**MEMORANDUM**

SUBJECT: Nutrient Application Updates to Watershed Model Phase 5.3.2

FROM: Larry Merrill, EPA, Chair of the Water Quality Goal Implementation Team

TO: Chesapeake Bay Program Water Quality Goal Implementation Team and Agriculture Workgroup

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**Summary**

In April 2010, the Chesapeake Bay Program Water Quality Goal Implementation Team (WQGIT) and Principals' Staff Committee (PSC) requested that EPA make two changes to Phase 5.3.0 of the Watershed Model Suite (the Chesapeake Bay Program Watershed Model, Chesapeake Bay Land Change Model and Scenario Builder) for use in the Phase II WIPs:

1. Simulation of nutrient application on agricultural lands (included eight updates); and
2. Estimation of urban lands in the watershed land cover.

EPA updated the Phase 5.3.0 of the Watershed Model Suite based upon these requests to create Phase 5.3.2, and the updates were approved by the Agricultural Workgroup on May 27, 2010 and the Agriculture and Watershed Technical Workgroups on January 14, 2011. The Urban Stormwater Workgroup reviewed the revised land cover and did not object to using the updates in place of the Phase 5.3.0 land cover. The WQGIT approved these changes on January 24, 2011.

Based on further review of the model changes, state members of the Agriculture Workgroup agreed on May 9, 2011 that EPA's changes did not fully address the intent of one of the eight recommended updates to the nutrient application simulation. As a result, they recommended that EPA make additional updates to the Phase 5.3.2 Watershed Model Suite and restart the Phase 5.3.2 Watershed Model calibration. Fulfilling this recommendation would mean that EPA would not complete the Watershed Model Suite updates and propose revised state-basin allocations until at least two to three months after the June 30 deadline.

The differences between the January 2011 approved changes and the Agriculture Workgroup recommendations on May 9, 2011 do not yield substantial differences in loads delivered to the Bay. Implementation of the May 9, 2011 recommendation would result in an increase of approximately one million pounds of nitrogen delivered to the Bay from the entire watershed compared to Phase 5.3.2. The May 9, 2011 recommendation would have an even smaller difference on nitrogen loads delivered to the Bay in the 2009 scenario and in future Watershed Implementation Plan (WIP) scenarios compared to Phase 5.3.2 because of increased acres under nutrient management. A detailed analysis is provided below.

EPA has determined that the potential difference in results relative to additional time delay for implementation supports moving forward with the January 2011 changes to Phase 5.3.2. EPA will address this refinement in the next round of model updates in advance of the Phase III WIPs in 2017. It is important to note that the Phase 5.3.2 updates provide greater nutrient reduction benefits for nutrient management than the prior Phase 5.3.0, consistent with the 2010 and 2011 recommendations of the Agriculture Workgroup, WQGIT and PSC. EPA recognizes that the implementation of nutrient management (NM) is an important strategy for reducing loads from agricultural lands.

EPA will consider the impact of the Agriculture Workgroup's concerns when evaluating WIP or milestone progress if necessary.

**Analysis of Nutrient Application Updates**

Summary of All Nutrient Updates

Over the past year, the Chesapeake Bay Program modeling team made several updates to how Phase 5.3.2 simulates nutrient loads from agricultural lands and livestock:

- Increased the application rate of inorganic fertilizer on acres not under NM to a rate greater than the NM rate. Analysis of the 2005 calibration scenario indicates that Phase 5.3.2 resulted in 19 million more pounds of inorganic nitrogen fertilizer applied to acres not under NM than under Phase 5.3.0;
- Stopped automatic transport of manure. Manure transport must be reported;
- Made manure nutrients that are conserved by BMPs on production areas such as waste management systems available to crops;
- Updated the numbers of animals in each county based on better state data;
- Used state-developed manure application rates and sequencing of land uses for disposal of excess manure;
- Incorporated better state data on nutrient application timing and fractions for specific crop species;
- Separated the plant and harvest dates for acres with double crops to create a more accurate nutrient application simulation; and
- Expanded the "nursery" land use to include nursery acres in the open in addition to nursery acreage under glass.

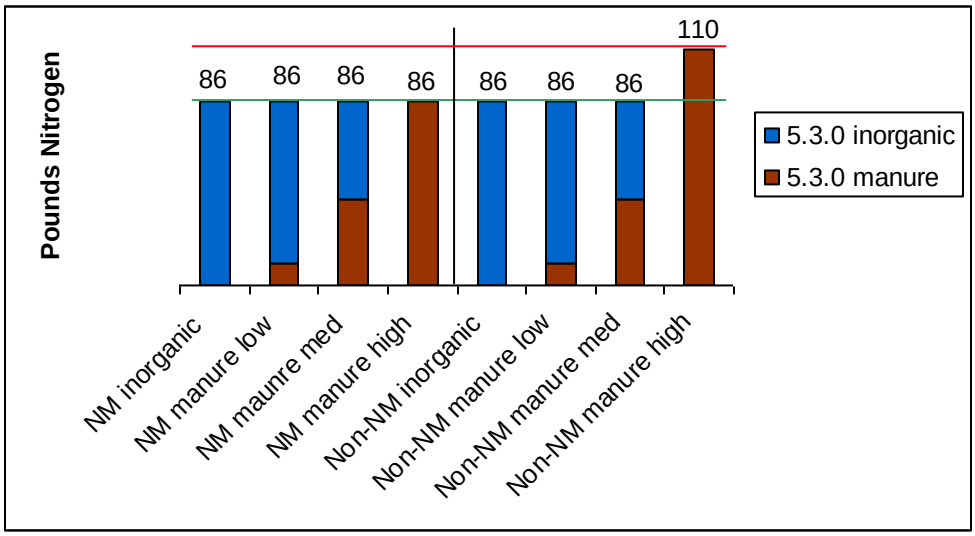
Dr. Frank Coale, Chair of the Agricultural Workgroup, stated on the May 23, 2011 WQGIT conference call that the agricultural updates to Phase 5.3.2 of the Watershed Model Suite are moving in the right direction overall. Dr. Coale explained that although additional modifications are necessary, Phase 5.3.2 does a better job than Phase 5.3.0 to characterize the differences in nutrient application rates between acres with and without NM plans. Dr. Coale acknowledged that EPA indicated some of these modifications may not be possible until the next round of model updates in advance of the Phase III WIPs.

Difference Between May 2010/January 2011 Decisions and May 9, 2011 Recommendation

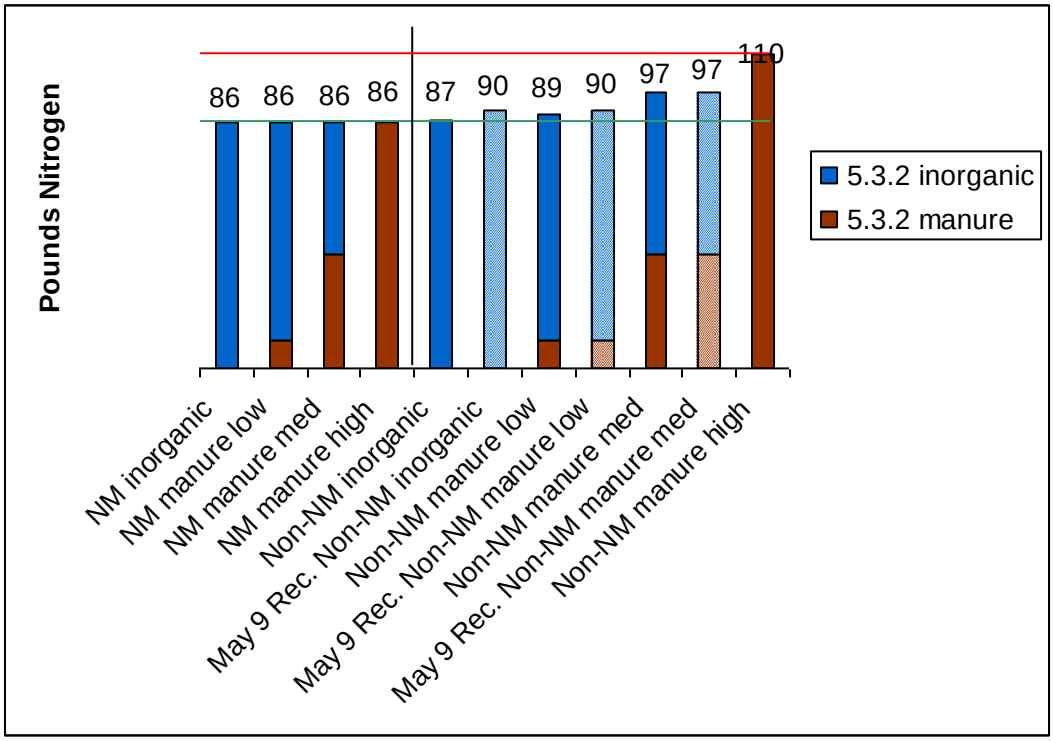
In the Phase 5.3.0 Watershed Model Suite used for Phase I WIP and Bay TMDL development, the nitrogen application rates for acres under NM plans and those without NM plans were identical for acres receiving inorganic fertilizers (see Figure 1a). In April 2010, the Agriculture Workgroup recommended that Phase 5.3.2 models create a sliding scale for nitrogen application rates depending on the portion of inorganic versus manure (i.e., organic) fertilizers. One end of the sliding scale would be defined by non-NM lands receiving all inorganic fertilizer. For these lands, the non-NM rate would be 5% greater than the NM rate, or Non-NM Rate $_{\text{all inorganic}}$ = 1.05 * NM Rate (see May 9, 2011 Rec. Non-NM Inorganic in Figure 1b).

Figure 1: Comparison of Hypothetical Nutrient Application Rates under Alternative Modeling Methods

1a: Nutrient Application under Phase 5.3.0. Red and green lines represent max and nutrient management rates, respectively.




1b: Comparison of Nutrient Application under Approved Phase 5.3.2 and May 2011 Recommendation

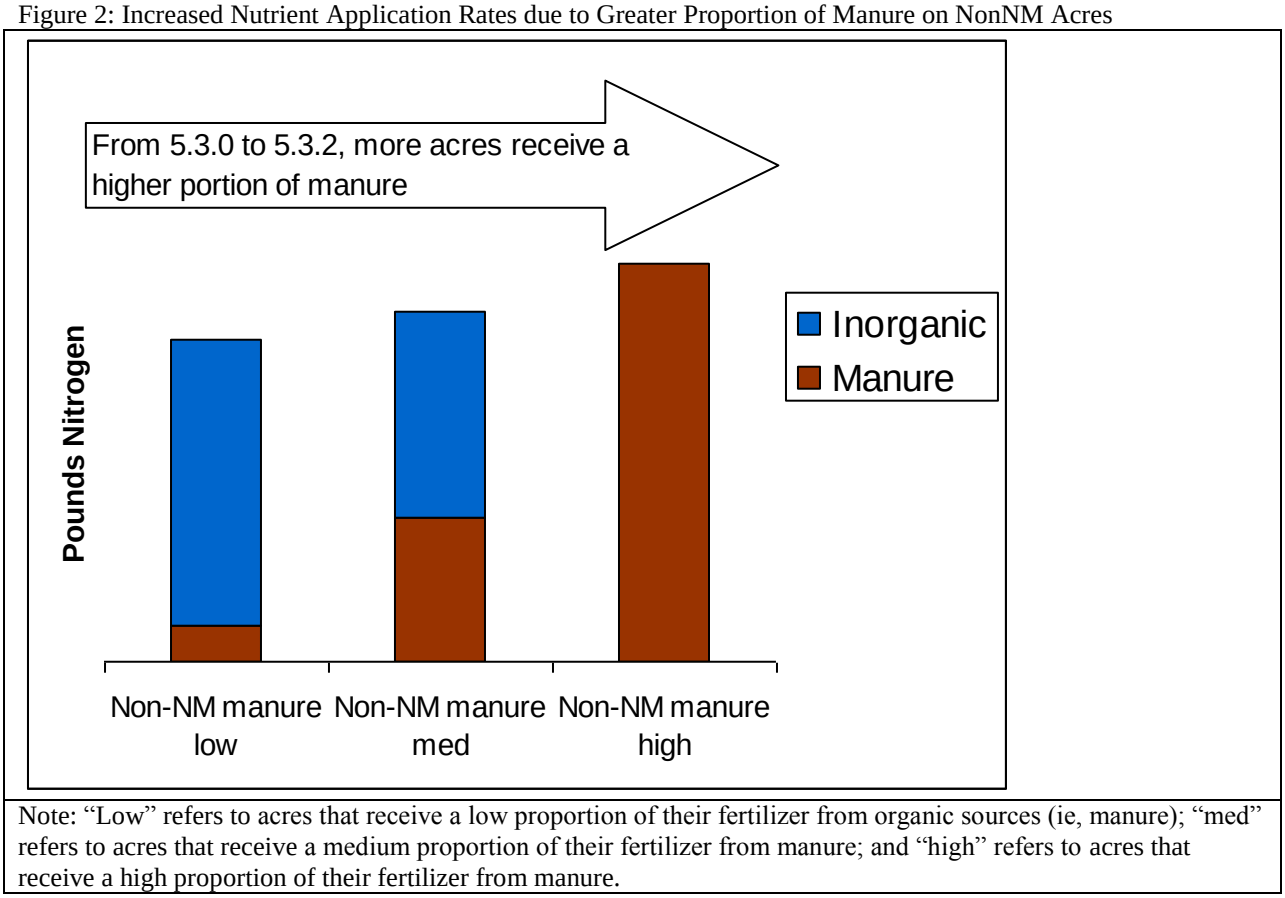



Note: The hashed bars in Figure 1b denote the May 9, 2011 Agriculture Workgroup recommendation differed from the changes to Phase 5.3.2 that were approved on May 27, 2010 and January, 2011. "Low" refers to acres that receive a low proportion of their fertilizer from organic sources (ie, manure); "med" refers to acres that receive a medium proportion of their fertilizer from manure; and "high" refers to acres that receive a high proportion of their fertilizer from manure.

On May 27, 2010, the Chesapeake Bay Program modeling team proposed to the Agriculture Workgroup a method for building the sliding scale into the model updates. The nutrient application rate for acres without NM plans receiving only inorganic fertilizer would equal the NM rate plus 5% of the difference between NM rate and the maximum rate for non-NM lands receiving all manure, or Non-NM Rate $_{\text{all inorganic}}$ = NM rate + 1.05*(Max Manure Non-NM rate – NM rate). Under the 2005 calibration scenario for Phase 5.3.2, this formula on average resulted in a nutrient application rate on non-NM receiving 100% inorganic fertilizer that is 1.4% greater than the NM rate. As Figure 1b illustrates, the Agriculture Workgroup recommendation in May 9, 2011 creates a higher application rate for acres without NM plans than the approved Phase 5.3.2 method, with the difference between the two methods being greater on acres receiving a higher proportion of inorganic fertilizer.

Many of eight components of the agricultural updates in Phase 5.3.2 described in the previous section increase the availability of manure nutrients for application on crops. This results in a higher proportion of manure nutrients compared to inorganic fertilizer nutrients being applied to agricultural lands without NM plans. As Figure 2 illustrates, this shifts the number of acres to the right along the sliding scale of nutrient application rates and results in an overall increase in total nutrients applied per acre to non-NM lands. Given the increased difference between the NM rate and the non-NM rate, there is a greater nutrient reduction benefit when acres switch from non-NM to NM.

Figure 2: Increased Nutrient Application Rates due to Greater Proportion of Manure on NonNM Acres




Note: "Low" refers to acres that receive a low proportion of their fertilizer from organic sources (ie, manure); "med" refers to acres that receive a medium proportion of their fertilizer from manure; and "high" refers to acres that receive a high proportion of their fertilizer from manure.

Effect of May 9, 2011 Recommendation vs. Phase 5.3.2 Updates on 2005 Delivered Loads

Analysis of the 2005 calibration scenario for Phase 5.3.2 indicates that the difference between what the Agriculture Workgroup and WQGIT approved in January 2011 and the recommendation in May 9, 2011 would not change the model outcomes substantially enough to affect management strategies to reduce loads from agricultural lands. Specifically, as Figure 1b illustrates, the greatest difference in nutrient application rates between the updates approved in January 2011 and the recommendation made in May 2011 occur on non-NM acres receiving 100% inorganic fertilizer. Under Phase 5.3.2, only 231,885 of acres, or 2% of agricultural lands in the Chesapeake Bay watershed, are not under NM and receive exclusively inorganic fertilizer. The vast majority of these acres are nursery and vegetable land uses that, by definition, are not eligible for manure application. Applying the May 9, 2011 recommendation to these acres would result in an increase in inorganic nitrogen application by approximately 1.1 million pounds. An increase of 1.1 million pounds of nitrogen represents an increase of less than 0.1% of nitrogen application across the Chesapeake Bay Watershed.

As Figure 1b also illustrates, non-NM acres receiving a mix of inorganic and manure fertilizers (i.e., "low" and "medium" bars in the figure) would increase their nutrient application rates by, at most, a few percent if the May 2011 recommendation were applied. To understand the extent of this change on nutrients delivered to the Bay, the Chesapeake Bay Program Office (CBPO) calculated the number of non-NM acres in the 2005 calibration scenario that received less than the Agriculture Workgroup's recommended minimum nutrient application rate of 1.05*NM rate. CBPO found that 4.86 million acres, or 75% of the agricultural acres in the watershed in 2005 that were not under NM, received less than the recommended 1.05*NM rate. Increasing the nutrient application rate on these acres to the recommended 1.05*NM rate while not allowing the nutrient application rate to exceed the maximum crop nutrient application rate would result in approximately 11 million pounds of additional inorganic nitrogen applied to non-NM acres for the entire Bay watershed. This increase would represent approximately 0.8% of the Bay-wide nitrogen application.

After calculating the crop uptake and attenuation between edge of field and the tidal Chesapeake Bay, implementing the May 9, 2011 recommendation would result in an increase of approximately 1 million pounds of nitrogen delivered to the Bay for the entire watershed. This increase would represent approximately 0.5% of the Bay-wide nitrogen allocation under the TMDL and approximately 1 - 2% of the necessary nitrogen reductions from 2009 to meet the TMDL, according to Phase 5.3.0 of the Watershed Model.

Effect of May 9, 2011 Recommendation vs. Phase 5.3.2 Updates on 2009 and WIP Scenarios

The difference between the Phase 5.3.2 updates and the May 9, 2011 recommendation on nutrient application rates and total nutrients delivered to the Bay would be even less in 2009 and future WIP scenarios for two reasons. First, the models will use updated animal numbers submitted by the states for 2009 and all subsequent progress runs and WIP scenarios. This updated information will increase the manure available for crops in some counties. Second, more acres will be under NM in 2009 based on additional implementation and in WIP scenarios due to increased implementation commitments. Given that the May 9, 2011 Agriculture Workgroup recommendation did not alter the NM application rates, the increase in NM acres in

2009 and the WIP scenarios that receive the same nutrient application rates would decrease the difference in total loads resulting from Phase 5.3.2 and the May 9 recommendation.

**EPA Response to May 9, 2011 Recommendation from the Agriculture Workgroup**

As a partnership, EPA and the jurisdictions have a shared obligation to clearly communicate to each other. The May 9, 2011 recommendation is an example of where this communication can be improved. EPA commits to redouble its efforts to clearly explain how modelers are building workgroup recommendations into future models and to a continued and open dialogue that seeks to ensure a full understanding by all parties.

In the nutrient application instance, the modelers explained how they had incorporated the Agriculture Workgroup's April 27, 2010 recommendation into Scenario Builder and the Chesapeake Bay Program Watershed Model on May 27, 2010 and again on January 14, 2011 when decisions were requested. Unfortunately, the misunderstanding over how the Chesapeake Bay Program modelers implemented one of the eight nutrient management changes did not arise until four months after the model updates were approved, implemented, and the Phase 5.3.2 was calibration was underway. Since that time, the schedule for model updates and Phase II WIPs has been reviewed by the Principals' Staff Committee (PSC) and finalized. EPA cannot refine this update at this time without falling months behind schedule. Implementing the recommendation now would decrease the additional time that the PSC has recommended for jurisdictions to develop their Phase II WIPs.

EPA will consider incorporating the May 9, 2011 recommendation, as well as other recommendations of the Agriculture Workgroup and the WQGIT, into updates to the Chesapeake Bay Program models that will be completed in advance of the Phase III WIPs in 2017.

As stated on page 2 of this memo, EPA recognizes that jurisdictions may be concerned that not implementing this recommended change could increase the likelihood of federal actions because a WIP did not meet its state-basin allocations, or a two-year milestone did not achieve expected pollutant reductions. However, EPA has full discretion to determine whether or not federal actions are appropriate based on the degree to which reduction goals are missed and/or the reasons why. EPA has already demonstrated this discretionary authority when deciding whether to establish backstop allocations and adjustments in the Chesapeake Bay TMDL established on December 29, 2010.

**Suggested Next Steps for Agriculture Workgroup**

During the May 23, 2011 WQGIT conference call, Dr. Frank Coale stated that the thorough review of the Phase 5.3.2 Watershed Model Suite and the resulting suggestions for future model updates is evidence of a healthy adaptive management process for ongoing improvement. The Agriculture Workgroup has already identified priorities for the next several years that will help to further refine the effect of agricultural lands, livestock and management actions on nutrient loads delivered to the Bay. Many of these recommendations directly relate to nutrient application rates.

Specifically, the Agriculture Workgroup has recommended evaluating the definitions and efficiencies associated with various forms of NM as a top priority for the Workgroup. The WQGIT approved this recommendation on January 24, 2011. Some changes to NM definitions and efficiencies could be made in advance of the next round of model updates and, when approved, be incorporated into annual progress runs and milestone assessments. In response to this priority need, the University of Maryland Mid-Atlantic Water Program is expected to complete this NM evaluation in 2012, dependent on funding. The Mid-Atlantic Water Program's 2009 report, *Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus and Sediment in the Chesapeake Bay Watershed,* is the basis for many of the BMPs currently simulated by the suite of Chesapeake Bay Program models.

The Agriculture Workgroup could also revisit other possible model improvements previously considered by the workgroup but not incorporated into Phase 5.3.2 due to time and resource constraints or the need to further identify and evaluate pertinent data. These additional modifications could be recommended and potentially included in the next set of model updates that will be completed in advance of the Phase III WIPs in 2017. Many of these recommendations would require additional documentation, method development, and data inputs that should start soon in order to be in place in the next Phase of the model.

**Closing**

Due to the significant delays that additional nutrient application modifications would have on the timeline for completing the approved updates to the Phase 5.3.2 Watershed Model Suite and developing Phase II WIPs, as well as the relatively small impact the modifications would have on delivered nutrient loads to tidal waters, EPA has decided not to implement further changes at this time. There are several near-term actions that the Agriculture Workgroup can undertake to refine the credit that the Chesapeake Bay Program models provide for NM which could be implemented once they are approved through the Chesapeake Bay Program protocol. Further, the Agriculture Workgroup should not delay in developing specific recommendations and methodologies for consideration in the next round of model updates.