

# NUTRIENT MANAGEMENT

Definitions and Recommended Nutrient Reduction Efficiencies of  
**Nutrient Application Management**  
for Use in Phase 5.3.2 of the  
Chesapeake Bay Program Watershed Model

Review of Tier 1 Approved Recommendation and Elements of Nutrient  
Reductions as Delineated from Tiers 2 and 3.  
Tier 2: Field Level Nutrient Application Management  
Tier 3: Adaptive Nutrient Management

Recommendations for Approval by the Water Quality Goal  
Implementation Team's Watershed Technical and Agricultural  
Workgroups

**Submitted by the Phase 5.3.2 Nutrient Management Expert Panel**

**Submitted to:**  
Agriculture Workgroup  
Chesapeake Bay Program

Tier 1 Approved: October 2013  
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# Contents

<b>ACRONYMS .....</b>	<b>5</b>
<b>SUMMARY OF RECOMMENDATIONS.....</b>	<b>8</b>
<b>1 INTRODUCTION .....</b>	<b>9</b>
<b>2 PRACTICE DEFINITIONS .....</b>	<b>10</b>
<b>3 EFFECTIVENESS ESTIMATES .....</b>	<b>14</b>
3.1 SUMMARY OF EFFECTIVENESS ESTIMATES.....	14
3.2 PROCESS FOR DEVELOPING EFFECTIVENESS ESTIMATES .....	16
3.3 JUSTIFICATION FOR EFFECTIVENESS ESTIMATES .....	23
3.3.1 Tier 1 N and P.....	23
3.3.2 Tier 2 N .....	27
3.3.3 Tier 2 P.....	30
3.3.4 Tier 3 N .....	36
3.3.5 Tier 3 P.....	40
3.3.6 Synthesis of Tier 2 and 3 Component Efficiencies into Overall Tier 2 and 3 Efficiencies .....	41
3.3.7 Summary of Recommended Effectiveness Estimates.....	45
<b>4 REVIEW OF LITERATURE AND DATA GAPS .....</b>	<b>46</b>
4.1 REVIEW OF THE AVAILABLE SCIENCE FOR TIER 1 .....	46
4.2 REVIEW OF THE AVAILABLE SCIENCE FOR TIERS 2 AND 3 .....	46
4.3 THE NEED FOR APPLIED RESEARCH ON BMP EFFECTIVENESS.....	50
<b>5 APPLICATION OF PRACTICE EFFECTIVENESS ESTIMATES.....</b>	<b>52</b>
5.1 LOAD SOURCES .....	52
5.2 PRACTICE BASELINE.....	52
5.3 HYDROLOGIC CONDITIONS .....	52
5.4 SEDIMENT.....	52
5.5 SPECIES OF NITROGEN AND PHOSPHORUS .....	52
5.6 GEOGRAPHIC CONSIDERATIONS .....	53
5.7 TEMPORAL CONSIDERATIONS.....	53
5.8 PRACTICE LIMITATIONS.....	53
5.9 POTENTIAL INTERACTIONS WITH OTHER PRACTICES.....	53
<b>6 PRACTICE MONITORING AND REPORTING .....</b>	<b>54</b>
6.1 PHASE 5.3.2 NUTRIENT APPLICATION MANAGEMENT TRACKING, VERIFICATION, AND REPORTING.....	61
6.2 FUTURE VERIFICATION OF NUTRIENT MANAGEMENT PRACTICES .....	62
<b>7 REFERENCES .....</b>	<b>63</b>
Appendix A: Approved Nutrient Management Expert Panel Meeting Minutes	
Appendix B: Summary of Survey and Interviews – Agricultural Nutrient Management Expert Panel	
Appendix C: Technical Requirements for Entering Nutrient Management BMPs into Scenario Builder and the Watershed Model	
Appendix D: Consolidated Response to Comments on: Definitions and Recommended Nutrient Reduction Efficiencies of Nutrient Application Management for Use in Phase 5.3.2 of the Chesapeake Bay Program Watershed Model (2014)	
Appendix E: Conformity with WQGIT BMP Protocol	

Appendix F: Consolidated Response to Comments on: Definitions and Recommended Nutrient Reduction Efficiencies of Nutrient Application Management for Use in Phase 5.3.2 of the Chesapeake Bay Program Watershed Model (July 30, 2015)

## Figures

Figure 1 Each tier is following program adoption of researched based evidence of nutrient application changes. ....	12
Figure 2. Illustration of how nutrient reduction credits can apply to an acre of cropland. ....	12
Figure 3. Phase 5 Chesapeake Bay Watershed Model land uses eligible for Nutrient Management by tier. ....	15
Figure 4. Plot of corn yield and fall residual soil NO <sub>3</sub> -N on Maryland Eastern Shore, showing reduction in fall residual NO <sub>3</sub> -N resulting from reduced Tier 1 N fertilizer recommendation (from Coale 2000). ....	24
Figure 5. Sensitivity analysis shows the difference between old NM BMP load change for N in blue with 20% change in corn application in red. ....	25
Figure 6. Sensitivity analysis shows the difference between old NM BMP load change for N in blue with 20% change in corn application in red. ....	26
Figure 7. Plot of tillage effects of P stratification in 3 soil test phosphorus depths and the change in STP with Poultry Litter amendments on the Delmarva (Staver and Brinsfield 2001). ....	31
Figure 8 Adapted from Vieth et al., 2005 Figure 3. Correlation between PA P index and SWAT vulnerability ratings. ....	34
Figure 9. Schematic of the process of adjusting a literature value to account for scaling up from plot scale, practice applicability to specific crop(s), and Panel best professional judgement on application to real world conditions. ....	42
Figure 10. Diagram that shows the most relevant of the 4Rs of nutrient management as considered by the panel to influence the recommended reduction efficiencies. ....	54
<b>Figure 11 Grain yield in bushels per acre for Maryland from the NASS exhibiting double digit percent increases over the simulation period for major commodity crops and illustrating a disproportionate number of low yield years captured by Ag Census, which is currently the only input data for yield in the Phase 5.3.2 CBWM. ....</b>	<b>20</b>

## Tables

Table 1. CBP Phase 5.3.2 Nutrient Management Expert Panel Membership .....	9
Table 2. Chesapeake Bay Program's existing Nutrient Management BMP definitions .....	10
Table 3. Chesapeake Bay Nutrient Management Efficiencies by CBP Partnership Chesapeake Bay Watershed Model Era. ....	10
Table 4. Combined efficiencies for Tiers as illustrated by example using 100 pounds of nutrient loads. ....	16
Table 5. LGU Agronomy Guide N Recommendations Before and during CBPWM calibration period for corn acres per bushel of expected yield .....	23
Table 6. Effects of incorporation of manures across Chesapeake Bay physiographic regions adapted from cited literature above. ....	32
Table 7. Nutrient reduction credits for each Tier component, adjustment factors applied, and final Tier credit recommendations .....	44

Table 8. TN and TP Efficiency Values for all tiers, including the increases from Tier 1 to 2 and 2N to 3N referred to as “Benchmark” .....	45
Table 9. Study Examples for Simulated Rainfall Studies for Fixed Time and Time/Volume for Runoff .....	48
Table 10. Study Examples for First Storm After Treatment and Multiple/Cumulative Storms .....	49
Table 11. Summary of current NM regulations adopted by the six Chesapeake Bay watershed states .....	56



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# Acronyms

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AFO	Animal feeding operation
AgWG	Agriculture Workgroup
ALF	Alfalfa
ANM	Adaptive Nutrient Management
AU	Animal unit
BMP	Best management practice
BPJ	Best professional judgment
CAFO	Concentrated animal feeding operation
CAO	Concentrated animal operation (Pennsylvania)
CBPO	Chesapeake Bay Program Office
CBPWM	Chesapeake Bay Program Watershed Model
CEAP	Conservation Effects Assessment Project
CGNAM	Crop Group Nutrient Application Management
CNMP	Comprehensive Nutrient Management Plan
CRC	Chesapeake Research Consortium
CSNT	Corn Stalk Nitrate Test
DEQ	Department of Environmental Quality (Virginia)
DP	Dissolved phosphorus
EONR	Economic Optimum N Rate
EPA	U.S. Environmental Protection Agency
FIV	Fertility index value
FLNAM	Field Level Nutrient Application Management
FSNT	Fall Soil Nitrate Test
HOM	High-till without manure
HWM	high-till with manure
HYO	Hay without nutrients
HYW	Hay with nutrients

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ISNT	Illinois Soil Nitrogen Test
LGU	Land Grant University
LTM	Low-till with manure
N	Nitrogen
NAL	Nutrient management alfalfa
NASS	National Agricultural Statistics Service
NHI	Nutrient management high-till with manure
NHO	Nutrient management high-till without manure
NHY	Nutrient management hay
NLO	Nutrient management low-till
NM	Nutrient management
NM rate	Nitrogen application rate
NMP	Nutrient management plan
NPA	Nutrient management pasture
NRCS	USDA Natural Resources Conservation Service
P	Phosphorus
PAN	Plant-available nitrogen
Panel	Nutrient Management Expert Panel
PAS	Pasture
PMT	Phosphorus Management Tool (Maryland)
PSI	Phosphorus Site Index
PSNT	Pre-sidedress Nitrate Test
STP	Soil test phosphorus
TN	Total nitrogen
TP	Total phosphorus
TRP	Riparian pasture
UMD	University of Maryland
URS	Nursery
USDA	U.S. Department of Agriculture

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VR	Variable rate [nutrient application]
VTCA	Virginia Tech Corn Algorithm
WMAM	Winter Manure Application Matrix (Pennsylvania)
WTWG	Watershed Technical Workgroup
WQGIT	Water Quality Goal Implementation Team

# Summary of Recommendations

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The Nutrient Management Expert Panel (Panel) recommends the revision of definitions and credits for nutrient management (NM) that reflect and incorporate current science; the best professional judgement (BPJ) of national experts in the fields of agronomy, soil science, animal agriculture, nutrient management; and the suite of practices necessary for containing and diminishing the release of agriculturally based nutrients and sediments to the environment. The recommended definitions strongly reflect the guidance and documentation developed by the Chesapeake Bay state land grant universities (LGUs) in their state-specific nutrient management recommendations.

The Panel determined that the current definition of NM in the Chesapeake Bay Program's Watershed Model (CBPWM) is vague and inadequate. Furthermore, the current credit for NM is inconsistent and does not reflect the BPJ of national experts on the suite of practices that constitute the change from a pre-best management practice (BMP) condition and LGU recommendations of the 1970s and early 1980s—a time in agriculture that pre-dates the CBPWM simulation period.

This document summarizes the Panel's recommendations for revised definitions and efficiencies for NM. The Panel proposes that the existing set of NM practices—nutrient management, enhanced nutrient application, and decision/precision agriculture—be replaced by three tiers of management: (1) Crop Group Nutrient Application Management (CGNAM), (2) Field Level Nutrient Application Management (FLNAM), and (3) Adaptive Nutrient Management (ANM). These practices are operationally defined in the body of the report.

The Panel proposed that Tier 1 CGNAM implemented consistent with the definition has the following efficiencies, which have been approved by the Water Quality Goal Implementation Team (WQGIT):

- 9.25 percent total nitrogen (TN) reduction and 10 percent total phosphorus (TP) reduction from land uses high-till with manure (HWM) and low-till with manure (LWM).
- 5 percent TN and 8 percent TP reduction from land uses high-till without manure (HOM), pasture (PAS), hay with nutrients (HYW), alfalfa (ALF), and nursery (URS).

The Panel proposes that Tier 2 FLNAM implemented consistent with the definition has an efficiencies of:

- 4.4 percent TN reduction from land uses high-till with manure (HWM) and low-till with manure (LWM) or 2.8 percent from the hay with nutrients (HYW) land use.
- 6.6 percent TP reduction from land uses HWM, LWM, ALF, and HYW.
- TN and TP credit can be earned independently or concurrently.

The Panel proposes that Tier 3 ANM implemented consistent with the definition has a credit of:

- 2.8 percent TN reduction from land uses HWM and LWM.

In addition, the Panel proposes that:

- Riparian pasture (TRP) and hay without nutrients (HYO) are still excluded from receiving any nutrient reduction credits from implementation of any form of nutrient management.
- The CBPWM code and land uses that simulate nutrient management as a land use change (NHI, NHO, NLO, NHY, NPA and NAL) should be retained in the modeling system for use by this and future panels. However, the Tier 1, Tier 2, and Tier 3 credits recommended in this report should replace the land use change method for all future progress and planning scenarios in the Phase 5.3.2 model.

The credits for Tier 1 (CGNAM) will be simulated as edge-of-stream load reductions in the reporting county from the non-BMP land use edge-of-stream load. Credits for Tier 2 (FLNAM) will be in addition to Tier 1 credits, and credits for Tier 3 (ANM) will be in addition to Tier 2 credits. The Panel determined that adjustments based on geography were not feasible at this time for these recommended credits.

# 1 Introduction

Nutrient Management Plans (NMPs) are implemented on millions of acres of agricultural lands across the Chesapeake Bay watershed. It is one of the oldest BMPs in agriculture and is the cornerstone of stewardship efforts by conservation groups, producers and jurisdictions. This document summarizes the Panel's recommendations for revised definitions and credits for NM. The Phase 5 NM Panel (the Panel), whose members are identified in Table 1, proposes that the Chesapeake Bay Program's existing definitions and credits associated with implementation of NM be replaced by three tiers of distinct management levels: CGNAM (Tier 1), FLNAM (Tier 2), and ANM (Tier 3) as defined below.

The Chesapeake Bay Program's (CBP) Agriculture Workgroup (AgWG) and Watershed Technical Workgroup (WTWG) recommended, and the WQGIT approved, the Tier 1 practice definition and credits for nitrogen (N) and phosphorus (P) for application in the Partnership's Phase 5.3.2 of the CBPWM in October 2013<sup>1</sup>. This report addresses the Panel's recommended Tier 2 and Tier 3 practice definitions and credits for N and P for application in the Partnership's Phase 5.3.2 of the CBPWM along with the WTWG's recommendations for tracking, reporting, and crediting of the Tier 2 and Tier 3 practices.

**Table 1. CBP Phase 5.3.2 Nutrient Management Expert Panel Membership**

Panelist	Jurisdiction	Affiliation
Chris Brosch, Chair	Virginia	Virginia Tech/Virginia Department of Environmental Quality
Greg Albrecht	New York	New York Department of Agriculture
Tom Basden	West Virginia	West Virginia University
Doug Beegle	Pennsylvania	Penn State University
Thomas Bruulsema	Industry	International Plant Nutrition Institute
Jim Cropper	New York, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, Industry	Northeast Pasture Consortium
Jason Dalrymple	West Virginia	West Virginia Department of Agriculture
Curtis Dell	Pennsylvania	US Department of Agriculture (USDA) Agricultural Research Service
Barry Evans	Pennsylvania	Penn State University
Doug Goodlander	Pennsylvania	Pennsylvania Department of Environmental Protection
Chris Gross	Maryland	USDA Natural Resources Conservation Service (NRCS)
Peter Kleinman	Pennsylvania	USDA Agricultural Research Service
Colin Jones	Maryland	Maryland Department of Agriculture
John Lea-Cox	Maryland	University of Maryland
Rory Maguire	Virginia	Virginia Tech
Jack Meisinger	Maryland	USDA Agricultural Research Service
Tim Sexton	Virginia	Virginia Department of Conservation and Recreation
Kim Snell-Zarcone	Pennsylvania	Conservation Pennsylvania
Ken Staver	Maryland	University of Maryland
Wade Thomason	Virginia	Virginia Tech
Larry Towle	Delaware	Delaware Department of Agriculture
Technical support by Steve Dressing, Don Meals, and Jennifer Ferrando (Tetra Tech); Mark Dubin, (UMD/CBPO); Jeff Sweeney (EPA CBPO); Matt Johnston (UMD/CBPO); and Emma Giese (CRC/CBPO).		

CBPO – Chesapeake Bay Program Office; CRC – Chesapeake Research Consortium; UMD – University of Maryland; USDA – U.S. Department of Agriculture

<sup>1</sup> <http://www.chesapeakebay.net/calendar/event/18976/>

## 2 Practice Definitions

Phase 5.3.2 of the CBPWM defines three tiers of BMPs for the existing NM practice—nutrient management, enhanced nutrient application, and decision/precision agriculture (Table 2 and Table 3).

**Table 2. Chesapeake Bay Program's existing Nutrient Management BMP definitions**

BMP	BMP Description
Nutrient Management	An NMP (crop) is a comprehensive plan that describes the optimum use of nutrients to minimize nutrient loss while maintaining yield. An NMP details the type, rate, timing, and placement of nutrients for each crop. Soil, plant tissue, manure and/or sludge tests are used to assure optimal application rates. Plans should be revised every 2 to 3 years.
Decision Agriculture	A management system that is information- and technology-based, is site specific and uses one or more of the following sources of data: soils, crops, nutrients, pests, moisture, or yield for optimum profitability, sustainability, and protection of the environment. This BMP is modeled as a land use change to a nutrient management land use with an effectiveness value applied to create an additional reduction.
Enhanced Nutrient Management	Based on research, the nutrient management rates of nitrogen application are set approximately 35% higher than what a crop needs to ensure nitrogen availability under optimal growing conditions. In a yield reserve program using enhanced nutrient management, the farmer would reduce the nitrogen application rate by 15%. An incentive or crop insurance is used to cover the risk of yield loss. This BMP effectiveness estimate is based on a reduction in nitrogen loss resulting from nutrient application to cropland 15% lower than the nutrient management recommendation. The effectiveness estimate is based on conservativeness and data from a program run by American Farmland Trust. This BMP is modeled as a land use change to a nutrient management land use with an effectiveness value applied to create an additional reduction.

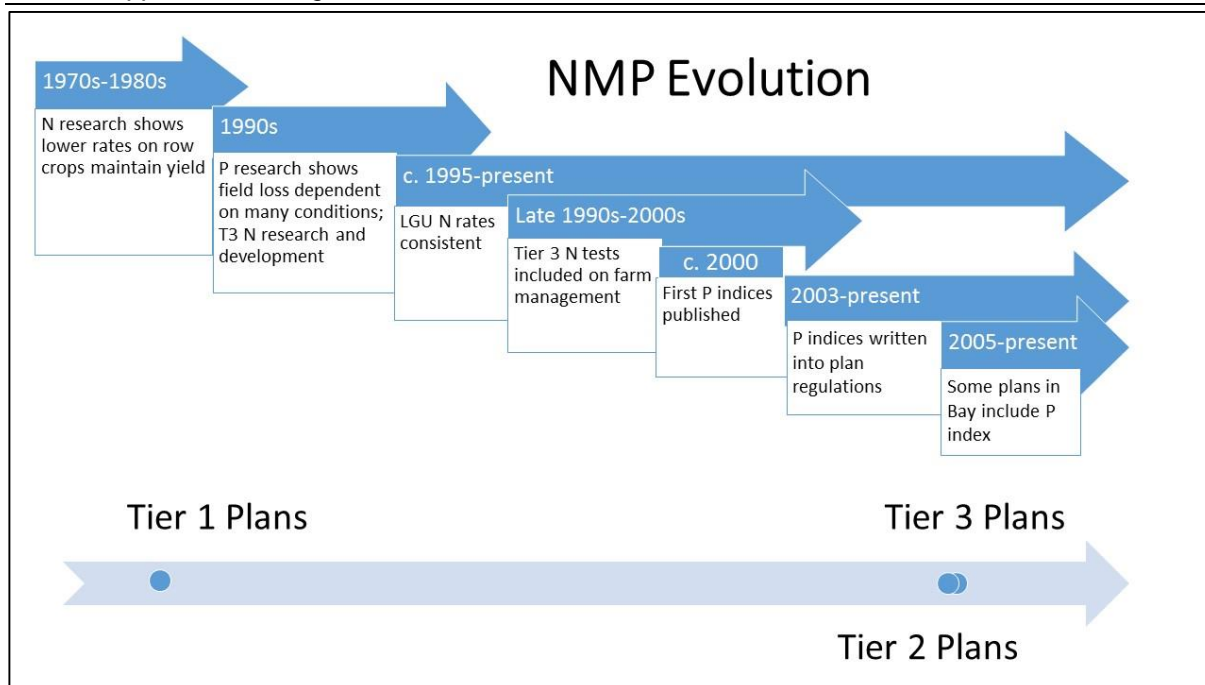
Source: Documentation for Scenario Builder 2.4 (Chesapeake Bay Program 2013a)

**Table 3. Chesapeake Bay Nutrient Management Efficiencies by CBP Partnership Chesapeake Bay Watershed Model Era**

Era	BMP	Nitrogen Efficiency	Phosphorus Efficiency	Notes
Phase 4.3 Watershed Model-Based Tributary Strategies	Nutrient Management	Application Reduction Range from 5 to 39	Application Reduction Range from 5 to 35	135% of modeled crop uptake
	Urban Nutrient Management	17	22	
Phase 5.3.0 Watershed Model-Based 2010 Bay TMDL and Phase I WIPs	Nutrient Management	Land Use Change Range from 0 to 21.6	Land Use Change Range from 0 to 30	Only effective in 13 high manure counties, all others 0%. Identified by WQGIT as fatal flaw.
	Decision Agriculture	+3.5	0	
	Enhanced Nutrient Management	+7	0	Used as a surrogate for NM in WIP I planning scenarios.
	Urban Nutrient Management	17	22	
Phase 5.3.0 Watershed Model-Based Phase II WIPs	Nutrient Management	Land Use Change Range from -8.6 to 20	Land Use Change Range from -0.5 to 39.5	Identified at Model Summit, October 2011, as still flawed. Short, medium and long term fixes identified.
	Decision Agriculture	+3.5	0	

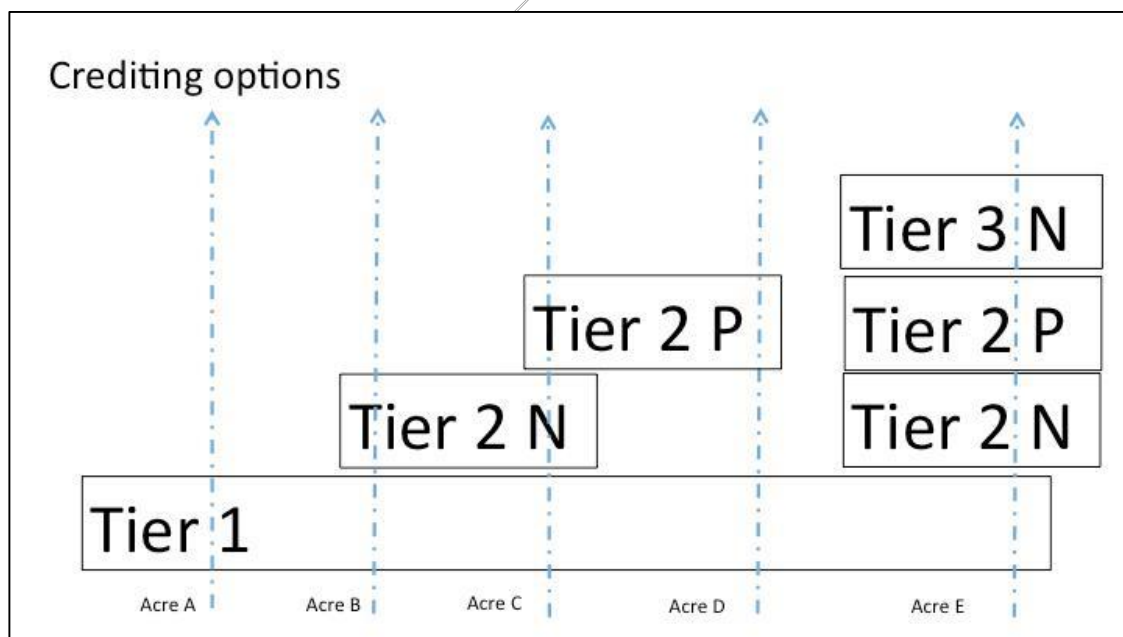
Era	BMP	Nitrogen Efficiency	Phosphorus Efficiency	Notes
	Enhanced Nutrient Management	+7	0	
	Urban Nutrient Management	17	22	
Phase 5.3.2 Watershed Model-March 2012	Interim Nutrient Management Efficiency	5.9	9.2	Established for WIP II and 2013 Milestones Planning as agreed "Short Term" patch
	Enhanced Nutrient Management Efficiency	12.9	9.2	
	Decision Agriculture Efficiency	9.4	9.2	
Phase 5.3.2 Watershed Model-March 2013	Urban Nutrient Management	Range from 6 - 20	Range from 3 - 10	Reductions are in addition to "P Ban" 60-70% reduction in P application rate
Phase 5.3.2 Watershed Model-October 2013	Tier 1 NM	Cropland 9.25	Cropland 10	<b><u>NM Panel recommended and WQGIT approved medium term fix for 2013 Progress and 2013 Milestones.</u></b>
		Other Ag 5	Other Ag 8	
Phase 5.3.2 Watershed Model-Proposed November 2014	Tier 2 NM	Cropland 15.75	Cropland 20	NM Panel recommended medium term fix for v5.3.2.
		Other Ag 11.5	Other Ag 18	

The Panel proposes that the Chesapeake Bay Program's existing definitions and credits be replaced by three tiers of distinct management levels: CGNAM (Tier 1), FLNAM (Tier 2), and ANM (Tier 3). Each tier builds in succession on the previous (lower) tier. The Panel used an example from New York to guide and develop definitions for all three tiers of nutrient management (Appendix B). Tier 1 (CGNAM) encompasses NMPs that capture a rate change for N and P fertilizer consistent with the standard revised LGU nutrient management application recommendations for those plant nutrients. Tier 1 parallels early NM era plans and focuses on practices that apply to an entire farm. Tier 2 (FLNAM) is the current, up-to-date method that incorporates phosphorus site indices and is informed by post-1995 LGU nutrient management application recommendations that apply to individual fields (Figure 2). Tier 3 (ANM) employs the use of adaptive management, encompassing more highly tailored nutrient recommendations extending to the sub-field level.



**Figure 1** Each tier is following program adoption of researched based evidence of nutrient application changes.

As illustrated by Figure 2, credit for Tier 2 is only available for those implementing both Tier 1 and Tier 2 practices. Credit for Tier 3 is only available for those implementing Tier 1, Tier 2, and Tier 3 practices; however, the Panel recognizes the potential for implementation of Tier 1 and Tier 3 practices without Tier 2 practices and defers consideration of this situation for refinements of the NM definitions for Phase 6.0 of the CBPWM.



**Figure 2.** Illustration of how nutrient reduction credits can apply to an acre of cropland.



Definitions of the three practices are as follows:

**Tier 1 – Crop Group Nutrient Application Management (CGNAM):** Documentation exists for manure and/or fertilizer application management activities in accordance with basic LGU recommendations. This documentation supports farm-specific efforts to maximize growth by application of N and P with respect to proper nutrient source, rate, timing and placement for optimum crop growth consistent with LGU recommendations. Crop group nutrient application management is defined operationally by the documentation of and adherence to the following four planning components: (1) standard, realistic farm-wide yield goals; (2) credit for N sources (soil, sod, past manure and current-year applications); (3) P application rates consistent with LGU recommendations based on soil tests for fields without manure; and (4) N-based application rates consistent with LGU recommendations for fields receiving manure.

**Tier 2 – Field Level Nutrient Application Management (FLNAM):** Implementation of formal NM planning is documented and supported with records demonstrating efficient use of nutrients for both crop production and environmental management. Field level nutrient application management is defined operationally as the presence of plan documentation that nutrient applications are based on a combination of: (1) standard yield goals per soil type, or historic yields within field management units; (2) credit for N sources (soil, sod, past manure, and current-year applications); (3) fields assessed for P loss risk with a LGU P risk assessment tool (Phosphorus Site Index [PSI]) and P applications are consistent with the PSI; and (4) other conservation tools necessary for proper nutrient source, rate, timing and placement to improve nutrient use efficiency.

Indicators demonstrating implementation of this practice includes the presence of a plan that addresses the four elements described above, plus practices such as but not limited to best N application timing, manure incorporation where appropriate, PSI application, and manure application setbacks. Credit for this practice is based on how the plan integrates such practices to provide an overall reduction in N and P losses, where as elements of N loss reduction can be implemented and credited separately and distinctly from P in the Chesapeake Bay Program's Watershed Model. Therefore three reporting classes are recommended: Tier 2 N, Tier 2 P, and Tier 2 N&P.

**Tier 3 – Adaptive Nutrient Management (ANM):** The Panel was unable to complete the definition ANM for P due to insufficient time. The following definition pertains only to ANM for N. Under this practice, implementation of Tier 2 nutrient application management (FLNAM), plus multi-year monitoring of nutrient use efficiency with the results of this monitoring being integrated into future NM planning are documented. This process evaluates and refines the standard LGU nutrient recommendations using field- and subfield-specific multiple-season records. It further promotes the coordination of amount (rate), source, timing, and placement (application method) of plant nutrients to further reduce nutrient losses while maintaining economic returns. In addition to the field assessments in FLNAM and presence of a plan that addresses the adaptive management elements above, Tier 3 N credit requires, but is not limited to, implementation of one or more of the following tools:

- Illinois Soil Nitrogen Test (ISNT)
- Corn Stalk Nitrate Test (CSNT)
- Pre-side dress Nitrate Test (PSNT)
- Fall Soil Nitrate Test (FSNT)
- Variable N rate application

Implementation of the ISNT, CSNT, PSNT, and FSNT is defined as including not only performance of the test(s) themselves, but also changing N application rates/timing in response to the information provided by the test(s).

While unable to complete definitions for ANM for P or recommend efficiencies, the Panel did discuss options such as variable rate P fertilizer application and whole farm nutrient balance and recommended that consideration of Tier 3 P practices be revisited for application in the Phase 6 CBPWM

## 3 Effectiveness Estimates

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This section begins with a brief summary of the approved N and P credits for Tier 1, the recommended N and P credits for Tier 2, and the recommended N credits for Tier 3 (section 3.1, *Summary of Effectiveness Estimates*). The credit summaries are followed by a description of the process that the Panel undertook to develop credits based on the effectiveness estimates in the literature (section 3.2, *Process for Developing Effectiveness Estimates*). Finally, section 3.3 (*Justification for Effectiveness Estimates*) details the rationale and use of specific data values from the available literature to develop the effectiveness estimates for the individual practice components for Tiers 2 and 3 and the basis for combining the individual component values to develop the recommended credits.

### 3.1 Summary of Effectiveness Estimates

The credits for Tier 1 (CGNAM) will be simulated as edge-of-stream load reduction efficiencies in the reporting county from the non-BMP land use edge-of-stream load. Credits for Tier 2 (FLNAM) will be in addition to Tier 1 credits, and credits for Tier 3 (ANM) will be in addition to Tier 2 credits. The Panel determined that geographically specific efficiencies were not prudent for this recommendation because only some components in the literature supported a difference and calculations including component averages were chosen to represent the tiers.

The land uses eligible for each of the three tiers of nutrient management are shown in Figure 3. Several land uses benefiting from Tier 1 LGU recommended rates based on source were identified by the Panel. Land uses eligible for Tier 3 credit were based on the crops utilized in the literature supporting the efficiency estimates. The land uses including row crops that can receive manure in the Chesapeake Bay Watershed Model were identified in the literature as being eligible for Tier 2 credit, but HYW was also chosen to be eligible because this land use is so commonly associated with farms that grow row crops with manure. These hay fields, while commonly associated with row crop farms in animal agriculture, are separately and distinctively managed in a Tier 2 NM Plan system with timing component benefits identified in the Tier 2 research.

Tier 1	Tier 2N	Tier2P	Tier 3
<ul style="list-style-type: none"> <li>• Row w/ manure</li> <li>• HWM</li> <li>• LWM</li> <li>• Specialty row crops (HOM)</li> <li>• Pasture (PAS)</li> <li>• Nursery (NUR)</li> <li>• Hay w/ nutrients (HYW)</li> <li>• Alfalfa (ALF)</li> </ul>	<ul style="list-style-type: none"> <li>• Row w/ manure</li> <li>• HWM</li> <li>• LWM</li> <li>• Hay w/ nutrients (HYW)</li> </ul>	<ul style="list-style-type: none"> <li>• Row w/ manure</li> <li>• HWM</li> <li>• LWM</li> <li>• Hay w/ nutrients (HYW)</li> <li>• Alfalfa (ALF)</li> </ul>	<ul style="list-style-type: none"> <li>• Row w/ manure</li> <li>• HWM</li> <li>• LWM</li> </ul>

Figure 3. Phase 5 Chesapeake Bay Watershed Model land uses eligible for Nutrient Management by tier.

## Tier 1

The Panel's proposed credits for CGNAM implemented consistent with the operational definition was previously approved by the WQGIT in October 2013<sup>2</sup>. They are:

- 9.25 percent TN reduction and 10 percent TP reduction from land uses high-till with manure (HWM) and low-till with manure (LWM).
- 5 percent TN and 8 percent TP reduction from land uses high-till without manure (HOM), pasture (PAS), hay with nutrients (HYW), alfalfa (ALF), and nursery (URS).

In addition, the Panel proposed, and the WQGIT approved, that:

- Riparian pasture (TRP) and Hay without nutrients (HYO) are still excluded from receiving any nutrient reduction credits from implementation of any form of nutrient management.
- The CBPWM code and land uses that simulate nutrient management as a land use change (NHI, NHO, NLO, NHY, NPA and NAL) should be retained in the Partnership's modeling system for use by this and future panels. However, the Tier 1, Tier 2, and Tier 3 efficiencies recommended in this report should replace the land use change method for running all future progress and planning scenarios through the Partnership's Phase 5.3.2 Chesapeake Bay Watershed Model.

## Tier 2

The Panel proposes that FLNAM implemented consistent with the operational definition has credits of:

- 4.4 percent TN reduction from land uses high-till with manure (HWM) and low-till with manure (LWM) or 2.8 percent from the hay with nutrients (HYW) land use.
- 6.6 percent TP reduction from land uses HWM, LWM, ALF, and HYW.
- TN and TP credit can be earned independently or concurrently.

The effectiveness estimates for Tier 2 (FLNAM) will be simulated as edge-of-stream reductions in the reporting county in addition to the Tier 1 land use edge-of-stream load (see Table 4).

<sup>2</sup> <http://www.chesapeakebay.net/calendar/event/18976/>

### Tier 3

The Panel proposes that ANM implemented consistent with the operational definition has an effectiveness of:

- 2.8 percent TN reduction from land uses high-till with manure (HWM) and low-till with manure (LWM).

The effectiveness estimates for Tier 3 (ANM) will be simulated as edge-of-stream reductions in the reporting county in addition to the Tier 2 land use edge-of-stream load (see Table 4).

For all three Tiers, the Panel recommends:

- Riparian pasture (TRP) and Hay without nutrients (HYO) are still excluded from receiving any nutrient reduction credits from implementation of any form of nutrient management.
- The Watershed Model code and land uses that simulate nutrient management as a land use change (NHI, NHO, NLO, NHY, NPA and NAL) should be retained in the Partnership's modeling system for use by this and future panels. However, the Tier 1 and Tier 2 efficiencies recommended in this report should replace the land use change method for running all future progress and planning scenarios through the Partnership's Phase 5.3.2 Chesapeake Bay Watershed Model.

**Table 4. Combined efficiencies for Tiers as illustrated by example using 100 pounds of nutrient loads.**

	Practice Tier	Stand-Alone Efficiencies	Initial Load	Pass-Through Load	Combined Efficiencies
Row crops eligible for manure	1N	0.0925	100	90.750	9.25%
	1P	0.1	100	90.000	10.00%
	2N	0.044	90.75	86.757	13.24%
	2P	0.066	90.00	84.060	15.94%
	3N	0.028	86.757	84.328	15.67%
Fertilized hays	1N	.05	100	95.000	5.00%
	1P	.08	100	92.000	8.00%
	2N (no alf)	.028	95	92.340	7.66%
	2P	.066	92	85.928	14.07%

The Panel did not review the Tier 1, Tier 2 or Tier 3 for external environmental benefits (e.g., habit, economic, or social benefits) because of time constraints despite the Partnership's BMP Protocol request to incorporate a narrative describing these benefits (WQGIT 2014).

### 3.2 Process for Developing Effectiveness Estimates

The CBP Partnership approved both the BMP definitions (Tiers 1-3) and Tier 1 credit recommendations in October 2013<sup>3</sup>. The process for developing the Tier 1 recommendations is described in the full report available [here](http://www.chesapeakebay.net/channel_files/22023/nutrient_management_interim_phase_5_3_2_final.pdf). The Panel released the second report in October 2014<sup>4</sup>. This report featured no changes to the Panel's approved 2013 recommendations, but included recommended credits for N and P following FLNAM (Tier 2).

The Panel presented its recommendations to the AgWG and WTWG on November 6, 2014<sup>5</sup>. The Partnership provided significant comments on the second report, including:

- Questions about verification requirements for the Phase 5 recommendations in the report; and

<sup>3</sup> <http://www.chesapeakebay.net/calendar/event/18976/>

<sup>4</sup> [http://www.chesapeakebay.net/channel\\_files/22023/nutrient\\_management\\_interim\\_phase\\_5\\_3\\_2\\_final.pdf](http://www.chesapeakebay.net/channel_files/22023/nutrient_management_interim_phase_5_3_2_final.pdf)

<sup>5</sup> <http://www.chesapeakebay.net/calendar/event/21402/>

- Questions about documentation of how the recommended N and P credits were derived from scientific literature.

The meeting resulted in a call for the Panel to respond to Partnership comments on the Nutrient Application Management Tier 2 report by November 14, 2014, in preparation for Special Joint AgWG/ WTWG and WQGIT meeting on November 21, 2014<sup>6</sup>. At this meeting the Panel provided a review of the recently revised draft Panel recommendation report and addressed comments received from the Partnership as part of the draft review process.

As a result, in January 2015<sup>7</sup>, the AgWG charged the Panel to:

- Re-evaluate the Tier 2 and Tier 3 efforts to separate the N and P benefits for those levels of nutrient management.
- Re-consider the agricultural land uses for which the benefits of nutrient management will be realized.
- Develop a checklist of the data needed to assess the presence or absence of the level of nutrient management necessary to qualify for each Tier as guidance to the jurisdictions.

The revised recommendations for Tier 2 and 3 N and P credits were due in March, 2015. The Panel met frequently after January 2015, creating a revised framework for assigning Tier 2 and 3 credits. This framework separated the N and P benefits in both Tier 2 and Tier 3. The resulting overall framework for assigning BMP efficiencies for N and P became:

- Tier 1 N and P (existing, CBP Partnership approved)
- Tier 2 N (new)
- Tier 2 P (new)
- Tier 3 N (new)
- Tier 3 P (new)

Through multiple meetings and conference calls, the Panel discussed various options for specifying management practices required under each of the four new tiers, including an assessment of available literature from which efficiencies could be determined. The Panel revisited the peer-reviewed literature and obtained gray literature and unpublished data from scientists and agencies within the Chesapeake Bay watershed to add to the body of knowledge on the efficiencies of these BMPs. While the Panel fully examined all practices suggested by Panel members for potential inclusion as Tier 2 or 3 components, many were ultimately dropped for a number of reasons, including: a lack of efficiency data; a low level of implementation opportunities in the Chesapeake Bay watershed; and redundancy (i.e., practice benefits were subsumed by another practice). The following sections summarize the Panel's deliberations over both the definitions and efficiencies of Tier 2 and 3 practices. Specific details regarding the literature and efficiencies of these practices are presented in the *Justification for Effectiveness Estimates* section of this report.

## **Tier 2 Revision Process**

In January 2015, the Panel began in-depth discussions to determine the Tier 2 effectiveness estimates. The Tier 2 recommendations, presented to the CBP Partnership in November, 2014, had focused on the following six conservation tools identified by the Panel as those most frequently employed to write a plan consistent with the Tier 2 FLNAM definition:

- Manure incorporation;
- Manure application timing;
- N split applications;
- N fertilizer banding;

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<sup>6</sup> <http://www.chesapeakebay.net/calendar/event/22199/>

<sup>7</sup> <http://www.chesapeakebay.net/calendar/event/22323/>

- P site indices; and
- Nutrient application setbacks.

As described above, the Partnership's questions on those recommendations led the AgWG to direct the Panel in January 2015 to revisit the draft recommendations for Tier 2 N and P credits. These six practices were also reconsidered in light of the direction to separate N and P reduction efficiencies.

In a conference call on January 22, 2015, Panel members reached general agreement that the Tier 2 P reduction benefit was essentially achieved through implementation of practices required to satisfy needs identified through application of the PSI. Because PSI-directed P reductions can be achieved with multiple combinations of practices, discussion centered on how to identify a set of practices or options for sets of practices that, once implemented, would be considered sufficient to claim that Tier 2 P management was in place. Recommendations to approach P practice requirements in an à la carte fashion, assigning efficiencies and stacking them as implemented, were countered by concerns that counting the individual BMPs was not possible for the states that would typically track PSI implementation at the plan level rather than tracking individual practices.

In the subsequent conference call on January 28, 2015, the Panel considered the range of additional component practices that could be considered under Tier 2. Suggestions included:

- Tier 2 N
  - Time-released fertilizers for Tier 2 N
  - Field specific analysis or planning
  - Nitrogen placement (e.g., banding), including split applications
- Tier 2 P
  - Banding

The Panel also discussed the interaction of practices such as tillage and incorporation as a complicating factor in assigning efficiencies. In addition, the Panel discussed the potential for soil P levels to rise under Tier 2 management, including ways to ensure that P reduction credits were assigned appropriately. The discussion included verification considerations (e.g., setbacks) and the assignment of mandatory versus optional components for Tier 2. The Panel again discussed how to define the set of components needed to claim a Tier 2 level of management.

During the conference call on February 5, 2015, Panel members discussed literature on manure incorporation effectiveness and whether to include the PSI as a practice for Tier 2 P reductions. Panel members noted that the practices implemented as a result of applying the PSI, not the PSI itself, drive P reductions. The Panel rejected a recommendation to use manure incorporation and STP as the Tier 2 P requirements because STP is not a good stand-alone indicator of environmental P loss potential. The Panel discussed practices to consider as potential specific practice requirements for Tier 2 in lieu of the PSI, including manure timing, application rates, and incorporation; soil erosion; and buffers. In the end, however, Panel members returned to the discussion of using the PSI as the primary Tier 2 P practice. Panel members agreed to seek data on P loss reductions in response to implementation of the PSI. The Panel briefly discussed whether there should be separate Tier 2 practices for manure-based and non-manure based management, but no decision was made.

The Panel again discussed inclusion of the PSI for Tier 2 P in the conference call on February 19, 2015. The Panel initiated an effort to see if a PSI efficiency value could be generated from a review of the literature by setting up a separate PSI sub-panel to consider the issue. However, there was still mixed support on the Panel for focusing on PSI components rather than the PSI itself. How states apply the PSI in their programs was a significant factor in determining the best approach. Sub-panels of the Panel membership were also set up to focus on manure timing for Tier 2, manure incorporation, and placement.

The Panel presented an update on the Phase 5.3.2 Nutrient Management Panel recommendations for workgroup feedback at the March 18-19, 2015<sup>8</sup>, AgWG meeting in preparation for requesting AgWG approval at the end of April. The Panel Chair noted that the Panel hoped to have its final vote on the report by the end of April 2015.

The Panel convened via conference call on March 20, 2015, to discuss AgWG input and plans for an April 6<sup>th</sup> outreach webinar. A Panel member summarized information on manure N mineralization rates and availability from eleven papers relevant to the Chesapeake Bay watershed. Papers reviewed addressed both surface application and incorporation of manure.

During the conference call on March 26, 2015, the Panel discussed setbacks and manure incorporation. A private sector planner developed a number of setback application plans based on a calculated representative value of 2,776 average feet of stream running through cropland on a typical, 100-acre Pennsylvania dairy farm. The purpose was to support discussion on the impact of setbacks on manure application in non-setback areas, the resulting export of nutrients, and the potential impact of excess manure being exported. The Panel agreed that considering the manner in which the Phase 5.3.2 Chesapeake Bay Watershed Model addressed setbacks was essential to determining the efficiency value.

The Panel discussed manure incorporation literature with some consideration for handing off the task of assigning efficiency values to the Phase 6.0 NM Panel that will address manure incorporation specifically. It was concluded, however, that the Panel should develop Phase 5.3.2 manure incorporation N and P efficiencies. Recognizing the importance of landscape position, soil cover and slope for P efficiency, the Panel determined that average slopes for each physiographic region would need to be assumed when determining efficiency values.

The Panel discussed split N applications (Tier 2 N) during the conference call on April 14, 2015, and determined that additional data for the Piedmont were needed. Because the literature provided data only on reductions in application rate, translation to reductions in edge-of-field loss would be required. Panelists also recognized a need to consider how to balance credits between PSNT and split applications. Discussion of papers found on manure incorporation P benefits revealed a need to adjust plot-scale data to the watershed scale, perhaps adopting the 0.75 scaling factor used for cover crops literature ([Chesapeake Bay Program 2013b](#)).

At that point in the process, the Panel had, with some exceptions, assembled and reviewed literature on all components considered for Tier 2 N and P. Efficiencies would depend on decisions regarding the land uses for which the BMPs applied. In addition, the Panel needed to decide how it would address the PSI and its components. Those Panel members in favor of using the PSI as a single component (rather than breaking it down into its component practices) pointed to the familiarity with the PSI, its track record in real-world applications, and state tracking and reporting. The Panel decided to take further efforts to determine if PSI efficiency values could be developed based on the published literature or modeling runs relating PSI values to P loads.

During a conference call on April 23, 2015, the Panel discussed a summary of three papers on the PSI (Johnson et al. 2005, Osmond et al. 2006, and Osmond et al. 2012). The recommendations contained in the summary incorporated review comments from Dr. Deanna Osmond, the lead or co-author of each paper. In addition, the Panel heard a presentation on the PSI research in Pennsylvania where SWAT modeling results were related to PSI ratings (Veith et al. 2005). Panelists agreed that PSI efficiency values would be derived from the Veith et al. 2005 paper, with consideration both for discounting the efficiency values to account for uncertainty in the relationship between PSI scores and measured loads as reported by Osmond et al. (2012) and for the lag time between PSI application and environmental results. Panelists expressed concern regarding the fact that the Veith et al. 2005 data came from one small watershed, once again highlighting the need for additional data. The Panel

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<sup>8</sup> <http://www.chesapeakebay.net/calendar/event/22429/>

agreed to attempt to develop additional data by selecting studies in each Chesapeake Bay watershed jurisdiction where P loads were monitored, assigning PSI values to the monitored lands in those studies based on information reported in the literature, and determining PSI efficiency values based on the measured changes in P loads and the associated changes in PSI rankings. Time constraints, however, prohibited completion of that effort. The Panel undertook an ancillary effort to gather information from experts on the factors driving PSI rankings in each jurisdiction and the extent to which and manner with which the PSI is applied in each jurisdiction.

At this point in its deliberations, the Panel was considering three components for Tier 2 P: application setbacks, manure incorporation, and the PSI. An analysis of Pennsylvania data indicated that setbacks might impact 8-10 percent of cropland acreage. Panel members proposed determining the P reduction per acre by calculating the difference between the CBPWM P losses for manured and non-manured lands. Multiplying that result by the 8-10 percent of acres receiving manure would give the total P reduction due to setbacks. (See *Tier 2 P: Setbacks* for details.)

Consideration of manure incorporation for both Tier 2 N and P included a discussion of whether and how to account for lag time. Panelists generally agreed that incorporation results in an immediate response. (See *Tier 2 N: Manure Incorporation* and *Tier 2 P: Manure Incorporation* for details.)

An extended discussion of the PSI addressed a number of issues including the relative importance of various elements of the PSI:

- how to credit PSI application (i.e., individual practices or practices lumped as PSI);
- the need to avoid double counting of practices implemented in response to PSI application (e.g., erosion control practices that are also implemented independently of the PSI);
- state reporting of PSI or practices implemented in response to the PSI; and
- the degree to which the PSI is implemented in the various Chesapeake Bay watershed jurisdictions.

See *Tier 2 P: Phosphorus Site Index* for details.

The Panel found and discussed the available split N application data for the Piedmont region during the conference call on May 1, 2015, thus enabling calculation of the efficiency for that Tier 2 N practice. The Panel agreed to refer more generally to improved timing of N applications rather than limit that Tier 2 N component only to split applications. Split N application is an example, but is not the only way that timing can be adjusted to improve nitrogen use efficiency. (See *Tier 2 N: Timing N Applications* for details.)

During the conference call on May 26, 2015, the Panel reviewed proposals for efficiency values for both Tier 2 and 3. Preliminary decisions were made regarding a subset of practices, with plans to fill in gaps and seek consensus on final decisions within a week.

### **Tier 3 Process**

On January 22, 2015, Panel members reached general agreement that Tier 3 P would be achieved with P management beyond the level achieved by implementing practices to satisfy needs identified through application of the PSI. As was the case for Tier 2 N and P, the Panel also recognized that Tier 3 N and Tier 3 P both included multiple possible combinations of practices and would, therefore, require decisions regarding the set or sets of practices that, once implemented, would be considered sufficient to claim that Tier 3 management was in place.

In the subsequent conference call on January 28, 2015, the Panel considered the range of additional component practices that could be considered under Tier 3. Suggestions included:

- Tier 3 N and P
  - Incorporation of fertilizer as well as manure



- Whole farm nutrient balance
- Tier 3 N
  - Site-based models such as dynamic weather-based computer modeling,

These practices were then considered in combination with the following practices that had been included in the Panel report from March 2014:

- Multiyear, ongoing records from tests or trials including field- and subfield-level STP.
- An N assessment including, but not limited to, the ISNT, CSNT, PSNT, and in-field monitoring/strip trials with yield determination to improve upon the standard LGU recommendations for application.
- Precision application technologies to more accurately deliver and record recommendations.

The Panel also discussed the need to consider the interaction of practices when assigning efficiencies and the assignment of mandatory versus optional components for Tier 3. For example, Tier 3 N might require implementation of two tests (e.g., PSNT, CSNT, ISNT).

The Panel conference call on February 5, 2015 focused on discussion of findings from the completed review of the PSNT literature. Efficiencies for N based on the literature were presented, discussed, and accepted. (See *Tier 3 N: Pre-Sidedress Soil Nitrate Test* for details.) Discussion revealed that current state tracking of PSNT acreage varied, and the Panel agreed to collect available state data to assess the extent of application.

During the Panel conference call on February 19, 2015, assignments were made to gather additional information on CSNT, ISNT, test strips, and dynamic models to aid in determining efficiencies for the various components under consideration for Tier 3.

The Panel held a conference call the day after receiving feedback at the AgWG meeting on March 18-19, 2015<sup>9</sup>. The Panel presentation on current plans for the Phase 5.3.2 Nutrient Management recommendations report was scheduled during that meeting to enable AgWG approval in April. During the March 20 call, Panel members discussed reviews of research on PSNT, whole-farm nutrient balance, and CSNT/ISNT. The Panel also considered reduction efficiency values for PSNT based on NO<sub>3</sub>-N leaching, fall residual NO<sub>3</sub>-N, and fertilizer application reductions.

The Panel discussed additional data on PSNT and variable rate fertilizer applications for Tier 3 where manure is not applied during a conference call on March 26, 2015. The Panel tasked a sub-group with determining an efficiency value for Tier 3 P, perhaps using STP as an efficiency measure. Research on Tier 3 variable rate N application was summarized in terms of rate reductions and yields—information that would be used to determine an efficiency value. An informal survey conducted during the conference call indicated that most states had little or no data on variable rate P usage.

During the conference call on April 14, 2015, Panel members agreed on the need to consider balancing credits between PSNT and split applications (as also noted above under *Tier 2 Process*). In addition, a synthesis of studies for Tier 3 practices yielded a number of useful observations. First, reductions from whole farm nutrient balances are driven primarily by feed management, which is already accounted for in another BMP. Because feed management drives whole farm nutrient balances and is already addressed in another BMP, Panelists concluded that whole farm nutrient balance need not be addressed for Phase 5.3.2. Panel members recommended, however, that whole farm nutrient balance be re-visited as a potential BMP component by the Phase 6.0 Nutrient Management Panel, especially if the feed management BMP definitions change. The Panel identified manure export as a potential tool to achieve a whole farm nutrient balance. It was suggested, therefore, that local manure transport should be discussed with the CBP Watershed Modeling Team for Phase

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<sup>9</sup> <http://www.chesapeakebay.net/calendar/event/22429/>

6.0. The second observation from the studies was that ISNT adaptive management N reductions were estimated at 33-40% based on four citations from NY. These reductions were based on a change in behavior following results of the soil test. It was found that CSNT application resulted in about a 20-30% N reduction beyond Tier 2, with testing primarily in PA and NY dairy settings. Finally, the Panel discussed information on the Adapt-N computer model which is designed to fine-tune sidedress N applications for corn based on weather data and field-specific user inputs. Efficiency values using simulated N leaching losses would be relative to the book values for soil N, sod N, and manure N common in Tier 2 nutrient management. The Panel determined that real-world measurements were also needed for the Adapt-N computer model. Panel members also discussed the need for potential adjustments to translate leaching data to edge-of-field losses and account for real-world farm management. An additional consideration for all of the Tier 3 information presented was that most of the results apply to corn only.

The Panel had now nearly completed the assembly and review of literature on all components considered for Tier 3 N and Tier 3 P. The Panel noted that efficiencies would depend on the land uses to which the BMPs applied.

A Panel member presented a literature summary on CSNT and ISNT during a conference call on May 1, 2015, noting that Tier 3 adaptive N management is based on information gained from the CSNT and ISNT, and the available literature indicated that 40-50% of corn fields would generally be non-responsive (i.e., did not need additional N) based on those tests. The Panel, therefore, concluded that about half of fields to which the CSNT and ISNT were applied could be managed differently from LGU recommendations. The next step would be translating that information into end-of-season N values and edge-of-stream delivery. The values were being developed in collaboration with Dr. Quirine Ketterings of Cornell University. The Panel also discussed the basis for efficiency credits for both CSNT and ISNT. (See *Tier 3 N: Adaptive N Management* for details.)

Proposed efficiency values were also discussed for the PSNT. (See *Tier 3 N: Adaptive N Management* for details.) The Panel considered methods for discounting efficiency values based on the literature. In addition, Panel members raised questions regarding reporting, for example, how to report all acres tested and then apply a discount to capture only those acres where the recommendation was followed. States track this type of information to differing degrees, with PA having no data and VA tracking the number of tests and acres tested. Panelists proposed and discussed a number of solutions to the tracking challenge. It was suggested that Phase 5.3.2 reporting could follow a preliminary approach that is later refined for Phase 6.0. (See *Section 6* for details).

After further discussion, the Panel decided against pursuing N reduction credits for the Adapt-N tool under Tier 3 N because the model has not yet been sufficiently validated. Panel members, therefore, agreed to drop the use of Adapt-N as a Tier 3 N component; this component should be picked up under Phase 6.0 as additional validation is performed and implementation levels increase.

The Panel agreed to table consideration of Tier 3 P for Phase 5.3.2, passing it on for consideration by the Phase 6.0 Nutrient Management Panel.

During a conference call on May 21, 2015, the Panel agreed to definitions for Tier 2 (N and P) and Tier 3 N, deferring Tier 3 P to Phase 6 efforts.

During a conference call on May 26, 2015, the Panel reviewed proposals for efficiency values for both Tier 2 and Tier 3. Preliminary decisions were made regarding a subset of practices, with plans to fill in gaps and seek consensus on final decisions within a week.

### 3.3 Justification for Effectiveness Estimates

The sections below detail how the Panel considered the available data to derive effectiveness estimates for Tier 1 (CGNAM), Tier 2 (FLNAM), and Tier 3 (ANM) nutrient management. A more general characterization of the literature that guided the Panel's discussions is provided in Section 4.0.

#### 3.3.1. Tier 1 N and P

The Panel based the effectiveness of CGNAM for row crops receiving manure solely on changes in application rates over time because of a lack of scientific literature documenting efficiencies of the proposed practice. The Panel was careful to exclude benefits from other practices in combination with CGNAM, like manure storage structures by finding scientific papers where no manure management structures were documented. Model runs to estimate efficiency based on LGU recommendation changes over time only changed nutrient application rates and held all other BMPs consistent with reported acreage and animal units covered. Other land use efficiencies were chosen based on model runs of the original land use change NM BMP.

In the absence of historic surveys on nutrient applications to crops, bay-wide representative NM and non-NM application rates were determined based on historical (i.e., before the CBPWM simulation period of 1985) and modern LGU agronomy guides (i.e., during the calibration period of the CBPWM; see Table 5). Agronomy guides were used in this timeframe as the guidelines for nutrient management planning, but in many states have been superseded by voluntary and regulatory programs.

Historical LGU agronomy guides (pre-1985) evaluated by panel members recommended a range of 15–40 percent more plant-available N than CBPWM calibration period LGU guides (Table 5). The Panel unanimously agreed to use this change in recommendations as a proxy for pre-NM versus NM conditions on corn acres across the Chesapeake Bay watershed. A 20 percent difference in non-NM and NM N applications was determined to be a conservative estimate based on the literature search. The proxy was used in conjunction with Panel-summarized literature comparing application rates, yields and spring or fall residual soil nitrate on corn.

Other crops of significant acreage (i.e. soy, wheat, alfalfa) did not have consistently lower recommended application rates from LGU agronomy guides; therefore, proxy non-NM application rates could not be determined for those crops. Instead of proxy rate changes, the Panel identified multi-year manure mineralization rates of more than 20% and N-fixation credits for legumes as contributing factors to Tier 1 plans that make the credit applicable to many crops across the land uses identified by the Panel.

**Table 5. LGU Agronomy Guide N Recommendations Before and during CBPWM calibration period for corn acres per bushel of expected yield**

Land Grant University	Pre-calibration Recommendation	Calibration period Recommendation
North Carolina State University	1.4 lbs PAN <sup>10</sup>	1.0 lbs PAN
Pennsylvania State University	1.3 <sup>11</sup>	1.0 <sup>12</sup>
University of Maryland	1.2 <sup>13</sup>	1.0 <sup>14</sup>

<sup>10</sup> North Carolina State University Extension. 1979 Agronomy Guide. North Carolina State University. Raleigh, NC.

<sup>11</sup> Penn State Extension. 1981 Agronomy Guide. The Pennsylvania State University, College of Agriculture Extension Service. University Park, PA.

<sup>12</sup> <http://extension.psu.edu/agronomy-guide/cm/sec2/sec24e3>

<sup>13</sup> Coop. Ext. Serv. 1981. Fertilizer Recommendations, sheet 3, corn for grain on medium textured soils without manure. Univ. MD Coop. Ext. Serv., College Park, MD.

<sup>14</sup> Coale, F.J. 1995. Plant nutrient recommendations based on soil tests and yield goals. Agronomy Mimeo No. 10, Coop. Ext. Serv. and Agronomy Dept. Univ. MD, College Park, MD

The method for determining the efficiency for row crops receiving manure from the change in LGU application rates on corn is described in the four enumerated steps below.

1. NM yield unit was determined from the LGU agronomy guides listed in Table 5.
2. A current LGU N application rate (NM rate) was calculated as well as a proxy non-NM rate of 1.2 times the current NM rate.
3. Application rates and yields for studies cited in Appendix B were plotted against residual soil N (see Figure 4).
4. A change in soil N resulting from a 20 percent nutrient application reduction to NM rates was determined from the plot (see Figure 4).

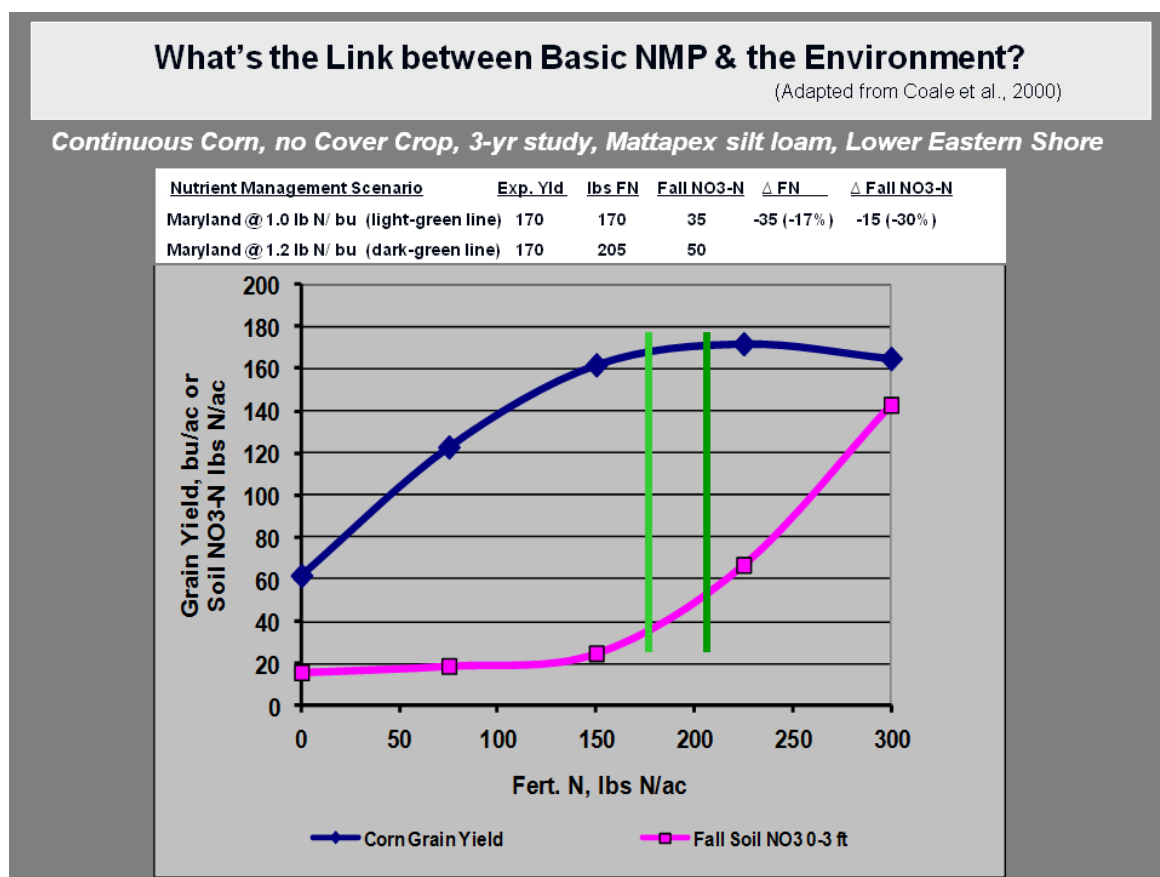


Figure 4. Plot of corn yield and fall residual soil NO<sub>3</sub>-N on Maryland Eastern Shore, showing reduction in fall residual NO<sub>3</sub>-N resulting from reduced Tier 1 N fertilizer recommendation (from Coale 2000).

The principal basis for the Tier 1 N reduction efficiency is a reduction in the fertilizer N requirement for corn from 1.2 lb N/bu in earlier LGU recommendations to 1.0 lb N/bu in current LGU recommendations. This reduction is supported by data from Coale (2000) that show corn yield response to fertilizer N with the associated post-harvest fall soil residual NO<sub>3</sub>-N concentration (Figure 4). In Figure 4, for an expected yield of 170 bu/ac, approximately 205 lb N/ac would be recommended (the dark green vertical line) based on the 1980s 1.2 lb N/bu standard LGU recommendation, which would leave approximately 50 lb of fall residual NO<sub>3</sub>-N vulnerable for leaching after harvest. However, for the same yield of 170 bu/ac, about 170 lb N/ac would now be the LGU recommendation which translated to the Tier 1 NMP standard of 1.0 lb N/bu (the light green vertical line in Figure 4). This N application (reduced by 35 lb N/ac, or 17%), which is consistent with current (post-1995) LGU recommendations, would leave 35 lb of fall residual NO<sub>3</sub>-N—a reduction of 15 lb or 30% in the NO<sub>3</sub>-N vulnerable to leaching after crop harvest. The greater percent

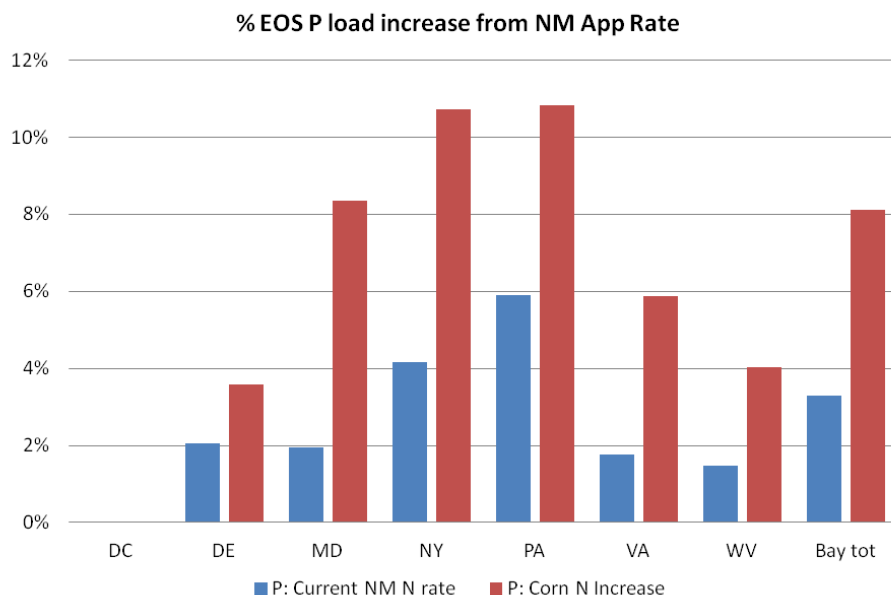
reduction in residual  $\text{NO}_3\text{-N}$  compared to the percent reduction in fertilizer N results from the steeper curve of fall residual  $\text{NO}_3\text{-N}$  compared to fertilizer N and the fact that the fertilizer N percent reduction is based on a larger number (total fertilizer N input) than is the residual-N percent reduction that is based on a smaller number (residual  $\text{NO}_3\text{-N}$  at ~205 lb fertilizer N/ac).

The same pattern has been confirmed by similar data in Virginia and Pennsylvania and represents an essentially universal phenomenon that crops are efficient users of N as long as crop growth increases, but when crop N needs have been met, additional N is subject to other losses (leaching, denitrification, etc.) that increase the odds for environmental impacts.

The Panel performed a sensitivity analysis that simulated a 20% change in nitrogen application rates on corn. This yielded a percent change in N and P load where a reduction in manure application on corn with a reduction in PAN in manure yields a companion reduction of P. The model run and analysis was performed on a 2007 progress scenario, choosing the year 2007 to avoid violating the Phase 5.3.2 CBPWM calibration.<sup>15</sup> Three scenario runs were performed:

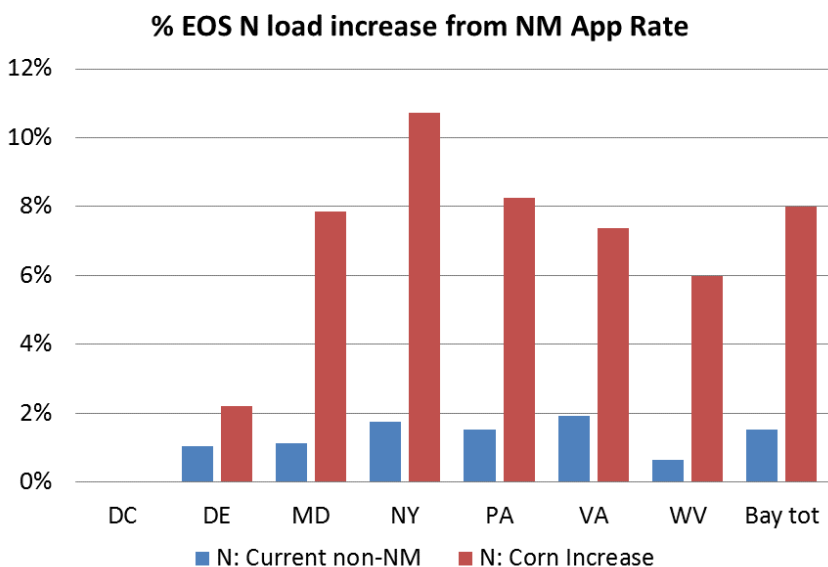
- Scenario 1: Phase 5.3.2 acres were modeled with current methods of determining non-NM application rates (see v2.4 Scenario Builder documentation [CBP 2013a]);
- Scenario 2: Phase 5.3.2 acres were modeled with current NM application rates; and
- Scenario 3: non-NM rates on corn were replaced with rates 1.2 times higher than the current Phase 5.3.2 CBPWM NM rate.

These runs were summarized for agriculture land uses in each state and across the whole Chesapeake Bay watershed (see Figure 5 **Error! Reference source not found.** and Figure 5, below).



**Figure 5. Phosphorus sensitivity analysis shows the difference in ag landuse loads between old NM BMP load change for N in blue with 120% increase in corn fertilizer and manure application in red.**

<sup>15</sup> Changing the outcomes of scenarios run for the Phase 5.3.2 CBPWM calibration period (1985–2005) would invalidate the model calibration and reduce the accuracy of the results in all runs.



**Figure 6. Nitrogen sensitivity analysis shows the difference in ag landuse loads between old NM BMP load change for N in blue with 120% increase in corn application in red.**

The Panel agreed the most defensible estimate of the NM proxy was to compare the land uses HWM and LWM that simulate row crops across the runs (not pictured), rather than all the Ag land uses (above). The average effectiveness estimate calculated in the comparison between NM and current non-NM landuse change runs for all other Ag land uses (HYW, HOM, PAS, ALF) was the only defensible efficiency the Panel could choose before the CBP deadline. The efficiencies described above were chosen to replace the current NM land uses and also to be available to nursery acres (URS).

The Panel unanimously chose the corn application rate proxy approach to affect all crops in the HWM land use. The primary reasons for expanding the effectiveness selected for corn to more crops were:

1. The majority of acres in the HWM land use were in corn in 2007, according to Scenario Builder data adapted from Agriculture Census (2007).
2. Other crops, like wheat, comprising the minority of acres in the land use, had even larger reductions in recommended application rates in the LGU agronomy guides through time, providing a higher confidence that the corn application rate proxy represents the most conservative effectiveness estimate<sup>1617</sup>.

### ***BMP Protocol Considerations of Note***

While the Panel agrees that the current method of calculating NM application rates based on yield is consistent with the concept of CGNAM, the yields from the National Agricultural Statistics Service (NASS) Census of Agriculture included in the CBPWM are considered to be far too low. Reduced application rates corresponding to load reduction efficiencies that reflect the BPJ of the Panel would not produce realistic

<sup>16</sup> <http://extension.psu.edu/agronomy-guide/cm/sec2/sec24e3>

<sup>17</sup> Coale, F.J. 1995. Plant nutrient recommendations based on soil tests and yield goals. Agronomy Mimeo No. 10, Coop. Ext. Serv. and Agronomy Dept. Univ. MD, College Park, MD

yields on the landscape. The Panel agreed that the NASS yields should be examined for accuracy in the Phase 6.0 CBPWM and other sources of yield data should be used in addition to NASS. The Panel notes that neither its recommendation, nor the NASS-provided data to the CBPWM account appropriately for the documented increase in corn grain yields through the simulation period. Consequently, the Panel could not identify the reason for the lack of documented change in N fertilizer use over the same period.

The available literature did not identify increases in pollution from CGNAM. Anecdotal evidence of a minority of producers increasing their nutrient application rates in response to LGU agronomy guide recommendations over time was considered by the Panel to be inconsequential bay-wide, and would be limited to producers that were using commercial fertilizers too conservatively based on cost and had to increase applications to achieve target yields based on the LGU recommendations.

Through the period of LGU agronomy guides which the Panel reviewed, the estimated rate of annual N mineralization from animal manure applied to land increased. The Panel agreed that the change in manure mineralization estimates through pre-1995 LGU agronomy guide publications adds a significant amount of conservativeness to the efficiency estimate because it does not account for N loss reductions attributable to more accurate mineralization estimates in post-1995 NM planning LGU agronomy publications.

The literature reviewed did not address the effects of CGNAM on surficial nutrient loss pathways. The literature reviewed was limited to subsurface loss.

### **3.3.2. Tier 2 N**

#### ***Manure Incorporation***

A direct effect of manure incorporation on N losses to the environment is reducing ammonia volatilization. Incorporation reduces ammonia losses by increasing the contact of manure with the soil's cation-exchange sites, thereby sequestering ammonia-N onto the soil rather than leaving ammonia vulnerable to volatilization. Manure incorporation is currently recommended in Maryland provided it does not interfere with erosion control practices (Maryland Coop. Ext. 2009).

Ammonia volatilization of unincorporated surface-applied manure commonly varies from 35-70% of the ammonium-N in liquid manures, and 20-45% of the ammonium-N in poultry litter (Meisinger and Jokela 2000, Thompson and Meisinger 2002). Many ammonia volatilization studies document the benefits of incorporating manure, which can commonly reduce ammonia losses by 20-95% depending on the time between application and incorporation, and the tillage intensity (Meisinger and Jokela 2000, Thompson and Meisinger 2002, Sommer and Hutchings 2001). The ammonia conserved by incorporation will reduce fertilizer N needs, but the most direct environmental benefit is reduced atmospheric deposition of ammonia in neighboring ecosystems in East Coast Bay ecosystems. Paerl (2002) concluded that atmospheric deposition should be factored into maintaining water quality, and Paerl et al. (2002) estimated that 10-40% of new N loadings to estuaries came from atmospheric deposition. Meisinger et al. (2008b) summarized a Canadian estimate of ammonia re-deposition to agricultural land that was estimated to be about 20% of the ammonia volatilized (Belzer et al. 1997, Zebarth et al. 1999) as derived from a literature summary used to estimate a regional N budget.

The final literature-based N reduction efficiency for manure incorporation was based on the ammonia conserved by incorporation within one day after application and using tillage implements that would leave at least 30% residue cover (chisel plow or light tandem-disk). The final small-plot estimate for N reduction was 10%, which was the amount of applied manure ammonium-N conserved. The Panel also applied a further adjustment factor for BPJ of the environmental benefit of lowering ammonia re-deposition to neighboring land; the adjustment factor of 20% was the average of the atmospheric deposition of Paerl et al. (2002) and from Belzer et al. (1997) and Zebarth et al. (1999) as summarized above. It should be emphasized that this

manure N incorporation factor is a temporary conservative estimate that will be reviewed by a new Phase 6.0 Expert Panel that will include a more comprehensive evaluation of manure incorporation benefits (ammonia reduction, possible surface runoff reductions) and detriments (reduced residue cover, possible greater erosion).

It is important to note that the Panel was made sufficiently aware of the existing framework of the Phase 5.3.2 CBPWM and how it includes a method for crediting conservation tillage practices on landuses that are eligible for Tier 2 credit. The Panel determined that the benefits of this component BMP were of sufficient value to surpass the value of conservation tillage and should be applied to that landuse. In addition, the incorporation of manure is not required for a plan that achieves credit, nor does it always result in fields that cannot qualify for conservation tillage. The costs and benefits to the environment are always weighed in a Tier 2 plan and the recommendation efficiency implicitly incorporates best professional judgement into its adjustment calculations from research values for these instances. Additionally, the application of this BMP component in NMPs did not exist until after the calibration period (see Figure 1). The benefit of this BMP was, therefore, never before captured properly in the Phase 5.3.2 Chesapeake Bay Watershed Model calibration and is, in fact, a BMP that should be separately and distinctly credited.

### ***Timing N Applications***

Improving the timing of N applications is one of the foundational elements of the “4 Rs”<sup>18</sup>. It is a well-accepted practice across the U.S. that is based on the fact that N use efficiency is increased by applying N in phase with crop need. This is because N applied before crop demand runs the risk of N losses to leaching, volatilization, and/or denitrification, especially in humid climates like the Chesapeake Bay watershed (Meisinger and Delgado 2002, Raun and Schepers 2008). Nitrogen timing is practiced on many crops in the watershed; the largest acreages are for corn and small grains.

The N reduction efficiencies from timing N applications were estimated by comparing corn yields from replicated N-response trials over many site-years (Fox et al. 1986, Fox and Piekielek 1993, Pers. Comm. J. Meisinger 2015). These studies compared yield vs. N applied (as urea-ammonium-nitrate) at planting, or N applied just before the crop begins its’ rapid period of growth. The rapid growth-period for corn is about a month after planting, for wheat it is about a month after breaking winter dormancy. Corn had the most N-response trials, which were summarized by fitting separate quadratic regression functions for each timing at each site-year of data, and then estimating the economic optimum N rate (EONR) for corn grain valued at \$4.00 per bushel and N priced at \$0.50 per pound. These regressions allowed estimation of the EONR and associated yield, which provided a method to compare optimum rates for N applied at planting vs. at a later time that was in harmony with crop N demand. The plot-based N reduction efficiency was estimated as the difference between the EONRs at planting vs. the delayed application, divided by the planting EONR. There was also adequate data from the Coastal Plain (21 site-years) and the Piedmont (18 site-years) regions to estimate separate N reduction efficiencies. These calculations produced a Coastal Plain estimated N reduction efficiency of about 16%, with the corresponding estimate for the Piedmont of 9%. The Panel discussion of these estimates produced a consensus that the Coastal Plain higher N-Timing reduction efficiency was likely due to the region having more coarse-textured soils and more shallow rooting soils than the Piedmont.

The N-timing reduction efficiencies for wheat used the two-years of field-plot total N uptake data of Gravelle et al. (1988) who compared an all-at-green-up application with a 50-50 split of N between green-up and an application approximately one month later. Four years of lysimeter nitrate-N leaching data (Pers. comm., J. Meisinger 2015) were also used from intact soil-column lysimeters described in Palmer et al. (2011) following the sample collection and analysis methods described in Meisinger et al. (2015). The lysimeter treatments were replicated twice in each of the four years (1992-93, 1997-98, 1998-99, and 1999-2000) with winter wheat

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<sup>18</sup> <http://www.nutrientstewardship.com/what-are-4rs>



receiving either all the N at green-up, or with the same N rate applied one-third at green-up and two-thirds about a month later. These two data sources produced an average wheat N-timing reduction efficiency of about 15%, which is similar to the Coastal Plain value for corn.

Hay crops that receive mechanical applications of nutrients generally receive manure and possibly fertilizer after each cutting following an initial application made at spring green-up. Spacing N applications in this way leads to generally more frequent and smaller doses of nutrients (three or more depending on number of cuttings in a season) compared to two split applications to row crops. Combining the effect of more efficient dosing with a perennial crop that has a more expansive and efficient root system, N uptake is considered to be as, if not more, efficient on non-leguminous hay fields than on row crops.

Moreover, the nature of the hay crop itself contributes to more efficient N utilization and smaller N losses compared to row crops because it is a perennial crop with a large active root mass all year long, which quickly restores complete ground cover within 10 days following a forage cutting. Hay is less prone to surface runoff and loss of N because of its high soil cover, root mass, numerous macropores and well-formed structure due to lack of tillage. Because it is less susceptible to runoff and leaching losses to begin with, nutrient application timing to hayland may be more forgiving than for annual crops that have nutrient requirements that are low at planting but ramp up as the crop grows to maturity and greater erosion potential due to tillage and exposed soil surface. In general, the purpose of split applications to hayland is often more of a logistical matter than one of nutrient management. For farms with animal manure, hayland is a synergistic place to spread manure during the growing season when row crops cannot be manured and avoids applying all the manure at once, which carries a risk of excessive N and K levels in forage that could cause livestock health problems.

As an indicator of this difference, Coale et al. (2000) reported fall soil nitrate concentrations of 50 lb/ac  $\text{NO}_3\text{-N}$  in corn fields with N applied at 205 lb/ac. In contrast, Sullivan et al. (2000) reported residual soil  $\text{NO}_3\text{-N}$  concentrations of less than 20 lb/ac N when total annual N rate applied to orchardgrass was 304 lb/ac.

Based on the understanding that the mechanism to credit improved N timing practices on hay is similar to that of row crops, and the relative way efficiency credit is applied in the Chesapeake Bay Model, the mean of the N timing data from above was used as a starting condition to calculate a final efficiency for hayland receiving nutrients. In the absence of good published data specific to hay production, a Panel-defined BPJ adjustment factor of 50 percent was applied to the N-timing mean to yield a N reduction efficiency of 6.6 percent for Tier 2 N application timing on hayland.

It is important to note that the Panel was made sufficiently aware of the existing framework of the Phase 5.3.2 CBPWM and how it includes a method for spacing out the timing of nutrient applications that is in some instances consistent with the current nutrient management recommendations. The application of this BMP, however, did not exist until after the calibration period (see Figure 1). The benefit of this BMP was, therefore, never captured properly in the Phase 5.3.2 Chesapeake Bay Watershed Model calibration and is, in fact, a BMP that should be separately and distinctly credited.

### ***Recommendations for Tier 2N FLNAM***

These data-derived estimates informed discussions among Panel members, who used BPJ following the general approach described below (*Synthesis of Tier 2 and 3 Component Efficiencies into Overall Tier 2 and 3 Efficiencies*) to develop credits for N reduction for the Tier 3 Adaptive N management BMP.

- Each literature document yielded one data point for the Tier 2 estimate.
- N timing data points ( $X_i$ ) were averaged, halved and then adjusted in a similar fashion to the N timing of row crops for scale, relevant crop contribution to the landuse and management factors (i.e.,  $(X_{i1} + X_{i2} + X_{i3})/3/2$ ). The adjusted hay with nutrients efficiency (i.e.,  $1/2X_{i\text{ avg}} \rightarrow$  adjustments) was calculated as 2.8 percent.

- Adjusted data points for N timing ( $X_f$ ) were utilized as a mean that contributed in an additive way to the Manure Incorporation adjusted value for the row crop efficiency of 4.4 percent (i.e.,  $(X_{f1} + X_{f2} + X_{f3})/3 + Y_{f1}$ ).

### 3.3.3. Tier 2 P

#### *Manure Incorporation*

Since the late 1970s, reduced tillage and no-till practices have been implemented as BMPs to reduce soil loss and the associated sediment bound nutrients, mainly P. Lake Erie experienced a well-documented rebound in water quality and the reduction in soil loss was a boon for soil health nation-wide. The Lake Erie water quality rebound soon fizzled and the finger was again pointed at P, but this time the no-till fields shared the blame. Enrichment of the uppermost soil veneer with P made it susceptible to P loss at similar rates to eroded fields with far less suspended sediment. In the Chesapeake Bay watershed, manure is a larger contributor to the source of agricultural P, but similar BMPs were implemented. The same hypothesis of enriched surficial soil P contributing to degraded water quality continues to be tested, here. NMPs that are written for manure-amended fields continue to recommend the incorporation of manure to minimize its exposure to runoff. This comes as a trade off with the increased risk of soil loss from bare soil with reduced structural integrity. In order to weigh the benefits of incorporation of manure against the costs of tillage, a brief literature review from each physiographic region is presented below and summarized in Table 6.

The Appalachian and Ridge and Valley provinces are characterized by the steepest slopes and highly weathered soils with the finest textures in the watershed. This makes the agricultural fields here particularly important to manage for soil loss with runoff. In a study that compared tillage effects on runoff from dairy manure amended soils, well drained soils were found to produce an increase in surface soil P loss compared to a reduction in surface soil P loss in a well-drained soil from the same area (Verbree et al. 2010). There are, however, significant portions of this region that are affected by Karst topography connecting shallow soil water to deeper groundwater. Dissolved P measured in springs was significantly higher in areas of agricultural activity. Another study compared the value of incorporation of dairy manure in this region for subsurface water quality and concluded that subsurface benefits were balanced by the increased potential for surface P loss due to runoff from certain soil types (Kleinman et al. 2008). The findings of both papers supported the conclusion that P loss from incorporated manure on soils prone to runoff loss was higher magnitude than the reduction in subsurface P loss, but poorly soils with drainage conditions poorer than well-drained do benefit from incorporation]. Given the complicated and mixed results for this region, the Panel could not estimate P reduction for manure incorporation and would recommend a 0% reduction efficiency.

On Coastal Plain soils, tillage effects to P loss were no different from control (Kibet et al. 2011). Benefit of incorporation from two runoff events was a 60% reduction in total P loss in surface flow and a 50% reduction in runoff volume. A companion study measuring the leachate from manure incorporation and injection was performed using lysimeters to collect subsurface flow, but P concentration was not measured (Feyereisen and Folmar 2009). The results revealed, however, that on this soil, 80% of water was lost to runoff, so the 60% efficiency applied to 80% of the loss yields a 48% P reduction at the plot scale. Spatial and temporal effects need to be taken into account for this efficiency to apply as an annual edge of field scale adjustment. Support for the direction of the efficiency determined above was generated elsewhere on the Delmarva by Staver and Brinsfield (2001). This study revealed the degree of stratification of STP (see Figure 7). Tillage had the effect of mixing the P enriched surface layer of soil and thereby reduced the effective loss rate where suspended sediment did not increase.

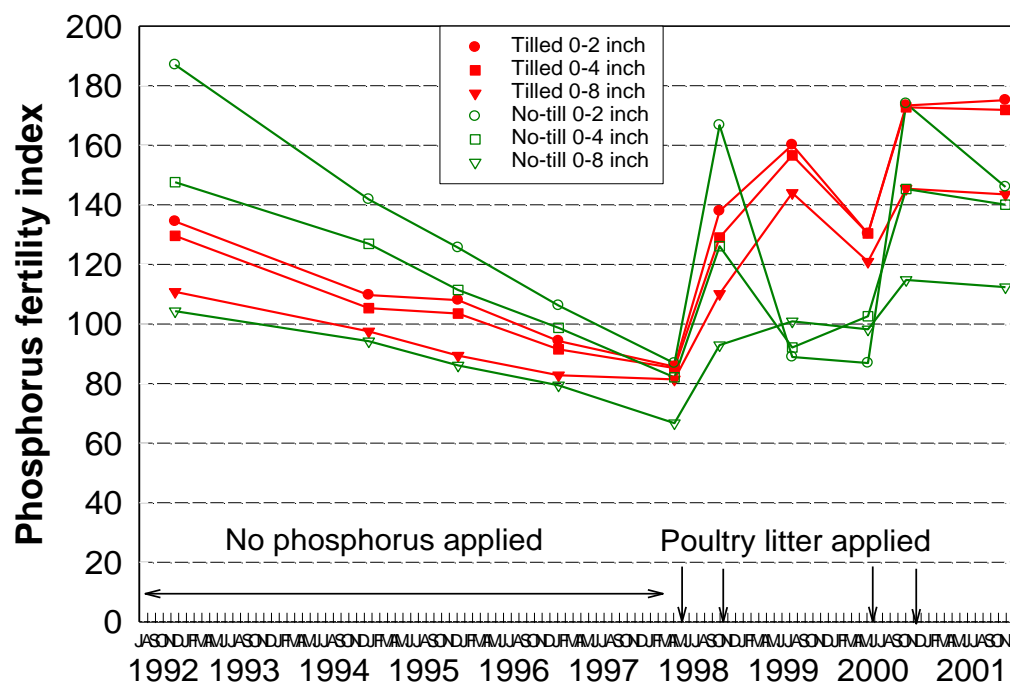


Figure 7. Plot of tillage effects of P stratification in 3 soil test phosphorus depths and the change in STP with Poultry Litter amendments on the Delmarva (Staver and Brinsfield 2001).

Piedmont soils were not represented with published experiments in the Chesapeake Bay watershed, but a single experiment from North Carolina was performed on a Piedmont soil that is prolific in the watershed. Tarkalson and Mikkelsen (2004) applied inorganic and broiler litter to plots similar to P application rates for corn with various levels of STP. The incorporation treatment yielded 88% less P loss than the treatment without incorporation. The mass of P loss from the incorporation treatment was not significantly different from a control. The runoff P was driven by a rainfall simulation performed on highly tilled (rototiller) plots of 2-3% slopes. While the runoff from a simulator was generated using a rainfall rate exceeding a 10 year recurrence interval storm, the tillage treatment would have been smooth and structureless on a relatively conservative slope for the region, so infiltration could be slightly above average. The study did not measure subsurface effects and found that on the tillage treatment, rate and source had no effect on total P loss in runoff. Best professional judgement (BPJ) of the value of this practice would have to reduce the percentage effectiveness of this BMP from the 88% measured, based on subsurface loss, rainfall intensity, annualized loss (compared to single simulation immediately following treatment amendments), and scaling effects of plots studies compared to watershed areas. Discounting the subsurface effects based on the measure benefit of the Appalachian/Ridge and valley subsurface effects paper, could have a measureable benefit (Kleinman et al. 2008). Adjusting for the subsurface effects of Feyereisen and Folmar (2009), in which only 80% of water was lost to runoff, the efficiency becomes 70.4% TP loss ( $0.88 * 0.8$ ). Adjusting further for the effect of a second storm, as in Kibet et al. (2008) where 66% of the loss benefit was in the first of two simulated storms, yields a 46% TP efficiency ( $0.704 * 0.66$ ). Using BPJ for spatial and temporal adjustments, an annual edge of stream efficiency for manure incorporation benefits out weigh surface broadcast application only.

Table 6. Effects of incorporation of manures across Chesapeake Bay physiographic regions adapted from cited literature above.

Physiographic region	Reduction efficiency proposed	Ways in which incorporation reduces P loss	Ways in which incorporation increases P loss
Appalachian and Ridge and Valley	0%	<ul style="list-style-type: none"> <li>Poorly drained soil surface runoff and</li> <li>disrupted macropore flow to groundwater</li> </ul>	<ul style="list-style-type: none"> <li>Well drained soils and/or slopes are susceptible to erosive surface P loss.</li> </ul>
Piedmont	< 46% (plot)	<ul style="list-style-type: none"> <li>Lowers TP loss in runoff</li> </ul>	<ul style="list-style-type: none"> <li>Poorly drained soils are susceptible to dissolved P subsurface loss</li> </ul>
Coastal Plain	<48% (plot)	<ul style="list-style-type: none"> <li>Lowers TP loss in surface runoff over multiple events.</li> <li>Better than injection.</li> </ul>	<ul style="list-style-type: none"> <li>Poorly drained soils are susceptible to dissolved P subsurface loss</li> </ul>

### Phosphorus Site Index (PSI)

The Panel members generally agreed early in their deliberations that the PSI should be the only quantitative component of Tier 2 P nutrient management. Achievement of Tier 2 P implementation, however, would be based on implementation of the practices determined necessary by state regulation as a result of applying the PSI at the field level, not by implementation of the PSI itself. The central tasks in assessing efficiency values, therefore, would be to:

- Characterize the field situations before and after application of the PSI;
- Determine the efficiencies of practices implemented after PSI application;
- Calculate overall PSI efficiency using the efficiencies of implemented practices; and
- Adjust overall efficiency of the PSI versus a baseline of Tier 1 nutrient management.

Although the overall process is logically straightforward, each of the tasks presented challenges for the Panel. First, characterizing field situations before and after application of the PSI is complicated by the wide range of possible combinations of soils, slopes, crops, STP levels, nutrient sources, and other factors that are used as input for the PSI across the Chesapeake Bay watershed. Because the PSI is used in cases where organic nutrients (i.e., manure, litter, biosolids) are applied, the Panel chose to limit applicability of this practice to lands receiving organic nutrients. Limiting applicability of the PSI simplified the task considerably while not compromising the true applicability of the practice. In addition, the Panel decided to focus on before and after conditions that would either result in a change from Very High to High risk or High Risk to Medium risk.

By focusing on fields where manure nutrients are applied and limiting the range of field conditions before and after PSI application, Panelists were able to use their expertise and field experience in combination with information obtained from the published literature to derive efficiency values. Panelists considered determining the overall PSI efficiency by combining the efficiencies of practices that would be implemented in response to PSI application, but that approach presented complications, including:

- Data limitations regarding individual practice efficiencies;
- Uncertainty regarding appropriate combinations of practices for calculating overall PSI efficiencies; and
- Uncertainty regarding how to weight individual practice efficiencies when calculating an overall PSI efficiency.

Recognizing these issues, the Panel decided to determine the overall PSI efficiency directly. An important aspect of determining efficiencies from a planning tool such as the PSI is field validation of the method. In this case, it is necessary to establish a relationship between PSI scores and P loads delivered to the edge of stream. The Panel reviewed the published literature and found several studies relating P loads (monitored and modeled) to PSI scores.

The Delaware PSI was evaluated in 2000-2001 using 272 fields located on seven farms (Leytem et al. 2003). The farms varied from cash grain operations, with no animal production on site, to small farms dominated by animal agriculture. In some cases the main form of P added was fertilizer while on other farms use of manure P dominated. PSI values were not directly related to measured P loads. The components of the DE PSI found to have the greatest influence on ratings were soil erosion, subsurface drainage, leaching potential, distance from field to surface water, soil test P and organic P application rates and methods. PSI ratings were found to vary by year, depending on manure applications, suggesting a need for yearly PSI evaluations or averages over a cropping rotation. The PSI worked well for identifying fields with differing relative potential risks of P loss; however, validation of these P loss assessments is needed to ensure that the risk categories assigned are sufficiently protective of water quality.

Vadas et al. (2009) developed new methods to predict annual dissolved P loss in runoff from surface-applied manures and fertilizers and validated the methods with data from 21 published field studies. They incorporated these manure and fertilizer P runoff loss methods into an annual, field-scale P loss quantification tool that estimates dissolved and particulate P loss in runoff from soil, manure, fertilizer, and eroded sediment. They validated the P loss tool using independent data from 28 studies that monitored P loss in runoff from a variety of agricultural land uses for at least 1 year. Results from this study demonstrated that it was possible to reliably quantify annual dissolved, sediment, and total P loss in runoff using relatively simple methods and readily available inputs. However, estimates of runoff and erosion are still needed that are accurate to a level appropriate for the intended use of the quantification tool.

Osmond et al. (2012) compared measured P runoff losses from prior edge-of-field studies to PSI scores for twelve southern states. The objectives were (i) to ascertain if measured P losses and PSI ratings and values were similar and (ii) to compare the PSIs for uniformity. A total of 34 different source, transport, and other factors are contained in the PSIs used in this study. Six previously published data sets from AL, AR, GA, MS, and OK were used to evaluate the PSIs. Input data for the 34 PSI factors had to be determined either directly from published papers or field study, or were assumed. PSI numeric values for each state were correlated with annual total P (TP) and dissolved P (DP) loads from the published data set, using linear regression procedures. Moderate to very strong relationships ( $r^2$  of 0.50 to 0.97) existed for five indices (AR, FL, GA, NC, and SC), and all but two indices were directionally correct. PSIs from TX, LA, TN, and AL had lower or much lower  $r^2$  values (0.40, 0.21, 0.13, and 0.09 respectively). There was no relationship between measured TP loss and PSI values for Mississippi. Measured DP was also regressed against PSI values. Five states (AR, FL, NC, GA, SC) had  $r^2$  greater than 0.50, with moderate to very strong ( $r^2$  of 0.55 to 0.95) relationships. There was very low to no relatedness between PSI ratings and measured DP loss for AL, LA, MS, TN, and TX. Directionally, the relationship for measured DP was negative for the Alabama PSI.

Sharpley et al. (2001) evaluated both a soil P threshold and components of a PSI by comparing site vulnerability estimates derived from these two approaches with measured runoff P losses in an agricultural watershed in PA. Rainfall-surface runoff simulations were conducted on 57 sites representing the full range of STP concentrations and management conditions found in the watershed. For sites that had not received P additions for at least six months prior to the study, Mehlich-3 P concentration was strongly associated with dissolved P concentrations ( $r^2 = 0.86$ ) and losses ( $r^2 = 0.83$ ) in surface runoff, as well as with total P concentration ( $r^2 = 0.80$ ) and loss ( $r^2 = 0.74$ ). However, Mehlich-3 P alone was poorly correlated with runoff P from sites receiving manure within three weeks prior to rainfall. The PSI effectively described 88 and 83% of the variability in dissolved P concentrations and losses from all sites in the watershed, and PSI ratings exhibited strong associations with total P concentrations ( $r^2 = 0.81$ ) and losses  $r^2 = 0.79$ ). When site-specific observations were extrapolated to all fields in the watershed, management recommendations derived from a PSI approach were less restrictive than those derived from the soil P threshold approach, better reflecting the low P loads exported from the watershed.

Veith et al. (2005) set out to show that the PSI can provide a simple assessment with a few, easily obtained inputs by comparing the PSI's portrayal of a watershed with that of SWAT (Soil and Water Assessment Tool) and observed data. They compared measured losses of P from the outlet of a 39.5 ha mixed land use watershed (FD-36) in south-central PA with watershed-level losses predicted by SWAT. Note that this is the same watershed used by Sharpley et al. (2001). Measured watershed exports of dissolved P ( $0.06 \text{ kg ha}^{-1}$ ) and total P ( $0.24 \text{ kg ha}^{-1}$ ) during the 7-month sampling period were similar in magnitude to SWAT-predicted losses ( $0.05$  and  $0.73 \text{ kg ha}^{-1}$ , respectively). Additionally, the study compared field-level P losses predicted by SWAT with field-level vulnerabilities to P loss derived by the PSI. The PSI and SWAT categorized 73% of the 22 fields similarly in terms of vulnerability to P loss, with Pearson correlation significant at  $p = 0.07$ ; all except one of the remaining six fields were over- or under-predicted by a single risk category. Results indicate that while actual P loss from FD-36 was small, three fields contributed a major proportion of this loss. Additionally, this study suggests that the PSI can provide land managers with a reliable assessment of where P loss occurs within a watershed, thus allowing more effective placement and selection of conservation practices, which lead toward improved downstream water quality. Figure 8 has been adapted from Figure 3 of Veith et al (2005), which relates PSI ratings (Low, Medium, etc.) to SWAT total P concentrations.

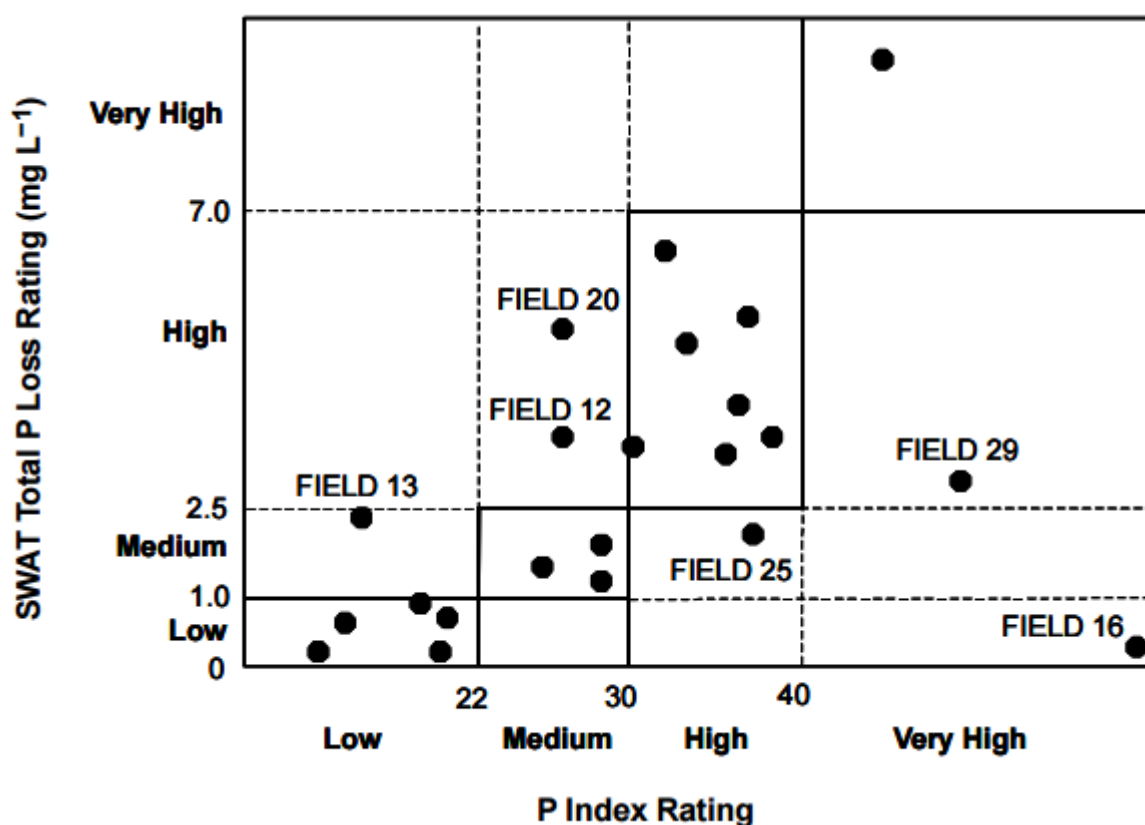


Figure 8 Adapted from Vieth et al., 2005 Figure 3. Correlation between PA P index and SWAT vulnerability ratings.

The Panel concluded that the most of the published research data was insufficient to make a quantitative estimate of the relationship between PSI scores and P loads but the Panel did conclude that a first-draft estimate could be provided from Figure 3 of Vieth et al (2005) (Figure 8). This relationship should be used with caution, however, because it is variable and the relationship will also depend on study conditions and the structure of each individual state's PSI. The Panelists concluded with a consensus BPJ that PSI efficiency values would be derived from Figure 3 of Veith et al. (2005), which produced an estimated P loss reduction. The Panel used that figure to derive a P loss reduction of 35 percent, which is the difference between P losses in PSI "High" and "Medium" ratings. This 35% estimate was used as the final "literature value" starting point, as shown in Table

7. There are several detailed points of emphasis, or caveats, that the Panel discussed in deriving their consensus BPJ efficiency value, based on Veith et al. (2005), specifically:

- The PSI is designed to reduce delivery of P to surface waters, so STP levels may or may not be reduced. It is possible to have high STP and low P delivery.
- The PSI is required on only a fraction of lands receiving manure or biosolids. In PA, for example, the PSI is required on only about 20 percent of such lands.
- Changes in nutrient and land management are only required on a portion of those lands for which the PSI is applied. The two basic, and most common, scenarios are:
  - Farms running PSI but at low-risk levels: they are already doing things to keep P from water even if they don't have to make any changes.
  - Farms running PSI with higher-risk levels: they have to make a change so there is some benefit. The benefit of PSI application may be derived primarily from these farms (~20 percent of acreage).
- Movement of manure from acres where the PSI is applied to other acres as a result of required management on PSI acres.
- The uncertainty in the relationship between PSI scores and measured loads as reported by Osmond et al. (2012).
- Lag time between PSI application and environmental results.
- Limitations of using the data, which came from a single, small watershed (Veith et al. 2005).

### ***Setbacks***

The Panel analyzed farm planning data from PA to develop a representative farm, with respect to an approximately average length of stream running through crop and hayland fields where manure would typically be applied. This process resulted in an estimated average of 2,776 ft of stream running through a representative 100-acre dairy farm. Assumptions about the width of required setbacks (35 and 100 ft) and cases where a setback was required only on one side of a stream due to property lines, roads, etc., yielded an estimated total of 8 acres of field area covered under setback restrictions.

The Panel had hoped to estimate loss reductions resulting from this level of setback restriction by using the CBPWM. The simple approach would be to apply the P load expected from non-manured fields to the buffer area and the load expected from manured fields to the non-buffered area, using this same proportion (i.e., 8/100). The modeling result would yield an estimated reduction resulting from application of the setback requirement. It should be noted that because of strong nutrient management plan requirements, the setback restrictions on manure application would not increase the application rate on non-setback field areas, but would require export of the excess manure from the field. This modeling could not be performed, however, due to time constraints and model limitations, so the efficiency of setbacks was not factored into the overall Tier 2 P efficiency. The exclusion of setback efficiency contributes to the overall conservative nature of the P reduction credit recommended for Tier 2 implementation.

### ***Recommendations for Tier 2P FLNAM***

It is important to note that the Panel was made sufficiently aware of the existing framework of the Phase 5.3.2 CBPWM and how it includes a method for crediting conservation tillage practices on landuses that are eligible for Tier 2 credit. The Panel determined that the benefits of this component BMP were of sufficient value to surpass the value of conservation tillage and should be applied to that landuse. In addition, the incorporation of manure is not required for a plan that achieves credit, nor does it always result in fields that cannot qualify for conservation tillage. The costs and benefits to the environment are always weighed in a Tier 2 plan and the recommendation efficiency implicitly incorporates best professional judgement into its adjustment calculations from research values for these instances. Additionally, the application of this BMP component in NMPs did not exist until after the calibration period (see Figure 1). The benefit of this BMP was therefore never before

captured properly in the Phase 5.3.2 Chesapeake Bay Watershed Model calibration and is, in fact, a BMP that should be separately and distinctly credited.

These data-derived estimates informed discussions among Panel members, who used the following BPJ-based general approach described below (*Synthesis of Tier 2 and 3 Component Efficiencies into Overall Tier 2 and 3 Efficiencies*) to develop credits for N reduction for the Tier 2 Field Level Nutrient Application Management BMP:

- Data points were adjusted to account for scaling effects, crops within the landuse and management factors.
- Setback values were not considered in the calculation explicitly, but by exclusion contribute conservativeness.
- The panel did not use manure incorporation efficiency estimates in the derivation of the final Tier 2P efficiency recommendation, but we note that the adjusted manure incorporation values would average out to an efficiency very close to the final PSI-based recommendation.
- The PSI adjusted efficiency (6.6%) was chosen to be representative of Tier 2 P, including all the components considered.

### **3.3.4. Tier 3 N**

#### ***Adaptive N Management***

N reductions for Tier 3 (ANM) were assigned based on application of any one of five practices, collectively referred to as Adaptive N Management. The Tier 3 Adaptive N Management BMP includes a choice of four practices designed to manage N fertilizer application rates specifically to crop and/or field conditions with the goals of avoiding unnecessary N applications, minimizing N remaining in the soil after harvest, and reducing the risk of runoff and/or leaching of residual N.

Options under Adaptive N Management include four mid-season soil or plant tissue tests: Pre-sidedress Soil Nitrate Test (PSNT), Corn Stalk Nitrate Test (CSNT), Illinois Soil Nitrogen Test (ISNT), and Fall Soil Nitrate Test (FSNT). Effective application of these practices requires that producers conduct the tests, then manage N fertilizer applications based on the test results so that excess N is not added where no yield response would be expected. Annual N fertilizer application rates are typically reduced through following recommendations based on test results.

The fifth component of Adaptive N Management is variable rate (VR) N fertilizer application. VR application adjusts fertilizer rates at a sub-field level, tailoring N application rates to varying needs in different parts of a crop field. VR application puts N fertilizer where it is needed to support yield goals and avoids placing excess fertilizer where crop growth would be unresponsive to additional N.

Individually, each of the five practices has limited applicability. The soil/plant tissue tests apply only to corn production and generate benefits only where testing shows the field to be non-responsive to standard N rate recommendations. VR fertilizer application would only generate benefits where there is a high degree of variability in N and soil conditions that affect crop yield significantly; fields with relatively homogeneous N requirements will not benefit. Under Adaptive N Management, cropland would receive BMP efficiency credit if the producer carried out any one of the four options as the basis for adjusting N fertilizer application.

The sections below describe derivation of Tier 3 N reduction efficiencies separately for each of the five practices.

#### **Pre-Sidedress Soil Nitrate Test (PSNT)**

The PSNT measures the soil NO<sub>3</sub>-N concentration in the surface 30 cm of soil when the corn is 20 to 30 cm tall. The PSNT monitors the spring accumulation of soil NO<sub>3</sub>-N, just before the warm-season corn crop begins its



period of rapid N uptake (Meisinger et al. 2008a). The PSNT is most often used to identify N sufficient sites (i.e., sites that do not need additional sidedress N). Some states use the PSNT to estimate the quantity of additional corn fertilizer N needed, although this quantitative use of the PSNT has met with varied success.

Extensive evaluation of the PSNT within the Chesapeake Bay watershed (Evanylo and Alley 1997, Klausner et al. 1993, Meisinger et al. 1992, Roth et al. 1992, Sims et al. 1995) has conclusively shown that the PSNT can successfully identify N sufficient sites. The PSNT is especially useful on soils that have been manured, or have a history of manure applications. On manured soils, the PSNT can serve to monitor the traditional estimates of plant available N from manure with ample time to make adjustments in sidedress fertilizer N applications, including the environmentally important adjustment of no additional fertilizer N needed.

Three peer-reviewed studies relevant to the Chesapeake Bay watershed have shown that application of the PSNT can provide significant environmental benefits. A three-year study on a manured silt-loam soil in Vermont by Durieux et al. (1995) reported that use of the PSNT gave an average reduction in fall residual  $\text{NO}_3\text{-N}$  of 56% compared to N applications based on traditional university N recommendations based on expected yield and manure credits. In Connecticut, Guillard et al. (1999) carried out a two-year lysimeter study on a sandy-loam soil that demonstrated an average reduction in  $\text{NO}_3\text{-N}$  leaching of 63%, compared to corn fertilized according to university recommendations. And in New York, a two-year study on a loamy-sand soil that monitored tile drainage from silage corn beneath large (18 m<sup>2</sup>) isolated plots (Sogbedji et al. 2000) reported an average reduction in  $\text{NO}_3\text{-N}$  losses of 42% for the PSNT treatment, compared to the non-PSNT university recommendation. Averaging the results of these three studies gives an estimated 54% reduction in the environmental variables of fall residual  $\text{NO}_3\text{-N}$  or  $\text{NO}_3\text{-N}$  leaching, which arose from an average 32% reduction in fertilizer N applications resulting from implementing the PSNT.

Application of these research-study based reductions in N application or losses must be tempered by consideration of the baseline condition, or starting point. All of the research studies cited above based their results on controls that were well-fertilized. Variability of conditions across the Chesapeake Bay watershed suggests that the highest reductions cited will not be universally achieved.

The Maryland and Virginia Nutrient Management Programs also provided important PSNT implementation data for estimating a PSNT N-reduction efficiency. These data originated from quarterly or annual reports from in-field nutrient management consultants that summarized PSNT activities and results in Maryland (Pers. Comm., Steinhilber 2015) and Virginia (Pers. Comm., Sexton and Am. Farmland Trust 2015). The Maryland summaries covered three years, which covered a total of 2,690 acres from the Piedmont and 27,850 acres from the Coastal Plain. The average estimated reduction in fertilizer N from implementing the PSNT, compared to using university recommendations without the PSNT, in Maryland's Piedmont region was 20%, while the corresponding value for the Coastal Plain region was 6%. The Maryland Coastal Plain region had a significantly lower reduction than the Piedmont because the Coastal Plain was reasoned to have more coarse-textured soils (leading to easier losses of  $\text{NO}_3\text{-N}$  before PSNT sampling) and use of more easily degraded poultry manure (leading to lower residual effects from manure) than the Piedmont region. A large 5,325 acre evaluation of the PSNT was also conducted in Virginia's Shenandoah Valley consisting of 1,246 PSNT tests that compared university recommendations with and without the PSNT. The Virginia results showed that use of the PSNT resulted in an estimated average savings of 30 lb N/ac on 29% of the tests and a savings of 60 lb N/ac on another 28% of the tests, with the remaining 43% of the tests having PSNT values that recommended the usual 150 lb N/ac. The average percent reduction of fertilizer N across the Virginia Piedmont study was 17%, which is consistent with the Maryland Piedmont estimate.

The above fertilizer N Reduction estimates were averaged across the three research studies and the two Piedmont region PSNT in-field evaluations, which produced a numeric estimate of 27% for the Piedmont, with a corresponding estimate of 8% for the Coastal Plain.

**Corn Stalk Nitrate Test (CSNT)**

The CSNT is a plant-tissue test that reflects N availability during the growing season. CSNT results are most useful when evaluated over a period of several years on the same field and can be used to make refined field-specific N application recommendations relative to standard university recommendations and farm-level nutrient management. Application of the CSNT as a BMP requires sampling on corn fields (2 years or more after sod) for at least two consecutive years and adjustment of N rates based on test results.

Most data are from yield response/calibration studies with a range of N rates and CSNT measurements. The studies report or project changes in N application rates based on active management of CSNT results. In New York, results reported by Ketterings et al. (2014, 2011a, 2011b), Wharton et al. (2010), and Hong et al. (2010) suggest that about 40% of tested corn silage fields were rated in the excess category and following the recommendations of the CSNT would result in a 20 – 30% reduction in N application (extending the percent of fields in the excess category across all corn fields). Emerging analyses not yet in press summarize the end-of-season residual soil nitrate across treatments. One yield response study with 6 N rate treatments and 4 replications on a high producing valley soil was performed in 2014 in Delaware County, NY. The results show a significant and linear increase in end-of-season nitrate for treatments with CSNT values in the excess category. The site had a history of yields higher than the LGU guidelines, so given the guidelines (similarly, NRCS 590 Standard) and higher documented yields, the recommended rate was 150 lbs N/acre for this site. The 150 lbs N/acre rate resulted in 20 ppm end-of-season soil NO<sub>3</sub>-N and a CSNT value in the excessive category. Using adaptive management via the CSNT to reduce rates conservatively to the next lower rate treatment (100 lbs N/acre in this case) would have reduced end-of-season NO<sub>3</sub>-N to 11 ppm or a 45% reduction without a yield reduction. Results indicate even lower rates did not impact yield. Prior studies clearly show residual NO<sub>3</sub>-N is lost from the soil profile before the next growing season if not utilized by a growing crop after corn harvest, so all residual NO<sub>3</sub>-N is presumed lost.

Results from the Midwest are consistent with those reported within the Chesapeake Bay watershed. In Iowa, Kyveryga et al. (2010) reported that of 215 fields receiving liquid swine manure, about 30% of fields were found to be unresponsive to additional N (beyond 25 lb N/ac starter) by multiple years of CSNT sampling. If extending this percentage over all silage corn fields under CSNT, following recommendations derived from CSNT would result in 15 – 30 lb N/ac application reduction annually, representing a 20 – 30% reduction over standard rate recommendations. Using the same logic, results reported by Yost et al. (2014) in Iowa and Minnesota suggest a 6 – 8% reduction in N application under CSNT.

**Illinois Soil Nitrogen Test (ISNT)**

The ISNT is a soil test tool used to make field-specific assessments of in-field N supply in order to fine-tune N applications relative to standard university recommendations and farm-level nutrient management. Successful application of the ISNT requires field sampling every 2 years and adjustment of N application rates based on test results.

There are, however, no research results at the time of this report signaling changes in N losses from cropland managed with the ISNT; data are limited to reported or projected changes in N application rates based on soil testing. Results of multi-year N rate trials on silage corn in New York over three crop years showed that about 50% of tested fields were non-responsive to additional N fertilizer (other than starter N at 25 lb N/ac), i.e., no additional N is required (Lawrence et al. 2009, Klapwyk et al. 2006, Lawrence et al. 2008, Ketterings et al. 2009). Because these fields would otherwise have received a recommended 75 – 125 lb N/ac, managing N applications based on the ISNT results would reduce N applications on the affected fields by 50 – 100 lb N/ac. Discounting this reduction because only 50% of corn silage fields were determined to be non-responsive by ISNT gives an estimated 25 – 50 lb N/ac reduction in N applications to silage corn, a reduction of 33 – 40% in N applications. Considering data from the CSNT yield response/calibration study, above, an initial linkage can be made to end-of-season NO<sub>3</sub>-N and ISNT levels. Because the ISNT sheds light on fields unresponsive to N, if not performed and used to alter rates, N will be added to fields unnecessarily and lead to higher levels of end-of-

season  $\text{NO}_3\text{-N}$  than those managed according to ISNT findings. Conservatively, such over-applications and associated soil  $\text{NO}_3\text{-N}$  levels would be similar to (if not greater than) those found in the CSNT study above, conservatively comparing the 150 lbs N/acre rate and its 20 ppm  $\text{NO}_3\text{-N}$  residual to the adaptive 100 lbs N/acre rate and its 11 ppm  $\text{NO}_3\text{-N}$  residual. Based on standard assumptions of soil density and depth of soil  $\text{NO}_3\text{-N}$  testing, a reduction of 9 ppm  $\text{NO}_3\text{-N}$  residual gives an efficiency of ~33%.

### **Fall Soil Nitrate Test (FSNT)**

The fall soil nitrate test measures the  $\text{NO}_3\text{-N}$  concentration in the surface soil after a corn crop, before winter small grains are planted, to determine if the small grains need starter-N (Forrestal et al. 2014). Winter small grains commonly follow corn, which is known for leaving highly variable quantities of residual nitrate, with high residual-N common after drought years or in soils with a history of manure applications (Scharf and Alley 1994, Forrestal et al. 2012). The FSNT provides an adaptive management tool for simultaneously improving economic production of small grains by identifying sites where small grains need starter-N, and also reducing nitrate-N loss to groundwater by not fertilizing N sufficient sites just before the fall-winter-spring water-recharge season when most nitrate leaching occurs (Forrestal et al. 2014, Meisinger et al. 2015). The test was first practiced in Virginia (Alley et al. 2009) and has been recently deployed in Maryland (Maryland Coop. Ext. 2009).

The N reduction efficiency was estimated from four years of lysimeter nitrate-N leaching data (Pers. comm., J. Meisinger 2015) using the intact soil-column lysimeter described in Palmer et al. (2011) and following the sample collection and analysis methods described in Meisinger et al. (2015). The lysimeter treatments were replicated twice each year with winter wheat receiving either a starter-N application of 30 lbs N/ac or no starter-N. Lysimeter drainage monitored  $\text{NO}_3\text{-N}$  leaching continuously between planting and the “green-up” development stage (usually occurs the first week of March). These treatments were repeated in 1997-98, 1998-99, 1999-2000, and 2009-2010 wheat growing seasons. The four-year average difference between the starter-N vs. no starter-N treatments was 15% of the fall starter-N applied. However, this series of years included two high rainfall growing seasons (including one “El Niño” winter) and two dry seasons, which required adjustment to an average winter condition. The winter rainfall adjustment was based on the average 140-year Baltimore rainfall record for the same winter months, which amounted to a discount of about 33% since the 140-year average was below the four-year average of the lysimeter studies. The final lysimeter-based N reduction efficiency was estimated to be 10%.

### **Variable Rate N Application**

Using unpublished data from studies conducted throughout Virginia, the Panel compared N application rates to corn for the Virginia Tech Corn Algorithm (VTCA) applied via the GreenSeeker<sup>®</sup> system versus the standard farmer’s N rate methods. Over 15 sites in 4 years, the average VTCA N rate was 24 kg/ha (~20 percent) less than the standard farmer’s rate, with no significant difference in grain yields. Additionally, data from field scale demonstrations from a total of 1600 acres over two years demonstrated a 10.4% decrease in N rate applied with no difference in corn yields (Virginia NRCS CIG 69-33A7-1131, final report). These data demonstrate the ability to reduce N application rates while maintaining crop yields. Other Virginia data for wheat (Thomason et al. 2011 and Virginia NRCS CIG 69-33A7-1131, final report) suggest that N rates for wheat could be decreased by ~7 percent with no change in yield.

### **Future options for Adaptive N Management**

Increasingly sophisticated tools for improved N management are under development and may become available in the foreseeable future. [Adapt-N](#) is a computer tool designed to fine-tune sidedress N applications for corn based on weather data and field-specific user inputs. Adapt-N requires annual field characterization and early summer monitoring to guide sidedress N applications and, as with other testing programs, requires adjustment of N rates based on model results.

Reported results of the use of Adapt-N are limited to simulations based on strip trials on New York and Iowa cropland (Moebius-Clune et al. 2011, 2012, 2013, 2014) where grower rates were compared to Adapt-N guided rates. Application of Adapt-N in New York resulted in a 52 lb N/ac decrease in N fertilizer application relative to growers' planned rates. This change gave a simulated reduction of N total loss of 36 lb N/ac, which included a simulated N leaching loss reduction of 11 lb N/ac. Yields were not significantly affected by the change in N rates recommended by Adapt-N.

However, ongoing work in the Midwest has not confirmed the effectiveness of Adapt-N. The Panel concludes that this procedure is in the developmental stage and is not ready for crediting in the Phase 5.3.2 CBPWM. The Panel recommends that the practice be revisited for Phase 6.0 when additional data may be available.

### ***Recommendations for Tier 3N: Adaptive N Management***

These data-derived estimates informed discussions among Panel members, who used the following BPJ-based general approach described below (*Synthesis of Tier 2 and 3 Component Efficiencies into Overall Tier 2 and 3 Efficiencies*) to develop credits for N reduction for the Tier 3 Adaptive N management BMP:

- Each literature document yielded one data point for the Tier 3 estimate.
- Data points were adjusted to account for scaling effects, crops within the landuse and management factors.
- Adjusted data points were averaged for across the tier for an overall efficiency of 2.8 percent.

It should be noted that in many cases, research has shown that the percentage reduction in environmental metrics of N loss (e.g., residual  $\text{NO}_3\text{-N}$  or  $\text{NO}_3\text{-N}$  leaching) are often greater than the percentage reduction in fertilizer N applied. This is because the environmental-variable reductions are greatly affected by the amount of N added beyond crop need, while the fertilizer-N reductions are less affected because the majority of the fertilizer N added goes into meeting crop N requirements that have small environmental losses. Thus, use of the PSNT and other tests in this BMP that emphasize reducing excess-N additions will have a greater impact on N loss variables compared to their percentage impact on total fertilizer applications. Thus, the focus on reductions in fertilizer N applications cited for the practices in this report generally represent conservative estimates of BMP efficiency.

### **3.3.5. Tier 3 P**

The Panel did not estimate ANM effectiveness for P because of time constraints. The Panel recommends that Tier 3 P efficiencies will be developed for the Partnership's Phase 6 Chesapeake Bay Watershed Model. The Panel did, however, discuss Whole Farm Nutrient Balance as a potential component practice for Tier 3 P. That discussion is captured below to inform future consideration of this practice for Phase 6. There was also discussion about variable rate application of P as another component. However, this practice is just gaining traction in the Bay Watershed and its impact will be slight until there is more adoption of the practice. It tends to drive down P application rates by reducing or eliminating applications where STP is already very high within a field due to uneven applications or uneven uptake of P in the past. It has been tabled from quantifying its effect until Phase 6.

### ***Tier 3 P: Whole Farm Nutrient Balance***

In the long term, achieving a balance between nutrient imports and exports at the whole farm level (and later at the watershed level) is believed to be an effective way to minimize nutrient surpluses, manage soil nutrient levels, and reduce runoff and leaching losses. For livestock farms, the whole farm nutrient balance approach has been invaluable in identifying opportunities for reducing N and P imports, making better use of on-farm nutrient sources, identifying the need for more land for nutrient recycling, and increasing nutrient exports. As shown over several years of research on 54 New York dairy farms, nutrient balance reductions averaged 29% for N and 36% for P (Soberon et al. 2015, Cela et al. 2014a and 2014b).

However, the observed reductions are attributable primarily to changes in feed formulation and management, rather than fertilizer management. Because the Phase 5.3.2 Chesapeake Bay Watershed Model includes a separate BMP for feed management, the Panel recommends that the benefits of whole farm nutrient balance are likely to be better captured in the feed management BMP in the Phase 5.3 model. The concept could be revisited for Phase 6 under adaptive N and P management, especially if definitions of the feed management BMP change in the future. The Whole Farm Nutrient Balance approach also may be relevant for Phase 6 to better account for nutrient loss reductions from manure transfer to lower risk fields/areas within a county, as the current approach only recognizes manure transfers from one county to another.

#### **Recommendations for Whole Farm Nutrient Balance**

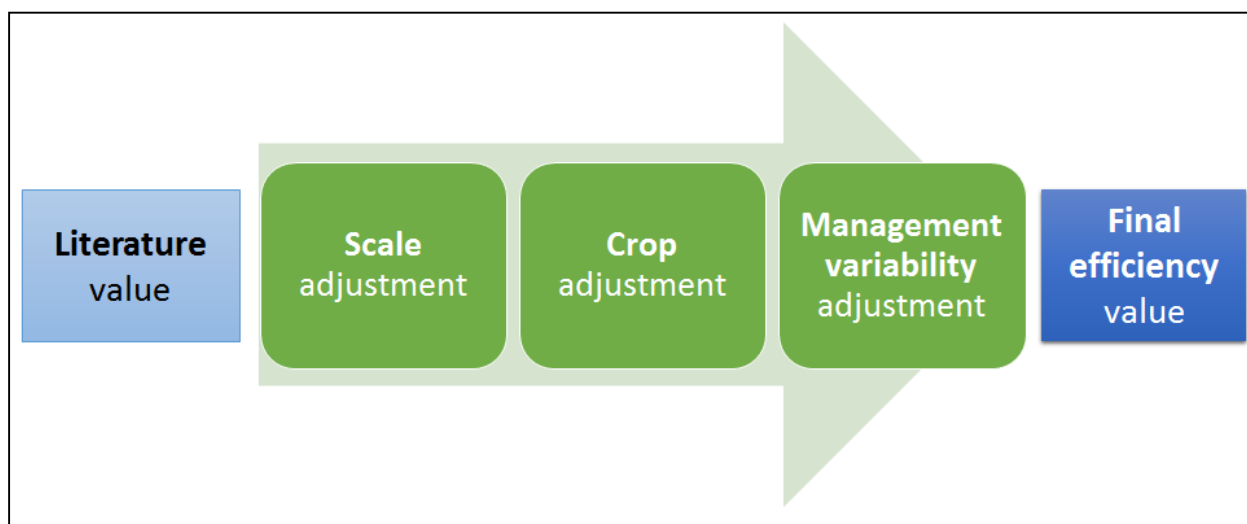
Whole Farm Nutrient Balance should not be included as a BMP for Phase 5.3.2 because its main effects are captured by a feed management BMP already included in the existing Chesapeake Bay Watershed Model. The Whole Farm Nutrient Balance BMP should be considered in the Phase 6 Chesapeake Bay Watershed Model, potentially as a way to account for manure transfers within county boundaries.

### **3.3.6. Synthesis of Tier 2 and 3 Component Efficiencies into Overall Tier 2 and 3 Efficiencies**

Based on review and interpretation of relevant literature, the Panel developed literature values for N and P reduction efficiencies for individual NM BMP components. These literature values typically represented the weighted mean of values from trials or data years reported in the papers cited. The panel members believe that it is advisable to adjust these literature values derived under controlled research conditions according to the following three real-world factors:

- **Scale** – Most of the work reported was conducted at the plot scale. Based on conventions adopted by other BMP expert panels and on professional judgment, the Panel decided to use 75 percent of the literature value to extrapolate from plot scale to field or watershed scale. This is the same scaling factor used by the Phase 5 cover crop expert BMP panel that was approved by the Chesapeake Bay Program Partnership in November 2014 ([Cover Crop Expert Panel, 2014](#)).
- **Land use/crop** – Some practices were reported in the literature only for a specific land use or crop type; other practices (e.g., the PSNT) apply only to a single crop (e.g., corn). Therefore, the Panel decided to multiply the literature values by the proportion of the total eligible land in the Chesapeake Bay watershed that is covered by the crop in question. This adjustment factor ranged from 15 percent for wheat to 70 percent for hay not including legumes or mixtures.
- **Management variability** – It was necessary to make further corrections to literature values based on certain limitations of the research data and model. Many research efforts, for example, reported changes in application rates as the response metric for a treatment like mid-season nitrate testing; it was necessary to estimate a loss reduction in response to this change in N application rate. Similarly, some research data were derived from results from a few runoff events rather than a full year of monitoring. While not explicitly listed in Table 7, model considerations like nutrient timing, interactive effects of landuses with the concepts of incorporation and the manure spread sequence of the Phase 5.3.2 CBPWM are contributing to the factor. The Panel applied BPJ to apply discount factors to adjust for these issues. The adjustment factors ranged from 20 percent for data from a few runoff events to 80 percent for model considerations, probable variability of implementation, and lag in response to application of the PSI.

The process used to adjust literature-derived effectiveness estimates is illustrated in Figure 9.



**Figure 9. Schematic of the process of adjusting a literature value to account for scaling up from plot scale, practice applicability to specific crop(s), and Panel best professional judgement on application to real world conditions.**

As shown in Table 7, the adjustment factors were applied in series to the starting literature values to arrive at proposed efficiency values. For the CSNT, for example, an average literature value of 20 percent reduction in N application rate was adjusted by 75 percent for scale effects, 51 percent for the proportion of the Chesapeake Bay watershed cropland in corn, and 40 percent to apply conservatism to the result in the CSNT affecting change in management of the subsequent crop (notice: 50% was chosen for the ISNT to account for a BPJ increase in confidence behind a change in management resulting from the test). This calculation results in a proposed N loss efficiency value of 3.0 percent for application of the CSNT.

Recommendations on tier efficiencies were calculated as follows:

### ***Tier 2 N***

- HYW was calculation driven, in absence of published data. Half of the average of the N timing data points for row crops was used as the starting point (i.e.,  $\frac{1}{2} (X_{i1} + X_{i2} + X_{i3})/3$ ). The same scale factor was applied for consistency. A crop adjustment to exclude acres of legumes from Ag Census was applied. The same management factor from row crop papers was applied resulting in a final efficiency of 2.8 percent (i.e.,  $\frac{1}{2}X_{i \text{ avg}} \rightarrow \text{adjustments} \rightarrow \text{final efficiency}$ ).
- Row crop (HWM, LWM) efficiency was calculated from the mean of the N-timing papers after appropriate adjustments added to the adjusted value for manure incorporation ( $Y_{fi}$ ).
  - Adjusted data points for N timing ( $X_f$ ) were utilized as a mean that contributed in an additive way to the Manure Incorporation adjusted value for the row crop efficiency of 4.4 percent (i.e.,  $(X_{f1} + X_{f2} + X_{f3})/3 + Y_{fi}$ ).

### ***Tier 2 P***

- The efficiency for row crop and hay with nutrients landuses was chosen from the adjusted value for the P risk assessment. This value was verified by the adjusted average of manure incorporation P credit for defensibility. Since manure incorporation is one of many elements of the P risk assessment tools, the panel judged that 6.6 percent efficiency was justified compared to the average 5.5 percent average P savings from implementing manure incorporation alone. Considering additional elements like setbacks and further reduction of rates an efficiency slightly above

**Tier 3 N**

- The scale and crop adjustments for the nitrogen tests and variable rate were consistent with the other tools.
- Management variability factors were assigned for the BPJ issue identified and can vary across issue based on factors of soil leaching potential and/or a difference in likelihood that the test result would change management in the course of the nutrient management plan.
- The efficiency for this tier, 2.8 percent, is the mean of the components' adjusted effectiveness estimate.

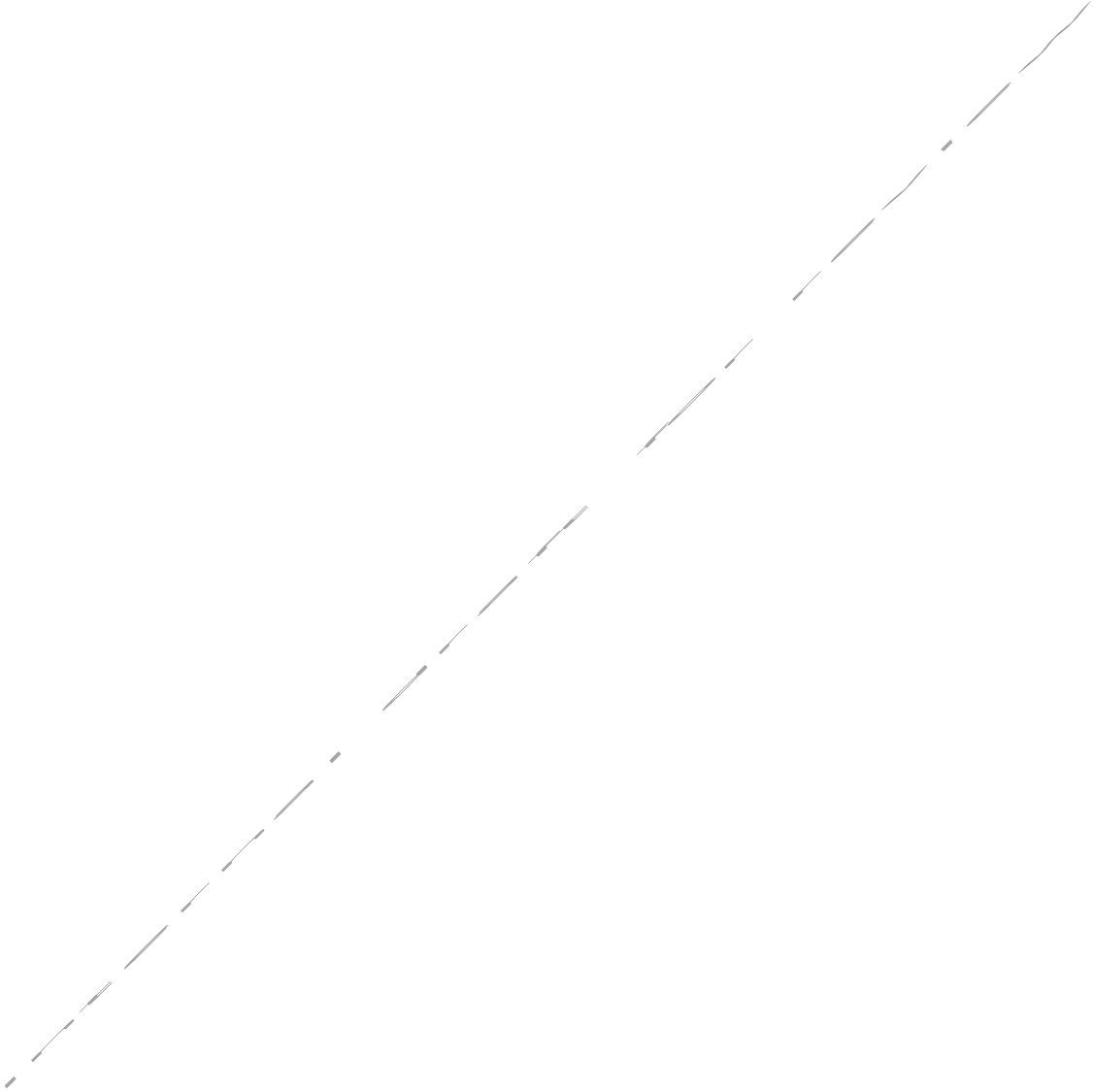


Table 7. Nutrient reduction credits for each Tier component, adjustment factors applied, and final Tier credit recommendations

Tier	Component	Geography	Literature value	Research scale	Scaling adjustment	Relevant crops	Land use/crop adjustment	Model Considerations and Mgt. Variability adjustment	Mgt. Variability adjustment	Adjusted efficiency	Tier credit
Tier 2 N	N timing	Coastal Plain	15.6%	plot	75%	Corn	51%	Impl. scheduling challenges	80%	4.7%	<b>Row Crop: 4.4%</b>
		Piedmont	8.9%	plot	75%	Corn	51%	Impl. scheduling challenges	80%	2.7%	
		All	14.9%	plot	75%	Small grains	15%	Impl. scheduling challenges	80%	1.4%	
	N timing – ½ Avg for hay	Hay with nutrients landuse	6.6%	plot	75%	Non-legumes	70%	Impl. scheduling challenges	80%	<b>2.8%</b>	<b>Hay w/ nutr.: 2.8%</b>
	Manure incorporation <sup>1</sup>		10%	plot	75%	Corn, small grains	66%	N savings → N loss	30%	1.5%	
	Enhanced efficiency fertilizers (deferred)										
Tier 2 P	Manure incorporation	Appl./R&V	0%	plot	75%	Corn, small grains	66%	Simulated storm effect	20%	0%	<b>6.6%</b>
		Piedmont	46%	plot	75%	Corn, small grains	66%	Simulated storm effect	20%	4.6%	
		Coastal Plain	48%	plot	75%	Corn, small grains	66%	Simulated storm effect	50%	11.9%	
	P Site Index	All	35%	farm	75%	All crops	100%	Model value, response lag, effect on farm P budget	25%	<b>6.6%</b>	
	Setbacks (deferred)										
Tier 3 N	PSNT	Coastal Plain	8.1%	plot	75%	Corn	51%	N savings → N loss	60%	1.8%	<b>2.8%</b>
		Piedmont	26.6%	plot	75%	Corn	51%	N savings → N loss	40%	4.0%	
	CSNT	All	20%	plot	75%	Corn	51%	Results inform future decision	40%	3.0%	
	ISNT	All	33%	plot	75%	Corn	51%	Results inform future decision	50%	6.3%	
	FSNT	All	10%	plot	75%	Small grains	15%		80%	0.9%	
	Variable rate N fertilizer	All	10%	plot	75%	Corn	51%		80%	3%	
		All	5%	plot	75%	Wheat	15%		80%	0.5%	
	Adapt-N (deferred)										
Tier 3 P	Variable rate P fertilizer (deferred)										
	Whole farm P balance (deferred)										

<sup>1</sup> Ammonia credit was the driving force behind incorporation N savings, but calculation was in PAN. This is consistent with the N-timing elements.



### 3.3.7. Summary of Recommended Effectiveness Estimates

Table 8 summarizes the recommended benchmark values including the separate reduction effectiveness values for Tiers 1, 2 and 3, and the combined efficiencies that results from stacking tiers (see far right columns in Table 7). Table 8 also lists by current agricultural land uses in the Phase 5.3.2 Chesapeake Bay Watershed Model, the application of the Tier 1, 2 and 3 estimates, and the combined stackable Tier 2 and 3 reduction efficiencies. Based on the Panel's recommendation, manure eligible lands receive a higher reduction efficiency than other land uses in Tier 1 N and Tier 2 N. Effectiveness values for Tier 2 N and Tier 2 P have been included for the Hay with nutrients landuse and the Alfalfa landuse gets a Tier 2 P benefit for P risk assessed acres. High till without manure, pasture and nursery have also been excluded for Tier 2 credit due to a lack of data. Alfalfa was excluded for Tier 2 N because it is a leguminous landuses that fixes atmospheric N. Only row crops eligible for manure application were recommended for Tier 3 N credit because this is the only landuse with crops for which evidence existed these components were used across the watershed.

**Table 8. TN and TP Efficiency Values for all tiers, including the increases from Tier 1 to 2 and 2N to 3N referred to as "Benchmark"**

		High-Till with Manure	Low-Till with Manure	High-Till without Manure	Pasture	Hay with Nutrients	Alfalfa	Nursery
Tier 1 Reduction	TN	9.25	9.25	5	5	5	5	5
	TP	10	10	8	8	8	8	8
Tier 2 Benchmark	TN	4.4	4.4	N/A	N/A	2.8	N/A	N/A
	TP	6.6	6.6	N/A	N/A	6.6	6.6	N/A
Tier 3 Benchmark	TN	2.8	2.8	N/A	N/A	N/A	N/A	N/A
Tier 2 Reduction from no BMP	TN	13.24	13.24	N/A	N/A	7.6	N/A	N/A
	TP	15.94	15.94	N/A	N/A	14.07	14.07	N/A
Tier 3 Reduction from no BMP	TN	15.67	15.67	N/A	N/A	N/A	N/A	N/A

## 4 Review of Literature and Data Gaps

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The following subsections provide a general characterization of the literature that the Panel considered when developing efficiency values for all three nutrient management tiers. Section 3.4, *Justification for Effectiveness Estimates*, provides more detailed discussion of how data values from individual references influenced calculation of the recommended efficiencies for the Tier 2 and Tier 3 component practice.

### 4.1 Review of the Available Science for Tier 1

The Panel determined the results in the references to be sufficiently consistent to use as the basis for model runs to determine the proposed interim efficiencies. The Panel found the Coale (2000), Angle et al. (1993) and Ditsch et al. (1991) data to have consistent results. The Angle et al. (1993) results were slightly lower; however, the study mixed in other BMPs in a different season and therefore was expected to yield results in the magnitude and direction presented when compared to Coale (2000), Ditsch et al. (1991) and anecdotal summaries of Jemison and Fox (1994), van Es et al. (2002) and Sogbedji et al. (2000).

The following are considerations from all studies:

- Data for yield were higher than current CBPWM estimates.
- Results were multiyear and should reflect an average of this annual practice.
- Leaching or soil-test nitrate were evaluated as edge-of-field loss and this was compared to CBPWM edge-of-stream loss (consistent with efficiency estimates) based on BPJ.
- Unpublished data were given the same weight as peer-reviewed journal articles and dissertation data because this data was deemed as equally relevant and the consistency supported the reliability of the results.
- Literature was drawn from across the Chesapeake Bay watershed, extending from New York to Virginia.
- Literature values for fall soil N related to variable application rates were consistent among the different states.
- The [Tier 1 Report](#) summarizes and applies the findings.

### 4.2 Review of the Available Science for Tiers 2 and 3

Many factors common to data produced under controlled research conditions likely require adjustment of reported efficiencies before application to real-world settings in the Chesapeake Bay watershed. Many of those factors are common across different nutrients and different practices and some aspects of these issues are discussed below as generally applicable to interpreting the available science for the effectiveness of Tier 2 or Tier 3 component practices.

#### **Scale**

All but a very few reviewed studies were conducted at a plot scale. Plot size ranged from 0.2 m<sup>2</sup> packed-soil runoff boxes (e.g., Kleinman and Sharpley 2003, Kleinman et al. 2004) up to 3,000 m<sup>2</sup> field plots used by Geohring et al. (2001). Most plots were in the 2 – 100 m<sup>2</sup> range. Very few studies were done on a field scale (Staver 2004, Franklin et al. 2007, Al-wadaey et al. 2010, and Pote et al. 2011), and only a few papers reported work done at a watershed scale (Jaynes et al. 2004, Pote et al. 2011).

Plot studies are widely used to test innovative practices or to isolate individual influences in a controlled and replicated experiment. Researchers' control of important variables like manure type, application methods, timing of rainfall and ability to accurately measure outputs allows the comparison of multiple

alternatives in a much shorter time frame than in full-scale watershed or even field studies. It is generally accepted that well-designed plot studies are useful in comparing the relative effects of different treatments under controlled conditions. Many researchers believe that plot studies are necessary (but not sufficient) precursors to making specific recommendations for new management practices. Smith and Pappas (2010) supported the hypothesis that plot-scale research should be used to support management decisions to improve runoff water quality at the field scale.

However, absolute data from small plots cannot always be reliably extrapolated directly to field conditions. Small plots, for example, cannot reproduce flow processes that develop over long flow paths. Runoff volumes and runoff coefficients are almost always higher from small plots than from fields. Plot studies generally do not account for landscape position as plot runoff can be produced from virtually any landscape position, but in the real-world, runoff water does not always reach the field edge. Finally, there are constraints on what practices can be investigated on small runoff plots. Use of full-scale tillage equipment and other implements in applying treatments may be impossible unless runoff plots are created within larger land areas after treatments are applied. Kleinman et al. (2004) noted several significant issues in interpreting and extrapolating results from soil-box experiments to field plots, including large differences with regard to erosion and in P concentrations in runoff. Sharpley and Kleinman (2003) noted that P concentrations and loads change significantly with plot scales, although noting that processes governing dissolved and particulate P transport in overland flow are consistent.

### **Pathways of Nutrient Loss**

Most of the reviewed studies focus on N and P losses via surface runoff. Several papers report on leaching losses and some address volatilization. A few (e.g., Dell et al. 2012, Kleinman et al. 2009, and Lamba et al. 2013) examined more than one loss pathway. However, none of the reviewed studies accounted for total nutrient losses in all pathways, i.e., conducted a complete mass balance of nutrients applied vs. nutrients lost. This is perhaps a direct result of research dominated by short-term plot studies where only a single storm or a few storms are monitored using simulated rainfall. However, the incompleteness of the resulting conclusions has some important implications for how the efficiency values might be applied in the Chesapeake Bay watershed. Should efficiency values observed only for surface runoff be discounted because leaching and volatilization were not included in the calculation? Should efficiencies of some practices be adjusted or discounted because they may shift loss pathways (e.g., increasing N leaching while decreasing N volatilization)? For example, Powell et al. (2011) monitored  $\text{NH}_3\text{-N}$  emissions and  $\text{NO}_3\text{-N}$  leaching while comparing manure applications by surface broadcast, aerator incorporation, and injection and found that slurry application method can differentially impact pathways of slurry N loss, which could have different impacts on air and groundwater quality. The magnitude of tradeoffs in N loss among different pathways was also influenced by such factors as percent dry matter, rainfall, total ammonia N, pH, and air temperature. How can present and future versions of the model account for the perhaps shifting balance between surface, subsurface, and airborne nutrient losses? Although some of the efficiency values used in Tier 3 are at least partially based in reducing N volatilization losses, the Panel did not have sufficient time to address all aspects of loss pathways for this model phase, but performed as comprehensive an estimate of the pathways as possible in the component justification portions of Section 3.3 Justification for Effectiveness Estimates. These are important questions for the Panel to address in Phase 6.0.

### **Rainfall Simulation**

All but two of the plot studies of surface runoff reported employed simulated rainfall to generate runoff; Gangbazo et al. 1995 and Rotz et al. 2011 were exceptions. Rainfall simulator research offers significant advantages, including the ability to control the timing as well as the rate and duration of precipitation. When combined with a plot design, relative differences in runoff losses from multiple treatments or different storm intensities can be assessed quickly. Plot or field studies that rely on natural rainfall can

take many years to generate data from appropriate combinations of storm intensity/duration and treatment condition. However, questions of the comparability of simulated and natural rainfall and the need to generate data from long-term average and/or extreme real-world conditions, suggest a need for natural rainfall experiments in the long run.

Of particular concern among the literature reviewed for Tier 2 Nutrient Management is a difference in experimental protocols for generating runoff from simulated rainfall. There was of course some variation in the technology used or the rate of rainfall application in different studies conducted in different geographic areas on different soils and/or crops. However, a more fundamental – and potentially significant – difference was in the approach used to generate runoff to sample. Some studies applied simulated rainfall for a fixed period of time (e.g., 30 minutes), then measured and sampled runoff from all plots. This approach tends to mimic natural rainfall and integrate the effects of treatment (e.g., incorporation by tillage) on runoff generation and nutrient loss. However, other studies applied simulated rainfall to generate a fixed or minimum duration (e.g., 1 hr) or volume of runoff, which was then measured and sampled. This approach is often cited as conforming to the [National Phosphorus Research Project](#) protocols. However, this latter approach tends to obscure the inherent effects of a treatment on runoff generation, differs significantly from a real-world storm of distinct duration, and may end up comparing different precipitation inputs on different treatments. While it is arguable which design is best for any specific objective, direct comparison of results from studies using these different protocols may not be advisable. Results from these two distinct protocols must be interpreted with care. Some of the papers reviewed that employed simulated rainfall according to these different protocols are listed in Table 9.

**Table 9. Study Examples for Simulated Rainfall Studies for Fixed Time and Time/Volume for Runoff**

<b>Simulated rainfall for fixed time</b>	<b>Simulated rainfall to generate time/volume of runoff</b>
Adeli et al. 2013	Allen and Mallarino 2008
Feyereisen et al. 2010	Andraski et al. 2003
Johnson et al. 2011	Bundy et al. 2001
Kibet et al. 2011	Butler et al. 2008
Kovar et al. 2011	Daverede et al. 2004
McDowell and Sharpley 2002	García et al. 2008
Pote et al. 2011	Grande et al. 2005
Shah et al. 2004	Kaiser et al. 2009
Tabbara 2003	Kleinman and Sharpley 2003
Verbree et al. 2010	Kleinman et al. 2009
	Little et al. 2005
	Lamba et al. 2013
	Nichols et al. 1994
	Pote et al. 2003
	Pote et al. 2009
	Schroeder et al. 2004
	Shah et al. 2004
	Sistani et al. 2009
	Smith et al. 2007
	Tarkalson and Mikkelsen 2004
	Watts et al. 2011
	Zhao et al. 2001

## **Monitored Storms**

The number and occurrence of storms (simulated or natural) monitored varied among the reported studies. Many studies conducted a single simulated rainfall event soon after treatment was applied, effectively monitoring the first storm after manure or fertilizer application. Other studies monitored multiple

(simulated or natural) storm events after application, at varying elapsed time after treatment (e.g., 1, 15, and 42 days after treatment), and a few examined cumulative losses over an extended period after treatment. It is generally recognized (and reported by many of the studies that documented multiple storms) that runoff losses tend to be greatest in the first storm after treatment and that both absolute losses and the differences between treatments tend to diminish with time. Thus, results from monitoring a single storm after treatment could be considered to be “worst case,” whereas results from studies of multiple storms may be more representative of long-term performance. Furthermore, N or P loading rates—and practice efficiencies—from just a few monitored storms are difficult to extrapolate to annual values.

Interpretation of much of this type of research reported in the literature is confounded by the prevalence of studies that only evaluate treatments in the near term, introducing bias toward certain conditions and processes that may not transfer to longer-term generalizations (García et al. 2008, Maguire et al. 2011). For instance, Little et al. (2005) measured runoff volume under simulated rainfall from surface-applied manure with no incorporation, or incorporated with an array of tillage methods. Their results showed that increasing cultivation lowered surface runoff volume by increasing simulated rainfall infiltration. However, results could not be generalized as this study included only one rainfall simulation after tillage, and did not test the effects of crusting and surface sealing that would be expected to become more apparent with subsequent rainfall events (Panuska et al. 2008).

Some examples of studies that looked at only the first storm after treatment and studies that monitored multiple or cumulative storms are shown in Table 10.

**Table 10. Study Examples for First Storm After Treatment and Multiple/Cumulative Storms**

First storm after treatment	Multiple or cumulative storms
Adeli et al. 2013	Allen and Mallarino 2008
Andraski et al. 2003	Ball Coelho et al. 2007
Bundy et al. 2001	Daverede et al. 2004
Butler et al. 2008	Feyereisen et al. 2010
García et al. 2008	Grande et al. 2005
Johnson et al. 2011	Kibet et al. 2011
Kaiser et al. 2009	Kleinman and Sharpley 2003
Kleinman et al. 2002	Kovar et al. 2011
Kleinman et al. 2009	Obour et al. 2010
Lamba et al. 2013	Schroeder et al. 2004
Little et al. 2005	Shah et al. 2004a
McDowell and Sharpley 2002	Shah et al. 2004b
Nichols et al. 1994	Sistani et al. 2009
Pote et al. 2003	Smith et al. 2007
Pote et al. 2009	Verbree et al. 2010
Tabbara 2003	
Tarkalson and Mikkelsen 2004	
Watts et al. 2011	
Zhao et al. 2001	

## **Nutrient Application Rates**

Many different N and P application rates were used in reviewed studies, applied either as inorganic fertilizers or as manure. Nitrogen application rates varied from as low as 84 kg N/ha to as high as 650 kg N/ha. Phosphorus application rates ranged from 16 to >300 kg P/ha. Some of this variation represented adjustments for soil fertility and crop type; often a rate was selected to conform to recommendations for crop need or soil test levels. Some of the higher rates were arbitrarily selected as extremes for testing practice performance.

This variation may make interpretation of results challenging because N and P reductions due to a practice do not always appear to be proportional to N or P application rate. In investigating the effects of poultry litter incorporation on soybeans, for example, Kaiser et al. (2009) reported P loss reductions of 90% at a low application rate (63 kg P/ha) vs. 84% at a high application rate (123 kg P/ha) on one soil, but reductions of 59% at low rate (58 kg P/ha) vs. 86% at high rate (113 kg P/ha) on another soil. Kleinman et al. (2002) reported similar disproportionate efficiencies at different rates of P application in dairy, poultry, and swine manure.

### **Applicability to the Chesapeake Bay Watershed**

Obviously, studies conducted within the watershed states offer results that are most relevant and applicable to management of the Chesapeake Bay watershed. For this reason, the literature review focused first on articles reporting work conducted in the Chesapeake Bay watershed states; however, other relevant work was included where location and conditions of climate, cropping, and soils seemed potentially comparable. All research results concerning nutrient reduction efficiencies were evaluated for applicability to the Chesapeake Bay watershed and many otherwise applicable papers were excluded.

### **4.3 The Need for Applied Research on BMP Effectiveness**

During the course of the Panel's discussions over the past three years, it has become apparent that *the main limiting factor for estimating BMP efficiencies is the paucity of data relating a given BMP to a water quality response*. This is true for both N and P, although it is especially acute for P. For example, the applied research on P and the PSI has almost exclusively used short-term rainfall simulators to compare various management practices, but it is virtually impossible to extrapolate the short-term runoff data from one or two simulations into annual P load reductions. This lack of data forces the Expert Panels to rely heavily on BPJ, which often leads to widely varying estimates and to circuitous paths for the Panelists to navigate en route to a consensus BPJ. Although the Nutrient Management Panel did not consider sediment per se, the situation for P also directly applies for sediment because few studies have documented annual sediment losses, especially with modern conservation tillage technologies.

Another concern is the scale issue, or the point-of-measurement problem. This arises because the data available for estimating nutrient efficiencies are at the edge-of-field scale, or the bottom-of-root-zone scale, but the CBPWMs assume an edge-of-stream estimate. The inclusion of ecosystem effects (natural riparian zones, wetlands, etc.) and geologic processes (ground water lag times, storm water transport, etc.) between the edge-of-field or bottom-of-root-zone and the edge-of-stream is very complex, but ecosystem effects and geologic processes are also areas that have little or no existing data.

The last item to emphasize is that developing more science-based BMP efficiencies would benefit several stakeholder/user groups. Some examples of these stakeholder groups, with their own objectives, are:

- i) The agriculture community, who have repeatedly asked the question "If I adopt a particular BMP, how do I know it will improve water quality?" (i.e., show me some water quality data and I'll consider the BMP);
- ii) The environmental community, who have similar concerns about BMP efficacy, but also have an additional concern regarding "How do I know the BMP has been implemented and is operating properly?" (i.e., show me some verification data); and
- iii) The policy-making community, who will have other concerns about "How do I track the BMPs and how do I compare or weight the BMPs so the ones applicable to my State receive priority support?" (i.e., where do I invest my limited resources to get the best return?).

Therefore, there is a critical need for science-based, water quality BMP efficiency data based on research that is conducted at the appropriate scale with modern cultural practices. Such data would benefit virtually

all of the Chesapeake Bay partners and stakeholder communities. The Panel suggests that this critical need be discussed and evaluated by appropriate Federal and State agencies to determine if a major Bay Watershed research program could be developed to fill this important data gap, and thereby provide more science-based estimates of BMP nutrient efficiencies that would benefit the entire Bay Partnership.

# 5 Application of Practice Effectiveness Estimates

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## 5.1 Load Sources

Nutrient Application Management addresses the nitrogen and phosphorus loads from agricultural land in the Chesapeake Bay watershed. Tier 1 CGNAM addresses loads from row crops with manure (HWM & LWM), specialty row crops (HOM), pasture (PAS), nursery (NUR), hay with nutrients (HYW), and alfalfa (ALF). Tier 2N FLNAM addresses loads from row crops with manure (HWM & LWM) and hay with nutrients (HYW). Tier 2P FLNAM addresses loads from row crops with manure (HWM & LWM), hay with nutrients (HYW), and alfalfa (ALF). Tier 3N ANM addresses loads from row crops with manure (HWM & LWM). Riparian pasture (TRP) and hay without nutrients (HYO) are not addressed by any form of Nutrient Application Management. Where the practice is not applicable for a Tier, the credit associated with practices under the definition were not able to be determined by the literature.

## 5.2 Practice Baseline

Practice effectiveness estimates are based on the expected change on the ground resulting from adoption of each Tier of Nutrient Application Management. The Panel recommends that the pre- and post-1995 LGU agronomy guide recommendations for corn application rates based on yield are a conservative estimate of the application rate differences between real-world non-NM acres and those acres under a real-world plan consistent with the definition for Tier 1 CGNAM. Similarly, Tier 1 is the baseline condition for the Tier 2 reductions, and Tier 2 is the baseline for Tier 3 reductions. Tier 2 is a combined efficiency of the Tier 1 improvements from baseline and additional actions above Tier 1 credit. Tier 3 is a combined efficiency of the Tier 2 credit plus credit for the additional adaptive management credit outlined in Section 3.3.4 Tier 3 N.

## 5.3 Hydrologic Conditions

The panel adjusted all literature values for scale and management variability, both of which relate to surface and subsurface mobility of nutrients. The management variability adjustment (Table 7) provided some discounting to literature values for experiments that used rainfall simulators, which measure only runoff, and lysimeter studies, which measure only leachate. Additionally, rainfall simulation studies typically applied very heavy rates of rainfall to generate runoff, so that was a consideration made in the BPJ adjustments cataloged and quantified in the efficiency adjustments from literature values. The issue of scale for plot or field size experiments from the literature was considered by the Panel and a universal adjustment was applied to literature values consistent with the Phase 5 CBPWM Cover Crop Report. This is a result of the consideration that the variability in hydrology of a small watershed, like those that are simulated in the Phase 5 CBPWM, are going to contribute to some reduction in the measured effect of a treatment at a field or plot sized scale.

## 5.4 Sediment

The Panel recommends no sediment reduction benefit for any Tier of Nutrient Application Management. The Panel discussed that coarser, well-drained soils are more susceptible to nutrient loss, even under NM type BMPs, but no specific recommendation for this case could be made in time for this report.

## 5.5 Species of Nitrogen and Phosphorus

The Panel documented the nutrient species measured in the literature and the pathways in which the reductions were measured, and determined that the species were conservatively representative of the Total N and Total P loss prevented by implementing Nutrient Application Management. The Panel recommended that since crops grow most efficiently with the proper application rate, method, timing and source, any measured reduction in loss of one pathway or nutrient species is consistent with a reduction in prevented nutrient load in the Phase 5 CPBWM.



## **5.6 Geographic Considerations**

Nutrient Application Management is applicable across all Chesapeake Bay watershed jurisdictions and land types (limited to the land uses described above), and the effectiveness estimates do not vary based on geography. The load reduction benefits are applied at the edge of stream.

## **5.7 Temporal Considerations**

Nutrient Application Management is intended to be represented as an annual practice effective immediately and covering the entire year. All active plans, whether single or multiyear plans, are intended to be represented as active and on the ground in all the years they can be verified. Lag time related to P loss from the fields that are under a Tier 2 P plan, is considered as a management variability adjustment and is described in more detail in Section 3.3.3 Tier 2 P.

## **5.8 Practice Limitations**

The Panel recommended specific land uses (Figure 3) for which Nutrient Application Management can be expected to achieve the reductions stated within this report. Reported acres should be collected from verifiable plans that are being followed to the intent of the plan as outlined by the state program.

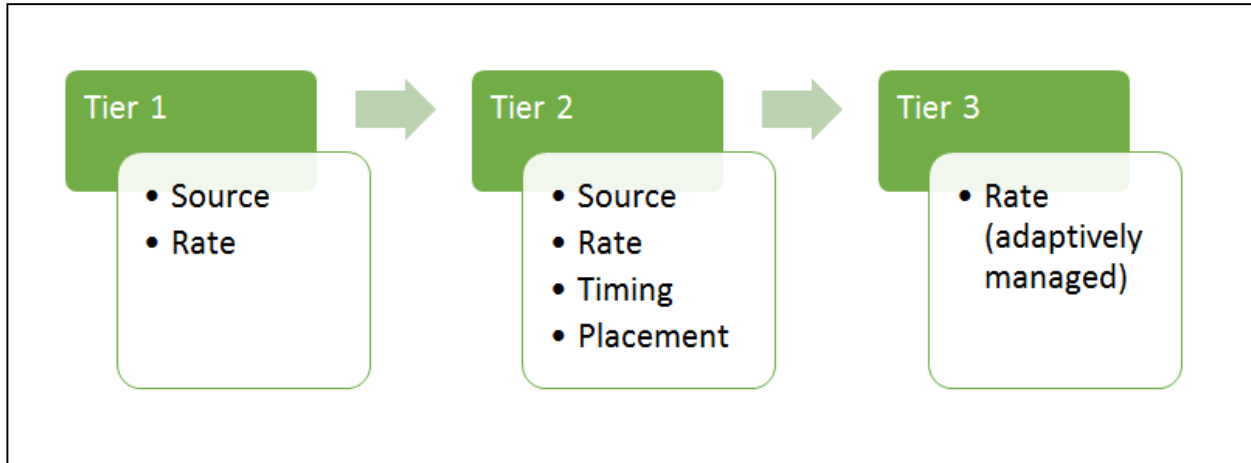
## **5.9 Potential Interactions with Other Practices**

Nutrient Application Management is applicable with any other BMP on the land uses to which both BMPs can be applied. Positive interactions with other BMPs could improve a combined effectiveness, but are not addressed in this report. The Tiers of NM are not expected to reduce the effects of any other practice, but in fact enhance the efficiency of those practices and this is a contributing factor to the recommendations' conservativeness.

## 6 Practice Monitoring and Reporting

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Activities in each tier relate to some of the components of the 4Rs of nutrient management (Figure 10).



**Figure 10.** Diagram that shows the most relevant of the 4Rs of nutrient management as considered by the panel to influence the recommended reduction efficiencies.

The Tier 1 CGNAM practice is intended to replace the current version of the CBP’s approved NM practice in Phase 5.3.2 Chesapeake Bay Watershed Model. The existing definition refers generally to nutrient application in accordance with the 4 Rs of nutrient management based on implementation of a nutrient management plan, but does not define the specific planning elements needed to achieve that level of nutrient management. The new definition for Tier 1 more clearly defines nutrient management expectations at the whole farm or crop group level by focusing on planning components related to nutrient applications from the right source and at the right rate with respect to both N and P. The recommended credit for nutrient management is consistent with the data currently available to describe the change from a pre-BMP condition (including LGU recommendations from a time in agriculture that pre-dates the CBPWM simulation period) to a CGNAM condition with implementation of practices that account for crop yield goals, nitrogen credits, soil test P recommendations for fields not receiving manure, and LGU N-based recommendations for manure application.

Tier 2 FLNAM is a new practice that reflects the substantive change in NM that addresses P applications and employs updated methods recommended by the LGUs, subsequently supporting changes adopted by the jurisdictions in policies and regulations beginning around 2005 (Table 11). This practice replaces the CBP’s existing approved enhanced nutrient management practice. The recommended Tier 2 definition incorporates all four elements of the 4Rs by focusing on practices that offer greater precision in selection of the right source, rate, timing, and placement of nutrients at the field level. Tier 2 builds on Tier 1 NM by addressing the nutrient source and application rate through the use of yield goals and N credits specific to fields or management units. Tier 2 NM further addresses source and rate and incorporates nutrient timing and placement through use of field-specific P loss risk assessments and other conservation tools.

Tier 3 ANM is a new practice that will credit the reductions in runoff and subsurface nutrient loss consistent with a sub-field scale, adaptive management approach to nutrient applications and management on agricultural lands. This practice captures the future of NM in the watershed and non-cost-shared practices that go beyond FLNAM, replacing the CBP's existing approved decision agriculture practice. Tier 3 focuses on increased nutrient use efficiency through addressing nutrient application rates using tools that target nutrient applications based on sub-field level management units or that optimize nutrient use relative to crop yield based on soil and tissue testing.

Tiers 2 and 3 are consistent with the USDA NRCS's Practice Standard Code 590 (NRCS 590 Standard). The NRCS 590 Standard establishes the minimum expectation for development and implementation of NMPs nationwide. State NRCS offices adopt and modify the national standard consistent with conditions in each state, often adding greater specificity and additional requirements relative to the national standard. Each of the Chesapeake Bay states has adopted its own version of the 590 standard. In addition, each state has established regulations requiring that certain agricultural operations develop NMPs in accordance with specific state standards. Table 11 summarizes current NM regulations that have been adopted by the CBW states and identifies the NM Tier that would be met in each state when an operation complies with the state NRCS 590 and/or other required standards for NMP development and implementation.

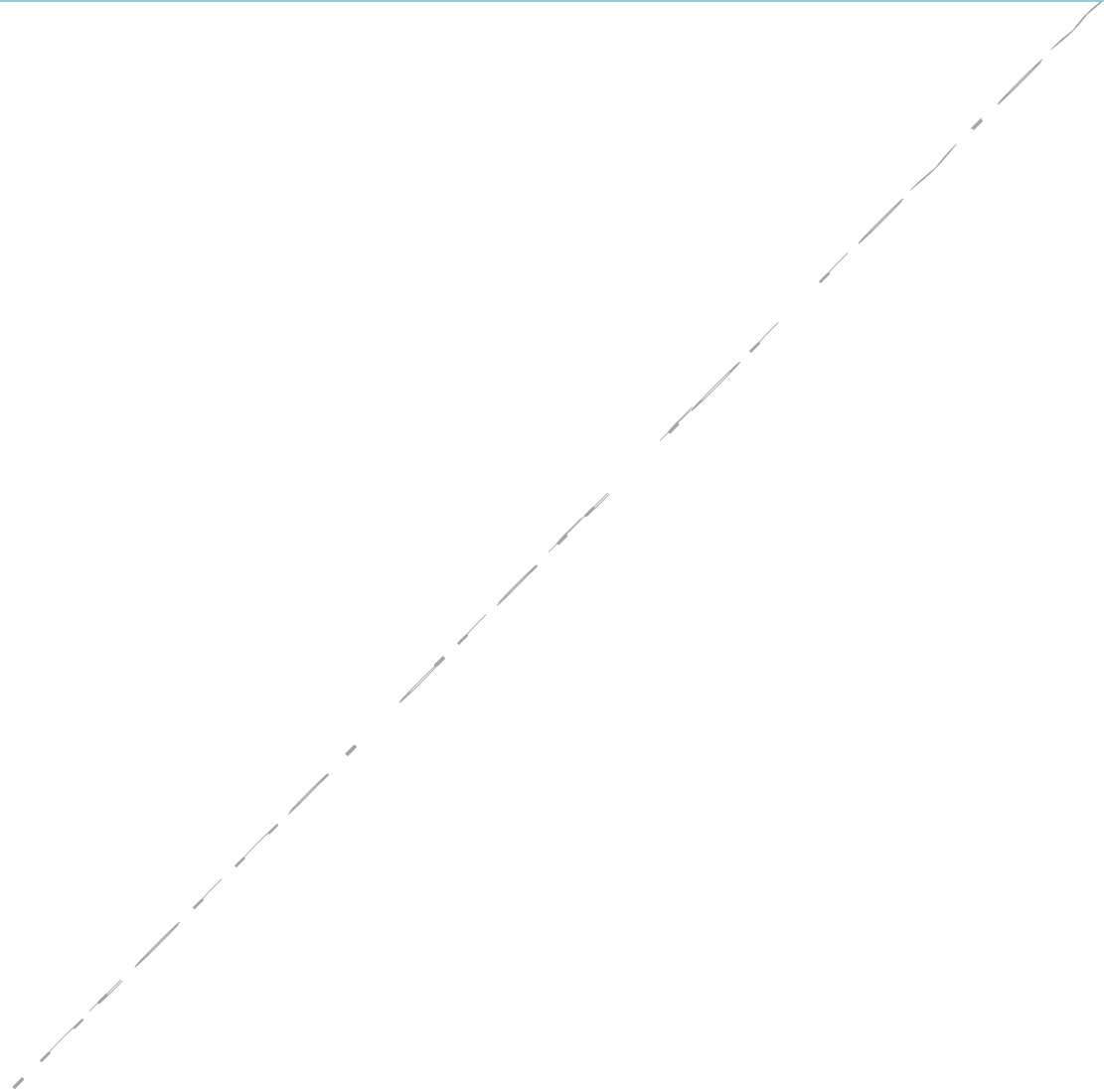
Table 11. Summary of current NM regulations adopted by the six Chesapeake Bay watershed states.

		Delaware	Maryland	New York	Pennsylvania	Virginia	West Virginia
<b>Current state nutrient management regulations adopted</b>		2007	2005 Revised 2012 Revised 2015	2004	2006	2006 Revised 2014	2011 47CSR10 "CAFO Rule"
<b>Regs apply to:</b>	<b>CAFOs</b>	All CAFOs	All CAFOs	All medium and large CAFOs (per EPA size thresholds)	All CAOs > 8 AUs and all CAFOs > 8 AUs	CAFOs/AFOs under DEQ permit ≥300 AU	All Permitted CAFOs and unpermitted Large CAFOs
	<b>Other animal operations</b>	Other animal operations ≥8 AU	Other animal operations ≥8 AU	Not a regulation, but required for producers engaged in State or Federal programs for nutrient management practices. Voluntary for others.	Tier 2 plans voluntary for non CAOs and non CAFOs. Tier 1 plans required for all operations where manure is produced or used	Voluntary	Voluntary Note: USDA requires a CNMP based on their 590 Standard for certain practices.
	<b>Cropland, pasture, nursery</b>	Cropland, pasture, nursery with applications to ≥10 ac	Cropland, pasture, nursery with applications to ≥10 ac	Not a regulation, but required for producers engaged in State or Federal programs for nutrient management practices. Voluntary for others.	Plans are required to include all cropland, hay land, pasture land, and heavy use areas. Plans also must include fields on farms that import manure from a CAO or CAFO	Voluntary	Voluntary Note: USDA requires a CNMP based on their 590 Standard for certain practices.
<b>Timing (N)</b>		Timing and method of nutrient application shall correspond as closely as possible with plant nutrient uptake characteristics, while considering cropping system limitations, weather and climatic conditions and field accessibility	(2005) Sept 1 to Nov 14 apply nutrients @ University rate; Nov 15 to Feb 28 no application of nutrients (exceptions for manure inadequate storage, apply @ P removal rates for spring crop)  (2012) 2012 to 2015 - Sept 10 to Nov 15 apply nutrients @ University rate; apply manure @ P removal rate for spring crop(not to exceed	Nutrient application timings are based on efficient crop nutrient utilization, cropping system logistics, field conditions, and several field-level environmental risk assessments concerning runoff, leaching, erosion, and volatilization losses.	PA Nutrient Mgmt regulations require nutrients to be applied during times and conditions that will hold the nutrients in place for crop growth, and protect surface water and groundwater.  The PA 590 standard requires that split applications of nutrients be considered when developing a nutrient management plan to address NPS pollution of surface and groundwater.  The PA 590 standard states	Every plan has specified timing recommendations to enhance uptake and reduce loss to the environment.	Nutrient application timing is required by PSI on a field by field basis. CAFO standards require split application of inorganic N on hay and grains.

		<p>50lbs PAN and cover crop is required) (exceptions Poultry litter must be applied to growing fall crop)</p> <p>Nov 16 to Feb 28 No nutrient application (exceptions per individual plan for in adequate storage)</p> <p>(2012) phased in 2013 No Fall N on small grains if FSNT is &gt;10-15ppm</p>		<p>that "nutrients must not be surface-applied if nutrient offsite losses are likely. This precludes spreading on frozen and/or snow-covered soils and when the top 2 inches of soil are saturated from rainfall or snow melt. Winter application of manure shall only be considered for use where it is a necessary for operation of the farm, and where fields identified for winter application are situated in such a way as to minimize the potential for manure or nutrient run off during the winter season." The PA Winter Manure Application Matrix (WMAM) is used to assess fields requesting winter application where it is necessary for operation of the farm.</p> <p>Winter manure application is not accepted on fields with a high loss potential as determined using the PA WMAM. Fields with a "Fair" rating on the WMAM can only be used for winter manure application if additional protective measures are incorporated on the field (such as increased setbacks, reduced rates, or where soils are not frozen or snow covered).</p> <p>The PA Phosphorus Index (PI) compels farmers to apply their manure during the growing</p>		
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				season to allow for farmer desired manure application rates.		
<b>Setbacks (P)</b>	Prohibited from applying manure within 100 feet of any down gradient surface water or conduit to surface water, or follow alternative compliance practices	(2012) phase in on Jan 2014 35' for all nutrients, reduce to 10' w/ direct application All animals are exclude from surface waters w/ 10' setback	Manure application setbacks from down-gradient surface waters: 100 ft.; 35 ft. of vegetated buffer; or 15 ft. if incorporated within 24 hours.  Manure application setbacks from wells, swallets, sinkholes, etc.: 100 ft.	100 foot manure application setback from streams, lakes and sinkholes unless there is a permanent vegetative buffer in which case the manure application setback is 35 feet. 100 foot setback from wells or other drinking water sources. For winter applications of manure there is a 100 foot setback from intakes to ag drainage systems and certain wetlands.	Required on environmentally sensitive sites and according to restrictions on permitted facilities	Required setbacks for Permitted CAFOs. Other setbacks are required by PSI on a field by field basis.
<b>Manure incorporation (N &amp; P)</b>	As soon as possible after application. BMP is 24 hours	(2012) phase in on Jan 2013 all organic nutrients injected/incorporated within 48 hrs (exceptions per individual plan)	The NY 590 and associated tools (NY P Index, Nitrate Leaching Index, Cornell University Groundwater Protection Guidelines, Cornell University Supplemental Manure Spreading Guidelines, and Cornell Nitrogen Guidelines) recommend manure incorporation in most field scenarios to improve N use efficiency and reduce runoff losses of N and P.	The PA 590 standard states that manure incorporation and injection must be considered in the nutrient management planning process to address NPS pollution of surface and groundwater.  Manure incorporation within 5 days is required for fall applications on low residue fields unless manure is applied to a cover crop.  The PA PI compels farmers to incorporate their manure to allow for farmer desired manure application rates.	Recognized as a useful practice for preventing loss. Part of the P index. Where P index is not used, incorporation is left to the discretion of the planner and farmer.	Manure incorporation is determined by PSI on a field by field basis.
<b>P risk assessment requirements</b>	Phosphorus applications should be consistent with the	(2005) The PSI must be completed on all sites with soil fertility index	The NY P Index is run in its entirety on every field.	The PA P Index (PI) is broken into two sections, Part A and Part B. Part A is used to	If soil P saturation is >65%, P application is not permitted. Otherwise,	Once P levels exceed 120 lbs per acre, no P applications will be made

	<p>rates recommended based on the soil test and/or the PSI assessment of the field or management unit. The PSI must be completed on all sites where the planned P application rate exceeds University of Delaware nutrient recommendations based on the results of a soil test for the planned crop(s) and/or where manure is applied.</p> <p><b>PI = 50-75 (Medium).</b> P based NM should be implemented 2 years out of 3.</p> <p><b>PI = 76-100 (High).</b> P applications should be limited to crop removal or soil test P based application recommendations.</p> <p><b>PI &gt; 100 (Very high).</b> No P should be applied.</p>	<p>value above 150.</p> <p><b>If risk is medium:</b> rates based on N plan needs as limiting factor no more than 1 out of every 3 years.</p> <p><b>If risk is high:</b> P rates shall be limited to the expected amount removed from the field by the crop or plant harvest or the amount indicated by soil testing.</p> <p><b>If risk is very high:</b> no additional P may be applied.</p> <p>(2015) PMT finalized June 8<sup>th</sup>, No P on fields &gt;500FIV effective immediate, 2 years of running PSI and PMT side by side, and then phased in restrictions through 2022 with possible extensions through 2024.</p>	<p>If P Index rating is <b>low or medium:</b> applications according to Land Grant N guidelines and associated environmental limits.</p> <p><b>High:</b> Applications to P crop removal and associated environmental limits.</p> <p><b>Very High:</b> No phosphorus applications allowed.</p>	<p>identify those fields that have a low risk of P loss. Fields that are identified as low risk in Part A do not need to go through Part B of the assessment. Part A of the PSI includes an assessment of P soil test levels (with 200 ppm requiring Part B), the proximity of the field to a stream or other water body (requiring Part B if the field is within 150' of water), requiring Part B on fields/farms with recent management changes and also requiring Part B if the receiving water body has a special protection designation. If Part A identifies the field as being of potential concern for P loss, then Part B of the index also needs to be run on the field.</p> <p><b>PI = 60-79 (Medium)</b> N based plans with conservation BMPs installed to address field runoff.</p> <p><b>PI = 80-99 (High).</b> P applications limited to P crop removal.</p> <p><b>PI &gt; 100 (Very high).</b> No P can be applied.</p>	<p>soil test P, P-Environmental Thresholds, or PI used to determine P application rate.</p>	<p>unless the P Field Risk Assessment in the 2010 West Virginia 590 Standard is utilized.</p>
Source of technical standards	<a href="#">DE NRCS 590 standard</a>	<a href="#">Maryland Nutrient Management Manual</a>	<a href="#">NY NRCS 590</a>	<a href="#">Pennsylvania Nutrient Management Program for Tier 2;</a> <a href="#">Pennsylvania's Manure Management Manual for Tier 1</a>	<a href="#">Virginia Nutrient Management Standards and Criteria</a>	<a href="#">Technical Standards For West Virginia CAFO Nutrient Management Planning</a>
Phase 5.3.2 NM Tier(s) supported by current state regulatory program(s)	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2	Tier 2





## 6.1 Phase 5.3.2 Nutrient Application Management Tracking, Verification, and Reporting<sup>19</sup>

The Agriculture Workgroup identified Nutrient Management Plans, including Tiers 1, 2 and 3, as non-visual BMPs in the [Agricultural BMP Verification Guidelines](#)<sup>20</sup>. Chesapeake Bay Program jurisdictions tracking, verifying, and reporting BMPs for Tiers 1, 2 and 3 NMPs can do so utilizing the non-visual BMP methods described in the Guidelines as well as the supplemental guidance described below.

### **Tier 1 Non-visual Assessment**

It is recommended that the Jurisdictions track CGNAM Tier 1 with operational NMPs by identifying the presence of all the following elements:

1. Plan is available in electronic or paper format.
2. Plan is developed cooperatively by a trained professional and the farmer.
3. Plan expiration date is no longer than three years after written.
4. Plan uses soil lab analysis from farm samples to inform application rates of nutrients.
5. Plan is implemented and followed according to the CGNAM definition and the intent where:
  - Crop yields are estimated based on records or soil productivity estimates for the entire farm;
  - Nutrient applications adhere to contemporary LGU specifications for N rate;
  - P fertilizers are applied at a rate consistent with the contemporary LGU recommendations; and
  - Nutrient application timing is considered to further reduce N and P losses.

### **Tier 2 Non-visual Assessment**

It is recommended that the Jurisdictions verify FLNAM Tier 2 with operational NMPs that meet or exceed the NRCS 590 Standard for NM. This includes all the elements of a Tier 1 plan listed above, and the specific enhancements shown in bold below. Jurisdictions are recommended to track Tier 2 plans with operational NMPs by identifying the presence of all the following elements:

1. Plan uses soil lab analysis from farm samples to inform application rates of nutrients.
  - If soil test levels of P warrant a **P risk assessment (or P-index)**, one is performed and the recommendations to reduce losses are followed for the entirety of the plan.
2. Plan is implemented and followed according to the FLNAM definition and the intent where:
  - Crop yields are estimated based on records or soil productivity estimates for **each field** using **contemporary guidelines from state programs**;
  - Nutrient application rates **do not exceed** contemporary LGU specifications for N and P **(including manure)**; and

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<sup>19</sup> Chesapeake Bay watershed jurisdictions' BMP verification programs will be phased in with full implementation by the 2018 annual progress reporting cycle. The Chesapeake Bay Program Partnership's new Phase 6.0 Chesapeake Bay watershed model will become operational at this time as well.

<sup>20</sup> Chesapeake Bay Program. 2014. *Strengthening Verification of Best Management Practices Implemented in the Chesapeake Bay Watershed: A Basinwide Framework*. (Appendix B) Chesapeake Bay Program Partnership, Annapolis, Maryland.

- Fertilizer and manure applications are **timed** and placed (e.g., lower risk times for runoff and leaching, setbacks, incorporation, etc.) to reduce risk of N and P loss.

### **Tier 3 Non-visual Assessment**

Jurisdictions are recommended to track ANM Tier 3 based on operational Tier 2 NMPs, as described above, which have supplementary records showing either:

1. Variable rate applications of N on each field were performed resulting in a net change in N rates for the field; or
2. An Illinois Soil Nitrogen Test (ISNT), Corn Stalk Nitrate Test (CSNT), Pre-side dress Nitrate Test (PSNT), or Fall Soil Nitrate Test (FSNT) was performed resulting in a net change in N rates for the field.

## **6.2 Future Verification of Nutrient Management Practices**

The seven jurisdictional partners are developing enhanced BMP verification programs based on the 2014 CBP Partnership's basinwide BMP verification framework that includes the [Agricultural BMP Verification Guidelines](#). The jurisdictional plans will be reviewed through the Partnership's BMP Verification Review Panel, approved by U.S. EPA, and phased in over a two-year period, with full implementation by the 2018 annual progress reporting cycle<sup>21</sup>. The Panel recommends that jurisdictional partners explore actions and methods to enhance their current levels of NMP monitoring, tracking, verification, and reporting based on the recommendations within this Panel report as well as the forthcoming recommendations from the Partnership's Phase 6 NM Expert Panel.

The capability of federal, state and local agency partners for monitoring, tracking, and reporting of nutrient management to the CBP partnership for application in the Phase 5 CBPWM has historically been limited to NMPs. This has led to the reporting of total acres covered by NMPs versus divisions between field or subfield levels, specific land uses, or varying levels of application management. The [Phase 5 CBPWM](#) has also been limited in its ability to accept BMPs on a crop basis because of the averaging of crop inputs and outputs to a land use. Enhancing the present capabilities of the jurisdictional monitoring, tracking, verification, and reporting and the Phase 6 CBPWM's tracking and crediting of these discrete elements of NMPs, will improve the accuracy and precision of all future NMEPs. The Panel notes that considerable time and effort by the federal, state and local agency partners will be required for these tasks.

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<sup>21</sup> See page 49 in Chesapeake Bay Program. 2014. *Strengthening Verification of Best Management Practices Implemented in the Chesapeake Bay Watershed: A Basinwide Framework*. Chesapeake Bay Program Partnership, Annapolis, Maryland for more details.

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## **Appendix A**

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### **Approved Nutrient Management Expert Panel Meeting Minutes**

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## Nutrient Management Panel

### Conference Call Minutes

December 6, 2013

12:00-2:00PM

#### 1. Welcome and Introductions

#### 2. USDA CEAP report

- Jeff Sweeney gave an overview of the recently released CEAP report, and requested that panel members review and respond to the nutrient application management aspects of the report.
- Chris Brosch will bring this up to the AgWG to see who should be tasked with reviewing the report.

**ACTION:** Jeff will send the CEAP report to panel members.

#### 3. Tier 2 Crediting Discussion

- Verification efforts have so far been left out of panel recommendations.
- Yield variability is drastic, and based on management more than soils.
  - Guidance systems are likely to fit in to Tier 3, however panel collecting this documentation now to prepare for the Tier 3 recommendation.
- Tim recommends comparing the effects of individual aspects of Tier 2 Nutrient Management.
  - Crediting the individual components of Tier 2 Nutrient Management could be an option in Phase 6.0.
  - This approach would simplify verification.
  - Comparing the effects of individual components may help the panel determine an effectiveness value for Tier 2.
- N Source credit?
  - Application rates over a larger area.

**ACTION:** Wade will send the panel spatial variability papers.

- Mark recommends working on Tier 2 and 3 at the same time because the literature may overlap. This way there can be a relationship between the effectiveness values based on a benchmark.
  - Benchmark is Tier 1 at this point; panel will define the additional benefit for Tiers 2 and 3.
  - Panel recommends quantifying the items in Tier 2 that are above Tier 1 to define credit for Tier 2.

**4. Next Steps:**

- Jack, Tim and Doug will collect and share additional literature for the panel.
  - Mark, Chris and Jeff will discuss follow up actions from the CEAP report.
  - Chris will summarize the literature findings and present to the panel at the next call.
- After this the panel can define the crediting method for Tiers 2 and 3.

**Participants**

Chris Brosch, VT-VADEQ  
Curt Dell, USDA-ARS  
Larry Towle, DE  
Tim Sexton, VA-DCR  
Wade Thomason, VT  
Jim Cropper, NE Pasture Consortium  
Jennifer Ferrando, TetraTech  
Jeff Sweeney, EPA  
Emma Giese, CRC  
Mark Dubin, UMD  
Matt Johnston, UMD  
Jack Meisinger, USDA-ARS  
Doug Goodlander, PA  
Tom Bruulsema, IPNI  
Greg Albrecht, NY

## Nutrient Management Panel

### Conference Call Minutes

January 23, 2014

10:00-12:00PM

#### 1. Welcome and Introductions

#### 2. Updates

- Chris reminded everyone that the group needs literature sources to support Tier 2 crop group nutrient application management to develop the next set of recommendations.
- TetraTech is editing the interim Phase 5.3.2 report. They will be providing the report back to the chairs for distribution to panel members prior to posting on the Bay Program website.
- Emma will send a doodle poll to schedule a February meeting

**ACTION:** Send literature sources supporting crop group nutrient management (Tier 2) to Chris before the February conference call.

#### Participants

Chris Brosch, VT-VADEQ

Tim Sexton, VA-DCR

Jennifer Ferrando, TetraTech

Jeff Sweeney, EPA

Emma Giese, CRC

Mark Dubin, UMD

Matt Johnston, UMD

Doug Goodlander, PA

Tom Bruulsema, IPNI

Doug Beegle, PA

Kim Snell Zarccone, Conservation PA

Jason Dalrymple, WV

Ken Staver, UMD

John Majsztrik, UMD

Steve Dressing, TetraTech

Don Meals, TetraTech

## Nutrient Management Panel

### Conference Call Minutes

February 25, 2014

11:00AM-12:00PM

#### 5. Welcome and Introductions

- Chris discussed a recent policy change with CBP expert panels. In the past, expert panel meetings have been closed to the public, now the public will be able to request call in information for all meetings. Expert panel members can choose to limit public participation to listening only if they choose. Panelists also may choose to resign from the panel if they are uncomfortable with the change.
- Recommend that the expert panel be able to schedule executive sessions that would not be open to the public.
- Does this policy change include allowing reporters to listen in?
  - Yes.
- Recommend posting minutes on the website in place of allowing the public to join the calls.
- Recommend that the public not be allowed to join the discussion during a call, only listen in.
- Panel members felt that this policy change would hurt the effectiveness of the expert panels. Panelists stressed the importance of the panel discussions as an exchange of ideas, not a public forum.
- Recommend keeping the expert panels separate from politics.

**ACTION:** Contact Chris with any additional comments about change in expert panel policy.

**ACTION:** Mark Dubin and the expert panel chairs will work on a response to CBPO regarding this policy change based on the reactions from panelists.

**ACTION:** Chris will pass along the official guidance to the panel from the bay program.

#### 6. Review of papers

- Chris gave an overview of two papers on phosphorus management.
- Kleinman paper reviewed differences in P loss from runoff based on soil types and animal types.
- Sharpley paper on modeling phosphorus transport (not including rate).
- How does 75 kg TP/ha line up with recommendations at the Tier 2 level?
  - In some cases it is consistent; however Tier 2 would have a range of recommended values.
  - Panelists noted that it will be difficult to calculate a consistent load reduction for Tier 2.



- Recommend researching the runoff difference between surface applications vs. injected, or between phosphorus applications based on soil test recommendations vs. no soil test. These differences could help inform a numeric reduction.
- The panel will be coming up with numeric efficiencies for Tier 2; ideally based on literature.
- Additional relevant literature is needed for the panel to make a numeric reduction recommendation for Tier 2 Nutrient Application Management.

**ACTION:** Chris and Tim will discuss alternate crediting options for Tier 2

**ACTION:** Panel will schedule another conference call in less than a month to continue the discussion

**ACTION:** Panelists will continue sending relevant papers to Chris to summarize for the group

### Participants

Chris Brosch, VT-VADEQ

Tim Sexton, VA-DCR

Jennifer Ferrando, TetraTech

Jeff Sweeney, EPA

Emma Giese, CRC

Mark Dubin, UMD

Doug Goodlander, PA

Tom Bruulsema, IPNI

Jason Dalrymple, WV

Ken Staver, UMD

John Majsztrik, UMD

Steve Dressing, TetraTech

Don Meals, TetraTech

Greg Albrecht, NY

Jim Cropper, NE Pasture Consortium

Wade Thomason, VT

## Nutrient Management Panel

### Conference Call Minutes

March 11, 2014

1:00-3:00PM

#### 7. Welcome and Introductions

- CBPO will be providing feedback on the public access to panel meetings policy

#### 8. Group Discussion – Placement in Tier 2 field level Nutrient Management

- Two poultry litter studies provided 85-95% reduction with subsurface application on pasture compared to surface applications
- Does incorporation fit into the Tier 2 definition?
  - VA: Incorporation often written up in the NM plans
  - PA: Not much incorporation of manure at this point
- **Additional needs for placement include: row crop results, metrics to compare runoff loss to field scale loss, other manure types, and other placement regimes**
- Note that these papers are a best case scenario, and that the tools are not in common use in the watershed at this point.
  - Panel will need to understand the standard practices in the watershed in order to recommend efficiencies.

**ACTION:** Panelists volunteered to provide the group with literature on the following:

- Row crop dairy manure injection (Curt Dell)
- Conventional incorporation (Don Meals)
- Side-dressing (Tim Sexton)
- Recommend that split application be considered in the Tier 2 definition
- Group discussed that there will likely be literature limitations, given that the literature may not have a direct link between crop response and environmental response and that many tillage practices don't have data yet.
- Group discussed how their recommendations will be representative of the average conditions (not ideal research conditions).
- Group will work toward capturing incorporation methods in Tier 2.
- Note that incorporation is made more complex by hours until rainfall. Recommend data from rainfall studies, which would recommend a worst case scenario.
  - Results may be widely varying
  - Recommend using APEX for the rainfall probability piece
- Recommend a simple approach to defining the reduction efficiencies, especially given that more work is coming up for Phase 6.0.

- Chris noted that the work done now will be used in the Phase 6.0 recommendations
- Recommend developing a framework containing the questions that the panel needs to answer.
  - The overall panel goal is to pick a number for Tier 2 nutrient management. There are many practices that fit in Tier 2, and can be quantified. Ideally the answer would be to define one number, but to not lose track of the individual components (to understand how much each of the components contribute).
  - Each Tier of Nutrient Management can have a different effectiveness for different land uses.

**ACTION:** Panelists will provide additional literature sources (with summaries if possible)

**ACTION:** Chris will put together the panel's framework

### Participants

Doug Goodlander, PA  
Tom Bruulsema, IPNI  
Jason Dalrymple, WV  
John Majsztrik, UMD  
Don Meals, TetraTech  
Jack Meisinger, USDA ARS  
Kim Snell-Zarccone, Conservation PA  
Matt Johnston, UMD  
Chris Gross, NRCS  
Curt Dell, ARS  
Steve Dressing, TetraTech  
Ken Staver, UMD  
Emma Giese, CRC  
Jim Cropper, NE Pasture Consortium

## Nutrient Management Panel

### Conference Call Minutes

April 7, 2014

10:00-12:00

1. Panel members discussed the components of Nutrient Management by tier level and applicable literature sources
  - Panel discussed application rates in Tier 2, and crediting differences between Tier 1&2
    - Nutrient guidelines support that there would be a rate change in field specific plans
    - Nuances in rates will be more difficult to assign values based on literature
    - Panel will need to determine what the edge of field loss difference would be in a rate specificity change between Tier 1 and Tier 2
    - Additional information is needed to understand the relationship between rate specificity and edge of field loss
    - A Tier 2 field specific plan should result in more refined rates than Tier 1
    - In PA field specific rates have become more specific based on P index
    - Panel considered whether N specificity rates change at the field specific level
      1. CSNT is a Tier 3 component
    - Chris and Greg will work on a recommendation for rate specificity
  - Panel discussed changes to the list of components:
    - Chris will change “timing” to “split application”
    - Add zone management
    - Add N leaching index
  - Recommend including P management tool
    - It is another version of the P site index, may not need to be mentioned specifically here because it is covered by P site index
  - Additional tabs of the worksheet list the literature sources for each component
    - Panel members are requested to review these tables, particularly looking for numbers that don't make sense. Lit sources will contribute to determining the efficiency for Tier 2.
    - Jack's studies on incorporation and injection will be included in the lit sources
    - Curt will review the lit sources and add any relevant PSU sources
    - Ken will send the Verbree paper
  - Panel members recommended referencing a transport model study to quantify effectiveness of P site index (rather than the P site index itself)
  - Panel members will continue gathering literature and organizing sources by component as discussed today, then select a final efficiency based on the collective information.
    - Panel will decide the overall value for Phase 5.3.2 Tier 2 based on the components
    - The literature will be used to inform the Phase 6.0 recommendations as well

**ACTION:** Chris will distribute the spreadsheet of Tier 2 and Tier 3 components

**ACTION:** Panel members will continue to submit literature sources, categorized into the components of Tier 2

and 3

**Participants**

Chris Brosch, VT-DCR  
Doug Goodlander, PA  
Greg Albrecht, NY  
Jason Dalrymple, WV  
Steve Dressing, TetraTech  
Tim Sexton, VA-DCR  
Emma Giese, CRC  
Mark Dubin, UMD  
Tom Bruulsema, IPNI  
Curt Dell, ARS  
Wade Thomason, VT  
Don Meals, TetraTech  
Matt Johnston, UMD  
Ken Staver, UMD

## Nutrient Management Panel Conference Call

June 5, 2014

10:00-12:00

1. TetraTech has been compiling a literature database and synthesis for the panel. TetraTech reviewed the spreadsheet summary which includes each of the nine Tier 2 nutrient management components.
2. T2 - manure incorporation:
  - Recommend looking at the annual loads (not the single events) to deal with the high outliers.
  - Mark recommended looking up the Wisconsin Manure Management Advisory System (risk analyses with rainfall events).
3. Mark suggested the panel consider separating manure injection and incorporation into separate BMPs rather than combining with Tier 2.
  - The practices can be counted separately and credited even if other aspects of Tier 2 are not followed.
  - Manure incorporation involves sediment loss; it will be easier to define it separately.
  - Separate tracking data for injection/incorporation could be available in VA.
  - Many panel members agreed that manure injection/incorporation should be handled by a future expert panel. Panel members recommended that this piece move forward quickly, as much of the literature collection is already complete.
    - i. Tom Bruulsema: Recommend keeping manure incorporation in Tier 2 to account for comprehensive Nutrient Management.
    - ii. Panel members discussed options and benefits to crediting incorporation together or separate from Tier 2:
      - Require incorporation for Tier 2, but count the efficiency separately.
      - Keep incorporation in the definition of Tier 2 as a consideration.
      - There are significant gains made by moving from Tier 1 to Tier 2 even without requiring incorporation.
4. Panel members discussed the remaining elements of Tier 2.
  - Banding may be an optional element.
  - Mark: check the FE-RI language for consistency with setbacks (application setbacks).
  - Panel decided to add leaching to the timing component.
  - Panel noted that field specific rate may be captured by other elements (P index).
5. TetraTech will continue to summarize the remaining components of Tier 2.
  - Jack proposed forming small subgroups to take on each of the remaining components.
  - Each group will meet about twice to develop a recommendation to the larger panel.
6. Volunteers for subgroups:
  - Split application
    - i. Jack, Ken, Wade
  - Timing for runoff and leaching prevention
    - i. Tim, Greg, Doug G.
  - Setbacks
    - i. Doug G., Tim, Ken

- P index & field specific rates
  - i. Greg, Larry, Rory, Peter Kleinman (Zach Easton at VT)
- Banding
  - i. Tom, Wade, Doug Beegle

#### 7. Next Steps

- Individual groups to meet in June/July to identify data gaps, review collected data, and develop an efficiency number.
- Panel members will then need to define an overall efficiency once the component efficiencies have been defined.
- Panelists will review the spreadsheet and literature.
  - i. Emma, Chris and TetraTech will set up a site to share literature files.

#### Participants

Chris Brosch, VT-VADCR  
Don Meals, TetraTech  
Steve Dressing, TetraTech  
Doug Goodlander, PA DEP  
John Majsztrik, UMD  
Tim Sexton, VA-DCR  
Emma Giese, CRC  
Greg Albrecht, NY  
Larry Towle, DE  
Mark Dubin, UMD  
Jason Dalrymple, WV  
Jack Meisinger, USDA ARS  
Jeff Sweeney, EPA  
Rory Maguire, VT  
Wade Thomason, VT  
Ken Staver, UMD

## Nutrient Management Panel

## Setbacks Subpanel

7/14/14

10:00-11:00AM

1. Doug Goodlander provided a summary of the setbacks papers provided by TetraTech: Sharples paper - reduction in concentration of P is due to dilution. NE paper did not find any effect in manure setbacks. DE paper did not assess the effect of setbacks, more the effect of cover crops in reducing setbacks. Overall the papers showed no reduction of phosphorus to the stream, perhaps a dilution.
  - TetraTech concurred with this summary, and noted that the literature on setbacks was thin.
2. Chris Brosch: The panel has three pieces of evidence in favor of no reduction, and no evidence for a reduction. Should the subpanel recommend no reduction until more information is available?
  - Ken Staver: There are no studies that compare directly to manure in the stream, which does occur in the real world. This comparison would be helpful to better understand the real world effects of setbacks.
  - Brosch: Is there a way to estimate the benefit vs. applying directly in the stream?
    - Panelists agreed that it would be difficult to calculate.
  - Brosch: Are setbacks followed when they're in nutrient management plans?
    - Goodlander: Setbacks are followed well when they're in the nutrient management plans in PA.
    - Staver: New rules recently incorporated setbacks in MD's plans, previously not part of the plans.
  - Staver: Note that the variability of data at this scale is not likely to show a statistical significant difference.
    - Particularly in a short time scale.
  - Goodlander: Based on the available studies, there is no reduction. However, as you setback, that prevents direct application to the stream. Panel could come up with a number (likely in the 1-2% range) to represent reduction in direct application to the stream due to setbacks. This would be based on the amount of manure spread next to water bodies. PA has been conducting setbacks since the mid 90s, and could make a recommendation based on this information.
    - Goodlander: Note that the setbacks limit manure application, not necessarily inorganic fertilizer.
  - Staver: The panel can recommend an acreage that shifts from manure to non-manure acres to run through the model to see the effect this reduction would have.
  - Staver: What is the percentage of setbacks on a typical farm in PA?
    - Goodlander: Approximately 10 out of 200 acres. 5% of the acreage.
  - Panel members discussed options for more precise estimates based on GIS analyses.
  - Tt: Note that the reduction might be radically difference between states.
    - Goodlander: There will be variation within states as well due to differences in stream density. The change will likely be small because the starting number will be very small.



- Members decided to pursue crediting based on shifting a small number of acres from manure to non-manured as a proxy for the effect of setbacks.

**ACTION:** Doug Goodlander will refine the acreage estimate to be modeled.

**ACTION:** Chris Brosch will talk to CBP modelers and GIS team about modeling and mapping options.

**Participants**

Doug Goodlander, PA-DEP

Ken Staver, UMD

Chris Brosch, VT-VADCR

Steve Dressing, TetraTech

Don Meals, TetraTech

Emma Giese, CRC

Nutrient Management Panel  
Split Applications Subpanel  
7/14/14  
10:00-11:00AM

1. Jack Meisinger: Container losses paper had good data. Recommend sending this paper to John Majsztrik and ask him to provide other similar sources.
  - a. Meisinger: If nurseries are going to be captured in land uses, then they don't need to be counted in BMPs.
  - b. The group did not believe they had the expertise to cover the nursery operations.
  - c. Brosch: The group can come up with a recommendation, and then run it by the nursery experts for their review.
  - d. Meisinger: Recommend that the nursery experts pull something together first.
  - e. Staver: Recommend focusing the split applications discussion on the largest acreages. (Nitrogen on corn and wheat). Other issues should be addressed under the timing component.
2. Brosch: Is there enough information to choose an efficiency for split applications? Is there additional information that would be needed?
  - a. Jack presented a slide of planting vs. sidedress N gray data from PSU. Recommend contacting Doug Beegle for more information. Quirine Ketterings may have similar information in NY. Jack has MD data. The panel will need to document the gray literature.
    - i. Staver: Note that most of these studies did not measure leaching.
    - ii. Meisinger: The limitations of the gray literature are that they often do not include environmental impacts. May need to figure out how to back out impacts from this data. Not sure if this N loss represents leaching or de-nitrification. The gray literature is often un-published because it is not new information. However, this information is needed for the panel.
    - iii. Staver: field modeling could be used to tease out the environmental information.
    - iv. Meisinger: Need a water budget for this. Better to supplement the gray lit with this than translating data from other regions.
  - b. Wade may have similar data for VA from 2001 or earlier.
  - c. What to do about irrigated corn in DE?
3. Panel discussed using the model to understand differences between split application vs. all at planting.
  - a. CBP modelers will be invited to join the next call and to discuss possibilities.
4. Meisinger: Is the panel considering phosphorus in split application, such as with wheat?
  - a. Brosch: That would be a p index question more than a split application question.
  - b. The focus of this subgroup is on pre-application vs. sidedress (not fall application) for N only, focusing on inorganic fertilizer, not manure.

**ACTION:** Jack will follow up with Doug Beegle for PA, and provide MD data. Chris will ask Greg will contact Quirine Ketterings for NY data. Wade will provide VA data. Chris will talk to Tom Basden for where to start in WV.

**ACTION:** Ken will ask Gary Shenk about modeling options

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**Participants**

Ken Staver, UMD  
Jack Meisinger, USDA-ARS  
Wade Thomason, VT  
Chris Brosch, VT-VADCR  
Steve Dressing, TetraTech  
Don Meals, TetraTech  
Emma Giese, CRC

## NM Banding Subpanel

July 18, 2014

9:00-10:00AM

1. Chris Brosch: What role should banding discussion play in larger NM discussion? E.g., manure vs. all fertilizers? Chris noted that the Nutrient Panel previously decided to separate manure injection from this recommendation.
  - a. Doug Beegle: Why was manure eliminated?
  - b. Brosch: Manure injection moved to another expert panel.
  - c. Beegle: Note that all the papers on the matrix are manure-based as well as PSU studies.
  - d. Brosch: Literature has been sparse for all the subpanels; have had to rely on gray literature and best professional judgment.
2. Wade Thomason: There is literature out there on fertilizer placement for both N and P.
3. Brosch: Is it worth pursuing fertilizer banding in Nutrient Management? Panel may need to know what additional lit source can be used.
  - a. Beegle: Both fertilizer and manure are important (manure may be more important in a Nutrient Management plan). There may not be current research on fertilizer banding. PSU hasn't done anything in recent years of fertilizer banding. Work they have done is ~20 yrs old now. Starter fertilizer may be an exception, which may be most popular form of banding.
  - b. Thomason: VT has a master's thesis that is a couple years old on nitrification and ammonia loss inhibitors. Deanna Osmond published on P on high-P soils.
  - c. Beegle also has research on P on high-P soils.
  - d. Beegle noted that much of the literature will be agronomic rather than environmental.
    - i. Thomason: Agreed. There will not be info on leaching losses – may be able to infer volatilization.
    - ii. Brosch: There is an uptake response, so something can be inferred.
    - iii. Beegle: Most of the effect will be in ammonia.
4. Brosch: What about banding of P? Is P relevant in discussion?
  - a. Beegle: When banded, P is almost always banded as starter, but not as a separate split application
5. Brosch: Is there an environmental benefit?
  - a. Beegle: Yes, for runoff. P is discounted in P index (when applied to frozen soil =1, when applied during non-crop season .8, when applied during crop season .6, when via injection as starter .2)
6. Next Steps
  - a. Brosch: Subpanel will request TetraTech to do another literature search on banding P starter fertilizer.
    - i. Beegle: Recommend starting with Andrew Sharpley.
  - b. Beegle: Can query SERA-17 group at next week's meeting.
  - c. Beegle: JEQ in 2011 had a series of papers on this topic (special issue); may want to add more of them to the collection that is passed onto the manure injection group.
  - d. Brosch: Once more data is collected a second call will be scheduled.

**Participants**

Steve Dressing, TetraTech

Don Meals, TetraTech

Doug Beegle, PSU

Wade Thomason, VT

Chris Brosch, VT/VADCR

Emma Giese, CRC

## Nutrient Management Panel

## Timing Subpanel

7/18/14

10:30-11:30AM

1. Chris Brosch asked for the panelists' opinions on what should be included in Nutrient Management Timing:
  - a. Split applications are being handled by another subpanel
  - b. Greg Albrecht: The AMS group is looking at the rules from states about when nutrients are applied.
    - i. Brosch: The model is currently run with ideal nutrient application timing.
  - c. Doug Goodlander: Is there any fall application of nutrients in the model?
    - i. Brosch: Not in the current model.
2. Doug Goodlander: Some studies indicate quite a bit of loss when manure is applied in the fall. If no manure is applied in the model in the fall, there wouldn't be a need for that reduction.
  - a. Tim Sexton: Have had to come up with a way in VA to do Nutrient Management Plans for farms with no storage, such as finding low risk places to spread.
  - b. Sexton recommends discussing the changes in inorganic fertilizer over time, then manure.
    - i. Brosch: literature likely thin.
  - c. Tt: Note one aspect of timing in the literature was finer scale timing, the timing of application with respect to the next rainfall.
    - i. Albrecht: NY dairies have some percentage operating on a daily haul scenario.
    - ii. Goodlander: PA also has farmers who do daily haul.
    - iii. Albrecht: Recommend looking at timing as a relative improvement. Farms that have 6 months storage have a different situation than those with daily spread, however both have opportunities to improve their practice.
    - iv. Sexton: Note that with timing in relation to rainfall – urea applications are preferred to be close to rainfall to activate and reduce volatilization losses.
  - d. Sexton: Historically, farmers were only concerned with rate, not split application. Recommend reviewing what the difference between what nutrient management was, and how nutrient management timing is today. Focus on inorganic fertilizer because it is simpler than manure.
  - e. Goodlander: Since the timing is for Tier 2 Nutrient Management, the panel should define the difference between Tier 1 and 2, and Tier 2 should be moving beyond application rate, to timing. Tier 2 is applying nutrients close to when the crop needs it. PA's Tier 2 does not involve timing to rainfall (with manure). PA Timing does involve closeness to when the crop will need nutrients.
    - i. Sexton: VA has certain conditions about when to apply: at planting rather than in the fall. If field has additional conditions that will affect the timing as well. Agree w/ Doug that timing is about when to apply the organics close to when the plant needs it.
    - ii. Albrecht: There are opportunities for all farms to improve on that aspect of timing. There are additional guidelines for frozen ground, snow, etc. in NY.
    - iii. Sexton: Recommend the panel review differences in losses between placing nutrients close to planting rather than at other times.
    - iv. Goodlander: Two of the posted studies indicated losses with manure spread in the fall, and with manure spread in the spring. Larger losses were associated with manure application in the fall. (van Es, Gangbazo).

- v. Albrecht: Timing with respect to rainfall is important for reducing losses.
  - vi. Albrecht: With N leaching, or denitrification – spring application cuts the losses in half.
  - vii. If model doesn't allow fall vs. planting, how to incorporate that into model?
    - 1. Brosch: Recommend the panel develop the best real world answer, regardless of the model. Then document how the idea was incorporated in to the current model.
  - viii. Albrecht: WI discovery farms research on P loss and winter applications. Greg will send this information.
  - ix. Sexton: There is a study from VT on amount of mineralization over winter months that may be helpful.
3. Albrecht: With the components of Tier 2 – is the goal to come up with a nutrient loss reduction percentage?
- a. Brosch: Subpanel will develop a number to combine with the other efficiencies. Timing will be heavily weighted, particularly if it applies to every plan.
4. Next Steps
- a. Sexton will summarize the documents related to fall vs. spring application (Van Es and Gangbazo)
  - b. Brosch: When Tim's summary goes out, panelists will send comments on the big picture ideas over email and discuss fatal flaws over a conference call.

#### **Participants**

Tim Sexton, VA-DCR  
Doug Goodlander, PA-DEP  
Greg Albrecht, NY  
Chris Brosch, VT-VADCR  
Steve Dressing, TetraTech  
Don Meals, TetraTech  
Emma Giese, CRC

# Nutrient Management Expert Panel

## Meeting Minutes

### Frederick County Extension Office

October 16, 2014

9:30AM-12:30PM

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#### 1. Welcome, Purpose and Process of Meeting

- Chris Brosch, panel chair, introduced the goals and framework for the meeting. The Partnership has recommended the panel begin developing their Phase 6.0 recommendations. Phase 5.3.2 recommendations will be in place only until 2017. The purpose is to help the states claim additional credit for Tier 2 Nutrient Management.
- Panel will develop Tier 2 efficiency value for the Nutrient Management BMP. The efficiency value will be based on information collected by the panel to date, previous panel discussions and best professional judgment.

#### 2. Option A: Assign values to each of 5 components and then weight the relative influence of each.

- Jack Meisinger: Note that Option A is what the panel will likely recommend for Phase 6.0. Working on this today could help with Phase 6.0 recommendations.

#### 3. Option B: Assume that Tier 2 is equivalent to enhanced NM and adopt a 6.5% N efficiency based on the 5 components of Tier 2 Nutrient Management.

#### 4. Benchmark discussion:

- Tim Sexton motion to establish 6.5% N as default benchmark efficiency.
  - Keppler: Second the motion.
- What is the width of setbacks?
  - 100ft if no vegetation, 35ft if vegetation.
- **P Benchmark**
  - Brosch: Recommend determining the phosphorus benchmark benefit either based on a N:P ratio, or by defining P index benefit and adding phosphorus benefit from setbacks.
  - Incorporation is not a BMP in the Phase 5 model, so it can be included as a 6<sup>th</sup> component of Tier 2 Nutrient Management.
  - Goodlander: On dairy operations in PA, P site index does not have a large effect.
  - Chris Gross: From Tier 1 and Tier 2 standpoint, would erosion be controlled as part of the NM activities?
    - Erosion was taken off the table early on.
    - Gross: Are we making the assumption that erosion is being controlled by other BMPs?
    - Meisinger: Cover crops and tillage practices are stackable with nutrient management.
  - Goodlander: The way Tier 2 is written, all components are required. #4 in the definition includes soil loss assessment.
  - Keppler: Recommend leaving incorporation out at this point and follow the existing definition.
    - Incorporation is implicit.
  - Keppler: Recommend adding a 10% P reduction on top of Tier 1.
    - Sexton: Second the 10% P benchmark reduction.

- Goodlander: What is the literature range that 10% would fall between?
- Brosch: Low range is 0%. They have no setbacks or change in application rate.
- Sexton: Based on the edge of field studies considered for the components, reductions were about 30%, so 10% would be conservative.

**DECISION:** Panel members agreed to a Tier 2 efficiency reduction of 10% for phosphorus in addition to the Tier 1 reduction.

- **Nitrogen benchmark**
  - The Tier 2 TN reduction should be less than Tier 1.
  - Goodlander: Comfortable with 6.5% N reduction.
  - Brosch: 6.5% based on TetraTech literature is a very conservative number.
- Panel members agreed to the benchmark values.

**DECISION:** Panel members agreed to a Tier 2 efficiency reduction of 6.5% for nitrogen in addition to the Tier 1 reduction.

## 5. Panel Discussion

- Jack presented timing differences in both coastal plain and piedmont.
  - The differences were consistent with the 6.5% benchmark.
- Ken Staver: Note that the soybean acres are not getting N nutrient management, so the actual benefit to corn is higher than it looks.

## 6. Next Steps

- Chris will send out a tracked changes draft report by the end of next week. Email any recommendations to Chris, otherwise the report will move forward.

## Adjourned Participants

Panelist	Affiliation
Chris Brosch, Chair	Virginia Tech/Virginia Department of Conservation and Recreation
Mark Dubin, Coordinator	University of Maryland
Kim Snell-Zarcone	Conservation Pennsylvania
Larry Towle	Delaware Department of Agriculture
Thomas Bruulsema	International Plant Nutrition Institute
Colin Jones	Maryland Department of Agriculture
Greg Albrecht	New York Department of Agriculture
Jim Cropper	Northeast Pasture Consortium
Doug Beegle	Penn State University
Doug Goodlander	Pennsylvania Department of Environmental Protection
John Majsztrik	University of Maryland
Ken Staver	University of Maryland
Curtis Dell	USDA Agricultural Research Service
Jack Meisinger	USDA Agricultural Research Service



Chris Gross	USDA Natural Resources Conservation Service
Tim Sexton	Virginia Department of Conservation and Recreation
Jason Dalrymple	West Virginia Department of Agriculture
Emma Giese	CRC
Jason Keppler	MDA

## Nutrient Management Expert Panel

### Conference Call Summary

January 13, 2015

2:00-3:30PM

1. Chris Brosch, panel chair, reviewed the status of panel recommendations to date. Following significant comments from the Partnership last fall, the AgWG and CBP have developed a revised charge to the Nutrient Management Panel.
  - a. Chris will make the Partnership comments available to panel members.
2. Jack Meisinger presented an option for revising the NM panel fall 2014 report. The proposal separates N management from P management. Each one would have its own set of tiered efficiencies. Ultimately the panel needs to recommend what the requirements will be for Tier 2 and Tier 3.
  - a. Tom Bruulsema: Caution against a high incentive for higher soil test P.
    - i. Ken Staver: Don't think any site should be restricted from having the highest level of P management.
    - ii. Doug Beegle: There would be more rigorous requirements for those in high soil test P conditions. The whole system drives toward higher level of management. Because in some cases of high soil P, they may not be able to apply P at all.
    - iii. Ken Staver: This doesn't necessarily equal a large reduction in load though, even if they stop applying P.
  - b. Beegle: I like the option for low or medium soil test results to still adopt Tier 3.
  - c. Tim Sexton: Tier 3 should be about applying at less than crop removal rate.
  - d. Beegle: Recommend that Tier 3 be about managing for a low P index, whatever that takes (rates, conservation practices, and application methods).
3. Meisinger: Panel should define the structure of the recommendations before getting in to the literature and values. The N piece has more tools and no buildup problem, so it is easier to manage year to year. P residual effects make it harder to deal with.
  - a. Matt Johnston: Suggest that the table of reduction elements be linked to state practices, such as what year the practice began.
  - b. Jim Cropper: How will Tier 2 be verified?
    - i. Meisinger: The panel will be asked to make suggestions or define options for verification, but is not asked to delve too deeply in to verification.
4. Chris Brosch will draft up a few options based on today's discussion. Are members comfortable with the N elements?
  - a. Staver: To get through the Bay Program review process, is each reduction element going to need to have a reduction efficiency? Should we just go a la carte beyond Tier 1?
  - b. Beegle: The next version of the P index will attempt to relate the index to loss.
5. A subgroup will discuss some alternative proposals next week. Jurisdictional members should participate in the subgroup if possible.

### Participants

Jim Cropper, Northeast Pasture Consortium

Tom Bruulsema, IPNI

Tim Sexton, VADCR

Larry Towle, DDA

Curt Dell, ARS

Don Meals, TetraTech  
Greg Albrecht, NYS  
Colin Jones, MDA  
Doug Beegle, PSU  
Quirine Ketterings, Cornell  
Jack Meisinger, ARS  
Ken Staver, UMD  
Matt Johnston, UMD  
Kristen Saacke Blunk, Headwaters LLC  
Emma Giese, CRC

Nutrient Management Expert Panel  
Conference Call Summary  
January 22, 2015

**Participants**

Don Meals  
Jim Cropper  
Mark Zolandz  
Greg Albrecht  
Jack Meisinger  
Ken Staver  
Steve Dressing  
Larry Towle  
Mark Dubin  
Jason Dalrymple  
Doug Goodlander  
Tom Bruulsema

**Tier 2 and Tier 3 phosphorus discussion**

Tier 2 P is achieved with the P index.

Tier 3 is achieved with the PI in the high or v. high category.

D. Beegle via J Meisinger: All PI is Tier 2, further P management beyond PI is tier 3.

Staver and Albrecht: P reductions should be practices regardless of the index. Use incorporation, improve rates or spread of manure, redistribution, observe setbacks.

What is the mechanism for reducing the load? What pieces of the tier need to be present for credit of a tier?

Staver and Brosch: Let's approach P practices a la carte. Assign values to the practices based on literature and stack them with the N tiers.

Goodlander: Individual BMPs are too difficult to count. We would count plans that are compliant with the practices built into a tier.

Brosch: What kind of data are available to show the coverage of these components?

Goodlander: PA knows that 5-10% of fields are affected with setbacks.

Some data is able to be gathered for components to help boost the defensibility of the recommendations.

Albrecht: increasing resolution between tier 1 and tier 2. Making field specific plans based on manure applications. Farm scale nutrient balance work would be adaptive and more in the realm of tier 3. Fewer nutrient imports would be balancing the phosphorus on a farm and is an adaptive approach. Decreasing imports and increasing exports.

Goodlander: We can't say that tier 2 actions do not reduce phosphorus.

Meisinger: Tier 2 is reducing applications, but not so much loads.

Staver: You're slowing the increase, but loads are still trending up.

Meisinger: Phosphorus people need to flush out better what the tools and examples are. Tier 1 is N based P mgmt. Tier 2 is P based tier, mandatory. Tier 3 Whole farm phosphorus budget based.

Staver: The P game is just a long game. We have to deal with it.

Goodlander: It is like crediting riparian forest buffers. We credit them in the year they are planted. Are they credited 1/10<sup>th</sup> of the amount of work that is being done for nutrients? We should handle phosphorus the same way.

Staver: Breaking this up, we can look at the short term application method and the long term soil load.

Nutrient Management Panel  
Conference Call Summary  
1/28/15  
10:30-12:00

1. Chris Brosch: Today's discussion will include options for how to break out N and P between Tier 2 and Tier 3. Are there additions to the component practices of Tier 2 or Tier 3?
  - Tom Bruulsema: Recommend adding time release formulated fertilizers to Tier 2 N (Tom will provide the actual AAPFCO title). And adding site specific models, (dynamic weather based computer modeling) to Tier 3 N.
    - Panel members agreed with adding both components.
  - Doug Goodlander: Recommend adding field specific analysis or planning to Tier 2 N.
    - Jim Cropper will send the group a paper on field specificity vs. farm scale for P.
    - Part of that credit will already be in Tier 1.
  - Weather based computer modeling would be less relevant for P.
  - Ken Staver: Add placement of nitrogen to Tier 2
    - Meisinger: We will need to define details of split applications.
    - Tim would recommend including banding in Tier 2 components.
    - Meisinger: There may not be much data on pre-plant application.
  - Bruulsema: Manure incorporation is listed, however by Tier 3 should ensure that all fertilizer application is subsurface.
    - Thomason: Concern about interaction between tillage and incorporation.
  - Cropper: Banding P should be at least Tier 2 if not Tier 1.
  - Panel will need NY's input on whole farm P balance.
    - Larry Towle: Suggest whole farm P balance optional for Tier 2 and mandatory in Tier 3?
    - Staver: Include a more explicit statement about soil P levels rather than farm P balance. Need to specify that the soil P levels are not going up if P reduction credits will be given.
2. Panel members discussed the optional vs. mandatory components for Tier 2 N and Tier 3 N.
  - Mandatory can be further broken out in to 1) mandatory assessment, where the practice is considered case by case by the planner, but may not fit everywhere and 2) mandatory implementation.
  - In some cases a subset of practices (e.g. 2 out of 4) could be mandatory.
  - PA currently does not require split applications until corn is up (no fertilizer only plans).
  - Pa noted it would be difficult to pull out information on set-backs for tracking and verification.
  - Manure timing would be mandatory on certain land uses (not hay).
  - For Tier 3 N, panel discussed requiring 2 out of the 4 tests (PSNT, CSNT, etc).
  - Panel discussed requiring 2 out of the 8 total components of Tier 3 N.

**Participants**

Colin Jones, MDA  
Emma Giese, CRC  
Jack Meisinger, USDA-ARS  
Chris Brosch, VT-VADCR  
Steve Dressing, TetraTech  
Curt Dell, ARS  
Don Meals, TetraTech  
Doug Goodlander, PADEP  
Jason Dalrymple, WVDA

Tom Bruulsema, IPNI  
Larry Towle, DDA  
Jim Cropper, NE Pasture Consortium  
Ken Staver, UMD  
Wade Thomason, VT



Nutrient Management Panel  
Conference Call Summary  
2/5/15  
2-4PM

1. TetraTech completed review of the PSNT literature, which the panel will discuss today. Panel will then go back to determining which components fit in to which tiers. Will be looking for volunteers to take over each of the four separate tiers moving forward.
2. Jack Meisinger presented N reduction efficiencies for the PSNT.
  - a. Ken Staver: Note that the original application rates were high in the control (Vermont) so the reductions might be too high or different in bay states.
  - b. Don Meals: The early 90s were the very start of nutrient management in Vermont.
3. Jack shared estimates within Maryland from nutrient management planners, showing reductions lower than Vermont 2012 and 2 other years.
  - a. Meisinger: This is technically gray literature, however it is tracking application in the Chesapeake Bay area.
  - b. Panel could break out animal density by county to estimate manure vs. fertilizer use.
  - c. Panel members supported use of the information Jack presented.
  - d. PA does not have follow up tracking on PSNT.
  - e. VA has tracking on PSNT manured acres. Some of it may be by county, but will be difficult to access within the timeframe of this panel.
4. Doug Beegle: Note that users of PSNT are likely to be outside of average anyway, so this is not a random sample.
  - a. Meisinger: We'll have similar problems with the CSNT.

ACTION: Panel will collect state PSNT data, where it is available.

5. Panel reviewed components of each Tier, members will volunteer to complete literature synthesis for individual components.

ACTION: Contact Jack to volunteer to review specific components. Will recruit additional people next week.

6. Tim has literature source on roughness affecting manure incorporation effectiveness.
7. Panel discussed removing full P index from Tier 2
  - a. The tool isn't what is driving the reductions.
8. New Tier 2 P requirements including incorporation and STP as indicator.
9. Beegle: STP not good indicator of environmental P loss (PSI is more comprehensive). If panel chooses one tool to guide P management it should be the PSI, otherwise take both tools out and rely on management.
10. Beegle: Suggest including management driven by PSI if PSI is taken out.
11. The P index is already in the approved definition for Tier 2.
12. Panelists discussed some of the management practices that could be included: manure timing, rates, incorporation, soil erosion, buffers.
13. Suggest defining how much P index reduces loss to estimate reduction efficiency.

**Participants**

Colin Jones, MDA  
Curt Dell, ARS  
Don Meals, TetraTech

Doug Beegle, PSU  
Greg Albrecht, NYSDEC  
Jack Meisinger, USDA-ARS  
Jason Dalrymple, WVDA  
Jim Cropper, NE Pasture Consortium  
Larry Towle, DDA  
Steve Dressing, TetraTech  
Emma Giese, CRC  
Doug Goodlander, PADEP  
Ken Staver, UMD  
Tim Sexton, VADCR



Nutrient Management Expert Panel  
Conference Call Summary  
2/19/15  
1:30-3PM

**Participants**

Chris Brosch, VT VADCR  
Don Meals, TetraTech  
Greg Albrecht, NYSDEC  
Emma Giese, CRC  
Curt Dell, ARS  
Jack Meisinger, USDA-ARS  
Mark Zolandz, EPA  
Doug Goodlander, PADEP  
Tim Sexton, VADCR  
Steve Dressing, TetraTech  
Doug Beegle, PSU  
Ken Staver, UMD  
Colin Jones, MDA  
Larry Towle, DDA

1. Chris reviewed the Tier assignments and volunteers. Tom will be asked to take on STP mapping and pool management.
2. Since the last call, there have been offline discussions around Tier 2 phosphorus. There was support in the last call around components that build the P index. Support against using the P index was based on how states use the P index in their programs. However some panelists have recommended reconsidering. Consider using P index to provide us with efficiency.
3. Curt Dell to take lead on P index with Doug Beegle and Greg Albrecht. This group will go over the P index literature gathered by TetraTech. TetraTech has a possible method of teasing out efficiency from the literature.
  - a. Chris will schedule a P index call in near future.
4. Tim will take lead on Tier 2 manure timing (Rory Maguire and Doug Beegle will assist)
5. Tim will take the lead on placement
6. Chris will take the lead on manure incorporation (Jim C., Doug B., Curt D. will assist)
7. TetraTech did not find much literature on the CSNT
  - a. Jack recommended Greg Benford (sp?) – if Larry Towle has contact info for him. Ask him if there is any literature or extension pubs for CSNT. Looks like it will be written up as useful tool with insufficient information to recommend an efficiency.
  - b. Larry will take the lead on CSNT – others will send useful backup information
  - c. Greg noted that the ISNT may be in the same situation
8. Test strips
  - a. Chris will contact Jim Baird regarding test strip data
9. Jack noted that the group will still need to decide which practices and how many are required for this Tier
10. Dynamic models
  - a. Contact Tom Bruulsema
  - b. Greg will contact Harold van Es and ask others to help evaluate how useful the data would be

- c. Willard has started using adapt N
- 11. Chris will send out the 5.3.2 report. TetraTech has been reframing the report since the fall. Panelists should send comments to Steve Dressing, who will coordinate comments on the 5.3.2 report.
- 12. We will be inviting CBPO modelers to a call soon to re-write technical appendix for a revised report.
- 13. There will be a webinar prior to the release of the 5.3.2 report.
- 14. Karl Blankenship of the Bay Journal will be writing about nutrient management
  - a. Recommend that Chris be the contact person for the full panel
- 15. Don Meals has continued compiling T2 and T3 literature for the new tiers
  - a. Component leads should contact Don for help identifying sources in the peer reviewed literature
  - b. Chris will send out the spreadsheet
- 16. At the next call panel will discuss the technical appendix, and the report template. The bulk of the work will be on the components. There will be a P index call scheduled soon.

Nutrient Management Panel  
Conference Call Summary  
3/20/15  
9:00-11:00AM

**Participants**

Colin Jones, MDA  
Don Meals, TetraTech  
Chris Brosch, VT VADCR  
Steve Dressing, TetraTech  
Tim Sexton, VADCR  
Curt Dell, ARS  
Greg Albrecht, NYSDEC  
Tom Bruulsema, IPNI  
Emma Giese, CRC  
Jeff Sweeney, EPA  
Jack Meisinger, ARS  
Wade Thomason, VT  
Jim Cropper, NE Pasture  
Ken Staver, UMD

**Announcements**

- Chris updated the Agriculture Workgroup last Wednesday on panel progress.
- On April 6<sup>th</sup> there will be a webinar offered to the larger Partnership to share information about the nutrient management panel progress and next steps.
- Karl Blankenship will be conducting interviews and writing a white paper this spring. Note that Chris will be the point of contact for the panel.

**Technical appendix questions**

- Jeff Sweeney: The purpose of the technical appendix is to give guidance to how states will transfer data on implementation to the Bay Program Office, and how the data will be processed through Scenario Builder.
- Jeff outlined the 15 technical appendix questions, which are very similar to what was in the report's technical appendix last fall. The answers will be slightly different this time, but essentially the same process for reporting and crediting in the tools. Typically the expert panels don't write the technical appendix, but it will help the panel to understand the questions that need to be answered.
- How can Scenario Builder credit BMPs that only apply to manure acres?
  - If there are acres within the same land use that have both manure and non-manure acres, the benefit would need to be apportioned down.
  - So if the panel has a non-manure BMP we will have to discount it.
  - Jack asked for data on manure and non-manure acres.
  - Jeff: We have ag census data on manure and non-manure acres at the county level, which other ag panels have used.
- Who will develop revised answers for the technical appendix?
  - Matt will probably write the first draft of answers to these questions again. Emma will help because she is engaged in this panel. The first draft of the report will help to guide the

modeling team to give full answers. The Q/A format works well for the review process. The panel is welcome to provide answers as well as review the modeling team answers.

**Progress over past few weeks: report out on component practices****Tim Sexton reported out on nutrient management nitrogen availability reviews**

- Tim found 11 relevant papers and gave Chris hard copies of the relevant papers this week. Tim's slides summarize the findings.
- Looked at mineralization rates, as well as incorporation vs. surface application. No surprises in literature in terms of nutrient availability of manures, or N/P loss, except for one source on poultry litter. Recommend Phase 6 panel take a closer look at N availability in poultry litter.
- Tim is compiling a spreadsheet to summarize the findings, and will send to the panel on Monday.
- Request that Tim send citations to the panel next week, because they may be relevant to other practice components.

**Jack Meisinger reported out on PSNT reviews**

- Based on literature from TetraTech, three were relevant to the watershed. Jack built a spreadsheet summarizing the data from these three. Jack summarized the average N reduction efficiency of environmental variables (NO<sub>3</sub>-N leached or fall residual NO<sub>3</sub>-N), and the average N reduction efficiency of fertilizer N variable (reduction in fertilizer N as % of control).
- Panel discussed difficulty of determining the control conditions in each study, and need for best professional judgment to define the control as well as keeping record of these BPJ decisions.
  - Land grant university recommendations can be a control, but need to define the time period as these change over time.
- Jack also reviewed some (gray literature) summary of Maryland recommended N reductions from PSNT, and VA DCR field testing of PSNT summarized by American Farmland Trust.

**Greg Albrecht reported out on multiple components**

- Tier 3 P whole farm nutrient balance: Data found doesn't support adaptive phosphorus, would be more applicable to feed management review. Recommend taking this component off the list.
- CSNT/ISNT: studies showing on fields that would have 60-100 N recommendation, actually don't need nitrogen.
  - Greg will create a spreadsheet similar to Jack's PSNT spreadsheet.

Nutrient Management Panel  
Conference Call Summary  
03/26/15 3:00-5:00PM

**Participants**

Chris Brosch, VT-VADCR  
Curt Dell, ARS  
Colin Jones, MDA  
Don Meals, TetraTech  
Doug Goodlander, PADEP  
Greg Albrecht, NYS  
Jennifer Ferrando, TetraTech  
Jim Cropper, NE Pasture  
Larry Towle, DDA  
Mark Zolandz, EPA  
Wade Thomason, VT  
Tom Bruulsema, IPNI  
Tim Sexton, VADCR  
Ken Staver, UMD  
Emma Giese, CRC  
Matt Johnston, UMD

**Report outs on component progress**

- Jack Meisinger: Have been discovering more data with the PSNT effort.
- Greg Albrecht asked for panelists to send him any ISNT or PSNT papers.
- The end of next week is the deadline for finalizing Tier components.
- Jim Cropper wrote a paper on P management practices for no manure Tier 3, variable rate applications. Jim asked for panel member feedback.
  - Meisinger: Did you look at the ARS watersheds in Ohio? They had good information on hydrology. Close enough to the Bay Watershed that it might be comparable. Jack will email the information to Jim.
- Brosch: How many acres of variable rate P do the states have or think they could report?
  - 3-4 thousand acres in VA.
  - Small amount in PA that would be reportable.
  - DE would have very few acres of variable rate if any.
  - MD has very few but could get this in the future.
  - NY has very few.
- Brosch: We could model variable rate P by capturing the change in application
  - Cropper: This paper found reduction of soil test P by 2.2 mg/kg/year.
- Wade Thomason: Would we be looking at changes in soil test P as change in risk?
  - Brosch: More complicated than the N question, where we can use a change in application rate. Moving forward it would be reasonable to use both the change in application rate and change in soil test phosphorus together to assign an efficiency. Ask Jim to lead up establishing an efficiency for Tier 3 phosphorus.
  - Cropper: Need to know, are you going to zero phosphorus on some grids with a variable rate application?
  - Thomason: Will work on this with Jim. Soil test levels, zone sizes should answer the question. Can ask the companies what they are doing, for the most part they are putting on crop removal rate.

- Tim Sexton will help with Tier 3 P estimation.
- Brosch: The panel will wrap this up and establish an efficiency for Tier 3 phosphorus on the next call.
- Goodlander: Note the limitation with state data on Tier 3 P. PA would have no acres to report under variable rate P.
  - Most states will have the same limitations.
- Group ultimately decided to move forward with defining an efficiency for Tier 3 P, given that the work is nearly complete and will also help set the stage for the Phase 6.0 Nutrient Management Panel.
- Wade Thomason presented results of variable rate N. Ability to reduce rates and maintain yields is tied to variable rate application.
  - Benefit would be in acres that are reflecting a conservative benefit.
  - Bruulsema: Could calculate a rough nutrient balance with this data, and come up with a conservative estimate.
  - Brosch: The panel will finalize an efficiency for this component next call.
- Doug Goodlander: For setback component went to our major private sector planner and had them develop a number of plans representing a normal farm in PA, averaged how many feet of streams run through a typical farm. Came up with 2776 average feet of stream running through crop of a normal 100 acre dairy farm. In absence of strong published literature, this is intended to provide a starting point for discussion.
  - Is it reasonable to assume if the setback is imposed the manure that would have been applied would not be applied to the rest of the field resulting in a higher rate on the rest of the field?
  - PA: It would not increase the application rate, it might increase the export. These farms are obligated to export manure anyway.
  - Johnston: PA should be tracking if the manure is exported off the farm. However if we mimic setbacks in the model we would need to place the extra nutrients somewhere. We do still have to apply all the nutrients.
  - Chris will ask Olivia Devereux about any literature differences between manure and non-manure loading rates in land use literature review.
- Chris Brosch looked through his unpublished thesis data, not sure how well it translates to the Bay scale. May recruit others to help to look through the data.
  - Panel may recommend putting this off until Phase 6.0, when a dedicated panel will be looking at manure incorporation specifically.
  - Thomason: If we assign a P value, it will have to that differ by landscape position and slope.
    - Landscape and slope rather than geographic region? Model doesn't account for landscape and slope.
    - Thomason: Take an average slope for piedmont, ridge & valley, etc.
  - The TetraTech literature review has data sources for benefits of manure incorporation across the watershed (and country).
  - Chris will present manure incorporation N efficiency for the watershed and P efficiencies by physiographic regions next week.
  - Curt will help Chris with the manure incorporation component.
- Jennifer Ferrando presented report changes (very few). Added comments where sections might be missing information. Reference section could be tightened up (TetraTech will work on this while panel members finalize the recommendations). Completed a light edit on typos/formatting. Also included a few comment bubbles on content, such as statements that might contradict one another. Moved some of the intro content in to the body of the report.

- Brosch: When Jim Cropper and Wade Thomason finish developing numbers, we will include their findings in the report. Will ask TetraTech to start fleshing out other sections, such as Doug Goodlander's.
- Next call will be scheduled around Wade/Chris' availability. Will talk about next steps in terms of weighting components in to each Tier. These types of discussions will be wrapped up in the next few calls, then report writing. Let Chris know if you don't have time by the end of April to work on finalizing component practices.

Nutrient Management Panel  
Conference Call Summary  
4/14/15  
10:00-12:00

**Participants**

Chris Brosch, VT/VADCR  
Doug Beegle, PSU  
Colin Jones, MDA  
Curt Dell, USDA-ARS  
Don Meals, TetraTech  
Greg Albrecht, NYSDEC  
Tom Bruulsema, IPNI  
Jim Cropper, NEPC  
Jack Meisinger, USDA-ARS  
Steve Dressing, TetraTech  
Doug Goodlander, PADEP  
Larry Towle, DDA  
Jason Dalrymple, WVDA  
Matt Johnston, UMD  
Mark Zolandz, EPA  
Emma Giese, CRC

Chris Brosch: The webinar on nutrient management last week was well attended. There were some good questions about the framework for the revised tier structure.

Jack Meisinger presented data on split N applications in the Piedmont. Jack asked the panel to help collect more piedmont data, since these initial results do not show much benefit for split N applications, which is unexpected.

- Panel will have to discuss how to balance credits between PSNT and split applications
- Note that these reductions are in application rate, not reduction in edge of field loss. Panel will need to translate the reductions.
- Greg has extension references on incorporation, which he will send to Jack.

Chris Brosch presented his write up on manure incorporation effects of P in various regions in the watershed.

- Panel will need to adjust plot scale to watershed scale to determine the final reduction efficiencies.
- Curt will ask others at PSU how plot scales were scaled up for SWAT model.
- Cover crop panel takes a factor of 0.75 when scaling up for cover crops from a plot scale.
- Greg Albrecht: Suggest considering the effects of manure incorporation in a regular tillage situation.
  - Brosch: Soil loss will happen either way. Increase in P loss from manure broadcast would be detrimental compared to incorporation. However, no papers looked at so far have had that scenario.

Greg Albrecht presented a synthesis of studies for Tier 3 practices.

- Greg found that the reductions from whole farm nutrient balances are driven by feed management, which is already accounted for in another BMP. Recommend re-visiting this with the Phase 6 panel especially if the feed management BMP definitions change.
- Does feed management translate in to manure management as well?
  - Suggest a BMP for local manure transport.
  - Curt Dell will check in with modeling team on possibility of local manure transport BMP.



- ISNT adaptive management reductions estimated at 33-40% based on 4 citations from NY, where there was a change in behavior following results of the soil test.
- CSNT resulted in about a 20-30% reduction beyond Tier 2.
  - PA has similar data showing about half of CSNT results are excess. Both NY and PA test results are primarily in dairy settings.
- Adapt N computer model designed to fine-tune sidedress N applications for corn based on weather data and field-specific user inputs. The approach stands relative to the book values for soil N, sod N, and manure N common in Tier 2 nutrient management. Adapt-N requires annual field characterization and early summer monitoring to guide sidedress N applications.
  - Results show simulated N leaching loss.
  - Meisinger: Note that we would need real world measurements for this component.
  - Albrecht: There was a lysimeter study that is not included in this summary.
- Panel to discuss how to translate the change in application to change in edge of field losses. Will any adjustments be needed to reflect imperfect nature of on farm management?
- Don Meals will translate Greg's summaries in to the final report.
- Albrecht: Note that most of these results and studies apply to corn, and the panel needs to address all crops.

#### Next Steps

- Brosch: We have much of the needed data to support the tiers now. With a soft deadline of the end of April, we are at the point where we have to take the literature we have and decide which land uses it applies to. Most literature supports row crop with manure in Scenario Builder. Panel may be able to make BPJ estimates about pasture, and possibly row crop without manure.
- Panel will still need to decide what to do with the P index as a whole? Incorporation of manure is just one piece of the puzzle. Value of the P-Index as a whole is better understood by the Partnership, so to not develop that in the report might be questionable.
  - Meisinger: The P index work over the past 15 years should be represented in the report.
  - Dell will re-convene the group at PSU to see if there are modeling results that would help add to the P-Index.
  - Beegle: concerned that we'll have any model runs by the time the panel needs results.
  - Dell: We could add a description of research needs in the report.
  - Brosch: Suggest that something from PSU come out by 4/24 for inclusion in the report. If there are materials that could be synthesized in a one-pager, that's an option. Or the PSU group could look at the paper Greg found to adjust the 20% reduction to what should be in the model.
  - PSU has done some comparisons between the Watershed model and SWAT.
  - Curt and Doug will look at the Ketterings and Czymmek paper as well as the paper from Deanna Osmond (Steve Dressing will summarize the paper).
  - The panel may recommend discounting the value of P Index since data is limited.
- Panel will discuss the P index at a meeting. A second meeting to go over all the moving pieces to put the Tiers together and get a report written will be scheduled before the end of April.
- Don Meals will be contacting panelists to clarify the written sections of the report.
- Chris will send out his, Greg, and Jack's write-ups to the full panel.

Nutrient Management Panel  
Conference Call Summary  
4/23/15  
1-3PM  
P-Index Discussion

**Participants**

Curt Dell, ARS  
Don Meals, TetraTech  
Greg Albrecht, NYSDEC  
Jack Meisinger, USDA-ARS  
Jennifer Ferrando, TetraTech  
Steve Dressing, TetraTech  
Colin Jones, MDA  
Tom Bruulsema, IPNI  
Emma Giese, CRC  
Matt Johnston, CBPO  
Chris Brosch, VT-VADCR  
Jason Dalrymple, WVDA

Steve Dressing reviewed the summary of 3 papers on P Index from Deanna Osmond, and her recommendations based on Steve's follow up discussion with her.

Jack presented summary of P index SWAT modeled data (Veith et al 2005). Panel discussed some possibilities for using this type of data to establish a reduction efficiency.

- Dressing recommended discounting the P Index component efficiency value to account for some of the uncertainty.
- Note that the outlier field in this dataset is also the smallest in size.
- Meisinger suggested the panel consider lag times perhaps by type of setting. How long would it take after the management actions take place before a change in P Index output could be expected?
  - Brosch: Suggest the panel consider building in the lag because BMP efficiencies are generally supposed to be at edge of stream.
  - Johnston: Note that other panels have considered similar issues, and have recommended what the average annual effect would be.
  - Chris will propose some options for capturing the lag time.
- Panel members discussed how to capture the extent of the P Index.
- Meisinger: Suggest having someone for each state propose area estimates by state and then compare with the panel.
- Curt will contact PSU colleagues for the data summarized in the small watershed, to come up with a regression line.
- Curt noted concern over using data from just one small watershed for the final efficiency.
- Dressing: Suggest estimating PI scores in studies where P loads were measured. This would allow for building a larger database.
  - Meisinger: Anyone that uses the P Index in the field should be able to estimate the PI value.
  - Dressing: The nutrient loading literature may be valuable resource.
- Brosch: Challenge will be completing this task by next week, which is when we plan to finalize the efficiencies with the full panel.
- Meisinger: Suggest volunteers in each state to look at a few data sources and come up with P Index estimates in studies where P loads were measured.

- Ken Staver/Frank Coale, Greg Albrecht, Doug Beegle, Pete Kleinman
  - Tasks to be complete in about a week and shared with the panel via email.
- Brosch: The panel will dedicate next week's agenda to finalizing the P index piece as well as combining the components in to a final product.
- Meisinger: Note the importance of recommending something on the P index, because without it we will just have N based manure management until 2017.

NM EP Phase 5.3.2 Call  
May 1, 2015**Participants**

Chris Brosch  
Doug Beegle  
Greg Albrecht  
Doug Goodlander  
Jack Meisinger  
Mark Zolanz, EPA Region 3  
Jason Keppler, MDA  
Ken Staver  
Tim Sexton  
Curt Dell  
Larry Towle  
Don Meals  
Steve Dressing

**CSNT, ISNT – Greg Albrecht**

Discussion based on GA's draft. Focused on T3 adaptive N management. Managing according to the signals gained from CSNT or ISNT. Generally, 40-50% of corn fields would be non-responsive based on these tests. So, using these tests ~half of fields can be managed differently from simply following LGU recommendations.

How to translate this into end-of-season N numbers – what gets into stream. He worked with Quirine and others who were focusing on CSNT. Six N treatments, 0-250, 4 reps; tight relationship between CSNT and end-of-season soil nitrate levels in top 12 inches. He also asked Quirine about other CSNT and ISNT studies – Q is working on it but won't be ready for 5.3.2.

Because this is T3, used as basis the LGU recommendation and then the change would be the next lower rate used in the studies. The reduction would be from 150 lb N/ac to 100 lb N/ac = 40% reduction in end-of-season soil nitrate. Greg applied similar logic to ISNT (Illinois Soil Nitrogen Test), resulting in 40-50% less end-of-season soil nitrate.

This is as far as we can get quantitatively, at least with NY data set

Beegle – comparable with limited PA data

Meisinger has been working on how to connect end of season soil nitrate with eof N loss

**PSNT (Pre-sidedress Nitrate Test) – Jack Meisinger**

This is T3 N.

Jack found 4 good lysimeter/deep soil nitrate studies (Durieux, Guillard, etc.). He derived the following N reduction efficiencies based on fertilizer N rate changes due to PSNT (3 lysimeter/deep soil nitrate): 0.286, 0.423, 0.254, and American Farmland Trust summary = 0.341 (2300 sites sampled in VA 2010-2013). With AFT study, Jack used similar approach to GA in calculating reduction for Tier 3: i.e., recommended rate down to next lower rate. In his case, 28% of fields (in green) received this reduction credit. ( $.28 = 355/1246$ ). So, the 40% reduction applied to 28% of the fields in the AFT study. DG raised this issue and JM agreed that we needed to account for the percentage of fields that actually get the reduction. So, reduction would be less than 40%.

TS said that in his 6 years of studies, 42% of the time there was an indication for no N or cutting N by 50%. VA uses two guidelines for PSNT test result: values of 15-20: cut back sidedress by 20 lb N/ac 20+ = no additional N. Tim had % values for how much had no N and how much had 50% reduction (I missed the numbers – they belong in the report).

For all four studies, an overall 0.341, or 34% reduction. This is for plot scale/strip trials. Need to adjust it for model. None of these reductions incorporate implementation discounts.

#### Discounting

What we've done with other panels, when adjusting to farm scale, can't be as complete/precise on all fields – use 0.75 discount to factor in scale-up

Land use/modeling discount – all three tests apply only to corn, but Ph. 5.3.2 have all row crops combined, so use proportion of corn acres:row crop acres to discount PSNT/CSNT/ISNT

$$.341 * .75 * XX = 0.0107$$

Ends up with 5-10 percent.

Staver – why do you need land use discount because only have PSNT/CSNT/ISNT on corn in the first place.

Meisinger – if you require PSNT reporting, don't need this discount

Sexton – given current price of N, most farmers willing to reduce app if test says so

Meisinger – don't need final answer today (?) but need to mull this over

Sexton – would want to report all acres tested, then discount by acres where recommendation was followed

Beegle – where do we get those numbers? PA does not track

Sexton – VA tracks testing, both numbers of tests and acres of field

DG said they don't have any other method for getting PSNT acreage data for CAFOs or other sources. Agri Analysis data – TS said they ran about 115, A&L labs ran about 400 last year. TS didn't get acreage from Agri Analysis (lab), but his staff tracks acreage. DG said PA uses Agri Analysis and doesn't get acreage.

KS suggested PA just needs to add a check box for acreage. TS said a 10% credit is a good incentive. DG not sure he'll get much on it from PA.

JM said this will be revisited in Phase 6, so we may want to consider a cruder approach for phase 5.3.2 and rely on phase 6 to get better reporting data.

KS said that the model should help organize data collection, but doesn't see the CBM doing that so well. He thinks moving forward the model needs can help direct reporting better.

JM suggested that maybe PA could use as a default the % for the other Bay states (MD, NY, VA).

DG said that he understands that the NM EP is currently contemplating reporting acres in T1, T2, and T3 in general, but not specific things like PSNT as a component of T3. Lumping vs. splitting, but he sees EP in a lumping mode at this time. If lumping, then need to determine an overall T3 efficiency that accounts for acreages of the different components of T3. JM said he made some good points, and we need to get some info on the various components, adjust efficiencies, etc. to accomplish the lumping approach – sees this perhaps as a short-term solution (lumping) for T3 N, and thinks 5-10% is likely where the efficiency will be. TS agrees with that. GA agrees with the 5-10% and considers NY in a similar position as PA with regard to reporting.

GA says the NY T3 reporting form doesn't include acres either.

JM, GA, TS all agreed that it will boil down to BPJ, but that we now have some numbers to use to justify the choice re: efficiency.

**Next Steps:** Need some Ag Census acreage estimates on corn acreage. JM suggests that CB asks modelers to get 2012 Ag Census data for Phase 5.3.2 LUs, breaking out corn and small grains. CB said they'd use Ag Census and get the data. He'll also break out corn grain and corn silage. Will also provide total row crop acreage.

GA said his CSNT and ISNT reductions were couched vs. Tier 2 N management. Wants to be sure people agree on that. TS agrees. CB then suggested looking at the summary that Don put together on status.

Don discussed his slides. It's a simplified status report on where folks are on the various T2 and T3 components.

#### **Tier 2 - N**

Recommendations are generally lacking. Don also pointed out outstanding issues for each component.

CB said the T2 N manure incorporation slot will be filled in shortly by JM. (Action Item)

JM gave an update on the T2 N slide: on split N he did some work and Doug got some data from Dick Fox. Says the piedmont issue will be resolved. Dick Fox' data shows some response to split application in piedmont whereas Jack's data hadn't shown a response. JM asked for more info from panelists on split app, particularly for piedmont.

On manure incorporation, JM has summarized his data, focused on ammonia loss. Curt Dell has given him some data and he will have a number for ammonia loss, but not on runoff. So, just for N.

#### **Tier 2 – P**

Application setbacks – have a working number from Doug Goodlander for PA

Manure incorporation – CB's data from lit

P Index

#### **Tier 3 – N**

Six BMPs in this slide.

#### **Tier 3 – P**

Quantified with variable rate P fertilizer and whole farm nutrient balance.

**Discussion:**

T2 P: Setbacks – DG said setbacks impact 8-10 % of the acres. This is not a P load reduction as shown in the slide. He suggests we used what model determines P losses for manure vs. non-manured acres are, and use the difference as the reduction. Then multiply that by the 8-10% of the acres receiving manure to get the reduction.

T3 N: Recommendation for PSNT, CSNT, and ISNT – possibly combine to single BMP using PSNT, CSNT, or ISNT to modify N applications. For CBW, need to proportion reductions by fraction of row crop land in silage corn.

JM isn't comfortable with the Adaptive N Management credit (36%) because the model hasn't been validated sufficiently. Says NY may be happy with it, but it flopped in Midwest testing. CB asked if anybody is actually reporting acreage for that. DG said no for PA, and DB agreed. Interest is there, but it's too early in the process. CB recommended tabling it for recommendations because implementation levels are low. GA says JM is right about validation needs, saying waiting for Phase 6 makes sense. JM suggested we call it a work in progress and move on.

CB asked about variable rate N fertilizer; lump it into PSNT, CSNT, and ISNT? JM said Wade Thomason was going to address N sensors and variable rate N, but nothing from him yet. JM sees variable rate/N sensors as a combo. CB will combine the two and asked TS to help him get WT to add some comments on how to incorporate that BMP with the others for T3 N. CB said we may need to wait for acreages for PSNT and use that acreage to help guide decisions. TS said WT had acreages on small grain vs. corn. CB sees combining N sensors/variable rate N with CSNT/PSNT/ISNT – e.g., if you use one of them, you get the credit (something to that effect). JM encouraged solving this because we have some backup research. TS sent WT an email during the call.

T2 P: GA discussed the need to get credit for incorporating manure. I missed the specific point GA was making but CB seemed to understand and said the lit was thin there.

JM discussed the lag time component he had applied to the lit, but talking to CB he found that modelers give the full credit up front. Jack said the .7% he had suggested becomes 7% when not factoring in the lag time. DB said you do get an immediate response from incorporation.

JM said the PI is a P mgmt tool nested within nutrient management. DB said PI doesn't do anything but suggests other BMPs. CD pointed out the need to avoid double counting because of this.

CB said he wanted to table the T3 P.

Regarding PI, CB posted summary of responses to his and JM's email asking about importance of PI components. CB said we are at a crossroads: we can credit timing and other components incentivized by the PI. JM deferred to DB on how to credit, whether to lump or split. Would like some consensus on how we deal with the PI for Phase 5.3.2.

DB said he wouldn't know what to say re: credit for the PI. He said it might make more sense to credit the prx but not sure how you'll get the data. Said it might be simpler to lump everything under the PI and use BPJ for an efficiency – he's not sure what it would be.

CB summarized responses he received from state managers on the PI – what they track and how to credit.

States take different approaches. VA is willing to just get some prx down without the PI; run the PI only when have no choice (same in MD). NY and PA take an approach where they run the PI. No response from WV and DE.

TS said about 65% of animal plan acreage (130,000 acres) have PI run on them. He said it was 96% 5 years ago. He says 85% of poultry operations transfer litter off farms so don't need PI. CB concluded that about 10% of acres have PI.

CB said MD reported about 20% of acres under PI.

CB asked GA about NY use of PI. GA said PI primarily drives source. GA said they felt a need to assess those cases with high manure app and high transport risk. Also, working with planners, they agreed to take a look at all farm lands to help with solutions on how to distribute manure more appropriately among all farm lands.

DB said PA also screens out fields that are lower risk. So, they "run" the PI without actually going the next step beyond screening. GA says that's what they do in NY as well – apply a screening tool and then use PI only where risk so dictates. DB said that in PA they report CAFOs, high animal density, etc acres in PA under nutrient management, and they run the full PI on those lands.

Seemed to be agreement with NY and PA that a screening/priority approach is used to determine where PI must be applied. DB says PA requires that farms "pass" the screening tool test in order to avoid needing full PI.

TS said VA applies a threshold method to determine where PI must be performed. Don't run it on every field every time. Use STP saturation levels as part of screening. ID farms at higher risk.

JM said it looks like there is a similarity in how states determine where P-based management is needed. So perhaps the T2 P reduction is applied to any lands required to go to P-based management.

P-based based on STP; if scoring at a certain level, you are P limited.

TS says you can run the PI and still have N-based management as a result. (I think that's true of all PI applications. Screening triggers running the PI, but running the PI doesn't guarantee P-based management).

KS says a subset of acreage on which PI is run are then under P management (much like the PSNT discussion earlier).

CB: Do we do our best to quantify the top 4 P-based PI components and then credit based on the 80% (PA's numbers) vs. 20% (22% need to implement the PA PI). DB said PI forces P-based management – PST will still be high but your management will change. CB is trying to zero in on where we credit T2 P. He's thinking the 20% may not get credit because they still have too much P in soils, whereas the 80% get credit because they are not at that P level (I think that's what he's saying).

Big issue is the PI doesn't necessarily reduce P in soils and therefore P losses. DB said the point of PI is to keep P out of water, not to reduce PST levels. DB said you can have a high PST and still not pollute (flat, no-till, no delivery).

CB asked if DB was disagreeing with his 80/20 approach, i.e., the 20% should get some credit, too. DB says there are probably two levels:



1. Farms running PI but at low-risk levels: they are already doing things to keep P from water even if they don't have to make any changes.
2. Farms running PI with higher-risk levels: they have to make a change so there is some benefit.

DB thinks the benefit may come from the higher-risk farms (i.e., the 20%).

GA asked about historic considerations. If getting low-risk PI now is that an indication that pre-1996? They were also low risk? DB said yes.

CB raised an issue of double-counting.

CB suggested that the 20% of acres having PI imposed on them (high risk) are where we assign credit due to new actions. JM liked that because T1 has a 10% reduction for P across the boards, thinking that will cover the 80%.

Discussion of Very High to High vs. High to Medium. DG thinks there is a truly significant P reduction for those that don't come in at high risk under PI. Lots of farmers start with a High and then make some changes to get down to a Medium when PI is re-run.

GA said he's not sure how to capture the time step in verification. i.e., no PI drops ever happened as a result of PI before 2005. Do we credit all acres that had PI applied or only those acres that effected a PI change in status.

GA said he doesn't think he can capture a change in PI level. Just focus on the current status.

DB said that on 20% of representative farms where PI was run, you get a change (he focused on High/Medium changes). This is a subset of representative farms they (DB and JM both involved) studied; not sure if it applies broadly. Also took Veith study and looked at modeled P loss vs. PI and showed 50% reduction. So if multiply  $0.2 * 0.5$  get 10% reduction in P loss by running P index. DB said this study was from running a raw PI, not something as part of planning process. i.e., just ran the PI without it being part of a planning process – not the end result. The farms on which the PI was run were under N-based plans. PI showed that 20% of the time the N-based wouldn't work, so they had to move to a P-based plan. DB said **both papers are published**: 11 farms (300 fields) in one ARS watershed in PA. DB cautioned that the dataset is narrow.

TS said in VA they just get the resulting PI so can't track a change. He doesn't have any "raw" PI scores like DB described in the above study.

CB suggested going with 10% reduction:  $0.20 * 0.50 = 0.10$

JM likes this if we can build that into some text.

Would need to add a discount for the research effects. DB can be comfortable with this is we use it short-term. He hopes to generate more data for PA (~10,000 modeled sites).

KS said reasons for using PI in MD.

- If FIV <150, off the radar for PI

- if FIV >150 need to run PI. People wanted to get the N from manure, so they worked to get into a PI category that would allow them to use manure.
- For those that had very high they had to add buffers, etc., to get down so could apply manure.

KS said you need to account for other acres getting the manure that are no longer applied on PI acres. DB said that in PA the manure has to meet the same criteria no matter where it ends up, including exported manure. KS said that isn't being captured in MD.

Tt will write up the PI argument, incorporating the info CB posted from state email survey. JM says if we use the Veith paper, need to use DB's summary of numbers in his last edits. DB and JM both did an eyeball regression – we need a more refined summary than the initial summary. CB will share the emails with us.

JM has a comment on T3 P. Should we limit whole-farm nutrient balance to livestock farms only? Wouldn't necessarily apply to crop-only farms. CB said he thinks it's mostly a NY thing, but said he'd follow up on the states to see who expects to get credit from this. GA says WFNB mostly addresses feed management, and for Phase 6 it may be more applicable to manure transfers on a watershed basis. We need to add this language to the report. TS asked then if biosolids application need to be classified as "animals" rather than cropland – CB said biosolids will be dropped for Phase 6, so not worth pursuing. TS is OK with that.

**For Next Time:**

Update Don's slides.

Tt to write up PI stuff.

CB will send out a poll for next call.

Nutrient Management Panel  
Conference call summary  
5/21/15  
1-3PM

Jack Meisinger presented a summary of split-N applications for corn and wheat.

- Tim suggested 2 efficiencies – one for the coastal plain and one for piedmont.
- Jack Meisinger: we could either separate the regions or take the average.
  - Either way, adjustments will be made for land uses and for scaling up from plot scale to field scale
  - No one was opposed to splitting the coastal plain from piedmont, and establishing two efficiencies for split applications on corn.
- Split applications on wheat showed similar results as corn, although not enough data to separate regions.
- Doug Beegle: Suggest calling this good timing rather than split application for clarity.
  - Panel agreed with this terminology.
- Matt Johnston: Note that split applications are already a process in Scenario Builder, need to make sure the BMP doesn't double count.
- Beegle: The nutrient management BMP should be making the right decision on timing, not doing split applications necessarily.

Jack Meisinger presented manure incorporation data at plot scale

- Jack noted that there is a panel forming to look at manure incorporation specifically, chaired by Curt Dell, who will get in to more detail with the data and recommendations than this Nutrient Management panel will.
- The average reduction efficiency based on Jack's summary was 10%. This is intended to be a starting point number, which can be adjusted based on the panel's recommendation.
- Chris suggested considering the efficiency in the context of the full tier, and determining if the overall reduction needs to be adjusted.

Jack Meisinger presented fall soil nitrate test data on wheat

- Based on the data, propose 15% reduction as a starting point. Consider flexing this efficiency down slightly, given the 2 wet years were very wet, and possible skewed the result.
  - Tim Sexton agreed with Jack's recommendations.
- Panel discussed changing efficiency to 10 or 12% to account for possible effect of data from very wet years.
- Tim thought about 40% of FSNT test results suggest the crops don't need additional N.
- Panel agreed with a 10% reduction efficiency for FSNT

Jack Meisinger presented PSNT data

- Starting efficiency is 0.25 for piedmont and 0.10 for coastal plain.
- Tim thought the efficiencies were reasonable for VA coastal plain vs. piedmont.

Steve Dressing presented the draft Tier 2 definition

- Suggest adding requirements for components to the practice definitions.

- Brosch: Are the components bulleted in TetraTech's draft consistent with what the panel wants to represent?
- Beegle: Listing manure incorporation suggests it's required for everyone, rather than required where applicable.
- Beegle: If you have bullet 4 regarding P risk assessment tool, you don't need bullet 3 regarding LGU P recs, they are redundant.
  - Brosch: Suggest striking 3 then?
  - Greg Albrecht: Land grant recommendations do go through P Index, resulting in a final rate with a P Index is a land grant recommendation. So 3 and 4 are redundant.
- Beegle: Don't like listing specific practices under the Tiers, because the purpose of nutrient management planning is to be site specific and flexible. Current bullet 5 covers the range of components without listing specifics. The planning itself should give a benefit.
  - Brosch: That is the approach the panel tried last fall. Pushback was that they want to know that the efficiency being assigned is connected to on the ground practices.
- Matt Johnston noted the importance of explaining how the regulations per state fit in to the tiers, which is necessary for tracking and accounting.
- Matt also stressed the importance of explaining that from 2005 to present, Tier 2 was occurring on the ground but not represented in the model, to avoid confusion about shifting NRCS 590 from Tier 1 to Tier 2.
- Steve drafted a new Tier 2 definition based on the panel's discussion

#### Tier 3 definition

- Tier 3 P is tabled for now.
- Tier 3 N would require for credit, implementation of 1 or more elements to get credit.
  - Beegle: same comment as before, not many are using variable N.
- Meisinger: Key to Tier 3 is adaptive management of the whole plan. Add language about assessing environmental impacts.
- Beegle: Add language "including but not limited to the following practices".
- Meisinger: Key to Tier 3 is that the nutrient management plan is being evaluated and improved upon.
- Jack noted that if only 1 tool out of the list of Tier 3 components is required, a number of acres would already qualify for Tier 3.
- Beegle: Add requirement that Tier 3 must include adaptive management elements.
- Albrecht: Is Tier 2 going to be a pre-requisite for Tier 3?
- Albrecht: Specify that the components are actually tools that inform practices.

#### Tier credit

- Panel was comfortable with the basic equation (Research based N reduction efficiencies) X (scale adjustment from plot to field 0.75) X (% of landuse that is crop in question)
- Chris will send out the actual estimates to the panel after doing the arithmetic
- Panel will reconvene next week to discuss.
- Possibility of including a BMP performance discount, which would be a BPJ adjustment. Panel will need to see the initial arithmetic before making a call about BMP performance discount.
- Are Tier 2 and Tier 3 only eligible on row crops?
  - Meisinger: Yes. Pasture and nursery will stay at Tier 1. Hay is important in terms of acreage, timing of applications is very common. Panel may have to think about what to do with hay.

- NY and PA thought hay would be eligible for Tier 2.
- Next call Tues 3:30-5pm.

**Participants**

Tim Sexton, VADCR  
Steve Dressing, TetraTech  
Chris Brosch, VT/VADCR  
Jack Meisinger, USDA-ARS  
Jim Cropper, NEPC  
Ken Staver, UMD  
Curt Dell, USDA-ARS  
Mark Zolandz, EPA  
Greg Albrecht, NYS  
Doug Beegle, PSU  
Colin Jones, MDA  
Larry Towle, DDA  
Jason Dalrymple, WVDA  
Tom Bruulsema, IPNI  
Jeff Sweeney, EPA  
Matt Johnston, UMD  
Don Meals, TetraTech  
Emma Giese, CRC

Nutrient Management Panel  
Call summary  
5/26/15

Chris has put together a powerpoint describing how the tiers were put together by the panel. These materials will be adapted for the report, the webinar, and other communications regarding the panel report. Panel member feedback on these materials and some draft graphics will be requested during the call today. Chris went over a slide summarizing the Tier 1 components from panel's initial recommendations. Even though these were already approved, the slide will be used in communicating recommendations to the Partnership.

- Sufficiency implies soil testing (which is in definition for T1)

Chris reviewed slides summarizing the Tier 2 and 3 components

Chris reviewed some graphics developed by Emma which are intended to be draft communication pieces for the report and webinar.

- Panel members agreed with the graphic demonstrating how adjustments were made to the literature values to determine final efficiencies.
- Slide illustrating primary driver of each tier of nutrient management.
  - Include narrative to help people remember that the Tiers build on each other.
- Crediting options. Add a provision for acre D scenario where Tier 3 is stacked on T1 without T2?
  - Cropper: Suggest leaving it in italics, and noting that it will be a Phase 6 determination.
  - Note that a T3 on T1 would have a lower efficiency than a T3 on top of T2 and T1.
  - Chris noted that some cases of using the T3 tools without a formal nutrient management plan.
  - Add asterisk to say that T3 would be based on nitrate tests in addition to T2 plan.
- Land uses
  - Chris recommended that efficiencies just be applicable to row with manure land use only. Pasture, hay acres would still be credited under tier 1.
  - Jack: Row without manure may be needed for T2 and T3, such as variable rate.
    - In current model row without manure is specialty crops only (peanuts, etc.).
    - Emma will clarify row without manure as "specialty" for the main part of the report. Will keep "row without manure" terminology in the technical appendix only.

Chris presented draft efficiencies based on literature values and proposed adjustments.

- Variation by region is included.
- Chris asked the panel to suggest values for management variability adjustments.

Chris reviewed P Index values

- Meisinger: Any change to the scale adjustment from 75% would need additional justification if the panel recommends.
- Meisinger: After looking at Quirine's data, did not see justification for 50% P Index reduction. 35% reduction is consistent with Veith data.
  - Panelists agreed with the 35% lit value as a starting point.
  - Panelists decided that due to the scale of the Veith data, the plot scale adjustment was applicable in this case as well.
  - P index should apply to all row crops
  - Panel discussed possible on-farm management variability.

- Comment received the last time, was that when fields don't break the threshold and therefore don't change – why should they receive credit.
- Panel will come back to this issue, but the panel felt the final efficiency should be lower than 8%.
- Chris asked the panel to ID other issues in addition to implementation and response lag:
  - Change in farm P budget – does the P index change it?

Jack reviewed manure incorporation (ammonia credit) values

- 10% literature value came from wind tunnel studies. 75% reduction from very small plots to field scale. 50% adjustment for on-farm management variability. Jack suggested lowering this even further, given that it is only the ammonia, studies had no data on the surface loss.
- Resulting efficiency was 1.5%, which Jack recommended was reasonable.

Timing

- Adjustments were made for scaling and land use
- Split applications on wheat less common

T2 N credit

- T2 credit will be automatically stacked on top of T1.
- Average all the timing pieces and add incorporation. Results in 4.5%
- Recommend being conservative rather than liberal on credit amount.

T3 N credit

- Wouldn't rely on CSNT until have at least 3 years of data. Recommend trimming the adjustment to 40%. CSNT more variable than ISNT.
- Most PSNT data was from nutrient managers, not a random sample and possibly high biased number, which was reason for adjustment.
- Brosch: Suggest taking an average across all tests to establish the T3 N credit. Result was ~3%.

Next steps

Chris will start an email discussion to finalize P index through the end of this week. Next week will ask for a few day comment period to finalize and approve. Will only schedule another call if further issues arise. We'll finalize the report write-up during that time.

### Participants

Curt Dell, ARS  
Colin Jones, MDA  
Jack Meisinger, USDA-ARS  
Greg Albrecht, NYS  
Mark Zolanz, EPA  
Chris Brosch, VT/VADCR  
Steve Dressing, TetraTech  
Jim Cropper, NEPC  
Don Meals, TetraTech  
Jennifer Ferrando, TetraTech  
Jason Dalrymple, WVDA

Nutrient Management Panel  
Conference call summary  
6/5/15

### Announcements

Panel recommendations are scheduled to be presented to the AgWG on 6/17-6/18. Chris will present the efficiencies spreadsheet, as well as the land uses, and other supporting information.

The report itself is scheduled to be released 6/25, with a webinar tentatively scheduled for 7/1.

### Hay land

Jack Meisinger noted that there is a lot of P Index use on dairies, which have a lot of hay land. So hay land use should probably be eligible for Tier 2.

- NY: Hay land is still being assessed with risk assessment tools, as well as receiving the improved rate and timing. Hay is heavily integrated with corn in terms of management. Loss reductions would be different on hay than on row crops. May need to discuss modeling implications further.
- Brosch: Although hay is intertwined with the row crops, row crops did have the literature support. If we include hay land, why not include pasture?
  - Meisinger: Difficult to manage direct deposition, which is a reason to exclude pasture.
  - Panel discussed that the cutoff could be with mechanical application of nutrients.
  - Cropper: Prescribed grazing is the primary way to manage the direction deposition, which is a different BMP.
  - PA Tier 2 nutrient management includes row crops, hay, and pasture.
- Panel agreed to state in the report that pasture was considered but deferred to the Phase 6 panel.
  - CBPO: Suggest describing the point mentioned earlier, that prescribed grazing accounts for the nutrient management on pasture in the current model.
- Jack suggested a conservative T2N reduction efficiency for hay land use, based on an average of the data for other land uses, and discounted 50%.
  - Johnston noted that the current model already simulates split applications on hay throughout the year, so offering a credit could be double counting.
  - Meisinger: The BMP status gives an incentive for farmers to apply split applications.
  - Johnston: If N timing changed after 2005, include this as justification in the report.
  - PA: In the last 10 years, there have been changes that have driven farmers to better timing actions on hay fields as well as row crop fields.
  - Panel members agreed that the manure incorporation credit would not apply to hay land use.
  - PA: With this approach, would we have to report hay nutrient management separate from row crop nutrient management?
    - Johnston: If a state did not track the acres separately, the default land use for nutrient management would be split between row crops and hay.
  - The panel agreed with the presented approach
  - PA: Need to defend the best professional literature value for hay.
    - PA: Need to document whether the full panel agreed with the efficiency.
    - Brosch: Will follow up with an email to the full panel, asking for concurrence.
    - Staver: Include a description of what production systems have these reductions on hay, and how the panel determined the reduction.
    - Brosch: Jack and Jim will help draft the justification for hay.
    - Goodlander: Document how the best professional judgment estimate was developed,



based on other papers on other land uses, and assessment of how the estimates changed.

Panel members agreed that for Tier 3, only 1 test is needed to qualify.

For Tier 2 N, panel felt that both incorporation and timing were required elements.

- PA: Important that the definition can be matched to state regulations. Suggest relating it to 590 standards.
- NY: 590 would cover Tier 2 in NY. Other jurisdictions would have to consider their state specific standards. The national NRCS standard aligns well with the Tier 2 definition.
- Brosch: Agree with documenting the state by state 590 standards. Will ask the programmatic person in each state to develop a table of how the programs are aligned with a standard in the 590.
- Chris and Emma will share a draft table for each jurisdiction to verify the information and fill in further.

### CNMPs

- NY has a second type of plan, CNMP that would qualify for Tier 2 credit.
- PA manure management plan is Tier 1. Nutrient Management plans required under the Act are consistent with Tier 2, are required on CAFOs, and consistent with 590. PA would only report one or the other for a single farm, so they wouldn't be double counted.
- Panel agreed to add CNMP to the write-up as eligible for reporting.

### Assignments:

Emma and Chris will share a draft table comparing 590 standards by state; state program panel members will edit and provide updated information as needed.

Report is missing documentation for the NY tiers for inclusion in the report.

- Greg will provide meeting documentation for the original NY recommendation (Winter/spring 2013)

Chris asked for a volunteer to author a future research needs section - improved research related to NMP effectiveness quantification.

- Jack will draft a future research needs section. Ken Staver and Doug Beegle will be asked to review Jack's draft.

Chris presented a diagram showing how LGU rec's evolve before plans and regulation

- Staver: 1985 is a little early for the 1.2 to 1.0 per bushel switch.
- PA did not write P indices in to plans until 2007.
- PSNT started in the late 1990s, doesn't fit well in to a point
- Chris will clarify the diagram based on these comments.

Chris is working on including Tier 1 additional info – including source for 1.2 to 1.0 switch.

The report will be emailed – asking first for fatal flaw, then for editorial comments prior to submitting report. Chris will catalog number of panelists who have approved numbers and documentation.

### Participants

Chris Brosch, VT/VADCR

Doug Goodlander, PADEP

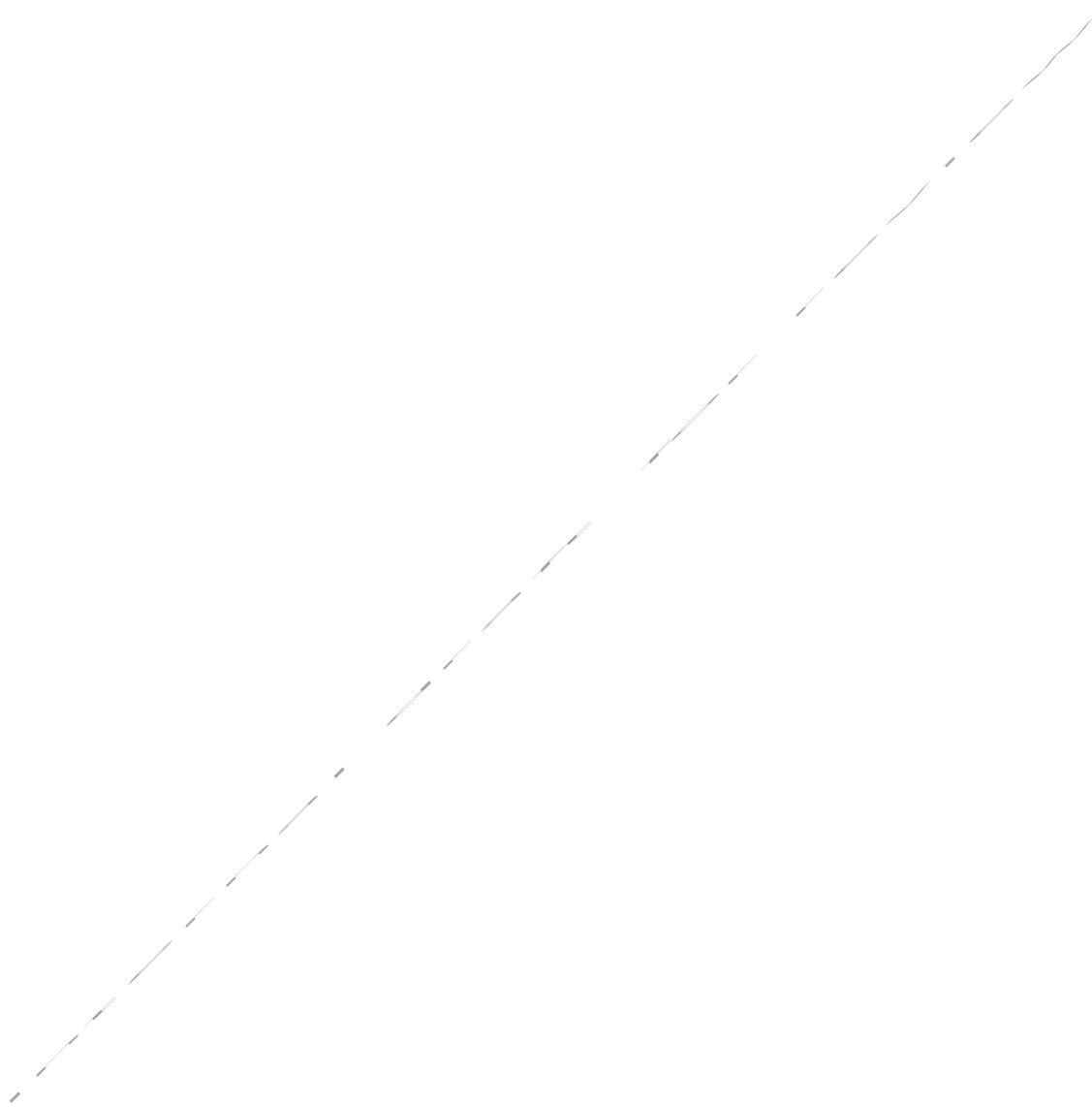
Jennifer Ferrando, TetraTech

Jack Meisinger, USDA-ARS

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Don Meals, TetraTech

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Curt Dell, USDA-ARS  
Ken Staver, UMD  
Emma Giese, CRC  
Matt Johnston, UMD



## **Appendix B**

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### **Summary of Survey and Interviews Agricultural Nutrient Management Expert Panel**

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# Summary of Survey and Interviews Agricultural Nutrient Management Expert Panel

## CONTENTS

<b>BACKGROUND .....</b>	<b>3</b>
<b>DEFINITIONS OF AGRICULTURAL NUTRIENT MANAGEMENT .....</b>	<b>4</b>
GENERAL OBSERVATIONS.....	5
BASIC OR N-BASED NM.....	29
P-BASED NM .....	29
ENM.....	29
STATE PROGRAMS.....	29
ALTERNATIVE DEFINITIONS.....	30
PRECISION/DECISION AGRICULTURE .....	31
N-BASED RECOMMENDATIONS .....	31
<b>STATE PROGRAM REQUIREMENTS FOR NUTRIENT MANAGEMENT .....</b>	<b>38</b>
GAPS IN PROGRAMS FOR NUTRIENT MANAGEMENT .....	43
PROGRAM COORDINATION.....	48
NUTRIENT MANAGEMENT TECHNICAL STANDARDS.....	48
PROCESS AND CRITERIA FOR DETERMINING LEVEL OF NUTRIENT MANAGEMENT REQUIRED .....	52
PREPARATION, REVIEW, APPROVAL, TRACKING, VERIFICATION AND REPORTING OF NUTRIENT MANAGEMENT PLANS.....	57
<b>STATUS OF IMPLEMENTATION OF NUTRIENT MANAGEMENT PLANS .....</b>	<b>60</b>
<b>NUTRIENT MANAGEMENT PRACTICE EFFECTIVENESS .....</b>	<b>67</b>
BASELINE CONDITION FOR ASSESSING EFFECTIVENESS.....	67
N-BASED NMEFFECTIVENESS .....	67
P-BASED NMEFFECTIVENESS.....	70
P/D AGRICULTURE EFFECTIVENESS .....	71
ENMEFFECTIVENESS.....	72
MAJOR FACTORS AFFECTING NMEFFECTIVENESS .....	72
<b>RECOMMENDATIONS FOR IMPROVED TRACKING, REPORTING, AND MODELING OF NUTRIENT MANAGEMENT .....</b>	<b>76</b>
RECOMMENDATIONS FOR TRACKING .....	76
RECOMMENDATIONS FOR VOLUNTARY PLAN TRACKING.....	77
RECOMMENDATIONS ON MODELING.....	77
<b>LITERATURE .....</b>	<b>77</b>
<b>ABBREVIATIONS, ACRONYMS, AND UNITS.....</b>	<b>78</b>
<b>SOURCES.....</b>	<b>80</b>
<b>EP MEMBERS SURVEYED .....</b>	<b>80</b>
<b>SUBAPPENDIX A: SYNOPSES OF STATE AGRICULTURE PROGRAMS .....</b>	<b>82</b>
SYNOPSIS OF NM TECH STANDARDS FOR DELAWARE.....	83
SYNOPSIS OF NM TECH STANDARDS FOR MARYLAND .....	85

SYNOPSIS OF NM TECH STANDARDS FOR NEW YORK.....	87
SYNOPSIS OF NM TECH STANDARDS FOR PENNSYLVANIA.....	90
SYNOPSIS OF NM TECH STANDARDS FOR VIRGINIA.....	92
SYNOPSIS OF NM TECH STANDARDS FOR WEST VIRGINIA .....	94
<b>SUBAPPENDIX B: ADAPTIVE NUTRIENT MANAGEMENT APPROACH .....</b>	<b>96</b>
<b>SUBAPPENDIX C: MARYLAND NUTRIENT MANAGEMENT REGULATIONS (EXCERPTS) .....</b>	<b>98</b>
<b>SUBAPPENDIX D: PENNSYLVANIA NUTRIENT MANAGEMENT REGULATIONS (EXCERPTS).....</b>	<b>107</b>
<b>SUBAPPENDIX E: VIRGINIA NUTRIENT MANAGEMENT REGULATIONS (EXCERPTS).....</b>	<b>116</b>
<b>SUBAPPENDIX F: WEST VIRGINIA NUTRIENT MANAGEMENT REGULATIONS (EXCERPTS).....</b>	<b>118</b>

## TABLES

TABLE 1. DEFAULT NUTRIENT MANAGEMENT DEFINITIONS USED IN SURVEY.....	4
TABLE 2. OFFICIAL STATE NUTRIENT MANAGEMENT DEFINITIONS AND NMP CONTENT.....	6
TABLE 3. ADDITIONAL COMMENTS AND ALTERNATIVE NUTRIENT MANAGEMENT DEFINITIONS .....	19
TABLE 4. METHODS FOR YIELD GOALS AND N RECOMMENDATIONS .....	33
TABLE 5. BASIC REQUIREMENTS FOR NUTRIENT MANAGEMENT.....	39
TABLE 6. MAJOR GAPS IN PROGRAMS FOR NUTRIENT MANAGEMENT .....	44
TABLE 7. SUMMARY OF TECHNICAL STANDARDS OR REQUIREMENTS FOR NUTRIENT MANAGEMENT .....	50
TABLE 8. P INDEX CHARACTERIZATION.....	53
TABLE 9. COMPUTATION OF P INDEXES.....	56
TABLE 10. EXTRACTS FROM INTERVIEWS – RESPONSE TO QUESTIONS CONCERNING RESPONSIBILITIES FOR VARIOUS STAGES OF NUTRIENT MANAGEMENT PLANNING AND IMPLEMENTATION .....	58
TABLE 11. EXTRACTS FROM INTERVIEWS RELATED TO STATUS OF NUTRIENT MANAGEMENT PLAN IMPLEMENTATION.....	62

## BACKGROUND

The Nutrient Management Expert Panel (EP) is focused on agricultural production in the Chesapeake Bay watershed under the sponsorship of the Agriculture Workgroup. This report will be used by the EP to develop programmatic recommendations to the Chesapeake Bay Program (CBP) Partnership for the improvement of existing model representation of the management of agricultural nutrients, as well as the improved tracking, verification and reporting of implementation information by the partnership. The process followed by the EP will be consistent with *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model* (March 15, 2010).

Tetra Tech (Tt) staff surveyed and interviewed 25 members of the 26-member EP (see Sources on p. 76) to obtain information and recommendations for the CBP Partnership regarding both technical and programmatic aspects of agricultural nutrient management (NM) in the Chesapeake Bay (CB) watershed. State agencies in Delaware (DE), Maryland (MD), New York (NY), Pennsylvania (PA), Virginia (VA), and West Virginia (WV) were all represented in the survey/interview process, as were federal agencies, state land grant universities, and nongovernmental organizations. Interviewees were given a survey form to complete prior to the interview call and Tt staff added information to the survey forms during the interview. These updated survey forms were then sent to the interviewees for review and comment before being finalized by Tt. Fourteen (56%) of the interviewees provided review comments.

This summary report is a compilation of these individual surveys, synopses of state agricultural NM programs that were developed by Tt and reviewed by state agriculture program experts with EP membership, and information on state programs obtained by Tt after the interviews. State-specific information summarized here was generally provided by either or both a state agriculture program expert and academic(s) living and working in the particular state. Similarly, information tailored to specific crops or land uses was frequently although not always provided by one or more experts on that subject area. Information presented here that has broader applicability is generally supported by specific input from two or more EP members. Conflicting information or recommendations are highlighted in those cases where such conflicts are readily apparent. Exceptions to these general rules are noted in the report. Overall, the goal was to be as inclusive as possible with the expectation that the EP will ultimately determine the relative merits and applicability of the information provided here.

## DEFINITIONS OF AGRICULTURAL NUTRIENT MANAGEMENT

EP members were asked to provide official (i.e., state) and suggested definitions of the following NM options: nitrogen-based (N-based) NM, phosphorus-based (P-based) NM, precision/decision (P/D) agriculture, and enhanced nutrient management (ENM). The default definitions in Table 1 were provided as an attachment to the survey form and interviewees had the option to either agree with those definitions or suggest alternatives. These default definitions were based primarily on those currently used in Scenario Builder (SB).

TABLE 1. DEFAULT NUTRIENT MANAGEMENT DEFINITIONS USED IN SURVEY

NM Type	Default Definition Used in Survey
Basic NM	Nutrient management plan (NMP) implementation (crop) is a comprehensive plan that describes the optimum use of nutrients to minimize nutrient loss while maintaining yield. A NMP details the type, rate, timing, and placement of nutrients for each crop. Soil, plant tissue, manure and/or sludge tests are used to assure optimal application rates. Plans should be revised every 2 to 3 years.
N-Based NM	Under N-based planning, rates for manure or commercial fertilizer applications are based on the N requirement of the crops to be grown, and, in some cases on other factors, such as soil type and soil test results. When animal waste or other organic sources are used exclusively without N-supplementation, N-based planning usually results in a buildup of P in the soil.
P-Based NM	Phosphorus-based plans are normally associated with animal waste or organic nutrient sources. Under P-based planning, rates for manure applications are based on the P requirement of the crops to be grown. P-based planning usually requires supplemental N application in the form of commercial fertilizer N. In some cases where planning indicates minimal environmental impact due to over-application of P, P-based planning may allow application rates exceeding the short-term P requirement of the crops as long as the rate does not exceed the rate allowed by the P Index.
P/D Agriculture	A farm management approach that begins with implementation of all requirements of the federal/state nutrient management standard but then seeks improved nutrient management efficiency based on observing and responding to within-field variations, e.g., in soil fertility, crop yield, soil characteristics. It relies on technology like satellite imagery and geospatial tools; it depends on farmers' ability to locate precise position on a field using GIS/GPS, and to control and vary activities such as fertilizer application by location. Precision agriculture aims to optimize field-level management with respect to crop needs (e.g., nutrient inputs), environmental protection (e.g., excessive soil P, N leaching), and economics (e.g., agrichemical usage, crop yield). Precision/decision agriculture includes analysis of all soil amendments, measurement of all field inputs and outputs, and detailed record-keeping.  Decision agriculture is defined in the documentation for Scenario Builder (Brosch 2010) as: "A management system that is information and technology based, is site specific and uses one or more of the following sources of data: soils, crops, nutrients, pests, moisture, or yield for optimum profitability, sustainability, and protection of the environment."
ENM	Based on research, the nutrient management rates of nitrogen application are set approximately 35% higher than what a crop needs to ensure nitrogen availability under optimal growing conditions. In a yield reserve program using enhanced nutrient management, the farmer would reduce the nitrogen application rate by 15%. An incentive or crop insurance <sup>1</sup> is used to cover the risk of yield loss. This BMP effectiveness estimate is based on a reduction in nitrogen loss resulting from nutrient application to cropland 15% lower than the nutrient management recommendation.

<sup>1</sup> This would not be federally subsidized crop insurance but rather an income guarantee such as that established by the American Farmland Trust for its BMP Challenge for Nutrient Management (<http://www.farmland.org/programs/environment/solutions/nutrient-BMP-Challenge.asp>).

Table 2 summarizes the information obtained regarding official state definitions of NM and NMPs, whereas Table 3 includes a range of alternative definitions and comments provided by interviewees. Information in Table 2 includes responses to survey/interview questions (in black) supplemented as needed by state guidance or regulatory language (in blue). All information in Table 3 is from survey/interview responses.

## GENERAL OBSERVATIONS

Nutrient management definitions are often not only dissimilar between states but may also be dissimilar between professionals in the same state. For example, participants noted that P-based planning as defined for SB and P-based planning relative to the NRCS 590 practice standard (nutrient management) are somewhat different. The existence of different definitions can cause confusion. Virtually all interviewees believed that NM definitions should be as close to the NRCS 590 practice standard as possible for consistency and to align the CB Watershed Model (the “Bay model”) with the major funding source implementing NM BMPs in the watershed. One expert made the observation that there is an inconsistency in defining basic NM as “a comprehensive plan that describes the optimum use of nutrients to minimize nutrient loss while maintaining yield” when the default definition of ENM includes an assumption that basic NM allows N applications that are 35% higher than crop needs. This interviewee suggested that such definitions should be compatible and show a transition of greater management inputs when going from the basic NMP to ENM, and then to P/D agriculture.



TABLE 2. OFFICIAL STATE NUTRIENT MANAGEMENT DEFINITIONS AND NMP CONTENT

State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
Delaware	<p>No technical standards exist for N.</p> <p><a href="#">Title 3, Chapter 22 § 2202 of the Delaware Code</a> definition of NM: “a plan by a certified nutrient consultant to manage the amount, placement, timing and application of nutrients in order to reduce nutrient loss or runoff and to maintain the productivity of soil when growing agricultural commodities and turfgrass.”</p> <p><a href="#">The CAFO rule</a> definition of NM: “Nutrient Management Plan” or “Plan” means a plan written by a certified nutrient consultant in accordance with State Technical Standards to manage the amount, placement, timing and application of nutrients in order to reduce nutrient loss or runoff and to maintain the productivity of soil when growing agricultural commodities and turf grass (14 DE Reg. 482 (11/01/10) (Final)).</p> <p><a href="#">The Delaware Nutrient Management Program</a> has the following interim conservation practice standard definition for NM: “Managing the amount, source, placement, form, and timing of the application of nutrients and soil amendments.”</p>	<p>Most of the focus is on P and standards have been developed.</p> <p><a href="#">From the interim 590</a>: When a P-based NMP is determined by the PI, applied manure or other organic amendments shall be <math>\leq</math> the recommended rates for both N and P.</p> <p><b>PI = 50-75.</b> Medium potential for P movement from site given current management and site characteristics. Practices should be implemented to reduce P losses. N-based NM should be implemented no more than 1 year out of 3. P based NM should be implemented 2 years out of 3 with P applications limited to the greater of crop removal or soil test P-based application recommendations.</p> <p><b>PI = 76-100.</b> High potential. P-based NM planning should be used for this site. P applications should be limited to crop removal or soil test P based application recommendations. Consistent with the Delaware Nutrient Management Law (DNML), P applications cannot exceed harvested crop removal for the next 3 years. When P is applied at the “3-year crop removal rate”, no more P can be applied the next 2 years. All practical management practices for reducing P losses should be implemented.</p> <p><b>PI&gt;100.</b> Very high potential. No P should be applied. Active remediation techniques should be implemented to reduce the P loss potential from the site. Consistent with the DNML, P applications cannot exceed harvested crop removal for the next 3 years.</p>	<p>DDA DNMC has its own technical standards for precision agriculture on their web site.</p> <p><a href="#">The DE Nutrient Management Program</a> has the following interim conservation practice standard definition: “Precision agriculture is defined as a management system that uses information, technology, and site specific data to manage variability within fields for optimum profitability, sustainability, and environmental protection. This method also includes guidance systems for agricultural equipment.”</p>	<p>“ENM” is a term not used in DE.</p>

State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
		When P is applied at the “3-year crop removal rate”, no more P can be applied the next 2 years. All practical management practices for reducing P losses shall be implemented, and alternatives for manure transport should be addressed.		
Maryland	<p>MD regulations address both N and P. The N-based approach is used until the FIV reaches a threshold of 150 ppm.</p> <p>Nursery and Greenhouse NM plans in MD are written to focus on NPK, water use, and sediment loss. Mandatory water and nutrient management (WNM) plans (submitted to MDA) are written to provide site-specific recommendations to growers.</p> <p><b>NOTE:</b> Additional details from MD’s regulations can be found in Subappendix C.</p> <p><u>COMAR 15-20-07</u> defines NMP as “a plan prepared by a certified nutrient management consultant to manage the amount, placement, timing, and application of animal manure, fertilizer, biosolids, or other plant nutrients in order to minimize nutrient loss or runoff, and maintain the productivity of soil when growing agricultural products.” At this time all operators who use chemical fertilizer, animal manure, and/or biosolids must have a NMP addressing both N and P as the limiting nutrients on that agricultural operation.</p> <p><u>COMAR 15-20-08</u></p> <p>The performance and technical standards provided in this subtitle are found in the Department of Agriculture's <i>Maryland Nutrient Management Manual</i> (MNMM), which is incorporated by reference in COMAR 15.20.07.02.</p> <p>Important NMP elements include: Any determination of the limiting nutrient as required under Regulation .04 of</p>	<p>MD regulations address both N and P.</p> <p>Nursery and Greenhouse NM plans in MD are written to focus on NPK, water use, and sediment loss. Mandatory WNM plans (submitted to MDA) are written to provide site-specific recommendations to growers.</p> <p><u>COMAR 15-20-08</u></p> <p>If the soil sample results show a <math>P\ FIV \geq 150</math>, a PI or other P risk assessment method acceptable to the Department, as provided in the MNMM, shall be used to determine the potential risk of P loss due to site characteristics.</p> <ul style="list-style-type: none"> <li>• If the risk for potential movement of P from the site is low, use N plant needs as the limiting factor.</li> <li>• If risk is medium: <ul style="list-style-type: none"> <li>○ Rates based on N plant needs as limiting factor no more than 1 out of every 3 years. Use the greater of crop or harvest removal P rates or the amount indicated by P soil testing the other 2 years; or</li> <li>○ May use N plant needs as the limiting factor if BMPs are implemented by the operator and address site or management characteristics to reduce the risk of P loss to low.</li> </ul> </li> </ul>	<p>ENM and P/D agriculture are not part of how MDA regulates, but are part of the education/promotion aspect of program. In the WIP they are looking for ENM and P/D agriculture to help move forward beyond basic NM.</p> <p>Most container nursery operations in MD have switched to Slow Release Fertilizer (also called CRF or Controlled Release Fertilizer), which is a P/D BMP.</p> <p>Most nursery and greenhouse producers have implemented various precision and/or decision-based BMPs. They have both N-based and P-based accounting systems within NM plans and encourage growers to pay attention to their water and leaching fraction. N:P ratios in container nurseries are typically close to plant uptake ratios, but some greenhouse crops still have excessive P applications compared to plant requirements. MD field</p>	<p>ENM and Precision Ag are not part of how MDA regulates, but are part of the education/promotion aspect of program. In the WIP they are looking for ENM and</p> <p>PA to help move forward beyond basic NM. If, for example, pasture has 50 lb N applied, but recommendation is 100 lb N, this could be credited as EN with 50 lb savings. The annual implementation reports (AIR) offers a way to track ENM and P/D agriculture.</p>

State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
	<p>this chapter, including use of a risk analysis tool indicating the potential for nutrients to move into surface water or ground water, based on current conditions. A plan shall contain data for each field and shall include:</p> <ul style="list-style-type: none"> <li>• A soil analysis and any available nutrients in the soil from the previous crop and mineralization and bioavailability assumptions for organic nutrient sources. Soil analysis results for a plan are valid for 3 years with some exceptions.</li> <li>• The expected crop or plant and expected crop yield or plant production goal and the source and type of information used to determine expected yield or production goal.</li> <li>• The primary nutrient requirements based on expected crop yield or plant production goals, and the nutrients to be applied from all fertilizer sources to meet the crop or plant nutrient requirements.</li> <li>• Any recommendation for liming, application timing for nutrients, including split applications, and the use of diagnostics to determine crop nutrient requirements.</li> <li>• Any nutrient application method and the incorporation of natural organic fertilizers.</li> <li>• The need to calibrate application equipment.</li> <li>• Any management strategy to achieve soil fertility within an optimal range.</li> <li>• Current or recommended tillage method.</li> </ul> <p>If the soil sample analysis results show a phosphorus FIV&lt;150 (or if FIV≥150 but PI shows low risk for P), nutrient recommendations may use N plant needs as the limiting factor.</p> <p>Specific additional NMP requirements for Container or Out-of-Ground Agricultural Production include:</p>	<ul style="list-style-type: none"> <li>• If risk is high: <ul style="list-style-type: none"> <li>○ P rates shall be limited to the expected amount removed from the field by the crop or plant harvest, or the amount indicated by soil testing; or</li> <li>○ If BMPs are implemented by the operator, and address site or management characteristics to reduce the risk of P loss to medium, nutrient rates may be based on N plant needs as the limiting factor not more than 1 out of every 3 years. Use the greater of crop or harvest removal P rates or the amount indicated by P soil testing the other 2 years.</li> </ul> </li> <li>• If risk is very high: <ul style="list-style-type: none"> <li>○ No additional P may be applied; or</li> <li>○ If BMPs are implemented by the operator, and address site or management characteristics to reduce the risk of P loss to high, recommended rates of application of P shall be limited to the expected amount removed from the field by the crop or plant harvest, or the amount indicated by soil testing.</li> </ul> </li> </ul>	<p>operations also typically split fertilizer into 3-6 applications over the growing season, and apply much lower rates compared to most agricultural operations.</p>	

State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
	<ul style="list-style-type: none"> <li>Assessment of the risk of nutrient losses to surface water, using the Environmental Risk Assessment for out-of-ground production provided in the MNMM. While High risk level results in use of controlled release fertilizer until medium risk is achieved, responses to risk level are generally neither N-based nor P-based.</li> <li>Recommended annual amounts of N, P, &amp; K.</li> <li>Estimated amounts of each source of nutrients to be applied each quarter.</li> <li>A listing or description of the application method or methods for each nutrient.</li> <li>General recommendations, including equipment calibration, timing and application methods for water and nutrients, options to maximize water use efficiency, management options to reduce nutrient losses, and other BMPs that may be applicable as provided in the MNMM.</li> <li>Recommendations to monitor runoff.</li> <li>Methods of sampling and testing.</li> </ul>			
New York	<p>The concepts of N-based, P-based, Enhanced, and P/D NM describe different over-arching management strategies that can be applied to any crop in NYS</p> <p>The NRCS 590 standard (currently under revision) and Cornell Nutrient Guidelines (CNG) are used as the standard for cropland, nurseries, and pasture.</p> <p>NYS CAFO regulations require all medium- and large-sized farms to be permitted and develop, implement, and maintain a Comprehensive Nutrient Management Plan (CNMP).</p> <p>The umbrella NRCS 590 standard in NYS requires that the CNG, NLI, PI, and RUSLE2 are integrated to determine sound recommendations for manure and fertilizer applications. NY's recommendation system is comprised of the following key elements.</p>	<p>The concepts of N-based, P-based, Enhanced, and P/D NM describe different over-arching management strategies that can be applied to any crop in NYS</p> <p>P applications on fields with PI ratings between 75 and 100 are limited to crop removal and P applications on fields with PI ratings of 100 or more are prohibited, meaning crop N guidelines (if any) would be satisfied by N fertilizer.</p>	<p>The concepts of N-based, P-based, Enhanced, and P/D NM describe different over-arching management strategies that can be applied to any crop in NYS</p>	<p>The concepts of N-based, P-based, Enhanced, and P/D NM describe different over-arching management strategies that can be applied to any crop in NYS</p>

State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
	<ul style="list-style-type: none"> <li>Every field managed according to the NRCS-NY 590 practice standard must undergo the full set of analyses in the standard (no threshold exists, under which a partial analysis is performed). This includes soil testing (at least every 3 years) and annual manure testing; risk assessment field walks to collect field attributes for the PI, RUSLE2, setbacks, and other resource concerns; collection of field history and management information; and significant analysis to integrate the CNG (based on a database of 600+ soil-specific yield potentials) and various risk assessments into a final recommendation for source, rate, timing, and method of nutrient application (4Rs).</li> <li>In addition to the risk assessment tools, above, the “Supplemental Manure Spreading Guidelines to Reduce Water Contamination Risk During Adverse Weather Conditions” is used to further guide fields selection and management during periods of saturated, frozen, and/or snow covered field conditions.</li> <li>Crop nutrient guidelines account for existing N credits from past crops, manure, and soil organic matter (OM) and are based on the sufficiency approach, developed through years of crop yield response studies, and not a crop removal approach. No blanket insurance factors exist.</li> <li>Additional N conservation BMPs are recommended on fields for NLI ratings of 10 or more.</li> <li>RUSLE2 is run on all fields and soil loss must be managed to T.</li> <li>Manure application setbacks from watercourses (100’, 35’ vegetated buffer, or 15’ buffer if incorporated within 24 hours) and 100’ from wells.</li> <li>Records are kept to drive future management.</li> </ul>			
Pennsylvania	ACT 38 technical manual criteria form the basis for NM	All plans address P but not all are P-indexed	NM plans are year and field	PA has no specific

State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
	<p>definition in PA.</p> <p>All regulatory plans in PA are N-based and P-based. The P management is based on the PI which is used to determine if an N-based, P-based or no P approach must be followed on a given field for a given management scenario. The non-approved plans are based on P removal unless soil tests are less than 200 ppm Mehlich 3P. Then an N-based plan can be used. These plans also have required setbacks from water. The soil test P limitation and the setbacks can be modified if the PI is used.</p> <p><b>NOTE:</b> Additional details from PA's regulations can be found in Subappendix D.</p> <p>Act 38 Regulations, Subchapter D. Nutrient Management</p> <p>NMP definition: a written site-specific plan which meets the requirements in the act. Important NMP elements include:</p> <ul style="list-style-type: none"> <li>The planned nutrient applications for each crop management unit listing acres; expected yield; nutrients applied as starter chemical fertilizer; planned manure application period, rate, type, and incorporation time; rate of other organic nutrient sources planned to be applied; and other nutrients applied through chemical fertilizer.</li> <li>N and P are the only nutrient elements of concern to be addressed by BMPs in the plan, but K crop needs and rates must be included in the plan.</li> <li>Manure testing. After approval of the initial plan, manure tests are required to be taken annually for each manure group generated on the operation.</li> <li>The amount of N available in the manure, and the residual N from legume crops and previous applications of manure.</li> </ul>	<p>or P-limited plans.</p> <p>All regulatory plans in PA are N-based and P-based. The P management is based on the PI which is used to determine if an N-based, P-based or no P approach must be followed on a given field for a given management scenario. The non-approved plans are based on P removal unless soil tests are less than 200 ppm Mehlich 3P. Then an N-based plan can be used. These plans also have required setbacks from water. The soil test P limitation and the setbacks can be modified if the PI is used.</p> <p><u>Act 38 Regulations, Subchapter D. Nutrient Management</u></p> <p>Methods for determining and managing the risk of P loss and related water quality impacts must comply with specified criteria; the PI can be used. Appropriate BMPs such as methods, rates and timing of application designed to minimize the effects of P losses from fields are established based on the risks and impacts determined. P-based NM arises from two situations:</p> <ul style="list-style-type: none"> <li>P application is limited to the level of P removal from the soil by the crop, if the application of P to the soil would be expected to pose an immediate risk of impacts to surface water unless the risk is managed by limiting the application based on P.</li> <li>P application is completely restricted, if the application of P to the soil would be expected to pose an immediate risk of impacts to a surface water which cannot</li> </ul>	<p>specific for CAFOs and CAOs – more prescriptive. NM plan under the MMM is less intense and more generalized. Calls this P addressed NMP.</p> <p>Everyone who generates or utilizes manure needs to have a NM plan or MM plan which addresses P. Farmers currently not obligated to implement enhanced or precision NM.</p>	<p>definition of ENM.</p> <p>Everyone who generates or utilizes manure needs to have a NM plan or MM plan which addresses P. Farmers currently not obligated to implement enhanced or precision NM.</p>



State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
	<ul style="list-style-type: none"> <li>• Acreage and realistic expected crop yields for each crop management unit.</li> <li>• Soil tests are required for each crop management unit at least every 3 years from the date of the last test.</li> <li>• Based on the soil tests, the plan must include recommendations for the amount of N, P, and K necessary for realistic expected crop yields.</li> <li>• The manure application rate shall be the lesser of the following:               <ul style="list-style-type: none"> <li>○ A rate equal to or less than the balanced manure application rate based on N. The rate is <math>\leq</math> N necessary for realistic expected crop yields or the amount of N the crop will use for an individual crop year. The rate will account for available residual N and applied N such as starter fertilizer.</li> <li>○ The rate as determined to minimize the effects of P losses from fields. The rate can be <math>\leq</math> N crop requirements (if P is not expected to pose an immediate risk of impacts to surface water), <math>\leq</math> P removal from the soil by the crop (if P application is expected to pose an immediate risk to surface water unless risk is managed via limiting the application based on P), or P application is completely restricted because P application is expected to pose an immediate risk impacts to surface water which cannot be managed via limiting the application based on P.</li> </ul> </li> <li>• Supplemental N needs can be determined via N availability testing.</li> </ul> <p>Nutrients shall be applied to fields during times and conditions that will hold the nutrients in place for crop growth, and protect surface water and groundwater using BMPs as described in the plan. The plan must</p>	<p>be managed by limiting the nutrients based on P.</p> <ul style="list-style-type: none"> <li>• If a pasture has been determined to require total restriction of P application, the risk of P loss shall be addressed by specified BMPs in lieu of total restriction of P application.</li> </ul>		

State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
	include intended target spreading periods for the application of manure and a statement indicating that the existing equipment has been calibrated. If manure will be applied using an irrigation system, application rates will be governed by nutrient application rate, soil infiltration capabilities and water holding capacity within the root zone or any restricting feature, depth of the root zone, depth to a shallow impervious soil layer, soil infiltration rate, soil texture and drainage, vegetation and ground slope. Nutrient applications are restricted by several setbacks and buffers. Winter application of manure is allowed but restricted, including a requirement that fields where manure will be applied in winter must have at least 25% residue, or an established cover crop. The NMP shall contain a list of specific stormwater control BMPs to address those critical runoff problem areas. Recordkeeping is required for nutrients, crop yields, soil tests, and manure generation.			
Virginia	<p>Standards and Criteria/regulations (VADCR. 2005. <i>Virginia Nutrient Management Standards and Criteria – Revised 2005</i>) are incorporated into the regulations by reference. Said answers to most all specific questions about N- and P-based management are in this document.</p> <p>Says VA NM standard criteria meet or exceed NRCS 590 standard. Says new national 590 standard creates no need to change state 590 standard or VA NM standard criteria.</p> <p>N-based NM is a yield-goal based approach in VA.</p> <p><b>NOTE:</b> Additional details from VA's regulations can be found in Subappendix E.</p>	<p>P-based NM is more restrictive planning based on soil test threshold. PI has to be run if P saturation (Al+Fe) is &gt;35%. No more P is allowed when P saturation is &gt;= 65%.</p> <p>P-based plan is when less P is applied than plant removal. Said that in the Bay model a P-based plan means P is applied at less than crop removal rate, but that no state in CB watershed has yet reported a P-based acre. Hopes to get there. PI, however, would allow up to 1.5xRate depending on conditions.</p> <p><a href="#">Virginia Nutrient Management Standards and Criteria, (Revised 2005): Section IV. Phosphorus Management</a> P application rates shall be managed to</p>	Precision agriculture is using variable rates for N, P, K and/or lime.	ENM is when less nutrients applied than recommended for N and less P applied than allowed. This probably reduces N application by > 15%. Farmer has to prove he applied nutrients at < crop-removal (based on soil productivity groups for and farmer records for N and farmer records for P). This is not tracked through c/s – person tracking plan adds to narrative that farmer is doing this.



State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
	<p><u>VPA General Permit Regulation for Animal Feeding Operations (9VAC25-192-70)</u></p> <p>All NMPs must include the most recent P management criteria adopted by Virginia DCR. All NMPs will include P as well as N limits. The operator shall implement a NMP that shall address the form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing N and P loss to ground and surface waters. The NMP shall contain the following information:</p> <ul style="list-style-type: none"> <li>• Site map</li> <li>• Site evaluation and assessment of soil types and potential productivities</li> <li>• NM sampling including soil and waste monitoring</li> <li>• Storage and land area requirements</li> <li>• Calculation of waste application rates</li> <li>• Waste application schedules</li> <li>• Buffer zones</li> </ul> <p>Records shall be maintained to demonstrate where and at what rate waste has been applied, that the application schedule has been followed, and what crops have been planted.</p>	<p>minimize adverse water quality impacts consistent with procedures contained in this section.</p> <ul style="list-style-type: none"> <li>• P applications from inorganic nutrient sources shall be <math>\leq</math> crop nutrient needs over crop rotation based on soil test.</li> <li>• P applications shall be indicated as 0 in NMPs for soils <math>&gt;65\%</math> P saturation levels (<math>&gt;458</math> ppm for Eastern Shore and Lower Coastal Plain, <math>&gt;375</math> for Middle and Upper Coastal Plain and Piedmont, and <math>&gt;525</math> for Ridge and Valley) regardless of the outcome of other procedures specified in this section. <b>Note:</b> Soil Test P values are shown as elemental P, expressed as a Mehlich I VA soil test value.</li> <li>• A single P application may be recommended to address multiple crops in the crop rotation identified within the NMP if; (a) the single application <math>\leq</math> the sum of the appropriate application rates for individual crops.</li> </ul> <p>For fields <math>\leq</math> the maximum P saturation levels listed, the Soil Test, Environmental Threshold (ET), or PI Method must be used to determine maximum organic nutrient source P applications for fields contained in NMPs. The ET and the Virginia PI Version 2.0 Technical Guide, Revised October 2005 are only applicable to organic nutrient sources. Additionally, plant available N in NMPs shall be <math>\leq</math> the crop nutrient needs for</p>		

State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
West Virginia	<p>The only WV requirement for NM is for CAFOs (WV CAFO regulations are not yet accepted by EPA) or producers who participate in USDA c/s programs for litter storage sheds and other NRCS practices. WVDA works with NRCS to provide technical assistance for NM planning following the NRCS 590 standard. All other technical service providers working through NRCS also follow the NRCS 590 standard. Said there are some planners working through other state and private sectors that use the 590 standard or Virginia Standards and Criteria. Also knows of a couple of other planners who use the 590 standard. Normally, producers do N-based plans.</p> <p>WVDA has a certification program and all NMPs in WV must be done by a certified NM planner to be considered legitimate. There is, however, no standard certified “plan,” just certification of the plans. State doesn’t have a list of criteria for plan development in the regulations to define components of a NMP.</p> <p>The state does have a NMP standard accepted by WV Department of Environmental Protection for writing CAFO NMPs: <i>Technical Standards For West Virginia Concentrated Animal Feeding Operation Nutrient Management Planning</i>. Most plan writers usually use either the NRCS 590 standard or the Virginia Standards and Criteria to develop plans.</p> <p><b>NOTE:</b> Additional details from WV’s regulations can be found in Subappendix F.</p> <p><a href="#">Title 47 Legislative Rule, Department Of Environmental Protection, Water Resources</a></p> <p>NMP must, to the extent applicable:</p>	<p><a href="#">any individual crop.</a></p> <p>P-Based plans usually occur when a farmer chooses to do a P-Based plan or is limited to a P-Based plan through the NRCS-590 P-index.</p> <p>The P-Index is a tool to assess the environmental risk of applying phosphorus. It is used when soil levels are at high (over 50 lbs.) and very high levels (over 80 lbs.).</p> <p>The P-Index takes into account soil P level, application method/timing, source of phosphorus, tolerable soil erosion, sediment to edge of field, and soil drainage class.</p> <p>Low and Medium rating is a N-Based plan, High rating is a P-Based plan, and Very High is a plan with no P application.</p> <p>Current P-Index is being revised and will show correlations with VA’s and NY’s.</p> <p>P-Index is used for the CAFO NMPs.</p>	<p>Some P/D agriculture is beginning to occur, especially in the eastern panhandle. Use of P/D agriculture is limited by the requirement for specialized equipment.</p>	<p>Some poultry farmers are starting to look at ENM; they seem to be cutting down litter applications and shipping some litter west. They see the need to lower their field phosphorus levels before they get too high.</p>

State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
	<ul style="list-style-type: none"> <li>Identify appropriate site-specific conservation practices to be implemented, including as appropriate buffers or equivalent practices to control runoff of pollutants into the waters of West Virginia;</li> <li>Identify protocols for appropriate testing of manure, litter, process wastewater, and soil;</li> <li>Establish protocols to land-apply manure, litter and/or process wastewater in accordance with site-specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients in the manure, litter and/or process wastewater; and</li> <li>Identify specific records that will be maintained to document the implementation and management of the minimum elements described hereinabove.</li> </ul> <p>Annual reporting will include the actual crop(s) planted and actual yield(s) for each field, the actual N and P content of the manure, litter or process wastewater, and the amount of manure, litter or process wastewater applied to each field during the previous 12 months; and, as applicable, the results of any soil testing for N or P taken during the preceding 12 months, and the amount of any supplemental fertilizer applied during the previous 12 months.</p> <p>The NMP must include field-specific rates of application of manure, litter or process wastewater to ensure appropriate agricultural utilization of the nutrients and any timing limitations for land application.</p>			
	<p>Either the linear approach or the narrative rate approach can be used for rates of application.</p> <p>Both the linear and narrative approach require the</p>			

State	Nutrient Management			
	Basic or N-Based	P-Based	Precision/Decision	Enhanced
	following: the outcome of the field-specific assessment of the potential for N and P transport from each field; the realistic yield goal and the N and P recommendations for each crop or use identified for each field; credits for all N in the field that will be plant- available; consideration of multi-year P application; and accounting for all other additions of plant-available N and P to the field. In addition, the terms include the form and source of manure, litter or process wastewater to be land-applied; the timing and method of land application; and the methodology to determine the amount of N and P in the manure, litter, and process wastewater to be applied.			

Several professionals discussed the concept that NM is a “process” rather than an “answer” and that this process is not well specified in state regulations. In addition, several participants suggested that the regulations need to consider newer tools (e.g., CSNT, PSNT, geospatial techniques, etc.) that could address NM in a site-specific fashion. Some participants suggested that NM plans (NMPs) set expectations so high that the farmer cannot meet them, and that the cumbersome procedure can cause farmers to reject plans. Further, several participants believe that regular assessments (and tracking) of management through in-field tests (CSNT, ISNT, variable rate technologies, sensor-based technologies, P and K soil tests, etc.) and adaptive management based on those tests are more likely to improve nutrient use efficiency and production to a greater degree than more prescriptive NMPs.

Most participants believed that the focus of NM should be on animal waste and other organic products (e.g. biosolids) because commercial fertilizer was believed to be already applied judiciously due to economic considerations. Most interviewees indicated that the concepts of N-based and P-based NM do not apply when commercial fertilizer is used because commercial fertilizers are ordinarily blended to meet specific levels of N, P and other nutrients recommended for each crop and field. They generally stated that N-based and P-based NM are approaches applicable when organic nutrient sources are used because the needed ratio of N and P is not available in the organic nutrient source. One interviewee strongly disagreed with this consensus, however, stating that P-based NM applies to both manure and inorganic fertilizer management.

TABLE 3. ADDITIONAL COMMENTS AND ALTERNATIVE NUTRIENT MANAGEMENT DEFINITIONS

Nutrient Management			
(each row contains comments by a single expert)			
Basic (N-Based)	P-Based	Precision/Decision	Enhanced
Most N-based planning focuses on pastoral systems only.	Involves following NRCS 590 standard and using a PI.		
Default definition seems OK based on quick reading.	Default definition seems OK based on quick reading.	An approach in which you use whatever information is available (e.g., yield goal, field history, soils, N management, injection of manure, use of PSNT) to come up with a better management decision on N. It may or may not be a geospatial approach and is not my state; if field sizes are small that is sufficient for site-specific approach.	ENM as defined by the CB is not a NM BMP. It is simply paying farmers to reduce their nutrient rates to less than what is required for optimum crop production.
Prefers the approach used by NRCS for cost-share qualification. Is OK with the default definition for basic NM, but adds that manure plans need to be revised every year because manure analysis required.  Is OK with the default definition for N-based NM.	Said that the default definition for P-based NM is too narrow – it is not just an animal waste/organic issue but also a fertilizer issue.	P/D isn't defined in state regulations. If used, then there is a need for definitions of ENM and P/D; need to have agreement regarding what they mean for tracking.	Said that the default definition for ENM agriculture demonstrates a misunderstanding of how N recommendations are developed. Vehemently disagrees with this formulation.  Noted that the sentence in the default definition regarding rates being set 35% higher than needed is inflammatory because NM recommendations do not currently set rates at 35% higher than needed – rates are set at what the crop actually needs.  Said that the yield-reserve concept used in a project some years back (N insurance policy to promote lower N rates and a payout when there is a resultant

Nutrient Management			
(each row contains comments by a single expert)			
Basic (N-Based)	P-Based	Precision/Decision	Enhanced
			crop loss) may work in some years, but not on a regular basis.
<p>Said that “comprehensive plan” in the default definition of Basic Nutrient Management is a term that already exists (CNMP) and has a specific connotation related to animal agriculture as defined by EPA and NRCS. Also noted that the 4Rs used by industry (right rate, right form, with the right timing, and the right placement) is a useful framework. It has traction and it could be useful to align with the industry effort in this direction.</p> <p>Basic definition talks about testing –need to emphasize that a “current” test is needed, not one that is many years old.</p> <p>Re: plan revisions – length of time a plan is valid is not as important as setting out criteria for what changes on the farm would require updating a plan – a NMP may be outdated the moment it’s completed.</p>	<p>Would prefer to see something mentioned about multi-year or multi-crop P application (corn-soybean rotation) rather than “over-application” for soil build-up purposes in the default definition. Does not agree with the concept of building up soil P by applying more than the crop needs. The building concept is not consistent with today’s recommendation. Thinks about the need to integrate NM with other conservation – not just prevent P buildup in soil but keep it in place.</p> <p>Also not sure about the meaning of the last sentence of definition re: P application exceeding “short-term P requirement.” There are instances where 2 years of P application are warranted where no application is made to the second crop in a rotation (e.g., soybeans in a corn-soybean rotation).</p>	<p>Is promoting the concept of adaptive NM. Under this concept, the rate, form, timing, and method of application of nutrients could/would be adapted from the established “strategic” NMP in a way that is considered “tactical” NM planning. Drawing on prior year(s) data collected from various methods/techniques (1. Late spring soil nitrate test, 2. Nitrate analysis of small plants, 3. Leaf tissue analysis, 4. Chlorophyll meters, 5. Aerial imagery, 6. Leaf firing, 7. Grain N content, 8. Stalk nitrate analysis, 9. Guided stalk nitrate testing, 10. Crop sensors, and 11. Replicated strip trials) the nutrient application rates, nutrient forms, application timing and placement would be adjusted.</p> <p>P/D agriculture requires a lot of intensive management up front. What has been done is primarily done for N, but not yet done for P because of sensor availability.</p>	<p>Said the default definition of ENM is “a very broad statement to be making across all crops and cropping conditions; 35% higher may have been true when 1.4 or 1.2 lbs of N per bu yield was the rule of thumb; with 1 lb of N per bu of yield and improvements in genetics in the last 5 years, I wonder if this statement is still accurate.” Also said ENM is more of a baseline than an enhanced condition</p> <p>Recommends the term “adaptive NM.” [See Precision/Decision column.]</p> <p>Said the notion of reducing application rates tends to be anecdotal, not really ENM – person may already be doing good NMP – how can you reduce N applications by 15% or 35%?</p>

Nutrient Management			
(each row contains comments by a single expert)			
Basic (N-Based)	P-Based	Precision/Decision	Enhanced
<p>Says we must look at individual practices in terms of the four categories of rate, form, timing, and method.</p> <p>Recommends using USDA CEAP data on NM, particularly the definitions and criteria</p>		<p>Hopes that NRCS weighs in on P/D agriculture because it's a focus of the new 590. Said we need to determine how P/D agriculture in the 590 relates to what states are doing on P/D to develop accurate definitions and credit implementation properly.</p>	
<p>for what counts as good NM. CEAP also identified deficiencies in NMPs that must be considered. Noted that ideas on what can be done better are in the new 590 Standard.</p> <p>Said that the EP needs to be consistent between what USDA tracks and what the Chesapeake Bay Program (CBP) credits for modeling. The EP needs to align practice definitions to the extent feasible, avoiding as much as possible the necessity to cross-walk different components (i.e., the 590, state NM practices, and what is modeled). Noted as an example that the Bay model often has more science-based detail than is found in the 590 standard.</p>			
<p>A more comprehensive statement of the purpose of basic NM would add clarity to the definition (minimizing nutrient loss to what?) The NRCS 590 standard does a fairly good job at this emphasizing 1) minimization of pollution to surface and groundwater, 2) protecting air quality by reducing odors and the formation of atmospheric particulates, and 3) improving</p>	<p>Conditions should be determined in which P buildup is no longer acceptable and P based-management (with N supplementation) should be substituted for N-based.</p> <p>“Minimal environmental impact” in the default definition has not been defined – so it is difficult to</p>		



Nutrient Management			
(each row contains comments by a single expert)			
Basic (N-Based)	P-Based	Precision/Decision	Enhanced
the physical chemical and biological condition of the soil and 4) the use/conservation of nutrients for plant production.  The basic NM definition stands alone without the last two sentences, which are more general guidance (not used	interpret. P thresholds are more understandable when defined by explicit processes or states rather than a tool (particularly one known to vary widely by state). If there are exceptions, it is important to explain how they will not undermine the		
consistently or exclusively across the Bay watershed) than specific criteria. If included need to specify the features of the environmental parameters that are of interest (e.g. nutrient content). Also, insert “at least” before “every 2 to 3 years” in the last sentence, to cover all circumstances (e.g. when there is a change in animals numbers or other factors that requires a more immediate update on the NMP).  N-based definition should also include biosolids and other organic material. Other factors and parameters that need to be defined more specifically include soil type, physical or OM.	underlying purpose of the NMP, particularly over long periods of time. As with N based planning refer to all types of nutrient sources that might be applied, including biosolids.		
“N-based” and “P-based” are terms that apply to the specific case of manure NM.	Rates for manure applications based on maintaining soil test P levels below acceptable thresholds by relating the rate of P application to the P removal of the crops grown.	An approach focused on all aspects of crop management including NM. Must include both N and P.	4R Nutrient Stewardship that uses a process of adaptive management each year through source, rate, time and place of nutrient application for each crop.

Nutrient Management			
(each row contains comments by a single expert)			
Basic (N-Based)	P-Based	Precision/Decision	Enhanced
Sees an inconsistency in defining Basic NM as “a comprehensive plan that describes the optimum use of nutrients to minimize nutrient loss while maintaining yield” when the default definition of ENM includes an assumption that Basic NM allows N/P applications 35% higher than crop needs. Says that these two definitions should be compatible and show a transition of greater management inputs when going from the Basic NMP to the ENM to P/D agriculture.	State PI approaches are often different than the definition due to state PI requirements.		This should be adaptive management for specific management units within a field that would include soil N evaluations (like the PSNT, CSNT, or yield monitoring N-rate test-strips, nutrient budgets, etc.) to adjust the basic “rules of thumb” N rates (e.g. 1.0 lb N/bu).
Default N-Based NM definition is OK.			
Default N-based definition is fine and correct. N-based NM is a yield-goal based approach in my state.	Default P-based definition is fine and correct. P-based NM is more restrictive planning based on soil test threshold (Mehlich 1 extraction value >50 ppm); if threshold is exceeded, then the PI is applied. Threshold is based on soil test P level, slope, and tillage factors.	Based on consideration for sub-field level soil testing/yield potential evaluation on the fly, geospatial fertilizer application, grid sampling, variable rate application (more lime than P and K). Sees a lot of potential for this based on variability of yields. Corn for silage is a problem because they may never cross a scale and don't have adequate yield data.	Not sure where the term “enhanced” came from for a practice that is simply an application rate reduction.

Nutrient Management			
(each row contains comments by a single expert)			
Basic (N-Based)	P-Based	Precision/Decision	Enhanced
Said that the default N-based definition looks OK; but we don't have a real effective soil test for N. Most N soil testing does not work well on Delmarva soils. PSNT is useful for side-dressing corn, but even that has R-square of only 0.4 (double that of using yield based alone). Encourages using a yield-based approach.	Said P-based NM can mean P applications based on soil test recommendation or applying at P removal rates. These can be the same once in the optimum soil P range. P-based may still allow starter P application even in the optimum soil test range, but above the optimum range, they do not recommend ANY P application. Said that a state PI <i>that allows</i> P application even in High range soil test is not true P-based NM.	Mentions Variable Rate Technology (VRT) with GreenSeeker and PSNT as examples of effective precision/decision (P/D) agriculture. In personal experience in own state farmers are at least making N decisions based on yield records, and P decisions based on soil tests. Said this fits definition of P/D agriculture.	Enhanced nutrient management (ENM) is not a valid nutrient management (NM) practice. University recommendations are NOT set higher than crop needs. If you apply less than university recommends under appropriate conditions – you WILL get a yield loss.
		P/D agriculture opportunities: Delineate areas of hydrologic activity on a sub-field basis; consider those areas where application rates should be minimized or avoided; emphasize transfer potential for P and not just crop production. Match precision of application to obvious transfer pathways. Hydrologically active areas are those with high runoff potential, places where saturation excess occurs. Variable source areas (VSAs) include wet	
		areas that migrate up slope in wet weather and swales and ditches that tend to stay wet or produce runoff frequently. Also, consider slope, i.e. spreader over-spray into ditches and near source areas. P/D agriculture also refers to better timing with respect to weather, etc.	
			Some poultry farmers are starting to look at ENM by cutting down litter applications and shipping some litter out.

Nutrient Management			
(each row contains comments by a single expert)			
Basic (N-Based)	P-Based	Precision/Decision	Enhanced
			State has no specific definition of ENM
	Less P is applied than plant removes.		
		Also includes consideration of pesticide applications.	Not used but basic NM probably meets Bay model criteria for ENM, although nutrients are not reduced.  Said that if this is a reduction from university recommendations, it won't work. Only with irrigation could they perhaps could get away with reduced application rates – spoon feed over time so can use less because timing is better.
		I think the default definition is close enough and focuses on its use to control fertilizer applications to what is exactly needed at a particular area within a field. Not so sure that decision agriculture has replaced the term, precision agriculture. P sensor availability has nothing to do	The default definition ENM is OK.

Nutrient Management			
(each row contains comments by a single expert)			
Basic (N-Based)	P-Based	Precision/Decision	Enhanced
		<p>with using P/D agriculture for P. P/D agriculture would differ between N and P, however. P/D agriculture for P would entail grid soil sampling to map differences in P availability throughout the field, crop yield monitoring and mapping, and then variable P application to account for differences in P availability across the field and differences in crop uptake based on yield differences across the same field. P would be applied before planting because crop response to in-season P applications is not worth the bother and expense. For N, however, in-season split applications and variable applications determined from yield-based crop N uptake needs are likely to be very helpful to avoid over- and under-applying N both throughout the growing season and spatially across the field.</p> <p>Precision agriculture needs to also be used on pastures. This will be a particularly tough sell as most pastures are rarely soil tested to begin with, let alone grid sampled at GPS points. Nitrate testing for pasture is not effective the way it might be for a corn crop. Decomposition of OM is highly variable, and there is no pre-sidedress equivalent.</p>	
The default definition of N-based manure management is consistent with my perception of the term. N-based NM is when manure application rate is set to meet N recommendation.	The default definition of P-based manure management is consistent with my perception of the term. P-based NM is when rate is set to meet P requirements of crop. Thinks of	The default definition of precision agriculture is consistent with my perception of the term. Believes that P/D agriculture could mean different things to different people. Variable rate, GIS use,	The Term “enhanced management” isn’t one I hear or use, but the concept of maximizing nutrient uptake and minimizing excess application is

Nutrient Management			
(each row contains comments by a single expert)			
Basic (N-Based)	P-Based	Precision/Decision	Enhanced
	“removal” and “requirement” as equivalent. Under P-based management considers that P utilization and requirement are more closely matched than are N utilization and requirement (because of volatilization, mineralization).	etc. are some of the elements, but thinks the definition isn’t so clear cut.	our goal in developing management practices. Although not very familiar with ENM, generally considers it to encompass optimizing nutrient application with nutrient use to avoid excess.
Basic definitions are OK.	Basic definitions are OK.	The P/D agriculture NM is currently vague and could potentially be redefined into new subcategories.	The ENM is primarily based on previous data from the American Farmland Trust’s BMP Challenge Program, which could be reviewed with new available information.
<p>I have no problem with this basic definition of basic NM. However, nursery and greenhouse NMPs integrate WATER MANAGEMENT into basic NM, since the vast majority of growers use irrigation of one form or another at some time during the year.</p> <p>Re: N-based NM – We do NOT have N uptake and use-efficiency data for the great majority (&gt;500) of the ornamental species grown in our state. Thus our process was developed as a farm-scale risk assessment process based on primarily on NPK application rate (lbs/acre) and total plant density.</p> <p>Re: “N-based planning usually results in a buildup of P in the soil” in default definition of N-based NM – Some field (soil-based) operations do incorporate</p>		Nursery and greenhouse growers typically apply nutrients based on the basic principles found in the default definition of P/D agriculture.	Default definition for ENM has practically no application to the nursery and greenhouse industry, since nutrient uptake rates are unknown for a large majority of the species and cultivars grown in the region.

Nutrient Management			
(each row contains comments by a single expert)			
Basic (N-Based)	P-Based	Precision/Decision	Enhanced
organic sources of nutrients, but are subject to the same soil-test (FIV limits) and P-site index requirements as other agronomic crops.			

## BASIC OR N-BASED NM

Several interviewees were satisfied with the default definitions of basic and N-based NM. Two experts suggested that the 4Rs (right rate, right form, with the right timing and the right placement) could serve as a useful framework for basic NM. Greater specificity and a focus on the specific parameters of NM were recommended by two interviewees as means for better understanding of NM objectives and assigning credit. The importance of accurate and current testing was mentioned from varying perspectives by three interviewees, and there was some agreement that plan updates are best triggered by relevant events and information on the farm.

## P-BASED NM

Accepted notions on application rates for P-based NM included P application less than crop P removal, P application equal to crop P removal, and P application equal to crop P removal or based on soil test recommendation. One expert stated that P-based NM may still allow starter P application even in the optimum soil test range, but above the optimum range, no P application is recommended. Another suggested the inclusion of multi-year or multi-crop P application in the definition.

There were several comments addressing soil P buildup and use of the Phosphorus (or Phosphorus Site or Phosphorus Runoff) Index (PI). Concern was expressed that P-based NM as practiced can cause soil P levels to increase, even on very high P soils. This situation is generally attributed to application of the PI. For example, MD regulations allow application at the N-based rate one in three years, with crop removal rate allowed in the other two years, even when the Fertility Index Value (FIV) is above threshold and no P is needed. Under this type of management P soil levels will continue to increase, and one expert commented that this is not true P-based NM.

## ENM

Several noted that the yield reserve concept in the current ENM definition presupposes that recommended N rates exceed optimum rates and disagreed with that assumption. They further stated that based on results from several areas, it appears that ENM under prescribes N for optimum yield. In short, although N would be used more efficiently under ENM, crop yields would suffer. Three experts stated or otherwise clearly indicated that ENM is not a BMP, while three others suggested that adaptive NM is a better alternative definition. Several recalled or mentioned the American Farmland Trust (AFT) program that paid for yield loss when fertilizer application rate was reduced as the origin of the ENM concept and pointed out that yield losses did occur in most of the cases in that program.

## STATE PROGRAMS

With the exception of WV, all CB states have regulations pertaining to NM on agricultural lands. The U.S. Environmental Protection Agency (EPA) has not yet accepted the CAFO regulations proposed by WV, and these are the only NM requirements in the state. State definitions of NM that were examined for this report are broad, and all generally address the amount, placement, timing, and application method of nutrients to both maintain the



productivity of soil and reduce nutrient loss or runoff. Whereas these NM definitions are often provided as line items in state regulations, NM is truly manifested through the implementation of NMPs. Comparison of specific NMP requirements and the implementation of the various elements of NMPs, therefore, is essential to making decisions regarding crediting and tracking NM across the CB watershed.

The general contents required of NMPs are similar across states as well, but those pertaining to regulated animal operations include many elements (e.g., storage of animal waste, mortality composting) that are not applicable to cropland farms. The specific details of state NMP requirements, however, vary from state to state. Differences also exist within states for different land uses, including agronomic field crops versus container or out-of-ground agricultural production in MD, and P-based limitations for pasture versus cropland in PA.

While the NRCS 590 practice standard (state or national version) may not be directly incorporated by reference in most of the regulations reviewed, elements of the practice standard (e.g., PI and P-based NM limitations) are often found in the regulations and program directors often identify the 590 practice standard as a guideline or source of acceptable elements of a NMP. Even if each state incorporated by reference the 590 practice standard to identify the basic requirements for NMPs, however, the quality of the supporting information required by the 590 practice standard (e.g., yield expectation data) can vary across the CB watershed, resulting in some differences in the execution of NMPs.

An interim conservation practice for P/D agriculture exists in DE, but definitions were not found in the regulations for other CB states. Precision/decision agriculture is being adopted in various locations across the CB watershed, including nurseries and greenhouses in MD and the eastern panhandle of WV. The specific elements of P/D agriculture in these areas are not defined, however, with the exception that the nurseries and greenhouses in MD manage water carefully and have both N-based and P-based accounting systems.

A definition of ENM could not be found in any of the regulations reviewed for this report. The concept or principles of ENM, however, were incorporated in limited ways in programs in MD, VA, and WV.

Additional details regarding the applicability of state requirements, yield goal estimation, technical standards, and application of the PI can be found in subsequent sections of this report.

## ALTERNATIVE DEFINITIONS

In addition to the many individual suggestions and comments summarized in Table 3, there was one detailed proposal that suggested three new definitions for NM in place of the current suite in SB:

*The new definitions attempt to provide categories of NM that are effective, practical, and accessible for a range of producers and management levels. Each practice has its own, stand-alone efficiency credit, so the practices are progressive, but not stackable.*

1. *Basic Nutrient Management: documentation of manure and fertilizer management activities identified in state risk assessment tools (such as a low risk rating in the AEM Tier II nutrient management worksheet) and demonstrating an animal density of 0.75 AU/acre or less. This practice would receive an efficiency credit at*

*an equivalent level to the NM land use change in the current version of SB.*

2. *Enhanced Nutrient Management: implementation of the NRCS 590 nutrient management practice standard as defined in NYS. That is, following nutrient guidelines, including: (1) standard, realistic yield goals (per soil type); (2) credit for N sources (soil, sod, past manure, and current year applications); (3) P and K recommendations based on soil tests and the sufficiency method (not crop removal); (4) soil erosion controlled to T per RUSLE2; (5) fields assessed for leaching and runoff risk with conservative tools (N Leaching Index (NLI) and PI); etc. This revised ENM practice would receive an efficiency credit similar to the current efficiency values for ENM.*
3. *Enhanced Nutrient Management – Continuous Improvement: implementation of the NY NRCS 590 practice standard, plus on-going management to improve nutrient use efficiency beyond initial implementation, including tracking performance and managing manure and fertilizer according to tools such as ISNT, CSNT, Mass Nutrient Balance, etc. This practice would receive a higher efficiency credit than the value currently associated with ENM in SB.*

Another interviewee submitted a draft technical note on adaptive management that could serve as a substitute for both P/D agriculture and ENM. This is included as Subappendix B.

## PRECISION/DECISION AGRICULTURE

Interviewees were asked whether P/D agriculture was focused on N and/or P, and to describe any differences for cropland, pasture, or nurseries. One interviewee stated that precision agriculture needs to also be used on pastures but noted that pastures are rarely soil tested and the literature shows pastures to be very variable in nutrient levels. Some nursery crops are grown with a high degree of precision (water and nutrients). Precision/decision agriculture for cropland had multiple definitions, and several interviewees were basically satisfied with the default definition despite noting that it is vague. Most participants were not sure what decision agriculture was and often decision and precision agriculture were separated as they were defined. Some interviewees discussed precision agriculture in terms of geospatial tools and all nutrient inputs. Others defined precision agriculture as improving nutrient decisions through more precision or information with such tools as PSNT or tissue testing. The majority of interviewees stated that P/D agriculture applied to both N and P, but three interviewees said that P/D agriculture has been primarily focused on N. One of these two respondents attributed this to greater sensor availability for N. It is important to note that not all interviewees defined precision agriculture through geospatial technologies. One expert offered Adaptive Nutrient Management as an alternative to both P/D agriculture and ENM. This approach is described in Subappendix B.

## N-BASED RECOMMENDATIONS

Interviewees were asked to describe how N recommendations are developed for crops in their state, program, or area. A description of the method for determining yield goals was also requested. Information on N recommendations and yield goals is presented in Table 4, with responses to survey/interview questions in black and additional information from state guidance or regulatory language in blue.

Interviewees generally agreed that N rates are determined based on yield goals. The source of the yield goal, however, can differ from state to state. Yield goals for some states are based on farmer records or experience whereas in other states yield goals are based on university-provided data. In some cases, university data are current and robust (e.g., Cornell University), but in other cases the published soil-based yield capabilities are as much as 30 years old (e.g., PSU) and not really useful today due in part to improved yields from genetics. It is important to recognize that productivity has been increasing over time, and that in the absence of a robust and current yield potential database, university recommendations are general recommendations rather than farm-specific recommendations. Two experts expressed a concern that the yield goal determination for specific plans is one of the weakest parts of the program, particularly when there is uncertainty as to whether the goal is based on actual records or optimism.

In an effort to create greater consistency across the CB watershed, one interviewee had the following specific recommendation for the EP:

*Pick one crop to document how nutrient decisions are made in all Bay states. Which states use sufficiency vs. crop removal for P and K recommendations? What do states do to capture carryover credit ("other N" – legumes, manure, etc.)? What are the nutrient recommendations and how are they made? What are the thresholds for reduced P application? What are the recommendations for P and K relative to each other across the CB? Would like to see more uniformity across the CB. Consider developing a table of state indicators and policies used in NM.*

TABLE 4. METHODS FOR YIELD GOALS AND N RECOMMENDATIONS

State	Method for N Recommendation	Yield Goal Method
Delaware	N-based is applied strictly on the basis of yield goals and university recommendations.	<p>The <u>CAFO rule</u> contains the following definition: “Realistic Yield Goals” means the expected crop yields based on the best four (4) out of seven (7) years of recorded data. Yield goals higher than the average require written justification from a certified nutrient consultant. Without actual crop yield data, use realistic yield goals in accordance with State Technical Standards (14 DE Reg. 482 (11/01/10) (Final)).</p> <p><u>Title 3, Chapter 22 § 2247 of the Delaware Code</u> (Nutrient Management) has the following statement regarding yield goal method: Expected yields based on best 4 out of 7 year data or, in the absence thereof, soil productivity charts.</p>
Maryland	<p>For crops grown a lot (e.g., corn, wheat, hay), N recommendation is based on yield goals, a direct function of yield goal. Yield and crop type are the primary consideration but MD also makes minor adjustments based on fertilizer type and management practices.</p> <p>Personal experience in MD indicates that farmers are at least making N decisions based on yield records.</p> <p>We do <u>NOT</u> have N uptake and use-efficiency data for the great majority (&gt;500) of the ornamental species and cultivars grown in MD. Thus, our water and NM planning process was developed as a farm-scale risk assessment process, based primarily on NPK application rate (lbs/acre) and total plant density. NMP process was also based on BMP implementation on site, irrigation type, and the likelihood of operation producing runoff that leaves the site.</p> <p><u>COMAR 15-20-08</u> B. Nutrient rates of the primary nutrients shall be calculated for plant growth requirements of the crop based on one of the following:</p> <ul style="list-style-type: none"> <li>• UMD Plant or Crop Nutrient Recommendations, as provided in the MNMM, or</li> <li>• Alternative standards, as provided in scientifically validated data for the development of a NMP acceptable to the Department.</li> </ul> <p>A consultant or certified farm operator may recommend nutrient rates based on a single variety tissue sample when used in conjunction with a soil sample.</p> <p>For Container or Out-of-Ground Production, a certified NM</p>	<p>Recommendations of yield potential are based on historic performance of farm or yield of similar soil type or county yields.</p> <p>Tech standards are based on UMD agronomic rate and timing recommendations. Yield goals are based on historic performance of farm. Originally allowed yield estimates based on soil types but now use yield history, based on 3 of 5 years.</p> <p>There are good research data on yields for crops grown the most (and with research money for studies). Added that yield goal determination for specific plans is one of the weakest parts of the program. The yield goal for the plan is usually taken from farmers’ words – no idea of how often they’re based on actual records vs. wishes.</p> <p>Using a farmer’s own records is by far the best approach to establish yield goals. State averages are not representative in a lot of cases, and using soil capability parameters is not accurate enough.</p> <p><u>COMAR 15-20-08</u> Expected Crop Yield or Production Goal. (1) The calculation of expected crop yield shall be based upon one of the following:</p> <ul style="list-style-type: none"> <li>(a) An average of the 3 highest-yielding years for the crop out of the latest consecutive 5-year cropping sequence; or</li> <li>(b) If yield information exists for more than 5 years for a given field or management unit, crop yield calculations may be based on the average of 60 percent of the highest-yielding years for all consecutive years that crop yield information is available.</li> </ul>

State	Method for N Recommendation	Yield Goal Method
	<p>consultant or certified farm operator shall make nutrient recommendations based on at least one of the following:</p> <ul style="list-style-type: none"> <li>• Label recommendations on fertilizer products for the plants being grown or similar plants;</li> <li>• UMD recommendations for plants being grown or for similar plants;</li> <li>• Recommendation from other state universities for the specific plants being grown or for similar plants;</li> <li>• The data from research done by accredited universities on the specific plants being grown or similar plants;</li> <li>• The general nutrition guidelines for similar plants; or</li> <li>• Any generally accepted growing practices for plants under comparable growing conditions.</li> </ul>	<p>(2) If field or management unit-specific yield or plant production goal information is unavailable or unrepresentative due to the inclusion of new seed varieties, irrigation, or new technologies, a consultant or certified farm operator shall use one of the following:</p> <ul style="list-style-type: none"> <li>(a) Any soil productivity information;</li> <li>(b) The average yield based upon an average of the 3 highest-yielding years for the crop out of the latest consecutive 5-year cropping sequence from nearby fields or management units with similar soil type and management conditions; or</li> <li>(c) Any data acceptable to the Department.</li> </ul>
New York	<p>All crops of significance in NYS have N and P guidelines established by Cornell University.</p> <p>Crop nutrient guidelines are based on the sufficiency approach, developed through years of crop yield response studies, and not a crop removal approach. The guidelines account for nutrient availabilities and efficiencies throughout the soil/crop environment, so no blanket insurance factors exist.</p>	<p>Crop nutrient guidelines are based on a database of 600+ soil-specific yield potentials (not wishful yield goals) and soil test-based yield response studies.</p>
Pennsylvania	<p>Basic N recommendations in PA are based on crop yield goals supplied by the farmer. N recommendations are adjusted for manure and legumes. The PSNT can be used to further adjust N rates for corn at side-dressing time.</p> <p><u>Act 38 Regulations- Subchapter D. Nutrient Management</u></p> <p>Based on soil tests, the plan must include recommendations for the amount of N, P, and K necessary for realistic expected crop yields. If necessary based on the type of crops planned, the recommendations from the initial soil test shall be adjusted to determine the appropriate amount of nutrients necessary to achieve realistic expected crop yields. This adjustment may be satisfied by using the methodologies in the <i>Soil Test Recommendations Handbook for Agronomic Crops</i> published by the Pennsylvania State University Agricultural Analytical Services Laboratory. Other methodologies for this adjustment shall be approved by the Commission.</p>	<p>In our regulatory programs yield goals must be realistic for soils and climate and after the plan is implemented, the yield goal must be based on yield records and actual yields must be at least 80% of planned yields.</p> <p><u>Act 38 Regulations- Subchapter D. Nutrient Management</u></p> <p>§ 83.292. Determination of nutrients needed for crop production.</p> <ul style="list-style-type: none"> <li>(a) The plan must include the acreage and realistic expected crop yields for each crop management unit.</li> <li>(b) For the development of the initial plan, expected crop yields may not exceed those considered realistic for the soil type and climatic conditions, as set by the operator and the specialist, and approved by the Commission or delegated conservation district (CD). If actual yield records are available during the development of the initial plan, the expected crop yields shall be based on these records.</li> </ul>

State	Method for N Recommendation	Yield Goal Method
		<p>(c) If after the first 3 years of implementing the plan, the yields do not average at least 80% of the planned expected yield, the plan shall be amended to be consistent with the documented yield levels unless sufficient justification for the use of the higher yields is approved by the Commission or delegated CD.</p> <p>(d) When determining expected crop yields for plan amendments, expected crop yields shall be based on documented yield levels achieved for the operation. Expected crop yields higher than historically achieved may be used if sufficient justification is approved by the Commission or delegated CD for the use of the higher yields.</p>
Virginia	<p>DCR tracks NM plans by crop type (880,000 acres) - the amount of corn, beans, alfalfa, and hay. Have specific rates for every crop. Most of the manure goes on row crops (corn, beans, small grain, cover crops – no fall application on cover crops, early spring application, trap crops in late fall/early winter if crop has reached growth stage 23. Need to withhold enough N to provide N as starter fertilizer.</p> <p>N-based plan uses soil management groups to set N rate. This probably reduces N application by 6-8%.</p> <p><u>Virginia Nutrient Management Standards and Criteria, (Revised 2005)</u></p> <ul style="list-style-type: none"> <li>The results of soil testing labs approved by the Department must be correlated to VT Mehlich I using provided table, and the provided conversion procedures. Only the VT soil test scale and the conversion of other approved labs to the VT soil test scale can be used to develop P and K recommendations when developing Virginia NMPs.</li> <li>N fertilizer recommendations are developed by identifying the soil productivity group for the crop to be grown in provided table, and selecting a recommended application rate from a provided list of various crops. P and K recommendations are determined based on a table of needs by crop, soil test level, and soil productivity group.</li> </ul>	<p>N-based yield-goals can be set from actual farm records or by using (primarily) the Virginia Agronomic Land Use Evaluation System (VALUES) Manual, which prescribes an achievable yield goal for a particular soil management group (e.g., soil type, wet, droughty, etc.). If farm records are used the producer would base the yield goal on the average of the best 3 of the previous 5 years.</p> <p><u>Virginia Nutrient Management Standards and Criteria, (Revised 2005)</u></p> <ul style="list-style-type: none"> <li>When producer records are used to establish expected crop yields, average the 3 highest yields achieved over the last 5 crop years the particular crop was grown in the field. The corresponding soil productivity group for the field is determined by finding the expected crop yield in provided table that is closest to the above determined yield. These yields must be adjusted to reflect standard moisture levels for grains and forages as indicated in provided table.</li> <li>When developing nutrient recommendations using VALUES, first determine the soil map units (soil series) within field boundaries from the soil survey maps of the subject farm. Using this information, the soil productivity group is determined from provided table for each crop to be grown.</li> <li>Using VALUES, the expected yield of a crop for any one field may be determined in one of two ways. If any single soil productivity group comprises 67% or more of a field, this is considered a predominant soil group, and it may be used to establish the expected yield for the entire field. The other method is to use a weighted average of all soil productivity groups to determine the</li> </ul>

State	Method for N Recommendation	Yield Goal Method
	<ul style="list-style-type: none"> <li>Use the VT soil test rating (such as M+) to determine P and K recommendations from provided tables. If the soil test level is L, M, or H use the midpoint of the recommended nutrient application range. If the soil test level is L-, M-, or H- use the highest value of the recommended nutrient application range. If the soil test level is L+, M+, or H+ use the lowest value of the recommended nutrient application range. Where there is only a single recommendation listed for any soil test rating use the same recommendation for any of the three soil test ratings.</li> <li>When using soil productivity groupings to determine expected yields, if a soil is listed in provided table as not suited (NS) for a particular crop, the farmer should be advised that the particular crop is not recommended to be grown on the soil. If the crop will still be grown in that soil type, use the lowest productivity group rating for that crop to determine the expected yield (i.e., if alfalfa will be grown on a soil listed as NS, then the planner would use productivity group III to determine nutrient application rates).</li> </ul>	<p>expected yield and nutrient recommendations. If several map units make up a field representing multiple productivity groups, none of which account for 67% or more of the field, then the weighted average method to determine the expected crop yield shall be used.</p> <ul style="list-style-type: none"> <li>When using the weighted average method, determine expected crop yield for each soil map unit from provided table, and determine the weighted average yield for the field by summing the fractional yields for each soil map unit. After the weighted average expected yield is calculated and any yield reductions are considered, the soil productivity group of the field is determined by finding the expected crop yield in provided table which is closest to the weighted average yield.</li> <li>To establish an expected yield for a soil series complex use a weighted average formula based on the percentages for each complex as specified in the county soil survey OR with percentages of 60%-40% for complexes with two named soils and 50%-30%-20% for complexes with three named soils. In complexes, the percentages shall be applied in descending order in the same order as the soils are denoted in the complex name.</li> <li>Once the expected yield for a crop is determined, a yield reduction will need to be applied if certain conditions exist within the soil profile such as eroded topsoil, slope, coarse fragments and rock outcrops.</li> </ul>
West Virginia	<p>Nutrient recommendations come from the 2005 VA standards, the PSU agronomy guide, or from the states Land Grant Institute.</p> <p><u>Title 47 Legislative Rule, Department Of Environmental Protection, Water Resources</u></p> <p>Both the linear and narrative approach specify that the factors that are terms of the NMP must include the realistic yield goal for each crop or use identified for each field; the N recommendations from sources specified by the Director for each crop or use identified for each field; credits for all N in the field that will be plant-available; and accounting for all other additions of plant-available N to the field. In addition, the terms include the form and source of manure, litter or process wastewater to be land-applied; the timing and</p>	<p>Yield goals come from farmer records (average of top 3 of last 5 years), soil surveys if they don't have records, 2005 VA standards, the PSU agronomy guide, or from the states Land Grant Institute. Says farm records generally result in higher yield goals because soil survey figures do not account for improvements in soil quality (e.g., OM) which tend to raise yields.</p> <p>We use a soil productivity potential table that is identical to VA Nutrient Management Criteria 2005. A second table lists crops, forages and pasture with bu., tons or AU per acre</p> <p><u>Additional Comments from Interview:</u> Soil productivity yield potential is set by soil type. They have a NM planning software program written by the same person who wrote it for VA. So, their approach is very similar to that of VA.</p>



State	Method for N Recommendation	Yield Goal Method
	method of land application; and the methodology by which the NMP accounts for the amount of N in the manure, litter, and process wastewater to be applied.	<u>Title 47 Legislative Rule, Department Of Environmental Protection, Water Resources</u> No language found regarding method for determining realistic yield goal
Not State-Specific	One of the major challenges in using a yield-based approach for determining fertilizer rates is that yield levels are known to vary widely in a given environment from year to year, as well as among growing seasons within a year where multiple cropping is practiced. Crop responsiveness to fertilizer also fluctuates as a result of the environment, independent of crop yield potential. Both yield potential and crop responsiveness affect the annual fertilizer rate requirement. Other factors that are often considered along with yield potential to estimate plant nutrient demand are cropping system, soil productivity, and fertilizer to crop price ratios. Equations and models that predict crop yield and nutrient uptake are also being utilized to fine-tune N rate recommendations.	<ul style="list-style-type: none"> <li>• A common approach to setting realistic yield goals is targeting 80% of the potential yield (with water and nutrients non-limiting) of a crop in a particular climatic condition. Crop simulation models can help determine potential yield.</li> <li>• A value somewhere between an above average yield and a maximum yield that has been achieved recently on that specific field, or one of similar production and management history, could be set as the target yield.</li> <li>• Setting a target of 10% above the 3 to 5-year average of crops not suffering a severe yield loss due to drought, excessive rainfall, or pests is also a commonly suggested method. This method requires that individual field records be maintained, and that only those fields of similar production potential be considered in making estimates. Rationale for using 10% above the 3 to 5-year average as the target is that there is an expectation that a person with that type of guideline is working to increase yield every year. Preference is for producers to do a regression projecting forward from their past 10 years to predict next year's yield, but this isn't simple because of weather factors. The 10% over the 3-5 year average approach is sort of more workable fudging of the regression approach.</li> <li>• The yield goal being fertilized for does not necessarily limit yield in any given year to that level. Unusually favorable weather resulting in exceptional yields also often results in exceptional nutrient release from the soil or unusually high nutrient use efficiency.</li> </ul>



## STATE PROGRAM REQUIREMENTS FOR NUTRIENT MANAGEMENT

Interviewees were asked to summarize the requirements for NM on agricultural lands in their state. Table 5 summarizes basic requirements for NMPs, including the thresholds (e.g., number of animal units) that trigger these requirements. Requirements for NMPs vary significantly among jurisdictions in the CB watershed. Nutrient management is currently required of CAFOs in all states. Some states, such as DE and MD require NM of essentially all animal operations, cropland, pasture, and nurseries. At the other end of the spectrum, WV requires NMPs only of permitted and large CAFOs. Most states have some capacity for voluntary NM, facilitated by state programs, required for voluntary participation in state or federal cost-share programs, or promoted through education and outreach. Some states have adopted their own extensive technical standards for NM into their regulations (e.g., DE, MD, PA), while others rely at least partially on the NRCS 590 practice standard (e.g., NY, WV).

A synopsis of each CB state's agricultural program as it pertains to NM is provided in Subappendix A.

TABLE 5. BASIC REQUIREMENTS FOR NUTRIENT MANAGEMENT

State	Nutrient Management Requirements				
	Animal Operations		Other Agricultural Land		
	CAFOs	Others	Cropland	Pasture	Nurseries
Delaware	<b>NMP Requirements:</b> NMP is required under CAFO permit, administered by DNREC. Required contents and standards of NMPs are in state regulation. Most plans are done by certified consultants. All CAFO NMPs are audited.	<b>NMP Requirements:</b> NMP is required of non-CAFOs, administered by DDA. Required contents and standards of NMPs are in state regulation and in DDA publications. Most plans are done by certified consultants. NMPs are self-reviewed, but a random sample is reviewed at the farm or at the consultant level	<b>NMP Requirements:</b> NMP is required, administered by DDA. Required contents and standards of NMPs are in state regulation and in DDA publications. Most plans are done by certified consultants. NMPs are self-reviewed, but a random sample is reviewed at the farm or at the consultant level	<b>NMP Requirements:</b> NMP is required, administered by DDA. Required contents and standards of NMPs are in state regulation and in DDA publications. Most plans are done by certified consultants. NMPs are self-reviewed, but a random sample is reviewed at the farm or at the consultant level	<b>NMP Requirements:</b> NMP is required administered by DDA. Required contents and standards of NMPs are in state regulation and in DDA publications. Most plans are done by certified consultants. NMPs are self-reviewed, but a random sample is reviewed at the farm or at the consultant level
	<b>Threshold:</b> all CAFOs; main focus on poultry operations	<b>Threshold:</b> $\geq 8$ AU	<b>Threshold:</b> nutrient application to $\geq 10$ ac	<b>Threshold:</b> nutrient application to $\geq 10$ ac	<b>Threshold:</b> nutrient application to $\geq 10$ ac
Maryland	<b>NMP Requirements:</b> NMP is required of all animal operations. NMP requirements are in MDA manuals under MD Nutrient Management law. NMPs are done by certified consultants. MDA Nutrient Management Program oversees licensing and certification for consultants, compliance activities, and education and training programs. An annual implementation report to MDA is required.	<b>NMP Requirements:</b> NMP is required of all animal operations. NMP requirements are in MDA manuals under MD Nutrient Management law. NMPs are done by certified consultants. MDA Nutrient Management Program oversees licensing and certification for consultants, compliance activities, and education and training programs. An annual implementation report to MDA is required.	<b>NMP Requirements:</b> NMP is required for all cropland, pastureland, nurseries, and forestland, including nutrient applicators. NMP requirements are in MDA manuals under MD Nutrient Management law. NMPs are done by certified consultants. MDA Nutrient Management Program oversees licensing and certification for consultants, compliance activities, and education and training programs. An annual implementation report to	<b>NMP Requirements:</b> NMP is required for all cropland, pastureland, nurseries, and forestland, including nutrient applicators. NMP requirements are in MDA manuals under MD Nutrient Management law. NMPs are done by certified consultants. MDA Nutrient Management Program oversees licensing and certification for consultants, compliance activities, and education and training programs. An	<b>NMP Requirements:</b> NMP is required for all cropland, pastureland, nurseries, and forestland, including nutrient applicators. NMP requirements are in MDA manuals under MD Nutrient Management law. NMPs are done by certified consultants. MDA Nutrient Management Program oversees licensing and certification for consultants, compliance activities, and education and training programs. An

State	Nutrient Management Requirements				
	Animal Operations		Other Agricultural Land		
	CAFOs	Others	Cropland	Pasture	Nurseries
			MDA is required.	annual implementation report to MDA is required. This report includes amount of nutrients applied to farm in the calendar year.	annual implementation report to MDA is required.
	<b>Threshold:</b> $\geq 8$ AU The consultant determines if the plan should be N or P based. If soil FIV < 150 then plan is based on N. If FIV is $\geq 150$ , then the farmer must use the PI to determine if the plan is based on N or P.	<b>Threshold:</b> $\geq 8$ AU	<b>Threshold:</b> all operations grossing $\geq \$2,500/\text{yr}$	<b>Threshold:</b> all operations grossing $\geq \$2,500/\text{yr}$	<b>Threshold:</b> all operations grossing $\geq \$2,500/\text{yr}$
New York	<b>NMP Requirements:</b> CNMPs are required for regulated CAFO. NRCS 590 standard is required for all CNMPs, including those required by the NYS DEC CAFO General Permits	<b>NMP Requirements:</b> NMP is not required. The NYS DA&M, NYS SWCC, and SWCDs provide support for NM on non-CAFOs through the Agricultural Environmental Management (AEM) program. NRCS 590 standard is required for all CNMPs.	<b>NMP Requirements:</b> NMP is not required,	<b>NMP Requirements:</b> NMP is not required.	<b>NMP Requirements:</b> NMP is not required.
	<b>Threshold:</b> $\geq 200$ AU	<b>Threshold:</b> none	<b>Threshold:</b> N/A	<b>Threshold:</b> N/A	<b>Threshold:</b> N/A
Pennsylvania	<b>NMP Requirements:</b> NMP is required of all CAFOs and CAOs under state law. The PA SCC provides detailed NMP criteria used for CAO and CAFO farms. PDA	<b>NMP Requirements:</b> Procedures covered in the PA DEP Manure Management Manual are required of all animal operations not regulated as	<b>NMP Requirements:</b> NMP is not required	<b>NMP Requirements:</b> NMP is not required	<b>NMP Requirements:</b> NMP is not required

State	Nutrient Management Requirements				
	Animal Operations		Other Agricultural Land		
	CAFOs	Others	Cropland	Pasture	Nurseries
	trains and certifies NMP preparers. NMPs are reviewed and approved by CCD or SCC staff.	CAOs of CAFOs.			
	<b>Threshold:</b> Concentrated Animal Operations (CAOs) are defined as operations with $\geq 2$ AU/ac of manured land.	<b>Threshold:</b> $>1$ AU	<b>Threshold:</b> N/A	<b>Threshold:</b> N/A	<b>Threshold:</b> N/A
	<b>NMP Requirements:</b> NMP required of CAFOs and AFOs under DEQ permit (which covers all poultry and swine operations and ~50% of dairy operations in VA.) NMP is required under 17 state cost-shared BMPs. NMP criteria are in VA state regulations. The VA DCR manages both agricultural and urban NMP programs, including NM training and certification. DCR staff write and approve most CAFO/CAO NMPs.	<b>NMP Requirements:</b> NMP is voluntary. NMP is required under 17 state cost-shared BMPs.	<b>NMP Requirements:</b> NMP is voluntary. NMP is required under 17 state cost-shared BMPs. All state and federal lands where fertilizer is applied are required to have a NMP. Private contractors write most voluntary NMPs; NMPs are reviewed by SWCD.	<b>NMP Requirements:</b> NMP is voluntary. NMP is required under 17 state cost-shared BMPs. All state and federal lands where fertilizer is applied are required to have a NMP. Private contractors write most voluntary NMPs; NMPs are reviewed by SWCD.	<b>NMP Requirements:</b> NMP is voluntary. Very few if any nurseries in VA receive nutrients.
Virginia	<b>Threshold:</b> $\geq 300$ AU	<b>Threshold:</b> N/A	<b>Threshold:</b> N/A	<b>Threshold:</b> N/A	<b>Threshold:</b> N/A

State	Nutrient Management Requirements				
	Animal Operations		Other Agricultural Land		
	CAFOs	Others	Cropland	Pasture	Nurseries
West Virginia	<p><b>NMP Requirements:</b> NMP is required for CAFOs or for producers who participate in USDA cost-share programs.</p> <p>Permitted CAFO NMPs must be written to follow <i>Technical Standards For</i></p>	<p><b>NMP Requirements:</b> NMP is mainly voluntary, but required for producers who receive USDA cost-share.</p> <p>All AFOs are targeted by</p>	<p><b>NMP Requirements:</b> NMP is mainly voluntary, but required for producers who receive USDA cost-share.</p>	<p><b>NMP Requirements:</b> NMP is mainly voluntary, but required for producers who receive USDA cost-share.</p>	<p><b>NMP Requirements:</b> NMP is mainly voluntary, but required for producers who receive USDA cost-share.</p>
	<p><i>West Virginia Concentrated Animal Feeding Operation Nutrient Management Planning.</i></p> <p>The WVDA works with NRCS to provide technical assistance for NM planning; they and all planners follow the NRCS 590 standard. All plans are written by certified planners available via NRCS, WV Conservation Agency (WVCA) staff, and WVU county faculty. The WVDA operates a voluntary NM certification program that includes education and training.</p>	<p>WVDA, monthly newsletters, WV Farm Bureau, and exploitation of the CAFO regulatory “fear factor.” to do voluntary NMPs in the near term.</p>			
	<p><b>Threshold:</b> CAFOs. Both permitted operations and poultry operations that fall into the large category must have a NMP.</p>	<p><b>Threshold:</b> N/A</p>	<p><b>Threshold:</b> N/A</p>	<p><b>Threshold:</b> N/A</p>	<p><b>Threshold:</b> N/A</p>

N/A = not applicable

## GAPS IN PROGRAMS FOR NUTRIENT MANAGEMENT

Interviewees were asked to identify any gaps in their overall programs to require or otherwise achieve NM on agricultural lands. Program gaps varied across the CB states. Authority to specifically address NM for inorganic nutrients is not explicitly defined in most CB states. In DE and MD, where NM is broadly required by statute, both organic and inorganic sources of nutrients come under NM requirements. Both NY and PA, however, lack authority to apply NM when only inorganic fertilizer nutrients are used, except under general discharge prohibitions and fertilizer labeling laws. Except in DE and MD, a full NMP is not required of small unregulated animal operations. NY, however, has the voluntary AEM program that is used by a majority of livestock operations in the state. PA recently included small AFOs in their MMM program, but this program does not require full-scale NM planning at the level required of large animal operations. Nurseries are not covered by NMP requirements in NY, PA, VA, or WV. Many interviewees considered the lack of verification, reporting, and tracking of voluntary NMPs in most CB states to be a significant gap in program coverage. Both DE and MD have formal programs that manage and track manure import/export among farm operations. However, such oversight does not exist in other CB states.

One respondent stated that consideration of NM for pasture is a gap because NM planning (especially ENM and P/D agriculture) is less available to pasture than to cropland. Nitrogen availability on pasture is uncertain due to the high variability of OM distribution and mineralization and the lack of an effective soil N test for pasture as for corn (i.e., the PSNT has not been adapted to pasture/grass).

No major gaps in application of NM to specific groups of people or land ownership categories were noted. MD NM regulations are crop-specific so do not differentiate on the basis of land ownership. Similarly, VA programs apply to the act of fertilizer application, regardless of land ownership status.

One interviewee stated that the variability in the definitions of NM among the CB states contributes to significant gaps across the watershed and urged consistent definitions of NM and component practices among the states.

Table 6 lists the significant gaps identified for each state.

TABLE 6. MAJOR GAPS IN PROGRAMS FOR NUTRIENT MANAGEMENT

Gaps in Programs for Nutrient Management							
State	Authority to Regulate Inorganic Nutrients When Organic Nutrients Are NOT Used	Specific Livestock Operation Types or Sizes	Import or Export of Manure	Manure Brokers	Specific Crops	Specific Groups of People or Land Ownership Categories	Other
Delaware	DE does not specifically regulate inorganic fertilizer applications. However, in the NM planning process, all nutrient applications must be listed and set to agronomic levels based on soil test and crop requirements. Hence, DE regulates inorganic nutrient applications by plan not statute.	No gaps noted.	DE has a formal manure transport program that includes manure transport out of the CB watershed. A cost-share program operates to fund manure transport ; verification that the receiving land is under NM (i.e., a nutrient need documented by a soil test) is required. However, a lot of poultry litter is transferred from farm to farm without the intervention of the DNMC.	No gaps noted.	No gaps noted.	No gaps noted.	
Maryland	The state NM law is written broadly and inorganic nutrients are included within the scope of authority.	MD statute includes all animal operations down to 8 animal units under the MDA program.	Both shippers and receivers of manure are required to keep records as part of their NM plans. MDA operates a program to match buyers and sellers and offers cost-share incentive to offset transportation costs	There is a program to register brokers, but it is not clear if they have to report all of the details on where the manure is applied.	No gaps noted - the programs are highly comprehensive and cover field crops, nurseries, and silviculture.	Because the regulations are crop specific, not owner specific, all lands (including state and federal) are included.	

Gaps in Programs for Nutrient Management							
State	Authority to Regulate Inorganic Nutrients When Organic Nutrients Are NOT Used	Specific Livestock Operation Types or Sizes	Import or Export of Manure	Manure Brokers	Specific Crops	Specific Groups of People or Land Ownership Categories	Other
New York	State has no specific authority to regulate inorganic nutrients except under standard discharge prohibitions. Producers using only inorganic nutrients can participate in the voluntary AEM program, as well as NRCS cost-share programs.	Dairy farms with <200 cows are not regulated and a NMP is not required; however small dairies generally have an adequate land base. Producers can participate in the voluntary AEM program, as well as NRCS cost-share programs. Poultry production is not a significant factor in the state.	Although some minor distribution issues exist, manure import/export is not a major issue in the state. A CAFO importing manure would need to account for the imported nutrients in their CNMP.	Manure brokers are not a significant factor in the state.	No gaps noted.	No gaps noted.	
Pennsylvania	There is no NMP requirement for commercial fertilizer, including industrial lands, or homeowners other than the PDA rule that users must follow the label.	There is a gap in oversight of the large number of small non-CAO farms that come under the state Manure Management Manual program.	No gaps noted.	Manure transferred by brokers is regulated, but there is no cost-share or financial incentive program.	No gaps noted.	No gaps noted.	Nurseries are not part of the state NMP program.



Gaps in Programs for Nutrient Management							
State	Authority to Regulate Inorganic Nutrients When Organic Nutrients Are NOT Used	Specific Livestock Operation Types or Sizes	Import or Export of Manure	Manure Brokers	Specific Crops	Specific Groups of People or Land Ownership Categories	Other
Virginia	No gaps noted	NMP is a requirement of AFO and CAFO permits; DEQ has all poultry and swine, but only half of dairy operations (those	There are no transfers of dairy or hog manure outside of permits. Poultry litter can be transferred to 3 <sup>rd</sup> party and the 3 <sup>rd</sup> party does not have to	Brokers are supposed to report where the litter is being transferred. However, documentation is poor and the	No gaps noted.	All federal lands have a NMP through NRCS. By statute, all state lands including roads, office	Biosolids are also regulated by DEQ; for some applications an approved NMP is
		>300 AU) under permit. There are ~500 unpermitted dairies in VA.	have a plan if they need either N or P. A problem with dairies importing poultry litter for application to land outside of the dairy NMP was noted; a permit that covers all acres on a facility is being worked on.	destination of much litter is unknown.		property, and state university lands must have a NMP if any type of fertilizer is applied over a 3-yr period. One recognized tribe has cropland that might require a NMP, but there are no provisions to track those acres.	required, but not for all.  The state lacks technical standards for NMPs for nurseries.

Gaps in Programs for Nutrient Management							
State	Authority to Regulate Inorganic Nutrients When Organic Nutrients Are NOT Used	Specific Livestock Operation Types or Sizes	Import or Export of Manure	Manure Brokers	Specific Crops	Specific Groups of People or Land Ownership Categories	Other
West Virginia	No gaps noted.	Large poultry operations are currently defined as CAFOs, so a NMP is required of large but not smaller poultry operations.	Manure exchanges are not regulated or reported. NMPs for poultry operators include amount and destination of litter shipped and a nutrient analysis, but a NMP is not required of the recipient.	Poultry litter brokers are supposed to keep records but are not required to report records to WVDA	No gaps noted.	No gaps noted.	Nurseries are not part of the state NMP program.

## PROGRAM COORDINATION

Interviewees were asked to describe any problems or concerns with NM program coordination. No interviewees expressed major issues with NM program coordination in their states. Coordination between DNREC and DNMC was reported to be the main feature of coordination of DE NM programs. The state Public Health department also serves on the DNMC to address issues of odor, flies, and other public health concerns. In NY, The NYS AEM program provides an umbrella for coordination of local, state, and federal partners and programs (both voluntary and regulatory) in terms of policy, cost-share funding, technical guidelines, conservation training, planner certification, and technical assistance. All of the PA NM regulatory programs are said to be fully coordinated. All participants – PA DEP and PDA, PSU, NRCS, and SWCDs – have roles to play in state NM programs and everyone reportedly communicates well with each other. The PA state NM programs have benefited from consistent technical standards that apply to all programs. In VA, where DCR staff write 90% of all animal operation plans and private sector NM planners write 90% of all cost-shared NMPs, coordination among NRCS, DEQ, and Agriculture groups has been improving over the last two years. Differences in compliance concerns between animal operations (striving to avoid notice of violation from DEQ) and crop farmers (some participating only to obtain cost-share money and not implementing NMPs) are a challenge to coordination of NM efforts. In WV, coordination is mainly provided through WVDA working with NRCS to provide technical assistance for NM through the NRCS 590 practice standard. Some coordination is also accomplished through NRCS training of WVDA staff in use of RUSLE2 and through state requirements that NM planners obtain continuing education credits to maintain certification. Different state and federal agencies in WV offer trainings to receive CEUs.

## NUTRIENT MANAGEMENT TECHNICAL STANDARDS

Interviewees were asked to report whether they had technical standards or requirements in their states for NMPs on cropland, nurseries, and pasture. Where technical standards or requirements exist, they were asked to specify whether N-based NM, P-based NM, P/D agriculture, or ENM were specified. They were also asked to describe any differences in these requirements for cropland, nurseries, and pasture.

Several states (DE, MD, and NY) apply the same technical standards for NM to cropland, pasture, and nurseries. The other states apply the same NM standards to cropland and pasture, but lack specific standards for nurseries. With the exception of WV, each of the CB states have adopted laws and regulations that contain most of their technical standards for NM. WV does have an accepted standard for permitted CAFOs. To some extent, all of the CB states include or reference the NRCS 590 practice standard in their NM technical standards. Interviewees from all of the CB states indicated that their technical standards do not themselves distinguish between N- and P-based NM, but use risk-based criteria (e.g., a PI or a soil test P level) to determine whether N- or P-based NM applies. In PA, for example, P-based NM is potentially triggered by a screening step in the PA PI that considers soil test P, proximity to water, and location in a special protection watershed. In general, ENM and P/D agriculture are not specifically part of state technical standards. These approaches are generally not specifically defined or widely used in most states, but are used in educational programs in some states. None of the interviewees commented on the likelihood that their state would adopt specific standards in the future where none exist today, nor on the likelihood of future standards requiring N-based, P-based, or ENM or P/D agriculture.

Some specific technical standards for NM for each state are presented in Subappendix A. Table 7 summarizes the existence of technical standards or requirements for NM for each CB state.

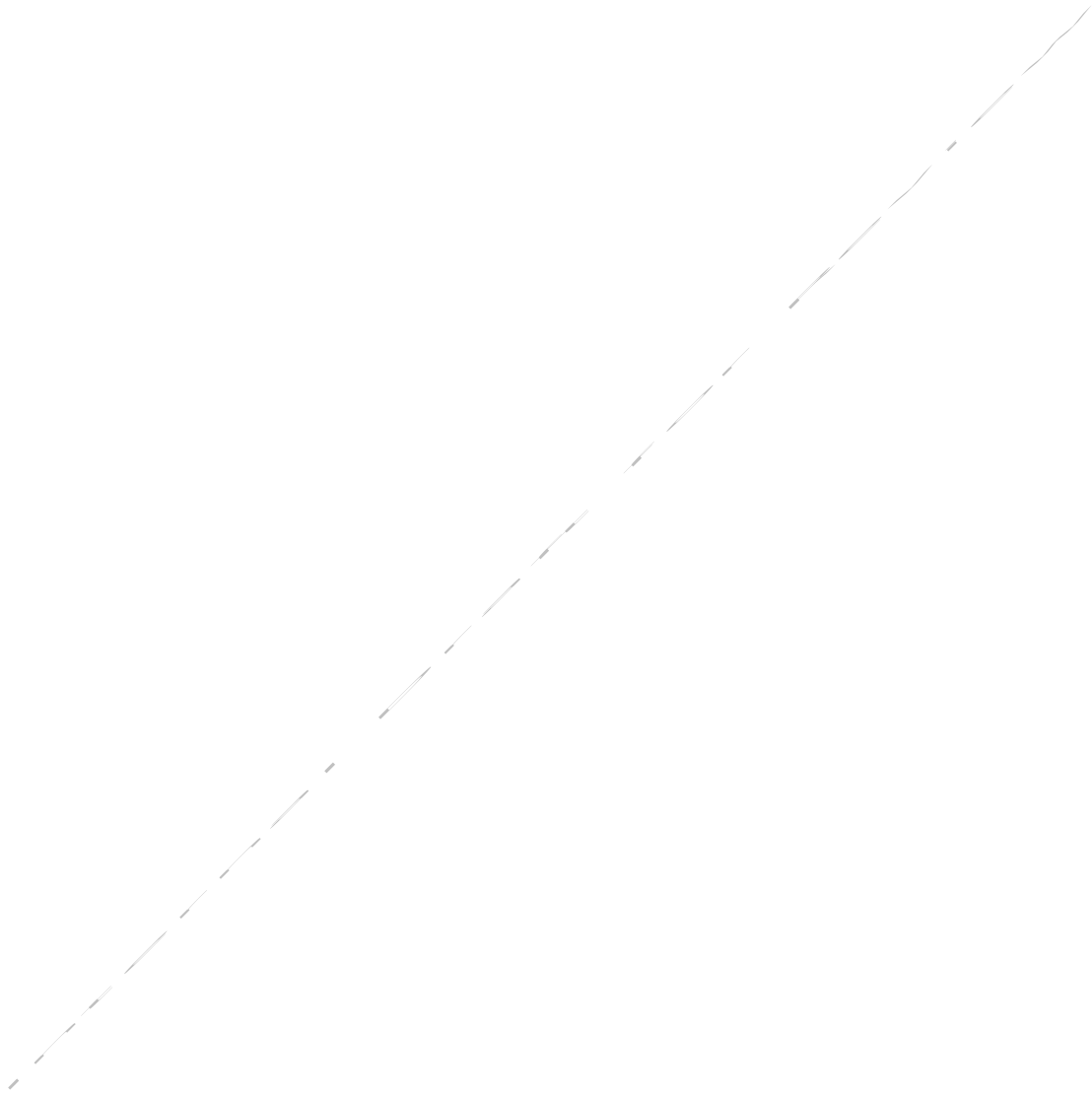


TABLE 7. SUMMARY OF TECHNICAL STANDARDS OR REQUIREMENTS FOR NUTRIENT

State	Commodity Group			Differences Across Commodity Groups	Principal sources of state technical standards	Notes
	Cropland	Pasture	Nurseries			
Delaware	Yes	Yes	Yes	No differences	<ul style="list-style-type: none"> <li>• State regulations</li> <li>• NRCS 590 standard</li> <li>• DDA standards</li> <li>• UD Extension resources</li> <li>• DE PI</li> </ul>	Because of the state's history of high-P soils, most of the focus is on P and standards have been developed. However, no technical standards exist for N; N-based is applied strictly on the basis of yield goals and university recommendations. If the FIV is greater than 150, producer is required to conduct a PI assessment, the results of which determine if application can be N-based vs. P-based vs. no P
Maryland	Yes	Yes	Yes	No differences	<ul style="list-style-type: none"> <li>• State regulations</li> <li>• Maryland <i>Nutrient Management: Consultant's Resource Notebook</i></li> <li>• MD PI</li> </ul>	The state regulatory program requires both N and P to be addressed. The PI is used as risk assessment tool. An FIV >150 triggers the need for a P loss assessment using the PI. If FIV <150, N-based NM is allowed. ENM and P/D agriculture are not part of how MDA regulates, but are part of the education/promotion aspect of program.
New York	Yes	Yes	Yes	No differences	<ul style="list-style-type: none"> <li>• NY General CAFO permit</li> <li>• NYS DEC <i>Agricultural Environmental Management Program</i></li> <li>• NRCS 312 and 590 standards</li> </ul>	All NM is based on the NRCS 590 standard and Cornell University crop and manure management guidelines.

State	Commodity Group			Differences Across Commodity Groups	Principal sources of state technical standards	Notes
	Cropland	Pasture	Nurseries			
					<ul style="list-style-type: none"> <li>• Cornell University Nutrient Management Program</li> <li>• NY PI</li> <li>• NLI</li> </ul>	
Pennsylvania	Yes	Yes	No	No differences between cropland and pasture NM.	<ul style="list-style-type: none"> <li>• State regulations</li> <li>• PA PI</li> <li>• PSU Agronomy Guide</li> <li>• PSU Nutrient Management Program</li> </ul>	ACT 38 technical manual criteria form the basis for NM definition in PA. All plans address P but not all are P-indexed or P-limited plans. P-based NM is triggered by a screening step in the PA PI (soil test P, proximity to water, location in special protection watershed). PA has no specific definition of ENM; neither ENM nor P/D agriculture is widely used due to small field sizes.
Virginia	Yes	Yes	No	No differences between cropland and pasture NM.	<ul style="list-style-type: none"> <li>• State regulations</li> <li>• VA <i>Nutrient Management Standards and Criteria</i></li> <li>• VA PI</li> </ul>	No NMP standards exist for nurseries – field nurseries rarely receive nutrients and container nurseries use a flow-through system. VA NM standard criteria meet or exceed the NRCS 590 standard
West Virginia	Yes	Yes	No	No difference between cropland and pasture NM.	<ul style="list-style-type: none"> <li>• State NPDES permit</li> <li>• NRCS 590 standard</li> <li>• WV PI</li> <li>• VA <i>Nutrient Management Standards and Criteria</i></li> </ul>	Most plans are N-based, unless P-based is triggered by the PI. P-based NM follows the NRCS 590 standard and the PI.

## PROCESS AND CRITERIA FOR DETERMINING LEVEL OF NUTRIENT MANAGEMENT REQUIRED

While Table 7 identifies whether technical standards or criteria exist for various commodity groups, it sheds no light on how these standards or requirements are applied in the field. Interviewees were asked to specify the set of criteria or circumstances used to determine requirements for N-based, P-based, P/D, ENM in their states. One specific type of risk assessment commonly performed involves application of a PI.

Each of the CB states has developed its own PI and the risk assessments are used in different ways. In many of the CB states, a PI is used to make the choice between N-based and P-based NM. In MD and DE, for example, if soil fertility exceeds a threshold value, the PI must be used to determine if a NMP is P-based or N-based. In PA, a preliminary PI screening determines the presence of risk of P loss to a water body and the outcome of the main PI determines P application restrictions. In NY, the PI is used to assess risk for winter manure application, as well as to guide selection of N-based vs. P-based NM. Most tree farms and in-ground nurseries in the CB are believed to use a PI.

Interviewees expressed some concerns about the variability of application of the PI to NM in the CB watershed. Some respondents noted that the differences between the state PIs can result in significantly different recommendations for the same set of circumstances and that these disparities need to be evaluated, particularly with respect to how they are accounted for in the Bay model. Several interviewees stated that the PI sometimes allows farmers to replace the nutrients removed by their crops each year even in very high-P soils as long as the risk assessed by the PI permits P to be added. This contributes to continual buildup of P in soils. The VA PI, for example, allows application of 1.5 times crop-removal P even under some High risk conditions. The MD PI also allows P application even in the High risk range soil test; it was noted that even though most MD animal operations apply the PI, only about 4% of the risk assessments disallow additional P application. Such results do not appear to represent true P-based NM. With dairy manure, the added cost of fertilizer N may encourage continued manure application to supply N even if no P is needed.

Several interviewees noted that work is needed on how the PI is interpreted. There are states with PIs that will never recommend zero P application, no matter how high the soil test P. A difference between agronomic and environmental thresholds was noted and it was asserted that a PI needs to be able to restrict P application in some set of circumstances to have an environmental benefit.

An overview of the characterization and computation of state PIs in the CB states is found in Tables 8 and 9 respectively. It is important to note that many CB state PIs are in a state of flux at present. The WV PI is currently under revision. UMD is revising the MD PI to better deal with transport processes; any transport pathway can be limiting for nutrient application. Use of soil P saturation is under consideration in PA. The revision of the national NRCS 590 practice standard in January, 2012 is giving impetus to broader revision of the PI.

TABLE 8. P INDEX CHARACTERIZATION

Group	Factor	DE	MD	NY	PA*	VA	WV
Site & Transport Factors	Soil erosion	2 x RUSLE	2 x RUSLE	RUSLE	RUSLE	RUSLE2	RUSLE2 soil loss, categorized by "T"
	Sediment delivery ratio	[not used]	[not used]	[not used]	[not used]	0.4 - 1.0 ~= riparian buffer factor	Ratings by tons of sediment delivered to eof
	Soil runoff class	Low – Vy High	Low – Vy High	Poor/Vy poor → Well/ Excessive	Poor/Vy poor – Excessive	[not used]	Ratings based on soil drainage class
	Runoff from field	[not used]	[not used]	[not used]	[not used]	Runoff (in.) est. from hsg, CN, and precip record	[not used]
	Runoff delivery factor	[not used]	[not used]	[not used]	[not used]	Runoff delivery est. from distance, presence of buffer	[not used]
	Leaching potential	Low – Vy High	Low – Vy High	[not used]	[not used]	"Percolation" est. from hsg, crop, tables – by region	[not used]
	Soil texture/drainage class	[not used]	[not used]	[not used]	[not used]	Est. from soil survey, table values	[not used]
	Distance to surface water	Low – High, buffer present	Low – High, buffer present	Flow distance to blue line stream (ft)	>500 ft → <100 ft	[not used]	[not used]
	Priority of receiving water	Vy Low – Vy High	Vy Low – Vy High	[not used]	[not used]	[not used]	[not used]
	Flood frequency	[not used]	[not used]	rare → frequent	[not used]	[not used]	[not used]
	Stream type	[not used]	[not used]	blue line vs.	[not used]	[not used]	[not used]



Group	Factor	DE	MD	NY	PA*	VA	WV
				ephemeral			
	Subsurface drainage	[not used]	[not used]	[not used]	None → patterned, direct outlet	[not used]	[not used]
	Modified connectivity	[not used]	[not used]	[not used]	Direct – grassed ww – riparian buffer	[not used]	[not used]
P Source & Management Practices	Soil test P/ FIV	0.2 x FIV	0.2 x FIV	Morgan, lb P/ac	0.2 x Mehlich 3	“Sediment total P factor” – Mehlich 1 soil test * enrichment factor	Categories based on stP value (Mehlich 1)
	Runoff DRP factor	[not used]	[not used]	[not used]	[not used]	DP released from soil to runoff – est. from Mehlich 1 soil test, table eqns.	[not used]
	Subsurface DRP factor	[not used]	[not used]	[not used]	[not used]	DP released from soil to percolating water – est. from Mehlich 1 soil test, table eqns.	[not used]
	P fertilizer application rate	0.6 x P <sub>2</sub> O <sub>5</sub> lb/ac	0.6 x P <sub>2</sub> O <sub>5</sub> lb/ac	P <sub>2</sub> O <sub>5</sub> lb/ac	P <sub>2</sub> O <sub>5</sub> lb/ac	“Applied fertilizer DRP factor” includes P <sub>2</sub> O <sub>5</sub> application rate, P source coefficient, and application method factors. Note: Although not	“Manure/ Fertilizer type, based on P source coefficients ~water extractable P

Group	Factor	DE	MD	NY	PA*	VA	WV
						explicit in tech guide, VA PI Spreadsheet appears to accept many kinds of fertilizer applications (including manure of different types and inorganic fertilizer)	
	P fertilizer application method	Injected → surface applied	Injected → surface applied	Injected → surface applied	Injected → surface applied	[combined with fertilizer DRP factor]	Injected → surface applied
	P fertilizer application timing	[combined with method]	[combined with method]	May-Aug → Feb-Apr	[not used]	[not used]	[part of app method rating]
	Organic P source application rate	Avail. Coeff x P <sub>2</sub> O <sub>5</sub> lb/ac	PSC x Varies by type of organic source; function of water extractable P P <sub>2</sub> O <sub>5</sub> lb/ac	P <sub>2</sub> O <sub>5</sub> lb/ac Has capacity to describe two separate organic P applications, re: rate, method, and timing	P <sub>2</sub> O <sub>5</sub> lb/ac Has page to enter multiple capacity to describe two separate organic P applications, re: rate and method	[not used]	[not treated separately from fertilizer]
	Organic P source application method	Injected → surface applied	Injected → surface applied	Injected → surface applied	Injected → surface applied	[not used]	[not treated separately from fertilizer]
	Organic P source application timing	[combined with method]	[combined with method]	May-Aug → Feb-Apr	[not used]	[not used]	[not treated separately from fertilizer]
	P source coefficient	[not used]	[see above under appl. rate]	[not used]	0.4 – 1.0, depends on manure type	[see above under applied fert DRP factor]	[see above under application rate]

\*In PA, the requirement to use the main PI does not apply unless: (1) special protection watershed; (2) significant farm management change; (3) soil test >200; and (4) distance to water <150 ft

TABLE 9. COMPUTATION OF P INDEXES

Parameter	DE	MD	NY	PA	VA	WV
<b>Computations</b>	Site/transport factors summed, then scaled by 0.02 Source/mgt factors added Index value = (site/transport) X (source/mgt)	Site/transport factors summed, then scaled by 0.02 Source/mgt factors added Index value = (site/transport) X (source/mgt)	Source, Dissolved Transport, Particulate transport Factors = product of component factors; source and dissolved or particulate risk factors summed for separate Index values	Fertilizer and manure ratings multiplied, then Source factors summed; Transport factors summed Index value = source X transport 2	Erosion, Runoff, and Subsurface Risk Factors = product of component factors; main risk factors summed for Index value	Each factor receives rating; factors summed for Index value
<b>Factors</b>	Quantitative/qualitative	Quantitative/qualitative	Quantitative/qualitative	Quantitative/qualitative	Quantitative	Qualitative
<b>Scale</b>	0 - >100	0 - >100	0 - >100	0 - >100	0 - >100	5 - 50
<b>Ratings</b>	<50      LOW 51 – 75    MEDIUM 76 – 100   HIGH >100      VY HIGH	<50      LOW 51 – 75    MEDIUM 76 – 100   HIGH >100      VY HIGH	<50      LOW 50 – 74    MEDIUM 75 – 99    HIGH >100      VY HIGH	<59      LOW 60–79    MED 80 – 99    HIGH >100      VY HIGH	<30      LOW 30 – 60    MED 61 – 100   HIGH >100      VY HIGH	<15      LOW 16 – 25    MED 26 – 35    HIGH >35      VY HIGH
<b>Management</b>	LOW: N-based nm is acceptable MEDIUM: N-based 1 yr/3; P-based 2 yrs/3 HIGH: P by crop removal or soil test only; implement all BMPs VY HIGH: no P applied; active remediation needed	LOW: N-based nm is acceptable MEDIUM: N-based 1 yr/3; P-based 2 yrs/3 HIGH: P by crop removal or soil test only; implement all BMPs VY HIGH: no P applied; active remediation needed	LOW: N-based nm acceptable MEDIUM: N-based nm with BMPs HIGH: P by crop removal only; VY HIGH: no P applied [both Dissolved and Particulate Indices must be <100 for manure application	LOW: N-based nm acceptable MEDIUM: N-based nm acceptable HIGH: P by crop removal only; VY HIGH: no P applied	LOW: N-based nm acceptable MEDIUM: P applications $\leq 1.5$ crop removal HIGH: P by crop removal only; VY HIGH: no P applied	LOW: N-based nm acceptable MEDIUM: N-based nm acceptable HIGH: P-based (crop removal); VY HIGH: no P applied
<b>Abbreviations in Table:</b> CN – runoff curve number, DP – dissolved P, DRP – dissolved reactive P, eof – edge of field, eqns – equations, fert – fertilizer, hsg – hydrologic soil group, mgt – management, precip – precipitation, stP value – soil test P value, Vy Poor – very poor, Vy High – very high, ww – waterway						

## PREPARATION, REVIEW, APPROVAL, TRACKING, VERIFICATION AND REPORTING OF NUTRIENT MANAGEMENT PLANS

Interviewees were asked several questions about the preparation, review, approval, tracking, verification, and reporting of NMPs in their states or otherwise within their program scope. Table 10 identifies the parties responsible for the various stages of the NM planning and implementation process. A summary of findings is presented below.

All the states require submission, approval, and tracking of large CAFO NMPs as part of their NPDES permitting processes, and where federal cost sharing is available, approval and tracking is done by NRCS and the CDs. Only MD and DE require formal NMPs for manure and fertilizer on all cropland, pastures, and nurseries. Pennsylvania changed its law in 2011 to require NMPs for all farms that use or generate manure or have animals at a density of 2 AU/ac. This change requires an additional 39,000 small farms to have NMPs, although the plan writers for the small farms need not be certified, and there is no submittal or approval process.

Currently there are very few permitted CAFOs in WV. Most poultry operations in WV already have voluntary plans, written by WVDA or by the poultry companies. Currently there is no approval, review, or tracking process to support the program.

Maryland and DE require virtually all users of fertilizer and/or manure to have a NMP prepared by a certified planner and to report annually (AIRs) on the amount of nutrients applied. Virginia, PA, and NY require certified NMPs for all manure systems that receive public money. Although certified planners must approve everything in MD, plans generally are developed in consultation with fertilizer dealers. This is likely to be true in other states as well.

The approval processes in the states focus on certification, training, and review of professional planners. Most states run their own training and certification programs, often in conjunction with certified crop advisor (CCA) programs or with NRCS technical service provider (TSP) training. Except for large CAFOs, NMPs are not reviewed or approved by the states

Tracking and verification of NMPs is variable across the region. Maryland and DE conduct on-farm QA/QC visits to inspect the planning and implementation of a small sample of farms. Pennsylvania visits all CAFOs annually, and Virginia visits farms on a 3-year rotation as plans are redone. New York's extensive voluntary AEM program, coordinated by the Upper Susquehanna Coalition (USC), uses an assessment system that includes one-on-one visits and consultation by an environmental professional housed in a SWCD. Virginia tracks all NMPs by GIS, keeping track of beginning and ending dates for all plans.

Voluntary programs are not significant in MD and DE as virtually all users of manure or fertilizer are under the mandatory programs. West Virginia is almost entirely voluntary, with NMPs provided to poultry operators by WVDA. New York has a voluntary AEM program, and PA has a large number of farms with NM planning requirement but no verification.

TABLE 10. EXTRACTS FROM INTERVIEWS – RESPONSE TO QUESTIONS CONCERNING RESPONSIBILITIES FOR VARIOUS STAGES OF NUTRIENT MANAGEMENT PLANNING AND IMPLEMENTATION

State	Nutrient Management Plan Process						
	Preparation	Review	Approval	Tracking	Verification	Reporting	Notes
Delaware	Most NMPs are done by certified crop management consultants (certified through the state or the Mid-Atlantic Certified Crop Advisors organization).	All AFO/CAFO plans are audited prior to submission for permit application. Non-CAFOs are self-reviewed (see Verification).	Only CAFO NMPs require approval.	Locations of CAFO with NMPs are recorded. No regulatory agency data exist on where non-CAFO plans are located, although the acreage treated by plans is substantial and needed for Watershed Implementation Plan (WIP) and total maximum daily load (TMDL).	Randomly selected NMPs are audited at the farm and consultant levels.	Everyone who has a NMP must file an annual report with the Nutrient Management Program.	There are a few nurseries and very few pastures with NMPs. No voluntary plans because plans are mandatory for all operations with 8 or more animals or 10 or more acres receiving nutrients.
Maryland	NMP writers are certified and consultants are also licensed. Farmer Training Certification (FTC) allows farmers to write their own plans. CCAs, county people etc. are also certified  Certified planners must approve all NMP content, but real world plans generally are developed in consultation with fertilizer dealers.	MDA QA/QC program includes spot checking to assure that plans are appropriate.  No plan writer has lost certification for developing an insufficient plan.  It is important to get somebody independent of the farm to do audits, but agrees it may be hard to find people who are qualified and acceptable to both the farm and environmental communities.	Private sector plan writers do their own reviews based on their own company policies.	AIRs from all farmers.  The on-farm audits provide a tracking opportunity.	Verification is done through the MDA QA/QC program.	Planners -Reporting requirements are associated with licensure (e.g. number of plans).  AIR is required from all farmers.  Currently little specific information required in AIR, but there is supposed to be more detailed back-up information.  There is an excellent opportunity for MDA to report on loading rates relative to agronomic	No voluntary plans because plans are required for all farm/nursery fertilizer and manure application.  The weakest phase in conservation programs in MD is plan design. Designs aren't made sufficiently for the purpose of addressing environmental concerns.

State	Nutrient Management Plan Process						
	Preparation	Review	Approval	Tracking	Verification	Reporting	Notes
						requirements based on AIRS data (would need to add a soil test P line to AIRS form). This type of reporting would be a more transparent measure, and more valuable to understanding inputs to the model and potential violations to state regulations.	
New York	NM planners are certified under the AEM program.	NRCS Conservation Activity Plans are reviewed by NRCS. Other NMPs and CNMPs developed by SWCD planners are spot checked.	There is no approval process except as required for NRCS funding.	CAFOs are tracked by NYSDEC and coordinated with the USC.	Verification is done through farm visits by SWCD staff.	Annual Compliance Reports are sent to the NYS DEC. In the CB watershed, an extra data sheet is used for input to SB via NEIN.  The AEM program collects farmer initiated BMP data.	The NY WIP contains data on how many farms participate in AEM. Participation may be as high as 95% of farms, but the level of participation varies.  NM certified plans are required only for CAFOs and those receiving public funding for agricultural waste management systems.

Nutrient Management Plan Process							
State	Preparation	Review	Approval	Tracking	Verification	Reporting	Notes
Pennsylvania	Certified planners are required for NMPs on CAOs and CAFOs (animal density $\geq 2$ AU/ac), NMPs for small farms can be prepared by farmers, 4-Hers, dealers, etc. PSU has nutrient budget	CDs verify plan with farmer and do their own on-site assessment before approval. NMPs are reviewed by CD or State Conservation Commission (SCC) They don't approve a NMP until they see the	The SCC approves all CAOs. The DEP is also involved if the operation is a CAFO There is no review and approval of plans written for	CDs track CAO NMPs. Smaller farms are not currently tracked. CDs keep an Access database of NMPs. Districts have expressed concern	CD personnel visit every CAO at least yearly to assess records and determine compliance with NM planning.	Plans are required to be updated every 3 yrs.	All small farm plans. 39,000 small farms come under the rules now. Most have self-prepared manure management plans. Programs without continual follow-up do not ensure
	work sheets that can be used to prepare NMPs.	spreader calibration data.	small farms.	on how they would track smaller farms without knocking on doors, which is something they are not interested or staffed to do.			compliance.
Virginia	Plans are prepared by NM planners, certified by the VA DCR. DCR Nutrient Management Team prepares 90% of CAFO plans. TSPs do 90% of plans required for NRCS cost-share.	Plans are redone at 3 yr. They are checked at that time.	All animal operations NMPs are approved by DCR. The CD approves plans for state or federal cost-share.	NMPs are tracked by DCR with location and beginning and ending dates. DCR tracks all reported NMPs in Virginia both on a private and public sector. Voluntary plans are tracked in the same manner as other plans. About 50% of small dairies have current NMPs.	Most sites are visited once each year. Plans are good for 3 years.		A lot of voluntary BMPs are not credited because the quality of plans/ implementation cannot be or hasn't been verified. NMP is a requirement of the permit (300 AU is size in VA.

State	Nutrient Management Plan Process						
	Preparation	Review	Approval	Tracking	Verification	Reporting	Notes
West Virginia	<p>NMPs for CAFOs are prepared by certified planners. Currently there is only a small number of permitted CAFOs.</p> <p>There are NMP writers at WVDA, WVU Extension, Crop Services, USDA-NRCS and WVCA that can write plans if asked to. The WVDA is short of staff needed to keep up with the demand for writing plans.</p>	There is no formal requirement for review.	WVDA has a certification program for NMP writers. All NMPs in WV must be done by a certified NM planner to be considered legitimate.	<p>They do not have good knowledge of what leaves farms and whether recipients have NMPs to use the litter/manure properly.</p> <p>Starting this year, WVDA will be tracking acres of NMP.</p>		WV is working on legislation requiring planners to report NM planning acres by county to meet the needs of the TMDL.	<p>All AFOs are targeted by the state to do voluntary NMPs in the future.</p> <p>Existing poultry litter NMPs are considered voluntary.</p>



## STATUS OF IMPLEMENTATION OF NUTRIENT MANAGEMENT PLANS

Interviewees were asked to describe the extent to which each practice (N-based NM, P-based NM, P/D agriculture, and ENM) is implemented fully as designed. They were also asked to identify the key factors that determine if the practice is implemented properly and completely, and identify and describe the major reasons for the practice not being fully implemented. Table 11 summarizes responses to these questions.

Interviewees in every state reported that most NMPs are implemented as designed. In MD, where virtually all farms and nurseries are regulated, random compliance audits typically find about 30% noncompliance, but most of the noncompliance is due to recordkeeping issues. The great majority of MD audits find compliance on all key provisions. The states that regulate only permitted CAFOs, report even higher compliance rates. New York achieves 95% compliance with NMPs that are part of CNMPs required in some NRCS contracts. New York, which has a strong educational component in their AEM program, reported about 75% incorporating NM planning into their business plans. Where commercial fertilizer was needed for the NM planning, farmers are more likely to under-apply nutrient than to over-apply, due to the high cost of fertilizer.

Some concern was expressed that, Bay-wide, the quality of plans may not be as high as needed. One interviewee noted addressing easy targets with the typical Extension and CD clientele is highly effective, but educating the “marginalized” and culturally distinct groups is still a problem. Further, plans that are easily explained and flexible are more effective than those that require a great deal of explanation or cover longer rotations. Several interviewees were concerned that plans were not designed to address environmental needs as much as they address agronomic issues. A specific concern was that the use of a PI allows continued application of manure to already high-P soils, with a consequence that soil P-levels would continue to increase and water quality problems would persist for many years. This view suggests the use of a PI is primarily a means of allowing disposal of P beyond the agronomic rate. Countering this view was the perception that the PI keeps manure application away from the most vulnerable areas thereby reducing off-site impact. (This is discussed further under *P-based NM Effectiveness* below).

The most commonly mentioned factor affecting implementation was economics. The high cost of fertilizer contributes to widespread implementation of NMPs on cropland by limiting the over-application of commercial fertilizer. Conversely, the economic burdens of manure storage and transport were seen as impediments to implementation of NM on animal operations. The high cost of N fertilizer was also noted to contribute to high rates of manure application where N-based application is allowed. Recordkeeping was viewed as both important and somewhat of an obstacle. Plans that called for precise timing in a short window ahead of corn planting were viewed as troublesome. Another factor mentioned as a key ingredient for compliance was continual follow-up between the oversight agency and the farmers. Finally there was concern for the quality of information in use for development of the plan, specifically the calibration of spreader equipment, knowledge of actual amount of litter to be spread, and information available for establishment of proper yield goals.

In some cases having sufficient land to utilize manure N and P was the key to compliance. Dairies in NY and some parts of PA were viewed as likely to achieve nutrient balance because

most had enough land, whereas poultry operations generally could not achieve on-farm nutrient balance. Litter marketing in MD and VA were viewed as important elements to achieve compliance with NMPs, but Delaware reported still having too much litter in some areas. One interviewee noted that MD farmers reported through AIRs that they had surplus manure in all counties in 2010, totaling 172,673 tons.

The major reasons noted for incomplete implementation were plan complexity, lack of available land, lack of flexibility to adjust for adverse weather or management demands, volatility in the commodities market, lack of trust that the nutrients specified would be adequate for the crop, and excessive recordkeeping requirements. Many of these negatives were viewed as being possible to overcome by education and experience with planning, but in some cases the quality of the plan or the ability of the managers were viewed as inadequate. Education was recognized as essential by these interviewees.

Nurseries and greenhouses were viewed as a special case of farming. In MD and DE they are required to have NMPs, but interviewees found it difficult to determine the actual extent of implementation because such details are confidential. Interviewees reported that (1) nurseries and greenhouses account for an extremely small part of the CB watershed, (2) nurseries use primarily slow-release fertilizers that generally leave the premises when the plants are sold, (3) field-based nurseries use very little fertilizer, and (4) BMPs are employed widely in the industry. Greenhouses may be more likely to use irrigation-based nutrient application than either containerized nurseries or field-based nurseries.

TABLE 11. EXTRACTS FROM INTERVIEWS RELATED TO STATUS OF NUTRIENT MANAGEMENT PLAN IMPLEMENTATION

State	Nutrient Management Implementation		
	Implemented as Designed?	Key Factors Affecting Proper Implementation	Major Reasons for Less Than Complete Implementation
Delaware	Survey results indicate that all NMPs are P-based and the P/D agriculture is implemented fully.	Farm-level recordkeeping is an issue.	There is still too much manure in some places.
Maryland (see notes on MD Nurseries)	<p>400-425 spot checks per year show 70% of farmers are generally in compliance with the key provisions of their NMPs. Of 30% non-compliant, most are due to plan not being current.</p> <p>AIR reporting shows that pasture generally gets less N than recommended.</p> <p>The practice should be considered implemented and properly completed if the NM planning results in the use of nutrients to support the target crop yields and minimize the loss of nutrients to surface or ground waters over time.</p>	<p>P/D agriculture and ENM will be adopted due to increased profit to farmer.</p> <p>Economic benefit to farmer is the driving force for NM.</p> <p>Timing of applications is problematic, with risky weather in spring and irrigation scheduling and fertigation not effectively used.</p> <p>For manure, yield goals and calibration of spreaders are key factors.</p> <p>NMPs address agronomic issues allow for application of nutrients even when agronomic needs have already been met and as a result don't always address environmental needs.</p>	<p>Farmers with very high yield goals who think they need additional nutrients.</p> <p>If the plan tells the farmer to implement what he/she already believes to be true, results were good. If the plan says to change management, results are not so great. Lack of calibration of spreaders.</p> <p>Manure management on small dairies often presents logistics problems and transportation issues. Manure injection requires specialized equipment that is often not available. Farmers may also have a problem implementing the plan because of insufficient storage area for manure. While MDA collects information on the presence or absence of storage facilities on MD farms, unfortunately it doesn't collect quantitative information on storage so it is difficult to gauge the extent of this problem.</p> <p>Land application of excess manure during the winter months, when it is not actively taken up by crops and is more likely to runoff due to less permeable, frozen soils.</p> <p>Insufficient incorporation of manure and biosolids and delays in incorporation.</p> <p>Land application in areas adjacent to waterways (no mandated protective buffers and setbacks) makes limiting nutrient runoff difficult.</p> <p>ENM - West of the Bay there is not the necessary infrastructure to support side-dress N application on all of the cropland, so there</p>

State	Nutrient Management Implementation		
	Implemented as Designed?	Key Factors Affecting Proper Implementation	Major Reasons for Less Than Complete Implementation
			is more pre-plant application. Further, it may be difficult for farmers to hit the 3-week window recommended for pre-plant application.
New York	<p>Regulated CAFOs in NY achieve 95% compliance with NMP elements of their CNMPs, based on farm inspections and annual compliance report information.</p> <p>Experience with follow-up activities on farms with NMPs suggests that 75% of the practices in NMPs are incorporated into their business routines and implemented as designed.</p>	<p>A combination of applied research, educational programming, economics, environmental regulation, technical and financial assistance, and BMP implementation over the last 15-20 years in the NY portion of the CB watershed has resulted in:</p> <ul style="list-style-type: none"> <li>• A significant drop in N and P fertilizer use;</li> <li>• A drop in stocking densities from 0.53 to 0.43 animal units/acre;</li> <li>• A drop in soil test P levels in the optimum and very high categories from 54% to 43% of soils tested at Cornell; and</li> </ul> <p>County level N and P balances (lbs/ac of cropland) being negative and, essentially, zero, respectively.</p>	<p>You have to convince the farmer that this is the right thing to do for the farm...that it makes them money and is in their economic best interest. Farmer has to be involved in writing of the plan.</p> <p>The major barriers to implementation of NM practices include:</p> <ul style="list-style-type: none"> <li>• Higher cost or the perception of higher cost.</li> <li>• Inadequate trust or experience with the practice on one's farm.</li> <li>• Requires additional management.</li> <li>• Requires additional labor.</li> <li>• Requires additional investment in equipment.</li> <li>• Has not recognized the value of regularly working with a NM planner.</li> <li>• Constraints from unpredictable weather conditions (e.g., the recent flooding).</li> <li>• Volatile economic/market conditions leading to risk aversion.</li> </ul>

Nutrient Management Implementation			
State	Implemented as Designed?	Key Factors Affecting Proper Implementation	Major Reasons for Less Than Complete Implementation
Pennsylvania	<p>All certified “large operation” NMPs in PA are verified to be fully implemented as designed.</p> <p>All regulatory plans in PA are N-based and P-based.</p>	<p>Programs without continual follow-up do not ensure compliance.</p> <p>Use of the PI, to allow application of manure to high P soils. So it’s a less info → more restrictive and more info → less restrictive (potentially) system.</p>	<p>Manure spreader calibration is a real problem.</p> <p>Record keeping is challenging for many farmers.</p> <p>Land shortage for poultry operations.</p> <p>Programs without continual follow-up do not ensure compliance.</p>
		<p>It is shifting manure applications away from the most vulnerable areas and protecting water quality.</p> <p>Dairies generally have land needed for forage and are therefore can follow a P-based plan without running out of land or encountering nutrient balance issues.</p>	<p>Farmers generally have a hard time understanding, and therefore implementing, a 150-page plan.</p> <p>Expectations are sometime too high – need to focus on practical aspects of plan.</p> <p>Under P-based NM there may be an excess manure issue that brings with it additional cost.</p>
Virginia	<p>P-based plans are being followed closely because they are regulated. Thinks N-based plans are likely treated as a starting point; based on farmer’s experience and recent history on farm (crop yields, weather, etc.) farmer may adjust the N rates.</p> <p>Feels that compliance with plans is very good ~80%. A lot of this knowledge is through plan writers working directly with farmers. Will start formal audits in 2013. But more NMPs written by private contractors than state employees, so future audits will look at those too.</p>	<p>Clarity of how plan is written, economics, ease of implementation.</p> <p>DCR staff also performs more than 750 PSNT tests each year to help farmers evaluate whether or not additional N applications are necessary or not.</p>	<ul style="list-style-type: none"> <li>• The written plan often doesn’t match reality</li> <li>• The plan might allow an application rate based on pre-side dress test or yield expectation, but depending on how things work out (e.g., decide to plant corn instead of beans) there may be a need to change actions</li> <li>• Inadequate built-in flexibility.</li> </ul>
West Virginia	<p>They have no information on calibration, litter transfer, etc.</p> <p>Soil testing is pretty widespread because of free sample collection and analysis and the threat associated with CAFO rule.</p> <p>CAFO NMPs are regulated through the WV</p>	<p>The economics of selling manures and buying N is not favorable, so it is general practice to use manures at N rates.</p> <p>Application timing due to weather conditions.</p>	<p>Without requirements, implementation boils down to economics.</p> <p>Farmers may apply less nutrients or even forego application when the plan calls for low rates of application or when the cost of fertilizer is high.</p>

Nutrient Management Implementation			
State	Implemented as Designed?	Key Factors Affecting Proper Implementation	Major Reasons for Less Than Complete Implementation
	Department of Environmental Protection.		Other situations occur where the farmer does not have the opportunity to spread fertilizer or litter due to weather conditions. Will have an effect on crop rotations.  The threat of CAFO regulation is influencing compliance with the NMPs.
Bay-wide	<p>NMPs are normally developed using pre-implementation expectations, which typically are modified by environmental conditions, crop response, operator decisions, etc. N and P based plans that are modified on an annual basis versus a three-year rotation will likely have a higher level of expected implementation.</p> <p>Education is required for successful implementation of plans. "Marginalized" groups outside of extension/conservation participants – need improved approaches to deal with cultural differences.</p> <p>In efforts to go after the easy target area, many critical source areas may be overlooked. Animal rest areas and previously ignored problems like heavy use areas are examples – need to treat the whole farmstead.</p>	<p>NM planning is developed to reflect and realistic conditions and expectations.</p> <p>NM planning is available and comprehensible to the operator/applicator.</p> <p>NM planning is modified to reflect changes to the conditions.</p> <p>NM planning is based on accumulated and current information from the operation.</p> <p>Economic pay back in the short-term (&lt;3 yrs).</p> <p>Supporting private industry infrastructure to take soil/plant samples, etc. to take soil/plant samples, etc.</p> <p>Depends on the extent of the practice, complexity of practice, and who is implementing the practice.</p> <p>NM for simple inorganic fertilizer rate is easier to implement than a more challenging manure application system – and who is actually doing it, farm hand vs. owner, makes all the difference.</p> <p>If it's a poor plan or the producer does not understand the plan, there is not much hope for full implementation.</p>	<p>Lack of record-keeping is a problem; this will be a greater potential problem with higher levels of NM where the amount of information to track and report increases.</p> <p>N-based or P-based rates shouldn't cost more, but under P-based NM there may be an excess manure issue that brings with it additional cost.</p> <p>There is a need for delivery of information that is responsive to weather, other sources of variability.</p> <p>Wide gap exists between recommendation and practice, especially among small farmers that fall outside the extension/conservation network.</p> <p>It is important for the farmer to know how much manure is generated, how much is needed for the crop, and how much is available for export.</p> <p>Plans may be incomplete – e.g. what to do with the "extra" manure that is not to be applied. Training/education is an important component.</p> <p>My impression is that we have a long ways to go within the CB watershed. Precision agriculture requires an economy of scale that is outside of most farmers' ability within the</p>

State	Nutrient Management Implementation		
	Implemented as Designed?	Key Factors Affecting Proper Implementation	Major Reasons for Less Than Complete Implementation
			CB watershed to afford. It may also be too high tech. and require a consultant to implement correctly that has the time and the inclination to do it. An added expense most farmers are going to eschew. Then, there is the cost of the equipment, such as variable-rate planters and fertilizer applicators and yield monitors on combines and other harvesting equipment.
MD Nurseries (JLC)	<p>This is very difficult for us to assess (since we do not have access to MDA plans, due to legal barriers (privacy issues with the Maryland Water Quality Improvement Act of 1998).</p> <p>Most of 400 nurseries use BMPs (slow-release fertilizer, drip irrigation, vegetative buffers, sensor – based irrigation control).</p> <p>Field-based tree nurseries use relatively low rates of fertilizer.</p>	Cost (economics) and grower's knowledge about the existence and efficiency of each practice. Maintenance is also an issue, for example maintaining sheet flow in vegetative buffers for maximum sediment removal, and cleaning out sediment ponds for maximum efficiency.	Usually cost, but also practicality (e.g. micro-sprinklers or drip emitters with small volume containers). Also, not all BMP's can be implemented at a given location. A particular problem can often be addressed effectively using a number of different BMP's

## NUTRIENT MANAGEMENT PRACTICE EFFECTIVENESS

Interviewees were asked to characterize the effectiveness of N-based and P-based NM, P/D, and ENM in reducing nutrient losses to the environment. They were asked to describe the baseline condition from which this effectiveness is determined, and to identify the major factors affecting effectiveness (e.g., crop, soil type, drainage, irrigation, weather, timing, rate, form, method, the presence of other practices). Below the results are divided by major categories of response

### BASELINE CONDITION FOR ASSESSING EFFECTIVENESS

Since the mid-1980s advances have been made in recognizing fertilizer value of manure with respect to N and P, establishing crop yield goals as the basis for N application, splitting applications of N to reduce environmental losses, testing soils and plants to determine the nutritional level of the plants at the time of fertilizer application, using sensor technology to recognize the nutritional level of crops and manage N application on the fly, and employment of advanced recordkeeping, remote sensing, and GIS-based technologies. P-based NM and P-risk evaluation also became part of the arsenal to reduce P-loss to runoff since mid-1980s. Below is a collection of extracts from interviews.

- Effort pre-dates law in 1998 - baseline should be pre-1995. N: Huge reduction because N is being applied based on need not “dumping”.
- The “pre” conditions should reflect typical practices for the area of interest, rather than always comparing to the worst case scenario. But deciding what is typical is difficult without information from individual farms.
- Late 1970s to 1985 should be baseline because prior to then, nutrients in manure were ignored. Since then, N-based management has had some positive impacts. Poultry litter used to be spread at 8-10 ton/acre using a box spreader, and farmers were still buying triple 19 fertilizers for N. By the mid-80s Extension had somebody promoting N-based management, so 1985 is a good baseline.
- Huge reduction in N loss have been achieved since the mid-1980s because manure is being applied based on need for N rather than “dumping” or disposal of manure. Generally, inorganic N application has less application limited by cost.
- Baseline year for modeling is 1985.

### N-BASED NM EFFECTIVENESS

Interviewees noted that the basic level of NM is N-based management. Prior to the mid-1980s manure application to the land was largely viewed as waste disposal, with severe water quality consequences. The first implementation of NM was just recognizing the nutrient content of manure as a valued source of crop nutrient, replacing some commercial fertilizer. Data showing the effectiveness of NM at the watershed scale are not available. Below is a collection of extracts from interviews.

- N-based: basic entry-level NM represents improvement over no NM at all, but is rough around the edges. In many cases, basic N-based NM introduces producers to fundamental NM practices. It has been shown effective in organic nutrient applications; but it may have resulted in increased application rates for inorganic nutrient sources in some cases. Some MD study information suggests only minor change have occurred in nutrient inputs for inorganic fertilizer from the pre-1998 (pre-regulation) condition.
- NM planning is very effective in dealing with nutrient imbalance across a farm. It is much needed.
- Split application of N, runoff control, and other BMPs (e.g., erosion control) help. N-based plans can work for volatilization, leaching, and surface losses.



- The problem of determining the effect of NM on losses to stream is still not resolved. Re: subsurface N, MD lacks data on effectiveness. They don't have data on how N applications changed and the resulting changes in N in groundwater. ...German Branch watershed (in 90s): everyone had voluntary NMPs and N levels in the stream didn't go down at all (went up actually).

## P-BASED NM EFFECTIVENESS

The effectiveness of P-based NM as implemented in the Bay states is controversial. Through the 1980s and 1990s emphasis was on N-based management for manure. This approach is well-known to result in a buildup of P in soils. A P-based plan could mean limiting the manure application rate to the crop's P requirements (or to crop removal). This approach would limit application rates to a level well below the N-based application rate wherever soil P is at an optimal agronomic level. In all but NY where risk assessment tools are required for all fields, soil test levels ranging from about 100 to 300 ppm (as Mehlich 3) trigger application of a PI. The PI scores determine whether N-based, P-based, or no P application is required. While the stated intent of this approach is to protect water quality by limiting manure application in the most vulnerable locations, several experts expressed concern that use of the PI too often results in manure application to high P soils.

Interviewees reported soil-P thresholds based on Mehlich 3 or Mehlich 1 extractions. The Mehlich 3 Phosphorus Saturation Test has been shown effective in predicting dissolved P, but most felt a change to this test was unnecessary for most soils. Several expressed the opinion that transport processes are more important than soil P concentration, so a refined test would not add enough to justify the extra expense.

Concerns were raised with this approach because it allows a continued soil-P buildup in most application areas. It may not adequately reflect the risk associated with all transport pathways, particularly subsurface pathways. It may not prevent spreading on variable source areas, hydrologically active areas that vary from season to season, and it may not apply well to no-till crops or pastures where incorporation below the surface is employed.

Progress with manure incorporation with a no-till tool was reported by one interviewee. Others noted that incorporation for pastures and no-till were not yet available in an economic system.

Several interviewees noted that dairies particularly in WV, parts of PA, and NY generally have enough land to utilize all their manure nutrients. This may not be true, however, in hotspots such as Lancaster County, PA, and a problem was noted with small dairies that may spread manure daily through all seasons.

Finally it was suggested that P-based planning is supported by free soil testing in several states, and that the soil test database generated could provide an opportunity to acquire data to evaluate trends in NM planning. Below is a collection of extracts from interviews.

- A conflict between reduced tillage and manure application is not completely resolved. Surface application of manure increases soluble P, but erosion would introduce much more particulate P.
- At high concentrations P moves vertically. New index will address the leaching component.
- P-based planning, with the P-index allows application of manure to high P soils can slow the rate of increase of P in soils. But this approach won't lead to a stable soil test level. Dairy manure is also a significant issue (not just poultry). Dairies may make 3 applications per year due to crop rotations. Some small dairies have no storage and use daily haul.
- P can be controlled for the most part if you control sediment loss by, for example, using buffers as a component of NMPs. Little dissolved P is generated under current conditions in WV, so the plans are effective.
- The P saturation test is more accurate at estimating environmental risk than using agronomic Mehlich 3 soil test. Soil water extractable P correlates well with Mehlich 3 P saturation ratio throughout its range of concentrations, even below the saturation level. Transport processes dominate P loss risk,

even in high P soils. An environmental soil test, such as the Mehlich 3 PSR is one component of risk assessment. Should be used as part of a tool, like the PI, that incorporates both source (soil, fertilizer) and transport factors.

- P-based planning is more effective, but is also more complex (where does extra N come from?) and more demanding. P/D agriculture is more effective still, partially because the expertise required by the farmer implementing P/D agriculture creates good potential for good management. This all assumes proper education/training has been done.
- P-based NM administration appears to allow P applications in some areas to continue that should have been P saturated years ago.
- A problem is that even with a P-based requirement, farmers may end up with a N-based plan (a consequence of using the PI).
- NM planning programs can be excellent in focusing farmers on recommended rates, but when there is a problem of excess manure (no easy market and the expenses associated with storage and transport) and regulations allow for applications well above agronomic demand or at times of limited crop growth (see comments above) they are not always effective means of reducing nutrient losses to the environment.
- Most DE agricultural soils are testing in the moderate range for P, but even so, most planners are writing P-based plans simply because of the history of high-P soils.
- Our lab has worked extensively on application methods and have found that manure injection is very effective in reducing surface runoff and can provide benefits of incorporation in no-till or other conservation tillage systems (although some question remain about impacts of leaching and greenhouse gas emissions).
- USDA-ARS is doing research on low-disturbance injection on no-till with liquid manure (they have a CIG grant putting liquid injectors out with commercial applicators), and are beginning to look at litter injection as an option... (but) Said that injection equipment slows the farmer down too much, increasing the time needed to spread the manure.

## P/D AGRICULTURE EFFECTIVENESS

P/D agriculture, or at least technologies that are related to P/D Agriculture, were viewed to offer promise, but concerns were expressed due to the cost of implementing some of the technologies, and in many places it was deemed unhelpful because fields are too small and field variability too great to make it cost-effective. In some cases the level of management and recordkeeping required would seem to be an additional barrier, particularly for small farms. Irrigation offers some opportunity as a tool for P/D agriculture, but there is concern that the technology is not currently used to advantage for NM, Below is a collection of extracts from interviews.

- P/D agriculture and ENM will be adopted due to increased profit to farmer.
- It is also difficult to know how precision agriculture is impacting water quality because of the wide range of approaches. There are not many reports of direct measurements of water quality impacts with precision agriculture.
- Probably could reduce N loss by ~20% with P/D agriculture, but we have not addressed the variability, so we don't know what the benefit really is.
- Precision agriculture is not very effective in most of the CB area because the fields are small.
- Application of N with irrigation can reduce losses from the very high yield corn (300 bu/ac corn). These systems use pre-plant poultry litter with N applied through the center pivot.
- We only get better N efficiency with irrigation if irrigation is scheduled on a rational basis; that's not happening now in MD. In addition MD farmers don't currently integrate irrigation and N application (i.e., no fertigation).
- P/D agriculture requires a lot of intensive management up front. What has been done is primarily done

for N, but not yet done for P because of sensor availability. Sees general reduction of application rates for P/D agriculture, similar to the intent of adaptive NM.

## ENM EFFECTIVENESS

ENM was viewed by most interviewees as too vague to define a BMP. The SB definition of reducing nutrient applications by 15% was rejected by almost all interviewees. It was pointed out several times that offering crop insurance to cover risk of yield loss due to shorting the fertilizer has already been shown not economically sustainable.

- Original definition was set at 15% below recommended rate, but there were some crop reductions, so AFT may have backed off from the 15% reduction level.
- If farmers cannot get credit for ENM, they will not buy-into the program.
- There is extensive research on application timing with mineral fertilizers, but we don't have the same flexibility for altering or splitting manure application within the growing season.
- Irrigation is increasing in DE – this could cut either way.
- Is recommending the term “adaptive NM” (see Subappendix B). Adaptive Management comes from work with Tom Morris. Subappendix B is a draft Tech Note on animal waste management. The notion of reducing application rates tends to be anecdotal, not really ENM – person may already be doing good NM planning – how can you reduce N applications by 15% or 35%?

## MAJOR FACTORS AFFECTING NM EFFECTIVENESS

### YIELD GOALS

One key to effective N-based management is to have realistic yield goals so that excessive N is not applied. Many respondents noted that applying fertilizer at a rate below the amount recommended for the yield goal is not acceptable because it would not maintain the high yield of modern agriculture, and it could result in increased erosion in pastures. There was substantial agreement that the recommendations of LGUs do not include excess nutrient that could be saved. One interviewee offered that future improvements in utilization efficiency were likely to achieve higher yield on the same fertilizer rates.

Yield goals are established in two basic ways: (1) actual records from producers and (2) research to provide soil-crop capability tables. New York reported having a reliable database for option (2), but most other states either had too little data or research that was outdated. Yield goals have not been identified for ornamental plants. Below is a collection of extracts from interviews.

- Using a farmer's own records (for yield goal) is by far the best approach to establish yield goals. State averages are not representative in a lot of cases, and using soil capability parameters is not accurate enough.
- All crops of significance in NY have N and P guidelines established by Cornell University – yield goals based on research, rather than farmer records.
- Accurate yield records (rather than yield potential from soil survey) - yields may have come up due to soil organic matter (OM) improvement over years.
- N-based yield-goals can be set from actual farm records or by using (primarily) the VALUES Manual, which prescribes an achievable yield goal for a particular soil management group

- A yield goal should be both realistic and challenging.
- A common approach to setting realistic yield goals is targeting 80% of the potential yield (with water and nutrients non-limiting) of a crop in a particular climatic condition. Crop simulation models can help determine potential yield.
- We are working to increase yields each year; preferred method would be projecting past growth in yield into the future by farmer records, but that's too much to expect of all farmers.
- Penn State's published soil-based yield capabilities are out of date and not really useful today due to improved yields from genetics. Farmers can exceed those tables (which are more than 30 years old) on a regular basis.
- One of the major challenges in using a yield-based approach for determining fertilizer rates is that yield levels are known to vary widely in a given environment from year to year, as well as among growing seasons within a year where multiple cropping is practiced.

### *TIMING AND FORM OF APPLICATION*

Issues raised here include the need to apply N within a small window near time of planting, use of commercial fertilizer formulations or manure, winter spreading of manure, use of N- stabilizers, and use of cover crops to scavenge excess N. Several interviewees recognized the desirability of limiting the amount of pre-plant N in corn production, applying within a short window, and adjusting side-dress N to meet plant needs. Most recognized the inherent risk associated with each of these recommendations. First is the risk of rainy weather in early spring. Further it was recognized that the busiest time for crop farmers is during the pre-plant window, making it more difficult to get the fertilizer application done when needed. It was pointed out that splitting N applications was particularly important in the Delmarva area because of the coarse-textured soils and not so important west of there and in the Piedmont province, where fine textured soils with lower infiltration rate predominate. It was also pointed out that the infrastructure to apply side-dress N was not available at the scale needed in the Piedmont. Below is a collection of extracts from interviews.

- Rate and timing is the primary concern. Form is secondary except for organics.
- Mineralization provides a buffer for available N during good yield years because it is coupled to growing conditions controlling yields, i.e., the mineralization pool adds more N when growing conditions are good. Thus, what is applied as fertilizer and/or manure each year isn't all that is available to the crops.
- They may apply a strategy of selective use of the injection systems to focus on problem areas and surface application elsewhere.

### *WINTER SPREADING*

Maryland, DE, and VA are firmly against winter spreading of manure, but MD has a loophole in the regulations that allows for winter spreading if there is insufficient storage. Pennsylvania and NY, on the other hand feel that winter spreading is acceptable and in some cases more desirable than the alternative. The issue is mostly related to small dairies that have limited manure storage. Specialists in PA and NY suggest that the impact of spreading a large slug of manure in late fall and early spring to manage their available storage can be more damaging than applying small amounts frequently throughout the winter. Further they argue the attention is better focused on location of spreading than timing - directing spreading to field areas that are not hydrologically active, runoff contributing areas. Allowing winter application with an N stabilizer can also have the benefit of extending the window for nutrient application and giving more N-credit to the manure that is spread. The result in this case would be a reduction in total N applied to the land and possibly a reduction in N-losses to runoff. Below is a collection of extracts from interviews.

- Winter manure application is a hot-button issue: states' winter application guidelines that consider slope as a risk factor are misplaced because it is the saturated toe slopes that generate runoff – these guidelines can actually push manure applications to higher risk areas. We should be focusing on source areas with a drainage risk, not simply high slope.
- Not sure how SB deals with winter spreading. Needs to look at how the model spreads out nutrients over the year even when the regulations prohibited winter spreading 12-month application of organic sources as assumed in the SB is a problem.
- With new tools for poultry litter injection, (we) can now inject nitrotyrene, a microbial nitrification inhibitor, in the winter and get more farmers to apply in a larger seasonal window – winter application may give a net benefit in this case. Currently, the application of manure is not allowed before March 1.
- Farmers can get more N credit from winter application. Giving more N-credit for winter application can reduce the total manure application because of losses with fall application.
- Nitrification inhibitors may reduce losses, but I remain skeptical. It does not have to be nitrate to leach and ammonia can be far worse to fisheries. Only a dry winter is likely to keep the applied N in place, but a wet spring can quickly cause leaching to occur before the corn crop is of sufficient size to begin using lots of N.

### COVER CROPS

Cover crops are viewed by some as an extremely important element of NM and by others as a secondary aspect. All seem to agree they are particularly important where crop failure has occurred and a large pool of N is still in the soil after harvest. Further they are a benefit to preventing soil erosion, which is viewed as extremely important to water quality. But others point out that it is more important to apply the right amount of fertilizer to feed the crop and not apply for two crops at one time. One interviewee pointed out that cover crops do very little for loss of soluble P and that the crop can be viewed as a slow-release fertilizer. Below is a collection of extracts from interviews.

- Cover crop vs. NM: Our field studies have indicated that the effects of a cover crop on nitrate leaching are much greater than those resulting from relatively minor reductions that are likely with a NMP where inorganic N was used.
- The Bay model puts an emphasis on the wrong practices – cover crops (CCs) are wonderful for soil erosion, but do nothing for dissolved P loads and can exacerbate dissolved P losses from high P soils with low erosion potential. Cover crops should be viewed as a “slow-release P fertilizer.” We should be working toward improving N-use efficiency with P/D agriculture. Thus, P/D agriculture could be more important than CC. CC is just a Band-Aid.
- Some areas use cover crops mostly as a way to apply more manure safely. The Bay model, however, gives no credit if they apply nutrients to cover crops.
- CC may be a benefit for the control of erosion and N, but can mobilize P from high-P soils – this is not picked up in SB or the Bay model because the modeling does not handle carryover/storage.
- Cover crop is important during fall-winter-spring water recharge season. This will be especially important on sites where excess N is likely, e.g. after droughts, after fall manure application (hopefully a modest rate of fall manure), sites with regular manure inputs, and short season crops like vegetables that provide a long fall period for soil N mineralization.
- CC is useful where the next level of management is not available (P/D agriculture), but the right rate and timing of applications is preferred to using CC to scavenge the excess application.
- To be effective in protecting Bay waters, CCs must have enough time and precipitation to grow to a height of at least 4 inches before or near winter dormancy to reduce soil loss and effectively scavenge

soil N unutilized by the production crop. Otherwise, the smooth seedbed often produced when planting a cover crop may actually exacerbate N runoff and soil loss.

### *IRRIGATION AND DRAINAGE*

Irrigation and drainage offer both concerns and potential benefits for NM in the Bay watershed. Both practices are effective for maintaining high crop yields, but the high yields justify extremely high nutrient application rates. Improved irrigation scheduling and controlled application of N through irrigation systems can reduce nutrient losses. These technologies, however, are not widely employed in the Bay watershed at this time. Similarly, controlled drainage technologies can reduce N losses through tile drain systems. Below is a collection of extracts from interviews.

- Yield goals are set very high (220 bushels/acre) with irrigation, and therefore there is very high nutrient application. This leads to a lot of N application and higher losses if irrigation is not managed carefully.
- Recognition of the different landforms and their typical management practices (i.e., bottomland cropland, bench and upland hay and grazing systems) is important. Most bottomlands are tile-drained and could be significant sources of nutrient to the CB watershed, particularly for loss of N. Permanent sod, pasture, and hayland receive surface applications and get surface enrichment of the top 2 inches.
- There is quite a bit of ditch drainage on the Eastern Shore and tile drainage on the Western Shore. This could be a major N loss mechanism. Ditches are easily seen but not all tiles are mapped.

### *CONSERVATION TILLAGE*

Several interviewees recognized trade-offs necessary in NM when reduced tillage is employed in combination with manure application. This system makes it difficult to incorporate the nutrients, so most are applied pre-plant to the surface. The result is high concentration of P at or near the surface, with an increased potential for runoff. Extracts from interview comments are shown below. Below is a collection of extracts from interviews.

- Tension exists between incorporating manure and the widespread use of conservation tillage in the CB watershed. Trade-offs between sediment and nutrient losses are apparent. Ken Staver's work shows P in runoff – trade-off between erosion control (sediment) and control of total P (driven largely by soluble P losses).
- Tradeoffs among practices are necessary. For example, manure application and reduced tillage operate in opposite directions and result in major tradeoffs.
- Reduced tillage can reduce sediment-attached P losses, but loss of dissolved P is not necessarily controlled by conservation tillage/no-till and may actually increase. May need to look at new ways to coordinate tillage types with NM practice. Different types of tillage will require different combinations of source-rate-time-place.

### *OTHER FACTORS*

Factors that do not fit easily in the categories above are presented below.

- Tillage and soil type affect N from soil, but these considerations seem to not be factored into the planning.
- Soil type, texture – e.g., WV silt loam soils have greater P sorption than eastern CB sandy soils and much lower infiltration rate.
- Timing - The recommendation for corn is to apply N in a short pre-plant window and use side-dress N, but in many places ALL of N is put down as pre-plant.
- Weather - e.g., if a farmer puts down fertilizer and doesn't get moisture, N won't get down to the root

zone; or big rain after spreading washes it away.

- Record-keeping (e.g., tracking yields and rotations).
- Stocking rates and grazing rotations.

## RECOMMENDATIONS FOR IMPROVED TRACKING, REPORTING, AND MODELING OF NUTRIENT MANAGEMENT

Interviewees were asked to provide recommendations for improved tracking, crediting, reporting, and modeling of NM practices at the local, state, and watershed levels. They were asked to consider the practicality of collecting the information, appropriate units of measure, and whether the practice is annual or cumulative. They were specifically asked for recommendations to account for voluntary NM. Those familiar with SB or the Bay model were also asked to provide any recommendations they had that are specific to those modeling tools.

### RECOMMENDATIONS FOR TRACKING

Below is a collection of extracts from interviews.

- MDA has six NM specialists who conduct on farm audits and inspections to verify that NM planning is current, records are in line with plans, and that the farmer is using the plan to properly manage nutrients. These 6 specialists audit about 5-10% of regulated farms each year. Concerns have been expressed by environmental organizations that a more transparent process to share audit results is needed in order to provide a much greater degree of confidence that NMPs are being fully implemented over the lifespan of practices functioning. There are a few 3rd party, independent organizations that are providing on-farm assessments. These organizations, due to the nature of the assessment being conducted by an objective assessor, provide a much greater degree of confidence to the public that the NM planning is being fully implemented.
- MD should track input process relative to agronomic requirements rather than plans processed.
- There is a very effective soil testing program through WVU. Plans are expected to have 3-yr soil testing, and since analyses are free, soil testing is widespread. Certified planners take the samples, so that is free too. Results of soil testing are available in county-based summaries on the WVU website. There was a marked jump in soil samples submitted when the CAFO rules were promulgated. This could be used as a source of data for tracking NM progress.
- We need to see how farms change their NM planning when they transport manure/litter off site. County to county transport records could be available for the modeling.
- We need to do a better job of tracking fertilizer usage in agriculture. State chemist records are severely lacking. This is the largest component in tracking meta-trends in nutrient balance.
- The technical nature of the planning process and the tools involved (PI), give the public the appearance that environmental issues are being addressed to a greater extent than they are.
- New York - The process for collecting agricultural BMPs starts with the state funded AEM program. AEM is the “umbrella program” that provides a consistent format to efficiently identify environmental concerns and opportunities through a comprehensive on-farm assessment. NRCS, Extension, AEM Planners, and farmers will coordinate to report their BMP progress.
- Track individual components of NM rather than “NM” as a whole.

## RECOMMENDATIONS FOR VOLUNTARY PLAN TRACKING

Below is a collection of extracts from interviews.

- It would be worthwhile considering ways to request such information from agricultural and agribusiness organizations. Each will report differently, but interest is increasing in uniform reporting standards, including sustainability reporting.
- Could seek reporting from certified NM consultants in MD and DE. They could report total acres they plan – not all of those are mandatory.
- Need trained technical experts to visit the farms to ensure that they meet specific standards so they can be counted properly and modeled properly. State will need a process to prove that these practices are consistent with model definitions or state standards.
- Perhaps the recommendation is to track practices not plans. Perhaps we should shift our focus to which specific practices are implemented?
- Some voluntary NMPs may not meet NRCS or Bay model standards and therefore would likely have a different efficiency associated with them.

## RECOMMENDATIONS ON MODELING

Below is a collection of extracts from interviews.

- It is going to be hard to do anything with NM prediction without first knowing the soil production capability matched up the crop actually growing on the field.
- Precision GIS data, even temporal data are available, but the model just averages over the county, losing all of the detail. Aggregating data at the county level isn't bad, but we don't know if corn (for example) is on land supporting high or lower yields – we need to know that (where is corn grown relative to the various soil types) to model better.
- The Bay model does not handle storage of P in the watershed – it converts application of fertilizer and manure P into part in the crop, part lost to CB, etc. but there is no carryover to the next year.
- Scenario Builder currently allocates supplemental fertilizer anytime that the crop uptake rate is not met with manure. This represents a fundamental mischaracterization associated with a crop uptake based model that does not consider soil organic N, soil test P, and important aspects of farm management.
- We need to factor in P saturated soils – more of a 2017 thing for the model. We also need consistency in the way that states apply their P Indexes.
- If NM planning is to gain credit under the model, it should reduce N or P flows to the bay, not maintain or increase them. In some cases negative credit should be applied for practices.
- Incorporate more BMPs into the model. Incorporate BMPs that are implemented by growers, but are not accounted for in the model (mostly because growers have paid for them themselves).

## LITERATURE

Interviewees were asked to identify any literature or other significant information sources on each practice (N-based nutrient management, P-based nutrient management, P/D agriculture, and ENM) that they believed the Nutrient Management Expert Panel should review. These materials have been uploaded to the SharePoint site created for the Agriculture Workgroup.



## ABBREVIATIONS, ACRONYMS, AND UNITS

4Rs - Right rate, right form, with the right timing, and the right placement

ac – Acre

AEM – Agricultural Environmental Management program of NY

AFO – Animal feeding operation

AFT – American Farmland Trust AEU – Animal equivalent unit

ARS – Agricultural Research Service

AU – Animal unit

Bay model – Chesapeake Bay watershed model

BMP – Best management practice

bu – Bushel

bu/ac – Bushels per acre

CAFO – Confined animal feeding operation

CAO – Concentrated animal operation (PA). ( $\geq 8$  AEUs where the animal density  $> 2$  AEUs/ac on an annualized basis.)

CB – Chesapeake Bay

CC – Cover crop

CCA – Certified Crop Advisor

CCD – County Conservation District

CD – Conservation District

CEU – Continuing Education Unit

CIG – Conservation Innovation Grants

CNG – Cornell Nutrient Guidelines

CNMP – Comprehensive Nutrient Management Plan

COMAR – Code of Maryland Regulations

c/s – Cost Sharing

CSNT – Corn stalk nitrogen test

DA&M – NYS Department of Agriculture & Markets

DCR – VA Department of Conservation and Recreation

DDA – Delaware Department of Agriculture

DEC – NYS Department of Environmental Conservation

DEQ – Department of Environmental Quality

DNMC – Delaware Nutrient Management Commission

DNML – Delaware Nutrient Management Law

DNREC – Delaware Department of Natural Resources and Environmental Control

ENM – Enhanced nutrient management

EP – Nutrient Management Expert Panel under the sponsorship of the Agriculture Workgroup  
EPA – United States Environmental Protection Agency  
FIV – Fertility index value  
GIS – Geographic information system  
GPS – Global positioning system  
ISNT – Illinois side-dress nitrogen test  
lb – Pound  
lb/ac – Pounds per acre  
MDA – Maryland Department of Agriculture  
MM – Manure management  
MMM - Manure Management Manual authorized under Chapter 91 of PA Code  
MNMM - Maryland Nutrient Management Manual  
N – Nitrogen  
NEIN - National Environmental Information Exchange Network  
NLI - Nitrate Leaching Index  
NM – Nutrient management  
NMP – Nutrient management plan  
NPDES – National Pollutant Discharge Elimination System  
NRCS – Natural Resources Conservation Service of USDA  
OM – Organic matter  
P – Phosphorus  
PA DEP – Pennsylvania Department of Environmental Protection  
P/D Agriculture – Precision/decision agriculture  
PDA – Pennsylvania Department of Agriculture  
PI – Phosphorus Index or Phosphorus Site Index or Phosphorus Runoff Index ppm – Parts per million  
PSNT – Pre-sidedress soil nitrate test  
PSU – Penn State University  
QA/QC – Quality assurance/quality control  
RUSLE/RUSLE2 – Revised universal soil loss equation  
SB – Scenario Builder  
SCC – State Conservation Commission  
SWCC – Soil and Water Conservation Committee  
SWCD – Soil and Water Conservation District  
t/ac – Tons per acre  
TMDL – Total maximum daily load  
TSP – Technical services provider  
UD – University of Delaware

UMD – University of Maryland

USC – Upper Susquehanna Coalition

USDA – United States Department of Agriculture

VALUES - Virginia Agronomic Land Use Evaluation System VT – Virginia Tech University

WIP – Watershed Implementation Plan

WNM - Water and nutrient management (plans)

WVCA – West Virginia Conservation Agency

WVDA – West Virginia Department of Agriculture

WVU – West Virginia University

yr - Year

## SOURCES

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- Virginia nutrient management standards and criteria, (revised 2005): section iv. phosphorus management. <http://www.dcr.virginia.gov/documents/StandardsandCriteria.pdf> (Accessed 2/16/2012).
- WVDEP. Title 47 legislative rule, series 10, Department Of Environmental Protection, Water Resources. <http://apps.sos.wv.gov/adlaw/csr/ruleview.aspx?document=8226> and <http://apps.sos.wv.gov/adlaw/csr/readfile.aspx?DocId=22371&Format=PDF> (Accessed 3/15/2012).

## EP Members Surveyed

Aaron Ristow, USC

Anne S. Marsh, Heinz Center

Barry Evans, PSU

Curtis Dell, USDA-ARS

Doug Beegle, PSU

Doug Goodlander, PA DEP

Frank Coale, Chair, UMD (not interviewed)

Greg Albrecht, NY DA&M  
Jack Meisinger, USDA-ARS  
Jason Dalrymple, WVDA  
Jim Cropper, Northeast Pasture Consortium  
John Lea-Cox, UMD  
John Majsztrik, UMD  
Josh McGrath, UMD  
Kelly Shenk, EPA  
Ken Staver, UMD  
Larry Towle, DDA  
Mark Dubin, Coordinator, UMD  
Peter Kleinman, USDA-ARS  
Royden Powell, MDA  
Thomas Bruulsema, International Plant Nutrition Institute  
Tim Sexton, VA DEQ  
Tom Basden, WVU  
Trish Steinhilber, UMD  
Wade Thomason, VT  
Chris Gross, USDA-NRCS

## SUBAPPENDIX A: SYNOPSES OF STATE AGRICULTURE PROGRAMS

## SYNOPSIS OF NM TECH STANDARDS FOR DELAWARE

<http://dda.delaware.gov/nutrients/index.shtml>

The Delaware Nutrient Management Program was established in June 1999 as a result of the Delaware Nutrient Management Law. The Delaware Nutrient Management Commission (DNMC members) was established to direct the program and develop regulations pertaining to nutrient management, waste management for Animal Feeding Operations (AFOs) and NPDES permits for CAFOs.

DE Department of Agriculture administers:

- Nutrient Management Relocation Program – cost assistance for manure transport
- Delaware Manure Matching – identifies manure providers, receivers, and brokers
- Nutrient Management Planning Program – cost-share program for NMP implementation
- Complaints
- Certification of CAFO operators, nutrient applicators, consultants

### Source(s) of technical standards for nutrient management:

- The required contents of a NMP are in 9 Delaware Reg. 440, Section 9.5.6.1
- Draft list of 42 standards is presented on a Delaware Department of Agriculture web site titled “DRAFT Delaware Nutrient Management Program State Technical Standards” ([http://dda.delaware.gov/nutrients/NM\\_TechStandards.shtml](http://dda.delaware.gov/nutrients/NM_TechStandards.shtml)).
- Components of technical standard include NRCS 590 standard, other NRCS standards, UD Extension documents

### Requirements for risk assessment:

- DE NRCS 590 Standard, *Field Risk Assessment – Phosphorus Site Index (PSI) Rating* (DE and MD share a common adapted PI)
- Specifics of when CAFOs are required to complete all field assessments are clearly articulated in their permit.

### Nutrient recommendations:

- U. of Delaware *Nutrient Management Handbook* (Sims and Gartley, 1996) contains specific recommendations for crop nutrient levels and discussion of adjustment factors based on manure, legumes, and other factors.

### Crop removal rates:

- U. of Delaware *Nutrient Management Handbook*
- UD Extension publication NM-06 *Phosphorus Removal by Delaware Crops* that includes tabular data on estimated P removal in the harvested portion of DE crops.

### Manure and soil testing:

- Manure nutrients must be analyzed prior to land application, as close to the application date as feasible
- Nutrient management planning shall be based on current (<3 yrs) soil test results. In addition, the Pre-Sidedress Soil Nitrate Test is recommended as a late spring soil test for assessment of nitrogen availability.

### Application restrictions:

- Delay field application if precipitation capable of producing runoff and erosion is forecast within 24 hours of the time of the planned application.
- Nutrients shall not be applied to frozen, snow-covered, or saturated soil.
- Nutrients shall not be applied to flooded or saturated soils when the potential for soil compaction and the creation of ruts is high
- For sites with high risk for P transport, P applications cannot exceed the amount of P removed in the harvested portion of the crops grown for the next three years.

**Modeling and tracking nutrient management<sup>1</sup>:**

- FSA and NRCS will report data through USGS, for transfer to the Watershed Model (system not yet final)
- Other state-funded practices are issued and tracked through the Dept. of Ag., e.g., manure relocation and nutrient management plan cost-share programs
- Cost-shared BMPs reported are aggregated by watershed and reported directly into the Bay model, through FSA and NRCS; not known if or how practices cost-shared by other programs are geo-referenced
- State reviews aerial photography and other records to establish implementing year as possible to avoid reporting previously existing practices as new; field verifications done by partner agencies
- No procedure in place to track operation, maintenance, or continued existence of practices

<sup>1</sup> from NAS review *Achieving Nutrient and Sediment Reduction Goals in the Chesapeake Bay*



## SYNOPSIS OF NM TECH STANDARDS FOR MARYLAND

[http://www.mda.state.md.us/resource\\_conservation/nutrient\\_management/index.php](http://www.mda.state.md.us/resource_conservation/nutrient_management/index.php)

The 1998 Water Quality Improvement Act requires all Maryland farmers grossing \$2,500 or more annually or raising 8,000 pounds or more of live animal weight to run their operations using a nutrient management plan that addresses both nitrogen and phosphorus inputs. Also applies to people who apply nutrients, poultry growers and companies, and Maryland-certified nutrient management consultants, who must write nutrient management plans based on both soil N and P.

The MD Dept. of Agriculture Nutrient Management Program oversees a licensing and certification program for consultants, compliance activities and education and training programs.

### Source(s) of technical standards for nutrient management:

- Part IV.B.8 of the General Permit (Protocols for the Land Application of Manure and Wastewater) states that animal waste shall not be applied at a rate higher than agronomic requirements in accordance with the Maryland Nutrient Management Manual.
- “Law, Regulations and Reference Manual” and “Consultant’s Resource Notebook” constitute the methodology and standards used to develop nutrient management plans that are required of CAFOs and certain AFOs in Maryland.

### Requirements for risk assessment:

- Maryland Nutrient Management: Law, Regulations and Reference Manual, Section I I-C (Phosphorus Site Index for Maryland)
- Use of the PI for Maryland required when the soil fertility index >150

### Nutrient recommendations:

- Maryland Nutrient Management: Law, Regulations and Reference Manual, Section I-B (Nutrient Recommendations by Crop) provides recommended nutrient application rates for various crops based on soil tests and yield goals.

### Crop removal rates:

- Maryland Nutrient Management: Consultant’s Resource Notebook, Section III (Developing Nutrient Recommendations), *Phosphorus Removal by Crops in the Mid-Atlantic States* includes data on crop P removal in lbs P<sub>2</sub>O<sub>5</sub>/yield unit.

### Manure and soil testing:

- General Permit requires at least annual manure analysis for P and N content.
- Maryland Nutrient Management Law specifies that a CAFO/AFO operator shall conduct manure analysis as close to application time as possible, or a consistent baseline for nutrient content may be established and used from analysis results taken at least twice a year until a uniform value is confirmed, and then for every second year thereafter.
- The General Permit requires that AFOs include analysis of soil samples for pH and P at least once every three years for all fields where animal waste may be applied.

### Application restrictions:

- The General Permit states that field application of animal waste shall not take place on frozen ground or snow covered ground without written permission and requires setbacks from waters of the state and property lines.
- The annual average hydraulic loading rate for land application of process wastewater shall not exceed 2 in./week, and application shall not exceed the long-term soil infiltration rate or result in surface runoff or ponding.

- Further, distribution of process wastewater shall not take place during periods of precipitation or high winds, or on frozen or snow covered ground or on saturated soil.
- Manure cannot be applied to frozen or snow-covered ground or on specific poorly drained soils. Also, manure application is prohibited from November 16 – February 28) unless the operation has inadequate storage capacity.

**Modeling and tracking nutrient management<sup>1</sup>:**

- MDA tracks agricultural BMPs and reports the information monthly to BayStat. Nutrient management plans are submitted monthly by the farmer; the operation, crops grown, fertilizer used, acreage managed, and animal production are tracked to determine the percentage of nutrient management plans in compliance.
- MDA strives to complete ~400 random field inspections annually, which include a review of the plan and all farm records. Plans are also reviewed at MDA headquarters; farmers must have their nutrient management plans reviewed and approved to participate in state incentive programs.
- MD plans to initiate a pilot program where soil conservation districts would conduct on-the-ground inventories of current practices farmers have installed without incentives; this inventory would include an on-farm nutrient calculation tool.
- Once a practice has exceeded its designated maintenance life (~10-15 years for most practices), it is removed from the list

<sup>1</sup> from NAS review *Achieving Nutrient and Sediment Reduction Goals in the Chesapeake Bay*

## SYNOPSIS OF NM TECH STANDARDS FOR NEW YORK

For a more detailed summary, please review the NYS Watershed Implementation Plan (WIP) ([www.dec.ny.gov/lands/33279.html](http://www.dec.ny.gov/lands/33279.html)).

CNMPs are required for CAFO regulated farms ( $\geq 200$  mature dairy cows) per the CAFO General Permits from NYS DEC (<http://www.dec.ny.gov/permits/6285.html>). The *Agricultural Environmental Management (AEM)* program from the NYS Department of Agriculture and Markets and the NYS Soil and Water Conservation Committee in partnership with county Soil and Water Conservation Districts also provides support for nutrient management planning and CNMP development and implementation on non-CAFO farms ([www.nys-soilandwater.org/aem](http://www.nys-soilandwater.org/aem)).

USDA-NRCS in NYS also provides support for nutrient management plan and CNMP development and implementation on non-CAFO farms ([www.ny.nrcs.usda.gov](http://www.ny.nrcs.usda.gov)).

### Source(s) of technical standards for nutrient management:

- NY NRCS Conservation Practice Standards 312 (Waste Management System) and 590 (Nutrient Management) are required for all CNMPs, including those required by the NYS DEC CAFO General Permits.
- Numerous resources available from Cornell University and Cornell Cooperative Extension, e.g., Cornell University Nutrient Management Spear Program (<http://nmssp.cals.cornell.edu>)

### Requirements for risk assessment:

- The New York PI, NY NLI, and RUSLE2 must be used to assess nutrient transport, and erosion potential, as well as plan field operations and guide implementation by farms. All are incorporated in the NY NRCS 590 standard.
- The NY PI assesses risk separately for particulate and dissolved P

### Nutrient recommendations:

- The Cornell Nutrient Management Spear Program provides nutrient guidelines for field crops as referenced in the NY NRCS 590 standard. Cornell's *Nitrogen Guidelines for Field Crops in New York* provides detailed descriptions of methods to calculate N recommendations for specific field crops. *Phosphorus Guidelines for Field Crops in New York* provides P recommendations for specific field crops. <http://nmssp.cals.cornell.edu/guidelines/nutrientguide.html>
- The umbrella NRCS 590 standard in NYS requires that the Cornell Nutrient Guidelines, NLI, PI, and RUSLE2 are integrated to determine sound recommendations for manure and fertilizer applications. New York's recommendation system is comprised of the following key elements:
  - Every field managed according the NRCS-NY 590 Standard must undergo the full set of analyses in the standard (no threshold exists, under which a partial analysis is performed). This includes risk assessment field walks to collect field attributes for the PI, RUSLE2, setbacks, and other resource concerns; collection of field history and management information; and significant analysis to integrate the Cornell Nutrient Guidelines and various risk assessments into a final recommendation for source, rate, timing, and method of nutrient application (4Rs).
  - In addition to the risk assessment tools, the "Supplemental Manure Spreading Guidelines to Reduce Water Contamination Risk During Adverse Weather Conditions" (<http://nmssp.cals.cornell.edu/publications/files/WinterSpreadingGuidelines.pdf>) is used to further guide fields selection and management during periods of saturated, frozen, and/or snow covered field conditions. Crop nutrient guidelines are based on a database of 600+ soil-specific yield potentials and soil test-based yield response studies.
  - Crop nutrient guidelines account for existing N credits from past crops, manure, and soil organic matter.
  - Crop nutrient guidelines are based on the sufficiency approach, developed through years of crop yield response studies, and not a crop removal approach. The guidelines account for nutrient availabilities and efficiencies throughout the soil/crop environment, so no blanket insurance factors exist.

- The NLI is based on seasonal and annual precipitation and soil hydrologic group. Additional N conservation BMPs are recommended on fields for NLI ratings  $\geq 10$ .
- The PI is a unit-less risk rating based on the integration of the pool of P for a field (source) and its potential to be lost from the field via runoff or erosion (dissolved transport and particulate transport, respectively).
- RUSLE2 is run on all fields and soil loss must be managed to T.
- Manure application setbacks from watercourses (100', 35' vegetated buffer, or 15' buffer if incorporated within 24 hours) and 100' from wells.
- Records are kept to drive future management.

#### **Crop removal rates:**

- The NY PI provides specific crops' P concentrations for purposes of calculating actual P removal rates based on crop yield expectations.

#### **Manure and soil testing:**

- NRCS 590 and the CAFO General Permits require annual manure sampling for N and P content.
- NRCS 590 and the CAFO General Permits require nutrient planning to be based on current soil test results (no more than 3 years old) developed in accordance with Cornell University guidance or industry practice.

#### **Application restrictions for fields guided by CNMPs or 590 Nutrient Management Plans:**

- Manure applications on fields guided by CNMPs or 590 nutrient management plans shall have:
  - 100 foot setbacks from wells, sinkholes, or surface inlets and down-gradient surface waters, or
  - 35 foot vegetated buffers to down gradient surface waters, or
  - 15 foot buffers to down gradient surface waters with manure incorporated within 24 hours of application.
- The NY PI restricts P applications to crop removal on fields with PI ratings of "High" (75 – 100) and prohibits all P applications to fields with PI ratings of "Very High" ( $\geq 100$ ). Additional crop N requirements (if any) would be satisfied by N fertilizer.
- Farmers and planners further manage manure nutrients and risk by following to sets of supplemental guidelines (<http://nmsp.cals.cornell.edu/guidelines/nutrientguide.html>):
  - *Supplemental Manure Spreading Guidelines to Reduce Water Contamination Risk During Adverse Weather Conditions*
  - *Manure and Groundwater: the case for protective measures and supporting guidelines*
- Delay field application of animal manures or organic by-products if precipitation capable of producing runoff and erosion is forecast within 24 hours of the time of the planned application.
- Nutrients shall not be applied to frozen, snow-covered or saturated soil if potential risks for runoff exist.
- When tillage can be performed, surface applications of manure that are subject to volatilization on the soil surface are encouraged to be incorporated into the soil within 24 hours.
- When manure or organic by-products are applied to grassland, hayland, pasture or minimum-till areas, the rate, form and timing of application(s) shall be managed to minimize volatilization losses.

#### **Modeling and tracking nutrient management<sup>1</sup>:**

- The Upper Susquehanna Coalition (USC) is charged with tracking agricultural nonpoint source implementation through their AEM Program work; only practices on-the-ground are reported to the Bay Program (NEIEN Node).
- USC field-checks agricultural practices. [www.u-s-c.org](http://www.u-s-c.org)

<sup>1</sup> from NAS review *Achieving Nutrient and Sediment Reduction Goals in the Chesapeake Bay*

# SYNOPSIS OF NM TECH STANDARDS FOR PENNSYLVANIA

<http://panutrientmgmt.cas.psu.edu/>

Under 2002 Act 38 and 2006 revised rules, CAOs are required to develop and implement nutrient management plans. The PA Dept. of Agriculture certifies specialists (and farmers) to write and review NMPs; NMPs must be reviewed and approved by county Cons. Dist. or State Cons. Comm. A manure management plan for using excess manure is a required part of the plan; the plan must include nutrient balance sheets and is subject to a review and approval process. Manure importing farms must have a nutrient management plan in place before they accept manure.

The PA NM program (web site housed at PSU, administered by PA State Conservation Commission) includes:

- Certification program
- Education program
- Financial assistance
- NM specialist directory

## **Source(s) of technical standards for nutrient management:**

- Title 25, Chapter 83, Subchapter D. Nutrient Management, along with Title 25, Chapter 92.5a CAFO Regulations, and Title 25, Chapter 91 regulations governing agriculture.
- Both Title 25, Chapter 92.5a CAFO Regulations and individual CAFO permits reference the requirement for preparation and implementation of a nutrient management plan meeting the requirements of Chapter 83, Subchapter D.

## **Requirements for risk assessment:**

- Title 25, Chapter 83.293 requires determining the risk of P loss based on soil P level; the method, rate and timing of P application; runoff and soil loss potential for the application area; distance to surface water; and the P source. Parts 5 and 6 of Chapter 293 direct farmers to use the PI and state guidance for risk assessment.
- The PA PI is a two-stage process. Part A is a screening process to determine if a field: 1) is in a special protection watershed, 2) has had a significant management change, 3) has a soil test Mehlich 3 P > 200 ppm, or 4) is within 150 ft of receiving water. If none of these conditions apply, N-based nutrient management is acceptable for the field. If any part of the Part A process is positive, Part B (the full risk assessment) is required and nutrient applications may be restricted, depending on site risk.

## **Nutrient recommendations:**

- Title 25, Chapter 83 requires that the nutrient management plan include crop recommendations based on soil tests, but does not provide a source for the recommendations
- The Penn State Agronomy Guide includes crop recommendations, but is not specifically identified as the source for determining crop nutrient needs

## **Crop removal rates:**

- Current guidance points to the PSU Agronomy Guide and other technical documents on the PSU Nutrient Management Program web page.

## **Manure and soil testing:**

- After the approval of the initial plan, manure tests are to be taken annually.
- When developing a plan, soil tests are to be conducted for each crop management unit; soil tests every three years thereafter are acceptable

## **Application restrictions:**

- The PA 590 standard states that nutrients should not be applied to frozen, snow-covered or saturated soil if the

potential for runoff exists

- PA regulations state that plans for manure application must include crop management units where winter application is planned or restricted. However, no specific criteria for where winter application should be restricted are provided.
- For irrigation systems, and where liquid or semisolid manure will be applied at rates > 9,000 gal/ac at a time, application rates must be limited based on the soil infiltration rate and water holding capacity
- Manure may not be mechanically applied on fields with <25% cover unless: 1) for fall applications, a cover crop is planted in time to control runoff or the manure is injected or incorporated within 5 days using minimal soil disturbance techniques, 2) for spring or summer applications, a cover crop is planted during that growing season, or 3) for winter applications, restrictions, procedures, and appropriate field conditions are described in the plan; setbacks are used; and fields have 25% residue or an established cover crop.

#### **Modeling and tracking nutrient management<sup>1</sup>:**

- PA DEP collects data from the PA Act 6 Nutrient Management program electronic spreadsheet reporting to county level
- Verification and quality assurance of BMPs implemented are considered to be the responsibility of the federal/state/NGO agencies providing the information.

<sup>1</sup> from NAS review *Achieving Nutrient and Sediment Reduction Goals in the Chesapeake Bay*

## SYNOPSIS OF NM TECH STANDARDS FOR VIRGINIA

Tim said this basically looks good.

[http://www.dcr.virginia.gov/stormwater\\_management/nutmtgt.shtml](http://www.dcr.virginia.gov/stormwater_management/nutmtgt.shtml)

The VA Dept. of Conservation and Recreation manages both agricultural and urban nm programs. Program activities include:

- NM training and certification
- Poultry litter transport incentive program
- Tax credit program
- Turf and landscape nutrient management

### **Source(s) of technical standards for nutrient management:**

- The regulatory NMP criteria are incorporated into Regulation 4 VAC 5-15 (Virginia Nutrient Management Training and Certification Regulations
- Virginia Nutrient Management Standards and Criteria (2005)
- Virginia Nutrient Management Training and Certification Regulations 4VAC-15-10 (2005)
- Two separate training programs: one for turf/landscape and one for crops

### **Requirements for risk assessment:**

- If soil P saturation is > 65%, P application is not permitted.
- Otherwise, soil test P, P-Environmental Thresholds, or PI to be used to determine maximum P application rate from organic sources
- Virginia P-Index Version 2.0 Technical Guide, Revised 2005

### **Nutrient recommendations:**

- Virginia Nutrient Management Standards and Criteria, Section V. Crop Nutrient Needs

### **Crop removal rates:**

- Virginia Nutrient Management Standards and Criteria, pages 55-59, Table 4-7

### **Manure and soil testing:**

- Nutrient Management Training and Certification Regulations 4 VAC 5-15-150 specify that most recent manure analysis or average of last 3-year period be used to determine manure nutrient content.
- Nutrient Management Training and Certification Regulations and VA Nutrient Management Standards and Criteria require that P and K application recommendations be determined based on soil test results  $\leq 3$  yrs old.

### **Application restrictions:**

- VA Nutrient Management Standards and Criteria state that no P applications shall be made for soils >65% P saturation regardless of the outcome of the VA PI.
- Applications of inorganic nutrient sources, liquid manure, etc. not to occur on frozen or snow-covered ground.
- When ground is frozen, dry or semi-solid manures may only be applied if the field has: (i) slopes < 6.0%; (ii) 60% uniform ground cover from crop residue or an existing actively growing crop such as a small grain or fescue with exposed plant height of three inches or more; (iii) a minimum of a 200-foot

vegetated or adequate crop residue buffer between the application area and all surface water courses; and (iv) soils characterized by USDA as “well drained.”

**Modeling and tracking nutrient management<sup>1</sup>:**

- Agricultural BMPs are reported through the Ag Cost Share Program Tracking Database by DCR; DEQ tracks poultry litter transport between counties
- Cost-shared agricultural practices have point locations recorded; system is being developed (as of 2010) for point locations for nutrient management plans
- Soil and Water Conservation Districts certify that installed practices fulfill all BMP requirements; practices that receive state financial incentives are subject to field spot checks. DCR monitors implementation of installed BMPs by randomly selecting 5% of installed practices in a program year and 5% of prior multi-year practices for field inspection. It is not known if this activity includes nutrient management plans.
- Soil and Water Conservation Districts have primary responsibility for collection, verification, and entry of agricultural BMP data; DCR web-based Agricultural BMP Tracking Program used by all SWCDs and will be modified to allow input of data on voluntary BMP installation

<sup>1</sup> from NAS review *Achieving Nutrient and Sediment Reduction Goals in the Chesapeake Bay*



## SYNOPSIS OF NM TECH STANDARDS FOR WEST VIRGINIA

[http://www.wvagriculture.org/programs/Nutrient\\_Management/Introduction.htm](http://www.wvagriculture.org/programs/Nutrient_Management/Introduction.htm)

WV requires NM for CAFOs (WV CAFO regulations are not yet accepted by EPA) or producers who participate in USDA cost-share programs. Most of the NM plans are written as “voluntary” plans. The WV Department of Ag operates a voluntary NM Certification Program that includes education and training

### **Source(s) of technical standards for nutrient management:**

- The WV NPDES permitting program intent is to make reference to the NRCS 590’s PI with WV’s CAFO standard in CAFO permits issued
- The WV CAFO standard refers specifically to the WV Phosphorus Field Risk Assessment and the 2005 Virginia Standards and Criteria.

### **Requirements for risk assessment:**

- Soil test P levels are used as an initial screening. The WV P Field Risk Assessment (PI) is optional for soils where the P level is high or very high (greater than 50 lbs/acre).
- The WV PI is currently under revision.
- The NLI is also required in areas where there are state and/or locally identified or designated nitrogen-related water quality impairments (e.g., karst and well-head protection areas)

### **Nutrient recommendations:**

- NRCS 590 refers to tables in the Penn State Agronomy Guide for N-P-K fertilizer recommendations and N recommendations for agronomic crops. Both tables specify that they provide base recommendations that do not consider manure application and refer to the “Manure Nutrient Management” section of the document for further guidance.
- 2005 Virginia Standards and Criteria
- Mid Atlantic Nutrient Planning Manual

### **Crop removal rates:**

- The 590 standard refers to “Typical Crop Nutrient Removal for Phosphorus and Potassium” in the Penn State Agronomy Guide.
- 2005 VA Standards and Criteria

### **Manure and soil testing:**

- Manure analysis is required within one year of the initial nutrient management plan and each year following.
- A soil test is required every three years, and within one year of the initial nutrient plan date.

### **Application restrictions:**

- Consider delaying application of manure if precipitation capable of producing runoff or erosion is forecast with 24-hours.
- Manure cannot be applied to frozen, snow-covered, or saturated ground. Emergency applications on frozen ground per new USDA 590

**Modeling and tracking nutrient management<sup>1</sup>:**

- WVDA tracks nutrient management plans, as well as all state cost-shared agricultural practices, as well as those from watershed associations and NGOs
- Some practices (like riparian buffers and stream restorations) have location data recorded on file but these are not transmitted to the CBP as part of the annual data submission; most other practices (probably including nutrient management) are reported by county
- WVDA plans to use nutrient management planners to assist in tracking and reporting activities while they are in the field

<sup>1</sup> from NAS review *Achieving Nutrient and Sediment Reduction Goals in the Chesapeake Bay*

## SUBAPPENDIX B: ADAPTIVE NUTRIENT MANAGEMENT APPROACH

The adaptive nutrient management approach can be used to:

- improve nutrient use efficiency
- decrease the loss of nutrients to the environment while maintaining yields
- evaluate the effectiveness and introduce new nutrient management technologies
- test and evaluate the performance of tools and/or techniques for nutrient management that are not currently in use
- evaluate post-season site-specific data that can be used to establish future optimal nutrient applications

### Definition of adaptive nutrient management

Adaptive nutrient management is a process used to evaluate and adjust nutrient application and utilization strategies over time (multiple seasons). The process allows for continued adjustments of the NRCS-assisted Conservation Practice Standard (CPS) Code 590, Nutrient Management to achieve better nutrient use efficiency. Adaptive nutrient management promotes the coordination of amount (rate), source, timing, and placement (method of application) of plant nutrients to minimize nutrient losses.

### Nutrient Management Practice (CPS Code 590) and the adaptive nutrient management process

State-approved adaptive nutrient management activities are considered in compliance with the operation and maintenance requirements of the CPS Code 590, Nutrient Management, and step 9 of Title 180, National Planning Procedures Handbook (NPPH), Part 600, Subpart A, Section 600.11.

**The Adaptive Management Process – Plan, review, learn, adapt.** Nutrient management plans, including adaptive nutrient management, require periodic reviews involving the grower and a nutrient planning specialist. The goal of planning in nutrient management is to coordinate the amount, source, placement, and timing of nutrient applications to protect the environment, lower production costs, and maximize the realized profit from each field or subfield. While all nutrient management strategies involve initial planning or predicting, most involve only implementation of the plan and do not include a structured or systematic evaluation component. Where adaptive nutrient management is different is in explicitly and systematically incorporating evaluation as part of the process, using those evaluations to guide management in current and future years.

With adaptive management, the purpose of the review is to use data collected from the field to evaluate how well the planned or implemented practice worked, identify how it could be improved, and make adjustments to the plan, as needed, to further improve nutrient use efficiency and reduced nutrient losses. In adaptive management, such evaluations are done at least once a year. If in-season adaptive management tools are used, such review is done twice a year. The most critical review of the plan and feedback data from evaluation tools happens during the winter when farmers meet as groups or one-on-one with an advisor to discuss management, collected information, and ways to adapt management in the next season to increase efficiency.

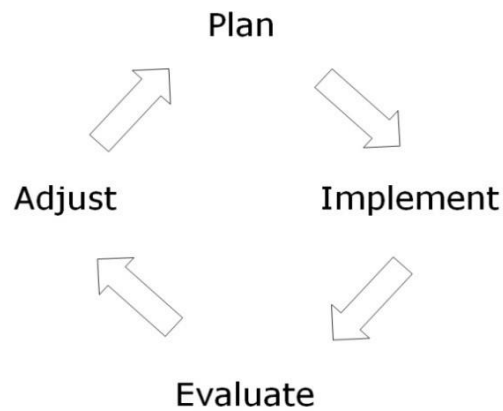
### How the adaptive nutrient management process works

Adaptive nutrient management is a process for evaluating and adjusting nutrient management based on data collected at the field level following a set of protocols. Adaptive management (fig. 1) can help producers make better nutrient management decisions leading to reduced nutrient inputs, higher yields, increased profits, and improved environmental benefits such as water quality.

Four basic steps are involved:

*Step 1* Develop the plan for the evaluation.

*Step 2* Implement the nutrient management plan. *Step 3* Evaluate the plan based on lessons learned. *Step 4* Adjust the nutrient management.



**Figure 1. Adaptive nutrient management process**

Adaptive nutrient management is a on-going evaluation and learning process, as compared with the more common prescriptive process used to develop nutrient management plans. Specifically, adaptive nutrient management tailors nutrient management for the grower's unique farming operation. The iterative evaluation also helps growers to better tailor conservation practices that are best suited to their unique farming operations to address identified natural resource concerns.

## SUBAPPENDIX C: MARYLAND NUTRIENT MANAGEMENT REGULATIONS (EXCERPTS)

COMAR 15-20-07 defines NMP as “a plan prepared by a certified nutrient management consultant to manage the amount, placement, timing, and application of animal manure, fertilizer, biosolids, or other plant nutrients in order to minimize nutrient loss or runoff, and maintain the productivity of soil when growing agricultural products.” At this time all operators who use chemical fertilizer, animal manure, and/or biosolids must have a NMP addressing both N and P as the limiting nutrients on that agricultural operation.

### COMAR 15-20-08

A nutrient management plan prepared for an agricultural operation indicates how primary nutrients are to be managed annually on farm fields for plant and crop production and for the protection of water quality. Plans contain recommendations to the agricultural operator based on expected crop yield or plant production goals, existing nutrient levels in the soil, organic residuals, optimum timing and placement of nutrients, environmental protection, and normal agricultural practices, such as liming, tillage, and crop rotation. The Department certifies and licenses qualified individuals to prepare plans under COMAR 15.20.04 and requires agricultural operations to implement the plans under COMAR 15.20.07.

The performance and technical standards provided in this subtitle are found in the Department of Agriculture's Maryland Nutrient Management Manual, which is incorporated by reference in COMAR 15.20.07.02.

NMPs will contain identification and a map in addition to D. Plan Elements. A plan shall contain the following, when applicable:

- (1) All nutrient recommendations for the period the plan is effective, including crop rotations or recommendations for alternative cropping plans, if applicable, within specific field or management unit information, described under §E of this regulation;
- (2) The type and average number of animals annually raised, maintained, or housed on the agricultural operation;
- (3) The quantities of animal manure or waste produced and available from animal housing or waste storage structures during the period the plan covers;
- (4) The total animal manure used as crop nutrients, including manure from on-farm and off-farm sources, and its nutrient analysis;
- (5) The quantity of animal manure or waste and location of alternative use, including land application off-site, processing, composting, or other uses of unused animal manure or waste;
- (6) The source and type of information used to determine expected crop yield or plant production goal;
- (7) Any recommendation to change management, install additional best management practices, or implement alternative technologies to reduce risk potential for nutrient movement;
- (8) Any recommendation to ensure efficient application of fertilizers; and
- (9) Any determination of the limiting nutrient as required under Regulation .04 of this chapter, including use of a risk analysis tool indicating the potential for nutrients to move into surface water or ground water, based on current conditions.

E. Field or Management Unit Specific Information. A plan shall contain data for each field or area where nutrients will be applied and shall include:

- (1) The date the recommendations are prepared or updated;
- (2) An account identification number;
- (3) The watershed location code;
- (4) The field or management unit number or identifier and acreage;
- (5) A soil analysis;
- (6) The expected crop or plant and expected crop yield or plant production goal for the period covered by the plan;
- (7) Any crop rotation or recommendation for alternative cropping plans, if applicable, to:
  - (a) Provide the operator greater flexibility, and
  - (b) Minimize the need for a plan update;
- (8) The primary nutrient requirements based on expected crop yield or plant production goals;
- (9) Any available nutrients in the soil from the previous crop and mineralization and bioavailability assumptions for organic nutrient sources;
- (10) The nutrients to be applied from all fertilizer sources to meet the crop or plant nutrient requirements;
- (11) Any recommendation for:
  - (a) The liming of the soil,
  - (b) The application time for nutrients, including split applications, and the use of diagnostics to determine crop nutrient requirements,
  - (c) Any nutrient application method,
  - (d) The need to calibrate application equipment,
  - (e) The incorporation of natural organic fertilizers, and
  - (f) Any management strategy to achieve soil fertility within an optimal range; and
- (12) Current or recommended tillage method.

F. Summary of Nutrient Recommendations. A plan shall contain a summary section that lists the following information for each farm field or management unit:

- (1) The field or management unit identifier or number;
- (2) The field or management unit acreage;
- (3) The expected crop or plant;
- (4) The expected crop yield or plant production goals for the period covered by the plan;
- (5) Any recommended nutrient rates;
- (6) The amount and type of nutrients, including chemical fertilizer or natural organic fertilizer, per acre or management unit;
- (7) The nutrient application method and, if application method requires incorporation of the nutrient, timing for incorporation; and
- (8) Any liming recommendations, if needed.

#### *.5 5 Nutrient Management—Required Plan Recommendations.*

A. A certified nutrient management consultant or certified farm operator shall address all of the elements and use the criteria described in §§B—I of this regulation to determine recommendations in a nutrient management plan. A consultant's or certified farm operator's recommendations shall be consistent with the Department technical standards and criteria as provided in the Maryland Nutrient Management Manual, Sections I, II, and III.

#### B. Nutrient Rates.

- (1) Nutrient rates of the primary nutrients shall be calculated for plant growth requirements of the crop.
- (2) Plant growth requirements shall be based on one of the following:
  - (a) University of Maryland Plant or Crop Nutrient Recommendations, as provided in the Maryland Nutrient Management Manual, Section I-B; or
  - (b) Alternative standards, as provided in scientifically validated data for the development of a nutrient management plan acceptable to the Department.
- (3) A consultant or certified farm operator may recommend the use of lime, secondary nutrients, or micronutrients needed for optimal plant growth.
- (4) A consultant or certified farm operator may recommend nutrient rates that deviate from University of Maryland Plant or Crop Nutrient Recommendations and alternative standards provided in the Maryland Nutrient Management Manual, Section I-B, for application on farm test plots with prior approval from the Department.
- (5) A consultant or certified farm operator may recommend nutrient rates based on a single variety tissue sample when used in conjunction with a soil sample.

#### C. Expected Crop Yield or Production Goal.

- (1) The calculation of expected crop yield shall be based upon one of the following:
  - (a) An average of the 3 highest-yielding years for the crop out of the latest consecutive 5-year cropping sequence; or
  - (b) If yield information exists for more than 5 years for a given field or management unit, crop yield calculations may be based on the average of 60 percent of the highest-yielding years for all consecutive years that crop yield information is available.
- (2) If field or management unit-specific yield or plant production goal information is unavailable or unrepresentative due to the inclusion of new seed varieties, irrigation, or new technologies, a consultant or certified farm operator shall use one of the following:
  - (a) Any soil productivity information;
  - (b) The average yield based upon an average of the 3 highest-yielding years for the crop out of the latest consecutive 5-year cropping sequence from nearby fields or management units with similar soil type and management conditions; or
  - (c) Any data acceptable to the Department.
- (3) A consultant shall document what information was used as the basis for determining expected yield goal as part of the consultant's record-keeping requirements.

#### D. Soil Analysis Results.

- (1) Soil analysis results for each field or management unit shall be based on standard soil sampling and analysis methods acceptable to the Department.
- (2) Soil Samples. Variations from the standard sampling process shall be documented by the consultant or certified farm operator and may include:
  - (a) Soil samples collected from larger fields or acreage with uniform characteristics, including soil types, moisture, or fertility management history; crop rotations may be sampled as one management unit;
  - (b) Soil samples from fields, such as those common to strip cropping, which may be combined if the soils, previous cropping history, and soil fertility management are similar; and
  - (c) Any specialized production unit which may warrant smaller sampling units.

- (3) Soil analysis results for a plan are valid for 3 years, except if the following conditions exist and are documented by the consultant or certified farm operator:
- (a) A less frequent soil analysis is required to implement a management system based on new technologies;
  - (b) The management system does not require any nutrient application; or
  - (c) The management system requires nutrient application at a frequency less than once every 3 years.
- (4) A recommendation for more than one planting season or crop may be made if anticipated soil fertility changes from the following are documented:
- (a) Previous and future crop rotations; and
  - (b) Residual soil nutrients and nutrients used for previous crops.

E. Determination of Limiting Nutrient.

- (1) A consultant or certified farm operator shall:
- (a) Use the criteria in this section to determine which nutrient is the limiting factor in the application of nutrients; and
  - (b) Recommend subsequent nutrient management strategies consistent with this section.
- (2) Soil fertility shall be used as an indicator of whether nutrient recommendations should be adjusted to address potential nutrient pollution problems.
- (3) If the soil sample analysis results show a phosphorus fertility index value (FIV) of less than 150, nutrient recommendations may use nitrogen plant needs as the limiting factor.
- (4) Phosphorus.
- (a) If the soil sample analysis results show a phosphorus fertility index value (FIV) of 150 or greater, a phosphorus site index or other phosphorus risk assessment method acceptable to the Department, as provided in the Maryland Nutrient Management Manual, Section II-B, shall be used to determine the potential risk of phosphorus loss due to site characteristics.
  - (b) If the risk for potential movement of phosphorus from the site is low according to the phosphorus site index, nutrient recommendations by the consultant or certified farm operator may use nitrogen plant needs as the limiting factor.
  - (c) If the risk for potential movement of phosphorus from the site is medium according to the phosphorus site index:
    - (i) Nutrient rates shall be based on nitrogen plant needs as the limiting factor no more than 1 out of every 3 years. Phosphorus rates the other 2 years shall be limited to the expected amount removed from the field by the crop or plant harvest, or the amount indicated by soil testing in accordance with the recommendations described in the Maryland Nutrient Management Manual, Section I-B, whichever is greater; or
    - (ii) Nutrient recommendations may use nitrogen plant needs as the limiting factor if BMPs are implemented by the operator and address site or management characteristics to reduce the risk of phosphorus loss to low.
  - (d) If the risk for potential movement of phosphorus from the site is high according to the phosphorus site index:
    - (i) Phosphorus rates shall be limited to the expected amount removed from the field by the crop or plant harvest, or the amount indicated by soil testing, in accordance with the recommendations described in the Maryland Nutrient Management Manual, Section I-B; or
    - (ii) If BMPs are implemented by the operator, and address site or management



characteristics to reduce the risk of phosphorus loss to medium, nutrient rates may be based on nitrogen plant needs as the limiting factor not more than 1 out of every 3 years. Phosphorus rates the other 2 years shall be limited to the expected amount removed from the field by the crop or plant harvest, or the amount indicated by soil testing or in accordance with recommendations described in the Maryland Nutrient Management Manual, Section I-B, whichever is greater.

(e) If the risk for potential movement of phosphorus from the site is very high according to the phosphorus site index:

- (i) No additional phosphorus may be applied; or
- (ii) If BMPs are implemented by the operator, and address site or management characteristics to reduce the risk of phosphorus loss to high, recommended rates of application of phosphorus shall be limited to the expected amount removed from the field by the crop or plant harvest, or the amount indicated by soil testing in accordance with recommendations described in the Maryland Nutrient Management Manual, Section I-B.

(5) Before the deadlines set forth in COMAR 15.20.07.03 for the development of a phosphorus-based plan, a certified nutrient management consultant or certified farm operator may use:

- (a) The requirements of §E(1)—(3) of this regulation as a planning tool to determine if future management changes are indicated by the P index, and if development of a phased-in approach to a phosphorus-based plan should be recommended; or
- (b) §E(1)—(3) of this regulation as a guide to determine nutrient management recommendations.

#### F. Natural Organic Fertilizer.

(1) An agricultural operator who uses natural organic fertilizer shall determine its nutrient value as specified in this section.

(2) Test results for natural organic fertilizer shall be determined by an operator, consultant, or certified farm operator using standard sampling and analysis methods acceptable to the Department.

(3) The consultant or operator shall conduct animal manure or waste analysis as close to application time as possible, or a consistent baseline for nutrient content may be established and used from analysis results taken at least twice a year until a uniform value is confirmed, and then for every second year thereafter to verify its consistency. If significant changes occur, including feed, management, animals, or storage, a new analysis for nutrient content shall be determined by the consultant or operator for the new manure.

(4) Biosolids analysis shall be conducted according to COMAR 26.04.06.09A(13)(d) as close to nutrient application time as possible, but at least once a year. If changes occur in a sewage treatment facility, or routine biosolids analysis reveals a significant change in available nutrient content during the permit period, nutrient application rates shall be adjusted accordingly by the consultant, or certified farm operator, or the operator.

(5) Analysis of any other natural organic fertilizer or organic materials shall be conducted by the operator as close to nutrient application time as possible, but at least once a year.

(6) Calculations for nutrient content from natural organic fertilizer shall consider mineralization rates and plant availability rates for different forms and sources of organic nutrients.

Mineralization of organic nitrogen from the 2 previous years of natural organic fertilizer

applications shall be accounted for in the plan.

G. Application Method for Nutrients. A consultant or certified farm operator shall consider the following when making recommendations on nutrient application methods in a plan:

- (1) Nutrient application shall be made to minimize nitrogen and phosphorus losses to waters and nitrogen volatilization losses to the atmosphere;
- (2) Techniques to achieve accurate and uniform application of nutrients shall be recommended by the consultant or certified farm operator and shall be used by the operator;
- (3) Split application of nitrogen on soils identified as having a high leaching potential;
- (4) Measures to minimize or control nutrient movement to sensitive areas, including natural or existing wetlands, sinkholes, and steep slopes; and
- (5) Recommendations shall ensure efficient application of fertilizers and may include crop rotation, agronomic practices, tillage, and cover crop management.

H. Timing of Nutrient Application. Timing for nutrient applications, as recommended by a consultant or certified farm operator and conducted by an operator, shall:

- (1) Be as close to plant nutrient uptake periods as possible;
- (2) Maximize plant utilization efficiency and minimize the potential for nutrient movement; and
- (3) Be consistent with the guidelines contained in the Maryland Nutrient Management Manual, Section I-D.

I. Manure Management. When an agricultural operation either produces animals or integrates animal manure use with crop production, a consultant or certified farm operator shall:

- (1) Take into account the current manure management measures being used to store, stockpile, and handle animal manure and waste nutrients associated with animal production in order to make appropriate recommendations for application rates, timing, and methods;
- (2) Evaluate existing conditions and procedures and advise the operator when manure management changes, such as improved stockpiling or storage facilities, would minimize the potential for nutrient loss or runoff or improve nutrient use efficiency and proper timing of manure utilization; and
- (3) Take into account animal manure or waste nutrients associated with animal production and all other sources of nutrients when making recommendations.

*.6 6 Nutrient Management for Container or Out-of-Ground Agricultural Production — Additional Required Plan Content.*

A. A certified nutrient management consultant or certified farm operator shall prepare, and an operator of container or out-of-ground agricultural production shall conform to the requirements of §§B—H of this regulation, in addition to applicable requirements described in this chapter, when developing and implementing, a nutrient management plan.

B. Plan Elements. A plan shall contain a summary of planned plant production applicable to the site, including:

- (1) A listing of plants to be grown by name, species, and variety and cultivar or both; however, if more than 20 different kinds of plants are grown, general plant categories may be used, such as herbaceous, deciduous shrub, coniferous evergreen, broadleaf evergreen, or trees;
- (2) The estimated greatest number of plants, units, or containers that will be in production at any one time during a calendar year and the month this will occur;

- (3) The estimated percentages of plants, units, or containers in the following container size categories:
- (a) Less than 1 gallon (less than 2,492 cubic centimeters container volume),
  - (b) From 1 to 3 gallons (2,492 to 12,164 cubic centimeters),
  - (c) Greater than 3 gallons and less than 15 gallons (more than 12,164, but less than 45,376 cubic centimeters), or
  - (d) 15 gallons or greater (45,376 cubic centimeters or more);
- (4) An inventory, which may include projected changes during the life of the plan, taken by the operator for any purpose within 12 months of completion of the plan, which shall meet the requirements of §B(1), (2), and (3) of this regulation, if the inventory is representative of planned production during the period covered by a nutrient management plan;
- (5) Total growing area under the plan, which may include projected changes in growing area planned to take place during the life of the plan.

C. Summary of Nutrient Recommendations. A plan shall contain summary information on the total amount of primary nutrients recommended for each calendar year covered by the plan, including:

- (1) The estimated total amounts of nitrogen, phosphorus, and potash;
- (2) A listing of all sources of nutrients;
- (3) The estimated amounts of each source of nutrients to be applied for each quarter of the year; and
- (4) A listing or description of the application method or methods for each nutrient.

D. Assessment of Environmental Risk. A nutrient management plan shall contain an assessment of the risk of nutrient losses to surface water, using the Environmental Risk Assessment for out-of-ground production provided in the Maryland Nutrient Management Manual, Section II-D.

E. General Management Recommendations. A plan shall contain general recommendations to ensure efficient application of nutrients, including:

- (1) The calibration of equipment;
- (2) The timing and application methods for water and nutrients;
- (3) Management options to maximize the efficient use of water;
- (4) Any operator management options to reduce nutrient losses; and
- (5) Any other best management practices that may be applicable as provided in the Maryland Nutrient Management Manual, Section II-E.

F. Specific Management Recommendations. A consultant or certified farm operator shall recommend growing area or section-specific management techniques to improve water use efficiency and minimize nutrient losses, including the following:

- (1) Grouping plants to improve water and nutrient usage;
- (2) Monitoring water and nutrient needs of plants;
- (3) Increasing the percentage of water and nutrients entering the plant root zone;
- (4) Reducing the amount of leachate or runoff; and
- (5) Reducing or containing the flow of water from growing areas.

G. Program for Monitoring Runoff. A nutrient management plan shall include recommendations to monitor runoff, as required in Regulation .07C of this chapter, including recommendations

on methods, frequency, and locations of monitoring.

H. Plan Maintenance. A plan shall contain information to maintain and update the plan.

General comments about plan maintenance may be summarized, but shall include:

- (1) The length of time the plan is effective, not to exceed 3 years; and
- (2) Identification of changes in the agricultural operation that would require the original plan to be modified or updated, including a:
  - (a) Change in area managed of 20 percent or greater, or 5 acres, whichever is less, or
  - (b) Substantial change in a production plan or method.

*.7 7 Nutrient Management—Required Plan Recommendations for Container or Out-of-Ground Production.*

A. Nutrient Recommendations. A certified nutrient management consultant or certified farm operator shall evaluate production cycles and methods and make nutrient recommendations based on at least one of the following:

- (1) The label recommendations on fertilizer products for the plants being grown or similar plants;
- (2) The recommendations of the University of Maryland Cooperative Extension for the specific plants being grown or for similar plants;
- (3) The recommendation from other state universities for the specific plants being grown or for similar plants;
- (4) The data from research done by accredited universities on the specific plants being grown or similar plants;
- (5) The general nutrition guidelines for similar plants; or
- (6) Any generally accepted growing practices for plants under comparable growing conditions.

B. Management Recommendations.

- (1) A consultant or certified farm operator shall use the Environmental Risk Assessment for out-of-ground production, as provided in the Maryland Nutrient Management Manual, Section II-D, to identify the potential risk to the environment of nutrient movement from out-of-ground growing areas.
- (2) For growing areas where there is zero or low risk of nutrient movement from the site, recommendations shall be made to maintain this zero or low level of risk.
- (3) For growing areas where there is medium risk of nutrient movement:
  - (a) Management recommendations shall be made to minimize the risk of nutrients moving to, or reaching, surface waters; and
  - (b) The consultant or certified farm operator shall recommend that the operator or other person responsible for irrigation and nutrient management attend Department-approved training on best management practices for out-of-ground production to minimize nutrient losses.
- (4) For growing areas where there is high risk of nutrient movement:
  - (a) Management recommendations shall be made for individual growing areas, as well as for the operation as a whole, to reduce the risk of nutrients moving to, or reaching, surface waters;
  - (b) The consultant or certified farm operator shall recommend that the operator or other person responsible for irrigation and nutrient management attend Department-approved training on best management practices for out-of-ground production that teaches how to minimize nutrient losses; and

- (c) Only controlled release fertilizer shall be recommended for use until management changes reduce the risk of nutrient loss to medium.
- (5) In recommending field or management unit practices to reduce or minimize nutrient losses, a consultant or certified farm operator shall consider the following:
  - (a) The appropriate nutrient application methods;
  - (b) Nutrient application timing; and
  - (c) Any plant nutrient needs.
- (6) Timing of nutrient application shall be as close to plant nutrient uptake as possible, except in the case of controlled release fertilizer, which may be applied at any time.

C. Recommendations for Monitoring Runoff. Unless an operation is assessed as zero risk for nutrient loss from the site, as provided in the Maryland Nutrient Management Manual, Section II-D, the nutrient management consultant shall recommend a monitoring program, including the following:

- (1) The periods for monitoring when plant nutrients can reasonably be expected to be available;
- (2) The locations immediately next to growing areas or areas where runoff or overflow from collection basins enters surface water, municipal stormwater, or drainage inlets; and
- (3) The frequency of sampling for nutrients:
  - (a) Where the risk of nutrient movement from any growing area is low, monitoring shall include samples for testing a minimum of two different times during each growing season or cycle from each location; and
  - (b) Where the risk of impacting surface water is medium or high, monitoring recommendations shall be conducted monthly when nutrients are being applied.

D. Methods of Sampling and Testing. Samples may be analyzed by the operator or consultant on-site using calibrated electrical conductivity (EC) or nutrient meters. To evaluate the accuracy of on-site test results, at least two samples per year shall be split, with one part being sent to an independent laboratory for analysis.

# SUBAPPENDIX D: PENNSYLVANIA NUTRIENT MANAGEMENT REGULATIONS (EXCERPTS)

## Act 38 Regulations

### Subchapter D. NUTRIENT MANAGEMENT

#### § 83.201. Definitions

*Plan—Nutrient management plan—*

(i) A written site-specific plan which meets the requirements in the act, and in § § 83.271, 83.272 and 83.281— 83.381.

*CAO—Concentrated animal operation—*Agricultural operations with eight or more animal equivalent units where the animal density exceeds two AEUs per acre on an annualized basis.

*VAO—Voluntary agricultural operation—*

(i) Any operation that voluntarily agrees to meet the requirements of this subchapter even though it is not otherwise required under the act or this chapter to submit a nutrient management plan.

(ii) The term includes agricultural operations applying for financial assistance under the act.

#### § 83.207. Compliance assistance and enforcement.

(a) The Department of Agriculture will assist the Commission in developing programs to assist those engaged in production agriculture to comply with the act and this subchapter.

(b) The Department of Agriculture will act as an ombudsman to help resolve issues related to county conservation district implementation of the act and this subchapter for those conservation districts delegated nutrient management program responsibilities under § 83.241 (relating to delegation to local agencies).

(c) The Commission will be responsible for taking enforcement actions under the act and this subchapter. In the exercise of its enforcement authority, the Commission will be assisted by the staff of the Department for actions resulting in violations of The Clean Streams Law (35 P. S. § § 691.1—691.1001) and will be assisted by the Department of Agriculture for all other violations.

*Commission—*The State Conservation Commission established by the Conservation District Law (3 P. S. § § 849—864).

#### § 83.241. Delegation to local agencies.

(a) The Commission may by written agreement delegate to a conservation district one or more of its administrative or enforcement authorities under the act.

(b) The delegation of administrative or enforcement authority may be made to a conservation district when the district demonstrates it has or will have an adequate program and sufficient resources to accept and implement the delegation.

#### § 83.272. Content of plans.

(e) The only nutrient elements of concern to be addressed by BMPs in the plan, based on their potential to impact the quality of surface water or groundwater, are nitrogen and phosphorus. Unless the context clearly indicates otherwise, “nutrients” as used in this subchapter means nitrogen and phosphorus.

(f) The plan must list potassium crop needs, and potassium application rates, from all nutrient sources, to ensure that adequate soil fertility levels are addressed to meet crop production goals.

#### **§ 83.272. Content of plans**

Required elements of a NMP include:

- The crop rotation planned to be used on the operation.
- The total acreage of land of the agricultural operation on which nutrients shall be applied.
- The total number of AEUs on the operation, and the number of AEUs per acre on the agricultural operation.
- The identification of all soil types and slopes on the agricultural operation.
- The location of areas where manure application is restricted.

*Phosphorus.* The plan must include an appendix containing information and calculations used to comply with § 83.293(c) (relating to determination of nutrient application rates). If the Phosphorus Index is used, the information must include the completed Phosphorus Index spreadsheet or other similar information summary which lists the individual source and transport factor values, as appropriate, and the final Phosphorus Index result, for each individual area evaluated on the operation, as developed under the Phosphorus Index.

Soil test results.

#### **§ 83.282. Summary of plan.**

(a) The plan must contain a summary that includes:

(1) A manure summary table listing:

- (i) The total amount of manure planned to be generated on the operation annually.
- (ii) The total amount of manure planned to be used on the operation annually.
- (iii) The total amount of manure planned to be exported from the operation annually.

(2) A nutrient application summary documenting the planned nutrient applications for each crop management unit listing:

- (i) Acres.
- (ii) Expected yield.
- (iii) Nutrients applied as starter chemical fertilizer.
- (iv) Planned manure application period.
- (v) Planned manure application rate and type of manure to be applied.
- (vi) Planned manure incorporation time.
- (vii) Rate of other organic nutrient sources planned to be applied.
- (viii) Other nutrients applied through chemical fertilizer.

### **NUTRIENT APPLICATION**

#### **§ 83.291. Determination of available nutrients.**

(a) The plan must address each type of nutrient source generated or planned to be used on the agricultural operation, including: manure, biosolids, compost, commercial fertilizers and other nutrient sources. Nitrogen and phosphorus are the only nutrient elements of concern to be addressed by BMPs in the plan.

(b) The plan must list potassium crop needs, and potassium application rates, from all nutrient sources, to ensure that adequate soil fertility levels are addressed to meet crop production goals.

(c) The amount and nutrient content of each manure group generated on the agricultural operation shall be documented in the plan as follows:

(1) List the average number of animals for each manure group, on the agricultural operation.

(2) List the amount of manure generated and when it is available for land application on the agricultural operation or for other planned uses.

(i) If actual manure production records are available for the operation, these records shall be used for determining the manure produced on the operation.

(ii) If actual records of manure production do not exist for the operation, the amount of manure produced shall be calculated based on the average number of animal units on the agricultural operation, and the storage capacity of manure storage facilities, if present. The plan must include the calculations or variables used for determining the amount of manure produced on the operation.

(3) Test the nutrient content of manure as follows:

(i) Analytical manure testing results shall be used in the development of the plan. These manure tests must include an analysis of the percent solids, total nitrogen (as N), ammonium nitrogen (as  $\text{NH}_4\text{-N}$ ), total phosphate (as  $\text{P}_2\text{O}_5$ ) and total potash (as  $\text{K}_2\text{O}$ ), for each manure group generated on the operation, and these analytical results shall be recorded in the plan.

(ii) These manure analyses shall be performed using manure sampling and chemical analysis methods which accurately represent the contents of the manure. Methods described in the *Pennsylvania Agronomy Guide* may be used to meet this requirement. Other methods shall be approved by the Commission.

(iii) For newly proposed operations, and for manure groups on existing operations where sampling and analysis are not possible prior to initial plan development, the following applies:

(A) The plan must use either standard book values, or analytical results from a similar facility as approved by the Commission or delegated conservation district.

(B) Standard book values contained in the *Pennsylvania Agronomy Guide* may be used to meet this requirement. Other values shall be approved by the Commission.

(C) A similar facility is one that uses similar animal housing, animal groups, feeding practices and wastewater management.

(D) The nutrient content of the manure, as determined in clauses (A)—(C), shall be recorded in the plan.

(E) Samples and chemical analysis of the manure generated on the operation shall be obtained within 1 year of implementation of the approved plan, and the requirements of §

83.371 (relating to plan amendments) shall be followed as applicable.

(iv) The nutrient content of manure deposited on pastures by grazing animals shall be determined using the methods contained in subparagraph (vi).

(v) After approval of the initial plan, manure tests are required to be taken annually



for each manure group generated on the operation.

(vi) The testing described in this subsection will not be required for manure groups associated with less than five AEUs of livestock or poultry at an operation. For these small quantity manure groups, the nutrient content of the manure may be determined using standard book values which represent the contents of the manure for the operation. Standard book values contained in the *Pennsylvania Agronomy Guide* may be used to meet this requirement. Other values shall be approved by the Commission or delegated conservation district.

(vii) Testing of manure groups may be consolidated when two or more manure groups on the same operation are produced by the same animal type and are managed in a similar manner.

(d) The nitrogen available from manure shall be based on availability factors which accurately represent the characteristics of the manure. Factors described in the *Pennsylvania Agronomy Guide* may be used to meet this requirement. Other methods shall be approved by the Commission. The plan must include the amount of nitrogen available in the manure, and the planned manure incorporation time used to determine the nitrogen available.

(e) The residual nitrogen from legume crops and previous applications of manure shall be determined using values which represent the common nitrogen residuals from the past crops and manure applications at the operation. Standard book values contained in the *Pennsylvania Agronomy Guide* may be used to meet this requirement. Other values shall be approved by the Commission. The values shall be recorded in the plan and credited when determining nutrient application rates.

Acreage and realistic expected crop yields for each crop management unit.

When developing the initial NMP, soil tests shall be conducted for each crop management unit on the operation, to determine the level of phosphorus (as P), potassium (as K), and soil pH. Soil tests conducted within the previous 3 years prior to submitting the initial plan are acceptable. After the approval of the initial plan, soil tests are required for each crop management unit at least every 3 years from the date of the last test.

Based on the soil tests in subsection (e), the plan must include recommendations for the amount of nitrogen (as total N), phosphorus (as P<sub>2</sub>O<sub>5</sub>) and potassium (as K<sub>2</sub>O) necessary for realistic expected crop yields.

### **§ 83.293. Determination of nutrient application rates.**

(a) *Application rate.* Application rates shall be developed to protect surface water and groundwater using BMPs as described in the plan. The manure application rate shall be the lesser of the following:

(1) A rate equal to or less than the balanced manure application rate based on nitrogen as determined under subsection (b).

(2) The rate as determined under subsection (c).

(b) *Nitrogen.* Land application of manure and other nutrient sources on cropland, hayland and pastures shall be managed to minimize the effects of nitrogen losses from fields. The rate may not exceed the amount of nitrogen necessary to achieve realistic expected crop yields or the amount of nitrogen the crop will utilize for an individual crop year.

(1) The balanced manure application rate based on nitrogen shall be determined by first

subtracting the amount of available residual nitrogen and any applied nitrogen, such as nitrogen applied in starter fertilizer, from the amount of nitrogen necessary for realistic expected crop yields, and then dividing that amount by the available nitrogen content of the manure as determined under § 83.291 (relating to determination of available nutrients).

(2) The calculations and variables used for determining the balanced manure application rates based on nitrogen shall be recorded in the plan.

(c) *Phosphorus*. Land application of manure and other nutrient sources on cropland, hayland and pastures shall be managed to minimize the effects of phosphorus losses from fields. Methods for determining and managing the risk of phosphorus loss, and related water quality impacts, must comply with the following:

(1) Determine the risk of phosphorus loss and related water quality impacts based on relevant factors including the following:

- (i) Soil phosphorus levels.
- (ii) The method, rate and timing of phosphorus application.
- (iii) Runoff and soil loss potential for the application area.
- (iv) Distance to surface water.
- (v) The type of phosphorus source being used.

(2) Based on the risks and impacts determined as described in paragraph (1), establish appropriate BMPs such as methods, rates and timing of application designed to minimize the effects of phosphorus losses from fields. These may be addressed by a range of options, including:

- (i) Manure application is limited to nitrogen requirements of the crop, if the application of phosphorus to the soil is not expected to pose an immediate risk of impacts to surface water.
- (ii) Phosphorus application is limited to the level of phosphorus removal from the soil by the crop, if the application of phosphorus to the soil would be expected to pose an immediate risk of impacts to a surface water unless the risk is managed by limiting the application based on phosphorus.
- (iii) Phosphorus application is completely restricted, if the application of phosphorus to the soil would be expected to pose an immediate risk of impacts to a surface water which cannot be managed by limiting the nutrients based on phosphorus.

(3) For CAOs and VAOs existing on October 1, 2006, the Commission will allow a phase-in period until December 31, 2010, to fully meet the requirements of paragraph (2).

- (i) The phase-in shall allow flexibility in controlling phosphorus loss, as long as the phosphorus application rates on any crop management unit where the phase-in is used do not exceed the levels of phosphorus removal from the soil by the crops.
- (ii) The phase-in in this paragraph also applies to operations that import manure from NMP operations existing on October 1, 2006.

(4) The phase-in period in paragraph (3) does not apply to the following:

- (i) An operation that commences after October 1, 2006.

- (ii) An operation that becomes defined as a CAO, due to an increase in animal numbers, after October 1, 2006.
- (iii) An operation that increases the total AEUs on the operation by 20% or more after October 1, 2006.
- (iv) An operation that adds a new animal type after October 1, 2006.
- (v) Fields where the nearest downgradient stream segment which receives runoff from the fields is classified as a special protection water under Chapter 93 (relating to water quality standards).

(5) The criteria and procedures in the current phosphorus application guidance issued by the Commission may be used to comply with paragraphs (1)—(4), including the use of a Phosphorus Index contained in the guidance.

(6) If the criteria and procedures in the phosphorus application guidance issued by the Commission are not followed, an alternative method of meeting paragraphs (1)—(4) will be approved by the Commission.

(7) For pastures which require complete restrictions on phosphorus application as determined under this section, § 83.294(j) (relating to nutrient application procedures) applies.

(d) *General nutrient calculation.* The plan must include calculations for each crop management unit indicating the difference between the amount of nitrogen, phosphorus and potassium necessary for realistic expected crop yields under § 83.292 (relating to determination of nutrients needed for crop production) and the nitrogen, phosphorus and potassium applied through all planned nutrient sources, including, but not limited to, manure, biosolids, starter fertilizer and other fertilizers and residual nitrogen. A nitrogen availability test may be used to determine supplemental nitrogen needs.

#### **§ 83.294. Nutrient application procedures.**

(a) *General.* Nutrients shall be applied to fields during times and conditions that will hold the nutrients in place for crop growth, and protect surface water and groundwater using BMPs as described in the plan.

(b) *Timing.* Intended target spreading periods for the application of manure shall be included in the plan.

(c) *Equipment capabilities.* Manure application rates and procedures must be consistent with the capabilities, including capacity and calibration range, of available application equipment. For existing operations using their own application equipment, the plan must include a statement indicating that the existing equipment has been calibrated to ensure implementation of the application rates described in the plan, and that the equipment has the capacity to meet those application rates. If a commercial manure hauler is used, the hauler shall be responsible for ensuring that the equipment is capable of complying with the application rate contained in the plan.

(d) *Irrigation systems.* If manure will be applied using an irrigation system, the following applies:

(1) Application rates for irrigated liquid manure shall be based on the lesser of the following:

- (i) The planned application rates in gallons per acre determined in accordance

with § 83.293(a) (relating to determination of nutrient application rates).

(ii) The combination of the following:

(A) The liquid application rate in inches per hour determined to be within infiltration capabilities of the soil.

(B) The liquid application depth in inches not to exceed the soil's water holding capacity within the root zone or any restricting feature at the time of application.

(2) The allowable liquid application rate and application depth shall be based on appropriate factors such as available water holding capacity of the soil, depth of the root zone, depth to a shallow impervious soil layer, soil infiltration rate, soil texture and drainage, vegetation and ground slope. Application BMPs that are consistent with the current versions of Penn State Fact Sheets F254 through F257, as applicable to the type of irrigation system planned to be used on the operation, and the *NRAES-89 Liquid Manure Application System Design Manual*, may be used to comply with this subsection. Other BMPs shall be approved by the Commission.

(3) The plan must include the computations for the application rate (in inches per hour) and application depth (in total inches) of the various application rates, and these applications may not exceed either the infiltration rate or the water holding capacity of the application sites, as listed in the plan.

(e) *Manure application at rates greater than 9,000 gallons per acre.* If liquid or semisolid manure is planned to be applied at rates greater than 9,000 gallons per acre at any one application time, the rates and amounts shall be limited based on the infiltration rate and water holding capacity of the application areas as described in subsection (d). In those instances, the plan must include the computations for the application rates in inches per hour, and in total inches, for the various application areas, and these applications may not be allowed to exceed either the infiltration rate or the water holding capacity of the application sites, as listed in the plan.

(f) *Setbacks and buffers.* Manure may not be mechanically applied in the following situations:

(1) Within 100 feet of the top of the bank of a perennial or intermittent stream with a defined bed and bank, a lake or a pond, unless a permanent vegetated buffer of at least 35 feet in width is used, to prevent manure runoff into the stream, lake or pond.

(2) Within 100 feet of an existing open sinkhole unless a permanent vegetated buffer of at least 35 feet in width is used.

(3) Within 100 feet of active private drinking water sources such as wells and springs.

(4) Within 100 feet of an active public drinking water source, unless other State or Federal laws or regulations require a greater isolation distance.

(5) On crop management units having less than 25% plant cover or crop residue at the time of manure application, unless:

(i) For fall applications, the crop management unit is planted to a cover crop in time to allow for appropriate growth to control runoff until the next growing season, or the manure is injected or mechanically incorporated within 5 days using minimal soil disturbance techniques consistent with no-till farming practices. The *Pennsylvania Technical Guide* contains practices which may be used to satisfy this requirement. Other practices shall be approved by the Commission. The practices must be consistent with those in the agricultural

erosion and sediment control plan.

(ii) For applications in the spring or summer, the crop management unit is planted to a crop that growing season.

(iii) For winter applications, the crop management unit is addressed under subsection (g).

(g) *Winter application.* For winter application of manure, the following apply:

(1) The application procedures shall be described in the plan.

(2) The plan must list the following:

(i) The crop management units where winter application is planned or restricted.

(ii) The application procedures that will be utilized at those crop management units.

(iii) The field conditions that must exist for winter application.

(3) Setbacks listed in subsection (f) shall be implemented. In addition, during winter manure may not be mechanically applied in the following situations:

(i) Within 100 feet of an above-ground inlet to an agricultural drainage system, if surface flow is toward the aboveground inlet.

(ii) Within 100 feet of a wetland that is identified on the National Wetlands Inventory Maps, if the following are met:

(A) The wetland is within the 100-year floodplain of an Exceptional Value stream segment.

(B) Surface flow is toward the wetland.

(4) Fields where manure will be applied in winter must have at least 25% residue, or an established cover crop. The BMPs contained in the *Pennsylvania Technical Guide* may be used to satisfy this requirement. Other practices shall be approved by the Commission.

*Pastures requiring phosphorus restrictions.* If a pasture has been determined to require total restriction of phosphorus application under § 83.293(c), the risk of phosphorus loss shall be addressed by the following BMPs in lieu of total restriction of phosphorus application:

(1) Grazing may not be conducted within 50 feet of a perennial or intermittent stream, a lake or a pond.

(2) A prescribed grazing system shall be used to maintain an established stand of forage on the pasture area.

(3) The stocking rate shall be limited to ensure that the level of phosphorus deposited by the animals does not exceed the level of phosphorus removal from the soil by vegetation in the pasture.

(4) BMPs contained in the *Pennsylvania Technical Guide* may be used to meet the requirements in paragraphs (1) and (2). Other BMPs shall be approved by the Commission.

### **§ 83.321. Stormwater control.**

(a) In the preparation of a nutrient management plan under this subchapter, the nutrient management specialist shall conduct a review of the adequacy of existing stormwater control practices on croplands, haylands and pastures included in the plan to prevent nutrient pollution of surface water and groundwater. The specialist may confer with NRCS, conservation district staff

or others with expertise with nutrient runoff control. Based on this review, the plan must identify critical runoff problem areas.

(b) The nutrient management plan shall contain a list of specific stormwater control BMPs to address those critical runoff problem areas identified in the review required under subsection (a). Recordkeeping for nutrients, crop yields, soil tests, and manure generation.

# SUBAPPENDIX E: VIRGINIA NUTRIENT MANAGEMENT REGULATIONS (EXCERPTS)

## General

The VPA General Permit Regulation for Animal Feeding Operations (VPA AFO) General Permit was re-issued on November 16, 2004 after the original 10-year permit expired. The re-issued General Permit will retain the 10-year life, and expires on November 15, 2014. All AFOs with 300 or more confined AUs are covered by the General Permit.

## 7. Nutrient Management Plans

All NMPs must be revised by December 31, 2006 to include the most recent phosphorus management criteria adopted by Virginia DCR. The regulation also specifies that all plans revised after December 31, 2005 will include phosphorus as well as nitrogen limits. Based on this language, a NMP based on nitrogen alone, with no phosphorus application limits specified, will expire on December 31, 2006 regardless of the revision date. VA DCR is expecting to complete amendments to the Nutrient Management Training and Certification regulation in 2005. This regulation will determine the nature of phosphorus limits to be included in the revised NMPs.

All NMPs written after December 31, 2005, shall be developed by a certified nutrient management planner in accordance with §10.1-104.2 of the Code of Virginia. This shall be documented by a letter from DCR, and this documentation may be included in the approval letter. The previous permit only specified that the NMP be approved by DCR.

Requirements of VA General Permit: 7. The operator shall implement a nutrient management plan (NMP) approved by the Department of Conservation and Recreation. All NMPs written after December 31, 2005, shall be developed by a certified nutrient management planner in accordance with § 10.1-104.2 of the Code of Virginia.

The NMP shall be maintained on site. The NMP shall address the form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and phosphorus loss to ground and surface waters. NMPs written after December 31, 2005, and NMPs implemented after December 31, 2006, shall also include provisions to minimize phosphorus loss to ground and surface waters according to the most current standards and criteria developed by DCR at the time the plan is written (current version is Virginia Nutrient Management Standards And Criteria Revised October 2005). The NMP shall be enforceable through this permit. The NMP shall contain at a minimum the following information:

- a. Site map indicating the location of the waste storage facilities and the fields where waste will be applied;
- b. Site evaluation and assessment of soil types and potential productivities;
- c. Nutrient management sampling including soil and waste monitoring;
- d. Storage and land area requirements;
- e. Calculation of waste application rates;
- f. Waste application schedules; and
- g. A plan for waste utilization in the event the operation is discontinued.

8. Buffer zones shall be maintained as follows:

- a. Distance from occupied dwellings not on the owner's property ..... 200 feet (unless the occupant of the dwelling signs a waiver of the buffer zone)
- b. Distance from water supply wells or springs ..... 100 feet
- c. Distance from surface water courses
  - (1) 100 feet (without a vegetated buffer); or
  - (2) 35-foot wide vegetated buffer; or
  - (3) Other site-specific conservation practices may be approved by the department that will provide pollutant reductions equivalent or better than the reductions that would be achieved by the 100-foot buffer, or 35-foot wide vegetated buffer.
- d. Distance from rock outcropping (except limestone) ..... 25 feet
- e. Distance from limestone outcroppings ..... 50 feet
- f. Waste shall not be applied in such a manner that it would discharge to sinkholes that may exist in the area.

9. Records shall be maintained to demonstrate where and at what rate waste has been applied, that the application schedule has been followed, and what crops have been planted.

From the *Virginia Nutrient Management Standards and Criteria*, (Revised 2005): In addition to other management practices discussed in this section, animal waste or biosolids shall not be applied within the following setback areas around the specific features listed...



## SUBAPPENDIX F: WEST VIRGINIA NUTRIENT MANAGEMENT REGULATIONS (EXCERPTS)

From *Title 47 Legislative Rule*, Department Of Environmental Protection, Water Resources:

NMP required as part of application: A nutrient management plan that, must, to the extent applicable:

- Identify appropriate site-specific conservation practices to be implemented, including as appropriate buffers or equivalent practices to control runoff of pollutants into the waters of West Virginia;
- Identify protocols for appropriate testing of manure, litter, process wastewater, and soil;
- Establish protocols to land-apply manure, litter and/or process wastewater in accordance with site-specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients in the manure, litter and/or process wastewater; and
- Identify specific records that will be maintained to document the implementation and management of the minimum elements described hereinabove.

Annual reporting requirements for CAFOs. The permittee must submit an annual report to the Director, which must include:

13.1.h.4.A. The number and type of animals, as listed in paragraphs 13.1.b.4 and 13.1.b.6 above, whether in open confinement or housed under roof;

13.1.h.4.B. The estimated amount of total manure, litter or process wastewater generated by the CAFO in the previous twelve (12) months, measured in tons or gallons;

13.1.h.4.C. The estimated amount of total manure, litter or process wastewater transferred to another person by the CAFO in the previous twelve (12) months, measured in tons or gallons;

13.1.h.4.D. The total number of acres of land application covered by the NMP developed in accordance with this rule;

13.1.h.4.E. The total number of acres under the control of the CAFO that were used for land application of manure, litter or process wastewater in the previous twelve (12) months;

13.1.h.4.F. summary of all manure, litter or process wastewater discharges from the production area in the previous twelve (12) months, including date, time, and approximate volume;

13.1.h.4.G. statement indicating whether the current version of the CAFO's NMP was developed or approved by a certified nutrient management planner; and

13.1.h.4.H. The actual crop(s) planted and actual yield(s) for each field, the actual nitrogen and phosphorus content of the manure, litter or process wastewater, the results of calculations conducted in accordance with parts 13.1.h.5.A.2 and 13.1.h.5.B.4 below, and the amount of manure, litter or process wastewater applied to each field during the previous twelve (12) months; and, for any CAFO that implements a NMP that addresses rates of application in accordance with subparagraph 13.1.h.5.B of this rule, the results of any soil testing for nitrogen or phosphorus taken during the preceding twelve (12) months, the data used in calculations conducted in accordance with part 13.1.h.5.B.4 below, and the amount of any supplemental fertilizer applied during the previous twelve (12) months.

The terms of the NMP with respect to protocols for land application of manure, litter or process wastewater required by subparagraph 13.1.h.1.H above and, if applicable, 40 C.F.R. §412.4(c), must include the fields available for land application; field-specific rates of application, properly developed in accordance with subparagraphs 13.1.h.5.A through 13.1.h.5.B below, to ensure appropriate agricultural utilization of the nutrients in the manure, litter or process wastewater; and any timing limitations identified in the NMP concerning land application on the fields available for such use. The terms must address rates of application using either the linear approach or the narrative rate approach.

13.1.h.5.A. Linear approach. An approach that expresses rates of application as pounds of nitrogen and phosphorus, according to the following specifications:

13.1.h.5.A.1. The terms include maximum application rates from manure, litter or process wastewater for each year of permit coverage for each crop identified in the NMP, in chemical forms determined to be acceptable to the Director, in pounds per acre per year for each field to be used for land application, and certain factors necessary to determine such rates. At a minimum, the factors that are terms must include: the outcome of the field-specific assessment of the potential for nitrogen and phosphorus transport from each field; the crops to be planted in each field or any other uses of a field, such as pasture or fallow fields; the realistic yield goal for each crop or use identified for each field; the nitrogen and phosphorus recommendations from sources specified by the Director for each crop or use identified for each field; credits for all nitrogen in the field that will be plant-available; consideration of multi-year phosphorus application; and accounting for all other additions of plant-available nitrogen and phosphorus to the field. In addition, the terms include the form and source of manure, litter or process wastewater to be land-applied; the timing and method of land application; and the methodology by which the NMP accounts for the amount of nitrogen and phosphorus in the manure, litter, and process wastewater to be applied.

13.1.h.5.A.2. Large CAFOs that use this approach must calculate the maximum amount of manure, litter or process wastewater to be land-applied at least once each year, using the results of the most recent representative manure, litter or process wastewater tests for nitrogen and phosphorus taken within twelve (12) months of the date of land application.

13.1.h.5.B. Narrative rate approach. An approach that expresses rates of application as a narrative rate of application that results in the amount in tons or gallons of manure, litter or process wastewater to be land-applied, according to the following specifications:

13.1.h.5.B.1. The terms include maximum amounts of nitrogen and phosphorus derived from all sources of nutrients for each crop identified in the NMP, in chemical forms determined to be acceptable to the Director, in pounds per acre for each field, and certain factors necessary to determine such amounts. At a minimum, the factors that are terms must include: the outcome of the field-specific assessment of the potential for nitrogen and phosphorus transport from each field; the crops to be planted in each field or any other uses of a field, such as pasture or fallow fields (including alternative crops identified in part 13.1.h.5.B.2 below); the realistic yield goal for each crop or use identified for each field; and the nitrogen and phosphorus recommendations from sources specified by the Director for each crop or use identified for each field. In addition, the terms include the methodology by which the NMP accounts for the following factors when calculating the amounts of manure, litter or process wastewater to be land-applied: results of soil tests conducted in accordance with protocols identified in the NMP required by subparagraph 13.1.h.1.G of this rule; credits for all nitrogen in the field that will be plant-available; the

amount of nitrogen and phosphorus in the manure, litter or process wastewater to be applied; consideration of multi-year phosphorus application; accounting for all other additions of plant-available nitrogen and phosphorus to the field; the form and source of manure, litter, and process wastewater; the timing and method of land application; and volatilization of nitrogen and mineralization of organic nitrogen.

13.1.h.5.B.2. The terms of the NMP include alternative crops identified in the CAFO's NMP that are not in the planned crop rotation. Where a CAFO includes alternative crops in its nutrient management plan, the crops must be listed in field, in addition to the crops identified in the planned crop rotation for that field, and the NMP must include realistic crop yield goals and the nitrogen and phosphorus recommendations from sources specified by the Director for each crop. Maximum amounts of nitrogen and phosphorus from all sources of nutrients and the amounts of manure, litter and/or process wastewater to be applied must be determined in accordance with the methodology described in part 13.1.h.5.B.1 above.

13.1.h.5.B.3. For CAFOs using this approach, the following projections must be included in the NMP submitted to the Director, but are not terms of the NMP the CAFO's planned crop rotations for each field for the period of permit coverage; the projected amount of manure, litter or process wastewater to be applied; projected credits for all nitrogen in the field that will be plant-available; consideration of multi-year phosphorus application; accounting for all other additions of plant-available nitrogen and phosphorus to the field; and the predicted form, source, and method of application of manure, litter or process wastewater for each crop. Timing of application for each field, insofar as it concerns the calculation of rates of application, is not a term of the NMP.

13.1.h.5.B.4. AFOs that use this approach must calculate maximum amounts of manure, litter or process wastewater to be land-applied at least once each year, using the methodology required by part 13.1.h.5.B.1 above, before land-applying manure, litter or process wastewater and must rely on the following data:

13.1.h.5.B.4.a. field-specific determination of soil levels of nitrogen and phosphorus, including for nitrogen a concurrent determination of nitrogen that will be plant-available consistent with the methodology required by part 13.1.h.5.B.1 above, and for phosphorus, the results of the most recent soil test conducted in accordance with soil testing requirements approved by the Director; and

13.1.h.5.B.4.b. The results of most recent representative manure litter or process wastewater tests for nitrogen and phosphorus, taken within twelve (12) months of the date of land application, in order to determine the amount of nitrogen and phosphorus in the manure, litter or process wastewater to be applied.

## **Appendix C**

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### **Technical Requirements for Entering Nutrient Management BMPs into Scenario Builder and the Watershed Model**

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**Background:** In June 2013 the Water Quality Goal Implementation Team (WQGIT) agreed that each BMP expert panel would work with CBPO staff and the Watershed Technical Workgroup (WTWG) to develop a technical appendix for each expert report. The purpose of the technical appendix is to describe how the expert panel's recommendations will be integrated into the modeling tools including NEIEN, Scenario Builder and the Watershed Model.

**Practice Definitions:** The new practices are organized into three tiers, each building on the previous tier in succession. Note that Tier 2 nutrient management can be submitted for either nitrogen credit, phosphorus credit or both, depending upon the nature of the nutrient management plan.

**Tier 1 – Crop Group Nutrient Application Management (CGNAM):** Documentation exists for manure and/or fertilizer application management activities in accordance with basic LGU recommendations. This documentation supports farm-specific efforts to maximize growth by application of N and P with respect to proper nutrient source, rate, timing and placement for optimum crop growth consistent with LGU recommendations. Crop group nutrient application management is defined operationally by the documentation of and adherence to the following four planning components: (1) standard, realistic farm-wide yield goals; (2) credit for N sources (soil, sod, past manure and current-year applications); (3) P application rates consistent with LGU recommendations based on soil tests for fields without manure; and (4) N-based application rates consistent with LGU recommendations for fields receiving manure.

**Tier 2 N – Field Level Nutrient Application Management (FLNAM):** Implementation of formal NM planning is documented and supported with records demonstrating efficient use of nutrients for both crop production and environmental management. Field level nutrient application management is defined operationally as the presence of plan documentation that nutrient applications are based on a combination of: (1) standard yield goals per soil type, or historic yields within field management units; (2) credit for N sources (soil, sod, past manure, and current-year applications); and (3) other conservation tools necessary for proper nutrient source, rate, timing and placement to improve nutrient use efficiency.

Indicators demonstrating implementation of this practice includes the presence of a plan that addresses the three elements described above, plus practices such as, but not limited to best N application timing, manure incorporation where appropriate, and manure application setbacks.

**Tier 2 P - Field Level Nutrient Application Management (FLNAM):** Implementation of formal NM planning is documented and supported with records demonstrating efficient use of nutrients for both crop production and environmental management. Field level nutrient application management is defined operationally as the presence of plan documentation that nutrient applications are based on a combination of: (1) standard yield goals per soil type, or historic yields within field management units; (2) fields assessed for P loss risk with a LGU P risk assessment tool (Phosphorus Site Index [PSI]) and P applications are consistent with the PSI; and (3) other conservation tools necessary for proper nutrient source, rate, timing and placement to improve nutrient use efficiency.

Indicators demonstrating implementation of this practice includes the presence of a plan that addresses the three elements described above, plus practices such as but not limited to manure incorporation where appropriate, PSI application, and manure application setbacks.

**Tier 2 N and P– Field Level Nutrient Application Management (FLNAM):**

Implementation of formal NM planning is documented and supported with records demonstrating efficient use of nutrients for both crop production and environmental management. Field level nutrient application management is defined operationally as the presence of plan documentation that nutrient applications are based on a combination of: (1) standard yield goals per soil type, or historic yields within field management units; (2) credit for N sources (soil, sod, past manure, and current-year applications); (3) fields assessed for P loss risk with a LGU P risk assessment tool (Phosphorus Site Index [PSI]) and P applications are consistent with the PSI; and (4) other conservation tools necessary for proper nutrient source, rate, timing and placement to improve nutrient use efficiency.

Indicators demonstrating implementation of this practice includes the presence of a plan that addresses the four elements described above, plus practices such as but not limited to best N application timing, manure incorporation where appropriate, PSI application, and manure application setbacks.

**Tier 3 N – Adaptive Nutrient Management (ANM):** The Panel was unable to complete the definition ANM for P due to insufficient time. The following definition pertains only to ANM for N.

Under this practice, implementation of Tier 2 nutrient application management (FLNAM), plus multi-year monitoring of nutrient use efficiency with the results of this monitoring being integrated into future NM planning are documented. This process evaluates and refines the standard LGU nutrient recommendations using field- and subfield-specific multiple-season records. It further promotes the coordination of amount (rate), source, timing, and placement (application method) of plant nutrients to further reduce nutrient losses while maintaining economic returns. In addition to the field assessments in FLNAM and presence of a plan that addresses the adaptive management elements above, Tier 3 N credit requires, but is not limited to, implementation of one or more of the following tools:

- Illinois Soil Nitrogen Test (ISNT)
- Corn Stalk Nitrate Test (CSNT)
- Pre-side dress Nitrate Test (PSNT)
- Fall Soil Nitrate Test (FSNT)
- Variable N rate application

Implementation of the ISNT, CSNT, PSNT, and FSNT is defined as including not only performance of the test(s) themselves, but also changing N application rates/timing in response to the information provided by the test(s).

***Q1: What are the efficiency reductions a jurisdiction will be credited for implementing the tiers of Nutrient Application Management for each tier by landuse?***

A1: A jurisdiction can reduce loads from modeled agricultural land uses by percentages listed in the table below. As evident in the table, the efficiencies build upon one another so that, for example, Tier 2 N automatically assumes that practices are in place to achieve Tier 1 phosphorus credit. If the reduction is listed as “NA,” states cannot take credit for the BMP on this land use.

**Table 1. Nutrient Application Management Percent Reductions by Land Use**

Practice	Nutrient	High-Till with Manure	Low-Till with Manure	High-Till without Manure	Pasture	Hay with Nutrients	Alfalfa	Nursery
Tier 1	TN	9.25%	9.25%	5.00%	5.00%	5.00%	5.00%	5.00%
	TP	10.00%	10.00%	8.00%	8.00%	8.00%	8.00%	8.00%
Tier 2 N	TN	12.79%	12.79%	NA	NA	7.66%	NA	NA
	TP	10.00%	10.00%	NA	NA	8.00%	NA	NA
Tier 2 P	TN	9.25%	9.25%	NA	NA	5.00%	5.00%	NA
	TP	15.94%	15.94%	NA	NA	14.07%	14.07%	NA
Tier 2 N and P	TN	12.79%	12.79%	NA	NA	7.66%	5.00%	NA
	TP	15.94%	15.94%	NA	NA	14.07%	14.07%	NA
Tier 3 N	TN	15.23%	15.23%	NA	NA	NA	NA	NA
	TP	15.94%	15.94%	NA	NA	NA	NA	NA

***Q2: Why is there no credit given for Tier 3 Phosphorus Nutrient Application Management?***

A2: At the time of publication of this document, the expert panel has not defined reduction efficiencies for Tier 3 Phosphorus. The Phase 6 expert panel may choose to provide credit for Tier 3 Phosphorus.

***Q3: Can jurisdictions still receive credit for the Enhanced Nutrient Application Management and Decision Agriculture BMPs?***

A3: No. The panel recommended retiring Enhanced Nutrient Application Management and Decision Agriculture BMPs. The three tiers of nutrient application management cover on-the-ground concepts of these retired BMPs.

***Q4: What combination of Nutrient Application Management practices can be reported on the same acre?***

A4: Only one practice may be submitted on each acre. Tier 2 practice efficiencies already assume that that Tier 1 practices components were followed. Acres should not be submitted multiple times. For example, if an acre qualifies for Tier 2 Nitrogen, that acre should be

submitted only under the Tier 2 Nitrogen practice name. The Tier 2 Nitrogen practice already assumes a phosphorus efficiency consistent with Tier 1 practice (i.e. one acre of row crops with manure receiving Tier 2N credit will achieve a load reduction of 12.79% TN and 10% TP). See Table 1 above for a complete listing of the credits available.

***Q5: How are the nutrient reductions calculated in Scenario Builder and the Watershed Model?***

A5: Reductions for all types of nutrient application management BMPs are applied as percent reductions of edge-of-stream loads exiting agricultural land uses. Therefore, the impact of these reductions in the Watershed Model will vary across the watershed as a result of hydrologic conditions, application rates to land uses, and nutrient export from land uses.

***Q6: What NEIEN data fields does a jurisdiction need to report in order to successfully process Nutrient Application Management BMPs in an annual Progress scenario?***

A6: Jurisdictions should report the following information:

- Nutrient Application Practice Type: Crop Group Nutrient Application Management (Tier 1); Field level Nutrient Application Management Nitrogen (Tier 2N); Field level Nutrient Application Management Phosphorus (Tier 2P); Field level Nutrient Application Management Nitrogen and Phosphorus (Tier 2N&P); Adaptive Nutrient Management (Tier 3N)
- Acres: Number of acres under a nutrient application management plan in the geographic reporting unit
- Land use: Approved NEIEN land uses
- Location: Approved NEIEN geographies: County; County (CBWS Only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4), State (CBWS Only)
- Date of Implementation: Year of plan implementation (not necessarily the year the plan was written)

***Q7: What data fields does a jurisdiction need to report to successfully process Nutrient Application Management BMPs in a planning scenario?***

A7: Jurisdictions should report the following information:

- Short Name: EffNutMan (Tier 1); EffNutMan2N (Tier 2N); EffNutMan2P (Tier 2P); EffNutMan2NP (Tier 2 N&P); EffNutMan3N
- Acres: Number of acres under a nutrient application management plan in the geographic reporting unit
- Land use: Approved SB land uses listed in Table 1 above
- Location: Approved SB geographies: County; County (CBWS Only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4), State (CBWS Only)
- Date of Implementation: Year of plan implementation (not necessarily the year the



plan was written)

***Q8: Do states need to report all acres under Nutrient Application Management BMPs annually – as opposed to cumulative?***

A8: Yes. Beginning in 2013, states began submitting the total number of acres concurrently under a tier for a given year.

***Q9: What is the order of credit for Nutrient Application Management BMPs in Scenario Builder?***

A9: To avoid double-counting on the same acres, the panel recommends that Scenario Builder will process the BMPs in the following order:

- 1) Tier 3 Nitrogen Nutrient Application Management
- 2) Tier 2 Nitrogen and Phosphorus Nutrient Application Management
- 3) Tier 2 Nitrogen Nutrient Application Management
- 4) Tier 2 Phosphorus Nutrient Application Management
- 5) Tier 1 Nutrient Application Management

If there are no agricultural acres available in the geographic reporting unit after a BMP is processed, the next BMP in the processing order will not receive credit.

***Q10: When are states eligible to receive credit for each Tier of Nutrient Application Management?***

A10: Jurisdictions may submit Tier 1 Nutrient Application Management starting in 1985. Jurisdictions may submit Tier 2 Nutrient Application Management starting in the year listed in table 3 below based on the years states adopted Tier 2 level nutrient management regulations. Tier 3N Nutrient Application Management eligibility begins the year Tier 2N and Tier 2P were adopted for each state. Please note that this table does not suggest that ALL acres within a state are eligible for this credit after the eligible year, but rather that a subset of acres with qualifying plans may be eligible for credit after the eligible year.

**State Eligibility for Tiers of Nutrient Management by Year**

State	Tier	Year Eligible
All	<b>T1</b>	<b>1985</b>
DE	<b>T2N</b>	<b>2007</b>
DE	<b>T2P</b>	<b>2007</b>
DE	<b>T3N</b>	<b>2007</b>
MD	<b>T2N</b>	<b>2005</b>
MD	<b>T2P</b>	<b>2005</b>

MD	T3N	2005
NY	T2N	2004
NY	T2P	2004
NY	T3N	2004
PA	T2N	2006
PA	T2P	2006
PA	T3N	2006
VA	T2N	2006
VA	T2P	2006
VA	T3N	2006
WV	T2N	2011
WV	T2P	2011
WV	T3N	2011

***Q11: What specific records, data and documentation does a jurisdiction need to provide to CBPO to ensure acres reported for the annual model progress assessment under Nutrient Application Management meet the definitions of the BMPs and meet all elements of Nutrient Application Management considered by the Panel for their determination of nutrient reductions?***

A11: This information is available in Section 6 under verification recommendations. Basically, implementation years and program elements have been documented for Tier 2N and Tier 2P for each jurisdiction. Plans that exist and are QA/QCd by the documented state programs are eligible to be reported and get credit. These plans are extensive documents that detail prescriptive elements and are where management actions are recorded. The results of these plans contain confidential information and do not exist in a centralized place. As a result of these characteristics, plans are not transmittable in NEIEN. Instead, states should submit acres summarized with the elements detailed above, in this appendix. Additionally, states should describe in their Chesapeake Bay Program Quality Assurance Project Plans (QAPPs) how nutrient management acres are divided between the various tiers for submission.

***Q12: If manure incorporation is a component of Nutrient Application Management, will additional model reductions be given to manure incorporation in the Phase 5 Watershed Model?***

A12: No. Because manure incorporation is now a component of Nutrient Application Management, no benefit will be given to manure incorporation in the Phase 5 Watershed Model. Manure incorporation will be considered for separate credit in the Phase 6 CBPWM following the recommendations of a separate Expert Panel.

***Q13: How is compliance with Nutrient Application Management plans taken into consideration in the acres submitted through NEIEN for the components of Nutrient Application Management?***

A13: Compliance of farmers to their NMPs is a recognized concern of the partnership, but as of the date this report is submitted for approval, the Panel defers judgment of how to handle compliance rates to the states which run the programs. The Panel recognizes that as a result of CBP Partnership approval of state verification programs that are due to be implemented by January 2018, new details

and data will result for which the Phase 6 CBPWM NM EP can deliberate how best to reconcile state verification efforts with compliance rates and reported acres for which credit is given. No existing framework for enhanced oversight and reliable compliance data exists for this panel to give a recommendation that can be reasonably implemented in the time for which these recommendations would be used in the Phase 5 CBPWM, but the Panel does recognize that compliance is not 100% in the watershed. The considerations the Panel made with regards to adjusting literature values includes “management challenges of schedule,” where a reduction in the credit from literature was applied to account in a BPJ way for the plans that are not implemented on every acre of every field.

***Q14: How did the panel take into account the various land and crop types in their recommendations of nutrient reductions, i.e., those that are eligible for manure applications; those that only use chemical fertilizer; those crops that aren’t fertilized, etc.?***

A14: The recommendations for N and P reductions are related in some part to the rate of manure and fertilizer applications. The framework for the Phase 5 CBPWM lumps all crops that are eligible for manure application together regardless of whether the each acre in that county has manure applied in reality. The reality of following a NMP resulting in less manure and fertilizer N and P lost to the environment was what the Panel’s recommendation was based on and so no adjustment for acres unlikely to receive manure was made. The Panel is encouraged by the recommendations of the Agriculture Modeling Subcommittee to the AgWG, which include some land uses of only one crop, and distinct acres that are eligible for manure. These model enhancements will make future NM crediting efforts more straightforward. The panel did adjust literature values based on individual crops by the proportion of those crops to the land use in the efficiency adjustment Table 7, in the report. Furthermore, Tier 2 and Tier 3 eligible landuses were carefully considered and only landuses that would be expected to produce nutrient loss reductions at or above our recommendation were included in the report. Therefore, Tier 1 eligible landuses (i.e., Pasture, nursery, row crops without manure) were not included in the Tiers 2 and 3 recommendations.

***Q15: Did the panel consider different species of nitrogen and phosphorus and the different loss pathways when creating total nitrogen and total phosphorus efficiencies?***

A15: The panel meticulously documented the nutrient species that were measured in the literature used to justify the recommendations. Through our deliberations of Tiers 2 and 3, the species of nutrient and the pathways in which the reductions were measured, the Panel determined that the species were conservatively representative of the TN and TP loss prevented by the components. The deliberations revolved around the fact that crops grow most efficiently with the proper application rate, method, timing and source, so any measured reduction in loss of one pathway or nutrient species is consistent with a reduction in prevented nutrient load in the Phase 5 CBPWM. BPJ was used and documented in the management variability adjustments in Table 7 related to measuring one species or pathway perhaps increasing the mass of nutrients lost by a different species or pathway.

***Q16. Did the panel consider how varying meteorological and hydrologic conditions affect the literature values were considered?***

A16: The panel adjusted all literature values for scale and management variability, both of which relate to surface and subsurface mobility of nutrients. The BPJ incorporated into the

management variability adjustment provided some discounting to literature values for experiments that used rainfall simulators, measuring only runoff or lysimeter studies, measuring only leachate. Additionally, rainfall simulation studies typically applied very heavy rates of rainfall to generate runoff, so that was a consideration made in the BPJ adjustments cataloged and quantified in the efficiency adjustments from literature values. The issue of scale for plot or field size experiments from the literature was considered by the Panel and a universal adjustment was applied to literature values consistent with the Phase 5 CBPWM Cover Crop EP. This is a result of the consideration that the variability in hydrology of a small watershed, like those that are simulated in the Phase 5 CBPWM, are going to contribute to some reduction in the measured effect of a treatment at a field or plot sized scale.

## **Appendix D**

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**Consolidated Response to Comments on  
Definitions and Recommended Nutrient Reduction Efficiencies of  
Nutrient Application Management for Use in Phase 5.3.2 of the  
Chesapeake Bay Program Watershed Model (2014)**

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**Appendix D**  
**Consolidated Response to Comments on**  
***Definitions and Recommended Nutrient Reduction Efficiencies of Nutrient Application Management***  
***for Use in Phase 5.3.2 of the Chesapeake Bay Program Watershed Model (2014)***

This appendix responds to the comments received on the above cited expert panel report which was first released in October of 2014<sup>22</sup>. As of December 10, 2014, written comments had been received from the Chesapeake Bay Foundation, Chesapeake Bay Commission, Chesapeake Bay Program Citizen's Advisory Committee, Chesapeake Bay Program Office Modeling Team, EPA Region III, Blue Water Baltimore, Anacostia Watershed Society, Chesapeake Wildlife Heritage, Elk Creeks Watershed Association, Friends of the North Fork of the Shenandoah River, Maryland League of Conservation Voters, Midshore Riverkeeper Conservancy, Nature Abounds, Peach Bottom Concerned Citizens Group, PennFuture, Potomac Conservancy, Shenandoah Riverkeeper, Sleepy Creek Watershed Association, St. Mary's River Watershed Association, Upper Potomac Riverkeeper, Virginia Chapter, Sierra Club, West Virginia Highlands Conservancy, Potomac Riverkeeper, and Waterkeepers Chesapeake. As a result of these comments, in January 2015<sup>23</sup>, the AgWG charged the Panel to:

- Re-evaluate the Tier 2 and Tier 3 efforts to separate the N and P benefits for those levels of nutrient management.
- Re-consider the agricultural land uses for which the benefits of nutrient management will be realized.
- Develop a checklist of the data needed to assess the presence or absence of the level of nutrient management necessary to qualify for each Tier as guidance to the jurisdictions.

The responses below indicate how the Panel addressed the fall 2014 comments in the revised 2015 version of the report.

**Comment 1:** There is a need for increased scientific support to justify Tier credit. Specifically, the panel report contains:

- Limited data to support manure application timing
- Limited N split application data on leaching and on total nitrogen
- Lack of justification for P site indices benefit
- Lack of data to support setbacks
- Lack of data to support fertilizer banding

There is a need for increased detail on how the literature sources were used by the panel to develop effectiveness estimates.

**Response to Comment 1:** The revised report section 3.3 explains the justification for effectiveness estimates for each component of each Tier in more detail. The effect of timing has shifted entirely to split applications, as opposed to some baseline from winter or early spring applications. The Panel identified leaching as the sole pathway to determine credit. The absence of volatilization and denitrification from this calculation adds implicit conservatism. The Panel reviewed additional P site index research, and on incorporation of manure. Banding and setbacks are no longer included in the calculation and therefore add implicit conservatism.

**Comment 2:** There is a need for increased transparency with panel process. The Panel report should include details of panel discussions and decision making.

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<sup>22</sup> [http://www.chesapeakebay.net/channel\\_files/22023/nutrient\\_management\\_interim\\_phase\\_5\\_3\\_2\\_final.pdf](http://www.chesapeakebay.net/channel_files/22023/nutrient_management_interim_phase_5_3_2_final.pdf)

<sup>23</sup> <http://www.chesapeakebay.net/calendar/event/22323/>

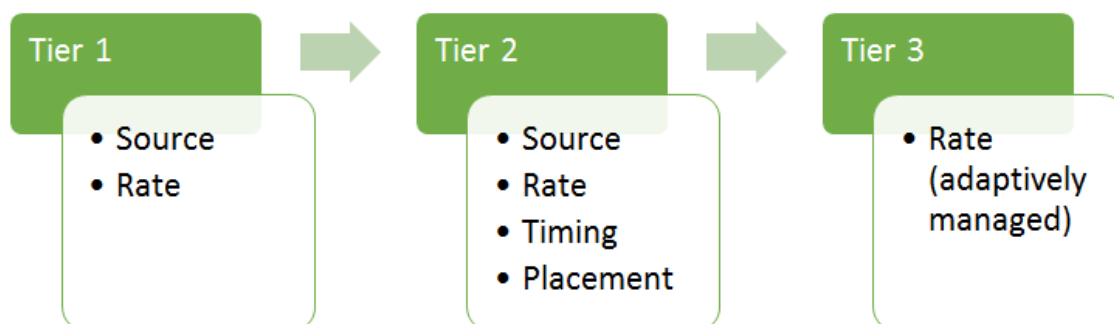
**Response to Comment 2:** The revised report section 3.2 explains the process for developing effectiveness estimates, including details of Panel discussions. The Panel also provided a 2-page summary of Panel discussions between January and June 2015.

**Comment 3:** The Panel needs to follow the Water Quality Goal Implementation Team's BMP protocol<sup>24</sup> and to 1) include all required elements in the report and 2) follow the process for Partnership review and approval.

**Response to Comment 3:** Appendix E contains a crosswalk between required components of BMP protocol and the report. The comment period will be held June 25 through July 16, and the Panel will host a webinar to review the report recommendations on July 1. The full schedule for the review and comment period was released on June 25 with the report.

**Comment 4:** There is a need for improved clarity of Tier definitions. Specifically, the definitions should provide clear understanding of whether a given acre is under Tier 1 vs. Tier 2 management. How do the 4Rs of Nutrient Management relate to each Tier? When did states adopt Tier 2 plans?

**Response to Comment 4:** The Panel re-visited and revised the Tier definitions. Table 11 (Section 6) in the report describes applicability of each of the State Programs to the Tier components, including the years those regulations were adopted. Figure 10 (copied below) shows the most relevant of the 4Rs of nutrient management as considered by the panel to influence the recommended reduction efficiencies.



**Diagram that shows the most relevant of the 4Rs of nutrient management as considered by the panel to influence the recommended reduction efficiencies.**

**Comment 5:** There is a need for additional detail on tracking and reporting and concern about increasing nutrient reductions due to accounting change rather than change on the ground. What records/data are needed to substantiate the reported implementation for each Tier?

**Response to Comment 5:** Nutrient Management has historically been tracked and reported to the CBPO on a farm acreage level (i.e. total acres of NMPs). This is the same tracking criteria for Tier 2 plans, but the magnitude of recorded data about the 4Rs has become much more rigorous, and includes:

- Manure testing for source information
- Calibration records for the fertilization equipment, if owned
- Contracts for nutrient services

<sup>24</sup> [http://www.chesapeakebay.net/channel\\_files/22798/nutrient-sediment\\_control\\_review\\_protocol\\_v7.14.2014.pdf](http://www.chesapeakebay.net/channel_files/22798/nutrient-sediment_control_review_protocol_v7.14.2014.pdf)

- Field or sub field level records of rates for each season
- Field or sub field level records of timing for each fertilization
- Field or sub field level records of method for each fertilization

**Comment 6:** How do the Panel recommendations account for USDA CEAP report information about level of nutrient management occurring in the Chesapeake Bay watershed?

**Response to Comment 6:** CEAP was not considered in more detail than the fall 2014 report.

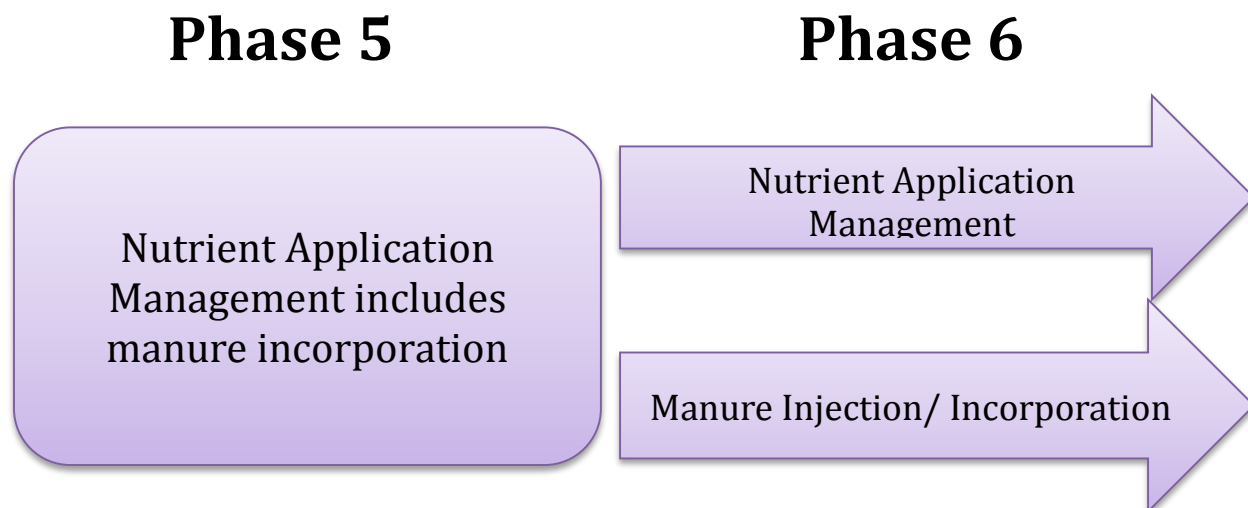
**Comment 7:** How do the Panel recommendations address BMP verification?

- Concerns about crediting Tier 2 NM now and then possibly having to remove some or all of the credit in the future when states have adopted verification protocols.
- Concerns about increasing credit for NM before verification protocols are adopted.
- Recommend that verification be a requirement for states to claim Tier 2 credit.

**Response to Comment 7:** Section 6.1 of the revised report describes the Panel's verification recommendations. The Panel acknowledges that non-visual BMPs are difficult to verify and there is a need to primarily rely on the state Nutrient Management Plans and on-farm documentation. The jurisdictions are currently developing BMP verification protocols which will identify the methods for verifying NM to implement in Jan 2018. Enabling the tracking and reporting of detailed management actions on specific fields or subfields will require retooling of the current partnership framework, as well as inspection and verification procedures. The panel recommends criteria for crediting acres to the tier and sub-tier (N vs. P), but adoption and reporting will be a new and unprecedented challenge for the partnership to address.

**Comment 8:** Concern about double counting manure incorporation as part of Nutrient Management and as a separate BMP.

**Response to Comment 8:** The Phase 5 Nutrient Management Panel Report recommendations include manure incorporation (but not injection), so manure incorporation should not be counted as a separate BMP in Phase 5. Manure incorporation will be considered for separate credit in the Phase 6 Chesapeake Bay Watershed Model following the recommendations of a separate Expert Panel.



**Comment 9:** How do the Panel recommendations account for crops that do not receive manure?



**Response to Comment 9:** The recommendations for N and P reductions are related in some part to the rate of manure and fertilizer applications in the real world. The Phase 5 Chesapeake Bay Watershed Model lumps all crops that are eligible for manure application together regardless of whether each acre in that county has manure applied. The Panel recommendation was based on a Nutrient Management Plan resulting in less manure and fertilizer N and P lost to the environment, and therefore did not adjust for acres unlikely to receive manure. The Panel is encouraged by Agriculture Modeling Subcommittee recommendations to the Agriculture Workgroup for increased specificity of crops and manure eligibility in the Phase 6.0 land uses. These model enhancements will make future Nutrient Management crediting efforts more straightforward.

The Panel adjusted literature values by the proportion of applicable crops in the land use (Table 7) before determining Tier credit. Tier 2 and Tier 3 eligible landuses were carefully considered and only landuses that would be expected to produce nutrient loss reductions at or above the Panel's recommendation were included in the report. Therefore, some Tier 1 eligible landuses (i.e., Pasture, nursery, row crops without manure) were not included in the Tiers 2 and 3 recommendations.

**Comment 10:** How do the Panel recommendations account for evidence of increases in manure and fertilizer applications?

**Response to Comment 10:** The Panel agreed that the documented increases in manure and fertilizer applications are offset by increases in yields over the same time period. The balance performed by the [Mid-Atlantic Water Program](#) is one example of many that show inputs and outputs increase together.

## **Appendix E**

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### **Conformity with WQGIT BMP Review Protocol**

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## **Appendix E: Conformity with WQGIT BMP Review Protocol**

The BMP review protocol established by the Water Quality Goal Implementation Team (WQGIT 2014) outlines the expectations for the content of expert panel reports. This appendix references the specific sections within the report where the panel addressed the requested protocol criteria.

- 1. Identity and expertise of panel members:** *See Table 1 in Section 1.*
- 2. Practice name or title:** *Nutrient Application Management, which consists of three tiers: 1) Crop Group Nutrient Application Management (CGNAM), (2) Field Level Nutrient Application Management (FLNAM), and (3) Adaptive Nutrient Management (ANM).*
- 3. Detailed definition of the practice:** *See Section 2 for detailed definitions of Tiers 1, 2, and 3 of Nutrient Application Management.*
- 4. Recommended N, P and sediment effectiveness estimates:** *See Table 8 (Section 3.3) for recommended TN and TP reductions by Tier for use in the Phase 5.3.2 Watershed Model. The panel did not recommend a sediment reduction rate for Nutrient Application Management.*
- 5. Justification of selected effectiveness estimates:** *See Section 3.2 for a description of the panel's process for developing effectiveness estimates. See Section 3.3 for justification of the effectiveness estimates.*
- 6. List of references used:** *See Section 7 for the full list of references.*
- 7. Detailed discussion on how each reference was considered:** *See Sections 3 and 4 for details on the review of available science.*
- 8. Land uses to which BMP is applied:** *See Figure 3 in Section 3.1 for applicable land uses by Tier.*
- 9. Load sources that the BMP will address and potential interactions with other practices:** *See sections 3.3 and 5.*
- 10. Description of pre-BMP and post-BMP circumstances and individual practice baseline:** *See Sections 3 and 5.*
- 11. Conditions under which the BMP works, including conditions where the BMP will not work, or will be less effective:** *See Section 5 and Table 8, which shows the applicability of the literature mined data to model landuses.*
  - a. Variations in BMP effectiveness across the watershed due to climate, hydrogeomorphic region, or other measureable factors.** *See Sections 3.3 and 5.*
- 12. Temporal performance of BMP including lag times between establishment and full functioning:** *See Sections 3.3 and 5.*
- 13. Unit of measure:** *Acres.*

- 14. Locations in Chesapeake Bay watershed where the practice applies:** *All acres of the applicable land uses in Figure 3(Section 3.1) in the Bay watershed.*
- 15. Useful life of the BMP:** *Nutrient Application Management is intended to be represented as an annual practice, so for the purposes of this report, however, the useful life of the practice is 1 year.*
- 16. Cumulative or annual practice:** *Annual.*
- 17. Description of how BMP will be tracked, reported, and verified:** *See Sections 6 and 6.1 for discussion of how Nutrient Application Management should be tracked and reported to the Bay Program. More details are also available in the Scenario Builder Technical Appendix (Appendix C).*
- 18. Ancillary benefits, unintended consequences:** *The Panel did not review Nutrient Application Management for external environmental benefits because of time constraints. The Panel did not identify any unintended consequences.*
- 19. Timeline for a re-evaluation of the panel recommendations:** *At the time of report release, a new Panel has already been convened to review Nutrient Application Management for the Phase 6.0 CBP Watershed Model.*
- 20. Outstanding issues that need to be resolved in the future and list of ongoing studies, if any:** *See Section 4.3 for a discussion of research needs.*
- 21. Documentation of dissenting opinion(s):** *While no dissenting opinions were expressed or recorded, significant notes related to recommendations were recorded in section 3.3.*
- 22. Operation and maintenance requirements and how neglect alters performance:** *The requirements and performance are covered by the state programs, which in their own way document these elements.*

# Appendix F

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Consolidated Response to Comments on:

***Definitions and Recommended Nutrient Reduction Efficiencies of Nutrient Application Management for Use in Phase 5.3.2 of the Chesapeake Bay Program Watershed Model (June 25, 2015)***

This appendix responds to the comments received on the above cited expert panel report which was first released June 25, 2015. Written comments were received by the deadline (July 30, 2015) from:

- Beth McGee, Chesapeake Bay Foundation (CBF)
- Bill Angstadt, Angstadt Consulting Inc. (ACI)
- Tom Simpson and Ron Korcak, Aqua Terra Science (ATS)
- Tarah Heinzen and Abel Russ, Environmental Integrity Project on behalf of Environmental Integrity Project, Waterkeepers Chesapeake, Assateague Coastal Trust, Potomac Riverkeeper Network, Potomac Riverkeeper, Upper Potomac Riverkeeper, Shenandoah Riverkeeper, Midshore Riverkeeper Conservancy, Maryland League of Conservation Voters, Sierra Club Maryland Chapter, and the Center for Progressive Reform (EIP)
- Jill Witkowski, Choose Clean Water Coalition (CCWC)
- Royden Powell, Maryland Department of Agriculture (MDA)
- Jeff Sweeney, Chesapeake Bay Program Modeling Team
- Kelly Shenk, EPA Chesapeake Bay Program Office (EPA)
- Marel King, Chesapeake Bay Commission (CBC)

The responses below indicate how the Panel addressed the comments in the revised version of the report. Comments are organized by theme.

## Tier 2

### Tier 2N

On the Tier 2 N efficiency, we think the supporting science is not strong – details in the attached. [CBF]

*Response: The Panel made a conscientious decision to use unpublished local data as we would have used local published data, if it exists. Analysis of this data was performed in a way to maximize the applicability to the model as discussed in the component sections in the report. This analysis on panel-reviewed data makes it as good or better than peer reviewed literature in the opinion of the Panel.*

As noted later on, we don't think manure incorporation should be included in the estimate of this efficiency and the benefits of timing appear to be based on expected increases in yield/crop uptake, not on any measured concentration reductions of soil N or N in runoff or leaching. [Efficiency T2N] [CBF]

*Response: Increases in uptake were approved by the panel as an appropriate proxy for N runoff and leaching because the nature of split timing or incorporation reduces availability for loss. Additionally, any increase in yield is a direct benefit of a reduction in loss because the lost N cannot contribute to the yield of the crop, so it is also a good indicator of quantity of pollution prevented at the EOF/plot scale. Appropriate adjustments were made to convert plot or EOF reductions into EOS efficiencies.*

**Table 12 Summary comparing BMP N reduction estimates derived from measured environmental variables (fall residual nitrate-N or mass of nitrate-N leached) and reduction estimates derived from decreases in recommended N soil amendments with BMP implementation**

Best Management Practice	Variable Measured	Without BMP	With BMP	Reduction, as % with-out BMP	Notes	Reference
		----- kg N/ha -----				
Reduce corn N requirement, 1.2 to 1.0 lbs N/bu.	Fall soil NO <sub>3</sub> -N, 0-90 cm	56	39	30%	Avg. over 3-yr study	Coale et al., (2000)
	Total PAN applied	230	191	17%		
Pre-sidedress soil nitrate test	Fall soil NO <sub>3</sub> -N, 0-120 cm	151	66	56%	Avg. over 3-yr study	Durieux et al., (1995)
	Total PAN applied	168	120	29%		
Pre-sidedress Soil Nitrate Test	Mass NO <sub>3</sub> -N leached, Pan lysimeters	50	19	62%	Avg. over 2-yr study	Guillard et al., (1999)
	Total PAN applied	196	113	42%		
Pre-sidedress Soil Nitrate Test	Mass NO <sub>3</sub> -N leached, Tile-drain lysimeters	28	16	43%	Avg. over 2-yr study	Sogbedji, et al., (2000)
	Total PAN applied	19	15	21%		
<b>Reduction Estimated from Environmental Variable :</b>				<b>48%</b>	<b>Avg. of % reductions, from all studies</b>	
<b>Reduction Estimated from Decrease in Total PAN applied :</b>				<b>27%</b>		

*The process of estimating N reduction efficiencies for any BMP should ideally be based on measurement of a suitable environmental variable (e.g. surface runoff, subsurface leaching, fall soil residual nitrate-N, etc.). As noted in section 4.3 however, there were very few reports that directly related a measured change in an environmental variable to implementation of a BMP. The most common BMP evaluation was to relate BMP implementation to a reduced need for N application, which results from an increase in a crop efficiently removing soil-N or more leaving less N available for loss through leaching, denitrification, or ammonia volatilization, etc.*

*Never-the-less, there were several studies that documented BMP performance by direct measurement of **both** an environmental variable and crop yield as measured by influence on PAN need. Table 1 summarizes the BMP evaluation studies and compares N loss reductions with N input reductions. These examples show reducing the corn N application coefficient from 1.2 to 1.0 lbs of N per bu of yield decreased fall nitrate-N from 56 to 39 kg N/ha, which is a 30% reduction in post-season soil nitrate-N (very susceptible to leaching). The corresponding percent reduction in total PAN was 17% (from 230 to 191 kg N/ha). Similar results were also found in a VA study by Ditsch (1991) and in all three PSNT evaluation studies in Table 1.*

*The reason the environmental variables show a larger percentage reduction, compared to the percent reduction based on applied total PAN, is because these BMPs successfully identified situations where excess-N that is added beyond crop need was being recommended or applied. The*

*applied PAN reduction directly reduces the total PAN applied to the crop. Because the majority of the total PAN goes to crop N needs, reducing the excess results in a smaller percentage reduction in PAN. Thus, practices that directly reduce excess-N will have a larger percentage impact on environmental losses compared to the percentage impact on total PAN applications. Furthermore, a closer examination of Table 1 studies having both environmental variables and total PAN-parameters measured, shows that in every case there was a larger percentage N reduction for estimates derived from environmental-based parameters than from estimates based on applied total PAN reductions, with the over-all average percent reduction based on environmental or fertilizer parameters being 48% and 27%, respectively.*

*The “bottom line” consequence in using applied total-PAN based reductions for N efficiencies is that they are an underestimate of the environmental N reduction; a situation that the Panel unanimously views as being conservative, particularly in view of the paucity of directly-measured environmental data.*

### Manure Incorporation

If less N is lost to volatilization, then more N will be kept in the soil, yes? What is missing from this discussion, I think, is support for the idea that reducing these losses via volatilization would result in a net benefit to the environment compared to the n losses from soil. That is, studies that would compare N runoff and N leaching from cropland with and without incorporation... instead the efficiency is based on reduced volatilization without taking into account additional soil losses. Also, the efficiency was based on manure incorporation within one day, according to Table 11, most states do not have this time limit or require incorporation at all...I would suggest this be a stand alone BMP as opposed to be used to justify Tier 2 credit because of the variation among states. [CBF]

*Response: The Panel recognized that manure incorporation is a multi-faceted management practice that requires the difficult task of balancing issues such as soil erosion, surface runoff of soluble nutrients and organic matter, denitrification losses, etc. However, the Panel responded to the need for a short-term place-holder estimate of the benefits of manure incorporation that could incorporate the existing, albeit limited, data.*

*It is well known the manure incorporation increases plant available N, not just soil N, by reducing ammonia loss, and NMPs that account for this reduce environmental loss by reducing manure application rates or lowering the recommendation for supplemental N (where manure is not expected to meet crop needs). Both of these N reductions would lead to reduced environmental losses, particularly leaching losses, which is the major loss process for N. This benefit, however, depends on the degree of soil cover produced by the incorporation and time between application and incorporation. The Panel chose to limit the use of this credit to situations where manure was incorporated by implements that would leave at least 30% residue cover and to cases where the incorporation occurred within one day of application. These conditions have therefore been listed as prerequisites for the manure incorporation credit. If a state did not have these conditions in their NMP then they would not be eligible for the manure incorporation credit in P5.3.2. It is the panel recommendation that this situation be given more comprehensive consideration in the Phase 6 CBWM Manure Incorporation Panel.*

I think this is the final efficiency estimate, but it isn't clear in the text. My suggested edits are to clarify; if I'm wrong about that point, please ignore my edits but try to explain where the 10% in Table 7 came from. [EIP]

*Response: The edits somewhat change the meaning of the text. 10% is a result of the PAN savings in applied PAN due to reduced volatilization and conservation of PAN. 10% is equivalent to 10% conserved applied N and the Panel asserts this will results in more than 10% reductions in edge of plot N loss. EOS loss prevention is calculated in Table 7.*

I don't see 20% as an adjustment factor in Table 7, and I don't see the adjustment factors in Table 7 discussed here. Could you explain how a 20% adjustment factor was applied (or explain what the 20% number represents if not an adjustment factor), and could you explain where the factors in Table 7 came from? [EIP]

*Response: 20% is the adjusted literature value based on the post-hoc analysis performed by the panel and documented in the paragraph.*

It isn't clear what 'conservative' means in this context – please explain whether you think the final adjusted efficiency is biased high or low. [EIP]

*Response: Conservative estimates are considered to be unbiased estimates, but the final value is lower than an expected result from a study that explicitly measures for the component or practice effect on representative soils and crops Bay-wide.*

Could you cite the study that this came from? [EIP]

*Response: The analysis for which a cite is desired was performed by the panel as a result of combining literature values in the above paragraph.*

This paragraph is very unclear to me. Would fields with no practices other than conservation tillage get Tier 2 credit? Or does conservation tillage get extra credit on top of Tier 2 credit? If one of these is true, please state... [EIP]

Please clarify – does 'this component BMP' mean manure incorporation or conservation tillage (or something else)? [EIP]

This suggests to me that conservation tillage land use will be given manure incorporation credit or the full Tier 2N credit. Which is it, if either? [EIP]

This sentence has a backstory that is probably obvious to folks who have been in the weeds for a long time, but could you please explain a little more what you mean here? [EIP]

*Response: The above comments concerning Manure Incorporation for N revolve around the conflict of crediting the NM component, Manure incorporation, on land that could be credited under Conservation Tillage (a separate BMP). What the paragraph explains is that reduced tillage is an effective means of accomplishing both BMPs together and therefore an additional N credit from the NM component (manure incorporation) is a substantiated claim.*

Figure 1 doesn't appear to be helpful on this point – are you referring to another figure? [EIP]



*Response: Figure 1 points out the timeframe in which the benefits of this BMP component would be credited. It occurs at such a point in time where Tier 1 NM has evolved into Tier 2 in some states and after a point in model simulation history where the calibration would not account for the component.*

#### Timing N Applications

Yes, aren't these practices typically linked? [PSNT & split applications] If so, then how can PSNT be used to justify Tier 3 credits? [CBF]

*Response: PSNT is related to the splitting of applications, but the intent to run the PSNT can be credited separately. The splitting of applications is worth a decrease in leaching potential. The decrease in application rates is creditable by the Tier 3 method which requires an adjustment in rate.*

So these numbers are based on difference in crop yield? If so, then there are several steps between that and actual reductions in runoff or leaching. [CBF]

*Response: From above: Increases in uptake were approved by the panel as an appropriate proxy for N runoff and leaching because the nature of split timing or incorporation reduces availability for loss. Additionally, any increase in yield is a direct benefit of a reduction in loss because the lost N cannot contribute to the yield of the crop, so it is also a good indicator of quantity of pollution prevented at the EOF/plot scale. Appropriate adjustments were made to convert plot or EOF reductions into EOS efficiencies.*

In general, it would be helpful to see the original literature values and how the panel quantitatively translated them into the 'literature values' shown in Table 7. [EIP]

*Response: the original literature values are from those cited in the report. Values that were calculated from the research and the result analysis the Panel performed and used are documented in the report. Some literature values are from unpublished data and cannot be shared without the scientists' consent.*

Did the panel make these calculations using the three sources cited at the beginning of the paragraph? [EIP]

*Response: Yes.*

These appear to be the final 'literature values' shown in Table 7. Is that right? [EIP]

*Response: The final values of literature analysis are presented in the literature values in Table 7. These were then adjusted for scale, crop type and management variability adjustments (compliance, BPJ).*

This is clearer – but what were the literature values that you averaged? [EIP]

*Response: Literature values were averaged in the final efficiency values located at the right right column of Table 7. An average value from literature for corn was halved as a proxy for the benefit of splitting N applications to Hay receiving nutrients was presented as the literature value for Hay.*

#### Tier 2P

As noted later on, we do not think manure incorporation and use of PSI justify this efficiency. The relatively high Tier 1 efficiency for P makes these additional proposed reductions even more problematic. [CBF]

*Response: Manure incorporation and the P risk assessments from various states were new practices involved in a NMP beyond the simple rate changes quantified in Tier 1. While manure incorporation was not used as a contributing factor in the Tier 2 P efficiency estimate explicitly, it is a contributing factor to states' P risk assessment tools, so the benefits are implicitly included. The resulting efficiency of manure incorporation as calculated by the Panel with appropriate scale, crop and management variability adjustments yielded a*

*reduction potential close to those of the P risk assessment tool, so this was supporting evidence the Panel chose to present in it's support of the controversial P risk tools.*

Tier 2 P efficiencies were based on the benefits of manure incorporation and use of P indices. The studies used to derive the benefits of manure incorporation did not consider subsurface P losses (an important P loss pathway). Without knowing what those losses are and how much they may counteract benefits from reduced surface runoff loss, we don't see how a pollution removal efficiency can be estimated. Benefits of using P indices were based on modeled benefits from a study that looked at the relationship of P index value and P losses. There is no empirical evidence showing that application of the P index has reduced P losses. In fact, the only study we are aware of looking at soils saturated with P is the infamous Green Run study that showed no reduction in P loss and no change in soil P even after poultry litter application was ceased for 10 years. While intuitively one might think that reductions in land application of manure driven by use of a P index should lead to reductions in P loss – it seems in many cases, the use of the P index is not making things better, perse, it just stops things from getting worse. An analogy is this: If I overeat, I will gain weight. If I stop overeating (e.g., apply P at agronomic rates), I don't lose weight, I just stop gaining weight. [CBF]

*Response: Manure incorporation was explicitly not used for the calculation of the Tier 2 P efficiency. Instead the Tier 2 P efficiency is derived by the P risk assessment tools (aka PSI). The study analyzing the change in load from soils with different PSI ratings did include subsurface loss potential in its estimation via the SWAT model. The Green Run study, performed in part by a panelist only eliminated manure application in the first 5 years of the 10 year duration. While the results did not show a reduction in P loss, the P index rating of this site also did not change. The Panel based the estimation of the PSI benefits on sites that change their status and we adjusted the efficiency by 25% to approximate only 1 in 4 sites having the measured benefit to P loss where the PSI is issued. This adjustment was a consensus approved approach and BPJ estimation after deliberations that included the very points raised in this comment.*

**Tier 2 Phosphorus Reductions do not appear to be supported by literature:** It's a long standing issue nationally that P indices were developed as risk management tools but are not necessarily protective of water quality. In fact studies documenting water pollution reductions and water quality benefits of P indices are sorely lacking. Just having a P index or just running a P index does not necessarily result in an immediate reduction of phosphorus losses from a field. For example on P-saturated soils, eliminating P application is not going to reduce the losses from the field immediately, it is just going to ensure that the problem does not get worse while the crop continues to draw down the reserve of P in the soil.

In order for these efficiencies to be justified I recommend that the panel define the situations where real reductions of P losses are likely and define the verification/reporting measures necessary for states to receive credit. Another option would be to wait until the CBP partnership refines the model to address P in the soils and until we have a CBP-approved manure incorporation efficiency in order to be able to back up any P reductions. [EPA]

*Response: See above. Additionally, the Panel considered situations where real P reductions occur as being well simulated by SWAT and the literature cited for this estimate uses SWAT and bases the reduction in P loss from a change in PSI category. The Panel agreed that these are scientifically reliable conditions to estimate P loss reductions.*

**Tier 2 Should Be Revised to Remove Phosphorus Reduction Credit because there is no Evidence that Using a Phosphorus Index will Actually Reduce the Amount of Phosphorus Reaching Local Waterways.** Tier 2

provides a phosphorus reduction credit for using a phosphorus index. However, there is no empirical evidence demonstrating that applying a phosphorus index will actually reduce phosphorus runoff. Where soil is already saturated with phosphorus, as in Green Run, a study shows no reduction in phosphorus loss and no change in soil phosphorus even after poultry litter application was ceased for 10 years. While the use of the phosphorus index may be stopping phosphorus runoff from getting worse, there is no proof that it is actually making things better. Without evidence demonstrating that use of a phosphorus index on phosphorus-saturated soils actually *decreases* phosphorus runoff, Tier 2 should give no phosphorus reduction credit for a phosphorus index on phosphorus-saturated soils. [CCWC]

*Response: See above responses regarding P risk assessment estimate techniques, justification and conditions for which the estimate was made accounting for the final efficiency. These responses also address the popular science article presented by multiple commenters regarding Green Run.*

### Manure Incorporation

This sentence is confusing and should be clarified. Is the point that the benefits of incorporation on certain soil types reduces surface runoff and these benefits outweigh the potential losses via subsurface pathways? If so, please clarify. Also, not sure what is meant by “less than well-drained soils did benefit from tillage.”? [CBF]

*Response: The report has revised the highlighted section of the report which was flagged for poor clarity.*

The studies above and Table 6 highlight the importance of subsurface P losses, yet this study did not look at that and the efficiency is based on reductions from surface runoff only, without considering effects on subsurface losses. This is not appropriate. [Tier 2P incorporation] [CBF]

*Response: This study did not consider subsurface P loss. Subsurface P loss is a significant concern on very limited acreage in the CBW. Despite the small acreage, incorporation was eliminated from the final Tier 2 P estimate and was instead used by the Panel as supporting evidence for the suite of conditions used to calculate a PSI. Management of high soil test P to reduce P loss is included in P risk assessment tools like the PSI and management options like incorporation are useful for both reducing risk and improving a PSI rating.*

What was the control? Not understanding how you can have 88% less P loss, but the mass of P loss was not different than the control? [Tier 2P incorporation] [CBF]

*Response: The control was an untilled site without manure application or a true control. In other words, untilled, dairy amended soils had the greatest runoff P and the least runoff (88% lower) was generated by tilled dairy amended soils as well as untilled soils with no amendment.*

I thought it said on the previous page that Feyereisen and Folmar did not measure subsurface P, just subsurface flow...if so, how can that be used to discount the efficiency? As noted for the coastal plain, without some quantification of subsurface losses of P in these studies, the derivation of efficiencies based on surface losses alone, is not justified, even if they are discounted. [Tier 2P incorporation] [CBF]

*Response: No efficiency was calculated from this section or specifically this paper. Adjustments to the resulting P loss reductions were made to compare the results of these studies to the estimate of the implementation of a complete P risk assessment. The paper mentioned sought to identify the surface and subsurface flow through soils that were used to generate P surface losses. If concentrations of P in surface and subsurface were proportional to flow in these pathways, as the analysis assumes, the 88% surface P loss reduction from tillage should be discounted to a number in the mid 40%.*

As noted earlier, without quantifying these losses and comparing to surface losses, it is not appropriate to establish an efficiency. Also, as noted earlier, the states have different timeframes and requirements around incorporation so it may not make sense to include it as justification for Tier 2 since it is not uniformly implemented. [Tier 2P incorporation] [CBF]

*Response: No papers connecting subsurface P loss to tillage were discovered in published literature by the panel. BPJ was used to reduction the efficacy of the paper results to a holistic efficiency. This contribution is manifest in management variability adjustments in Table 7. Ultimately this component of Tier 2 P was not included in the final estimation of the efficiency, it was supportive of the efficiency the panel derived from the P risk assessment tools, which includes incorporation as an option.*

Interesting data. Suggest CBP use the 1992-1198 P drawdown information from this in subsequent discussions on drawdown. Data was before this was being discussed and indicates a linear drawdown with greater negative slope for higher initial STP (high P soils reduced STP at faster rate). [Figure 7] [ATS]

*Response: The P drawdown information from this figure is illustrative only. Because the CBWM does not account for accumulated STP, the load generated from STP is captured in the calibration and is simulated, to some degree in all landuses. For this reason, it is difficult to assign a reduction on one landuse from drawing down P. Additionally, P drawdown is not a speedy BMP and is inappropriate for credit in the Phase 5.3.2 CBWM considering the planned longevity of this modeling tool.*

Don't these two sentences contradict each other? [EIP]

*Response: This comment refers to the control in the Tarkalson & Mikkelsen paper and is answered above.*

Please rewrite or expand – I can't figure out what you are trying to say here. [EIP]

*Response: This section was edited to improve clarity and understanding.*

Unclear. What are you trying to say here? That manure incorporation produces lower P loads than surface broadcast application? [EIP]

*Response: This section was edited to improve clarity and understanding, but yes, that is the correct understanding.*

This is just a string of words – please put a complete sentence here to explain! [Table 6] [EIP]

*Response: It is appropriate to interpret "Poorly drained soil surface runoff and disrupted macropore flow to groundwater" to mean soil surface runoff from poorly drained soils is reduced by tillage and subsurface flow of P in these soils is diminished by disrupting macropore flow of P also due to the tillage.*

### P-Risk Assessment Tools

The cited studies do a good job of demonstrating that PSIs can do a fairly good job of predicting P losses, but that is different than saying the application of these indices will reduce P losses. One well known study, paired watershed assessment/ Green run would suggest that even eliminating land application of manure for 10 years did not result in a decrease in P soil concentrations

[http://www.bayjournal.com/article/10\\_years\\_of\\_management\\_fails\\_to\\_reduce\\_phosphorus\\_in\\_study\\_are\\_a](http://www.bayjournal.com/article/10_years_of_management_fails_to_reduce_phosphorus_in_study_are_a)

I recognize that the watershed model does not have lag times, but in this case, until we see actual changes in soil PSI values it is premature to give credit for their implementation alone as there is no monitoring data to support a reduction in P losses. This in contrast to other BMPs like cover crops and buffers that do have

lag times, but also have lots of studies supporting the notion they actually do reduce nutrient losses. As noted in the article: “The results show that 10 years of management actions failed to reduce the amount of phosphorus that had built up in the soil during the previous four decades. They only slowed the rate at which phosphorus was accumulating.”

This efficiency is based on modeled losses – that is not sufficient, particularly in light of the Green Run results. [CBF]

*Response: The credit available for P index use is a result of the ability of management decisions to influence P loss short and long term. The credit is driven by P risk assessment tools performed in the field and then re-run as a result of management changes dropping the rating to a less deleterious level. See also, Tier 2 P responses regarding Green Run, above.*

Paragraph is hard to follow and redundant but the conclusion appears to be that 5 of the 12 southern states evaluated had moderate to strong relationships between PSI and published load data while 7 of the twelve had weak, no or negative relationships with published loading data. Is that interpretation correct and how should the PSI assessment be viewed as rationale for increased reductions, if it is? Given lack of clarity on derivation of the Tier 1 P reduction, do these data support a higher reduction for PSI use in Tier 2? [ATS]

*Response: These data were on southern PSIs, below the watershed. This analysis was not used in the quantification of our recommendation because better data was gleaned and analyzed. Again, this data has no bearing on the watershed, or any recommendations: Tiers 1-3 from this Panel. This section was dedicated to a review of literature synopsis for the general audience to show the commitment to literature review consistent with the BMP Protocol.*

Insufficient data for panelist to make recommendation but use graph of PSI vs SWAT model estimates above as basis for reduction. Isn't this a weak basis for a reduction? By visual observation, appears big reduction is from medium to low rather than from high to medium. Should this be considered if graph is used to estimate reductions (need to move from medium to low PSI to get credit)? Which PSI was used (location) and how does it correlate to CB W/S PSIs or newer tools? [ATS]

*Response: The Panel deemed this data sufficient for an estimate in the absence of any other peer reviewed literature being available to draw a conclusion from. Categories Medium and Low would not result in a P risk assessment tool triggering a management change. The Panel understands that some NM planners would advise improvements to get a producer's field in a low category from a medium, but to base the estimate on this change would bias the result toward a greater estimation.*

In addition to Tier 1 P reductions? Do not most CB W/s states now require some P risk assessment tool as part of a basic NMP. If so, why additional reduction. [ATS]

*Response: Tier 2 is recommended to be its own efficiency combining the Tier 1 credit with Table 7 Tier 2 P efficiencies to form a Tier 2 P credit. Tier 1 credit is earned by a reduction in manure applications to LGU recommended N rates and additional credit is earned by a reduction from the benefits of P risk assessment tools reducing the P loss risk.*

## Tier 3

It appears you get full credit for using any one of the five practices. Is that correct, and, if so, why? [ATS]

*Response: Credit is recommended to be granted for the change in rate of application from results of any of these tools. There is no current method to collect Tier 3 components individually by the states, so to deliver*

*an estimate that can be used for the period this recommendation is advised, combining the estimates was the prudent strategy.*

## PSNT

Suggest some language be included to indicate the rationale for why this should be given additional credit beyond benefits of split application/timing in Tier 2. [CBF]

*Response: PSNT is related to the splitting of applications, but the intent to run the PSNT can be credited separately. The splitting of applications is worth a decrease in leaching potential. The decrease in application rates is creditable by the Tier 3 method, which requires an adjustment in rate.*

I can't figure out how these numbers are averages of any of the numbers above – please clarify, preferably with a table showing which studies/results contributed to which averages. [PSNT narrative] [EIP]

*Response: Each adjusted literature value from Table 7 is taken from the component sections' conclusions from the literature. Then, each adjusted value is summed and divided by the total number of values for an arithmetic mean. This is, in the Panel's opinion, the most responsible way to give credit for practices that are not tracked individually or could be reported individually.*

## CSNT

Where does the value in Table 7 come from? And what is the rationale for applying to all geographies? Seems like the benefits would be more like the PSNT? If not, can you provide a sentence for why you don't expect it to vary by geography? [CBF]

Please add a sentence or two explaining how you ended up selecting 20% as the 'literature value' in Table 7. [EIP]

*Response: Results are consistent across Bay and non-Bay geographies indicating a consistent reduction. 20% is representative of combining silage with grain application rates.*

## ISNT

Given this, seems like assigning a value to this is pretty weak. Suggest deleting from consideration. Also, do any other states besides NY employ this approach? [ISNT data limitations] [CBF]

*Response: Results from trials indicate similar reductions. Pathways of prevented loss are similar to other methods. This tool is useful to NY farmers now, but perhaps others later. Sampling with this approach requires two years of testing before rate change is implemented. Credit cannot be applied until rate is changed, therefore the implicit conservatism in this tool is supportive of the reduction and inclusion in the average Tier 3 BMP.*

Are you saying that you used reductions in N applications as a proxy for reductions in EOS N loads? If so, please state that clearly up front. And, in addition, please explain how the 33% was derived. Is it the difference between 150 lbs/acre and the 100 lbs/acre? Why not the difference between 20 ppm soil residual and 9 ppm (55%)? What are the standard assumptions and how do they play into the calculations? [EIP]

*Response: The context of the explanation leads the reader through the change in soil residual between the two trials being 9ppm, which is roughly a 33% reduction from non-BMP soil residuals using standard*

*assumptions for soil density and depth of soil NO<sub>3</sub> testing. The ISNT captures the root zone residuals and not N lost due to leaching, so a deeper profile of soil must be considered for the percent reduction estimate.*

### Variable Rate N

Again, are you using reduced applications as a proxy for reduced loads? If so, please state clearly up front. [EIP]

*Response: Yes. This conclusion should not cloud the scientific analysis noted in the section and is not appropriate for prioritization at the beginning of the section. See also, response regarding N rate coefficient changes compared to N loss risk prevention with appropriate data slide.*

### Tier 3P Discussion

As there is no Tier 3 P recommendation, think this should either be removed or put in an appendix for the PH. 6 EP. Data and experience indicate there is likely more than feed management and even whole farm P balances (both of which are important) to getting substantial reductions in P losses. Since no conclusion is reached on Tier 3 P, suggest the discussion not be included as part of the main report. [ATS]

*Response: While the comment is valid, this section will remain in the body of the report for consistency with the other components.*

### Effectiveness estimates for Tiers 2 and 3 (Table 7)

The “literature values” in this table are apples and oranges e.g., some like the manure incorporation are based on ammonia conserved (N) or reduced surface runoff (P) while others are based on reduced N application or I think, differences in nutrient uptake as reflected in crop yield...yet, they appear to be treated the same? Or maybe that is what the “mgt. Variability adjustment takes into account? Would suggest clarifying what the literature values represent and then explicitly adding discounts if they do not represent actual monitored losses to surface or groundwater. [CBF]

*Response: All N values can be interpreted as reduced N application. As noted in Tier 2 N responses, reduced N application is the common metric for which literature was analyzed, because N efficiency relevant to crop production is the most common metric supported by funding agencies, and it is the basis for economic survival in agriculture. Hence, increased PAN from ammonia reduction is manifest in a NMP as lower application of manure and greater plant recovery of N, which reduces N losses to the environment. See also, response regarding N rate coefficient changes compared to N loss risk prevention with appropriate data slide. Likewise, nitrogen testing after a season of corn can reduce N application in the next season, which is a basic principle in adaptive management. Split timing of N results in less applied N due to decreased N losses to denitrification and decreased leaching, both of which impact the environment. The Panel recognizes the monitored losses in surface and groundwater would be excellent metrics to evaluate NM, but they are a critical “missing links” in the NM databases at this point in time due to an extreme shortage of funds to monitor surface and groundwater quality. Therefore, the Panel used reductions in N application rates as the best available metric to evaluate the environmental impacts of NM.*

As noted in the text, it is not clear how this value based on conserved ammonia would relate to net reductions in N loss, given the total amount of N is the same. [Table 7: Tier 2N manure incorporation literature value] [CBF]

*Response: See above and the Tier 2 related response.*



As noted in text, these values do not consider subsurface losses of P, so would suggest they are not appropriate for inclusion. [Table 7: Tier 2P manure incorporation literature value] [CBF]

*Response: Tier 2 P does not include manure incorporation in the estimate; it is merely an informative exercise to adjust the literature values because incorporation is a major management component to the PSI. The PSI is, in fact, the sole factor in estimating credit for Tier 2 P reductions.*

As noted in text, this is based solely on a model – there are no studies documenting P loss reductions from implementing the PSI and in fact the Green Run study suggests a VERY long time lag. Also, states vary in their use and form of this tool. Would suggest no credit be given. [Table 7: Tier 2P, PSI literature value] [CBF]

*Response: See Tier 2 P response, above.*

As noted in text, this value seems high given there is relatively little information on the benefits. Also, how widely used in the region is this? Suggest deleting. [Table 7: Tier 3P, ISNT literature value] [CBF]

*Response: The studies cited and the summary written on pages 39-40 of the report for the Tier 3N – ISNT values demonstrate consistent and significant reductions in N application rates (over multiple sites and years) when the ISNT is used to adaptively manage N based on field-specifically characterized soil N supply versus standard book values used in Tier 2 N management. Like other adaptive N management tools, the ISNT is used more and more each year, especially in cropping systems involving significant organic N contributions from hay in rotation, cover crops, manure, and/or compost. For conservatism, the rate reductions and associated leaching losses were further and significantly discounted to arrive at the final value.*

This is some kind of combination of the average of the three N timing estimates and the manure incorporation estimate, right? I can't reproduce the math – could you explain in a footnote? [Table 7: Tier 2N on row crop] [EIP]

*Response: Adjusted data points for N timing ( $X_i$ ) were utilized as a mean that contributed in an additive way to the Manure Incorporation adjusted value for the row crop efficiency of 4.4 percent (i.e.,  $(X_{f1} + X_{f2} + X_{f3})/3 + Y_{f1}$ ). Where X is an N timing value of row crops (excluding hay) and Y is Manure Incorporation effects. This mathematical approach attempts to average similar timing components, while allowing the non-timing component to be independent of timing. The Panel recognizes that this approach may exceed the accuracy of the data, however, the Panel chose to use this approach to put more emphasis on incorporation which was considered to be significantly undervalued - indeed manure incorporation will be the subject of a completely new BMP in the Phase 6 model.*

For the nutrient reduction efficiencies to be more defensible, it was very important to accommodate the “discount” factors. Section 4 and Section 5 are valuable write-ups and point to the need for the discount factors. However, it also highlights what literature and studies to consider for determining the benefits of BMPs. Small-scale, short-term studies in controlled environments are the opposite of what's needed to inform the model, particularly when a panel's recommendation are single efficiency units applied across the 64K sq. mile watershed. The panel's extrapolations could be difficult to defend – even with the accounting for discounts – particularly because of the large extent of reported acres in this BMP and the sensitivity among many stakeholder groups. National and large regional studies of nutrient balances/imbalances should have been accommodated to some degree in the panel's assessment – and these exist. Even large scale-model results using monitored, survey and/or published data are preferable to small-scale, short-term



studies – as important lines of evidence to inform the CB WSM. The premise of Tier 1 benefits is changing land-grant recommendations over time. Why not use data of changes in large-scale nutrient balances of what occurred on the ground – rather than what was supposed to occur on the ground. Maybe the benefits would be greater than the panel’s recommendations. Maybe the benefits would be less. [ Team]

*Response: The Panel agrees that smaller scale nutrient budgets could improve the estimated adjustment factors, but it is the Panel’s opinion that the current large scale of the P5.3.2 model and the uncertainties in its nutrient budgets (particularly the fertilizer inputs and manure generation data) magnify the complexities of recommending a nutrient budget approach. The suggestions of using small-scale nutrient budgets should be revisited in the new Phase 6 model where fertilizer and manure inputs plan to be improved. Footnotes will be added to address confusion about the nature of the adjustments. See also Section 4.3 of the Report entitled: The Need for Applied Research on BMP Effectiveness.*

This is of limited importance as Tier 1 reductions are by far the largest yet least justified. However, some estimates are cited as having no published (or gray?) literature so unsure how you apply the chart below. Also, applicability to the CB w/s may have been considered but was not shown in decision support diagram. [Tier 2 and 3 synthesis of efficiencies] [ATS]

**The Panel should not average efficiencies for practices and geographies unless it is necessary for implementation of the Bay Model.** The rationale behind the Panel’s decision to average its adjusted efficiencies for certain practices and geographies into one Tier credit value is also unclear. For example, though the Panel derived significantly different adjusted efficiencies for Tier 2 N timing in different geographic regions, these values are averaged into one Tier credit. And although the Panel started with distinct pollution reduction values from the literature for five Tier 3 N practices, the Panel ultimately recommends a single adjusted efficiency for any and all of these practices. If this is necessary due to limitations in the Model, the Panel should make that clear. This approach is also at odds with other calculation methods, because rather than weighting the values based on relevant criteria such as the prevalence of the Tier in different geographic areas, the final credit is an unweighted mean. Without further explanation, the decision to average these values seems arbitrary. [EIP]

**The Panel should clarify how it derived adjusted efficiencies from literature values for pollution reduction.** The NM Efficiencies document lacks critical detail on the Panel’s methodology for translating the relevant literature values into the final literature value adopted for each adjusted efficiency. For example, the draft indicates that the Panel has “weighted” the available literature values in deriving its numbers, but provides no explanation of how the different values were weighted and why. The final document should provide a clear explanation of the calculations leading to the literature values adopted and the Panel’s rationale for its approach. We have provided specific comments on this issue in the attached track changes copy of the draft report. [EIP]

Please add an appendix listing these values and the weights that were applied in averaging. Without that level of detail, the reader doesn’t know how you got from point A to point B. [Literature values for Tier 2 and 3 component efficiencies, and adjustments] [EIP]

*Efficiencies and averages Response: Averages in Table 7 were applied to percent nutrient reductions therefore units are not appropriate. Measures can be found in the preceding NM component subsection. The averages performed by the panel were a result of tracking limitations in the framework of the Phase 5.3.2 CBWM. When Phase 6.0 CBWM is developed and tracking and verification programs are enhanced by*

*2018, these elements of the recommendation should be revised by the appropriate panel. The Panel weighed unpublished or gray literature as heavily as peer reviewed papers collected by the Panel based on personal communication with the researchers to ensure its applicability to this report. In all cases of component BMPs, watershed scale, peer reviewed, local data were not available despite the Panel's best efforts in several years of active discussion and deliberation.*

Please explain how these are applied e.g., is 80% meaning it is multiplied by 0.8? or 0.2? *[Management variability factor]* [CBF]

*Response: An 80% adjustment to the Management Variability factor is applied by multiplying by 0.8 (see N timing section).*

With the discounts, the panel seems to have somewhat accommodated what's measured with what's needed for the model – an accounting of the net change in fluxes after considering all pathways (runoff, subsurface, and groundwater loads), all species (e.g. NO<sub>3</sub>-N, NH<sub>4</sub><sup>+</sup>-N, and organic N), etc. However, the 25% reduction for “scale” and those for management variability (from literature values) are generous in light of the usefulness of information that informed the recommendations. An Expert Panel shouldn't use a particular “discount” value because another Expert Panel used it. The point of each panel is to revise the data and methods with an approach and information that are more defensible than the ones currently being used. For example, the panel used a discount value from the Cover Crop Panel which used the particular discount because an earlier group used it – and this same number goes back through a few version of the Watershed Model. [CBPO Modeling Team]

*Response: The Panel used previously approved discounts in part because they are decent estimates and improvement on those estimates would require time and effort, which this panel could not spare. Secondly, the Panel was relying on approved adjustments and even terms for adjustments to be consistent and avoid dissent from the recommended approach by the CBP Partnership. See also Section 4.3 The Need for Applied Research on BMP Effectiveness.*

## Tier 1

*Response note: A series of comments were received specifically addressing technical and clarifying questions about Tier 1, its definition, and the efficiencies that were recommended and approved by the Partnership in October 2013. These comments are fully captured in this section. A number of the Tier 1 comments have been addressed within the Tier 2 and 3 discussions above as they pertained to critical elements of the recommendations for the Tier 2 and 3 efficiency recommendations. Other comments, especially those pertaining to the currently applied efficiencies of Tier 1, however, will be handled as follows:*

### General Comments

**The Panel should accept comment on Tier 1 efficiencies and adjust its Tier 1 recommendations as necessary.** Although the Panel has characterized its Tier 1 recommendations as “approved,” it should take comment on those recommendations here because load reduction efficiencies for Tiers 2 and 3 quantitatively incorporate Tier 1 efficiency values. In other words, the three tiers are not distinct, either conceptually or quantitatively. To the extent that the Panel does accept comments on Tier 1, we will comment here that the Panel should adjust Tier 1 efficiencies for known rates of non-compliance (see comment III. above). In addition, there does not appear to be any basis for assuming a reduction in phosphorus load under Tier 1 nutrient application management, which is based on crop nitrogen needs, and so we urge the Panel to eliminate Tier1 P efficiencies. [EIP]

*Response: All Tier 1 comments will be provided to the new, Phase 6.0 Nutrient Management Panel at its Open Session scheduled to take place on September 10, 2015. The Tier 1 comments will be informative to the new Panel's consideration but are outside of the scope of the current Panel's charge. It is critical to note that the current Phase 5.3.2 Nutrient Management Panel, in the revised charge issued in January 2015, was not asked to revisit, review, or revise Tier 1, approved definition and efficiencies. The current charge to the Panel was developed in response to extensive stakeholder review and input that took place over the course of Fall 2014 when the Expert Panel's recommendations for Tier 2 efficiencies were not approved across the Partnership. The Agriculture Workgroup, in consultation with the Water Quality Goal Implementation Team and the Chesapeake Bay Program Office, reconvened the 5.3.2 Expert Panel in January 2015 for a short-term re-evaluation to address the specific comments and questions that were raised in response to the Fall 2014 report. Collectively, the Agriculture Workgroup and the Partnership issued the following charge:*

**Phase 5.3.2 Panel Charge** The Expert Panel will be re-convened during Winter 2015 and charged as follows:

**The 5.3.2 Nutrient Application Management Expert Panel** will conduct a short-term re-evaluation that will separate the N and P benefits for Tier 2 and Tier 3 levels of nutrient management effort and re-consider the agricultural land uses for which the benefits will be realized. The resulting report will clearly communicate the basis for each recommendation, including the supporting summary tables and figures, and the literature citations used by the Panel including the process for informing best professional judgment.

The Panel will also develop a checklist for the data needed for assessing the presence/absence of the level of nutrient management necessary to qualify for each Tier to provide jurisdictions with the necessary guidance for generating the reports and necessary Quality Assurance Plan documentation for reporting under the recommended definitions.

*Commenters are invited to register to present their recommendations, findings, data, or other information at the September 10, 2015 Open Session for the new, Phase 6.0 Expert Panel for Nutrient Management. To register as a presenter to the Panel at its Open Session, go to: [http://www.chesapeakebay.net/groups/group/agriculture\\_workgroup](http://www.chesapeakebay.net/groups/group/agriculture_workgroup), "Meeting Tab". In addition, all Tier 1-related comments received to date will be provided to the Phase 6.0 Expert Panel.*

**Tier 1 Should Be Revised to Remove Phosphorus Reduction Credit Where Practices Actually Increase Phosphorus Runoff.** The Choose Clean Water Coalition understands that the Tier 1 efficiencies have been previously approved. However, because the Tier 1 efficiencies form the foundation for Tier 2 and Tier 3, it is important that the Tier 1 efficiencies are robust and supported by the science. Tier 1 gives a 10% phosphorus reduction credit for application of manure at crop need nitrogen rates. It is our understanding that applying manure to crops based on nitrogen need will result in over- application of phosphorus. This over-application will lead to phosphorus runoff into adjacent waterways. For this reason, Tier 1 should give a 0% phosphorus reduction credit for applying manure at crop need nitrogen rates. [CCWC]

*Response: Any application of manure in-line with NM recommended rates is assumed to be a reduction from a non-BMP rate condition. Anecdotal evidence from popular press suggests that rates of manure application prior to NM planning were 3 or more times higher than recommended rates based on N, despite the application of P being above crop removal rates. Additionally, rates of application of P in manure above crop removal are not necessarily responsible for increased loads. Soil has a very high retention of P amendments when applied to fields with good adsorptive properties and where STP levels are low, so to say that N need based applications of manure is over-applying P is a misnomer. The Panel asserts the recommendations in both the approved Tier 1 report and this draft report are consistent with scientific findings of this Panel.*

**Tier 1 must be re-assessed and revised before approval of current EP report as it has fatal flaws and is the basis for Tiers 2 and 3 efficiencies, adversely impacting their efficiencies.**

Specific Tier 1 Fatal Flaws

- As defined, will result in increases in P losses rather than the claimed 10% P reduction
- EP report acknowledges Tier 1 as 1970-80s Nutrient Management (Chart p 13), which is Pre-CBP and several generations behind current “basic NM” definition and state requirements

Rationale for expected increases in P loss under Tier 1

- Tier 1 allows N based applications of manure/litter and LGU recommended fertilizer P where “fertilizer only” is applied
  - Given high cost of fertilizer P, farmers are unlikely to apply P substantially above recommended rates, as claimed in past, and some may apply less, so efficiency for Tier 1 type of fertilizer only P application should be zero (0)
- Application of manure at crop need N rates will result in over application of P
  - Rate of increase in P loss may slow if excess manure previously applied but P application at N-based manure rates will continue to increase P losses, so how can this result in a 10% P reduction efficiency?

Implications of NOT addressing fatal flaws in Tier 1

- Substantial over estimation of progress in P reductions
- Directionally incorrect estimate: Will credit reduction for a practice that increases P loss

Implication for Tier 2

- Tier 2 P efficiencies will be too high since use Tier 1 as base so will result in over estimation of P reduction progress where credited

Implication for Phase 6.0

- If proposed Ph. 5.3.2 NAM Tier 1 recommendations are approved as written and corrected for Ph. 6.0, will create confusion and controversy, particularly while both models are in use.

2013 approval of Tier 1 appears to only have been for 2013 Progress and Milestone assessment (see P 12 of report) of report. Is there documentation of approval for use through 2018 (P 13 of report)? Regardless of answer, since Tier 1 gives a 10% P reduction while actually increasing P losses, it cannot be credibly used for progress assessments or as basis for Tiers 2 and 3.

Nitrogen in Tier 1: Current NM (and that reported prior to 2010) assumes N applied at recommended rates. Unclear why or how to apply proposed Tier 1 N efficiency to existing NM acres. [ATS]

As noted later on, I don’t see justification for reduction in P loss on non-manured acres. Though the focus of our comments is on Tier 2 and 3, since these efficiencies build on Tier 1, Tier 1 is a consideration. [CBF]

Overriding issue is that Tier 1 is *directionally incorrect* and will result in continued increases in P losses due to N-based manure application and little to no change in fertilizer only P use, rather than the “approved” 10% reduction. Was this issue discussed with the panel? Tier 2 and three are reductions were developed relative to Tier 1 which makes them derived from an incorrect base.

The reported approval was for use in 2013 Progress and milestone runs according to the table on P 12. It was not approved in 11-14 and was re-opened so unclear why Tier 1 was “approved” as it was well past the 2013 uses. Tier 1 is also discussed throughout the report with a more detailed technical discussion on pp24-28 so it was considered during panel deliberations. Again, was the issue that the definition does not support the reduction discussed by panel members? [ATS]

Tier 2 and 3 appear to be based on additionally from Tier 1. As stated above, literature citations are provided for the enhancements from “basic NAM”, the relative reductions added to Tier 1 reductions discredits the reductions for these tiers. [ATS]

*Response: See responses immediately above.*

**The Panel should clarify how Tier 1 practices are credited in baseline model runs.** The NM Efficiencies document’s discussion of Practice Baseline is not completely clear, and warrants further explanation. Section 5.2 indicates that practices satisfying 1995 Land Grant University recommendations are comparable to those meeting Tier 1 conditions. But it is not clear how those practices implemented before 2009 were identified prior to assigning credit for post-Total Maximum Daily Load (“TMDL”) nutrient reductions for Tier 1 practices achieved pursuant to the TMDL. Given that the practices receiving credit conform to recommendations pre-dating the TMDL by 14 years, it does not seem appropriate to award credit for all Tier 1 practices without first verifying when the practices (and related nutrient loss reductions) went into effect. Similarly, there is no discussion of the verification or quality assurance requirements for the determinations of which practices are post-TMDL and therefore appropriate recipients of nutrient efficiency credits in the Bay Model. If the model baseline assumes that no farms were using Tier 1 practices in 2009, then the authors should clearly say so. Otherwise, the authors should clearly state that Tier 1 practices implemented before 2009, and therefore assumed to be part of the baseline, are not eligible for Tier 1 credit. [EIP]

*Response: This is clarified in the [Tier 1 approved Panel Report](#).*

### Tier 1 Process

Based on comments on earlier report, were there never any suggestions that the Tier 1 definition and reductions either be better explained/documented and/or revisited??? [ATS]

Since Tier 1 was “approved, was there no justification to discuss it? If that was the reason, why is it discussed in detail on pp 24-28? [ATS]

Appears to document that THIS panel considered and decided on Tier 1 [ATS]

*Response: No suggestions related to Tier 1 were considered in the Panel’s response to comment on the Fall 2014 Tier 2 Report recommendations because comments related to Tier 1 were deemed irrelevant based on the Tier 1 report being previously approved and incorporated into the model. Tier 1 details were included in the July 2015 report at the request of the AgWG to frame the era of nutrient management the Panel already captured and approved, but did not discuss in detail during the late 2014 and 2015 meetings. To clarify, this Panel was responsible for the Tier 1 recommendations and approved report.*

### Tier 1 Timeline

Figure 1 appears to indicate that Tier 1 represents NM from the 1970s-80s. NM was started in the mid-1980s although LGU fertilizer recommendations started before then. Is this level of NM intended to get Tier 1 credit through 2017 despite the current knowledge base strongly indicating that N-based manure applications result in continued build-up and loss of P? Was this discussed with EP? [ATS]

*Response: Figure 1 indicates that research from the 70s and early 80s was the backbone for Tier 1 type NM and this BMP is available for credit throughout the modeling timeframe. From 2005 to present, the Panel agrees that the majority of plans were and continue to be written to a standard consistent with the Tier 2 definition and have improved upon the Tier 1 plans written for millions of acres before 2005. See also response to Tier 1 Justification comments.*

## Tier 1 Definition

Follows LGU recs for N and P would include some P risk factor assessment in most/all (?) states, would it not? [ATS]

*Response: Plans written beginning in 2005 had the first acres planned with P risk assessments in the Chesapeake Bay watershed.*

Don't current LGU recommendations require some type of P risk assessment evaluation for soils above a certain soil test P level, in most, if not all Bay states? [ATS]

*Response: Yes. P risk assessment is not part of the Tier 1 definition, it is part of the Tier 2 definition.*

As stated on numerous occasions before, it is very hard to find scientific rationale for a 10% P reduction under these conditions. The rate of increase in P loss may be slowed by only applying crop N needs but P loss should continue to increase. This may have been done to work within limits of PH5.3.2 WSM capabilities to handle P but that would not appear to justify the 10% P reduction [ATS]

*Response: The scientific rationale for the 10% P reduction is based on manure P decreasing in application by a significant amount in the model. The decrease is calculated from a difference of P loss from corn acres receiving 100% v 120% non-nutrient management N rates in fertilizer and manure. The Panel agreed that non-nutrient management application rates in the model were consistent with nutrient management rates in the real world and the 20% N increase was a proxy for real world non-nutrient management. Using non-NM rates in the simulation as a baseline also minimizes the benefit of any resulting efficiency calculation because non-nutrient management acres are receiving idealized rates of N as a baseline condition.*

## Tier 1 Justification

On manured acres? Or all acres? If all acres, how can you justify assuming 20% lower P on non-manured acres? [Scenario 3 in developing Tier 1 efficiency] [CBF]

*Response: Non-manure acres are not affected by the 20% N adjustment (the % P adjustment was dependent on county specific manure N:P ratios resulting in 8% efficiency). High-till without manure acres get standard efficiency of 5% TN and 8% TP from a prior NM sensitivity run. Only fertilizer and manure on corn was adjusted because the LGU rates for all forms of nitrogen was 20% or more greater than late 1980s and 1990s rates.*

I had a very hard time understanding this paragraph...I understand that Tier 1 efficiencies have already been approved, but as they influence Tier 2 and 3 credits, it is important to understand the logic. This paragraph is not clear, especially the second sentence. [Tier 1 credit] [CBF]

*Response: This section of text (pgs XXX) was revised to improve its clarity and comprehension.*

I don't see any support for why we would expect reductions in P loss on non-manured acres... [Tier 1 credit] [CBF]

*Response: The P reduction is commensurate with the model derived efficiency change from the landuse conversion previously credited in the Phase 5.3.2 CBWM. This reduction was based on the assumption that application rates on unimproved (non-NM) acres was high for various reasons including insurance fertilizations attempting to improve yield prior to yield response studies that proved no yield response from N or P additions beyond crop need would result in improved yield. Additionally, some amendments of P were made in accordance with P build-up of soil stores to improve the availability of P to crop uptake. These*

concepts predated scientific understanding that beyond a certain, soil-specific, threshold soil test phosphorus levels cannot reduce crop stress and perceived crop stress is likely due to early-season temperature effects.

This claim about yields being wrong should be supported by data. [CBF]

*Response: The panel believes this claim to be supported by data they are familiar with and is expanded upon further in the next response.*

So, is this suggesting that the reason we haven't documented an actual decrease in N application historically is because yields have increased? If so, then as noted above, providing data to support this assertion is important. [CBF]

*Response: Yield data included in the model is based upon 5 year intervals of Ag Census interpolated for annual yield data in the CBWM. Specifically illustrated in Maryland as illustrated, Ag Census yield data was collected on disproportionately low yield years compared to average annual yields collected by the National Ag Statistics Service. The chart appended below shows a clear trend in corn yields increasing through time and point data from Ag Census occurring at noticeably low levels, presumably due to weather. This skewing of the data incorporated into the Phase 5.3.2 CBWM results in low estimations of N and P application rates by the Phase 5.3.2 CBWM and obfuscates the improvements in expected yield of roughly 30% during the simulation period. Also included in the analysis, performed by a panel member, are the major row crops, wheat, soybeans and barley which make up the vast majority of high till with manure acres simulated in the CBWM.*

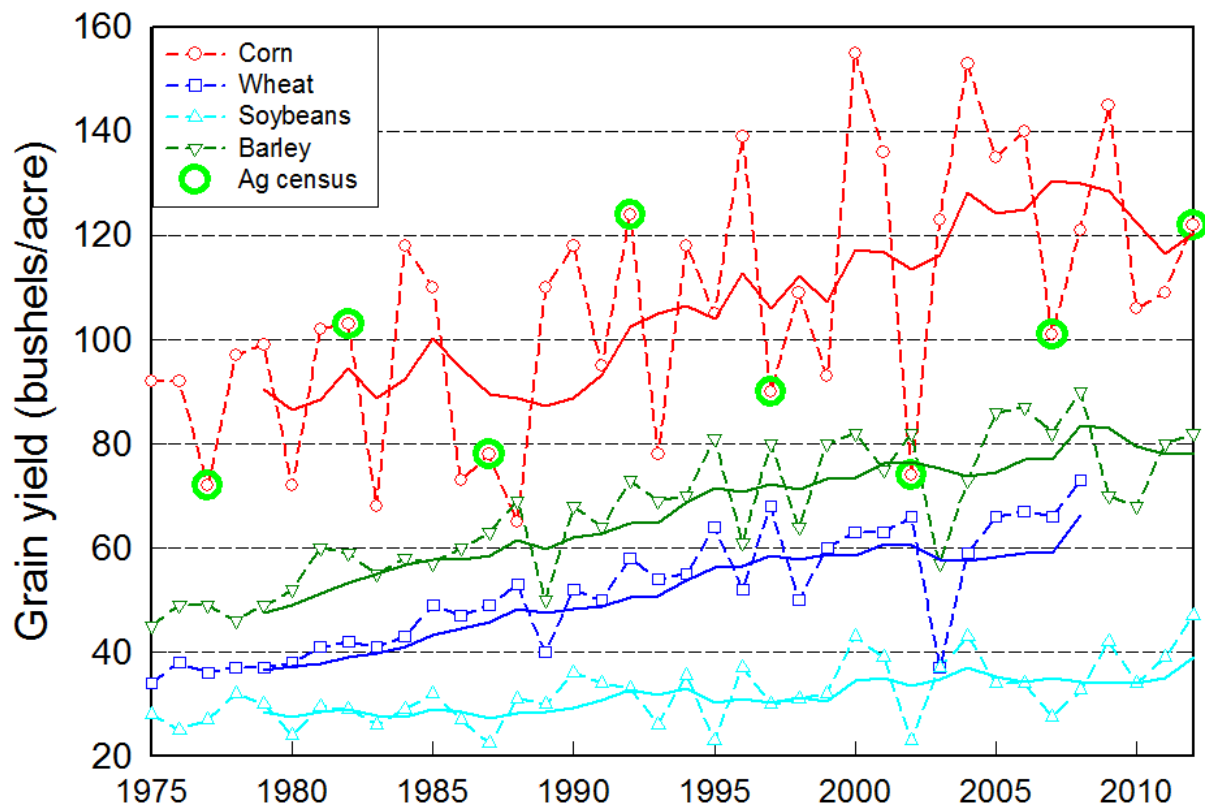




Figure 11 Grain yield in bushels per acre for Maryland from the NASS exhibiting double digit percent increases over the simulation period for major commodity crops and illustrating a disproportionate number of low yield years captured by Ag Census, which is currently the only input data for yield in the Phase 5.3.2 CBWM.

Hmm, results of CEAP data indicate an increase in fertilizer/manure application in recent years. The Panels' response to this observation is that yields have also increased...again, data to support this assumption should be provided. [CBF]

*Response: Yield data has been provided above to support the report's claim of yield increases driving the more modest increases in N and P application rates Bay-wide.*

In 2014 Report regarding Tier 1, states "The Panel based the effectiveness solely on LGU recommendation changes over time because of a lack of scientific literature documenting efficiencies of the proposed practice." It appears Ph 5.3.2 model runs were made based on the changes in LGU recommendations from the 1970s or 80s? Is that correct

*Response: The LGU recommendations from the 1970s and early 1980s were used as a proxy for the baseline condition where no NM was planned or implemented. The change in LGU recommended rates from this time to the simulation period: late 1980s and early 1990s, was the basis for the 20% increase in application rates of nitrogen on corn in the CBWM simulations used to estimate an EOS efficiency for High and low till crops eligible for manure application (landuses: HWM & LWM). The model runs were not basing Tier 1 on a change from a true baseline condition for which no data exists to a LGU recommendation from the 1970s or early 1980s because this period predates an NM credit afforded in the model as a result of the approved Tier 1 CGNAM BMP. This recommendation is further explained in the Tier 1 report available [here](#).*

Concerns about use of WSM to generate reductions but NOW also concerned about crediting changes in LGU recommendations over last 30-40 years as a creditable BMP. Were not these changes an optimistic suggestion for what a farmer was supposed to be applying at base level NM at any point in time??? [ATS]

*Response: The CBWM was used to inform the approved recommendation for credit because the CBWM was already calibrated for the NMPs given credit in the suite of model runs used to inform the TMDL. Any other recommendation could have violated the CBWM calibration and invalidate the TMDL. NM plan writers generally immediately used contemporary recommendations from LGUs. This fact was especially resonant for N, but in the case of P, the adoption of P risk assessment tools was slightly delayed due to the time involved in adapting a research tool to the more binary regulatory environment. See also Tier 1 Justification response.*

Appears to relate to LGU recommendations since the 1970s as discussed above, or perhaps to some other data? This appears to be giving credit for changes in LGU recommendations and/or practice for the last 30+ years to annual progress runs from 2010 thru 2017? Please explain this. [Tier 1 justification] [ATS]

*Response: See Tier 1 Justification response, below.*

Does this not support the comment above? Also supports concerns about P reductions being directionally correct and whether N reduction level can be justified based on 1970s recommendations. [Absence of historic surveys on nutrient applications to crops] [ATS]

*Response: See Tier 1 Justification response, below.*



Perhaps for N but allowing N=based manure rates negates any credit for P (losses increase). How is it verified that farms are following changes in LGU recommendations since 1985, or is this assumed? *[LGU guides informing Tier 1]* [ATS]

*Response: See Tier 1 Justification response, below. There has been a separate, but concurrent effort to clean BMP historical records in the CBWM.*

Only applies to N and not P and not certain about the rationale for N. *[Applicability of Tier 1 to land use]* [ATS]

*Response: See Tier 1 Justification response, below.*

All LGUs in w/s were only recommending 1lb/bu of yield for corn by 1985/? Unless 1lb/bu was credited as NMP throughout calibration period, would not application below that rate have to occur to get post calibration (and post 2009 credit)? [ATS]

*Response: see below.*

What is basis for manure PAN application only being 20% above LGU fertilizer recommendation? Not sure we understand what is being said here. [ATS]

*Response: By 1985 and through to 1990, LGUs decreased the recommended application rates by 20% or more. Some LGUs had a piecemeal reduction from 1.4 to 1.0, but prior to 1985 and after 1985, all supporting LGU literature collected reflected a 20% or more drop in N rates for manure and fertilizer. LGU recommendations from the 1970s and early 1980s as a proxy for real world baseline conditions for which no useable data exists. See also, Tier 1 Justification response, below.*

## Figures 5 & 6

Made 20% manure application reduction and then calculated P reductions from WSM scenarios – no data? [ATS]

*Response: Figures 5 and 6 were mislabeled, the typo has been fixed. See also Tier 1 Justification response.*

WSM issue with P. Agree if you apply less P, the rate of accumulation will decrease but WSM cannot handle concept of losses related to accumulation of P above crop needs over time? [ATS]

*Response: CBWM can handle the concept of losses related to accumulation of P, but the CBWM only simulates accumulation over a 10 years simulation period and the losses are annualized with an average of these simulated years.*

*Tier 1 Justification Response: Tier 1 CGNAM is an approved model-derived estimate and recommendation based on two simulations in the CBWM, results are illustrated in Fig 5 & 6.*

- 1. A run was completed using the original Phase 5.3.2 landuse change designation where all available agricultural land in the watershed was converted to the nutrient management version of the landuse, where high-till with manure was converted to nutrient management high-till with manure, high-till without manure was converted to nutrient management high-till without manure, pasture was converted to nutrient management pasture, alfalfa was converted to nutrient management alfalfa, and hay was converted to nutrient management hay. The NM and no NM run were compared at the watershed level. A watershed scale percent difference at the edge of stream level*

load was used as an estimate of an efficiency for landuses, alfalfa, hay, nursery and high-till without manure.

2. A run was completed using the CBWM where non-NM corn in the high-till with manure landuse was subject to a 20% increase in nitrogen application commensurate with the proxy-higher application rates recommendation by LGUs in the late 1970s and early 1980s. Only corn among the other landuse's crops was adjusted to be consistent with the historical LGU documents. This run was compared at the EOS level to a no-NM run with regular corn application rates for an increase in load from the increased ammonium nitrate and manure rates consistent with pre-model LGU rates. The change in EOS loads was recommended and approved at the Tier 1 efficiency for high and low till with manure landuses.

These runs were in an effort to replicate and model the best professional judgment of the panel relating historical recommended rates on corn with a calibration for the CBWM, that should not be violated with the panel's interim NM recommendation. The landuses beyond that which simulate corn used a calibrated CBWM estimation procedure designed by the CBPO modeling team and panel analysis. This efficiency takes a variable county specified rate of reduction from a Tier 1 acre and averages it for the whole watershed to ensure uniformity among the states for practices performed throughout the history of the model's simulations. The improvement of the EOS efficiency for high-till with manure landuse is a result of a simulation increasing corn application rates to contemporary rates predating the watershed model. This is the best professionally judged proxy for pre-BMP application rates and was deemed conservative by the panel and the CBP Partnership when it was approved in Oct 2013 because it only affected corn acres and any increase in phosphorus was related to the excreted ratio of N to P in the manure which was applied at 1.2 times the modern N rate.

The Panel does not see the multiplicative nature of the Tier 2 and 3 NM BMPs as reason for revisiting our approved recommendation on Tier 1. The concept of stacking Tier 2 and 3 credits beyond the Tier 1 credit were included in the Panel's approved Tier 1 recommendation and the framework of the elements differentiating Tier 1 plans with Tier 2 plans was approved in the 3 definitions recommended and approved in Oct 2013. The July 2015 report clarifies elements of Tier 2 and Tier 3 NM acres based on feedback from the 2014 report stating that Tier 2 components were not worthy of the efficiencies we recommended with the science we presented as evidence. The recommendation for Tier 2N, Tier 2P and Tier 3N credit are each singular values derived from literature that approximates the difference between Tier 2 in addition to Tier 1 levels of effort for a constituent nutrient or Tier 3 components in addition to Tier 2 levels of effort for nitrogen. The recommendation of this report is designed for Phase 5.3.2 of the CBWM. This is inclusive of the 2013 Progress run, milestones and subsequent progress runs until the Phase 6.0 model is approved for use in 2018. The notion that the recommendation was only for 2013 Progress was a misinterpretation of the impetus for a recommendation for only part of the Phase 5.3.2 Panel's charge at that time. Implications on Phase 6.0 of the CBWM are null and, at this stage model development, speculative. Comments and suggestions for that Panel should be referred to that Panel at their [public meeting](#).

The Panel disagrees that the Tier 1 recommendation is fatally flawed. The panel judged the CBWM's estimation of N and P reductions from calibrated landuse changes and an increased rate of fertilizer and manure nitrogen on corn as both conservative relative to the actual real-world benefit of NMPs from 1985 to present and protective of the Phase 5.3.2 CBWM calibration. The Tier 1 credit is based on late 1980s and 1990s era nutrient management; non-nutrient management or pre-nutrient management rates were simulated with 1970s or early 1980s nutrient management recommendations as a proxy. This recommendation does allow for P application rates of manure greater than crop need or removal, but no P

*risk assessment. This is consistent with contemporary plans from the late 80s, 90s and early 2000s. The consistency with this management approach is part of the reason the Panel uses Tier 1 to define this era. The Panel disagrees with the comment that farmers would not waste manure P based on monetary value. During the era where Tier 1 was the penultimate in nutrient management technology, manure P had a nominal value. The Panel agrees that fertilizer P would be applied at economic rates and simulated no increase in fertilizer P with the model runs simulating a pre-BMP condition on corn acres.*

*The Panel asserts that the Tier 1 NAM is applicable to historical reporting of NM acres. Modern NM acres are generally more consistent with the definition and efficacy of the Tiers 2 and 3 recommendations herein. Further inquiries about the Tier 1 report should reference appropriate sections of the approved Tier 1 report and general comments about that report can be referred to the CBPO who in turn can forward questions to the Panel according to the BMP Protocol.*

## Practice, monitoring, reporting and verification

For CBP review and approval, states should provide basis for claimed number of acres implementing NM (how reported numbers were determined, not verification protocol).

- EPA CBPO has been reluctant to question state submissions except where there were insufficient acres in a county on which to apply a BMP. EPA should review both the reported numbers and the basis for them and discuss questions and concerns with each state as part of its regulatory responsibility under the TMDL.
- Both the state report on the basis of submissions and EPA's response and actions should be public information. [ATS]

*Response: This concern should be addressed within state QAPPs. See also verification and CEAP responses below.*

How would a state know this, especially regarding the intent? Shouldn't you be discounting efficiency estimates by the expected rate of noncompliance? *[That a plan is implemented and followed]* [EIP]

*Response: This type of raw data does not exist for the Panel to comment on, analyze or recommend.*

States should not get credit unless they can document what percentage of their crops receive split or better timing of applied fertilizer, as these studies are the driver of this benefit. *[Tier 2 N]* [CBF]

*Response: The splitting of fertilizer applications is based on a crop's portion of the CBWM landuse as an adjustment. Only corn is credited wholesale within the row crop landuse, so this is already a conservative estimate for percentage of acres.*

I understand the CBP, Nutrient Management Panel is reviewing nutrient reduction efficiency policies and the discount rate for application to farm operation acreage implementing nutrient management. I am clarifying Maryland's current reporting and how this may be adjusted in the future in accordance with any CBP policy adjustments.

We believe that a default discount rate should not apply when other means are available to determine performance. This is particularly valid in regulatory programs where compliance evaluation is an integral component of the program.

Currently Maryland mandates nutrient management of all agricultural land, however we do not claim a reduction on 100% of acreage subject to the law. Instead, we have voluntarily discounted the acreage by a percent consistent with the outcome of compliance inspections. While attempting to present realistic data

related to practice implementation, this discount or reduction is still not the most accurate statistical representation of compliance in Maryland for the following reasons:

- Maryland targets compliance inspections to those individuals with the most risk of problems through complaints, discrepancies in reporting and other operations thought to be high risk. For this reason we are more likely to find compliance issues on a greater percent of these operations.
- Operations are considered out of compliance if their nutrient management plan is not up to date, regardless of whether otherwise following nutrient management requirements. Out-of-date NMPs account for the largest percent of noncompliance issues.
- Actual operations that are out of compliance by virtue of over-applying or misapplying nutrients represent less than 10% of those sited for noncompliance since we have been keeping these records (9 years).

We have concerns that a discount rate will be set using faulty criteria. For the above reasons, we are concerned that Maryland's compliance rate which includes an inherent bias, would be used for the region. Alternatively, we do not believe it is reasonable to consider use of CEAP report outcomes of 30% adhering to NMP, because the CEAP report does reflect performance or outcomes at the State scale. Practice or program performance should be reportable in a construct that allows for or considers respective jurisdictional variations. Respective states have widely ranging set of protocols for tracking program and practice performance. To the extent a jurisdiction has capacity to track and report more refined information, such accuracy should be provided for in modeled calculations. Finally, if the Chesapeake Bay Model begins applying a percent reduction to reported nutrient management acres by default, Maryland will report 100% of its acres. Otherwise, we would be subject to the model reduction on top of the discount we already voluntarily apply prior to reporting acreage. [MDA]

*Response: This comment addresses some concerns of other commenters, but largely the context and not the content of this report. These estimates of compliance are more supportive of the BPJ included in our Management Variability adjustments and are in contrast to the CEAP interpretations offered herein. The Panel does not recommend a default reduction on reported acres after tracking, reporting or verification by a jurisdiction with an approved QAPP. Management Variability adjustments where not otherwise states are generally used to capture BPJ of non-compliance, non-applicability for a field based on physical characteristics, omission from an NMP for BPJ by a Planner or poor environmental response from the BMP.*

## State Programs Table

**590 Nutrient Management should not be automatically considered equivalent with Tier 2 or Tier 3 nutrient management without verification documentation.** I was surprised to see the panel recommend that 590 Nutrient Management be considered as Tier 2 or Tier 3. The expert panel acknowledges that "The NRCS 590 Standard establishes the minimum expectation for development and implementation of NMPs nationwide." In its national Farm Bill database, USDA tracks acres under the 590 nutrient management as a whole and does not distinguish between standard/baseline level of nutrient management versus precision agriculture-based nutrient management. Likewise most state NRCS offices do not track different levels of nutrient management separately. I recommend that if states want to receive Tier 2 or Tier 3 credit for 590 nutrient management acres, then they must provide information to verify that the level of nutrient management implemented is on par with the requirements for Tier 2 or Tier 3. [EPA]

I would offer that 590 is more applicable to Tier 1. [CBF]

As noted earlier in the matrix, PA regulations also provide for “Tier 1” plans for those farms that use manure but are not CAOs or CAFOs. This should be clarified here. Are there situations in other states where “Tier 1” is likely to be reported? If so, they should be noted. [CBC]

**Nutrient reduction credit should reflect variability in state nutrient management programs.** It’s important that pollution reduction credit is on par with the rigor of the state nutrient management program. The Panel did an excellent job of illustrating the wide variability in state nutrient management programs. I recommend that the panel clearly articulate how the variability in rigor of state nutrient management programs translates into P reduction credit.

- How can each state receive the same P reduction credit under Tier 2 from having a P index when P indices vary among states? Can we address this question through verification/reporting requirements?
- How can each state receive the same P reduction credit under Tier 2 when some states have manure incorporation requirements while others do not? Can we address this question through verification/reporting requirements? [EPA]

*State Program Table Response: The Panel borrows language from the 590 standard considering it “minimum expectation...” The Panel agrees that this national standard of NM be analogous to an expectation for a jurisdiction to report credit for Tier 2 acreage. The Panel also disagrees that USDA’s 590 standard be considered indicative of a Tier 1 plan because timing and placement and erosion prevention are integral parts to 590 and Tier 2 (omits explicit erosion standards, but maintains conservation tillage baselines), but only proper N rate is considered for crediting Tier 1. All plans meeting the 590 standard are consistent with the Tier 2 definition. While many plans approved in states have elements that address goals for P loss reduction, they do so with distinctly separate tools. These particular plans like those in VA which use an Environmental Threshold Method, developed by Virginia Tech for estimating soil loss and soluble P loss, are still eligible for Tier 2 credit despite not receiving Federal cost share. Additionally, 590 requires certain pH adjustment protocols that are not particularly resonant in the Chesapeake Bay Watershed and do not significantly impact soil water quality. Finally, 590 includes prescriptions for field shape and size that land managers may not adhere to, like field lengths because these physical attributes do not have a significant impact where there is no slope. The table of state programs comes directly from a Tetra Tech survey report. The classifications of the plans in this table are intended to be recommendations based on cursory reviews of this information cross-walked with the section 6.1 guidance. See also verification, compliance and CEAP responses below.*

## Verification

Is this “guidance” or is this a checklist that describes the elements needed to meet the definitions for each tier? For instance, item #2 here for Tier 1 says that the plan is developed cooperatively between the farmer and trained professional, but that is not the case for PA Manure Management Plans (identified as a “Tier 1” plan in the matrix), which can be developed by the farmer alone. Therefore, will only the plans developed with a trained professional count? Another example is whether “Tier 1” plans that may be N-based only will still get the P credit, or only N credit. The Panel should clarify its expectations regarding these elements for each tier. Additionally, because the regulatory requirements vary across the states, each jurisdiction should provide a description of how their NMP meets the elements of the Tier they intend to report it as. [Tracking, verification] [CBC]

*Response: The Manure Management Plans being tracked are those developed either by trained professionals, assessed and approved by trained professionals, or developed by farmers assisted and overseen by trained professions to write these plans. Winter manure applications are allowed but only in limited conditions and in limited locations (reduced winter application rates, added application setbacks, winter cover or established crop required on application fields, limited field slope for application fields). This is consistent with the Tier 1 definition. The plans do NOT allow manure and fertilizer applications to be in excess of LGU N rates. These plans also address barnyard manure losses, losses from pastures and manure stacking losses.*

Checklist for determining Implementation was in the EP charge and is included on p 61.

- Does not provide any recommendations on how to verify.
- Comment: Experience indicates verifying NM is extremely difficult to impossible unless fertilizer and manure sale, distribution and use reporting is made much more stringent, comparable to or greater than that currently required for pesticide use.
- Comment: Much effort is directed to definitions, efficiencies and verification protocols and use for NM yet there are serious concerns about adequacy of information to verify NM implementation at a minimum and to explain CBP-CEAP implementation discrepancy. [ATS]

**The Panel should incorporate the Chesapeake Bay Program’s Verification Framework requirements.**

Rather than directly address the need for verification of nutrient management practices receiving pollution reduction credit, the Panel has elected to postpone the incorporation of verification practices in this version of the NM Efficiencies. Instead, the Panel has recommended “non-visual assessments” of basic plan elements. NM Efficiencies Section 6.1. However, these recommendations fall short of ensuring that credited practices are in place and implemented correctly, and some of the recommendations simply cannot be implemented without a visual assessment. For example, the Panel recommends non-visually “identifying the presence” of the nutrient management plan’s *implementation*, including the rate and timing of nutrient applications. The Jurisdictions can track the existence of plan elements, such as whether a plan is current, in electronic format, and developed by a professional, without a visual assessment, but cannot evaluate implementation of any of the eligible practices simply by reviewing plan documents. By postponing the incorporation of verification requirements until the Phase 6 Panel, the Panel risks crediting NM Efficiencies that are not realized in practice. In addition to overestimating pollution reductions, this is likely to create inconsistencies in reporting across Jurisdictions. The Panel has stated, for example, that Maryland chooses not to report all NM practices due to imperfect implementation and compliance. The other Jurisdictions report all NM Efficiencies from farms with documentation for Tier 1 or Tier 2 practices, but certainly also lack perfect implementation and compliance. Requiring some basic verification would improve consistency and accuracy in the Model. A failure to address the lack of verification in the Efficiencies will also affect the Phase III WIP development process. If the Phase III WIPs are based on a Model that credits NM Efficiencies for practices that have not been verified and may not be properly implemented, they will underestimate the remaining reductions needed. Even though the Jurisdictions are still in the process of creating their BMP verification plans, the Bay Program’s Verification Framework document provides the Panel with more than enough information about the criteria for an adequate program to begin to factor verification into the NM Efficiencies at this stage. [EIP]

*Verification Response: See compliance and CEAP responses below. The guidance for non-visual indicators in Section 6.1 is a list the Panel has recommended for states to use in the reporting process to determine if*



*plans reported should be credited as Tier 1, 2N, 2P, 2N&P or 3N. Verification is performed in accordance with a jurisdiction's approved QAPP.*

## Compliance Rates

Application of efficiencies to acres needs to consider compliance rates in each state (e.g., anecdotal evidence for PA suggests compliance/knowledge of state regs is low, and this should be accounted for when assigning efficiencies to acres). Along the same lines, Tier 2 N efficiency is largely based on improved timing/split application. Before getting credit for Tier 2, states need to clearly demonstrate improvement over Tier 1 (i.e., that a certain % of farmers/acres are doing split application), particularly in light of the CEAP findings about low rates of appropriate timing, especially with manure. And for example, assuming that implementation of 590 standard nutrient management plan is equivalent to Tier 2 is not sufficient. [CBF]

**Nitrogen and Phosphorus Reduction Credit Must Be Adjusted to Account For Compliance Rates.** The draft Nutrient Reduction Efficiencies overestimate nitrogen and phosphorus reduction by assuming that all farms required to have a Nutrient Management Plan will actually have them, or those that do have them will implement the plan as written. Such an optimistic approach fails to recognize the current reality of spotty implementation. In 2013, the USDA Conservation Effects Assessment Project (CEAP) examined the extent of basic nutrient management on fertilized land in the Bay Watershed.<sup>1</sup> For nitrogen, only 7% of acres met all nutrient management criteria in 2011.<sup>2</sup> This was a decline from 13% in 2003-2006. For phosphorus, only 21% of acres met all nutrient management criteria.<sup>3</sup> Studies also show that many Nutrient Management Plans are not fully implemented, that rates of non-compliance are high, and that practices are not always implemented optimally. In 2010, a University of Maryland survey found that, of farms that chose to respond, 36.9% of those required to have Nutrient Management Plans did not even have them.<sup>4</sup> This number is likely low, as it only represents farms that chose to respond to the survey. While many of these farms may have adopted some sort of Nutrient Management Plans in the past five years, a 2015 Journal of Environmental Quality article recently found that non-compliance with existing plans is even higher across Delmarva. Sixty-one percent of farmers interviewed in Maryland, Delaware, and Virginia expressly or impliedly stated that they are not adhering to their Nutrient Management Plans.<sup>5</sup> We applaud Maryland for not reporting all Nutrient Management Plans acres to the Bay Program for Tier 1 credit as a result of demonstrated non-compliance. However, all of the states should adopt a consistent and conservative approach based on actual Nutrient Management Plan compliance rates. Without specific information on Nutrient Management Plan compliance rates in each state, the proposed Nutrient Reduction Efficiencies should assume at least as much non-compliance in other states as has been demonstrated in Maryland. This can be done by including a “non-compliance adjustment” in the efficiency calculations. It is critical that the proposed Nutrient Reduction Efficiencies adjust for the lack of Nutrient Management Plan implementation. Without this adjustment, the proposed Nutrient Reduction Efficiencies will over-estimate phosphorus and nitrogen reduction. Over-estimating the nitrogen and phosphorus reduction will cause a gap between estimated and modeled nutrient reduction and actual water quality improvements. To avoid this, these Nutrient Reduction Efficiencies must be adjusted to reflect the realities of current levels of compliance and implementation. [CCWC]

**The Panel should adjust nutrient reduction credits to account for known rates of non-compliance with nutrient management plans.** The NM Efficiencies also fail to account for significant, well-known rates of Nutrient Management Plan (“NMP”) non-compliance. Even if the Panel does not specifically address verification to improve the accuracy of the credited practices and, in turn, the Watershed Model, the

Efficiencies should adopt a conservative approach with regard to NMP implementation. In general, full implementation of nutrient application management is rare. A recent survey by the USDA Conservation Effects Assessment Project (CEAP) examined the extent of basic nutrient management (appropriate rate, timing, and method) on fertilized land in the Bay Watershed.<sup>1</sup> For nitrogen, only 7% of acres met all nutrient management criteria in 2011.<sup>2</sup> This was a decline from 13% in 2003-2006. For phosphorus, only 21% of acres met all nutrient management criteria.<sup>3</sup> The extent of nutrient application management may be higher in the subset of farms with NMPs, but studies have shown that many NMPs are not fully implemented, that rates of non-compliance are high, and that practices are not always implemented optimally. For example, a 2010 University of Maryland survey found that, of farms that chose to respond, 36.9% of those required to have NMPs did not even have them.<sup>4</sup> This number is likely low, as it only represents farms that chose to respond to the survey. While many of these farms have likely adopted some sort of NMP in the past five years, a 2015 Journal of Environmental Quality article recently found that non-compliance with existing plans is even higher across Delmarva. Sixty-one percent of farmers interviewed in Maryland, Delaware, and Virginia expressly or impliedly stated that they are not adhering to their NMPs.<sup>5</sup> The Panel has indicated that Maryland alone has chosen not to report all NMP acres to the Bay Program for Tier 1 credit as a result of demonstrated non-compliance. While this is commendable, the Panel should require all of the Jurisdictions to adopt a consistent and conservative approach. If the other Jurisdictions lack basic research on NMP compliance rates due to a lack of verification practices, the Panel should presume that they have at least as much non-compliance as Maryland, rather than permitting them to report NM Efficiencies based on an assumption of perfect compliance. The Panel should incorporate this revised presumption into the Efficiencies directly by including a “non-compliance adjustment” in the efficiency calculations, and should represent it in Table 7. The estimated non-compliance rate should be based on existing research, such as the Maryland and Delmarva studies cited herein. Although the Panel has already adopted a conservative methodology to address other NM Efficiency uncertainties, such as the 75% adjustment to apply a plot-scale measure to the watershed scale, these existing adjustments do not adequately address the uncertainties that arise from unknown—but likely high—rates of NMP non-compliance. [EIP]

*Compliance Response: See CEAP response below. In addition the Panel was not charged with determining the extent of compliance of NM BMPs. The recommendations in the report should apply to compliant NMPs as they are categorized into tiers based on the non-visual indicators presented in section 6.1. Management Variability adjustments also capture a BPJ estimate of real world non-compliance within the Bay watershed and are specific for different tier components due to the nature of interaction with the component to physical challenges in different locations.*

## Membership

Not all of these members participated in the 2015 efforts, would suggest those that did, be distinguished somehow. [CBF]

*Response: This is not consistent with the BMP Protocol, but participating members from each meeting are summarized in the meeting minutes appendix with the members’ affiliation.*



### Table 3: 2014 Report

Were not concerns about this proposal and associated concerns about its basis in Tier 1 the reason the panel was reconvened in 201? Note it was not “approved” in 2014. [ATS]

*Response: The unapproved 2014 report was not approved for a variety of concerns and comments addressed and redressed by the Panel in meetings and webinars.. The comments related to the multiplicative nature of tiered BMPs were addressed wholesale with the complete revision and subsequent July 2015 recommendation.*

### Tables 4 and 8

Commenters noted that Table 4 is incorrect and should be updated to match Table 8.

*Response: Table 4 (revised and pasted below) reviews the multiplicative calculation of the recommendations as they are to be interpreted by the Phase 5.3.2 CBWM. Table 8 is a review of the final recommended efficiencies derived in Table 4. Table 4 was missing a Tier 1 line for HYW including pass-through load resulting in a different initial load for Tier 2 (HYW). This table was revised to reflect this difference. Tier 3N in Table 4 also had a typographical error citing the wrong initial load and both the pass-through load and combined efficiency have been updated to be consistent with Table 8.*

Practice Tier	Stand-Alone Efficiencies	Initial Load	Pass-Through Load	Combined Efficiencies
1N	0.0925	100	90.75	9.25%
1P	0.1	100	90	10.00%
1N(HYW)	0.05	100	95	5.00%
2N	0.039	90.75	87.2108	12.79%
2N(HYW)	0.028	95	92.34	7.66%
2P	0.066	90	84.06	15.94%
3N	0.028	87.2108	84.7689	15.23%

### Alternate Tier Proposal

- **Recommend merging Tier 1 and Tier 2 into Basic Nutrient Management (BNM) that represents state requirements, NRCS standards and technical expectations**
  - BNM should require application of the “4Rs” and use of a P risk assessment tool
  - Since Tier 1 P reduction should be negative (see above), propose assuming it equals 0 and subtracting 10% from current Tier 2 P BNM efficiency.
  - BNM N recommended at 9% (round efficiency to whole number - “significant digits”?)
    - Actual difference between proposed Tier 1 and Tier 2 N reductions is unclear
    - 4Rs for N use has been the NM expectation since before 4R term was coined
  - Define BNM as N application based on LGU recommendations and use of 4R approach with 9% N efficiency; use P risk assessment tool with 7% P efficiency
    - Tier 2 had 6.6% P reduction. Whole number rounding makes it 7%. [ATS]

*Response: The Panel recognizes this alternative approach as supportive of the method for estimating credit for P risk assessment. The Panel disagrees with the comment suggesting Tier 1 P as a negative reduction due to the reduction in P applied as manure from the 2013 CBWM simulation as explained in the general Tier 1 response above. Significant figures was discussed as a panel, but rounding was abandoned to prevent miscommunication of adjustment results and comments about applicability in the stacking summary provided in Table 4, for which no rounding was advised by the CBPO Modeling Team.*

*Differences between Tier 1 and Tier 2 N are summarized in Section 6.1, where differences are highlighted in bold as the Panel itemized elements of Tiers 1, 2 and 3 non-visual assessment. The LGU recommendations related to the 4Rs have adapted over time including during the CBWM simulation period, so the Panel has recommended these distinct eras be separate in their definition and efficiency as outlined in the report.*

- **Recommend Tier 3 be renamed “Advanced Nutrient Management” (ANM) and the Ph. 6.0 EP be charged with defining/developing efficiencies for different ANM practices**
  - Explanation needed why five different N rate practices have the same efficiency in Tier 3.
  - PSNT has been in use since before 2000 and should be part of BNM when manure is applied (perhaps CSNT should as well) rather than a Tier 3 practice
  - Variable rate application is a different practice/technology and should have a different efficiency or be omitted until adequate data available for efficiency estimate
  - The reason for the apparent decision not to include an efficiency for reducing N application rate is unclear. The nitrogen response curve in the report (p 25) illustrates the level of knowledge of response and N losses of row crops, particularly corn, to N applications. Knowledge of response to decreased N application is sufficient for an efficiency estimate, compared to basis for other estimates in report
- Checklist for determining Implementation was in the EP charge and is included on p 61.
  - This needs to be revised to address changes to BNM and ANM levels [ATS]

*Response: Tier 3 utilizes tests or in-field variability to determine adaptive N application rates. While these components are advanced, the panel feels Adaptive is more representative a title for these practices. Five components with individual reduction rates from literature were averaged to consolidate reporting framework difficulties within the states for the lifespan of P 5.3.2 CBWM. See also Tier 2 Justification comments. Tracking and reporting each of these components is too burdensome and specific to warrant such a recommendation. The Panel does not intend to change any non-visual indicators of the Tiers as a result of declining the proposed Basic NM and Advanced NM BMPs submitted via comment.*

## Geographic considerations

Overall, understand comment but provides opportunity to ask why “edge of stream” loads are so much lower below the fall line (in the coastal plain) than above the coastal plain. Probably related to lack monitoring and calibration approach but IS CAUSE OF LOW MODELED LOADS, PARTICULARLY FOR P IN DELMARVA POULTRY REGION COMPARED TO SHENANDOAH AND LANCASTER. [ATS]

*Response: The Panel’s recommendation is limited to the literature surveyed and best professional judgment considerations to adjust literature values to those more applicable to the CBWM framework and the cause of modeled loads (specifically located in the Coastal Plain and/or DELMARVA) was not in the purview of the original AgWG’s charge nor the revised charge from January 2015.*

## Tier Definitions

Better explanation of farm level vs. field level is needed if important in differentiating between Tier 1 vs 2 and 3. Depending on perspective are not all three field level (or farm level)? [ATS]

Presence of a plan does not indicate/document implementation; see both CEAP reports. How do you verify it? [Tier 2 definition] [ATS]

Why would this not also be required for Tier 1 if it is allowed to remain (which should not occur)? [Formal NM planning recs for Tier 2] [ATS]

*Response: Not all the Tiers are related to field level application of estimated or reasonably expected yield. A tier 1 plan would provide one estimate for each crop and the resulting rates of N and P depending on the nutrient source (P different for manure v fertilizer). A tier 2 plan would have independent yield estimates for each field based on soil tests of each field or productivity class estimations for each field in the absence of a soil test, so on a farm with 4 fields of corn a Tier 1 plan has one corn rate and a Tier 2 plan has 4. A Tier 3 plan could have variable rate applications in all 4 fields or 4 rates that have been adaptively managed based on the results of in-season or previous season testing, this is a significantly different level of effort from Tiers 1 and 2.*

*A plan is expected to be verified by state procedures in accordance with their QAPPs, approved by EPA. The Panel recognizes that current efforts to verify the actions in the plan are occurring in the field are not resulting in reducing the number of acres reported in a measured way to the CBPO, but the panel has provided estimates of management variability and adjusted the recommendations based on the likelihood that some producers cannot or do not follow the intent of the plan during some years. These estimates are manifested as an adjustment in Table 7, but are based on best professional judgment, so they include tacit knowledge and estimation that the AgWG entrusted the Panel to perform upon formation, consistent with the BMP Protocol. The Panel's response to comments regarding the CEAP report is discussed in the next subsection.*

## CEAP

When considering how many acres that Tier 1 or Tier 2 should be applied to, we think some consideration needs to be given to the CEAP data regarding rate and timing: For example, CEAP reports that:

- 54 % of cropped acres met the criteria for timing of N applications; 58% for P applications on all crops. However, for manured acres only, these percentages drop to 16% and 17%, respectively.
- Only 35% of cropped acres met criteria for application rate for N; 37% for P on all crops. However, for manured acres only, these percentages drop to 30% and 19%, respectively. [CBF]

Report refers to millions of acres of land implementing NMPs but two recent CEAP reports conclude that NMP implementation is about 12%. Recommend report include NM findings from the two CEAP reports and explain differences between report and CEAP findings, or remove report statements. Although not directly part of panel charge, differences between CBP and CEAP estimates of NM implementation need to be explained and this panel has the expertise to do so. [ATS]

*Response: The Panel has concluded that the applicability of the CEAP results suggesting that only 12% of NMPs are followed without exception is not related to this recommendation. The Panel instead sought to*

*credit actions in a plan that are related to nutrient reduction outcomes in the application of nutrients to land and not portions of written NMPs related to tillage, waste management, storage, handling or any management of grazed land or other conservation practices. These elements could all be considered as part of a plan that was not followed in the perception of CEAP surveys and reports. The Panel also considered that the CEAP report is based on a voluntary survey tool, which was originally developed outside the watershed and has different results between the original and most recent reports, which the Panel deemed worthy of excluding it from our final recommendations. The opinion of the Panel is that CEAP, while scientifically performed and published is not applicable to our recommendation because it has a different purpose than the interpretation of its results as being indicative of compliance with conservation practices reported by the States to the CBPO. See also, the response to comments related to verification above.*

## Pathways of Nutrient Loss

Are the implications different for N and for P? Also, didn't you partially correct for this in your application of adjustment factors? If so, it would be worth explaining that again here (briefly). [EIP]

*Response: Phosphorus recommendations were based on a model simulation of surface and subsurface losses. Nitrogen reductions were calculated from literature values as reduced application of PAN from prevented volatilization or decreased leaching potential from split applications of nitrogen. The Panel understands that preventing volatilization conserves N in the field, but conserving it as PAN reduces the total application rate and the reduction of PAN prevents more pollution than the quantity conserved. Additionally, the inhibition of N loss is enhanced by more efficient plant uptake or denitrification due to split applications. The diminished leaching potential due to Tier 2 N manure incorporation is more than offset by the exclusion of setbacks as a quantified contributor to the efficiency and the benefits of split applications*

## General Comments

Comments/responses to questions often include "will be addressed by Ph. 6 panel". It appears both Ph. 5.3.2 and Ph. 6.0 will be running similar scenarios during 2017 (2018?).

- Will that panel not use the Ph. 5.3.2 EP report as basis/starting point for their work?
- If efficiencies in current report are revised similar to recommendations above, based on science, major reversals in progress estimates from Ph. 5.3.2 should occur.
- Other possible changes, such as land use load increases "below fall line" would also increase total load to Bay (as not previously included in load) or reduce estimated progress and magnify progress reversals.
- Past history and policy responses in general indicate that reporting reversals or "negative progress" on any effort, even if due to improvements in science, data or experience are unlikely to occur.
- It is imperative that as many changes as possible that may result in progress reversals, including changes to the NAM report, be included in Ph. 5.3.2 model, BMP definition, efficiencies and scenario protocols. Concern over impacts on calibration or other "model world" issues should not preclude this from occurring. Failure to do this in Ph. 5.3.2 will create immense confusion and controversy if done in Ph. 6.0, but more likely will assure that no changes in net progress will result from Ph. 6.0. [ATS]

*Response: The Phase 6.0 Panel will be an independent process and the recommendations of that Panel will be based on a different set of landuses, acres of crops, nutrient mass balance and verification protocols.*

*The efficiencies in the report will not be revised consistent with any comments provided. The current recommendation is scientifically sound, consensus approved and has been provided to the AgWG and CBP Partnership consistent with the BMP Protocol elements the AgWG has advised we adopt from the various generations of the Protocol produced during the tenure of this Panel.*

*The Panel considered and decided not to adopt any comments related to changes in efficiencies, landuses or adjustment factors in Table 7. This is due to the robust review performed on available literature, consistency in recommendation adjustments with other approved panel reports, lack of evidence provided in popular literature cited by commenters to rebuff the science presented in the report and disbelief that any recommendation in this report would be reduced or discounted in future versions of the CBWM, given the same framework of parameters and assumptions.*

*The Panel does not expect any progress reversal as a result of the recommendations for the longevity of the Phase 5.3.2 CBWM. The Tier 1 recommendation is consistent with the BPJ of the model outcomes and is also consistent with the Phase 5.3.2 CBWM calibration. Violating the calibration was not recommended or needed to produce Tier 2 and 3 recommendations.*

In review of the “Definitions and Recommended Nutrient Reduction Efficiencies of **Nutrient Application Management** for Use in Phase 5.3.2 of the Chesapeake Bay Program Watershed Model”, I see no items that I would dispute.

I follow the rationale of the several discussions that end with this science issue should be consider for WSM6.0 (Adapt-N, Tier 3 P) or be a separate BMP under WSM 6.0 (manure application, application timing). I would agree with the challenge and recommendation of the “scale issue”.

1. Agronomic research primarily focuses on available nutrients in the root zone versus environmental nutrient loss.
2. This agronomic research does not relate well to the WSM 5.3.2 calibration at EOS.
3. If WSM 6.0 does calibrate based on EOF loads, the agronomic research maybe more viable.
4. Unfortunately, there is limited EOF monitoring data in the CB for nutrient loads or individual BMP efficiencies.

Another concern is the scale issue, or the point-of-measurement problem. This arises because the data available for estimating nutrient efficiencies are at the edge-of-field scale, or the bottom-of-root-zone scale, but the CBPWMs assume an edge-of-stream estimate. The inclusion of ecosystem effects (natural riparian zones, wetlands, etc.) and geologic processes (ground water lag times, storm water transport, etc.) between the edge-of-field or bottom-of-root-zone and the edge-of-stream is very complex, but ecosystem effects and geologic processes are also areas that have little or no existing data.

Therefore, there is a critical need for science-based, water quality BMP efficiency data based on research that is conducted at the appropriate scale with modern cultural practices. Such data would benefit virtually all of the Chesapeake Bay partners and stakeholder communities. The Panel suggests that this critical need be discussed and evaluated by appropriate Federal and State agencies to determine if a major Bay Watershed research program could be developed to fill this important data gap, and thereby provide more science-based estimates of BMP nutrient efficiencies that would benefit the entire Bay Partnership. Finally, the insight on science-based efficiencies are very real. Both farmers & watershed researchers desire to implement nutrient bmps. But ask: show me the data on effectiveness and we will adopt?

- i) The agriculture community, who have repeatedly asked the question “If I adopt a particular BMP, how do I know it will improve water quality?” (i.e., show me some water quality data and I’ll consider the BMP);
- ii) The environmental community, who have similar concerns about BMP efficacy, but also have an additional concern regarding “How do I know the BMP has been implemented and is operating properly?” (i.e., show me some verification data); and

iii) The policy-making community, who will have other concerns about “How do I track the BMPs and how do I compare or weight the BMPs so the ones applicable to my State receive priority support?” (i.e., where do I invest my limited resources to get the best return?). [ACI]

*Response: The Panel agrees with this thoughtful and supportive comment. The questions above have been interpreted as being addressed to a community beyond the Panel and suggest they be considered by the larger CBP Partnership as a result of this report.*