MEMORANDUM

SUBJECT: **Annual Permit Limits for Nitrogen and Phosphorus for Permits Designed to Protect Chesapeake Bay and its tidal tributaries from Excess Nutrient Loading under the National Pollutant Discharge Elimination System**

FROM: James A. Hanlon, Director
Office of Wastewater Management

TO: Jon Capacasa, Director
Water Permits Division, EPA Region 3

Rebecca Hanmer, Director
Chesapeake Bay Program Office

This memo responds to your proposal to use National Pollutant Discharge Elimination System (NPDES) permit effluent limits for nitrogen and phosphorus expressed as an annual limit in lieu of daily maximum, weekly average, or monthly average effluent limitations, for the protection of Chesapeake Bay and its tidal tributaries from excess nutrient loading. Based on the information provided by your staff and for the reasons and under the circumstances outlined herein, I concur that permit limits expressed as an annual limit are appropriate and that it is reasonable in this case to conclude that it is "impracticable" to express permit effluent limitations as daily maximum, weekly average, or monthly average effluent limitations. This memo describes the scientific and policy rationales that support this approach.

EPA Region 3 has developed recommended water quality criteria for certain parameters designed to protect water quality in Chesapeake Bay and its tidal tributaries.[1] The main cause of water quality impairment for these parameters in the main stem of the Bay is loading of nutrients, specifically nitrogen and phosphorus, from point and

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[1] See EPA's Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll for the Chesapeake Bay and Its Tidal Tributaries, April 2003. "Chesapeake Bay and its tidal tributaries" is the portion of the Chesapeake Bay watershed subject to the ebb and flow of ocean tides. This area encompasses all of the mainstem Bay and the area north and east to the fall line. The fall line is a physical barrier on the Bay's larger tributaries marked by waterfalls and rapids.

nonpoint sources throughout the entire Chesapeake Bay watershed. The States are in the process of adopting revised water quality standards based on EPA Region 3's recommended water quality criteria and developing wasteload allocations for point sources discharging to the Chesapeake Bay watershed that are designed to protect water quality in Chesapeake Bay and its tidal tributaries from excess nutrient loading.

Establishing appropriate permit limits that implement nitrogen and phosphorus wasteload allocations for discharges that cause, have the reasonable potential to cause, or contribute to excursions of water quality criteria for Chesapeake Bay and its tidal tributaries is different from setting limits for other parameters such as toxic pollutants because: the exposure period of concern for nutrients loadings to Chesapeake Bay and its tidal tributaries is very long; the area of concern is far-field (as opposed to the immediate vicinity of the discharge); and the average pollutant load rather than the maximum pollutant load is of concern. Thus, developing appropriate effluent limitations requires innovative implementation procedures.

Applicablility

Your proposal addresses implementation of wasteload allocations for nitrogen and phosphorus designed to achieve compliance with water quality standards of Chesapeake Bay. Your proposal and the rationale discussed in this memorandum are not intended to address wasteload allocations to meet other water quality standards in areas outside of Chesapeake Bay and its tidal tributaries. Smaller scales such as embayments and smaller tributaries than the major Eastern and Western shore rivers were not examined and therefore the rationale in this memorandum does not address and may not apply to the protection of these smaller scale situations.

This rationale also does not apply to parameters other than nitrogen and phosphorus that may exhibit an oxygen demand to waters of the Bay. Such parameters include dissolved oxygen, biochemical oxygen demand, and ammonia.

Of course, all local water quality standards apply and must be met when evaluating appropriate point source permit effluent limits. States are developing water quality standards for nutrients to be applied to local waters as stand-alone criteria. In any case where the nutrient wasteload allocations for protection of water quality in a river, tributary, or other part of Chesapeake Bay are expressed on a shorter term basis, i.e., seasonal, monthly, weekly or daily values, the permit limits that derive from and comply with the wasteload allocation expressed on such shorter term basis must be used. Shorter averaging periods might be appropriate and necessary to protect against local nutrient impacts in rivers or streams in the basin.

Additionally, it is important to note that the nutrient dynamics of the Bay may not be unique. The establishment of an annual limit with a similar finding of “impracticability” pursuant to 40 CFR 122.45(d) may be appropriate for the

implementation of nutrient criteria in other watersheds when: attainment of the criteria is dependent on long-term average loadings rather than short-term maximum loadings; the circumstances match those outlined in this memo for Chesapeake Bay and its tidal tributaries; annual limits are technically supportable with robust data and modeling as they are in the Chesapeake Bay context; and appropriate safeguards to protect all other applicable water quality standards are employed.

Why are annual loadings appropriate for wasteload allocations for nutrients for Chesapeake Bay and its tidal tributaries?

The nutrient dynamics of Chesapeake Bay and its tidal tributaries are complex. Unlike toxics and many conventional pollutants that have a direct and somewhat immediate effect on the aquatic system, nutrients have no direct effect, but instead are "processed" in several discreet steps in the Bay ecosystem before they have their full effect. Each processing "step" further delays and buffers the time between the time of nutrient discharge in an effluent and the resultant nutrient effect on the receiving waterbody.[2] Chesapeake Bay and its tidal tributaries' biological and physical processes can be viewed as "integrating" variations of nutrient load magnitude over time. The integration of nutrient loads from all sources over time ameliorates intraannual load fluctuations from individual sources, with the Bay responding to overall loads on an annual scale, while showing little response to monthly variations within an annual load.[3]

EPA has conducted complex modeling of the effect of nutrient loading to the Bay specifically from individual point source discharges.[4] Based on the results of the model, EPA concluded that Chesapeake Bay and its tidal tributaries in effect integrate variable point source monthly loads over time, so that as long as a particular annual total load of

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[2] More specifically, nutrients are taken up by algae throughout the year, and once taken up, settle to the bottom to decay in the warmer summer waters, contributing to summer anoxia/hypoxia. Thus, summer anoxia is the result of organics, primarily from algal deposition, which accumulates throughout the year, with peak algal biomass generated in the bloom of early spring, and that these organics are stored in Chesapeake Bay and tidal tributary sediments throughout the year and between years.

[3] The seasonal build-up of the volume of hypoxic water in the deep channel results from the integration of effects of microbial metabolism acting over long time scales. With respect to the Chesepeake Bay, Boynton et al. stated "… the coupling between nutrient loading, water column production of organic matter, and recycling of nutrient from sediments occurs over time scales of about several years or less."

[4] The complex movement of water within Chesapeake Bay and its tidal tributaries, particularly the density-driven vertical estuarine stratification, is simulated with a Chesapeake Bay hydrodynamic model of more than 13,000 cells. The Water Quality Model is linked to the hydrodynamic model and uses complex nonlinear equations describing 26 variables of relevance to the simulation of dissolved oxygen, water clarity and chlorophyll *a*. Coupled with the Water Quality Model are simulations of settling organic material into and upon the sediments and its subsequent decay and flux of inorganic nutrients from the sediment, as well as a coupled simulation of underwater Bay grasses in the shallows.

nitrogen and phosphorus is met, constant or variable *intraannual* load variation from individual point sources has no effect on water quality of the main bay.[5]

Based on the model, EPA and the affected States are developing "tributary strategies" that will assign wasteload allocations expressed as annual loads for the point source dischargers to the Bay and it tributaries that achieve the water quality standards of Chesapeake Bay and its tidal tributaries.[6]

Why is it impracticable to express limits for nutrients on a daily, weekly or monthly basis?

The NPDES regulations at 40 CFR 122.45(d) require that all permit limits be expressed, unless impracticable, as both average monthly limits and maximum daily limits for all dischargers other than publicly owned treatment works (POTWs), and as average weekly limits and average monthly limits for POTWs.

The Office of Wastewater Mangement cautions that the steady-state statistical procedures described in EPA's *Technical Support Document for Water Quality-based Toxics Control*[7] (TSD) are not applicable or appropriate for developing nutrient limits for the main stem of Chesapeake Bay and its tribal tributaries. Developing permit limits for nutrients affecting Chesapeake Bay and its tidal tributaries is different from setting limits for toxic pollutants because the exposure period of concern for nutrients is longer than one month, and can be up to a few years, and the average exposure rather than the maximum exposure is of concern. The statistical derivation procedure described in the TSD for acute and chronic aquatic life protection is not applicable to exposure periods more than 30 days (see TSD page 105). If the procedures described in the TSD for aquatic life protection (i.e., criteria with 1-day and 4-day averaging periods) were used for developing permit limits for nutrients (with much longer averaging periods), both the maximum daily limit or the average weekly limit (as appropriate) and average monthly limit would be less stringent than the wasteload allocation necessary to protect the

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[5] The Water Quality Model was used to examine the differences between a constant monthly load and a variable monthly load, but each at the same annual load levels. For nitrogen, the constant monthly discharge estimate is based on a scenario that assumes the level of point source loads based on a constant 5 mg/l discharge applied against point source flow. The variable load scenario is based on the records of 54 sewage treatment plants (STPs) that discharge to Chesapeake Bay that have complete monthly records. The Total Nitrogen average concentration for each month was calculated and then converted to a concentration that would be at the same annual loads as the constant 5 mg/l case, but still preserve the observed monthly variations. Monthly changes in flow were also taken into account. The variation in monthly concentrations varied from a low of 3.76 mg/l in August to a high of 8.46 mg/l in January. The derived monthly variation, equivalent on an annual basis to the constant 5 mg/l monthly loads was applied to all point source dischargers in the Chesapeake Bay watershed. Water quality results of the two scenarios were indistinguishable, no difference was seen in the achievement of Chesapeake Bay water quality criteria. A similar analysis was performed for phosphorus and the same conclusion was reached.

[6] The "tributary strategies" determine appropriate load and wasteload allocation designed to achieve water quality standards for the Chesapeake Bay and its tidal tributaries. The analysis is similar in scope to what EPA would expect in a TMDL.

[7] Document reference EPA/505/2-90-001, March 1991.

criteria. Thus, even if a facility was discharging in compliance with permit limits calculated using these procedures, it would be possible to constantly exceed the wasteload allocation. Such an approach clearly is unacceptable.

The TSD in Section 5.4.4 provides guidance for establishing daily and monthly effluent limits for human health protection based on long term exposure periods. However, this approach is also not appropriate for deriving permit limits for nutrients. This is because this TSD procedure is a steady-state approach that assumes that the distribution of effluent load is constant. However, the efficiency of treatment of nutrients by biological nutrient removal is highly sensitive to ambient temperature and is not effective at lower temperatures. Thus, the effluent loading of nutrients is not constant due to seasonal temperature fluctuations in northern climates. Even a simple steady-state model for permit development such as dividing the annual limit by 12 and establishing that value as the monthly limit is therefore, not appropriate. Such a limit does not account for seasonal fluctuations in effluent loading. To establish appropriate weekly or monthly limitations, due to the effect of temperature on treatment efficiency for nutrients, the permitting authority would need to be able to predict with some accuracy the expected annual temperature over that time frame, which is virtually impossible to do given the normal temperature variability in any given week or month.[8] Because of the effect of temperature on the treatment efficiency and the normal variation in ambient temperature over shorter time periods, it is impracticable to develop appropriate daily, weekly or monthly limits for nutrients that are protective of the wasteload allocation expressed as an annual load.

Thus, we conclude that due to the characteristics of nutrient loading and its effects on the water quality in Chesapeake Bay and its tidal tributaries and because the derivation of *appropriate* daily, weekly or monthly limits is not possible for the reasons described above, that it is therefore "impracticable" to express permit effluent limitations as daily maximum, weekly average, or monthly average effluent limitations.

Recommendations for implementing an annual limit

The permit should state the method for determining compliance with the annual limit. When expressing an effluent limit as an annual value, it is recommended that the permit provide the ability to assess compliance at interim dates.[9]

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[8] For example, the National Weather Service reported that for Baltimore, MD the month of November 2003 was one of the warmest on record, the first three weeks of December 2003 were "decidedly cold," followed by a last 10 days of the month that were "unseasonably warm," however, the annual average temperature for 2003 at the same weather station was within 1EC of the annual norm.

[9] Permit compliance is regularly determined on a monthly basis, and Discharge Monitoring Reports are prepared and submitted on a monthly basis.

The frequency of compliance monitoring should also be specified in the permit. The Office of Wastewater Management recommends that the effluent discharge volume should be monitored continuously. Nutrient monitoring should be specified on at least a weekly basis, and the monthly mass load should be summarized based on the total flow during the month and reported as a monthly load.

cc: Water Management Division Directors, Regions 1-10
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