DO Water Quality Standard Attainment Analysis of the Estimated Influence of Conowingo Infill on Chesapeake DO Using Linked WSM, ADH, and WQSTM Simulations

Modeling Quarterly Review

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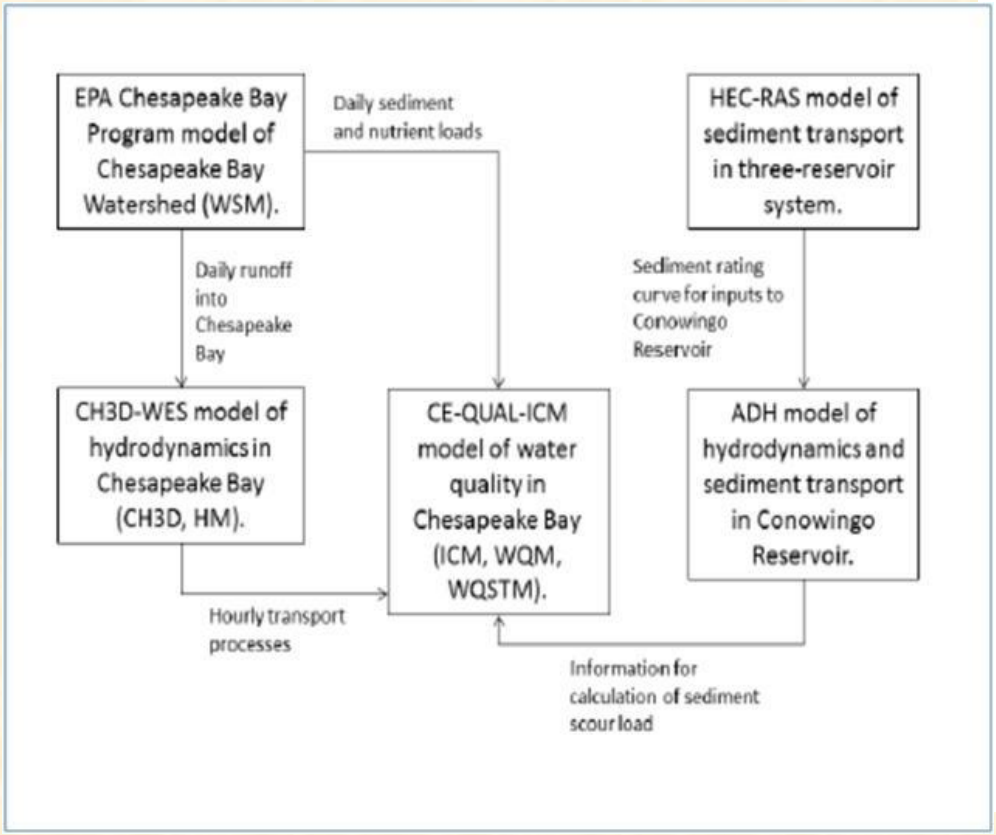
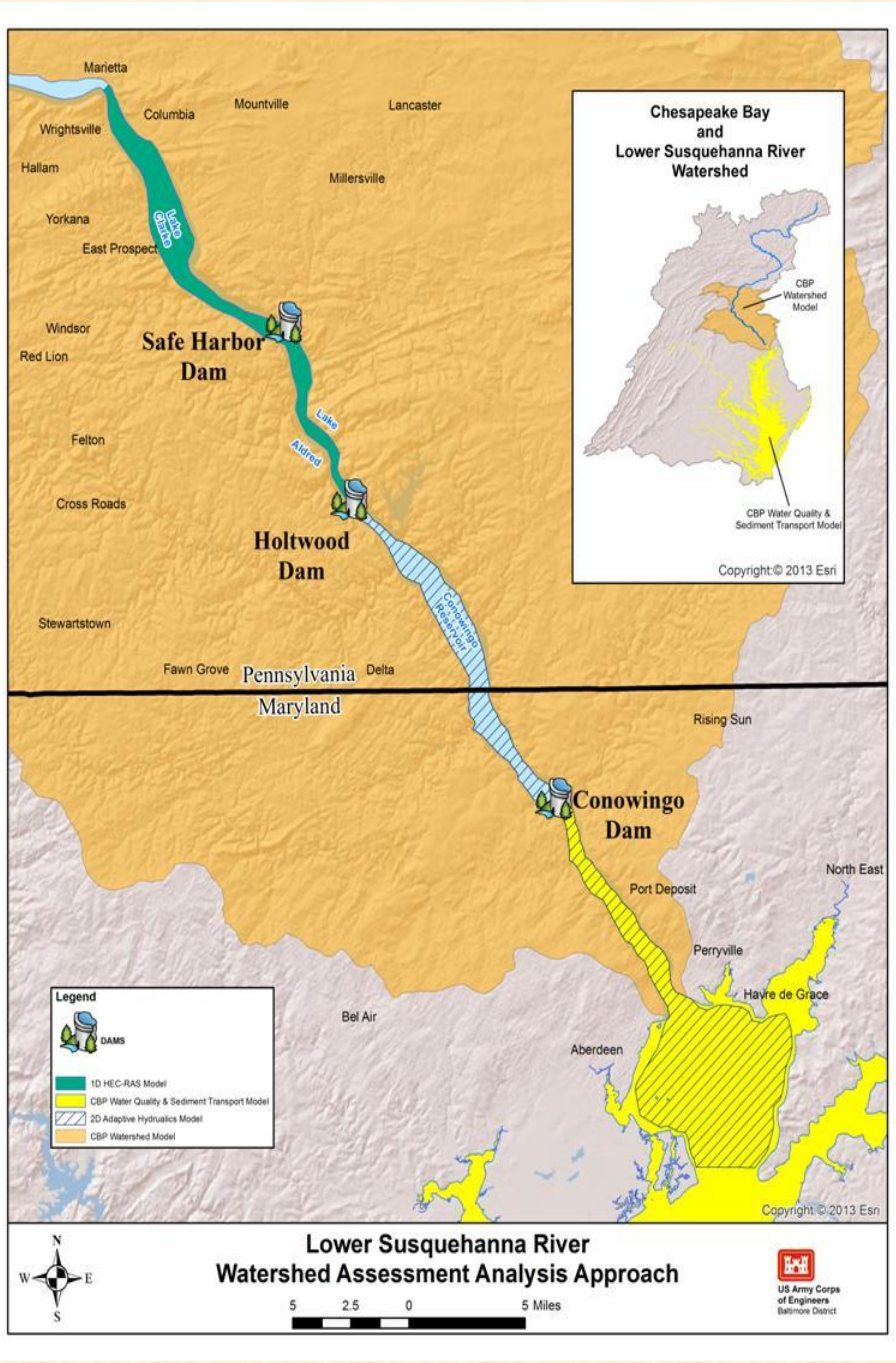
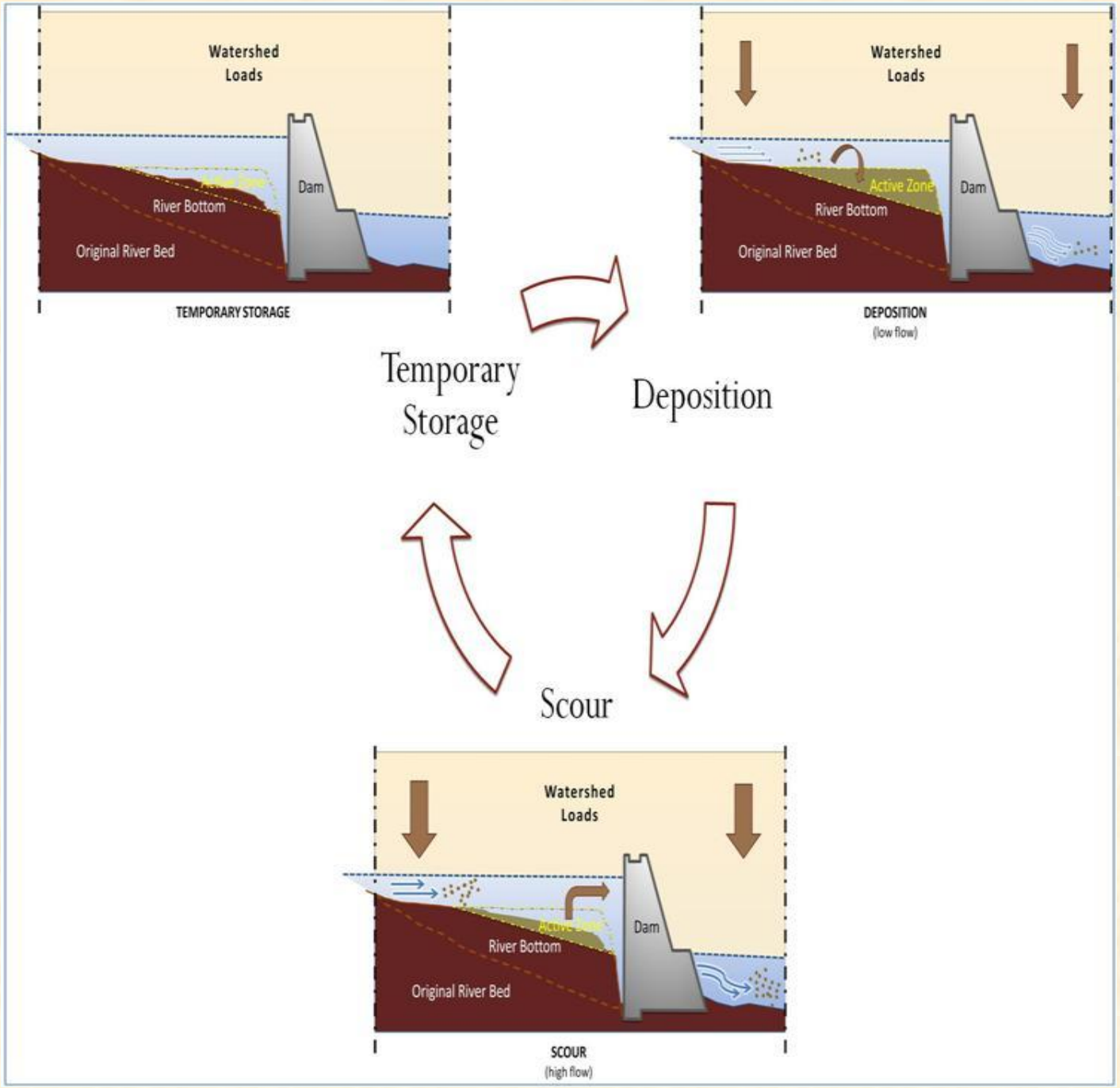
Domains of HEC-RAS, ADH, WSM, & WQSTM Models





Dynamic Equilibrium Schematic



Assessment of Chesapeake Bay DO Deep-Channel water quality standard nonattainment for key scenarios.

CB Segment	Scenario→ / Year → / State	No Action (N-Based) Scenario 371 TN, 37.6 TP, 10630TSS '93-'95 DO Deep Channel	1985 Scenario 353 TN, 24.6 TP, 10100 TSS '93-'95 DO Deep Channel	2007 Scenario 269 TN, 19.5 TP, 8770 TSS '93-'95 DO Deep Channel	2010 (LSRWA-4) Scenario 263 TN 19.4 TP 8360 TSS '93-'95 DO Deep Channel	WIP (LSRWA-3) Scenario 191 TN 15 TP 6675 TSS '93-'95 DO Deep Channel	E3 (2010 N-Based) Scenario 135 TN, 10.4 TP, 4850 TSS '93-'95 DO Deep Channel	All Forest Scenario 54 TN, 2.6 TP, 1340 TSS '93-'95 DO Deep Channel
CB3MH	MD	22%	17%	12%	5%	0%	0%	0%
CB4MH	MD	54%	49%	40%	23%	1.49%	0%	0%
CB5MH	both	22%	17%	10%	0%	0%	0%	0%
CHSMH	MD	45%	39%	36%	28%	15.01%	5%	0%
EASMH	MD	38%	29%	24%	14%	1.09%	0%	0%
PATMH	MD	46%	42%	25%	18%	0%	0%	0%
POTMH	both	27%	20%	13%	0%	0%	0%	0%
RPPMH	VA	29%	23%	6%	0%	0%	0%	0%

* CB4MH and EASMH Deep-Channel variance of 2% and CHSMH has a Deep-Chanel variance of 16%.

Assessment of Chesapeake Bay DO Deep-Water water quality standard nonattainment for key scenarios.

Cbseg	Scenario → Year → State	No Action (N-Based) Scenario 371 TN, 37.6 TP, 10630TSS '93-'95 DO Deep Water	1985 Scenario 353 TN, 24.6 TP, 10100 TSS '93-'95 DO Deep Water	2007 Scenario 269 TN, 19.5 TP, 8770 TSS '93-'95 DO Deep Water	2010 (LSRWA-4) Scenario 263 TN, 19.4 TP, 8360 TSS '93-'95 DO Deep Water	WIP (LSRWA-3) Scenario 191 TN, 15 TP, 6675 TSS '93-'95 DO Deep Water	E3 (2010-N Based) Scenario 135 TN, 10.4 TP, 4850 TSS '93-'95 DO Deep Water	All Forest Scenario 54 TN, 2.6 TP, 1340 TSS '93-'95 DO Deep Water
CB3MH	MD	4%	2%	2%	1%	0%	0%	0%
CB4MH	MD	28%	22%	17%	11%	4.7%	3%	0%
CB5MH	both	7%	5%	3%	2%	0%	0%	0%
CB6PH	VA	1%	1%	0%	0%	0%	0%	0%
CHSMH	MD	39%	32%	21%	11%	0%	1%	0%
EASMH	MD	34%	14%	4%	2%	0.90%	0%	0%
PATMH	MD	31%	21%	11%	6%	0%	0%	0%
PAXMH	MD	23%	12%	2%	0%	0%	0%	0%
POTMH	both	9%	5%	2%	0%	0%	0%	0%
RPPMH	VA	13%	8%	3%	0%	0%	0%	0%
SBEMH	VA	5%	3%	0%	0%	0%	0%	0%
YRKPH	VA	0%	0%	0%	0%	0%	0%	0%

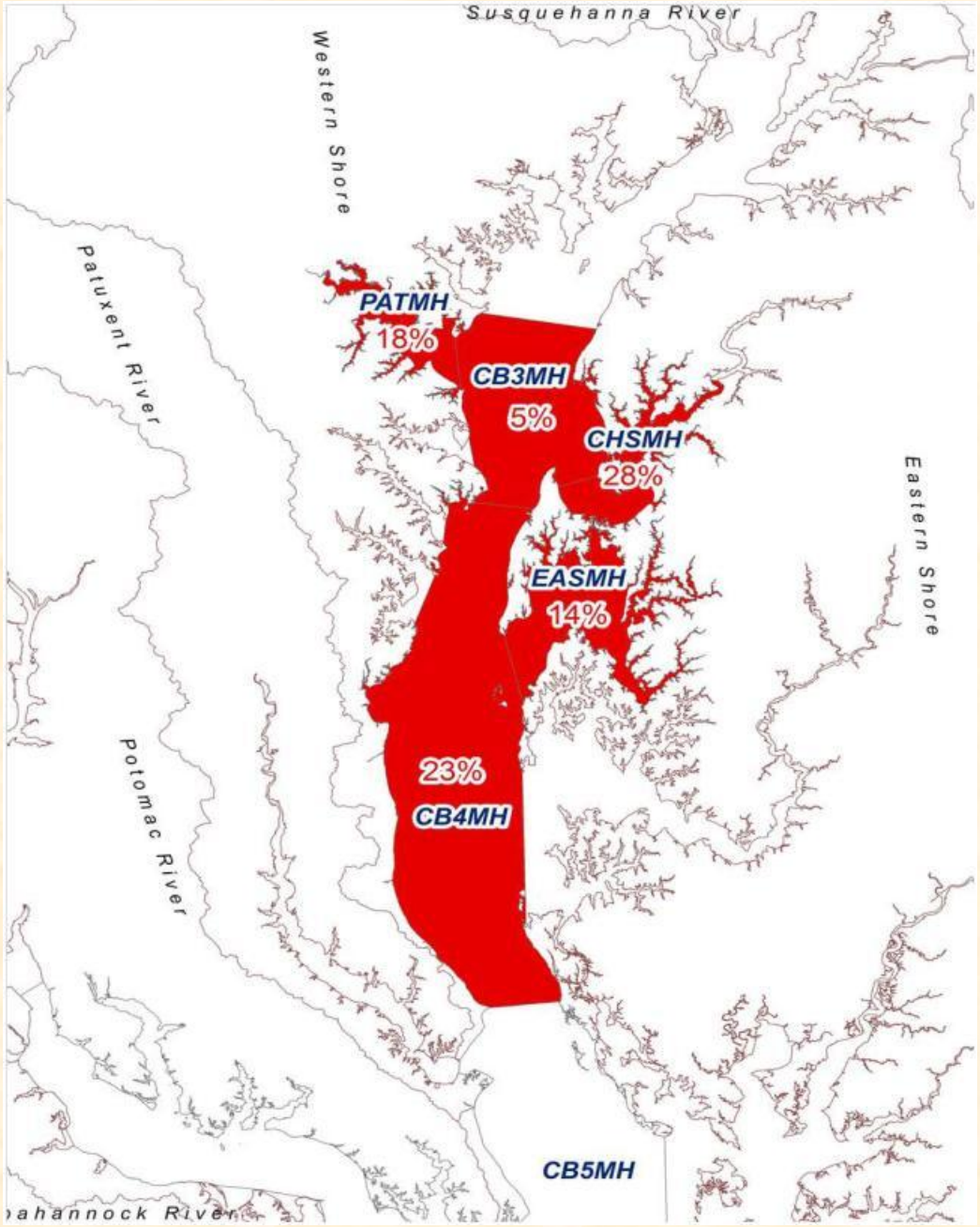
* CB4MH and PATMH have a Deep-Water variance of 7%.

Assessment of the Chesapeake Bay Deep-Channel DO water quality standards attainment for key scenarios in the Conowingo Reservoir infill analysis.

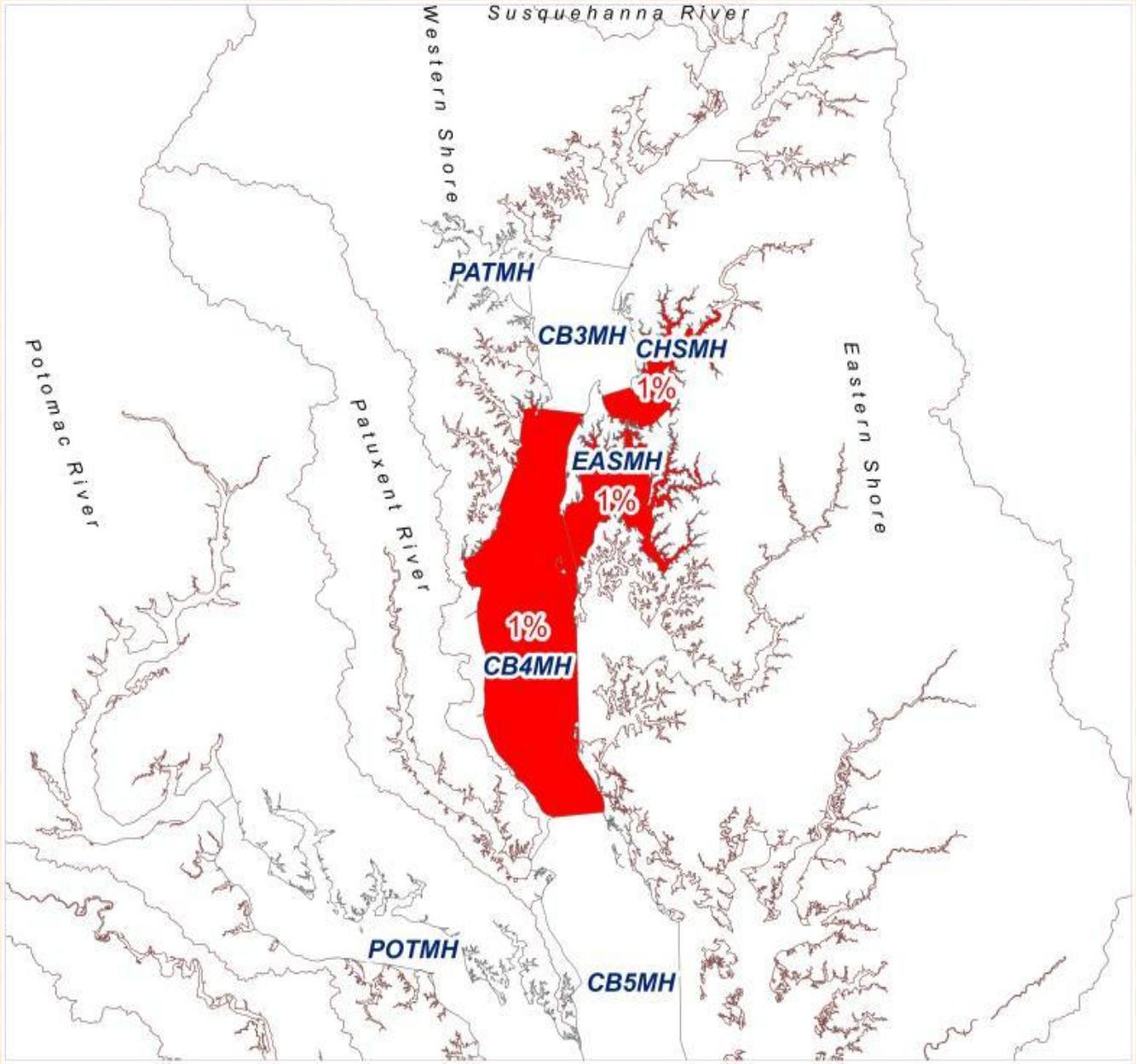
	1. What is the system's current (existing) condition? **Scenario LSRWA-4**	2. What is the system's condition if the WIPs are in full effect and reservoirs are still trapping? Scenario **LSRWA-3**	3. What is the system's condition when WIPS are in full effect, reservoirs are still trapping sediments and a scour event occurs during winter? **Scenario LSRWA-21**	4. What is the system's condition when WIPS are not in effect, reservoirs are full and there is a winter scour event? Scenario **LSRWA-18**	5. What is the system's condition when WIPs are in full effect, the reservoirs are full and there is a winter scour event? **LSRWA-30**	6. What is the system's condition if WIPs are in full effect, reservoirs are full and a large scour event occurs during summer **(LSRWA-24),** fall **(LSRWA-25)** or winter **(LSRWA-21)?**
Deep Channel DO Water Quality Standard Achievement for Total Maximum Daily Load (TMDL)	Widespread nonattainment of TMDL of Deep Channel DO. Nonattainment of 23% in the CB4 mainstem, 14% in Eastern Bay, and 28% in the Lower Chester River was estimated. This and other areas of nonattainment in the Deep Channel amounted to more than half of the Deep Channel habitat.	Complete attainment of the Deep Channel DO standard was estimated.	Using the 1996-1998 period to capture the January 1996 "Big Melt" event, an increase of 1% nonattainment over the Base TMDL Scenario (LSRWA-3) was estimated for CB4MH, EASMH, and CHSMH.	Using for comparison, the scenario of the systems current condition (LSRWA-4), an increase of 1% nonattainment for CB4MH, and PATMH was estimated.	Using the 1996-1998 period to capture the January 1996 "Big Melt" event, an increase of 1% nonattainment over the Base TMDL Scenario (LSRWA-3) was estimated for CB4MH, EASMH, and CHSMH.	Generally, a June high flow storm event has the most detrimental influence on Deep Channel DO followed by a storm of the same magnitude in January and then October.

*** The June high flow event scenario (LSRWA-24) had an estimated increase in Deep-Channel nonattainment of 3%, 6%, and 2% in segments CB4MH, CHSMH, and EASMH over Scenario 2 (LSRWA-3/Base). October event was in attainment.**

Estimated nonattainment of the Deep-Channel DO standard in Chesapeake Bay segments CB3MH, CB4MH, EASMH, PATMH, and CHSMH under the 2010 Scenario (LSRWA-4).



An estimated 1 percent increase of nonattainment of the Deep-Channel DO standard in Chesapeake Bay segments CB4MH, EASMH, and CHSMH under the LSRWA-21 Scenario compared to the LSRWA-3 Scenario using the 1996-1998 hydrology period.



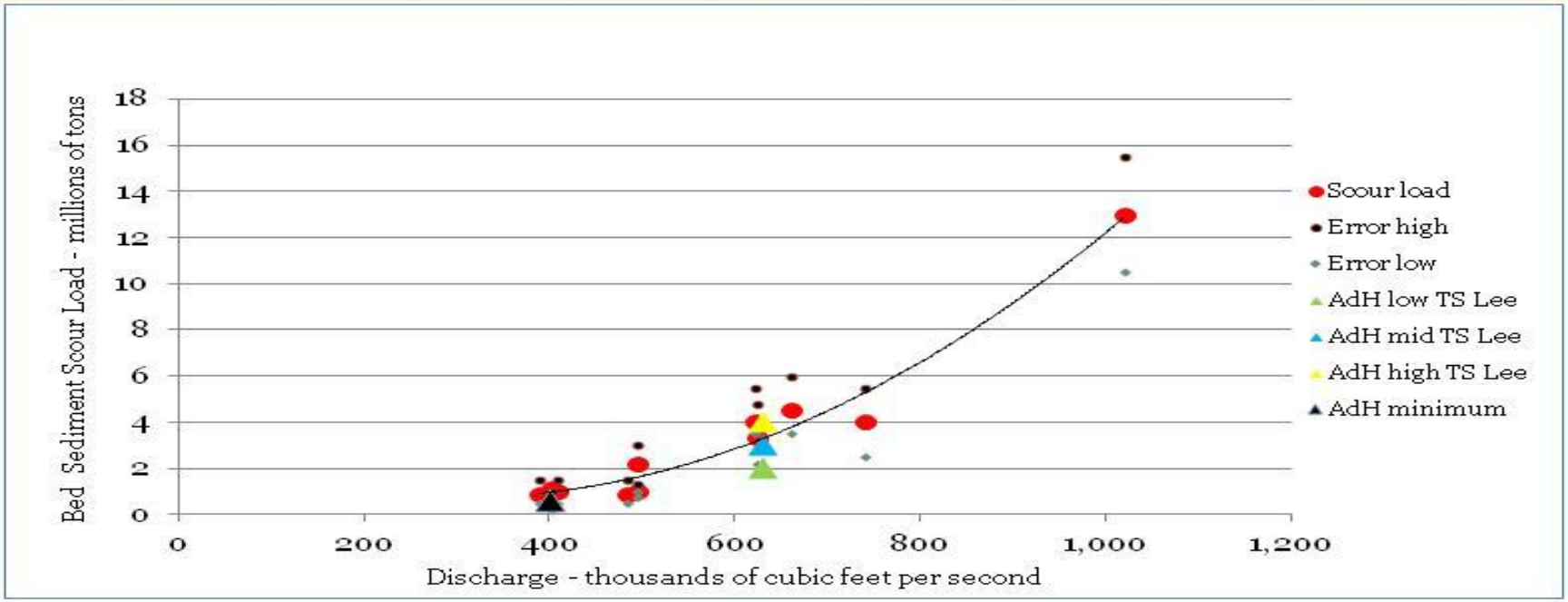
Assessment of the Chesapeake Bay Deep-Water and Open-Water DO water quality standards attainment for key scenarios in the Conowingo Reservoir infill analysis.

	1. What is the system's current (existing) condition? **Scenario LSRWA-4**	2. What is the system's condition if the WIPs are in full effect and reservoirs are still trapping? Scenario **LSRWA-3**	3. What is the system's condition when WIPS are in full effect, reservoirs are still trapping sediments and a scour event occurs during winter? **Scenario LSRWA-21**	4. What is the system's condition when WIPS are not in effect, reservoirs are full and there is a winter scour event? Scenario **LSRWA-18**	5. What is the system's condition when WIPs are in full effect, the reservoirs are full and there is a winter scour event? **LSRWA-30**	6. What is the system's condition if WIPs are in full effect, reservoirs are full and a large scour event occurs during summer **(LSRWA-24),** fall **(LSRWA-25)** or winter **(LSRWA-21)?**
Deep Water DO Water Quality Standard Achievement for TMDL	Widespread nonattainment of TMDL of Deep Water DO. Estimated nonattainment of 11% in the CB4 mainstem, 2% in Eastern Bay, and 11% in the Lower Chester River.	Complete attainment of the Deep Water DO standard was estimated to be attained.	Using the 1996-1998 period to capture the January 1996 "Big Melt" event, an increase of 1% nonattainment over the Base TMDL Scenario (LSRWA-3) was estimated for CB4MH and CB5MH.	Using for comparison, the scenario of the systems current condition (LSRWA-4), an increase of 1% nonattainment for CB3MH and PAXMH was estimated.	Using the 1996-1998 period to capture the January 1996 "Big Melt" event, an increase of 1% nonattainment over the Base TMDL Scenario (LSRWA-3) was estimated for CB4MH and CB5MH.	Generally, a June high flow storm event has the most detrimental influence on Deep Channel DO followed by a storm of the same magnitude in January and then October.
Open Water DO Water Quality Standard Achievement for TMDL	Widespread, but not complete attainment of the Open Water DO standard was estimated to be attained.	Complete attainment of the Open Water DO standard was estimated.	Complete attainment of the Open Water DO standard was estimated.	Complete attainment of the Open Water DO standard was estimated.	Complete attainment of the Open Water DO standard was estimated.	Complete attainment of the Open Water DO standard was estimated.

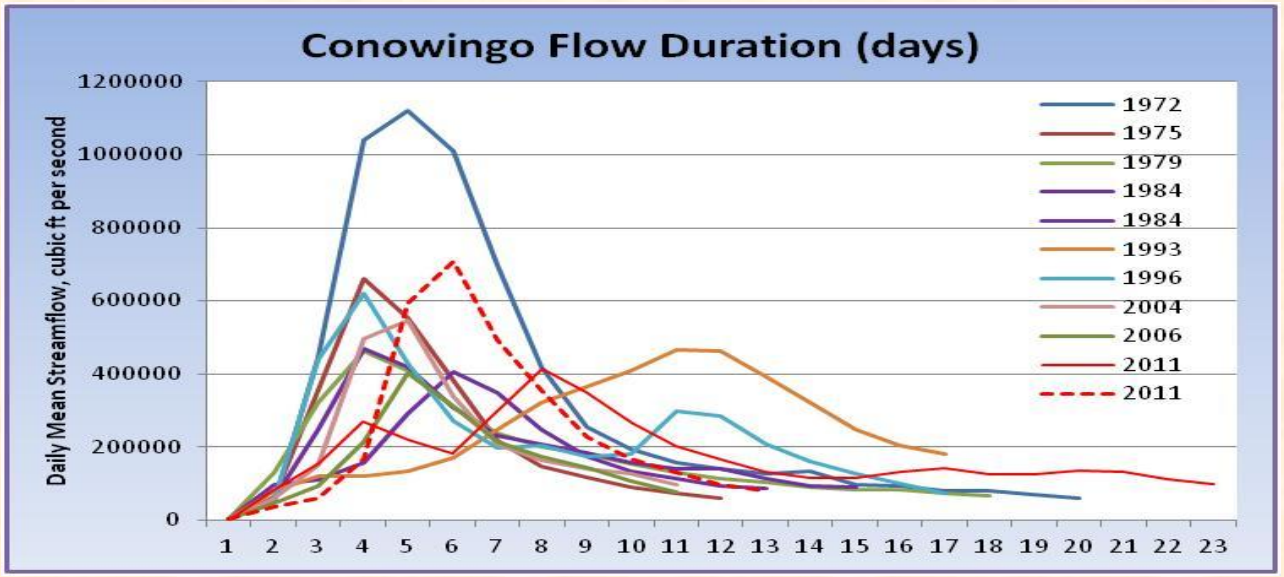
Assessment of the Deep-Channel DO, Deep-Water DO, and Open-Water DO water quality standard for key management scenarios in the Conowingo infill analysis.

	What are the effects of strategic dredging? **LSRW-28**	What are the effects of passing sediment downstream for 3 winter months, over-time for a period of 10 years? **LSRWA-29**	What are the effects of extreme long-term removal out of system) restoring to 1996 bathymetry? **LSRWA-31**
Deep-Channel DO Water Quality Standard Achievement for Total Maximum Daily Load (TMDL)	Using the 1996-1988 period to capture the January 1996 "Big Melt" event, water quality was estimated to be improved by a decrease of 0.2% nonattainment over the Base WIP (**LSRWA-21)** Scenario for CB3MH and CB4MH and a 0.1% decrease in attainment in EASMH.	Using the 1996-1988 period to capture the January 1996 "Big Melt" event, water quality was estimated to increase nonattainment by an estimated 4%, 5%, 3%, 4%, and 2% over the comparative LSRWA-21 Scenario for CB3MH, CB4MH, CHSMH, EASMH, and PATMH, respectively.	Using the 1996-1988 period to capture the January 1996 "Big Melt" event, water quality was estimated to be improved by a decrease of 0.3%, 0.5%, and 0.2% nonattainment over the Base WIP (**LSRWA-21)** Scenario for CB3MH, CB4MH, and EASMH, respectively.
Deep-Water DO Water Quality Standard Achievement for TMDL	Using the 1996-1998 period to capture the January 1996 "Big Melt" event, nonattainment in CB4MH was estimated to decrease by 0.1% over the Base WIP Scenario (**LSRWA-21)**	Using the 1996-1998 period to capture the January 1996 "Big Melt" event, nonattainment in CB4MH was estimated to decrease by 0.2% over the Base WIP Scenario (**LSRWA-21)**	Using the 1996-1998 period to capture the January 1996 "Big Melt" event, nonattainment in CB4MH was estimated to decrease by 0.2% over the Base TMDL Scenario (**LSRWA-21)**
Open-Water DO Water Quality Standard Achievement for TMDL	Complete attainment of the Open Water DO standard was estimated.	Complete attainment of the Open Water DO standard was estimated.	Complete attainment of the Open Water DO standard was estimated.

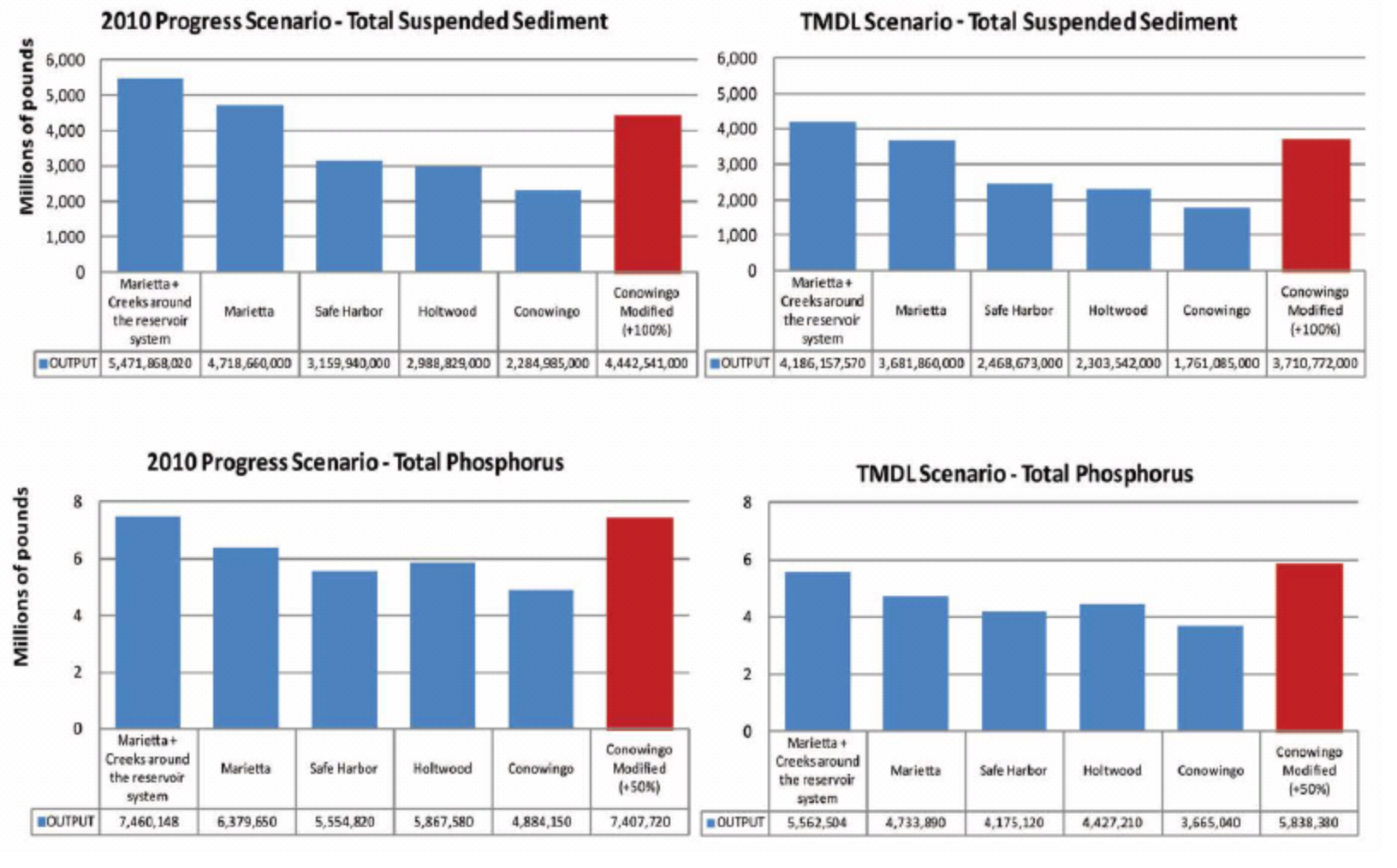
USGS "scour equation" used to predict scour from flows generally exceeding 400,000 cubic feet per second Combined with AdH model results



Flow Hydrographs for 11 Recent High Flow Events at Conowingo, MD



In work being done by the CBP Modeling Workgroup scenarios were developed to represent the Conowingo loads calculated by Hirsch (2012). Two types of scenarios were developed where sediment and phosphorus loads were increased from the Conowingo Pool representing current infill and complete infill conditions. The scenarios were created by recalibrating the river simulation only at the Conowingo segment and adjusting parameters that would increase sediment and phosphorus loads.



Assessment of Chesapeake Bay DO Deep-Channel water quality standard nonattainment for key scenarios.

CB Segment	Scenario → Year → State	2010 No Action N-Based Scenario 371 TN, 37.6 TP, 10630TSS '93-'95 DO Deep Channel	1985 Scenario 353 TN, 24.6 TP, 10100 TSS '93-'95 DO Deep Channel	2007 Scenario 269 TN, 19.5 TP, 8770 TSS '93-'95 DO Deep Channel	2010 Scenario 263 TN 19.4 TP 8360 TSS '93-'95 DO Deep Channel	2010 scour100% '93-'95 DO Deep Channel	TMDL Scenario 191 TN 15 TP 6675 TSS '93-'95 DO Deep Channel	TMDL scour100% '93-'95 DO Deep Channel	E3 2010 N-Based Scenario 135 TN, 10.4 TP, 4850 TSS '93-'95 DO Deep Channel	All Forest Scenario 54 TN, 2.6 TP, 1340 TSS '93-'95 DO Deep Channel
CB3MH	MD	22%	17%	12%	5%	8%	0%	0%	0%	0%
CB4MH	MD	54%	49%	40%	23%	30%	1.49%	3.39%	0%	0%
CB5MH	both	22%	17%	10%	0%	2%	0%	0%	0%	0%
CHSMH	MD	45%	39%	36%	28%	31%	15.01%	15.66%	5%	0%
EASMH	MD	38%	29%	24%	14%	17%	1.09%	3.73%	0%	0%
PATMH	MD	46%	42%	25%	18%	23%	0%	0%	0%	0%
POTMH	both	27%	20%	13%	0%	0%	0%	0%	0%	0%
RPPMH	VA	29%	23%	6%	0%	0%	0%	0%	0%	0%

Assessment of Chesapeake Bay DO Deep-Water water quality standard nonattainment for key scenarios.

Cbseg	Scenario → Year → State	2010 No Action N-Based Scenario 371 TN, 37.6 TP, 10630TSS '93-'95 DO Deep Water	1985 Scenario 353 TN, 24.6 TP, 10100 TSS '93-'95 DO Deep Water	2007 Scenario 269 TN, 19.5 TP, 8770 TSS '93-'95 DO Deep Water	2010 Scenario 263 TN 19.4 TP 8360 TSS '93-'95 DO Deep Water	2010 scour100 % '93-'95 DO Deep Water	TMDL Scenario 191 TN 15 TP 6675 TSS '93-'95 DO Deep Water	TMDL scour100 % '93-'95 DO Deep Water	E3 2010 N-Based Scenario 135 TN, 10.4 TP, 4850 TSS '93-'95 DO Deep Water	All Forest Scenario 54 TN, 2.6 TP, 1340 TSS '93-'95 DO Deep Water
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CB4MH	MD	28%	22%	17%	11%	12%	4.7%	5.7%	3%	0%
CB5MH	both	7%	5%	3%	2%	2%	0%	0%	0%	0%
CB6PH	VA	1%	1%	0%	0%	0%	0%	0%	0%	0%
CHSMH	MD	39%	32%	21%	11%	13%	0%	3.3%	1%	0%
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PAXMH	MD	23%	12%	2%	0%	4%	0%	0%	0%	0%
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RPPMH	VA	13%	8%	3%	0%	1%	0%	0%	0%	0%
SBEMH	VA	5%	3%	0%	0%	0%	0%	0%	0%	0%
YRKPH	VA	0%	0%	0%	0%	0%	0%	0%	0%	0%

The 2010 Chesapeake Bay TMDL report's Appendix T points out that in developing the Chesapeake Bay TMDL, an array of factors that affected the loadings to the Chesapeake Bay were accounted for and the Chesapeake Partnership worked to appropriately assign load allocations to each state (USEPA, 2010d). A large influencing factor in sediment and nutrient loads to the Chesapeake Bay are the major dams of the lower Susquehanna River (Safe Harbor, Holtwood, and Conowingo) which retain large quantities of sediment and nutrients in their reservoirs. Appendix T describes the case where "future monitoring shows that the trapping capacity of the reservoir has been reduced" and suggests that "then the Chesapeake Bay Program Partners will need to consider adjusting the Pennsylvania, Maryland, and New York 2-year milestone loads based on the new delivered loads to ensure that all are meeting their target load obligations."

Using the slope of the line relating TN and TP to percent non-attainment of CB4MH Deep-Channel in the previous stoplight plots, **a rough estimate of the load reduction needed Bay-wide to offset 1 percent nonattainment is about 4.4 million pounds of total nitrogen and 0.41 million lbs of total phosphorus.** Scoping scenarios provide an estimate of the nitrogen and phosphorus pollutant load reductions from the Susquehanna River watershed needed to offset the increase in DO nonattainment. In this case, **a nutrient reduction solely from the Susquehanna River watershed to offset the increase in DO nonattainment from Conowingo Reservoir infill would be about 2.4 million pounds of nitrogen, or alternately, a reduction of 0.27 million pounds of phosphorus.**

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POTMH	both	27%	20%	13%	0%	0%	0%	0%
RPPMH	VA	29%	23%	6%	0%	0%	0%	0%

Going forward, further research and analysis is needed to provide a refined assessment of the influence of Conowingo Reservoir infill on Chesapeake Bay water quality, including an improved understanding of the fate and transport of particulate organic and inorganic nutrients associated with scoured sediment from the Conowingo Reservoir. Refinements in monitoring, research, and model simulation of the particulate organic and inorganic nutrients associated with Conowingo Reservoir sediment, their fate when scoured with sediment from the Conowingo Reservoir, and their subsequent transport to the Chesapeake Bay along with their diagenesis and utilization in tidal waters would advance considerably the understanding of the influence Conowingo Reservoir infill has on Chesapeake water quality.