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

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Introduction

In developing the Chesapeake Bay Total Maximum Daily Load (TMDL), EPA must account for a vast array of dynamics that affect the loadings to the Chesapeake Bay and how to appropriately assign load allocations to each state. A large influencing factor in sediment and nutrient loads to the Chesapeake Bay are the dams along the lower Susquehanna River, which retain large quantities of sediment in their reservoirs. The three major dams along the lower Susquehanna River are the Safe Harbor Dam, Holtwood Dam, and the Conowingo Dam. This document looks at the dams' effects on the pollutant loads to the Chesapeake Bay and how those loads will change when the dams no longer function to trap sediment.

Sediment Trapping and Storage Capacity

Annually, the reservoir system traps approximately 70 percent of the sediment passing through the system (Langland and Hainly 1997). The trapping capacity is the ability of a reservoir to continue storing sediment before reaching an equilibrium, after which the amount of sediment flowing into the reservoir equals the amount leaving the reservoir, and the stored volume of sediment is relatively static. The sediment storage capacity is the actual maximum amount of sediment that can be stored in a reservoir when it is at equilibrium.

Safe Harbor Dam (Lake Clarke) and Holtwood Dam (Lake Aldred)

Lake Clarke and Lake Aldred have no remaining sediment trapping capacity. The two lakes have been in long-term equilibrium for 50 years or more.

Conowingo Dam and Reservoir

The Conowingo Reservoir is divided into three parts: upper, middle and lower. The upper and middle portions of the reservoir are in long-term equilibrium. Other than temporary increases in sediment storage due to scour events, there is no remaining storage capacity (Langland 2009a).

The lower part of the reservoir is the final 4 miles from just above Broad Creek to the Conowingo Dam. Between 1996 and 2008, 12,000,000 tons of sediment were deposited in the Conowingo Reservoir, primarily in the lower part (Langland 2009a). The total amount of sediment stored in the lower part of the reservoir was 103,000,000 tons by 2008 (Langland 2009a). The lower part of the Conowingo Reservoir is the only section of the entire three-reservoir system that has not reached long-term sediment storage equilibrium. Some trapping capacity remains in this portion of the reservoir.

Expected Time Remaining until Sediment Storage Capacity Is Reached

The sediment storage capacity of Conowingo Reservoir has been decreasing since 1929, except during temporary scour events, such as the one during the *Big Melt* in January 2006 (Langland 2009a). The average reservoir sediment-deposition rate from 1959 to 2008 was 2,000,000 tons per year (Langland 2009). The long-term trapping efficiency of the Conowingo Reservoir has remained relatively stable at around 55 percent for the last 30 years (Michael Langland, USGS, personal communication, November 4, 2009).

According to the U.S. Geological Survey's (USGS's) most recent study, 20,000 acre-feet of sediment storage remain in the Conowingo Reservoir from Hennery Island to the dam; this translates to 30,000,000 tons of sediment (Langland 2009a). Given the rate of transport is 3,000,000 tons per year, and the rate of deposition is 2,000,000 tons per year, if there are no major scouring events in the Conowingo Reservoir and the sediment input does not change, the remaining capacity will be filled in 15–20 years (Langland 2009a). Once the sediment storage capacity is reached, sediment loads transported downstream past the reservoir will approach the loads transported from upstream (Langland 2009a).

However, because Langland notes that the time until the reservoir reaches capacity is affected by three factors—sediment transport into the reservoir, scour removal events, and sediment trapping efficiency—the time until steady state conditions are reached could be extended to 25–30 years (Langland 2009b). That assumes sediment transport decreases from 3.2 to 2.5 million tons/year, statistically expected scour events occur, and the long-term trapping efficiency remains at 55 percent (Langland 2009b).

It should be noted that the sediment trapping efficiency of the reservoir is highly variable, depending on rainfall. During drought conditions, the trapping efficiency can increase to 85 percent, and during wet periods, the trapping efficiency can fall to 40 percent (Michael Langland, USGS, personal communication January 15, 2010).

Effects on Chesapeake Bay Once Sediment Storage Capacity is Reached

As of 1997 the Susquehanna River contributed roughly 50 percent of the fresh water discharge to the Chesapeake Bay and about 66 percent of the annual nitrogen load, 40 percent of the phosphorus load, and 25 percent of the suspended sediment load from non-tidal parts of the Bay (Langland and Hainly 1997).

According to USGS water quality sampling in 1985–1989, pollutant loads in the Susquehanna River increase substantially below Harrisburg, Pennsylvania: total nitrogen increased 42 percent, total phosphorus increased 49 percent, and total suspended sediment increased 50 percent compared to loads at Harrisburg (Reed et al. 1997). The increased load is a result of more urbanized areas, agrochemical fertilizers and manure, and fewer forested areas (Reed et al.

1997). A significant percentage of those pollutant loads are captured by sediment deposition behind the dams, primarily the Conowingo Dam.

Once the Conowingo Reservoir reaches the sediment trapping capacity, the sediment and nutrient loads delivered to the Chesapeake Bay via the Susquehanna River will equal the load delivered into the reservoir system (Langland and Cronin 2003). Once storage capacity is reached, the nitrogen load will increase by 2 percent; the phosphorus load will increase by 40 percent; and the suspended sediment load will increase by at least 150 percent (Langland and Cronin 2003).

Proposed Activities to Address Sediment Build up Behind the Dam

Dredging

The Susquehanna River Basin Commission Sediment Task Force examined the issue of finding options to address the sediment accumulation behind the Conowingo Dam and concluded that dredging may provide the needed sediment storage capacity behind the dams (SRBC 2002).

In 2009 the U.S. Army Corps of Engineers (USACE) Baltimore District received funds to conduct a study of sediment management in the Conowingo Reservoir. The investigation could be developed as a Sediment Management Plan, to prioritize areas for work and make recommendations to implement sediment reduction options (Compton 2009). The study approach outlined by the USACE is conceptual, and the final components will be determined with input from the cost-share sponsor. The USACE has not yet found a cost-share partner for this feasibility study (Anna Compton, USACE Baltimore District, personal communication, December 22, 2009).

Conowingo Hydroelectric Project Relicensing Process

The Conowingo Hydroelectric Project is undergoing relicensing. On February 4, 2010 FERC (Federal Energy Regulatory Commission) accepted Exelon's Revised Study Plan, including the requested study *Sediment Introduction and Transport (Sediment and Nutrient Loading)* which will address "the effects of the Conowingo Project and its operation on upstream sediment and nutrient accumulation, sediment transport past the project, and sediment deposition and distribution upstream and downstream of the projects" (Exelon Corporation 2009). Specific tasks include a review of existing information regarding sediment and nutrient storage capacity, accumulation rates, scouring events, and such, in the Conowingo Reservoir; an analysis of the effects of project operations on habitat and substrate below the dam; and a review of watershed-based management efforts and load reduction successes. Exelon noted that the "estimated cost in 1995 dollars of dredging to simply keep up with annual sediment inflow (estimated to be 2.3 million cubic yards per year at the time) was $28 million per year. Using Means Cost Indices the comparable 2009 cost would be $48.44 million.

Cost Comparison of Dredging and Other Nutrient and Sediment Reduction Strategies

Comparisons with cost estimates for dredging Baltimore Harbor and Channels from the *Dredged Material Management Plan and Final Tiered Environmental Impact Statement* (Weston Solutions 2005) reveal that dredging costs are highly variable, and, to a large extent, depend on the selected destination and use of the dredged materials. Costs can be as little as $\$12/yd^3$ for artificial island creation or beach nourishment and as much as $\$69/yd^3$ if dredged materials are taken to a confined disposal facility (Weston Solutions 2005). The sediment management feasibility study proposed by the USACE, and awaiting a cost-share sponsor, is likely the best mechanism to determine the true cost of dredging the Conowingo Reservoir.

Cost-Effective Strategies for the Bay (Chesapeake Bay Commission 2004) outlines the six most cost-effective practices to reduce nutrient and sediment loading to the Chesapeake Bay. Table T-1 summarizes the six selected practices and their estimated costs and compares them to the estimated costs of dredging the Conowingo Reservoir. Rough estimate calculations of dredging costs at Conowingo were based on the cost assumptions used by Exelon and SRBC and the assumption that 1 yd^3 of sediment weighs 0.945 tons. It is not known, at this time, what is included in Exelon's estimate of the cost to dredge; an assumption was made that the costs include disposal of the dredged materials, and any other associated costs.

Table T-1. Cost-Effective Strategies for Reducing Nitrogen and Sediment Loads to the Bay Compared to Estimated Dredging Costs

Practice	Annual nitrogen reduction at maximum feasible level of implementation	Annual phosphorus reduction at maximum feasible level of implementation	Annual sediment reduction at maximum feasible level of implementation
Wastewater Treatment Plant Upgrades	35 million lbs @ $8.56/lb	3 million lbs @ $74.00/lb	Not applicable
Diet and Feed Adjustments	Under development	0.22 million lbs @ no additional cost (poultry only)	Not applicable
Traditional Nutrient Management	13.6 million lbs @ $1.66/lb	0.8 million lbs @ $28.26/lb	Not applicable
Enhanced Nutrient Management	23.7 million lbs @ $4.41/lb	0.8 million lbs @ $95.79/lb	Not applicable
Conservation Tillage	12.0 million lbs @ $1.57/lb	2.59 million lbs @ no additional cost	1.68 million tons @ no additional cost
Cover Crops	23.3 million lbs @ $3.13/lb	0.44 million lbs @ no additional cost	0.22 million tons @ no additional cost
Rough estimate calculations of dredging costs	Annual nitrogen dredged based on removal equal to annual trapped amount	Annual phosphorus dredged based on removal equal to annual trapped amount	Annual sediment dredged based on removal equal to annual trapped amount
Dredge Conowingo Reservoir	3 million lbs @ $16.42/lb	3.48 million lbs @ $14.15/lb	4,420 million lbs @ $0.01/lb

Source: CBC 2004

Proposal for Addressing the Sediment and Phosphorus Load in the Chesapeake Bay TMDL

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. The steady state condition is at the limits of the planning horizon for the TMDLs and, depending on conditions, could be well beyond the planning horizon.

Under these assumptions, the wasteload allocations (WLA) and load allocations (LA) would be based on the current conditions at the dam. This represents a business-as-usual scenario in which the future diminished trapping capacity behind the Conowingo Dam is not considered in developing of the wasteload WLA and LA.

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.

Future increases in sediment and phosphorus downstream of the dam can be minimized by making implementation activities above the dam a management priority. This will decrease the overall loads of sediment and phosphorus, and extend the time until trapping capacity is reached. The states should work together to develop an implementation strategy for the Conowingo Dam and take the opportunity to work with FERC during the relicensing process for Conowingo Dam.

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