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Technical Memorandum

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Re: Analysis of January-May Inflows to the Chesapeake Bay during the 1996-98 Period

BACKGROUND

Under USEPA guidance (40 CFR 130.7), total maximum daily loads (TMDLs) must be developed to attain water quality standards under critical conditions. For many TMDLs, critical conditions are defined as a hydrologic condition of a given return frequency, such as the 7Q10 streamflow or a storm of a specific return period. For the Chesapeake Bay nutrient TMDL, USEPA plans to model attainment of dissolved oxygen (DO) standards for a ten-year period representing 1991-2000 hydrology. The intention is to meet the critical conditions requirement by basing the TMDL on the "worst" 3-year attainment period within the larger 10-year period.

Preliminary model results indicate that the controlling 3-year period is 1996-1998. In Bay segments such as CB4, attainment of DO standards in 1996-98 is projected to require more nutrient load reductions than for other 3-year periods within the 1991-2000 hydrologic period (CBPO, 2009). A question has arisen regarding whether the 1996-98 period represents unusual hydrologic conditions, or more precisely, whether it represents a hydrologic condition of a longer return period than is normally selected to represent critical conditions for a TMDL. This technical memorandum presents an investigation of that question.

It is well established that the magnitude and extent of hypoxia in the Chesapeake Bay is largely controlled by the magnitude of freshwater and nutrient inputs during the preceding winter and spring months (Malone and others, 1993; Boesch and others, 2001). Freshwater input during this period affects the extent of hypoxia not only by conveying a large proportion of the annual nonpoint source nutrient loads, but also by affecting the degree of stratification of the Bay water column. Scavia and others (2006) developed a simple empirical model of Bay hypoxia as a function of nutrient inputs from January to May, and this model is now used annually to forecast the size of the "dead zone" that develops in late spring and summer. The amount of freshwater inflow to the Bay during January-May, therefore, is a useful indicator of hydrologic conditions associated with DO standards attainment.

METHODS

The daily average input of freshwater flow to the Chesapeake Bay was computed as the sum of daily average streamflows at two USGS stream gaging stations:

- Susquehanna River at Conowingo Dam (USGS 1578310); period of record: Oct 1967 to June 2009
- Potomac River near Washington DC (USGS 1646502); period of record: March 1930 to May 2009

The total inflow to the Bay will be higher than the sum of the inflow at these two stations. However, flows from the Susquehanna and Potomac Rivers together represent almost 80 percent of the gaged inflows to the Bay (Sprague and others 2000), and an even higher proportion of gaged inflows that strongly affect hypoxia in the critical mid-Bay segments. The overlapping period of record for these stations was October 1967 to May 2009, a period of about 42 years. The average daily inflow from January through May was calculated for each year in this period. The average daily inflow from January through May was also calculated for each of the forty 3-year periods within the 42-year period.

RESULTS AND DISCUSSION

Results (Table 1) demonstrate that the 1996-1998 period had the highest average Jan-May inflow of the entire period of record, representing the 100th percentile of the data. Because this period represents one of forty 3-periods included in the analysis, the resulting estimate of return period is 40 years.

The 1996-1998 period is so usual because it contains two years—1996 and 1998—that represent the 93rd and 98th percentiles, respectively, of Jan-May inflows. Although it is not extremely rare for any given 3-year period to have one such year, it is rare for any 3-year period to have two such years. High inflows in the year 1996 are partly due to extreme meteorological/hydrologic conditions. In January 1996, warm rains fell on a winter snowpack and caused an event known as the "Big Melt". This event has been labeled an "extreme" event by the Chesapeake Bay Program Office and required special consideration during calibration of the Chesapeake Bay simulation models (Shenk, 2008). Inflows during January-May of 1998 were even higher than in 1996.

USEPA guidance does not define "critical conditions" nor address the issue of reasonable return periods for TMDL development. However, a survey of nationwide TMDL documents reveal that the vast majority of TMDLs are developed for hydrologic conditions that represent return periods of 10 or fewer years. The majority of TMDLs developed for critical low flow conditions have used the 10-year return period associated with 7Q10 or 1Q10 streamflow statistics. The reviewed identified TMDLs developed for high flow conditions that used specific design storms with return frequencies of 1, 2, 5, or 10 years. Based on this non-comprehensive review, no specific TMDL examples were discovered that used a return period of 40 years or higher, although some might exist.

Based on this analysis, the critical condition currently being planned for the Chesapeake Bay TMDL appears to be significantly more infrequent than is normally used for TMDL development. Flow percentiles such as those presented in Table 1 can be used to select alternate 3-year periods that represent critical but not extreme conditions. For example, the 1993-1995 and 1994-1996 periods had very high January-May inflows, but were much closer to a 10-year return period than the 1996-1998 period.

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TABLE 1

Sum of Average Daily Streamflow Values (January Through May) from at the Susquehanna River at Conowingo Dam (USGS 1578310) and Potomac River near Washington DC (USGS 1646502)

Year	Individual Year Average (cfs)	Percentile	Running 3 Yr-Average* (cfs)	Percentile
1968	56,460	22%		
1969	42,438	0%		
1970	84,427	63%	61,098	5%
1971	84,120	61%	70,601	26%
1972	93,471	83%	87,353	77%
1973	87,377	71%	88,334	79%
1974	79,204	59%	86,699	74%
1975	86,470	66%	84,278	69%
1976	72,630	46%	79,419	54%
1977	69,439	39%	76,172	38%
1978	110,325	90%	84,106	67%
1979	108,111	85%	95,838	90%
1980	74,977	51%	97,754	95%
1981	54,093	17%	79,051	51%
1982	70,444	41%	66,524	13%
1983	88,004	73%	70,749	28%
1984	108,544	88%	89,041	82%
1985	52,674	7%	83,130	64%
1986	72,839	49%	78,086	49%
1987	66,681	32%	64,413	8%
1988	62,667	29%	67,385	21%
1989	71,255	44%	66,859	15%
1990	68,896	37%	67,595	23%
1991	77,275	56%	72,458	31%
1992	55,991	20%	67,363	18%
1993	125,978	100%	86,348	72%
1994	115,417	95%	99,034	97%
1995	50,775	2%	97,228	92%
1996	115,181	93%	93,838	87%
1997	62,227	27%	76,147	36%
1998	123,730	98%	100,412	100%
1999	53,581	10%	79,848	56%
2000	67,687	34%	81,635	62%
2001	51,596	5%	57,644	0%
2002	53,935	15%	57,762	3%
2003	90,567	78%	65,368	10%
2004	87,155	68%	77,241	46%
2005	91,598	80%	89,768	85%
2006	61,593	24%	80,131	59%
2007	77,155	54%	76,762	44%
2008	90,357	76%	76,399	41%
2009	53,906	12%	73,843	33%

* Running average of the listed year and the two previous years