Poster #28

The Problem and Consequences of Conowingo Reservoir Infill on the Chesapeake Bay Water Quality

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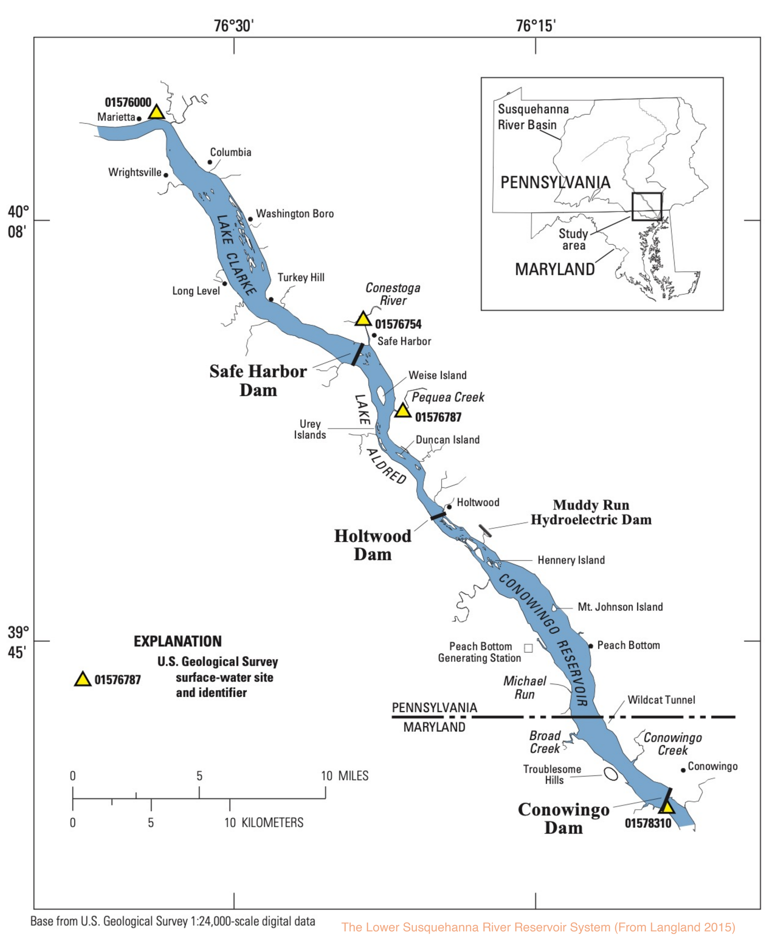
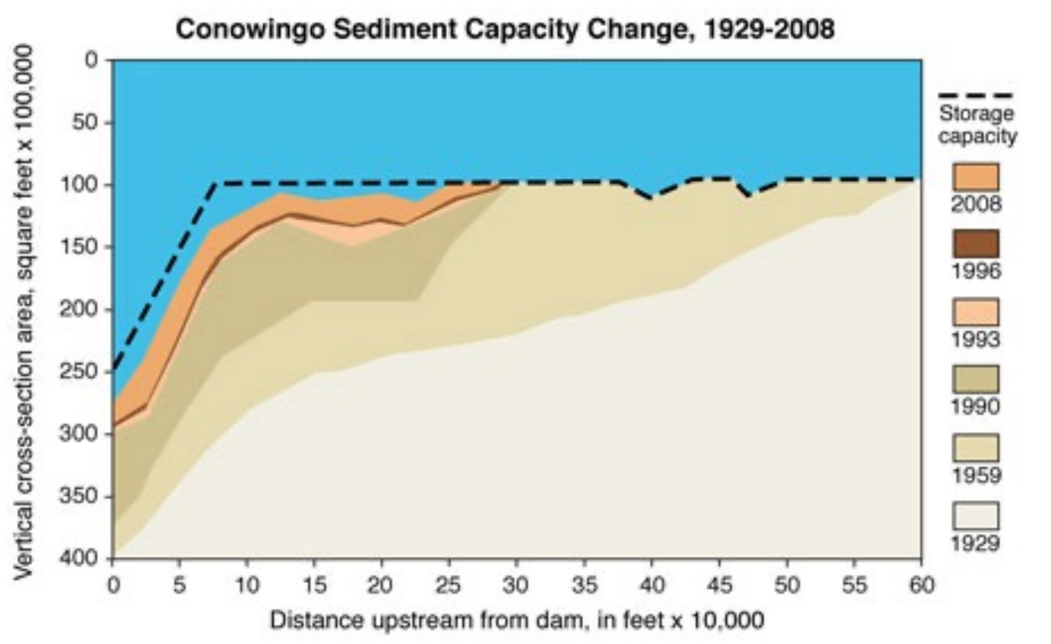
1. Abstract

The Susquehanna River is the largest tributary to the Chesapeake Bay that contributes approximately 41% of nitrogen, 25% of phosphorus, and 27% of sediment to the tidal Bay. Recent studies have documented how, over time, sedimentation has filed in the three Lower Susquehanna reservoirs, altering their behavior. The upper two reservoirs, Lake Clarke and Lake Aldred, reached full infill capacity, also called dynamic equilibrium, prior to the beginning of the Chesapeake Bay Program (CBP) partnership's Phase 6 Watershed Model simulation period of 1985 to 2014, and recent research has indicated that the most downstream reservoir, the Conowingo, is at or approaching dynamic equilibrium. Refinements were made to the CBP partnership's Phase 6 Watershed Model using multiple lines of evidence in the estimation of how the deposition and scour rates have changed as well as variability in the bioavailability of nutrients. The model was applied to estimate changes in sediment and nutrients delivery under different watershed management, climate, and reservoir infill states. The estimates provided by the model was used by the CBP partnership to support decision-making and estimating additional management actions that will be needed for mitigating these additional loads.

2. Introduction



The Susquehanna River is the largest tributary to Chesapeake Bay and the amount of sediment, nitrogen and phosphorus loads transported to the bay are substantially affected by the retention behind three hydroelectric dams on the lower Susquehanna River near the mouth.



Conowingo is at or 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, as well as variability in the bioavailability of nutrients, which are incorporated in our modeling and analyses.

3. Key Questions

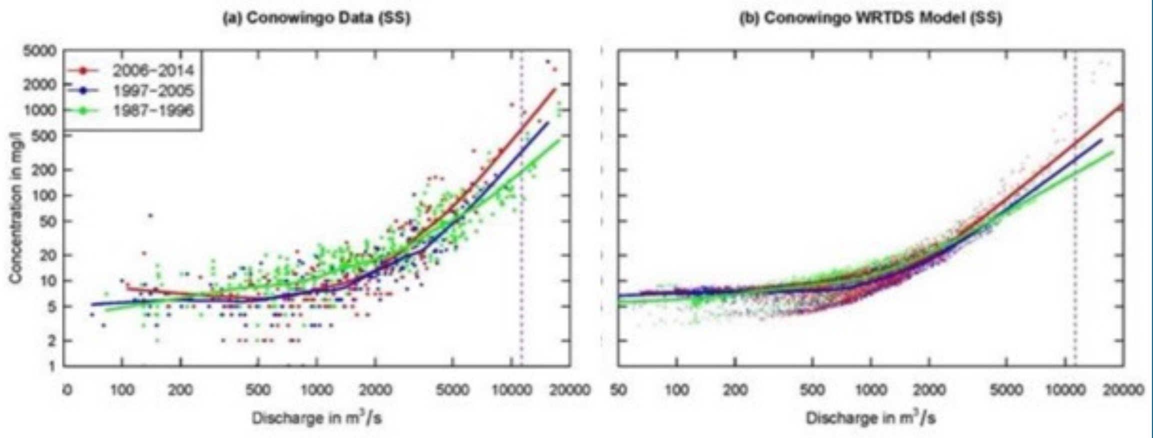
Question 1: What Is the Current State of the Conowingo and the Two Upper Reservoirs With Regard To Long-Term Mass Balance?

Based on abundance of evidence, all three reservoirs in the Lower Susquehanna reservoir system are currently in dynamic equilibrium (Hainly et al., 1995; Hirsch, 2012; Langland 2009, 2015; Zhang et al., 2013, 2015, 2016).

Question 2: What Information Can Be Used to Estimate the Change In Scour and Deposition Over Time for the Purposes Of Calibration?

Multiple studies have shown that the relationship between flow and concentration is changing over time downstream of the Conowingo reservoir.

Linker and others (2016b), Zhang and others (2016a and 2016b) attributed it to changes in scour and deposition related to changes in the bathymetric state of the reservoirs.



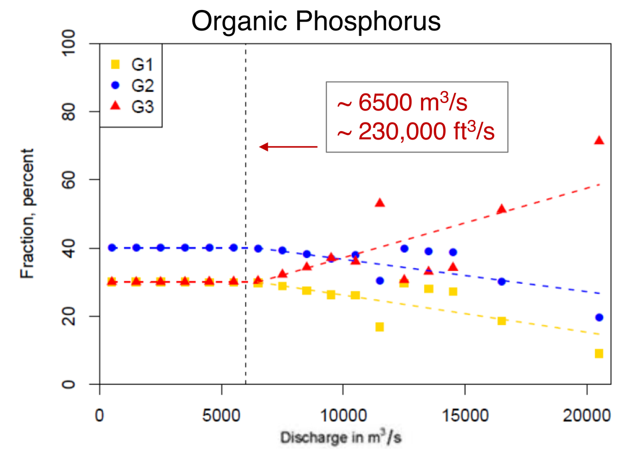
Question 3: Does the Trapping Efficiency Change with Different Levels of Nutrient Inputs?

Modeling conducted for a wide range of nutrient and sediment reduction scenarios using a state of the science the Conowingo Pool Model (CPM), a 3D hydrodynamic and sediment flux model found that trapping efficiency (ratio of output to input) of the reservoir does not change.

Question 4: How Does the Availability of Organics Change with Respect to Flow?

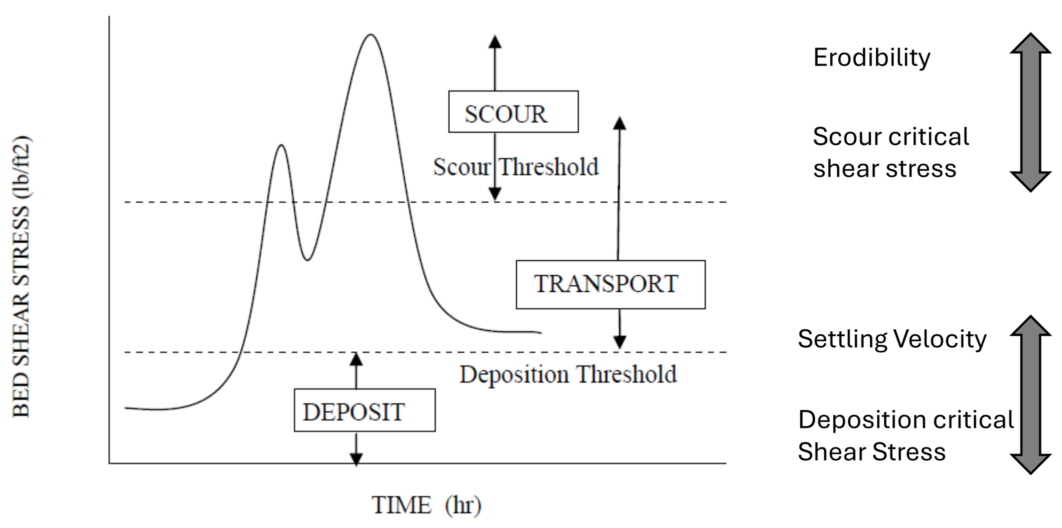
Using the core data, the Conowingo Pool Model (CPM) explicitly modeled the burial and diagenetic transformation of particulate organics in the sediment.

Less bioavailable particulate organics are available during high flow events at mass wasting flows greater than about 230,000 ft^3/s at Conowingo.

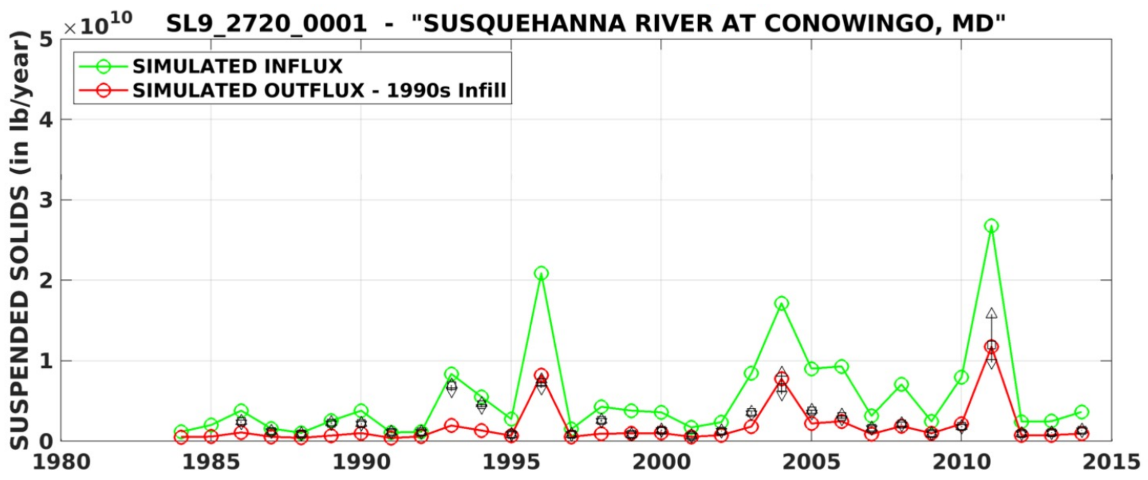


4. Modeling and Calibration Framework

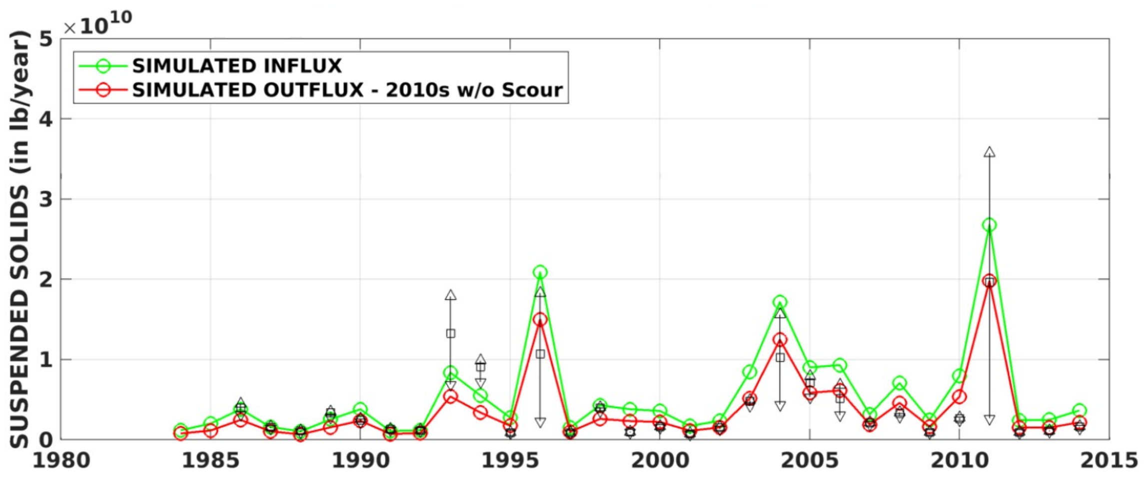
- HSPF RCHRES simulates scour of sediment, particulate inorganic phosphorus, and ammonia.
- We added a process module for the scour of Organic N and P with the net scoured sediment.



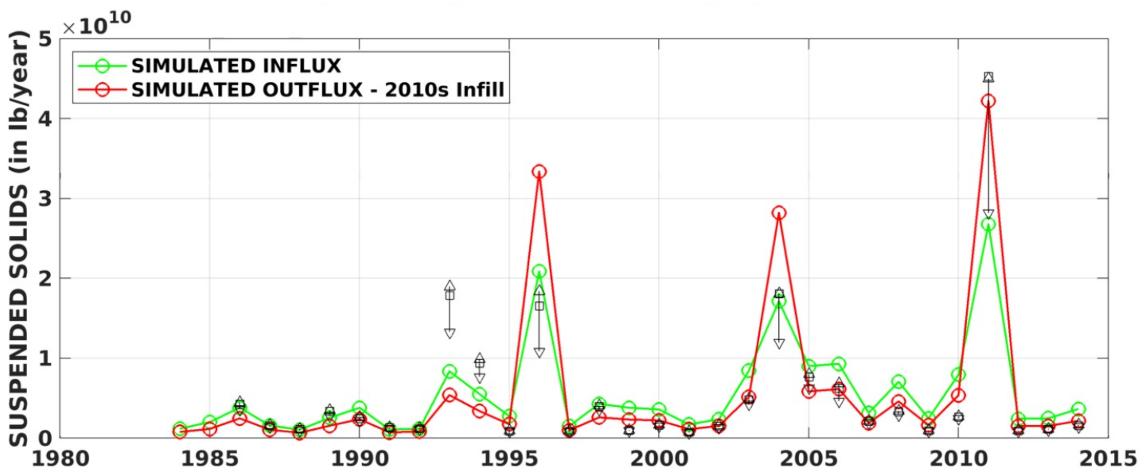
A four-step calibration approach was established to incorporate multiple lines of evidence in the estimation of how the deposition and scour rates have changed over time with reservoir infill.



Step 1: Estimate the model parameters for the Conowingo response for late-1980s and early-1990s infill state.

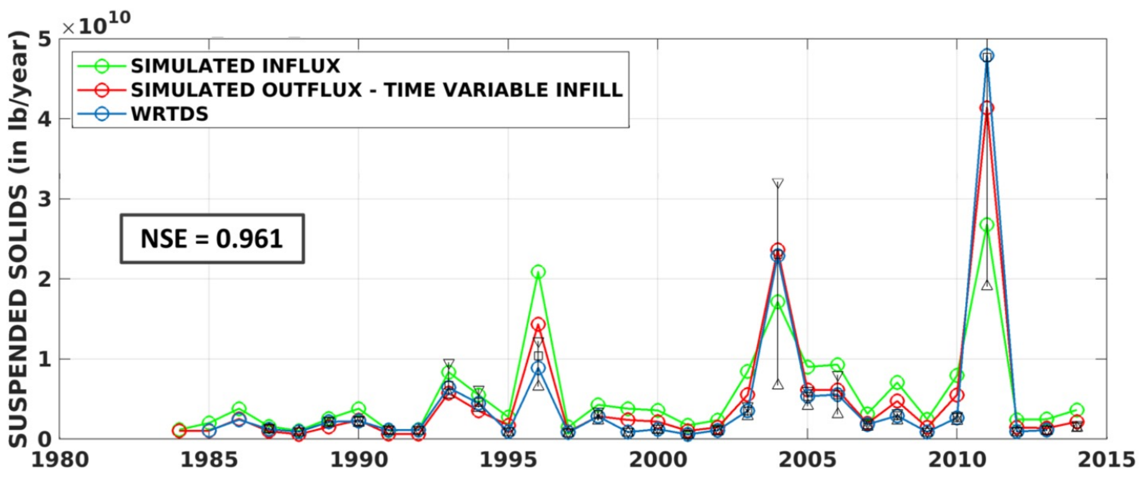


Step 2: Decreased deposition rates of sediment and particulate nutrients in the Conowingo reservoir was guided by WRTDS estimates (Zhang et al. 2016) and for better consistency with observed sediment and phosphorus data.



Step 3: Increased erosion rates during mass wasting events in the Conowingo reservoir were applied as appropriate, guided by the observational record and WRTDS estimates.

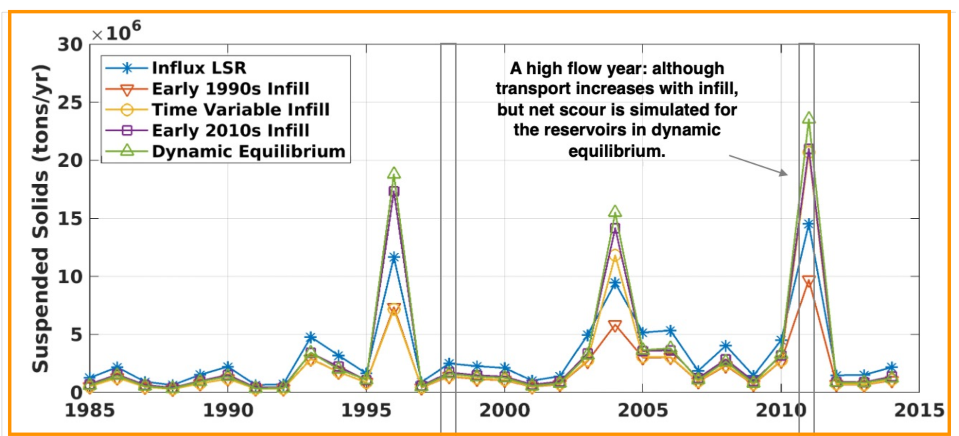
Changes in particulate organic scour bioreactivity were applied.

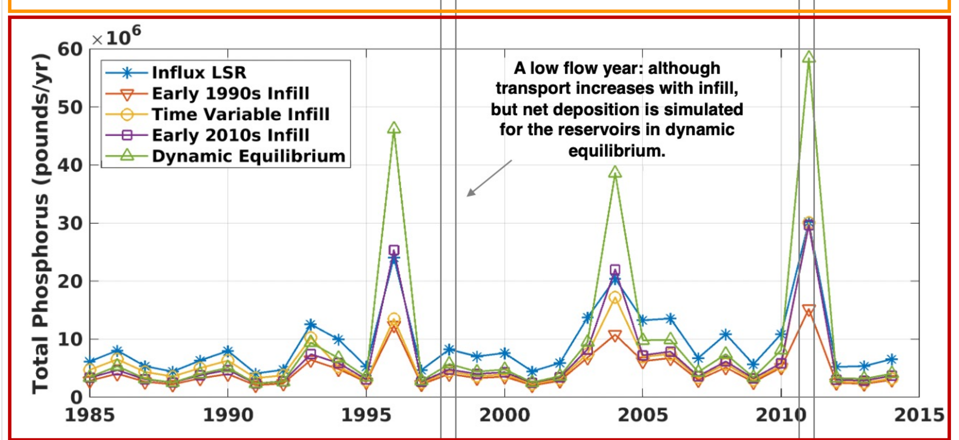


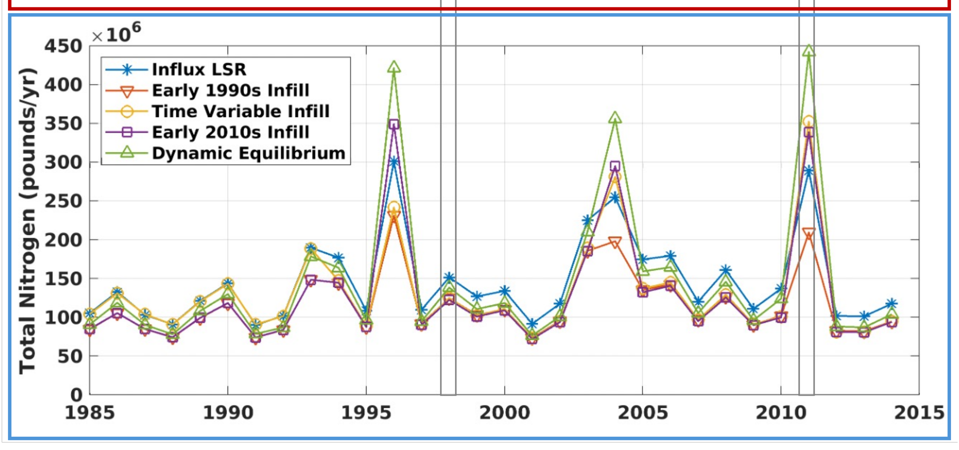
Step 4: Estimate the temporal variability in the deposition and scour over time by varying parameters estimated in the previous steps for the early 1990s and early 2010s infill state with considerations to (a) mass balance for silt, clay, and phosphorus, (b) achieving best possible agreement with the monitoring data for nitrate, nitrogen, dissolved orthophosphate, phosphorus and sediment during the simulation period, (c) agreement with USGS-WRTDS nitrate, nitrogen, dissolved orthophosphate, phosphorus, and sediment loads.

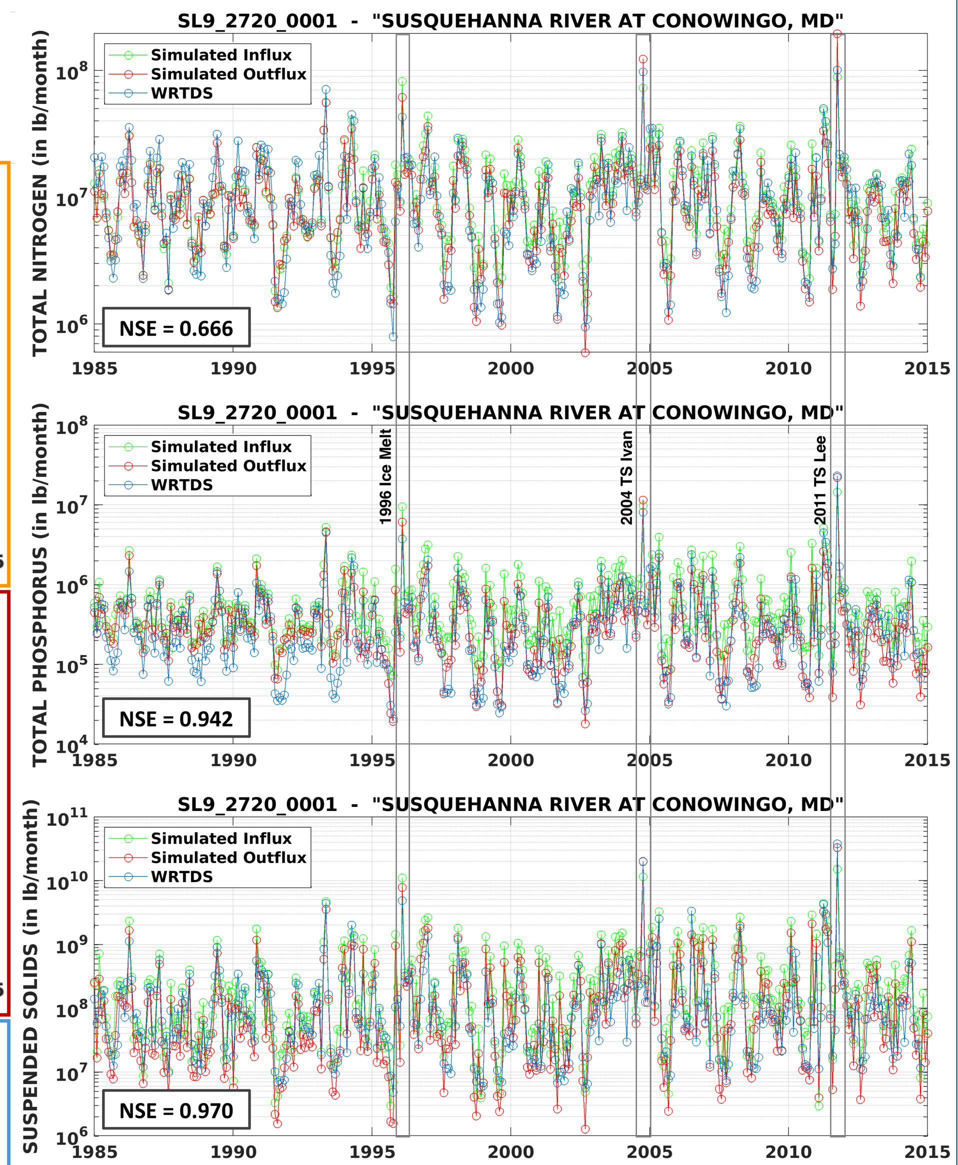
5. Results

Influx and **Outflux** time series show periods of net deposition and scour.







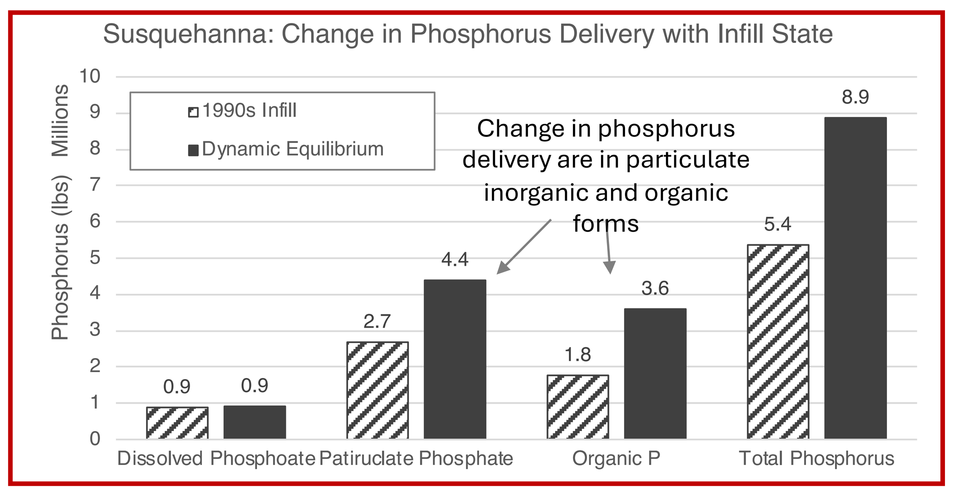


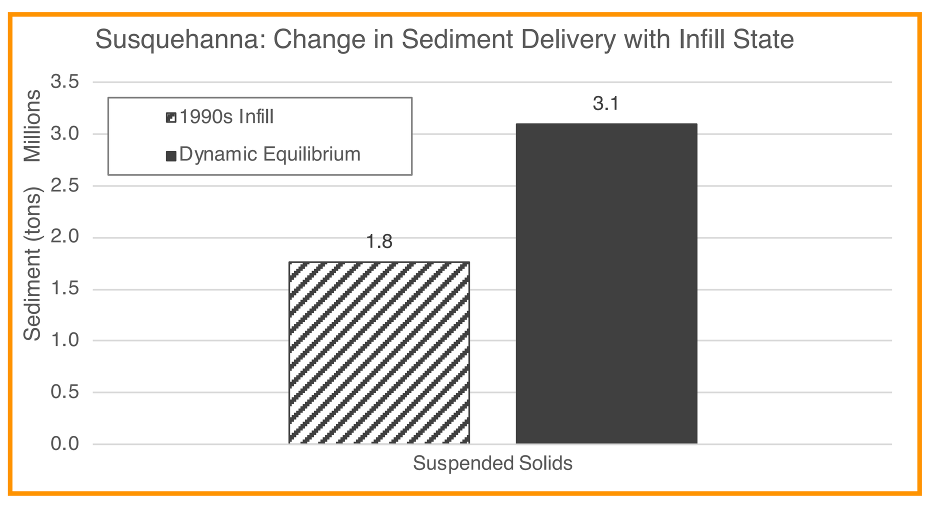
Three key events during the simulation period are shown where the stormflow was greater than 400,000 ft^3/s but 1996 was a net deposition period but there was net erosion in 2004 and 2011 events.

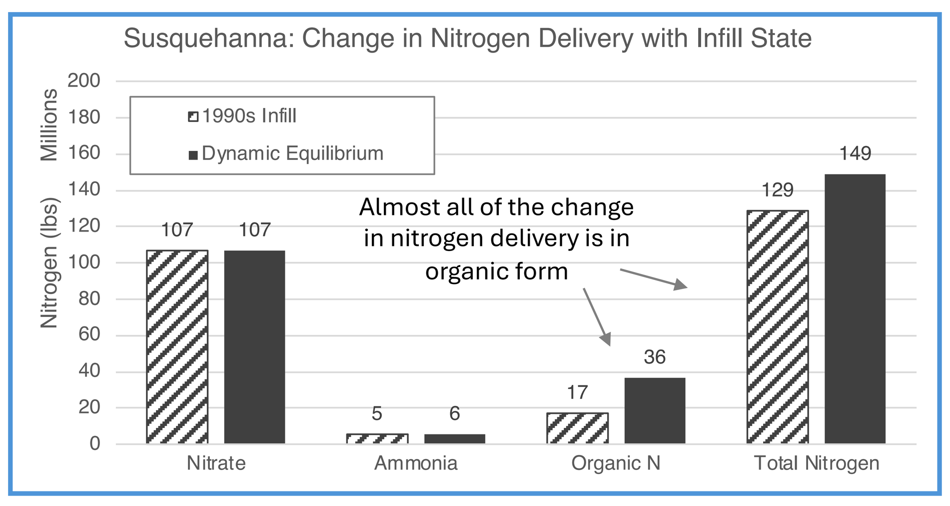
Model Application:

(a) Under the 1995 management, additional delivery of about 20 Mlb/yr of nitrogen, 3.5 Mlb/yr of phosphorus, and 1.3 Mton/yr of sediment was estimated between 1995 Infill and the current state of dynamic equilibrium, and

(b) An additional delivery of 12 Mlb/yr of nitrogen, 1.8 Mlb/yr of phosphorus, and 0.7 Mton/yr of sediment under the Phase 2 Watershed Implementation Plan.







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