Initial Applications of the Draft Phase 6 Watershed Model – Conowingo Infill

Water Quality Goal Implementation Team – Aug 2017

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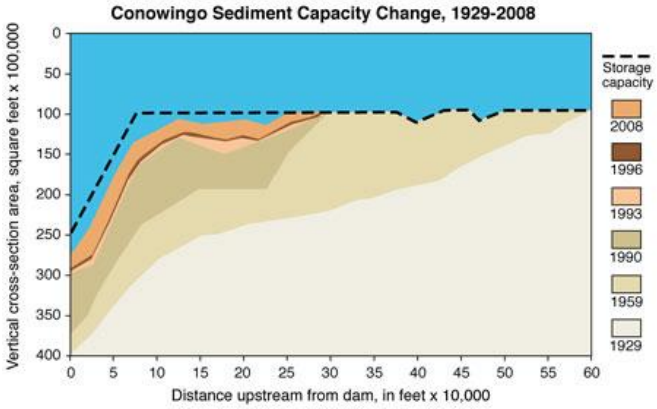
Presentation Outline

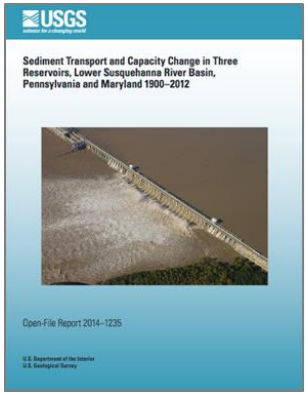
Conowingo Infill: A *draft* assessment of the delivery of nutrients and sediment for different infill conditions, including the dynamic equilibrium, was made using the Draft Phase 6 watershed model.

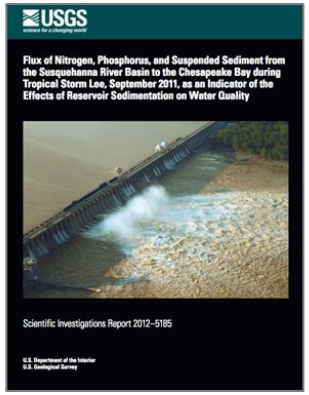
A brief overview of Conowingo Infill

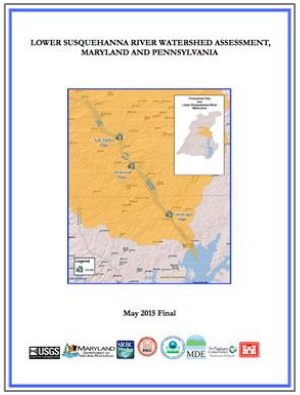
- Conowingo is effectively at dynamic equilibrium, which has reduced its ability to trap sediment and nutrients.
- Numerous research articles have documented it, and they provide an analysis of changes in transport, which were incorporated in the Phase 6 Model.

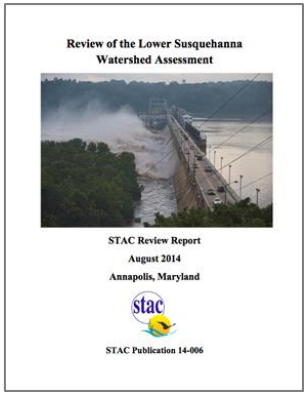


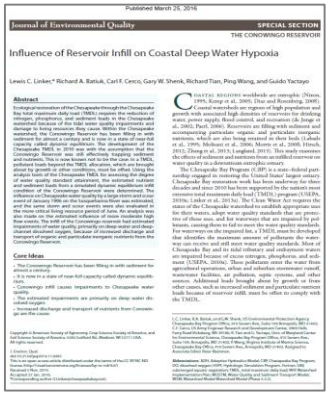
Source: Graph, Michael Langland, U.S. Geological Survey



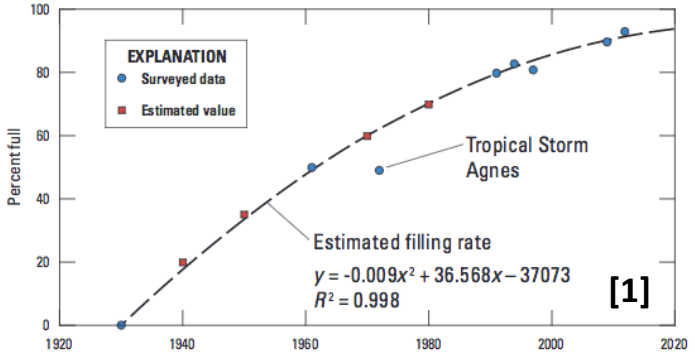


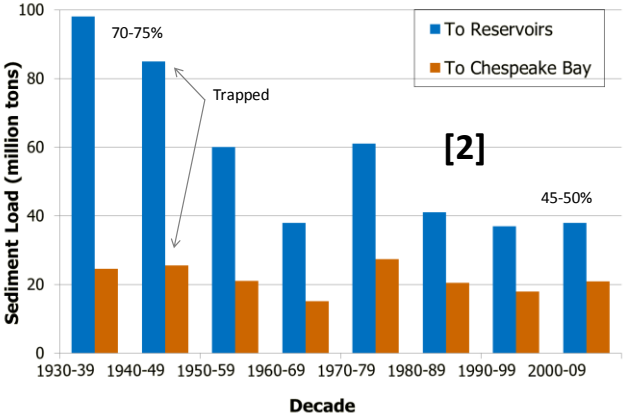


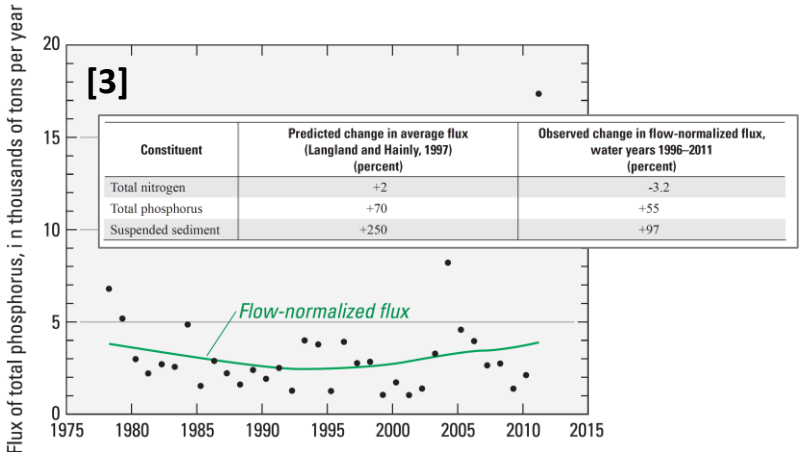


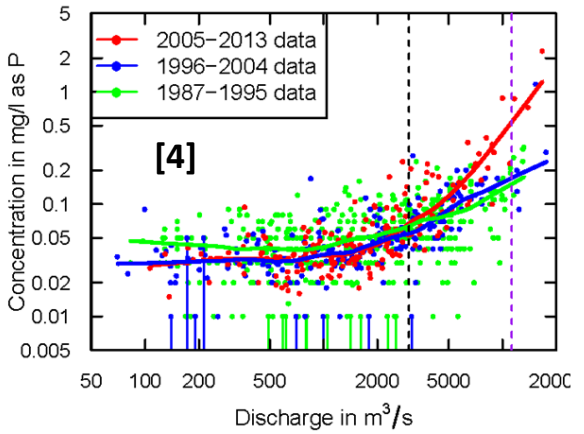


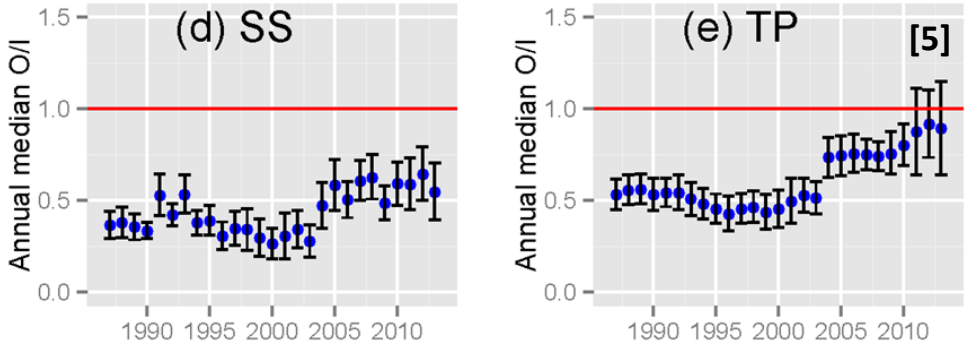
The multiple lines of evidence

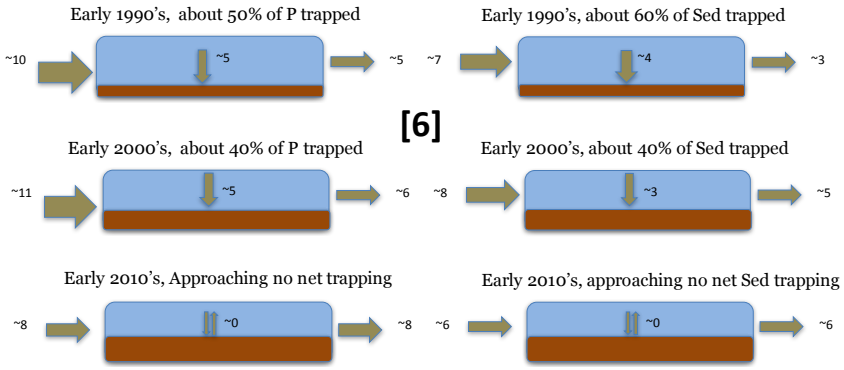












[1][2] Langland, M.J., 2009. Bathymetry and sediment-storage capacity change in three reservoirs on the lower Susquehanna River, 1996–2008: U.S. Geological Survey Scientific Investigations Report 2009–5110, 21 p.
[3] Hirsch, R.M., 2012. Flux of nitrogen, phosphorus, and suspended sediment from the Susquehanna River Basin to the Chesapeake Bay during Tropical Storm Lee, September 2011, as an indicator of the effects of reservoir sedimentation on water quality: U.S. Geological Survey Scientific Investigations Report 2012–5185, 17 p.
[4][5] Zhang, Q., Hirsch, R.M., Ball, W.P., 2016. Long-term changes in sediment and nutrient delivery from Conowingo Dam to Chesapeake Bay: Effects of reservoir sedimentation, Environ. Sci. Technol, 50(4), 1877-1886.
[6] Currey, L., 2017, Conowingo dam update, WQGIT

Incorporation of Conowingo Infill in Phase 6

- The Modeling Workgroup, with guidance from CBP and STAC[1], has made four key state-of-the science decisions for the simulation of Conowingo infill:
  - The Lower Susquehanna Reservoirs are now in the state of dynamic equilibrium (no long-term trapping) [2][3][4][5].
  - The information on changes in the trapping capacity provided by USGS-WRTDS should be used in the the model calibration [2][3][4].
  - Constant delivery factors should be used for scenarios involving both increases or decreases in the sediment and phosphorus inputs [5].
  - Use of a flow dependent dynamic G-series response for the organic- nitrogen, phosphorus, and carbon [6].

[1] Linker, L., R. Hirsch, W. Ball, J. Testa, K. Boomer, C. Cerco, L. Sanford, J. Cornwell, L. Currey, C. Friedrichs, R. Dixon. 2016. Conowingo Reservoir Infill and Its Influence on Chesapeake Bay Water Quality. STAC Publication Number 16-004, Edgewater, MD. 51 pp
[2] Hirsch, R.M., 2012, 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: U.S. Geological Survey Scientific Investigations Report 2012–5185, 17 p.
[3] Zhang, Q., D.C. Brady, and W.P. Ball, 2013. Long-term Seasonal Trends of Nitrogen, Phosphorus, and Suspended Sediment Load from the Non-tidal Susquehanna River Basin to Chesapeake Bay, Science of the Total Environment, 452–453: 208–221
[4] Zhang, Q., R.M. Hirsch, and W. Ball. 2016a. Long-term Changes in sediment and nutrient delivery from Conowingo Dam to Chesapeake Bay: Effects of reservoir sedimentation. Environmental Science & Technology 50(4): 1877-1886
[5] HDR Inc. Coupled Sediment Flux Model and Conowingo Pond Mass Balance Model (2017) - http://www.chesapeakebay.net/channel_files/24718/2017-02-14_conowingo_hdr_models_2.pdf
[6] HDR Inc. Coupled Sediment Flux Model and Conowingo Pond Mass Balance Model (2017) - http://www.chesapeakebay.net/channel_files/24719/2017-04-04_conowingo_hdr_g1g2g3_2.pdf

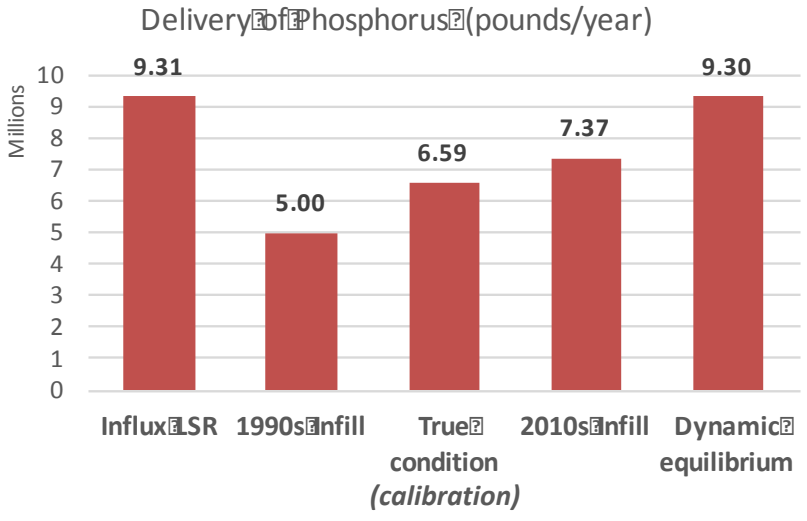
Simulation of Conowingo infill in Phase 6

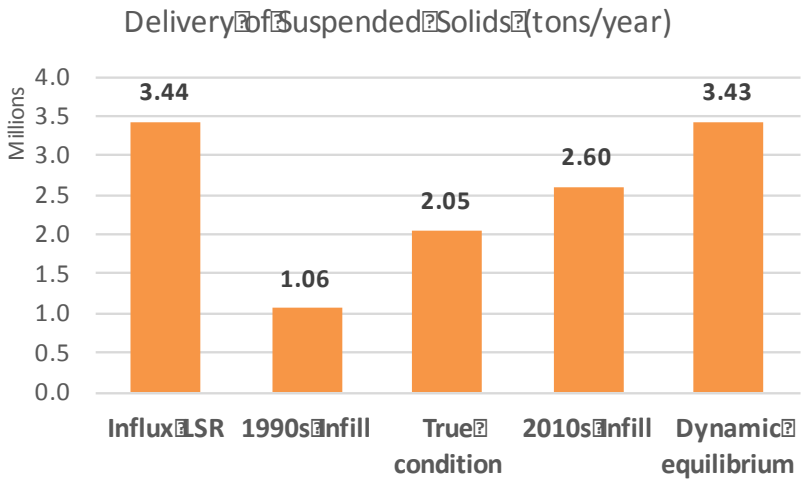
- In this work, an assessment for the delivery of nutrients and sediment under different infill conditions, including the dynamic equilibrium, was made using the Draft Phase 6 watershed model.
- The model was used for estimating the nutrients and sediment delivery for the following infill states –
  - True-condition (*calibration, time variable infill*)
  - 1990s infill condition
  - 2010s infill condition
  - Dynamic equilibrium (no net-trapping)
- The results are ***preliminary*** as they are based on currently available information that is subject to revisions by the partnership.

[1] http://www.chesapeakebay.net/channel_files/25164/20170615_-_bhatt_kh_-_cbp_-_mwcc_-_draft_phase_6.pdf
[2] http://www.chesapeakebay.net/channel_files/24720/20170725_-_bhatt_-_cbp_-_mwqm_-_draft_phase_6_applications.pdf

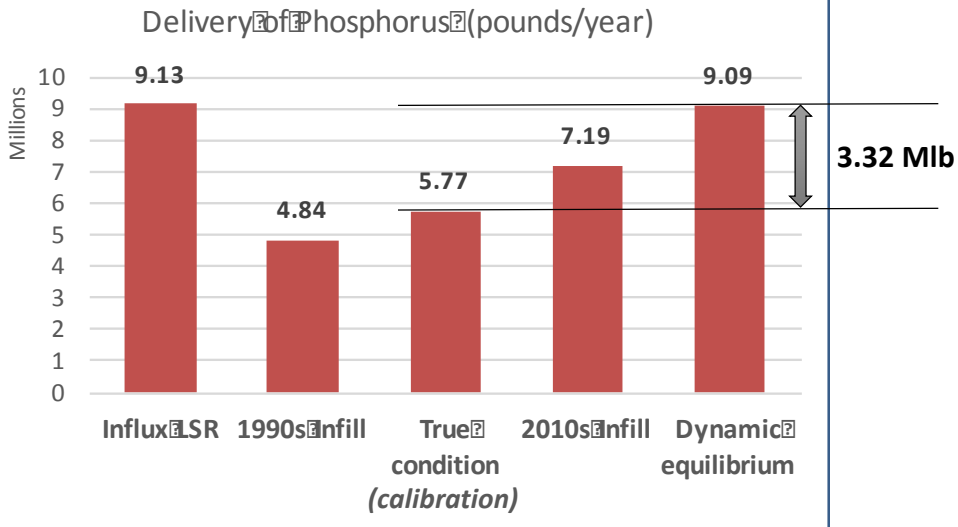
Lower Susquehanna Reservoirs – Calibration Average

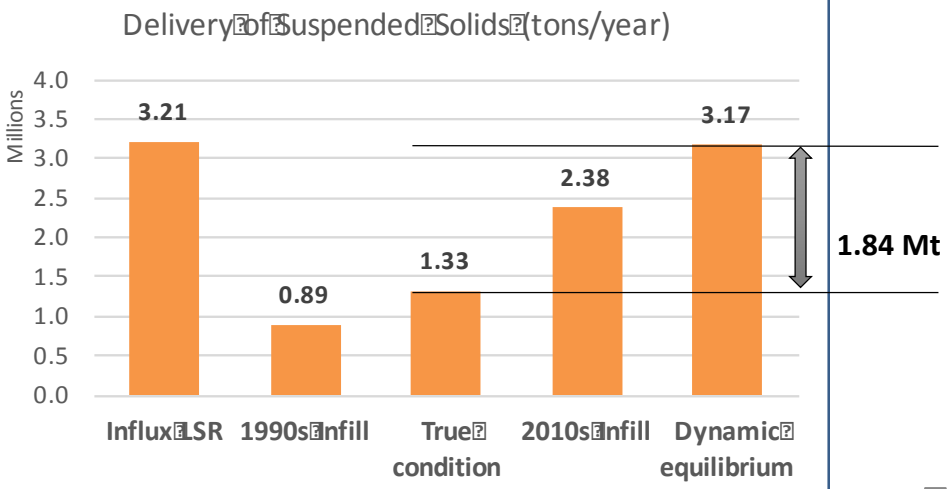
1985 – 2014





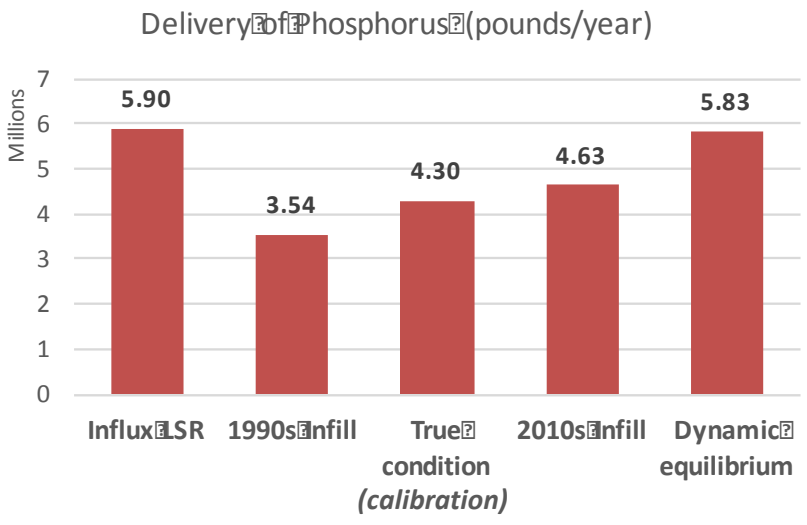
1991 – 2000

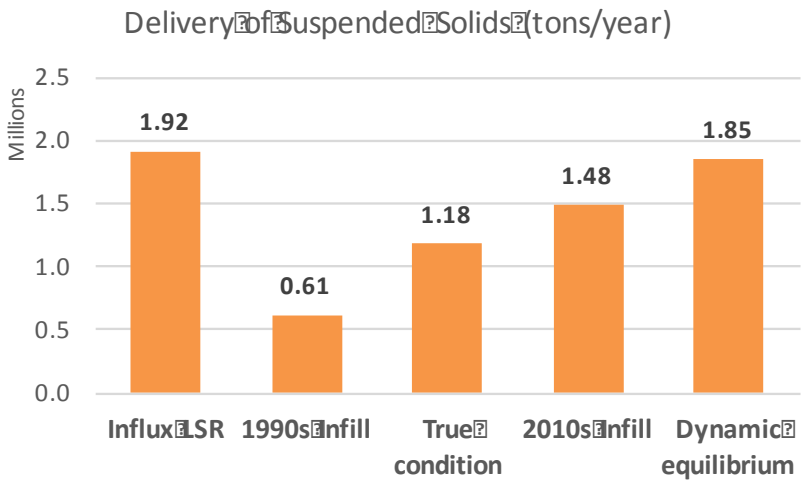




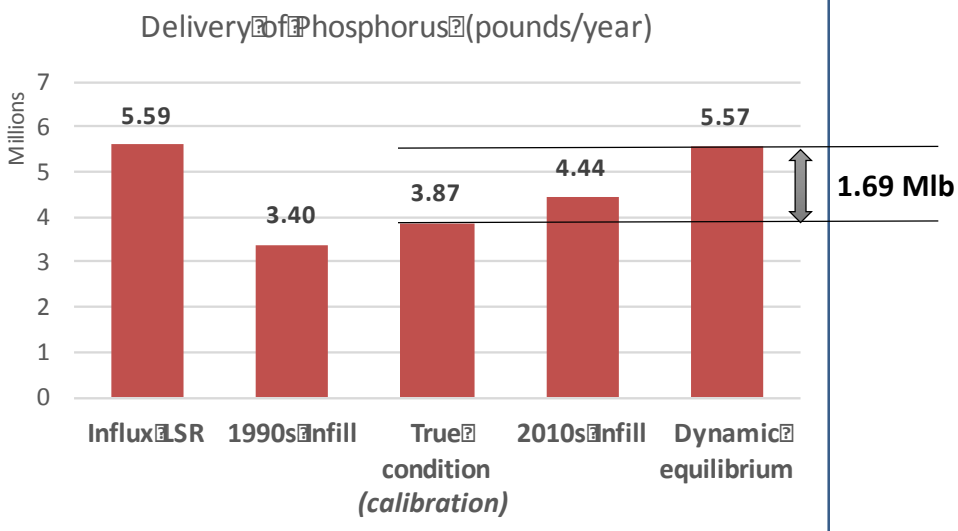
Lower Susquehanna Reservoirs – 2010 WIP2

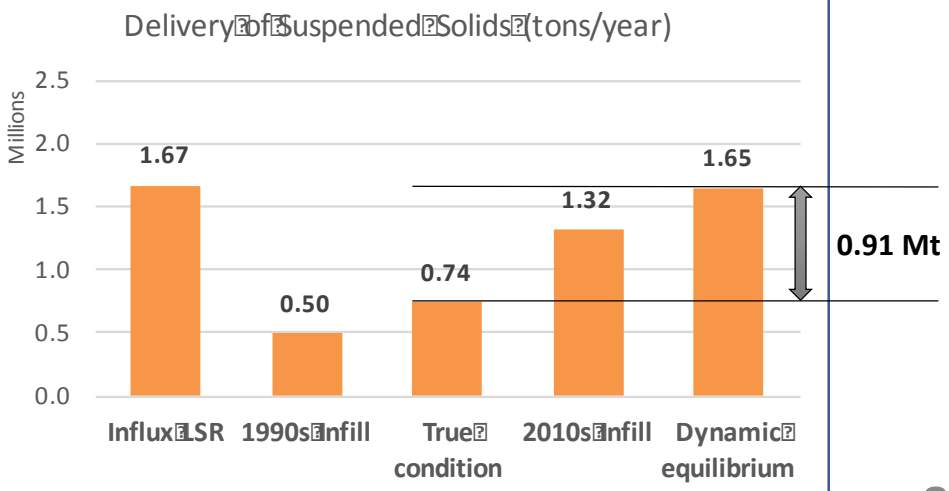
1985 – 2014





1991 – 2000





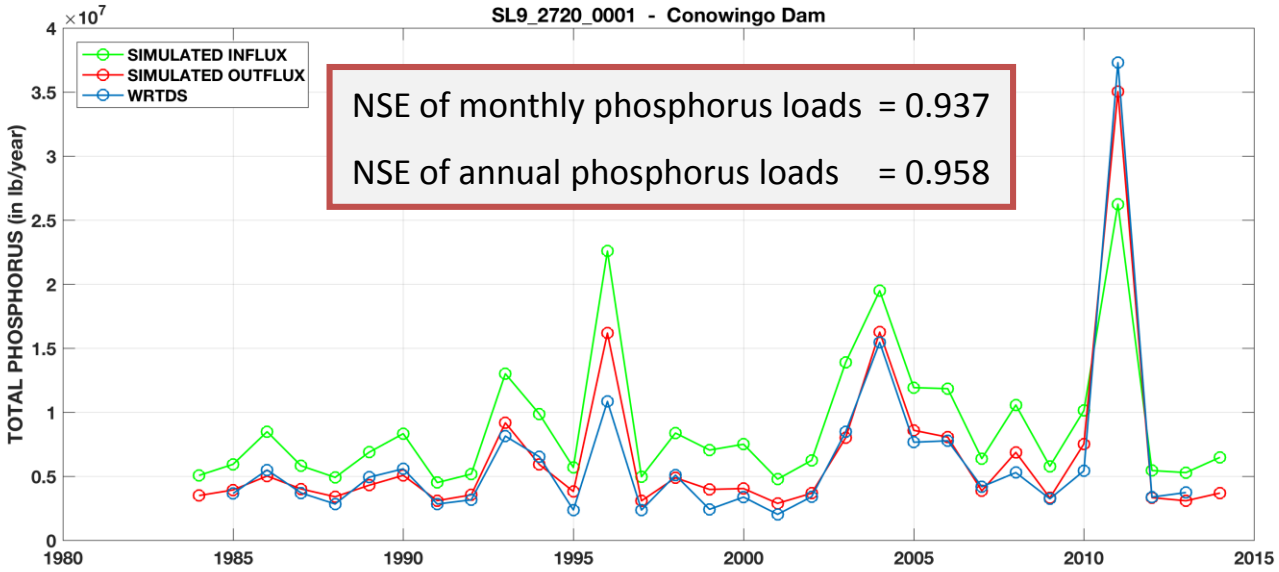
Summary and Conclusions

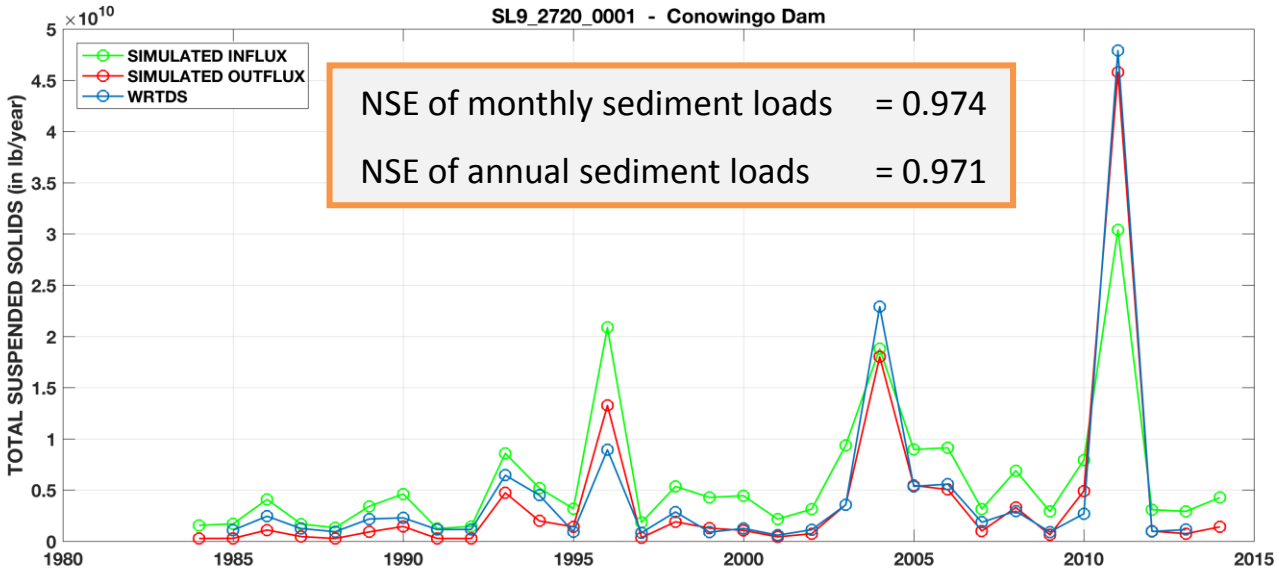
- The results shown were based on the Draft Phase 6 Watershed Model of July 2017.
- The simulations for a range of Conowingo infill conditions were made, leading to the evaluation of the changes in the delivery of nutrients and sediment, for both true-condition (calibration) and 2010 WIP2.
- The increase of about 1.7 million pounds phosphorus is consistent with the previous analyses (2 million pounds) going back to 2015[1].

[1] Linker, L.C., Batiuk, R.A., Cerco, C.F., Shenk, G.W., Tian, R., Wang, P., Yactayo, G., 2016. Influence of Reservoir Infill on Coastal Deep Water Hypoxia. Journal of Environmental Quality, 45: 887-893.

Appendices

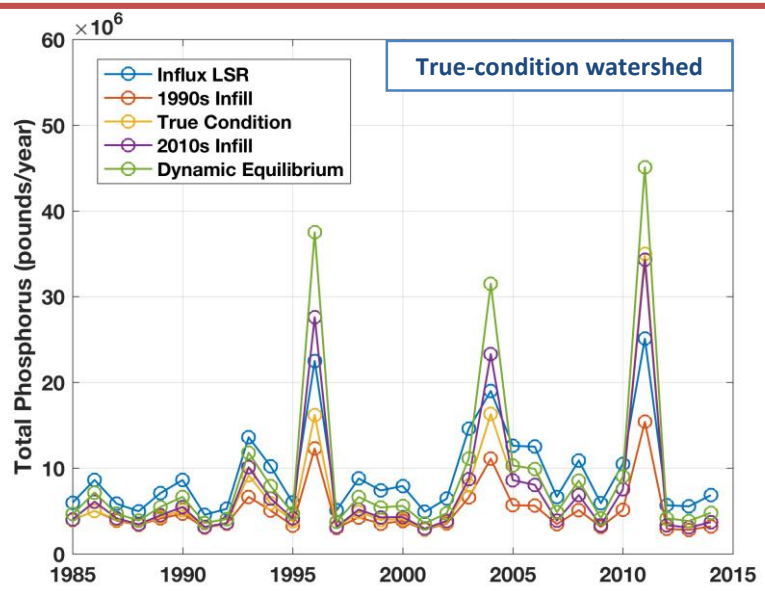
Phase 6 Calibration and WRTDS estimates

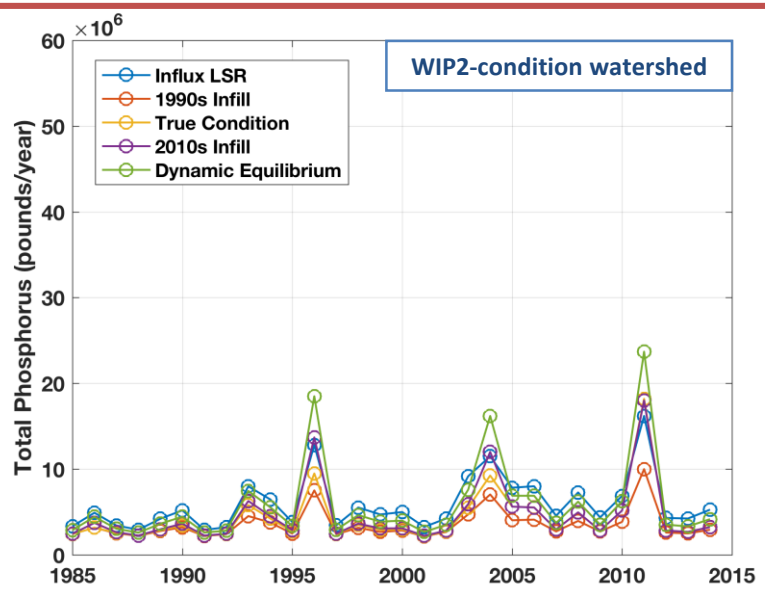


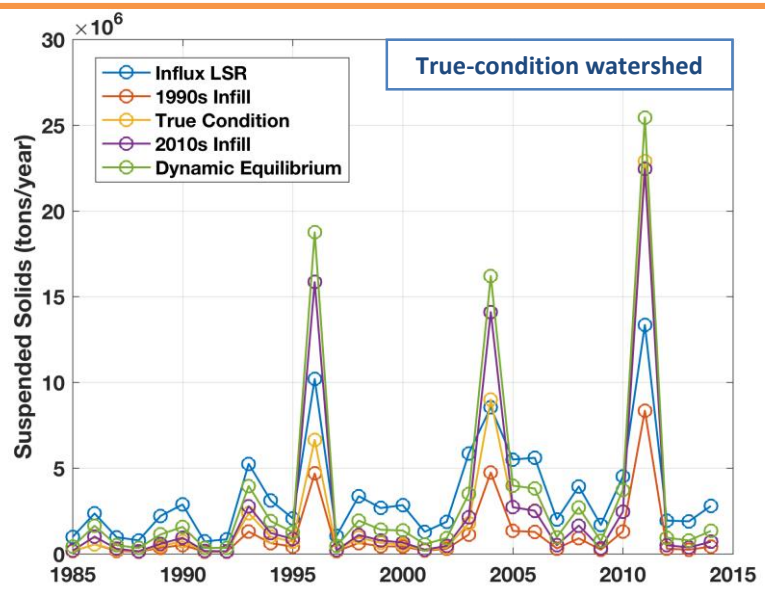


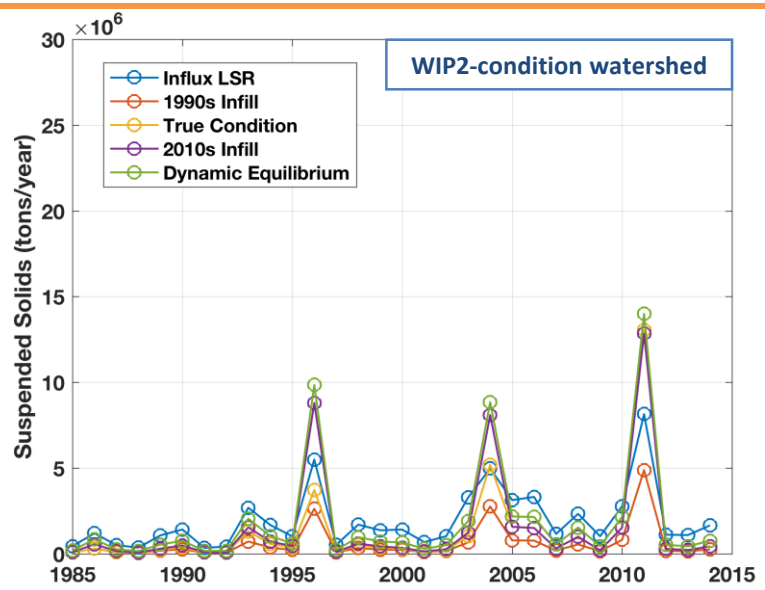
The annual and monthly Nash-Sutcliffe efficiencies (NSE) for the suspended solids and phosphorus confirm good model performance.

Simulated responses for different infill conditions









Lower Susquehanna Reservoirs – Transport Factors

$$Transport\ Factor = \frac{Output}{Input}$$

1985 – 2014	1990s Infill	True Condition	2010s Infill	Dynamic Equilibrium
Phosphorus	0.536	0.707	0.791	**0.998**
Suspended Solids	0.308	0.597	0.757	**0.998**

1991 – 2000	1990s Infill	True Condition	2010s Infill	Dynamic Equilibrium
Phosphorus	0.530	0.632	0.787	**0.996**
Suspended Solids	0.277	0.413	0.741	**0.987**

The dynamic equilibrium transport factor for the 1991-2000 average hydrology period is slightly lower than that for the 1985-2014 period.

Phosphorus (85-14)	Annual TF Range
1990s Infill	0.45-0.68
True Condition	0.51-1.39
2010s Infill	0.54-1.37
Dynamic Equilibrium	0.69-1.80