Explaining Trends Through Multiple Lines of Evidence

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An analysis will be described that will use monitoring, modeling, and land management data to understand major changes in nutrient concentration and load across the Chesapeake watershed.

The USGS will highlight recent information on trends in load at River Input Monitoring Stations and discuss ideas for a partnership to explain major drivers for these changes.

Current plans are to focus upcoming work on the Potomac watershed.

Explaining Trends in Chesapeake Bay Tributaries

An example of what would we **like** to be able to say for key locations across the watershed:

- Loads have decreased by xx percent.

- 50 percent of this reduction is due to point source management plans

- 10 percent of this reduction is due to loss of ag lands.

- 15 percent of this reduction is due to BMP implementation on croplands.

- 25 percent of this reduction is due to improved ag manure management.

- An additional xx pound per year will be reduced by 2025 as groundwater discharges become effective on stream loads.

Multiple Lines of Evidence

- Stream Monitoring Data
  - Load trends
  - Concentration trends and streamflow patterns
  - Constituent analyses

- Independent Descriptive Data
  - Land use change (Satellite)
  - Land practice change (Census, Ag Census, CEAP surveys)
  - Wastewater loads
  - Atmospheric deposition
  - Fertilizer application rates

- Model Results
  - SPARROW (source share assessment, Dynamic modeling)
  - WSM (Normalized Trend, Principal Factor Analysis)

- Additional Supporting Science
  - Ground-water response time assessments
 - Sediment studies

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Assessing Trend In Load

Comparison of two Regression-Based Approaches for Determining Nutrient and Sediment Loads and Trends in the Chesapeake Bay Watershed

Douglas L. Moyer, Robert M. Hirsch, and Kenneth E. Hyer

MANAGEMENT CONCERNS

- Can we report a measure of trend in ANNUAL LOAD of nutrients and sediment delivered to the Chesapeake Bay that is indicative of changes in the watershed (e.g. BMPs, land conversion, …) and not influenced by random year-to-year variations in streamflow?

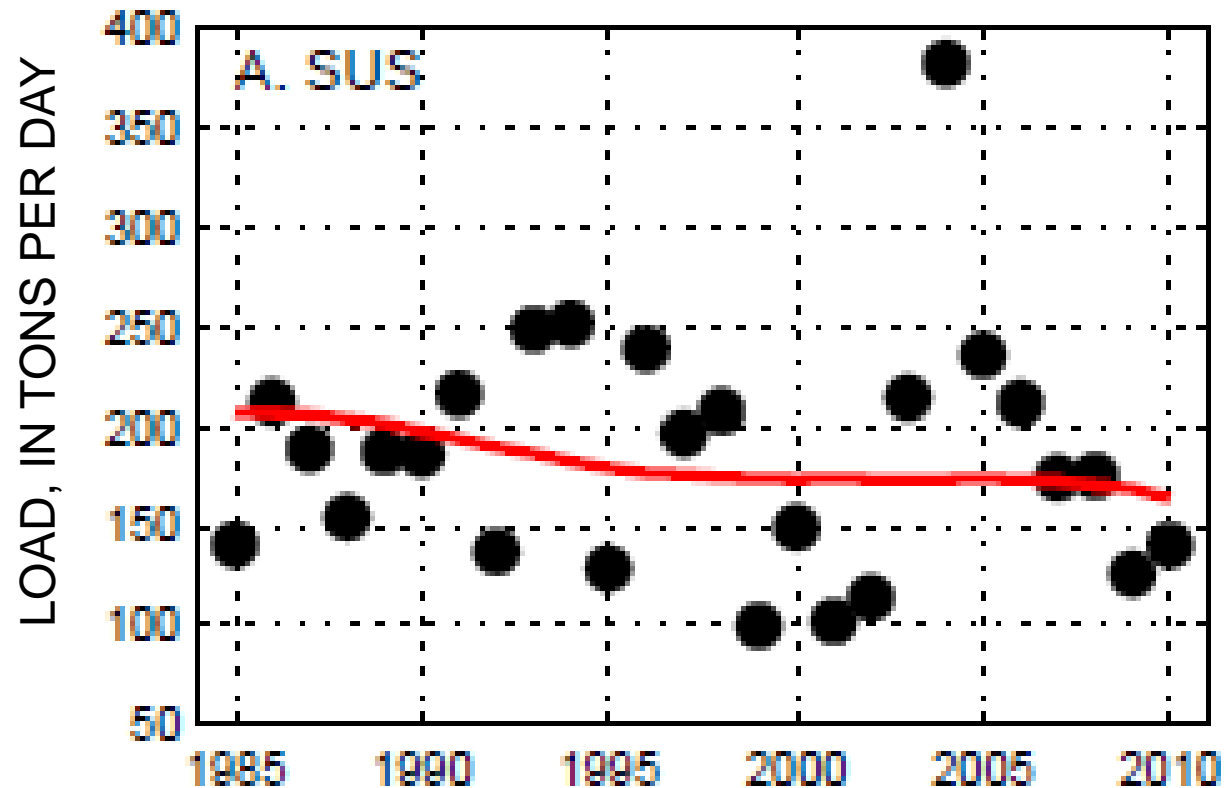Phosphorus Loads and Annual Average River Flow
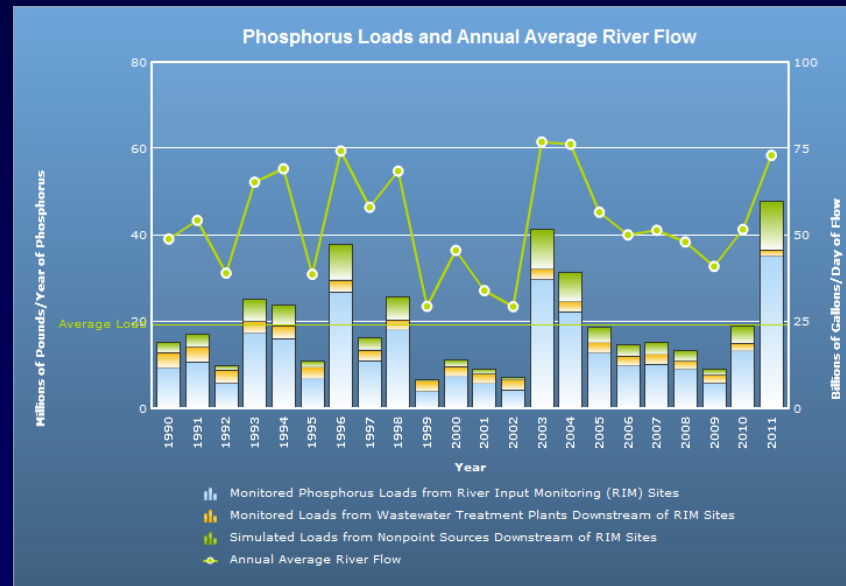
Trends in Total Nitrogen Annual Load

Total Nitrogen Load: Susquehanna (RIM)

- Influence of year-to-year variation in flow

With WRTDS, we now can communicate how annual loads have changed once the year-to-year variation in Q has been removed

Trend in load for:
1985 to 2010 = Total reduction of 21% at a rate of -0.8% per year
2001 to 2010 = Total reduction of 6% at a rate of -0.6% per year

Black Dots = Annual Load   Red Line = Flow Normalized Load

Chesapeake Bay: River Input Monitoring Stations

Stations:

- **Susquehanna**   **Pamunkey**
- **Potomac**   **Mattaponi**
- **James**   **Patuxent**
- **Rappahannock**   **Choptank**
- **Appomattox**

Why these stations:

- **Greater than 75% of the land area**
- **Vast majority of the total discharge from the nontidal areas passes these stations**
- **Robust datasets: nearly 30 years of monitoring with total observations ranging from 600 to 1,400**

Constituents:

- **Total Nitrogen**
- **Nitrate**
- **Total Phosphorus**
- **Orthophosphorus**
- **Suspended Sediment**

Therefore 9RIM * 5 Constituents = 45 possible analytical combinations

EXPLANTION

- ● River Input Monitoring site
- — Streams
- State boundaries
- Susquehanna River
- Chesapeake Bay
- Western Shore
- Choptank River
- Patuxent River
- Potomac River
- Rappahannock River
- Mattiponi River
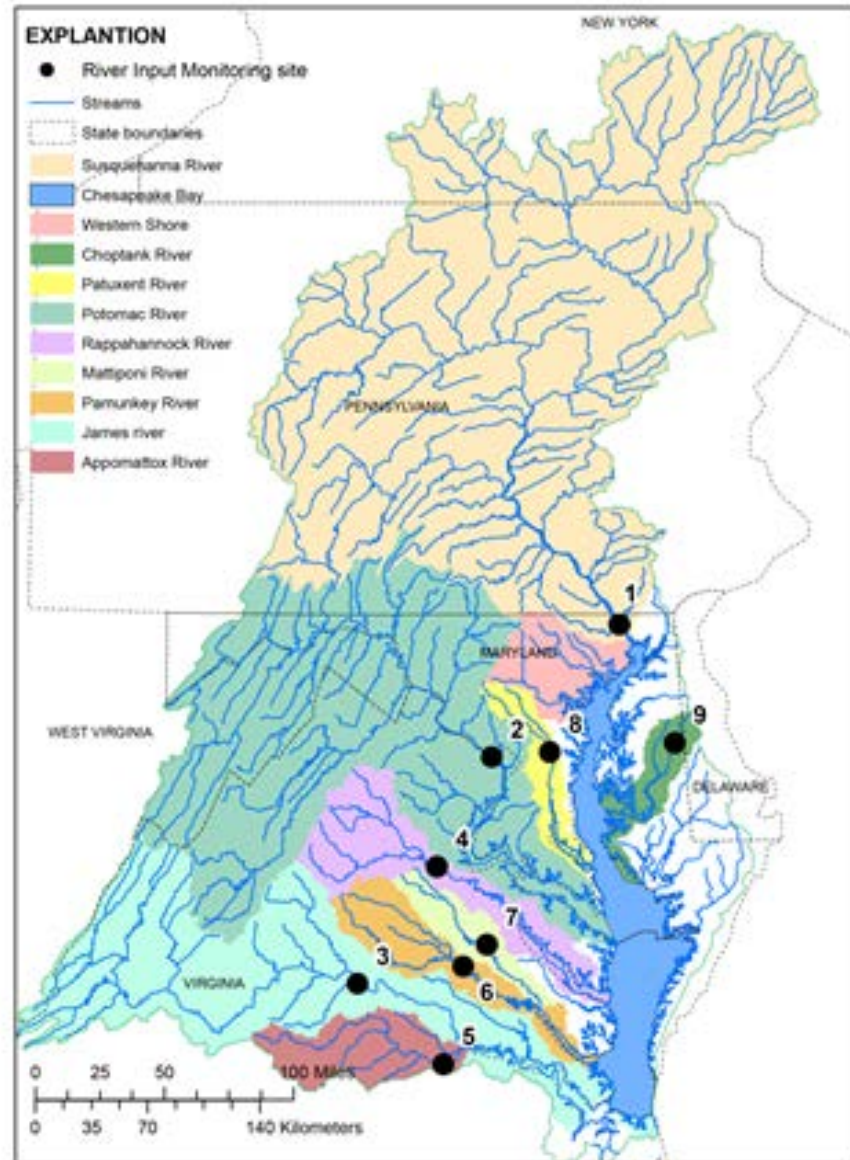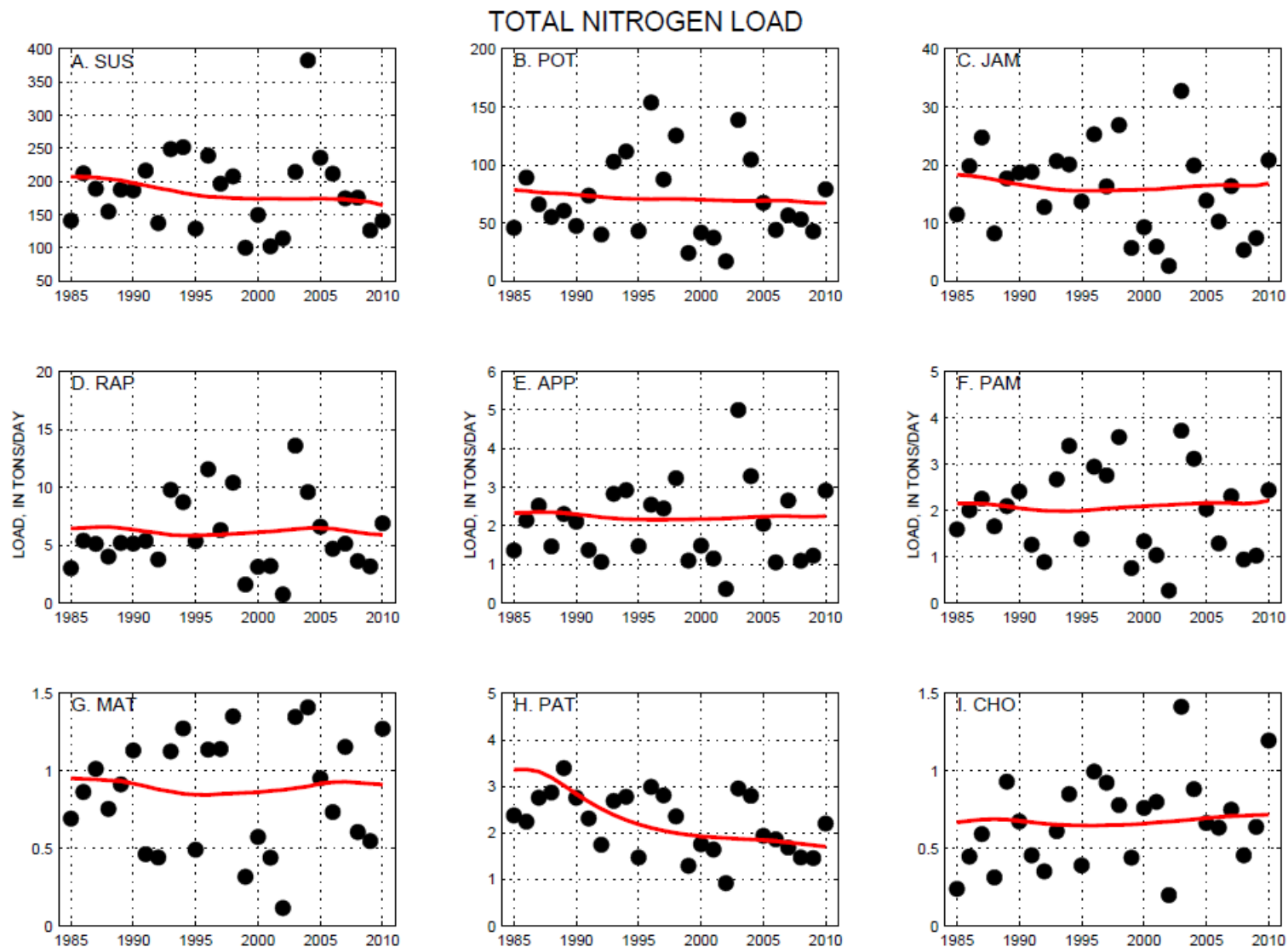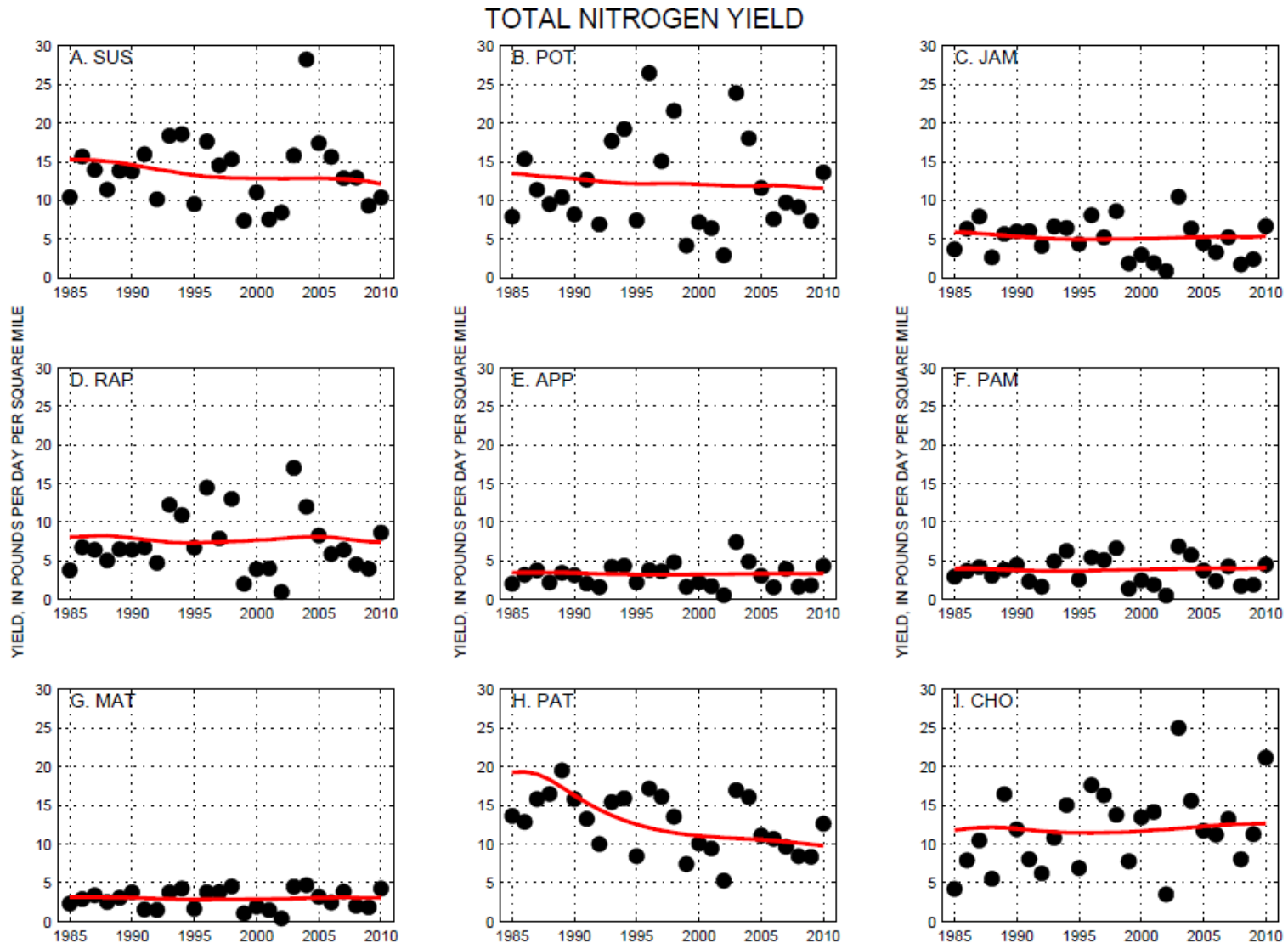- Pamunkey River
- James river
- Appomattox River

Figure 1. Map showing the location of the 9 River Input Monitoring (RIM) stations in the Chesapeake Bay watershed.

Trends in Total Nitrogen Load

TOTAL NITROGEN LOAD

Black Dots = Annual Load   Red Line = Flow Normalized Load

Trends in Total Nitrogen Yield
Yield = Load divided by the Basin Drainage Area

TOTAL NITROGEN YIELD

Black Dots = Annual Yield   Red Line = Flow Normalized Yield

Assessing Trend in individual nutrient species

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Trends in Nitrogen Loads

Station	Long-Term Trend (1985-2010)	
	Nitrate	Total Nitrogen
Susquehanna	Improving	Improving
Potomac	Improving	Improving
James	Improving	Minimal
Rappahannock	Improving	Minimal
Appomattox	Improving	Minimal
Pamunkey	Minimal	Minimal
Mattaponi	Minimal	Minimal
Patuxent	Improving	Improving
Choptank	Degrading	Minimal

Minimal Trend = total change less than or equal to |10%|

Improving Trend = total load reduction greater than 10%

Degrading Trend = total load increase greater than 10%

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Trends in Phosphorus Loads

Station	Long-Term Trend (1985-2010)	
	Ortho-phosphorus	Total Phosphorus
Susquehanna	Improving	Minimal
Potomac	Improving	Improving
James	Improving	Degrading
Rappahannock	Improving	Degrading
Appomattox	Improving	Degrading
Pamunkey	Improving	Degrading
Mattaponi	Improving	Minimal
Patuxent	Improving	Improving
Choptank	Degrading	Degrading

Minimal Trend = total change less than or equal to |10%|

Improving Trend = total load reduction greater than 10%

Degrading Trend = total load increase greater than 10%

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Trends in Suspended Sediment Load

Station	Long-Term Trend (1985-2010)	Short-Term Trend (2001-2010)
Susquehanna	Degrading	Degrading
Potomac	Degrading	Degrading
James	Not Available	Degrading
Rappahannock	Not Available	Degrading
Appomattox	Not Available	Degrading
Pamunkey	Not Available	Degrading
Mattaponi	Not Available	Improving
Patuxent	Improving	Degrading
Choptank	Improving	Degrading

Light shaded boxes = total change less than or equal to |10%|
Dark shaded boxes = total change greater than |10%|

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Summary of Trend in Load Results

- Nitrogen Load Trends:
  - Trends in Nitrate – Majority of the sites are showing considerable improvement/reduction
  - Trends in Total Nitrogen – Only 3 RIM sites are showing long-term improvements; while, 6 RIM sites only exhibit minimal change

- Phosphorus Load Trends:
  - Trends in orthophosphorus – 8 of the 9 RIM sites are showing considerable improvements
  - Trends in Total Phosphorus – Only 2 RIM sites are showing long-term improvements; while, 5 RIM sites are showing long-term degradation

- Suspended Sediment Trends:
  - Long-term – 2 of 4 sites exhibiting degradation
  - Short-term – 8 of the 9 RIM sites are exhibiting degradation

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Understanding Response to Streamflow

Trends Agree

Example where trend in concentration and trend in load are in the same direction (Susquehanna Nitrate)

Categorize water-quality observations based on 3 discharge conditions:
- High
- Intermediate
- Low

ESTIMATOR trend in concentration indicates improving conditions (total reduction of approx. 16%)

WRTDS trend in load indicates improving conditions (total reduction of approx. 16%)
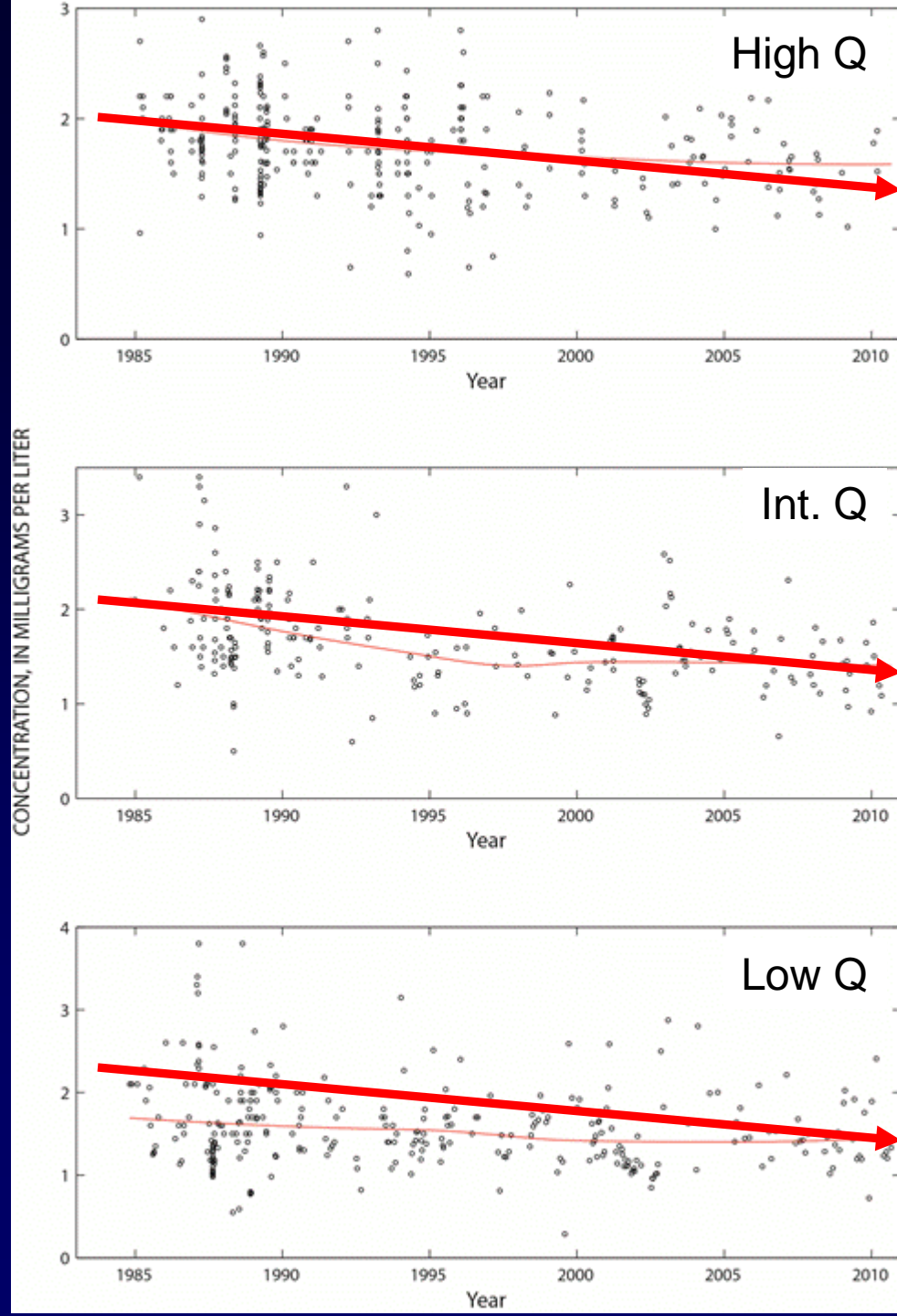
Trends Disagree

Example where trend in concentration and trend in load are in opposite direction (James River Total Phosphorus)

ESTIMATOR trend in concentration indicates improving conditions (total reduction of approx. 60%)

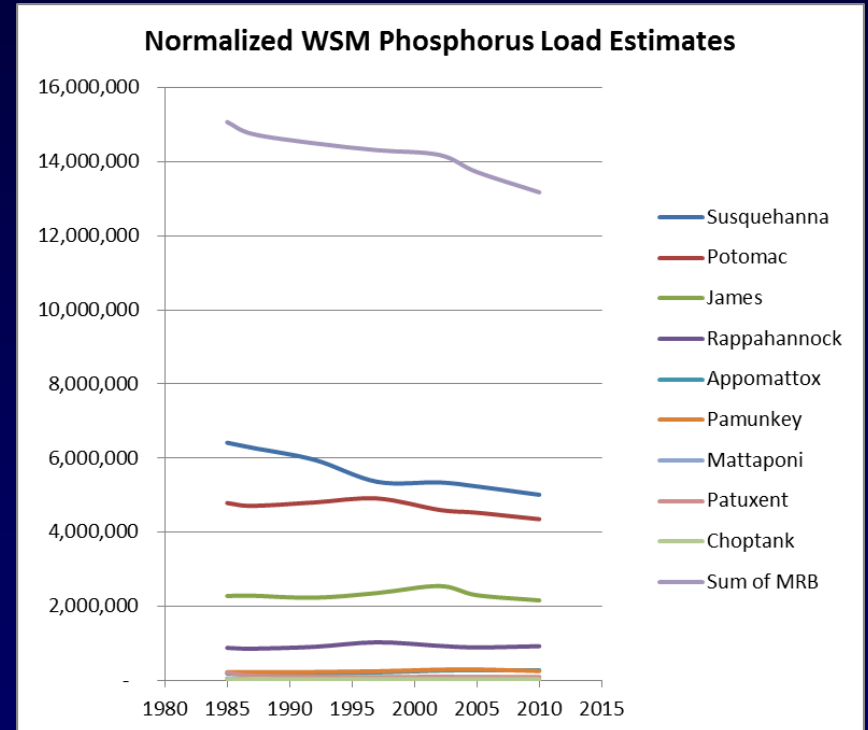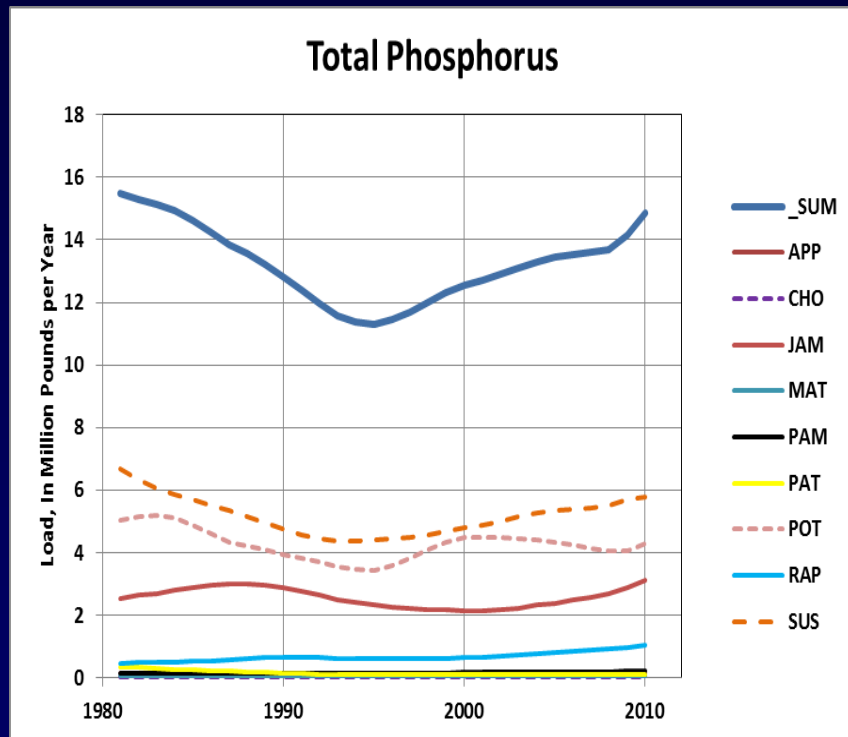WRTDS trend in load indicates degrading conditions (total increase of 10%)

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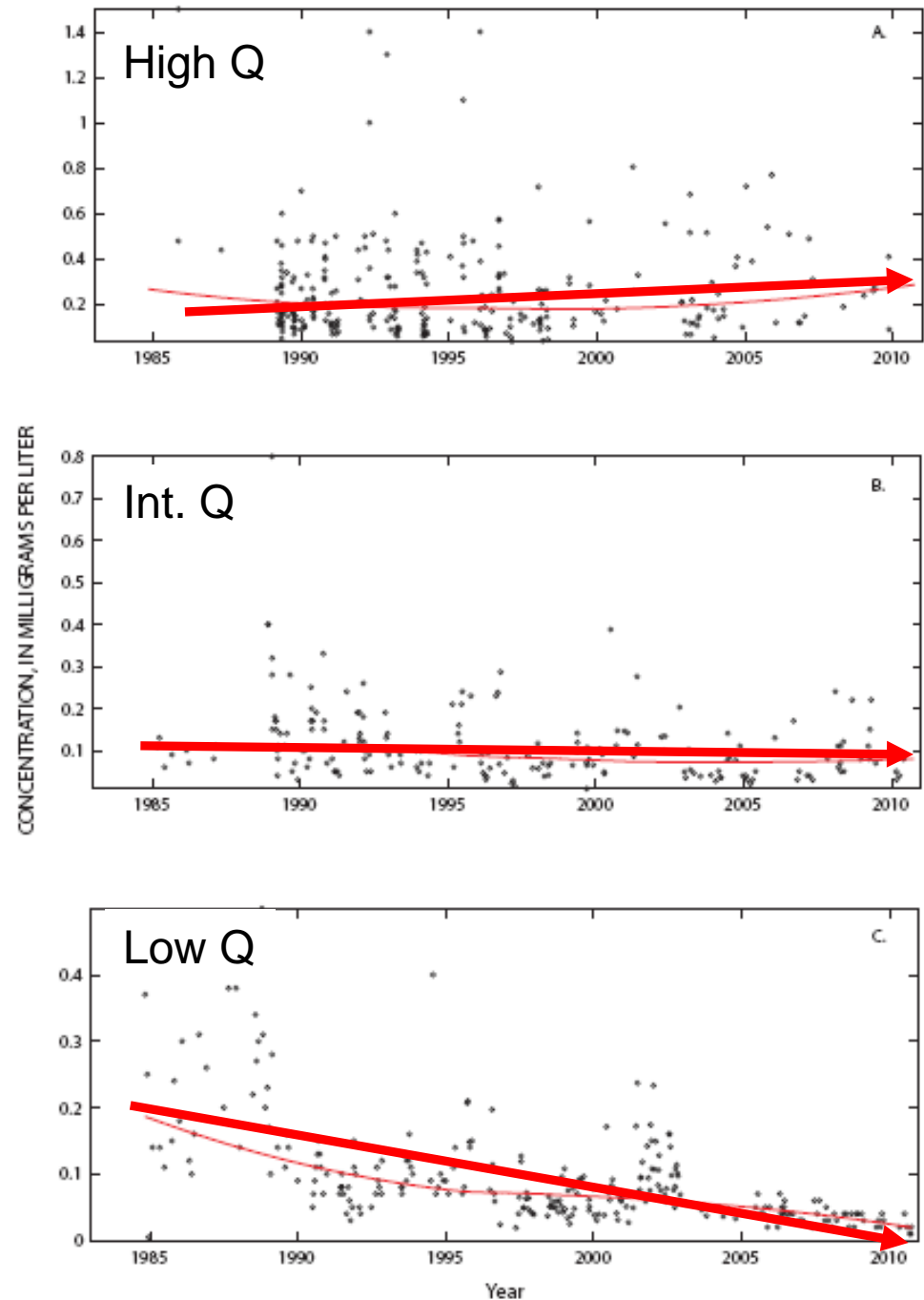
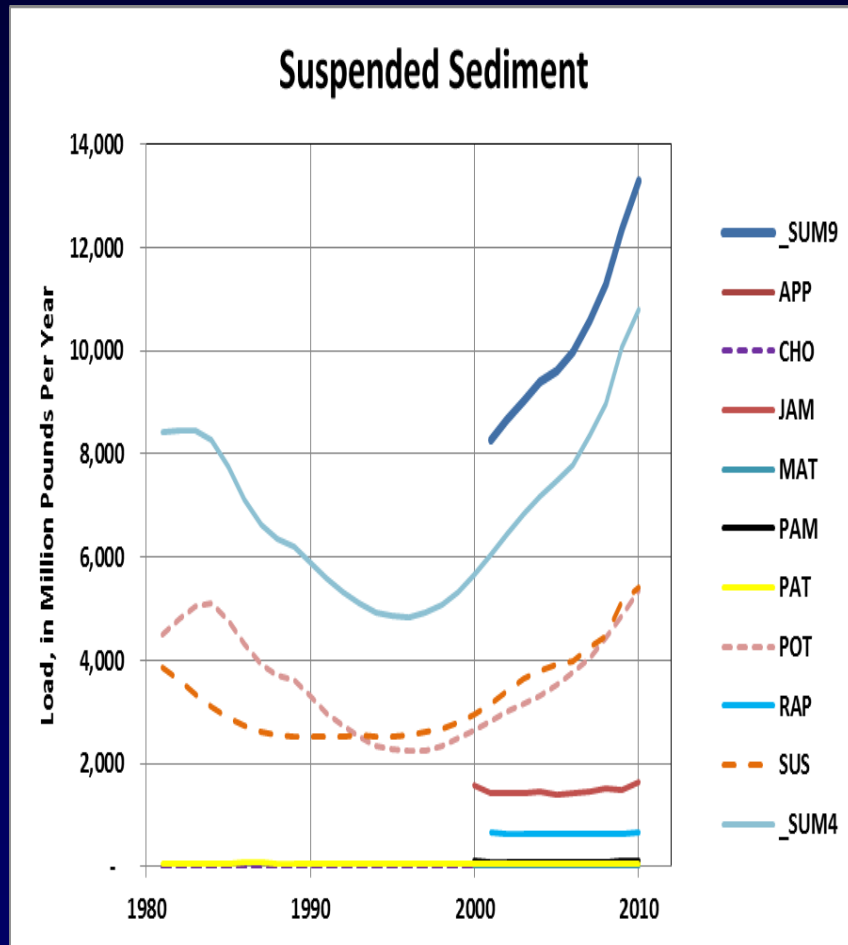# Assessing Models Relative to Monitoring Results

Comparing Normalized loads from Monitoring data to normalized loads from CB WSM: Nitrogen

USGS
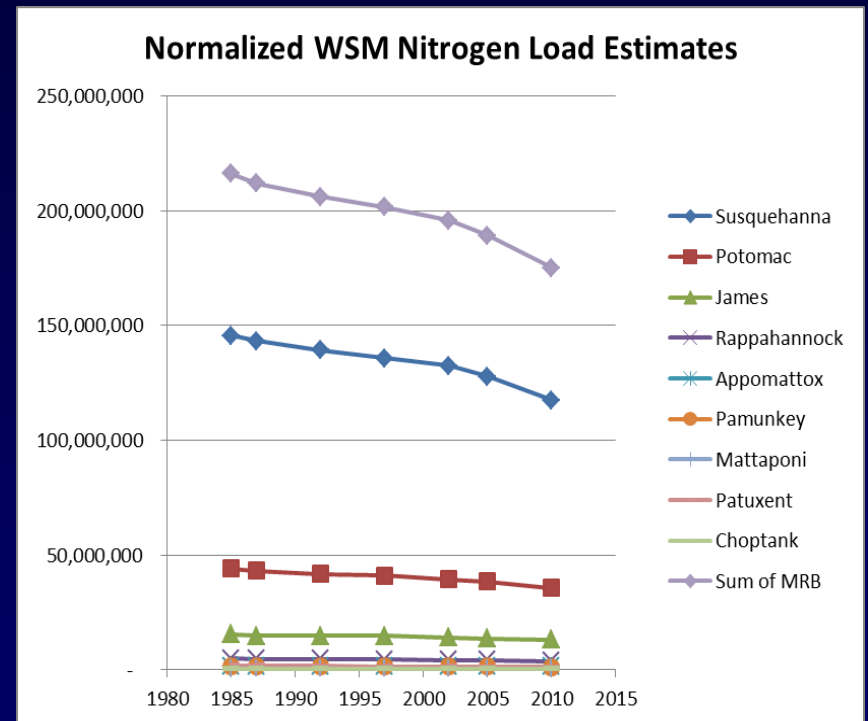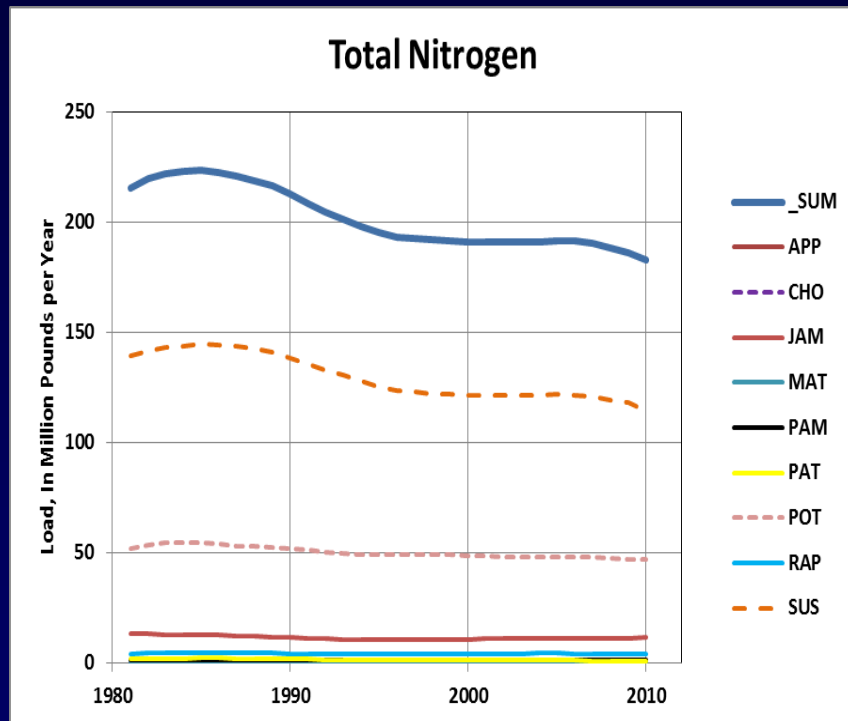
Comparing Normalized loads from Monitoring data to normalized loads from CB WSM: Phosphorus
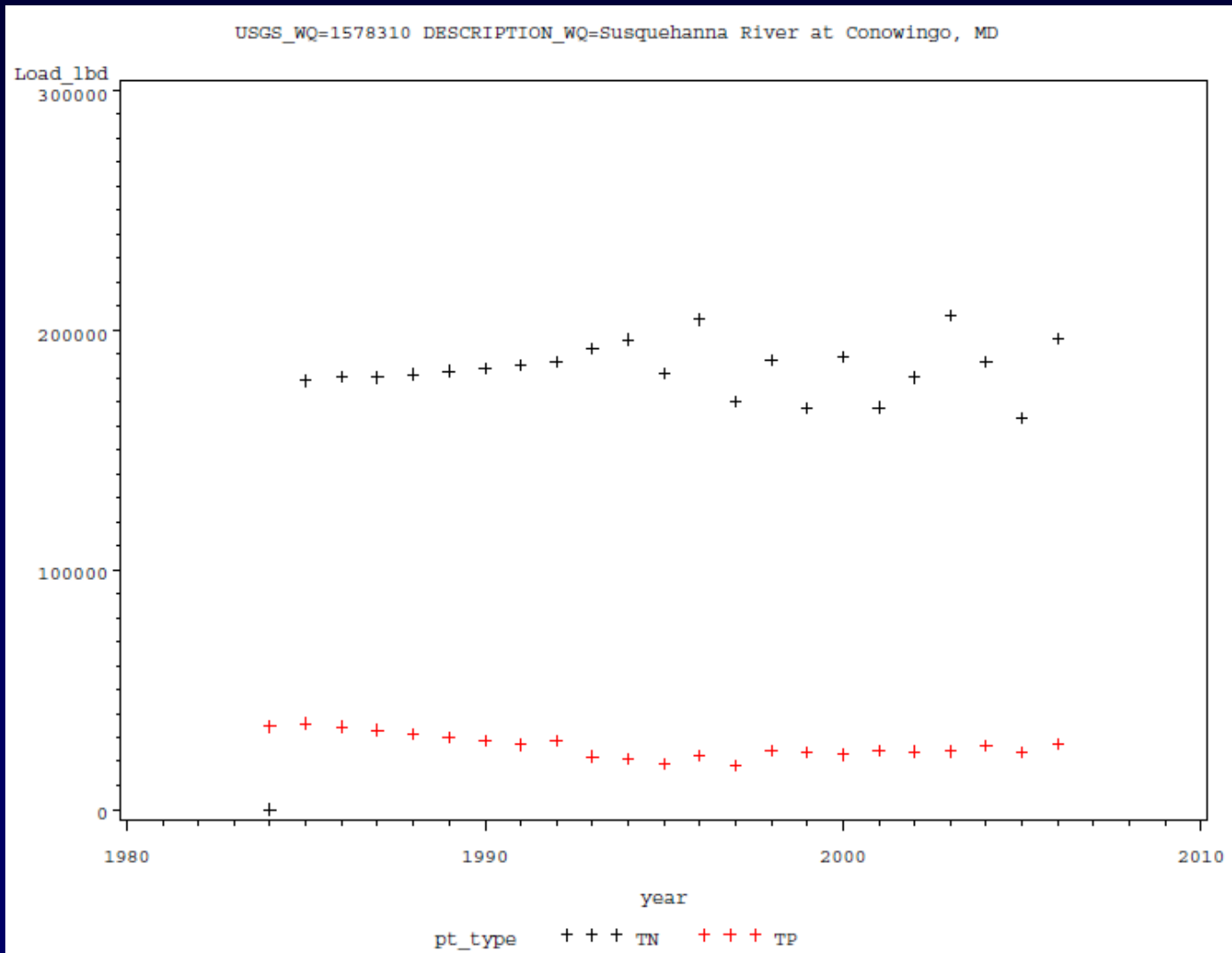
Comparing Normalized loads from Monitoring data to normalized loads from CB WSM: Sediment
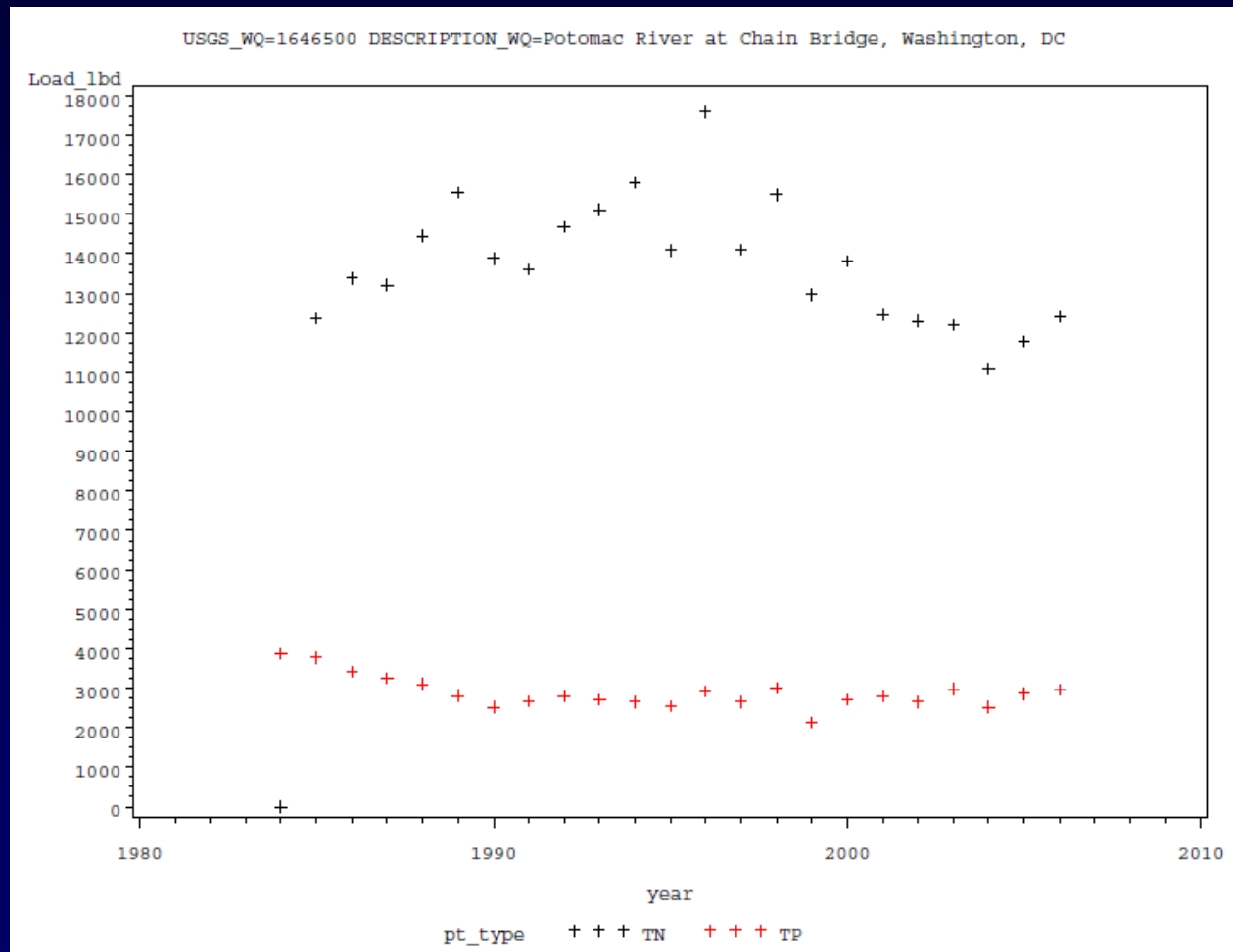

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Susquehanna River Point Source Loads

USGS_WQ=1578310 DESCRIPTION_WQ=Susquehanna River at Conowingo, MD

Potomac River at Washington, DC Point Source Loads

Next Steps for trend explanation

1. Compare FNL and WSM at nine RIM Stations.
2. Begin Focused efforts on Potomac Tributaries.
3. Describe major watershed changes.
4. Begin to unravel WSM drivers. Assess by source sector Assess changes by individual practice
5. Validate with independent data

6. Incorporate knowledge of response times.

7. Get creative with partners!
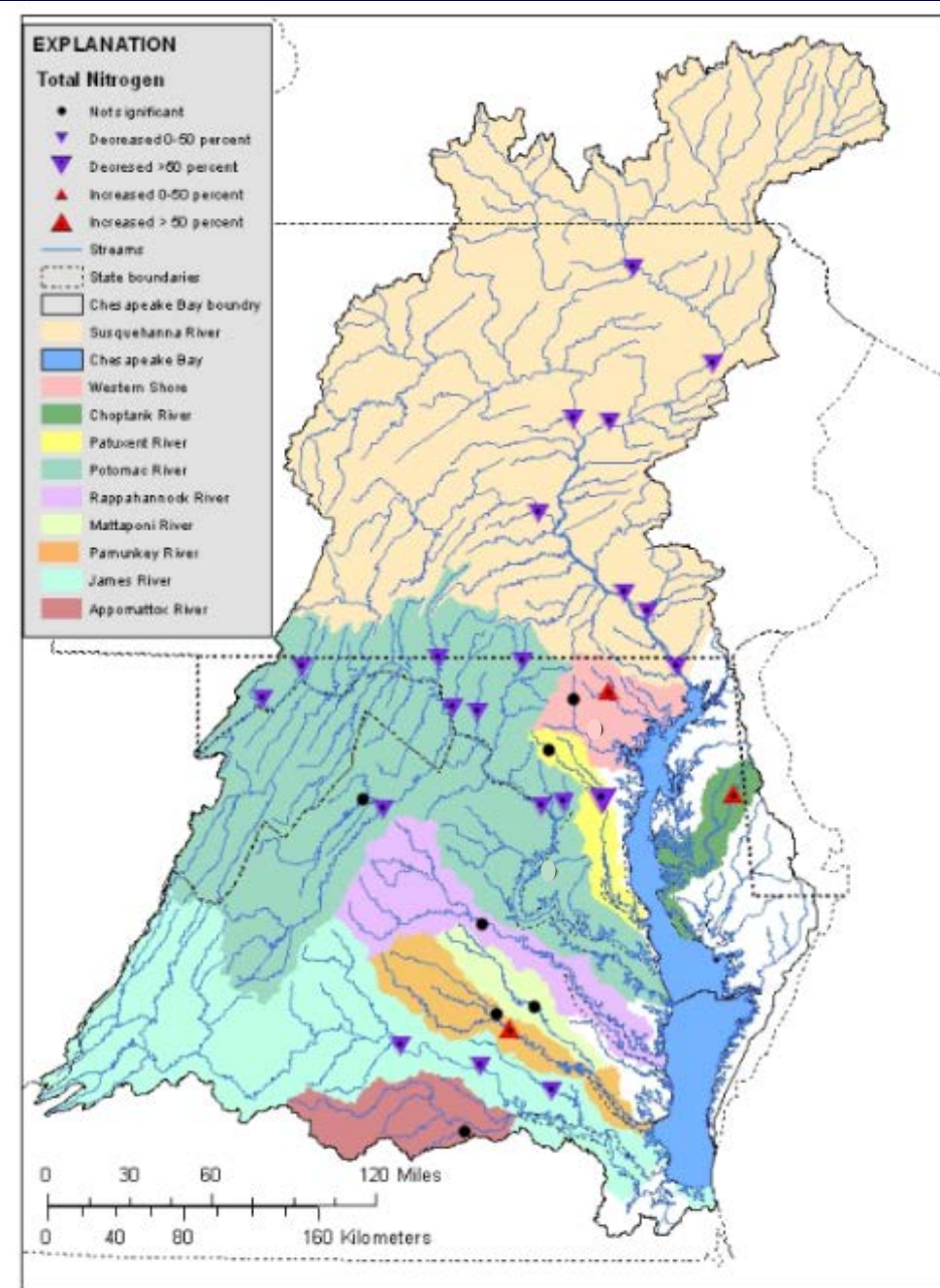
Flow-adjusted trends for total nitrogen for 31 sites in the Chesapeake Bay Watershed, 1985-2011.

Trends in Suspended Sediment Load

SUSPENDED SEDIMENT FLUX

Black Dots = Annual Load   Red Line = Flow Normalized Load