are lumped into the oxidized nitrogen atmospheric deposition dryfall inputs. Table L-5 shows the estimated atmospheric deposition loads to the Bay's tidal surface waters of the different nutrient species.

Air sources contribute about a third of the total nitrogen loads delivered to the Chesapeake Bay by depositing directly onto the Bay's tidal surface waters and onto the surrounding Bay watershed. Direct nitrogen atmospheric deposition to the Bay's tidal surface waters is estimated to be 6 to 8 percent of the total (air and non-air) nitrogen load delivered to the Bay. The atmospheric nitrogen deposited onto the watershed and subsequently transported to the Bay is estimated to account for 25 to 28 percent of the total nitrogen loadings to the Bay.

Atmospheric Deposition Input Trends

Between 1985 and 2005, the simulation period of the Phase 5.3 Bay Watershed Model, atmospheric deposition loads of nitrate have tended to decrease overall in the Chesapeake Bay watershed. Over that 20-year period, nitrate loads have decreased by about 30 percent (Figure L-2); however, considerable variability exists across the Bay watershed, with the greatest reductions occurring in the northern and western portions. In Figure L-2, the average annual concentration is used as an adjustment to smooth out the high and low rainfall years, which bring different amounts of deposition load to the Bay watershed, primarily from the volume of precipitation. Use of the dissolved inorganic nitrogen (DIN), nitrate (NO_3), and ammonia (NH_3) concentrations provides a reasonable estimate of the trend in atmospheric deposition.

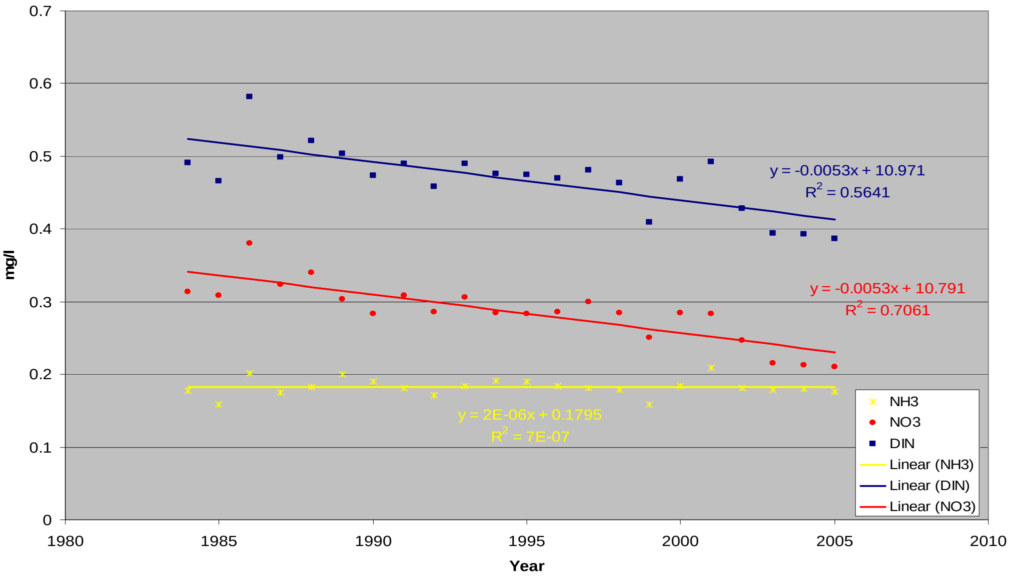
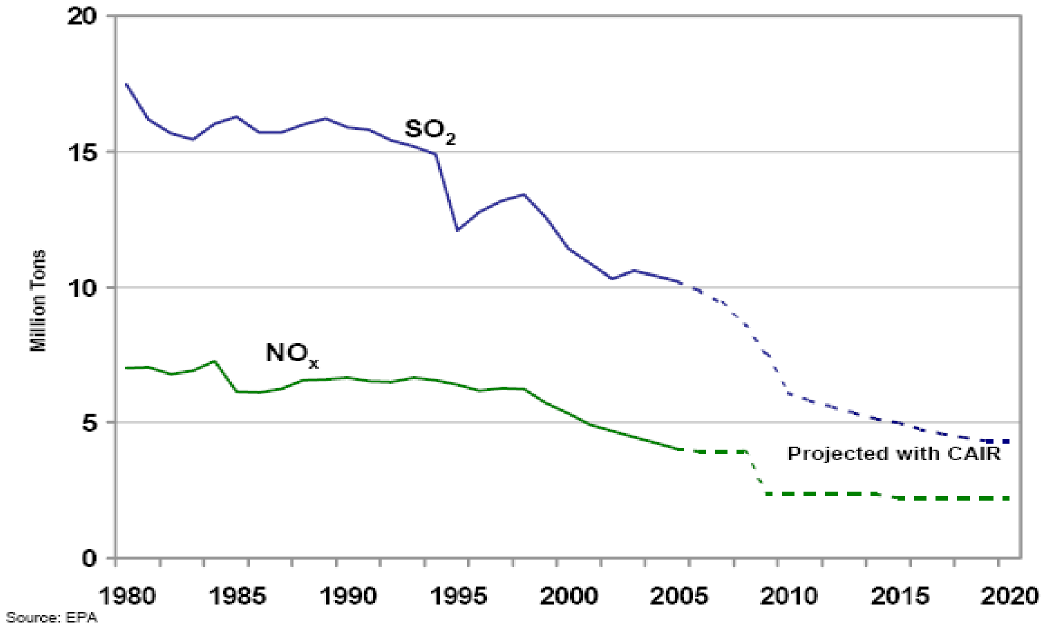


Figure L-2. Trend of estimated average NO_3, NH_3 and DIN deposition concentrations input to the Phase 5.3 Chesapeake Bay Watershed Model.

Much of the reduction has been due to point source air emission reductions, particularly from electric generating units (EGUs) as shown in Figure L-3. More rapid declines in air emissions are expected between 2008 to 2010 as the Clean Air Transport Rule (previously the Clean Air Interstate Rule [CAIR]) controls on power plant emissions and the air quality standards for ozone and particulate matter come into enforcement deadlines by 2010 (Figure L-3). Further reductions are expected with the reduced ozone air quality standard announced in August 2010. Reductions from mobile sources are another large contributor to the downward trend. Reductions from mobile sources will continue past the year 2020 as large off-road diesel and marine diesel fleets are replaced.

Table L-1 shows the estimated portion of deposited NO_x loads on the Chesapeake Bay watershed from four sectors including EGUs, mobile sources, industry, and all other sources. From 1990 to 2010, considerable reductions have been made in the electrical generation sector. In addition, both on road and off-road mobile sources have ongoing fleet turnover and replacement, which is putting cleaner spark and diesel engines in service; that is expected to continue beyond 2020. Note that some NOx sources like mobile sources seem to increase in percentage relative to other sources like EGUs. Both sources are actually decreasing and the total projected deposition load in 2020 is less than 1990, however, EGU emission reductions are relatively more than mobile reductions.

Average ammonia atmospheric deposition loads over the Chesapeake Bay watershed have followed the trend in overall manure loads in the watershed and have remained steady over the 1985 to 2005 simulation period (Figure L-2). Ammonia deposition is very site specific and strongly influenced by local emissions. Local and regional trends in manure, such as the rise of poultry animal units in the Eastern Shore and Shenandoah, and dairy's diminishment in the northern portions of the watershed in the late 1980s, affect regional ammonia deposition in the Bay watershed.



Source: EPA

Figure L-3. Estimated nationwide emissions of NOx and SO_2 from EGUs since 1980 and estimated emissions to 2020.

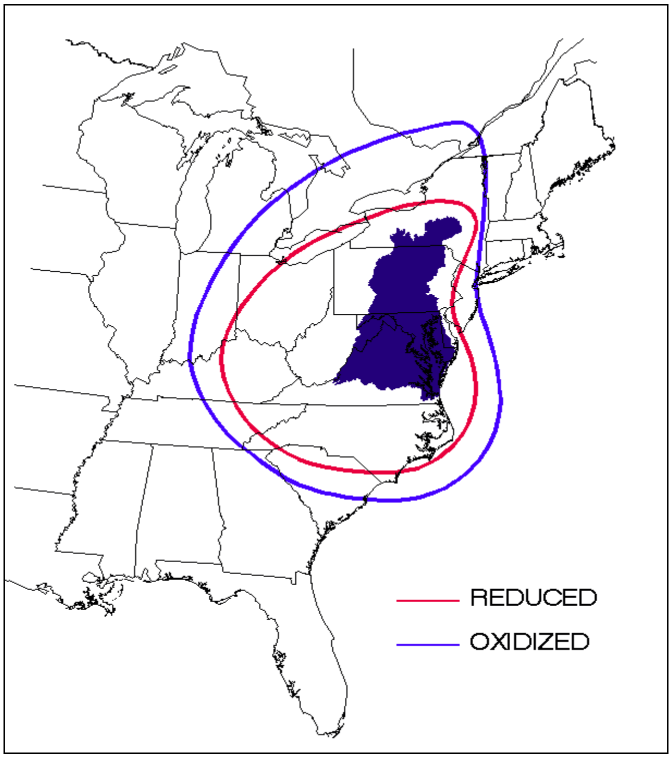
Table L-1. Estimated portion of atmospherically deposited NOx loads on the Chesapeake watershed from four sectors including EGUs, mobile sources, industry, and all other sources in 1990 and projected out to 2020

Sectors	1990	2020 (Preliminary)
Power Plants (EGUs)	40%	17%
Mobile Sources (on-road)	30%	32%
Industry	8%	20%
Other (off-road construction; residential & commercial)	21%	31%

The Bay's NOx airshed—the area where emission sources that contribute the most airborne nitrates to the Bay originate—is about 570,000 square miles, or seven times the size of the Bay's watershed. The ammonia airshed is slightly smaller (Figure L-4). Close to 50 percent of the NOx deposition to the Bay is from air emission sources located in the seven Bay watershed jurisdictions. Another 25 percent of the atmospheric deposition load to the Chesapeake Bay watershed is from the remaining area in the airshed and the remaining 25 percent of deposition is from the area outside the airshed. The ammonia airshed is similar to the NOx airshed, but slightly smaller (Figure L-4).

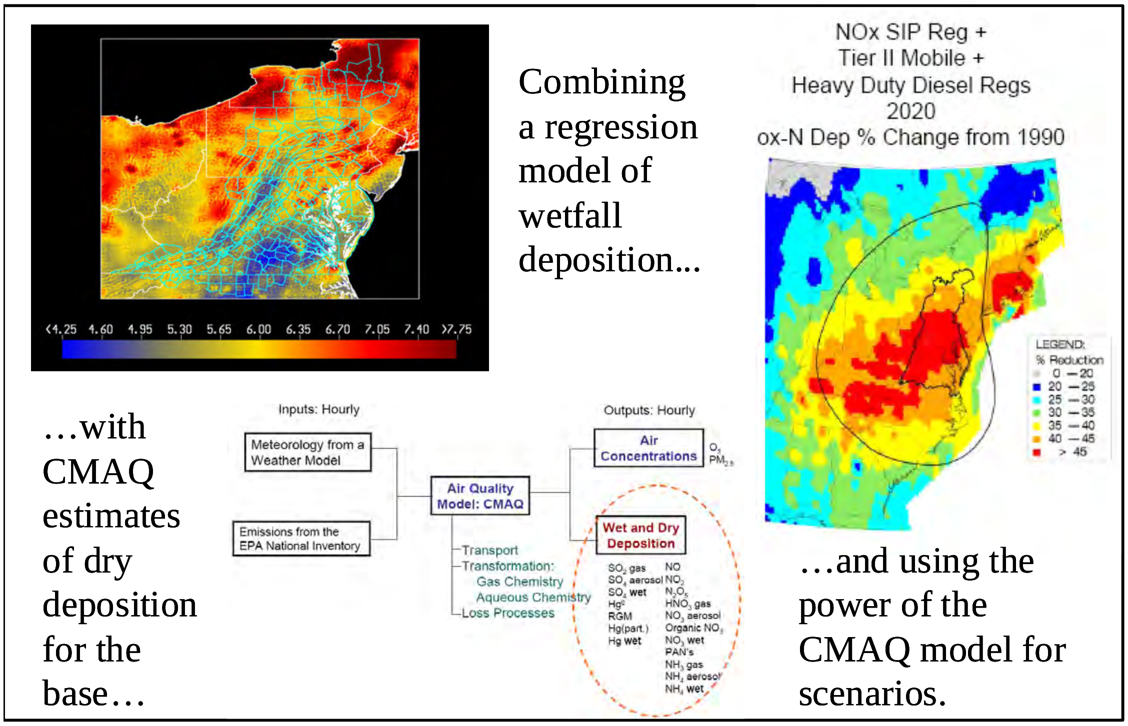
CBP Airshed Model

The Chesapeake Bay Airshed Model is a combination of a regression model of wet deposition (Grimm and Lynch 2005) and a continental-scale air quality model of North America called the CMAQ for estimates of dry deposition (Dennis et al. 2007; Hameedi et al. 2007). The Bay Airshed Model is represented in Figure L-5.



Source: Chesapeake Bay Program Office

Figure L-4. The oxidized nitrogen airshed (blue line) is the principle area of NO_X emissions that contribute nitrogen deposition to the Chesapeake Bay and its watershed. The reduced nitrogen airshed (red line) of ammonia deposition is slightly smaller.


Combining a regression model of wetfall deposition...

…with CMAQ estimates of dry deposition for the base…

…and using the power of the CMAQ model for scenarios.

Figure L-5. The Chesapeake Bay Airshed Model is a combination of a regression model of wet deposition and the Community Multi-scale Air Quality Model of dry deposition.

The regression and deterministic airshed models that provide atmospheric deposition input estimates, have gone through a series of refinements with increasingly sophisticated models of both applied over time (Linker et al. 2000; Grimm and Lynch 2000, 2005; Lynch and Grimm 2003). The amount and timing of the wet atmospheric deposition input in the Phase 5.3 Bay Watershed Model is hourly, and is related to the timing and amount of hourly rainfall in the Phase 5.3 Bay Watershed Model precipitation input data. The dry deposition estimates are monthly constants that are input daily and are based on the CMAQ model (Dennis et al. 2007; Hameedi et al. 2007).

Wet Deposition Regression Model

Wet deposition is simulated using a regression model developed by Grimm and Lynch (2000, 2005; Lynch and Grimm 2003). The regression model provides hourly wet deposition loads to each land segment on the basis of each land segment’s rainfall. The regression model uses 29 National Atmospheric Deposition Program (NADP) monitoring stations and 6 AIRMoN stations to form a regression of wetfall deposition in the entire Chesapeake Bay watershed over the entire simulation period (Figure L-6).

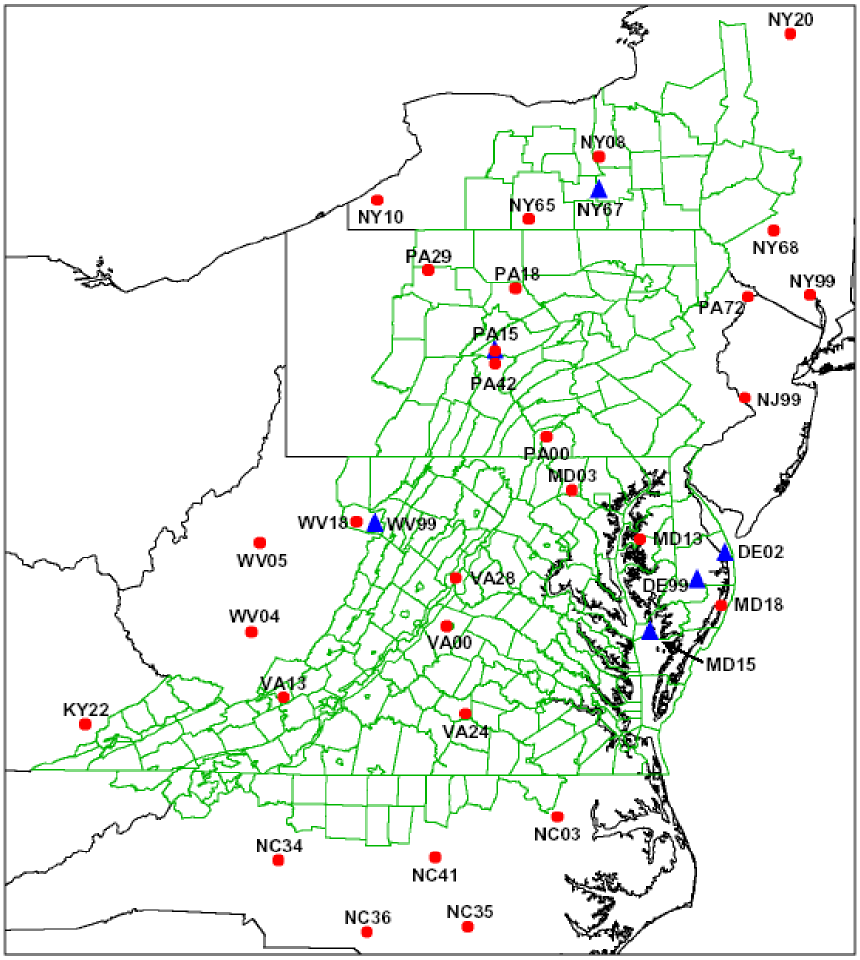


Figure L-6. Atmospheric deposition monitoring stations used in developing the wet deposition regression model.

To improve the accuracy of the regression estimates over previous regression analyses (Linker et al. 2000) a number of improvements in the sampling and representation of spatial and temporal patterns of land use activities and intensities and of emission levels were made. Also, detailed meteorological data were assimilated into the regression model to identify contributing emission source areas and to estimate the impact of the contributions on daily deposition rates on a per-event basis.

This version of the regression model included nine additional NADP/NTN sites in the regression estimates (DE99, MD07, MD08, MD15, MD99, PA47, VA10, VA27, VA98, and VA99) that were placed in operation in and around the Chesapeake Bay watershed since 2001, providing a comprehensive representation of agricultural influences.

Refinements also involved developing a more accurate and comprehensive representation of the spatial and temporal distribution and intensity of livestock production and other agricultural activities across the Bay watershed. An improved accounting of livestock production activities was achieved by combining county- and watershed unit-specific livestock production statistics with high-resolution (30 meters) land use data from the USGS's National Land Cover Database (NLCD). Estimates of local ammonia emissions from fertilizers and manure applications to croplands were also assimilated into the model using EPA inventories and high resolution NLCD to identify likely cropland areas. Last, localized estimates for NH_3 and NO_x emissions for the Phase 5 Chesapeake Bay Watershed Model domain and surrounding states were developed by combining facility and county-specific emissions reports from the EPA's National Emissions Inventory (NEI) database with the NLCD classifications.

For each day of rain, wetfall atmospheric deposition is estimated by the regression that has the general form

$\text{Log10}(c) = b_o + b_1 \log10(ppt) + \sum b_{2s} season + b_3 v_3 + \ldots + b_n v_n + e$

where

c = daily wet-fall ionic concentration (mg/L)
b_o = intercept
ppt = daily precipitation volume (inches)
b_1 = coefficient for precipitation term
season = vector of 5 binary indicator variables encoding the 6 bi-monthly seasons
b_{2s} = vector of 5 coefficients for season terms
$v_3 \ldots V_n$ = additional predictors selected through stepwise regression

- National Land Cover Data (NLCD)
  - Within proximities of 0.8, 1.6, 3.2, 8.0, and 16.1 km of each NADP/NTN site: open water, forested, residential, industrial/transportation, croplands, and vegetated wetlands
- Local emission levels of ammonia and nitrous oxides from EPA National Emission Trends (NET)
  - County emission totals 1985-2005
  - County containing each NADP/NTN monitoring site and for the nearest three counties

$b_3 \ldots b_n$ = coefficients corresponding to $v_3 \ldots V_n$

The daily precipitation nitrate and ammonium concentration models were developed using a linear least-squares regression approach and single-event precipitation chemistry data from the 29 NADP/NTN sites and six AIRMoN stations in Figure L-6. The most significant variables in both models included precipitation volume, the number of days since the last event, seasonality, latitude, and the proportion of land within 8 km covered by forests or devoted to transportation and industry. (Local and regional ammonia and nitrogen oxides emissions were not as well correlated as land cover.) The abilities of these variables to predict wet deposition arise primarily from their relationship to either (1) the spatial and temporal distribution of emissions of ammonium and nitrate precursors from sources within or upwind of the Bay watershed; or (2) the chronology and characteristics of precipitation events. Modeled concentrations compared very well with event chemistry data collected at six NADP/AIRMoN sites within the Chesapeake Bay watershed. Wet deposition estimates were also consistent with observed deposition at selected sites.

Volume, duration, and frequency of precipitation events have obvious roles in determining wet deposition rates. However, these parameters alone do not completely describe all of the characteristics of a precipitation event. In particular the intersection of a precipitation event and a volume of air with a particular history is also important in determining wet deposition flux, so the interactions between storm trajectories and emission sources were also incorporated into the wet deposition regression model.

Using metrological data from the National Center for Environmental Prediction’s North American Regional Reanalysis (NARR), components were added to daily ammonium and nitrate wet deposition models that predict the rate at which emissions from area and point sources are emitted, dispersed, and transported to specific deposition locations. Surface and upper-level vertical and horizontal air movement data from the NARR allowed estimates of the extent to which emissions were transported and mixed into surface and upper-level atmospheric layers; and, thereby, enabled construction more realistic multilevel air mass trajectories with which to predict the movement of emissions from multiple source locations to deposition points of interest.

Dry Deposition - Community Multi-scale Air Quality Model (CMAQ)

The CMAQ Model is a fully developed air simulation of North American (Dennis et al. 2007; Hameedi et al. 2007). The CMAQ model simulates atmospheric deposition to the Chesapeake Bay watershed (indirect deposition) and tidal Bay (direct deposition) for every hour of every day for the representative year. A variety of input files are needed that contain information pertaining to the modeling domain which is all North America. Those include hourly emissions estimates and meteorological data in every grid cell and a set of pollutant concentrations to initialize the model and to specify concentrations along the modeling domain boundaries. The initial and boundary concentrations were obtained from output of a global chemistry model.

The CMAQ model simulation period is for one year, 2002, because 2002 is characterized as an average precipitation year and, therefore, an average deposition year. The 2002 CMAQ simulation year was used to provide the monthly dry deposition estimate for all years of the 1985 to 2005 Phase 5.3 Bay Watershed Model simulation. Phase 5.3 Bay Watershed Model dry deposition input estimates are derived from the CMAQ model as monthly average inputs expressed as a daily load.

An adjustment for the 20-year trend in atmospheric deposition loads was applied by using the trend developed in the wet deposition regression model, and assuming the dry deposition trend to be the same as the wet in the separate nitrate and ammonia estimates. Figure L-7 shows the 12-km grid used to provide better resolution of the Phase 5 Chesapeake Bay Watershed Model's atmospheric deposition loads. The improved spatial resolution of direct atmospheric deposition of loads to tidal surface waters and the atmospheric deposition of loads to the watershed adjacent to tidal waters from metropolitan and mobile sources was an important improvement (STAC 2007).

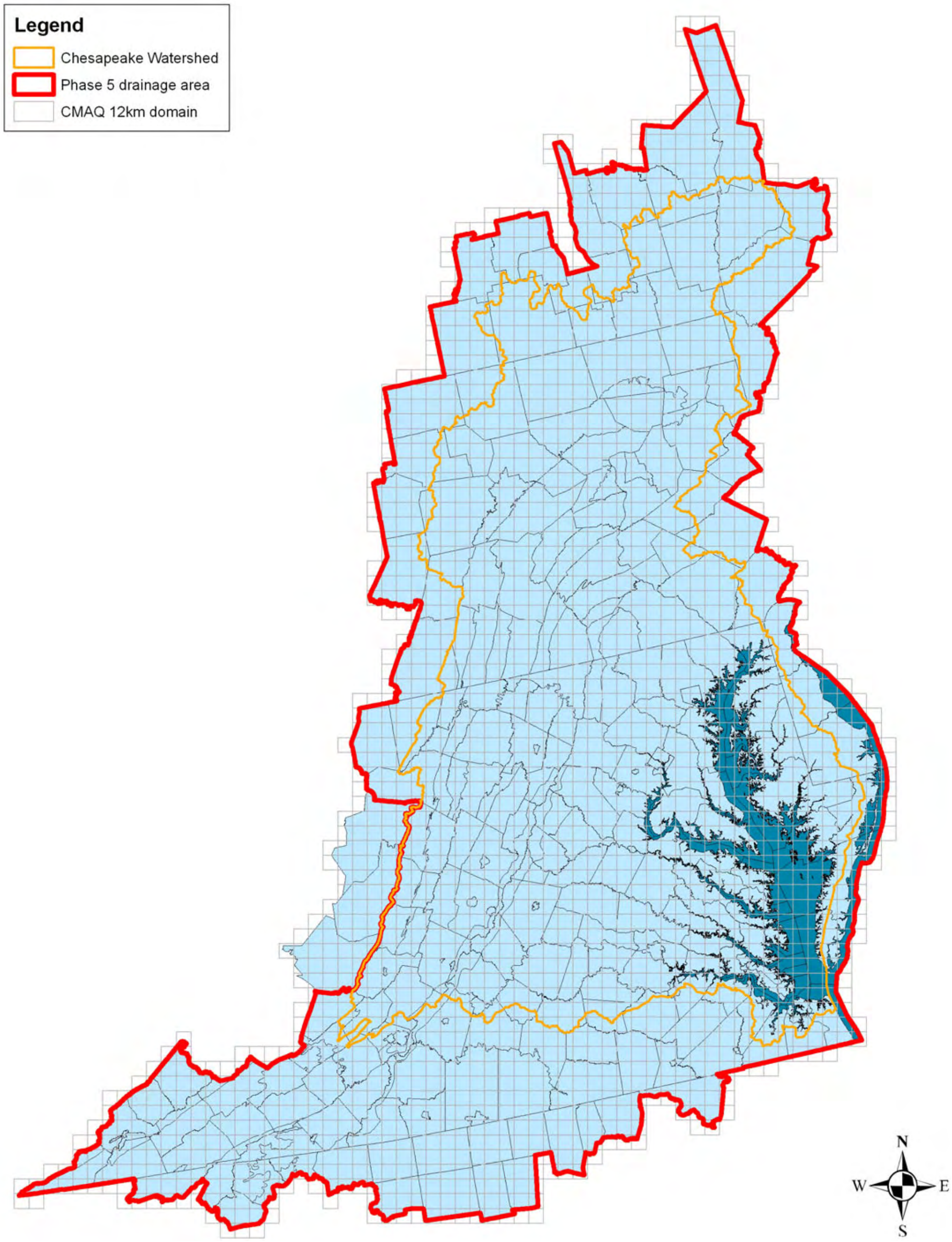


Figure L-7. The CMAQ model's 12-km grid over the Phase 5 Chesapeake Bay Watershed Model domain.

Organic Nitrogen Deposition

The Phase 5.3 Bay Watershed Model accounts for estimated loads of atmospheric organic nitrogen to the open water land use on the assumption that all organic nitrogen is derived from aeolian or wind processes that result in no net change in organic nitrogen on terrestrial surfaces but do result in a net gain when deposited on water surfaces. Organic nitrogen is represented as wet fall only, i.e., DON. The magnitude of dry fall organic nitrogen is unknown.

Dryfall Organic Nitrogen Deposition

The dryfall organic nitrogen is likely to be sorbed onto large and small particles or even to be particles themselves, like pollen. Such dryfall organic carbon species can be involved in long-range transport, such as the pollens and organic nitrates found on the dust coming over from Africa, but EPA does not have a good estimate of the fraction of the dry deposition that these particles compose.

Also, the latest CMAQ simulations with updated chemical mechanisms include peroxyacyl nitrates **(**PAN, $CH_3COOONO_2$) and an NTR. The NTR represents several organic nitrates that are produced from ozone photochemistry. Both of these species are relatively small in magnitude, and both are biologically labile. Therefore, the dryfall PAN and NTR are lumped into the oxidized nitrogen atmospheric deposition dryfall inputs.

Wetfall Organic Nitrogen Deposition

In the 1992 Phase 2 version of the Chesapeake Bay Watershed Model, organic nitrogen was assumed to be about 670 micrograms per liter (µg/L) (as nitrogen) based on data summarized by Smullen et al. (1982). The data showed considerable seasonal variability. The organic nitrogen load was constant in all watershed model segments. An equivalent annual load was used in the tributary model with application of the seasonal variability suggested by Smullen et al. (1982).

Organic nitrogen measurements from Bermuda are calculated at about 100 µg/L (as nitrogen) (Knap et al. 1986). Moper and Zita (1987) reported an average DON concentration from the western Atlantic and Gulf of Mexico of about 100 µg/L (as nitrogen). That is consistent with the reported range from the North Sea and northeast Atlantic of between 90 µg/L to 120 µg/L (Scudlark and Church 1993). Scudlark et al. (1996) reported an annual volume-weighted average DON concentration in the mid-Atlantic coastal areas to be about 130 µg/L (as nitrogen). Measurements in this study are consistent with the interannual variation (maximum in spring) reported by Smullen et al. (1982).

A later study identified methodological problems with some of the previous studies and suggests the wet deposition of organic nitrogen in the Chesapeake watershed would be closer to 50 µg/L on an annual average basis (Keene et al. 2002). This study also documented the highest concentrations of organic nitrogen in the spring.

On the basis of Keene et al. (2002), a value of 50 µg/L (as nitrogen) was selected as representative of an average annual wet deposition concentration to the watershed and tidal waters with the seasonal loading pattern suggested by Smullen (1982) and Scudlark et al. (1996). That applies an average concentration of 40 µg/L from July to March in rainfall and an average concentration of 80 µg/L from April to June. The load of organic nitrogen would depend on the precipitation in a particular land segment, but assuming 40 inches of precipitation, the load would be on the order of 0.4 lb/ac-yr.

Total Atmospheric Deposition Inputs of Nitrogen from Wet and Dry Deposition

The annual rate of total atmospheric deposition to Phase 5 land segments is shown in Figure L-8 and Table L-2.

Table L-2. Annual average atmospheric deposition of reduced DIN, oxidized DIN and total DIN on land segments in the entire Phase 5.3 Chesapeake Bay watershed model

Land Segment	NH4	NO3	Total DIN
A10001	2.50	3.21	**5.71**
A10003	1.68	2.87	**4.55**
A10005	5.62	4.55	**10.16**
A11001	0.24	0.44	**0.68**
A24001	0.41	1.37	**1.78**
A24003	1.02	2.99	**4.01**
A24005	2.02	4.42	**6.44**
A24009	0.40	1.29	**1.69**
A24011	1.60	1.64	**3.25**
C51071	0.17	0.53	**0.69**
C51165	0.45	0.28	**0.72**
Total	**264.07**	**556.59**	**820.66**

Organic and Inorganic Phosphorus Deposition

The Phase 5.3 Bay Watershed Model accounts for estimated loads of atmospheric organic and inorganic phosphorus to the open water land use on the assumption that, like organic nitrogen, the load is derived from aeolian or wind processes that result in no net change in organic nitrogen on terrestrial surfaces but do result in a net gain when deposited on water surfaces. Following Smullen (1982), annual loads of organic and inorganic phosphorus are set at 47 µg/L and 16 µg/L, respectively. Seasonally, those loads are treated in the same way as organic nitrogen, assuming that organic phosphorus will follow a pattern similar to organic nitrogen and that an aeolian source of inorganic phosphorus might well increase during the bare ground of spring agricultural practices. Accordingly, organic and inorganic phosphorus concentrations are set at 74 µg/L and 25 µg/L, respectively, from April to June, and at half those concentrations for the other nine months of the year.

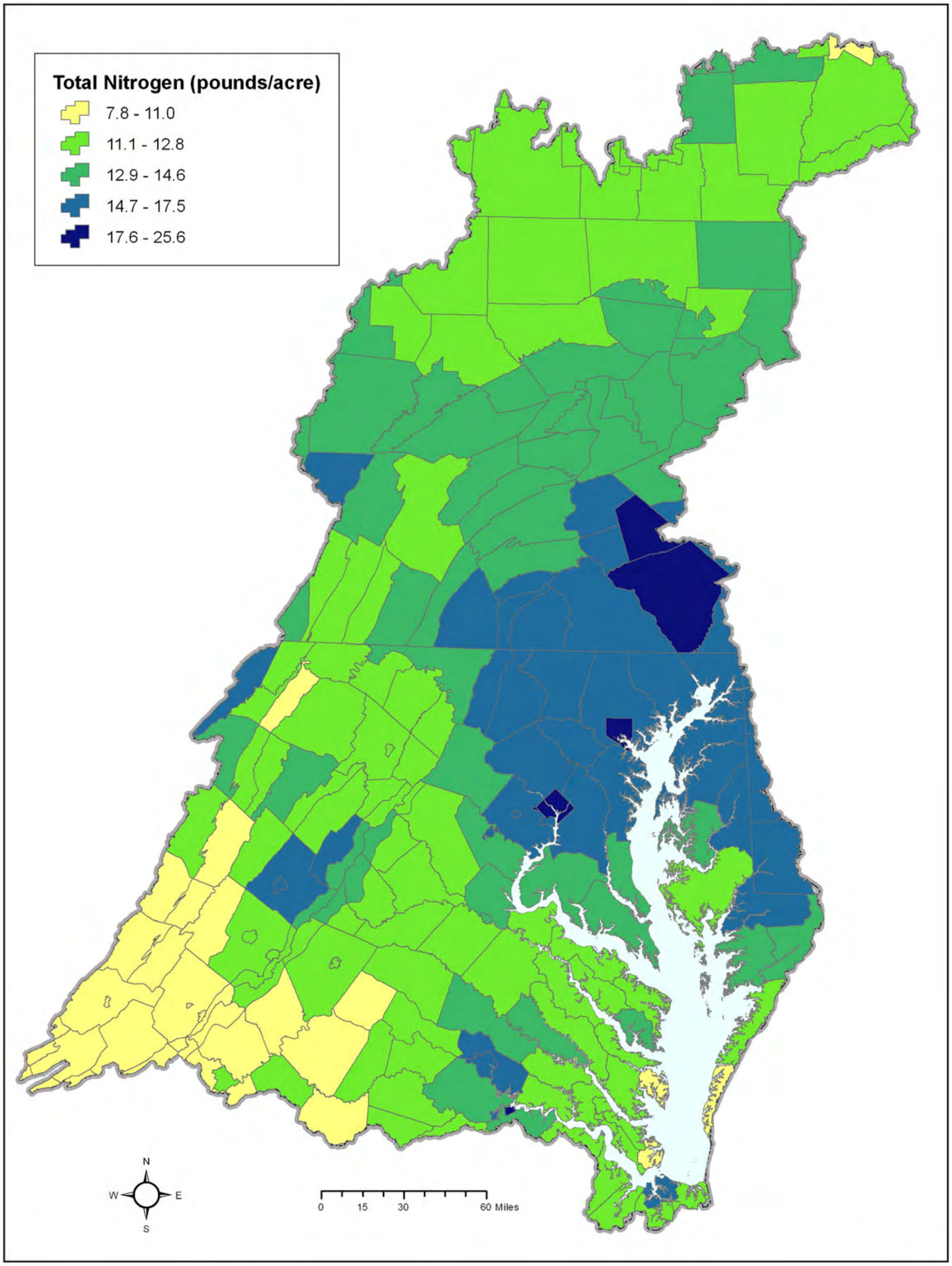


Figure L-8. Annual average DIN atmospheric deposition on land segments in the entire Phase 5.3 Chesapeake Bay Watershed Model domain.

CMAQ Airshed Scenarios

The CMAQ model also provides estimates of nitrogen deposition resulting from changes in emissions from utility, mobile, and industrial sources due to management actions or growth. For the CMAQ model the base deposition year is 2002 and scenarios include the management actions required by the Clean Air Act in 2010, 2020, and 2030. The future year scenarios reflect emissions reductions from national control programs for both stationary and mobile sources, including the CAIR, the Tier-2 Vehicle Rule, the Nonroad Engine Rule, the Heavy-Duty Diesel Engine Rule, and the Locomotive/Marine Engine Rule. Although CAIR has been remanded to EPA, it will remain in place pending a rulemaking to replace it. It is unclear how the replacement rule will compare to the remanded rule. However, EPA anticipates that NOx emissions reductions close to those originally projected will occur.

To develop a Bay watershed model scenario using one of the CMAQ model air scenarios below, a monthly factor is determined by the CMAQ model by comparing the CMAQ model's atmospheric deposition loads in the scenario year to the CMAQ 2002 base year. The CMAQ scenario factor is then used to adjust the base atmospheric deposition conditions in the Phase 5.3 Bay Watershed Model over the 1991 to 2000 scenario years.

CMAQ 2010 Scenario

The 2010 Scenario represents emission reductions from regulations implemented through the Clean Air Act authority to meet National Ambient Air Quality standards for criteria pollutants in 2010. This includes National, Regional and available State Implementation Plans (SIPs) for NOx reductions. Other components of the 2010 Scenario include Tier 1 vehicle emission standards reaching high penetration in the vehicle fleet for on-road light duty mobile sources along with Tier 2 vehicle emission standards that were fully phased in by the 2006 model year and will begin to show an impact in 2010. For EGUs the 2010 controls assume that the NOx SIP call, NOx Budget Trading Program, and the CAIR program that regulates the ozone season NOx are all in place and that the CAIR program is designed for annual NOx reductions to match the ozone season reductions under the 2010 CAIR first phase conditions.

CMAQ 2020 Scenario

The 2020 Scenario has all components of the 2010 Scenario and includes the Clean Air Mercury Rule (CAMR), the Best Available Retrofit Technology (BART) used for reducing regional haze and the off-road diesel and heavy-duty diesel regulations. The 2020 scenario represents emission reductions from regulations implemented through the Clean Air Act authority to meet National Ambient Air Quality standards for criteria pollutants in 2020. Those include:

- <u>On-Road mobile sources</u>: For on-road light duty mobile sources, this includes Tier 2 vehicle emissions standards and the Gasoline Sulfur Program that affects SUVs pickups, and vans, which are now subject to same national emission standards as cars.
- <u>On-Road Heavy Duty Diesel Rule – Tier 4</u>: New emission standards on diesel engines starting with the 2010 model year for NOx, plus some diesel engine retrofits.

- Clean Air Non-Road Diesel Rule: Off-road diesel engine vehicle rule, commercial marine diesels, and locomotive diesels (phased in by 2014) require controls on new engines. Off-road large spark ignition engine rules affect recreational vehicles (marine and land-based).
- EGUs: CAIR second phase in place (in coordination with earlier NOx SIP call); Regional Haze Rule and guidelines for BART for reducing regional haze; CAMR all in place.
- Non-EGUs: Solid Waste Rules (Hospital/Medical Waste Incinerator Regulations).

CMAQ 2020 Maximum Feasible Scenario

The 2020 Maximum Feasible scenario includes additional aggressive EGU, industry, and mobile source controls. Emissions projections were developed that represented incremental improvements and control options (beyond 2020 CAIR) that might be available to states to meet a more stringent ozone standard. The more stringent standard is due to a reconsideration of the national ambient air quality standards for ozone that were promulgated in 2008 along with a review of the secondary national ambient air quality standards for oxides of nitrogen and sulfur. The new ozone standard was proposed in 2010 of between 0.070 ppm and 0.060 ppm. EPA now expects that the ozone standards will be final by the end of July 2011. The 2020 Maximum Feasible Scenario was designed to meet a 0.070 ppm ozone standard, which is less than the 0.075 ppm ozone standard in place since 2008.

Incremental control measures for five sectors were developed:

- EGUs: lower ozone season nested emission caps in OTC states; targeting use of maximum controls for coal fired power plants in or near non-attainment areas.
- Non-EGU point sources: new supplemental controls, such as low NOx burners, plus increased control measure efficiencies on planned controls and step up of controls to maximum efficiency measures, e.g., replacing SNCRs (Selective Non-Catalytic Reduction) with SCRs (Selective Catalytic Reduction) control technology.
- Area (nonpoint area) sources: switching to natural gas and low sulfur fuel.
- On-Road mobile sources: increased penetration of diesel retrofits and continuous. Inspection and maintenance using remote onboard diagnostic systems.
- Non-Road mobile sources: increased penetration of diesel retrofits and engine rebuilds.
- Reduced NOx emissions from marine vessels in coastal shipping lanes.

The 2020 Maximum Feasible Scenario also includes a reduction of ammonia deposition of 15 percent from estimated ammonia emission programs in the Bay watershed jurisdictions. Estimates of up to about 30 percent ammonia emission reductions from manures can be achieved through rapid incorporation of manures in to soils at the time of application, biofilters on poultry houses, and other management practices (Mark Dubin 2009, personal communication). From a state and sector analysis of NOx emissions and deposition, an estimated 50 percent of emissions from Bay states becomes deposition to the Chesapeake Bay watershed, along with a further 50 percent of the ammonia deposition load coming from outside the Bay watershed. Assuming that only 50 percent of the emissions are from watershed sources, a 30 percent reduction of emissions results in an estimated 15 percent decrease in wet and dry ammonia deposition for the Maximum

Feasible Scenario from ammonia emission control management practices in the Bay watershed jurisdictions.

CMAQ 2030 Scenario

The 2030 scenario is in some areas a further decrease in emissions beyond the 2020 Maximum Feasible Scenario due to continuing fleet replacement of heavy diesels, off road diesels, and mobile sources of all types. These emission decreases are offset by continued growth in the Chesapeake Bay region. The emissions projections assume continued stringent controls are in place, such as:

- Tier 2 vehicle emissions standards fully penetrated in the fleet.
- Heavy Duty Diesel vehicle fleet fully replaced with newer heavy-duty vehicle that comply with new standards.
- On-Road mobile sources: Increased penetration of diesel retrofits maintained.
- Non-Road mobile sources capped at 2020 Maximum Feasible Scenario levels.
- EGUs and Non-EGUs emissions capped at 2020 Maximum Feasible Scenario levels.
- Area sources emissions capped at 2020 Maximum Feasible Scenario levels, assuming energy efficiency and control efficiencies keep up with growth.
- Marine Vessels: Further reductions in NOx emissions from marine vessels in coastal shipping lanes.

Atmospheric Deposition Loads to the Watershed and Tidal Bay

Nitrogen loads atmospherically deposited to the Chesapeake Bay watershed by jurisdiction and by nitrogen species of wet and dry deposition for key scenarios are tabulated in Table L-3. Table L-4 lists the loads delivered to the Bay from the key scenarios, in millions of pounds, using the Phase 5.2-August 2009 version of the Chesapeake Bay Watershed Model.

All the scenarios in Table L-4 use the 2002 scenario as a base year. The point sources, human and animal populations, septic system loads and so on, are the same 2002 levels in all these scenarios. Only the atmospheric deposition changes. The 1985 CMAQ scenario uses the trend of atmospheric deposition described in Figure L-2, and the same trend was used for the 2002 atmospheric deposition in the 2002 scenario. The scenarios of 2010, 2020, 2020 Maximum Feasible, and 2030 used estimated atmospheric deposition loads from the CMAQ model.

Atmospheric Deposition of Nitrogen to the Tidal Chesapeake Bay

The regression and CMAQ models provide estimates of direct atmospheric deposition to the Bay's tidal surface waters. Table L-5 lists the estimates of direct atmospheric deposition to the Bay's tidal surfaces for seven key scenarios.

Two key factors in the relative increase in the estimated reduced nitrogen deposition over time are the downward pressure on oxidized nitrogen emissions and the lack of controls on ammonia emissions. It is notable that changes in atmospheric chemistry of SO_X and NO_X in the seven key

Table L-3. Atmospheric deposition loads of nitrogen (millions of pounds as nitrogen) to the Chesapeake watershed for key scenarios by jurisdiction

	STATE							**Chesapeake Watershed**
Total Nitrogen	**DE**	**DC**	**MD**	**NY**	**PA**	**WV**	**VA**	
1985 Scenario	7.8	0.8	97.4	53.7	221.7	30.6	179.8	591.8
1985-2000 Calibration	7.1	0.7	84.0	46.0	192.2	26.2	159.3	515.4
2002 Scenario	6.5	0.6	73.0	39.5	167.3	22.5	142.3	451.6
2010 Scenario	6.3	0.5	59.6	30.6	133.3	17.2	112.8	360.2
2020 Scenario	6.6	0.4	54.6	26.2	117.6	15.3	99.9	320.6
2020 Maximum Feasible	6.5	0.4	51.9	24.8	111.2	14.5	95.0	304.3
2030 Scenario	7.4	0.4	56.9	26.1	121.4	15.4	100.0	327.6
Dry NOx Deposition								
1985 Scenario	3.1	0.5	51.0	23.1	102.1	15.7	97.5	293.0
1985-2000 Calibration	2.6	0.4	42.2	19.2	84.9	13.1	83.2	245.4
2002 Scenario	2.2	0.3	35.2	16.2	71.3	10.9	71.8	207.8
2010 Scenario	1.6	0.2	23.1	10.8	46.2	6.7	46.7	135.4
2020 Scenario	1.3	0.1	16.6	7.9	32.5	4.8	33.3	96.5
2020 Maximum Feasible	1.1	0.1	14.3	6.9	28.2	4.2	29.6	84.5
2030 Scenario	1.0	0.1	13.7	6.7	27.0	4.1	28.9	81.6
Dry NH_3 Deposition								
1985 Scenario	2.1	0.1	12.2	5.0	25.3	2.9	18.2	65.8
1985-2000 Calibration	2.2	0.1	12.1	4.7	25.3	2.8	18.5	65.7
2002 Scenario	2.3	0.1	12.1	4.5	25.4	2.8	18.7	65.7
2010 Scenario	3.0	0.1	15.8	5.3	32.0	3.7	24.8	84.7
2020 Scenario	3.7	0.1	18.7	5.6	36.5	4.4	29.2	98.3
2020 Maximum Feasible	3.9	0.1	19.4	5.8	37.2	4.5	29.8	100.7
2030 Scenario	4.8	0.1	23.9	6.6	45.5	5.2	34.0	120.3
Wet NOx Deposition								
1985 Scenario	1.6	0.1	22.2	17.0	63.4	8.1	42.0	154.4
1985-2000 Calibration	1.3	0.1	17.9	13.9	51.7	6.6	35.4	126.9
2002 Scenario	1.1	0.1	14.1	11.0	40.9	5.2	29.4	101.8
2010 Scenario	0.7	0.1	9.4	7.3	26.7	3.4	19.6	67.2
2020 Scenario	0.6	0.0	7.2	5.3	19.3	2.5	14.7	49.6
2020 Maximum Feasible	0.5	0.0	6.4	4.7	16.9	2.2	13.3	44.1
2030 Scenario	0.5	0.0	6.2	4.6	16.7	2.2	13.0	43.3
Wet NH_3 Deposition								
1985 Scenario	0.9	0.1	12.0	8.7	30.9	3.9	22.0	78.6
1985-2000 Calibration	1.0	0.1	11.8	8.2	30.3	3.7	22.3	77.4
2002 Scenario	1.0	0.1	11.7	7.8	29.7	3.6	22.5	76.4
2010 Scenario	1.0	0.1	11.3	7.3	28.3	3.5	21.7	73.0
2020 Scenario	1.0	0.1	12.0	7.4	29.2	3.6	22.7	76.1
2020 Maximum Feasible	1.0	0.1	11.8	7.4	28.9	3.6	22.4	75.1
2030 Scenario	1.1	0.1	13.0	8.1	32.2	3.9	24.1	82.4

Source: Phase 5.2-August 2009 Version of the Chesapeake Bay Watershed Model
Note: This table does not include the 15 percent decrease in wet and dry ammonia deposition for the Maximum Feasible scenario due to ammonia emission.

scenarios also affect ammonia dry deposition. In the scenarios with decreased SO_X and NO_X emissions, the dry deposition of ammonia increases, even though the total nitrogen deposition is decreasing. The interplay of how decreased SO_X and NO_X emissions affect an increase of NH_3 dry deposition is seen in Figure L-9.

Table L-4. Total nitrogen delivered to the Bay (millions pounds per year) from the nine major river basins under different key CMAQ atmospheric deposition scenarios.

Basins	CMAQ Atmo. Deposition 1985 Scenario	CMAQ Atmo. Deposition 2002 Scenario	CMAQ Atmo. Deposition 2010 Scenario	CMAQ Atmo. Deposition 2020 Scenario	CMAQ Atmo. Deposition 2020 Maximum Feasible Scenario	CMAQ Atmo. Deposition 2030 Scenario
Susquehanna	160.4	148.1	141.4	138.7	137.6	139.3
West Shore	15.7	15.3	15.07	15.0	14.9	15.0
Potomac	77.0	72.2	69.4	68.3	67.9	68.6
Patuxent	4.8	4.5	4.4	4.3	4.3	4.3
Rappahannock	11.0	9.8	10.0	9.8	9.8	9.8
James	37.9	36.7	35.6	35.2	35.	35.1
York	9.3	8.9	8.6	8.4	8.4	8.4
East Shore MD-DE	31.6	29.8	29.2	29.2	29.1	29.7
East Shore VA	3.0	2.9	2.8	2.8	2.8	2.8
Total	350.7	328.1	316.5	311.7	309.7	313.0

Note: All the scenarios were applied to a 2002 Base condition of land use, BMPs, and point source discharges in order to show the relative effect of changing atmospheric deposition.

Table L-5. Direct atmospheric deposition loads of nitrogen (millions of pounds as nitrogen) to Chesapeake Bay's tidal surface waters for seven key scenarios

Scenario	Wet NOx Deposition	Dry NOx Deposition	Wet NH3 Deposition	Dry NH3 Deposition	Total Inorganic Nitrogen Deposition	Wet Organic Nitrogen Deposition	Total Nitrogen Deposition	Wet PO4 Deposition	Wet Organic Phosphorus Deposition	Total Phosphorus Deposition
1985 Scenario	6.57	13.15	3.34	1.97	25.03	1.05	26.08	0.33	0.98	1.31
2002 Scenario	4.81	10.04	3.57	2.12	20.54	1.05	21.59	0.33	0.98	1.31
2010 Scenario	3.27	6.85	3.49	2.76	16.37	1.05	17.42	0.33	0.98	1.31
2020 Scenario	2.56	5.11	3.72	3.24	14.63	1.05	15.68	0.33	0.98	1.31
2020 Maximum Feasible Scenario	2.30	4.48	3.64	3.41	13.83	1.05	14.88	0.33	0.98	1.31
2020 Max Feas w/ 15% NH4 Drop	2.30	4.48	3.09	2.90	12.77	1.05	13.82	0.33	0.98	1.31
2030 Scenario	2.22	4.30	3.96	4.08	14.56	1.05	15.61	0.33	0.98	1.31

Note: This table includes two entries for the Maximum Feasible Scenario. The 2020 Max Fes w/15% NH4 Drop scenario includes the 15% decrease in wet and dry ammonia deposition for the Maximum Feasible Scenario due to ammonia emission control management practices in the Bay watershed jurisdictions described in CMAQ 2020 Maximum Feasible Scenario; the 2020 Maximum Feasible Scenario does not.

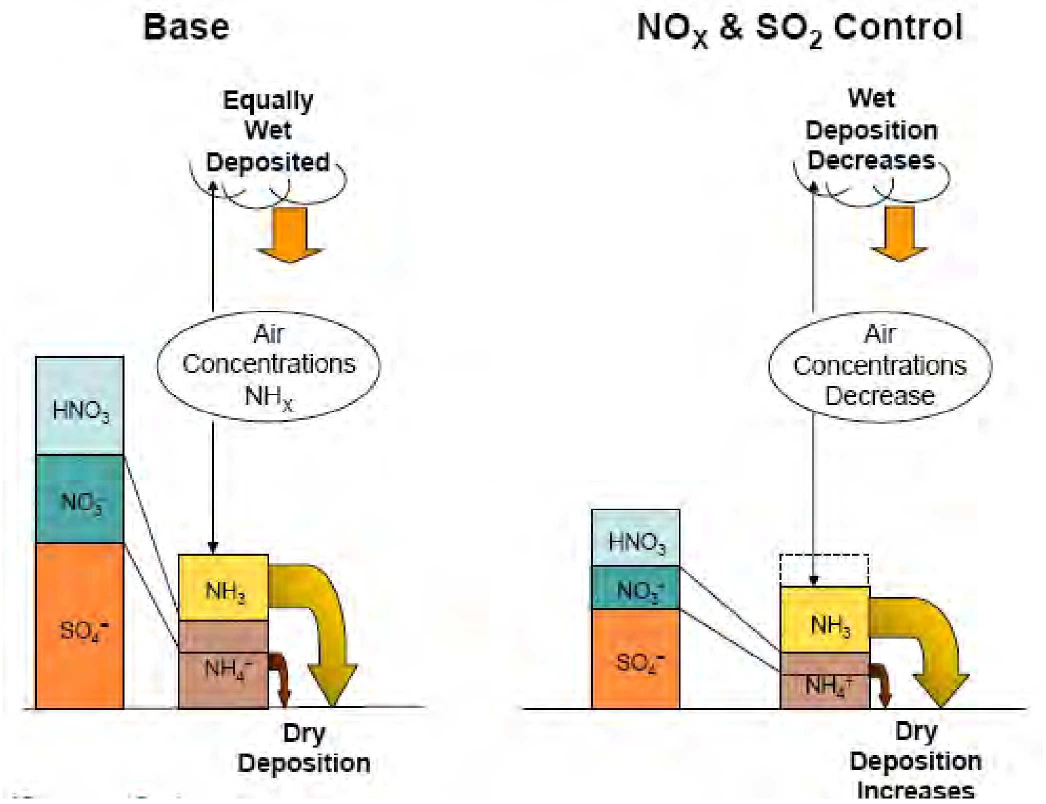


Figure L-9. Decreased SO_X and NO_X emissions cause increased NH_3 dry deposition.

How the percentage of ammonia, or reduced atmospheric deposition, to total nitrogen deposition is changing can be seen in Table L-5. For the 1985 Scenario, the percent ammonia deposition compared to the total DIN deposition was estimated to be 21 percent. For the 2010 and 2030 scenarios, the percentage of ammonia deposition to the tidal Chesapeake was estimated to increase to 38 percent for the 2010 scenario and 55 percent for the 2030 scenario. The respective estimated ammonia deposition on the watershed for these same three scenarios—1985, 2010, and 2030—are 24 percent, 44 percent, and 64 percent.

Atmospheric Deposition of Nitrogen to the Coastal Ocean

The CMAQ Model allows us to estimate atmospheric deposition loads to the coastal ocean at the mouth of the Chesapeake Bay, which contributes to the coastal ocean nutrient budgets made by others (Fennel et al. 2006; Howarth et al. 1995; Howarth 1998). The estimated distribution of 2001 atmospheric deposition loads to North America and adjacent coastal ocean is shown in Figure L-10. Howarth (1998) reported that atmospheric deposition loads are roughly equivalent to watershed loads in the northeast United States (Maine to Virginia). Howarth (1998) estimated that the watershed inputs of nitrogen to the northeast coastal waters to be 0.27 teragram. Inputs from direct atmospheric deposition to coastal waters are 0.21 teragram, and inputs from deep ocean upwelling are 1.54 teragrams, for a total input to the coastal ocean of 2.02 teragrams (Howarth 1998).

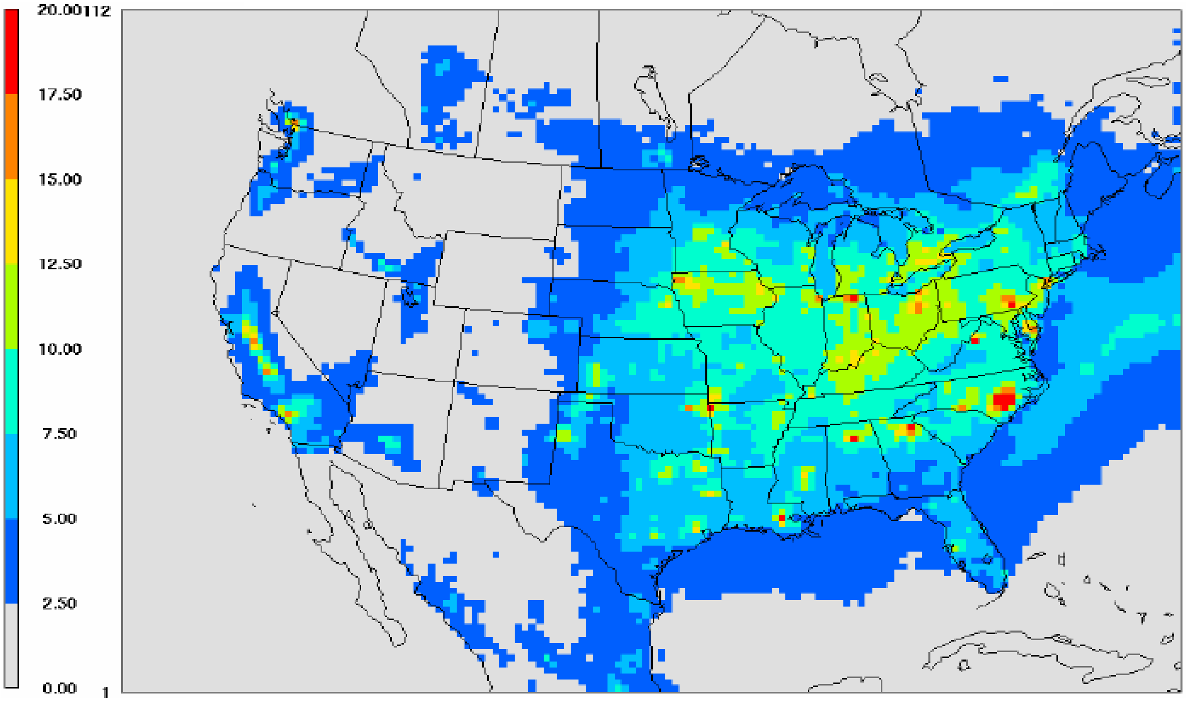


Figure L-10. Estimated 2001 annual total deposition of nitrogen (kg-N/ha) to North America and adjacent coastal ocean based on outputs from the CMAQ Air Quality Model, 36 km x 36 km grid.

That has implications for the fixed-ocean boundary condition used in the Chesapeake Bay Water Quality Sediment Transport Model. Atmospheric deposition total nitrogen loads to the coastal ocean are estimated to be about 6.63 kg/ha in the Base Case 2002 scenario (Table L-6). That correlates to 43.8 million kilograms of total nitrogen deposition to a region of the ocean that can exchange waters with the Chesapeake (Table L-6). In the case of the 2020 Maximum Feasible scenario, the nitrogen atmospheric deposition to the same region is estimated to be 29.4 million pounds, a reduction of 32 percent. If that same reduction is extrapolated to the coastal ocean, the direct atmospheric inputs to the coastal ocean would decrease to 0.14 teragram. Assuming the watershed loads discharged to the ocean and the deep upwelling pelagic loads are constant, that would give a combined watershed, direct deposition, and uncontrollable deep upwelling load of 1.95 teragrams, a decrease of 3 percent relative to the estimated current ocean boundary condition. Table L-6 lists the estimated reductions of the ocean boundary for the five key CMAQ scenarios.

Table L-6. Atmospheric deposition loads of nitrogen (kg per hectare) to the coastal water area shown in Figure L-11 for key scenarios

Scenario	Dry deposition	Wet deposition	Total deposition
Base 2002 Scenario	3.32	3.31	6.63
2010 Scenario	2.59	2.68	5.27
2020 Scenario	2.26	2.49	4.75
2020 Maximum Feasible	2.10	2.35	4.45
2030 Scenario	2.13	2.40	4.53

To determine CMAQ estimates of atmospheric deposition to the coastal ocean region affecting nitrogen loads through the ocean boundary EPA assigned boundaries as shown in Figure L-11 that correspond to the proximate region of the coastal ocean exchanging waters with the Chesapeake Bay. The boundary is adjacent to the shore, and is inside, or west, of the Gulf Stream. To account for the prevailing north to south current along the coast, the coastal ocean boundary includes more of the coastal waters north of the Chesapeake Bay mouth.

Estimated atmospheric deposition loads to the coastal waters are listed in Table L- 7 for key scenarios. The loads to the coastal ocean in kilograms per hectare for the CMAQ Base 2002 scenario are shown in Figure L-12. Table L-8 lists the relative reduction of atmospheric deposition of nitrogen in coastal waters versus the Base Calibration scenario.

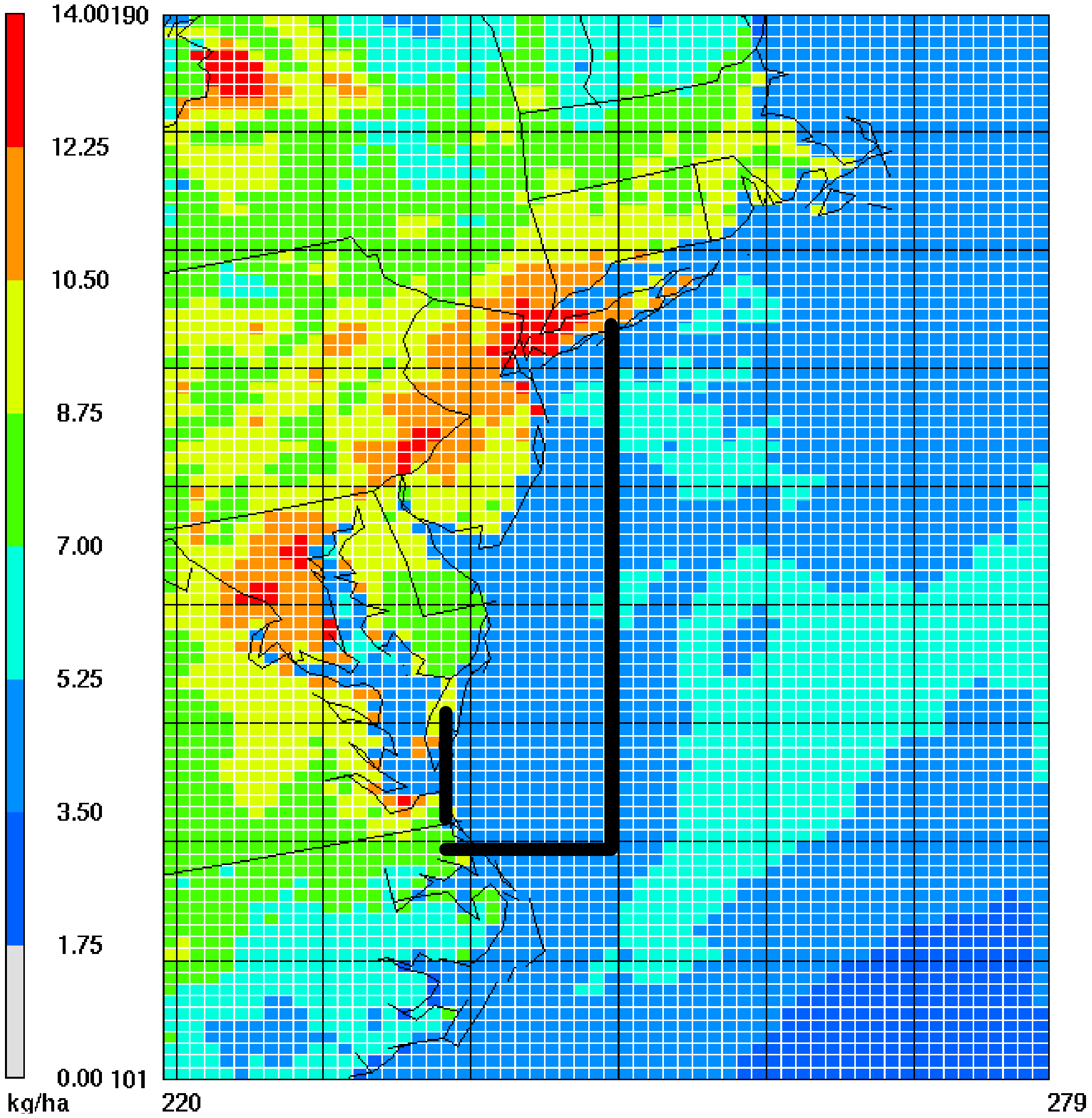


Figure L-11. Boundaries of the coastal ocean region used to adjust the ocean boundary conditions in the Chesapeake Bay WQSTM.

Table L-7. Total atmospheric deposition loads of nitrogen (millions of kg) to coastal waters for key scenarios

Scenario	Dry deposition	Wet deposition	Total deposition
Base 2002 Scenario	21.90	21.89	43.80
2010 Scenario	17.12	17.71	34.82
2020 Scenario	14.94	16.45	31.39
2020 Maximum Feasible	13.87	15.50	29.37
2030 Scenario	14.06	15.88	29.95

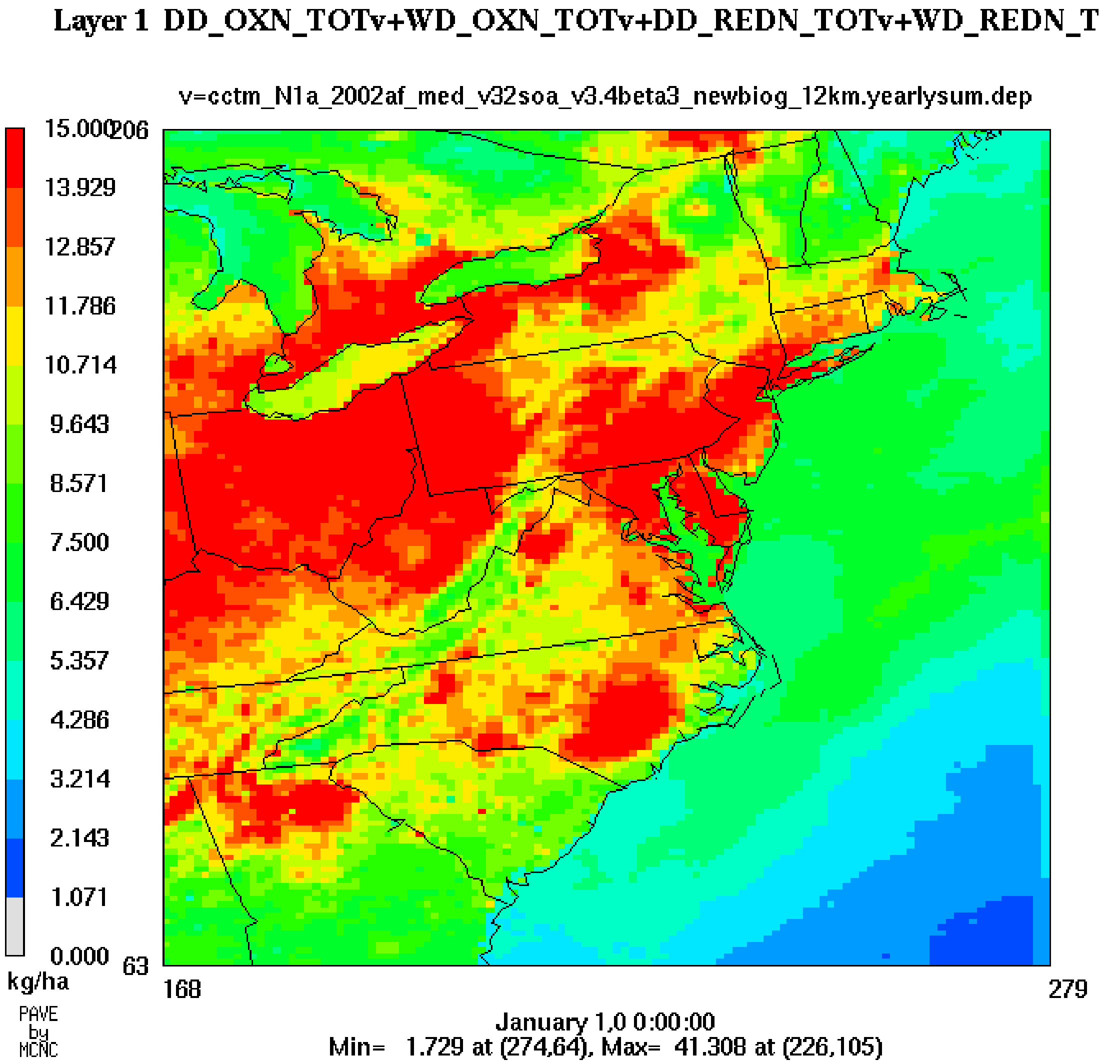


Figure L-12. Nitrogen atmospheric deposition loads (kg/ha) to the coastal ocean region for the Base 2002 scenario.

Table L-8. Adjustment of the ocean boundary load for all nitrogen species for key CMAQ Model scenarios' deposition to coastal waters adjacent to the Chesapeake Bay mouth

Scenario	% Reduction of ocean boundary
Base 2002 Scenario	0%
2010 Scenario	2.1%
2020 Scenario	2.9%
2020 Maximum Feasible	3.5%
2030 Scenario	3.3%

Adjustment of Ocean Boundary Concentrations in the WQSTM from Reductions in Atmospheric Deposition to Coastal Waters and Internal Bay Load Changes

Ocean boundary concentrations of the Bay Water Quality and Sediment Transport Model state-variables are set based on monthly observations at the Bay mouth water quality monitoring stations. The exchange of materials at the Bay mouth/ocean boundary follows the two layer flows of the estuary. Net outflow occurs predominantly at the upper and southern boundaries with the ebb tides, while net inflow occurs predominantly at the lower and northern boundaries. The ocean boundary values govern the inflowing flux of ocean nutrients and sediment to the Bay. Specifically, adjustments are made to the ocean boundary conditions to adjust for changes in loads in the Chesapeake and for changes in atmospheric deposition.

Adjustment of Nutrient Boundary Conditions Due to Load Reductions in the Chesapeake

Previous versions of the Bay Water Quality Model (8k grid version) found that a 90 percent reduction in nitrogen load from the watershed produced a 10 percent reduction in inflowing nitrogen concentration at the Bay mouth. Likewise, a 90 percent phosphorus load reduction produced a 5 percent reduction in inflowing phosphorus.

Accordingly, for each load reduction scenario, the percent reduction (or increase) of total nitrogen and total phosphorus loads in the entire Bay versus the Base Calibration scenario is calculated

TN reduction = 100 × (TN Base Calibration scenario – TN scenario) / TN Base Calibration scenario

TP reduction = 100 × (TP Base Calibration scenario – TP scenario) / TP Base Calibration scenario

EPA further calculates the following factors:

TN Factor = 1 – 0.1 × TN reduction/90

TP Factor = 1 – 0.05 × TP reduction/90

EPA then uses the TN factor and TP factor to multiply the Base Calibration ocean boundary concentrations of all the nitrogen and phosphorus nutrient species in each boundary cell, with the only exception of the cells in the southern boundary, because the southern Bay cells have predominantly outflows. No adjustments are made to ocean boundary sediment because it responds do different dynamics, and the source of the ocean input is primarily from courser particles entrained in the southbound long-shore current.

Adjustment of Nutrient Boundary Conditions from Atmospheric Deposition Load Reductions in the Coastal Shelf

If a load reduction scenario involves reducing nitrogen load from the atmosphere, a further adjustment in the boundary conditions is done. A reduction of nitrogen atmospheric deposition on the coastal ocean adjacent to the Chesapeake Bay causes reductions of nitrogen concentrations in the shelf waters and thereby, reduction to inputs of nitrogen to the Bay.

For example, with the 2020 Clean-Air scenario, the reduction of atmospheric deposition of nitrogen versus the Base Calibration scenario in the shelf waters is 0.029 (Table L-8). In that case, the ocean boundary TN factor is further reduced by the third term on the right-hand side of the following equation:

$$\text{TN Factor} = 1 - 0.1 \times \text{TN reduction}/90 - 0.029 \times 26/32$$

In the above formula, the 0.029 is multiplied with a ratio of 26 to 32. That is based on the average salinity at the boundary to be 26 ppt, and the average salinity of shelf waters to be 32 ppt. The ratio of 26 to 32 represents the ratio of the incoming ocean water over the sum of the incoming water and the freshwater going out the boundary (i.e., the mixing water at the boundary).

Allocation of Atmospheric Deposition of Nitrogen to Tidal Waters

In determining the allowable loading from air deposition, EPA separated the nitrogen deposition into two discreet parcels: (1) deposition occurring on the land and non-tidal waters which is subsequently transported to the Bay, also called indirect deposition; and (2) atmospheric deposition occurring directly onto the Bay’s tidal surface waters also called direct deposition (Figure L-13).

The deposition on the land becomes part of the allocated load to the jurisdictions because the air deposition on the land becomes mixed with the nitrogen loadings from the land based sources and, therefore, becomes indistinguishable from land based sources. Furthermore, once the nitrogen is deposited on the land, it would be managed and controlled along with other sources of nitrogen that are present on that parcel of land. That is also called the referenced allocation as Clean Air Act mandates nationwide reductions, as estimated in the CMAQ 2020 scenario, are required to reduce the air deposition to the watershed and are assumed to be in place as the Bay watershed jurisdictions finalize and implement their Watershed Implementation Plans to reduce nitrogen loads further with land-based Best Management Practices (BMPs). In contrast, the nitrogen deposition directly to the Bay’s tidal surface waters is a direct loading with no land-based management controls and, therefore, needs to be linked directly back to the air sources and air controls as EPA’s allocation of atmospheric nitrogen deposition.

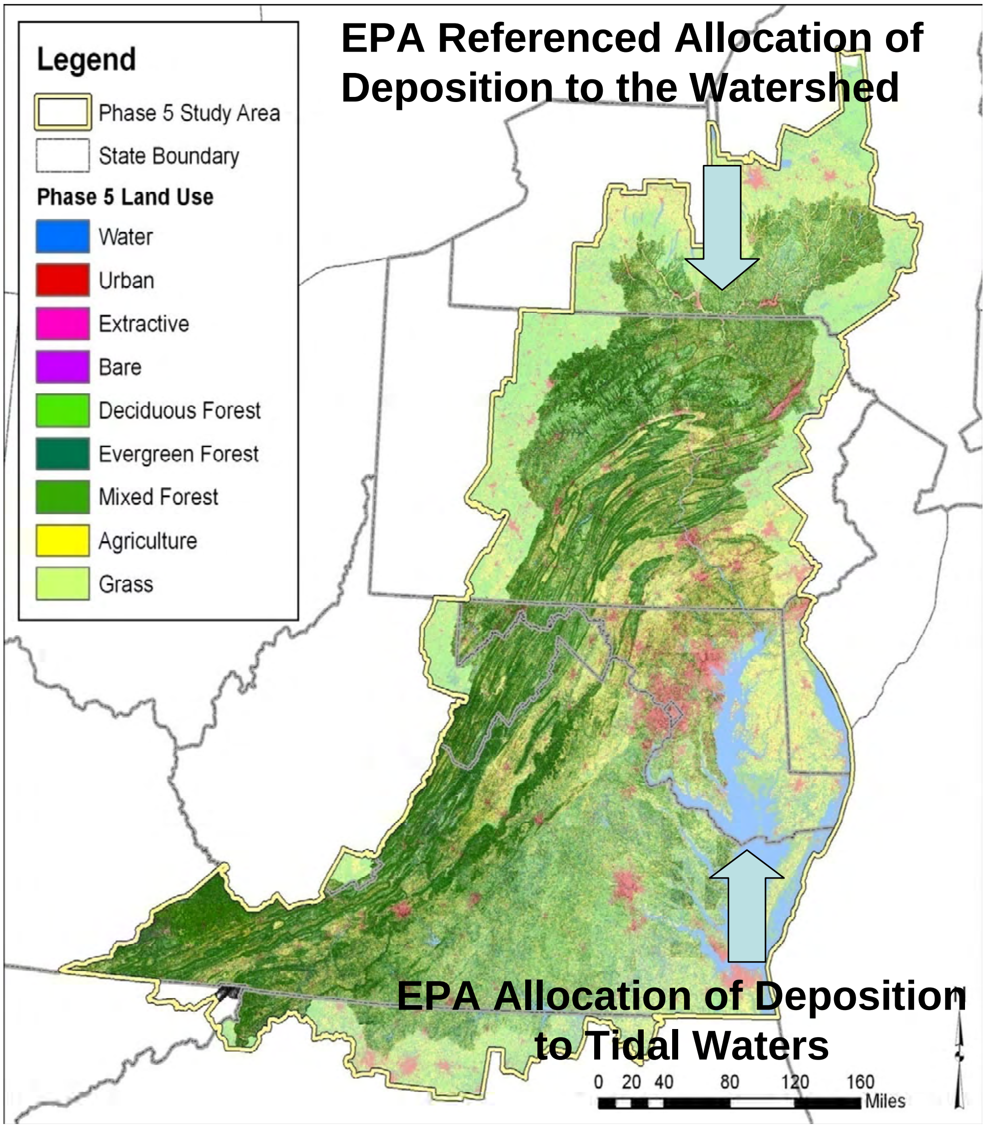


Figure L-13. EPA's reference allocation of nitrogen atmospheric deposition to the Bay watershed and the allocation of nitrogen atmospheric deposition direct to Bay's tidal surface waters.

EPA included an explicit basinwide nitrogen allocation, which was determined to be 15.7 million pounds of atmospheric deposition loads direct to Chesapeake Bay and tidal tributary surface waters. Activities associated with implementation of federal Clean Air Act regulations by EPA and the jurisdictions through 2020 will ensure achievement of this allocation. This nitrogen atmospheric deposition allocation is already accounted for within the jurisdiction and major river basin nitrogen allocations. Any additional nitrogen reductions realized through more stringent air pollution controls at the jurisdictional level, beyond federal requirements to meet air quality standards, may be credited to the individual jurisdictions through future revisions to the jurisdictions' Watershed Implementation Plans, 2-year milestones, and the Chesapeake Bay TMDL tracking and accounting framework.

In determining the amount of air controls to be used as a basis for the air allocation, EPA relied on current laws and regulations under the Clean Air Act. These requirements, together with national air modeling analysis, provided the resulting allocated load to air from direct deposition to the tidal waters of the Bay and its tidal tributaries.

The air allocation scenario represents emission reductions due to regulations implemented through the Clean Air Act authority to meet National Ambient Air Quality Standards for criteria pollutants in 2020. The air allocation scenario includes:

- The CAMR.
- The BART used for reducing regional haze, and the off-road diesel and heavy duty diesel regulations.
- On-Road mobile sources: For On-Road Light Duty Mobile Sources this includes Tier 2 vehicle emissions standards and the Gasoline Sulfur Program, which affects SUVs pickups, and vans, which are now subject to same national emission standards as cars.
- On-Road Heavy Duty Diesel Rule – Tier 4: New emission standards on diesel engines starting with the 2010 model year for NOx, plus some diesel engine retrofits.
- Clean Air Non-Road Diesel Rule: Off-road diesel engine vehicle rule, commercial marine diesels, and locomotive diesels (phased in by 2014) require controls on new engines.
- EGUs: CAIR second phase in place (in coordination with earlier NOx SIP call).
- Non-EGUs: Solid Waste Rules (Hospital and Medical Waste Incinerator Regulations).

The controls described above were modeled using the national air models (CMAQ) and the amount of deposition direct to the Chesapeake Bay's tidal surface waters was determined. On the basis of the air allocation scenario as described above, the nitrogen deposition direct to tidal surface waters is 15.7 million pounds per year. Therefore, the air allocation for the Chesapeake Bay TMDL is 15.7 million pounds per year of nitrogen.

EPA anticipates that the loading cap of 15.7 million pounds of atmospheric deposition loads direct to Chesapeake Bay and tidal tributary surface waters will be achieved through implementation of federal Clean Air Act regulations by EPA and the states through 2020. Projected reductions in atmospheric deposition loads to the surrounding watershed over this same period are already accounted for within the individual jurisdiction and major river basin nitrogen load allocations. Any additional nitrogen reductions realized through more stringent air pollution controls at the jurisdiction level, beyond minimum federal requirements, as for example in ammonia deposition reductions, may be credited to the individual jurisdictions through future revisions to the jurisdictions' Watershed Implementation Plans, 2-year milestones and the Bay TMDL tracking and accounting framework.

Crediting the States with Additional Air Controls

As mentioned above, it is possible, that individual or statewide air emission reductions, beyond those used to derive the air deposition allocation may be achieved by a state. In this case, for the purpose of evaluating the 2-year milestone progress, the state can be credited with the reductions that would result for its portion of the Chesapeake Bay watershed. EPA will use the following steps to determine, with the state, the amount of nitrogen credit to apply to air emission controls that go beyond the air allocation scenario described above.

1) Determine whether the emission source for which the state is seeking credit already assessed credit for reductions in the State's State Implementation Plan (SIP) for achieving the State's air quality standards)

All of the Chesapeake Bay Watershed states are in nonattainment of current air quality standards. When new air quality standards for ozone are complete in July 2011, the gap between current air quality conditions and air quality standard achievement is expected to grow. Since the Chesapeake Bay Program tracks the SIP management actions in an ongoing series of scenarios designed to track expanded SIP implementation in the watershed and credit these additional air reductions in the two-year milestones, the inclusion of air emissions reductions that are already captured in the SIP will double count the reduction. Examples of air reductions that are not in the SIPs are reductions in any ammonia emissions and reductions in NOx emissions that are not needed for air quality standard achievement.

2) Determine whether the emission reduction is a state-wide emission or point source

Currently only a state-wide source emission reduction can be applied in the Phase I Watershed Implementation Plans. As modeling capacity to handle air to water trading develops, the capability to handle the specificity of latitude and longitude of point source emissions that are being reduced will be applied in the Chesapeake models.

3) Determine if the emission controls will impact NOx and/or NH_3 emission

There are situations in some air management actions where, for example, a NOx point source emission is reduced, which in turn reduces the ammonia slip emissions (ammonia slip occurs with NOx control technologies). States might be provided additional credit if both are reduced.

4) Determine the annual average emission reduction

Estimates are needed of the emission reduction on an annual average basis, and whether the emission reduction occurs year round or is seasonal. Estimates of current emissions, which serve as a baseline for the reduction, are also needed.

It should be noted that the reduction in nitrogen loads to the Bay can be orders of magnitude less than the actual reduction in air emissions. Operationally, the emission reductions could be discounted by the following:

1. Discounting the mass of NO_2 measured in air programs to the "as N" units used in water programs and in the WIP
2. Discounting for what is deposited within the State from the emissions reduced based on a CMAQ State and sector analysis (also, the reduced deposition in other States will be calculated if operationally possible)
3. Discounting for estimated attenuation from the land
4. Discounting for estimated attenuation in the rivers.

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Appendix M.
Chesapeake Bay Water Quality/Sediment Transport Model Management Scenario Criteria Attainment Assessment Results and 2008 303(d) List Assessment Results

This appendix presents the Chesapeake Bay water quality criteria attainment assessment results of various Chesapeake Bay Water Quality and Sediment Transport Model (Bay Water Quality Model) management scenarios in the stoplight format used by the U.S. Environmental Protection Agency and its partner jurisdictions in developing the Chesapeake Bay TMDL. The stoplight spreadsheets summarize the percentage of space and time exceeding the four Bay jurisdictions' water quality criteria for each of the 92 Chesapeake Bay segments. The spreadsheets are produced from an assessment of Bay Water Quality Model outputs and Bay water quality monitoring data as described in Sections 6.2.4 and 6.4.4. The spreadsheets were used to evaluate whether a management scenario met all applicable criteria across all designated use-segments. Green highlighted percentages represent attainment of the applicable water quality standards. Red highlighted percentages represent a violation or an exceedance of applicable water quality standards. The assessment results provided in this appendix are in three spreadsheets:

- Appendix M-1: Chesapeake Bay Dissolved Oxygen Criteria Attainment Assessment Results (AppendixM1_DO_Stoplight.xls)
- Appendix M-2: Chesapeake Bay Chlorophyll *a* Criteria Attainment Assessment Results (AppendixM2_Chlor_Stoplight.xls)
- Appendix M-3: Chesapeake Bay SAV/Water Clarity Criteria Attainment Assessment Results (AppendixM3_SAV-Clarity_Stoplight.xls)

The loading values in appendices M-1 and M-2 were derived in one of two ways. Loading values for the 1985 Scenario, 2009 Scenario, Tributary Strategy, and E3 2010 Scenario were derived from explicit management scenarios and described further in Appendix J. Loading values for the remaining scenarios were calculated as ratios of existing management scenarios to achieve particular basinwide loading targets.

This appendix also contains the Chesapeake Bay segments 2008 303(d) list assessment results spreadsheet.

Interpreting the Spreadsheets

Appendix M-1: Chesapeake Bay Dissolved Oxygen Criteria Attainment Assessment Results

The dissolved oxygen water quality criteria stoplight plots describe the degree of nonattainment (as percent of volume and time) of dissolved oxygen water quality criteria for each Chesapeake Bay segment by designated use criteria. The dissolved oxygen criteria attainment assessment results are based on assessing the open-water 30-day mean, deep-water 30-day mean, and deep-channel instantaneous minimum criteria during the June 1 through September 30 summer period (see Table 3-4 in Section 3.1.2). The green highlighted percentages represent attainment of the applicable dissolved oxygen criterion. The red highlighted percentages represent nonattainment of dissolved oxygen criterion. The rows show the percent nonattainment by Bay segment. The columns show the percent nonattainment by the respective Bay Water Quality Model scenario and are listed from left to right in descending order of loading values for total nitrogen (TN), total phosphorous (TP), and total suspended solids (TSS). The Bay Water Quality scenarios are grouped by 3-year water quality model assessment windows and are ordered chronologically. The Bay Water Quality Model scenarios marked with an asterisk (*) had loading values derived from the key management scenario spreadsheets (see Appendix J). All other scenarios' loading values were calculated as ratios of existing management scenarios to achieve particular basinwide loading targets. The critical period for the Chesapeake Bay TMDL was selected as 1993–1995 for assessment of the dissolved oxygen criteria (see Section 6.2.1).

Appendix M-2: Chesapeake Bay Chlorophyll a Criteria Attainment Assessment Results

The chlorophyll *a* water quality criteria stoplight plots show the percent nonattainment of chlorophyll *a* (CL) criteria by two periods: CL Spring Seasonal (March 1 through May 31) and CL Summer Seasonal (July 1 through September 30). The green highlighted percentages represent attainment of chlorophyll *a* criteria. The red highlighted percentages represent nonattainment of chlorophyll *a* criteria. The rows show percent nonattainment by Bay segment. The columns show the percent attainment by Bay Water Quality Model scenario and are listed from left to right in descending order by loading values for TN and TP. The Bay Water Quality Model scenarios are grouped by 3-year water quality model assessment windows and are ordered chronologically. For the allocation scenarios specific to the James River Basin, loading values were calculated as ratios of existing management scenarios to achieve particular loading targets. Analyses failed to identify a critical period for the chlorophyll *a* water quality criteria, so all 3-year periods had equal weight in the Bay TMDL assessment (see Section 6.2.1).

Appendix M-3: Chesapeake Bay SAV/Water Clarity Criteria Attainment Assessment Results

The submerged aquatic vegetation (SAV)/water clarity stoplight spreadsheets describe the degree of nonattainment (as percent of SAV acreage + water clarity acres—see Section 6.4.4 and Appendix P) of SAV/water clarity criteria for each of the Bay segments assigned a shallow-water bay grass designated use. The green highlighted percentages represent the percent nonattainment of SAV/water clarity criteria. The red highlighted percentages represent the percent nonattainment of SAV/water clarity criteria. The rows show the percent nonattainment by Bay segment. The columns show the percent nonattainment by Bay Water Quality Model scenario and are listed from left to right in descending order of loading values for TN, TP, and TSS.

The Bay Water Quality scenarios are grouped by 3-year water quality model assessment windows and are ordered chronologically. The Bay Water Quality Model scenarios marked with an asterisk (*) had loading values derived from the key management scenario spreadsheets (see Appendix J). All other scenarios' loading values were calculated as ratios of existing management scenarios to achieve particular basinwide loading targets. The critical period for the Chesapeake Bay TMDL was selected as 1993–1995 for assessment of the SAV/water clarity criteria (see Section 6.4.1).

Appendix M-4: Chesapeake Bay Segments 2008 303(d) List Assessment Results

The following are short descriptions of the information/data in each column in the Appendix M-4 Chesapeake Bay segments 2008 303(d) list assessment results spreadsheet (AppendixM4_Bay_Segments_2008_303d.xls). Green means the criterion/designated use was attained; red means the criterion/designated use was not attained; and yellow means insufficient data for criterion assessment or no published criteria assessment protocol. The key to each lettered column of information and data are as follows:

A: Chesapeake Bay segment

B: Jurisdiction

C: Designated used: MSN-migratory spawning and nursery; SWSAV-shallow-water bay grass, OW- open water; DW-deep-water; DC-deep-channel

D: Season for criteria application: Summer-June 1 through September 30; Rest of year (ROY)-October 1 through May 31

E: 30-day mean dissolved oxygen criterion with the value being the applicable criterion

F: 7-day mean dissolved oxygen criterion with the value being the applicable criterion

G: 1-day mean dissolved oxygen criterion with the value being the applicable criterion

H: Instantaneous minimum dissolved oxygen criterion with the value being the applicable criterion

I: Temperature based dissolved oxygen criterion protective of shortnose sturgeon (species listed as endangered)

J: Numerical chlorophyll *a* criteria assessment results

K: SAV restoration acreage criteria assessment results with the value being the applicable SAV restoration acreage

L: Water clarity acreage assessment results

M: Combined SAV restoration acreage + water clarity acreage assessment results

N: Water clarity criteria assessment results

O: Description of criteria attainment assessment results by designated use-segment

P: 303(d) listing category

Q: Benthic community impairment status

Appendix N.
Resolution of Segments Failing to Attain the Jurisdictions' Water Quality Standards

Segments failing to attain the Dissolved Oxygen Standards

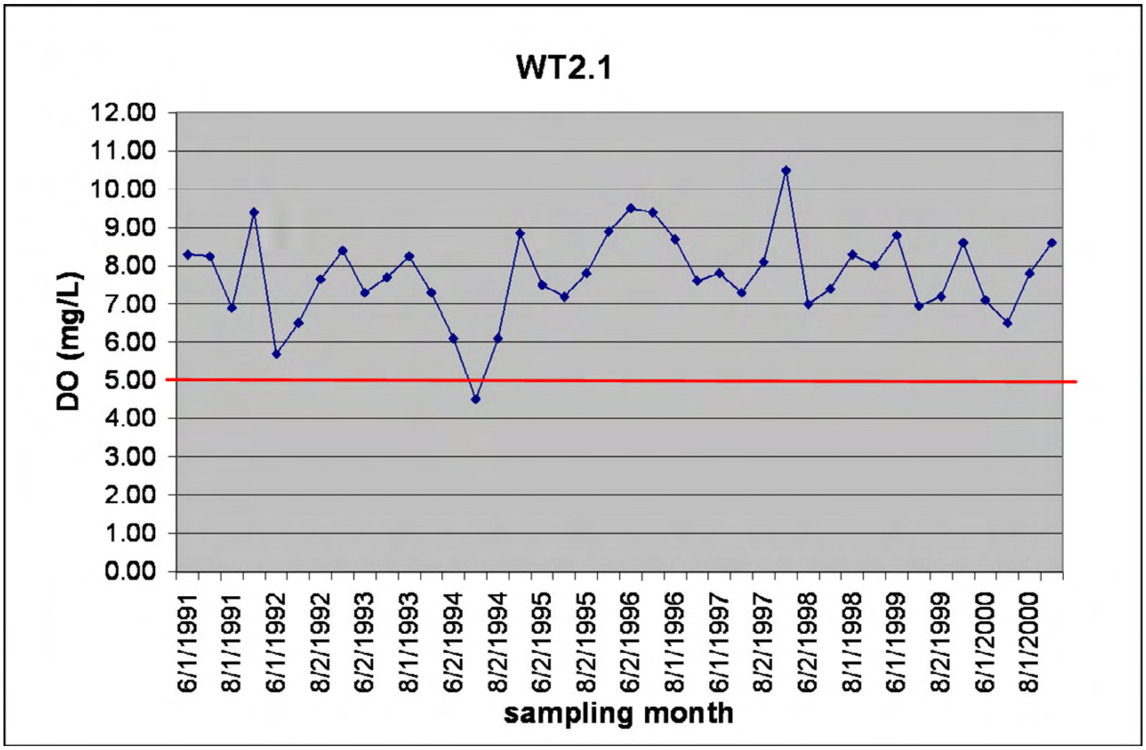
In the process of determining the target nitrogen and phosphorous load allocations, it was observed that in a limited number of Chesapeake Bay segments, poor dissolved oxygen (DO) conditions appeared to persist even under scenarios of dramatically reduced nitrogen and phosphorous loads. A series of systematic diagnostic analyses were conducted to determine the drivers of such persistent violations. The findings of those analyses, summarized in Section 6.4.4, are described in more detail here.

The most important analyses to explain the anomalous results in these segments were to determine whether the Chesapeake Bay Water Quality Model (WQM) effectively simulated historical conditions and improvement in those conditions with reduced loads. If the WQM was determined to be non responsive in the affected Bay segments, additional lines of evidence were explored to determine whether the apparent nonattainment represented an area of real concern, or whether those segments could reasonably be expected to show sufficient improvement to attain water quality standards (WQS) given the nitrogen and phosphorous load reductions. Each Bay segment was evaluated to determine the following:

1. Whether violations of the DO criteria were isolated or widespread
2. Whether the Chesapeake Bay WQM effectively simulated historical conditions and improvement in those conditions with reduced loads
3. Whether nearby Bay segments also exhibited persistent or widespread hypoxia (low to minimal DO levels)

Gunpowder River

The DO criteria nonattainment in the tidal Gunpowder River (GUNOH) was driven by two converging factors. First, the historical water quality DO monitoring data for this location show that the water in the Gunpowder River is generally well-oxygenated in the summertime, with only a single instance of hypoxia observed (July 1994) over the course of 10 consecutive summers from 1991 to 2000 that violated the open-water criterion of 5.0 milligrams per liter (mg/L) (red line in Figure N-1). Recall that the assessment process includes overlaying the improvement in water quality predicted by the model onto the observed water quality from the hydrologic period. For that reason, anomalous observed water quality measures can be critical to the assessment results.



Source: http://www.chesapeakebay.net

Figure N-1. Measurements taken in summer months (June–September) at water quality monitoring station WT2.1 in the Gunpowder River 1991–2000.

Second, the Bay WQM's simulations for this location, which ranged from about 8 to 10 mg/L, were only moderately higher than the average historical summertime conditions. However the Bay WQM did not simulate conditions below 8 mg/L in this region. Because no simulated hypoxia existed, there was no example of simulated improvement in DO concentrations with reduced nitrogen and phosphorous inputs for this region. With summertime DO concentrations at or above 8 mg/L, the Bay WQM generally simulated a minimal increase in DO concentrations in response to reduced nitrogen and phosphorous loads. That is in clear contrast to the Bay WQM's performance when hypoxic conditions are simulated under calibration (i.e., historical) conditions—for an example from the middle of the Chesapeake Bay, see Figure N-2. That figure is an example of a regression plot showing WQM performance consistent with historical observations. The pink symbols and line represent DO concentrations from the calibration scenario; the blue symbols and line represent DO concentrations under reduced nitrogen and phosphorous loads of the E3 Scenario. The range of DO concentrations in the calibration scenario spans the range of historical observations. Greater increase in DO concentrations is observed with reduced loads when the initial (calibration) concentrations are low. In those cases, the Bay WQM's predictions are consistent with empirical findings, namely, that hypoxic conditions will improve with reduced loads to a greater degree than will initially high DO concentrations.

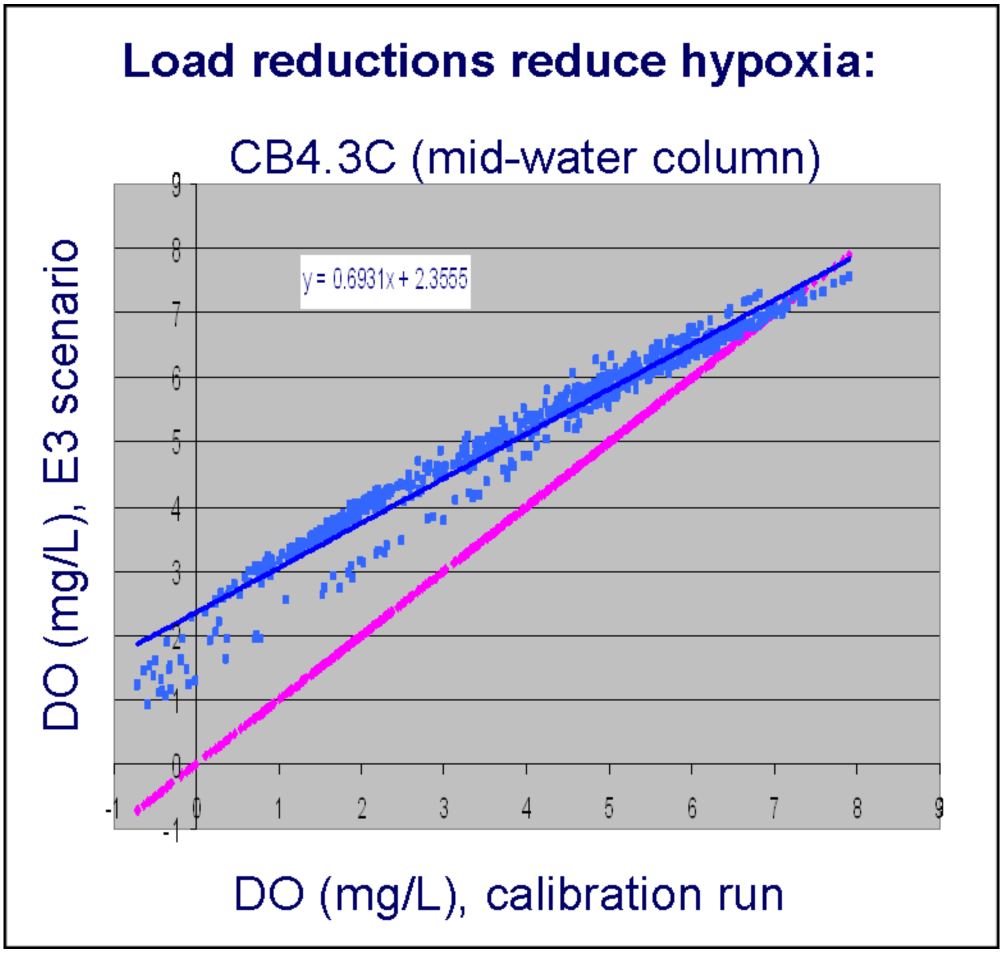


Figure N-2. Example of a regression plot showing Bay WQM performance consistent with historical water quality monitoring DO observations in the lower central Chesapeake Bay segment CB4MH at station CB4.3C.

The regression equation that is used to scenario-modify DO concentrations (for a description of the scenario-modification procedure, see Section 6.2.2) is generated from a comparison of DO concentrations simulated in the calibration scenario with those simulated in a management scenario such as E3. When little change is observed in DO concentrations between the two scenarios, the resulting regression equation reflects it (Figure N-3). When simulated DO concentrations are consistently at or above 8 mg/L in the calibration scenario, the Bay WQM generally does not show dramatic improvements in concentrations with reduced pollutant loads. Furthermore, when the resulting regression equation is applied to a DO concentration well outside the range of the simulated data, it can cause a *DO response* that does not accurately reflect the information provided by the Bay WQM.

In the case of Gunpowder River monitoring station WT2.1 for July 1994, the Bay WQM-simulated DO concentrations fell between about 8 and 10 mg/L for the calibration scenario as well as the numerous reduced loading *management* scenarios. In Figure N-3, the pink symbols and line represent the calibration scenario DO concentrations; the light blue symbols and black line show the change in DO concentrations from the calibration to the E3 scenario. The red arrows show the predicted change in an initial DO concentration of 4.5 mg/L. In that case, a historical observation of 4.5 mg/L was scenario-modified to a concentration of 4.4 mg/L for the E3 scenario.

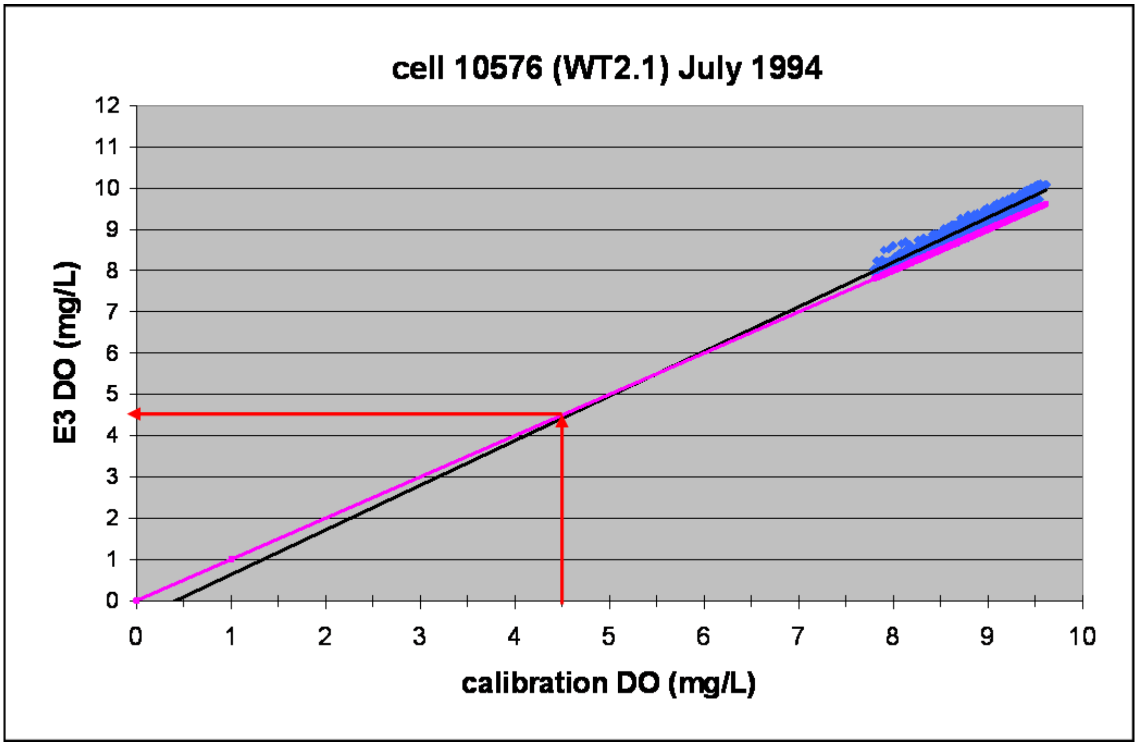
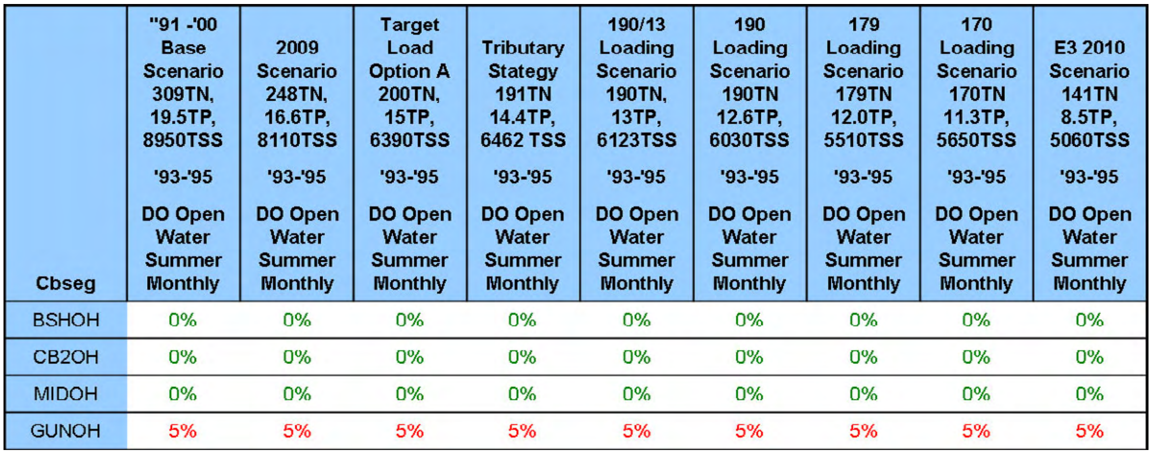


Figure N-3. Bay WQM scenario DO concentrations and regression for station WT2.1 in the Gunpowder River.

As is shown here, even at the *E3* scenario (for a description of management scenarios, see Appendix J) only a slight increase in DO concentrations is observed across the range of simulated concentrations. Typically, a greater response—in the form of higher DO concentrations—is observed when the initial (i.e., calibration) DO concentrations are low (i.e., less than 5 mg/L). In such a case, when the linear regression representing the relationship between the calibration and E3 DO concentrations is extrapolated far below the range of simulated conditions, the result suggests that under E3 conditions, hypoxia could actually get worse rather than better. That prediction is not an accurate representation of model simulations; rather it is the effect of extrapolating the regression equation well outside the range of the simulations from which it was generated. Such was the case for July 1994, when a historical observation of 4.5 mg/L was scenario-modified to a concentration of 4.4 mg/L under the dramatically reduced load conditions of the E3 scenario.

Examination of nearby segments—the Bush River (BSHOH), the upper Chesapeake Bay (CB2OH), and the Middle River (MIDOH)—showed attainment of DO WQS under historical loading conditions and under all load reduction scenarios (Figure N-4).



Cbseg	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Open Water Summer Monthly	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Open Water Summer Monthly	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Open Water Summer Monthly
BSHOH	0%	0%	0%	0%	0%	0%	0%	0%	0%
CB2OH	0%	0%	0%	0%	0%	0%	0%	0%	0%
MIDOH	0%	0%	0%	0%	0%	0%	0%	0%	0%
GUNOH	5%	5%	5%	5%	5%	5%	5%	5%	5%

Figure N-4. Open-water DO criteria attainment *stoplight plot* of the Gunpowder River segment GUNOH and nearby segments.

In summary, the incidence of hypoxia in the tidal Gunpowder River was isolated. In that single, isolated case, the Bay WQM was unable to provide information on the magnitude of expected improvement in DO conditions with reduced nitrogen and phosphorous loads in the region. Examination of nearby segments showed consistent attainment of DO WQS under historical (Base) and reduced loading scenarios. Therefore, it is reasonable to expect that the open-water designated use of GUNOH will attain DO WQS under the basinwide target allocation of 190 million pounds per year total nitrogen (TN) and 12.7 million pounds per year total phosphorus (TP).

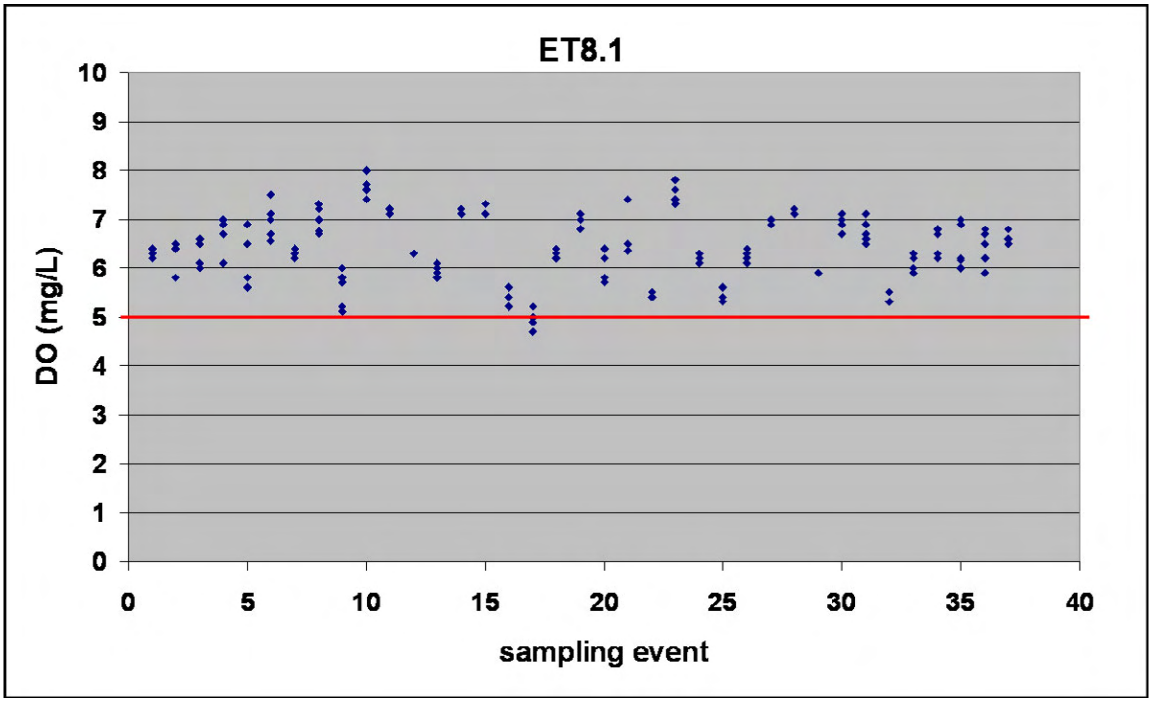
Manokin River

In the Manokin River (MANMH), violations of the segment's open-water DO WQS for the years 1991–2000 were limited to three measurements, ranging from 4.7 to 4.9 mg/L, taken during one sampling event in July 1995 (Figure N-5).

The isolated, marginal violations of the DO WQS under historical conditions were scenario-modified to greater nonattainment under simulated load reductions. At the same time, adjacent and nearby segments—Tangier Sound (TANMH), Big Annemessex River (BIGMH), and the lower Pocomoke River (POCMH)—all attained their respective DO WQS under historical conditions and reduced loading scenarios (Figure N-6).

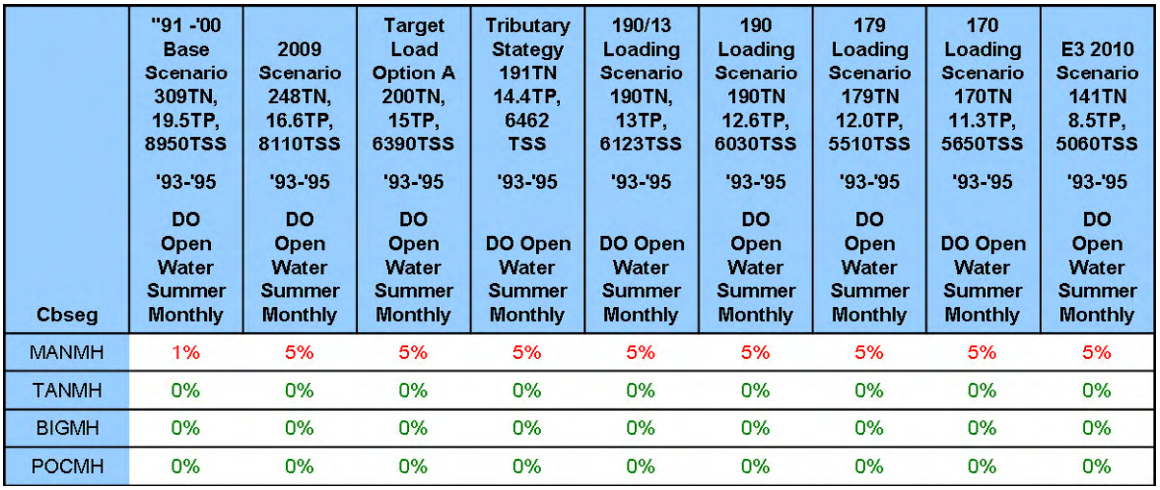
Further examination of the performance of the Bay WQM in the vicinity of water quality monitoring station ET8.1 (MANMH's single tidal monitoring station) showed lower—rather than higher—DO concentrations under reduced loading scenarios (Figure N-7).

The grid location that represents the Manokin River's single monitoring station is shallow and directly adjacent to the land. The highlighted cell (cell 6705) in Figure N-8 coincides with the location of long-term fixed station ET8.1. In such cases, the Bay WQM often struggles to integrate the multiple, interacting drivers of a parameter such as DO. Further investigation showed that chlorophyll *a* concentrations in cell 6705 decreased to zero (or less) at the E3 scenario (data not shown). If chlorophyll *a* concentrations had *increased* in concert with lower DO concentrations, a temporal anomaly in pollutant loads to cell 6705 or its vicinity would have been suspected. However, the combination of nonexistent chlorophyll *a* concentrations and low DO concentrations observed here indicates that the WQM struggled to integrate the effect of reduced loads on the feedbacks among multiple drivers of DO concentrations.



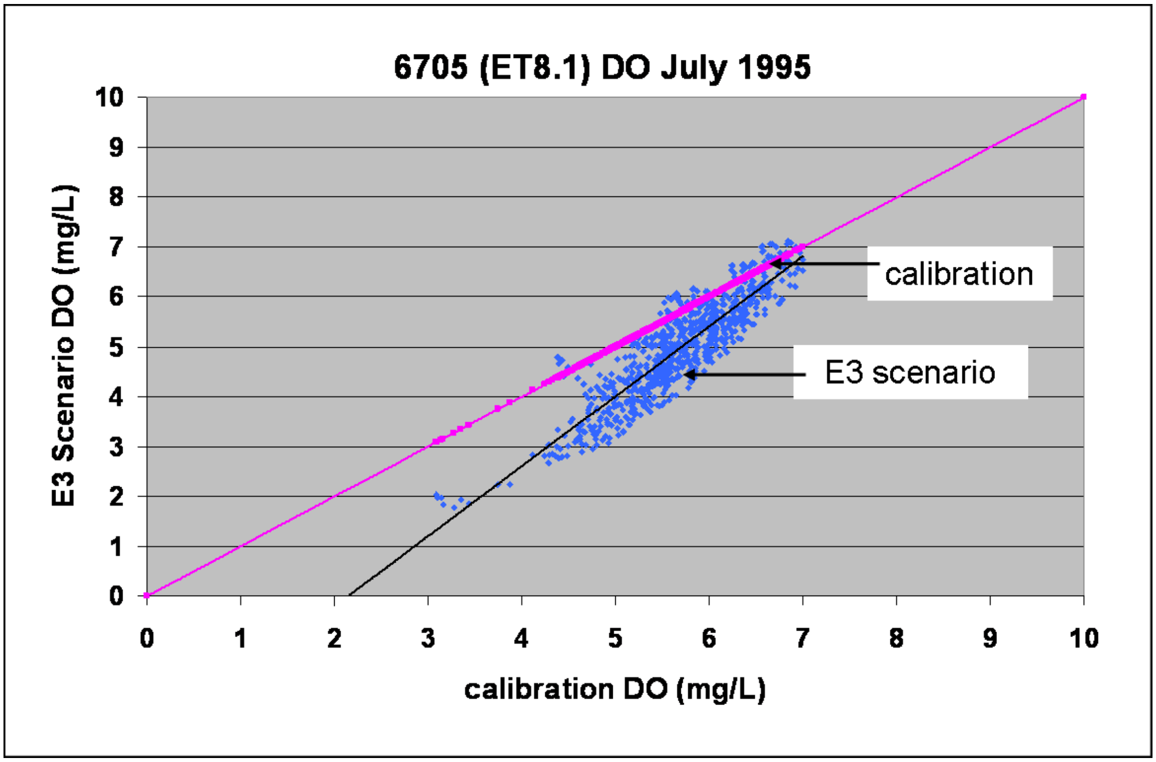
Source: http://www.chesapeakebay.net

Figure N-5. Summertime DO observations (dark blue symbols) at water quality monitoring station ET8.1 in the Manokin River 1991–2000.



Cbseg	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Open Water Summer Monthly	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Open Water Summer Monthly	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Open Water Summer Monthly
MANMH	1%	5%	5%	5%	5%	5%	5%	5%	5%
TANMH	0%	0%	0%	0%	0%	0%	0%	0%	0%
BIGMH	0%	0%	0%	0%	0%	0%	0%	0%	0%
POCMH	0%	0%	0%	0%	0%	0%	0%	0%	0%

Figure N-6. Open-water DO criteria attainment *stoplight plot* of the Manokin River segment MANMH and nearby segments.

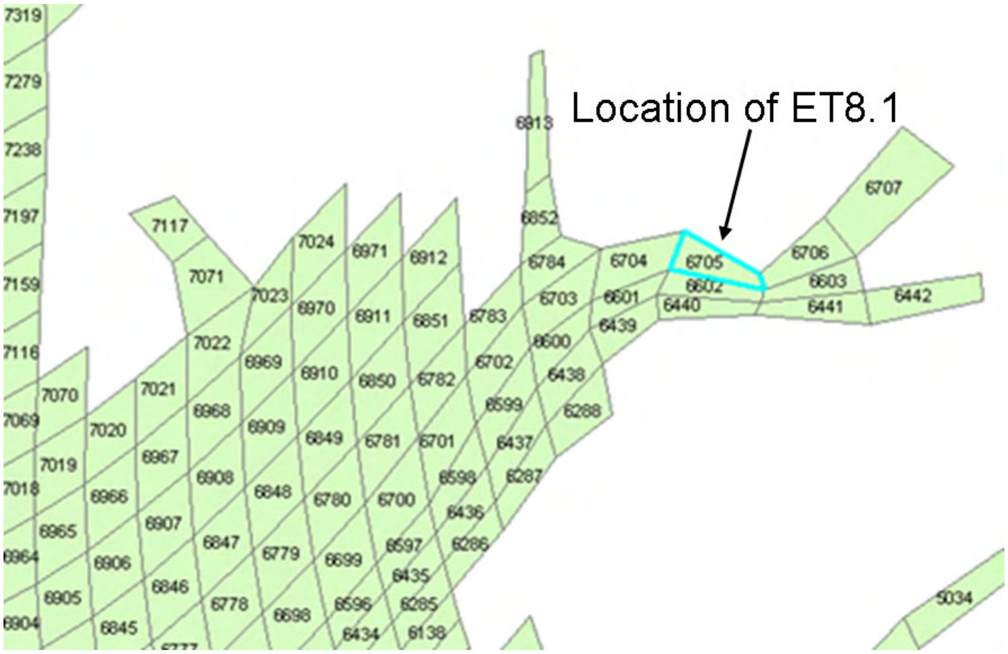


6705 (ET8.1) DO July 1995

calibration

E3 scenario

Figure N-7. Regression plot for the Bay WQM cell (6705) corresponding to the MANMH water quality monitoring station (ET8.1).



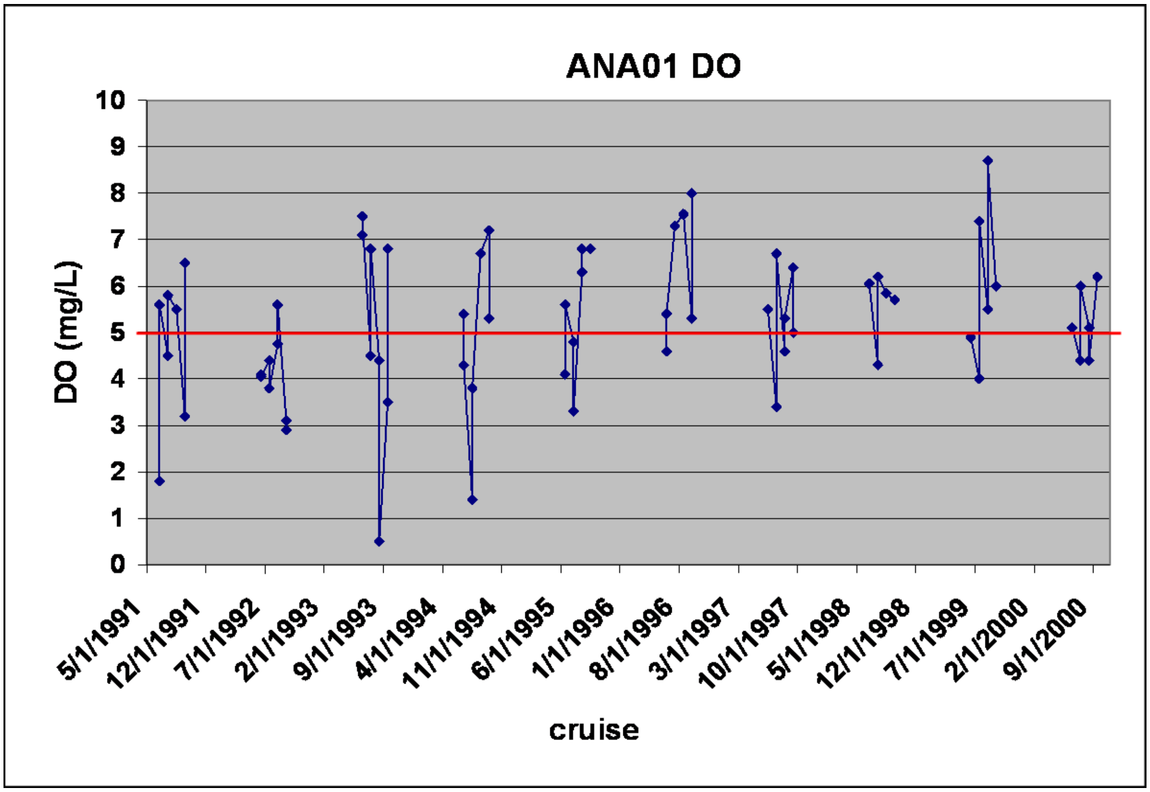
Location of ET8.1

Figure N-8. Chesapeake Bay WQM grid for the Manokin River and a portion of Tangier Bay.

Given the isolated nature of DO criteria violations in MANMH under historical conditions, the poor performance of the WQM, and the unimpaired nature of adjacent waterbodies under historical conditions and simulated reduced loadings, EPA concludes that it is reasonable to expect full attainment of the DO WQS in MANMH at the basinwide target allocation of 190 million pounds per year TN and 12.7 million pounds per year TP.

Maryland Portion of the Anacostia River

In the Maryland portion of the tidal Anacostia River (ANATF_MD), substantial violations of the segment's open-water DO WQS were observed historically, with particularly serious violations occurring at station ANA01 in August 1993 and July 1994 (Figure N-9).



Source: http://www.chesapeakebay.net

Figure N-9. Summertime water quality DO monitoring observations at Maryland's tidal Anacostia River water quality monitoring station ANA01 1991–2000.

Table N-1 shows the modeled DO violations under a model calibration scenario and under a lower loading scenario of 179 million pounds per year of nitrogen and 12 million pounds per year of phosphorus. The majority of the historical violations were estimated to improve substantially or even reach full attainment with further load reductions. However, for the two months during the critical period with the most serious violations—August 1993 and July 1994—no improvement in DO WQS nonattainment percentage was predicted (Table N-1).

Table N-1. Monthly open-water DO criteria nonattainment percentages for ANATF_MD in the 1993–1995 critical period

		violation rate	
year	month	calibration	179 TN, 12TP
1993	6	0.0%	0.0%
1993	7	20.3%	10.1%
1993	8	100.0%	100.0%
1993	9	53.6%	11.6%
1994	6	79.7%	0.0%
1994	7	100.0%	100.0%
1994	8	20.3%	0.0%
1994	9	20.3%	0.0%
1995	6	100.0%	0.0%
1995	7	100.0%	0.0%
1995	8	0.0%	0.0%
1995	9	0.0%	0.0%

For those months, EPA Chesapeake Bay Program Office (CBPO) analysts compared Bay WQM simulated DO concentration with historical water quality monitoring observations. For July 1994, model simulated DO concentrations at Bay WQM grid cell 6443—the location coincident with monitoring station ANA01—ranged from 7.2 to 13.0 mg/L. In contrast, monitoring observations for the same month ranged from 1.0 to 3.8 mg/L. Similar results were found for the month of August 1993, when Bay WQM-simulated DO concentrations for cell 6443 ranged from 7.5 to 15.5 mg/L while historical observations at the same location (ANA01) ranged from 0.5 to 4.4 mg/L. Because the Bay WQM did not simulate severe hypoxia in the region for those summer months, it was not able to provide a sufficient estimate of the magnitude of DO response to be expected with nitrogen and phosphorous load reductions.

CBPO analysts also considered the attainment status of the two downstream segments closest to ANATF_MD: the District of Columbia's portion of the Anacostia River (ANATF_DC) and the District's portion of the tidal Potomac River (POTTF_DC) (Figure N-10). Unlike segment ANATF_MD, ANATF_DC and POTTF_DC both attained their respective DO WQS at the target basinwide allocation of 190 million pounds per year TN and 12.7 million pounds per year TP.

Given the lack of Bay WQM fit in this segment and the Bay WQM-projected DO WQS attainment of the two segments immediately downstream, EPA concludes that it is reasonable to expect attainment of the DO WQS in Maryland's tidal Anacostia River at the basinwide target allocation of 190 million pounds per year TN and 12.7 million pounds per year TP.

In addition, EPA approved in June 2008, a established by Maryland and the District of Columbia. The TMDL will address any localized water quality impairments.

Cbseg	1985 Scenario 342TN, 24.1TP, 9790TSS '93-'95 DO Open Water Summer Monthly	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly
DCATF	38%	28%	10%	14%	1%	2%	1%
DCPTF	10%	1%	0%	0%	0%	0%	0%
MDATF	34%	39%	19%	18%	12%	12%	12%

Figure N-10. Open-water DO criteria nonattainment in ANANTF_MD MDATF and nearby Bay segments. TN, TP, and total suspended sediment loads (TSS) are in million pounds per year.

West Branch Elizabeth River

Violations of the DO WQS were not uncommon in the Western Branch of the Elizabeth River (WBEMH), particularly in the early half of the 1991–2000 decade. Violations of the 5.0 mg/L open-water DO criterion (red line in Figure N-11) were common during summer months, particularly at depths below 0.5 meter.

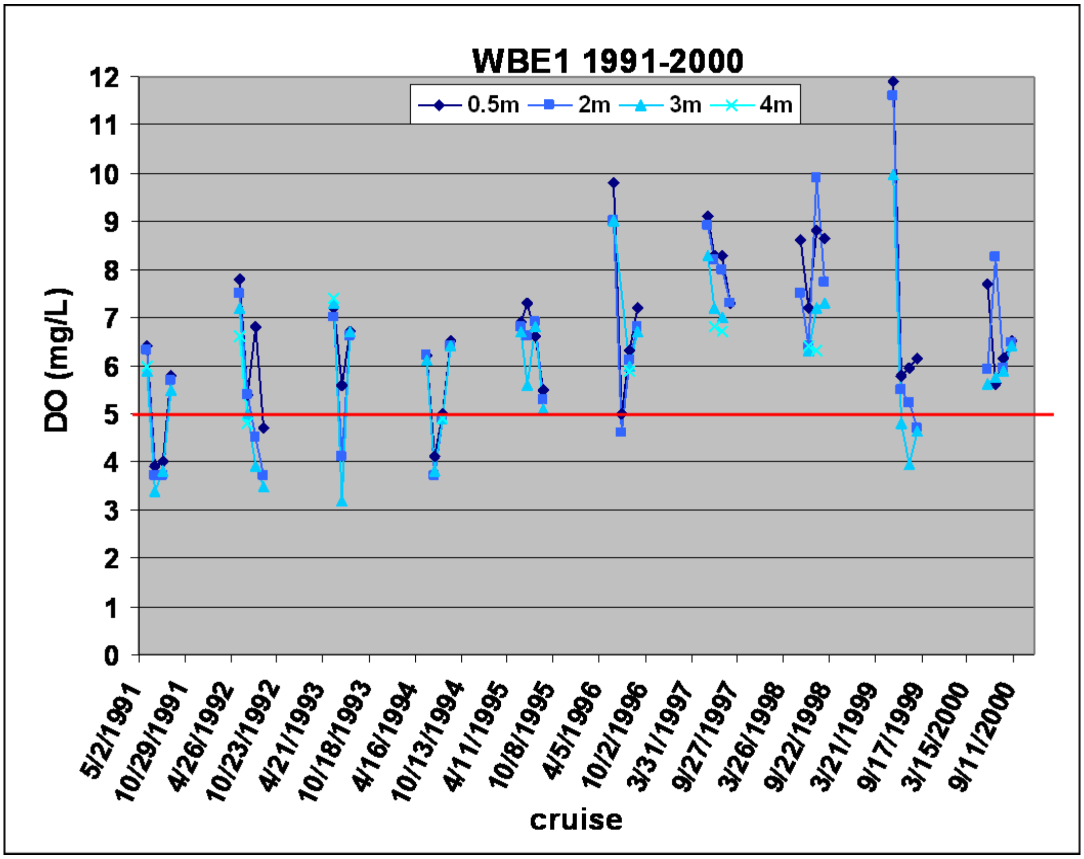


Figure N-11. Summertime DO concentrations observed at water quality monitoring station WBE1 in segment WBEMH 1991–2000.

Some of the violations improved with model-simulated load reductions such as those represented in Table N-2; however, for two months in particular—July 1993 and July 1994—no improvement in monthly violation rate was observed under scenario-modified conditions.

Table N-2. Monthly open-water DO criteria nonattainment percentages for water quality monitoring station WBE1 in the 1993–1995 critical period

year	month	violation rate	
		calibration	179TN, 12TP
1993	6	0.0%	0.0%
1993	7	45.9%	45.9%
1993	8	0.0%	0.0%
1994	6	0.0%	0.0%
1994	7	100.0%	100.0%
1994	8	49.2%	0.0%
1994	9	0.0%	0.0%
1995	6	0.0%	0.0%
1995	7	0.0%	0.0%
1995	8	0.0%	0.0%
1995	9	0.0%	0.0%

Further investigation of model performance in WBEMH showed that the Bay WQM failed to simulate the range of DO concentrations observed at WBE1 for either of these months. While the Bay WQM consistently simulated concentrations greater than 7 mg/L for the Bay WQM cell at station WBE1, monitoring observations for the same month and year were below 5.0 mg/L. In Figure N-12, the pink symbols represent DO concentrations for the calibration scenario; blue symbols and line represent DO concentrations and linear regression for the 179 TN, 12 TP load reduction scenario. Dark blue symbols represent DO observations for July 1994 at depths ranging from 0.5 to 3 meters.

As described for previous segments, when the range of Bay WQM simulations falls in this range, the model fails to provide an estimate of improvement in hypoxic conditions with load reductions.

When Bay WQM simulations do not span the range of hypoxic conditions observed, additional lines of evidence such as the attainment of nearby segments are considered in determining the necessity for further load reductions. In the case of WBEMH, adjacent and nearby segments attained their respective open-water DO WQS at or before the basinwide target nitrogen and phosphorous allocations (Figure N-13).

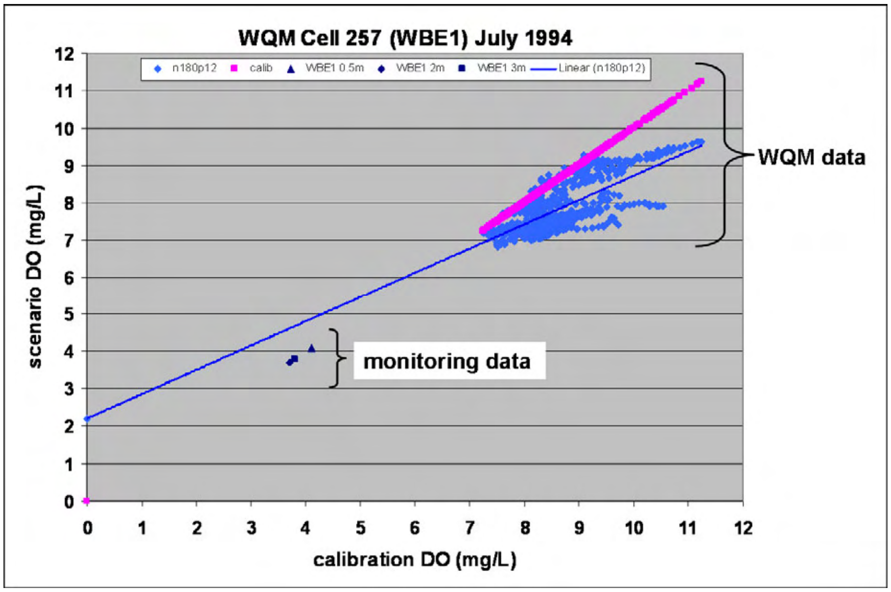
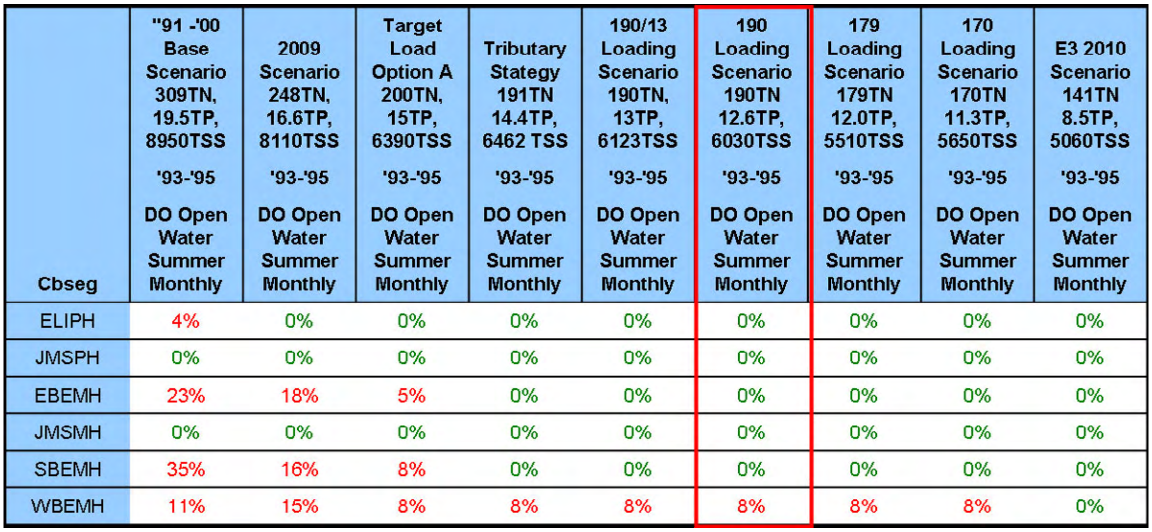


Figure N-12. Chesapeake Bay WQM simulations at WQM cell 257 and observations at water quality monitoring station WBE1 for July 1994.



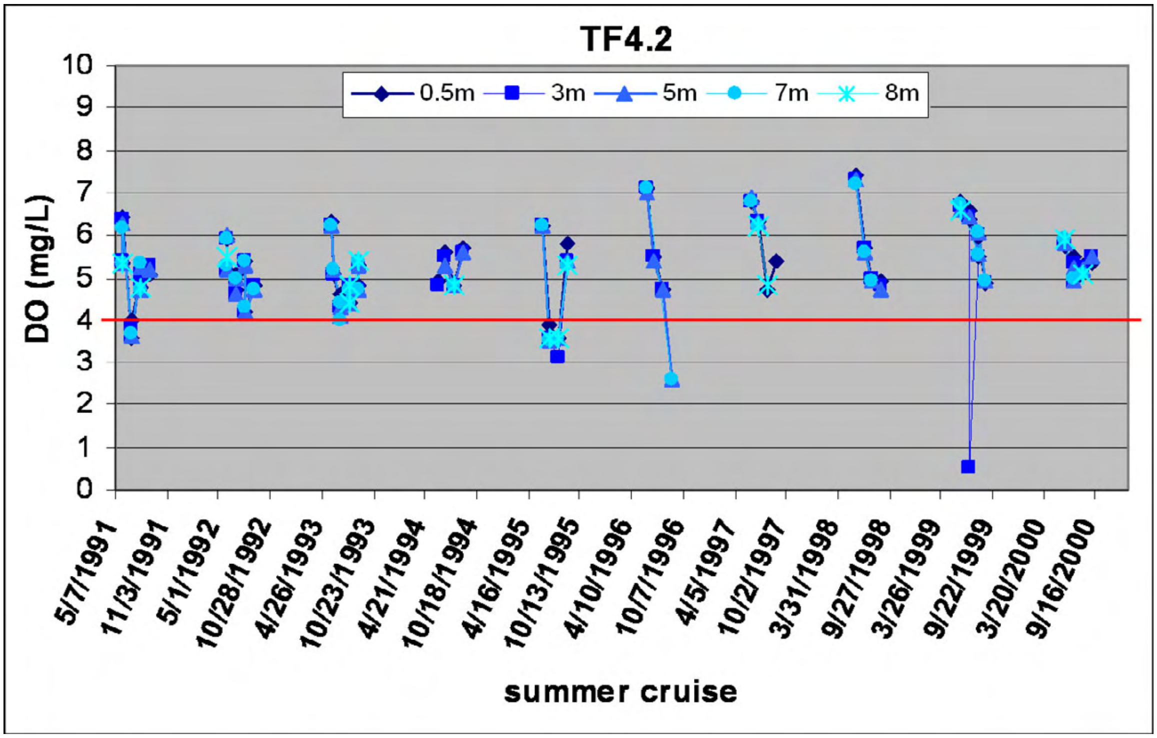
Cbseg	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Open Water Summer Monthly	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Open Water Summer Monthly	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Open Water Summer Monthly
ELIPH	4%	0%	0%	0%	0%	0%	0%	0%	0%
JMSPH	0%	0%	0%	0%	0%	0%	0%	0%	0%
EBEMH	23%	18%	5%	0%	0%	0%	0%	0%	0%
JMSMH	0%	0%	0%	0%	0%	0%	0%	0%	0%
SBEMH	35%	16%	8%	0%	0%	0%	0%	0%	0%
WBEMH	11%	15%	8%	8%	8%	8%	8%	8%	0%

Figure N-13. Attainment of the open-water DO WQS for WBEMH and nearby Bay segments under progressively stringent load reduction scenarios.

While the periodic occurrence of hypoxia in the Western Branch of the Elizabeth River remains a matter of concern, in this case the WQM provided no information on the magnitude of response in DO concentrations to be expected with load reductions. Considering the attainment of DO WQS observed in adjacent segments well before the target basinwide allocation, EPA concludes that it is reasonable to expect attainment of the DO WQS in Western Branch of the Elizabeth River at the basinwide target allocation of 190 million pounds per year TN and 12.7 million pounds per year TP.

Upper Pamunkey River

DO concentrations at station TF4.2 in the upper Pamunkey River (PMKTF) occasionally violated this segment's open-water DO criterion of 4.0 mg/L (Figure N-14). Violations during the 1993–1995 critical period were moderate and limited to the summer of 1995.



Source: http://www.chesapeakebay.net

Figure N-14. Summertime monitored DO concentrations (mg/L) at station TF4.2 in segment PMKTF.

A closer look at DO violations occurring in July and August of 1995 (Table N-3) showed that while DO concentrations in August improved sufficiently to attain WQS with simulated load reductions, no improvement was observed in the July 1995 violation rate.

Investigation of the Bay WQM-derived regression for July 1995 revealed that as with other small tidal tributaries discussed in this section, simulated DO concentrations for the calibration scenario did not match historical observations for the same month and location in the upper Pamunkey River. In Figure N-15, DO concentrations for the 190 TN, 12.7 TP load reduction scenario (blue symbols and linear regression line) showed little or no improvement compared with those of the calibration scenario (pink symbols). DO concentrations for both scenarios were greater than those observed at station TF4.2.

It is also worth noting that the observed violations were only marginally lower than the 4.0 mg/L criterion. Furthermore, the two segments immediately downstream from PMKTF—the lower Pamunkey River (PMKOH) and the mesohaline York River (YRKMH)—attained their respective open-water DO WQS at or before the target load allocation (Figure N-16).

Table N-3. Monthly open-water DO criteria nonattainment percentages for water quality monitoring station TF4.2 in segment PMKTF in the summer months of 1993-1995 critical period

year	month	violation rate	
		calibration	190 TN, 12.7 TP
1993	6	0.0%	0.0%
1993	7	0.0%	0.0%
1993	8	0.0%	0.0%
1993	9	0.0%	0.0%
1994	6	0.0%	0.0%
1994	7	0.0%	0.0%
1994	8	0.0%	0.0%
1994	9	0.0%	0.0%
1995	6	0.0%	0.0%
1995	7	100.0%	100.0%
1995	8	100.0%	0.0%
1995	9	0.0%	0.0%

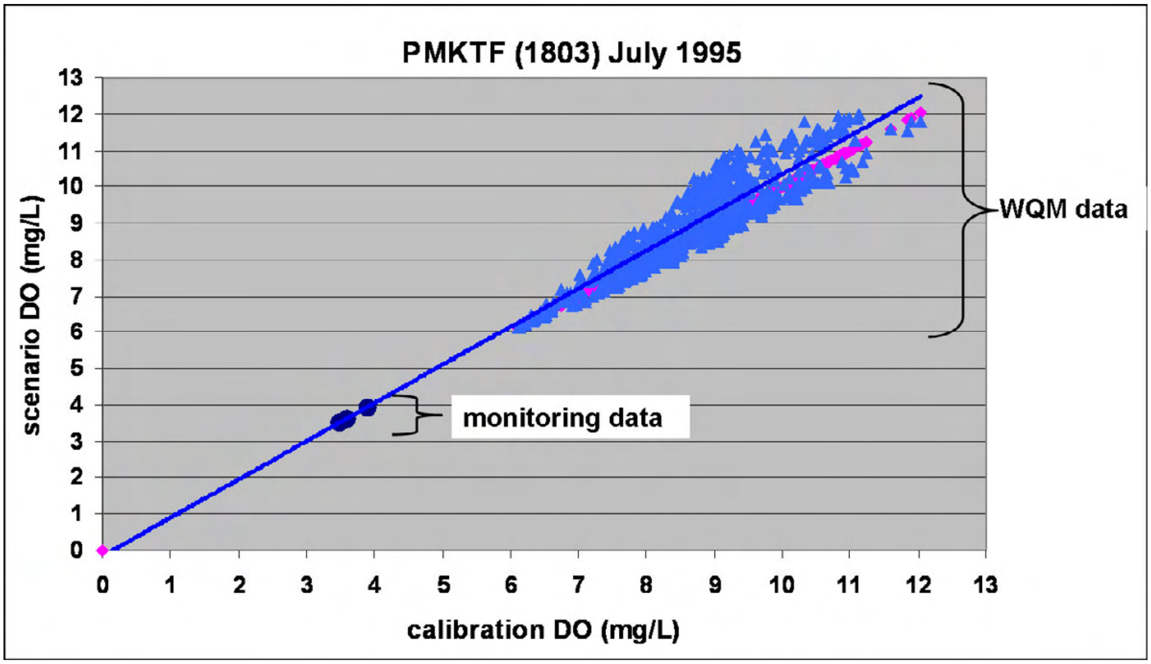
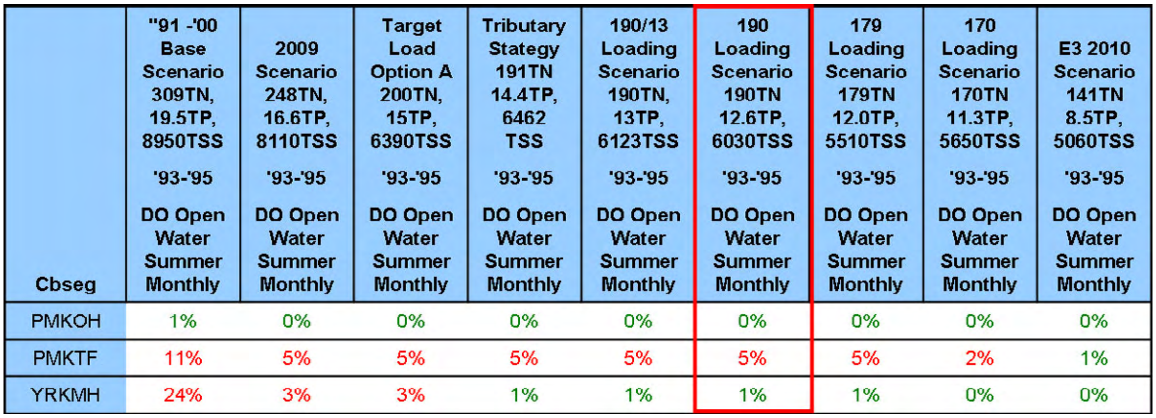


Figure N-15. Simulated DO concentrations for cell 1803, the Bay WQM grid cell coincident with monitoring station TF4.2 in segment PMKTF.



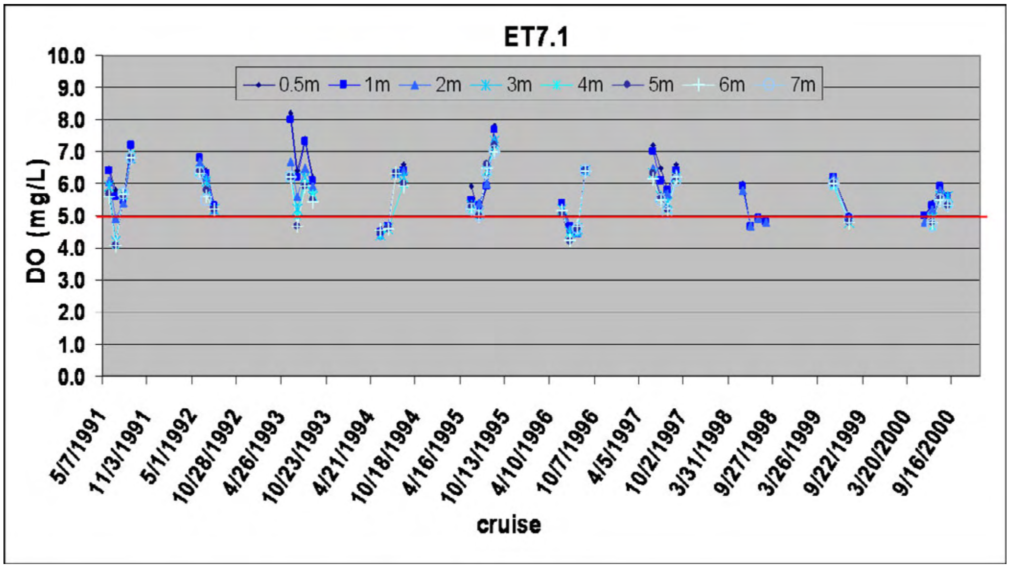
Cbseg	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Open Water Summer Monthly	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Open Water Summer Monthly	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Open Water Summer Monthly
PMKOH	1%	0%	0%	0%	0%	0%	0%	0%	0%
PMKTF	11%	5%	5%	5%	5%	5%	5%	2%	1%
YRKMH	24%	3%	3%	1%	1%	1%	1%	0%	0%

Figure N-16. Attainment of the open-water DO WQS for PMKTF and nearby Bay segments under progressively stringent load reduction scenarios.

Given the mismatch between historical water quality monitoring observations and the Bay WQM simulations in the segment, the complete lack of response in DO concentrations with simulated load reductions, the moderate nature of violations observed in PMKTF for the critical period, and the attainment of the two nearest downstream segments at or before the target basinwide allocation, EPA concludes that it is reasonable to expect attainment of the DO WQS in upper Pamunkey River at the basinwide target allocation of 190 million pounds per year TN and 12.7 million pounds per year TP.

Wicomico River

Moderate excursions below the open-water criterion for Wicomico (WICMH) of 5.0 mg/L were not uncommon in summer months (Figure N-17) between 1991–2000; however, few were extensive enough to cause high percentages of WQS nonattainment. For the 1993–1995 critical period, two months—June and July 1994—had extensive violations of the DO criterion.



Source: http://www.chesapeakebay.net

Figure N-17. DO concentrations observed at station ET7.1 (WICMH) in the summers months 1991–2000.

While the historical violations present in July 1994 were resolved under scenario-modified conditions of the target basinwide allocation (190 TN, 12.7 TP Loading Scenario), DO concentrations in June 1994 showed no improvement in violation rate, even under the extensive load reductions of the E3 Scenario (Table N-4).

Table N-4. Monthly open-water DO criteria nonattainment percentages for water quality monitoring station ET7.1 in segment WICMH in the summer months of 1993–1995 critical period.

WICMH		violation rate		
year	month	calibration	190TN, 12.7TP	E3
1993	6	0.0%	0.0%	0.0%
1993	7	5.5%	0.0%	1.9%
1993	8	0.0%	0.0%	0.0%
1993	9	0.0%	0.0%	0.0%
1994	6	100.0%	100.0%	100.0%
1994	7	100.0%	0.0%	0.0%
1994	8	0.0%	0.0%	0.0%
1994	9	0.0%	0.0%	0.0%
1995	6	0.0%	0.0%	0.0%
1995	7	0.0%	0.0%	0.0%
1995	8	0.0%	0.0%	0.0%
1995	9	0.0%	0.0%	0.0%

Further investigation of the conditions causing the persistent violation revealed that DO concentrations simulated by the Bay WQM's Calibration Scenario for grid cell 7658 are higher than those observed at station ET7.1 for June 1994. In Figure N-18, the DO concentrations observed at station ET7.1 (dark blue symbols) are shown for June 1994. The E3 linear regression falls below those monitoring observations, illustrating the predicted decrease in scenario-modified DO concentrations. Furthermore, DO concentrations in the location were generally similar to (or sometimes even lower than) calibration conditions. In other words, no improvement in DO concentrations was observed at the location when even dramatically reduced loads were simulated. As a result, the mildly hypoxic conditions observed in June 1994 were scenario-modified to lower, rather than higher, values with reduced nitrogen and phosphorous loads.

In contrast with predictions for WICMH, adjacent Tangier Sound (TANMH) and other nearby segments attained DO WQS at or before the target basinwide load allocation (Figure N-19).

As with other segments described herein, the Bay WQM effectively simulated neither the observed historical conditions nor the expected improvement in those conditions with reduced nitrogen and phosphorous loads in this small, shallow region of the Wicomico River. Given the moderate nature of the observed violations the unimpaired condition of adjacent and nearby segments and the considerable level of effort already required of this river basin with the current target load allocation, EPA considers that it is reasonable to expect WICMH to attain WQS at the target load allocations.

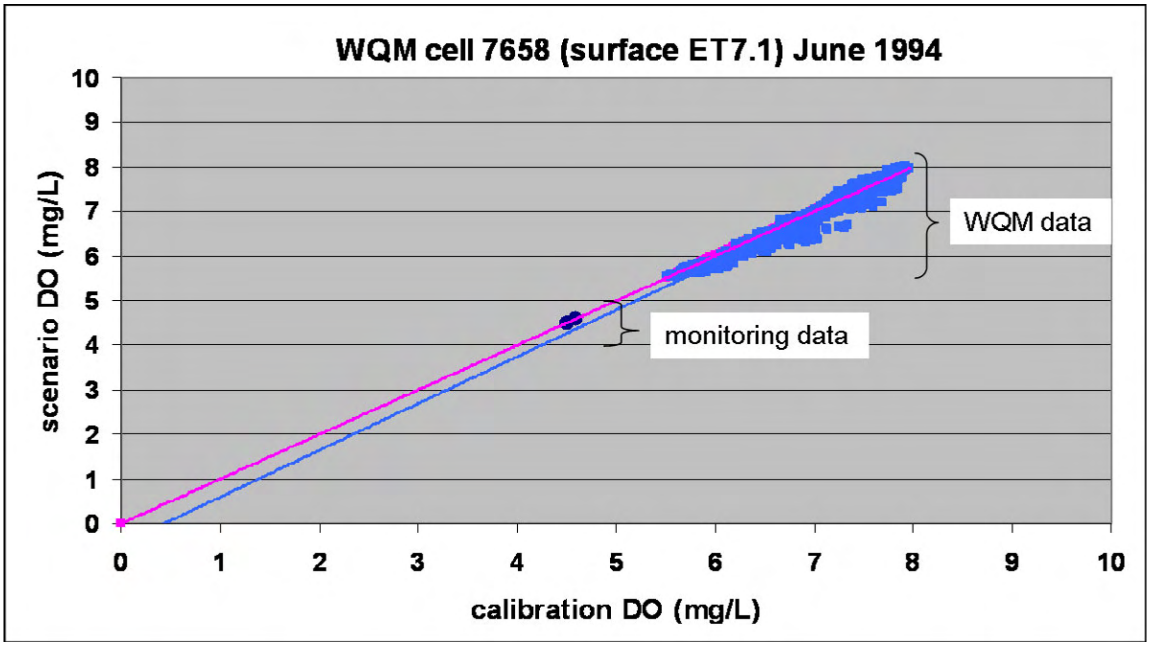
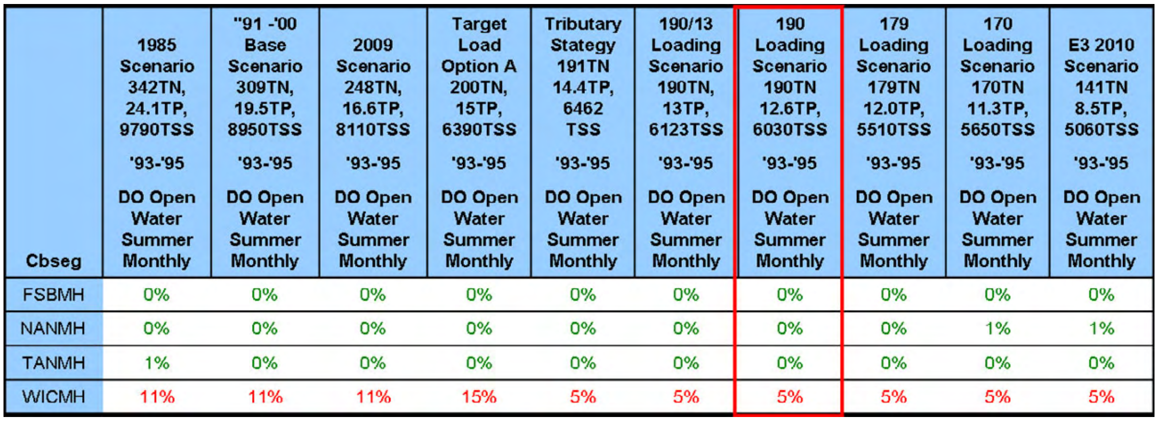


Figure N-18. Simulated DO concentrations for the Calibration Scenario (pink symbols with 1:1 linear regression line) compared to those for the E3 Scenario (blue symbols and blue linear regression line).



Cbseg	1985 Scenario 342TN, 24.1TP, 9790TSS '93-'95 DO Open Water Summer Monthly	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Open Water Summer Monthly	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Open Water Summer Monthly	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Open Water Summer Monthly
FSBMH	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
NANMH	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%
TANMH	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
WICMH	11%	11%	11%	15%	5%	5%	5%	5%	5%	5%

Figure N-19. Attainment of the open-water DO WQS for WICMH and nearby Bay segments under progressively stringent load reduction scenarios.

Magothy River

The Magothy River (MAGMH) is a small, shallow tidal tributary adjacent to the upper-central Chesapeake Bay segment CB3MH. The Magothy River is represented by one long-term fixed monitoring station, WT6.1. The narrow, embayment-like nature of the Magothy River is evident in the portion of the Bay WQM grid that represents it; the entire tributary is represented by only five WQM cells. The grid cell representing station WT6.1 highlighted in Figure N-20.

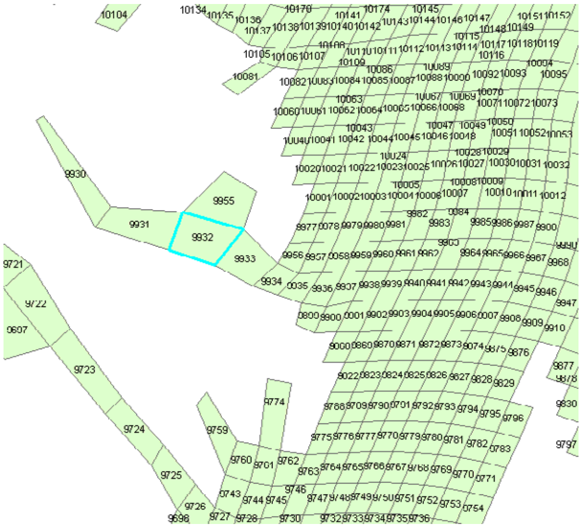
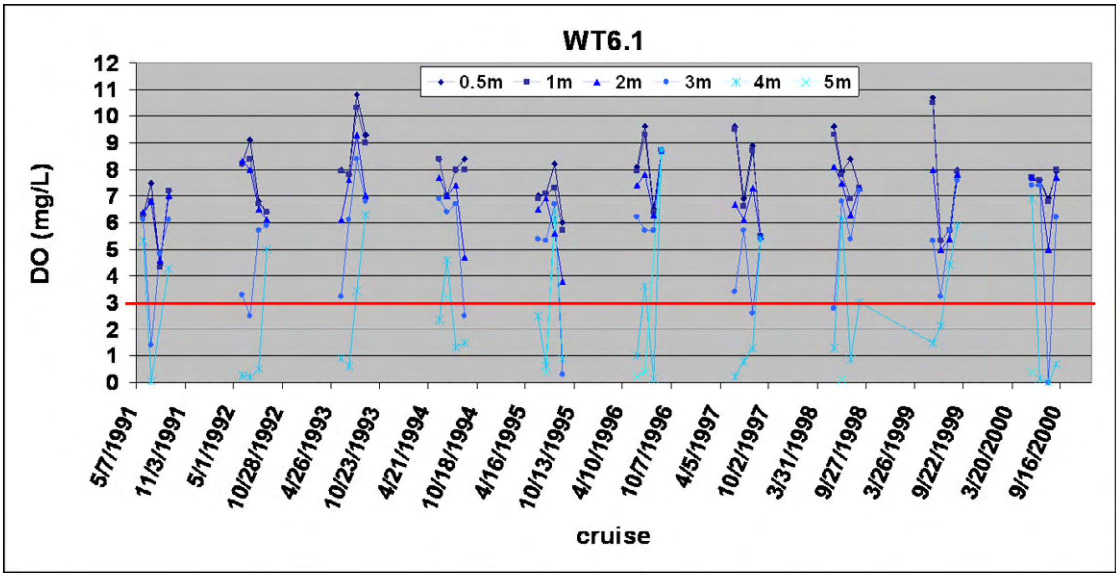


Figure N-20. Chesapeake Bay WQM grid for the Magothy River and the adjoining portion of the mainstem Chesapeake Bay.

Severely hypoxic conditions are common during the summer months in the Magothy River (Figure N-21). Low DO concentrations are often exacerbated by water column stratification, which prevents the vertical mixing that would otherwise re-oxygenate bottom waters. Concentrations often fell below the deep-water criterion of 3.0 mg/L (red line), particularly at depths greater than 2 to 3 meters (Figure N-21). The documented presence of an upper pycnocline boundary in the Magothy River recently led EPA and Maryland to recommend adding a Summer Deep Water designated use to the Magothy River (USEPA 2010). However, even when the deep-water criterion of 3.0 mg/L is applied to stratified bottom waters, nonattainment of the DO WQS persists with simulated load reductions at the level of the target basinwide allocation (see Figure N-23).

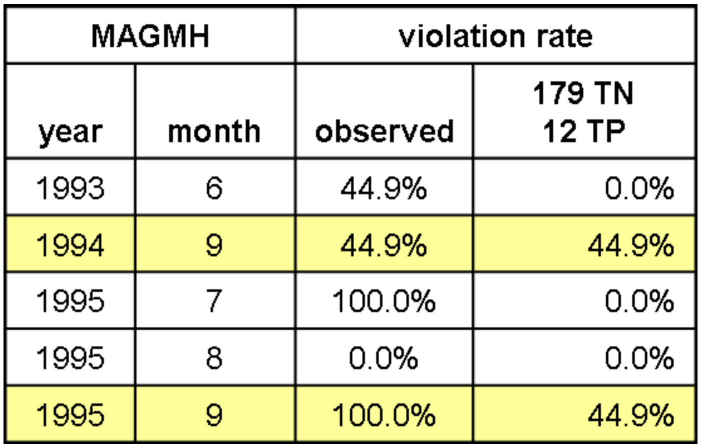


Source: http://www.chesapeakebay.net

Figure N-21. DO concentrations observed at station WT6.1 in segment MAGMH during summer months 1991–2000.

Further investigation of the persistent nonattainment of DO WQS observed in MAGMH showed that while violations occurring in some summer months improved with load reductions, hypoxic conditions in other months improved to a much lesser degree or not at all (Table N-5). In particular, violations of the DO criterion that occurred in September 1994 showed no improvement, even when loads were reduced to the 179 TN, 12 TP level.

Table N-5: Summer monthly violation rates for MAGMH during the 1993–1995 critical assessment period



MAGMH		violation rate	
year	month	observed	179 TN 12 TP
1993	6	44.9%	0.0%
1994	9	44.9%	44.9%
1995	7	100.0%	0.0%
1995	8	0.0%	0.0%
1995	9	100.0%	44.9%

The performance of the Bay WQM in the location of the MAGMH monitoring station was examined. As illustrated in Figure N-22, simulated DO concentrations in the WQM cell representing the bottom depths at station WT6.1 were consistently higher than 5.0 mg/L for September 1994. However, historical measurements for the lower depths at station WT6.1 showed concentrations less than 3.0 mg/L. In Figure N-22, the Calibration Scenario (pink symbols and regression line) is compared with the 179 TN, 12.0 TP Loading Scenario (light blue symbols and linear regression). Historical observations (dark blue circles) fall well outside the range of simulations. As described previously, the failure of the Bay WQM to simulate hypoxic conditions affects its ability to predict the magnitude of improvement that will occur in DO concentrations when nitrogen and phosphorous loads are reduced.

The inability of the Bay WQM to simulate the hypoxic conditions observed during summer months in the Magothy River reduces its ability to predict the magnitude of improvement in DO concentrations that can be expected as nitrogen and phosphorous loads are reduced. However, the Bay WQM much more effectively simulates historical conditions and, therefore, predicted improvements, in nearby deeper, wider regions of the Chesapeake Bay. Thus, the predicted attainment of WQS in the deep-water designated use of CB3MH, well before the target basinwide load allocation (see Figure N-23), can help to inform expectations of attainment for the Magothy River.

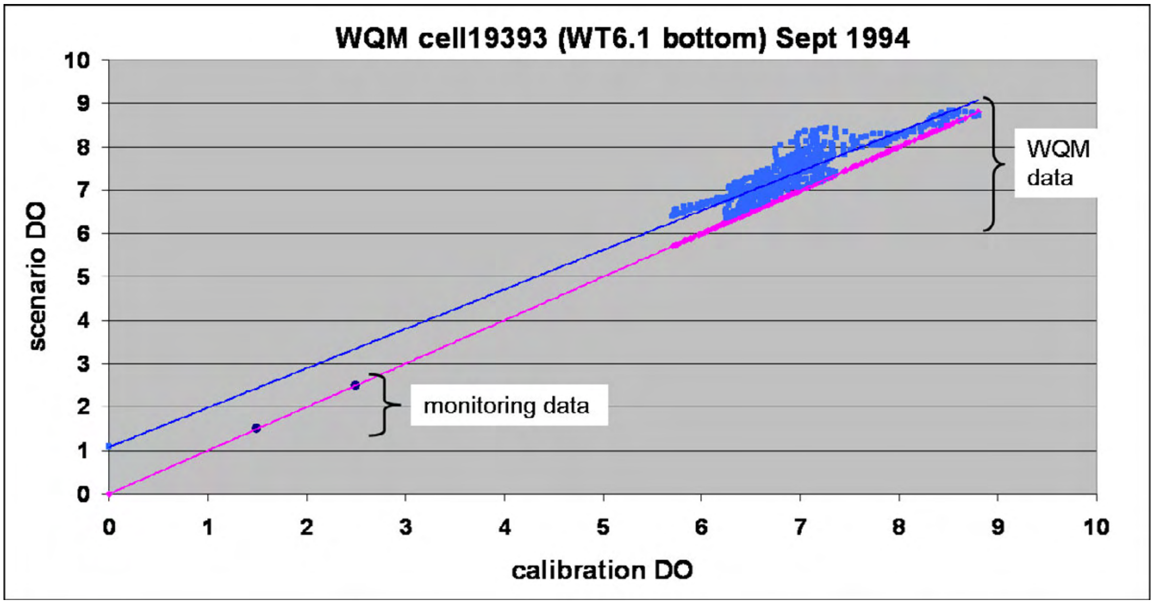


Figure N-22. Simulated DO concentrations in grid cell 19393 of the Bay WQM for September 1994.

Cbseg	1985 Scenario 342TN, 24.1TP, 9790TSS '93-'95 DO Deep Water	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Deep Water	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Deep Water	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Deep Water	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Deep Water	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Deep Water	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Deep Water	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Deep Water	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Deep Water	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Deep Water
CB3MH	3%	2%	0%	0%	0%	0%	0%	0%	0%	0%
MAGMH	35%	35%	35%	16%	16%	16%	3%	3%	1%	1%

Figure N-23. Predicted attainment of DO WQS for the summer deep-water designated use in CB3MH and MAGMH.

While the severely hypoxic conditions commonly observed in the Magothy River during the summer months remain a matter of concern, EPA lacks data to effectively predict the recovery of the Magothy River in those months when the Bay water quality fails to simulate historical conditions. However, given attainment of adjacent deep-waters of CB3MH, and the extensive load reductions already required of the Magothy River basin for the target basinwide allocation of 190 million pounds per year TN and 12.7 million pounds per year TP, EPA anticipates that the MAGMH deep-water designated use will attain WQS when the target load allocation is achieved.

Resolution of Segments Failing to Attain the SAV/Water Clarity Criteria

After assessing attainment of the combined submerged aquatic vegetation (SAV)/water clarity criteria on the basis of Bay Water Quality/Sediment Transport Model outputs for the nitrogen and phosphorous Allocation Scenario (190 TN/12.7 TP), four Bay segments were initially found to be in nonattainment of the SAV/water clarity criteria.

On the basis of recent observed SAV acre or allowance of 1 percent nonattainment of the water clarity criteria (see Section 6.6.2 and Appendix I), the four remaining segments were judged to actually be currently in attainment. Those segments are the Mattawoman Creek (MATTF), the Gunpowder River (GUNOH), the Appomattox River (APPTF), and Virginia's portion of the lower Potomac River (POTMH_VA).

Virginia Middle Potomac River

The SAV restoration acreage criterion is for 4,250 acres for Virginia's portion of the middle Potomac River (POTMH_VA) (Figure N-24). At the nitrogen and phosphorous Allocation Scenario loading levels, the segment was at 10 percent nonattainment. Nonattainment was persistent and was estimated to be 9 percent at E3 Scenario and 6 percent at the All Forest Scenario nitrogen and phosphorous and sediment load levels. With its high SAV restoration acreage criterion and the low levels of SAV acres estimated by the assessment approach described in Appendix P for the segment, the estimated level of attainment is largely achieved through water clarity acres only. As a consequence of the high SAV restoration acreage criterion, the calculated water clarity acreage-based criterion is also very high—10,625 acres. However, the available shallow-water area out to the maximum application depth of 2 meters is less than the water clarity acres criterion for this segment.

The observed SAV record shows overall improvement in SAV coverage in recent years. Because the 1993–1995 SAV coverage was close to its lowest recorded acreage, EPA used the recent observed SAV area (2004–2005) in the SAV/water clarity criteria assessment procedure described in Appendix P. Starting with this SAV acreage, more consistent with recent years of observed SAV acreage (Figure N-25), Virginia's portion of the lower Potomac River achieved its SAV/water clarity WQS at the sediment allocation levels.

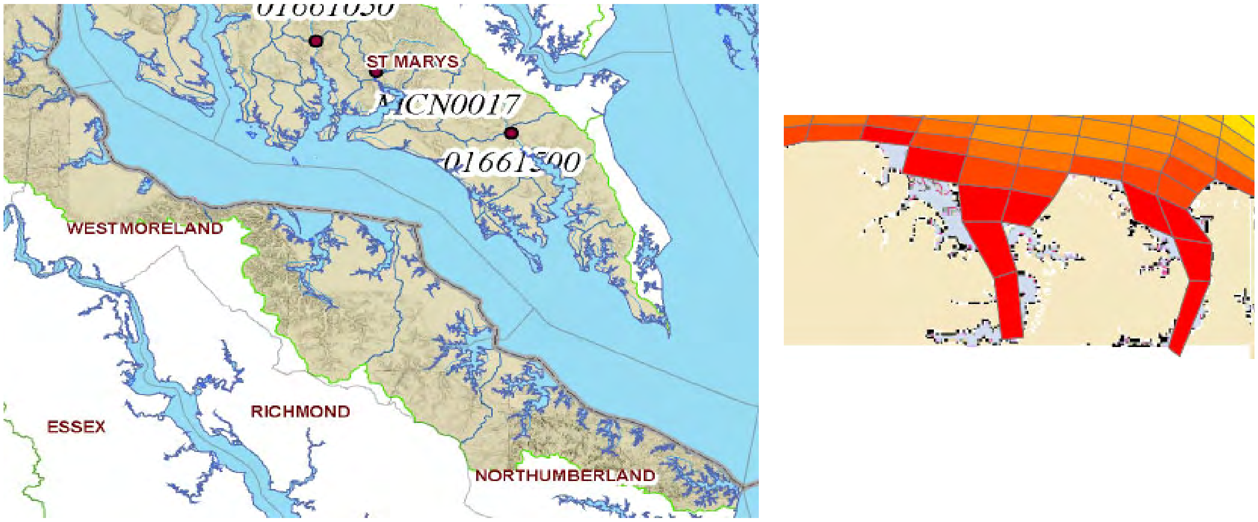
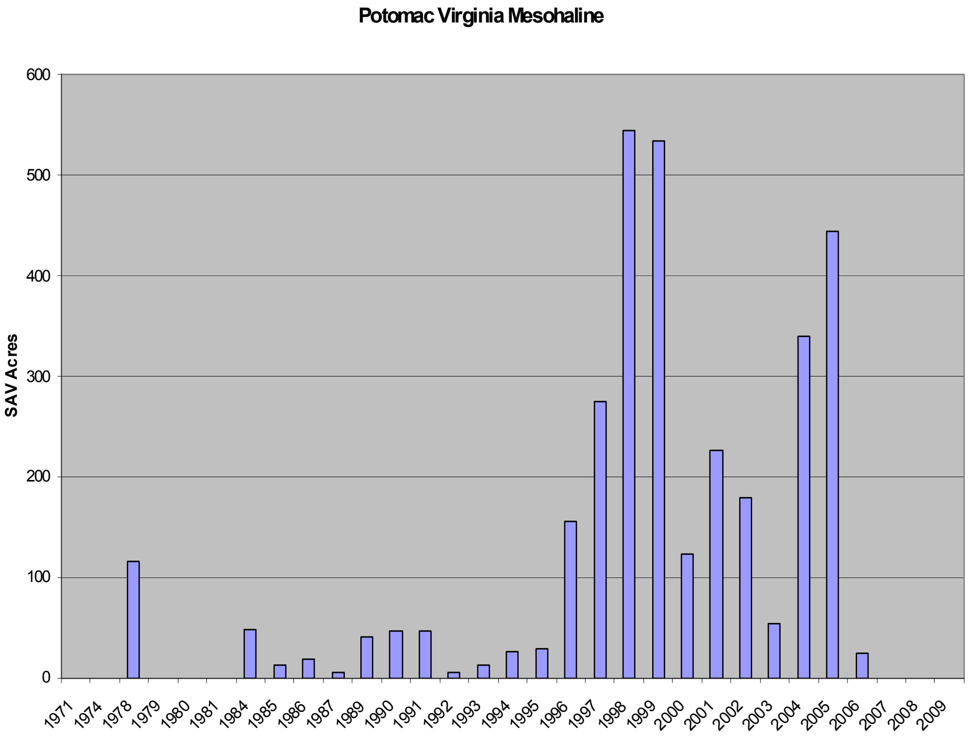


Figure N-24. The location of the different embayments of Virginia's portion of the lower Potomac River (above left) and its representation of the Nomini Bay region of the segment by the Chesapeake Bay WQM (above right).



Source: http://www.vims.edu/bio/sav

Figure N-25. Observed SAV acres in Virginia' lower Potomac River segment.

Mattawoman Tidal Fresh—MATTF

Initially, the Mattawoman Creek (Figure N-26) appeared to be in nonattainment of its SAV/water clarity standards on the basis of Bay WQM simulation of the nitrogen and phosphorous Allocation Scenario loading levels. Subsequently, a fuller analysis that included the recent SAV monitoring data found that the Mattawoman Creek segment had 877 acres of observed SAV in 2008, and 866 acres in 2009 (Figure N-27). Both recent years of observed SAV exceeded the 792 acres SAV restoration acreage criterion. From the recent observed SAV data and the upward trend of SAV expected with continued nitrogen and phosphorous and sediment reduction in the Mattawoman Creek, those other lines of evidence supported the finding that the sediment allocations for this segment will achieve the SAV standards.

Figure N-26. The location of Mattawoman Creek in the upper Potomac River (above left) and the Chesapeake Bay WQM representation of Mattawoman Creek (above right).

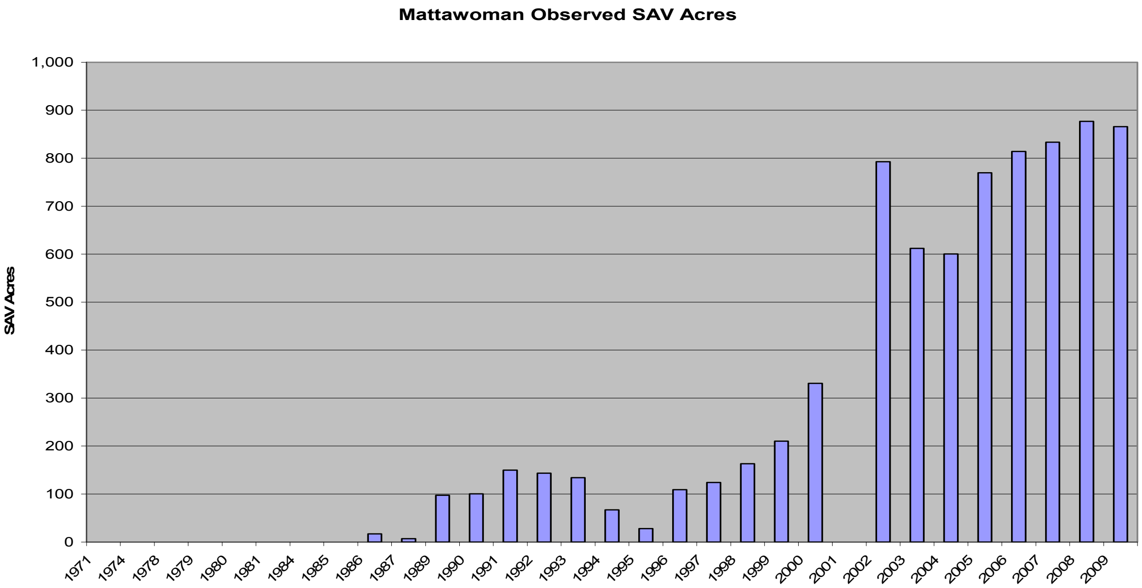


Figure N-27. The observed SAV data for Mattawoman Creek from 1971 to 2009.

Gunpowder River

Initially, the Gunpowder River (GUNOH) (Figure N-28) appeared to be in nonattainment of its SAV/water clarity standards according to the Bay WQM simulation of the nitrogen and phosphorous Allocation Scenario loading levels. Subsequent analysis found that the Gunpowder River segment had essentially reached its SAV restoration acreage criterion of 2,432 acres in recent years (2000, 2004) and found a generally increasing trend of SAV expansion as nitrogen and phosphorous and sediment loads continue to decrease toward the allocation scenario loads (Figure N-29). Consequently, that other line of evidence supports the finding that further sediment reductions beyond the phosphorus-based sediment loads within the nitrogen and phosphorous Allocation Scenario would be unwarranted.

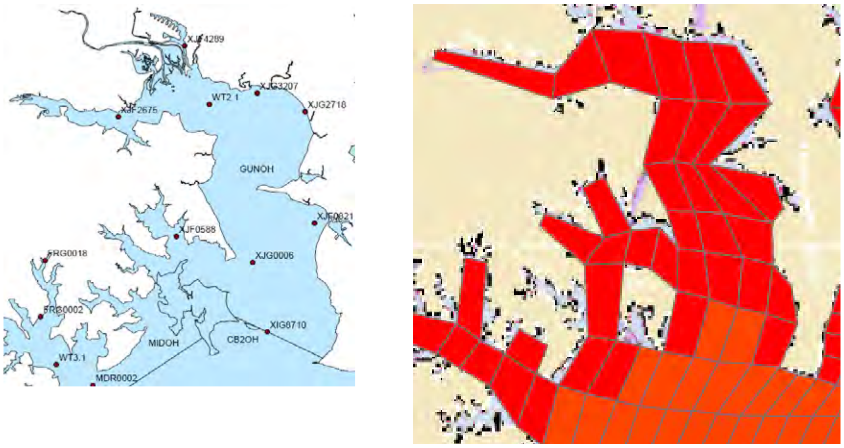


Figure N-28. The location of the Gunpowder River (above left) and the Chesapeake Bay WQM representation of Gunpowder River (above right).

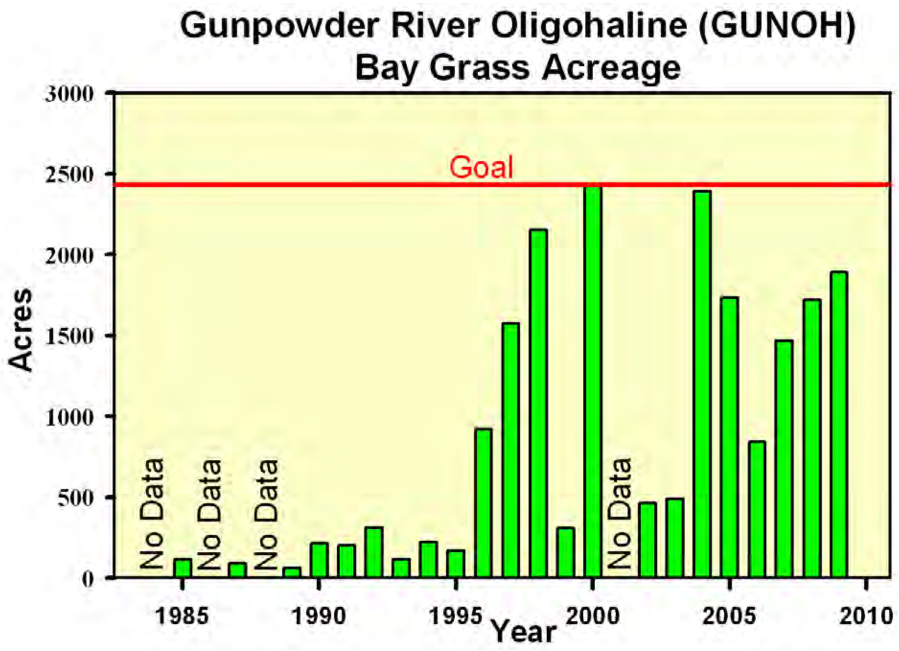


Figure N-29. The observed SAV data for the Gunpowder River from 1985 to 2009.

Appomattox River

In the Appomattox River (Figure N-30), the SAV restoration acreage criterion is 379 acres, although no SAV has been observed from 1978 to present. A persistent, low-level nonattainment (1 percent), which is based on attainment of the water clarity criteria only, is estimated at the Sediment Allocation Scenario loading level. Allowance of 1 percent persistent nonattainment of the water clarity criteria moves the segment into attainment.

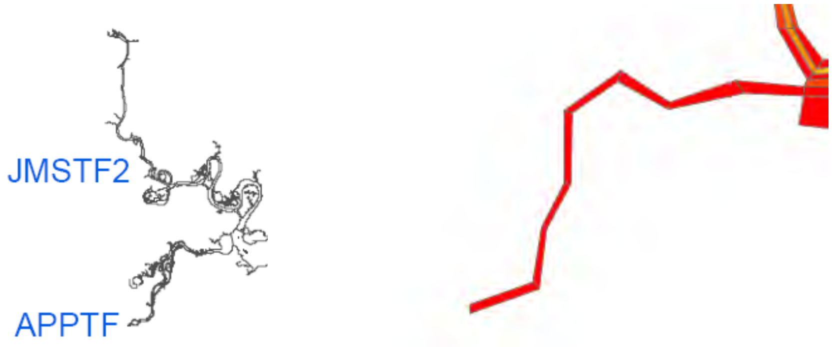


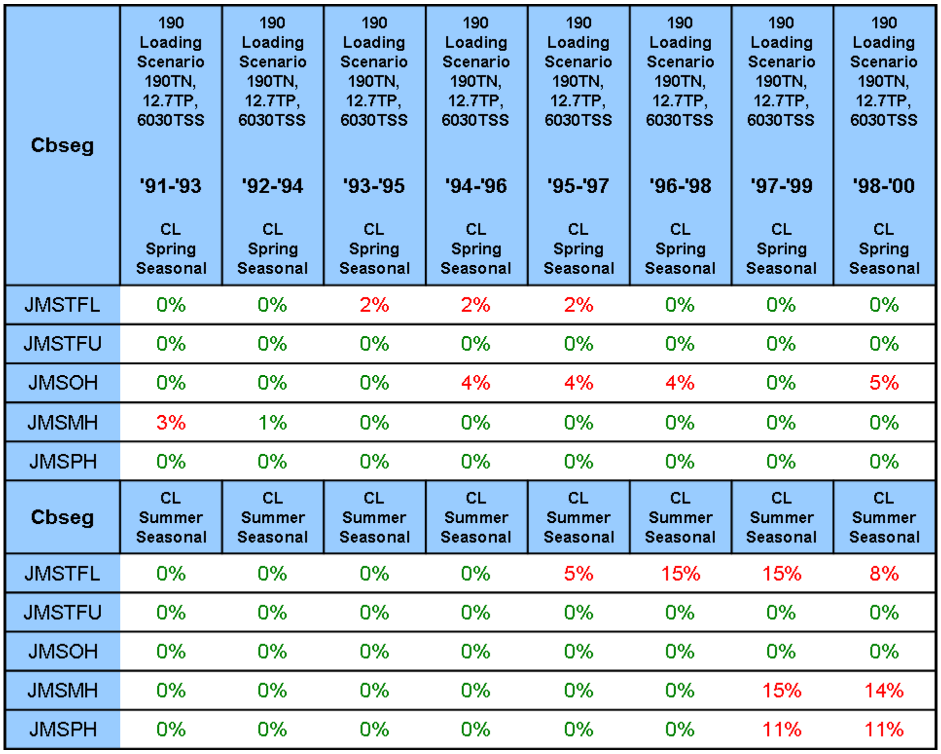
Figure N-30. The location of the Appomattox River in the upper tidal James River (above left) and its representation by the Chesapeake Bay WQM (above right).

References

USEPA (U.S. Environmental Protection Agency). 2010. *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries: 2010 Technical Support for Criteria Assessment Protocols Addendum*. May 2010. EPA 903-R-10-002. CBP/TRS 301-10. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD.

Appendix O.
Setting the Chlorophyll *a* Criteria-Based Nutrient Allocations for the James River Watershed

The initial Draft Target Load Allocation of 190 million pounds per year (mpy) total nitrogen (TN) and 12.7 mpy total phosphorus (TP) was determined on the basis of attainment of Chesapeake Bay basinwide numeric dissolved oxygen standards. At that loading level, an assessment of predicted chlorophyll *a* concentrations showed nonattainment of Virginia's numeric chlorophyll *a* water quality standard (WQS) in the James River for several 3-year assessment periods, in multiple segments and in both spring and summer seasons (see Figure O-1). The narrative rationale for Virginia's numeric chlorophyll *a* criteria (see Table O-1) is described in EPA's 2003 *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll* a *for the Chesapeake Bay and Its Tidal Tributaries* (USEPA 2003a).



Cbseg	190 Loading Scenario 190TN, 12.7TP, 6030TSS '91-'93 CL Spring Seasonal	190 Loading Scenario 190TN, 12.7TP, 6030TSS '92-'94 CL Spring Seasonal	190 Loading Scenario 190TN, 12.7TP, 6030TSS '93-'95 CL Spring Seasonal	190 Loading Scenario 190TN, 12.7TP, 6030TSS '94-'96 CL Spring Seasonal	190 Loading Scenario 190TN, 12.7TP, 6030TSS '95-'97 CL Spring Seasonal	190 Loading Scenario 190TN, 12.7TP, 6030TSS '96-'98 CL Spring Seasonal	190 Loading Scenario 190TN, 12.7TP, 6030TSS '97-'99 CL Spring Seasonal	190 Loading Scenario 190TN, 12.7TP, 6030TSS '98-'00 CL Spring Seasonal
JMSTFL	0%	0%	2%	2%	2%	0%	0%	0%
JMSTFU	0%	0%	0%	0%	0%	0%	0%	0%
JMSOH	0%	0%	0%	4%	4%	4%	0%	5%
JMSMH	3%	1%	0%	0%	0%	0%	0%	0%
JMSPH	0%	0%	0%	0%	0%	0%	0%	0%
Cbseg	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal
JMSTFL	0%	0%	0%	0%	5%	15%	15%	8%
JMSTFU	0%	0%	0%	0%	0%	0%	0%	0%
JMSOH	0%	0%	0%	0%	0%	0%	0%	0%
JMSMH	0%	0%	0%	0%	0%	0%	15%	14%
JMSPH	0%	0%	0%	0%	0%	0%	11%	11%

For this scenario, the James River Basin allocation is 26.6 mpy TN and 2.7 mpy TP.
Failure to attain WQS is shown in red text as percent nonattainment.

Figure O-1. Attainment of numeric chlorophyll *a* WQS in the James River at the draft Target Load Chesapeake Bay basinwide allocation of 190 mpy TN and 12.7 mpy TP.

Table O-1. James River numeric chlorophyll *a* criteria

Segment	Seasonal mean criterion (µg/L) spring/summer
JMSTFU	10/15
JMSTFL	15/23
JMSOH	15/22
JMSMH	12/10
JMSPH	12/10

µg/L = micrograms per liter

To identify the level of load reductions necessary to achieve chlorophyll *a* WQS in the James River, the EPA Chesapeake Bay Program’s (CBP’s) modeling and monitoring teams investigated the underlying drivers of those remaining instances of nonattainment.

Determining Chlorophyll *a* attainment for spring in the Tidal Fresh James River

First, the drivers of nonattainment in the lower tidal fresh James during the spring for the three assessment periods spanning 1993–1997 were examined. For all three assessment periods, failure to attain the WQS at draft target loading levels was driven by conditions and estimated levels of improvement in the spring of 1995 at stations TF5.5 and TF5.5A, where chlorophyll *a* concentrations exceeding the seasonal mean chlorophyll *a* criterion of 15 µg/L were observed.

Stations TF5.5 and TF5.5A are marked with black dots and circled in red.

Figure O-2. James Tidal Fresh Lower (JMSTFL) segment of the James River, with long-term fixed monitoring stations shown.

CBP analysts next investigated whether the estuarine Water Quality Sediment Transport Model (WQSTM) was sufficiently calibrated to observed conditions in that region of the James River. A comparison of observed values at station TF5.5 with those generated by the WQSTM during its calibration run demonstrated that the WQSTM simulated the range of surface chlorophyll *a* conditions experienced in the region in 1995 (Figure O-3).

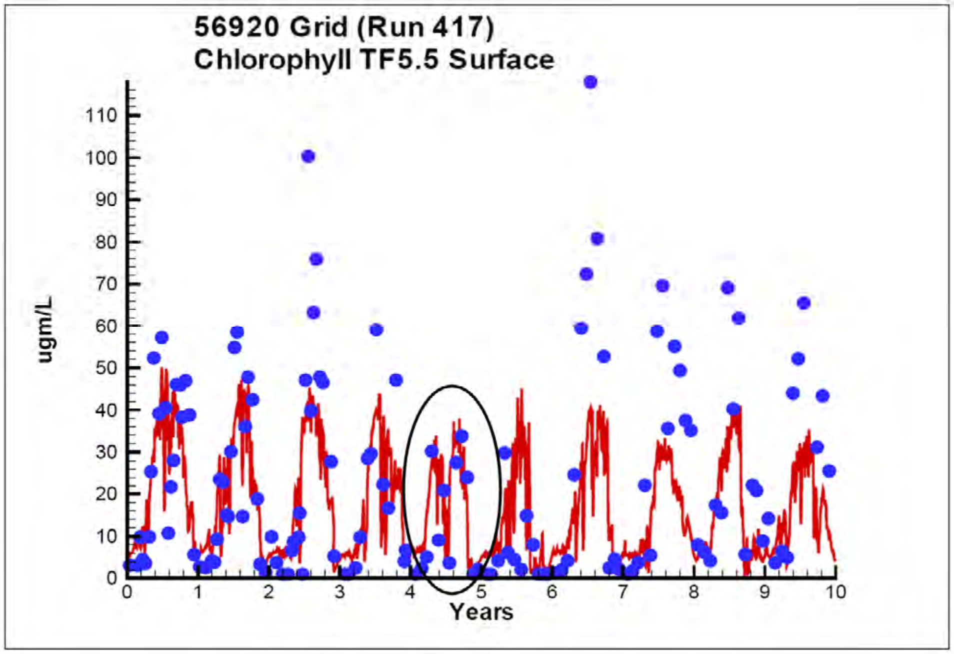


Figure O-3. Plot comparing WQSTM-simulated surface chlorophyll *a* values (red line) with historical observations (blue dots). For the year 1995 (circled in black), simulated values captured the range of observed conditions.

Furthermore, a comparison of the WQSTM's response to load reductions in the region showed a consistent response in the form of a reduction of undesirable surface chlorophyll *a* levels (i.e., those exceeding the seasonal mean criterion) when loads were reduced (see Table O-2). From those lines of evidence, it was determined that this instance of nonattainment represented a best available estimate of remaining nonattainment in the JMSTFL for the spring seasons of 1993–1995, 1994–1996, and 1995–1997 periods. Those periods reached attainment of WQS with the *170 TN, 11.3TP Loading Scenario*, for which James River Basin loads were 25.5 mpy TN and 2.5 mpy TP. At that loading level, some individual surface chlorophyll *a* values exceeded the seasonal mean criterion, but the average seasonal degree of criteria violation fell within the allowable exceedance of 1 percent.

Table O-2. Observed and scenario-modified chlorophyll *a* concentrations (µg/L) at stations TF5.5 (a) and TF5.5A (b) in the spring of 1995. The 26.6 TN, 2.7 TP loading level represents James River Basin load reductions for the global 190 TN, 12.7 TP loading.

(a)

TF5.5			
Month	observed	26.6 TN 2.7 TP	25.5 TN 2.5 TP
March 1995	5.1	5.5	5.6
April 1995	30.2	18.8	17.7
May 1995	9.1	7.7	7.2

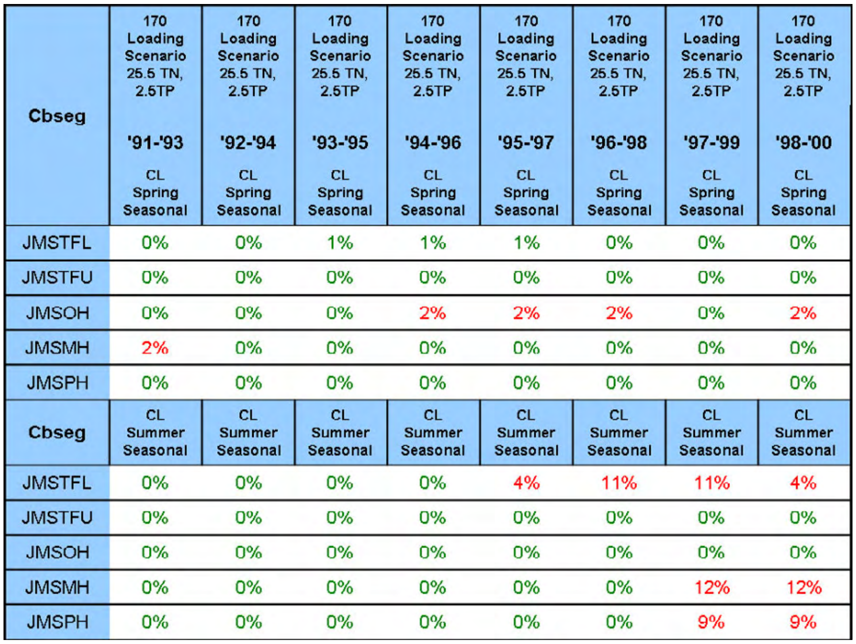
(b)

TF5.5A			
Month	observed	26.6 TN 2.7 TP	25.5 TN 2.5 TP
March 1995	48.7	29.7	26.8
April 1995	38.8	21.8	20.3
May 1995	7.7	9.6	9.2

Verification of the violations described above, and determination of their resolution at the James River-specific loading level of 25.5 mpy TN and 2.5 mpy TP, enabled EPA CBP analysts to confirm a minimum required reduction scenario for James River to this loading level.

Determining the remaining Chlorophyll *a* attainment in the James River

Remaining violations at the 25.5 mpy TN/2.5 mpy TP loading level (170 Loading Scenario) were investigated. To determine the maximum necessary additional loading reductions, analysts focused on the greatest remaining levels of nonattainment—those occurring for the summer season in JMSTFL, JMSMH, and JMSPH (see Figure O-4).



Cbseg	170 Loading Scenario 25.5 TN, 2.5TP '91-'93 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '92-'94 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '93-'95 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '94-'96 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '95-'97 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '96-'98 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '97-'99 CL Spring Seasonal	170 Loading Scenario 25.5 TN, 2.5TP '98-'00 CL Spring Seasonal
JMSTFL	0%	0%	1%	1%	1%	0%	0%	0%
JMSTFU	0%	0%	0%	0%	0%	0%	0%	0%
JMSOH	0%	0%	0%	2%	2%	2%	0%	2%
JMSMH	2%	0%	0%	0%	0%	0%	0%	0%
JMSPH	0%	0%	0%	0%	0%	0%	0%	0%
Cbseg	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal	CL Summer Seasonal
JMSTFL	0%	0%	0%	0%	4%	11%	11%	4%
JMSTFU	0%	0%	0%	0%	0%	0%	0%	0%
JMSOH	0%	0%	0%	0%	0%	0%	0%	0%
JMSMH	0%	0%	0%	0%	0%	0%	12%	12%
JMSPH	0%	0%	0%	0%	0%	0%	9%	9%

For this scenario, the James River Basin allocation is 25.5 mpy TN and 2.5 mpy TP.
Failure to attain WQS is shown in red text as percent nonattainment.

Figure O-4. Attainment of numeric chlorophyll *a* WQS in the James River at the Chesapeake Bay basinwide loading level of 170 mpy TN and 11.3 mpy TP.

Using the same systematic procedure employed for the JMSTFL violations described above, the 12 percent nonattainment observed for JMSMH in the summers of 1997–1999 and 1998–2000 was examined. The primary driver of the nonattainment was traced to conditions occurring at James River monitoring stations LE5.2 and LE5.3 in September 1999. Examination of observed and scenario-modified data for the summer of 1999 in the region of LE5.2 and LE5.3 showed that individual historical observations did in some cases exceed the summer seasonal mean criterion of 10 µg/L for JMSMH. But more importantly, the regression equations used to scenario-modify chlorophyll *a* concentrations (for details on the scenario-modification procedure, see Section 6.4) at the stations in September 1999 were generating *higher* chlorophyll *a* concentrations with reduced loads rather than lower concentrations.

A comparison of the WQSTM simulation against observed values at LE5.3 showed that the WQSTM simulated the range of surface chlorophyll *a* conditions observed in 1999 (see Figure O-5). For the year 1999 (circled in black), simulated values captured the range of observed conditions.

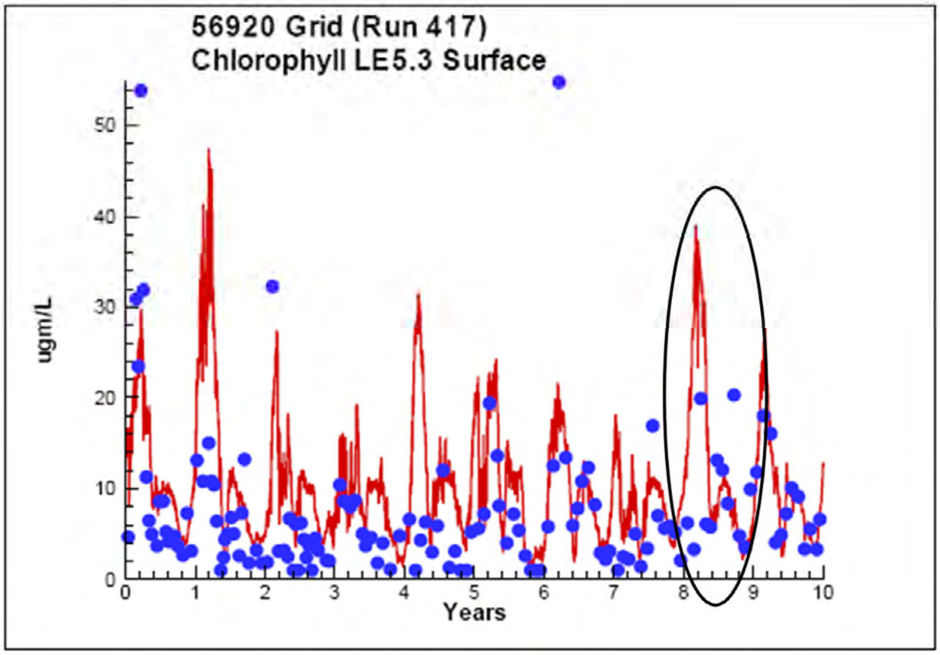


Figure O-5. Plot comparing WQSTM-simulated surface chlorophyll *a* values (red line) with historical observations (blue dots).

A closer look at simulated surface conditions at LE5.2 and LE5.3 in the summer of 1999 showed that from June through early September, simulated chlorophyll *a* concentrations were within the range or moderately lower than observed surface chlorophyll *a* values and that chlorophyll *a* concentrations consistently declined when loads were reduced. However, an anomaly occurred in some driver of the model simulation that caused poor scenario performance in the latter half of September 1999 at LE5.2 (see Figure O-6) and, to a lesser degree, LE5.3 (not shown). Specifically, chlorophyll *a* concentrations suddenly increased in all scenarios, and concentrations for the load reduction scenarios increased to even higher levels than for the calibration scenario.

For most of the summer, load reduction scenarios such as the 179 TN/12.0 TP loading scenario (light blue symbols and line, *180 TN*) and the E3 scenario (dark blue symbols and line, *E3*) simulated consistently reduced surface chlorophyll *a* concentrations relative to the calibration scenario (pink symbols and line, *calib*). After September 15, load reduction scenarios generated higher chlorophyll *a* concentrations than the calibration scenario. As a result, regression equations used to scenario-modify chlorophyll *a* observations from September 1999 generated higher chlorophyll *a* concentrations under reduced loading scenarios.

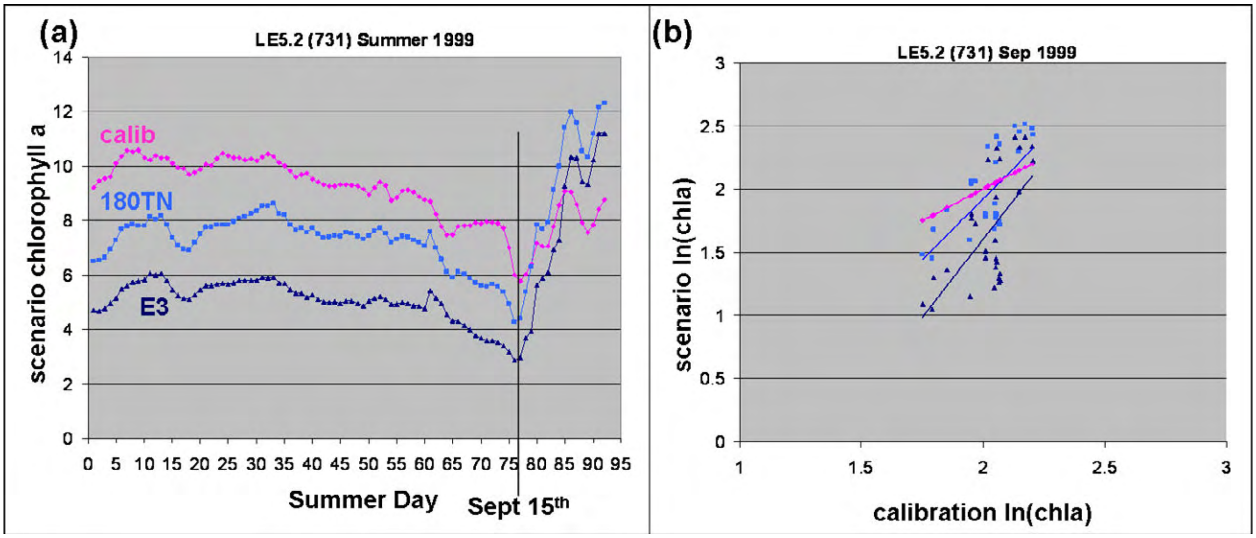


Figure O-6. Plot of simulated surface chlorophyll *a* concentrations for WQSTM cell 731 (location of station LE5.2) during the summer of 1999 (a), and resulting regression plot for September 1999 LE5.2 chlorophyll *a* (b).

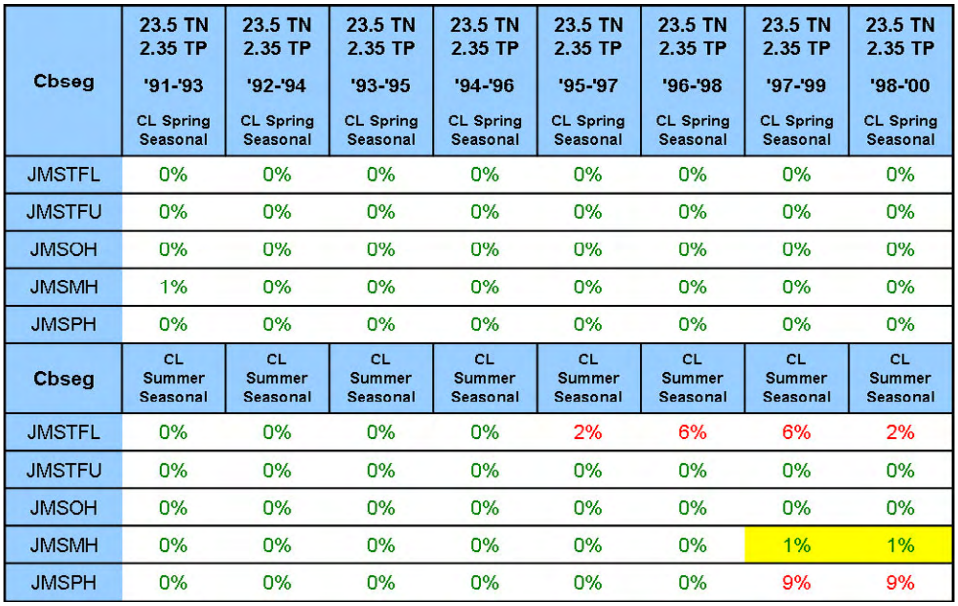
The effect of that anomaly was to generate flawed regression equations for the September period which caused chlorophyll *a* observations to be scenario-modified to higher rather than lower concentrations under reduced-load scenarios (see Table O-3).

Table O-3. Observed, scenario-modified (190 TN), and refined scenario-modifed chlorophyll *a* concentrations at LE5.2 in summer 1999

LE5.2	**chlorophyll *a* (µg/L)**		
Month	Observed	190 TN	190 TN, refined
July 1999	11.1	8.94	8.94
August 1999	6.19	5.34	5.34
September 1999	14.0	23.7	10.8

When the anomalous data generated after September 15 were removed from the analysis, the resulting regression equations better reflected the information provided by the WQSTM with regard to predicted improvements in chlorophyll *a* concentrations with reduced pollutant loads. Using the *refined regression* for September 1999, the percent nonattainment of 12 percent for JMSMH in the summer 1997–1999 and 1998–2000 summer periods shown in Figure O-5 declined to only 2 percent at the 170 Loading Scenario level of 25.5 mpy TN and 2.5 mpy TP for the James River Basin.

As with the violations described for JMSTFL above, the newly verified nonattainment levels were used to identify further load reductions required to achieve attainment of summer seasonal WQS in JMSMH. Scenarios were generated with progressively more stringent load reductions. Attainment of summer seasonal chlorophyll *a* WQS was achieved in JMSMH for the 1997–1999 and 1998–2000 assessment periods at the 23.5 TN, 2.35 TP loading level for the James River Basin (see Figure O-7).



Cbseg	23.5 TN 2.35 TP '91-'93 CL Spring Seasonal	23.5 TN 2.35 TP '92-'94 CL Spring Seasonal	23.5 TN 2.35 TP '93-'95 CL Spring Seasonal	23.5 TN 2.35 TP '94-'96 CL Spring Seasonal	23.5 TN 2.35 TP '95-'97 CL Spring Seasonal	23.5 TN 2.35 TP '96-'98 CL Spring Seasonal	23.5 TN 2.35 TP '97-'99 CL Spring Seasonal	23.5 TN 2.35 TP '98-'00 CL Spring Seasonal
JMSTFL	0%	0%	0%	0%	0%	0%	0%	0%
JMSTFU	0%	0%	0%	0%	0%	0%	0%	0%
JMSOH	0%	0%	0%	0%	0%	0%	0%	0%
JMSMH	1%	0%	0%	0%	0%	0%	0%	0%
JMSPH	0%	0%	0%	0%	0%	0%	0%	0%
Cbseg	**CL Summer Seasonal**	**CL Summer Seasonal**	**CL Summer Seasonal**	**CL Summer Seasonal**	**CL Summer Seasonal**	**CL Summer Seasonal**	**CL Summer Seasonal**	**CL Summer Seasonal**
JMSTFL	0%	0%	0%	0%	2%	6%	6%	2%
JMSTFU	0%	0%	0%	0%	0%	0%	0%	0%
JMSOH	0%	0%	0%	0%	0%	0%	0%	0%
JMSMH	0%	0%	0%	0%	0%	0%	1%	1%
JMSPH	0%	0%	0%	0%	0%	0%	9%	9%

Figure O-7. Attainment stoplight plot of James River chlorophyll *a* WQS for the 23.5 TN, 2.35 TP load reduction scenario. Highlighted fields show attainment in JMSMH for summers 1997–1999 and 1998–2000.

At that load reduction level, two blocks of nonattainment remained: JMSTFL summer for the assessment periods 1995–1997 through 1998–2000, and JMSPH summer for the assessment periods 1997–1999 and 1998–2000.

Summer nonattainment in JMSPH for assessment periods 1997–1999 and 1998–2000 was traced to conditions at station LE5.4W in the summer of 1999. Chlorophyll *a* concentrations in that region consistently exceeded the summer seasonal mean criterion for JMSPH of 10 µg/L (see Table O-4).

Table O-4. Observed and scenario-modified chlorophyll *a* concentrations at LE5.5-W in the summer of 1999

LE5.5W	**chlorophyll *a* (µg/L)**		
Month	Observed	26.6 TN, 2.7 TP	25.5 TN/2.5 TP
July 1999 cruise 1	14.7	11.9	11.3
July 1999 cruise 2	22.7	19.3	18.3
Aug 1999 cruise 1	12.9	9.98	9.48
Aug 1999 cruise 2	14.2	11.0	10.4
September 1999	39.2	15.5	14.0

When historical observations fall well outside the range of concentrations simulated by the water quality model, the WQSTM's ability to estimate the predicted magnitude of response to reduced loads is compromised. Some of the concentrations observed at LE5.5W in the summer of 1999 were within the range of the WQSTM simulations. However, the September 1999 observation of 39.2 µg/L was well outside the range of simulated conditions, reducing confidence in estimates of expected improvement in chlorophyll *a* concentrations. While concern remains regarding such clear violations of chlorophyll *a* WQS, insufficient information exists to justify further load reductions from estimates of remaining nonattainment for JMSPH in the 1997–1999 and 1998–2000 assessment periods.

The case of remaining summer nonattainment in JMSTFL is similar to that of JMSPH but even more pronounced. Remaining nonattainment could be traced back to summer conditions in 1997 and 1998, when surface chlorophyll *a* concentrations regularly exceeded the summer seasonal mean criterion of 23 µg/L. In Figure O-3, summer observations ranging from about 50 to more than 100 µg/L can be seen to far exceed the WQSTM's simulated average summer conditions for the region. Similarly, conditions at station TF5.5A ranged from 75.6 to 113 µg/L in the summer of 1997. Such bloom conditions exceed the range of simulated conditions to such a degree that it is difficult to predict the expected magnitude of improvement with load reductions. Therefore, insufficient information exists to justify further load reductions on the basis of estimates of remaining nonattainment for JMSTFL in those summer assessment periods.

Using the information gained from the analyses described above, the chlorophyll *a*-based nutrient load allocations for the James River Basin were set at 23.5 mpy TN and 2.35 mpy TP. At that load allocation, verified events of nonattainment in JMSTFL for the spring seasons of 1993–1995, 1994–1996, and 1995–1997, as well as verified events of nonattainment in JMSMH for the summer seasons of 1997–1999 and 1998–2000, were resolved. Regions with remaining instances of nonattainment (i.e., JMSTFL and JMSPH summer seasonal conditions) will be closely monitored in coming years to ensure that the allocated load reductions result in the conditions necessary to achieve attainment of chlorophyll *a* WQS.

Appendix P.
Setting the SAV/Water Clarity Criteria Based Sediment Allocations

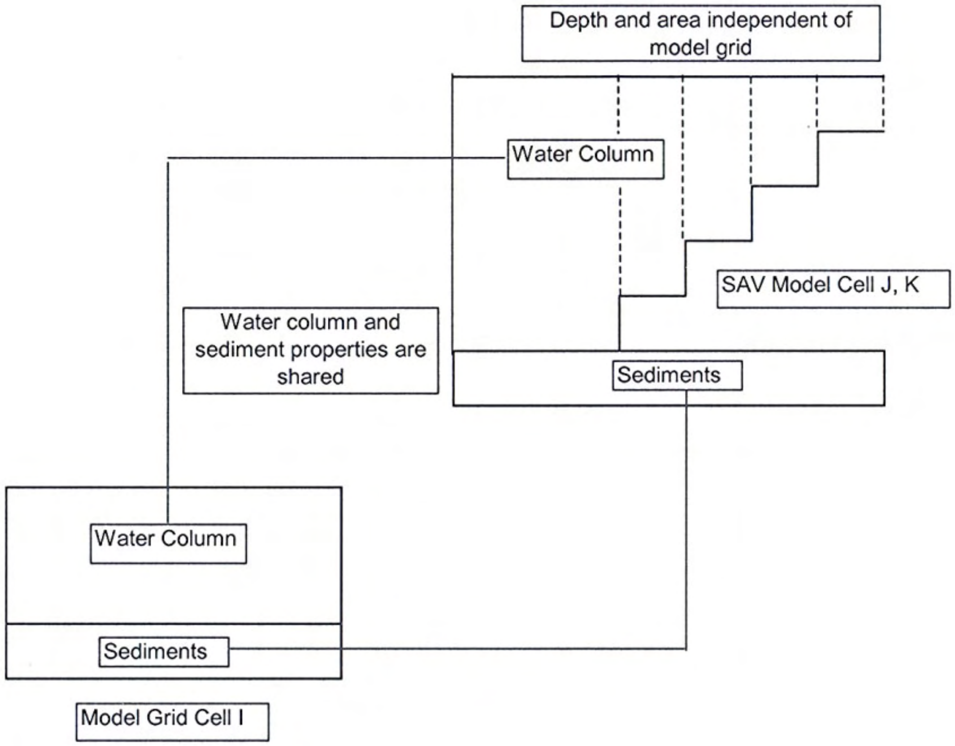
Introduction

The scale of the Chesapeake Bay Program partnership's models extend from the extreme of the continental scale of the Community Multiscale Air Quality Bay Airshed Model and watershed-wide scale of the Phase 5.3 Bay Watershed Model to the other extreme of the narrow ribbon of shallow water adjacent to the Bay's more than 11,000 miles of tidal shoreline. The ribbon of shallow water of 2 meters or less in depth is the region where the jurisdictions' submerged aquatic vegetation (SAV)/water clarity criteria are applied to assess protection of the shallow-water bay grass designated use. This region of a convoluted shoreline is spatially and temporally more heterogeneous than the rest of the Chesapeake Bay Water Quality and Sediment Transport Model (WQSTM) domain covering the open and contiguous waters of the Chesapeake. Episodic loads from shoreline erosion, resuspension, and watershed inputs all transit this narrow band of land and water interface.

The challenge of assessing SAV and water clarity criteria at these scales has only recently been taken up by the Chesapeake Bay Program partnerships in the past 5 years. Monitoring, modeling and research in these shallow-water systems is in its relative infancy compared to the more mature environmental science surrounding dissolved oxygen in eutrophic estuarine ecosystems. In addition, while moving toward these finer scales, the retention of system-wide representation of loading sources, boundary conditions must be preserved.

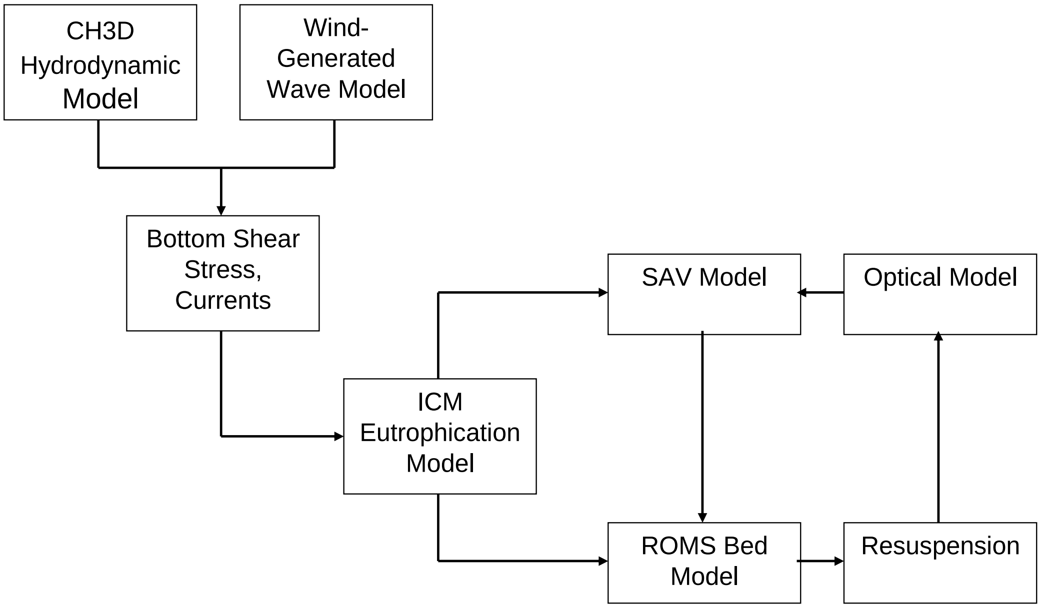
Key Model Refinements in Simulating Water Clarity-SAV

The Bay Water Quality Model used in setting the 2003 Chesapeake Bay nutrient and sediment allocations (Cerco and Noel 2004; Linker et al. 2000; Cerco et al. 2004) was refined to include full sediment transport of four classes of inert particulates approximating the settling and transport behavior of sand, silt, clay, and a sediment fraction of slowly settling clay. The resulting Chesapeake Bay WQSTM was capable of resolving turbidity maximum zones in the Bay and appropriately setting the boundary conditions for the shallow water region of the SAV/water clarity criteria. Resuspension of sediment was generated by currents, both tidal and residual, and by waves. Additional refinements included high resolution at half-meter depths of the shallow-water SAV growth areas (Figure P-1), an advanced optics model of underwater light attenuation, improvements to the SAV simulation, and refinements to shoreline erosion. Those model refinements and additions are shown schematically in Figure P-2.



Source: Cerco et al. 2010

Figure P-1. A schematic of the half-meter depths of the SAV sub-grid unit cells mapped to the WQSTM grid cell, which provides light attenuation and other model state variables the SAV growth cell.

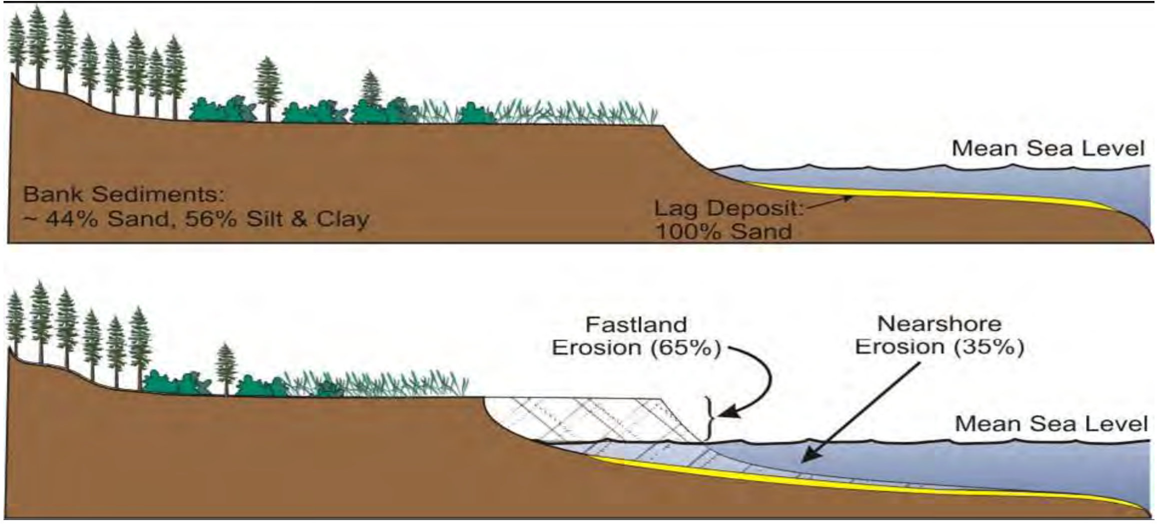


Source: Cerco et al. 2010

Figure P-2. A schematic of the WQSTM refinements applied for the simulation of the SAV/water clarity water quality standard.

Refinements to Shore Erosion Estimates

Consistent temporal and spatial data for erosion rates, bank heights, shoreline protection, and sediment type were needed for the entire Chesapeake Bay to better estimate the role of shoreline erosion in the overall sediment budget (Hennessee et al. 2006; Hardaway et al. 1992). The refined shoreline sediment load estimates included both bank load (e.g., fastland erosion) and nearshore erosion (Figure P-3). Spatially explicit erosion rates by *reach* that allowed for variance with bank height, shoreline orientation, and sediment composition were calculated. Best estimates of the actual shoreline lengths were used, including reduced erosion rates for enclosed minor inlets where reduced wave and current erosion would be expected. The different shoreline loading estimates were then incorporated into the appropriate WQSTM cells.



Source: Hopkins and Halka 2007

Figure P-3. Example of fastland and nearshore components of the shoreline sediment loads.

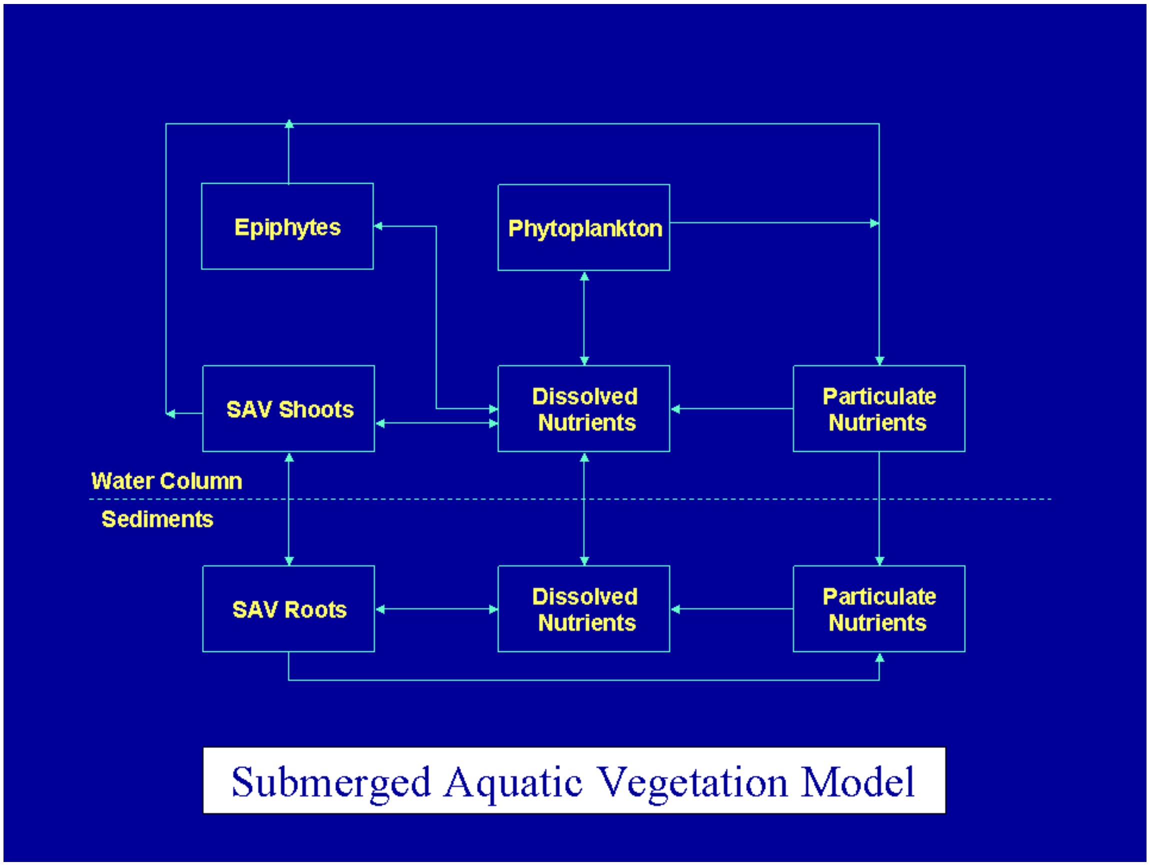
For unprotected shorelines the shoreline erosion computation was as follows:

- Eroded Fastland Volume = Shoreline Length × Elevation × Erosion Rate/Day
- Total Eroded (Fastland + Nearshore) = Fastland Mass / 0.65
- Eroded Silt/Clay Mass = Total Eroded Volume × Bulk Density × Silt Clay %
- Different silt/clay proportions for bank and marsh sources (Applied to Maryland portion tidal shoreline only)
- Different silt/clay proportions for north and south banks of each major river (Applied to Virginia tidal shoreline only)

For protected shorelines everywhere, the assumption was that fastland erosion was eliminated, but that nearshore erosion continued. Nearshore erosion was estimated for protected shorelines by using adjacent or nearby unprotected shoreline.

Simulating SAV

The unit SAV simulation computes SAV density (mass / unit area) as a function of irradiance and nutrients for SAV shoot and roots as shown in Figure P-4. Irradiance and epiphytes are calculated separately, and the SAV model fully interacts with water column and bed sediments (see Figure P-4).



Source: Cerco 2009

Figure P-4. The Chesapeake Bay WQSTM's SAV unit model.

The current simulation of SAV considers light to be the sole determinant of SAV abundance, but other factors such as composition of bottom substrate, SAV community structure, and seed bank availability are significant. Those factors are not explicitly simulated in the WQSTM but are accounted for via an empirical *probability of success.*

The probability function was empirically set to best represent SAV biomass under current nutrient loads and adjusted to improve the probability of SAV growth under conditions that are more representative of mid-1900s Chesapeake nutrient loads (Hagy et al. 2004). The use of the empirically set probability function for SAV allowed appropriate SAV levels to best simulate water clarity, which was solely used to assess the water clarity criteria. Moving forward, in the next generation of the Bay Model, the probability function will be replaced with salient first principal forcing functions.

Process of Assessing the Water Clarity-SAV Criteria

Three methods are used to assess attainment of the Bay jurisdictions' SAV/water clarity water quality standards. Any one of the following three methods can be used to determine whether the SAV and water clarity goal is achieved. The SAV/water clarity criteria assessment applied to the Bay WQSTM scenario output is always on the combined SAV and water clarity criteria assessment method.

> *Using only acres of SAV coverage:* A segment attains the goal if the SAV acreage of single best year in the segment is met in the preceding 3 years (including the current year) (USEPA 2003).
>
> *Using only water clarity acres:* A segment attains the goal if the single best year water clarity acreage in the preceding 3 years exceeds 2.5 times the SAV restoration acreage. The water clarity acres for a year are assessed on the basis of the arithmetic mean of monthly water clarity in the criteria months that meets the water clarity criteria (see Section 3.1.4, Table 3-5 of the TMDL Report) (USEPA 2007).
>
> *Using combined SAV and water clarity achievement:* This method considers both the achieved SAV acreage and water clarity acre in a segment. In the assessment, the water clarity acre can be converted to an SAV-equivalent acre by dividing the water clarity acre by 2.5, which will be credited along with the SAV coverage estimated by regression model.

Estimating SAV/Water Clarity in a WQSTM Loading Scenario

In the combined SAV and water clarity assessment, both the SAV acres and water clarity acres need to be estimated in load-reduction scenarios. The light extinction coefficient, *Ke*, is the metric used to measure water clarity. The Ke in a load-reduction scenario is estimated using the Chesapeake Bay WQSTM. The SAV area in a load reduction scenario is estimated from a regression model.

Ke Assessment by the WQSTM

The simulated Ke in the WQSTM is based on the amounts of simulated clay, silt, sand, organic particulates, and dissolved organic matters in a model cell. Because the simulated Ke is an imperfect representation of the observed Ke, a data-correction method is used to obtain an adjusted scenario Ke in each shallow cell for the target loading scenario. While several more sophisticated data correction methods were tried, a simple proportional adjustment of the shallow-water Ke to the nearest observed water quality monitoring station was found to provide the best shallow-water data correction as determined by independent, shallow-water monitoring sites.

The shallow-water bay grass designated-use habitat is considered the are located between the 2-meter depth contour and the adjacent shoreline. A segment consists of Bay WQSTM cells. Because of inconsistency between the model cell boundary and the 2-meter contour area, EPA remapped and extended the model cells to cover tidal water up to the shoreline, and subdivided the area into 0–0.5 meters, 0.5–1.0 meters, 1.0–1.5 meters, and 1.5–2.0 meter depths. For each half-meter contour area, EPA applies corresponding Ke criteria (see Section 3, Table 3-5). Note that the areas of defined no-growth zone are excluded from the cell/segment area in the assessment.

Credit of SAV Area Based on Observed SAV Area

The projected SAV acreage in a target scenario is based on a regression of observed SAV in the Bay segments which, together, compose the major tributaries and the nutrient and sediment loads from each corresponding land basin (i.e., the major subwatershed) of the Chesapeake Bay watershed, which provides loads to the collective set of segments (Table P-1).

Through the Baywide SAV aerial survey, the partners have access to annual SAV distribution and abundance data for almost every year in the past 30 years. The attached Excel file, Appendix P SAV Coverage 1971-2009 Spreadsheet.xls, shows observed SAV for Bay segments in 1971-2009. The observed SAV areas from 102 segments are aggregated into SAV areas for the 8 tidal basins for each year.

Total nitrogen (TN), total phosphorus (TP), and total suspended sediment (TSS) loads from the 8 major basins are estimated from the Phase 5.3 Chesapeake Bay Watershed Model's progress scenarios under years 1985, 1987, 1992, 1998, 2002, 2005, 2007, and 2009 management conditions.

Linear regression of SAV versus load of TN or TP or TSS, respectively, is conducted for each basin, yields

$$\text{SAV} = m\,\text{Load} + b$$

where, coefficient m is the slope and b is the intercept from the linear regression. The results are presented in Table P-1.

For individual basins, we use the regression of SAV with Load component TN or TP or TSS, which has the highest R2 of regression.

The Bay TMDL's critical period of 1993–1995 is our reference for the TMDL. The load in the reference year for each basin can be estimated from Bay Watershed Model calibration, and the corresponding SAV is known from the observation. They also have the relationship

$$\text{SAV\_ref} = m\,\text{Load\_ref} + b.$$

A projected SAV of the basin in a load reduction scenario is calculated as follows:

$$\text{Proj\_SAV} = m\,\text{Proj\_load} + b$$

Therefore, $\text{Proj\_SAV} - \text{SAV\_ref} = m\,(\text{Proj\_load} - \text{Load\_ref})$.

We can calculate the ratio

$$\text{Rate} = \text{Proj\_SAV} / \text{SAV\_ref} = (\text{Proj\_SAV} - \text{SAV\_ref}) / \text{SAV\_ref} + 1 = m\,(\text{Proj\_load} - \text{Load\_ref}) / \text{SAV\_ref} + 1 = (m\,(\text{Proj\_load} - \text{Load\_ref}) + \text{SAV\_ref}) / \text{SAV\_ref}$$

Thus, the projected SAV of this basin for the target loading scenario can also be estimated by

Proj_SAV = Rate × SAV_ref.

EPA assumes that the rate calculated from a major river basin is applicable to individual Bay segments contained within that basin. That rate is then used to calculate projected SAV in the reference hydrology year for each Bay segment within that basin:

Proj_SAV (seg) = Rate × SAV_ref (seg).

The projected SAV in segments is then used for SAV credit in the assessment.

Table P-1. Results of linear regression of SAV versus TN, TP, and TSS loads for 8 major basins

Basin	Component	R2	Slope	Intercept
Susquehanna	TN	0.8983	-4.16E+02	6.43E+04
Susquehanna	TS	0.8049	-2.77E+01	9.11E+04
Susquehanna	TP	0.6847	-8.54E+03	5.12E+04
Potomac	TN	0.9068	-2.85E+02	2.82E+04
Potomac	TS	0.8769	-2.13E+01	6.83E+04
Potomac	TP	0.8449	-1.28E+04	7.04E+04
York	TN	0.0468	1.09E+03	1.79E+03
York	TS	0.8948	-8.81E+01	2.65E+04
York	TP	0.7539	-9.38E+03	1.79E+04
Eastern Shore	TN	0.1615	-1.87E+03	7.69E+04
Eastern Shore	TS	0.5769	-2.29E+02	1.20E+05
Eastern Shore	TP	0.3518	-2.18E+04	8.09E+04
Rappahannock	TN	0.5900	-6.93E+02	6.57E+03
Rappahannock	TS	0.5425	-8.42E+00	7.88E+03
Rappahannock	TP	0.6609	-5.44E+03	7.68E+03
James	TN	0.9624	-8.54E+00	3.81E+02
James	TS	0.8763	-3.59E-01	5.89E+02
James	TP	0.7467	-3.27E+01	2.21E+02
MD Western Shore	TN	0.5437	-2.35E+02	6.11E+03
MD Western Shore	TS	0.7106	-4.79E+01	1.49E+04
MD Western Shore	TP	0.5361	-3.50E+03	5.17E+03
Patuxent	TN	0.5940	-2.02E+02	9.31E+02
Patuxent	TS	0.5693	-3.66E+00	7.66E+02
Patuxent	TP	0.3253	-1.38E+03	6.89E+02

Assessing Attainment of the SAV/Water Clarity Standard

Before the assessment, EPA converted the SAV restoration goal acreage (see Section 3.1.4, Table 3-6 of the TMDL Report) with a factor of 2.5 to establish the water clarity acre for each Bay segment.

For individual months, EPA compared the monthly average Ke in a cell at four depth-interval areas (0–0.5, 0.5–1.0, 1.0–1.5, and 1.5–2.0) with the applicable water clarity criterion for the four application depths (i.e., 0.5, 1.0, 1.5, and 2.0), respectively. If it meets the criterion for that depth, the area is accounted. Adding the area achieving the water clarity criterion for each depth of all cells in the segment, yields the total area achieving the water clarity criterion for the month. Averaging (using arithmetic mean) the monthly achieving areas in the criteria months (i.e., SAV growing seasons—see Section 3.1.4, Table 3.5 of the TMDL Report) produces the water clarity acres for that year for each segment. If the water clarity acre is smaller than the SAV area, EPA uses 2.5 of the assessed SAV area as the total water clarity acre from the combined SAV/water clarity assessment in the year. If the water clarity acre is greater than the SAV area, EPA credits 1.5 of the assessed SAV area, into the total water clarity acre of this year for this combined SAV/water clarity assessment.

Finally, the water clarity acre in single best year of the 3 consecutive assessment years (i.e., 1993–1995 hydrology years) is regarded as the achieved water clarity acreage. If the achieved water clarity acre was greater than the water clarity acre goal (i.e., 2.5 times SAV acre goal), the combined SAV/water clarity criteria were projected to be achieved in this segment under model loading scenario. Otherwise, i.e., the achieved water clarity acre is less than the water clarity acre goal, a percent violation is calculated as follows:

$$100 \times (\text{water clarity acre goal} - \text{water clarity acre}) / \text{water clarity acre goal}.$$

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Appendix S.

Offsetting New or Increased Loadings of Nitrogen, Phosphorus, and Sediment to the Chesapeake Bay Watershed

As an assumption of the Chesapeake Bay total maximum daily load (TMDL), U.S. Environmental Protection Agency (EPA) expects Chesapeake Bay jurisdictions to account for and manage new or increased loadings of nitrogen, phosphorus, and sediment.

As explained in Section 10.1, where the TMDL does not provide a specific allocation to accommodate new or increased loadings of nitrogen, phosphorus, or sediment, a jurisdiction may accommodate such new or increased loadings only through a mechanism allowing for quantifiable and accountable offsets of the new or increased load in an amount necessary to implement the TMDL and applicable water quality standards (WQS) in the Chesapeake Bay and its tidal tributaries.

Therefore, the Chesapeake Bay TMDL assumes and EPA expects that the jurisdictions will accommodate any new or increased loadings of nitrogen, phosphorus, or sediment that lack a specific allocation in the TMDL with appropriate offsets supported by credible and transparent offset programs subject to EPA and independent oversight. This appendix provides details of common elements from which EPA expects the jurisdictions to develop and implement offset programs.

Source Documents

The common elements are based on, and consistent with, the following documents provided or made available to the jurisdictions:

National Guidance

- *Water Quality Trading Policy*, EPA, 2003 (http://www.epa.gov/owow/watershed/trading/finalpolicy2003.pdf).
- *Water Quality Trading Toolkit for NPDES Permit Writers*, EPA, 2007 (http://www.epa.gov/owow/watershed/trading/WQTToolkit.html).

Regional/Chesapeake Bay Specific Documents

- *Expectations Letter*, EPA Region 3 to Principals' Staff Committee, Nov. 4, 2009 (http://www.epa.gov/reg3wapd/pdf/pdf_chesbay/tmdl_implementation_letter_110409.pdf).
- *Federal Actions Letter*, EPA Region 3 to Chesapeake Bay jurisdictions, Dec. 29, 2009 (http://www.epa.gov/region3/chesapeake/bay_letter_1209.pdf).
- *A Guide for EPA's Evaluation of Phase I Watershed Implementation Plans*, EPA Region 3, Apr. 2, 2010 (http://archive.chesapeakebay.net/pubs/Guide_for_EPA_WIP_Evaluation_4-2-10.pdf).

- *Strategy for Protecting and Restoring the Chesapeake Bay Watershed*, Federal Leadership Committee, May 12, 2010 (http://executiveorder.chesapeakebay.net/category/Reports-Documents.aspx).

Definitions

The terms used in this appendix are to be interpreted consistently with the above-listed source documents, unless specifically defined below.

1. *Offset*. For purposes of the Chesapeake Bay TMDL, means (n.) a reduction in the loading of a pollutant of concern from a source or sources that is used to compensate for the loading of the pollutant of concern from a different point or nonpoint source in a manner consistent with meeting WQS; or (v.) compensating for the loading of a pollutant of concern from a point or nonpoint source with a reduction in the loading from a different source or sources, in a manner consistent with meeting WQS.
2. *Credit*. For purposes of the Chesapeake Bay TMDL, means a measured unit of nitrogen, phosphorus, or sediment pollutant reduction per unit of time at a location designated and standardized by the jurisdiction that can be generated, sold, or traded as part of an offset.
3. *Offsets Baseline*. For purposes of the Chesapeake Bay TMDL, means the amount of pollutant loading allowed by wasteload allocation (WLA) or load allocation (LA) that applies to individual credit generators in the absence of offsets. Sources generating credits are expected to first achieve their applicable offset baselines before credits may be generated.
4. *New or Increased Loading* of nitrogen, phosphorus or sediment. For purposes of the Chesapeake Bay TMDL means, for a point or nonpoint sources meeting its Chesapeake Bay TMDL WLA or LA as of the date of establishment or modification of the Chesapeake Bay TMDL, any nitrogen, phosphorus, or sediment loading from the point or nonpoint source in an amount greater than reflected by WLAs or LAs in the Chesapeake Bay TMDL; for a point or nonpoint sources not meeting its Chesapeake Bay TMDL WLA or LA as of the date of establishment or modification of the Chesapeake Bay TMDL, any nitrogen, phosphorus, or sediment loading from the point or nonpoint source in an amount greater than reflected by WLAs or LAs in the Chesapeake Bay TMDL, after the point in time the source begins meeting its WLA or LA.

Common Elements

As an assumption of the Chesapeake Bay TMDL, EPA expects that offset credits will be generated under programs that are consistent with the common elements described below. Those common elements are not presented here as regulatory requirements. However, EPA believes that in the aggregate, they will help to ensure that offsets are achieved through reliable pollution controls and that the goals of the Bay TMDL are met. EPA recognizes the value that consistent offset programs will have in promoting effective regional implementation of the TMDL.

1. *Authority*. That legal authority exists to authorize the new or increased loading of nitrogen, phosphorus, and sediment on the basis of offsetting reductions from another point or nonpoint source and to implement, monitor, and enforce such offsets.

2. *Offsets Baseline (for credit generators)*. That any point or nonpoint source generating a credit has implemented practices or met any reductions necessary to be consistent with the Chesapeake Bay TMDL allocations:
    - (a) For point sources generating credits, the TMDL assumes that the offsets baseline is the water quality-based effluent limit (WQBEL) included in that discharger's permit consistent with the applicable WLA in the TMDL. For some point sources, the baseline will be a numeric limitation; for others, it will be a suite of BMPs determined to be protective of WQS.
    - (b) For nonpoint sources generating credits, baseline options should be consistent with the TMDL LA for the appropriate sector and may be further defined in terms of load, geographic scale, minimum practices, schedule of implementation and/or time needed to facilitate improved environmental compliance with WQS.
3. *Minimum Controls (for credit users)*. That any point or nonpoint source using a credit has implemented certain minimum controls:
    - (a) For point sources using credits, that the discharger using a credit will meet on-site any relevant minimum technology-based standards or secondary treatment standards.
    - (b) For nonpoint sources using credits, that the source has met all federal, state, and local requirements applicable to nonpoint sources.
4. *Eligibility*. Inclusion in the basis and record for any offset, any additional criteria the jurisdiction will use to determine when a point source or nonpoint source may generate credits. Inclusion of a statement defining the eligibility requirements for and acceptable roles of aggregators or third parties in generation, sale, and purchase of offsets on behalf of others.
5. *Credit Calculation and Verification:* Ensuring that credits are quantified using appropriate metrics and are routinely verified to ensure that they are producing expected reductions, including the following:
    - (a) Appropriately quantifying pollutant loading credits generated and ensuring that offsets acquired reflect load reductions equivalent to or greater than the new or increased loadings being offset, including the following:
        - i. Accounting for the equivalency of pollutants to compensate for changes in pollutant form, e.g., total nitrogen versus dissolved nitrogen;
        - ii. Accounting for uncertainty of source reductions due to factors such as practice efficiencies related to the use of BMPs, a lack of required monitoring or reporting compared to other sources, and/or the lack of regulation of the source by federal, state and/or local regulations;
        - iii. Accounting for any distance between the generating and acquiring sources that could affect water quality including the potential for

water chemistry variations and other delivery factors that could cause pollutant attenuation;

iv. Accounting rules for inclusion of practices implemented through public cost-share incentives; and

v. Accounting for degradation in the effectiveness of a practice over the projected term of the practice.

(b) Validating that proposed activities to create reductions (e.g., treatment or BMP installation) are expected to generate the credits offered for offsets, including identifying the metrics and data used to quantify the offset/credit generated and the period for credits.

(c) Verifying that the credit was and continues to be generated, via monitoring, inspection, reporting, or some other mechanism, including articulating the frequency of on-site or other monitoring and the entity responsible for conducting monitoring or inspections.

(d) Articulating whether third parties may verify and certify credits and offsets within and between jurisdictions.

6. *Safeguards.* Inclusion in the basis and record for any offset, safeguards to ensure that the entire delivered load is accounted for and that water quality will be protected, such as the following:

(a) Prohibiting the use of offsets where such use would cause or contribute to exceedances of WQS, TMDLs, WLAs or LAs in affected receiving waters, locally or elsewhere;

(b) Restricting the use or generation of offsets by an unpermitted point source or a source that is not in compliance with its NPDES permit or a jurisdiction equivalent, or other federal or state law or regulation;

(c) Protecting affected communities from disproportionate harm arising from offsets; and

(d) Ensuring temporal consistency between the period when a credit or offset is generated and when it is used. As provided for in EPA's *Water Quality Trading Toolkit*, "credits should not be used before the time frame in which they are generated." That includes any credits expected to be generated under a contract between a new discharger and a generating source, or credits generated under an in-lieu fee program in which the jurisdiction uses discharger paid fees to achieve loadings reductions beyond baseline. For NPDES dischargers, credits should be created and used within the periods that are used to determine compliance with effluent limitations. The permitting authority may have discretion to determine the appropriate averaging period for WQBELs, depending on the pollutants of concern and other watershed specific factors. The permitting authority should decide whether and when a credit expires.

7. *Certification and Enforceability*. Designating the process to be used and the institutional entity responsible for credit/offset program operation and certification, and ensuring the enforceability of Clean Water Act discharge permits and offset transactions, including the following:
    (a) Requiring that any offsets, along with the enforceable WQBELs based on the applicable WLA (e.g., zero for new dischargers), will be included and recorded in the NPDES permit.
    (b) Estimating annually the increased pollutant loading from nonpoint sources and discharges from point sources that will not be permitted, acquiring offsets needed to fully offset such increases, and recording those offsets in an appropriate instrument.
    (c) Determining whether offsets may occur without reopening or modifying a NPDES permit to incorporate the offset transaction.
    (d) Ensuring that transactions can be enforced by the jurisdiction. Articulating how transactions can otherwise be protected by the jurisdiction, for example through a credit reserve insurance account, if failure by the offset generator occurs.
    (e) Determining whether a civilly enforceable agreement exists between an offset generator and an offset user.
    (f) Ensuring that an NPDES permittee remains accountable for meeting the WQBEL(s) in its permit, for example through a standard condition in all NPDES permits within a jurisdiction.
8. *Accountability and Tracking*. Developing accountability and tracking system(s) that are holistic and focused on performance outcomes while providing maximum transparency, operational efficiency, and accessibility to all interested parties. Such system(s) should demonstrate the following:
    (a) An appropriate offset baseline is used to generate credits.
    (b) The offset is quantified and verified according to standards established by the jurisdiction.
    (c) The offset or credit is sold to no more than one purchaser at a time.
    (d) The nutrient delivery equivalency of the offset generated and the offset consumed both in terms of the equivalency of pollutants and appropriate attenuation.
    (e) The locations(s) of the offset, including where the offset or credit is generated.
    (f) Authentication of ownership.
    (g) The NPDES permit number or other identification of the purchaser of the offset or credit.
    (h) Documentation of agreements between parties to the offset transaction.

    (i) Whether sufficient offsets will be acquired over the period of the new or increased loading.
    (j) Compliance status of NPDES parties.
    (k) The results of monitoring and verification for each offset.
    (l) Time frames for regular review and evaluation of the offset program.

9. *Nutrient-impaired Segments*. In addition to the safeguards in 6 above, ensuring that offsets in nutrient-impaired water segments
    (a) Result in progress toward attainment of WQS in the impaired segment;
    (b) Do not result in exceedances of WQS in the purchaser's impaired segment; and
    (c) Do not increase delivery loads in downstream impaired segments, do not violate WQS in any intermediary segments, and do not violate local WQS.
10. *Credit Banking.* Appropriate roles and operating practices of credit banks should be specified. It is recommended that credit banking on a basin or interstate basis be authorized subject to meeting the elements noted above. Expectations concerning necessary costs and reasonable expenses of banks that acquire and sell credits should be described.

The Chesapeake Bay jurisdictions also can consider whether to use the additional offset program features discussed in Section 10.1.3 to build their offset programs for new or increased loadings of nitrogen, phosphorus, and sediment. Those include net improvement offsets, aggregated programmatic credits, and a reserve-offset hybrid.

In developing and implementing their offset programs, EPA encourages jurisdictions to consult with EPA to facilitate alignment with the Clean Water Act and the Chesapeake Bay TMDL. EPA intends to fulfill its various oversight responsibilities of these offset programs by conducting periodic audits and evaluations as detailed in Section 10.1.4. Where questions or concerns arise, EPA will use its oversight authorities to ensure that offsets and offset programs are fully consistent with the Clean Water Act and its implementing regulations.

Appendix T.
Sediments behind the Susquehanna Dams Technical Documentation

Assessment of the Susquehanna River Reservoir Trapping Capacity and the Potential Effect on the Chesapeake Bay

Prepared for: United States Environmental Protection Agency
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Introduction

In developing the Chesapeake Bay Total Maximum Daily Load (TMDL), EPA must account for a vast array of dynamics that affect the loadings to the Chesapeake Bay and how to appropriately assign load allocations to each state. A large influencing factor in sediment and nutrient loads to the Chesapeake Bay are the dams along the lower Susquehanna River, which retain large quantities of sediment in their reservoirs. The three major dams along the lower Susquehanna River are the Safe Harbor Dam, Holtwood Dam, and the Conowingo Dam. This document looks at the dams' effects on the pollutant loads to the Chesapeake Bay and how those loads will change when the dams no longer function to trap sediment.

Sediment Trapping and Storage Capacity

Annually, the reservoir system traps approximately 70 percent of the sediment passing through the system (Langland and Hainly 1997). The trapping capacity is the ability of a reservoir to continue storing sediment before reaching an equilibrium, after which the amount of sediment flowing into the reservoir equals the amount leaving the reservoir, and the stored volume of sediment is relatively static. The sediment storage capacity is the actual maximum amount of sediment that can be stored in a reservoir when it is at equilibrium.

Safe Harbor Dam (Lake Clarke) and Holtwood Dam (Lake Aldred)

Lake Clarke and Lake Aldred have no remaining sediment trapping capacity. The two lakes have been in long-term equilibrium for 50 years or more.

Conowingo Dam and Reservoir

The Conowingo Reservoir is divided into three parts: upper, middle and lower. The upper and middle portions of the reservoir are in long-term equilibrium. Other than temporary increases in sediment storage due to scour events, there is no remaining storage capacity (Langland 2009a).

The lower part of the reservoir is the final 4 miles from just above Broad Creek to the Conowingo Dam. Between 1996 and 2008, 12,000,000 tons of sediment were deposited in the Conowingo Reservoir, primarily in the lower part (Langland 2009a). The total amount of sediment stored in the lower part of the reservoir was 103,000,000 tons by 2008 (Langland 2009a). The lower part of the Conowingo Reservoir is the only section of the entire three-reservoir system that has not reached long-term sediment storage equilibrium. Some trapping capacity remains in this portion of the reservoir.

Expected Time Remaining until Sediment Storage Capacity Is Reached

The sediment storage capacity of Conowingo Reservoir has been decreasing since 1929, except during temporary scour events, such as the one during the *Big Melt* in January 2006 (Langland 2009a). The average reservoir sediment-deposition rate from 1959 to 2008 was 2,000,000 tons per year (Langland 2009). The long-term trapping efficiency of the Conowingo Reservoir has remained relatively stable at around 55 percent for the last 30 years (Michael Langland, USGS, personal communication, November 4, 2009).

According to the U.S. Geological Survey's (USGS's) most recent study, 20,000 acre-feet of sediment storage remain in the Conowingo Reservoir from Hennery Island to the dam; this translates to 30,000,000 tons of sediment (Langland 2009a). Given the rate of transport is 3,000,000 tons per year, and the rate of deposition is 2,000,000 tons per year, if there are no major scouring events in the Conowingo Reservoir and the sediment input does not change, the remaining capacity will be filled in 15–20 years (Langland 2009a). Once the sediment storage capacity is reached, sediment loads transported downstream past the reservoir will approach the loads transported from upstream (Langland 2009a).

However, because Langland notes that the time until the reservoir reaches capacity is affected by three factors—sediment transport into the reservoir, scour removal events, and sediment trapping efficiency—the time until steady state conditions are reached could be extended to 25–30 years (Langland 2009b). That assumes sediment transport decreases from 3.2 to 2.5 million tons/year, statistically expected scour events occur, and the long-term trapping efficiency remains at 55 percent (Langland 2009b).

It should be noted that the sediment trapping efficiency of the reservoir is highly variable, depending on rainfall. During drought conditions, the trapping efficiency can increase to 85 percent, and during wet periods, the trapping efficiency can fall to 40 percent (Michael Langland, USGS, personal communication January 15, 2010).

Effects on Chesapeake Bay Once Sediment Storage Capacity is Reached

As of 1997 the Susquehanna River contributed roughly 50 percent of the fresh water discharge to the Chesapeake Bay and about 66 percent of the annual nitrogen load, 40 percent of the phosphorus load, and 25 percent of the suspended sediment load from non-tidal parts of the Bay (Langland and Hainly 1997).

According to USGS water quality sampling in 1985–1989, pollutant loads in the Susquehanna River increase substantially below Harrisburg, Pennsylvania: total nitrogen increased 42 percent, total phosphorus increased 49 percent, and total suspended sediment increased 50 percent compared to loads at Harrisburg (Reed et al. 1997). The increased load is a result of more urbanized areas, agrochemical fertilizers and manure, and fewer forested areas (Reed et al.

1997). A significant percentage of those pollutant loads are captured by sediment deposition behind the dams, primarily the Conowingo Dam.

Once the Conowingo Reservoir reaches the sediment trapping capacity, the sediment and nutrient loads delivered to the Chesapeake Bay via the Susquehanna River will equal the load delivered into the reservoir system (Langland and Cronin 2003). Once storage capacity is reached, the nitrogen load will increase by 2 percent; the phosphorus load will increase by 40 percent; and the suspended sediment load will increase by at least 150 percent (Langland and Cronin 2003).

Proposed Activities to Address Sediment Build up Behind the Dam

Dredging

The Susquehanna River Basin Commission Sediment Task Force examined the issue of finding options to address the sediment accumulation behind the Conowingo Dam and concluded that dredging may provide the needed sediment storage capacity behind the dams (SRBC 2002).

In 2009 the U.S. Army Corps of Engineers (USACE) Baltimore District received funds to conduct a study of sediment management in the Conowingo Reservoir. The investigation could be developed as a Sediment Management Plan, to prioritize areas for work and make recommendations to implement sediment reduction options (Compton 2009). The study approach outlined by the USACE is conceptual, and the final components will be determined with input from the cost-share sponsor. The USACE has not yet found a cost-share partner for this feasibility study (Anna Compton, USACE Baltimore District, personal communication, December 22, 2009).

Conowingo Hydroelectric Project Relicensing Process

The Conowingo Hydroelectric Project is undergoing relicensing. On February 4, 2010 FERC (Federal Energy Regulatory Commission) accepted Exelon’s Revised Study Plan, including the requested study *Sediment Introduction and Transport (Sediment and Nutrient Loading)* which will address “the effects of the Conowingo Project and its operation on upstream sediment and nutrient accumulation, sediment transport past the project, and sediment deposition and distribution upstream and downstream of the projects” (Exelon Corporation 2009). Specific tasks include a review of existing information regarding sediment and nutrient storage capacity, accumulation rates, scouring events, and such, in the Conowingo Reservoir; an analysis of the effects of project operations on habitat and substrate below the dam; and a review of watershed-based management efforts and load reduction successes. Exelon noted that the “estimated cost in 1995 dollars of dredging to simply keep up with annual sediment inflow (estimated to be 2.3 million cubic yards per year at the time) was $28 million per year. Using Means Cost Indices the comparable 2009 cost would be $48.44 million.

Cost Comparison of Dredging and Other Nutrient and Sediment Reduction Strategies

Comparisons with cost estimates for dredging Baltimore Harbor and Channels from the *Dredged Material Management Plan and Final Tiered Environmental Impact Statement* (Weston Solutions 2005) reveal that dredging costs are highly variable, and, to a large extent, depend on the selected destination and use of the dredged materials. Costs can be as little as $12/yd^3 for artificial island creation or beach nourishment and as much as $69/yd^3 if dredged materials are taken to a confined disposal facility (Weston Solutions 2005). The sediment management feasibility study proposed by the USACE, and awaiting a cost-share sponsor, is likely the best mechanism to determine the true cost of dredging the Conowingo Reservoir.

Cost-Effective Strategies for the Bay (Chesapeake Bay Commission 2004) outlines the six most cost-effective practices to reduce nutrient and sediment loading to the Chesapeake Bay. Table T-1 summarizes the six selected practices and their estimated costs and compares them to the estimated costs of dredging the Conowingo Reservoir. Rough estimate calculations of dredging costs at Conowingo were based on the cost assumptions used by Exelon and SRBC and the assumption that 1 yd^3 of sediment weighs 0.945 tons. It is not known, at this time, what is included in Exelon's estimate of the cost to dredge; an assumption was made that the costs include disposal of the dredged materials, and any other associated costs.

Table T-1. Cost-Effective Strategies for Reducing Nitrogen and Sediment Loads to the Bay Compared to Estimated Dredging Costs

Practice	Annual nitrogen reduction at maximum feasible level of implementation	Annual phosphorus reduction at maximum feasible level of implementation	Annual sediment reduction at maximum feasible level of implementation
Wastewater Treatment Plant Upgrades	35 million lbs @ $8.56/lb	3 million lbs @ $74.00/lb	Not applicable
Diet and Feed Adjustments	Under development	0.22 million lbs @ no additional cost (poultry only)	Not applicable
Traditional Nutrient Management	13.6 million lbs @ $1.66/lb	0.8 million lbs @ $28.26/lb	Not applicable
Enhanced Nutrient Management	23.7 million lbs @ $4.41/lb	0.8 million lbs @ $95.79/lb	Not applicable
Conservation Tillage	12.0 million lbs @ $1.57/lb	2.59 million lbs @ no additional cost	1.68 million tons @ no additional cost
Cover Crops	23.3 million lbs @ $3.13/lb	0.44 million lbs @ no additional cost	0.22 million tons @ no additional cost
Rough estimate calculations of dredging costs	Annual nitrogen dredged based on removal equal to annual trapped amount	Annual phosphorus dredged based on removal equal to annual trapped amount	Annual sediment dredged based on removal equal to annual trapped amount
Dredge Conowingo Reservoir	3 million lbs @ $16.42/lb	3.48 million lbs @ $14.15/lb	4,420 million lbs @ $0.01/lb

Source: CBC 2004

Proposal for Addressing the Sediment and Phosphorus Load in the Chesapeake Bay TMDL

EPA's intention is to assume the current trapping capacity will continue through the planning horizon for the TMDL (through 2025). The Conowingo Reservoir is anticipated to reach a steady state in 15 – 30 years, depending on future loading rates, scour events and trapping efficiency. The steady state condition is at the limits of the planning horizon for the TMDLs and, depending on conditions, could be well beyond the planning horizon.

Under these assumptions, the wasteload allocations (WLA) and load allocations (LA) would be based on the current conditions at the dam. This represents a business-as-usual scenario in which the future diminished trapping capacity behind the Conowingo Dam is not considered in developing of the wasteload WLA and LA.

If future monitoring shows the trapping capacity of the dam is reduced, then EPA would consider adjusting the Pennsylvania, Maryland and New York 2-year milestone loads based on the new delivered loads. The adjusted loads would be compared to the 2-year milestone commitments to determine if the states are meeting their target load obligations.

Future increases in sediment and phosphorus downstream of the dam can be minimized by making implementation activities above the dam a management priority. This will decrease the overall loads of sediment and phosphorus, and extend the time until trapping capacity is reached. The states should work together to develop an implementation strategy for the Conowingo Dam and take the opportunity to work with FERC during the relicensing process for Conowingo Dam.

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Appendix U.
Accounting for the Benefits of Filter Feeder Restoration Technical Documentation

Strategies for Allocating Filter Feeder Nutrient Assimilation into the Chesapeake Bay TMDL

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Introduction

Filter feeders play an important role in the uptake of nutrients from the Chesapeake Bay and have the potential to significantly improve water quality if present in large numbers. The current goal for the Chesapeake Bay is to increase the native Eastern oyster, *Crassostrea virginica*, population tenfold. A population increase of that magnitude could remove 10 million pounds of nitrogen annually (Cerco and Noel 2005). Menhaden fish, *Brevoortia tyrannus,* are another filter feeding organism in the Chesapeake Bay. This paper explores the options for incorporating the effects of filter feeders into the Chesapeake Bay TMDL and implementation plans. As a way of fostering management and restoration of filter feeders, the U.S. Environmental Protection Agency (EPA) intends to investigate future monitored levels of filter feeder populations and incorporate that into EPA's model-based tracking of State progress in achieving the 2-year milestones.

Current Harvest Situation

The Atlantic States Marine Fisheries Commission (ASMFC) reports that the reduction[1] fishery harvested 85,000 metric tons of menhaden from the Chesapeake Bay in 2008 and 21,150 metric tons from bait landings (ASMFC 2009b). The vast majority of the catch is in the Virginia portion of the Chesapeake Bay using the purse seining method. Purse seining has been banned in the Maryland portion of the Chesapeake Bay for decades, where menhaden are primarily harvested via pound nets.

Addendum IV to Amendment 1 to the Atlantic Menhaden Fishery Management Plan (Chesapeake Bay Reduction Harvest Cap Extension) extends the annual harvest cap established under Addendum III at 109,020 metric tons on reduction fishery harvests from the Chesapeake Bay (ASMFC 2009a). That will extend the cap through 2013. The cap was extended to allow further investigation into the abundance of menhaden in the Chesapeake Bay. There is concern that localized depletion of menhaden in the Bay is occurring. Stock assessments are conducted on a coast-wide basis and not on the Bay individually, so the Bay population is unknown.

According to the National Marine Fisheries Service (NMFS) Annual Commercial Landings Statistics (NMFS 2010), 249,485 pounds of eastern oyster were harvested in Maryland in 2008, and in Virginia, 352,678 pounds of eastern oysters were harvested. Current oyster populations are about 1 percent of the historic population. This is because of a number of factors including,

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[1] A reduction fishery takes the harvested fish and processes or "reduces" the fish into non-food products, typically to fish meal and oil.

historical overharvesting, disease, loss of habitat, excess sedimentation from deforestation, agricultural practices, urban development, and natural predation (CBP 2009).

Strategies to Increase Filter Feeder Populations in the Chesapeake Bay

Menhaden Nutrient Assimilation

According to Brush et al. (2009), the Chesapeake Bay larval menhaden appear to feed on zooplankton, then transition to phytoplankton as juveniles and return to higher zooplankton consumption rates as adults (age 1+). Given calculated consumption rates for menhaden, based on age, "adults are unlikely to significantly impact phytoplankton biomass and production on a baywide basis" (Brush et al. 2009). Juvenile consumption of algae is estimated to be a few percent of the daily phytoplankton biomass in the summer and fall, and up to 5 percent and 20 percent of daily productivity in the summer and fall, respectively" (Brush et al. 2009). Menhaden might influence water quality on a smaller scale, such as an individual tributary, Bay segment, or menhaden school (Brush et al. 2009). A menhaden simulation is fully operational in the Water Quality and Sediment Transport Model of the Chesapeake Bay, and the model corroborates the findings of Brush et al. (2009). Although the influence of menhaden on water quality is estimated to be less than that of oyster filter feeders, even a small percentage of nutrient assimilation or chlorophyll reduction in the Chesapeake Bay would ease the pressure in meeting 2-year milestones.

Oyster Nutrient Assimilation

Research shows that 700 to 5,500 pounds of total nitrogen are removed annually per 1,000,000 market-sized oysters harvested from the system. That is a wide range of biomass needed for offsets. Assuming the 2:1 reduction requirement under Virginia's trading program, 3.6–28.5 million oysters would be needed to offset 10,000 pounds of total nitrogen (Stephenson 2008).

Stephenson (2009) estimates the cost of total nitrogen reduction from oyster assimilation at $0–$100 per pound. In comparison, agricultural best management practices (BMPs) costs in Virginia range from $4 to $200 per pound and urban stormwater BMPs can be $25 to more than $1,000 per pound or more (Stephenson 2009).

Oyster Restoration and Preservation

Sanctuaries are already part of the planning process in the Virginia Oyster Restoration Plan and Maryland Priority Restoration Areas. Sanctuary areas could provide spawning areas to increase the population of wild oysters.

The *2009 Maryland Oyster Restoration and Aquaculture Development Plan* would increase sanctuary areas from 9 percent to 24 percent of the remaining quality habitat (36,000 acres) in certain locations: Magothy River, Chester River, the area between Patapsco and Back Rivers, Upper St. Mary's River, Point Lookout, Little Choptank River, Upper Patuxent River, and the area between Hooper Strait and Smith Island.

The *Maryland Oyster Restoration and Aquaculture Development Plan* also outlines 600,000 acres newly available for bottom leasing, including 95,524 acres of formerly off-limits natural oyster bars, and develops Aquaculture Enterprise Zones, which are areas preapproved for leasing (MDNR 2009).

Challenges to Increasing Oyster Populations

A limited amount of bottom is suitable and available as oyster habitat. The *Oyster Management Plan* (CBP 2004) suggests that there are 10,000 to 20,000 acres of restorable habitat in Maryland and about 28,500 acres in Virginia. Even within suitable habitat areas, disease mortality and reduced fecundity are major inhibitors to population expansion.

There is a need to provide greater incentives for aquaculture of native oysters. Oyster aquaculture is limited by the supply of disease-resistant seed oysters. Expansion of aquaculture investment is not likely until more seed is available, which is limited by cost-effective market production from seed (CBP 2004).

Accounting for Filter Feeders in the TMDL

EPA has based the filter feeder component of the TMDL on the current population of filter feeders. Potential future population changes are not accounted for in the TMDL itself. Restoration efforts have been underway for years to increase filter feeder populations with minimal observed population change. The combined factors of disease, lack of suitable substrate and excess nutrients fuel the growth of algae blooms that deplete oxygen in deeper waters and can hinder the development of oysters. Until some of the stressors on the oyster population are alleviated it is not practical to heavily rely on filter feeders to address the water quality issues in the Chesapeake Bay. If future monitoring data indicate changes in the filter feeder population, the 2-year milestone delivered load reductions can be adjusted accordingly. The adjusted loads will be compared to the 2-year milestone commitments to ensure each state is meeting its obligations.

Crediting Filter Feeder Benefits

During the 2-year milestone evaluation of filter feed populations, credits or debits for changes in populations and associated nutrient assimilation can be assigned in one of two ways that EPA is considering.

Under Option A, only the state responsible for the filter feeder changes would obtain a credit/debit towards reaching its 2-year milestones. It would be possible for any state or the District of Columbia to receive credit toward increasing filter feeder populations. Maryland and Virginia can implement their programs directly. Nontidal states and the District of Columbia could provide support to Maryland and Virginia programs to increase filter feeder populations. Maryland and Virginia would have to ensure that any projects funded by other jurisdictions are in addition to activities planned by Maryland or Virginia or both. To eliminate double counting, each project credit must be properly assigned to the jurisdiction paying for the project.

Under Option B, any nutrient credit/debit associated with a change in filter feeder populations would be distributed proportionally across all the states and the District of Columbia, regardless of the jurisdiction responsible for funding or implementing the project.

Under both options, the changes in filter feeder populations would be based on monitoring data. To accurately assign credits to the appropriate jurisdiction and ensure milestones are reached, restoration activities and population increases must be tracked and verified. Regardless of the crediting option chosen, Maryland and Virginia should address filter feeder management in their watershed implementation plans. EPA and the jurisdictions will work together to establish a future strategy for crediting filter feeder benefits.

Other Issues of Concern

While increasing filter feeder populations can provide nutrient assimilation to mitigate the effects of excess nutrients, it is not a method of pollutant source reduction. Because nutrient assimilation can be considered an in-stream treatment technology by some regulators, there is some concern that it might be used in lieu of advanced wastewater treatment technologies (Stephenson 2009). Additionally, filter feeders reduce the pollutant downstream and pollutants are not reduced at or near the source. Reliance on filter feeders to reduce nitrogen downstream could create a problem with meeting local water quality standards in the upstream jurisdictions. Further consideration should be given to address these issues.

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Appendix X.
Staged Implementation Approach for Wastewater Treatment Facilities in the Virginia James River Basin

With the exception of one portion of the tidal Potomac River, the tidal James River is unique throughout the Chesapeake Bay watershed in that ten chlorophyll-*a* water quality criteria (5 segments*2 seasons) are applicable to protect local and tidal water quality conditions. In the July 1, 2010 allocation of nutrients, EPA determined that attainment of these numeric chlorophyll a criteria would require achievement of much lower levels of nutrients than previously expected.

Specifically, in the July 2010 letter, EPA determined allocations for the James River in the amounts of 23.48 million pounds per year of total nitrogen and 2.34 million pounds per year of total phosphorus. To achieve the dissolved oxygen and water clarity criteria, EPA had previously calculated that the levels of 26.8 million pounds per year of total nitrogen and 2.69 million pounds per year of total phosphorus would be sufficient. [See TMDL Appendix O - *Setting the Chlorophyll a Criteria-Based Nutrient Allocations for the James River Watershed*] Those higher levels (to achieve DO) are roughly equivalent to the 2003 James River cap load allocation of 26.4 million pounds per year of total nitrogen and 3.41 million pounds per year of total phosphorus. (Secretary Tayloe Murphy, 2003).

Up until the July 2010 allocation, Virginia had been working to implement past strategies to meet the previous, higher 2003 cap load allocations of total nitrogen and total phosphorus for the James. To achieve total nitrogen and total phosphorus allocations sufficient to comply with the current chlorophyll-*a* criteria, absent significant reductions from other pollution sectors, it is estimated that every significant municipal and industrial wastewater treatment facility in the river basin (39 facilities) would have to install nutrient removal technologies at or below limit of technology levels. In addition, due to the geographic location of the James River (southernmost river in the Bay watershed), Bay circulation patterns, and strong tidal flushing from the Atlantic Ocean, total nitrogen, total phosphorus and sediment loadings from the James River have a relatively small impact on water quality in the mainstem Bay. For these reasons, a staged implementation approach has been developed for implementing necessary nutrient reduction controls at wastewater facilities in the James River Basin to achieve the wasteload allocations of the Chesapeake Bay TMDL. As part of that staged implementation approach, EPA is establishing in this TMDL the wasteload allocations (WLA) for significant facilities in the James River as aggregate WLAs for total nitrogen and total phosphorus (Table 9-4 in Section 9 of the TMDL Report).

Total nitrogen and total phosphorus allocations from the tributary strategy for the James River sufficient to attain the dissolved oxygen criteria for the James River and Chesapeake Bay do not concurrently provide for the attainment of the James River Chlorophyll *a* criteria. Therefore, it is necessary in the TMDL to allocate more stringent total nitrogen and total phosphorus reductions in the James River than previously expected to attain the Chlorophyll *a* criteria (an additional 3 million pounds per year and 0.3 million pounds per year respectively). To facilitate that staged implementation approach, in this TMDL, EPA is establishing the more stringent wasteload allocations (WLA) for significant facilities in the James River as aggregate WLAs for total nitrogen and total phosphorus (Table 9-4 in Section 9 of the TMDL Report). The key components of the implementation strategy include:

- Near-term (2011-2017) interim effluent limits and controls under the Watershed General Permit for individual facilities implementing current and planned facility upgrades, including sixteen upgrade projects at POTWs, to achieve those portions of the wasteload allocations for total nitrogen and total phosphorus reductions that are based on the DO standards attainment, plus reductions of an additional 1.6 million pounds of total nitrogen and 200,000 pounds of total phosphorus.
- Achievement of 60% of the TMDLs overall total nitrogen and total phosphorus allocations by 2017 and 100% of the wastewater treatment plant component by no later than January 1, 2023.
- Near-term *aggregate* Chlorophyll-*a*-based effluent limits for total nitrogen and total phosphorus that apply under the Watershed General Permit to all 39 significant wastewater facilities to achieve the remaining 40% of the load reductions needed to meet the applicable aggregate wasteload allocations and the applicable Chlorophyll-*a* criteria with compliance as soon as possible pursuant to 40 CFR 122.47. Existing information suggests that compliance with this aggregate limit may not be possible until after 2017, but not later than January 1, 2023.
- Sufficient time for the Commonwealth of Virginia to perform an engineering/cost optimization study to establish which of the 39 facilities under the Watershed General Permit, and in what order, will need to upgrade treatment to meet the aggregate Chlorophyll-a-based limits.
- Establishment in 2017 of *facility-specific* effluent limits necessary to achieve reductions of an additional 1.0 million pounds per year of TN and 250,000 pounds per year of TP by January 1, 2022, and *facility-specific* TN and TP wasteload allocations, to inform the permit requirements of the 2018 Watershed General Permit reissuance, for each of the 39 significant WWTPs as stringent as necessary to achieve the remaining load reductions needed to meet the applicable Chlorophyll-*a* criteria. Also continue the enforceable aggregate Chlorophyll-*a*-based effluent limits for TN and TP that apply to all 39 facilities, with compliance required as soon as possible after 2017, based on present information, and not later than January 1, 2023.
- Establishment in 2018 of *facility-specific* effluent limits for TN and TP based on the facility WLAs established in 2017, as stringent as necessary to achieve the applicable Chlorophyll-*a* water quality criteria, and facility-specific compliance schedules requiring compliance with the effluent limitations for TN and TP limits as soon as possible, but not later than January 1, 2023
- EPA expects Virginia (and Virginia has committed) to reissue the Watershed General Permit and fact sheet in 2012, 2017 and 2018 to include all elements of the staged implementation approach, including any schedule of interim milestones pursuant to 40 CFR 122.47. To guide issuance of adequate permits in the James River, EPA is including the description of the projected schedule of the staged implementation approach in the Chesapeake Bay TMDL as assumptions and requirements of the applicable James River wasteload allocations. Federal law and regulation require that water quality-based effluent limits in permits must be derived from and comply with the applicable water quality standards and be consistent with the assumptions and requirements of TMDL wasteload allocations. 40 C.F.R. 122.44(d)(1)(vii)(A)&(B).