Nitrogen, Phosphorus, and Suspended-Sediment Loads and Trends Measured at the Chesapeake Bay Nontidal Network Stations

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Objective

- Communicate the latest (through 2014) nitrogen, phosphorus, and suspended-sediment load and trend results for stations in the Chesapeake Bay nontidal network

Questions

(1) How are nitrogen, phosphorus, and suspended-sediment loads responding to restoration activities and changing land use across the bay watershed?

(2) What are the trends in nitrogen, phosphorus, and suspended-sediment loads being delivered to the bay from the nontidal portions of the watershed?

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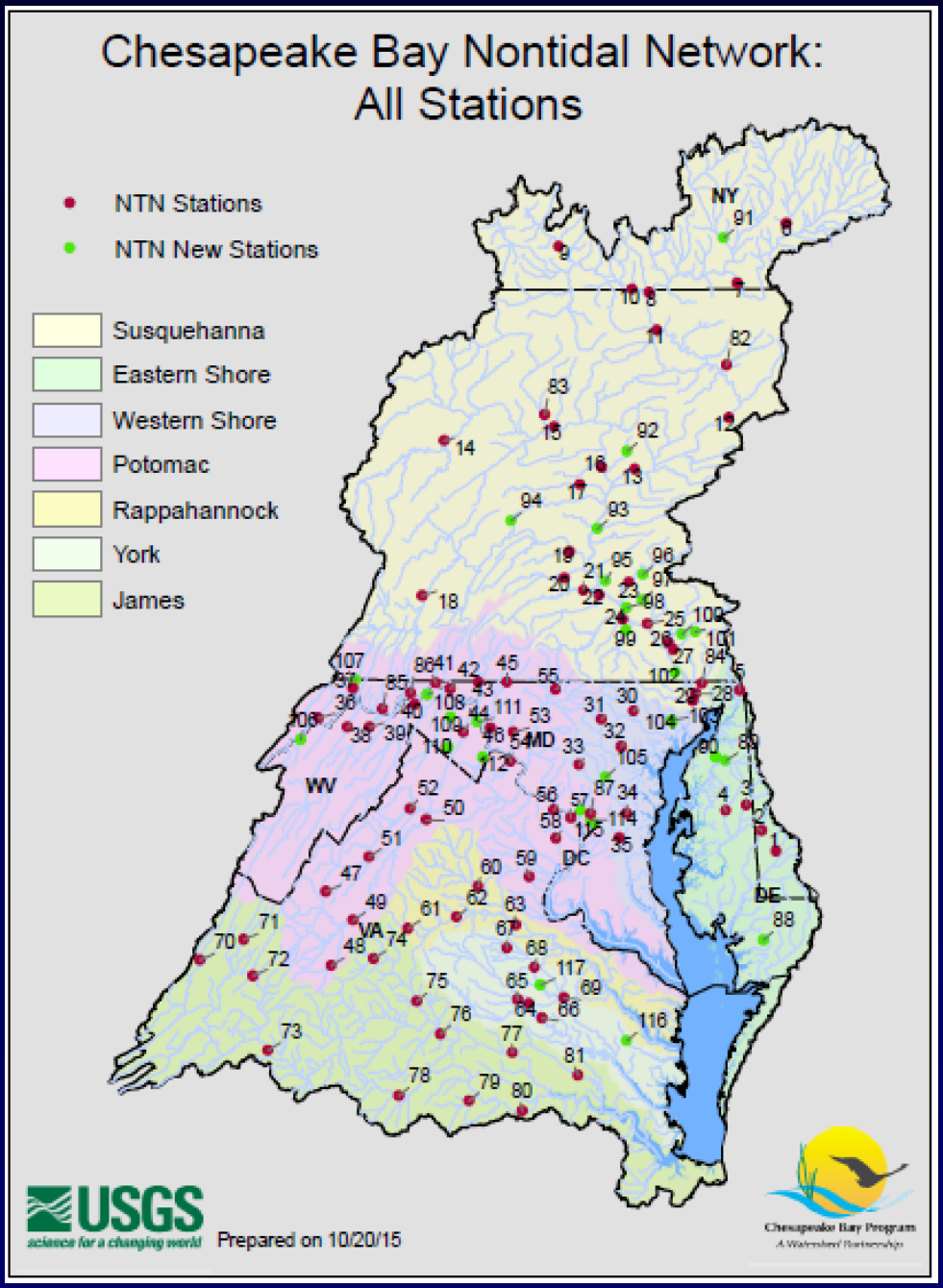
Chesapeake Bay Nontidal Monitoring Network



How are nitrogen, phosphorus, and suspended-sediment loads responding to restoration activities and changing land use?

Monitoring Stations (117 stations)

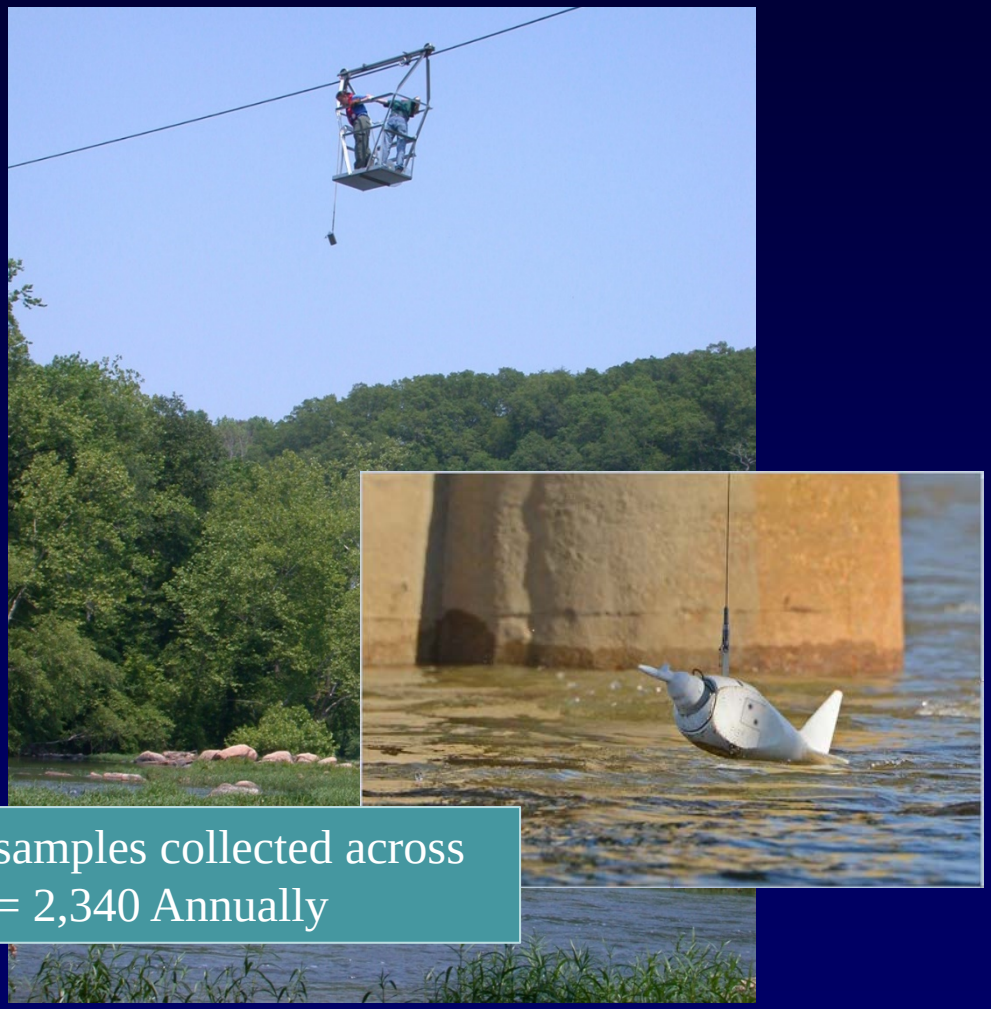
- 87 stations with ≥ 5 years
- 81 stations ≥ 10 years
- 30 stations with ≥ 30 years
- Drainage areas range from 1 to 27,100 mi^2
- 37 station in the Potomac Watershed

Load and Trend Estimation

Daily Load = Daily Concentration * Mean Daily Discharge

Discrete water quality samples, typically 12 “routine” and 8 “storm” are collected at or near gaging stations.

Samples are analyzed for total N, NO_{23}, total P, ortho-P and sediment



Total samples collected across NTN = 2,340 Annually

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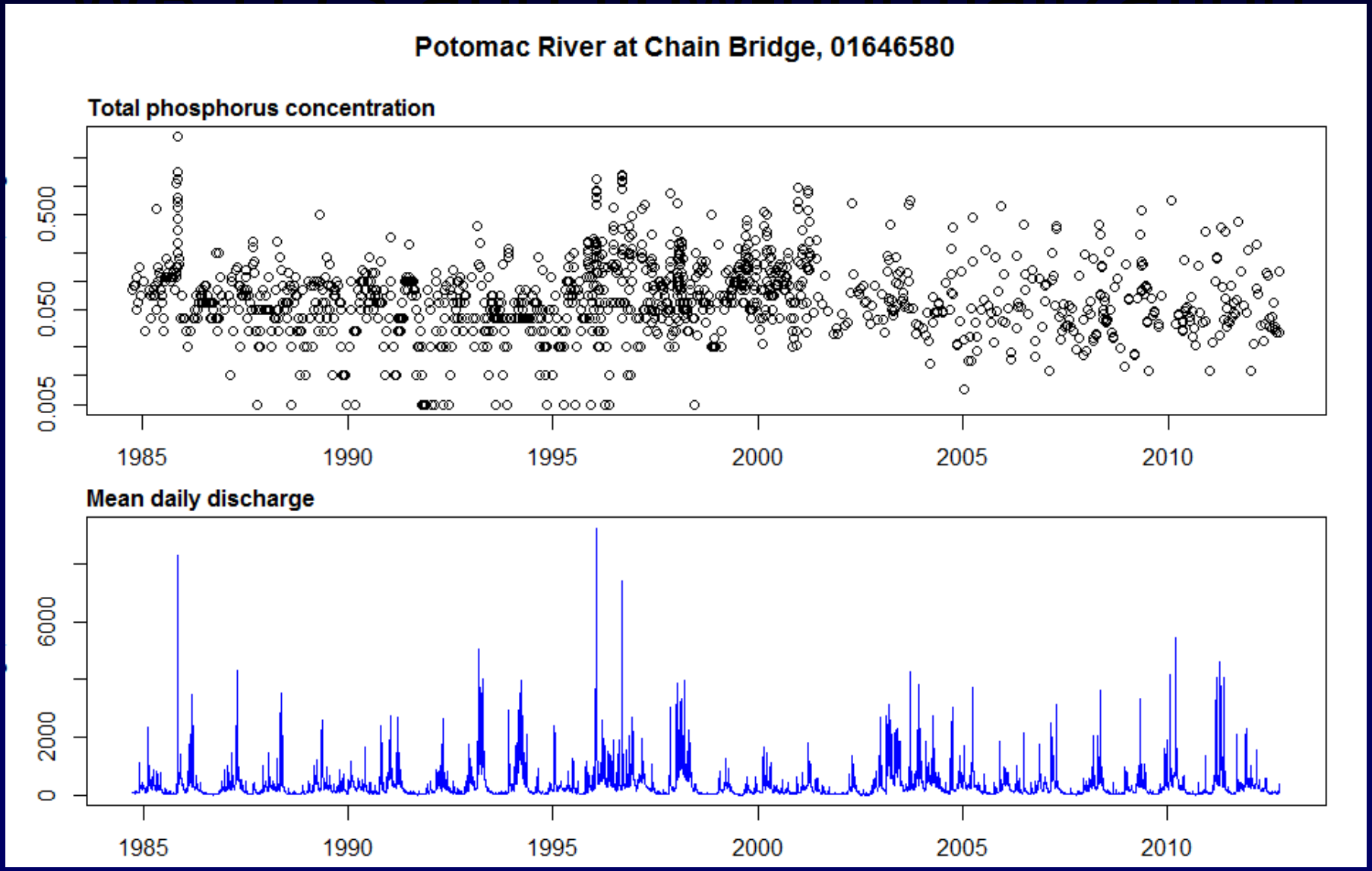
Load and Trend Estimation

Daily Load = Daily Concentration * Mean Daily Discharge



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Load and Trend Estimation

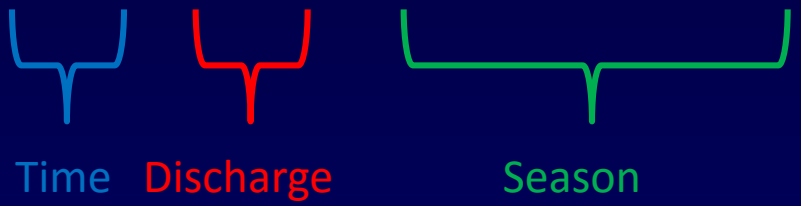
Daily Load = Daily Concentration * Mean Daily Discharge

Weighted Regression on Time, Discharge, and Season (WRTDS)

(Hirsch and others, 2010)

Primary Load Computation Model 2012-2015

$$\ln(c) = \hat{\beta}_0 + \hat{\beta}_1 t + \hat{\beta}_2 \ln(q) + \hat{\beta}_3 \sin(2\pi t) + \hat{\beta}_4 \cos(2\pi t) + \varepsilon$$



- Unique regression model for each point at which a concentration estimate is required
- Models weight observations based on “proximity”, in *time, discharge, and season*, to conditions at the time each estimate is required

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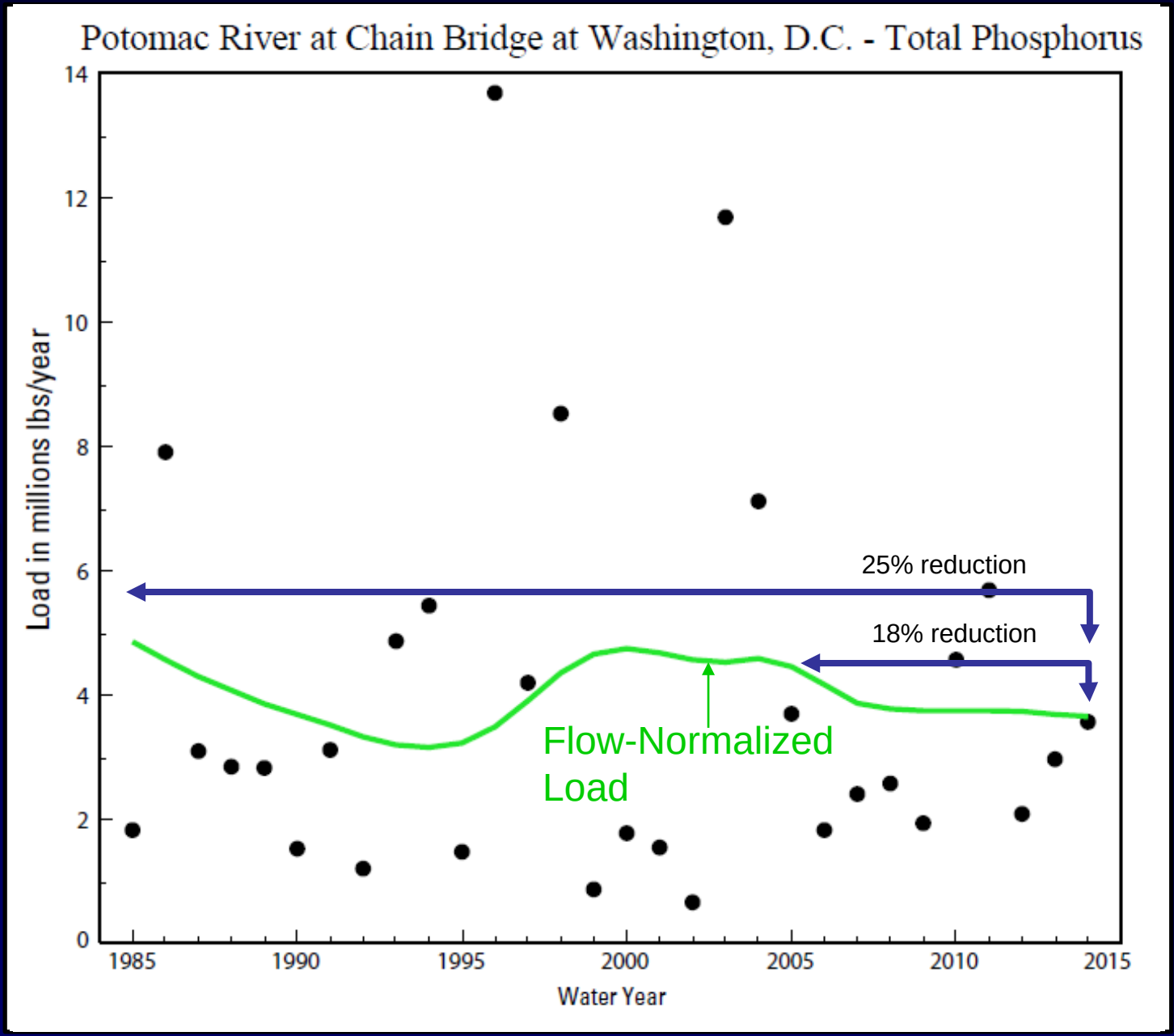
WRTDS Load and Trend Example: Potomac River Total Phosphorus

Total reduction in RIM total nitrogen:
1985 to 2014 = -25%
2005 to 2014 = -18%



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Total Nitrogen per Acre Loads and Trends: 2005-2014

Total nitrogen loads range from 1.19 to 33.4 lbs/ac with an average load of 7.33 lbs/ac

Improving Trends = 44 of 81 (54%)
Degrading Trends = 22 of 81 (27%)
No Trend = 15 of 81 (19%)

Of the 14 stations with the highest per acre loads for Total Nitrogen:

- 6 have improving trends
- 3 have degrading trends
- 4 have no trends
- 1 has insufficient data for trends

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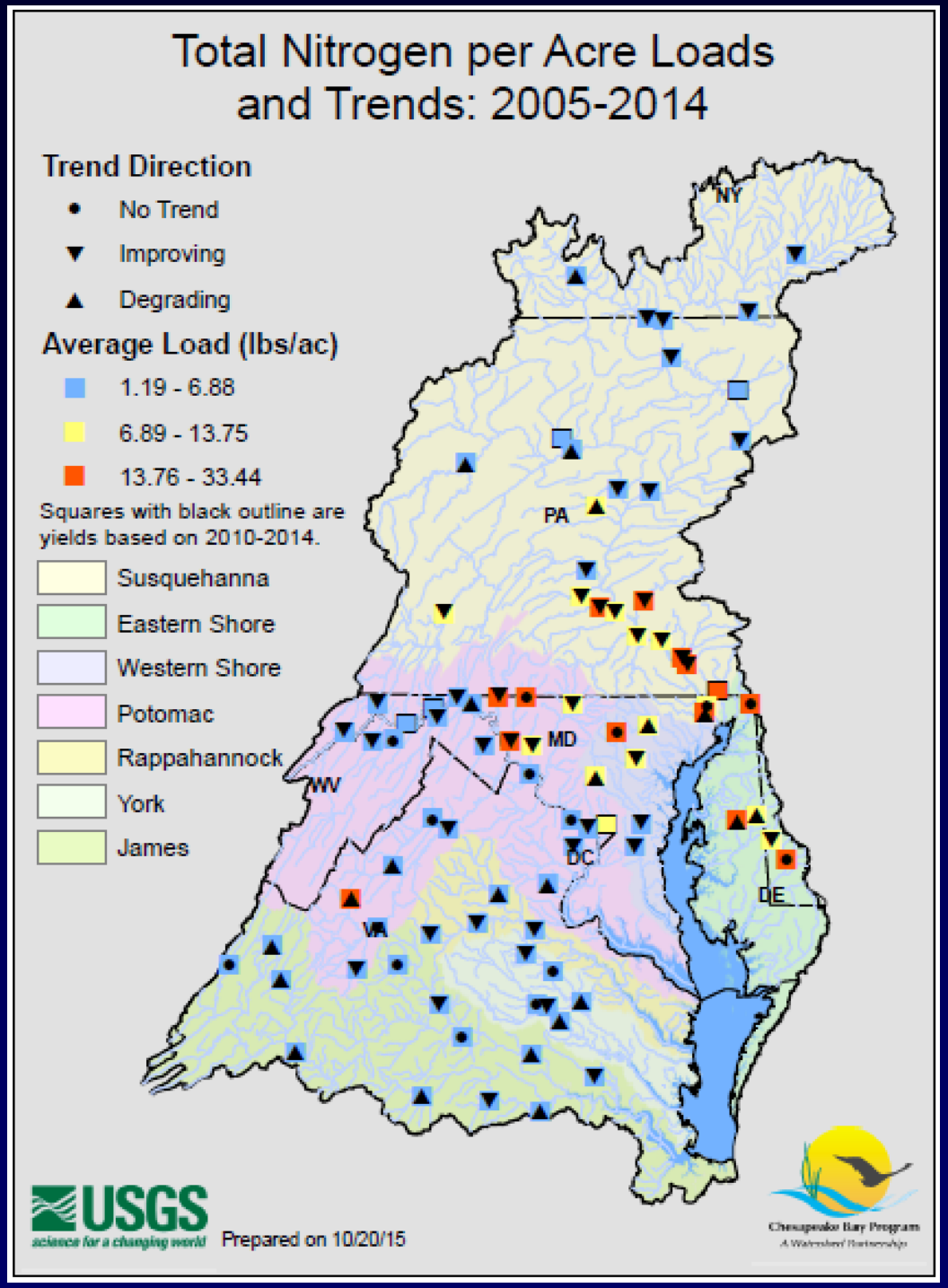

Potomac Total Nitrogen per Acre Loads and Trends: 2005-2014

Potomac Loads:

- 1.5-17.2 lbs per acre
- Average = 6.8 lbs per acre

Potomac: Majority improving

- Improving: 14
- Degrading: 4
- No change: 6

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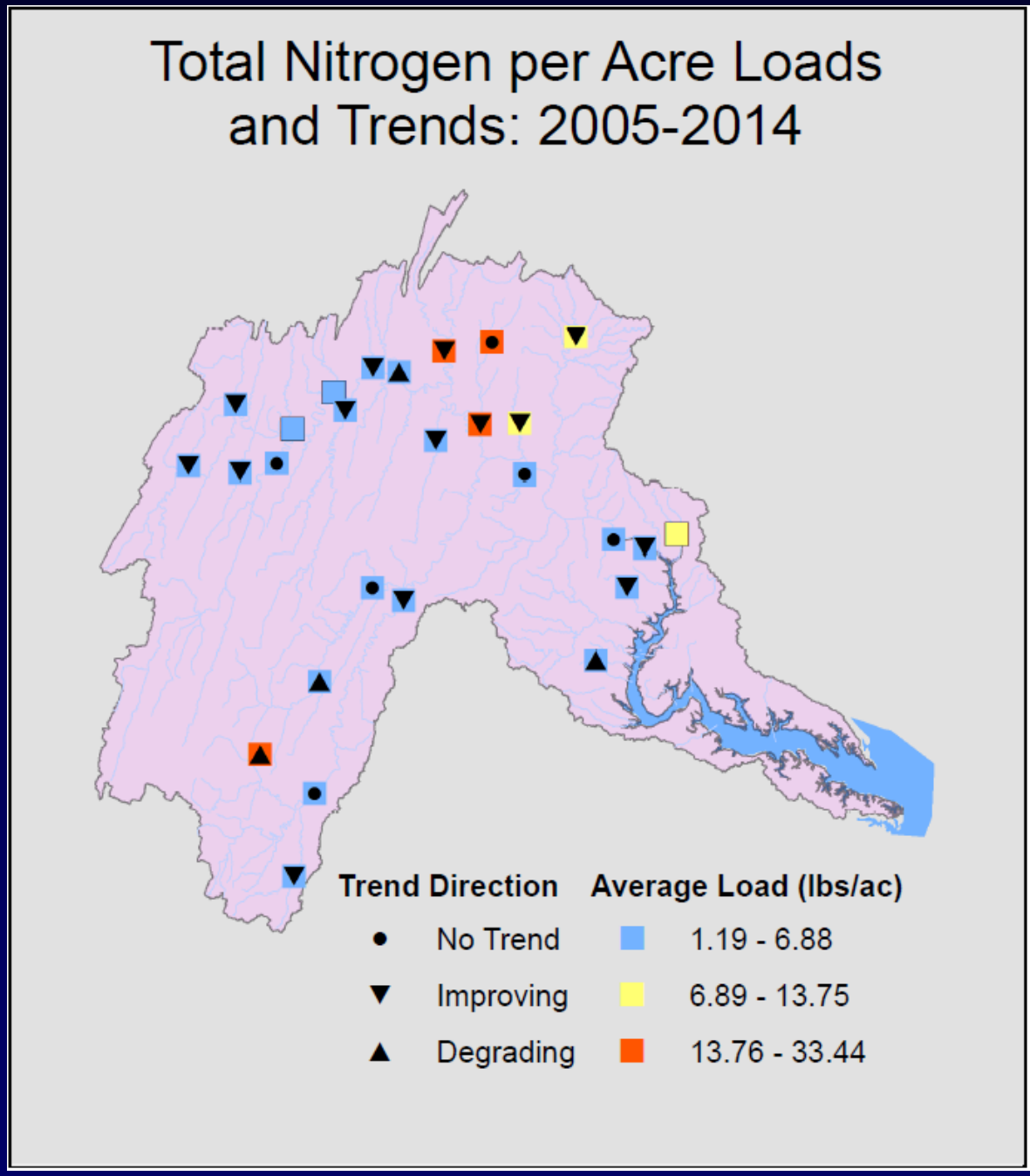
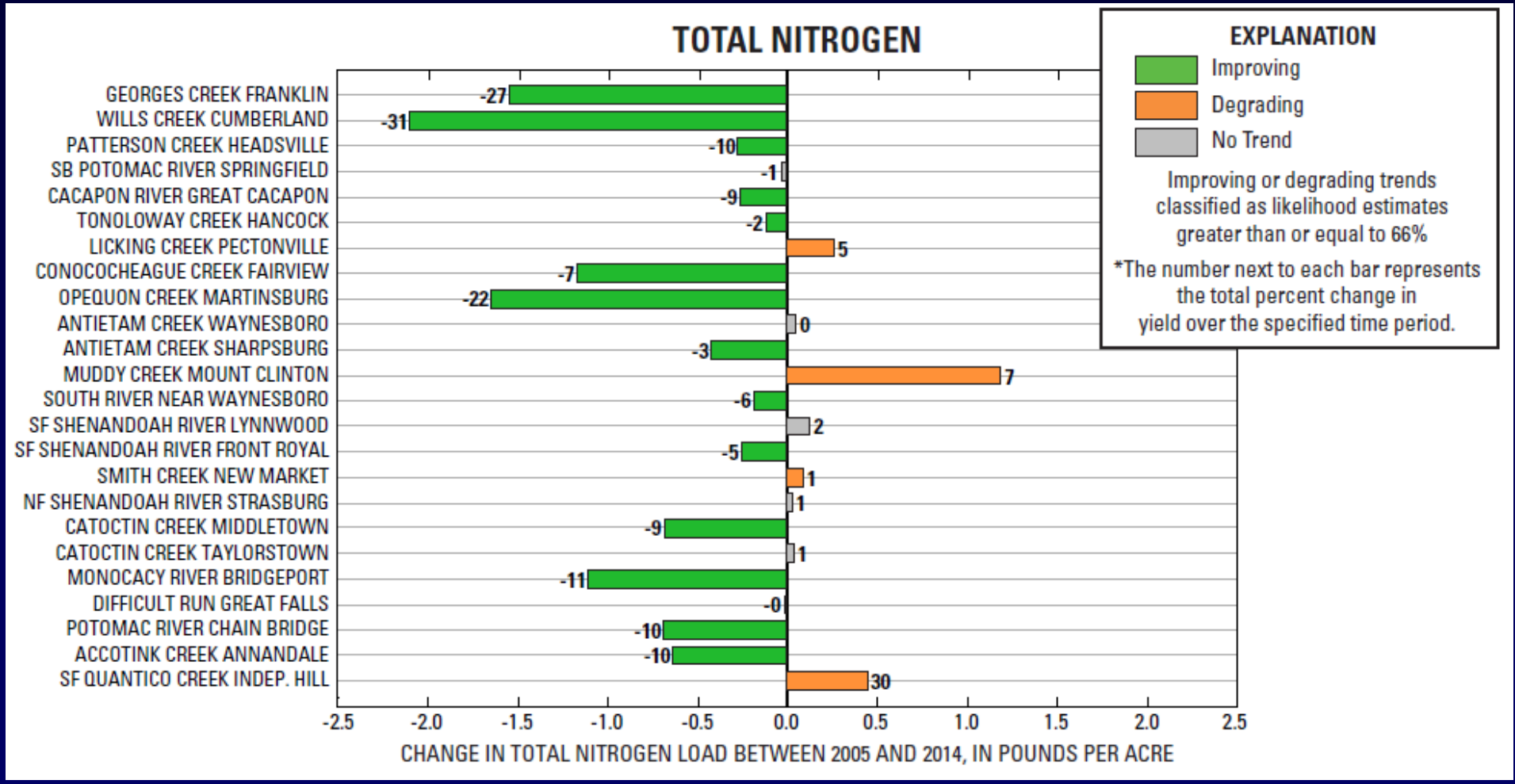


Squares with black outline are yields based on 2010-2014

Changes in Nitrogen per Acre Loads: 2005-2014

Potomac Watershed



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Changes in Nitrogen per Acre Loads: 2005-2014

Trend in load network is the first of its kind

Improving Trends = 44 of 81 (54%)
Degrading Trends = 22 of 81 (27%)
No Trend = 15 of 81 (19%)

Improving Stations
Range = -0.10 to -5.07 lbs/ac
Median = -0.68 lbs/ac (-10.0%)

Degrading Stations
Range = 0.04 to 1.21 lbs/ac
Median = 0.33 lbs/ac (7.84%)

Download figure:
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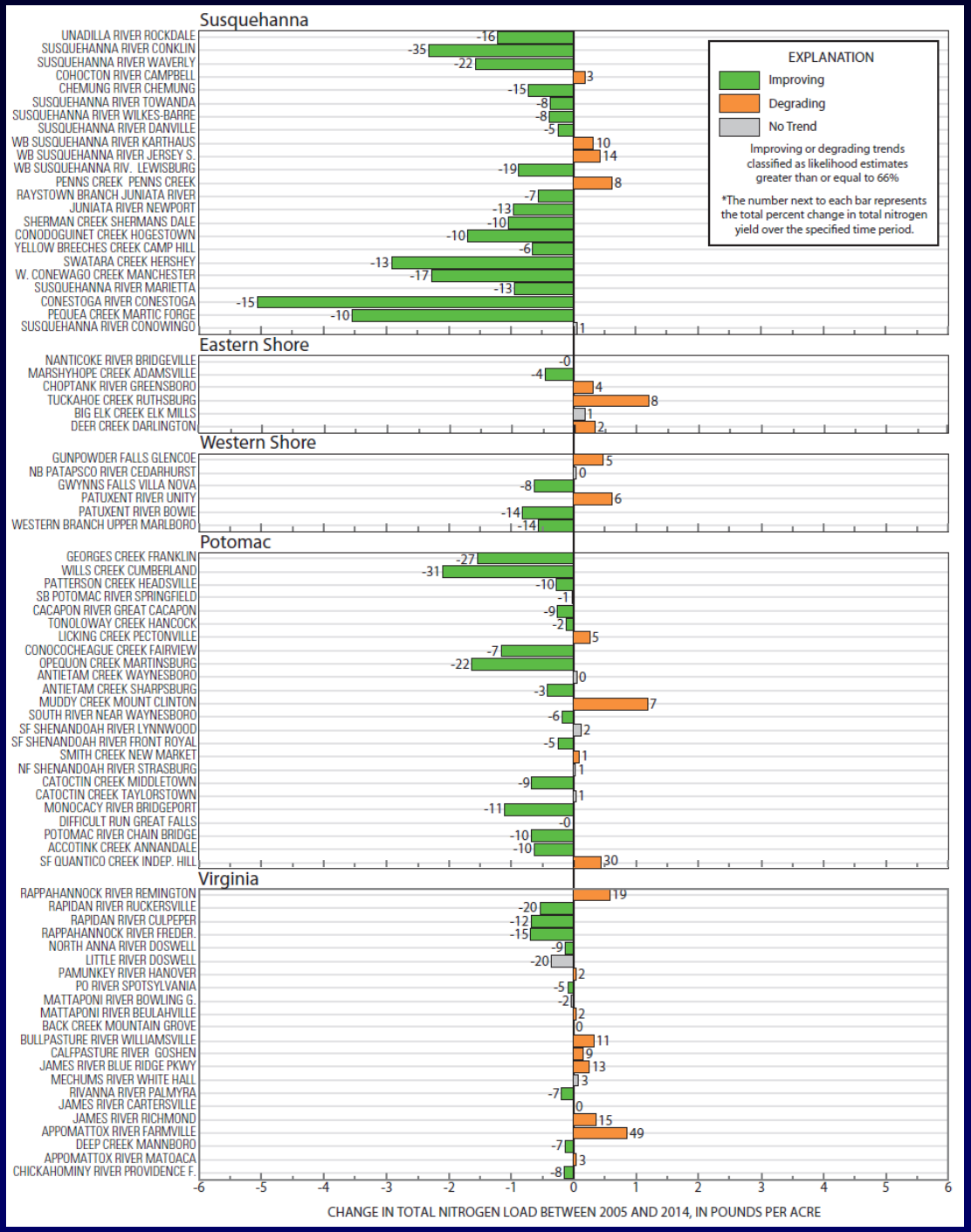

Total Phosphorus per Acre Loads and Trends: 2005-2014

Total phosphorus loads range from 0.13 to 2.31 lbs/ac with an average load of 0.52 lbs/ac

Improving Trends = 41 of 60 (68%)
Degrading Trends = 12 of 60 (20%)
No Trend = 7 of 60 (12%)

Of the 6 stations with the highest per acre loads for Total Phosphorus:

- 4 have improving trends
- 1 have degrading trends
- 1 has insufficient data for trends

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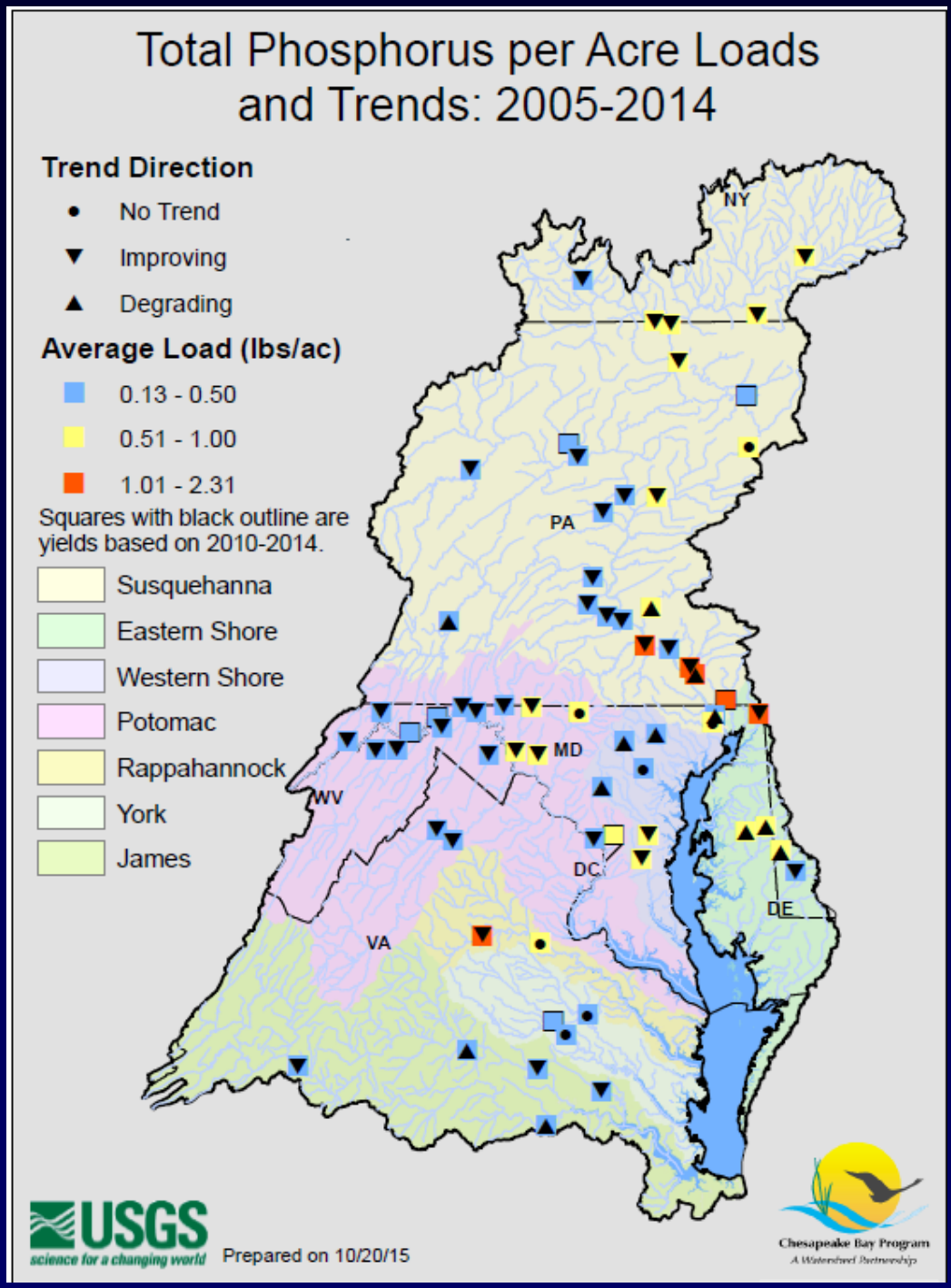


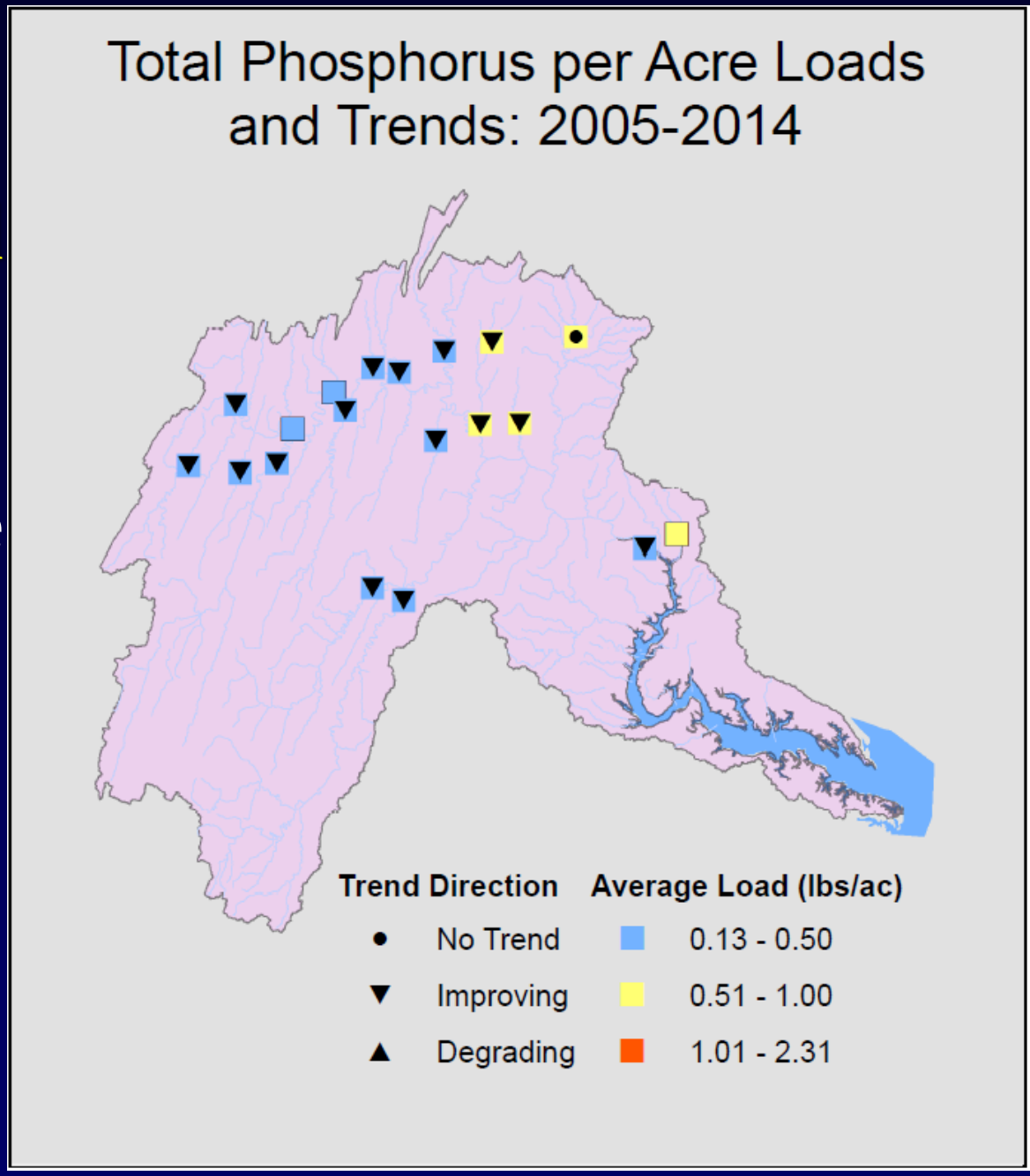
Potomac Total Phosphorus per Acre Loads and Trends: 2005-2014

Potomac Loads :

- 0.13-0.98 lbs per acre
- Average = 0.39 lbs per acre

Potomac: Majority improving

- Improving: 15
- Degrading: 0
- No change: 1



Squares with black outline are yields based on 2010-2014

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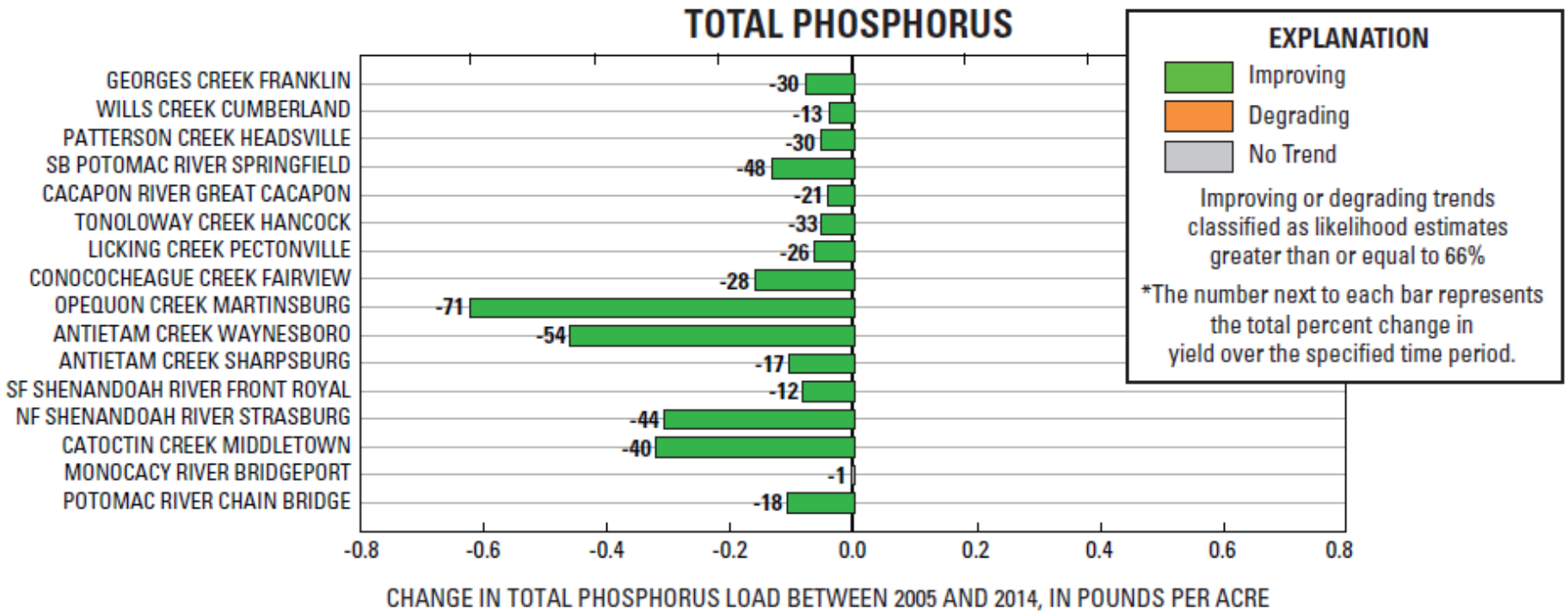
Changes in Phosphorus per Acre Loads: 2005-2014

Potomac Watershed



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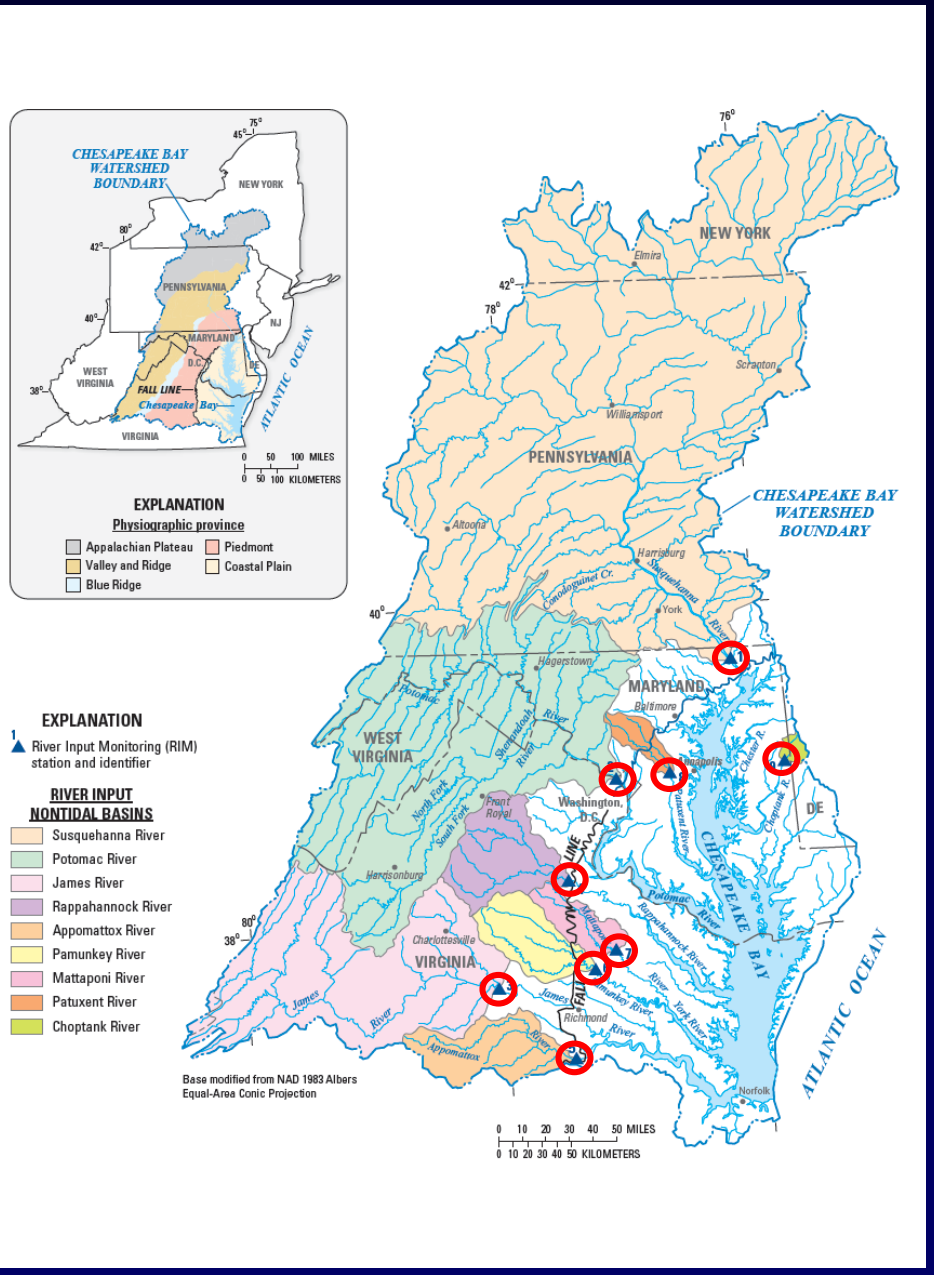
Chesapeake Bay Nontidal Monitoring Network



- What are the trends in nitrogen, phosphorus, and suspended-sediment loads being delivered to the bay from the nontidal portions of the watershed?
- To answer this question, we look to the loads delivered from the nine River Input Monitoring stations.

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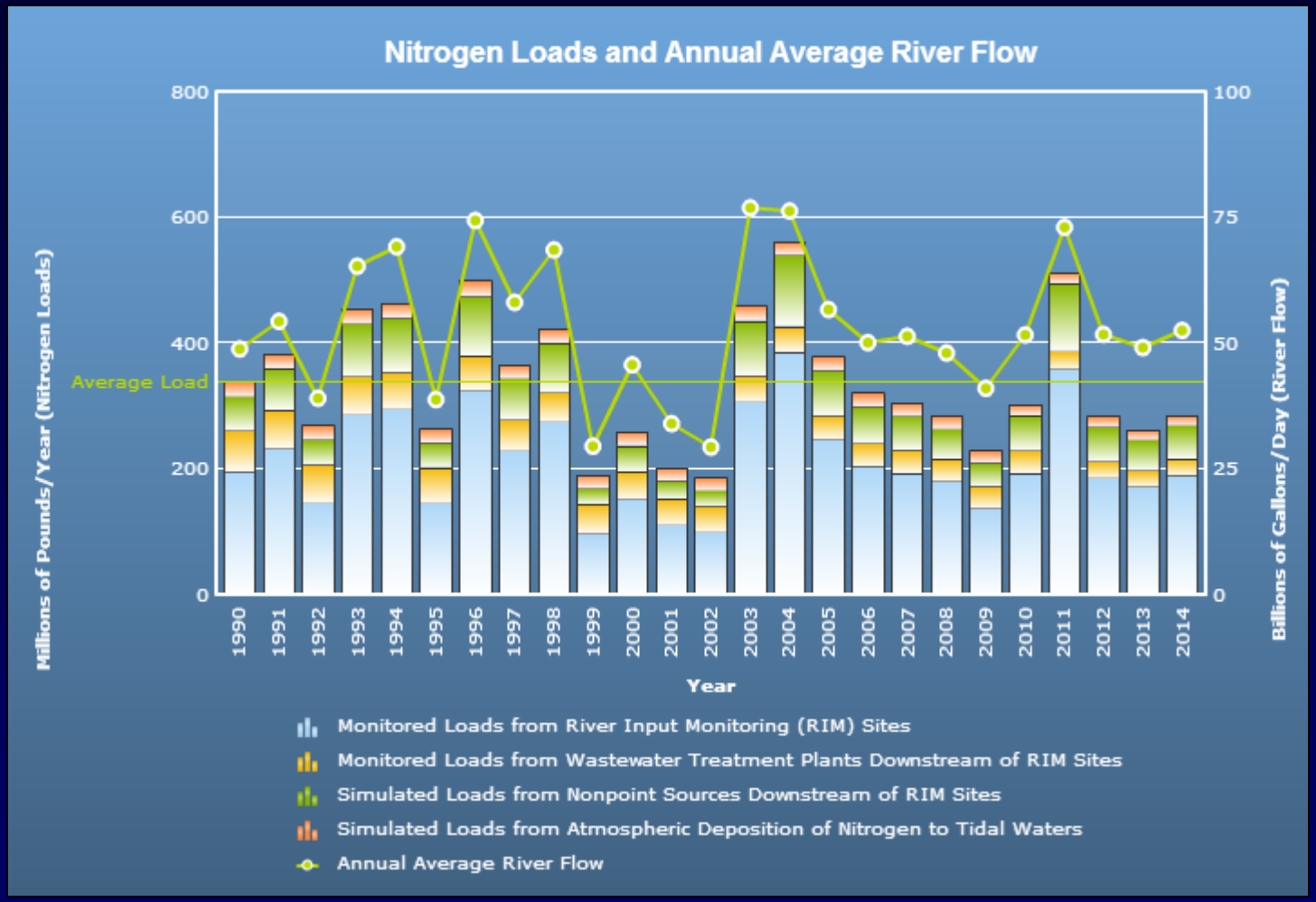
Total Nitrogen Delivered to the Bay

The cumulative total nitrogen load from the 9 RIM stations accounts for 63% (on average) of the total nitrogen load delivered annually to the bay.



Source: Chesapeake Bay Program
http://www.chesapeakebay.net/indicators/indicator/nitrogen_loads_and_river_flow_to_the_bay1

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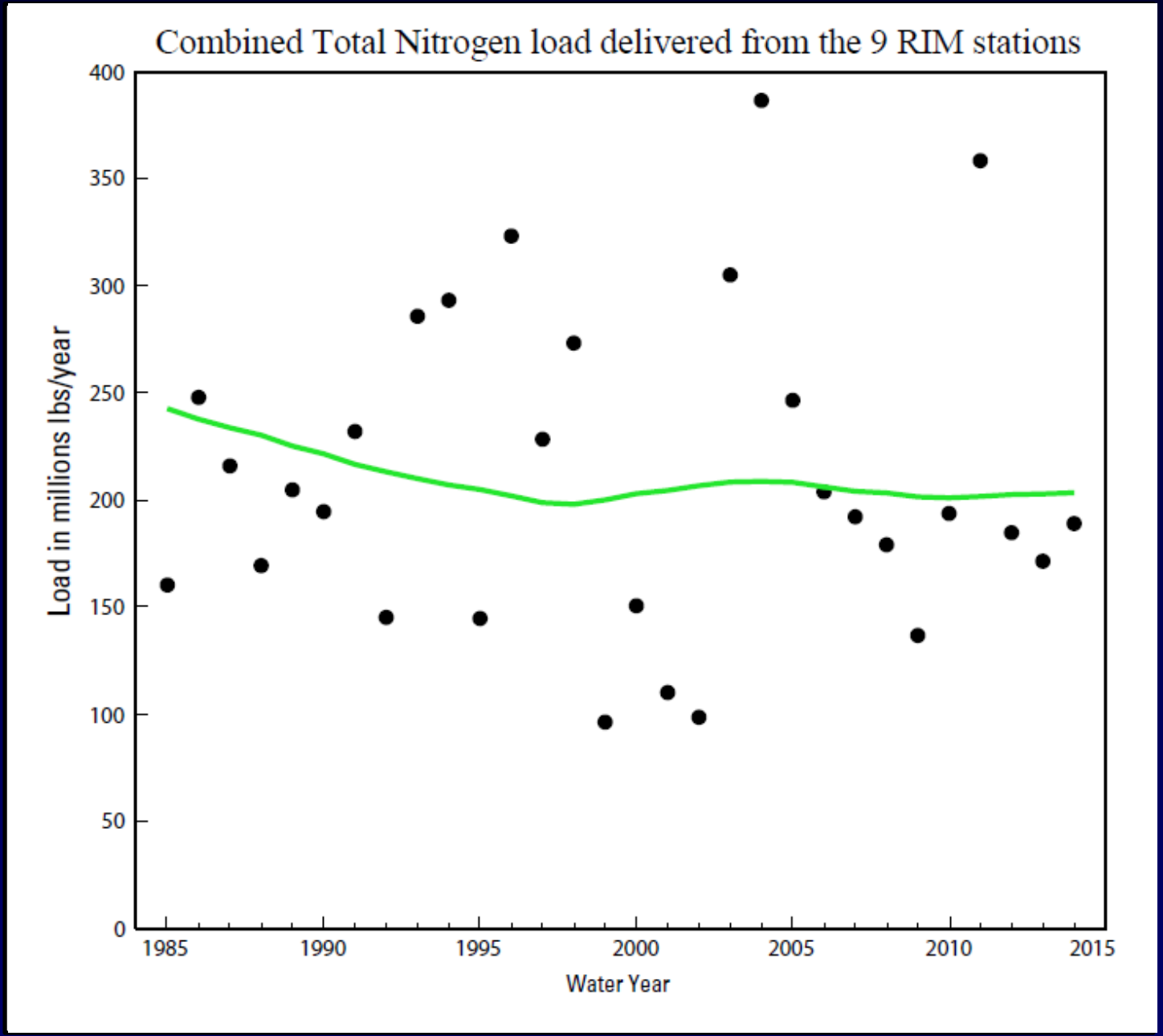
Changes in Total Nitrogen Delivered to the Bay Estuary from the 9 RIM Stations

Percent of total RIM load

Susquehanna	=	66%
Potomac	=	24%
James	=	5%
Rappahannock	=	2%
Appomattox	=	<1%
Pamunkey	=	<1%
Mattaponi	=	<1%
Patuxent	=	<1%
Choptank	=	<1%



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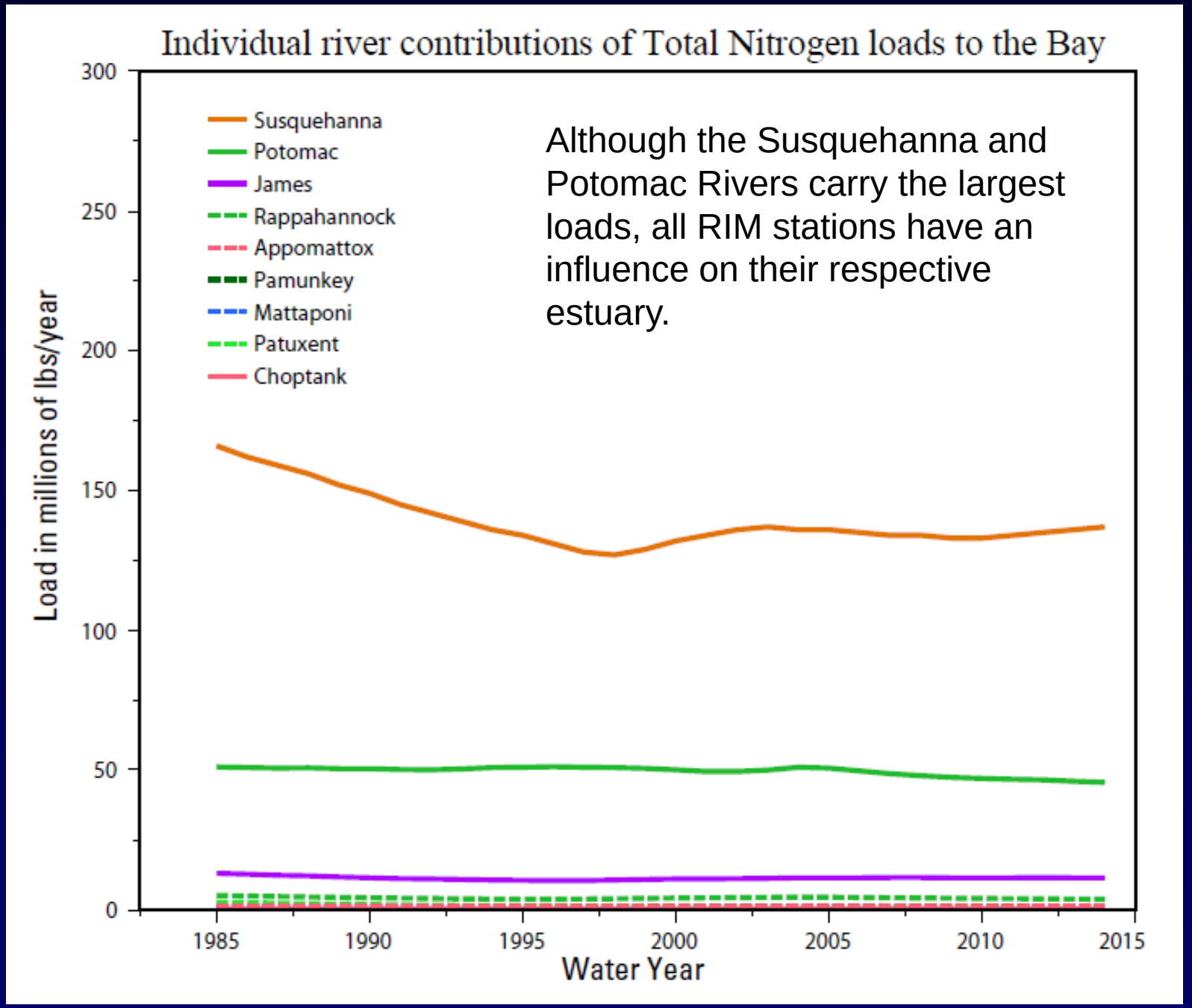
Individual river contributions of Total Nitrogen loads to the Bay
Susquehanna
Potomac
James
Rappahannock
Appomattox
Pamunkey
Mattaponi
Patuxent
Choptank
Although the Susquehanna and Potomac Rivers carry the largest loads, all RIM stations have an influence on their respective estuary.
Load in millions of lbs/year
300
250
200
150
100
50
0
1985
1990
1995
2000
2005
2010
2015
Water Year

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Changes in Total Nitrogen Delivered to the Bay from the 9 RIM Stations

Monitoring station	Total nitrogen load	
	Long term	Short term
SUSQUEHANNA RIVER AT CONOWINGO, MD	Improving	No trend
POTOMAC RIVER AT WASHINGTON, DC	Improving	Improving
JAMES RIVER AT CARTERSVILLE, VA	Improving	No trend
RAPPAHANNOCK RIVER NR FREDERICKSBURG, VA	Improving	Improving
APPOMATTOX RIVER AT MATOACA, VA	Improving	Degrading
PAMUNKEY RIVER NEAR HANOVER, VA	No trend	Degrading
MATTAPONI RIVER NEAR BEULAHVILLE, VA	Improving	Degrading
PATUXENT RIVER NEAR BOWIE, MD	Improving	Improving
CHOPTANK RIVER NEAR GREENSBORO, MD	Degrading	Degrading

http://cbrim.er.usgs.gov/summary.html

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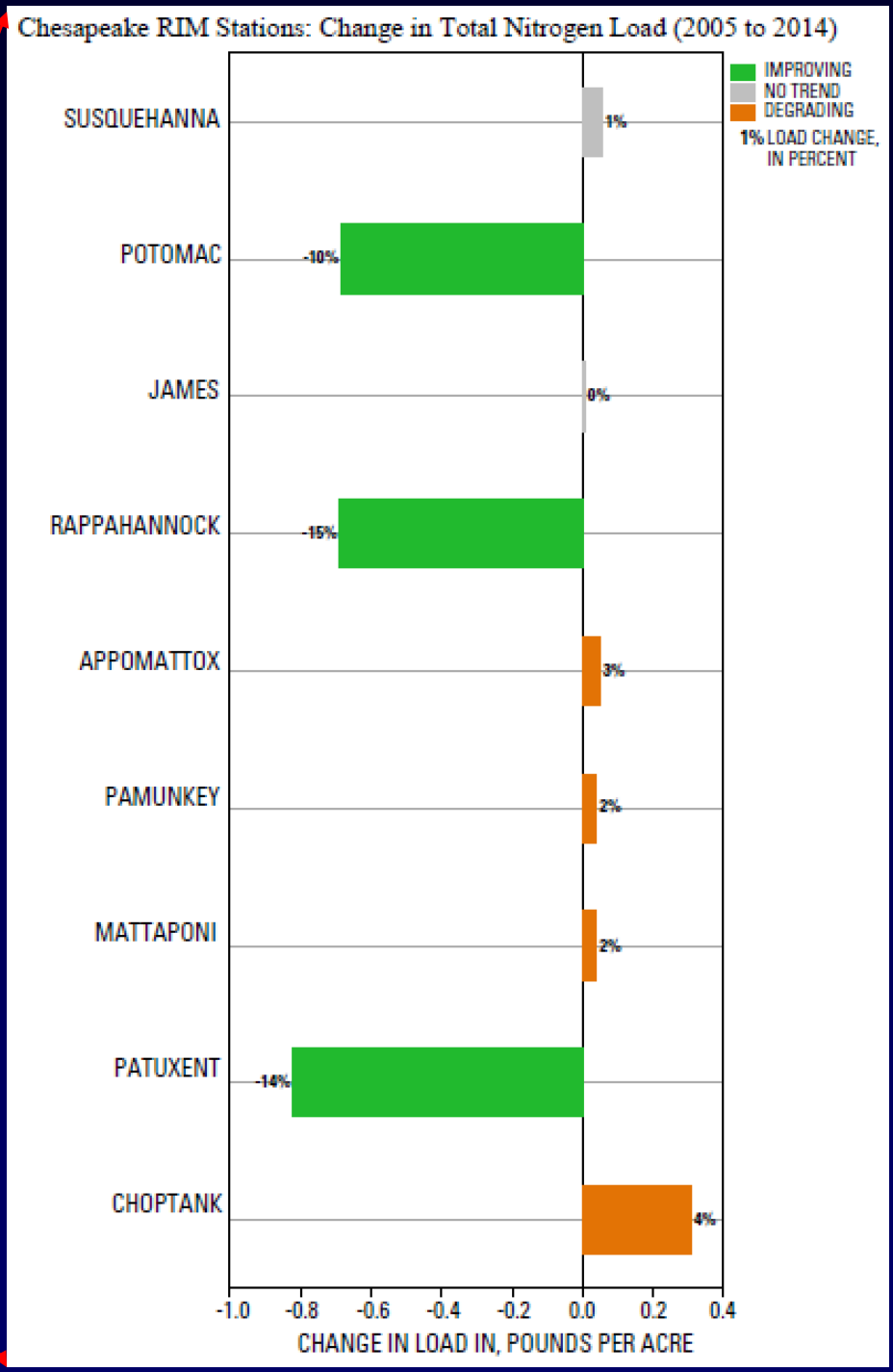
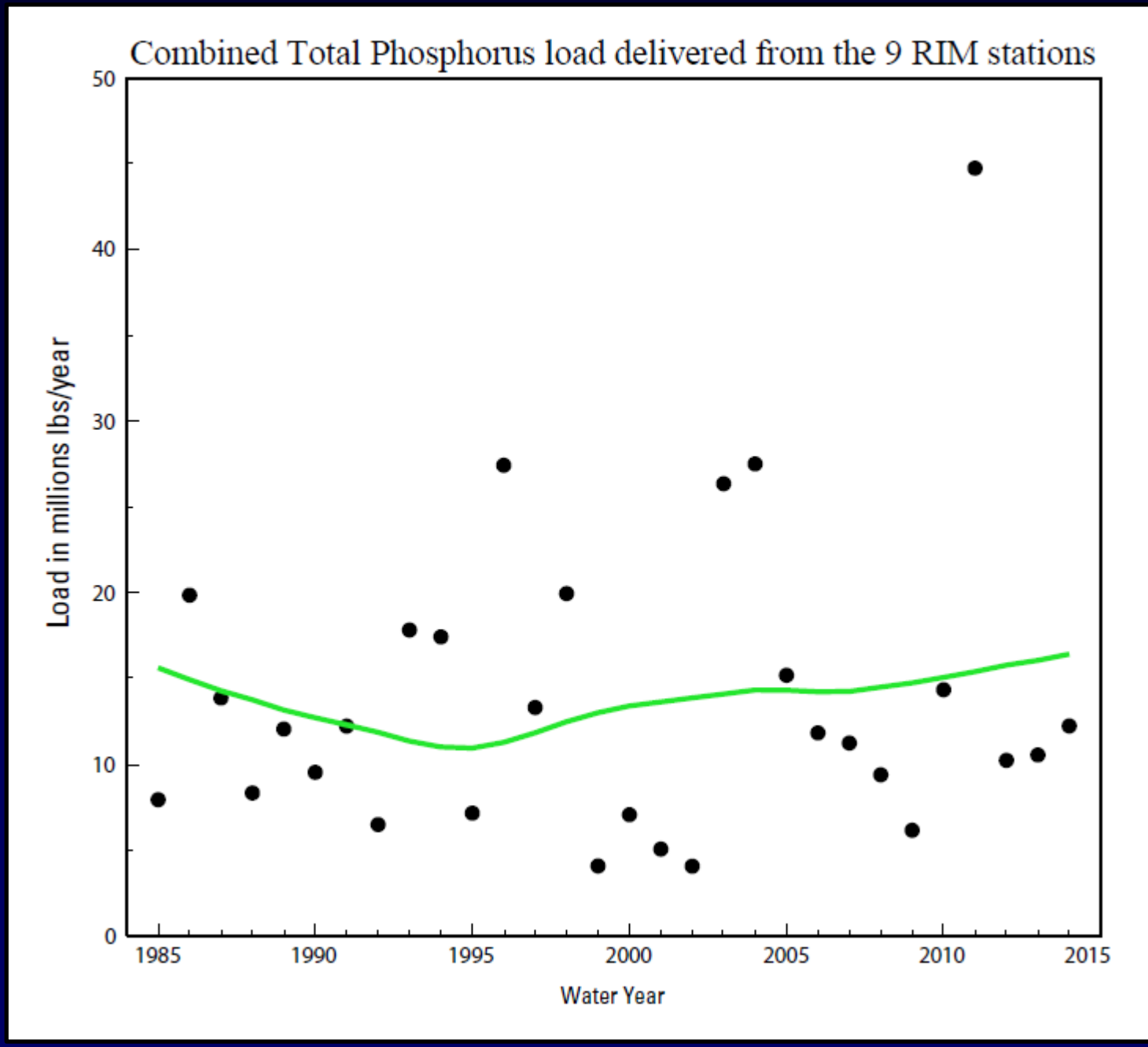


Changes in Total Phosphorus Delivered to the Bay Estuary from the 9 RIM Stations

Percent of total RIM load

Susquehanna = 45%
Potomac = 29%
James = 18%
Rappahannock = 5%
Appomattox = 1%
Pamunkey = 1%
Mattaponi = <1%
Patuxent = <1%
Choptank = <1%



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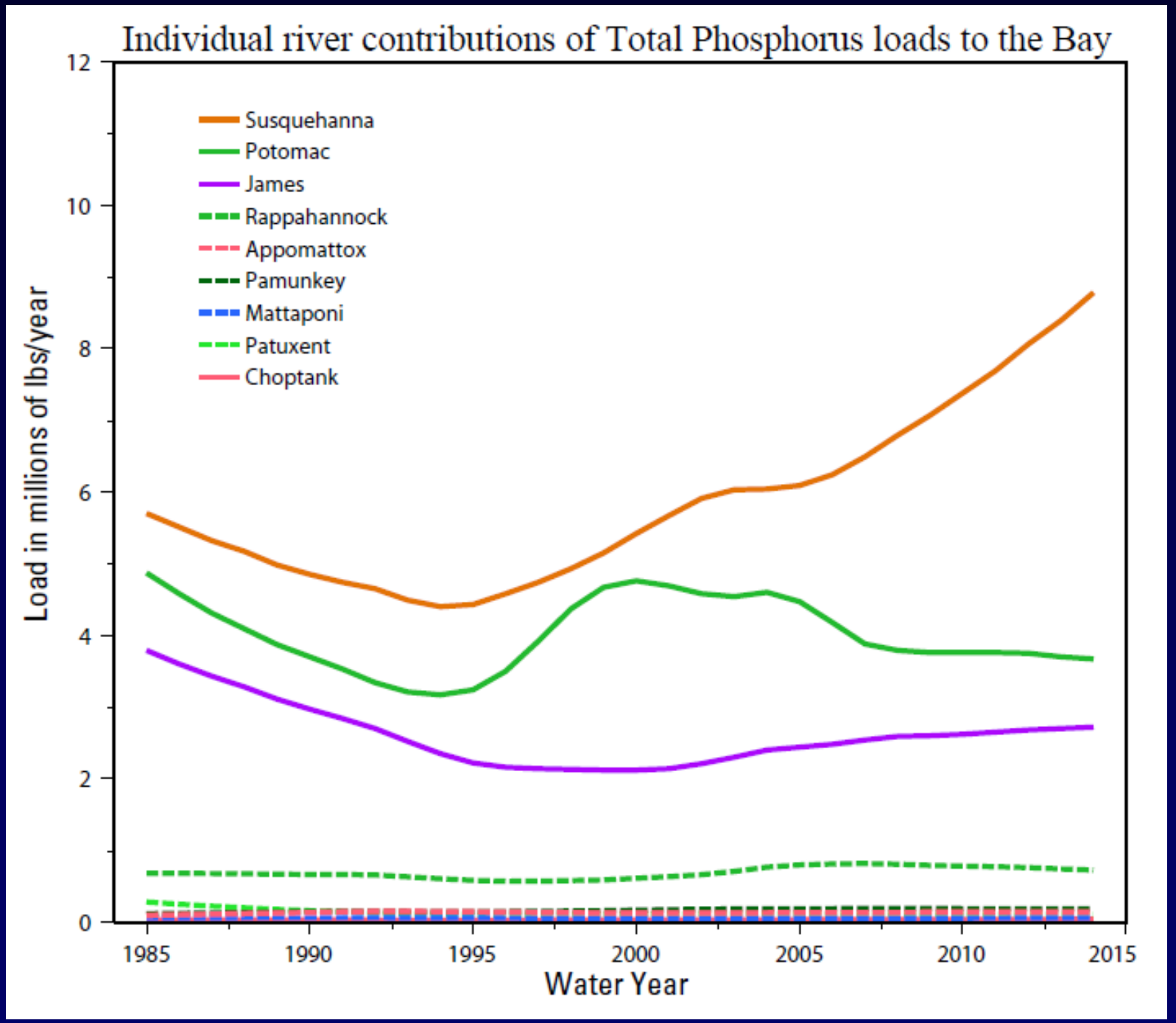
Individual river contributions of Total Phosphorus loads to the Bay
Susquehanna
Potomac
James
Rappahannock
Appomattox
Pamunkey
Mattaponi
Patuxent
Choptank
Load in millions of lbs/year
0
2
4
6
8
10
12
1985
1990
1995
2000
2005
2010
2015
Water Year

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Changes in Total Phosphorus Load Delivered to the Bay from the 9 RIM Stations

Monitoring station	Total phosphorus load	
	Long term	Short term
SUSQUEHANNA RIVER AT CONOWINGO, MD	Degrading	Degrading
POTOMAC RIVER AT WASHINGTON, DC	Improving	Improving
JAMES RIVER AT CARTERSVILLE, VA	Improving	Degrading
RAPPAHANNOCK RIVER NR FREDERICKSBURG, VA	No trend	No trend
APPOMATTOX RIVER AT MATOACA, VA	Degrading	Degrading
PAMUNKEY RIVER NEAR HANOVER, VA	Degrading	No trend
MATTAPONI RIVER NEAR BEULAHVILLE, VA	Improving	No trend
PATUXENT RIVER NEAR BOWIE, MD	Improving	Improving
CHOPTANK RIVER NEAR GREENSBORO, MD	Degrading	Degrading

http://cbrim.er.usgs.gov/summary.html

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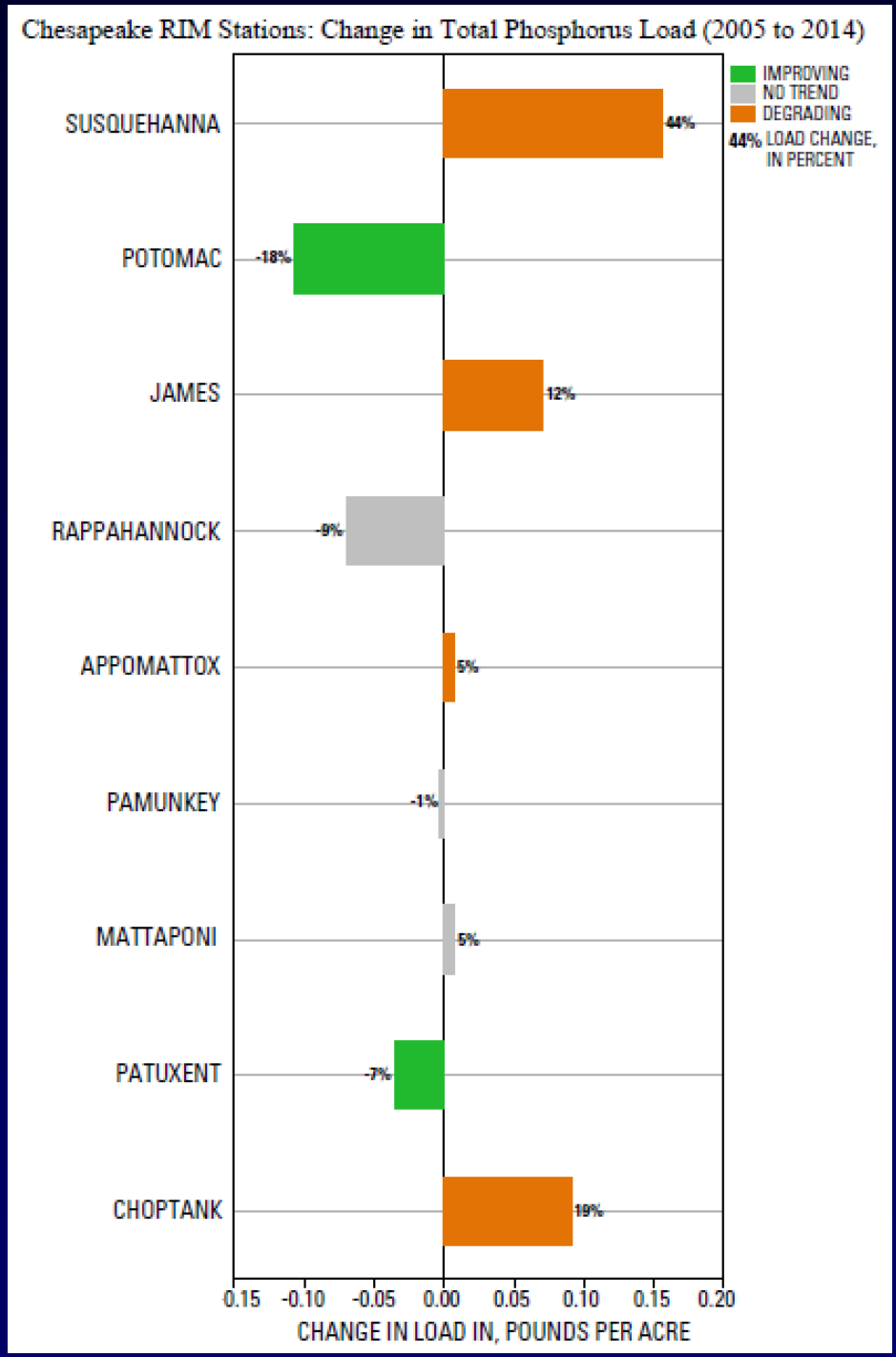

Summary

- Watershed Trends in Loads
  - Nitrogen: 14 stations show improving trends while only 4 show degrading trends
  - Phosphorus: 15 stations show improving trends while none show degrading trends
  - Suspended Sediment: 10 show improving trneds whil 5 show degrading trends
  - New “Urban Stations” – 6 stations will have load results in 2 years.
- RIM Stations: loads to tidal waters
  - Potomac is the only bay tributary that has improving trends for Nitrogen, Phosphorus, and Suspended Sediment loads.

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USGS Nontidal Web Page

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Water-Quality Loads and Trends at Nontidal Monitoring Stations in the Chesapeake Bay Watershed

Navigate Menu

Home

Background

Introduction
Methods
Glossary
Bibliography

Results and Maps

Load and Trend Summary
Interactive Map
Tables and Figures

Downloads

Model Input Data
Load Table
Yield Table
Trend Results Table

Contacts

Partners
USGS Chesapeake Activities
Technical Contacts
Web Administrator

Welcome

This web site is dedicated to providing water-quality load and trend results for the nontidal rivers of the Chesapeake Bay watershed.

What are the Objectives of the Chesapeake Bay Nontidal Monitoring Program?

- Quantify nutrient and sediment loads in the nontidal rivers of the Chesapeake Bay watershed. These loads are defined as the mass of nutrient or sediment passing a monitored location per unit time.
- Estimate changes over time (trends) in sediment and nutrient loads, in a manner that compensates for any concurrent trend in stream discharge. Trends estimated in this manner can indicate changes in the watershed, such as the effects of best management practices that cannot be attributed primarily to climatic fluctuation.

How the Program Works

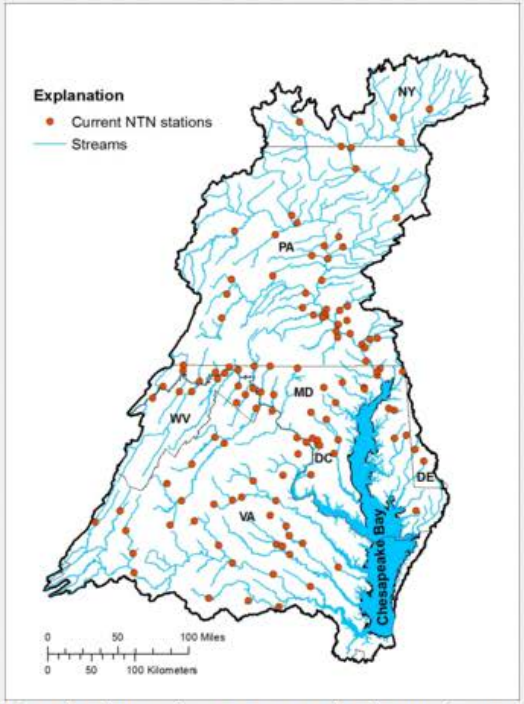
- Monitoring data are collected by numerous agencies through the nontidal monitoring partnership.
- Results are updated on even-numbered water years for the network of water-quality monitoring stations distributed throughout the Chesapeake Bay watershed.

What Data and Related Information Are Available?

Methods, data, results, and interpretations are available for

- Nutrient and sediment loads and yields (per-acre loads)
- Trends in nutrient and sediment loads

Load and trend results are available from the Chesapeake Bay nontidal monitoring network through the 2014 water year.



Click on the image above to access the interactive map

Suspended Sediment per Acre Loads and Trends: 2005-2014

Suspended Sediment loads range from 18 to 2,206 lbs/ac with an average load of 482 lbs/ac

Improving Trends = 29 of 59 (50%)
Degrading Trends = 19 of 59 (30%)
No Trend = 11of 59 (20%)

Of the 7 stations with the highest per acre loads for Suspended Sediment:

- 3 have improving trends
- 1 has a degrading trend
- 1 has no trend
- 2 have insufficient data for trends

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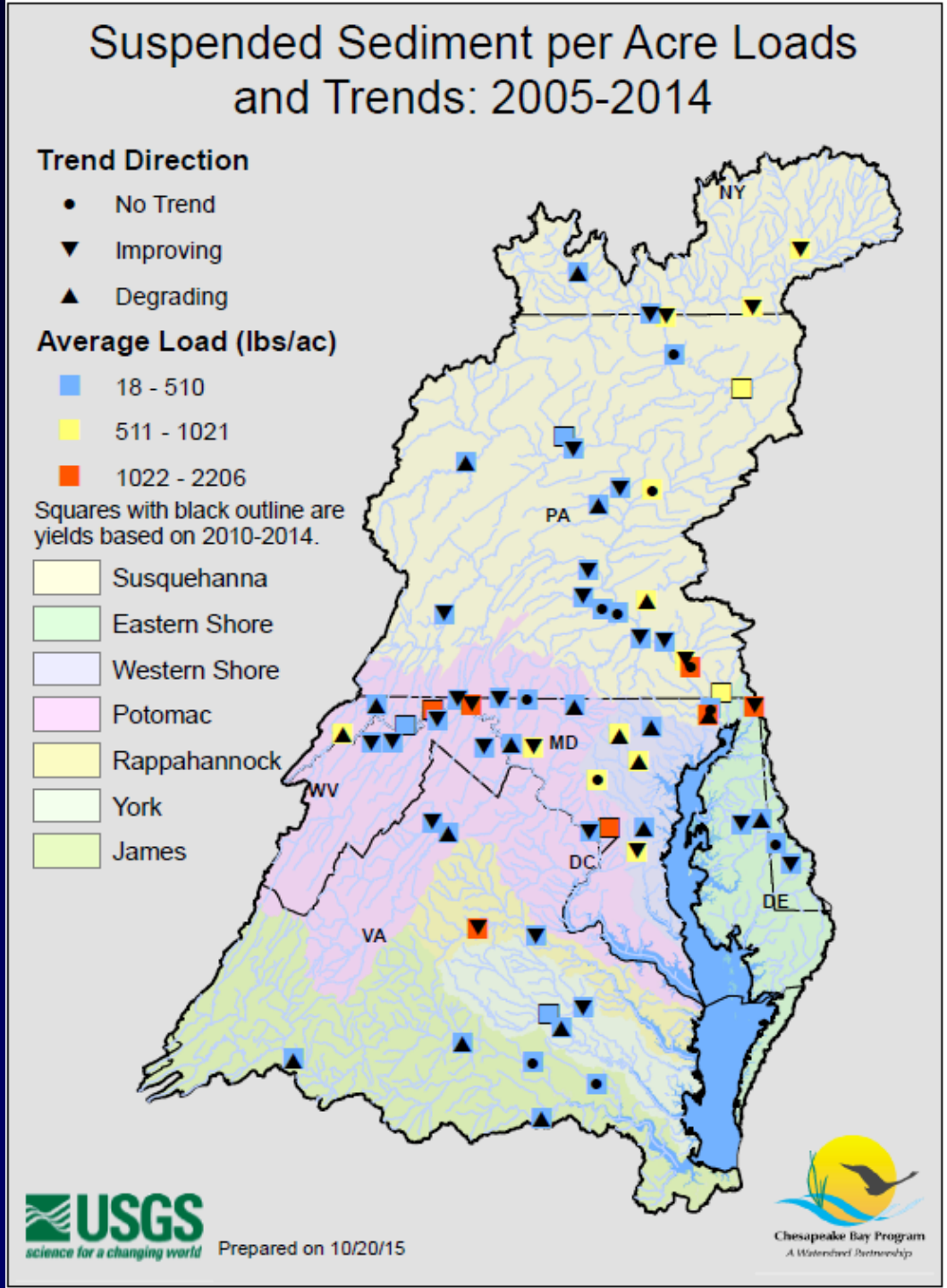


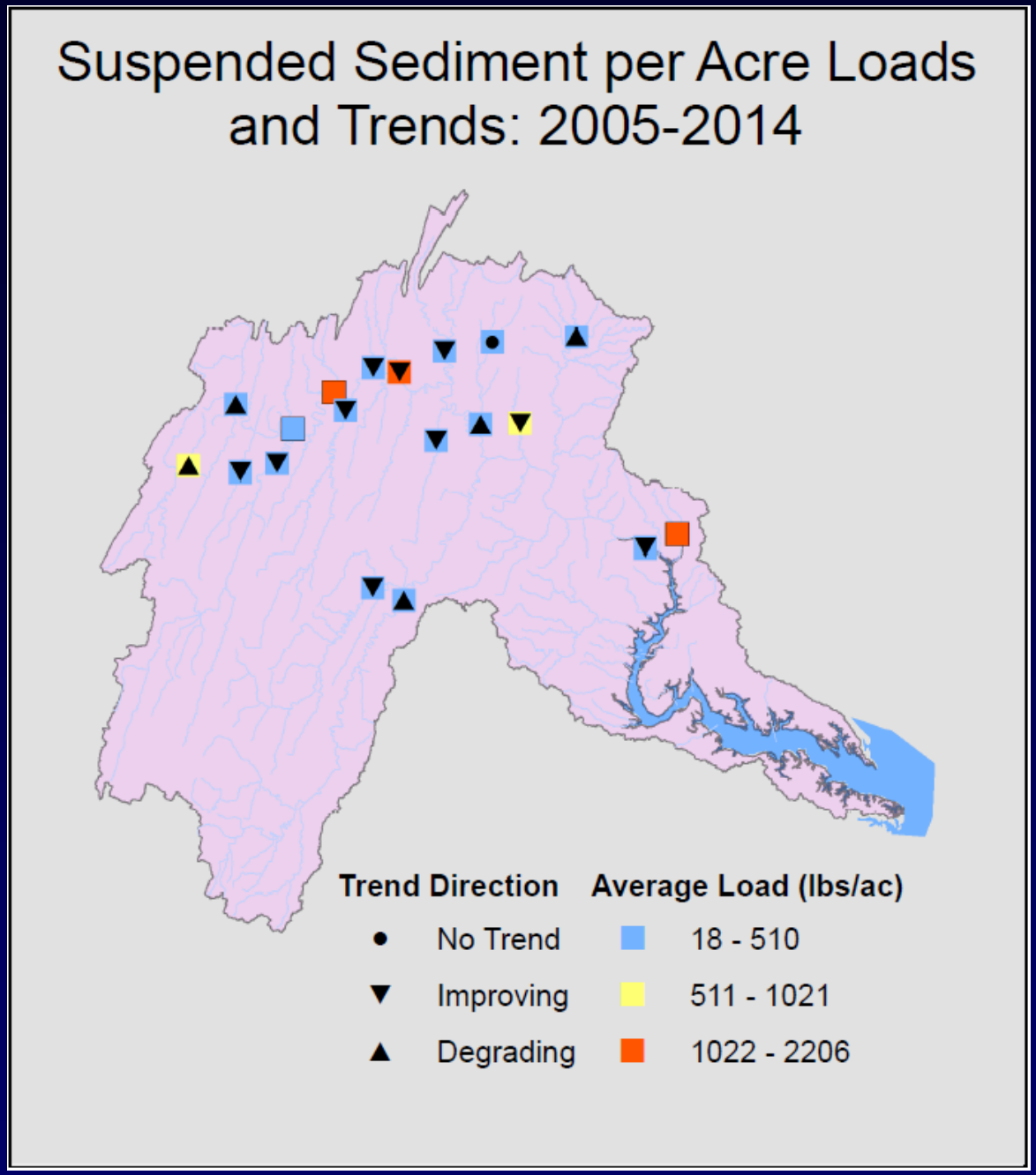
Potomac Suspended Sediment per Acre Loads and Trends: 2005-2014

Potomac Loads :

- 119-1,344 lbs per acre
- Average = 387 lbs per acre

Potomac: Majority improving

- Improving: 10
- Degrading: 5
- No change: 1



Squares with black outline are yields based on 2010-2014

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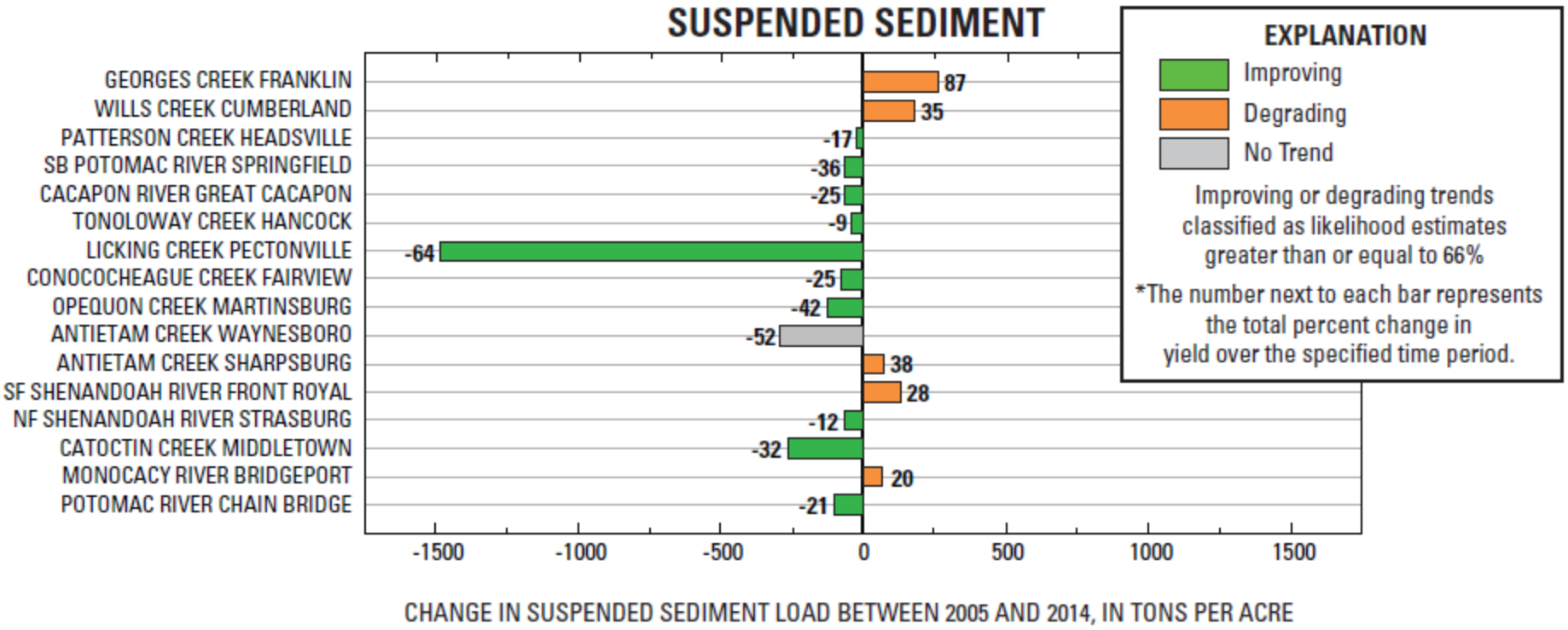
Changes in Suspended Sediment per Acre Loads: 2005-2014

Potomac Watershed



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Changes in Suspended Sediment per Acre Loads: 2005-2014

Improving Stations

Range = -8.11 to -1,490 lbs/ac

Median = -221 lbs/ac (-29.4%)

Degrading Stations

Range = 4.75 to 341 lbs/ac

Median = 118 lbs/ac (42.8%)

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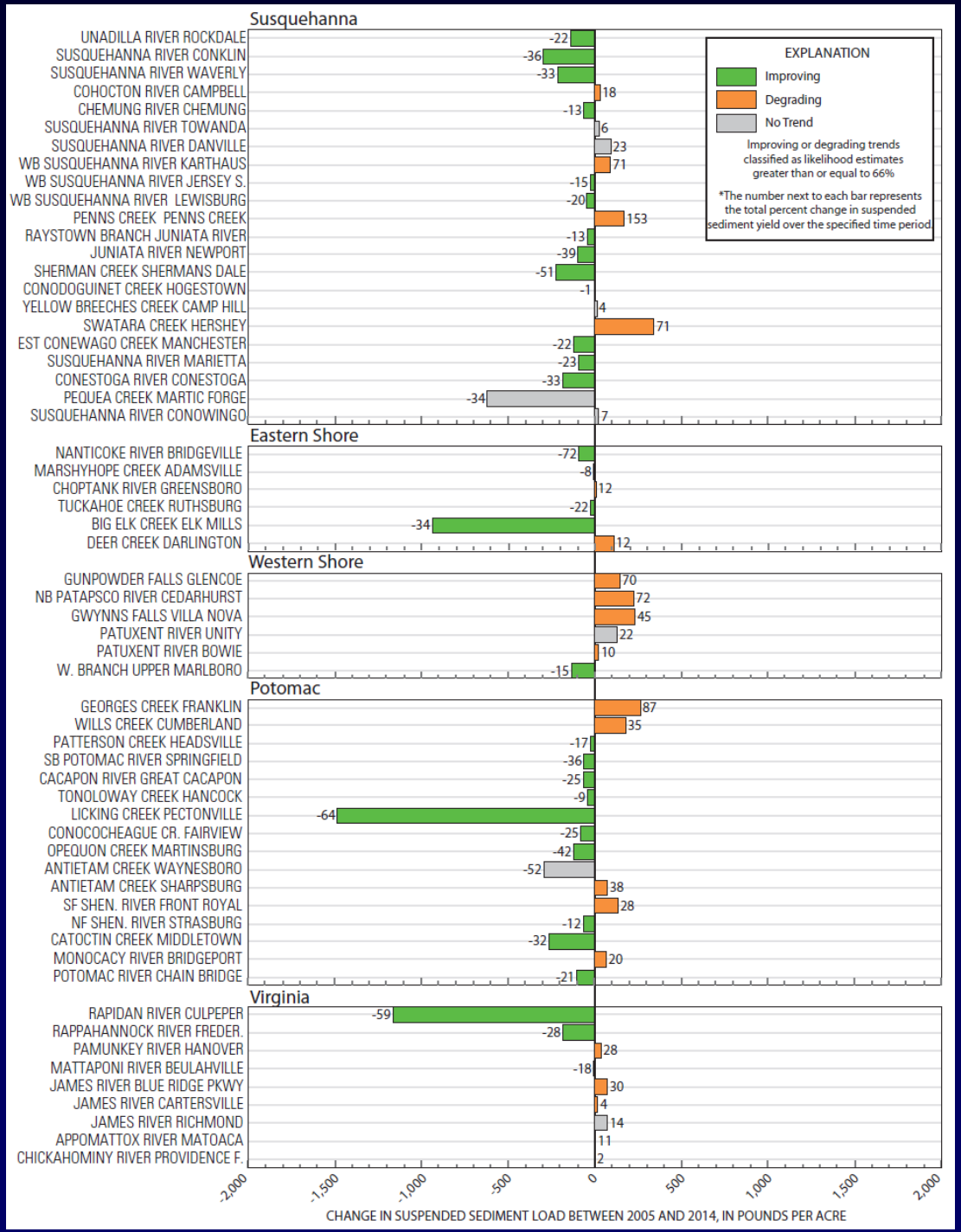

Changes in Phosphorus per Acre Loads: 2005-2014

Improving Trends = 41 of 60 (68%)
Degrading Trends = 12 of 60 (20%)
No Trend = 7 of 60 (12%)

Improving Stations
Range = -0.014 to -1.08 lbs/ac
Median = -0.11 lbs/ac (-24.7%)

Degrading Stations
Range = 0.007 to 0.43 lbs/ac
Median = 0.07 lbs/ac (18.2%)

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