

Simulation of Conowingo Infill

Modeling Workgroup Quarterly Meeting

Gopal Bhatt

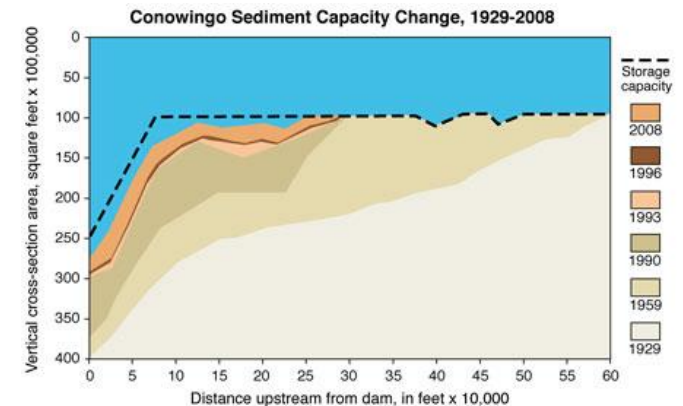
Penn State University

Presentation Outline

- Brief review
- Incorporation into HSPF
- Stationary model
- Simulation using Phase 6 Model
- A scenario

Brief Review of Conowingo Infill

- Conowingo is nearing dynamic equilibrium, which has reduced its ability to trap sediment and nutrients.
- Several research articles have documented it, and they provide an analysis of changes in transport, which are incorporated in this analysis.



Source: Graph, Michael Langland, U.S. Geological Survey



Sediment Transport and Capacity Change in Three Reservoirs, Lower Susquehanna River Basin, Pennsylvania and Maryland 1900-2012



Open-File Report 2014-1235

U.S. Department of the Interior
U.S. Geological Survey



Flux of Nitrogen, Phosphorus, and Suspended Sediment from the Susquehanna River Basin to the Chesapeake Bay during Tropical Storm Lee, September 2011, as an Indicator of the Effects of Reservoir Sedimentation on Water Quality



Scientific Investigations Report 2012-5185

U.S. Department of the Interior
U.S. Geological Survey



Long-Term Changes in Sediment and Nutrient Delivery from Conowingo Dam to Chesapeake Bay: Effects of Reservoir Sedimentation

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ABSTRACT: Reduction of suspended sediment (SS), and phosphorus (TP) and total nitrogen (TN) is important for the Chesapeake Bay watershed management. The Susquehanna River, the bay's largest tributary, has shown dramatic losses of SS, TP, and TN since the Conowingo Dam. Over the past 100 years, the river has been losing sediment, TP, and TN at rates that are not sustainable. To better understand the effects of sedimentation on the river, we conducted a long-term study of sediment, TP, and TN transport and delivery from the Conowingo Dam to the Chesapeake Bay. We used a combination of field measurements and modeling to estimate the sediment, TP, and TN transport and delivery from the Conowingo Dam to the Chesapeake Bay. Our results show that the Conowingo Dam has significantly reduced the sediment, TP, and TN transport and delivery to the Chesapeake Bay. This reduction has led to a decrease in the sediment, TP, and TN transport and delivery to the Chesapeake Bay, which has led to a decrease in the sediment, TP, and TN transport and delivery to the Chesapeake Bay. This reduction has led to a decrease in the sediment, TP, and TN transport and delivery to the Chesapeake Bay, which has led to a decrease in the sediment, TP, and TN transport and delivery to the Chesapeake Bay.

LOWER SUSQUEHANNA RIVER WATERSHED ASSESSMENT, MARYLAND AND PENNSYLVANIA



May 2015 Final



Review of the Lower Susquehanna Watershed Assessment



STAC Review Report
August 2014
Annapolis, Maryland



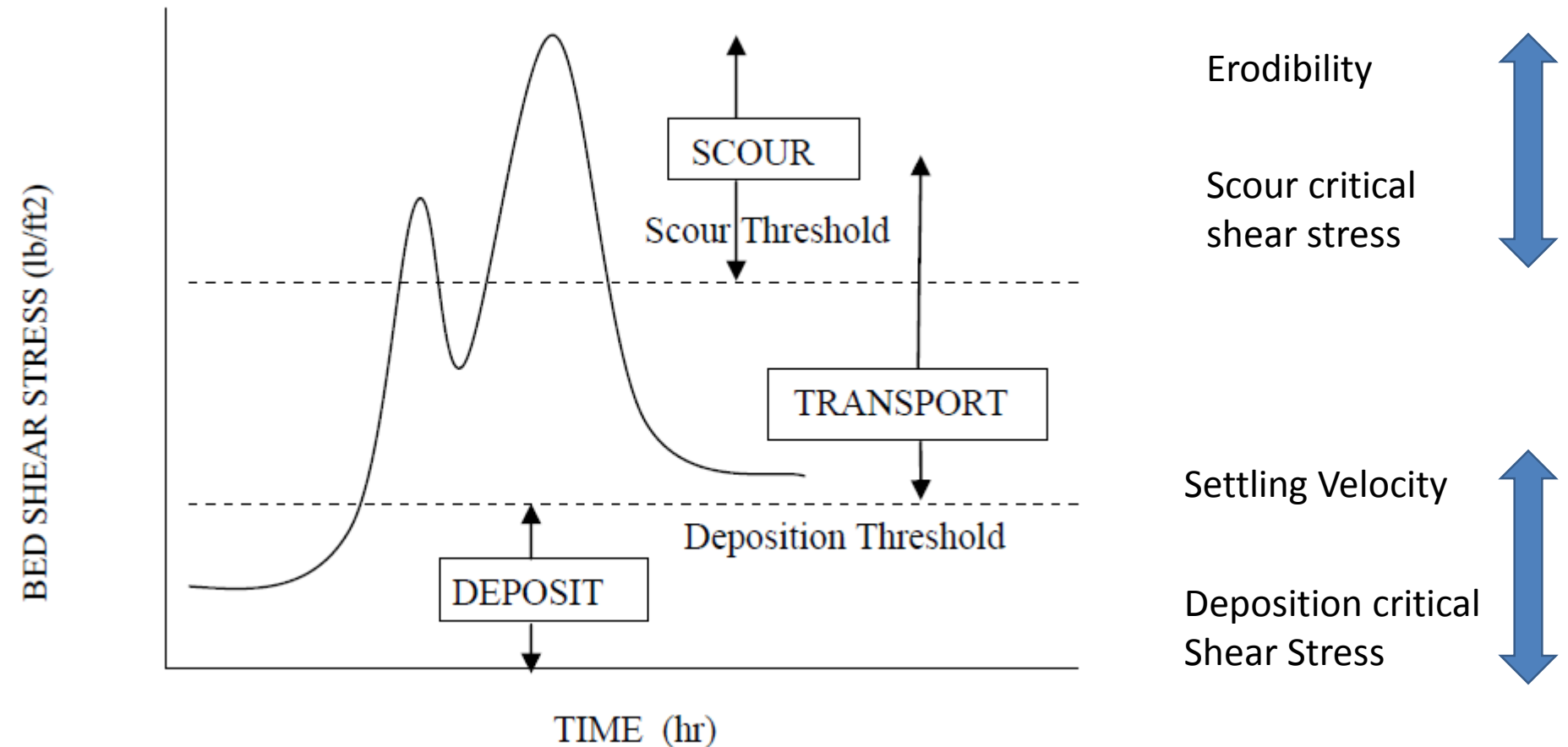
STAC Publication 14-006

STAC Guidance on Conowingo Infill

Paraphrasing...

- Conowingo models should be evaluated based on the ability to “hindcast” data from observations and statistical analyses
- Address the full range of flows
- Address bioavailability of sediment nutrients

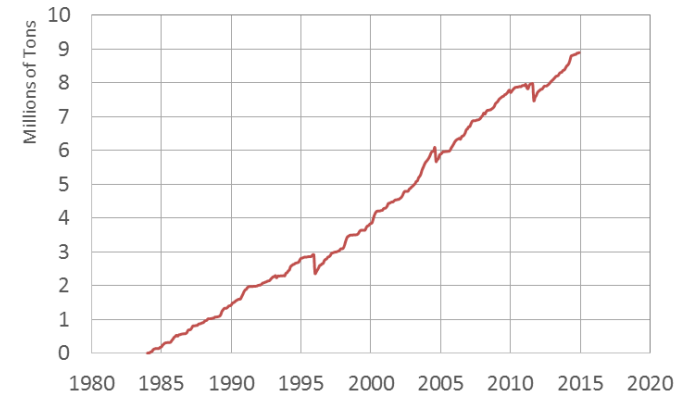
HSPF SEDTRN simulation



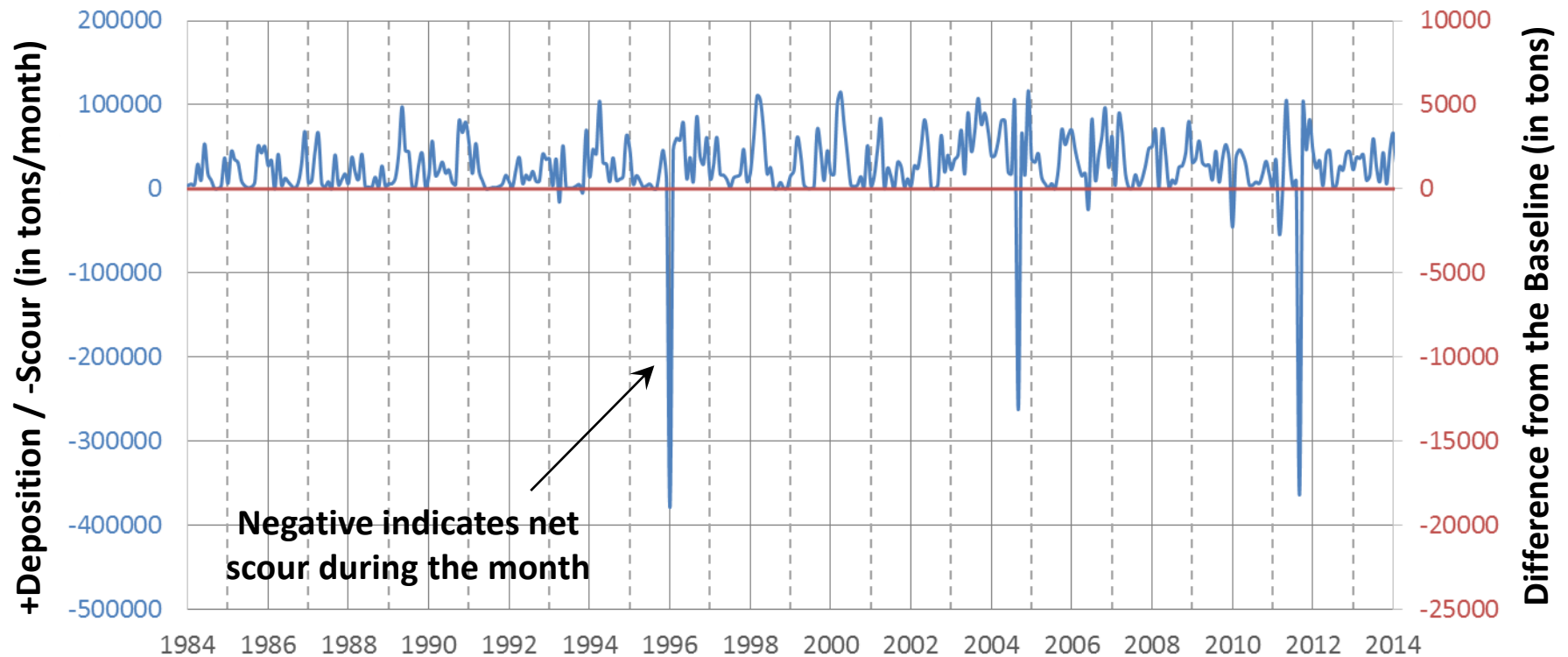
τ_{CD} , τ_{CS} , Erodibility, and Settling Velocity are all changeable through time.

Baseline Calibration

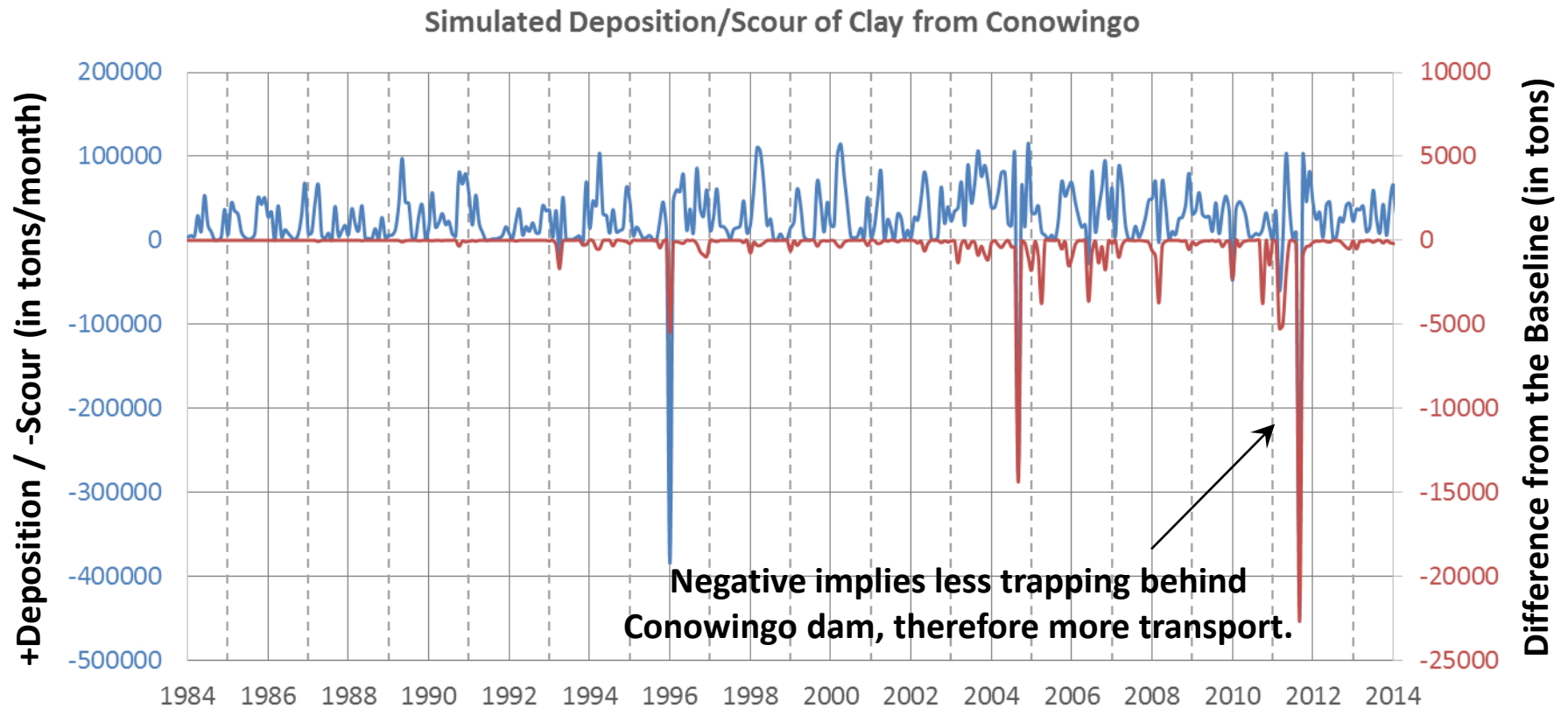
Change in Sediment Storage behind Conowingo Dam



Simulated Deposition/Scour of Clay from Conowingo



Variable Critical Shear Stress for Clay Deposition Prototype



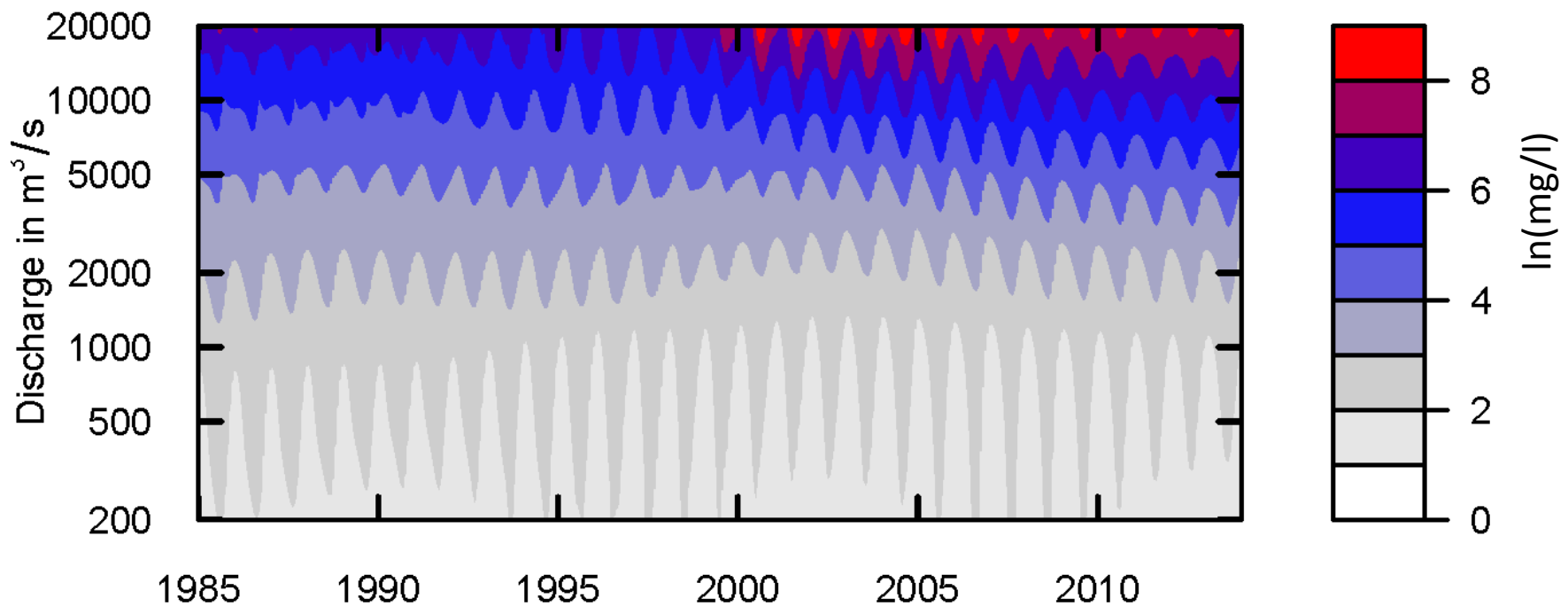
Lines of evidence for incorporating Conowingo Infill in Phase 6

- Zhang, Hirsch, and Ball (2016) can be used for a WRTDS based analysis of changes in sediment and nutrient transport with Conowingo infill.
- Conowingo Pool Mass Balance Model (CPMBM) and Sediment Flux Model (SFM) can potentially provide information on changes in transport mechanism (settling vs. scour) for sand/silt/clay.
- Hirsch and Langland analyses can be used for validation.

WRTDS

- WRTDS uses time, discharge, and seasonality as regression variables for estimating concentration.

**Susquehanna River at Conowingo, MD (All Samples)
Estimated log of Concentration Surface in Color**

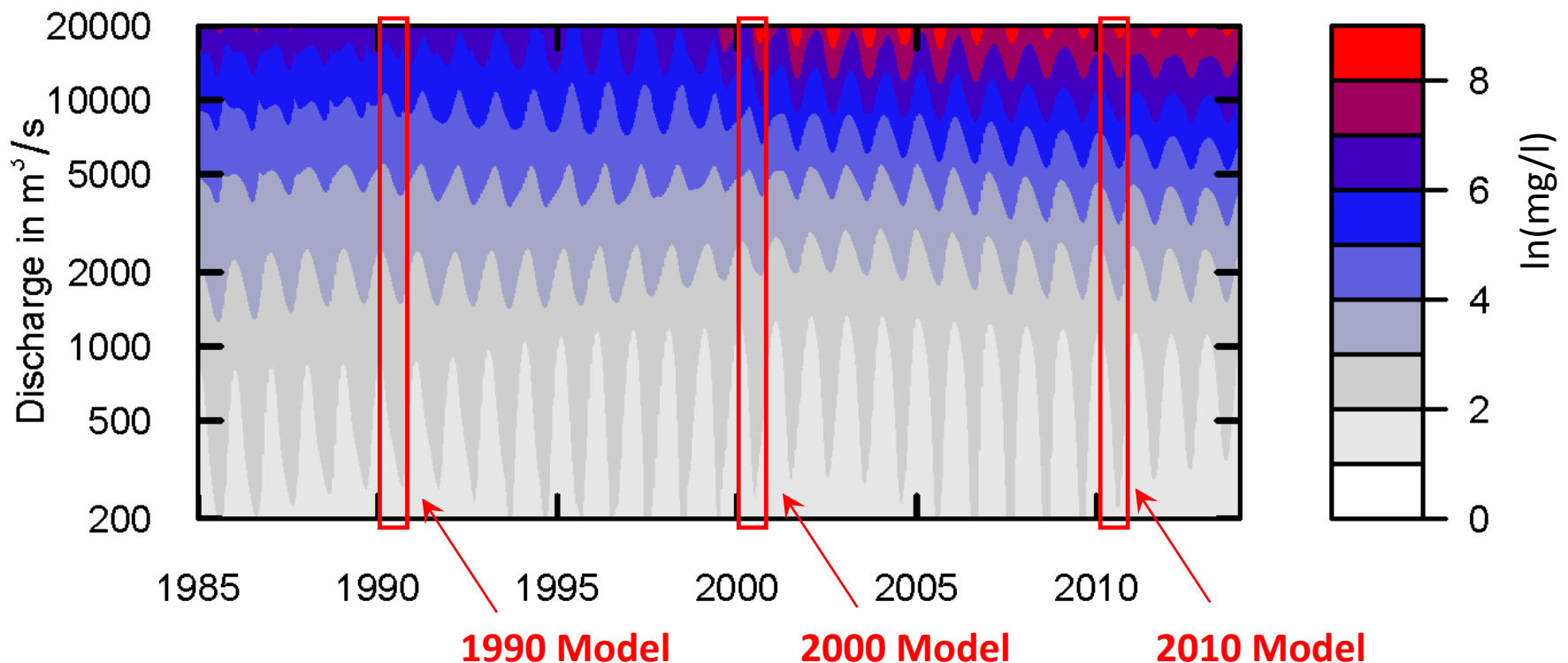


Stationary Model of Conowingo: an analysis using WRTDS

Qian Zhang

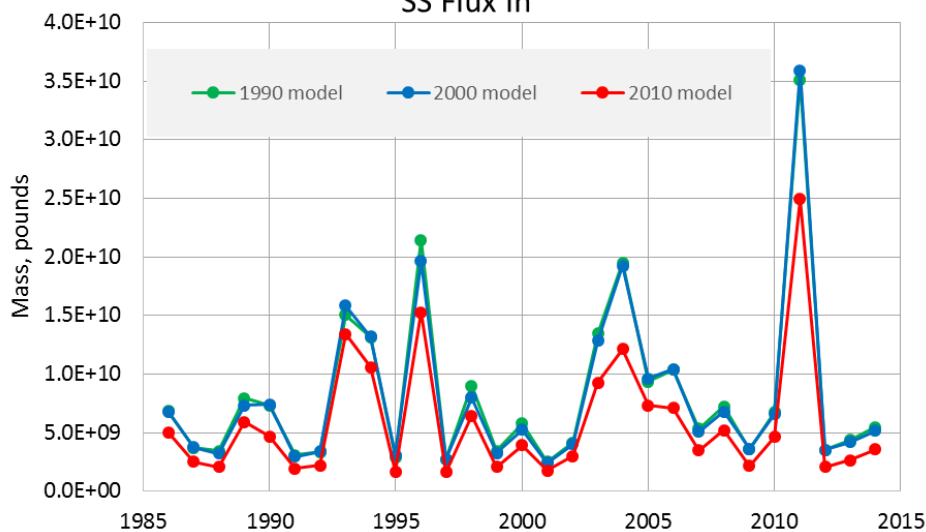
- Stationary WRTDS concentration surfaces were developed:

Susquehanna River at Conowingo, MD (All Samples)
Estimated log of Concentration Surface in Color

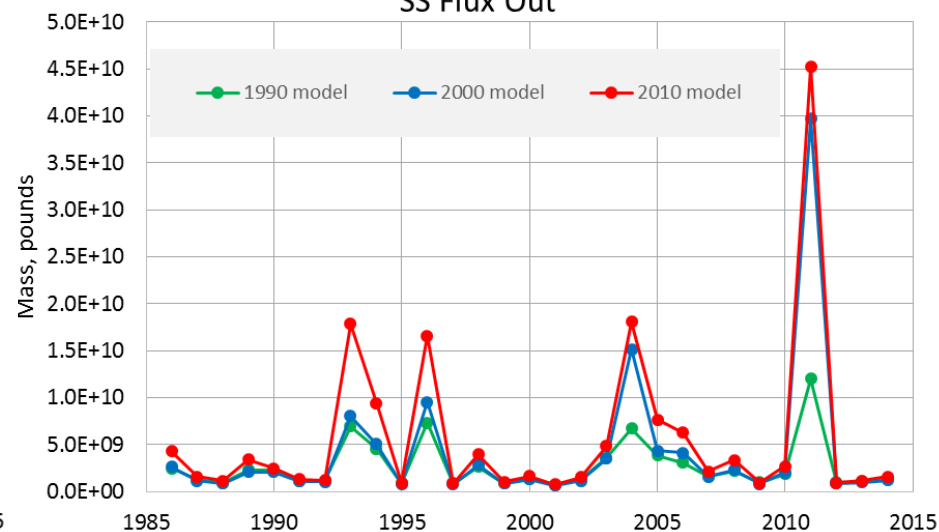


Sediment

SS Flux in

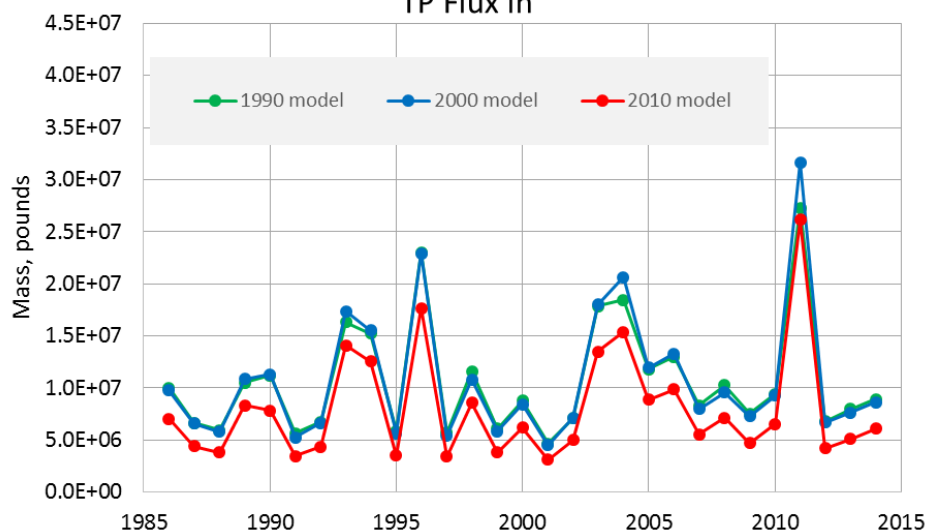


SS Flux Out

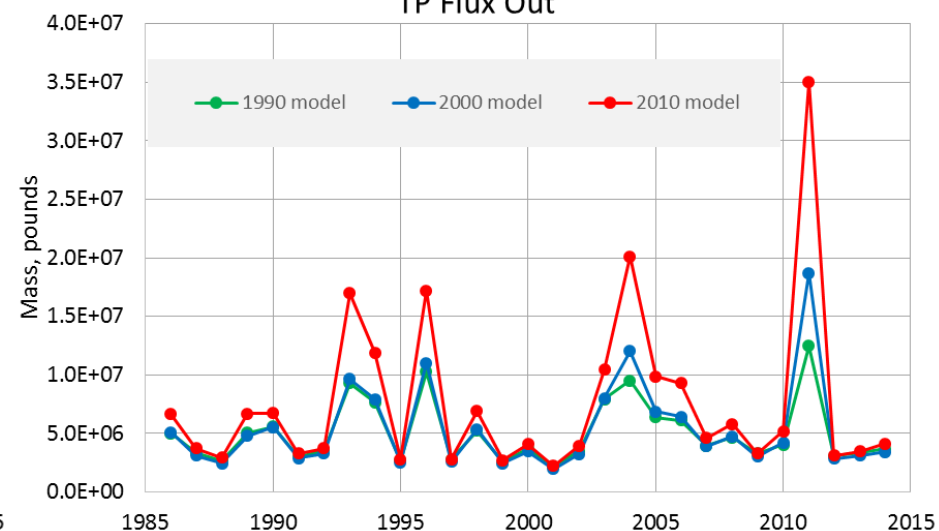


Phosphorus

TP Flux in

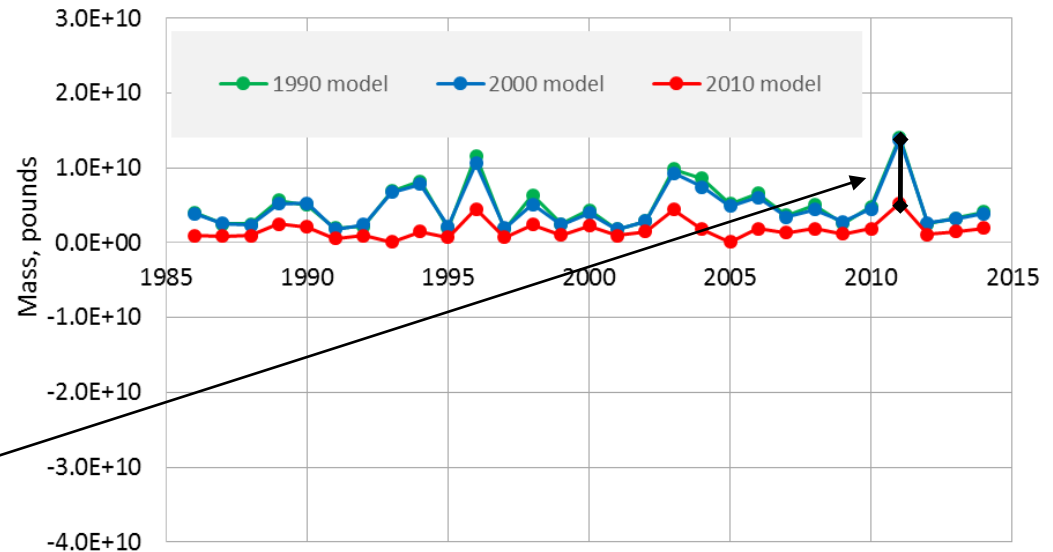


TP Flux Out

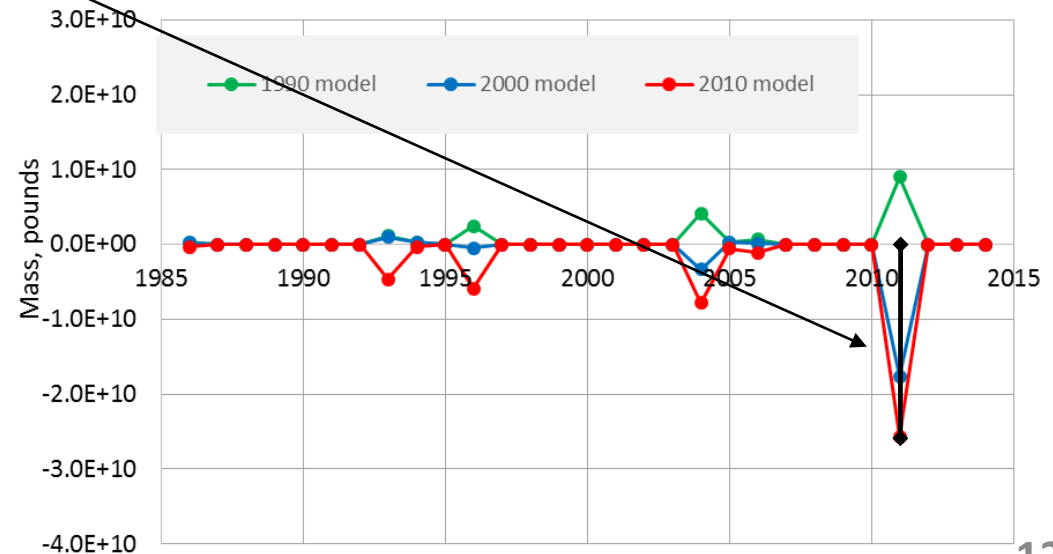


Sediment

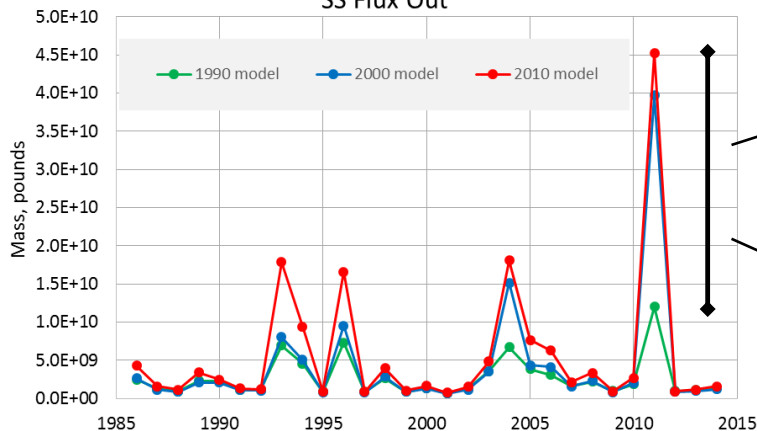
Behavior of reservoir under 10,000 cms (353k cfs)



Behavior of reservoir above 10,000 cms (353k cfs)

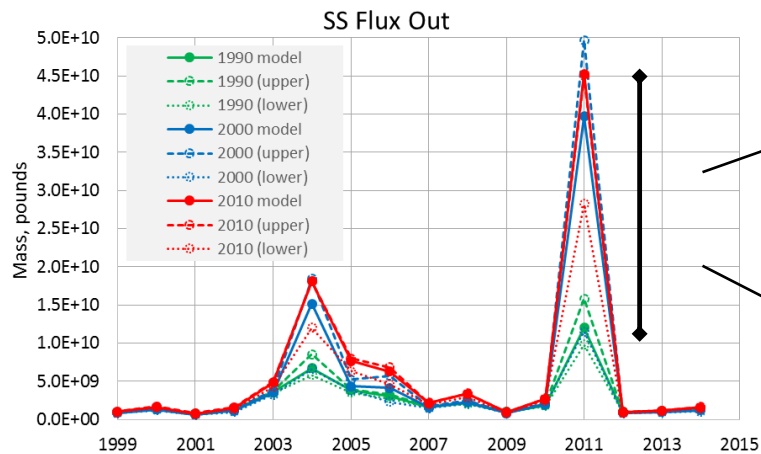


SS Flux Out



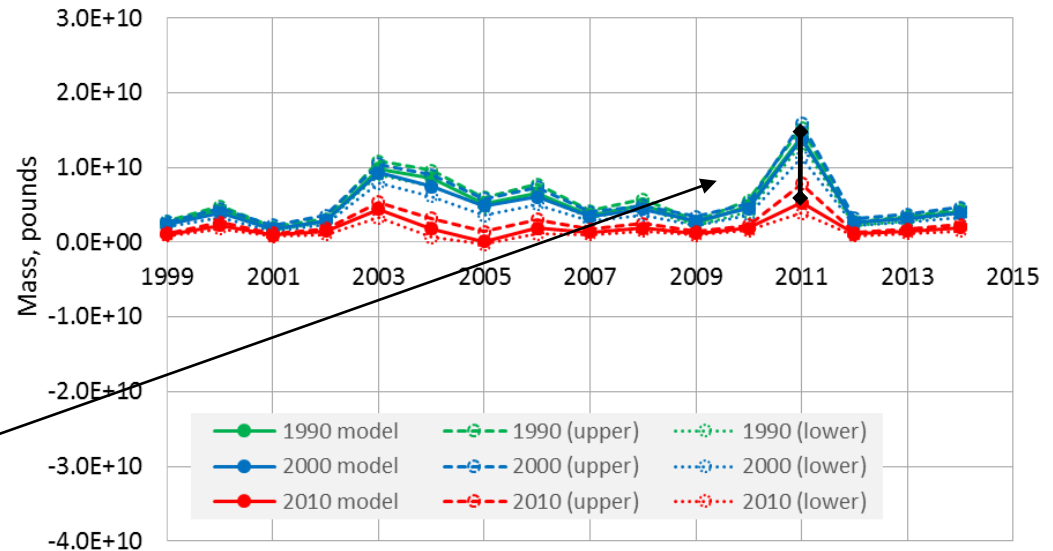
The stationary models provide a quantitative estimate of changes in scour and deposition.

Sediment (uncertainty)

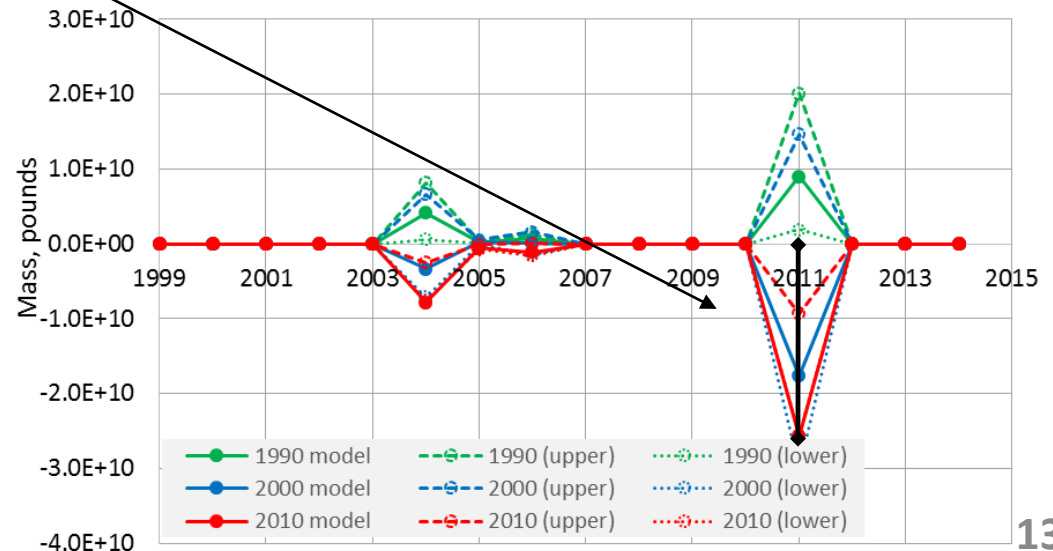


*These uncertainty bounds
are considered in the
model calibration.*

Behavior of reservoir under 10000 cms (353k cfs)

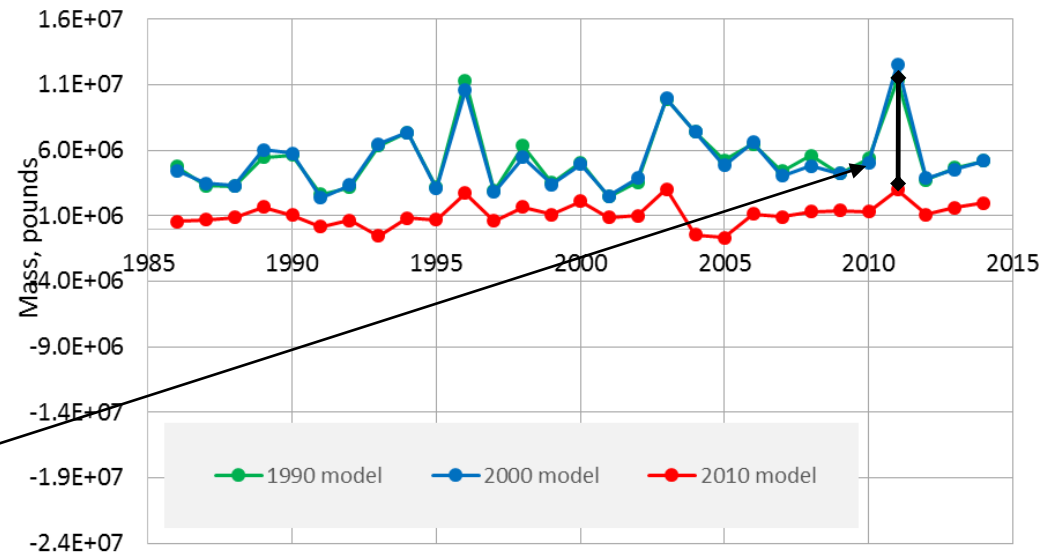
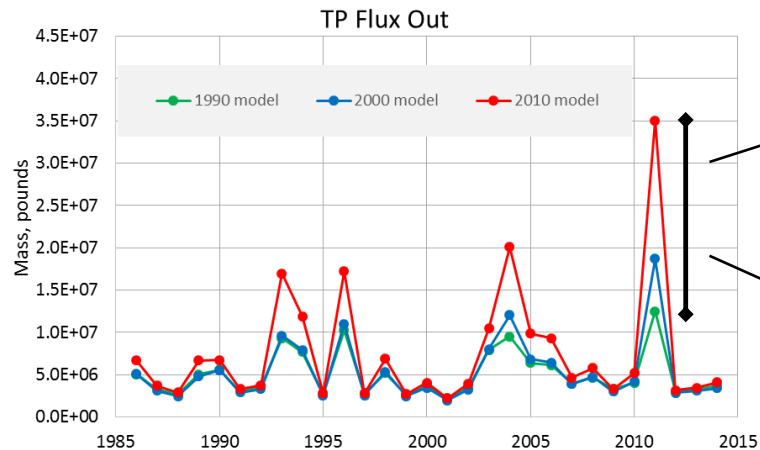


Behavior of reservoir above 10000 cms (353k cfs)

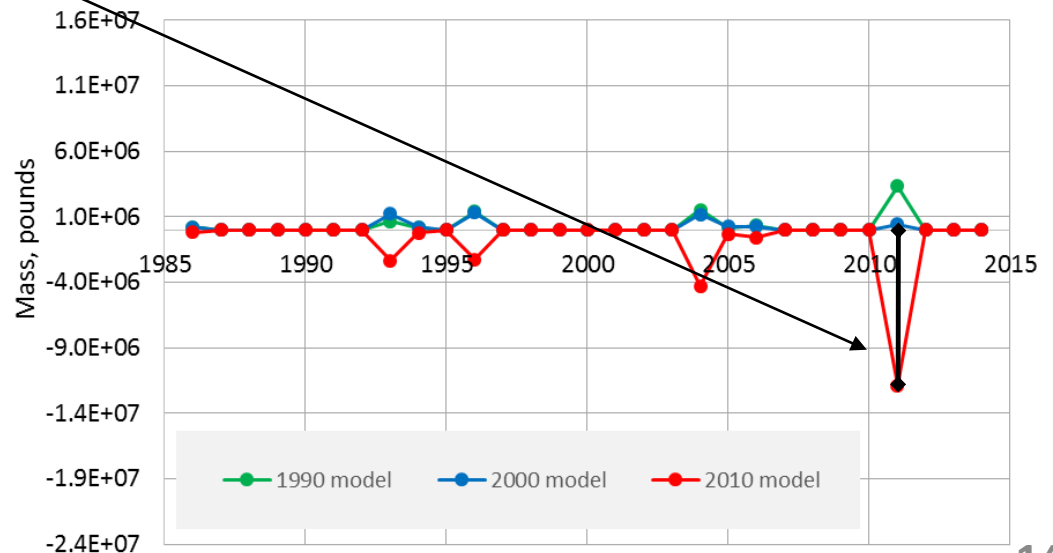


Phosphorus

Behavior of reservoir under 10000 cms (353k cfs)

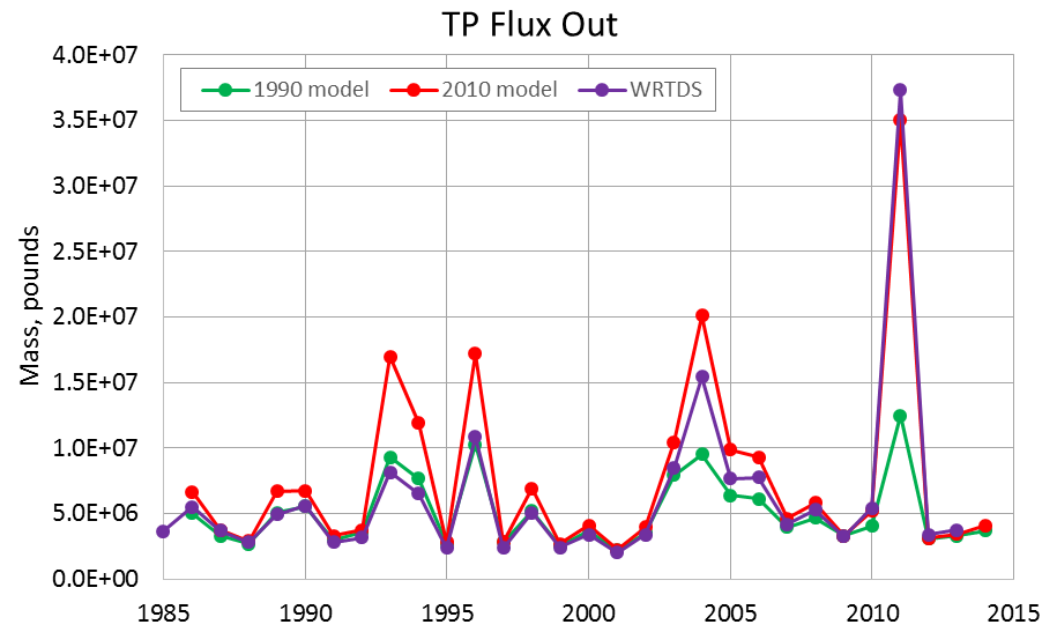
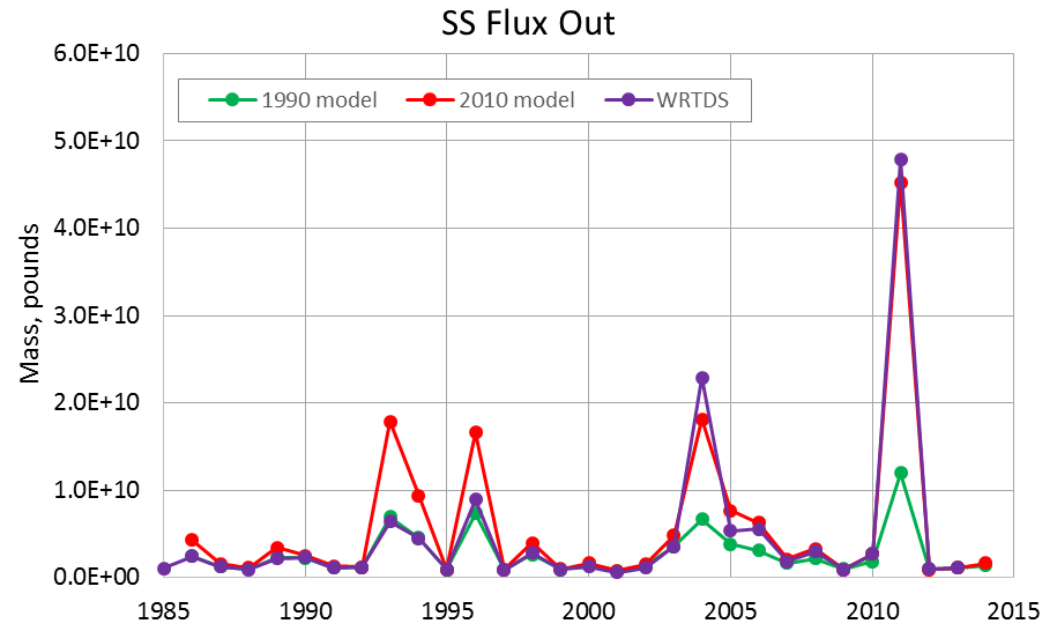


TP Scour



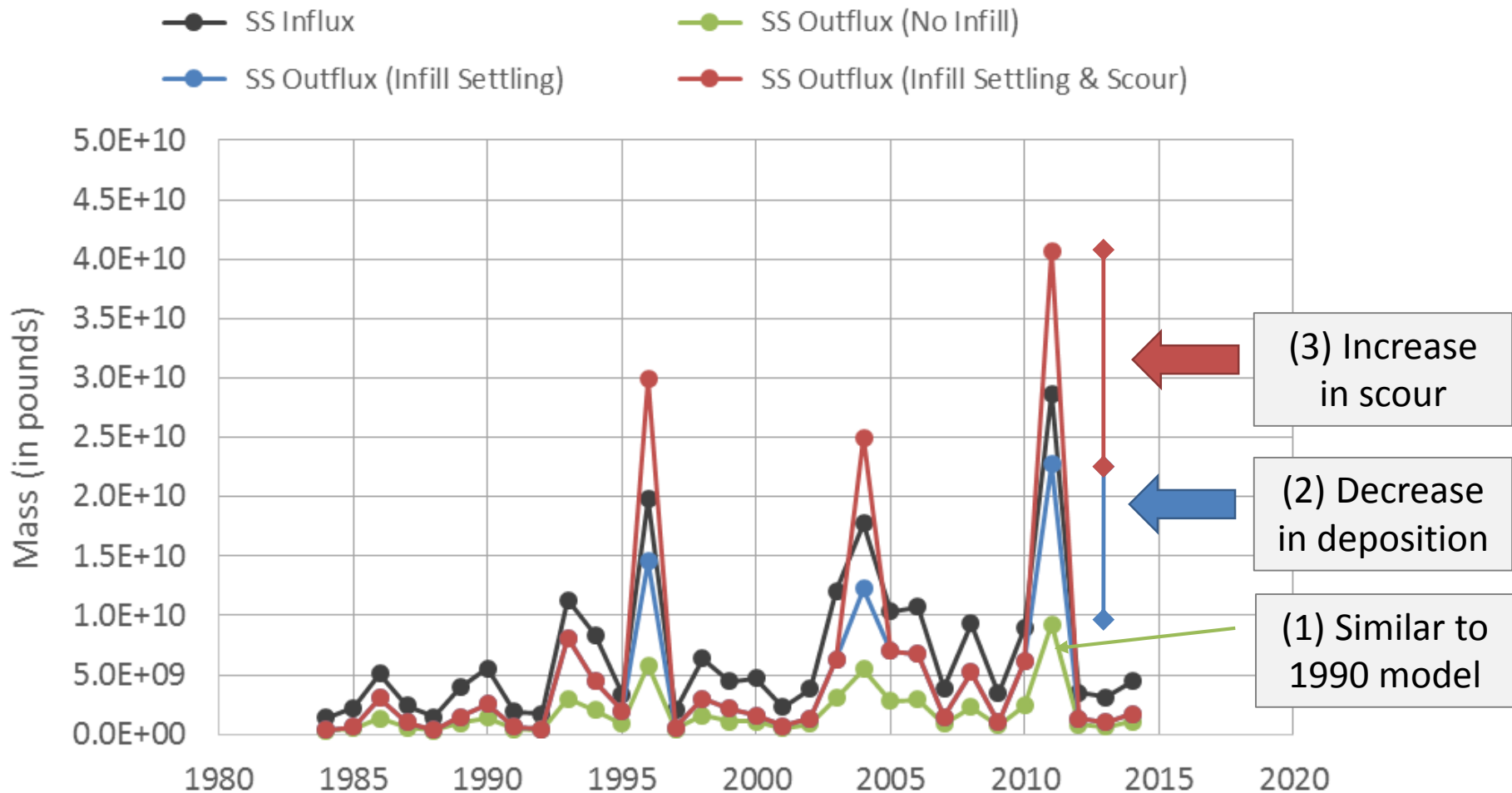
The stationary models provide a quantitative estimate of changes in phosphorus transport with scour and deposition.

- The goal is to estimate how model parameters should change with infill.
 - A transition from 1990 to 2010 model.
- Calibrated parameters would change with time or storage (bathymetry).
- Once parameters are known, scenarios can be run using fixed parameters that represent infill condition.

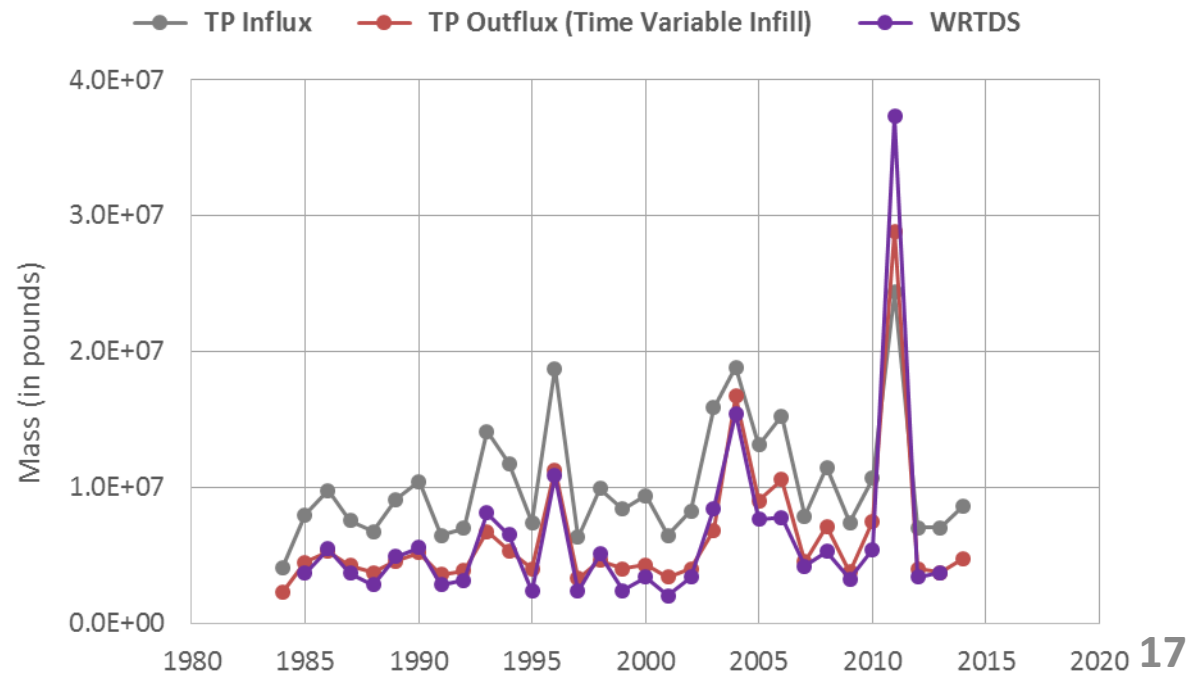
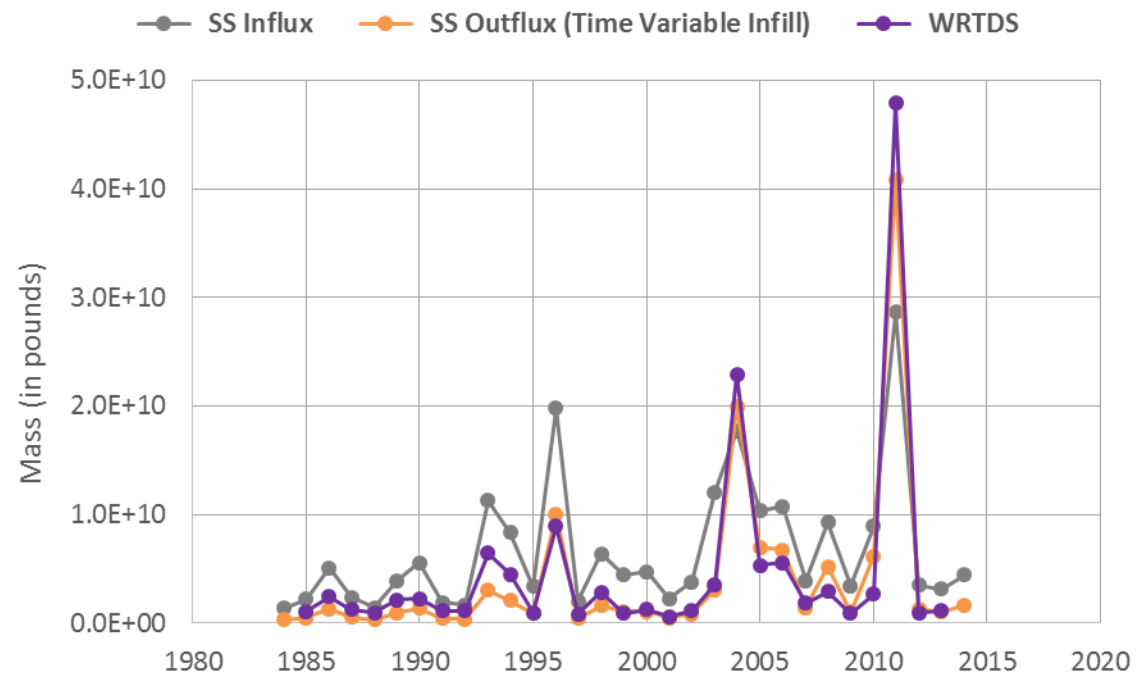


Three step calibration strategy:

1. Estimate no-infill model parameters
2. Estimate changes in deposition parameters
3. Estimate changes in scour parameters

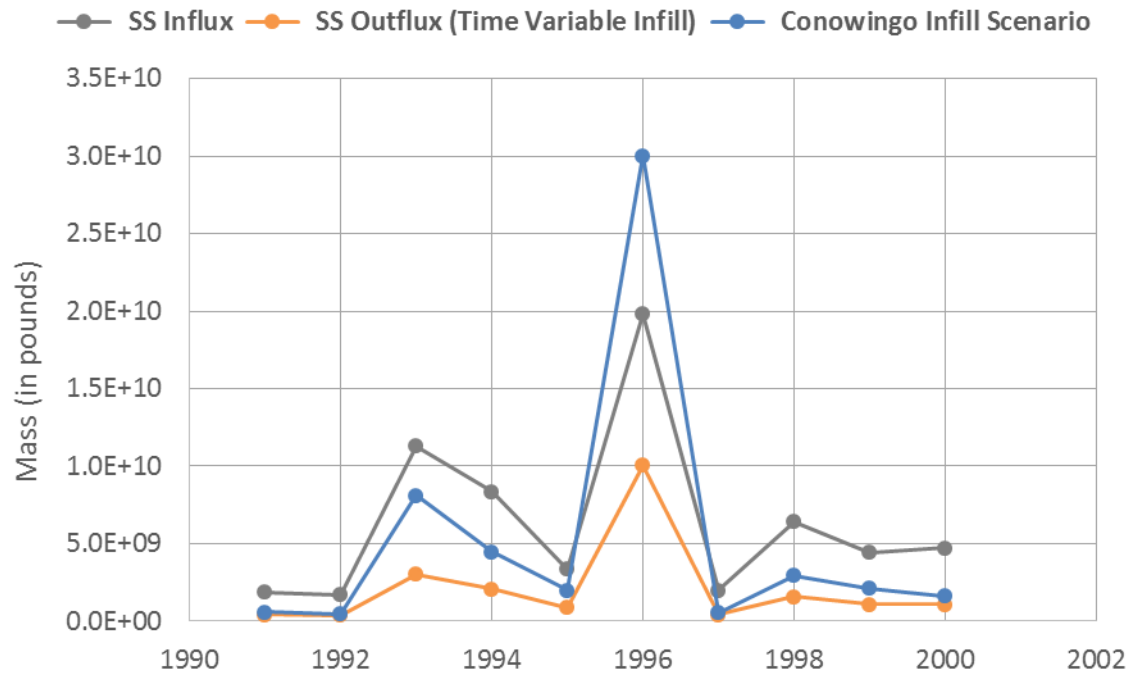
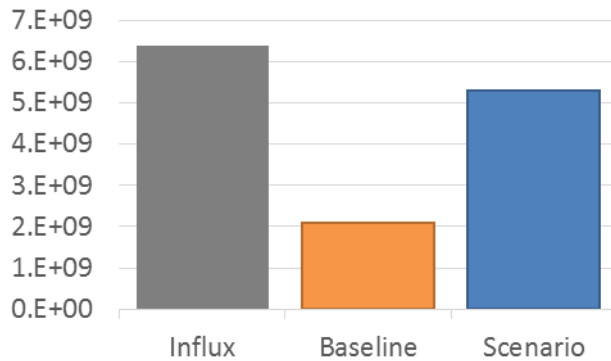


- Refined Beta 3 calibration of sediment and phosphorus.
- Here both scour and deposition parameters change with time.

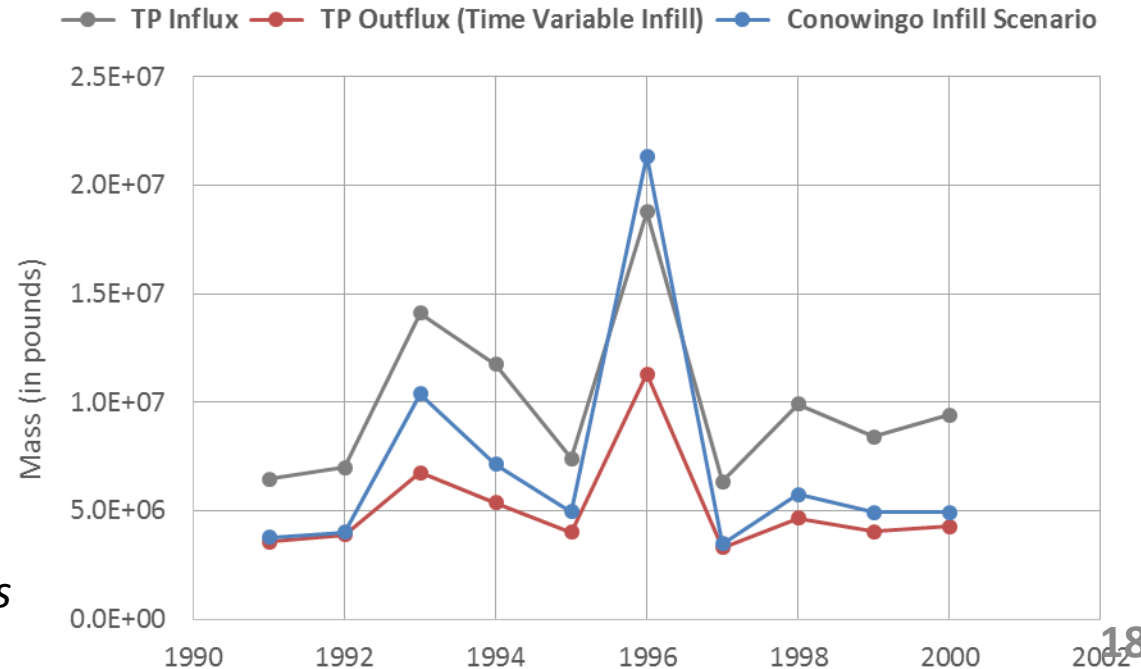
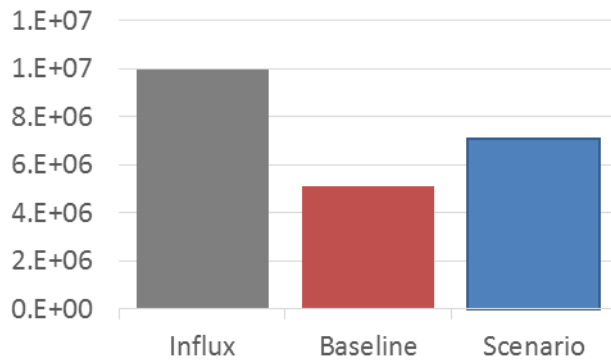


Conowingo Infill Scenario

SS: 152% higher under Infill



TP: 38% higher under Infill



less net deposition over the 10 years period as compared to baseline

Next Steps...

- WRTDS is one piece of evidence
- CPMBM/SFM will provide additional dataset to refine calibration
- Langeland 2015 provides additional sediment data for corroboration

