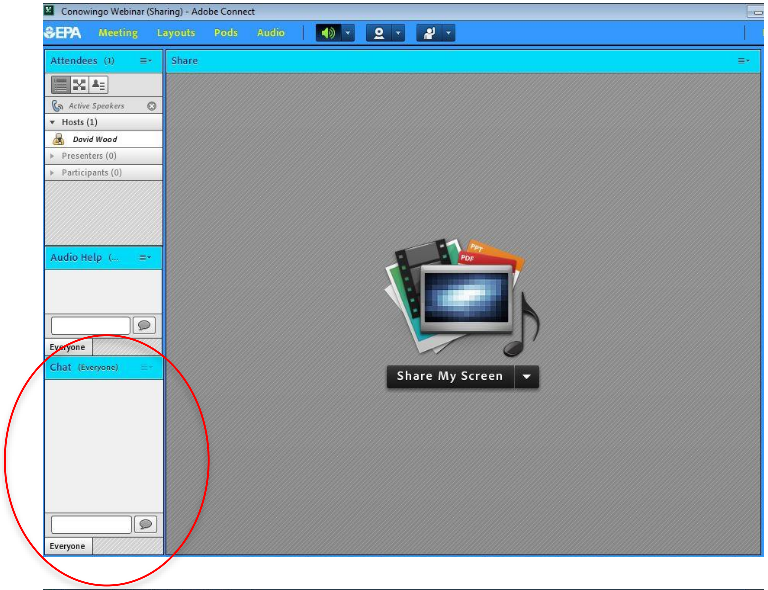
Understanding the Influence of the Conowingo Reservoir Infill on Expectations for States' Nutrient and Sediment Pollutant Load Reductions

Chesapeake Bay TMDL 2017 Midpoint Assessment Webinar Series
October 20, 2016

Chesapeake Bay Program
Science, Restoration, Partnership

Welcome to the Reservoir Conowingo Infill Webinar

- To Ask a Question
  - Submit your question in the chat box, located in the bottom left of the screen, at any time during the webinar. We will answer as many as possible during a Q&A session following the presentation.



- For A/V Help
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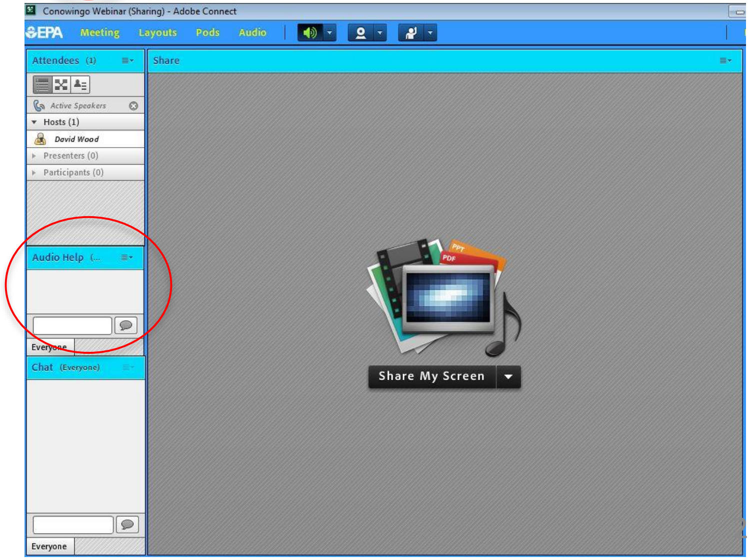


Welcome to the Reservoir Conowingo Infill Webinar

- We ARE Recording this Session
  - The recording and related resources will be available on the Chesapeake Bay Program's calendar page for today's webinar.
  - http://www.chesapeakebay.net/calendar/event/24340/

Goals for Today's Webinar

- Increasing understanding of what current research, modeling and monitoring is telling us about changes in the lower Susquehanna reservoir system

- Insights on how these findings could influence expectations for the states' nutrient and sediment pollutant load reductions between 2018 and 2025

- Partnership timeline for deciding on how much and who will be responsible for offsetting the additional loads coming through the reservoir system

Today's Speakers

Lee Currey
Maryland Department of the Environment
CBP Modeling Workgroup Co-Chair

Joel Blomquist
U.S. Geological Survey
CBP Integrated Trend Analysis Workgroup Co-Chair

Dr. Robert Hirsch
U.S. Geological Survey
CBP Scientific and Technical Advisory Committee Member

Lew Linker
U.S. Environmental Protection Agency
CBP Modeling Workgroup Coordinator

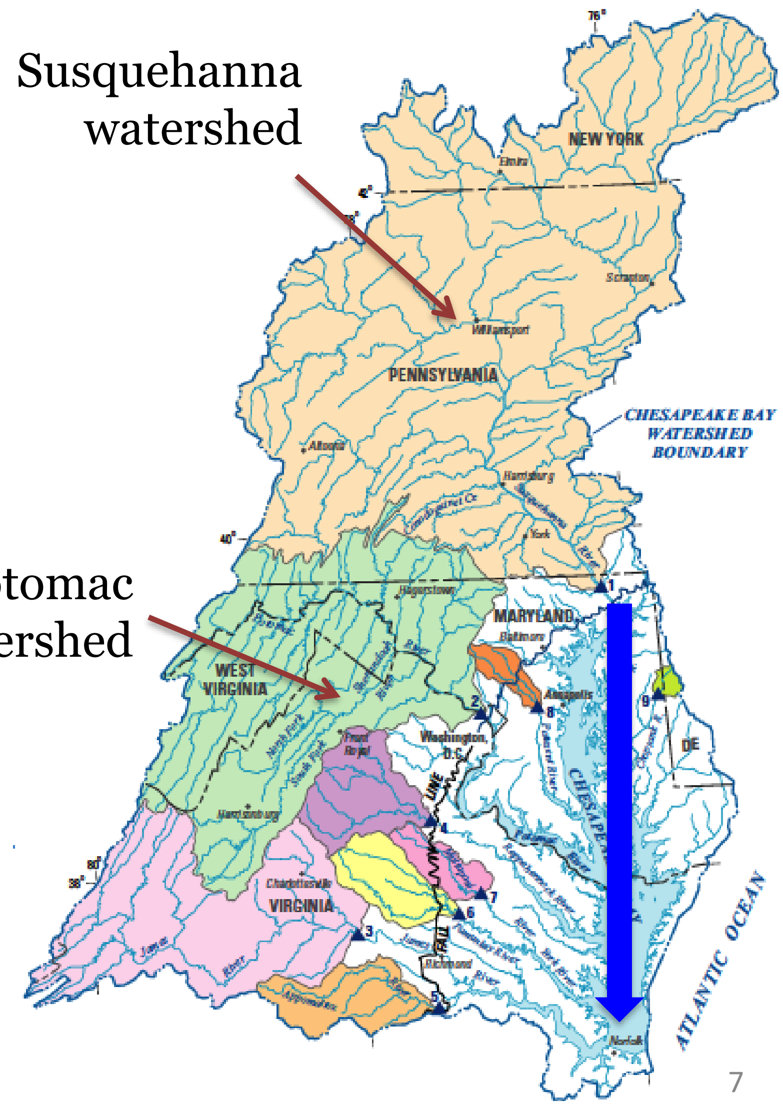
David Wood
Chesapeake Research Consortium
CBP Water Quality Goal Implementation Team Staff

Putting the Susquehanna River Watershed and the System of Reservoirs into Perspective

Lee Currey
Maryland Department of the Environment
CBP Modeling Workgroup Co-Chair

Susquehanna River Has a Major Influence on Chesapeake Bay Water Quality

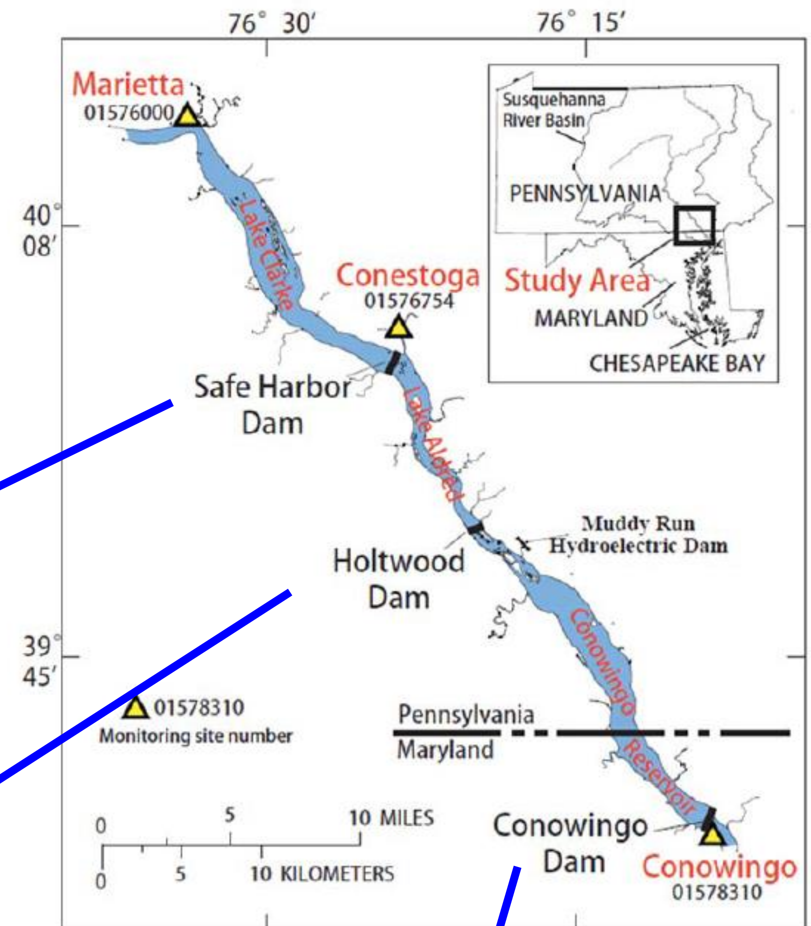
- 43% of Chesapeake Bay watershed
- 47% of freshwater flow into the Bay
- 41% of nitrogen loads to the Bay
- 25% of phosphorus loads to the Bay
- 27% of sediment loads to the Bay
- Influences Bay water quality well into Virginia's portion of the Bay

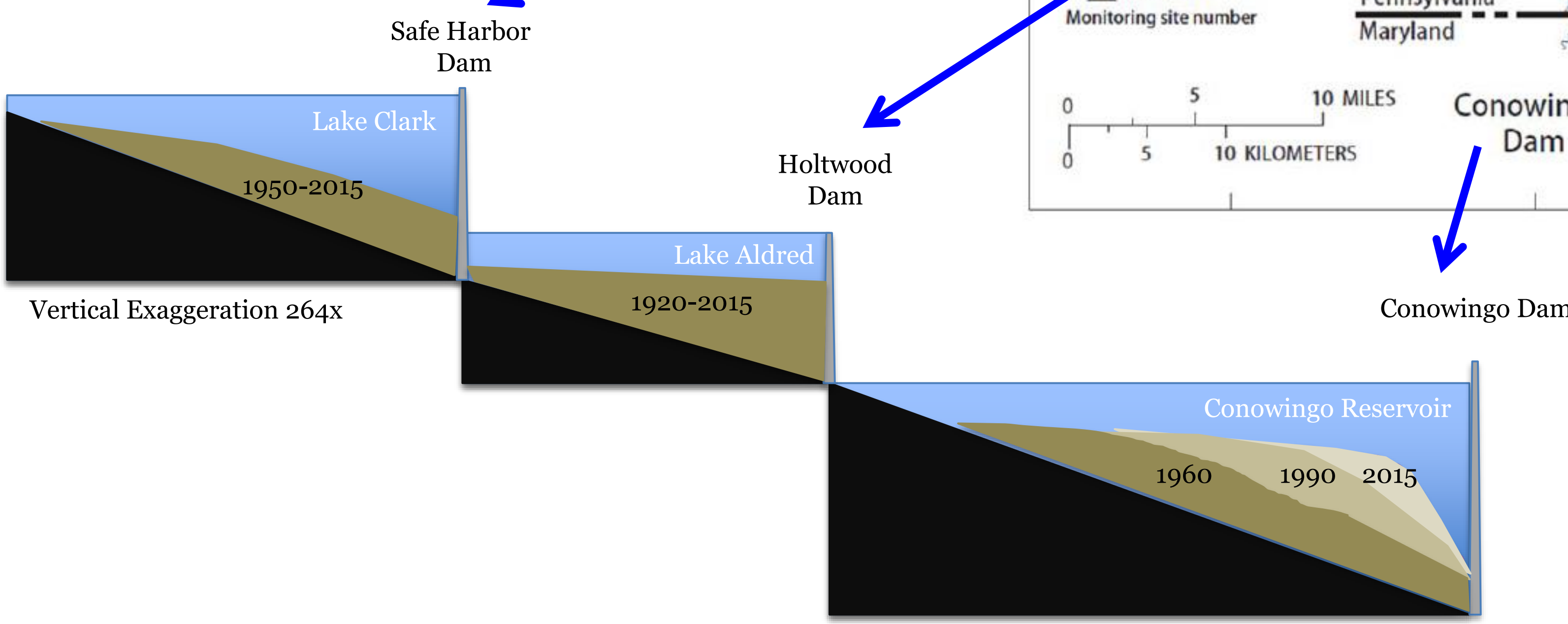


Source: Linker (2014)

Three Reservoirs in the Lower Susquehanna

The System of Reservoirs has been filling over time.





Source: Langland and Blomquist, USGS, personal communication

Timeline for Lower Susquehanna River Reservoirs: 1900-2020

Conowingo Dam

1900

1910 – Holtwood Dam constructed

1920 – 1920 – Holtwood Dam reaches equilibrium

1928 – Conowingo Dam constructed

1931 – Safe Harbor Dam constructed

1940

1950 – Safe Harbor Dam reaches equilibrium

1960 – 1960s – Historical lowest flows in Susquehanna

1972 – Tropical Storm Agnes

1980 – 1979 – Systematic water quality monitoring begins on the Susquehanna River at Conowingo Dam

1996 – “Big Melt” flood event

2000 – 2001 – SRBC convenes “Susquehanna Sediment Task Force” Symposium; publishes report

2010 – Chesapeake Bay TMDL established

2012 – Hirsch 2012 scientific paper publishes clear evidence for Conowingo Reservoir at or near dynamic equilibrium

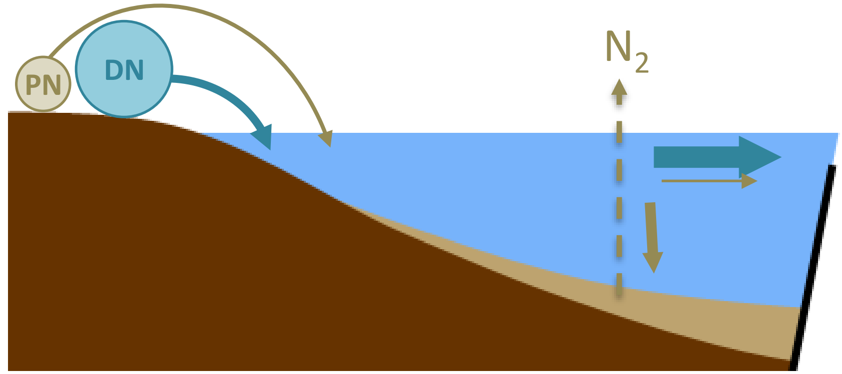
2017 – Bay TMDL Midpoint Assessment

2020

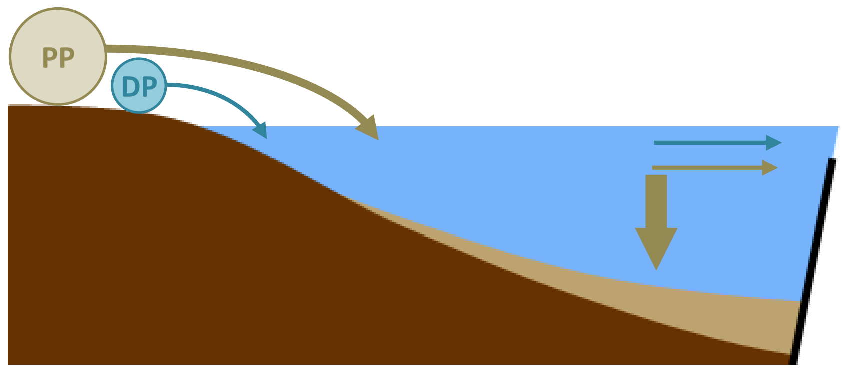
Source: Langland, USGS, Personal Communication

Characteristics of Net Reservoir Trapping

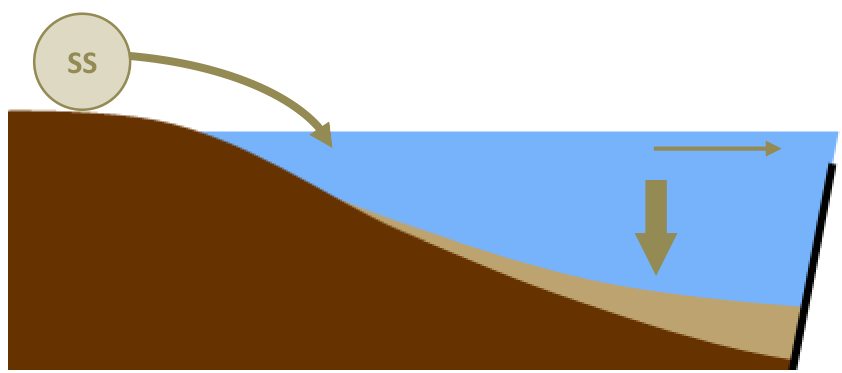
Nitrogen



Phosphorus



Sediment



Key:	
PN=	Particulate Nitrogen
DN=	Dissolved Nitrogen
PP=	Particulate Phosphorus
DP=	Dissolved Phosphorus
SS=	Suspended Sediment

Source: Currey, MDE, Personal Communication

Recent History of Working to Understand Conowingo/Bay Interrelationships

Lee Currey
Maryland Department of the Environment
CBP Modeling Workgroup Co-Chair

Significant New Monitoring, Research Since 2011 is Guiding Modeling Advancements/Refinements

- U.S. Geological Survey (USGS) (2012, 2014, 2015)
- U.S. Army Corps of Engineers (2015)
- Johns Hopkins University (2013, 2015, 2016)
- CBP Scientific and Technical Advisory Committee (2014, 2016)
- Enhanced Monitoring and Modeling funded by Exelon and conducted by Gomez and Sullivan, University of Maryland and USGS (2014-2016)

2016 STAC Conowingo Workshop

Key Workshop Findings:

- Reservoir system has long been a trap for particulate nutrients and sediment but is now at or near a condition of dynamic equilibrium

- Ability of reservoir system to trap sediment and attached nutrients has decreased compared to the first 90 years because the deposited sediment has caused the reservoirs to become shallower and thus less able to trap sediment and more prone to scour

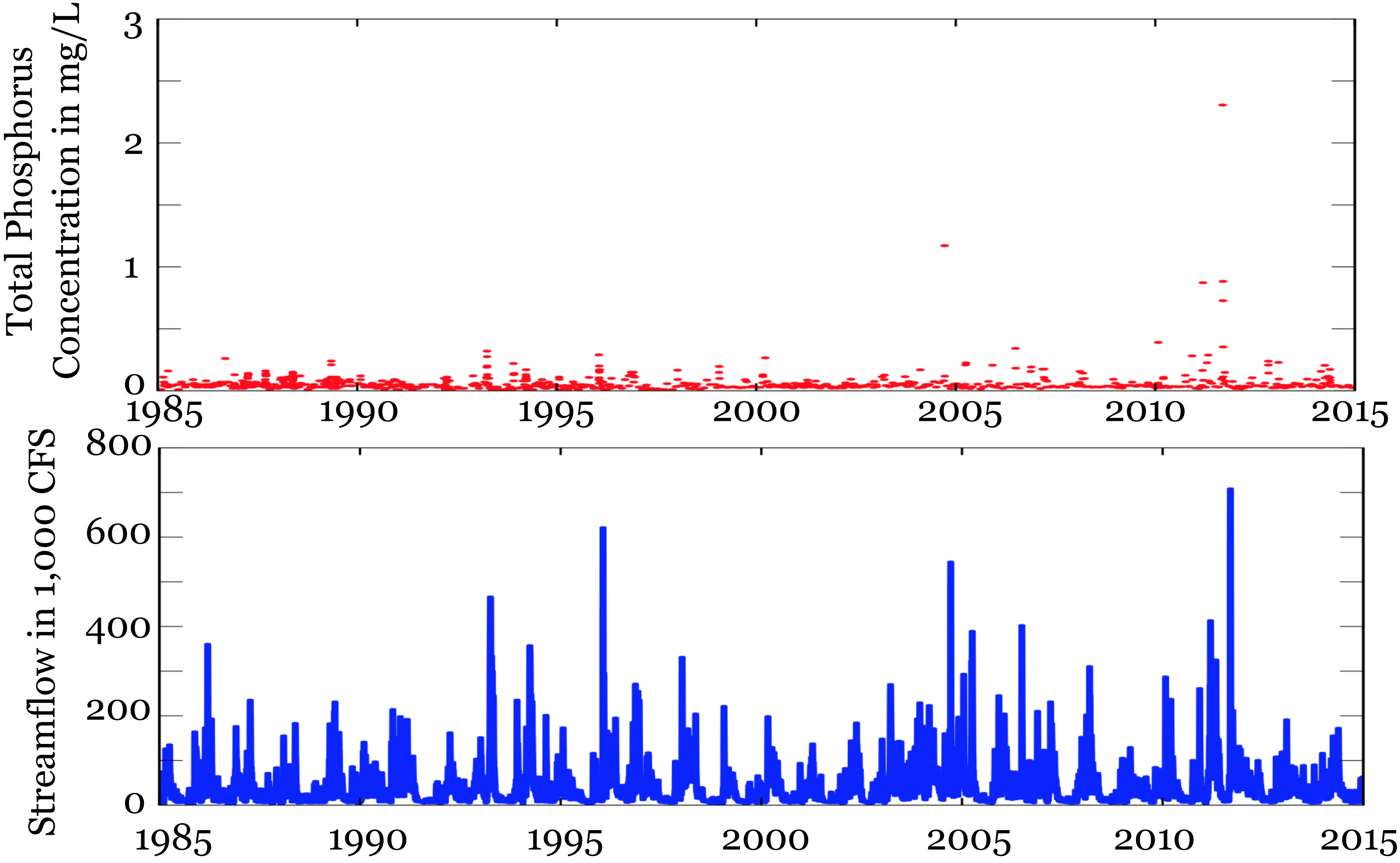
- To quantify the influence of infill conditions, the following must be considered:
  - Loss of trapping during low to moderate flow
  - Change in scour threshold during higher flows
  - Relatively rare extreme events
  - Fate of particulate material to the Bay

Source: CBP Scientific and Technical Advisory Committee (2016)

Observed Water Quality Trends Throughout the Susquehanna River Watershed

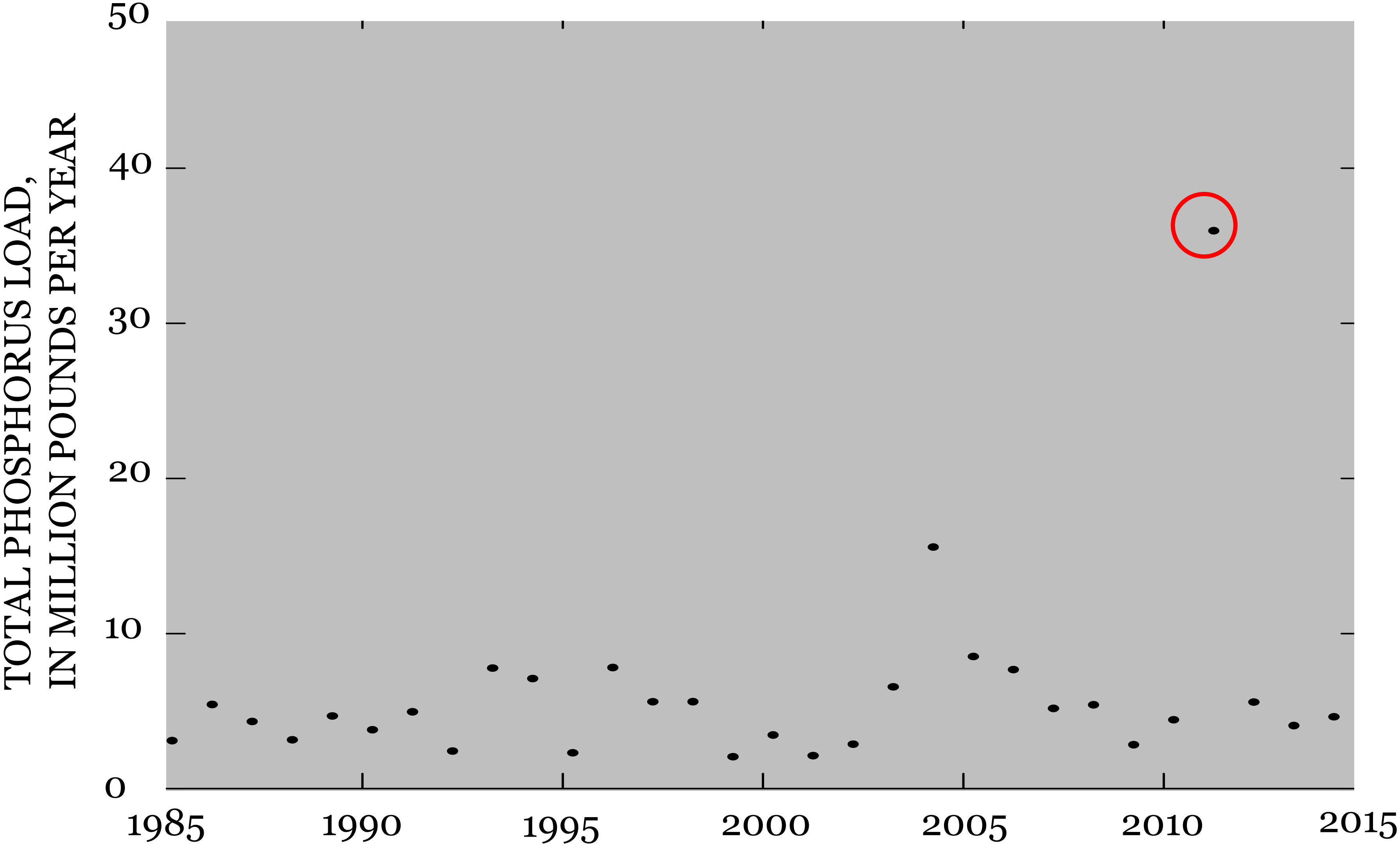
Joel Blomquist
U.S. Geological Survey
CBP Integrated Trends Analysis Team Co-Chair

Monitoring
Susquehanna River at Conowingo

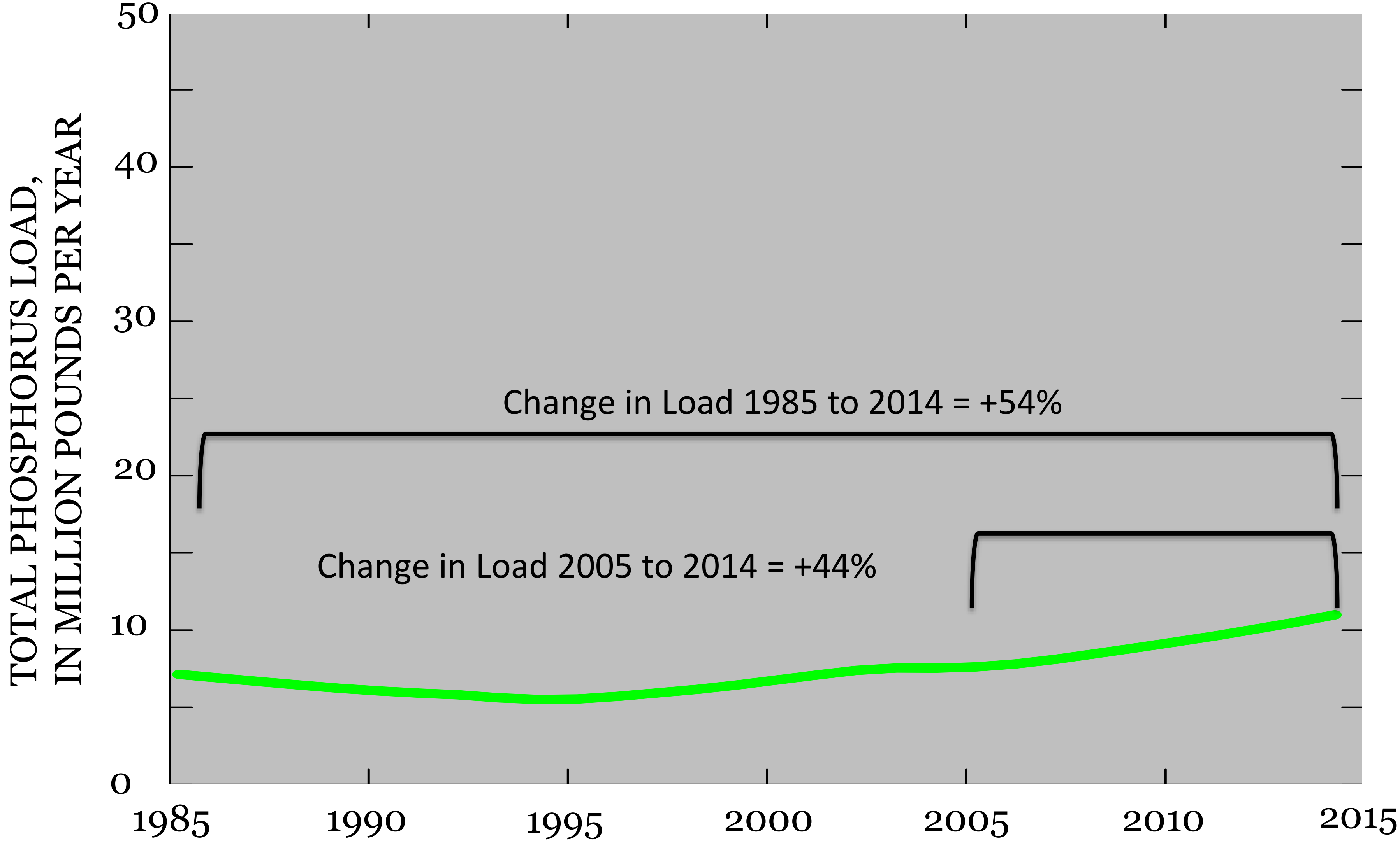


Total Phosphorus Annual Load

Susquehanna River at Conowingo



Flow-Normalized Phosphorus Load
Susquehanna River at Conowingo



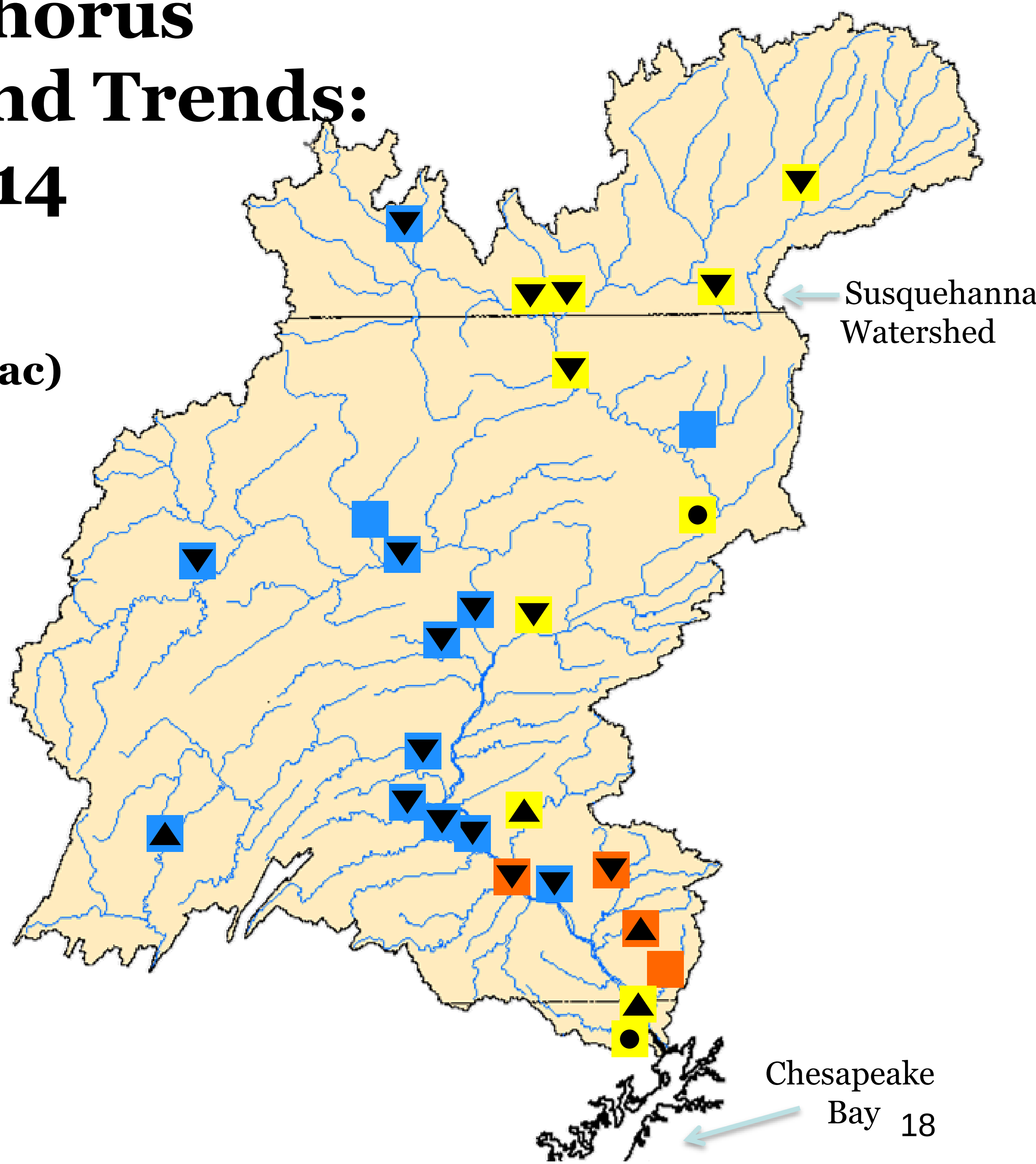
Total Phosphorus per Acre Loads and Trends: 2005-2014

Average Load (lbs/ac)

- 0.13- 0.50
- 0.51– 1.00
- 1.01– 2.31

Trend Direction

- ● No Trend
- ▼ Improving
- ▲ Degrading



Source: http://cbrim.er.usgs.gov/maps.html, Modified to highlight Susquehanna Watershed

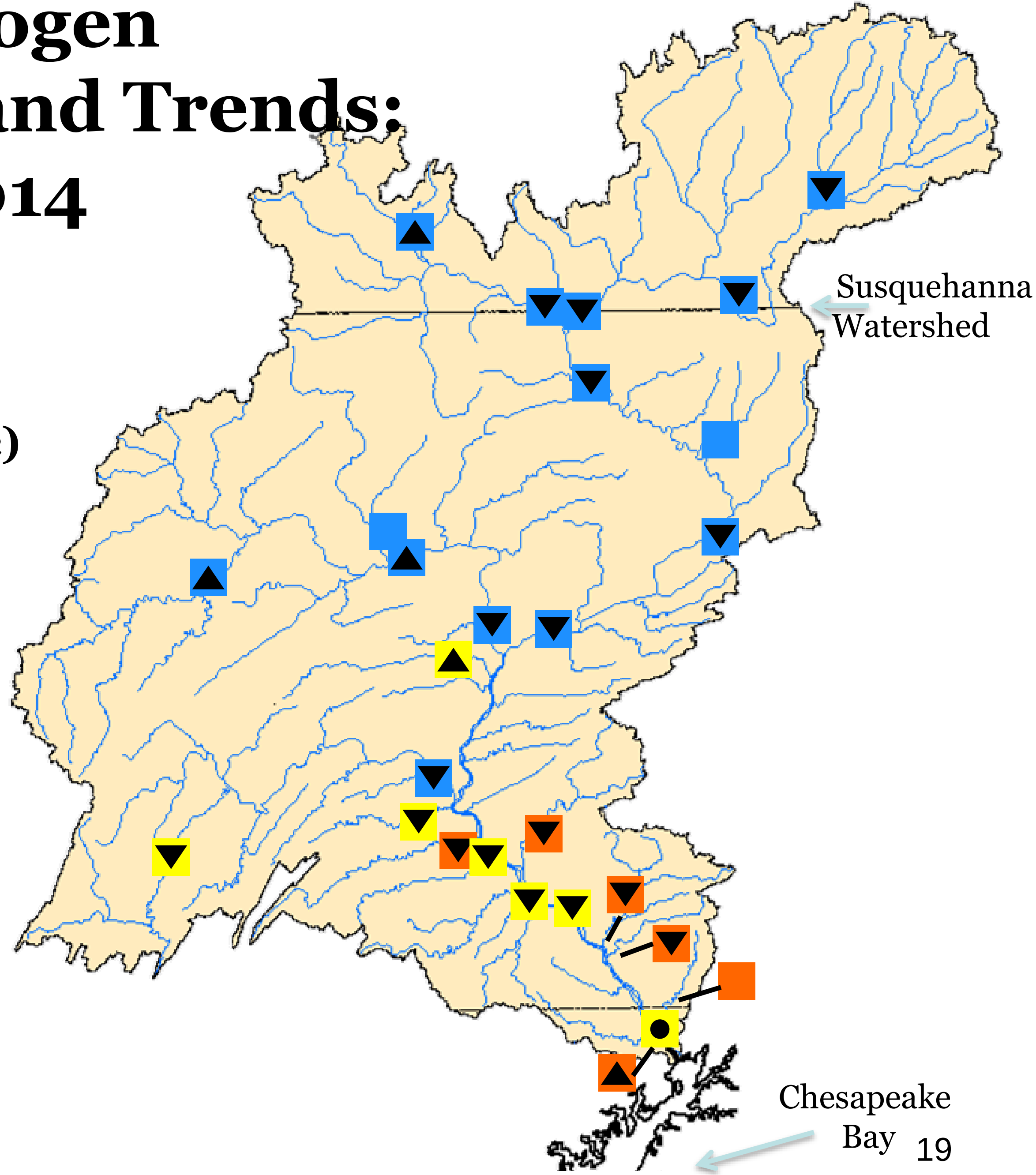
Total Nitrogen per Acre Loads and Trends: 2005-2014

Average Load (lbs/ac)

- 1.19 – 6.88
- 6.89– 13.75
- 13.76– 33.44

Trend Direction

- ● No Trend
- ▼ Improving
- ▲ Degrading



Source: http://cbrim.er.usgs.gov/maps.html, Modified to highlight Susquehanna Watershed

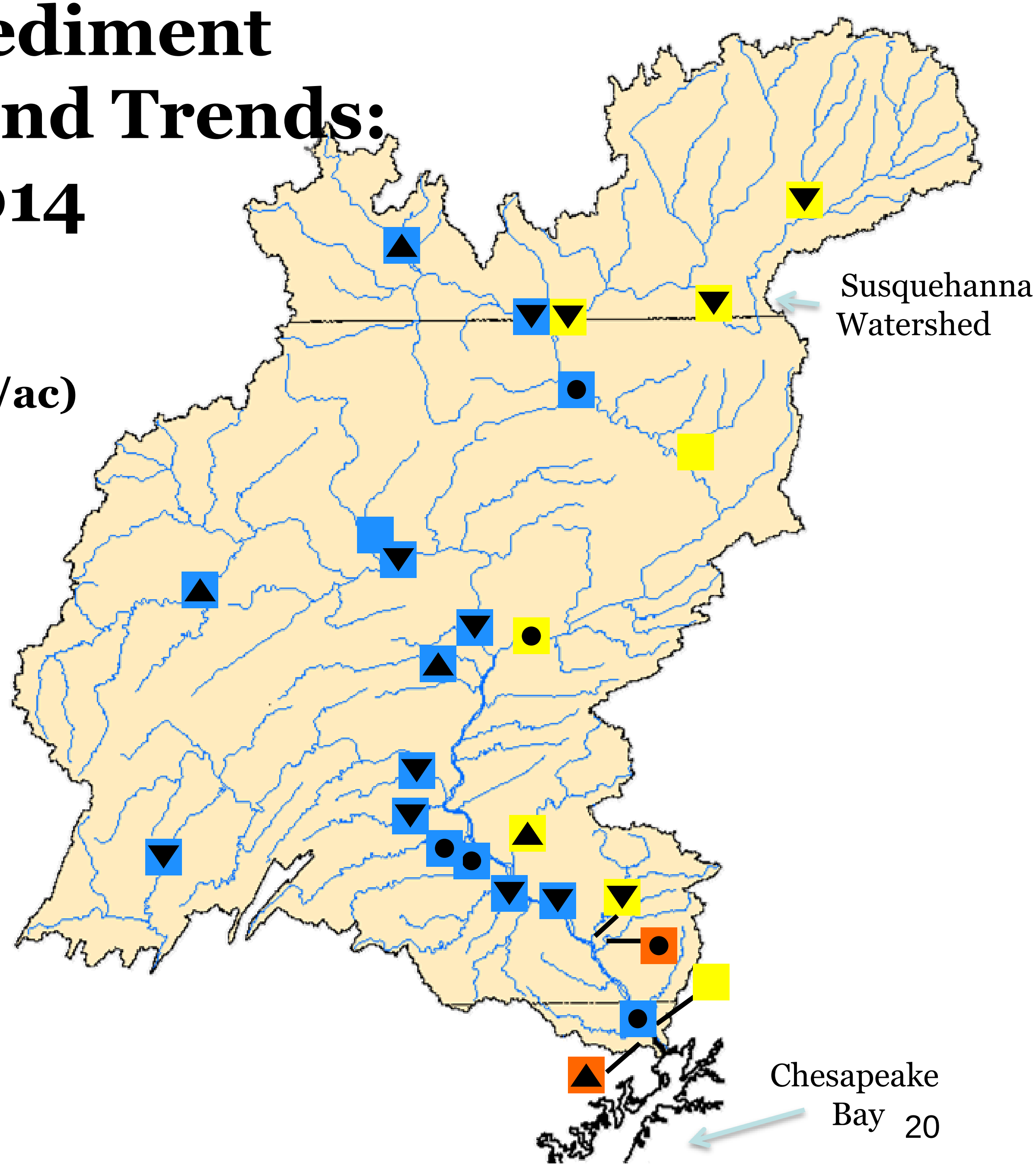
Suspended Sediment per Acre Loads and Trends: 2005-2014

Average Load (lbs/ac)

- 18 - 510
- 511 – 1,021
- 1,022 – 2,206

Trend Direction

- ● No Trend
- ▼ Improving
- ▲ Degrading

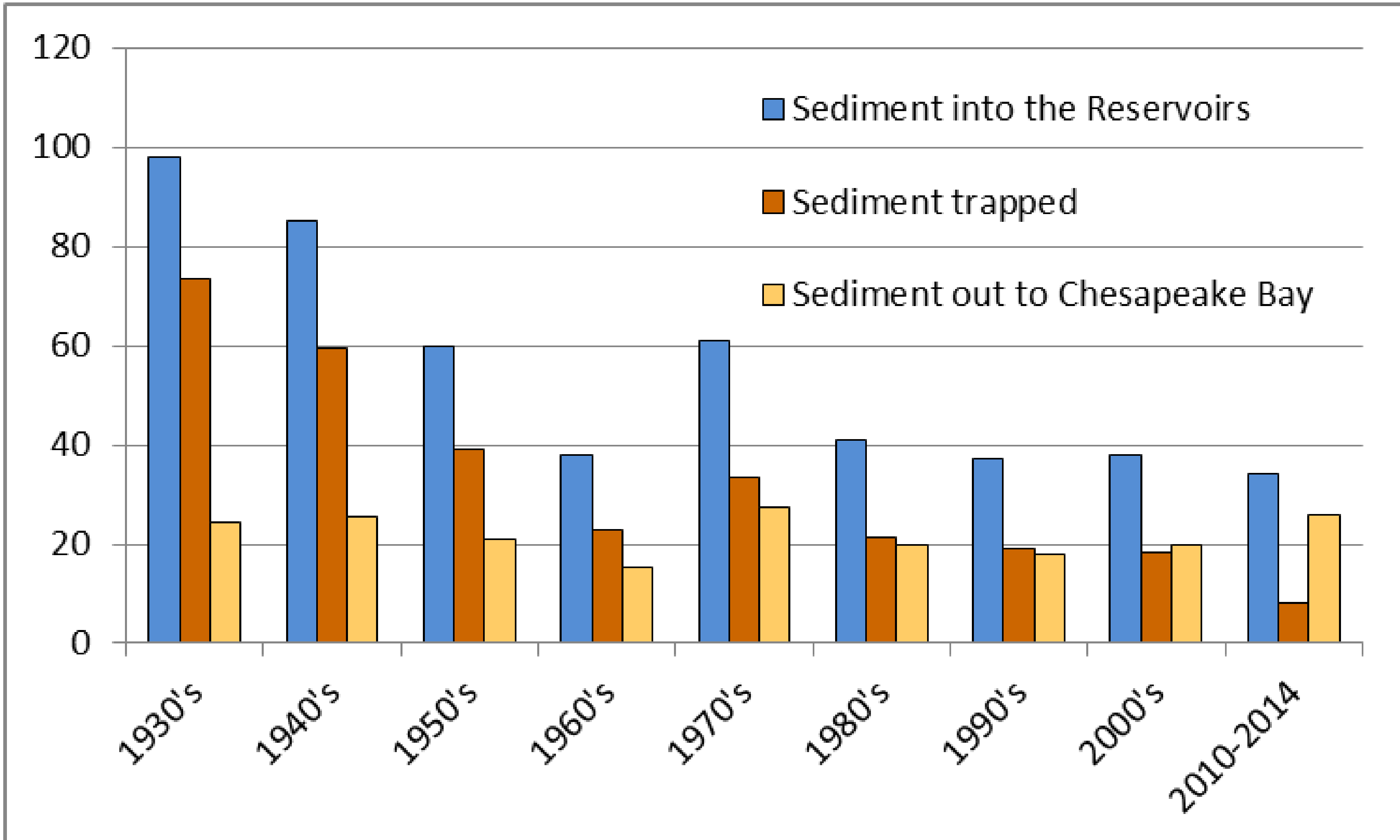


Source: Modified to highlight Susquehanna Watershed, results from http://cbrim.er.usgs.gov/maps.html

Better Understanding What's Happening in the System of Reservoirs

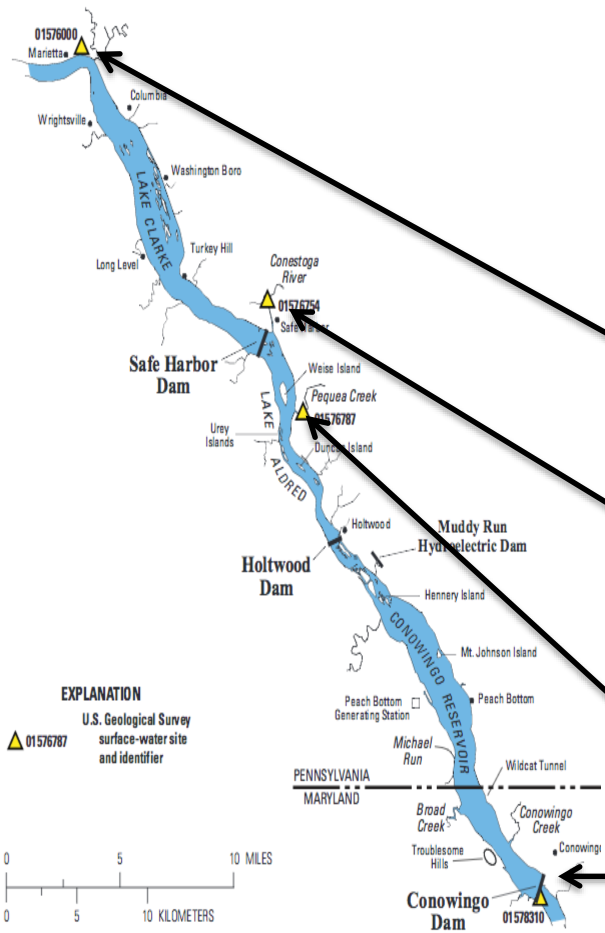
Dr. Robert Hirsch
U.S. Geological Survey
CBP Scientific and Technical Advisory Committee Member

Trapping Significantly Decreased over Last Century-Now Considered to be in Dynamic Equilibrium



Source: Langland 2016

Nutrient and Sediment Loading Trends into and Out of the Reservoir System (1985 to 2014)

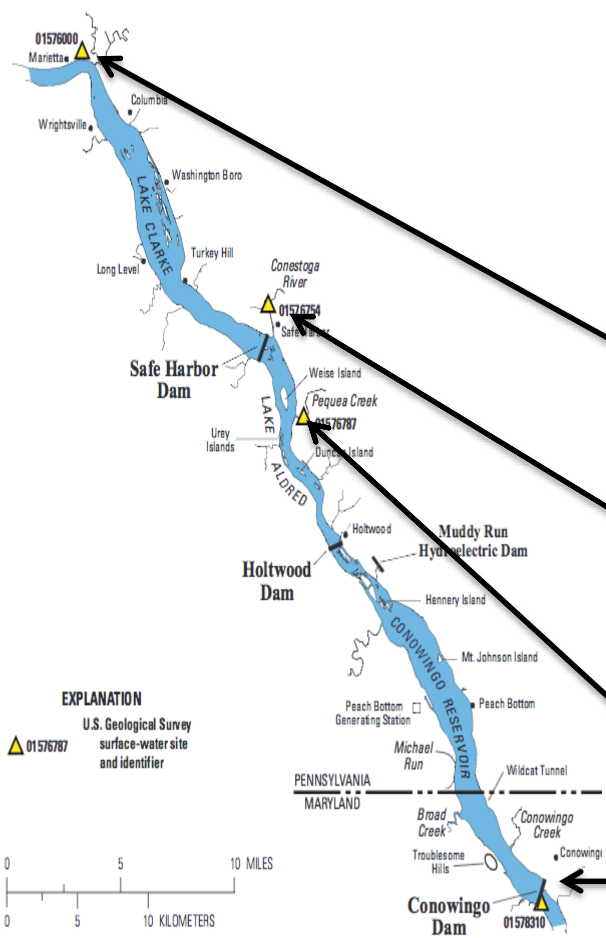


Long-Term Monitoring Trends			
Monitoring Station Name	**Total Nitrogen**	**Total Phosphorus**	**Sediment**
Susquehanna at Marietta	↓	↓	↓
Conestoga River	↓	↓	↓
Pequea Creek	*	*	*
Susquehanna at Conowingo	↓	↑	↑

↓ - improving ↑ - degrading

Source: USGS Trend Results published to internet in 2016
* WQ data record not long enough for establishing trends

Nutrient and Sediment Loading Trends into and Out of the Reservoir System (2005 to 2014)



Recent Monitoring Trends			
Monitoring Station Name	**Total Nitrogen**	**Total Phosphorus**	**Sediment**
Susquehanna at Marietta	↓	↓	↓
Conestoga River	↓	↓	↓
Pequea Creek	↓	↑	?
Susquehanna at Conowingo	?	↑	?

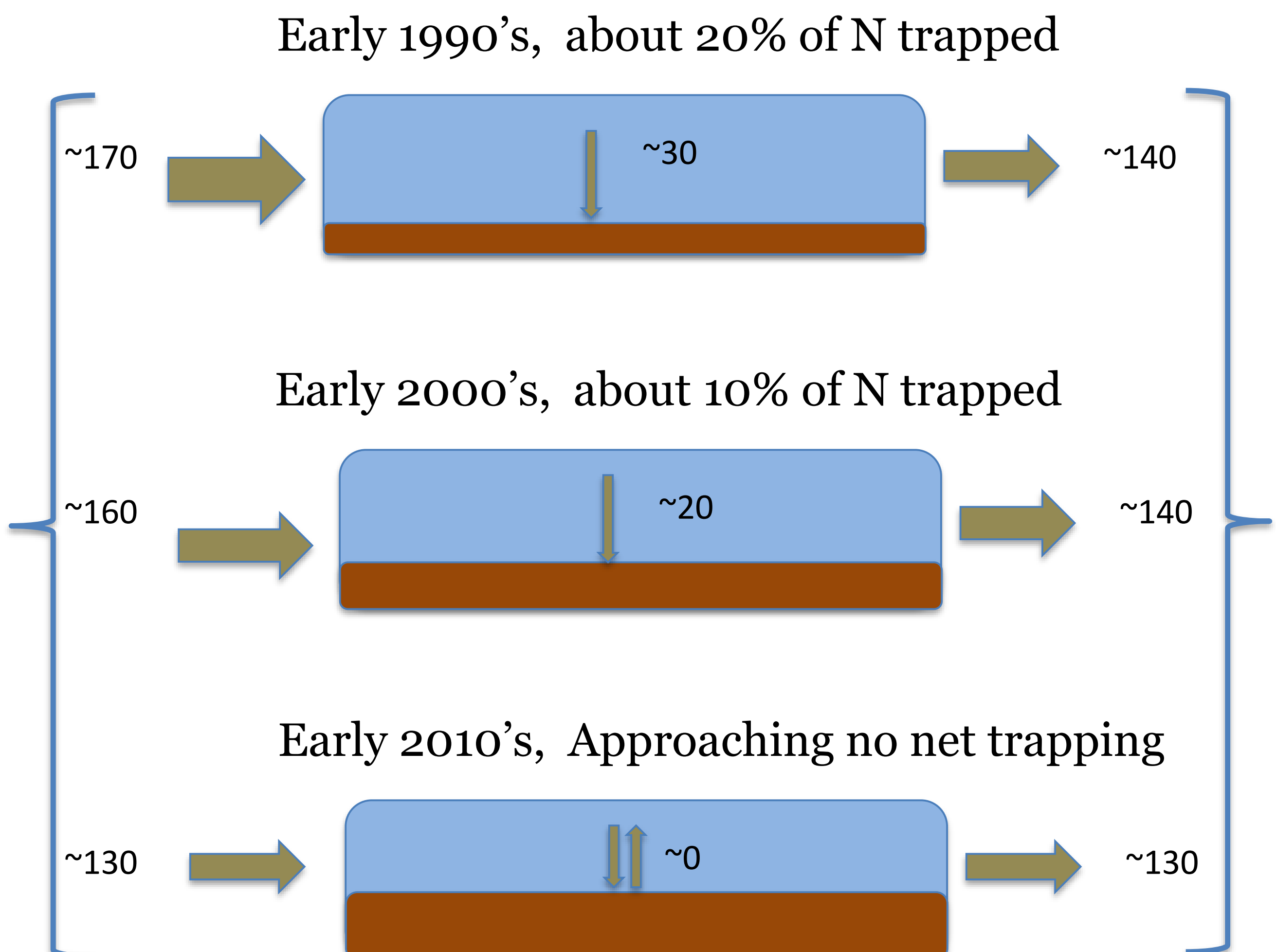
↓ - improving ↑ - degrading

Source: USGS Trend Results published to internet in 2016
? Indicates that trend analysis was inconclusive

Nitrogen Loads Into, Trapped Within and Exiting the Reservoir System: 1990s-2010s

<u>Loads Into Reservoir System</u>

Long term improving trend



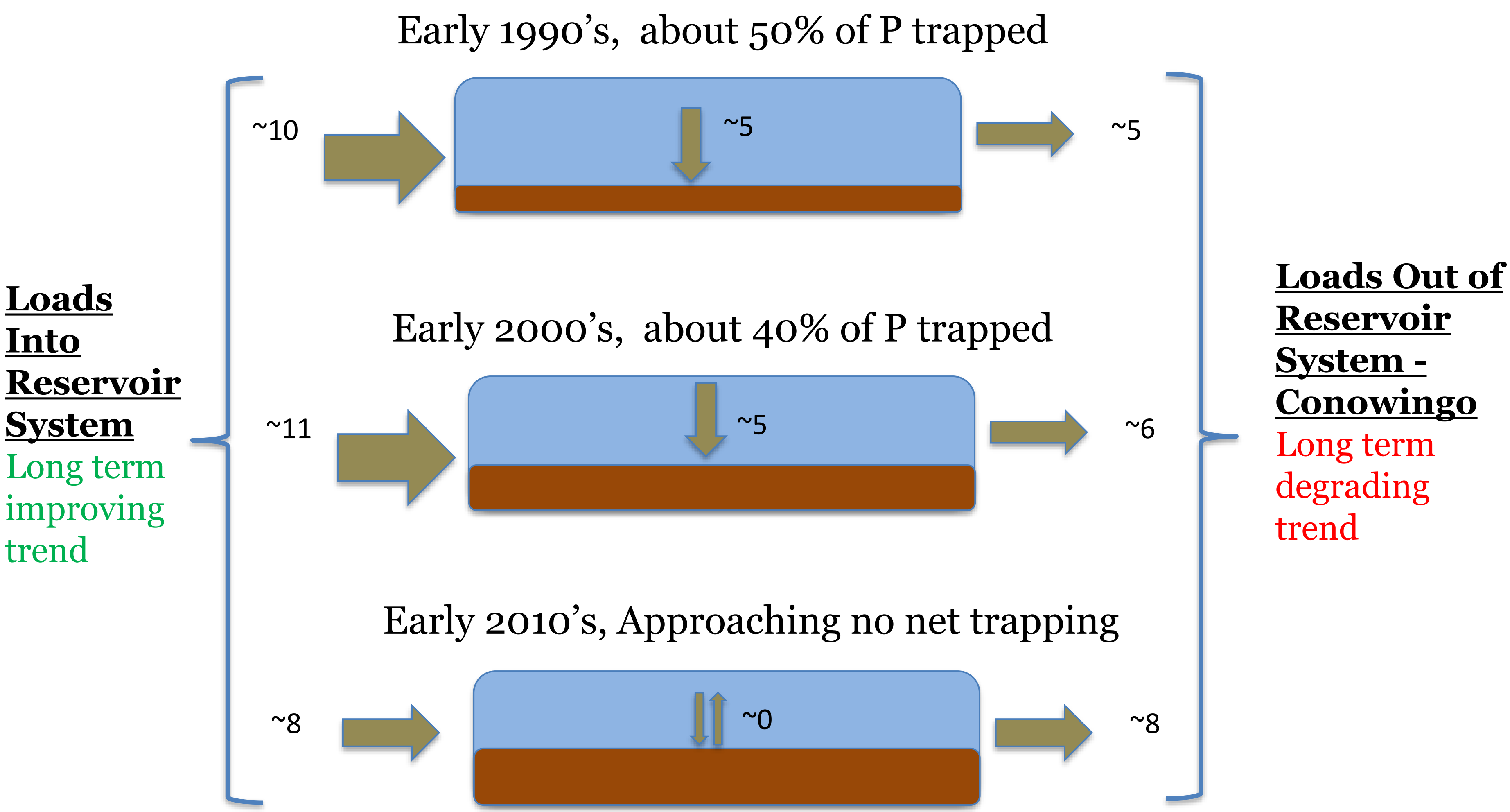
<u>Loads Out of Reservoir System - Conowingo</u>

long term improving trend

Source: Data from USGS (2016), http://cbrim.er.usgs.gov/loads_query.html

loads are approximate and in units of million lbs/year using estimates for 1992, 2002, and 2012

Phosphorus Loads Into, Trapped Within and Exiting the Reservoir System: 1990s-2010s

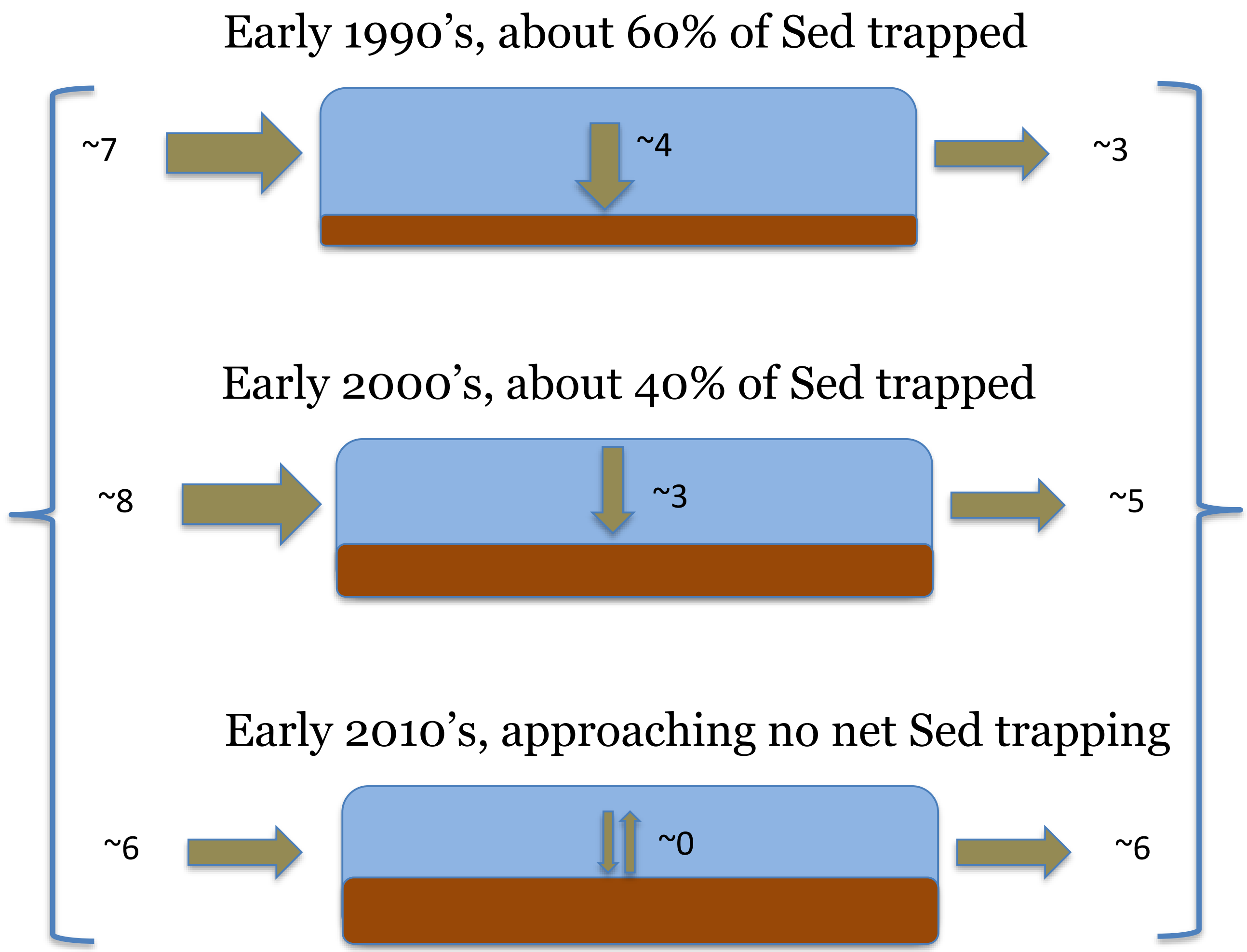


Source: Data from USGS (2016), http://cbrim.er.usgs.gov/loads_query.html
loads are approximate and in units of million lbs/year using estimates for 1992, 2002, and 2012

Sediment Loads Into, Trapped Within and Exiting the Reservoir System: 1990s-2010s

<u>Loads Into Reservoir System</u>

Long term improving trend



<u>Loads Out of Reservoir System - Conowingo</u>

Long term degrading trend

Source: Data from USGS (2016), http://cbrim.er.usgs.gov/loads_query.html
loads are approximate and in units of billion lbs/year using estimates for 1992, 2002, and 2012

What's Happening in the System of Reservoirs: A Summary

- For all three variables Total Nitrogen, Total Phosphorus, and Suspended Sediments the net trapping by the reservoir system has gone to approximately zero in the last decade or so.

- Net trapping is likely to remain at that level in the future.

- As a consequence the trends towards decreased loads in all three variables for the inputs result in either level or increased loads at the bottom of the system.

- Future decreases in loads into the system can be expected to lead to decreases at the bottom of the system because in the future long-term mean output is likely to equal long-term mean input.

- This history of changing system storage behavior provides a basis for verifying the formulation of the reservoir reach processes in the phase 6 watershed model.

Reminder:

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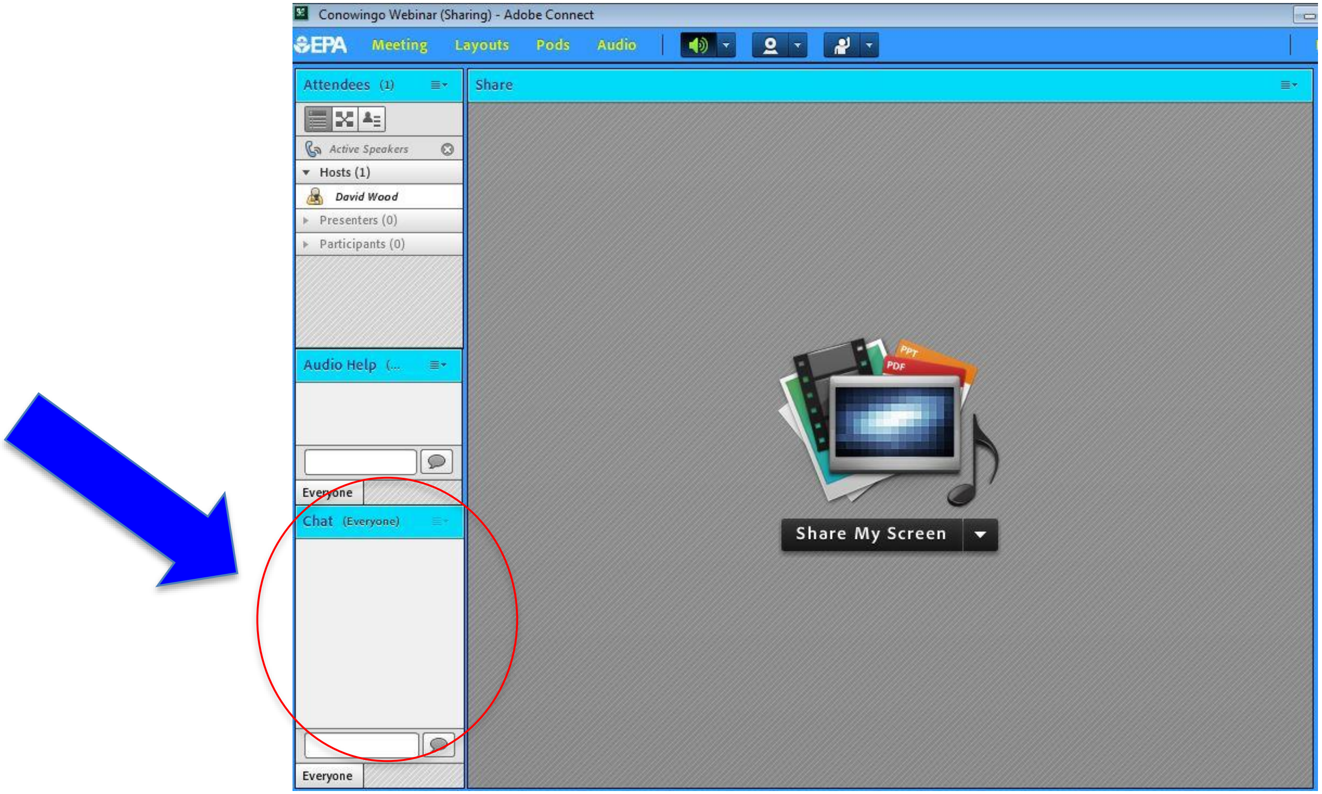
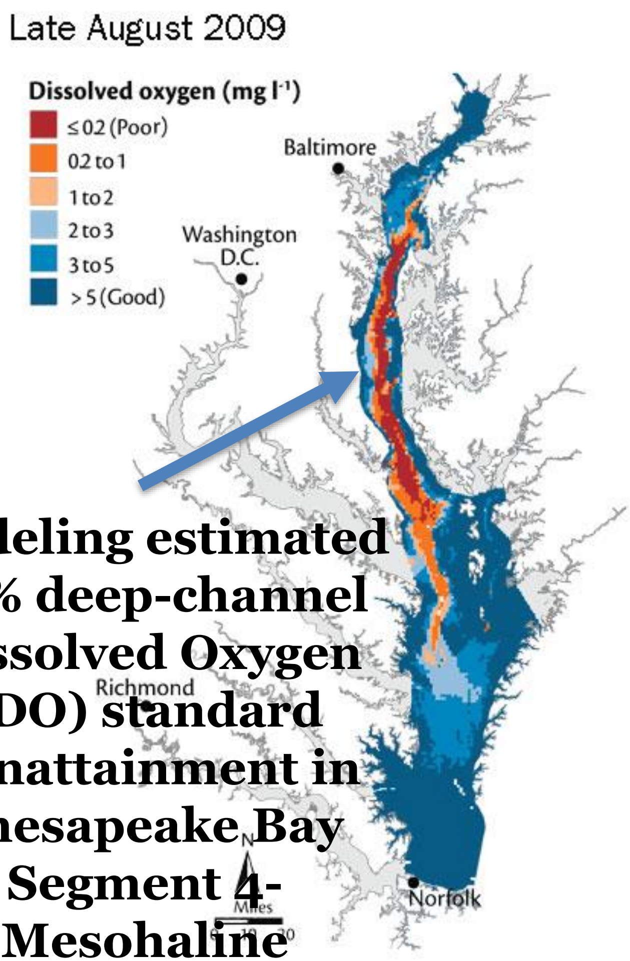


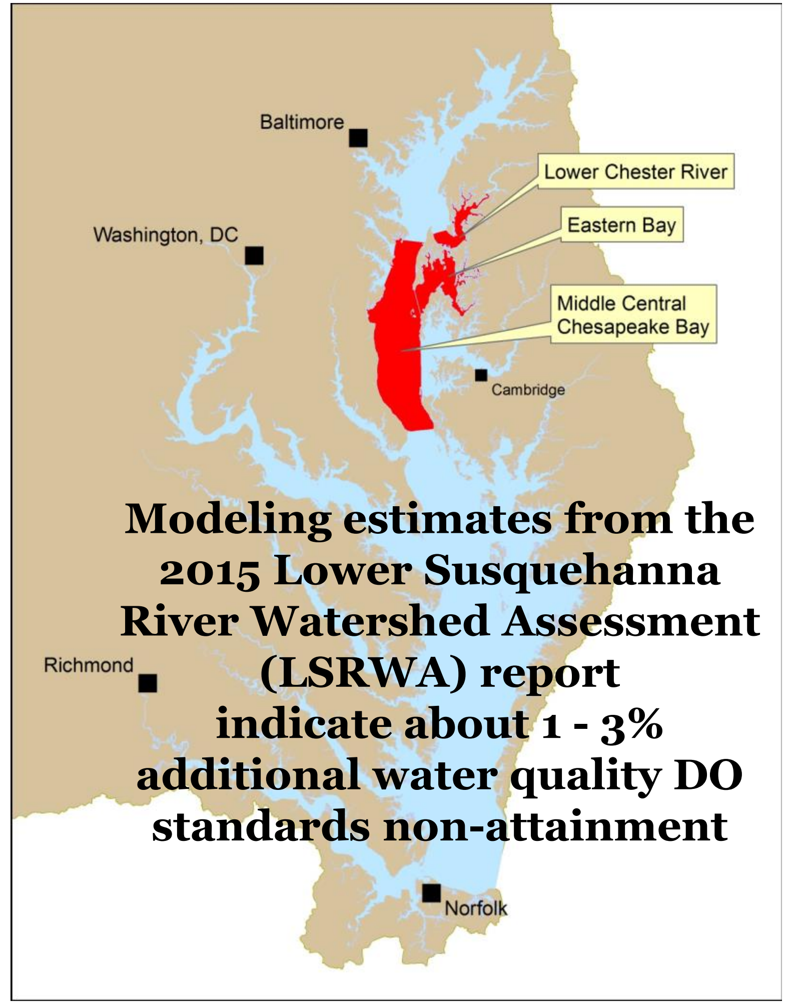
Implications for the Jurisdictions' Phase III WIPs Planning Targets

Lee Currey
Maryland Department of the Environment
CBP Modeling Workgroup Co-Chair

Nutrients Associated with Sediments No Longer Trapped in the Conowingo Reservoir are Influencing Bay WQ



Modeling estimated 23% deep-channel Dissolved Oxygen (DO) standard nonattainment in Chesapeake Bay Segment 4-Mesohaline



Modeling estimates from the 2015 Lower Susquehanna River Watershed Assessment (LSRWA) report indicate about 1 - 3% additional water quality DO standards non-attainment

Source: Linker et al. (2016), LSRWA (2015)

The 2010 Chesapeake Bay TMDL said…

"EPA's intention is to assume the current trapping capacity will continue through the planning horizon for the TMDL (through 2025). The Conowingo Reservoir is anticipated to reach a steady state in 15 – 30 years, depending on future loading rates, scour events and trapping efficiency."

Source: Appendix T. Sediments behind the Susquehanna Dams Technical Documentation: Assessment of the Susquehanna River Reservoir Trapping Capacity and the Potential Effect on the Chesapeake Bay (U.S. EPA 2010)

The 2010 Chesapeake Bay TMDL said…

"Under these assumptions, the waste load allocations (WLA) and load allocations (LA) would be based on the current conditions at the dam."

Source: Appendix T. Sediments behind the Susquehanna Dams Technical Documentation: Assessment of the Susquehanna River Reservoir Trapping Capacity and the Potential Effect on the Chesapeake Bay (U.S. EPA 2010)

The 2010 Chesapeake Bay TMDL said…

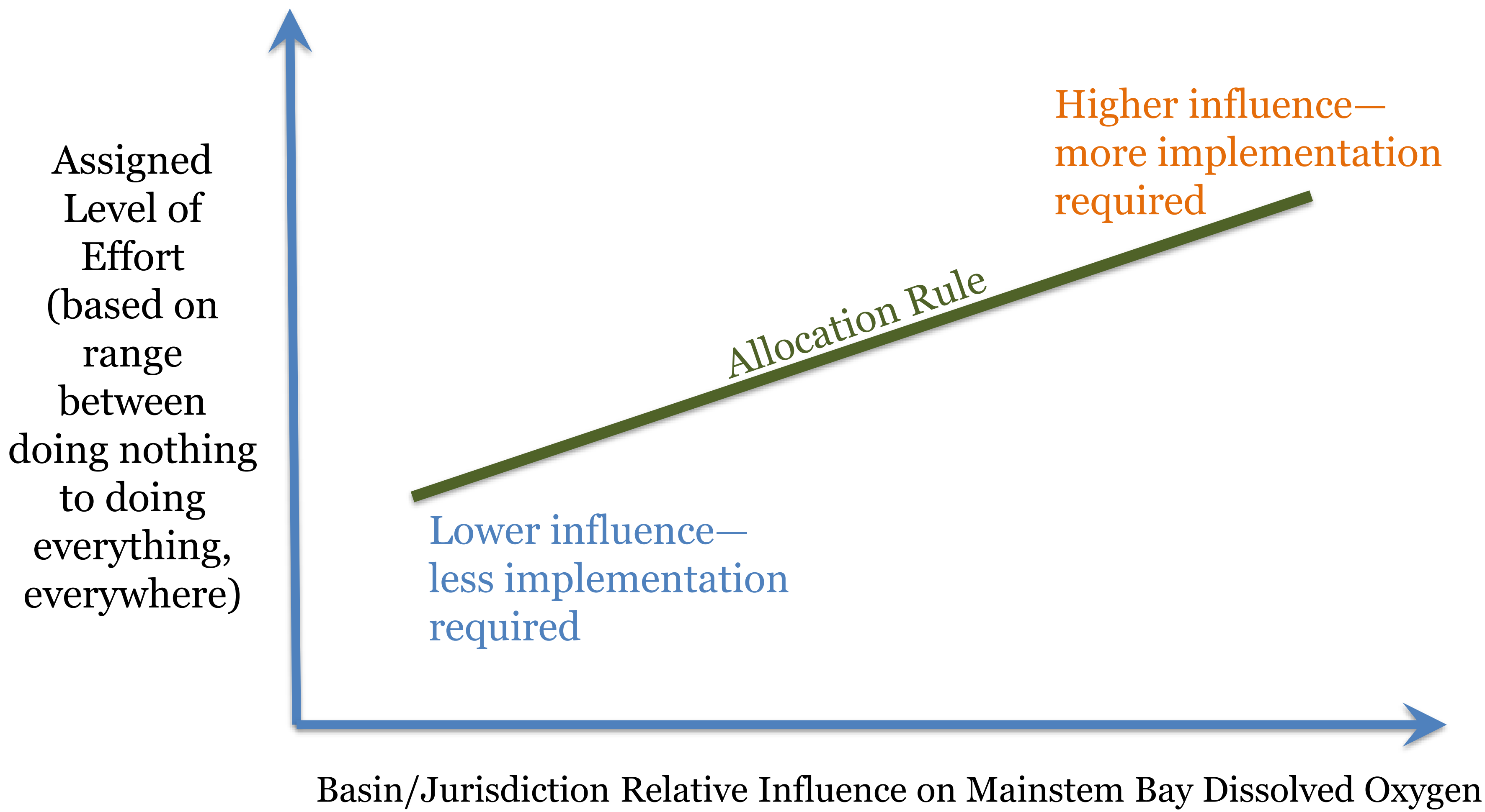
"If future monitoring shows the trapping capacity of the dam is reduced, then EPA would consider adjusting the Pennsylvania, Maryland and New York 2-year milestone loads based on the new delivered loads. The adjusted loads would be compared to the 2-year milestone commitments to determine if the states are meeting their target load obligations."

Source: Appendix T. Sediments behind the Susquehanna Dams Technical Documentation: Assessment of the Susquehanna River Reservoir Trapping Capacity and the Potential Effect on the Chesapeake Bay (U.S. EPA 2010)

How Does Infill Influence 2010 Bay TMDL Allocation Principles to Set Jurisdiction Targets

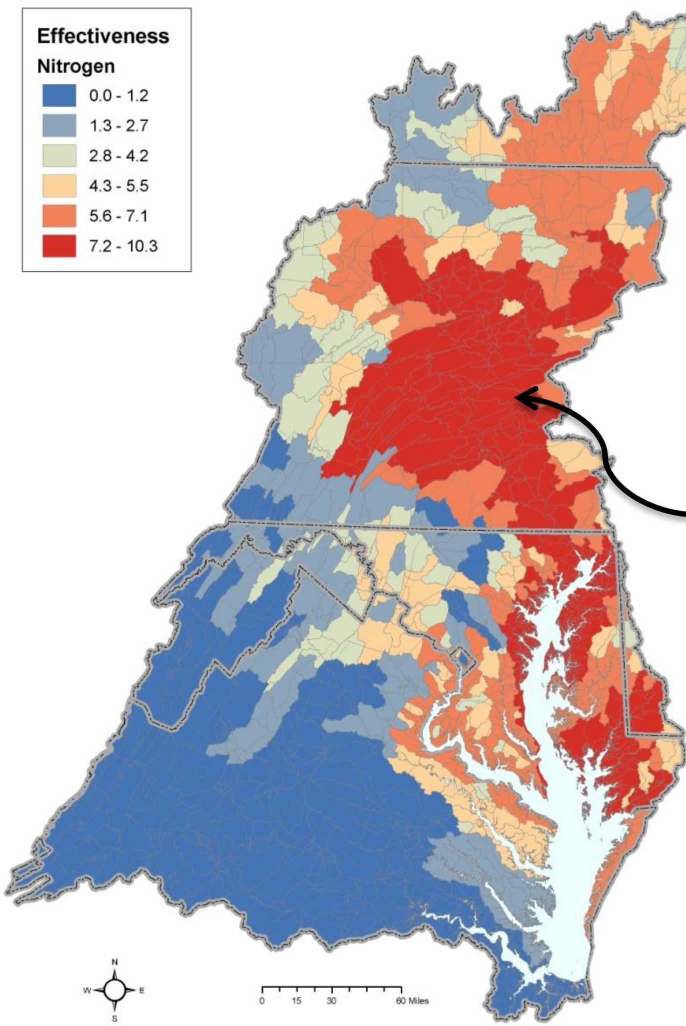
- Allocated loads will result in achievement of the states' Chesapeake Bay water quality standards
- Areas that contribute the most to the Bay water quality problems must do the most to resolve those problems (on a pound-per-pound basis)
- All tracked and reported reductions in nitrogen and phosphorus loads are credited toward achieving final assigned loads
- Special considerations for the headwater states
- Principles implemented through modeling tools

Allocation Methodology Used to Divide the Cap Loads Among Jurisdictions

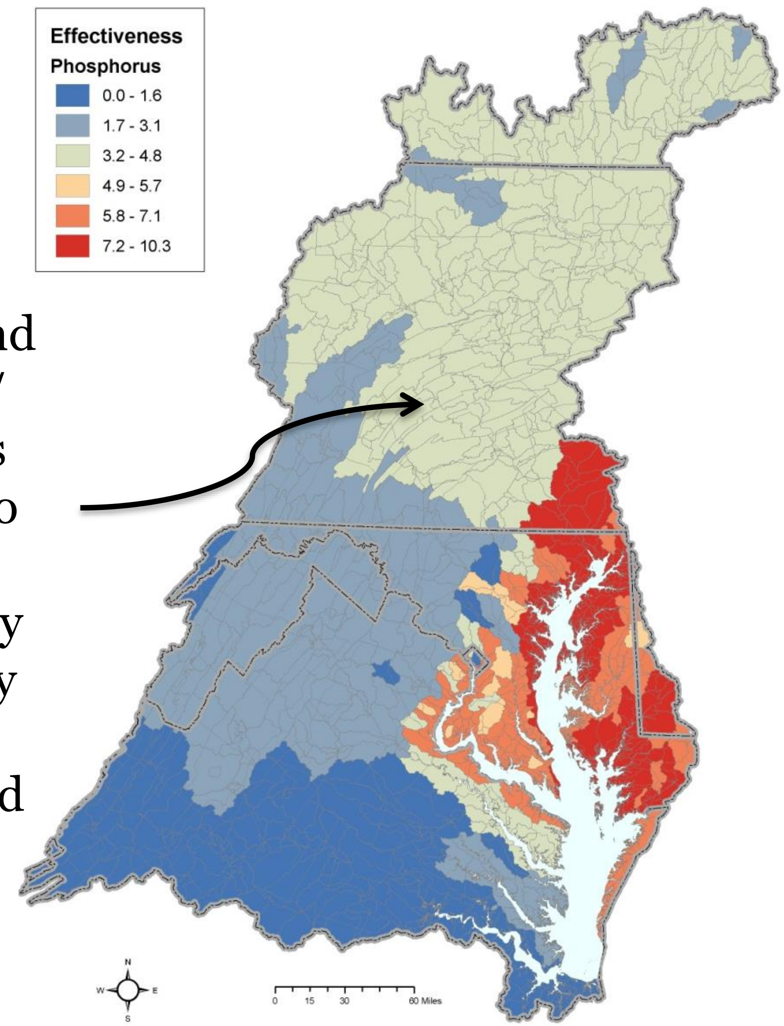


Source: U.S. EPA 2010

Relative Influence on Bay Dissolved Oxygen Changing as a Result of Reservoir Infill



Less trapping and more nutrient/ sediment loads may translate to higher relative influence on Bay water quality by Susquehanna River Watershed loads



Source: U.S. EPA 2010

Impact of Extreme Flow Events on Chesapeake Bay Water Quality Standards Attainment

"[The Bay TMDL's] 10-year return period captures a good balance between guarding against extreme events and ensuring attainment during more frequent critical events"

- Extreme events have impacts but are relatively rare
- Timing of the events is important
- Water clarity recovers relatively quickly
- Resiliency between events important for recovery

Source: Appendix G. Determination of Critical Conditions for the Chesapeake Bay TMDL Introduction (U.S. EPA 2010)

Improving our Decision Support Tools to Better Understand Reservoir System Responses to Management Actions

Lew Linker
U.S. Environmental Protection Agency
CBP Modeling Workgroup Coordinator

Improving the Decision Support Tools "The Models" for the 2017 Midpoint Assessment

- From STAC Workshop in Conowingo Infill:
  - "Conowingo models should be evaluated based on the ability to "hindcast" data from observations and statistical analyses, simulate the full range of flows, and address bioavailability of sediment nutrients"
- Applying multiple lines of evidence:
  - Statistical model results (WRTDS)
  - Physically based models (HEC-RAS2, Conowingo Pool Model (CPM))
  - Historic observations, measured bathymetry/infill, etc. provide additional sediment data for corroboration

Multiple Lines of Evidence for Simulating Conowingo Infill Conditions

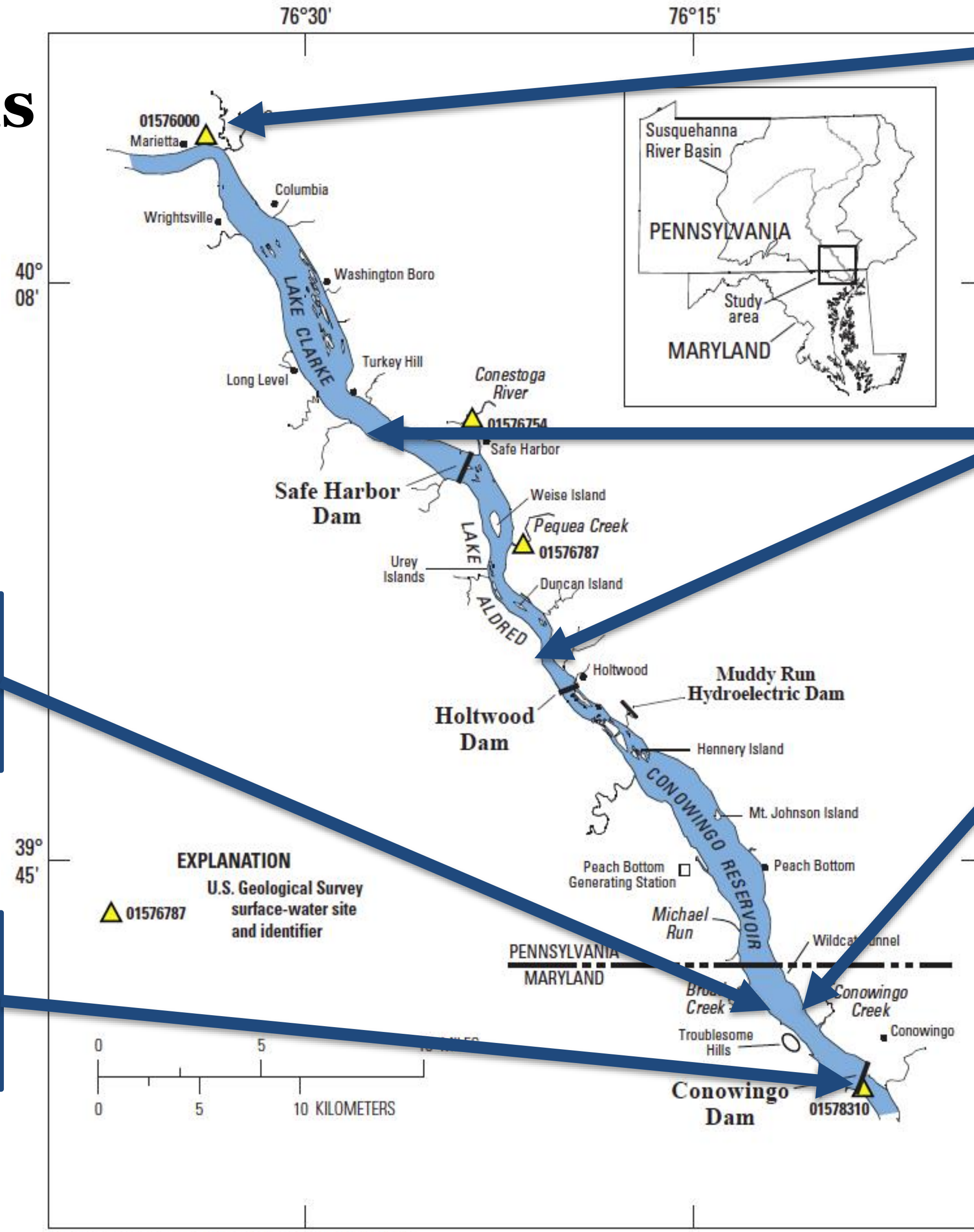
More data and new statistical model (WRTDS)

HEC-RAS2 Model of Holtwood and Safe Harbor

Physically based Conowingo Pool Model (CPM)

Five historic bathymetric surveys & recent core samples

More data and new statistical model

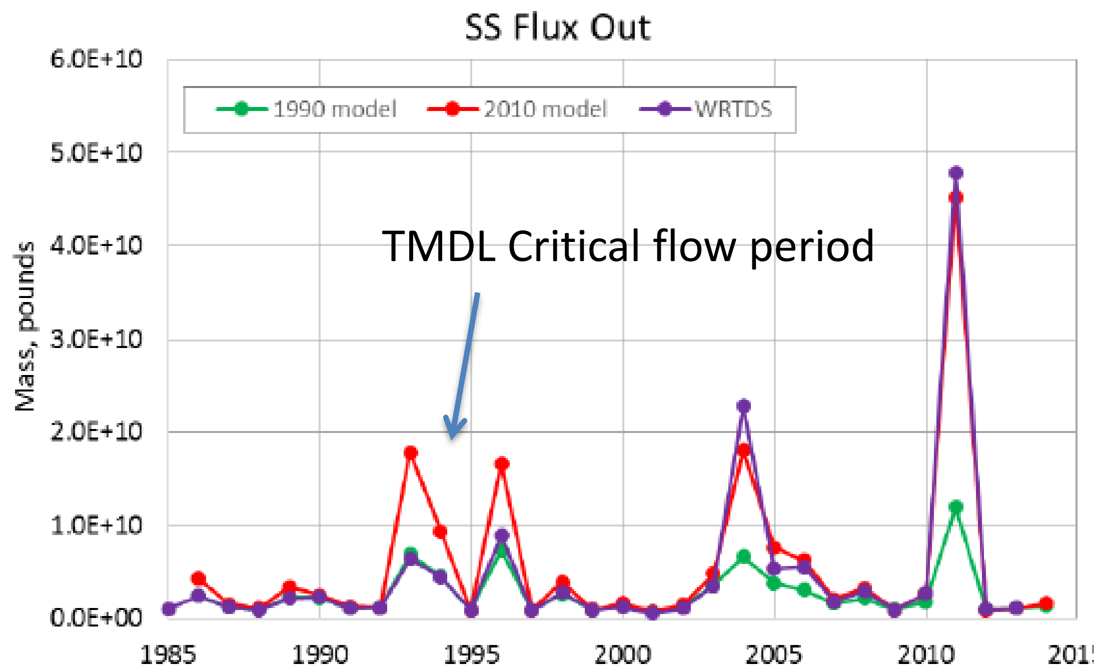


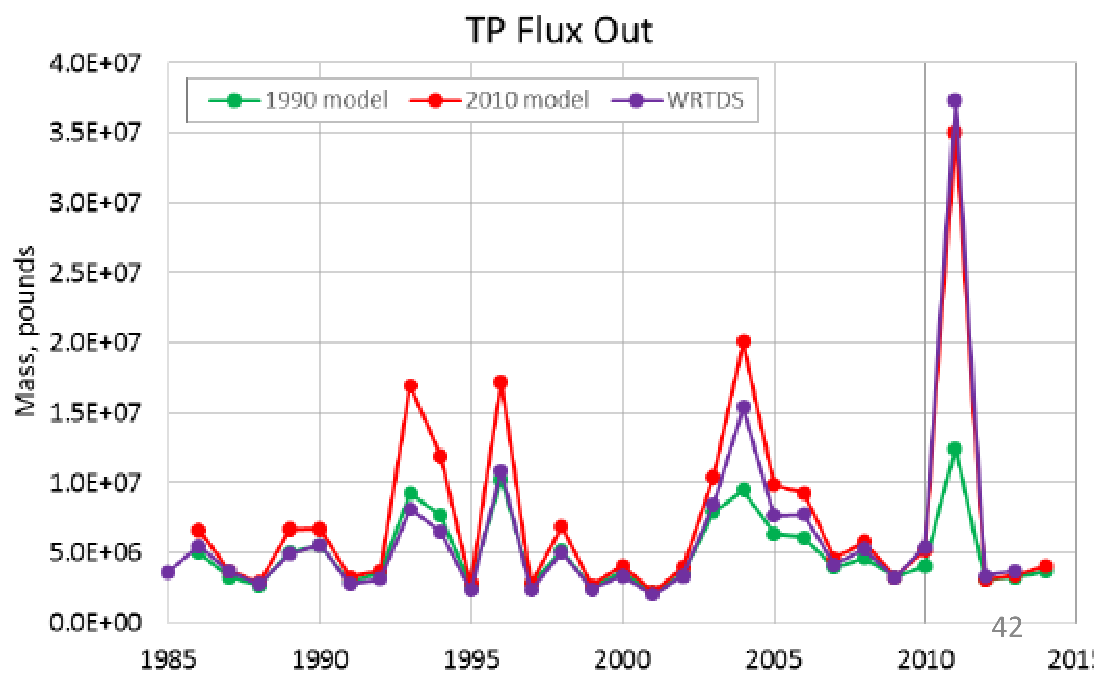
Base from U.S. Geological Survey 1:24,000-scale digital data

Source: Langland 2015

New Phase 6 reservoir model captures reservoir behavior under various flow & infill conditions.

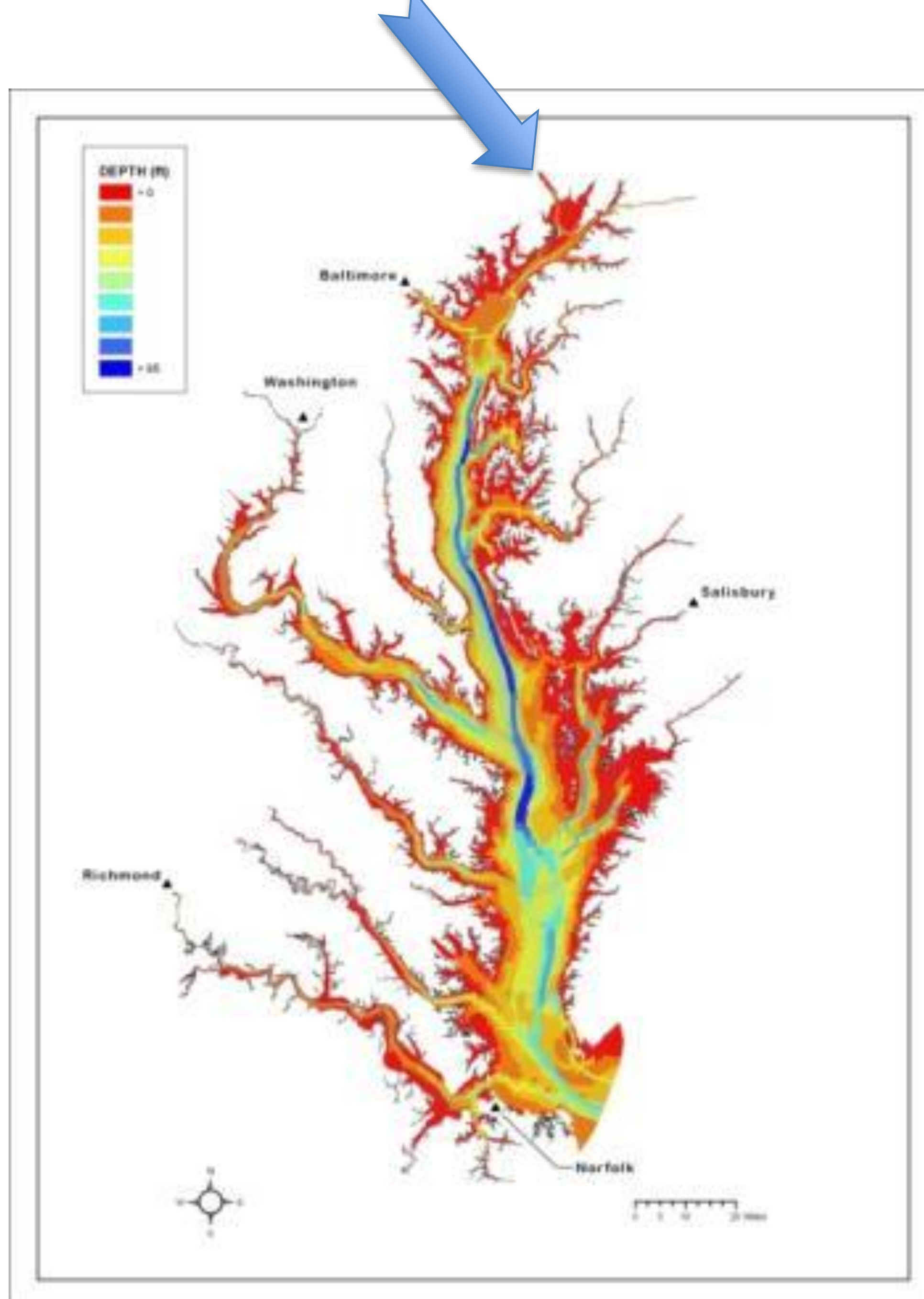
In addition, the biogeochemical reactivity of scoured material is represented.





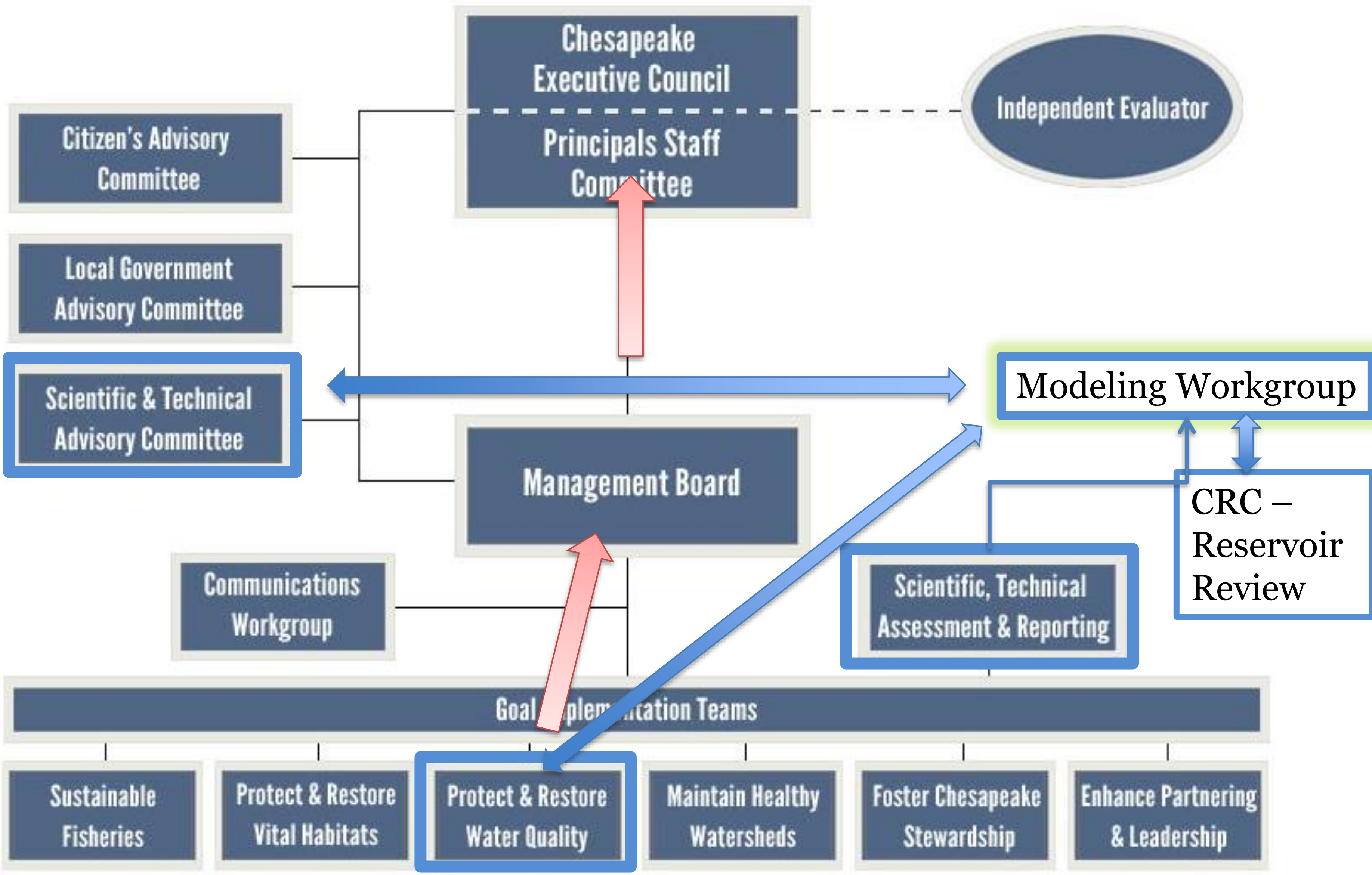
Chesapeake Bay Model

- New reservoir model provides improved input into Bay model.
- Bay model used to evaluate attainment of State water quality criteria.
- Refinements to biogeochemistry and factoring in recent monitoring are included.



Chesapeake Bay Water Quality and Sediment Transport Model

Review Process to Finalize the Modeling Tools and Communication to Senior Leadership



Take away Messages:

- The CBP Modeling Workgroup is factoring into the Phase 6 Model the latest research on Conowingo infill from the Geologic Survey (USGS), U. Maryland Center for Environmental Studies (UMCES), Hydroqual Inc., WEST Inc., and other sources.
- Additional information from UMCES research will be used to better represent the modeled Chesapeake tidal water response to particulate nutrient and sediment loads scoured from Conowingo sediment.
- Scientific peer reviews of the Conowingo infill research and its simulation by the CBP models will be conducted by the CBP Scientific and Technical Advisory Committee (STAC) and the Chesapeake Research Consortium (CRC).
- The CBP Models are under development with the current (*Beta* 3) version including most elements of the latest Conowingo research and the December 2016 (*Beta* 4) version to include the detailed Conowingo Pool Model. The results presented today will be refined going forward.

Key Findings to Date and Next Steps To Support Partnership Decision-Making

Lee Currey
Maryland Department of the Environment
CBP Modeling Workgroup Co-Chair

Take Away Messages

- Outputs from the Susquehanna basin has a significant influence on Chesapeake Bay water quality.
- The net reservoir trapping ability is near zero.
- Loss of net trapping ability has an effect on outputs of TN, TP, and SS, but the effect is greatest on SS and least on TN.
- New information available for factoring in the influence of particulate nutrients on Bay WQ

Take Away Messages

- The loss of net trapping has an impact on how upstream pollution management practices will translate into downstream impacts on water quality.

- The ability to model this change is challenging, but new data and research will result in improved ability to predict how watershed strategies will influence the ability to achieve the states' water quality standards.

- The majority of nutrients are transported to the Bay during moderately high flow periods.

- The key issue is not just scour during flood events, but is rather the net trapping over the entire range of hydrologic conditions

Conowingo Reservoir Infill Decision-Making Timeline

Three Key Sets of Partnership Decisions:

- **December 2016***: Which jurisdictions will be responsible for addressing the additional nutrient and sediment loads resulting from infill of the Conowingo Reservoir
- **May 2017***: How much additional nutrient and sediment loads must be addressed resulting from infill of the Conowingo Reservoir
- **December 2017**: Final Phase III WIP planning targets fully reflect best understanding of additional loads from infill of the Conowingo Reservoir

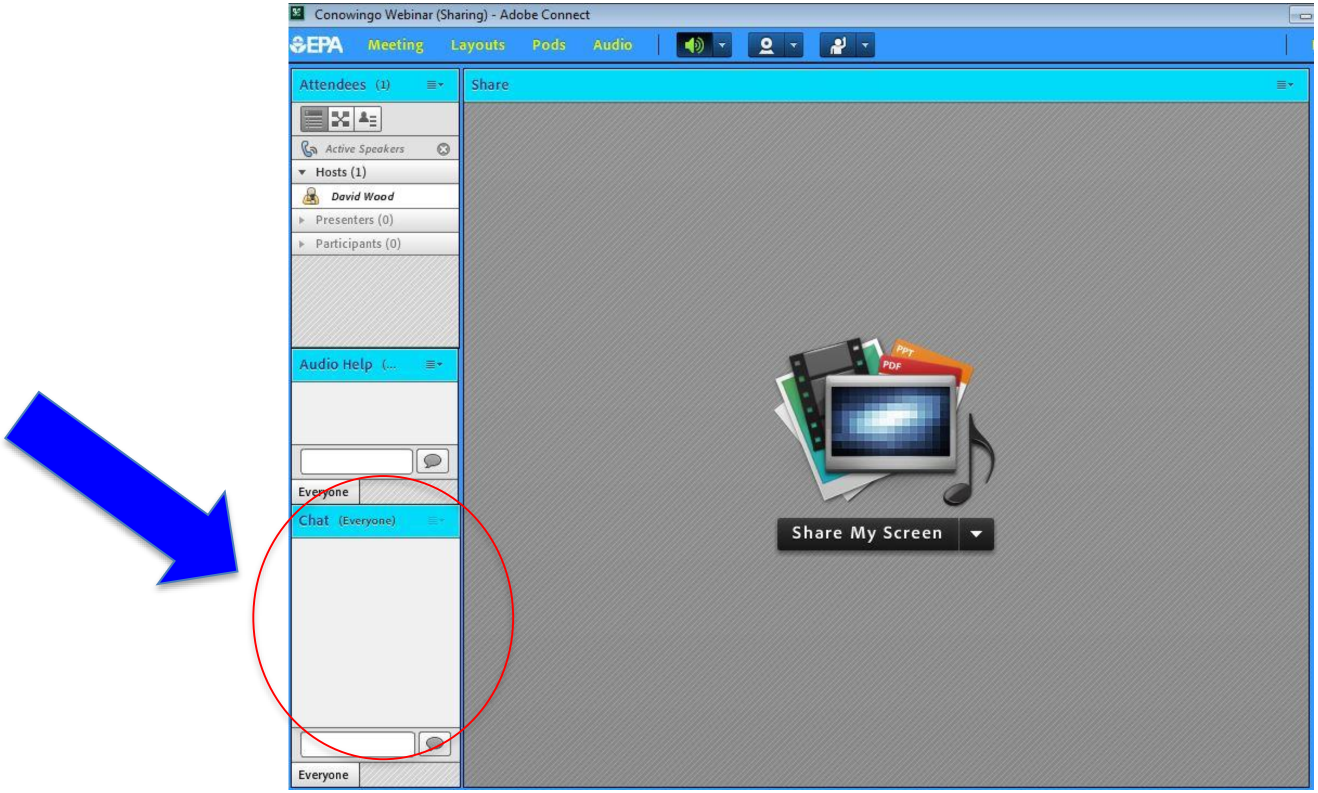
* Date of PSC approval – WQGIT and MB recommendations will be made in preceding months

Questions and Answers Session

David Wood
Chesapeake Research Consortium
CBP Water Quality Goal Implementation Team Staff

Questions and Answers Session

- To Ask a Question
  - Submit your question in the chat box, located in the bottom left of the screen.



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Access to Conowingo Reservoir Infill Webinar Recording

A recording of this webinar along with the presentation will be posted to the following page on the Chesapeake Bay Program Partnership's website:

https://www.chesapeakebay.net/what/programs/watershed_implementation