1. Background

- Reduction of nitrogen (N), phosphorus (P), and suspended sediment (SS) loads has been a principal focus of Chesapeake Bay Watershed management for decades.
- Susquehanna River is of special interest because it is the largest tributary to Chesapeake Bay in terms of freshwater discharge (16% TN load, 20% TP load, and 24% (Beial and Sumpnur, 1999)).
- Seasonal loading trends need to be examined to capture impacts of seasonal (e.g., variations in temperature and rainfall), fertilizer application, deforestation, and/or changes in methodologies.
- In the lower Susquehanna River, N, P, and SS have been trapped by a reservoir system consisting of the Conowingo Dam, the Conestoga Dam, and the Conowingo Reservoir.
- The Conowingo Reservoir is the largest reservoir in the system, was projected to reach its sediment storage capacity (SCC) in 2024–2029 (Jankowski, 2009). At this time, nutrient and sediment delivery from Susquehanna River to Chesapeake Bay would increase considerably.
- Recent analysis has suggested that increased net scouring of sediment in the Conowingo Reservoir may already be occurring at flow rates much lower than the previously reported scour threshold (Mitchel et al., 2012).

2. Research Objectives

- Evaluation of the relative changes in reservoir performance during discharge into and emanating from the reservoir system to assess the reservoir performance in nutrient and sediment retention.

3. Study Area and Data

- The Conowingo Station is located on the mainstem of the Potomac River at the Conowingo Dam. It was considered as the outlet of the reservoir system (Fig. 1). The Manette and Conowingo Stations in Pennsylvania were considered as the inputs of the reservoir system. Together, the two sites monitor flow and nutrient concentrations, namely, SS, TN, TH, TN, DH, orthophosphate discharge (DOP), dissolved nitrite plus nitrate (DNNOx), and dissolved ammonium plus nitrite (DN).

4. Estimation Method

- We applied a recently developed method called weighted regression on time series, and season (WRTDS) (Hirsch et al., 2010) to estimate daily concentration and load for nutrient and sediment.
- In general, WRTDS produces two types of estimates for both concentration and load: (a) so-called the "true-condition" and (b) so-called the "flow-normalized" or "reservoir" estimates of concentration and load. For each "Estimation Day," the WRTDS selects 100 or more "surrounding Sample Days" (Fig. 2) and does a weighted regression to estimate the true-condition concentration and load (Fig. 3a), and the flow-normalized estimates of concentration and load (Fig. 3b).

5. Results and Discussion

- The combined flow-normalized TP loads from Manette and Conowingo also show downward trends in all four seasons (Fig. 4).
- The flow-normalized TP loads at Conowingo show generally "fall-and-rise" trends in all four seasons (Fig. 7), closely following the seasonal discharge trend.
- Overall, the TP load at Conowingo has decreased significantly from the TMDL goal. The effect is clearly related to particular seasons. This is consistent with the seasonal variations in the true-condition concentration and load. However, the flood-normalized estimates do show downward trends in all four seasons. The downward trend of TP load at Conowingo can be largely attributed to the impact of the reservoirs.

6. Conclusions

- Long-term trends of flow-normalized N, P, and SS load generally followed similar patterns in all seasons, implying that nutrient and sediment loads are linked on nutrient and sediment load of the lower times of the Susquehanna River.
- Flow-normalized loads of N, P, and SS have been gradually reduced in the Susquehanna River above the reservoir system. The greatest changes have occurred in the three decades, which are thought to be most likely attributed to a suite of management control actions on point, agricultural, and stormwater sources.
- Flow-normalized loads of SS, TN, and PP at the outlet of the Conowingo Reservoir are still in excess of the TMDLs and, to some degree, the Ashland Reservoir. The reservoirs’ capacity to trap these materials has been diminishing, and the Conowingo Reservoir has never been sediment-starved.
- The changes in reservoir performance will pose significant new kinds of challenges to attainment of total maximum daily loads (TMDLs) of the Susquehanna River Basin, which are comprised by increases in storm frequency and intensity due to climate change. Accordingly, the reservoir issue may need to be factored into the proper establishment of regulatory requirements and the development of watershed implemented plans.

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