MARYLAND DEPARTMENT OF NATURAL RESOURCES
Tidewater Ecosystem Assessment

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Potomac River
Water Quality and Habitat Assessment
Overall Condition 2012-2014

The Potomac River watershed includes area in Maryland, Virginia, Pennsylvania, West Virginia and Washington D.C. For the purpose of this report, the basin is divided into four regions: the Upper Potomac, Shenandoah, Middle Potomac and Lower Potomac (Figure 1).

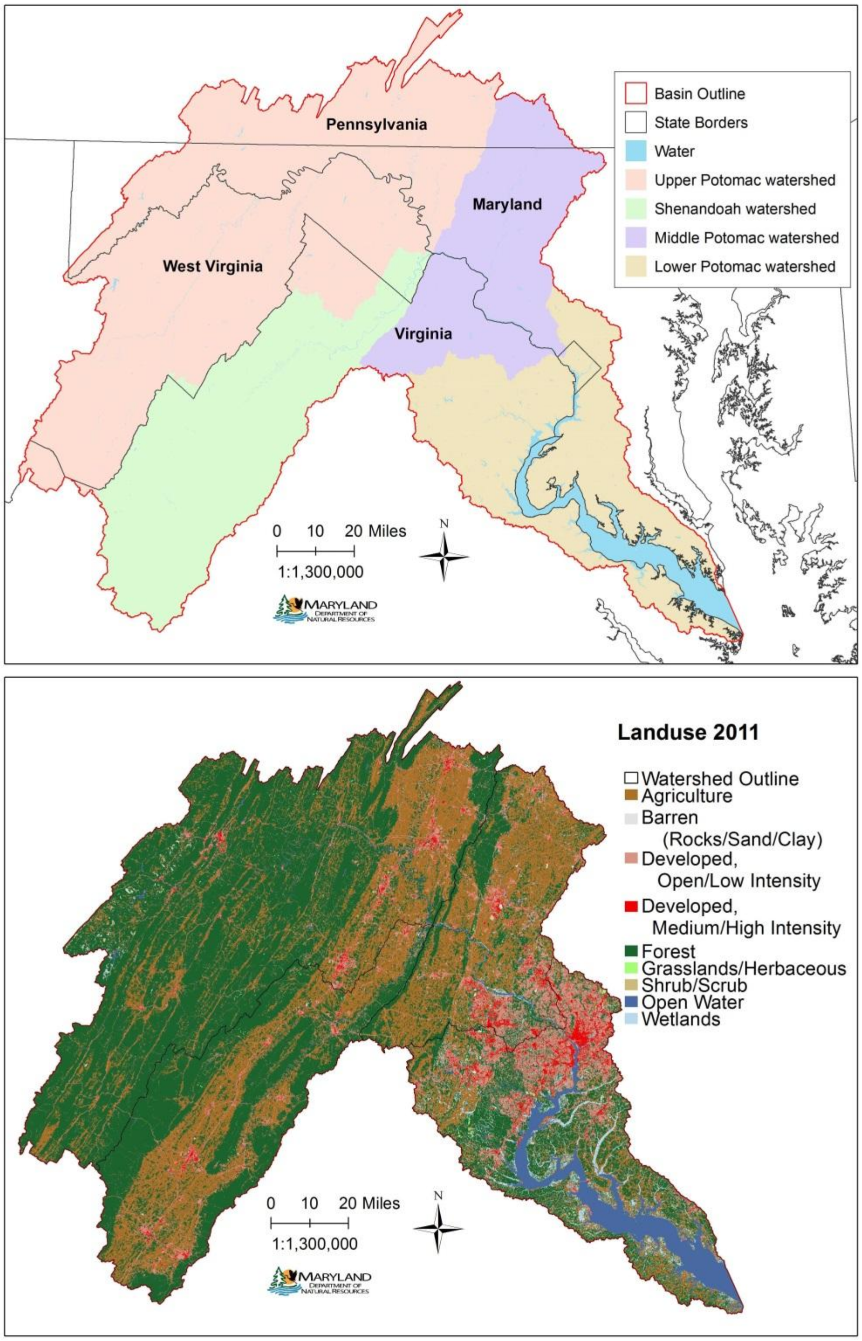


Figure 1 Potomac River basin
Top panel shows state boundaries and the individual watersheds. Bottom panel shows the land use throughout the basin for 2011.[1]

Land use in the upper Potomac River watershed was estimated to be 69% forest and 22% agriculture (Figure 1, Table 1).[1] The Upper Potomac watershed is largely within West Virginia (54%), with other portions in Pennsylvania (22%), Maryland (18%) and Virginia (7%). Impervious surfaces cover 1% of the Maryland potion of the Upper river basin (Table 1).[2]

Land use in the Shenandoah watershed was estimated to be 56% forest and 34% agriculture. The Shenandoah watershed is almost entirely in Virginia (96%), with a small area in West Virginia (4%).

Land use in the Middle Potomac watershed was estimated to be 44% agriculture, 32% forest and 20% developed. The Middle Potomac watershed includes areas in Maryland (55%), Virginia (34%), Pennsylvania (13%) and Washington D.C. (0.1%). Impervious surfaces cover 7% of the Maryland potion of the Middle river basin.

Land use in the Lower Potomac watershed was estimated to be 41% forest, 30% developed, and 16% agriculture. The Lower Potomac watershed includes areas in Virginia (56%), Maryland (42%) and Washington D.C. (2%). Impervious surfaces cover 9% of the Maryland potion of the Lower river basin.

For the Maryland portion of the Potomac River basin, agriculture is the largest source of nitrogen, phosphorus and sediment loadings to the upper portion of the basin; stormwater is also a large source of nitrogen, phosphorus and sediment loadings, and wastewater is a large source of nitrogen loadings (Table 2).[3] Stormwater is the largest source of nitrogen, phosphorus and sediment loadings to the lower portion of the basin; agriculture is also large source of nitrogen, phosphorus and sediment loadings and forest lands are a large source of nitrogen loadings. Loadings sources from the other states are shown in Table 2.

Table 1. Land Use in the Potomac River Basin.
Dominant land use[1], percent of the watershed in each State and percent impervious surfaces (MD only)[2] within each watershed. All values are in percent (%). Abbreviations include: Ag (Agriculture), Dev (Developed), For (Forest).

Watershed	Dominant land use	% of Basin Land Use by State					% Impevious (MD only)
		MD	VA	DC	PA	WV	
Upper Potomac	For (69), Ag (22)	17.8	7.1		21.5	53.6	1.0
Shenandoah	For (56), Ag (34)		96.1			3.9	n/a
Middle Potomac	Ag (44), For (32), Dev (20)	55.4	34.2	0.1	10.3		6.8
Lower Potomac	For (41), Dev (30), Ag (16)	41.5	56.3	2.2			9.1
Total Potomac Basin	For (55), Ag (27), Dev (14)	**24.2**	**39.6**	**0.4**	**11.2**	**24.7**	5.6

Table 2. Loadings sources from the Potomac River Basin.
Dominant loadings sources[3] by Chesapeake Bay Program segment and State (only sources accounting for approximately 20% or larger are shown). Columns include TN (Total Nitrogen), TP (Total Phosphorus) and Sed (Sediment) loadings. All values are in percent (%). Loading information is available based on Chesapeake Bay Program segment. The loads from the upper portion of the Potomac River basin (including the Upper Potomac, Shenandoah, Middle Potomac and the upper portion of the Lower Potomac watersheds (Figure 1, Table 1) are summarized as the total loads for two segments: POTTF (Potomac Tidal Fresh) and ANATF (Anacostia Tidal Fresh). The loads from the lower portion of the Potomac River Basin (including most of the Lower Potomac watershed) are summarized as the total loads for four segments: PISTF (Piscataway Tidal Fresh), MATTF (Mattawoman Tidal Fresh), POTOH (Potomac Oligohaline) and POTMH (Potomac Mesohaline). Sources are Agriculture (Ag), Non Regulated Stormwater (Urban), Regulated Stormwater (Stormwater), Wastewater-CSO (CSO), Wastewater, and Forest.

			MD			VA			DC			PA			WV		
Watershed	Segments	Source	% TN load	% TP load	% Sed load	% TN load	% TP load	% Sed load	% TN load	% TP load	% Sed load	% TN load	% TP load	% Sed load	% TN load	% TP load	% Sed load
Upper, Shenandoah, Middle, part of Lower	POTTF, ANATF	Ag	41	51	54	37	61	62				70	70	75	45	55	62
		Urban									17						
		Stormwater	25	26	33	19				18	62						
		CSO								26							
		Wastewater	17						85	52							
		Forest													29		
Lower Potomac	PISTF, MATTF, POTOH, POTMH	Ag	27	37	45	39	61	30									
		Urban						23									
		Stormwater	17	33	26			29									
		Forest	23		17	25		17									

How healthy is the Potomac River?

Maryland Department of Natural Resources (MDDNR) measures water and habitat quality at 36 non-tidal long-term monitoring stations and at 13 tidal long-term monitoring stations in the Potomac River (Figure 2). Current conditions are determined from the most recent three years of data; trends are determined from the 1999-2014 data.

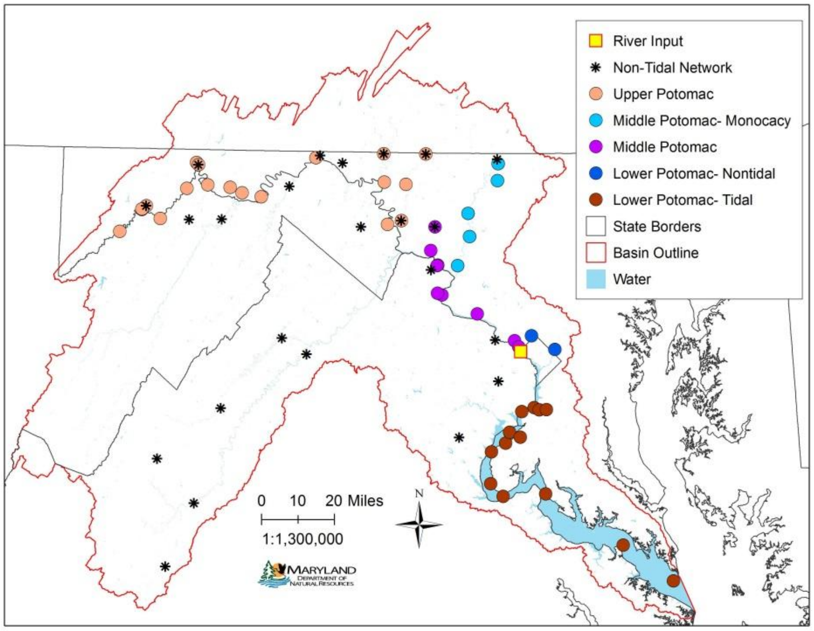


Figure 2 Water quality sampling stations in the Potomac River basin. MD DNR sampling stations (non-tidal and tidal) and the Non-tidal Network stations in the basin where trends were determined for 2014. The River Input station for loadings trends is also shown.

Maryland DNR also participates in the Non-tidal Network, a partnership with the United States Geologic Survey (USGS), the Chesapeake Bay Program, and the other states in the basin, to measure non-tidal water quality using the same sampling and analysis methods. Six of Maryland's long-term non-tidal stations are also part of the Non-tidal Network (Figure 2, Table 3); three additional stations are only part of the Non-tidal Network. USGS completes the trends analysis for all Non-tidal Network stations. USGS combines river flow data and the nutrient and sediment data for the most recent 10-year period. The USGS method accounts for changes in river flow so that underlying changes in nutrient and sediment levels can be determined.[4] Trends results from the Non-tidal Network stations from the other states are included below because of the consistency in monitoring and analysis methods.

USGS and MDDNR also measure the nutrient and sediment loadings at the fall-line station located at Chain Bridge (River Input station on Figure 2) to determine trends in loadings at this station.[4]

Upper Potomac: This portion of the river includes from the headwaters down to the confluence with the Shenandoah River, and is all non-tidal.

Measured nitrogen levels decreased at most of the stations in the upstream portion of the Upper Potomac, but increased at some stations in Conococheague Creek and Antietam Creek (Table 3, MDDNR method). However, when changes in river flow are accounted for, the underling nitrogen levels in Conococheague Creek decreased and the nitrogen trend in Antietam Creek is not significant (at the stations that are also part of the Non-tidal Network, USGS method).

Phosphorus levels also decreased at many of the stations throughout the Upper Potomac basin, even after changes in river flow are accounted for. Measured sediment levels decreased at some of the stations in the downstream portion of the Upper Potomac, but increased in Georges Creek. However, most stations do not have a significant sediment trend when changes in river flow are accounted for.

While decreased nutrients indicate improvement overall, they do not necessarily indicate healthy stream habitat. Non-tidal river habitat is influenced by many issues beyond nutrient and sediment conditions (for example, acid mine drainage, pollutants, impervious surfaces, etc.). Also, newer concerns include harmful algal blooms in this farthest upstream region of the Potomac River and the occurrence of invasive species such as *Didymo*.

Shenandoah: Virginia measures water quality at six Non-tidal Network stations. Phosphorus levels decreased at the North Fork Shenandoah station when changes in river flow are accounted for.

Middle Potomac: This portion of the river extends from the confluence of the Shenandoah downstream to the head of tide at Chain Bridge. The Monocacy River drains to this portion of the river. This portion of the river is all non-tidal.

Measured nitrogen levels decreased in the Monocacy River and Seneca Creek and at one of the main river stations (though none of these stations are part of the Non-tidal Network so the effect of changes in river flow cannot be determined). Catoctin Creek nitrogen levels decreased when changes in river low are accounted for.

Measured phosphorus levels decreased at most of the stations in the Middle Potomac, but the trends were not significant when the effect of changes in river flow is accounted for. There are no significant trends in sediment levels in the Middle Potomac.

Lower Potomac: This portion of the river extends from the head of tide at Chain Bridge downstream to the mouth of the river at Point Lookout. Loadings and water quality are determined at the fall-line station at Chain Bridge (River Input station, Figure 2). Four additional stations are monitored in non-tidal areas, and thirteen stations are monitored by Maryland in tidal portions of the Lower Potomac basin.

<u>Non-tidal areas</u>: Nitrogen, phosphorus and sediment loadings have decreased at the fall-line station at Chain Bridge.[4] Nitrogen levels in the water also decreased at this station when the effects of river flow are accounted for.

Nitrogen levels also decreased in Accotink Creek (in Virginia) when changes in river flow are accounted for. Measured phosphorus and sediment levels in the Anacostia River increased. Nitrogen levels increased in the South Fork of Quantico Creek (in Virginia) when changes in river flow are accounted for.

<u>Tidal areas/ Tidal Fresh</u>: Water quality in the tidal fresh portion of the Potomac River is fair because nitrogen levels are too high, but improving because nitrogen and phosphorus levels have decreased throughout this section of the river (Table 4). Phosphorus and sediment levels meet the habitat requirements for underwater grasses (also called submerged aquatic vegetation, SAV). Habitat quality for underwater grasses is fair at the upper three stations because algal densities are low but water clarity is poor. Habitat quality for underwater grasses is poor at the lower station because algal densities are high and water clarity is poor. Summer bottom dissolved oxygen levels are good at all four stations.

Underwater grass beds in the tidal fresh Potomac River overall covered 97% of the area needed to meet the restoration goal during this period.[5] Bottom dwelling animal populations are not healthy and conditions have degraded in this section of the river.

Table 3. Summary of non-tidal water quality trends.
Trends for nitrogen (N), phosphorus (P) and sediment (Sed). Trends at MD DNR long-term non-tidal monitoring stations (columns labeled ‘MDDNR’) are determined for 1999-2014; analysis does not include use of flow data. Trends at Non-tidal Network stations (columns labeled ‘USGS’) are determined by USGS for 2005-2014 (at some stations there is no 2005 data); analysis includes use of flow data.[4] Non-tidal Network stations include the corresponding USGS gage number and the state responsible for collecting the data. Stations in bold typeface are MD DNR long-term non-tidal monitoring stations that are also part of the Non-tidal Network. The River Input Station at Chain Bridge (fall-line station) is highlighted in yellow. Decreasing trends (‘Dec’) are improving trends and shown with green typeface. Increasing trends (‘Inc’) are degrading trends and shown with red typeface. Blanks indicate no significant trend. Grey shading indicates that the station does not have data for that parameter. Stations are ordered roughly from upstream to downstream.

					MDDNR 1999-2014 (without flow)			USGS 2005*-2014 (with flow)		
Watershed	**USGS Gage #**	**State**	**MD DNR Station**	**River/Creek**	**N**	**P**	**Sed**	**N**	**P**	**Sed**
Upper Potomac			NBP0689	North Branch Potomac						
			NBP0534	North Branch Potomac	Dec					
			SAV0000	Savage River	Dec					
	01599000	**MD**	**GEO0009**	**Georges Creek**	Dec	Dec	Inc	Dec	Dec	
			NBP0461	North Branch Potomac	Dec	Dec				
			NBP0326	North Branch Potomac	Dec	Dec				
			BDK0000	Braddock Run	Dec					
	01601500	**MD**	**WIL0013**	**Wills Creek**	Dec			Dec		
	01604500	WV		Patternson Creek					Dec	
			NBP0103	North Branch Potomac	Dec	Dec				
	01608500	WV		South Branch Potomac					Dec	
			NBP0023	North Branch Potomac	Dec	Dec	Dec			
			TOW0030	Towns Creek	Dec					
			POT2766	Potomac River	Dec	Dec				
	01611500	WV		Cacapon River						
			POT2386	Potomac River	Dec	Dec	Dec			
	01613095	MD		Tonoloway Creek						
	01613525	MD		Licking Creek						
	01614500	**MD**	**CON0180**	**Conococheague Creek**	Inc	Dec	Dec	Dec	Dec	
			CON0005	Conococheague Creek		Dec	Dec			
	01616500	WV		Opequon Creek				Dec	Dec	Dec
			POT1830	Potomac River		Dec				
	01619000	PA		Antietam Creek					Dec	
			ANT0366	Antietam Creek	Inc	Dec	Dec			
			ANT0203	Antietam Creek		Dec	Dec			
	01619500	**MD**	**ANT0044/47**	**Antietam Creek**	Inc	Dec			Dec	
Shenandoah	01621050	VA		Muddy Creek						
	01626000	VA		South River						
	01628500	VA		South Fork Shenandoah						
	01631000	VA		South Fork Shenandoah						
	01632900	VA		Smith Creek						
	01634000	VA		North Fork Shenandoah					Dec	

Table 3 (cont). Summary of non-tidal water quality trends.
Trends for nitrogen (N), phosphorus (P) and sediment (Sed). Trends at MD DNR long-term non-tidal monitoring stations (columns labeled 'MDDNR') are determined for 1999-2014; analysis does not include use of flow data. Trends at Non-tidal Network stations (columns labeled 'USGS') are determined by USGS for 2005-2014 (at some stations there is no 2005 data); analysis includes use of flow data.[4] Non-tidal Network stations include the corresponding USGS gage number and the state responsible for collecting the data. Stations in bold typeface are MD DNR long-term non-tidal monitoring stations that are also part of the Non-tidal Network. The River Input Station at Chain Bridge (fall-line station) is highlighted in yellow. Decreasing trends ('Dec') are improving trends and shown with green typeface. Increasing trends ('Inc') are degrading trends and shown with red typeface. Blanks indicate no significant trend. Grey shading indicates that the station does not have data for that parameter. Stations are ordered roughly from upstream to downstream.

					MDDNR 1999-2014 (without flow)			USGS 2005*-2014 (with flow)		
Watershed	**USGS Gage #**	**State**	**MD DNR Station**	**River/Creek**	**N**	**P**	**Sed**	**N**	**P**	**Sed**
Middle Potomac	**01637500**	**MD**	**CAC0148**	**Catoctin Creek**		Dec		Dec		
Middle Potomac			CAC0031	Catoctin Creek		Dec				
Middle Potomac	01638480	VA		Catoctin Creek						
Middle Potomac			POT1596	Potomac River (VA Side)	Dec	Dec				
Middle Potomac			POT1595	Potomac River (MD Side)		Dec				
Middle Potomac – Monocacy River	**01639000**	**MD**	**MON0546**	**Monocacy River**						
Middle Potomac – Monocacy River			MON0528	Monocacy River	Dec	Dec				
Middle Potomac – Monocacy River			BPC0035	Big Pipe Creek		Dec				
Middle Potomac – Monocacy River			MON0269	Monocacy River		Dec				
Middle Potomac – Monocacy River			MON0155	Monocacy River	Dec	Dec				
Middle Potomac – Monocacy River			MON0020	Monacacy River	Dec	Dec				
Middle Potomac			POT1472	Potomac River		Dec				
Middle Potomac			POT1471	Potomac River		Dec				
Middle Potomac			SEN0008	Seneca Creek	Dec	Dec				
Middle Potomac	01646000	VA		Difficult Run						
Middle Potomac			CJB0005	Cabin John Creek						
Middle Potomac			POT1184	Potomac River		Dec				
Lower Potomac	01646580	MD		Potomac R-Chain Bridge				Dec		
Lower Potomac	01654000	VA		Accotink Creek				Dec		
Lower Potomac			RCM0111	Rock Creek						
Lower Potomac			ANA0082	Anacostia River		Inc	Inc			
Lower Potomac	01658500	VA		South Fork Quantico Creek				Inc		

Table 4. Summary of tidal water quality and habitat quality indicators.
Annual trends for 1999-2014 for nitrogen (total nitrogen), phosphorus (total phosphorus), sediment (total suspended solids), algal densities (chlorophyll *a*), and water clarity (Secchi depth). Summer bottom dissolved oxygen (DO) trends are for June through September data only. Trends are either 'Increasing' or 'Decreasing' if significant at $p \leq 0.01$; blanks indicate no significant trend. Improving trends are in green, degrading trends are in red. Nitrogen (dissolved inorganic nitrogen) levels below the level for nitrogen limitation 'Meet' criteria, otherwise 'Fail' criteria for 2012-2014 data. Phosphorus (dissolved inorganic phosphorus), sediment (total suspended solids), algal densities (chlorophyll *a*) and water clarity (Secchi depth) either 'Meet' or 'Fail' submerged aquatic vegetation (SAV) habitat requirements for 2012-2014 data. Summer (June through September) bottom dissolved oxygen levels either 'Meet' or 'Fail' EPA open-water 30-day dissolved oxygen criteria.

		Water Quality			Habitat Quality		
River portion	Station	Nitrogen	Phosporus	Sediments	Algal Densities	Water Clarity	Summer Bottom DO
Piscataway	PIS0033	Decreasing / Fail	Fail	Meet	Meet	Fail	too shallow
Piscataway	XFB1986	Decreasing / Fail	Decreasing / Meet	Fail	Meet	Fail	too shallow
Mattawoman	MAT0078	Decreasing / Meet	Meet	Meet	Meet	too shallow	too shallow
Mattawoman	MAT0016	Decreasing / Fail	Decreasing / Meet	Meet	Decreasing / Fail	Fail	too shallow
Main River- Tidal Fresh	TF2.1	Decreasing / Fail	Decreasing / Meet	Meet	Meet	Fail	Meet
Main River- Tidal Fresh	TF2.2	Decreasing / Fail	Decreasing / Meet	Meet	Meet	Fail	Meet
Main River- Tidal Fresh	TF2.3	Decreasing / Fail	Decreasing / Meet	Meet	Meet	Fail	Meet
Main River- Tidal Fresh	TF2.4	Decreasing / Fail	Decreasing / Meet	Meet	Fail	Fail	Meet
Main River- Oligohaline	RET2.1	Decreasing / Fail	Decreasing / Meet	Increasing / Fail	Increasing / Meet	Decreasing / Fail	Meet
Main River- Oligohaline	RET2.2	Decreasing / Fail	Fail	Increasing / Meet	Increasing / Meet	Decreasing / Fail	Meet
Main River- Mesohaline	RET2.4	Decreasing / Fail	Fail	Meet	Increasing / Fail	Fail	Fail
Main River- Mesohaline	LE2.2	Meet	Decreasing / Meet	Decreasing / Meet	Meet	Meet	Fail
Main River- Mesohaline	LE2.3	Decreasing / Meet	Decreasing / Meet	Meet	Meet	Decreasing / Meet	Fail

Piscataway Creek is a tributary to the tidal fresh portion of the Potomac River. Water quality in upper Piscataway Creek is poor because nitrogen and phosphorus levels are too high, but nitrogen levels decreased and sediment levels meet the habitat requirements for underwater grasses. In contrast, water quality in the lower Piscataway Creek is poor due to nitrogen and sediment levels that are too high, but nitrogen and phosphorus levels have improved and phosphorus levels meet the habitat requirements for underwater grasses. Algal densities are low in Piscataway Creek, but water clarity is too low.

Underwater grass beds in Piscataway Creek covered 60% of the area needed to meet the restoration goal during this period.

Mattawoman Creek is also a tributary to the tidal fresh portion of the Potomac River. Water quality in upper Mattawoman Creek is good because nitrogen, phosphorus and sediment levels meet habitat requirements for underwater grasses and nitrogen levels decreased. Water quality in the lower Mattawoman Creek is fair due to nitrogen levels that are too high, but nitrogen and phosphorus levels have improved and phosphorus and sediment levels meet the habitat requirements for underwater grasses. Algal densities are too high in the lower Mattawoman Creek but are improving. Water clarity is too low in the lower Mattawoman Creek; water depth is too shallow in the upper Mattawoman Creek to measure water clarity with a Secchi disc.

Underwater grass beds in Mattawoman Creek covered 68% of the area needed to meet the restoration goal during this period.

<u>Tidal areas/ Oligohaline</u>: Water quality in the oligohaline Potomac River is poor. At the upper station nitrogen and phosphorus levels are too high; nitrogen and phosphorus levels decreased but sediment levels increased. At the lower station nitrogen and phosphorus levels are too high; nitrogen levels decreased but sediment levels increased. Habitat quality for underwater grasses is poor at both stations due to poor water clarity. Algal densities and water clarity have also gotten worse in this portion of the river. Summer bottom dissolved oxygen levels are good.

Underwater grass beds in the mesohaline Potomac River overall covered 74% of the area needed to meet the restoration goal during this period. Bottom dwelling animal populations are not healthy in most the areas sampled during this period in this section of the river.

<u>Tidal areas/ Mesohaline</u>: Water quality at the upper station in the mesohaline Potomac River is poor. Nitrogen and phosphorus levels are too high at the upper station but nitrogen levels decreased and sediment levels meet habitat requirements for underwater grasses. Habitat quality for underwater grasses is poor at the upper station because algal densities are too high and increasing and water clarity is too low. Summer bottom dissolved oxygen levels at this station are also too low.

Water quality at the lower two stations in the mesohaline Potomac River is good and improving. Phosphorus and sediment levels decreased at the middle station and nitrogen and phosphorus levels decreased at the lower station. Habitat quality for underwater grasses is good at both stations, but water clarity is decreasing at the lower station at the mouth of the river. Summer bottom dissolved oxygen is poor at both stations.

Underwater grass beds in the mesohaline Potomac River overall covered 9% of the area needed to meet the restoration goal during this period. Bottom dwelling animal populations are very unhealthy in this area of the river and conditions have degraded.

How does the tidal Potomac River compare to other Maryland rivers?

The Potomac River basin as a whole (combining the Upper, Middle, Shenandoah and Lower watersheds) is in the 'High Agriculture/Low Developed' land use category. All data for the tidal portion of the river was combined to compare the Potomac River to the other Maryland rivers (Figure 3). Nitrogen and phosphorus levels are moderate compared to other rivers. Sediment levels and algal densities are low compared to other rivers, and water clarity is moderate. Summer bottom dissolved levels are moderate (combining all tidal stations) even though summer bottom dissolved oxygen levels are too low at the individual mesohaline stations.

What has already been done in Maryland to improve water and habitat quality in the Potomac River?

Wastewater, Stormwater and Septic Loads

Blue Plains is the largest wastewater treatment plant in the basin. Blue Plains accounts for more than half of the nitrogen loadings to the entire Potomac River Basin, but is a smaller portion of phosphorus loadings (Figure 4).[6] Previous upgrades at Blue Plains already reduced nitrogen loadings to less than one-third the levels in the early to mid 1990s and also reduced phosphorus loadings to two-thirds the previous levels. Construction on additional upgrades began in 2010 and is expected to be complete by the end of 2018.

In the Upper Basin in Maryland, six of the major wastewater treatment plants completed upgrades between 2006 and 2013. The remaining eight major wastewater treatment plants have started construction of upgrades and all projects are scheduled to be completed by mid 2017. In the Middle Basin in Maryland, upgrades were completed between 2010 and 2013 at three of the four major treatment plants and the construction has begun at the fourth facility, planned for completion by 2016. In the Lower basin in Maryland, four of the five major wastewater treatment plants were upgraded between 2007 and 2014, and upgrades are under construction at the final facility and will be complete by 2017.

Stormwater retrofits have reduced nitrogen loadings from urban and suburban sources and prevented 49,995 pounds of nitrogen from entering streams.[7] Also, 597 septic upgrades were completed between 2008 and 2013.

Agricultural Loads[7]

In 2014, 82,302 acres of cover crops have been planted in between growing seasons to absorb excess nutrients and prevent sediment erosion. Fencing on 14,741 acres of farmland has been used to keep livestock out of streams and prevent streambank erosion. A total of 1,514 containment structures have been built to store animal wastes and allow nutrients to be applied to the land in the most effective manner at the appropriate time. Stream buffers were in place on 25,515 acres, allowing areas next to streams to remain in a natural state with grasses, trees and wetlands.

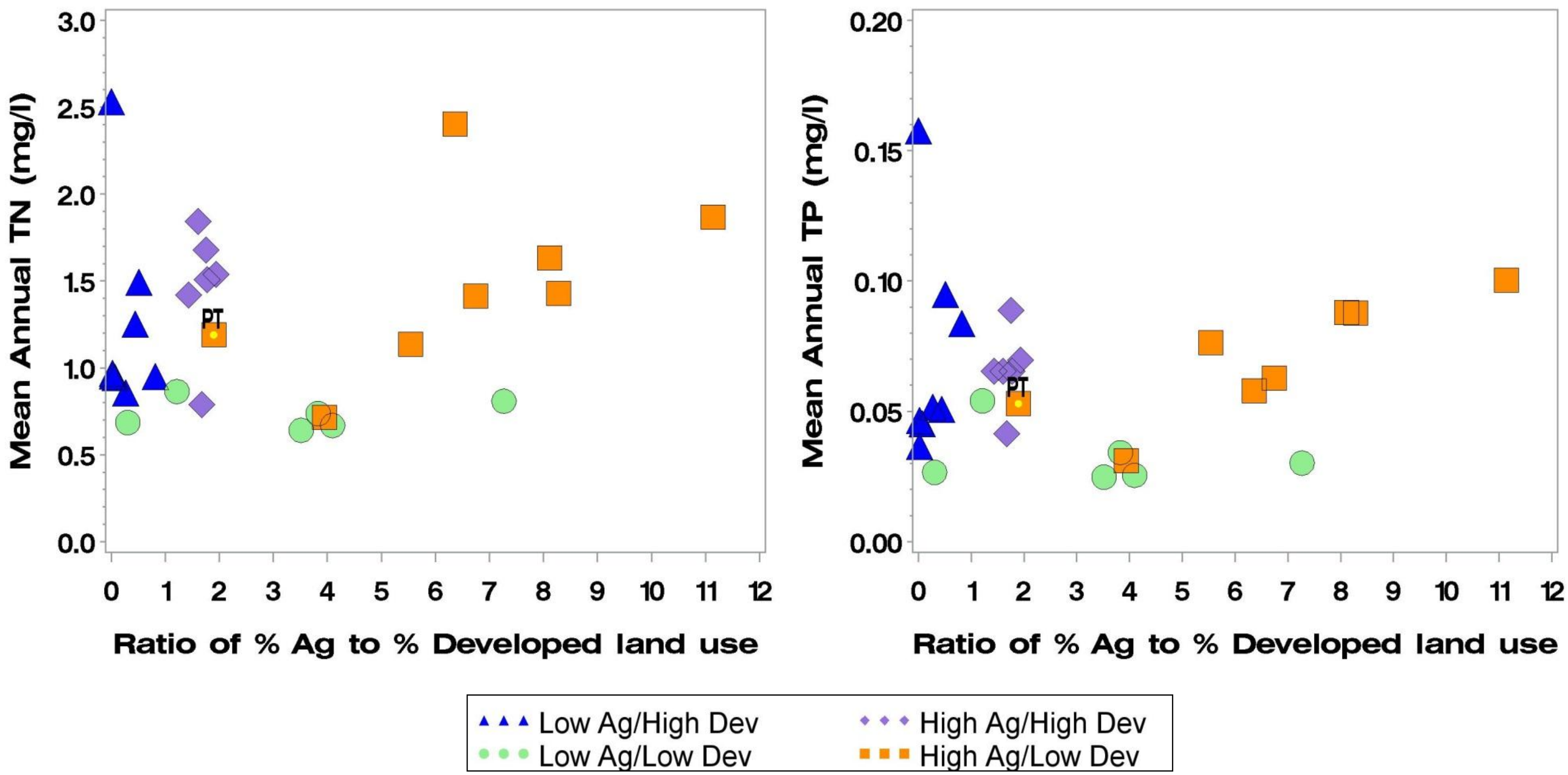


Figure 3. Water quality conditions versus land use.
Water quality is shown relative to the ratio of % Agriculture (Ag) to % Developed (Dev) land use. Data for 2012-2014 are summarized as mean annual concentration (in mg/L) for total nitrogen (TN) and total phosphorus (TP). Rivers are color coded by their land use categories (see legend). Yellow dot highlights the Potomac (PT) river data.

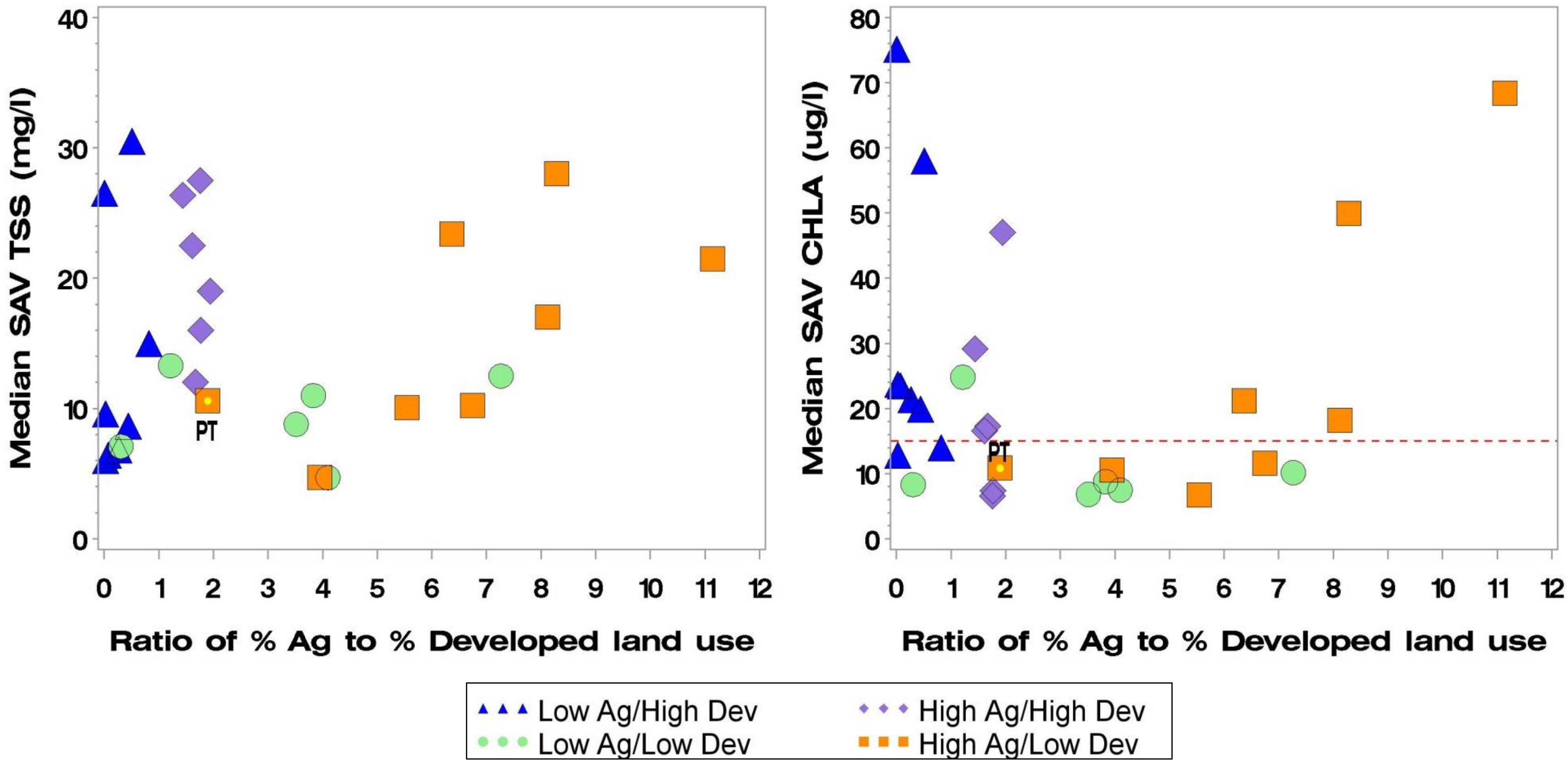


Figure 3 (cont.). Water quality conditions versus land use.
Water quality is shown relative to the ratio of % Agriculture (Ag) to % Developed (Dev) land use. Data for 2012-2014 are summarized as submerged aquatic vegetation (SAV) growing season (April-October) median for total suspended solids (TSS, in mg/L), chlorophyll *a* (CHLA, in µg/L). Reference lines are included on the CHLA graph. Rivers are color coded by their land use categories (see legend). Yellow dot highlights the Potomac (PT) river data.

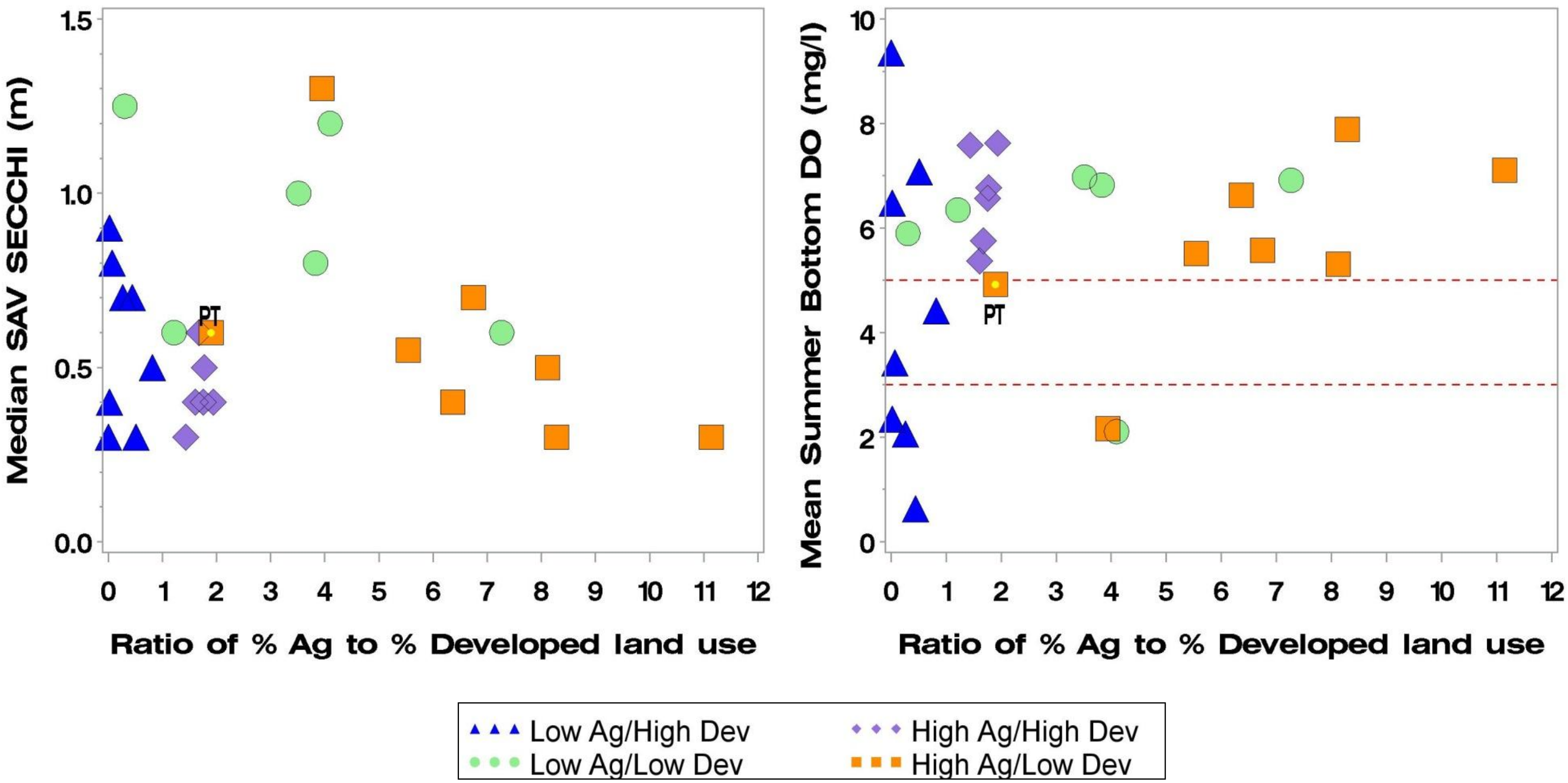


Figure 3 (cont.). Water quality conditions versus land use.
Water quality is shown relative to the ratio of % Agriculture (Ag) to % Developed (Dev) land use. Data for 2012-2014 are summarized as submerged aquatic vegetation (SAV) growing season (April through October) median for Secchi depth (in m) and as mean for summer (June through September) bottom dissolved oxygen (DO, in mg/L). Reference lines are included on the DO graph. Rivers are color coded by their land use categories (see legend). Yellow dot highlights the Potomac (PT) river data.

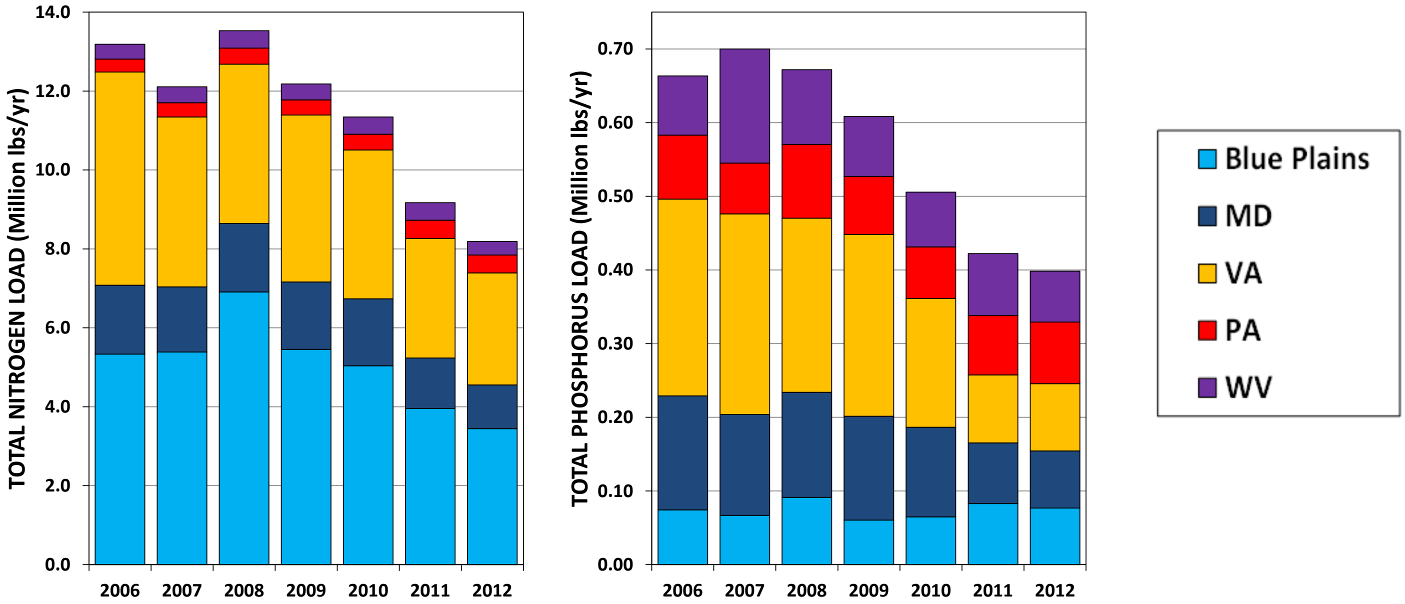


Figure 4. Total Wastewater Treatment Plant loads by state. Summed total of total nitrogen (left graph) and total phosphorus (right graph) loads from wastewater treatment plants designated as 'significant' and 'municipal' (in million pounds per year) that discharge into the Potomac River by state.[6] Blue Plains is shown separately and serves areas in Maryland, Virginia and Washington DC.

For more information

An integrative assessment of the water and habitat quality of the Potomac River for 1985-2012 is available online at http://eyesonthebay.dnr.maryland.gov/eyesonthebay/tribsums.cfm. Current water and habitat quality information is also available from Maryland DNR's Eyes on the Bay website www.eyesonthebay.net.

References and data sources

Data not collected and/or analyzed by the Maryland Department of Natural Resources include:

[1] Land use by basin determined from 2011 National Land Cover Database (NLCD).
Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354
GIS layer downloaded on 11/24/2015 from http://www.mrlc.gov/nlcd11_data.php

[2] Impervious surfaces data downloaded from Maryland Department of the Environment (MDE) website on 12/1/2015
http://www.mde.state.md.us/programs/Water/TMDL/DataCenter/Pages/phase6_development.aspx

[3] Nutrient and sediment loads data for Progress 2014 model run downloaded on November 16, 2015 from http://baytas.chesapeakebay.net/. Source categories from BayTas website were renamed to conform to those used on the ChesapeakeStat website http://stat.chesapeakebay.net/?q=node/130&quicktabs_10=1 as follows: Agriculture = Ag; Agriculture_Regulated = Ag_Reg; Non Regulated Stormwater = Urban; Regulated Stormwater = Stormwater; WasteWater-CSO = CSO; PS = Wastewater; Forest = Forest; Non-Tidal Water Deposition = NT_Dep; Septic = Onsite.

[4] Nutrient and Sediment non-tidal loadings trends results are through WY2014 from USGS website http://cbrim.er.usgs.gov/summary.html for Short-term period (WY2005-WY2014) accessed February 4, 2016.
Nutrient and sediment non-tidal concentrations trends results are through WY2014 from USGS website http://cbrim.er.usgs.gov/trends_query.html file dated 2/02/2016, downloaded 2/4/2016. Trends are determined using the Weighted Regressions on Time, Discharge, and Season (WRTDS) model, Hirsch and others, Environmental Modelling & Software 2015, http://www.sciencedirect.com/science/article/pii/S1364815215300220. Results are reported in the text if the trend was 'Extremely Likely' (Likelihood values ≥ 0.95) or 'Very Likely' (Likelihood values $0.95 > p \geq 0.90$).

[5] Underwater grasses (submerged aquatic vegetation, or SAV) data are available from the Virginia Institute of Marine Sciences SAV in Chesapeake Bay and Coastal Bays webpage, Tables tab http://web.vims.edu/bio/sav/SegmentAreaTable.htm#. Coverages and restoration goals were summed by overall Chesapeake Bay Program segment to include areas in Maryland, Virginia and Washington DC, as appropriate. Single best year for 2012-2014 is reported.

[6] WWTP loadings data were downloaded from the Chesapeake Bay Program Nutrient Point Source Database website on 02/17/2016 (http://www.chesapeakebay.net/data/downloads/bay_program_nutrient_point_source_database). Data by month for calendar year 2006-2012 was used because many facilities did not have data reported prior to 2006. Total nitrogen and phosphorus loads for all facilities designated 'significant' and 'municipal' were used to determine overall total loads by state. For missing data, estimates were determined by using the methods the Maryland Department of Environment (MDE) http://www.chesapeakebay.net/channel_files/18593/maryland_qapp_for_wastewater_072612.pdf. If data was missing, the most recent years' data for the same month was used as an estimate.

[7] Data are from Maryland's 2014 - 2015 Milestone Goals and Progress Report website http://baystat.maryland.gov/solutions-map/.

This project has been funded in part by the United States Environmental Protection Agency under assistance agreement (CB-97390101) to Maryland Department of Natural Resources. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does the EPA endorse trade names or recommend the use of commercial products mentioned in this document.

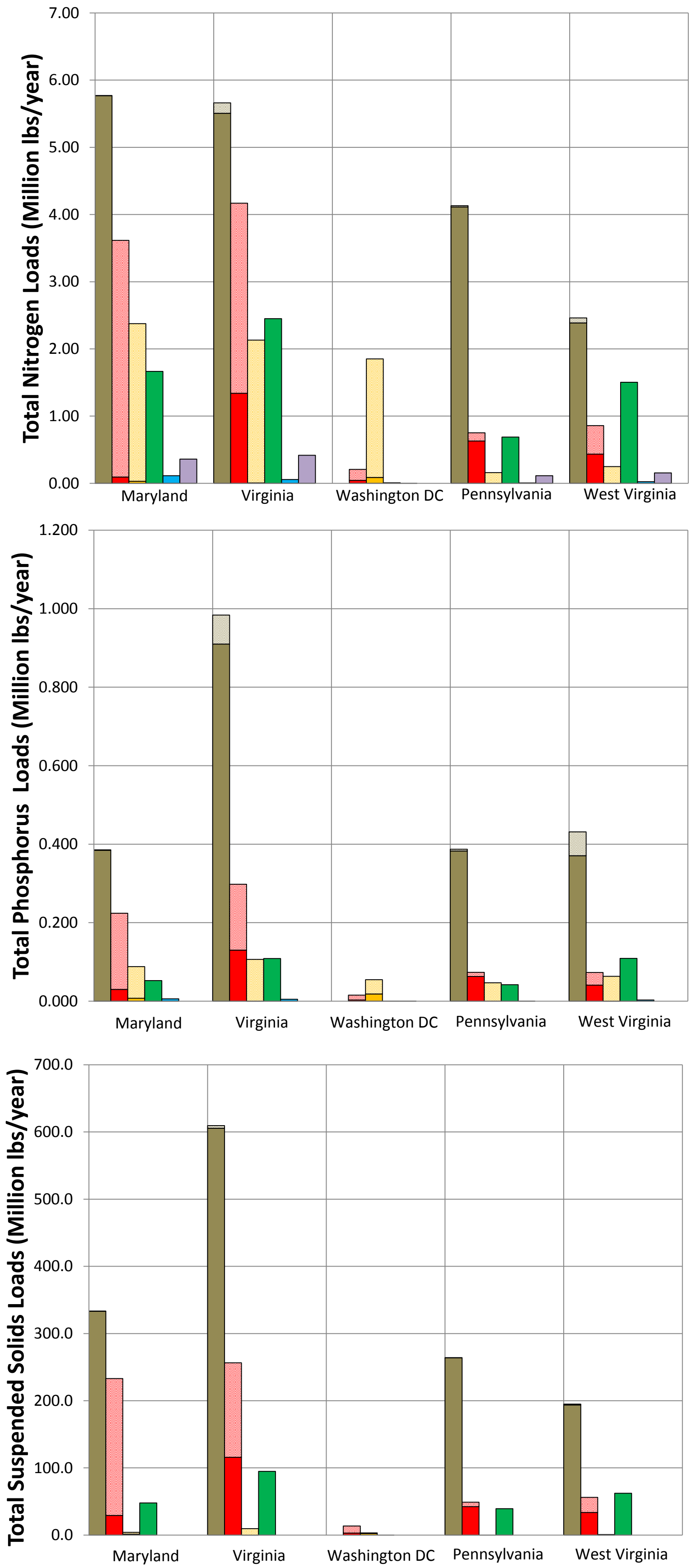
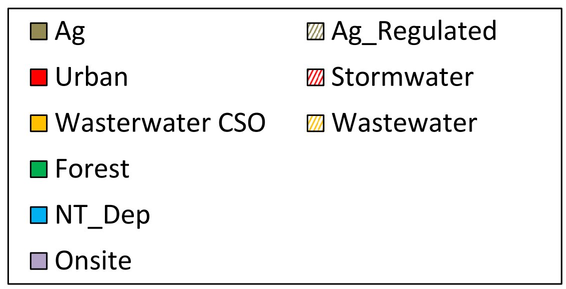


Figure 4. Nitrogen, phosphorus and sediment loads to upper portion of the Potomac River basin. Loads (in million lbs/year) are summarized by Chesapeake Bay Program model segment and by source category. Data for Progress 2014 model run downloaded on November 16, 2015 from http://baytas.chesapeakebay.net/. Source categories from BayTas website were renamed to conform to those used on the ChesapeakeStat website http://stat.chesapeakebay.net/?q=node/130&quicktabs_10=1 as follows: Agriculture = Ag; Agriculture_Regulated = Ag_Reg; Non Regulated Stormwater = Urban; Regulated Stormwater = Stormwater; WasteWater-CSO = CSO; PS = Wastewater; Forest = Forest; Non-Tidal Water Deposition = NT_Dep; Septic = Onsite. The loads from the upper portion of the Potomac River basin (including the Upper Potomac, Shenandoah, Middle Potomac and the upper portion of the Lower Potomac watersheds (Figure 1, Table 1) are summarized as the total loads for two segments: POTTF (Potomac Tidal Fresh) and ANATF (Anacostia Tidal Fresh).



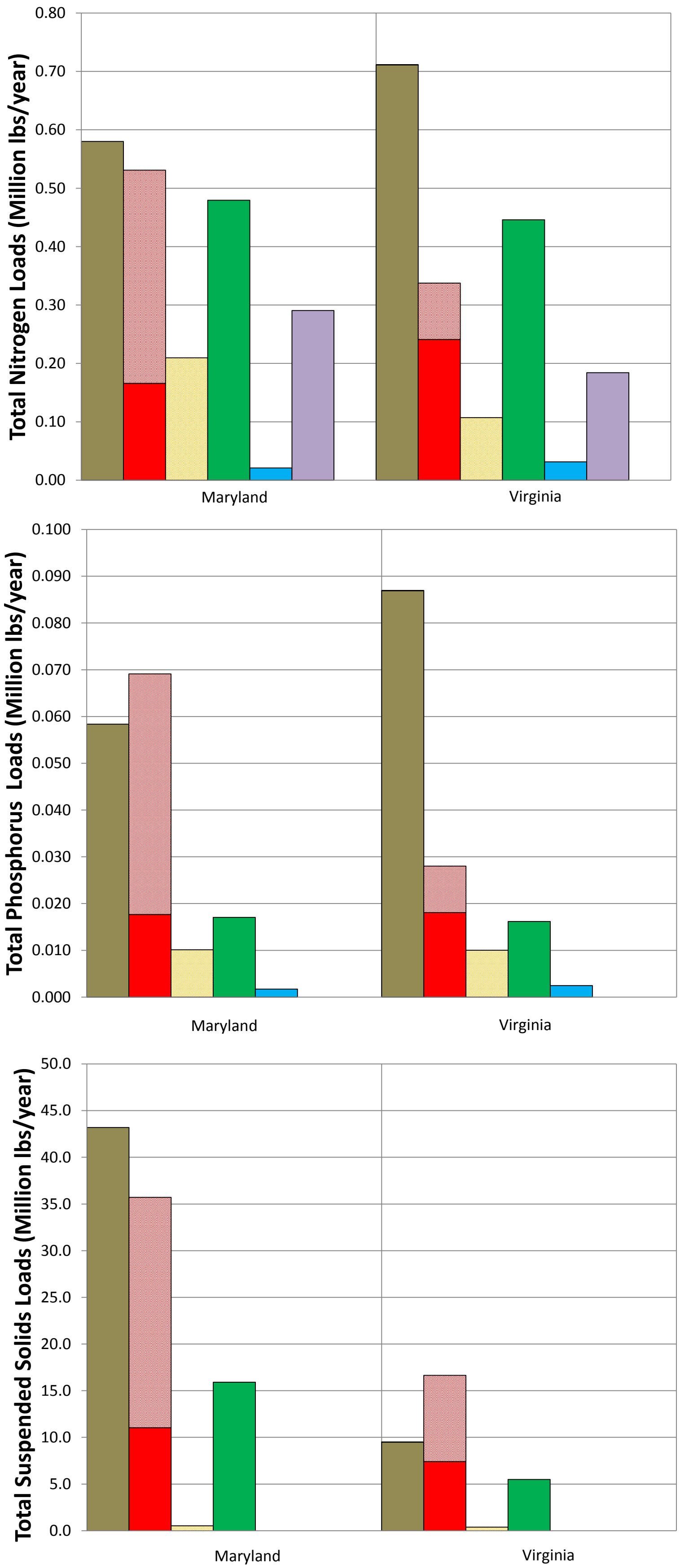


Figure 4 (cont). Nitrogen, phosphorus and sediment loads to lower portion of the Potomac River basin. Loads (in million lbs/year) are summarized by Chesapeake Bay Program model segment and by source category. Data for Progress 2014 model run downloaded on November 16, 2015 from http://baytas.chesapeakebay.net/. Source categories from BayTas website were renamed to conform to those used on the ChesapeakeStat website http://stat.chesapeakebay.net/?q=node/130&quicktabs_10=1 as follows: Agriculture = Ag; Agriculture_Regulated = Ag_Reg; Non Regulated Stormwater = Urban; Regulated Stormwater = Stormwater; WasteWater-CSO = CSO; PS = Wastewater; Forest = Forest; Non-Tidal Water Deposition = NT_Dep; Septic = Onsite. The loads from the lower portion of the Potomac River Basin (including most of the Lower Potomac watershed) are summarized as the total loads for four segments: PISTF (Piscataway Tidal Fresh), MATTF (Mattawoman Tidal Fresh), POTOH (Potomac Oligohaline) and POTMH (Potomac Mesohaline).

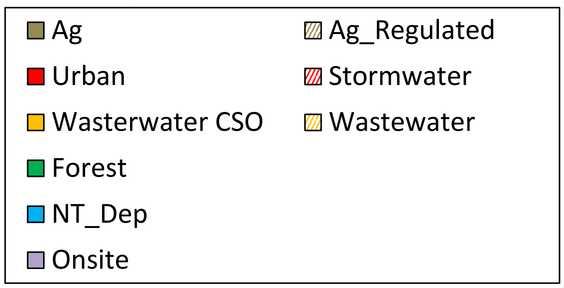
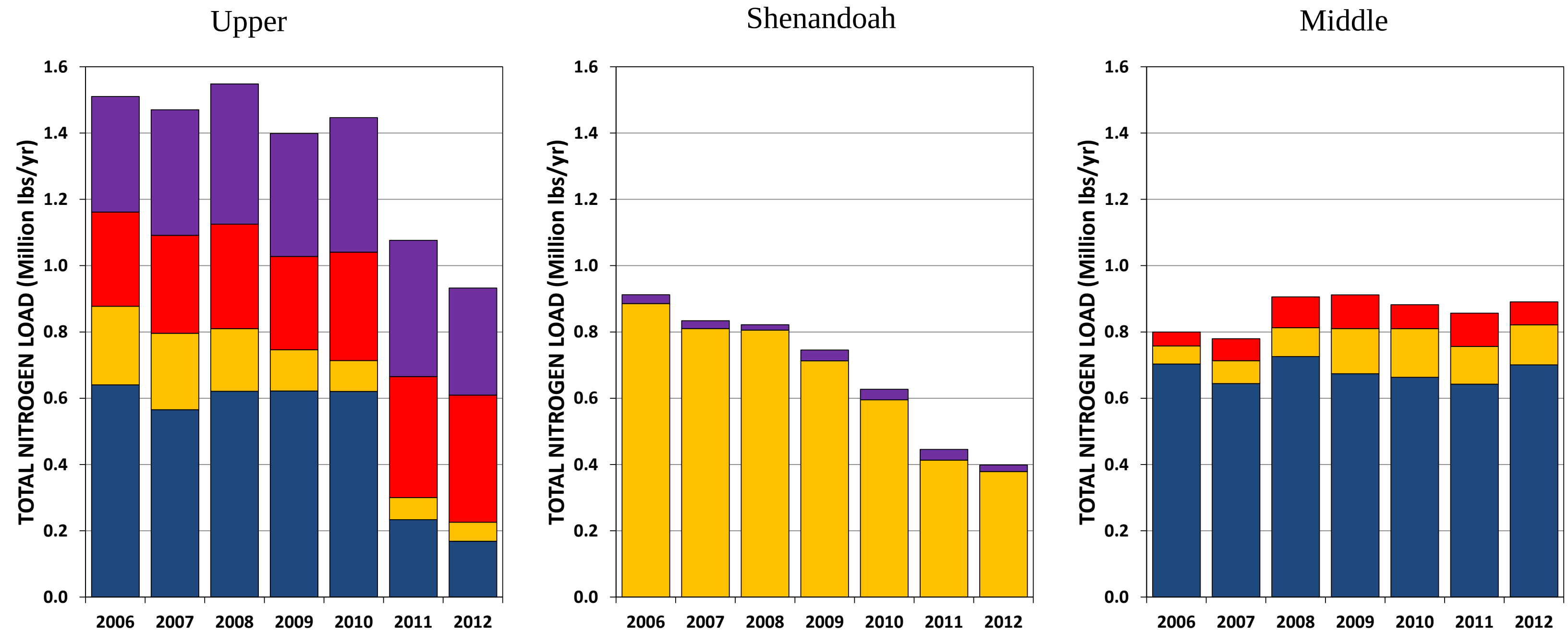
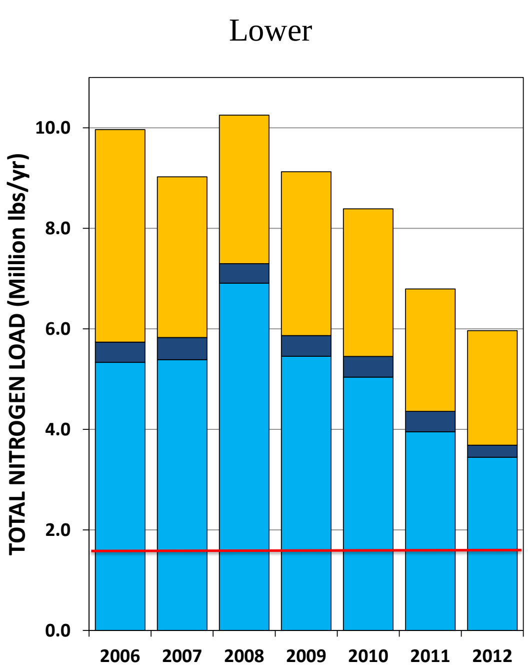


Table 5. Nitrogen, phosphorus and sediment loads to Potomac River. Loads (in million lbs/year) are summarized by Chesapeake Bay Program model segment and by source category. Data for Progress 2014 model run downloaded on November 16, 2015 from http://baytas.chesapeakebay.net/. Source categories from BayTas website were renamed to conform to those used on the ChesapeakeStat website http://stat.chesapeakebay.net/?q=node/130&quicktabs_10=1 as follows: Agriculture = Ag; Agriculture_Regulated = Ag_Reg; Non Regulated Stormwater = Urban; Regulated Stormwater = Stormwater; WasteWater-CSO = CSO; PS = Wastewater; Forest = Forest; Non-Tidal Water Deposition = NT_Dep; Septic = Onsite.

			MD			VA			DC			PA			WV		
Watershed	**Segments**	**Source**	**TN Load (delivered)**	**TP Load (delivered)**	**Sed. Load (delivered)**	**TN Load (delivered)**	**TP Load (delivered)**	**Sed. Load (delivered)**	**TN Load (delivered)**	**TP Load (delivered)**	**Sed. Load (delivered)**	**TN Load (delivered)**	**TP Load (delivered)**	**Sed. Load (delivered)**	**TN Load (delivered)**	**TP Load (delivered)**	**Sed. Load (delivered)**
Upper, Shenandoah, Middle, part of Lower	POTTF	Ag	5.732	0.3809	328.35	5.507	0.9097	605.53				4.113	0.3826	263.87	2.388	0.3704	193.53
		Ag_Reg	0.006	0.0012	0.19	0.155	0.0742	3.92				0.019	0.0045	0.15	0.073	0.0607	1.31
		Urban	0.094	0.0298	29.22	1.340	0.1301	115.83	0.026	0.0017	2.28	0.629	0.0627	42.32	0.434	0.0406	33.64
		Stormwater	2.992	0.1470	143.76	2.829	0.1679	140.59	0.096	0.0049	8.02	0.122	0.0108	6.62	0.426	0.0323	22.50
		CSO	0.029	0.0072	1.46	0.006	0.0008	0.07	0.084	0.0178	2.33				0.004	0.0006	0.10
		Wastewater	2.327	0.0768	2.30	2.126	0.1056	9.47	1.764	0.0360	0.87	0.159	0.0466	0.45	0.245	0.0627	0.74
		Forest	1.625	0.0515	45.91	2.449	0.1087	94.79	0.006	0.0001	0.36	0.688	0.0420	39.28	1.503	0.1088	62.14
		NT_Dep	0.112	0.0059		0.056	0.0046		0.002	0.0001		0.006	0.0008		0.024	0.0030	
		Onsite	0.353			0.418						0.114			0.154		
		Total Load	**13.270**	**0.7003**	**551.18**	**14.886**	**1.5016**	**970.20**	**1.977**	**0.0606**	**13.85**	**5.851**	**0.5498**	**352.70**	**5.251**	**0.6791**	**313.97**
	ANATF	Ag	0.034	0.0035	4.78												
		Ag_Reg															
		Urban							0.016	0.0014	0.62						
		Stormwater	0.531	0.0472	59.96				0.070	0.0074	2.60						
		CSO	0.000	0.0000	0.00				0.002	0.0004	0.05						
		Wastewater	0.019	0.0039	0.25				0.002	0.0003	0.01						
		Forest	0.040	0.0009	2.01				0.001	0.0000	0.03						
		NT_Dep	0.001	0.0001					0.003	0.0002							
		Onsite	0.008														
		Total Load	**0.633**	**0.0555**	**67.00**				**0.094**	**0.0096**	**3.30**						

			MD			VA			DC			PA			WV		
Watershed	**Segments**	**Source**	**TN Load (delivered)**	**TP Load (delivered)**	**Sed. Load (delivered)**	**TN Load (delivered)**	**TP Load (delivered)**	**Sed. Load (delivered)**	**TN Load (delivered)**	**TP Load (delivered)**	**Sed. Load (delivered)**	**TN Load (delivered)**	**TP Load (delivered)**	**Sed. Load (delivered)**	**TN Load (delivered)**	**TP Load (delivered)**	**Sed. Load (delivered)**
Lower Potomac Watershed	PISTF	Ag	0.016	0.0023	1.95												
		Ag_Reg															
		Urban	0.001	0.0002	0.06												
		Stormwater	0.113	0.0145	6.35												
		CSO															
		Wastewater	0.153	0.0040	0.11												
		Forest	0.032	0.0011	0.88												
		NT_Dep	0.001	0.0000													
		Onsite	0.010														
		Total Load	**0.324**	**0.0222**	**9.34**												
	MATTF	Ag	0.014	0.0019	1.63												
		Ag_Reg															
		Urban	0.001	0.0005	0.24												
		Stormwater	0.072	0.0126	5.34												
		CSO															
		Wastewater	0.004	0.0005	0.02												
		Forest	0.047	0.0018	1.20												
		NT_Dep	0.001	0.0001													
		Onsite	0.022														
		Total Load	**0.162**	**0.0174**	**8.44**												
	POTOH	Ag	0.068	0.0053	4.45	0.043	0.0069	2.75									
		Ag_Reg				0.000	0.0000	0.00									
		Urban	0.000	0.0000	0.01	0.078	0.0071	3.82									
		Stormwater	0.062	0.0073	2.01	0.094	0.0092	8.89									
		CSO															
		Wastewater	0.023	0.0018	0.05	0.033	0.0018	0.30									
		Forest	0.126	0.0041	2.33	0.220	0.0075	3.49									
		NT_Dep	0.005	0.0004		0.011	0.0009										
		Onsite	0.047			0.087											
		Total Load	**0.331**	**0.0190**	**8.84**	**0.566**	**0.0334**	**19.25**									
	POTMH	Ag	0.482	0.0488	35.16	0.668	0.0801	6.73									
		Ag_Reg															
		Urban	0.164	0.0170	10.72	0.163	0.0110	3.60									
		Stormwater	0.118	0.0170	10.99	0.003	0.0007	0.34									
		CSO															
		Wastewater	0.030	0.0038	0.34	0.074	0.0082	0.09									
		Forest	0.275	0.0100	11.49	0.226	0.0086	2.00									
		NT_Dep	0.014	0.0012		0.020	0.0016										
		Onsite	0.211			0.097											
		Total Load	**1.294**	**0.0978**	**68.70**	**1.251**	**0.1102**	**12.76**									





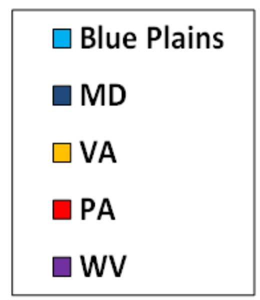
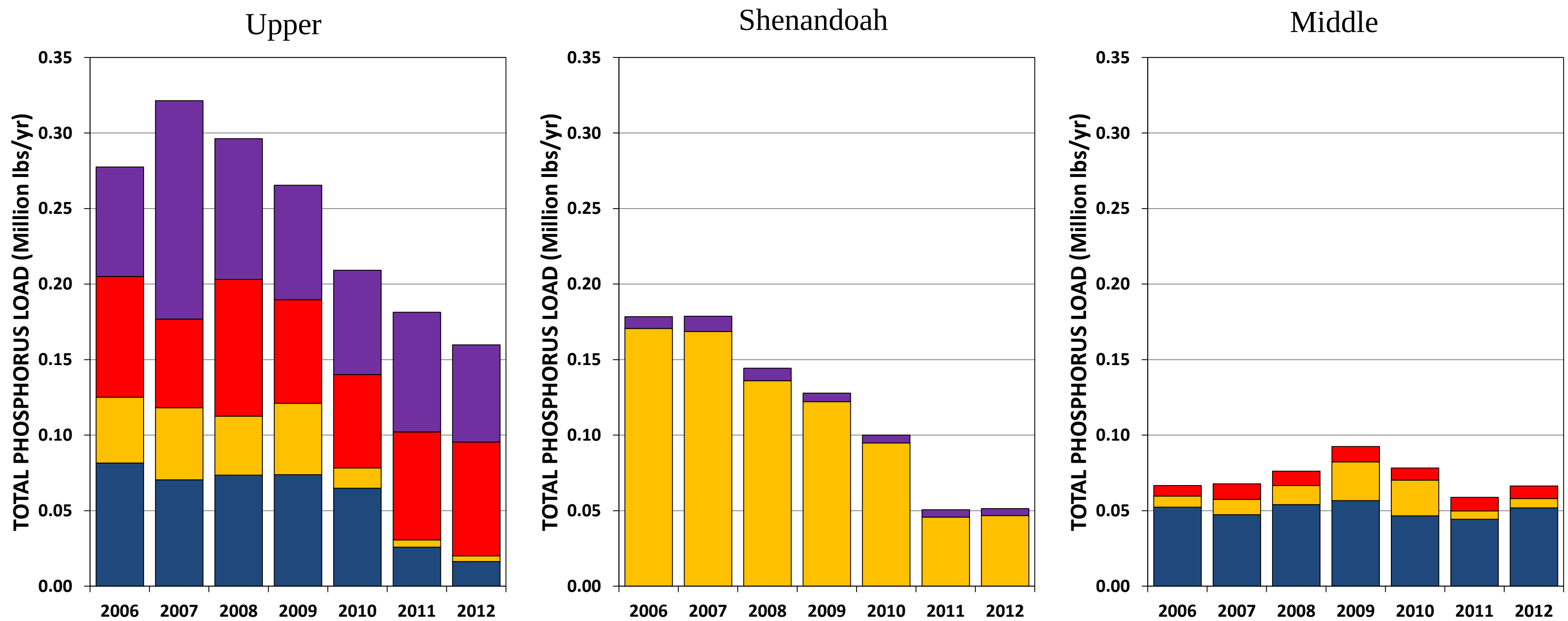
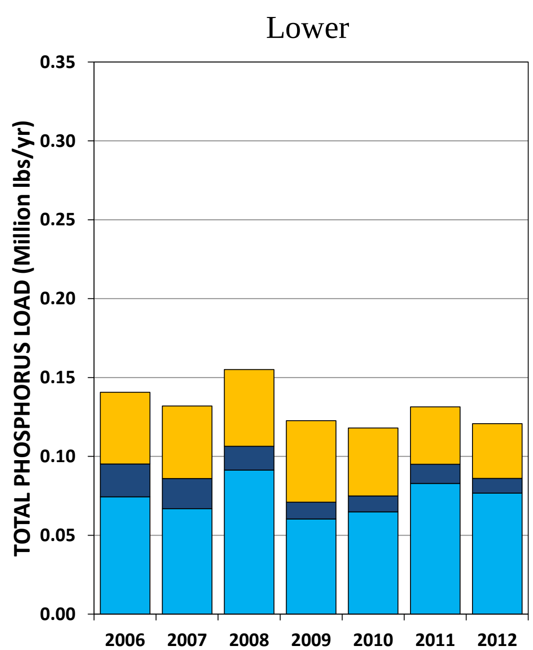


Figure 5. Total Wastewater Treatment Plant Nitrogen loads by basin and state. Summed total of total nitrogen loads from wastewater treatment plants designated as 'significant' and 'municipal' (in million pounds per year) that discharge into the Potomac River by basin and state. Upper, Shenandoah and Middle basin graphics have same y-axis scale; Lower basin graphic has a red reference line to show the maximum value shown in the upper three graphics for comparison. WWTP loadings data were downloaded from the Chesapeake Bay Program Nutrient Point Source Database website on 02/17/2016 (http://www.chesapeakebay.net/data/downloads/bay_program_nutrient_point_source_database). Data by month for calendar year 2006-2012 was used because many facilities did not have data reported prior to 2006. For missing data, estimates were determined by using the methods the Maryland Department of Environment (MDE) http://www.chesapeakebay.net/channel_files/18593/maryland_qapp_for_wastewater_072612.pdf. If data was missing, the most recent years' data for the same month was used as an estimate.





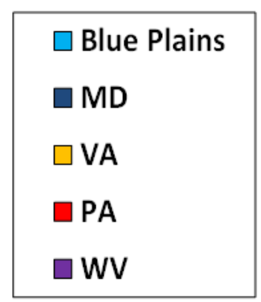


Figure 6. Total Wastewater Treatment Plant Phosphorus loads by basin and state. Summed total of total phosphorus loads from wastewater treatment plants designated as 'significant' and 'municipal' (in million pounds per year) that discharge into the Potomac River by basin and state. All graphics have the same y-axis range for comparison. WWTP loadings data were downloaded from the Chesapeake Bay Program Nutrient Point Source Database website on 02/17/2016 (http://www.chesapeakebay.net/data/downloads/bay_program_nutrient_point_source_database). Data by month for calendar year 2006-2012 was used because many facilities did not have data reported prior to 2006. For missing data, estimates were determined by using the methods the Maryland Department of Environment (MDE) http://www.chesapeakebay.net/channel_files/18593/maryland_qapp_for_wastewater_072612.pdf. If data was missing, the most recent years' data for the same month was used as an estimate.