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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

MAR 0 2 2000

The Honorable Jane T. Nishida
Secretary
Maryland Department of the Environment
2500 Broening Highway
Baltimore, Maryland 21224

Dear Secretary Nishida:

The Environmental Protection Agency (EPA), Region III has reviewed the report "Total Maximum Daily Load (TMDL) of Phosphorus to Broadford Lake, Garrett County, Maryland" which was submitted by the Maryland Department of Environment (MDE) on January 3, 2000. Pursuant to 40 CFR Section 130.7(d), EPA is approving the Broadford Lake TMDL.

The definition of Load Allocation (LA) at 40 CFR Section 130.2(g) states, in part, that "Load allocations are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading." Further, a wasteload allocation (WLA), according to 40 CFR Section 130.2(h), is "The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation." In addition, a TMDL is defined at 40 CFR Section 130.2(I) as "The sum of the individual WLAs for point sources and LAs for nonpoint sources and natural background."

EPA has determined that the TMDLs and technical report are consistent with the regulations and requirements of 40 CFR Section 130 (see enclosed Decision Rationale). Pursuant to 40 CFR Sections 130.6 and 130.7(d)(2), the TMDLs and the supporting documentation, should be incorporated into Maryland's current water quality management plan.

If you have any further questions or concerns, please contact me at 215-814-5422 or contact Thomas Henry, of my office, at 215-814-5752.

Sincerely,

Jon M. Capacasa, Acting Director
Water Protection Division

Enclosure

Decision Rationale

Total Maximum Daily Load of Phosphorus to Broadford Lake, Garrett County, MD

I. Introduction

This document will set forth the Environmental Protection Agency's (EPA) rationale for approving the Total Maximum Daily Loads (TMDLs) of Phosphorus to Broadford Lake in Garrett County, Maryland submitted for final Agency review on January 3, 2000. Our rationale is based on the TMDL, Technical Memorandum, and other information provided in the submittal document to determine if the TMDL meets the following 8 regulatory conditions pursuant to 40 CFR §130.

1) The TMDLs are designed to implement applicable water quality standards.
2) The TMDLs include a total allowable load as well as individual waste load allocations and load allocations.
3) The TMDLs consider the impacts of background pollutant contributions.
4) The TMDLs consider critical environmental conditions.
5) The TMDLs consider seasonal environmental variations.
6) The TMDLs include a margin of safety.
7) The TMDLs have been subject to public participation.
8) There is reasonable assurance that the TMDLs can be met.

The Technical Memorandum, *Significant Phosphorus Nonpoint Sources in the Broadford Lake Watershed* submitted by the Maryland Department of the Environment (MDE), specifically allocates phosphorus to each of 4 separate land use/source categories (direct atmospheric deposition of phosphorus to the water surface is obviously not considered a "land use" source). Each land use or source is allocated some percentage of the total load originating from nonpoint sources. Current nonpoint source load estimates were based on the Chesapeake Bay Model Phase IV loading coefficients from segment 160 which considers natural background, loads from septic tanks, as well as baseflow contributions. Likewise, the load allocations to each land use also consider natural background, septic tanks and baseflow. Each land use load allocation represents yearly allowable loads of phosphorus.

II. Summary

In 1971, an impoundment named Broadford Lake[1] was created through the construction of an earthen dam on Broadford Run. The lake, which was created for flood control, water

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[1] Lake Habeeb is owned by the City of Oakland.

supply and recreational purposes, lies on Broadford Run which is tributary to the Little Youghiogheny River[2] in the Youghiogheny River Watershed (05-02-02). Inflow to the lake is through 2 tributaries. No information was provided regarding the phosphorus load originating from these 2 tributaries. MD assumes direct deposition of watershed derived phosphorus to the lake based on the land use/loading coefficient approach. Broadford Run represents the majority of the flow into Broadford Lake, while one unnamed tributary contributes significantly smaller flows. The dominant land use in the watershed is forested/herbaceous (63%), with agricultural (25%), developed (9%), and water (3%) comprising the remaining land use distribution.

As a result of the Maryland Lake Water Assessment Report (MLWAP) (MDDNR, 1998), Broadford Lake was included on the 1998 Clean Water Act (CWA) Section 303(d) list of water quality impaired waterbodies. Based on this report, Maryland determined that nuisance levels of algae and low dissolved oxygen levels in the hypolimnion were causing violations of the designated uses[3] of Broadford Lake. The violations applied only to the water contact recreation and protection of aquatic life designated uses. Maryland believes that the overenrichment of nutrients, specifically phosphorus, lead to excessive algae growth and the subsequent death and decay of algae in the hypolimnion cause low dissolved oxygen levels experienced in Broadford Lake. Additionally, the thermal stratification of the lake prevents mixing of the hypolimnion with the epilimnion, which is currently attaining the dissolved oxygen water quality criterion which applies to surface waters (refer to footnote 6). These decreased levels of dissolved oxygen in the hypolimnion can potentially cause violations of the designated uses of the lake by disrupting the ecosystem balance and causing fish kills. Nutrients resulting from nonpoint sources were listed as the cause and source of the water quality impairment, respectively. Broadford Lake was given low priority on the 1998 303(d) list. Section 303(d) of the CWA and its implementing regulations require a TMDL to be developed for those waterbodies identified as impaired by the State where technology-based and other controls did not provide for attainment of water quality standards.

MDE developed a TMDL to address the excessive nutrient enrichment that Broadford Lake is currently experiencing. This TMDL is designed to satisfy the water quality standards and designated uses of Broadford Lake only. Impairments in the remainder of the Little Youghiogheny River watershed and Youghiogheny River watershed are not addressed by this TMDL.

Maryland has interpreted its narrative water quality standards in order to determine an appropriate endpoint for the TMDL. In order to control nutrient enrichment in Broadford Lake to restore designated uses, a phosphorus TMDL was developed by MDE predicated on the

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[2] The Little Youghiogheny River is a tributary of the Youghiogheny River. The Little Youghiogheny River Watershed is listed on the 1998 303(d) list as Basin Code 05-02-02-02.

[3] The Code of Maryland Regulations (COMAR) at Section 26.08.02.07 list the designated uses of Broadford Lake as Use I-P- Water Contact Recreation, and Protection of Aquatic Life and Public Water Supply.

identification of phosphorus as the limiting nutrient. When phosphorus enters surface waters in substantial amounts it becomes a pollutant, contributing to the excessive growth of algae and other aquatic vegetation and, thus, to the accelerated eutrophication of lakes and reservoirs[4]. MDE determined that phosphorus is the limiting nutrient by dividing the total nitrogen by the total phosphorus concentrations in the lake[5]. The phosphorus TMDL is designed to control the growth and death/decay of algae in the lake which in turn will prevent excessive algae growth and decreased levels of dissolved oxygen in the hypolimnion. In addition, MDE links the control of phosphorus loading to the attainment of the dissolved oxygen water quality standard in the hypolimnion of Broadford Lake. Based on MDE's previous interpretation of the dissolved oxygen water quality criterion as it applies to surface waters[6] of lakes, MDE states that "*Although the numeric criterion is not applied to the bottom waters of lakes, the information provided by such data is assessed by water quality managers, in conjunction with other information, to ensure that the designated uses are being attained*". Broadford Lake is currently attaining the dissolved oxygen water quality criterion as it applies to surface-waters. Using this interpretation, MDE links the attainment of the hypolimnion dissolved oxygen water quality criterion to the phosphorus loading according to the TMDL through the use of a nomogram relating water temperature, hypolimnion dissolved oxygen saturation percentage, and dissolved oxygen concentration[7]. EPA believes that this endpoint is acceptable for assuring that the designated uses and water quality criteria of Broadford Lake will be restored. Table 1 below summarizes the phosphorus TMDL.

Table 1, Phosphorus TMDL Summary

Parameter	Rate	TMDL	WLA	LA	MOS
Phosphorus	lbs/yr	1,217	0	1,095	122
	lbs/day[1]	3.33	0	3	0.33

[1] The TMDL rate of pounds per day is derived by dividing the pounds per year values by 365.

[4] Soil and Water Quality, 1993, Committee on Long-Range Soil and Water Conservation, National Academy Press.

[5] MDE estimated a total nitrogen to total phosphorus ratio of 12.5:1 based on the 1993 Lake Water Quality Assessment Project (MDE).

[6] Maryland has provided an interpretation regarding how the dissolved oxygen water quality standard applies to lakes in a June 17, 1999 letter to Tom Henry, EPA from Robert Summers, MDE. The dissolved oxygen water quality criterion only applies to the well-mixed surface layers of the lake.

[7] Reid, George K., R.D. Wood, Ecology of Inland Waters and Estuaries, Second Edition, 1976, D. Van Nostrand Company.

III. Discussion of Regulatory Conditions

EPA finds that Maryland has provided sufficient information to meet all of the 8 basic requirements for establishing a phosphorus TMDL for Broadford Lake. EPA therefore approves the TMDLs, Technical Memorandum, and supporting documentation for phosphorus in Broadford Lake. Our approval is outlined according to the regulatory requirements listed below.

1) The TMDL is designed to implement the applicable water quality standards.

Maryland does not currently have numeric water quality standards for nutrients (phosphorus or nitrogen). Therefore, Maryland utilized its General Water Quality Criteria[8] and the Vollenweider Approach[9] to establish an endpoint for phosphorus such that the designated uses of Broadford Lake are restored. Utilizing landuse specific phosphorus loading coefficients from the Chesapeake Bay Program model Phase IV Segment 160, the current areal annual phosphorus load to Lake Habeeb was calculated as 1.4 g/m^2 yr (1,699 lbs/yr total). This current phosphorus load and the ratio of the mean depth to hydraulic residence time of Broadford Lake were used to classify the lake as eutrophic according to the Vollenweider Plots. The endpoint of the phosphorus TMDL was identified as the areal phosphorus loading which is consistent with achieving a meso-eutrophic status according to the loading plots. MDE believes that achieving a meso-eutrophic status will support the designated uses and general water quality criteria of Broadford Lake. The areal phosphorus loading must be reduced from the current loading of 1.4 g/m^2 yr to the TMDL value of 1.0 g/m^2 yr which represents the upper level of the mesotrophic zone based on the lake's current characteristics and Maryland's interpretation of the mesotrophic zone according to the Vollenweider plots. This areal load was then converted to 1,217 lbs/yr for consistency with the TMDL process. Implementation of the TMDL will result in 38% reduction to current phosphorus loading into Broadford Lake.

Although nutrients, both nitrogen and phosphorus, are listed as the cause of impairment in Broadford Lake, a TMDL for phosphorus was developed to control algae blooms, excessive plant growth, and possible dissolved oxygen criteria violations in the hypolimnion because phosphorus is often the major nutrient in shortest supply and is frequently a prime determinant of the total biomass[10]. Phosphorus is also the most effectively controlled using existing engineering

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[8] The Code of Maryland Regulations at Section 26.08.02.03B(5)(a).

[9] The Vollenweider Approach (1968, 1975) is a simple empirical model which uses a linear relationship between phosphorus loading and the ratio of the lake's mean depth to hydraulic residence time to establish the lake's eutrophication status.

[10] Modeling Phosphorus Loading and Lake Response under Uncertainty: A manual and compilation of Export Coefficients, 1980, EPA 440/5-80-011.

technology and land use management[11]. Schindler (1977) maintains that all freshwater lakes will eventually be phosphorus limited because other nutrients have an atmospheric pathway in their biogeochemical cycles and are thus more subject to internal regulation, whereas phosphorus cycling is strictly geologic and is more sensitive to external factors[12].

Lake eutrophication is both a natural and culturally-based phenomenon. Natural eutrophication is a slow, largely irreversible process associated with the gradual accumulation of organic matter and sediments in lake basins. Cultural eutrophication is an often rapid, possibly reversible process of nutrient enrichment and high biomass production stimulated by cultural activities causing nutrient transport to lakes[13]. Lakes are considered to undergo a process of "aging" which can be characterized by the trophic status as oligotrophic, mesotrophic, or eutrophic. Oligotrophic lakes are normally associated with deep lakes which have relatively high levels of dissolved oxygen throughout the year, bottom sediments typically contain small amounts of organic matter, chemical water quality is good, and aquatic populations are both productive and diverse. Mesotrophic lakes are characterized by intermediate levels of biological productivity and diversity, slightly reduced dissolved oxygen levels, and generally have adequate water quality to support designated uses. However, there is a recognition that these lakes are naturally or culturally moving towards a eutrophic state. Lakes which are classified as eutrophic typically exhibit high levels of organic matter, both suspended in the water column and in the upper portions of sediments. Biological productivity is high , often indicated by seasonal algae blooms and excessive plant growth. Dissolved oxygen concentrations are low, and may reach extreme levels during critical periods. In addition, water quality is often poor resulting in violations of the designated uses[14]. The following table illustrates typical water quality variables of these three trophic designations.

[11] Id.

[12] Schindler, D.W. 1977. Evolution of phosphorus limitation in lakes. Science 195:260-262.

[13] Supra, footnote 10.

[14] Technical Guidance Manual for Performing Water Load Allocations, Book IV, Lakes and Impoundments, Chapter 2, Nutrient/Eutrophication Impacts, EPA 440/14-84-019.

Table 2, Trophic-state classifications and typical variables[15]

	Trophic-state		
Variable	Oligotrophic	Mesotrophic	Eutrophic
Total Phosphorus (ug/l P L^{-1})	<10	10-20	>20
Chlorophyll-a (ug/l Chl-a L^{-1})	<4	4-10	>10
Secchi-disk depth (m)	>4	2-4	<2
Hypolimnion oxygen (% saturation)	>80	10-80	<10

In a conceptual sense, the Vollenweider Approach attempts to provide a standard means of expressing nutrient input so that the supply to different lakes could be compared on a common basis in the hopes that this would lead to relationships between this standard measure of nutrient supply and the degree of eutrophication of the lakes[16]. In that regard, Vollenweider first attempted to plot the areal total phosphorus loading against mean depth on a log-log scale, in essence the volumetric loading. This simple empirical model worked well for lakes with phosphorus loading data available at that time. However, it was soon recognized that this model was an approximation at best and required further development. Vollenweider refined his model to incorporate the flushing rate of lakes by plotting the phosphorus loading against the mean depth divided by the mean residence time of water, which is equivalent to the height of water load that is supplied to the lake in one year. This refinement added significant accuracy for the prediction of trophic states of lakes. Dillion[17] comments that a plot of phosphorus loading against mean depth divided by mean residence time would have the same corrective result as a plot which included both the flushing rate and the phosphorus retention rate. The difference being that the latter plot would account for one more source of variation.

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[15]Chapra, Steven, C., Surface Water-Quality Modeling, 1997, p. 538, McGraw Hill Companies.

[16] The Application of the Phosphorus Loading Concept to Eutrophication Research, Vollenweider, R.A. and P.J Dillion, Canada Centre for Inland Waters, NRCC 13690, Environmental Secretariat, 1975.

[17] Id.

As previously mentioned, MDE links the attainment of a hypolimnion dissolved oxygen water quality criterion to the phosphorus loading according to the TMDL through the use of a nomogram relating water temperature, hypolimnion dissolved oxygen saturation percentage, and dissolved oxygen concentration. The nomogram is displayed in Figure 1 below.

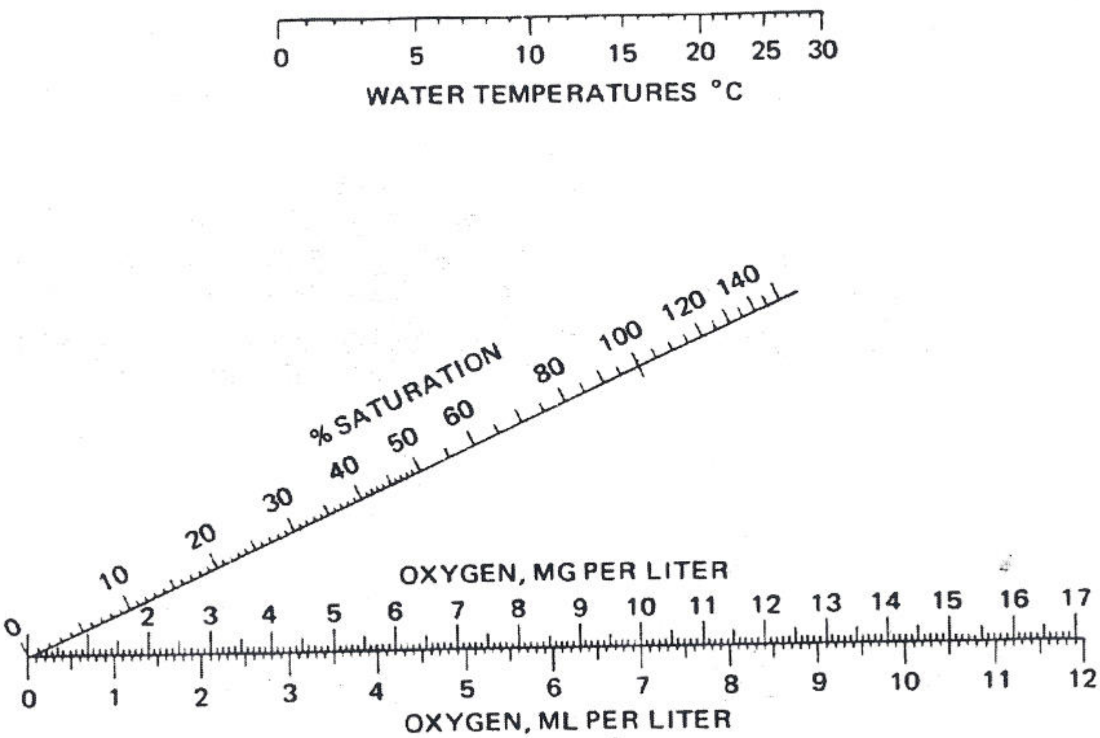

Figure 1

A nomogram for determining expected dissolved oxygen concentrations in the hypolimnion based on water temperatures and dissolved oxygen saturation values (Reid 1976).

MDE uses this nomogram to determine the expected hypolimnion dissolved oxygen concentrations based on the expected phosphorus load resulting from the TMDL. The nomogram is utilized by using a straight-edge to connect the observed water temperature and the expected dissolved oxygen saturation which corresponds to a meso-eutrophic status to determine the expected dissolved oxygen concentration. According to the MLWAP data (MDDNR, 1998), the highest observed water temperature was 21°C. In order to determine the dissolved oxygen saturation expected with a meso-eutrophic status, MDE extrapolated the mesotrophic data on hypolimnion oxygen (% saturation) seen in Table 2 above. It appears that MDE simply divided the available range of saturation percentages (10%-80%) by 3 in order to provide an appropriate scale which would now include the trophic states of meso-eutrophic, and oligo-mesotrophic. This results of this extrapolation exercise are seen in table 3 below.

Table 3, Extended trophic states and relationship to hypolimnion oxygen (% saturation)

Trophic Status	Hypolimnion Oxygen (% saturation)
Eutrophic	0%
Meso-eutrophic	10%
Mesotrophic	33%
Oligo-mesotrophic	56%
Oligotrophic	80%

Continuing the exercise, Maryland connects the line originating from the observed water temperature of 21°C and the expected oxygen saturation percentage of 10% to determine that this TMDL should result in an expected hypolimnion dissolved oxygen concentration of 0.9 mg/l. This is considered the "worst-case" based on sample water temperature observations and expected TMDL phosphorus loads. Maryland also includes the lowest observed water temperature to provide a range of expected hypolimnion dissolved oxygen concentrations. Using a water temperature of 11°C and an expected 10% oxygen saturation value, the expected DO concentration in the hypolimnion is 1.2 mg/l.

2) The TMDLs include a total allowable load as well as individual waste load allocations and load allocations.

Table 4, Summary of Phosphorus Loads

	Phosphorus	
	lbs/year	lbs/day
TMDL	1,217	3.33

<u>A) Waste Load Allocations</u>

Maryland states that there are no point source discharge permits (National Pollutant Discharge Elimination System) for nutrients issued in the Broadford Lake watershed. Therefore, the WLA is set at zero.

<u>B) Load Allocations</u>

While Maryland did have adequate land use and loading coefficient data, they did not distribute the total load allocation to the specific land uses within the Broadford Lake watershed within the TMDL document. The total load allocation for phosphorus can be found in table 1 of this document. Land use/source specific load allocations are contained within the Technical Memorandum which accompanied the TMDL document.

According to federal regulations at 40 CFR 130.2(g), load allocations are best estimates of the loading, which may range form reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished. MDE uses the Chesapeake Bay Program model Phase IV loading coefficients (Segment 160) which are land use specific and include natural background contributions, atmospheric deposition, and baseflow contributions.

As noted above, Maryland did not provide a breakdown of the load allocation in the TMDL report, however, such a breakdown was provided in the Technical Memorandum. The TMDL is based on the phosphorus loading from the 4 land uses/sources within the watershed. According to the Technical Memorandum, the specific load allocations for the TMDL are as follows:

Table 5, Summary of Technical Memorandum Load Allocations for phosphorus

Land Use Category	Percent Land Use	Watershed area (acres)	% Nonpoint source current load	Nonpoint source current load (lbs/yr)	% Nonpoint source TMDL load	Nonpoint source TMDL load (lbs/yr)	% reduction needed
Agriculture (Crops)	25%	1,088	72.3%	1,280	72%	791	38%
Forest and other herbaceous	63%	2,741.8	4.5%	79	5%	49	38%
Developed	9%	391.7	19.2%	340	19%	210	38%
Direct Atmospheric Deposition to water surface	3%	130.5	4%	72	4%	45	38%
Total	100%	4,352	100%	1,771	100%	1,095	38%

<u>Allocation Scenario</u>

EPA realizes that the above breakout of the load allocations for phosphorus to specific land uses is one allocation scenario. As implementation of the established TMDL proceeds or more detailed information becomes available, Maryland may find other combinations of land use allocations that are more feasible and/or cost effective.

3) The TMDL considers the impacts of background pollutant contributions.

As previously stated, MDE relies on the EPA Chesapeake Bay Program model Phase IV loading coefficients (segment 160) to determine the amount of phosphorus originating from land uses in Broadford Lake watershed. Natural background contributions as well as contributions from base flow are included within those loading coefficients.

4) The TMDLs consider critical environmental conditions.

EPA regulations at 40 CFR 130.7(c)(1) require TMDLs to take into account critical conditions for streamflow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of Broadford Lake is protected during times when it is most vulnerable.

Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards.[18] Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence. In specifying critical conditions in the waterbody, an attempt is made to use a reasonable "worst-case" scenario condition. For example, stream analysis often uses a low-flow (7Q10) design condition as critical because the ability of the waterbody to assimilate pollutants without exhibiting adverse impacts is at a minimum.

In terms of phosphorus, one critical condition occurs during precipitation events which increases the loading of phosphorus to the lake from overland flow. In general, phosphorus loss by leaching to groundwater is not a problem[19]. Furthermore, the majority of phosphorus lost from agricultural lands is through surface flow, both in solution (soluble phosphorus) and bound to eroded sediment particles (particulate)[20]. Another critical period specific to phosphorus occurs during times when the lake experiences warmer temperatures which encourage algae growth.

Critical environmental conditions such as those described above are implicitly considered by the Vollenweider Approach. Phosphorus loads are given on a yearly basis and would effectively include precipitation events. The TMDLs also consider the critical water temperatures which may be experienced by this lake during the summer months through the use of temperature values in the dissolved oxygen calculations in the hypolimnion which cover the range of those experienced by the lake.

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[18] EPA Memorandum regarding EPA Actions to Support High Quality TMDLs from Robert H. Wayland III, Director, Office of Wetlands, Oceans, and Watersheds to the Regional Water Management Division Directors, August 9, 1999.

[19] Gilliam, J. W., T.J. Logan, and F.E. Broadbent. 1985. Fertilizer use in relation to the environment. Pp. 561-588 in Fertilizer Technology and Use, O.P. Engelstead, ed. Madison, Wis.: Soil Science Society of America.

[20] Supra, footnote 4.

5) The TMDLs consider seasonal environmental variations.

Seasonal variations involve changes in streamflow as a result of hydrologic and climatological patterns. In the continental United States, seasonally high flow normally occurs during the colder period of winter and in early spring from snowmelt and spring rain, while seasonally low flow typically occurs during the warmer summer and early fall drought periods[21]. Consistent with our discussion regarding critical conditions, the Vollenweider Approach will effectively consider seasonal environmental variations.

6) The TMDLs include a margin of safety.

This requirement is intended to add a level of safety to the modeling process to account for any uncertainty. Margins of safety may be implicit, built into the modeling process, or explicit, taken as a percentage of the wasteload allocation, load allocation, or TMDL.

MDE utilizes an explicit process for determining the margin of safety for the phosphorus TMDL by allocating 10% of the total allowable load to the margin of safety.

7) The TMDL has been subject to public participation.

The TMDLs of phosphorus and sediments to Lake Habeeb were open for public comment from November 4, 1999 through December 6, 1999. Only one set of written comments were received by MDE, which was provided along with their response document with the TMDL report.

8) There is a reasonable assurance that the TMDL can be met.

EPA requires that there be a reasonable assurance that the TMDL can be implemented. MDE states that reasonable assurance can be provided through implementation of the phosphorus reduction plan by three specific programs: 1) the Water Quality Improvement Act of 1998 (WQIA); 2) the Clean Water Action Plan of 1998 (CWAP); and 3) the State's Chesapeake Bay Agreement's Tributary Strategies for Nutrient Reduction. EPA believes that these programs will be able to provide the necessary tools for implementing the TMDLs and achieving water quality standards.

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[21] Technical Guidance Manual for Developing Total Maximum Daily Loads, Book 2, Part 1, Section 2.3.3, (EPA 823-B-97-002, 1997).