Measuring Changes in Nutrient and Suspended-Sediment Loads in the Chesapeake Bay Watershed

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Chesapeake Bay Watershed

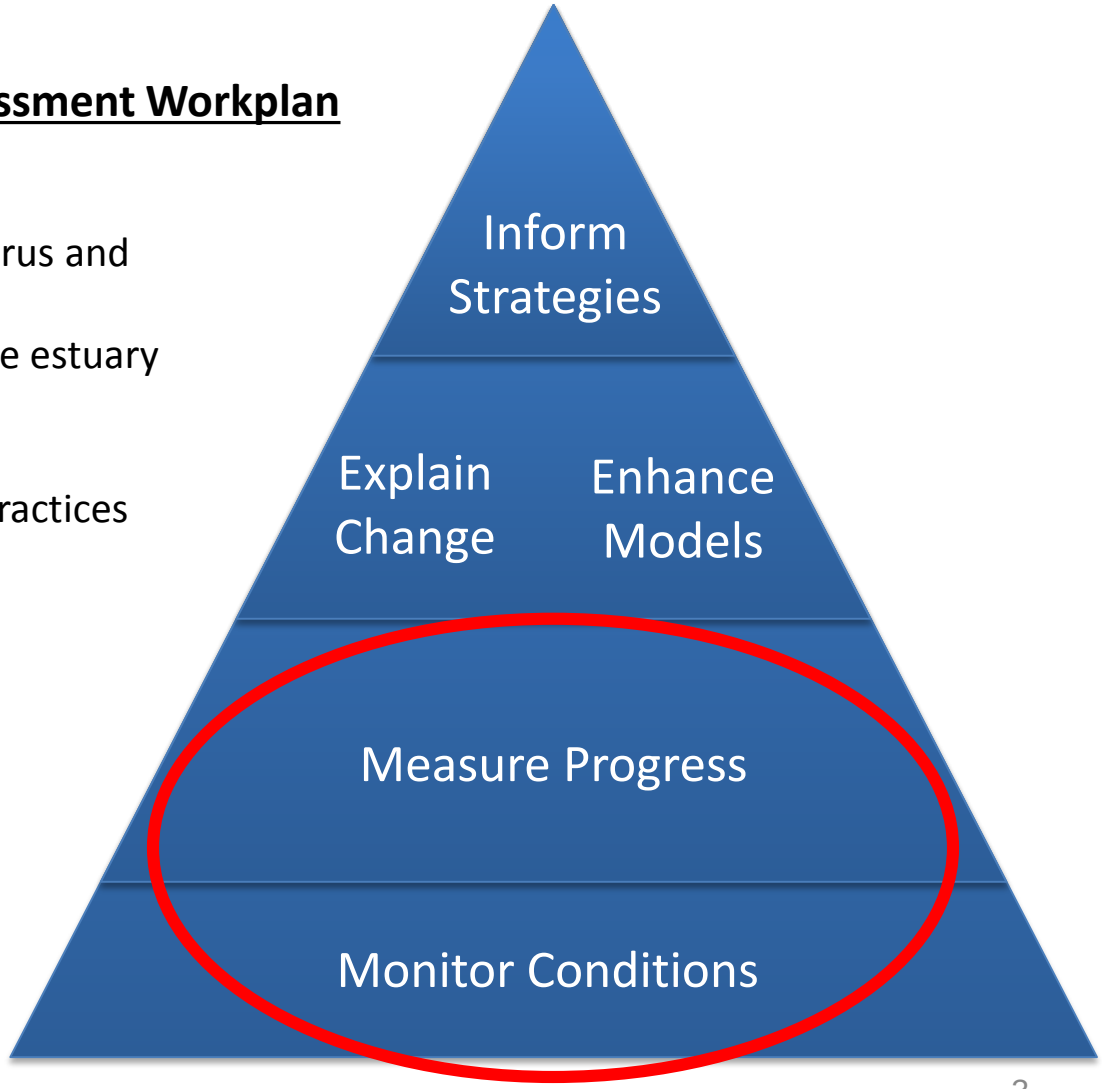
- Watershed Facts
  - Drainage area of 64,000 mi^2
  - Contains more than 100,000 rivers and streams
  - Drains parts of NY, PA, MD, DE, WV, and VA
- Nations largest estuary
  - Supports 3rd largest fishery in Nation
  - Atlantic Flyway
- Decline of Ecosystem
  - Degraded water quality
  - Loss of habitat
  - Decline of fish and wildlife populations
- Many resources have been spent and strategies have been implemented to improve water-quality as an outgrowth of the formation of the Chesapeake Bay Program (1983) and the latest being an Executive Order (2009), and TMDL (2010)

Using Monitoring Data To Measure Progress and Explain Change

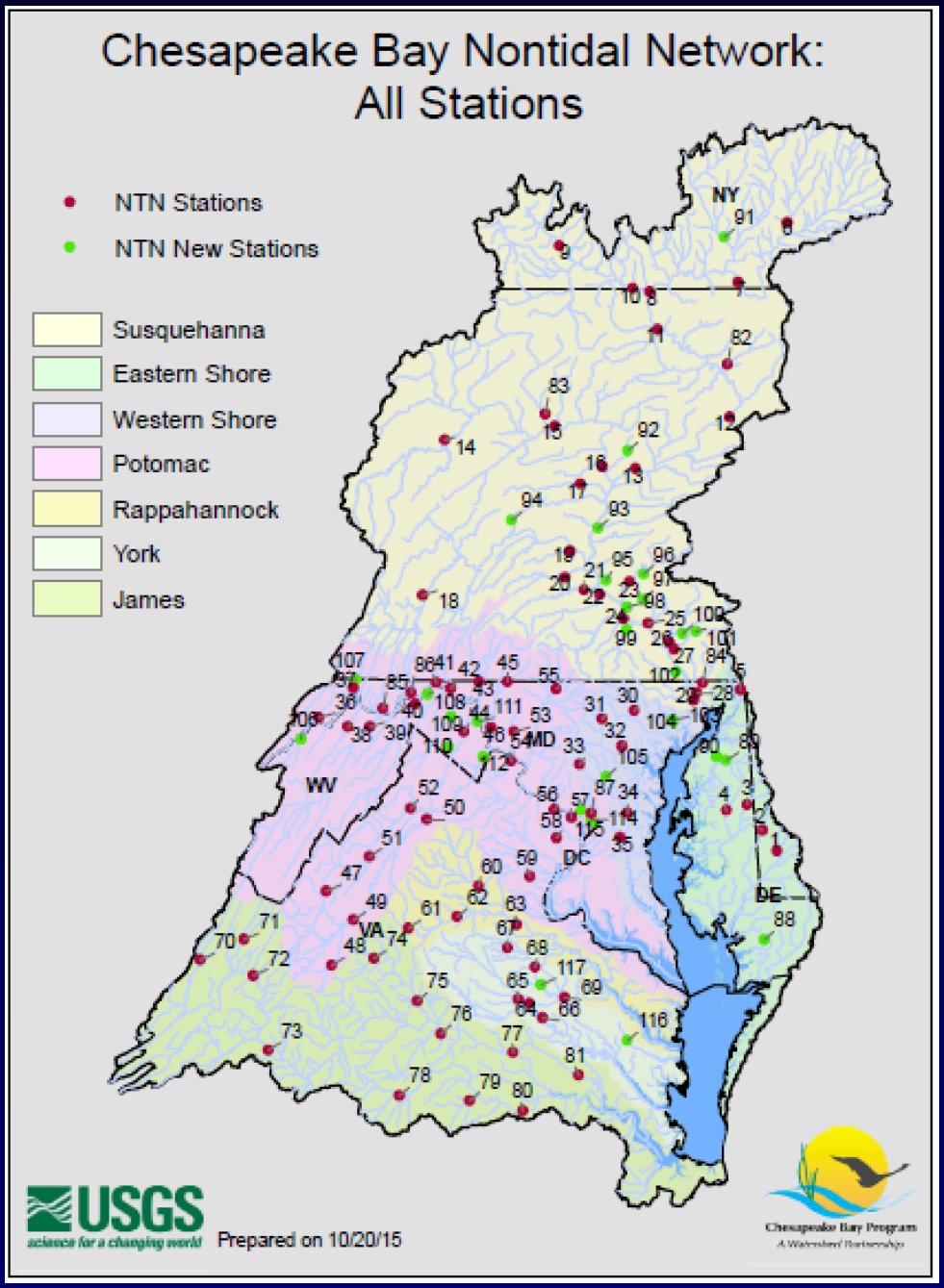
Overview: STAR Workplan Elements

Elements of STAR Mid-Point Assessment Workplan

1. Measure progress
   - Trends of nitrogen, phosphorus and sediment in the watershed.
   - Trends of water quality in the estuary
2. Explain water-quality changes
   - Response to management practices
3. Enhance CBP models
   1. WSM
   2. SPARROW
4. Inform management strategies
   - WIPs
   - Water-quality benefits



Chesapeake Bay Nontidal Monitoring Network



Purpose

- Quantify *loads* of nutrients and sediment in the nontidal rivers of the Chesapeake Bay watershed
- Estimate *trends* (changes over time) in loads to detect effects of changes in land management effects on water quality

Monitoring Stations

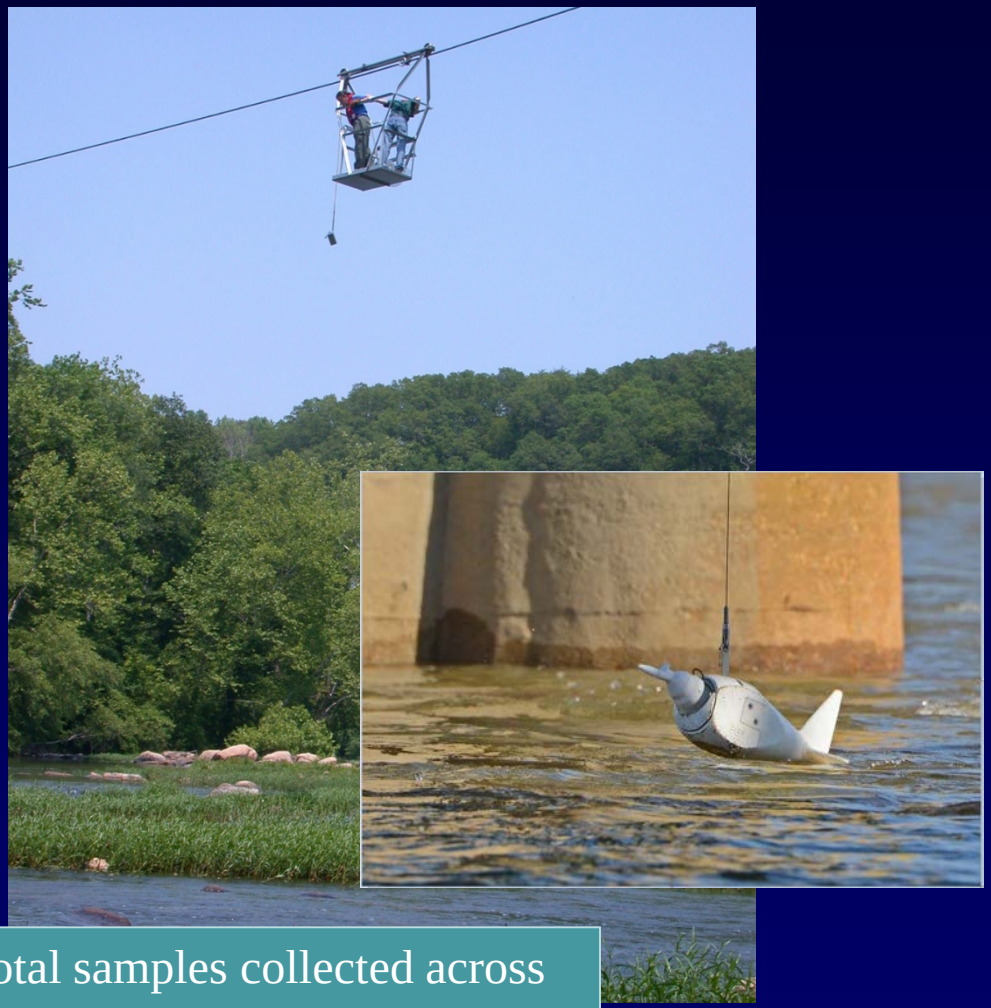
- 117 monitoring stations
  - 30 with records > 30 yrs
  - 81 with records > 10 yrs
  - 6 with records 5-10 yrs
  - 30 (green on map) with records < 5 years
- Drainage areas range from 1 to 27,100 mi^2
- Multiple monitoring partners using consistent methods
- USGS responsible for load and trend computation

Load and Trend Estimation

Daily Load = Daily Concentration * Mean Daily Discharge

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

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



Total samples collected across NTN = 2,340 Annually

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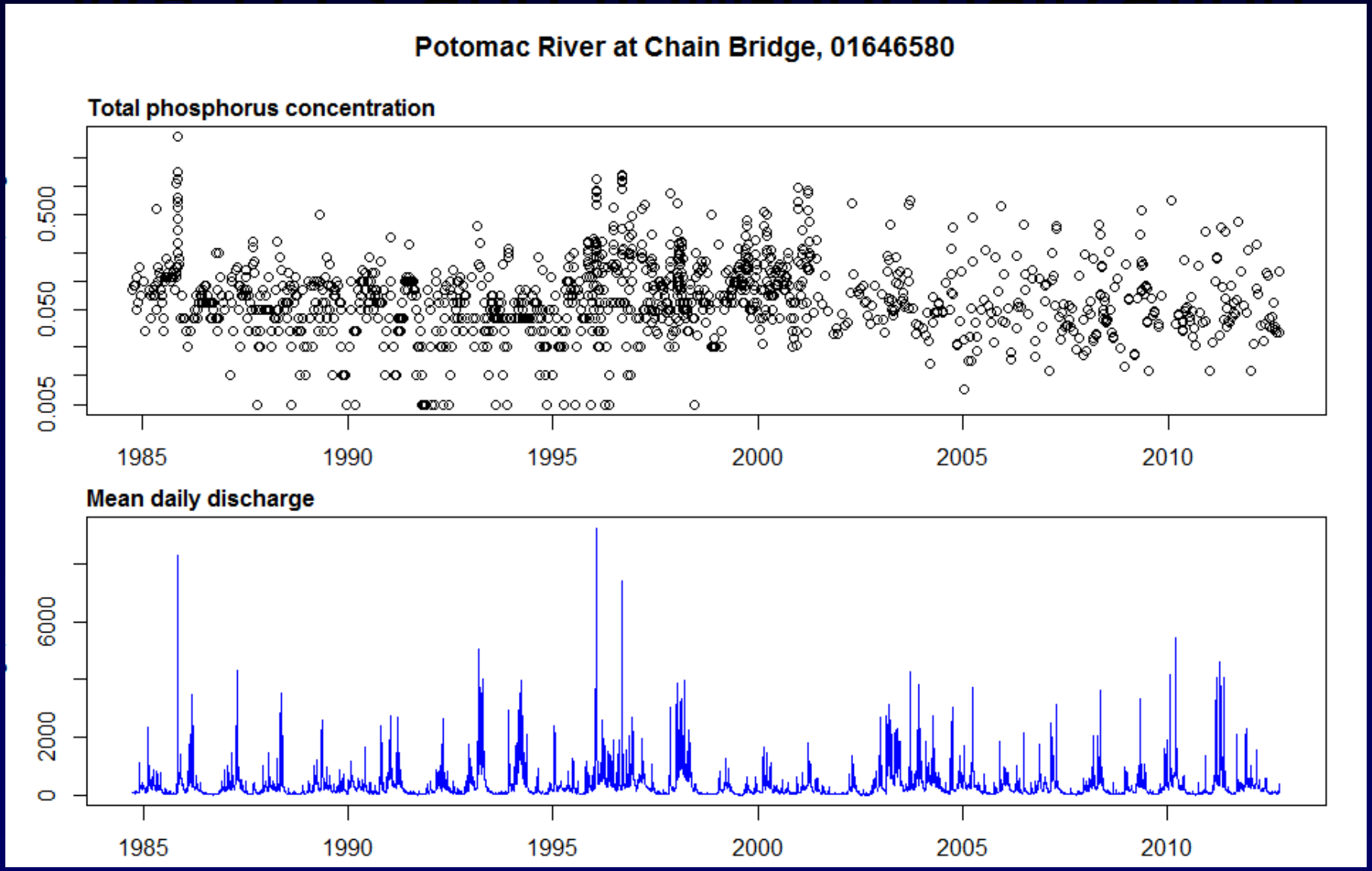
Load and Trend Estimation

Daily Load = Daily Concentration * Mean Daily Discharge



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Load and Trend Estimation

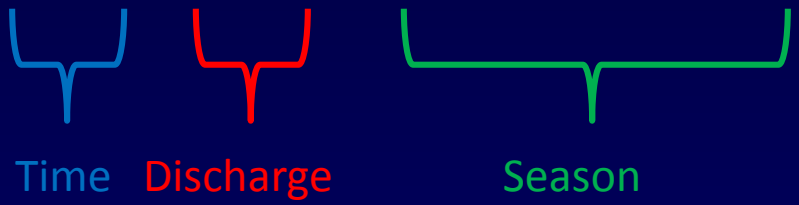
Daily Load = Daily Concentration * Mean Daily Discharge

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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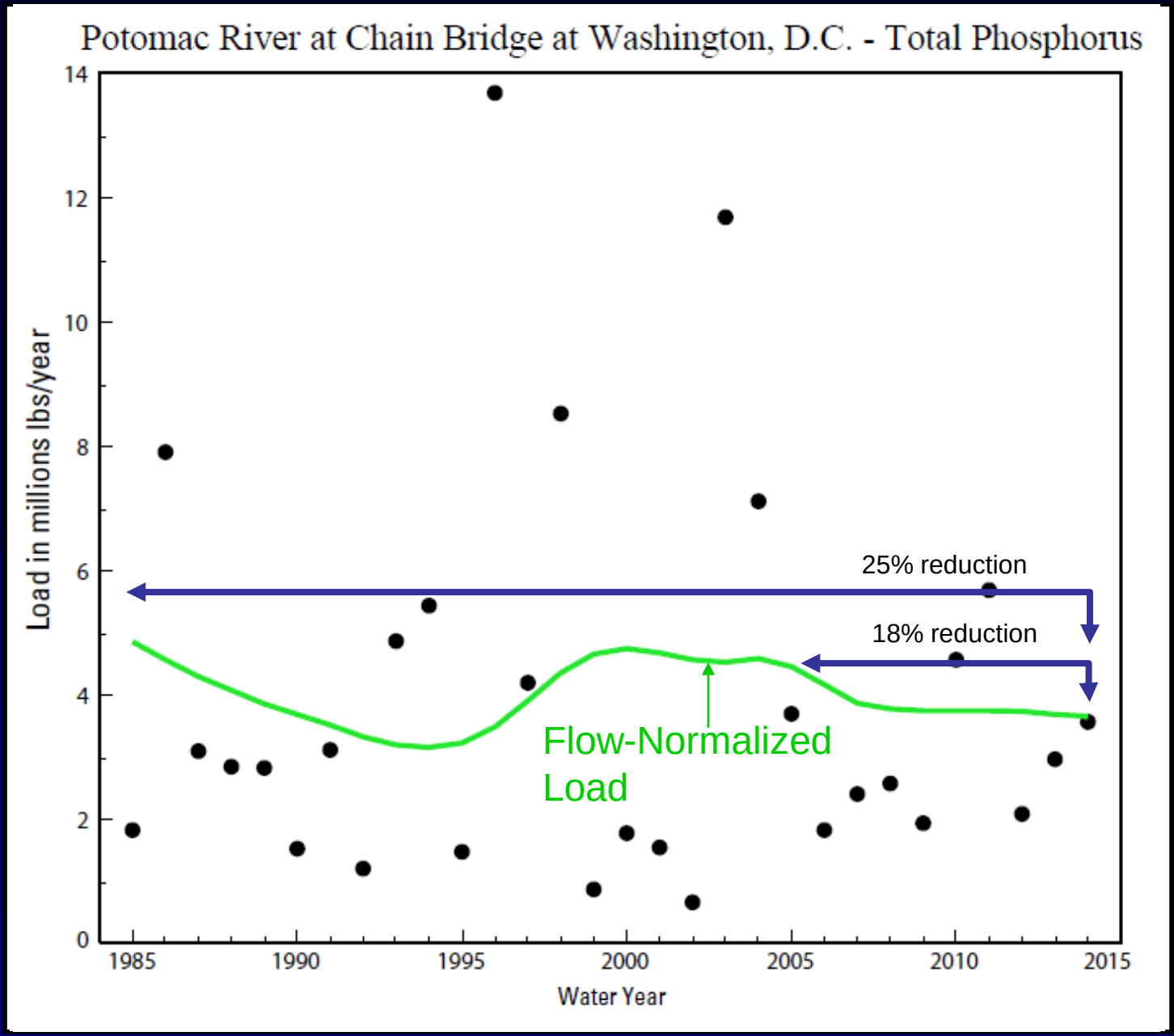
WRTDS Load and Trend Example: Potomac River Total Phosphorus

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



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Total Nitrogen per Acre Loads

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

3 Categories of Loads:

(1) Low =

≤ 6.88 lbs/ac

52 of 81 stations

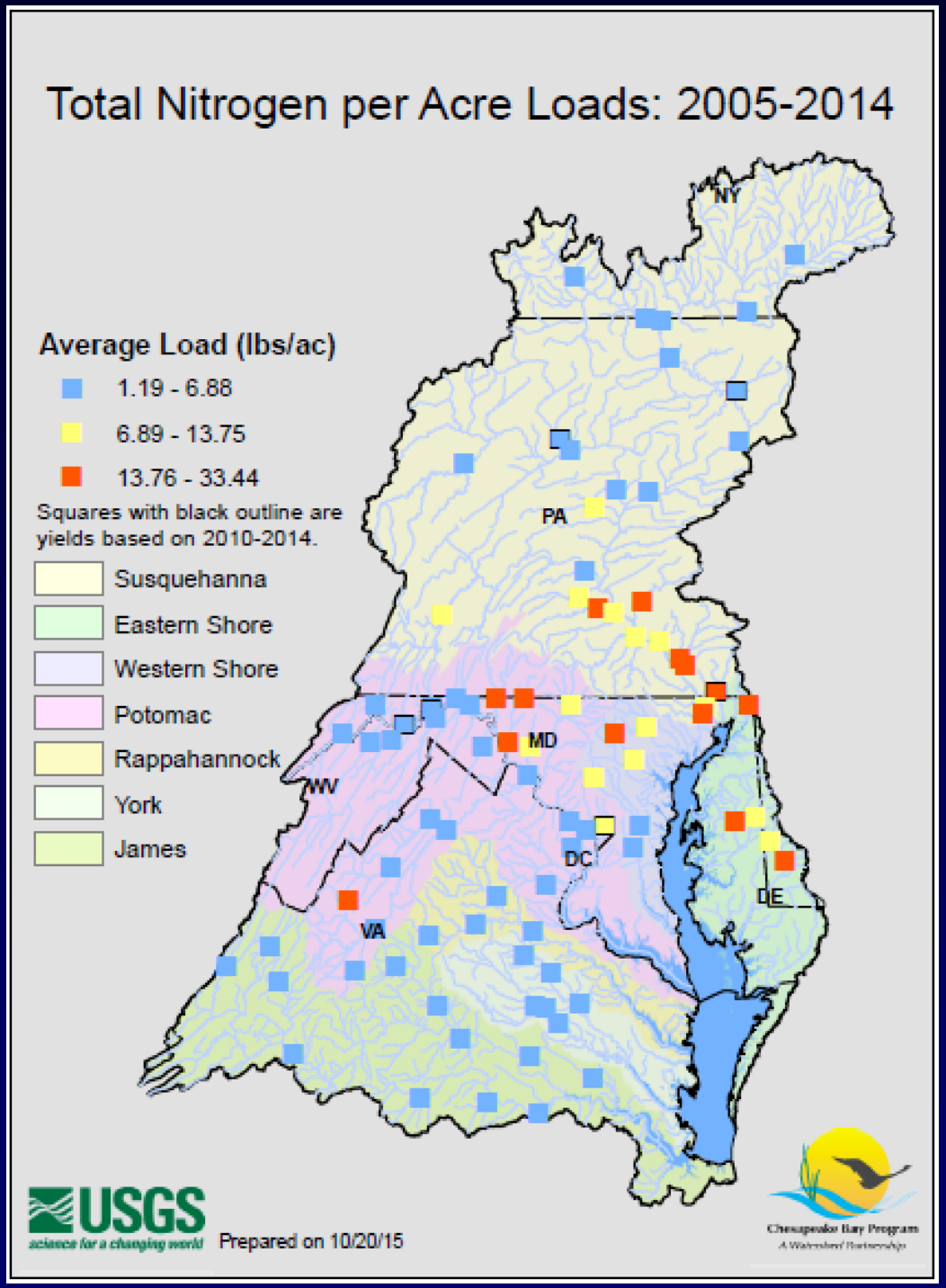
(2) Medium =

> 6.88 to ≤ 13.75

15 of 81 stations

(3) High Yields = ≥ 13.76

14 of 81 stations



Total Nitrogen per Acre Loads and Trends: 2005-2014

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 trend analysis

Results by major basins

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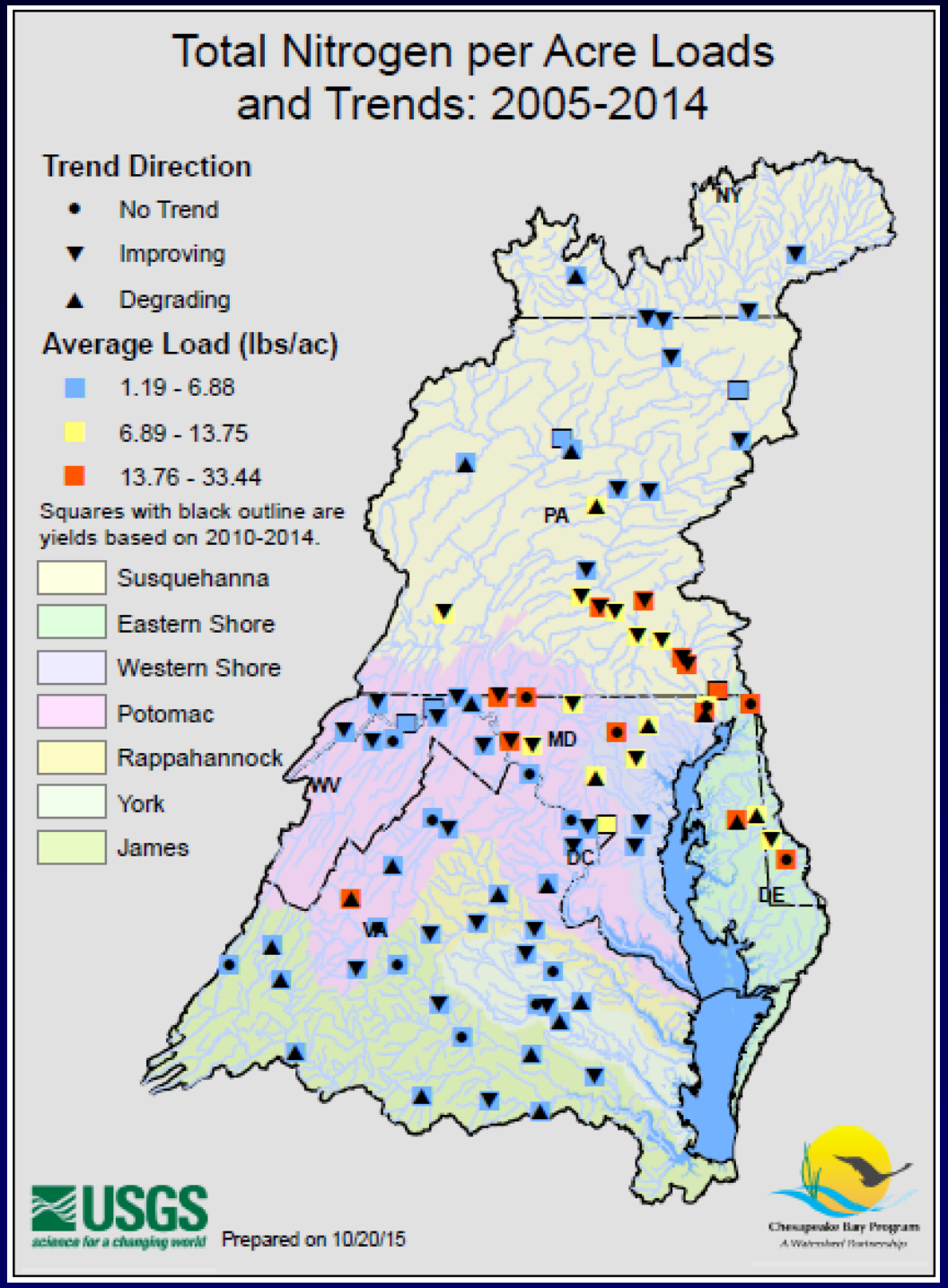
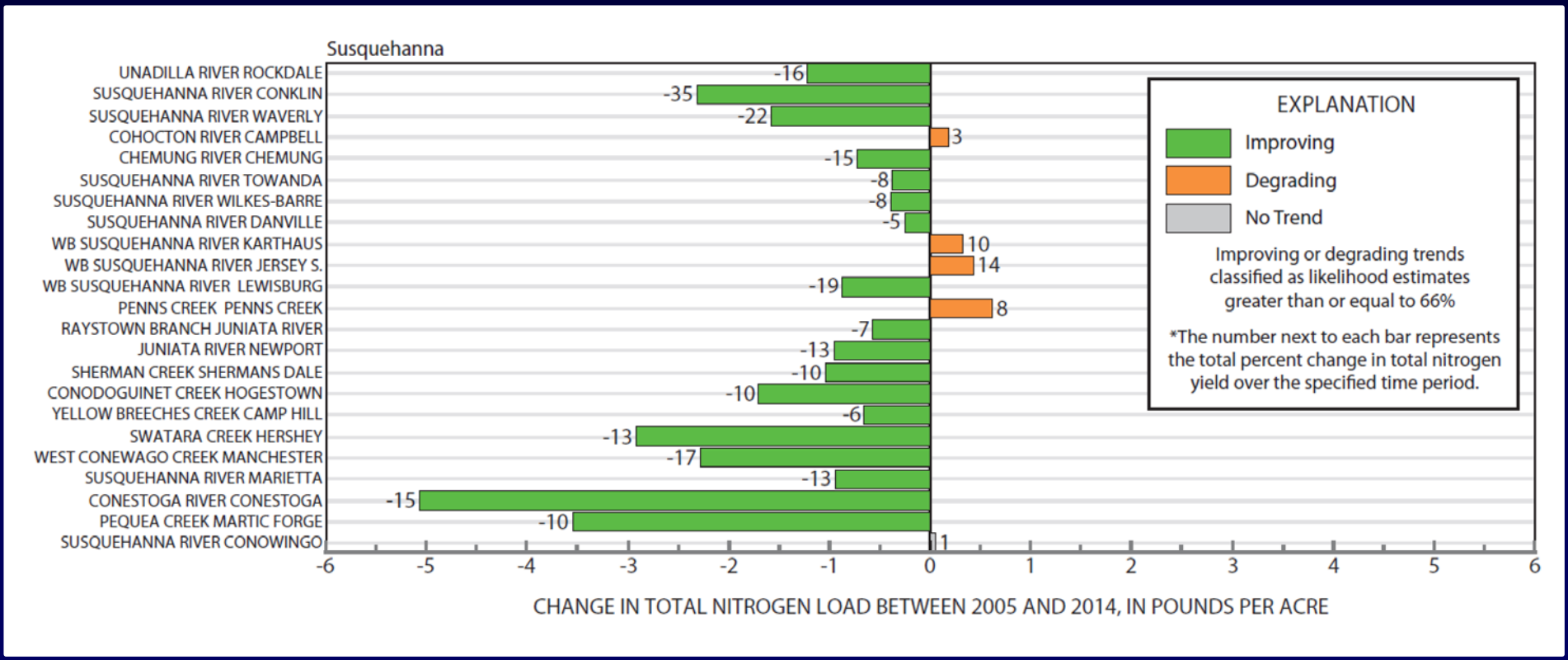


Changes in Nitrogen per Acre Loads: 2005-2014

Example from the Susquehanna Watershed



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Changes in Nitrogen per Acre Loads: 2005-2014

Trend in load network is the first of its kind

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

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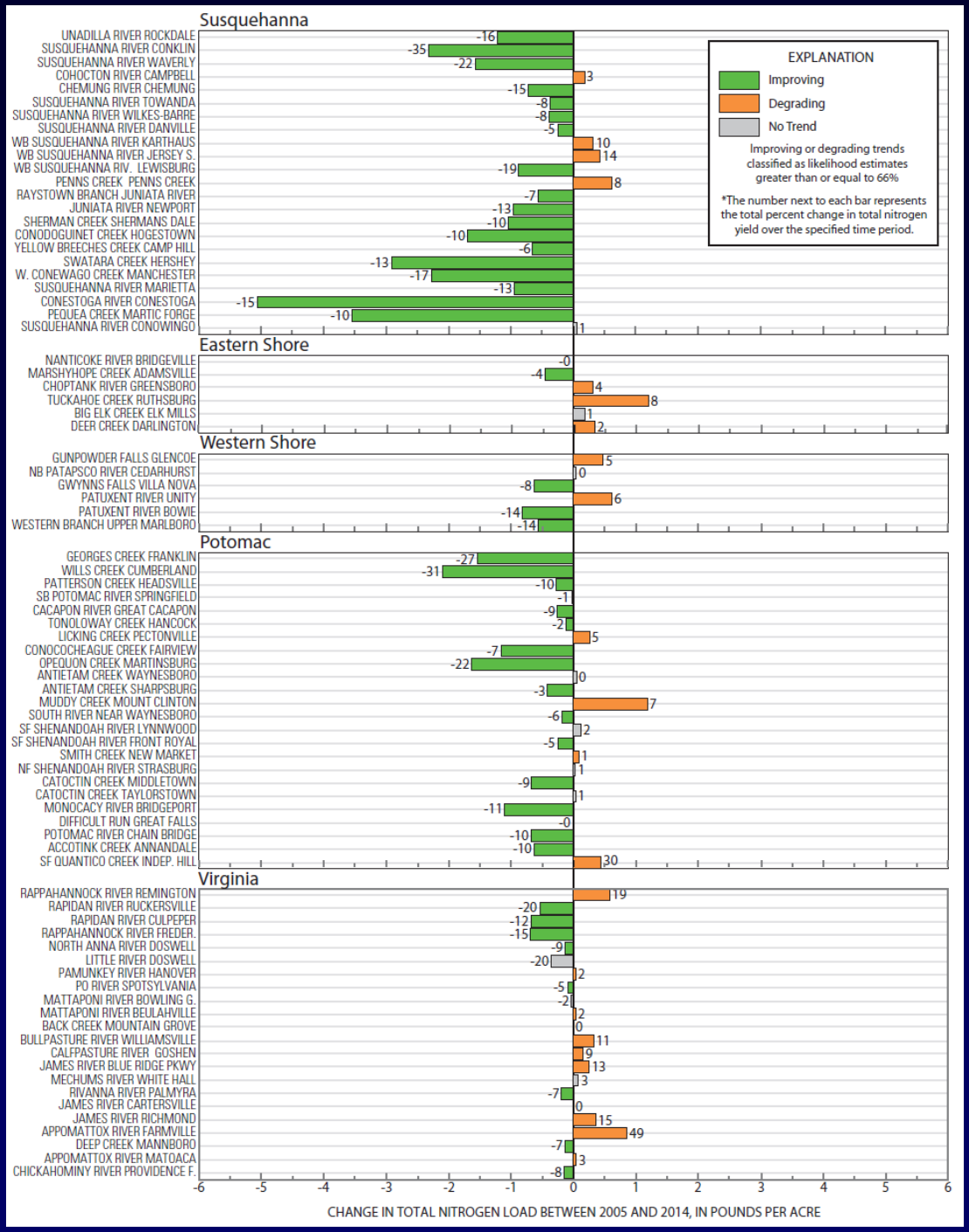

Total Phosphorus per Acre Loads and Trends: 2005-2014

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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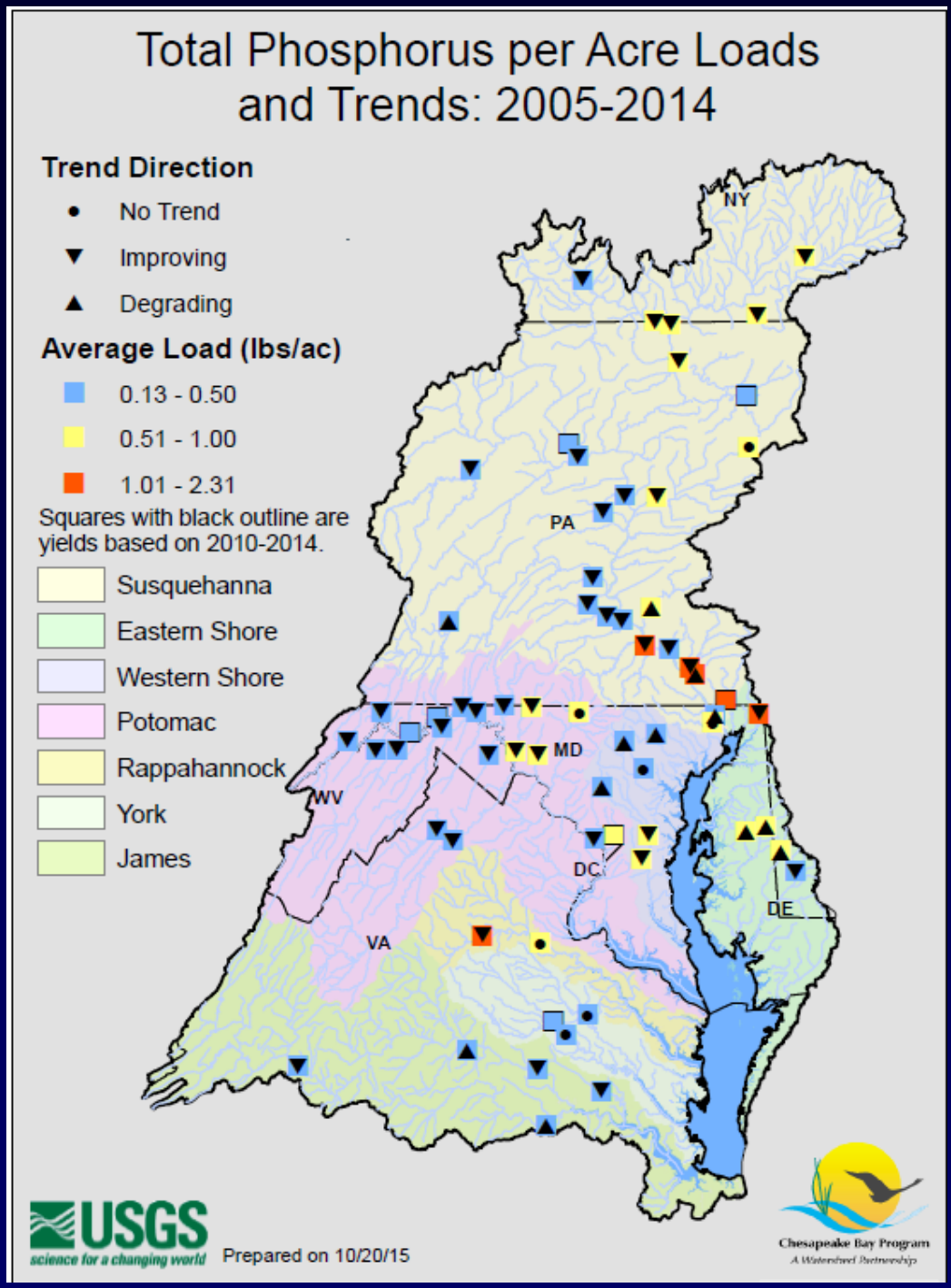

Changes in Phosphorus per Acre Loads: 2005-2014

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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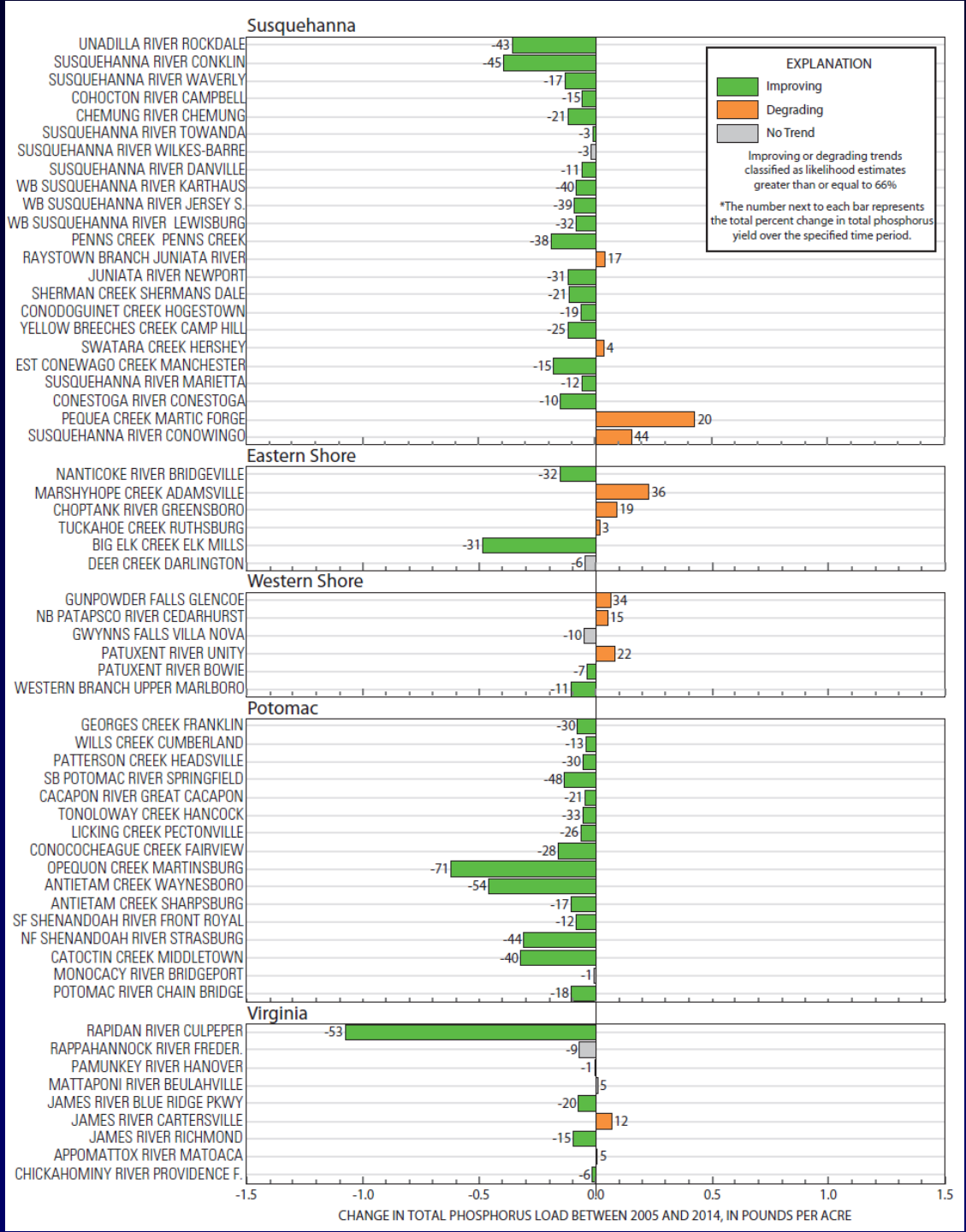

Changes in Suspended Sediment per Acre Loads: 2005-2014

Improving Stations (29 of 59)
Range = -8.11 to -1,490 lbs/ac
Median = -221 lbs/ac (-29.4%)

Degrading Stations (19 of 59)
Range = 4.75 to 341 lbs/ac
Median = 118 lbs/ac (42.8%)

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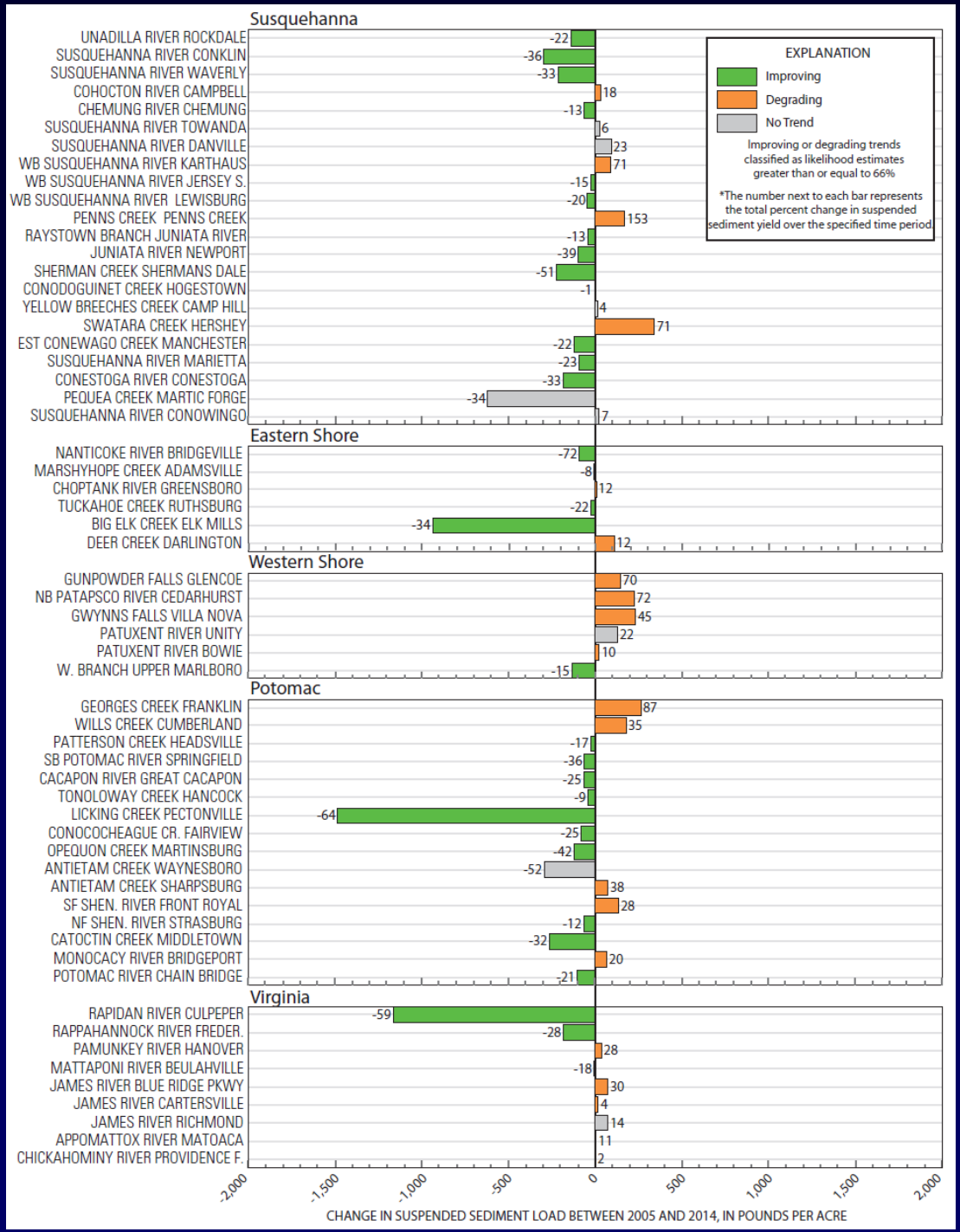

Summary

- Extensive montoring effort
- Weighted regression (WRTDS) to determine how “flow-normalized” loads are changing over time
- Measurable improving trends at 50% or more of the monitoring stations.
- What are the driving factors governing these trends?

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USGS Nontidal Web Page

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

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

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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

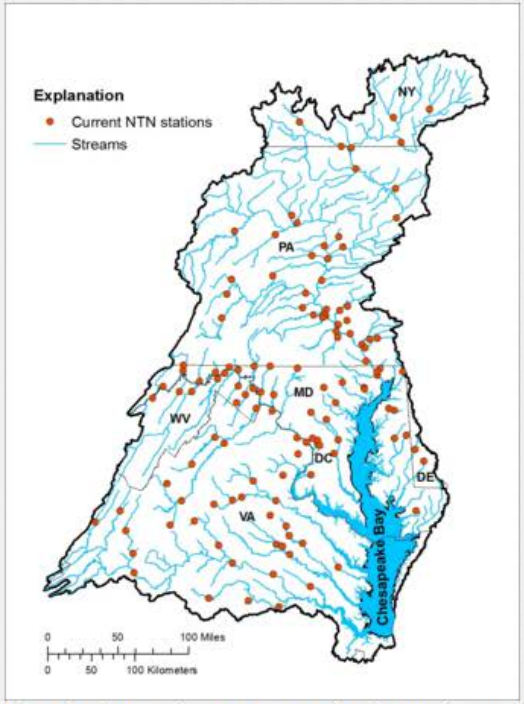
- Monitoring data are collected by numerous agencies through the nontidal monitoring partnership.
- Results are updated on even-numbered water years for the network of water-quality monitoring stations distributed throughout the Chesapeake Bay watershed.

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