Appendix N.
Resolution of Segments Failing to Attain the Jurisdictions' Water Quality Standards

Segments failing to attain the Dissolved Oxygen Standards

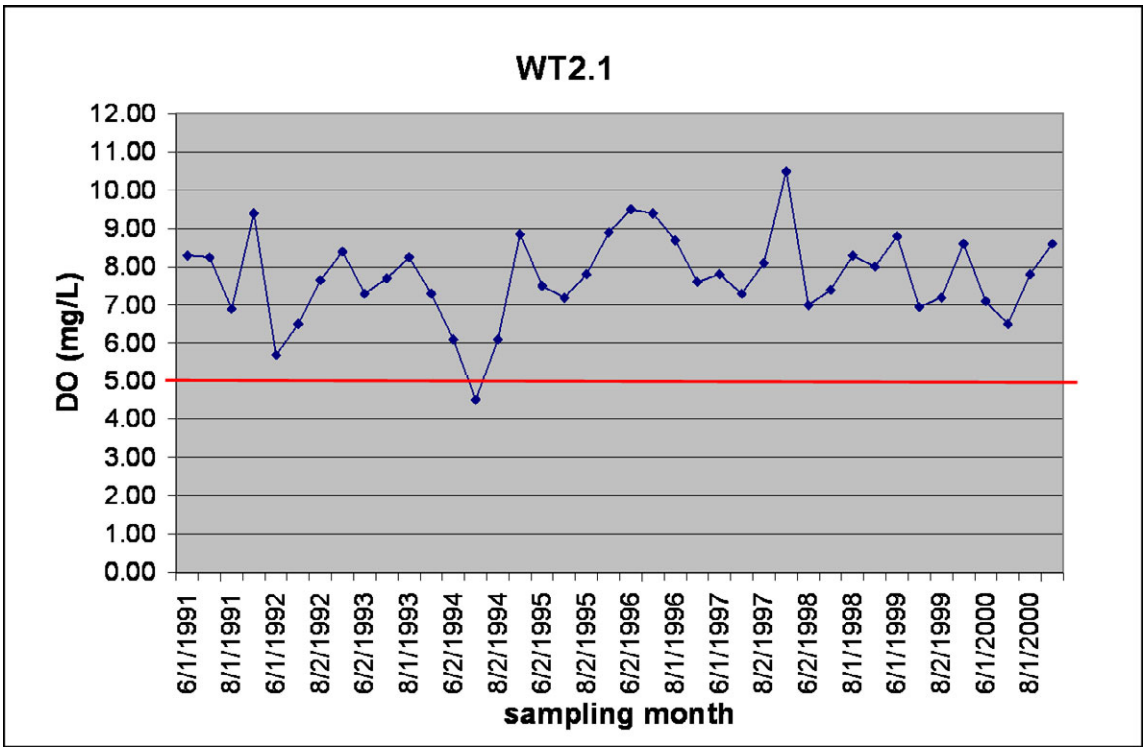
In the process of determining the target nitrogen and phosphorous load allocations, it was observed that in a limited number of Chesapeake Bay segments, poor dissolved oxygen (DO) conditions appeared to persist even under scenarios of dramatically reduced nitrogen and phosphorous loads. A series of systematic diagnostic analyses were conducted to determine the drivers of such persistent violations. The findings of those analyses, summarized in Section 6.4.4, are described in more detail here.

The most important analyses to explain the anomalous results in these segments were to determine whether the Chesapeake Bay Water Quality Model (WQM) effectively simulated historical conditions and improvement in those conditions with reduced loads. If the WQM was determined to be non responsive in the affected Bay segments, additional lines of evidence were explored to determine whether the apparent nonattainment represented an area of real concern, or whether those segments could reasonably be expected to show sufficient improvement to attain water quality standards (WQS) given the nitrogen and phosphorous load reductions. Each Bay segment was evaluated to determine the following:

1. Whether violations of the DO criteria were isolated or widespread
2. Whether the Chesapeake Bay WQM effectively simulated historical conditions and improvement in those conditions with reduced loads
3. Whether nearby Bay segments also exhibited persistent or widespread hypoxia (low to minimal DO levels)

Gunpowder River

The DO criteria nonattainment in the tidal Gunpowder River (GUNOH) was driven by two converging factors. First, the historical water quality DO monitoring data for this location show that the water in the Gunpowder River is generally well-oxygenated in the summertime, with only a single instance of hypoxia observed (July 1994) over the course of 10 consecutive summers from 1991 to 2000 that violated the open-water criterion of 5.0 milligrams per liter (mg/L) (red line in Figure N-1). Recall that the assessment process includes overlaying the improvement in water quality predicted by the model onto the observed water quality from the hydrologic period. For that reason, anomalous observed water quality measures can be critical to the assessment results.



Source: http://www.chesapeakebay.net

Figure N-1. Measurements taken in summer months (June–September) at water quality monitoring station WT2.1 in the Gunpowder River 1991–2000.

Second, the Bay WQM's simulations for this location, which ranged from about 8 to 10 mg/L, were only moderately higher than the average historical summertime conditions. However the Bay WQM did not simulate conditions below 8 mg/L in this region. Because no simulated hypoxia existed, there was no example of simulated improvement in DO concentrations with reduced nitrogen and phosphorous inputs for this region. With summertime DO concentrations at or above 8 mg/L, the Bay WQM generally simulated a minimal increase in DO concentrations in response to reduced nitrogen and phosphorous loads. That is in clear contrast to the Bay WQM's performance when hypoxic conditions are simulated under calibration (i.e., historical) conditions—for an example from the middle of the Chesapeake Bay, see Figure N-2. That figure is an example of a regression plot showing WQM performance consistent with historical observations. The pink symbols and line represent DO concentrations from the calibration scenario; the blue symbols and line represent DO concentrations under reduced nitrogen and phosphorous loads of the E3 Scenario. The range of DO concentrations in the calibration scenario spans the range of historical observations. Greater increase in DO concentrations is observed with reduced loads when the initial (calibration) concentrations are low. In those cases, the Bay WQM's predictions are consistent with empirical findings, namely, that hypoxic conditions will improve with reduced loads to a greater degree than will initially high DO concentrations.

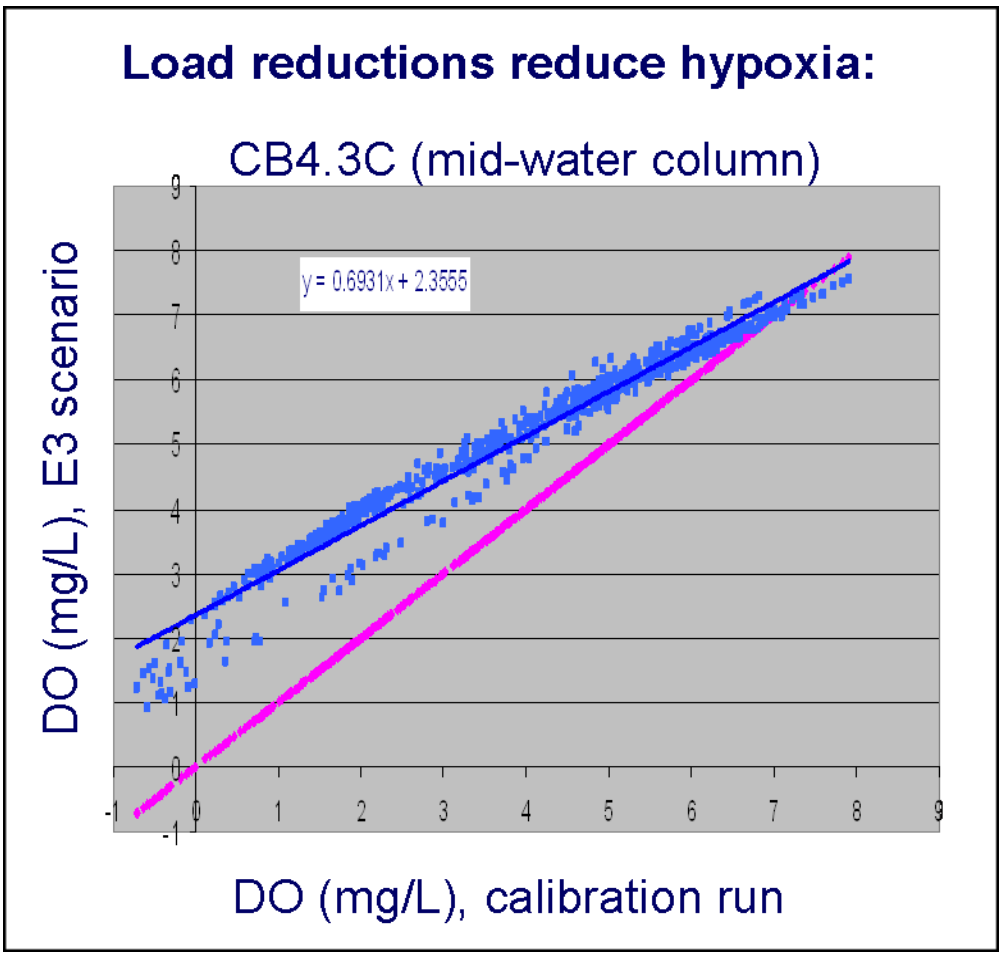


Figure N-2. Example of a regression plot showing Bay WQM performance consistent with historical water quality monitoring DO observations in the lower central Chesapeake Bay segment CB4MH at station CB4.3C.

The regression equation that is used to scenario-modify DO concentrations (for a description of the scenario-modification procedure, see Section 6.2.2) is generated from a comparison of DO concentrations simulated in the calibration scenario with those simulated in a management scenario such as E3. When little change is observed in DO concentrations between the two scenarios, the resulting regression equation reflects it (Figure N-3). When simulated DO concentrations are consistently at or above 8 mg/L in the calibration scenario, the Bay WQM generally does not show dramatic improvements in concentrations with reduced pollutant loads. Furthermore, when the resulting regression equation is applied to a DO concentration well outside the range of the simulated data, it can cause a *DO response* that does not accurately reflect the information provided by the Bay WQM.

In the case of Gunpowder River monitoring station WT2.1 for July 1994, the Bay WQM-simulated DO concentrations fell between about 8 and 10 mg/L for the calibration scenario as well as the numerous reduced loading *management* scenarios. In Figure N-3, the pink symbols and line represent the calibration scenario DO concentrations; the light blue symbols and black line show the change in DO concentrations from the calibration to the E3 scenario. The red arrows show the predicted change in an initial DO concentration of 4.5 mg/L. In that case, a

historical observation of 4.5 mg/L was scenario-modified to a concentration of 4.4 mg/L for the E3 scenario.

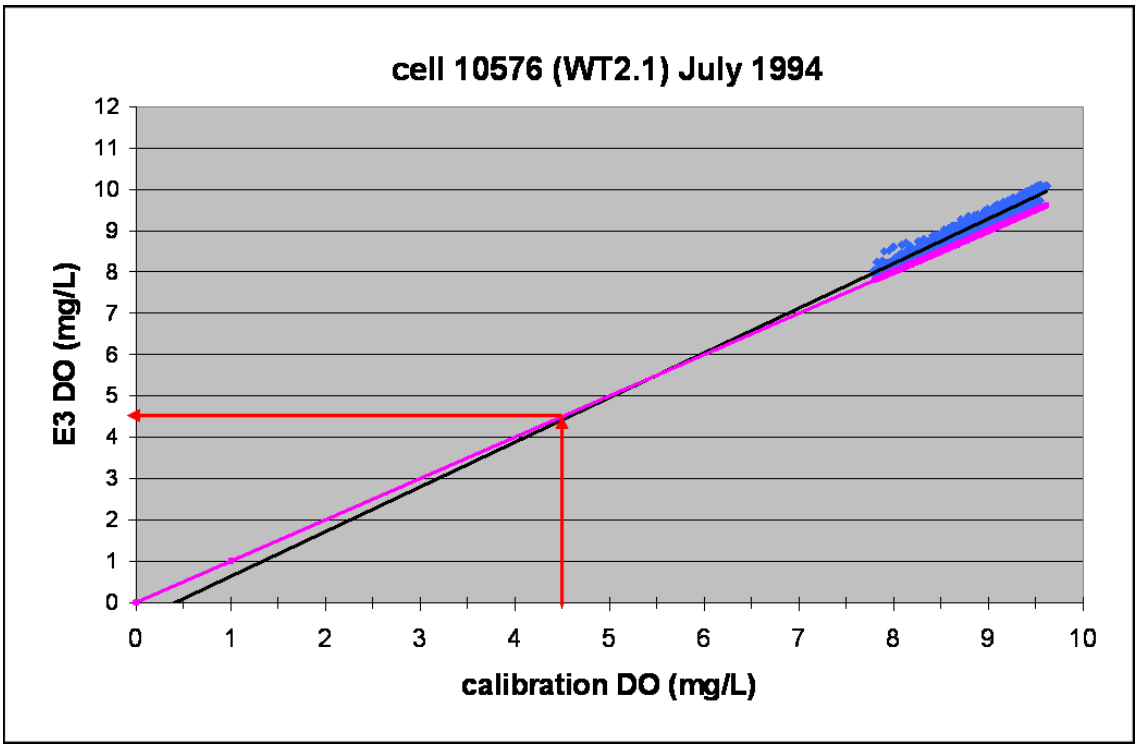


Figure N-3. Bay WQM scenario DO concentrations and regression for station WT2.1 in the Gunpowder River.

As is shown here, even at the *E3* scenario (for a description of management scenarios, see Appendix J) only a slight increase in DO concentrations is observed across the range of simulated concentrations. Typically, a greater response—in the form of higher DO concentrations—is observed when the initial (i.e., calibration) DO concentrations are low (i.e., less than 5 mg/L). In such a case, when the linear regression representing the relationship between the calibration and E3 DO concentrations is extrapolated far below the range of simulated conditions, the result suggests that under E3 conditions, hypoxia could actually get worse rather than better. That prediction is not an accurate representation of model simulations; rather it is the effect of extrapolating the regression equation well outside the range of the simulations from which it was generated. Such was the case for July 1994, when a historical observation of 4.5 mg/L was scenario-modified to a concentration of 4.4 mg/L under the dramatically reduced load conditions of the E3 scenario.

Examination of nearby segments—the Bush River (BSHOH), the upper Chesapeake Bay (CB2OH), and the Middle River (MIDOH)—showed attainment of DO WQS under historical loading conditions and under all load reduction scenarios (Figure N-4).

Cbseg	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Open Water Summer Monthly	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Open Water Summer Monthly	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Open Water Summer Monthly
BSHOH	0%	0%	0%	0%	0%	0%	0%	0%	0%
CB2OH	0%	0%	0%	0%	0%	0%	0%	0%	0%
MIDOH	0%	0%	0%	0%	0%	0%	0%	0%	0%
GUNOH	5%	5%	5%	5%	5%	5%	5%	5%	5%

Figure N-4. Open-water DO criteria attainment *stoplight plot* of the Gunpowder River segment GUNOH and nearby segments.

In summary, the incidence of hypoxia in the tidal Gunpowder River was isolated. In that single, isolated case, the Bay WQM was unable to provide information on the magnitude of expected improvement in DO conditions with reduced nitrogen and phosphorous loads in the region. Examination of nearby segments showed consistent attainment of DO WQS under historical (Base) and reduced loading scenarios. Therefore, it is reasonable to expect that the open-water designated use of GUNOH will attain DO WQS under the basinwide target allocation of 190 million pounds per year total nitrogen (TN) and 12.7 million pounds per year total phosphorus (TP).

Manokin River

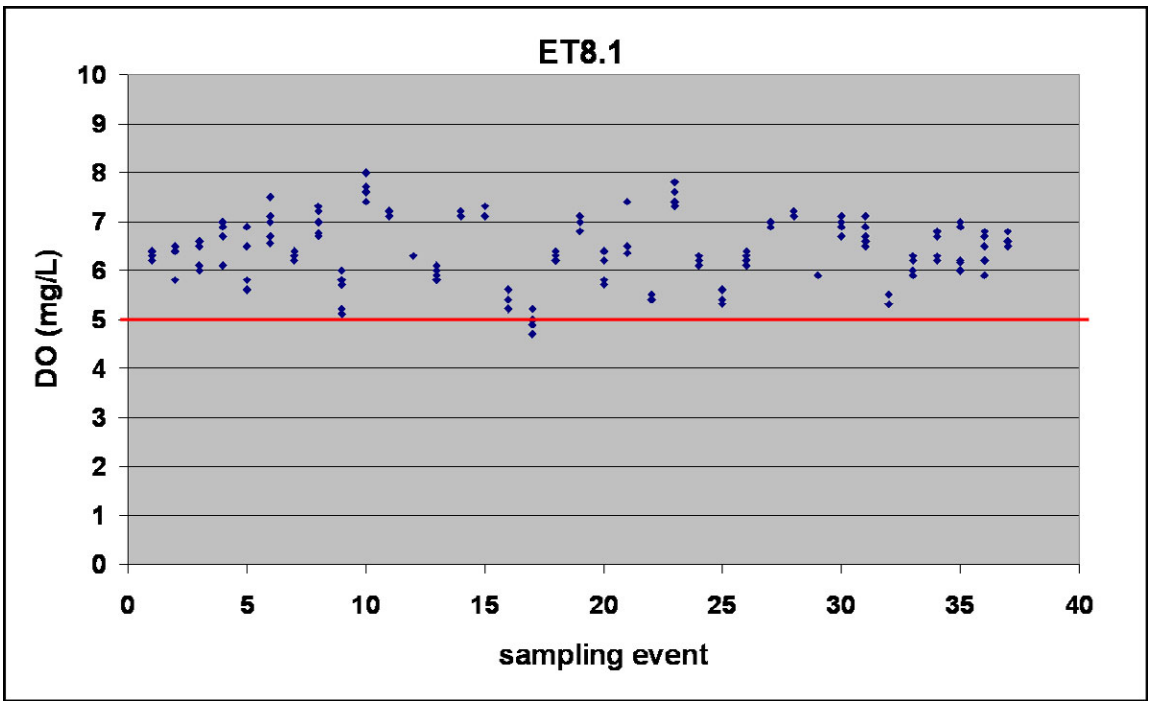
In the Manokin River (MANMH), violations of the segment's open-water DO WQS for the years 1991–2000 were limited to three measurements, ranging from 4.7 to 4.9 mg/L, taken during one sampling event in July 1995 (Figure N-5).

The isolated, marginal violations of the DO WQS under historical conditions were scenario-modified to greater nonattainment under simulated load reductions. At the same time, adjacent and nearby segments—Tangier Sound (TANMH), Big Annemessex River (BIGMH), and the lower Pocomoke River (POCMH)—all attained their respective DO WQS under historical conditions and reduced loading scenarios (Figure N-6).

Further examination of the performance of the Bay WQM in the vicinity of water quality monitoring station ET8.1 (MANMH's single tidal monitoring station) showed lower—rather than higher—DO concentrations under reduced loading scenarios (Figure N-7).

The grid location that represents the Manokin River's single monitoring station is shallow and directly adjacent to the land. The highlighted cell (cell 6705) in Figure N-8 coincides with the location of long-term fixed station ET8.1. In such cases, the Bay WQM often struggles to integrate the multiple, interacting drivers of a parameter such as DO. Further investigation showed that chlorophyll *a* concentrations in cell 6705 decreased to zero (or less) at the E3 scenario (data not shown). If chlorophyll *a* concentrations had *increased* in concert with lower DO concentrations, a temporal anomaly in pollutant loads to cell 6705 or its vicinity would have

been suspected. However, the combination of nonexistent chlorophyll *a* concentrations and low DO concentrations observed here indicates that the WQM struggled to integrate the effect of reduced loads on the feedbacks among multiple drivers of DO concentrations.



Source: http://www.chesapeakebay.net

Figure N-5. Summertime DO observations (dark blue symbols) at water quality monitoring station ET8.1 in the Manokin River 1991–2000.

Cbseg	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Open Water Summer Monthly	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Open Water Summer Monthly	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Open Water Summer Monthly
MANMH	1%	5%	5%	5%	5%	5%	5%	5%	5%
TANMH	0%	0%	0%	0%	0%	0%	0%	0%	0%
BIGMH	0%	0%	0%	0%	0%	0%	0%	0%	0%
POCMH	0%	0%	0%	0%	0%	0%	0%	0%	0%

Figure N-6. Open-water DO criteria attainment *stoplight plot* of the Manokin River segment MANMH and nearby segments.

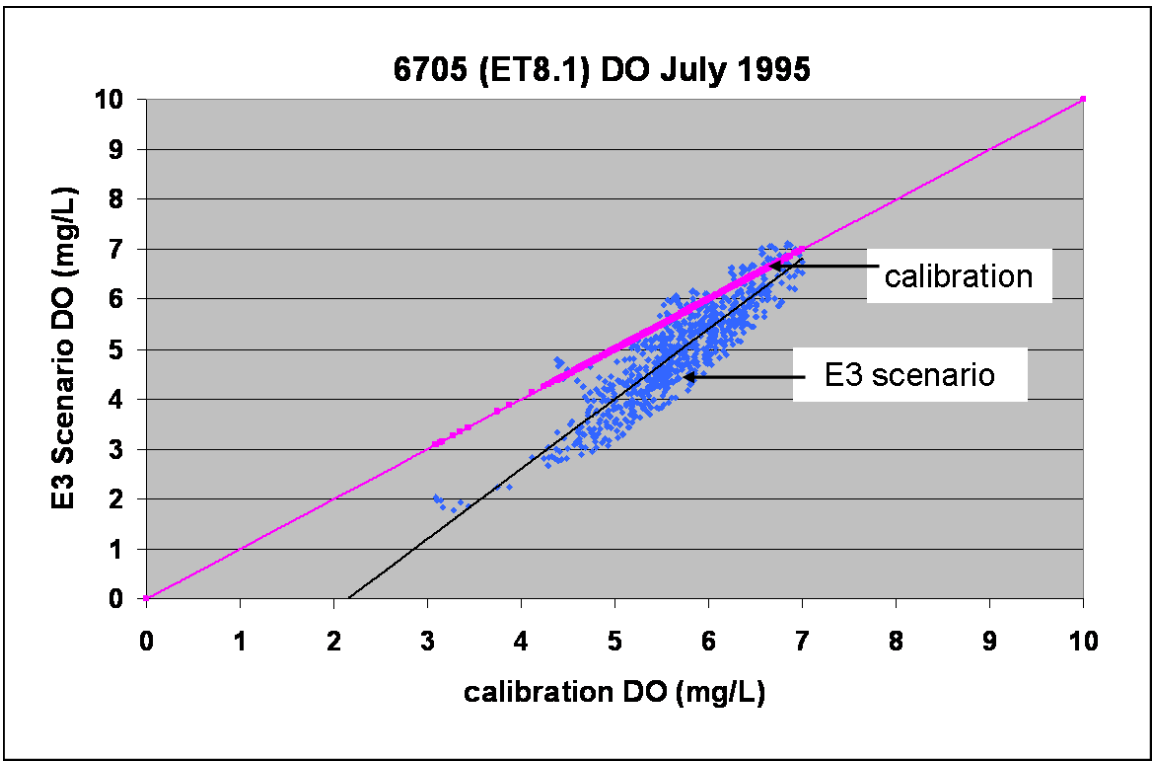


Figure N-7. Regression plot for the Bay WQM cell (6705) corresponding to the MANMH water quality monitoring station (ET8.1).

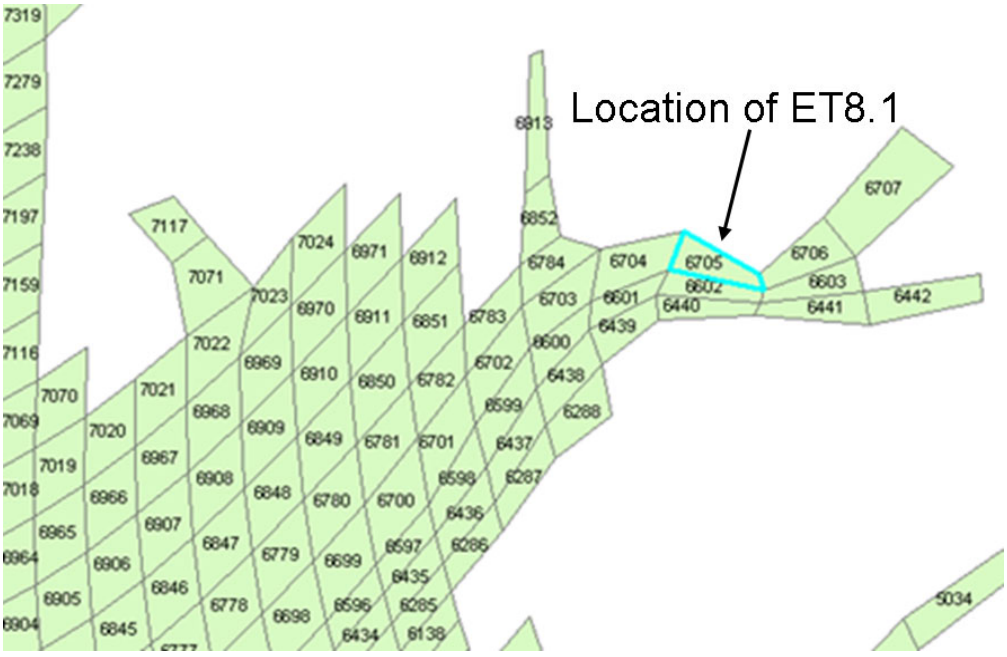
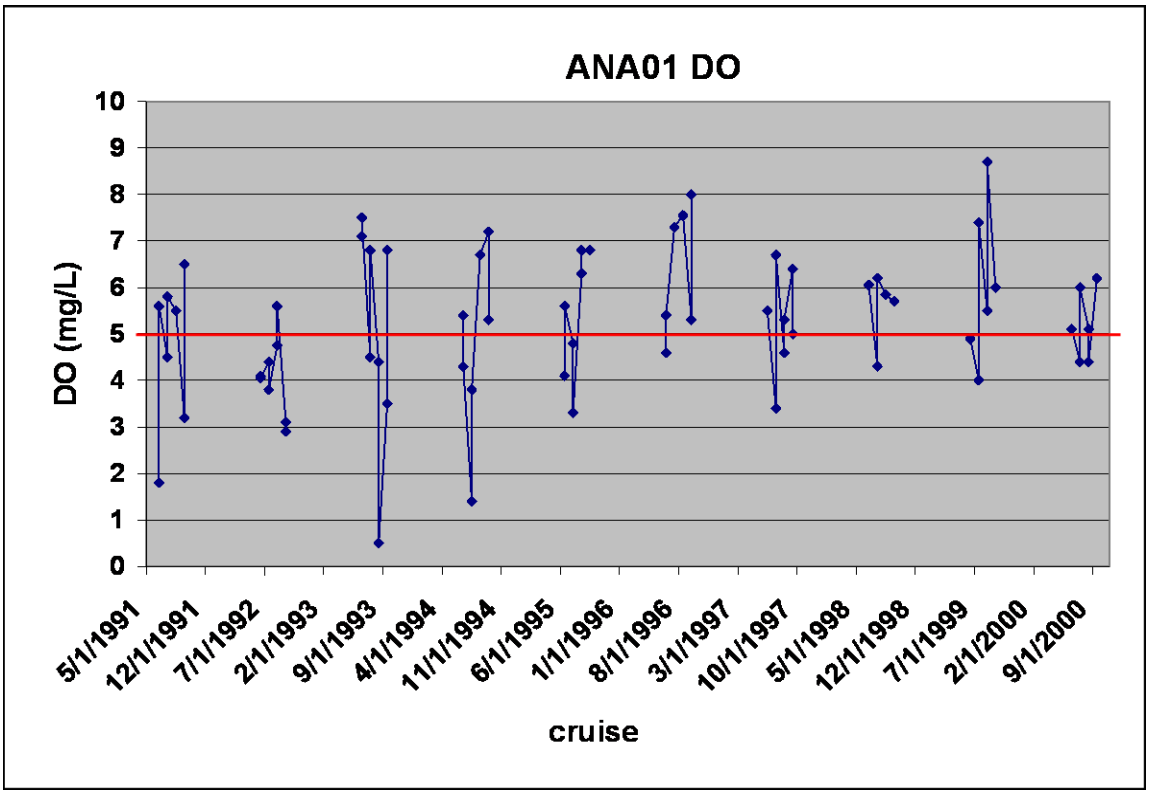


Figure N-8. Chesapeake Bay WQM grid for the Manokin River and a portion of Tangier Bay.

Given the isolated nature of DO criteria violations in MANMH under historical conditions, the poor performance of the WQM, and the unimpaired nature of adjacent waterbodies under historical conditions and simulated reduced loadings, EPA concludes that it is reasonable to expect full attainment of the DO WQS in MANMH at the basinwide target allocation of 190 million pounds per year TN and 12.7 million pounds per year TP.

Maryland Portion of the Anacostia River

In the Maryland portion of the tidal Anacostia River (ANATF_MD), substantial violations of the segment's open-water DO WQS were observed historically, with particularly serious violations occurring at station ANA01 in August 1993 and July 1994 (Figure N-9).



Source: http://www.chesapeakebay.net

Figure N-9. Summertime water quality DO monitoring observations at Maryland's tidal Anacostia River water quality monitoring station ANA01 1991–2000.

Table N-1 shows the modeled DO violations under a model calibration scenario and under a lower loading scenario of 179 million pounds per year of nitrogen and 12 million pounds per year of phosphorus. The majority of the historical violations were estimated to improve substantially or even reach full attainment with further load reductions. However, for the two months during the critical period with the most serious violations—August 1993 and July 1994—no improvement in DO WQS nonattainment percentage was predicted (Table N-1).

Table N-1. Monthly open-water DO criteria nonattainment percentages for ANATF_MD in the 1993–1995 critical period

year	month	violation rate	
		calibration	179 TN, 12TP
1993	6	0.0%	0.0%
1993	7	20.3%	10.1%
1993	8	100.0%	100.0%
1993	9	53.6%	11.6%
1994	6	79.7%	0.0%
1994	7	100.0%	100.0%
1994	8	20.3%	0.0%
1994	9	20.3%	0.0%
1995	6	100.0%	0.0%
1995	7	100.0%	0.0%
1995	8	0.0%	0.0%
1995	9	0.0%	0.0%

For those months, EPA Chesapeake Bay Program Office (CBPO) analysts compared Bay WQM simulated DO concentration with historical water quality monitoring observations. For July 1994, model simulated DO concentrations at Bay WQM grid cell 6443—the location coincident with monitoring station ANA01—ranged from 7.2 to 13.0 mg/L. In contrast, monitoring observations for the same month ranged from 1.0 to 3.8 mg/L. Similar results were found for the month of August 1993, when Bay WQM-simulated DO concentrations for cell 6443 ranged from 7.5 to 15.5 mg/L while historical observations at the same location (ANA01) ranged from 0.5 to 4.4 mg/L. Because the Bay WQM did not simulate severe hypoxia in the region for those summer months, it was not able to provide a sufficient estimate of the magnitude of DO response to be expected with nitrogen and phosphorous load reductions.

CBPO analysts also considered the attainment status of the two downstream segments closest to ANATF_MD: the District of Columbia's portion of the Anacostia River (ANATF_DC) and the District's portion of the tidal Potomac River (POTTF_DC) (Figure N-10). Unlike segment ANATF_MD, ANATF_DC and POTTF_DC both attained their respective DO WQS at the target basinwide allocation of 190 million pounds per year TN and 12.7 million pounds per year TP.

Given the lack of Bay WQM fit in this segment and the Bay WQM-projected DO WQS attainment of the two segments immediately downstream, EPA concludes that it is reasonable to expect attainment of the DO WQS in Maryland's tidal Anacostia River at the basinwide target allocation of 190 million pounds per year TN and 12.7 million pounds per year TP.

In addition, EPA approved in June 2008, a established by Maryland and the District of Columbia. The TMDL will address any localized water quality impairments.

Cbseg	1985 Scenario 342TN, 24.1TP, 9790TSS '93-'95 DO Open Water Summer Monthly	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly
DCATF	38%	28%	10%	14%	1%	2%	1%
DCPTF	10%	1%	0%	0%	0%	0%	0%
MDATF	34%	39%	19%	18%	12%	12%	12%

Figure N-10. Open-water DO criteria nonattainment in ANANTF_MD MDATF and nearby Bay segments. TN, TP, and total suspended sediment loads (TSS) are in million pounds per year.

West Branch Elizabeth River

Violations of the DO WQS were not uncommon in the Western Branch of the Elizabeth River (WBEMH), particularly in the early half of the 1991–2000 decade. Violations of the 5.0 mg/L open-water DO criterion (red line in Figure N-11) were common during summer months, particularly at depths below 0.5 meter.

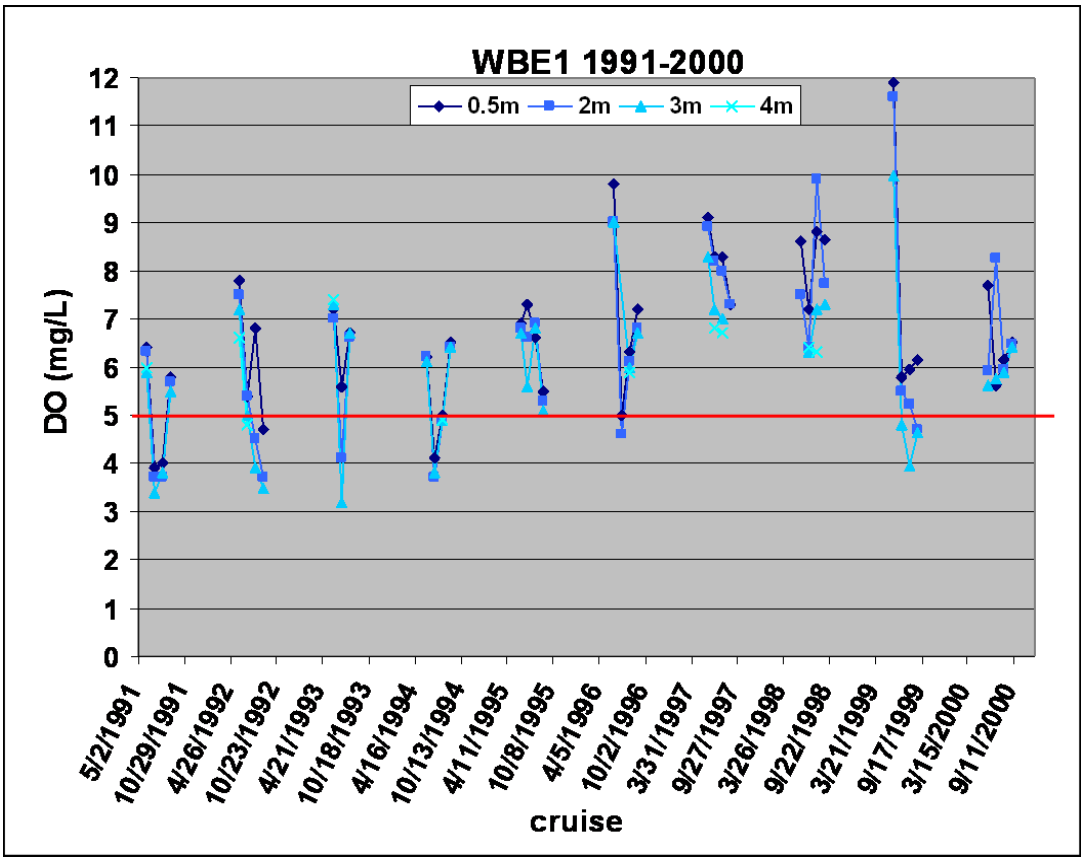


Figure N-11. Summertime DO concentrations observed at water quality monitoring station WBE1 in segment WBEMH 1991–2000.

Some of the violations improved with model-simulated load reductions such as those represented in Table N-2; however, for two months in particular—July 1993 and July 1994—no improvement in monthly violation rate was observed under scenario-modified conditions.

Table N-2. Monthly open-water DO criteria nonattainment percentages for water quality monitoring station WBE1 in the 1993–1995 critical period

year	month	violation rate	
		calibration	179TN, 12TP
1993	6	0.0%	0.0%
1993	7	45.9%	45.9%
1993	8	0.0%	0.0%
1994	6	0.0%	0.0%
1994	7	100.0%	100.0%
1994	8	49.2%	0.0%
1994	9	0.0%	0.0%
1995	6	0.0%	0.0%
1995	7	0.0%	0.0%
1995	8	0.0%	0.0%
1995	9	0.0%	0.0%

Further investigation of model performance in WBEMH showed that the Bay WQM failed to simulate the range of DO concentrations observed at WBE1 for either of these months. While the Bay WQM consistently simulated concentrations greater than 7 mg/L for the Bay WQM cell at station WBE1, monitoring observations for the same month and year were below 5.0 mg/L. In Figure N-12, the pink symbols represent DO concentrations for the calibration scenario; blue symbols and line represent DO concentrations and linear regression for the 179 TN, 12 TP load reduction scenario. Dark blue symbols represent DO observations for July 1994 at depths ranging from 0.5 to 3 meters.

As described for previous segments, when the range of Bay WQM simulations falls in this range, the model fails to provide an estimate of improvement in hypoxic conditions with load reductions.

When Bay WQM simulations do not span the range of hypoxic conditions observed, additional lines of evidence such as the attainment of nearby segments are considered in determining the necessity for further load reductions. In the case of WBEMH, adjacent and nearby segments attained their respective open-water DO WQS at or before the basinwide target nitrogen and phosphorous allocations (Figure N-13).

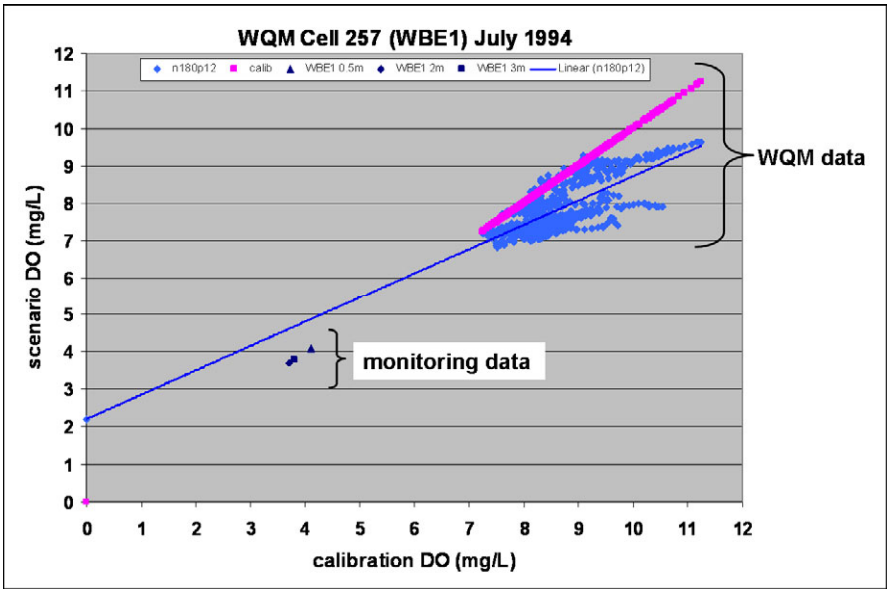


Figure N-12. Chesapeake Bay WQM simulations at WQM cell 257 and observations at water quality monitoring station WBE1 for July 1994.

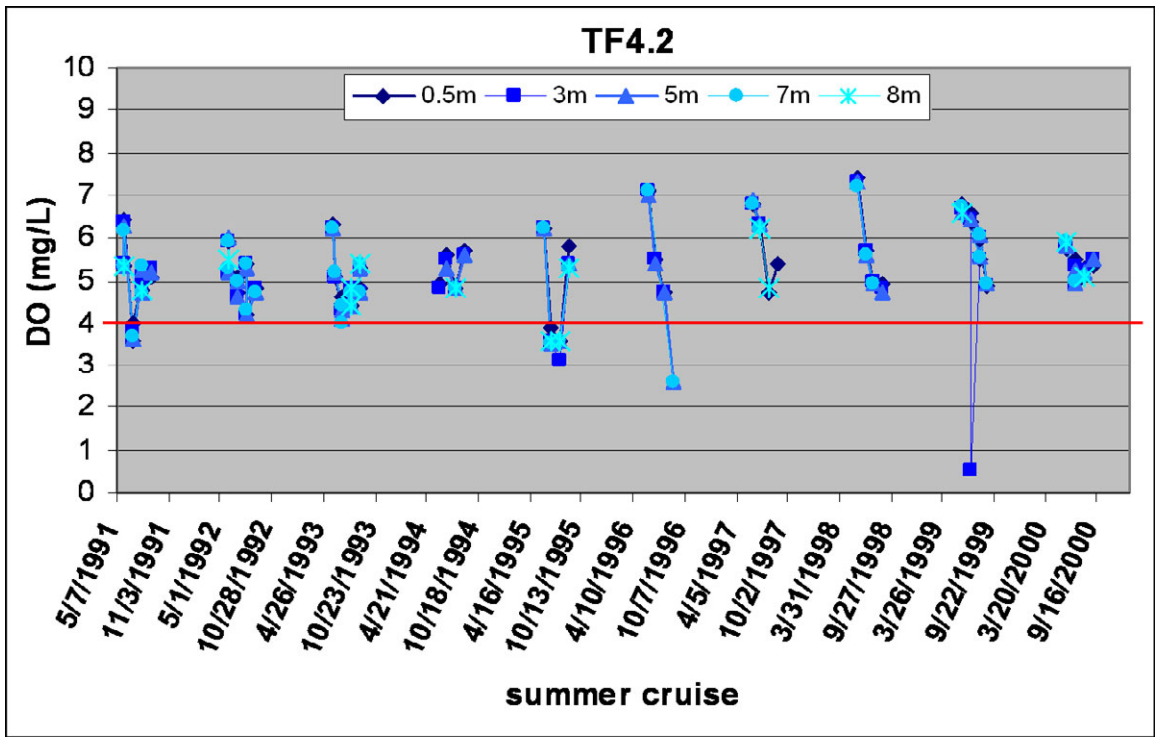
Cbseg	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Open Water Summer Monthly	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Open Water Summer Monthly	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Open Water Summer Monthly
ELIPH	4%	0%	0%	0%	0%	0%	0%	0%	0%
JMSPH	0%	0%	0%	0%	0%	0%	0%	0%	0%
EBEMH	23%	18%	5%	0%	0%	0%	0%	0%	0%
JMSMH	0%	0%	0%	0%	0%	0%	0%	0%	0%
SBEMH	35%	16%	8%	0%	0%	0%	0%	0%	0%
WBEMH	11%	15%	8%	8%	8%	8%	8%	8%	0%

Figure N-13. Attainment of the open-water DO WQS for WBEMH and nearby Bay segments under progressively stringent load reduction scenarios.

While the periodic occurrence of hypoxia in the Western Branch of the Elizabeth River remains a matter of concern, in this case the WQM provided no information on the magnitude of response in DO concentrations to be expected with load reductions. Considering the attainment of DO WQS observed in adjacent segments well before the target basinwide allocation, EPA concludes that it is reasonable to expect attainment of the DO WQS in Western Branch of the Elizabeth River at the basinwide target allocation of 190 million pounds per year TN and 12.7 million pounds per year TP.

Upper Pamunkey River

DO concentrations at station TF4.2 in the upper Pamunkey River (PMKTF) occasionally violated this segment's open-water DO criterion of 4.0 mg/L (Figure N-14). Violations during the 1993–1995 critical period were moderate and limited to the summer of 1995.



Source: http://www.chesapeakebay.net

Figure N-14. Summertime monitored DO concentrations (mg/L) at station TF4.2 in segment PMKTF.

A closer look at DO violations occurring in July and August of 1995 (Table N-3) showed that while DO concentrations in August improved sufficiently to attain WQS with simulated load reductions, no improvement was observed in the July 1995 violation rate.

Investigation of the Bay WQM-derived regression for July 1995 revealed that as with other small tidal tributaries discussed in this section, simulated DO concentrations for the calibration scenario did not match historical observations for the same month and location in the upper Pamunkey River. In Figure N-15, DO concentrations for the 190 TN, 12.7 TP load reduction scenario (blue symbols and linear regression line) showed little or no improvement compared with those of the calibration scenario (pink symbols). DO concentrations for both scenarios were greater than those observed at station TF4.2.

It is also worth noting that the observed violations were only marginally lower than the 4.0 mg/L criterion. Furthermore, the two segments immediately downstream from PMKTF—the lower Pamunkey River (PMKOH) and the mesohaline York River (YRKMH)—attained their respective open-water DO WQS at or before the target load allocation (Figure N-16).

Table N-3. Monthly open-water DO criteria nonattainment percentages for water quality monitoring station TF4.2 in segment PMKTF in the summer months of 1993-1995 critical period

year	month	violation rate	
		calibration	190 TN, 12.7 TP
1993	6	0.0%	0.0%
1993	7	0.0%	0.0%
1993	8	0.0%	0.0%
1993	9	0.0%	0.0%
1994	6	0.0%	0.0%
1994	7	0.0%	0.0%
1994	8	0.0%	0.0%
1994	9	0.0%	0.0%
1995	6	0.0%	0.0%
1995	7	100.0%	100.0%
1995	8	100.0%	0.0%
1995	9	0.0%	0.0%

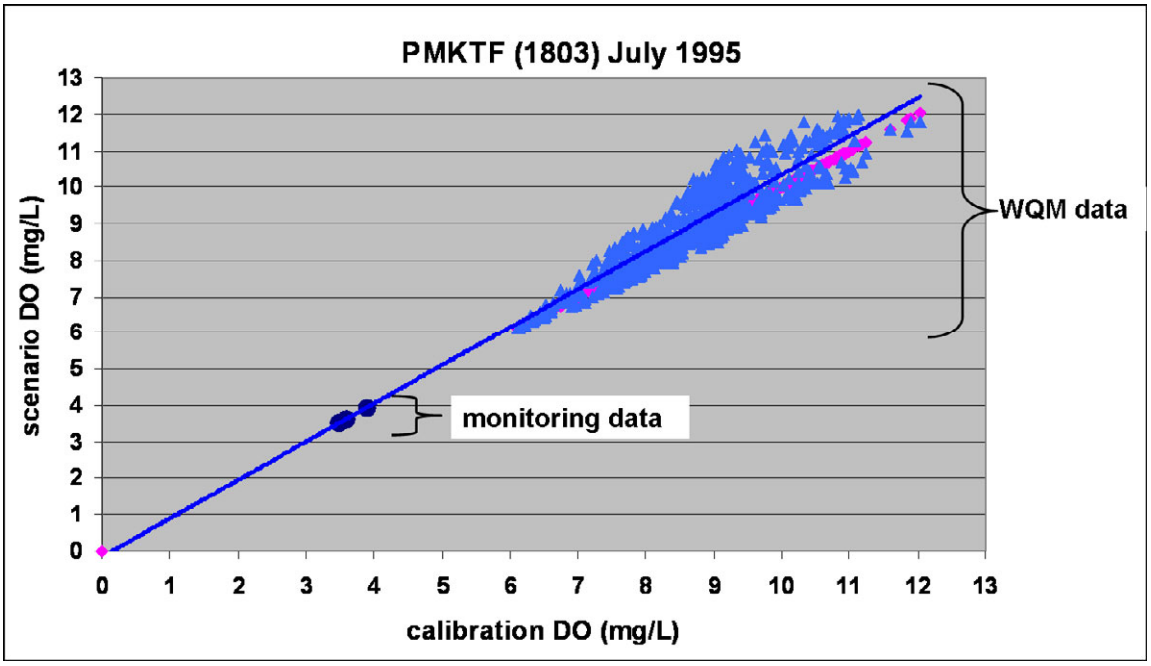


Figure N-15. Simulated DO concentrations for cell 1803, the Bay WQM grid cell coincident with monitoring station TF4.2 in segment PMKTF.

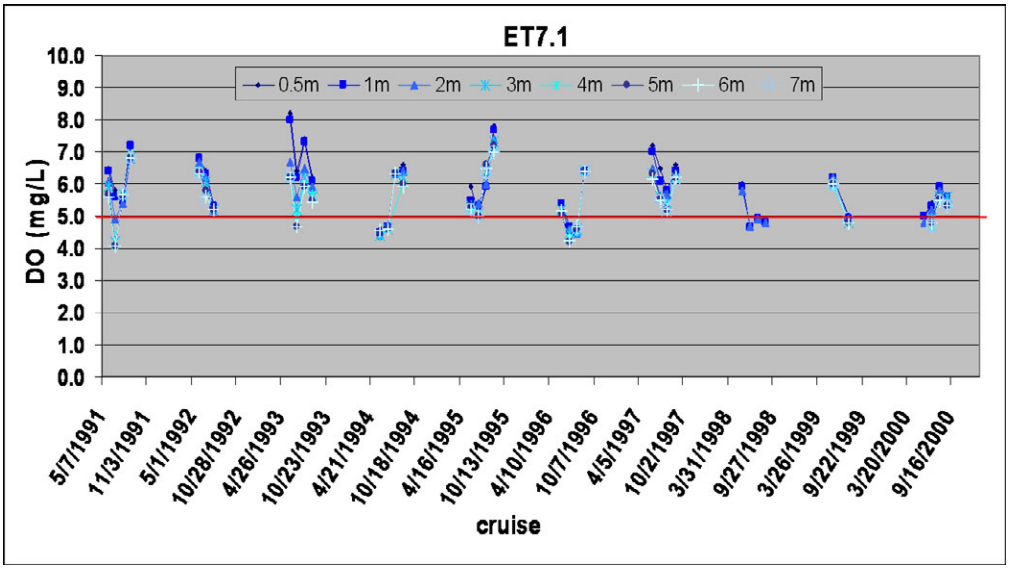
Cbseg	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Open Water Summer Monthly	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Open Water Summer Monthly	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Open Water Summer Monthly
PMKOH	1%	0%	0%	0%	0%	0%	0%	0%	0%
PMKTF	11%	5%	5%	5%	5%	5%	5%	2%	1%
YRKMH	24%	3%	3%	1%	1%	1%	1%	0%	0%

Figure N-16. Attainment of the open-water DO WQS for PMKTF and nearby Bay segments under progressively stringent load reduction scenarios.

Given the mismatch between historical water quality monitoring observations and the Bay WQM simulations in the segment, the complete lack of response in DO concentrations with simulated load reductions, the moderate nature of violations observed in PMKTF for the critical period, and the attainment of the two nearest downstream segments at or before the target basinwide allocation, EPA concludes that it is reasonable to expect attainment of the DO WQS in upper Pamunkey River at the basinwide target allocation of 190 million pounds per year TN and 12.7 million pounds per year TP.

Wicomico River

Moderate excursions below the open-water criterion for Wicomico (WICMH) of 5.0 mg/L were not uncommon in summer months (Figure N-17) between 1991–2000; however, few were extensive enough to cause high percentages of WQS nonattainment. For the 1993–1995 critical period, two months—June and July 1994—had extensive violations of the DO criterion.



Source: http://www.chesapeakebay.net

Figure N-17. DO concentrations observed at station ET7.1 (WICMH) in the summers months 1991–2000.

While the historical violations present in July 1994 were resolved under scenario-modified conditions of the target basinwide allocation (190 TN, 12.7 TP Loading Scenario), DO concentrations in June 1994 showed no improvement in violation rate, even under the extensive load reductions of the E3 Scenario (Table N-4).

Table N-4. Monthly open-water DO criteria nonattainment percentages for water quality monitoring station ET7.1 in segment WICMH in the summer months of 1993–1995 critical period.

WICMH		violation rate		
year	month	calibration	190TN, 12.7TP	E3
1993	6	0.0%	0.0%	0.0%
1993	7	5.5%	0.0%	1.9%
1993	8	0.0%	0.0%	0.0%
1993	9	0.0%	0.0%	0.0%
1994	6	100.0%	100.0%	100.0%
1994	7	100.0%	0.0%	0.0%
1994	8	0.0%	0.0%	0.0%
1994	9	0.0%	0.0%	0.0%
1995	6	0.0%	0.0%	0.0%
1995	7	0.0%	0.0%	0.0%
1995	8	0.0%	0.0%	0.0%
1995	9	0.0%	0.0%	0.0%

Further investigation of the conditions causing the persistent violation revealed that DO concentrations simulated by the Bay WQM's Calibration Scenario for grid cell 7658 are higher than those observed at station ET7.1 for June 1994. In Figure N-18, the DO concentrations observed at station ET7.1 (dark blue symbols) are shown for June 1994. The E3 linear regression falls below those monitoring observations, illustrating the predicted decrease in scenario-modified DO concentrations. Furthermore, DO concentrations in the location were generally similar to (or sometimes even lower than) calibration conditions. In other words, no improvement in DO concentrations was observed at the location when even dramatically reduced loads were simulated. As a result, the mildly hypoxic conditions observed in June 1994 were scenario-modified to lower, rather than higher, values with reduced nitrogen and phosphorous loads.

In contrast with predictions for WICMH, adjacent Tangier Sound (TANMH) and other nearby segments attained DO WQS at or before the target basinwide load allocation (Figure N-19).

As with other segments described herein, the Bay WQM effectively simulated neither the observed historical conditions nor the expected improvement in those conditions with reduced nitrogen and phosphorous loads in this small, shallow region of the Wicomico River. Given the moderate nature of the observed violations the unimpaired condition of adjacent and nearby segments and the considerable level of effort already required of this river basin with the current

target load allocation, EPA considers that it is reasonable to expect WICMH to attain WQS at the target load allocations.

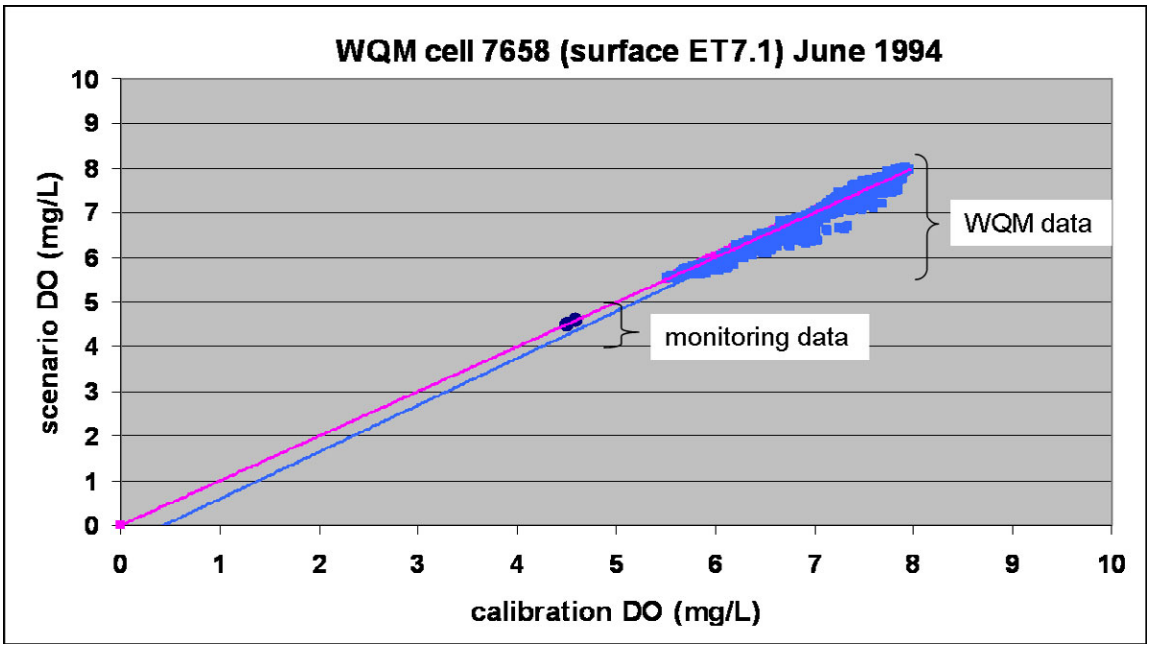


Figure N-18. Simulated DO concentrations for the Calibration Scenario (pink symbols with 1:1 linear regression line) compared to those for the E3 Scenario (blue symbols and blue linear regression line).

Cbseg	1985 Scenario 342TN, 24.1TP, 9790TSS '93-'95 DO Open Water Summer Monthly	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Open Water Summer Monthly	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Open Water Summer Monthly	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Open Water Summer Monthly	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Open Water Summer Monthly	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Open Water Summer Monthly	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Open Water Summer Monthly	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Open Water Summer Monthly	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Open Water Summer Monthly	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Open Water Summer Monthly
FSBMH	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
NANMH	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%
TANMH	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
WICMH	11%	11%	11%	15%	5%	5%	5%	5%	5%	5%

Figure N-19. Attainment of the open-water DO WQS for WICMH and nearby Bay segments under progressively stringent load reduction scenarios.

Magothy River

The Magothy River (MAGMH) is a small, shallow tidal tributary adjacent to the upper-central Chesapeake Bay segment CB3MH. The Magothy River is represented by one long-term fixed monitoring station, WT6.1. The narrow, embayment-like nature of the Magothy River is evident in the portion of the Bay WQM grid that represents it; the entire tributary is represented by only five WQM cells. The grid cell representing station WT6.1 highlighted in Figure N-20.

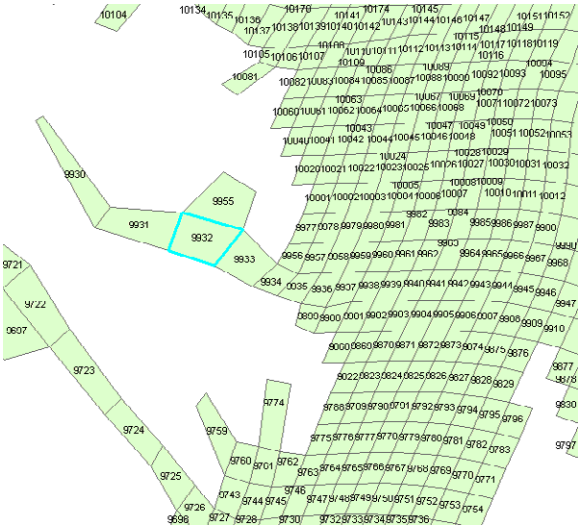
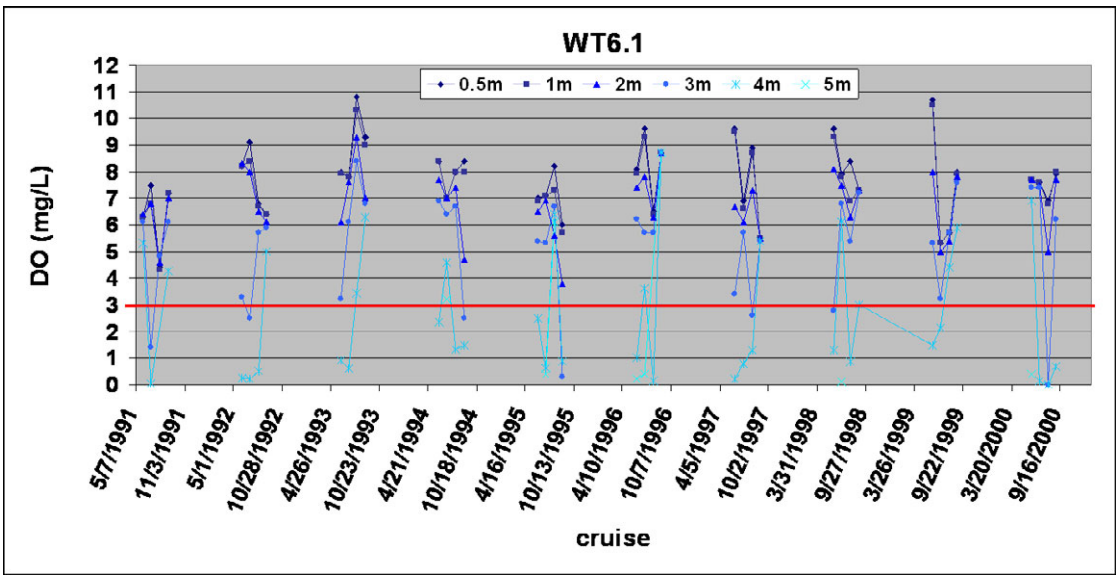


Figure N-20. Chesapeake Bay WQM grid for the Magothy River and the adjoining portion of the mainstem Chesapeake Bay.

Severely hypoxic conditions are common during the summer months in the Magothy River (Figure N-21). Low DO concentrations are often exacerbated by water column stratification, which prevents the vertical mixing that would otherwise re-oxygenate bottom waters. Concentrations often fell below the deep-water criterion of 3.0 mg/L (red line), particularly at depths greater than 2 to 3 meters (Figure N-21). The documented presence of an upper pycnocline boundary in the Magothy River recently led EPA and Maryland to recommend adding a Summer Deep Water designated use to the Magothy River (USEPA 2010). However, even when the deep-water criterion of 3.0 mg/L is applied to stratified bottom waters, nonattainment of the DO WQS persists with simulated load reductions at the level of the target basinwide allocation (see Figure N-23).



Source: http://www.chesapeakebay.net

Figure N-21. DO concentrations observed at station WT6.1 in segment MAGMH during summer months 1991–2000.

Further investigation of the persistent nonattainment of DO WQS observed in MAGMH showed that while violations occurring in some summer months improved with load reductions, hypoxic conditions in other months improved to a much lesser degree or not at all (Table N-5). In particular, violations of the DO criterion that occurred in September 1994 showed no improvement, even when loads were reduced to the 179 TN, 12 TP level.

Table N-5: Summer monthly violation rates for MAGMH during the 1993–1995 critical assessment period

MAGMH		violation rate	
year	month	observed	179 TN 12 TP
1993	6	44.9%	0.0%
1994	9	44.9%	44.9%
1995	7	100.0%	0.0%
1995	8	0.0%	0.0%
1995	9	100.0%	44.9%

The performance of the Bay WQM in the location of the MAGMH monitoring station was examined. As illustrated in Figure N-22, simulated DO concentrations in the WQM cell representing the bottom depths at station WT6.1 were consistently higher than 5.0 mg/L for September 1994. However, historical measurements for the lower depths at station WT6.1 showed concentrations less than 3.0 mg/L. In Figure N-22, the Calibration Scenario (pink symbols and regression line) is compared with the 179 TN, 12.0 TP Loading Scenario (light blue symbols and linear regression). Historical observations (dark blue circles) fall well outside the range of simulations. As described previously, the failure of the Bay WQM to simulate hypoxic conditions affects its ability to predict the magnitude of improvement that will occur in DO concentrations when nitrogen and phosphorous loads are reduced.

The inability of the Bay WQM to simulate the hypoxic conditions observed during summer months in the Magothy River reduces its ability to predict the magnitude of improvement in DO concentrations that can be expected as nitrogen and phosphorous loads are reduced. However, the Bay WQM much more effectively simulates historical conditions and, therefore, predicted improvements, in nearby deeper, wider regions of the Chesapeake Bay. Thus, the predicted attainment of WQS in the deep-water designated use of CB3MH, well before the target basinwide load allocation (see Figure N-23), can help to inform expectations of attainment for the Magothy River.

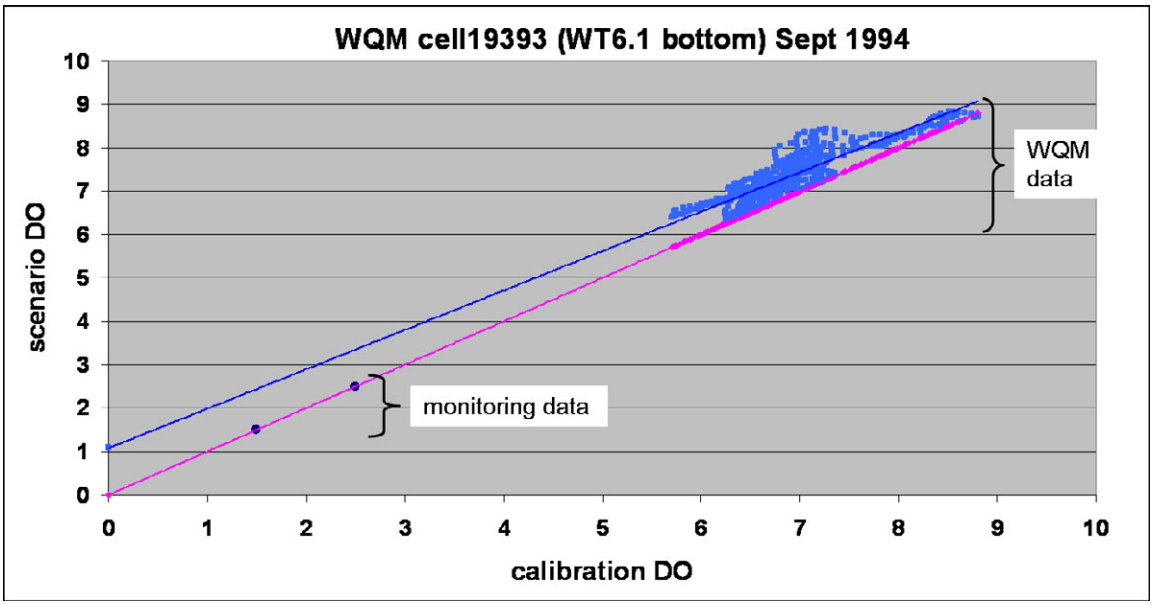


Figure N-22. Simulated DO concentrations in grid cell 19393 of the Bay WQM for September 1994.

Cbseg	1985 Scenario 342TN, 24.1TP, 9790TSS '93-'95 DO Deep Water	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Deep Water	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Deep Water	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Deep Water	Tributary Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Deep Water	190/13 Loading Scenario 190TN, 13TP, 6123TSS '93-'95 DO Deep Water	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Deep Water	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Deep Water	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Deep Water	E3 2010 Scenario 141TN 8.5TP, 5060TSS '93-'95 DO Deep Water
CB3MH	3%	2%	0%	0%	0%	0%	0%	0%	0%	0%
MAGMH	35%	35%	35%	16%	16%	16%	3%	3%	1%	1%

Figure N-23. Predicted attainment of DO WQS for the summer deep-water designated use in CB3MH and MAGMH.

While the severely hypoxic conditions commonly observed in the Magothy River during the summer months remain a matter of concern, EPA lacks data to effectively predict the recovery of the Magothy River in those months when the Bay water quality fails to simulate historical conditions. However, given attainment of adjacent deep-waters of CB3MH, and the extensive load reductions already required of the Magothy River basin for the target basinwide allocation of 190 million pounds per year TN and 12.7 million pounds per year TP, EPA anticipates that the MAGMH deep-water designated use will attain WQS when the target load allocation is achieved.

Resolution of Segments Failing to Attain the SAV/Water Clarity Criteria

After assessing attainment of the combined submerged aquatic vegetation (SAV)/water clarity criteria on the basis of Bay Water Quality/Sediment Transport Model outputs for the nitrogen and phosphorous Allocation Scenario (190 TN/12.7 TP), four Bay segments were initially found to be in nonattainment of the SAV/water clarity criteria.

On the basis of recent observed SAV acre or allowance of 1 percent nonattainment of the water clarity criteria (see Section 6.6.2 and Appendix I), the four remaining segments were judged to actually be currently in attainment. Those segments are the Mattawoman Creek (MATTF), the Gunpowder River (GUNOH), the Appomattox River (APPTF), and Virginia's portion of the lower Potomac River (POTMH_VA).

Virginia Middle Potomac River

The SAV restoration acreage criterion is for 4,250 acres for Virginia's portion of the middle Potomac River (POTMH_VA) (Figure N-24). At the nitrogen and phosphorous Allocation Scenario loading levels, the segment was at 10 percent nonattainment. Nonattainment was persistent and was estimated to be 9 percent at E3 Scenario and 6 percent at the All Forest Scenario nitrogen and phosphorous and sediment load levels. With its high SAV restoration acreage criterion and the low levels of SAV acres estimated by the assessment approach described in Appendix P for the segment, the estimated level of attainment is largely achieved through water clarity acres only. As a consequence of the high SAV restoration acreage criterion, the calculated water clarity acreage-based criterion is also very high—10,625 acres. However, the available shallow-water area out to the maximum application depth of 2 meters is less than the water clarity acres criterion for this segment.

The observed SAV record shows overall improvement in SAV coverage in recent years. Because the 1993–1995 SAV coverage was close to its lowest recorded acreage, EPA used the recent observed SAV area (2004–2005) in the SAV/water clarity criteria assessment procedure described in Appendix P. Starting with this SAV acreage, more consistent with recent years of observed SAV acreage (Figure N-25), Virginia's portion of the lower Potomac River achieved its SAV/water clarity WQS at the sediment allocation levels.

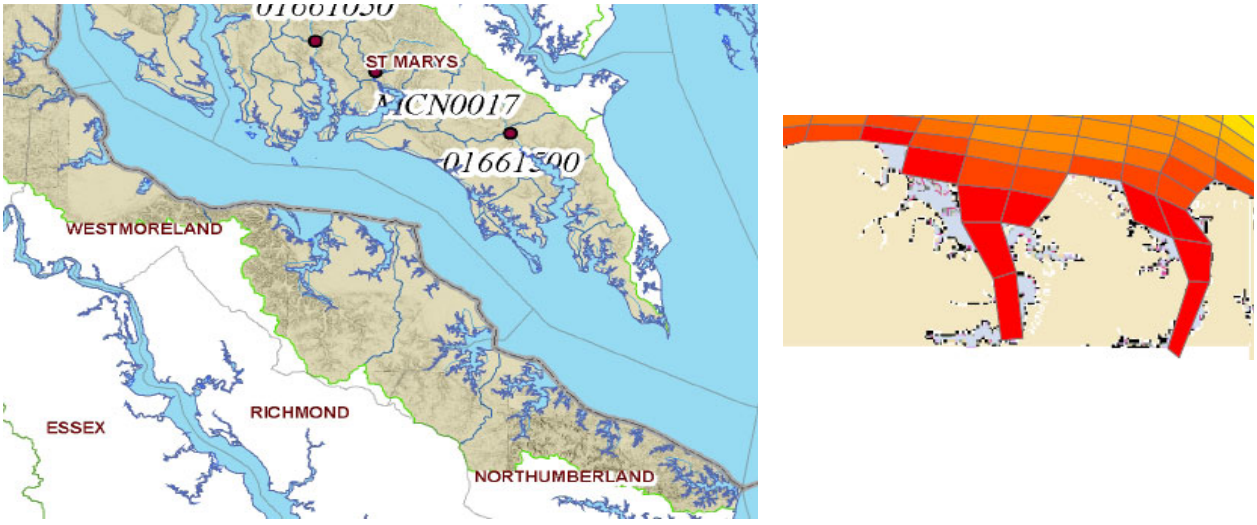
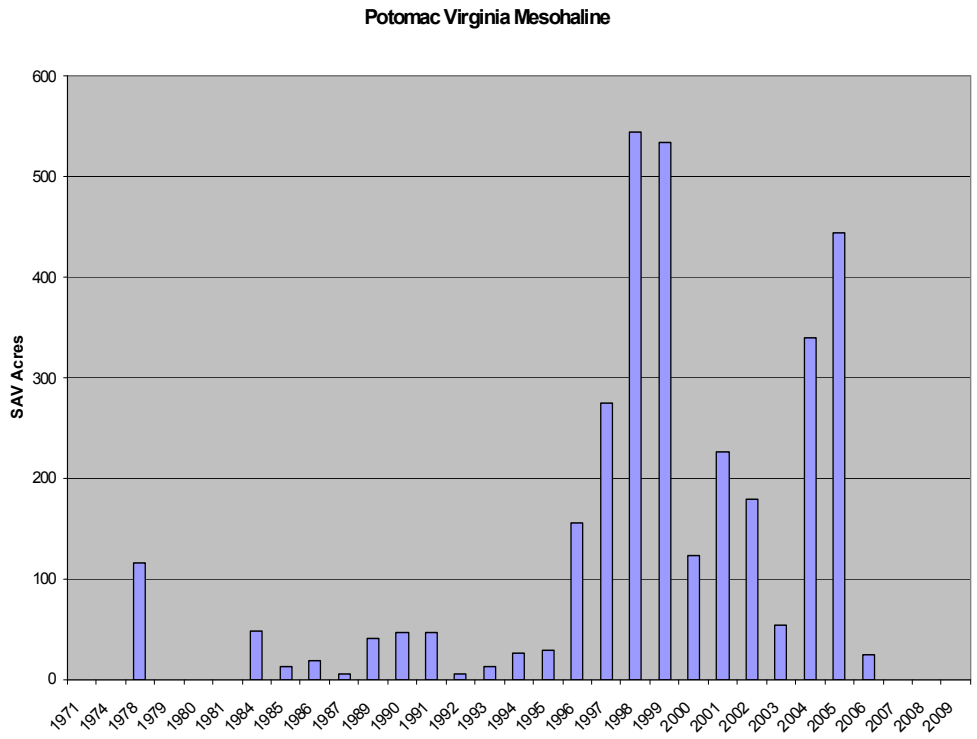


Figure N-24. The location of the different embayments of Virginia's portion of the lower Potomac River (above left) and its representation of the Nomini Bay region of the segment by the Chesapeake Bay WQM (above right).



Source: http://www.vims.edu/bio/sav

Figure N-25. Observed SAV acres in Virginia' lower Potomac River segment.

Mattawoman Tidal Fresh—MATTF

Initially, the Mattawoman Creek (Figure N-26) appeared to be in nonattainment of its SAV/water clarity standards on the basis of Bay WQM simulation of the nitrogen and phosphorous Allocation Scenario loading levels. Subsequently, a fuller analysis that included the recent SAV monitoring data found that the Mattawoman Creek segment had 877 acres of observed SAV in 2008, and 866 acres in 2009 (Figure N-27). Both recent years of observed SAV exceeded the 792 acres SAV restoration acreage criterion. From the recent observed SAV data and the upward trend of SAV expected with continued nitrogen and phosphorous and sediment reduction in the Mattawoman Creek, those other lines of evidence supported the finding that the sediment allocations for this segment will achieve the SAV standards.

Figure N-26. The location of Mattawoman Creek in the upper Potomac River (above left) and the Chesapeake Bay WQM representation of Mattawoman Creek (above right).

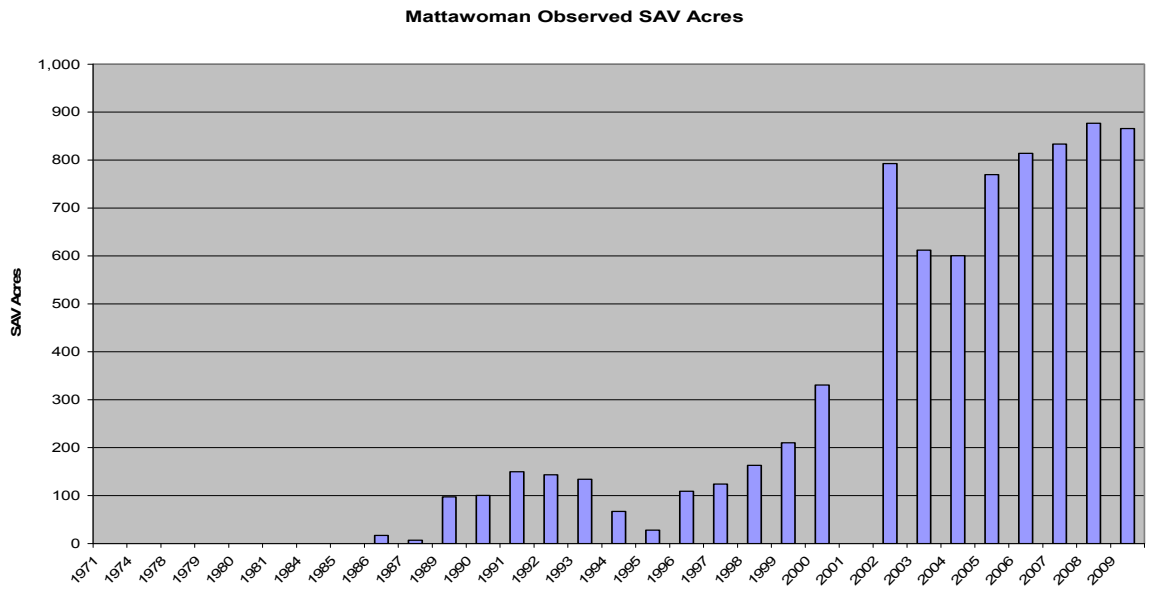


Figure N-27. The observed SAV data for Mattawoman Creek from 1971 to 2009.

Gunpowder River

Initially, the Gunpowder River (GUNOH) (Figure N-28) appeared to be in nonattainment of its SAV/water clarity standards according to the Bay WQM simulation of the nitrogen and phosphorous Allocation Scenario loading levels. Subsequent analysis found that the Gunpowder River segment had essentially reached its SAV restoration acreage criterion of 2,432 acres in recent years (2000, 2004) and found a generally increasing trend of SAV expansion as nitrogen and phosphorous and sediment loads continue to decrease toward the allocation scenario loads (Figure N-29). Consequently, that other line of evidence supports the finding that further sediment reductions beyond the phosphorus-based sediment loads within the nitrogen and phosphorous Allocation Scenario would be unwarranted.

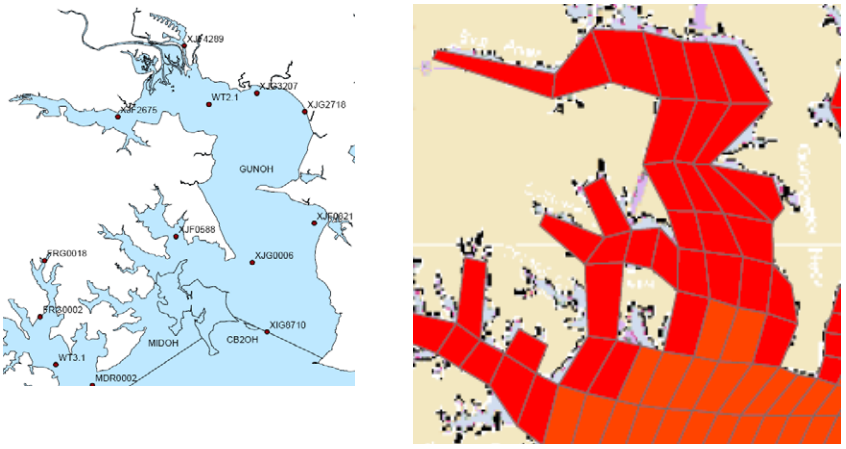


Figure N-28. The location of the Gunpowder River (above left) and the Chesapeake Bay WQM representation of Gunpowder River (above right).

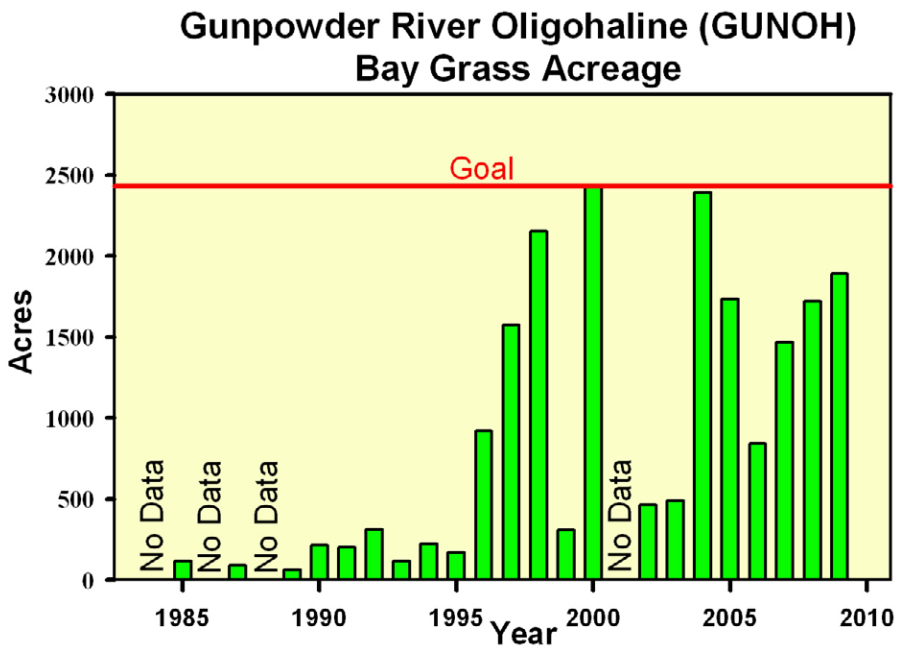


Figure N-29. The observed SAV data for the Gunpowder River from 1985 to 2009.

Appomattox River

In the Appomattox River (Figure N-30), the SAV restoration acreage criterion is 379 acres, although no SAV has been observed from 1978 to present. A persistent, low-level nonattainment (1 percent), which is based on attainment of the water clarity criteria only, is estimated at the Sediment Allocation Scenario loading level. Allowance of 1 percent persistent nonattainment of the water clarity criteria moves the segment into attainment.

Figure N-30. The location of the Appomattox River in the upper tidal James River (above left) and its representation by the Chesapeake Bay WQM (above right).

References

USEPA (U.S. Environmental Protection Agency). 2010. *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries: 2010 Technical Support for Criteria Assessment Protocols Addendum*. May 2010. EPA 903-R-10-002. CBP/TRS 301-10. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD.