# Upper Eastern Shore Basin
# Water Quality and Habitat Assessment
# Overall Condition 2012-2014

The Upper Eastern Shore basin includes five major rivers and one embayment. This basin includes areas in Cecil, Kent, Queen Anne's and Talbot counties in Maryland, New Castle and Kent counties in Delaware, and Chester County in Pennsylvania (Figure 1). Land use is predominantly Agriculture (Table 1). Impervious surfaces covered approximately 5% of the Northeast River, Elk River and Eastern Bay watersheds; the remaining watersheds had 3% or less impervious surfaces (Table 1). Agriculture is the most important source of nitrogen, phosphorus and sediment loadings (Table 1).

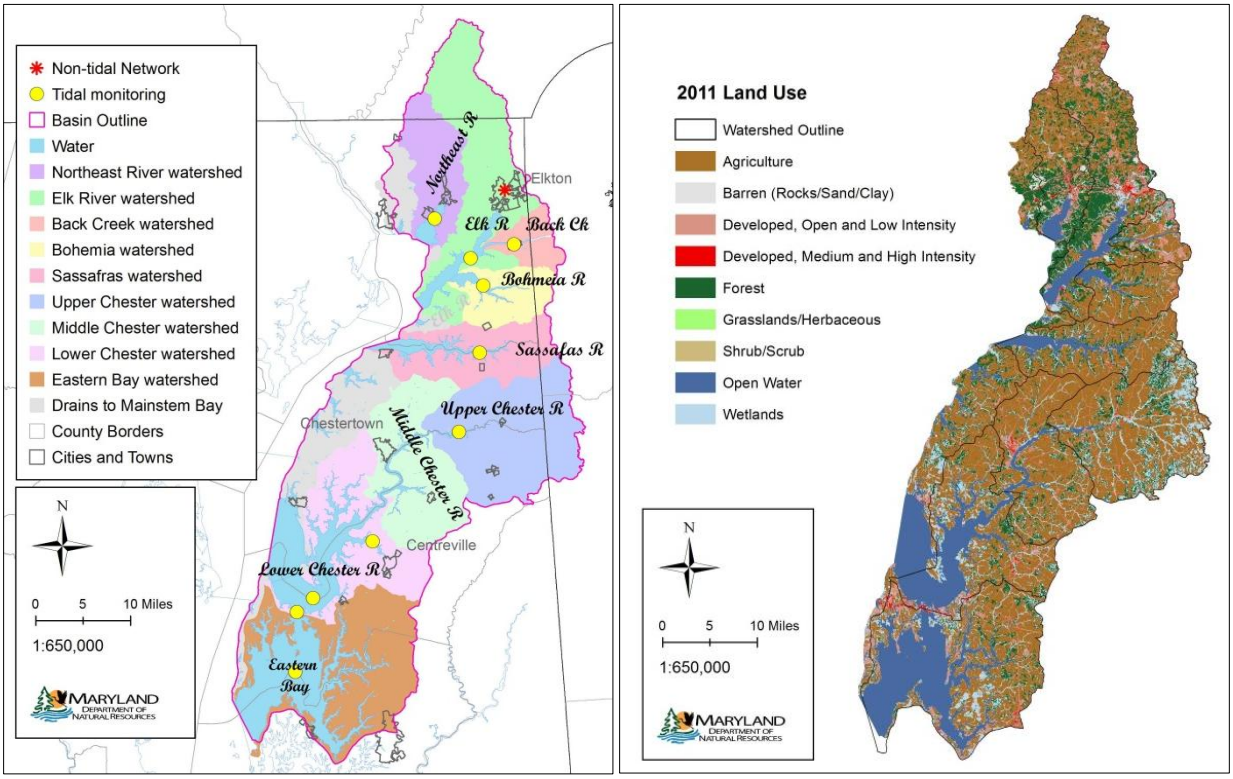


**Figure 1 Upper Eastern Shore Basin**
Left-side panel shows the individual watersheds and locations of long-term non-tidal and tidal water quality monitoring stations; gray areas of the basin drain to the mainstem Bay. Right-side panel shows the land use throughout the basin for 2011.[1]

## *How healthy are the Upper Eastern Shore Rivers?*

Maryland Department of Natural Resources (MDDNR) measures water and habitat quality at long-term monitoring stations in the tidal areas of the major rivers and one embayment (Figure 1). Current conditions are determined from the most recent three years of data; trends are determined from the 1999-2014 data.

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 Chesapeake Bay watershed, to measure non-tidal water quality using the same sampling and analysis methods. One of Maryland's Non-tidal Network stations is on Big Elk Creek, a tributary to the Elk River (Figure 1). 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]

**Northeast River**: Water quality in the Northeast River is poor (Table 2). Nitrogen and sediment levels are too high. Habitat quality for underwater grasses is poor due to poor water clarity and high algal densities. Even with reduced habitat quality, the area covered by underwater grass beds was 81% of the restoration goal during this period.[5] Summer bottom dissolved oxygen levels in bottom waters are good.

**Back Creek (C&D Canal):** Water quality in Back Creek is poor because nitrogen and sediment levels are too high. Habitat quality is fair for underwater grasses due to poor water clarity, and habitat quality has gotten worse as algal densities increased and water clarity decreased. Underwater grass beds covered only 11% of the area needed to meet restoration goals during this period. Summer bottom water dissolved oxygen levels are good.

**Bohemia River:** Water quality in the Bohemia River is fair but sediment levels are too high. Habitat quality is poor for underwater grasses due to poor water clarity and high algal densities, and algal densities have increased. Bohemia River underwater grass beds covered only 23% of the area needed to meet restoration goals during this period. Summer bottom dissolved oxygen levels are good.

**Elk River:** Non-tidal areas: No trends in nitrogen, phosphorus or sediment were found at the non-tidal Network station on Big Elk Creek (Table 3).

Tidal areas: Water quality in the tidal Elk River is poor because nitrogen, phosphorus and sediment levels are too high (Table 2). However, nitrogen levels have improved. Habitat quality is fair for underwater grasses but has gotten worse as algal densities increased and water clarity decreased. The area covered by underwater grass beds was 26% of the area needed to meet restoration goals during this period. Summer bottom water dissolved oxygen levels are good. Bottom dwelling animal populations are healthy in the upper Elk River in areas sampled during this period, but are not healthy in the middle and lower river.

**Sassafras River:** Water quality in the Sassafras River is fair due to high sediment levels. Habitat quality for underwater grasses is poor due to poor water clarity and high algal densities, and has gotten worse due to increasing algal densities. Harmful algal blooms of blue-green algae occur in most years and have led to human health impacts and beach closures at Betterton Beach. The area covered with underwater grass beds was 23% of the restoration goal during this period. Summer bottom dissolved oxygen levels are good.

**Chester River:** Water and habitat quality differs between the upper and lower Chester River (there is no long-term water quality monitoring station in the middle Chester). The upper Chester has poor but improving water quality. Habitat quality for underwater grasses in the upper Chester is fair due to poor water clarity but algal densities are low and have decreased. Summer bottom dissolved oxygen levels are good.

The lower Chester has fair water quality but nitrogen levels are too high. Habitat quality for underwater grasses in the lower Chester is good but has gotten worse due to increasing algal densities and decreasing water clarity.

Summer bottom dissolved oxygen levels are poor in the lower Chester, and bottom dwelling animal populations are not healthy in most of the areas sampled during this period.

The Corsica River is a tributary of the Chester River. Water quality is poor because phosphorus and sediment levels are too high. Habitat quality for underwater grasses is poor because algal densities are high and water clarity is low. Summer bottom dissolved oxygen levels are good.

The upper Chester has very little underwater grass beds, and the restoration goal is only 1 acre; however, in 2014 there was an unexpected jump in the area covered by underwater grasses to 8.8 acres. Underwater grass beds in the middle Chester also surged in 2014 to 58% of the area needed to meet the restoration goal. Underwater grass beds in the lower Chester were very large in 1998 but have dropped to less than 6% of the restoration goal during this period.

**Eastern Bay:** Water quality of Eastern Bay is good. Habitat quality for underwater grasses is good. Underwater grass beds covered less than 4% of the restoration goal area during this period. Summer bottom dissolved oxygen levels are extremely low and indicate impaired habitat for bottom dwelling animals. Bottom dwelling animal populations are unhealthy in most areas sampled during this period.

**Table 1. Land Use and Loadings sources to the Upper Eastern Shore Basin.**
Land Use columns include: dominant land use[1,] percent of the watershed in each State, and percent impervious surfaces (MD only)[2] within each watershed. Dominant Loadings Sources[3] columns include TN (Total Nitrogen), TP (Total Phosphorus) and Sed (Sediment) loadings sources that are 20% or more of the total loadings to that river from each State. All values are in percent (%). Abbreviations include: Ag (Agriculture), Dev (Developed), Wetl (Wetlands), For (Forest); Storm (Stormwater), and Urb (Urban).

| Watershed | Land Use | | | | | Dominant Loading Sources (%) By State | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dominant land use | % of Watershed by State | | | % Impevious (MD only) | MD | | | DE | | | PA | | |
| | | MD | DE | PA | | TN load | TP load | Sed. load | TN load | TP load | Sed. load | TN load | TP load | Sed. load |
| **NorthEast** | Ag (36) For (35) | 89 | | 11 | 5.1 | Ag (39) Storm (23) | Ag (56) Storm (24) | Ag (59) Storm (28) | | | | Ag (69) | Ag (83) | Ag (89) |
| **Bohemia** | Ag (69) | 82 | 18 | | 1.9 | Ag (71) | Ag (82) | Ag (87) | Ag (66) | Ag (79) | Ag (75) | | | |
| **Back Creek (C&D Canal)** | Ag (44) Dev (25) | 45 | 55 | | 3 | Ag (50) | Ag (68) | Ag (74) | Ag (41) Urb (38) | Ag (57) Urb (38) | Ag (53) Urb (38) | | | |
| **Elk** | Ag (37) Wetl (37) For (33) | 64 | 1.5 | 34 | 4.8 | Ag (38) Storm (22) | Ag (55) Storm (23) | Ag (64) Storm (25) | Urb (43) Ag (23) Septic (20) | Urb (50) Ag (38) | Urb (50) Ag (33) | Ag (49) | Ag (65) | Ag (79) |
| **Sassafras** | Ag (66) | 90 | 10 | | 1.7 | Ag (79) | Ag (86) | Ag (88) | Ag (80) | Ag (89) | Ag (86) | | | |
| **Upper Chester** | Ag (57) Wetl (22) | 76 | 24 | | 1.8 | Ag (82) | Ag (89) | Ag (88) | Ag (75) | Ag (83) | Ag (79) | | | |
| **Middle Chester** | Ag (71) | 100 | | | 2.3 | Ag (81) | Ag (84) | Ag (86) | | | | | | |
| **Lower Chester** | Ag (60) Wetl (18) | 100 | | | 2.9 | Ag (75) | Ag (83) | Ag (80) | | | | | | |
| **Eastern Bay** | Ag (55) Wetl (17) | 100 | | | 4.6 | Ag (70) | Ag (82) | Ag (67) Urb (25) | | | | | | |

**Table 2. 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** | **River portion** | **Nitrogen** | **Phosporus** | **Sediments** | **Algal Densities** | **Water Clarity** | **Summer Bottom DO** |
| Northeast | | Fail | Meet | Fail | Fail | Fail | Meet |
| Back Creek (C&D Canal) | | Fail | Meet | Fail | Increasing<br>Meet | Decreasing<br>Fail | Meet |
| Bohemia | | Meet | Meet | Fail | Increasing<br>Fail | Fail | Meet |
| Elk | | Decreasing<br>Fail | Fail | Fail | Increasing<br>Meet | Decreasing<br>Fail | Meet |
| Sassafras | | Meet | Meet | Fail | Increasing<br>Fail | Fail | Meet |
| Chester | Upper | Decreasing<br>Fail | Decreasing<br>Fail | Decreasing<br>Fail | Decreasing<br>Meet | Fail | Meet |
| | Lower | Fail | Meet | Meet | Increasing<br>Meet | Decreasing<br>Meet | Fail |
| | Corsica | Meet | Fail | Fail | Fail | Fail | Meet |
| Eastern Bay | | Meet | Meet | Meet | Meet | Meet | Fail |

**Table 3. Summary of non-tidal water quality trends.**
Trends for nitrogen (N), phosphorus (P) and sediment (Sed). Trends at Non-tidal Network stations (columns labeled 'USGS') are determined by USGS for 2005-2014; analysis includes use of flow data.[4] Non-tidal Network stations include the corresponding USGS gage number; both stations are monitored by the State of Delaware. 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.

| | | | | USGS 2005-2014 (with flow) | | |
|---|---|---|---|---|---|---|
| **Watershed** | **USGS Gage #** | **MD DNR Station** | **River/Creek** | **N** | **P** | **Sed** |
| Elk | 01495000 | BEL0053 | Big Elk Creek | | | |

## *How do the Upper Eastern Shore Rivers compare to other Maryland rivers?*

The Northeast River is in the 'High Agriculture/ High Developed' land use category. Nitrogen, phosphorus and sediment levels are moderate compared to other high developed rivers (Figure 2). Algal densities are among the highest of all rivers. Water clarity is moderate compared with similar rivers. Summer dissolved oxygen levels are higher than in almost all of the other Maryland rivers.

Back Creek (C&D Canal) is in the 'High Agriculture/ High Developed' land use category. Nitrogen, phosphorus and sediment levels are among the highest of the high developed rivers, but algal densities are among the lowest of all rivers. Water clarity is moderate compared to similar rivers. Summer dissolved oxygen levels are moderate.

The Bohemia River is in the 'High Agriculture/Low Developed' land use category. Agricultural land use in this basin is among the highest of all systems in Maryland. Nitrogen levels are moderate compared to other high agricultural rivers, but phosphorus and sediment levels are high. Algal densities are among the highest of all rivers. Water clarity is very low compared to other rivers. Summer bottom water dissolved oxygen levels are among the highest of all Maryland rivers.

The Elk River is in the 'High Agriculture/High Developed' land use category. Nitrogen, phosphorus and sediment levels are moderate compared to similar rivers. Algal levels are also low and water clarity is high compared to other similar rivers. Summer bottom dissolved oxygen levels are moderate.

The Sassafras River is in the 'High Agriculture/Low Developed' land use category. Nitrogen and phosphorus levels are higher than most rivers and sediment levels are moderate. Algal levels are among the highest of all the rivers and water clarity is very low. Summer bottom dissolved oxygen levels are moderate.

The Chester River is in the 'High Agriculture/Low Developed' land use category. As a whole, the Chester has high nitrogen and phosphorus levels and moderate sediment levels compared to high agricultural rivers. Algal densities are low and water clarity and summer bottom dissolved oxygen levels are moderate compared to similar rivers.

Eastern Bay is in the 'High Agriculture/Low Developed' land use category. Total nitrogen, total phosphorus and total suspended solids levels are among the lowest of all rivers. Algal levels are low and water clarity is the highest of all Maryland rivers. However, summer bottom dissolved oxygen levels are low and indicate impaired habitat.

## *What has been done to improve water and habitat quality in the Upper Eastern Shore Rivers?*

### Wastewater, Stormwater and Septic Loads

Upgrades to the six of the seven largest wastewater treatment plants in the basin were completed between 2007 and 2013; upgrades at the final facility (discharging to the Northeast River) are scheduled for completion in 2016. Wastewater treatment plant nitrogen loadings have been reduced to Furnace Bay (43%), Northeast River (18%), Elk River (77%), Chester River (two facilities, total of 79%) and Eastern Bay (89%) since 1985.[6] Also, since 1985, wastewater treatment phosphorus loadings have been reduced to Furnace Bay (46%), Northeast River (15%), Elk River (90%), Chester River (two facilities, total of 92%) and Eastern Bay (96%). The final

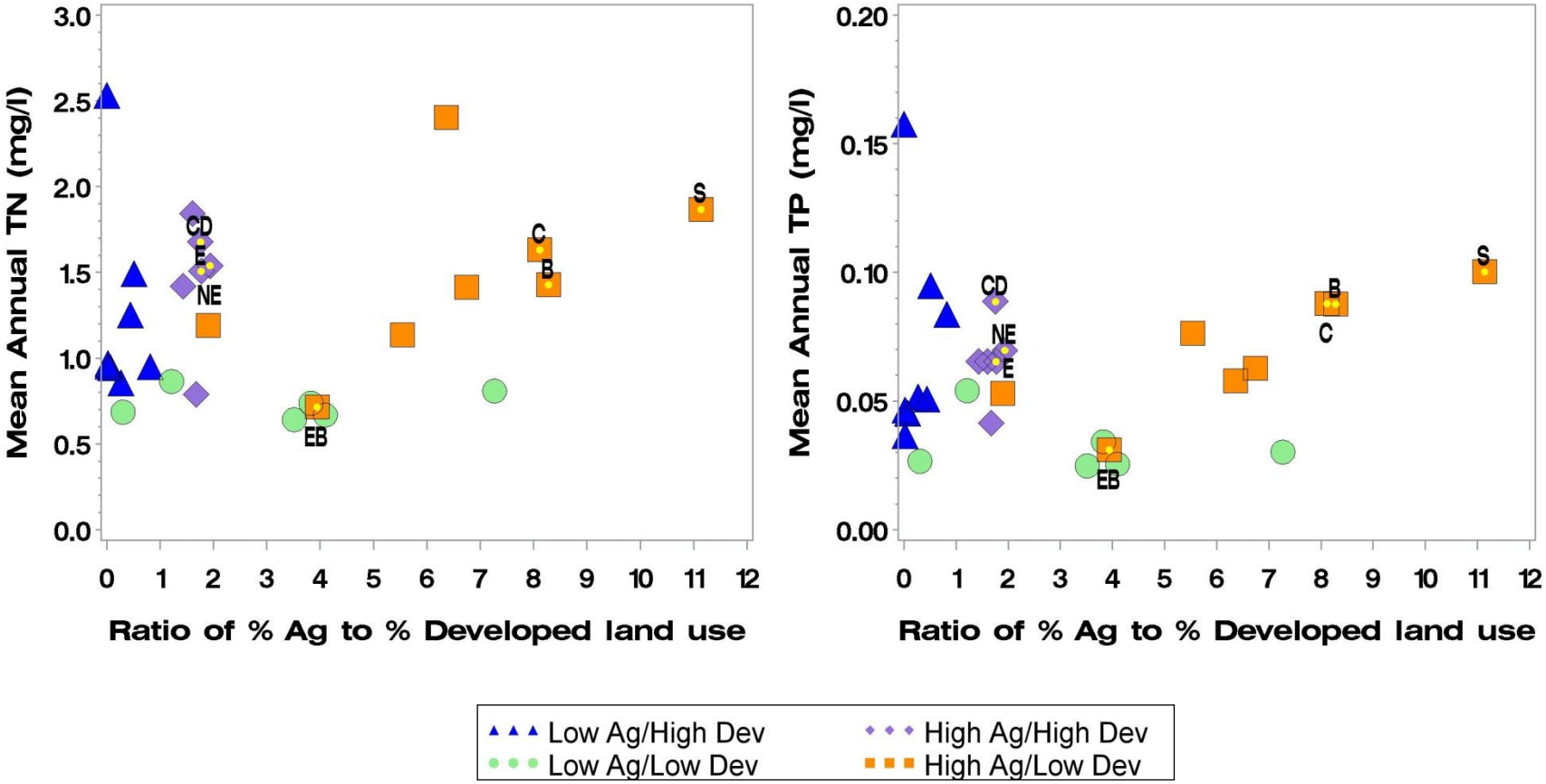


**Figure 2. Water quality conditions versus land use.**
Water quality is shown relative to the ratio of % Agriculture to % Developed land use. Data for 2012-2014 summarized as mean annual concentration for total nitrogen (TN) and total phosphorus (TP). Rivers are color coded by their land use categories (see legend). Yellow dots highlight the data for the Northeast (NE), Bohemia (B), Elk (E), Sassafras (S), Chester (C) rivers, Back Creek (CD) and Eastern Bay (EB).

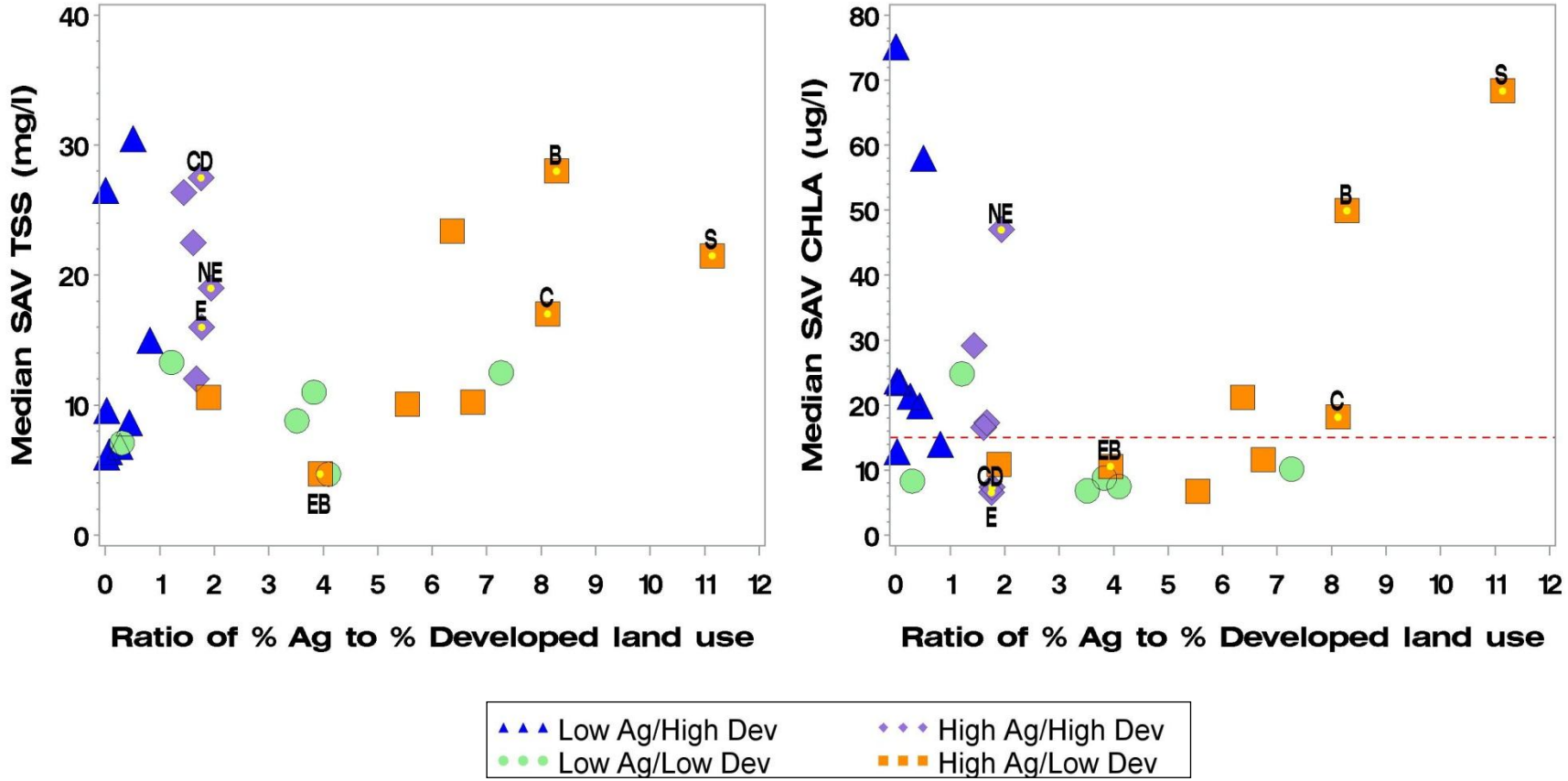


**Figure 2 (cont.). Water quality conditions versus land use.**
Water quality is shown relative to the ratio of % Agriculture to % Developed land use. Data for 2012-2014 summarized as SAV growing season median for total suspended solids (TSS), chlorophyll *a* (CHLA). Reference lines are included on the CHLA graph. Rivers are color coded by their land use categories (see legend). Yellow dots highlight the data for the Northeast (NE), Bohemia (B), Elk (E), Sassafras (S), Chester (C) rivers, Back Creek (CD) and Eastern Bay (EB).

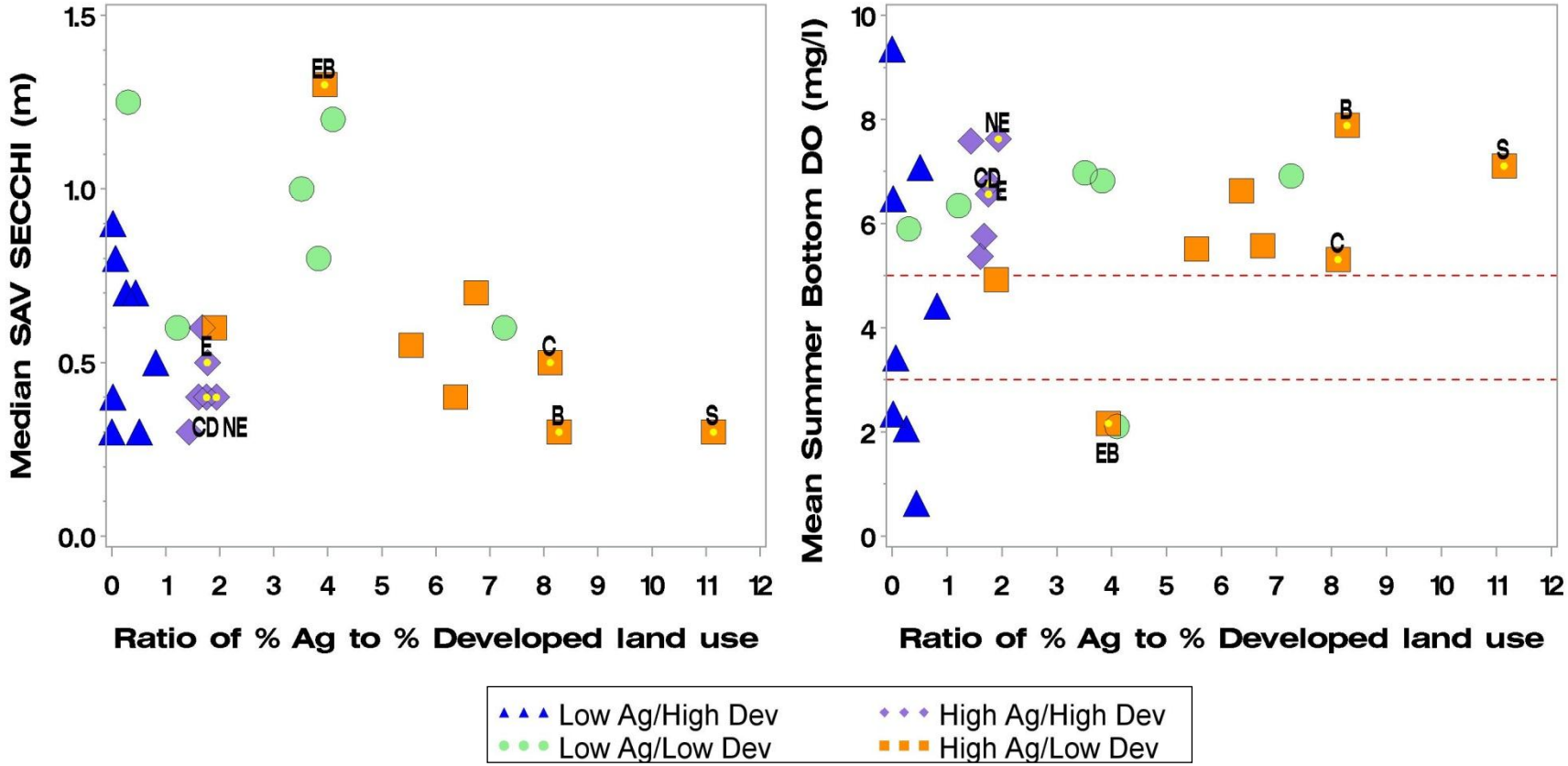


**Figure 2 (cont.). Water quality conditions versus land use.**
Water quality is shown relative to the ratio of % Agriculture to % Developed land use. Data for 2012-2014 summarized as SAV growing season median for Secchi depth and as mean for summer bottom dissolved oxygen (DO). Reference lines are included on the DO graph. Rivers are color coded by their land use categories (see legend). Yellow dots highlight the data for the Northeast (NE), Bohemia (B), Elk (E), Sassafras (S), Chester (C) rivers, Back Creek (CD) and Eastern Bay (EB).

facility (Kent Island) discharges directly to the mainstem Bay; nitrogen loadings have been reduced 73% and phosphorus loadings have been reduced 92% at this facility.

In the basin as a whole, 710 septic system retrofits were completed between 2008 and 2013, and stormwater retrofits have reduced nitrogen loadings and prevented 2,500 pounds of nitrogen from entering the rivers since 2003.[7]

**Agricultural Loads**[7]

In 2014, cover crops were planted in between growing seasons on 112,808 acres to absorb excess nutrients and prevent sediment erosion. Fencing on 1,894 acres of farmland was used to keep livestock out of streams and prevent streambank erosion. A total of 338 containment structures had been built to store animal wastes and allow these nutrients to be applied to the land in the most effective manner at the appropriate time. Stream buffers were in place on 25,501 acres of land, allowing areas next to streams to remain in a natural state with grasses, trees and wetlands.

## *For more information*

An integrative assessment of the water and habitat quality of the Upper Eastern Shore Rivers for 1985-2010 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 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 $\geq 0.95$) 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#.

[6] WWTP loadings data were downloaded from the Chesapeake Bay Program Nutrient Point Source Database website on 10/14/2015 (http://www.chesapeakebay.net/data/downloads/bay_program_nutrient_point_source_database). Changes in loadings determined from the difference of the average of the first three and last three years of data. Data for calendar year available for 1985-2012.

[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 3. Nitrogen, phosphorus and sediment loads to Upper Eastern Shore rivers.** 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.

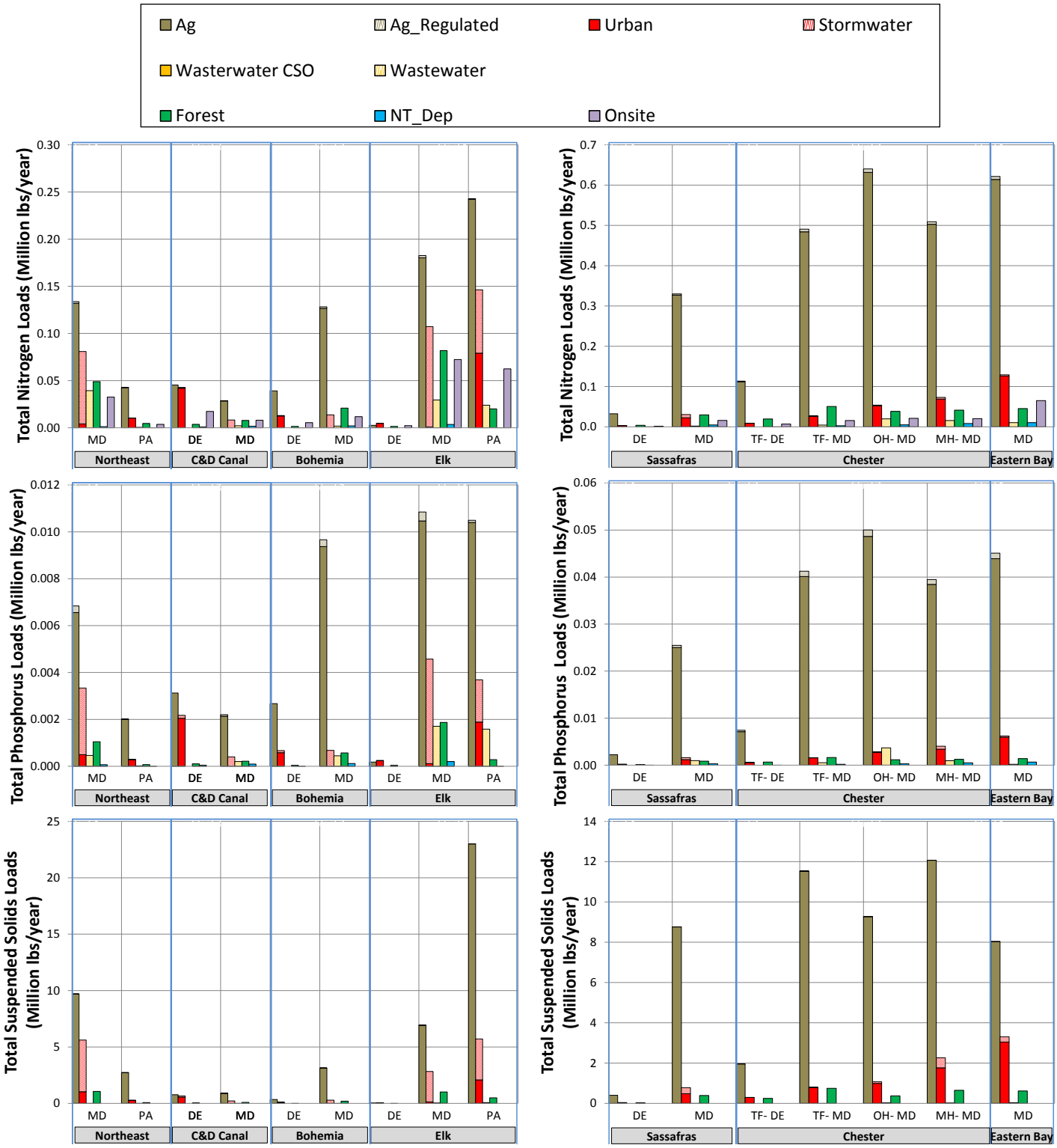

**Table 4. Nitrogen, phosphorus and sediment loads to Upper Eastern Shore rivers**. Loads (in million lbs/year) are summarized by Chesapeake Bay Program model segment and by source category. Data for Progress 2014 model run downloaded on November 16, 2015 from http://baytas.chesapeakebay.net/. Source 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.

| River | Segment | State | Source | TN Load (delivered) | % TN load | TP Load (delivered) | % TP load | Sed. Load (delivered) | % Sed. Load |
|---|---|---|---|---|---|---|---|---|---|
| Northeast | NORTF | MD | Ag | 0.132 | **39.2%** | 0.0066 | **55.8%** | 9.69 | **59.2%** |
| | | | Ag_Reg | 0.002 | 0.5% | 0.0003 | 2.4% | 0.00 | 0.0% |
| | | | Urban | 0.004 | 1.2% | 0.0005 | 4.2% | 1.03 | 6.3% |
| | | | Stormwater | 0.077 | **22.8%** | 0.0028 | **24.2%** | 4.59 | **28.0%** |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | 0.039 | 11.7% | 0.0005 | 3.9% | 0.01 | 0.1% |
| | | | Forest | 0.049 | 14.5% | 0.0010 | 8.9% | 1.06 | 6.5% |
| | | | NT_Dep | 0.001 | 0.3% | 0.0001 | 0.6% | | 0.0% |
| | | | Onsite | 0.032 | 9.6% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.336** | | **0.0117** | | **16.38** | |
| Northeast | NORTF | PA | Ag | 0.043 | **69.1%** | 0.0020 | **83.4%** | 2.72 | **88.9%** |
| | | | Ag_Reg | 0.000 | 0.2% | 0.0000 | 0.8% | 0.00 | 0.0% |
| | | | Urban | 0.010 | 16.6% | 0.0003 | 11.9% | 0.27 | 8.7% |
| | | | Stormwater | 0.000 | 0.1% | 0.0000 | 0.2% | 0.01 | 0.2% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | 0.000 | 0.6% | 0.0000 | 0.6% | 0.00 | 0.0% |
| | | | Forest | 0.005 | 7.3% | 0.0001 | 2.9% | 0.06 | 2.1% |
| | | | NT_Dep | 0.000 | 0.2% | 0.0000 | 0.2% | | 0.0% |
| | | | Onsite | 0.004 | 5.9% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.062** | | **0.0024** | | **3.06** | |
| Back Creek | C&DOH | DE | Ag | 0.045 | **41.4%** | 0.0031 | **57.4%** | 0.76 | **52.5%** |
| | | | Ag_Reg | | 0.0% | | 0.0% | | 0.0% |
| | | | Urban | 0.042 | **38.2%** | 0.0020 | **37.6%** | 0.55 | **37.8%** |
| | | | Stormwater | 0.001 | 0.7% | 0.0001 | 2.3% | 0.11 | 7.4% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | | 0.0% | | 0.0% | | 0.0% |
| | | | Forest | 0.004 | 3.3% | 0.0001 | 1.9% | 0.03 | 2.3% |
| | | | NT_Dep | 0.001 | 0.7% | 0.0000 | 0.9% | | 0.0% |
| | | | Onsite | 0.017 | 15.7% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.110** | | **0.0054** | | **1.45** | |
| Back Creek | C&DOH | MD | Ag | 0.028 | **50.2%** | 0.0021 | **68.6%** | 0.89 | **74.4%** |
| | | | Ag_Reg | 0.000 | 0.7% | 0.0001 | 2.1% | 0.00 | 0.0% |
| | | | Urban | | 0.0% | | 0.0% | | 0.0% |
| | | | Stormwater | 0.008 | 14.7% | 0.0004 | 12.9% | 0.22 | 18.1% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | 0.002 | 3.7% | 0.0002 | 6.4% | 0.00 | 0.3% |
| | | | Forest | 0.008 | 13.8% | 0.0002 | 7.0% | 0.09 | 7.1% |
| | | | NT_Dep | 0.002 | 2.9% | 0.0001 | 3.0% | | 0.0% |
| | | | Onsite | 0.008 | 14.1% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.056** | | **0.0031** | | **1.19** | |

**Table 4 (cont.). Nitrogen, phosphorus and sediment loads to Upper Eastern Shore rivers**. 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.

| River | Segment | State | Source | TN Load (delivered) | % TN load | TP Load (delivered) | % TP load | Sed. Load (delivered) | % Sed. Load |
|---|---|---|---|---|---|---|---|---|---|
| Bohemia | BOHOH | DE | Ag | 0.039 | 66.4% | 0.0027 | 78.8% | 0.34 | 75.3% |
| | | | Ag_Reg | | 0.0% | | 0.0% | | 0.0% |
| | | | Urban | 0.012 | 21.1% | 0.0006 | 17.1% | 0.07 | 15.9% |
| | | | Stormwater | 0.000 | 0.8% | 0.0001 | 2.7% | 0.03 | 7.2% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | | 0.0% | | 0.0% | | 0.0% |
| | | | Forest | 0.001 | 2.3% | 0.0000 | 1.1% | 0.01 | 1.6% |
| | | | NT_Dep | 0.000 | 0.3% | 0.0000 | 0.3% | | 0.0% |
| | | | Onsite | 0.005 | 9.1% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.059** | | **0.0034** | | **0.45** | |
| Bohemia | BOHOH | MD | Ag | 0.126 | 71.0% | 0.0094 | 81.7% | 3.13 | 86.8% |
| | | | Ag_Reg | 0.002 | 1.0% | 0.0003 | 2.5% | 0.00 | 0.0% |
| | | | Urban | | 0.0% | | 0.0% | | 0.0% |
| | | | Stormwater | 0.014 | 7.7% | 0.0007 | 5.9% | 0.28 | 7.7% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | 0.002 | 1.0% | 0.0004 | 3.9% | 0.00 | 0.0% |
| | | | Forest | 0.021 | 11.7% | 0.0006 | 5.0% | 0.20 | 5.4% |
| | | | NT_Dep | 0.002 | 1.1% | 0.0001 | 1.0% | | 0.0% |
| | | | Onsite | 0.012 | 6.6% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.178** | | **0.0115** | | **3.60** | |
| Elk | ELKOH | DE | Ag | 0.003 | 23.0% | 0.0002 | 38.1% | 0.03 | 33.1% |
| | | | Ag_Reg | | 0.0% | | 0.0% | | 0.0% |
| | | | Urban | 0.005 | 43.1% | 0.0002 | 50.3% | 0.04 | 49.7% |
| | | | Stormwater | 0.000 | 0.6% | 0.0000 | 2.9% | 0.01 | 6.4% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | | 0.0% | | 0.0% | | 0.0% |
| | | | Forest | 0.001 | 12.9% | 0.0000 | 8.6% | 0.01 | 10.9% |
| | | | NT_Dep | | 0.0% | | 0.0% | | 0.0% |
| | | | Onsite | 0.002 | 20.3% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.011** | | **0.0005** | | **0.09** | |
| Elk | ELKOH | MD | Ag | 0.180 | 37.8% | 0.0105 | 54.5% | 6.92 | 64.2% |
| | | | Ag_Reg | 0.002 | 0.5% | 0.0004 | 2.0% | 0.00 | 0.0% |
| | | | Urban | 0.001 | 0.1% | 0.0001 | 0.6% | 0.12 | 1.2% |
| | | | Stormwater | 0.107 | 22.4% | 0.0045 | 23.2% | 2.70 | 25.0% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | 0.029 | 6.2% | 0.0017 | 8.9% | 0.03 | 0.2% |
| | | | Forest | 0.082 | 17.2% | 0.0019 | 9.7% | 1.01 | 9.4% |
| | | | NT_Dep | 0.004 | 0.7% | 0.0002 | 1.1% | | 0.0% |
| | | | Onsite | 0.072 | 15.2% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.477** | | **0.0192** | | **10.78** | |
| Elk | ELKOH | PA | Ag | 0.242 | 48.9% | 0.0104 | 64.8% | 23.00 | 78.6% |
| | | | Ag_Reg | 0.001 | 0.2% | 0.0001 | 0.6% | 0.01 | 0.0% |
| | | | Urban | 0.079 | 15.9% | 0.0019 | 11.7% | 2.07 | 7.1% |
| | | | Stormwater | 0.067 | 13.6% | 0.0018 | 11.2% | 3.63 | 12.4% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | 0.024 | 4.8% | 0.0016 | 9.9% | 0.06 | 0.2% |
| | | | Forest | 0.020 | 4.0% | 0.0003 | 1.7% | 0.49 | 1.7% |
| | | | NT_Dep | 0.000 | 0.0% | 0.0000 | 0.0% | | 0.0% |
| | | | Onsite | 0.062 | 12.6% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.496** | | **0.0160** | | **29.26** | |

**Table 4 (cont.). Nitrogen, phosphorus and sediment loads to Upper Eastern Shore rivers**. 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.

| River | Segment | State | Source | TN Load (delivered) | % TN load | TP Load (delivered) | % TP load | Sed. Load (delivered) | % Sed. Load |
|---|---|---|---|---|---|---|---|---|---|
| Sassafras | SASOH | DE | Ag | 0.032 | 79.9% | 0.0022 | 89.1% | 0.40 | 85.8% |
| | | | Ag_Reg | | 0.0% | | 0.0% | | 0.0% |
| | | | Urban | 0.003 | 7.0% | 0.0002 | 6.2% | 0.03 | 7.2% |
| | | | Stormwater | 0.000 | 0.1% | 0.0000 | 0.3% | 0.00 | 0.7% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | | 0.0% | | 0.0% | | 0.0% |
| | | | Forest | 0.004 | 9.5% | 0.0001 | 4.4% | 0.03 | 6.2% |
| | | | NT_Dep | 0.000 | 0.0% | 0.0000 | 0.0% | | 0.0% |
| | | | Onsite | 0.001 | 3.5% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.041** | | **0.0025** | | **0.47** | |
| Sassafras | SASOH | MD | Ag | 0.327 | 79.3% | 0.0250 | 85.7% | 8.76 | 88.1% |
| | | | Ag_Reg | 0.003 | 0.7% | 0.0005 | 1.6% | 0.00 | 0.0% |
| | | | Urban | 0.022 | 5.4% | 0.0012 | 4.0% | 0.48 | 4.8% |
| | | | Stormwater | 0.008 | 1.9% | 0.0004 | 1.4% | 0.30 | 3.0% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | 0.002 | 0.5% | 0.0010 | 3.3% | 0.00 | 0.0% |
| | | | Forest | 0.030 | 7.2% | 0.0008 | 2.9% | 0.39 | 3.9% |
| | | | NT_Dep | 0.005 | 1.1% | 0.0003 | 0.9% | | 0.0% |
| | | | Onsite | 0.016 | 3.8% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.412** | | **0.0292** | | **9.94** | |

**Table 4 (cont.). Nitrogen, phosphorus and sediment loads to Upper Eastern Shore rivers**. 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.

| River | Segment | State | Source | TN Load (delivered) | % TN load | TP Load (delivered) | % TP load | Sed. Load (delivered) | % Sed. Load |
|---|---|---|---|---|---|---|---|---|---|
| Upper Chester | CHSTF | DE | Ag | 0.112 | 75.2% | 0.0071 | 82.5% | 1.96 | 78.5% |
| | | | Ag_Reg | 0.002 | 1.1% | 0.0003 | 3.4% | 0.00 | 0.0% |
| | | | Urban | 0.009 | 5.9% | 0.0005 | 6.3% | 0.29 | 11.6% |
| | | | Stormwater | 0.000 | 0.0% | 0.0000 | 0.0% | 0.00 | 0.1% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | | 0.0% | | 0.0% | | 0.0% |
| | | | Forest | 0.019 | 13.1% | 0.0007 | 7.6% | 0.24 | 9.8% |
| | | | NT_Dep | 0.000 | 0.1% | 0.0000 | 0.1% | | 0.0% |
| | | | Onsite | 0.007 | 4.6% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.149** | | **0.0086** | | **2.49** | |
| Upper Chester | CHSTF | MD | Ag | 0.484 | 82.0% | 0.0401 | 88.9% | 11.53 | 88.1% |
| | | | Ag_Reg | 0.007 | 1.1% | 0.0011 | 2.5% | 0.00 | 0.0% |
| | | | Urban | 0.027 | 4.5% | 0.0016 | 3.4% | 0.79 | 6.0% |
| | | | Stormwater | 0.000 | 0.0% | 0.0000 | 0.0% | 0.01 | 0.1% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | 0.004 | 0.7% | 0.0005 | 1.1% | 0.00 | 0.0% |
| | | | Forest | 0.050 | 8.6% | 0.0016 | 3.6% | 0.75 | 5.7% |
| | | | NT_Dep | 0.003 | 0.5% | 0.0002 | 0.4% | | 0.0% |
| | | | Onsite | 0.016 | 2.6% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.590** | | **0.0451** | | **13.08** | |
| Upper Chester | CHSOH | MD | Ag | 0.632 | 81.2% | 0.0486 | 84.0% | 9.27 | 86.4% |
| | | | Ag_Reg | 0.009 | 1.1% | 0.0014 | 2.4% | 0.00 | 0.0% |
| | | | Urban | 0.052 | 6.7% | 0.0027 | 4.6% | 0.99 | 9.2% |
| | | | Stormwater | 0.001 | 0.2% | 0.0002 | 0.3% | 0.08 | 0.8% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | 0.020 | 2.5% | 0.0037 | 6.3% | 0.02 | 0.2% |
| | | | Forest | 0.039 | 5.0% | 0.0011 | 2.0% | 0.37 | 3.5% |
| | | | NT_Dep | 0.005 | 0.6% | 0.0003 | 0.5% | | 0.0% |
| | | | Onsite | 0.021 | 2.7% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.778** | | **0.0579** | | **10.73** | |
| Lower Chester | CHSMH | MD | Ag | 0.503 | 75.3% | 0.0384 | 83.3% | 12.06 | 80.5% |
| | | | Ag_Reg | 0.007 | 1.0% | 0.0010 | 2.3% | 0.00 | 0.0% |
| | | | Urban | 0.069 | 10.3% | 0.0034 | 7.4% | 1.76 | 11.8% |
| | | | Stormwater | 0.004 | 0.6% | 0.0006 | 1.3% | 0.50 | 3.3% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | 0.016 | 2.3% | 0.0009 | 2.0% | 0.01 | 0.1% |
| | | | Forest | 0.041 | 6.2% | 0.0012 | 2.7% | 0.65 | 4.3% |
| | | | NT_Dep | 0.008 | 1.2% | 0.0005 | 1.1% | | 0.0% |
| | | | Onsite | 0.020 | 3.0% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.667** | | **0.0461** | | **14.99** | |
| Eastern Bay | EASMH | MD | Ag | 0.614 | 69.7% | 0.0439 | 82.1% | 8.03 | 67.0% |
| | | | Ag_Reg | 0.007 | 0.8% | 0.0012 | 2.2% | 0.00 | 0.0% |
| | | | Urban | 0.126 | 14.3% | 0.0059 | 11.1% | 3.04 | 25.4% |
| | | | Stormwater | 0.003 | 0.3% | 0.0003 | 0.5% | 0.26 | 2.2% |
| | | | CSO | | 0.0% | | 0.0% | | 0.0% |
| | | | Wastewater | 0.010 | 1.2% | 0.0002 | 0.3% | 0.03 | 0.3% |
| | | | Forest | 0.045 | 5.1% | 0.0014 | 2.6% | 0.61 | 5.1% |
| | | | NT_Dep | 0.010 | 1.2% | 0.0007 | 1.2% | | 0.0% |
| | | | Onsite | 0.065 | 7.4% | | 0.0% | | 0.0% |
| | | | **Total Load** | **0.881** | | **0.0535** | | **11.98** | |

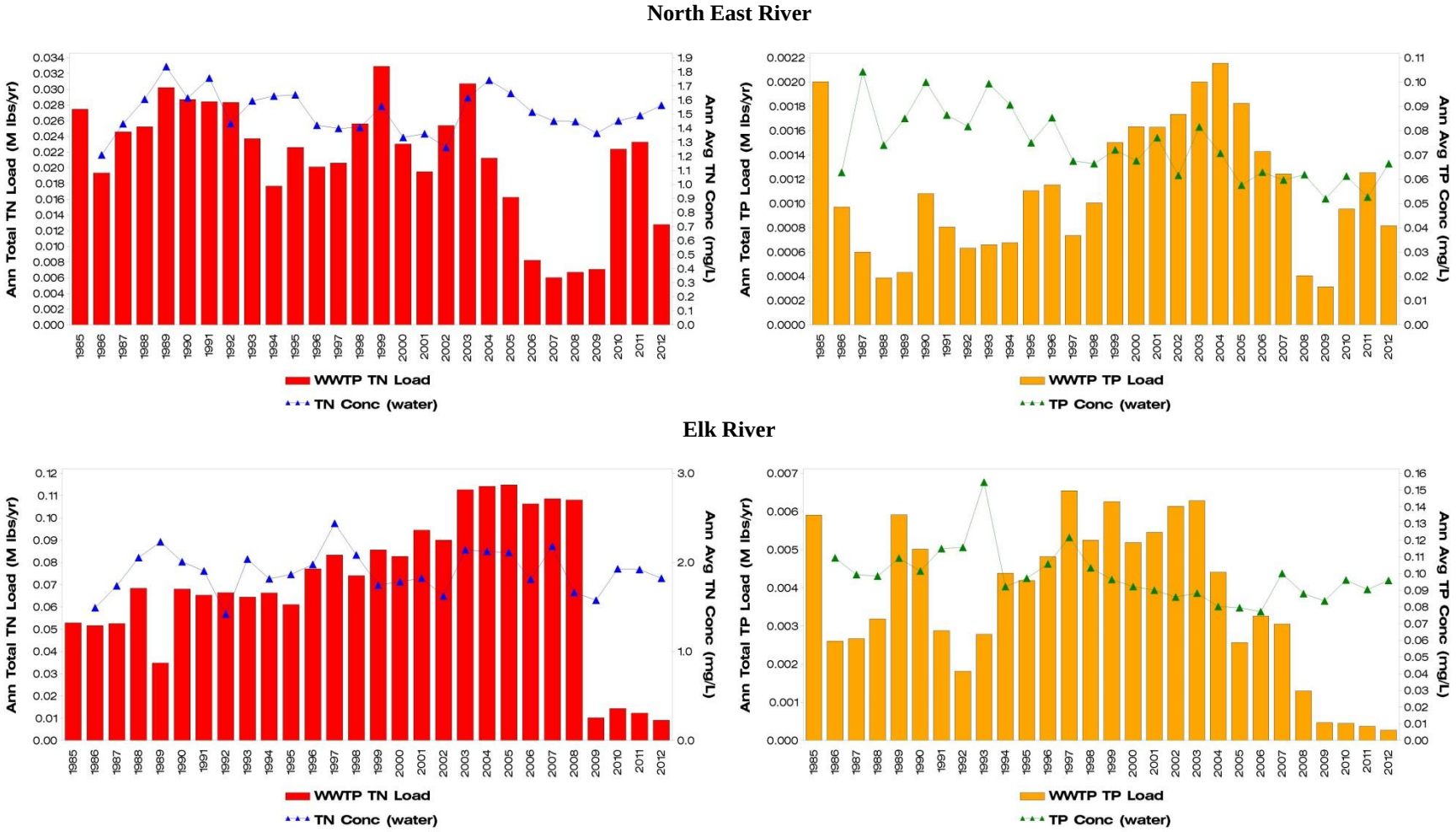


**Figure 4. Total Wastewater Treatment Plant loads versus water quality.** Loads from each major wastewater treatment plants (in million pounds per year, M lbs/yr) that discharges into the North East River (top graphs) and the Elk River (bottom graphs) compared to annual mean nutrient concentrations (in mg/L) at the long-term monitoring site in each river. Total nitrogen loads (red bars) compared to total nitrogen concentrations (blue triangles) are shown in the left side graphs; total phosphorus (orange bars) compared to total phosphorus concentrations (green triangles) are shown in the right side graphs. Full calendar year loadings data is only available through 2012, and was downloaded from the Chesapeake Bay Program Nutrient Point Source Database website on 10/14/2015 (http://www.chesapeakebay.net/data/downloads/bay_program_nutrient_point_source_database).

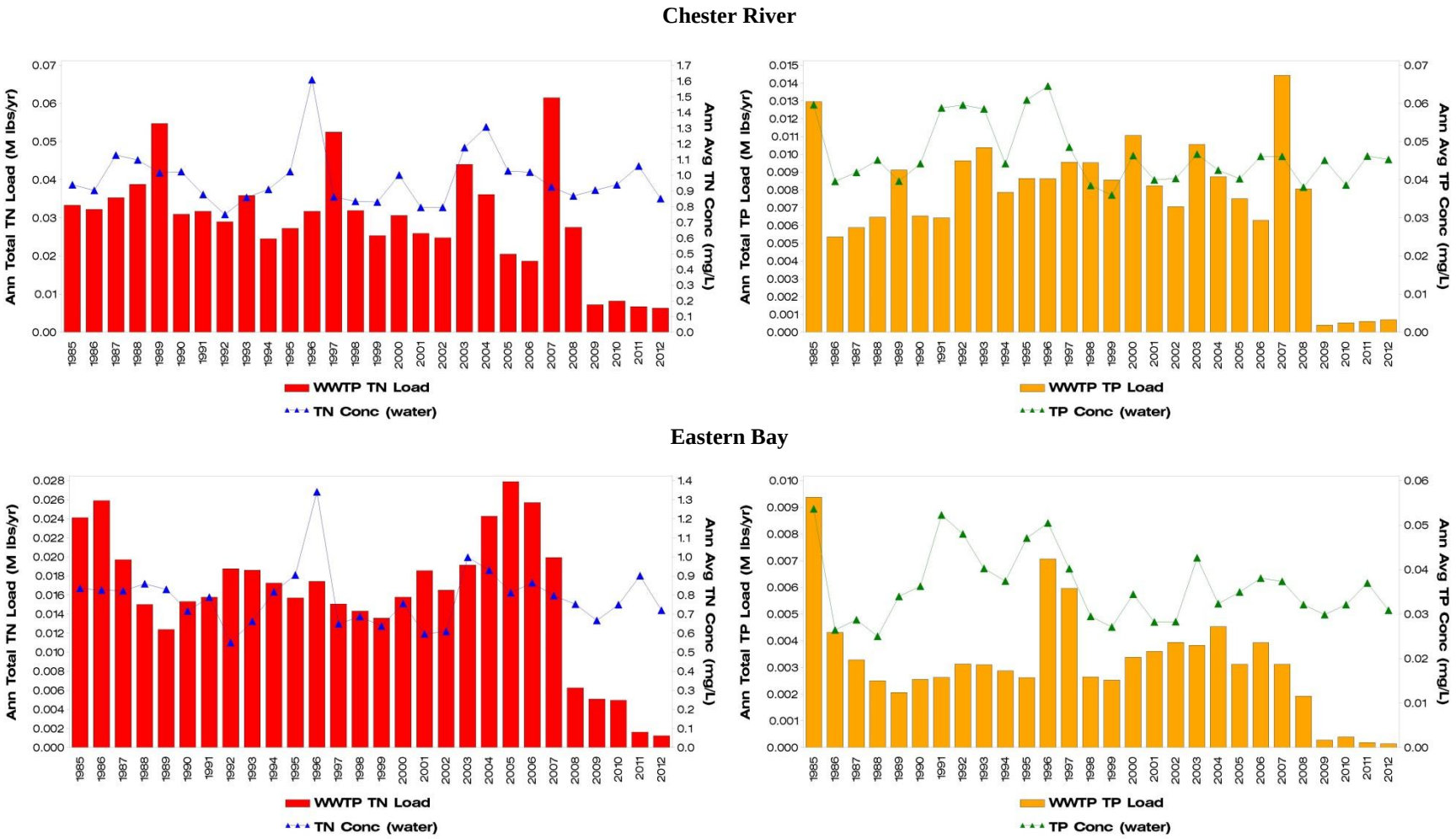


**Figure 4 (cont) . Total Wastewater Treatment Plant loads versus water quality.** Total loads from the two major wastewater treatment plants (in million pounds per year, M lbs/yr) that discharge into the Chester River (top graphs) and the single plant that discharges into Eastern Bay (bottom graphs) compared to annual mean nutrient concentrations (in mg/L) at the long-term monitoring site(s) in each . Total nitrogen loads (red bars) compared to total nitrogen concentrations (blue triangles) are shown in the left side graphs; total phosphorus (orange bars) compared to total phosphorus concentrations (green triangles) are shown in the right side graphs. Full calendar year loadings data is only available through 2012, and was downloaded from the Chesapeake Bay Program Nutrient Point Source Database website on 10/14/2015 (http://www.chesapeakebay.net/data/downloads/bay_program_nutrient_point_source_database).