DEVELOPING BEST MANAGEMENT PRACTICE DEFINITIONS AND EFFECTIVENESS ESTIMATES FOR NITROGEN, PHOSPHORUS AND SEDIMENT IN THE CHESAPEAKE BAY WATERSHED

Final Report
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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Severe eutrophication in the Chesapeake Bay has lead to degraded water quality and anoxic conditions. Jurisdictions within the Chesapeake Bay watershed have adopted nutrient and sediment cap loads to combat eutrophication and achieve water quality standards. To achieve standards jurisdictions have outlined tributary specific nutrient and sediment reduction strategies, called Tributary Strategies, that lay out a plan to reduce point and non-point source pollution. Point source loads are reduced through waste water treatment plant upgrades while non point source loads are reduced through the implementation of agricultural, forestry and urban stormwater best management practices (BMPs). BMP implementation is annually reported to the Environmental Protection Agency's Chesapeake Bay Program Office (EPA/CBPO) for inclusion in the Chesapeake Bay Watershed Model. The Model is used as a management tool to estimate progress towards meeting those cap loads by applying reported BMP implementation levels and the nutrient and sediment reduction values (also termed "effectiveness estimates") associated with the practices.

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project commissioned and funded by the EPA/CBPO to develop the definitions and effectiveness estimates of select BMPs that states were implementing or proposing to implement as part of the Tributary Strategies. The objective was to scientifically-rigorous approach for development of definitions and effectiveness estimates by reflecting the average operational condition representative of the entire Chesapeake Bay Watershed. Prior to this project effectiveness estimates were assigned using limited science from a controlled research site that were highly managed and maintained by a BMP expert. Best professional judgment was used extensively in developing these estimates as performance data on BMP effectiveness was limited. The resulting estimates were not reflective of the variability of effectiveness estimates in real-world conditions where farmers or local government staff, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. In the 1990's, CBP began using model estimates of reductions in nutrient loads as surrogates for reporting progress in water quality improvement. Modeled progress overestimated actual progress as BMP effectiveness estimates were based on research scale data where implementation of BMPs, and their operation and maintenance, were assumed to be accurate or properly done. The inconsistency between modeled progress and actual water quality resulted in negative press which drove federal programmatic reviews that emphasized the need for the Chesapeake Bay Program to revise BMP effectiveness estimates based on the latest science and knowledge of how the practices operate in the watershed.

BMPs were evaluated and their effectiveness estimates revised to better reflect current research and knowledge, providing more realistic, science-based estimates of expected pollution reduction levels. UMD/MAWP searched for data on spatial and temporal factors that affect effectiveness estimates such as BMP design, BMP age and time to maturity, phased in implementation, soil type, surface and subsurface flow patterns, climate and other natural conditions. Scientists with expertise on specific BMPs took the lead in drafting practice definitions and proposing effectiveness estimates based on the latest science and research applicable to the Chesapeake Bay watershed's natural conditions. Further review of the accuracy of the definition and effectiveness estimates was provided by additional scientists and program managers. The Chesapeake Bay Program reviewed definition and effectiveness estimates to determine if tracking and reporting data needed to receive credit is available in each jurisdiction and also ensure all pollution reduction mechanisms the BMP provides is captured by the definition and effectiveness estimate. The updated BMP definitions and effectiveness estimates will be available for use in Total Maximum Daily Load (TMDL) implementation plans and nutrient trading programs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios will serve as a better management tool as they more directly reflect on the ground loads.

This project was divided into two phases referred to as year one and year two. BMPs were selected by the Chesapeake Bay Program based on new data and prominence in jurisdictional watershed plans. Year one BMPs focused on practices already assigned a definition and effectiveness estimate where an update was warranted based on new data. Year two BMPs were considered new practices as a placeholder definition and effectiveness estimates was used for modeling scenarios but no formal review had been conducted. Bay jurisdictions were beginning to promote these new BMPs and wanted to receive credit for this implementation in the watershed model.

This report provides definitions for each BMP, and when applicable, subcategories of definitions based on level of management, BMP design, hydrogeomorphic location or the land use to which the practice is applied. Effectiveness estimates are provided for total nitrogen, total phosphorus and total suspended sediment. Revised definitions and effectiveness estimates are closer to operational conditions, but there are still data gaps that led to the use of best professional judgment. These gaps should be researched to replace technical opinion with scientific observations. Each BMP is analyzed individually where a summary of all the studies used to determine effectiveness estimates, technical discussion, and justification for decisions is provided. A list of future research needs is included to help steer upcoming BMP studies. A uniform set of guidelines and criteria, and a rigorous scientific process for developing BMP definitions and effectiveness estimates was developed by UMD/MAWP and applied to both year one and year two BMPs. UMD/MAWP recommends applying the process used for all future BMP definition and effectiveness updates. This process is consistent across all BMP sectors, as well as technically and scientifically defensible. A complete recording of this process and individual BMP chapters is available below and at www.chesapeakebay.net/marylandBMP.aspx

UPDATED BMP EFFECTIVENESS ESTIMATES			
BMPs	**BMP Effectiveness Estimate (%)**		
	TN	**TP**	**TSS**
Conservation Plans			
Conventional tillage	8	15	25
Conservation tillage	3	5	8
Hayland	3	5	8
Pastureland	5	10	14
Conservation Tillage	8	22	30
Forest Buffer			
Inner Coastal Plain	65	42	56
Outer Coastal Plain Well Drained	31	45	60
Outer Coastal Plain Poorly Drained	56	39	52
Tidal Influenced	19	45	60
Piedmont Scnist/Gneiss	46	36	48
Piedmont Sandstone	56	42	56
Valley and Ridge - marble/limestone	34	30	40
Valley and Ridge - Sandstone/Shale	46	39	52
Appalachian Plateau	54	42	56
Grass Buffer			
Inner Coastal Plain	46	42	56
Outer Coastal Plain Well Drained	21	45	60
Outer Coastal Plain Poorly Drained	39	39	52
Tidal Influenced	13	45	60
Piedmont Scnist/Gneiss	32	36	48
Piedmont Sandstone	39	42	56
Valley and Ridge - marble/limestone	24	30	40
Valley and Ridge - Sandstone/Shale	32	39	52
Appalachian Plateau	38	42	56
Wetland Restoration and Creation			
Appalachian (1% of Watershed in wetlands)	7	12	15
Piedmont and Valley (2% of watershed in wetlands)	14	26	15
Coastal Plain (4% of watershed in wetlands)	25	50	15
Cover Crops			
Coastal Plain/Piedmont/Crystalline/Karst Settings:			
Drilled Rye early	45	15	20
Drilled Rye normal	41	7	10
Drilled Rye late	19	0	0
Other Rye early	38	15	20
Other Rye normal	35	7	10
Other Rye late	16	0	0
Aeiral/soy Rye early	31	15	20
Aerial/soy Rye normal	N/A	N/A	N/A
Aerial/soy Rye late	N/A	N/A	N/A

Aerial/corn Rye early	18	15	20
Aerial/corn Rye normal	N/A	N/A	N/A
Aeiral/soy Rye late	N/A	N/A	N/A
Drilled Wheat early	31	15	20
Drilled Wheat normal	29	7	10
Drilled Wheat late	13	0	0
Other Wheat early	27	15	20
Other Wheat normal	24	7	10
Other Wheat late	11	0	0
Aerial/soy Wheat early	22	15	20
Aerial/soy Wheat normal	N/A	N/A	N/A
Aerial/soy Wheat late	N/A	N/A	N/A
Aerial/corn Wheat early	13	15	20
Aerial/corn Wheat normal	N/A	N/A	N/A
Aerial/corn Wheat late	N/A	N/A	N/A
Drilled Barley early	38	15	20
Drilled Barley normal	29	7	10
Drilled Barley late	N/A	N/A	N/A
Other Barley early	32	15	20
Other Barley normal	24	7	10
Other Barley late	N/A	N/A	N/A
Aerial/soy Barley early	27	15	20
Aerial/soy Barley normal	N/A	N/A	N/A
Aerial/soy Barley late	N/A	N/A	N/A
Aerial/corn Barley early	15	15	20
Aerial/corn Barley normal	N/A	N/A	N/A
Aerial/corn Barley late	N/A	N/A	N/A
Mesozoic Lowlands/Valley and Ridge Siliciclastic:			
Drilled Rye early	34	15	20
Drilled Rye normal	31	7	10
Drilled Rye late	15	0	0
Other Rye early	29	15	20
Other Rye normal	27	7	10
Other Rye late	12	0	0
Aeiral/soy Rye early	24	15	20
Aerial/soy Rye normal	N/A	N/A	N/A
Aerial/soy Rye late	N/A	N/A	N/A
Aerial/corn Rye early	14	15	20
Aerial/corn Rye normal	N/A	N/A	N/A
Aeiral/soy Rye late	N/A	N/A	N/A
Drilled Wheat early	24	15	20
Drilled Wheat normal	22	7	10
Drilled Wheat late	10	0	0
Other Wheat early	20	15	20
Other Wheat normal	18	7	10
Other Wheat late	9	0	0

Aerial/soy Wheat early	17	15	20
Aerial/soy Wheat normal	N/A	N/A	N/A
Aerial/soy Wheat late	N/A	N/A	N/A
Aerial/corn Wheat early	10	15	20
Aerial/corn Wheat normal	N/A	N/A	N/A
Aerial/corn Wheat late	N/A	N/A	N/A
Drilled Barley early	29	15	20
Drilled Barley normal	22	7	10
Drilled Barley late	N/A	N/A	N/A
Other Barley early	25	15	20
Other Barley normal	19	7	10
Other Barley late	N/A	N/A	N/A
Aerial/soy Barley early	20	15	20
Aerial/soy Barley normal	N/A	N/A	N/A
Aerial/soy Barley late	N/A	N/A	N/A
Aerial/corn Barley early	12	15	20
Aerial/corn Barley normal	N/A	N/A	N/A
Aerial/corn Barley late	N/A	N/A	N/A
Off-Stream Watering With Fencing	25	30	40
Off-Stream Watering Without Fencing	15	22	30
Forest Harvesting	50	60	60
Urban Wetlands and Wet Ponds	20	45	60
Urban Erosion and Sediment Control	25	40	40
Dry Extended Detention Basins	20	20	60
Dry Detention Ponds/Basins and Hydrodynamic Structures	5	10	10
Ammonia Emission Reduction			
Poultry Litter Treatment	50	N/A	N/A
Poultry House Biofilter	60	N/A	N/A
Cover	15	N/A	N/A
Dairy Feed Management **default numbers for when direct measurement not an option*	24	25	N/A
Mortality Composting	40	10	0
Infiltration and Filtration:			
Bioretention			
C/D soils, underdrain	25	45	55
A/B soils, underdrain	70	75	80
A/B soils, no underdrain	80	85	90
	±15	±20	±15
Filters			

All (sand, organic, peat)	40 ±15	60 ±10	80 ±10
Vegetated Open Channels *C/D soils, no underdrain* *A/B soil, no underdrain*	10 45 ±20	10 45 ±20	50 70 ±30
Bioswale	70 ±15	75 ±20	80 ±15
Permeable Pavement (no sand/veg) *C/D soils, underdrain* *A/B soils, underdrain* *A/B soils, no underdrain*	10 45 75 ±15	20 50 80 ±20	55 70 85 ±15
Permeable Pavement (with sand, veg) *C/D soils, underdrain* *A/B soils, underdrain* *A/B soils, no underdrain*	20 50 80 ±15	20 50 80 ±20	55 70 85 ±15
Infiltration Practices (no sand/veg) *A/B soils, no underdrain*	80 ±15	85 ±15	95 ±10
Infiltration Practices (with sand/veg) *A/B soils, no underdrain*	85 ±15	85 ±10	95 ±10

A one sentence definition and effectiveness estimate for each BMP reviewed follows.

Ammonia Emission Reduction:

Poultry Litter Treatment: a surface application of alum, an acidifier, to poultry litter to acidify poultry litter and maintain ammonia in the non-volatile ionized form (ammonium).

Poultry House Biofilters: are comprised of poultry housing ventilation systems that pass air through a biofilter media that incorporates a layer of organic material, typically a mixture of compost and wood chips or shreds, that supports a microbial population and reduces ammonia emissions by oxidizing volatile organic compounds into carbon dioxide, water and inorganic salts.

Covers: the use of a permeable plastic over liquid dairy storage that creates a physical barrier to prevent mass transfer of volatile chemical compounds from the liquid by decreasing wind velocity (decrease surface area), and reducing radiation onto the manure storage surface (lower temperature).

Conservation Plans: are a combination of practices, other than conservation tillage or no-till, that reduces soil loss to or below tolerance, defined as the maximum amount of erosion at which the quality of a soil as a medium for plant growth can be maintained. Nutrient and sediment reductions vary by the land use, e.g. conventional tillage, conservation tillage, hayland or pastureland, in the model that a conservation plan is applied to.

Conservation Tillage: involves the planting, growing and harvesting of crops with minimal disturbance to the soil surface through the use of minimum tillage, mulch tillage, ridge tillage, or no-till.

Cover Crops: Non-harvested winter cereal cover crops, including wheat, rye and barley, designed for nutrient removal.

Dairy Precision Feeding: reduces the quantity of phosphorous and nitrogen fed to livestock by formulating diets within 110% of Nutritional Research Council recommended level in order to minimize the excretion of nutrients without negatively affecting milk production.

Dry Detention Basins and Hydrodynamic Structures:

Dry Detention Ponds are depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms.

Hydrodynamic Structures are devices designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads that are designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.

Dry Extended Detention Basins: depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms using a low flow control outlet that releases water over time drying out between storm events.

Forest Harvesting Practices: a suite of practices that reduce sediment and nutrient pollution to water bodies originating from forest management activities to acceptable levels.

Infiltration and Filtration: The infiltration BMPs included bioretention, permeable pavement and pavers, and infiltration trenches and basins. The filtration BMPs were filters and vegetated open channels:

> *Bioretention:* An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants.
>
> *Permeable Pavement and Pavers:* Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain.
>
> *Infiltration Trenches and Basins:* A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration.
>
> *Filters:* Filters capture and treat runoff by filtering through a sand or organic media.
>
> *Vegetated Open Channels:* Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils.

Mortality Composters: Composting routine animal mortality in a designed, on-farm facility, with subsequent land application of the compost.

Offstream watering with fencing: This BMP excludes animals from streams. It incorporates both alternative watering and installation of fencing that eliminates livestock access to narrow strips of land along streams. The implementation of stream fencing should substantially limit livestock access to streams, eliminating direct manure deposition to streambeds and banks and reducing erosion and nutrient deposition to riparian areas.

Offstream watering without fencing: This BMP requires the use of alternative drinking water sources away from streams to reduce the time livestock spends near and in streams and streambanks reducing direct manure deposition to streambeds and banks and also reducing erosion and nutrient deposition to riparian areas.

Riparian Forest Buffers: an area of trees at least 35 feet wide on one side of a stream, usually accompanied by trees, shrubs and other vegetation, that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals.

Riparian Grass Buffers: an area of grasses that is at least 35 feet wide on one side of a stream that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals.

Urban Erosion and Sediment Control: protecting water resources from sediment pollution and increases in runoff associated with land development activities by retaining soil on-site so sediment and attached nutrients are prevented from leaving disturbed areas and polluting streams.

Urban Wetponds and Wetlands:

Urban Wetponds: depressions or basins created by excavation or berm construction that receive sufficient water via runoff, precipitation, and groundwater to contain standing water year-round at depths too deep to support rooted emergent or floating-leaved vegetation (in contrast with dry ponds, which dry out between precipitation events). Nutrients and suspended particles are removed via settling. Nitrogen is further removed primarily via plant and microbial uptake, and the nitrification-denitrification reactions, while phosphorus is further removed by soil sorption.

Urban Wetlands: Wetlands have soils that are saturated with water or flooded with shallow water that support rooted floating or emergent aquatic vegetation (e.g. cattails). Nutrients and suspended particles are removed via settling. Nitrogen is further removed primarily via plant and microbial uptake and the nitrification-denitrification reactions, while phosphorus is further removed by soil sorption.

Wetland Restoration and Creation:

Wetland Restoration: Returning natural/historic functions to a *former* wetland. Results in a gain in wetland acres. Nutrients and suspended particles are removed via settling. Nitrogen is further removed primarily via plant and microbial uptake and the nitrification-denitrification reactions, while phosphorus is further removed by soil sorption.

Wetland Creation: Developing a wetland that did not previously exists on an upland or deepwater site. Results in a gain in wetland acres. Nutrients and suspended particles are removed vai settling. Nitrogen is further removed primarily via plant and microbial uptake and the nitrification-denitrification reactions, while phosphorus is further removed by soil sorption.

PROCESS AND GUIDELINES FOR BMP DEFINITION AND EFFECTIVENESS ESTIMATE DEVELOPMENT

Introduction

The BMP Project was divided into two separate phases called year one and year two. Year one practices were those with Chesapeake Bay Program-established definitions and effectiveness estimates that needed to be refined with more up to date data. Chesapeake Bay states already received nutrient and/or sediment reduction credits in the Chesapeake Bay Watershed Model for implementing these practices. Year two practices did not have established Chesapeake Bay Program definitions and effectiveness estimates and thus needed to be developed. These practices are practices that the Bay watershed state partners decided to implement to meet their nutrient and sediment reduction caps, and therefore wanted to be credited in the Chesapeake Bay Watershed model for these practices. While the overall guidelines and criteria remained the same between the two phases the process used in year two was refined based on lessons learned during year one.

YEAR ONE PROCESS

Process Overview

There are four main steps, scientific literature search, development of BMP definition and effectiveness estimates, CBP review and approval, and finally, documentation and reporting. The first step was to collect data on the structure and performance of the BMPs. A template was also created that outlined the information needed to determine BMP definitions and effectiveness estimates. Next, experts were contracted to evaluate the science for its applicability and draft recommendations for definitions and effectiveness estimates. Scientists selected by the Scientific and Technical Advisory Committee (STAC) of the CBP reviewed the experts' reports for applicability and accuracy and then UMD/MAWP reviewed reports for consistency in effectiveness estimation across BMPs and attention to project objectives. Based on the expert opinion and scientific review, UMD/MAWP submitted a recommendation for a draft definition an effectiveness estimate for each BMP to the appropriate workgroup of the CBP for a technical review. These workgroups were comprised of scientists, technical experts, and program managers who fund and implement these practices. The workgroups reviewed the report and submitted their recommendations to the higher level Nutrient Subcommittee (NSC) for final technical approval (refer to each individual BMP report for a complete list of all expert scientists and reviewers from CBP workgroups, subcommittees and committees). The NSC then submitted the agreed upon BMP reports to the Water Quality Steering Committee for adoption for use in Bay policy. Meanwhile, the Scientific and Technical Advisory Committee (STAC) reviewed the process for developing BMP definitions and effectiveness estimates to determine if it was sound and applied appropriately. After review by the NSC the recommendations moved onto the Water Quality Steering Committee (WQSC) for final approval and use in Phase V of the Watershed Model.

Scientific Literature Searches

Scientific literature searches were conducted to collect data that could aid in the revision of BMP definitions and effectiveness estimates. Literature that is applicable to the Chesapeake Bay Watershed, defined as humid, temperate climates east of the Rockies were used. These searches identified information available on the proposed BMPs in refereed journals. In addition, gray literature provided by experts, advisors, reviewers, CBP workgroups or subcommittees was evaluated. All literature was screened for applicability, usefulness and quality. Specifically, studies were evaluated to determine if research site conditions were representative of those in the Chesapeake Bay watershed and if appropriate methods were used to sample and analyze data, particularly for the gray literature.

UMD/MAWP also searched for data on factors that affect effectiveness estimates, but there were very limited data describing factors that will influence a BMP's pollution reduction ability and it usually did not estimate a quantitative adjustment for these factors. Best professional judgment, using scientific panels, was used to discount effectiveness estimates to reflect the variability of operational systems. Site specific conditions considered include soils, hydrology, lag times, scale, land use change, species composition, BMP age and maturity and climate and temporal effects.

Template

The next step to developing practice definitions and effectiveness estimates was to develop a review and reporting template to provide thorough documentation, assure consistency in information provided by each reviewer for each BMPs and facilitate an adaptive management approach. Adaptive management calls for recommendations for BMP effectiveness estimates in situations when data on all aspects of the practice are unknown. Effectiveness estimates are needed to inform policy and planning decisions even without all information currently available. UMD/MAWP always recommended an effectiveness estimate using the best available science and technical opinion even though data is not always available on all aspects of BMP pollution removal. The template also lists questions related to future research needs, tracking and reporting, references, and statement of conservatism. The following is a summary of the template all experts were asked to fill in and use when reporting on the BMP.

Experts were asked to provide a definition and description of the BMP. This includes describing the nutrient and sediment reduction benefits and a brief narrative describing any other benefits (e.g., habitat, economic or social benefits). All loss pathways associated with the practice are also included in the BMP description. When reporting the effectiveness estimate, experts provided the range in of effectiveness values encountered in the literature. The experts were then asked to explain how effectiveness estimates should be adjusted for operational conditions including planning, hydrologic, operational and maturity lag times (Simpson, et al 2003, Lindsey et al., 2003, Gregory, et al. 2007). The expected spatial variability for a practice was estimated based on available science and knowledge of the geographic extent and hydro-geomorphic variability of the practice. Experts were also asked to discuss the relative importance of surface water and groundwater flow paths in controlling BMP effectiveness. Experts discussed how the effectiveness estimate is altered when moving from the research/demonstration scale to implementation at a watershed scale application. Experts also defined the impact of extreme climatic events on BMP effectiveness (Maule et al., 2005; Glozier et al., 2006) and discussed the BMPs effectiveness in events above its designed maximum.

Experts provided a qualitative or quantitative statement about the soundness of the BMP effectiveness estimate and the amount of data. First they included a narrative on how they dealt with any uncertainty or incompleteness in the data. Based on uncertainty or incompleteness experts recommend a certain level of conservatism that should be applied to the effectiveness estimate. If applicable, experts explained how they adjusted the effectiveness estimates to be more conservative; mentioning what effectiveness estimate they had initially calculated based solely on research scale data calculated and explained the level of conservatism they are recommending to reflect operational conditions. Experts also indicated their confidence in their proposed effectiveness estimates stating if they have high, somewhat limited, or limited confidence in their recommendation.

Scientific experts developed definition and effectiveness estimates using the most recent, applicable data and their professional expertise. UMD/MAWP's contracted with experts to produce a BMP report that provided extensive documentation of the data and decisions made. For BMPs where experts were not contracted UMD/MAWP project staff provided leadership for drafting definitions and effectiveness estimates using scientists as advisors. This was needed for field and pasture management, conservation tillage, and riparian buffers.

Scientific Review

The first step in the review process was for draft definitions and effectiveness estimates to undergo an independent peer review by individual scientists from the Chesapeake Bay Program's Scientific and Technical Advisory Committee (STAC) or MAWP who were not involved in the original development of the practice report. Scientists were identified by a member of STAC or recommended by the CBP workgroups and reviewed the expert's report. Reviewers evaluated reports for accuracy and applicability to the Chesapeake Bay watershed.

UMD/MAWP Review- Use of Guidelines

After experts developed their BMP reports and reviewers submitted comments, UMD reviewed recommended effectiveness estimates. Even with a template to guide them, experts approached effectiveness development and adjustment in various ways. Thus some overview and adjustment of all recommendations must occur to be consistent among BMP evaluations. Ranking exercises highlighted inconsistencies used when various experts recommend efficiencies and adjustments were made accordingly. During its review UMD/MAWP used five guidelines to ensure consistency among the factors considered in adjusting research-based scale effectiveness estimates and in the data included and omitted when developing effectiveness estimates:

1. Effectiveness recommendations should reflect operational conditions, defined as the average watershed wide condition. Research scale estimates were adjusted to account for differences upon scaling up.

2. Studies with negative effectiveness estimates (the BMP acted as a source, not a sink for pollution) were included in the development process as they reflect operational

conditions, when studies demonstrate the BMP performance, and not study analysis, is responsible for the negative effectiveness estimate.

3. Since multiple experts were contracted to recommend effectiveness estimates, consistency among the experts' evaluation criteria and process was needed. This does not mean all estimates are adjusted equally because with each BMP there is variability in site specific and management conditions. But the evaluation criteria used by the expert to adjust research scale effectiveness estimates were uniform.

4. Peer reviewed literature has been subject to stringent evaluation and results from that literature were given more weight than literature that has not undergone the same review process.

5. Data from individual BMP project sites were utilized over median or average values calculated from analysis incorporating multiple BMP project sites.

After BMP reports were reviewed by UMD/MAWP they were sent to the appropriate CBP technical workgroup with the experts recommended effectiveness estimate, reviewers comments and UMD/MAWP's recommendation.

STAC Process Review

During updates to CBP workgroups on project approach and progress, workgroup members (comprised of state program managers) expressed their concern with incorporating studies with negative effectiveness values into the development of effectiveness estimates, even when they were scientifically understandable. Concerns were also raised over the use of peer-reviewed literature preferentially over design state manuals. Design manuals usually reflect aspirational goals for a practice, not average operational conditions and therefore, UMD/MAWP did not give them as much weight as peer-reviewed studies. UMD/MAWP also used single site studies over multi-site meta- analyses. Multi site analysis often use design ratings for particular BMPs based on multiple BMP project sites or professional judgment. Often location information is not available with multi-site studies. Understanding the climate, soils, and hydrology will determine the applicability of the study included in the analysis. In addition, multi-site studies often to not provide the details of the methodology used. Information on sampling and testing techniques and other characteristics of the study are not available for review and cannot be reviewed for errors or caveats.

To respond to CBP workgroup concerns about the literature and data used, a task group within STAC was requested to review and assess the process whereby UMD/MAWQ arrived at BMP effectiveness estimate recommendations. Specifically, they were requested to review the logic, approach and process used to develop BMP definitions and efficiencies. The STAC report concluded:

"The Chesapeake Bay model must be calibrated to function with operational rather than research BMP efficiencies. Hence, if reported negative efficiencies reflect operational conditions, they should be considered in an assessment of the BMP efficiency literature. Peer-reviewed literature has more credibility than do design standards/manuals which have not been subjected to independent examination."

Chesapeake Bay Program Review

CBP workgroups with expertise on specific BMPs, the Agricultural and Urban Stormwater Workgroups, reviewed the BMP reports. They first determined if tracking and reporting data on BMP implementation was available in each jurisdiction to receive credit in the Watershed Model for the BMPs associated project nutrient and sediment reductions . Some BMP's are subcategorized based on certain design elements. If a jurisdiction did not have existing infrastructure in place to report at this more detailed level either the jurisdictional program managers refined reporting procedures to reflect this new detail or the CBP, along with the jurisdiction, established a default definition and effectiveness estimate to be substituted when subcategorical information was unavailable.

The report was further reviewed to ensure all pollution reduction mechanisms the BMP encompasses was captured by the definition and effectiveness estimate. Applicable NRCS practice codes were added to the BMP definitions to assist with tracking and reporting. While the source area workgroups reviewed and modified the practice reports, the Tributary Strategy Workgroup (TSWG) analyzed the reports for their modeling components. How the practices are modeled (e.g., land use the BMP applied to) needed to be agreed upon. After the TSWG and source area workgroups approved the BMP definitions and effectiveness estimates, the Nutrient Subcommittee (NSC), along with UMD/MAWP conducted a ranking exercise across all the BMPs. This process was used to evaluate the logic and consistency of all the BMP effectiveness estimates. Following NSC approval of the BMP reports, the Water Quality Steering Committee approved the BMP definitions and effectiveness estimates for use in Bay policy and modeling.

YEAR TWO PROCESS

The process used to develop the BMP definition and effectiveness estimates for year two, 'new' practices, differed slightly from year one, existing practices. The biggest process change was the use of a panel to develop BMP reports versus one expert per practice. For all practices a panel of scientists with specific BMP expertise was convened and consulted when developing the BMP definitions and effectiveness estimates. Based on the review of the year one process by STAC UMD/MAWP provided the guidelines and criteria, endorsed and approved by UMD/MAWP, STAC, and CBP, to all panelists in the first email or phone call soliciting assistance (guidelines presented earlier in paper). Also a list of questions used by UMD/MAWP when conducting its literature search, and used by panelists when considering papers to be included in the data set, were previously listed.

UMD/MAWP encouraged panel members to be conservative when estimating effectiveness and panelists strived to recommend effectiveness estimates reflective of operational conditions. Panel members were sometimes reluctant to recommended percent removal values because of data gaps, but when this occurred they were conservative in their estimation. When developing BMP definitions, parameters from the study sites were used by the panel to capture the characteristics of the BMP present during effectiveness testing or monitoring. Meaning, if something influenced the effectiveness of the BMP, these parameters were incorporated into the definition to capture that factor determining effectiveness (i.e. for the infiltration bioretention BMP a soil P-index range was included in the definition because it will determine phosphorus removal rates).

While there is peer reviewed to gray literature available on the BMP definition and components, these BMPs are 'new' and either do not have data, or very limited data, that directly analyzes the effectiveness of the practice. It must also be recognized that practice effectiveness estimates are being developed using an adaptive management approach that recognizes that our knowledge is incomplete but proposes a science-based but conservative approach to effectiveness estimates that will be reviewed and updated at recurring intervals based on new research, monitoring and experience. The conservative approach is always advisable in adaptive management and is particularly warranted here since there is little if any data that suggests actual widespread implementation performance as high as those in the research literature and several recent small watershed studies have indicated considerably lower reductions when groups of practices are applied than would have been expected based on current effectiveness estimates.

UMD/MAWP provided full documentation and reporting of both year one and two BMPs in written form. UMD MAWP hosted a one day forum on December 4, 2008 in Frederick, MD present the BMP reports and solicit additional input for developing a consistent BMP development process.

CONCLUSIONS

Overall, this project not only developed BMP definitions and effectiveness estimates for a select list of new BMPs but it also identified future research needs to increase accuracy of BMP efficiencies and showcased the need for a consistent, rigorous BMP development and refinement process. We provided data on performance for the new BMPs, however much of it is in its infancy thus more information is warranted. These reports provided a better understanding of how practices function and highlighted factors that adjust performance.

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CRITERIA AND PROTOCOL WHEN DEVELOPING BMP EFFECTIVENESS ESTIMATES

Introduction

The UMD/MAWP refined definition and effectiveness estimates for best management practices (BMPs) implemented and reported by the Chesapeake Bay watershed jurisdictions. The main objective was to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) has historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

Another objective was to utilize an adaptive management approach to developing effectiveness estimates for BMPs. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances in knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

Criteria for Literature

UMD/MAWP conducted a literature search and synthesis on BMP effectiveness. Many different levels and types of data are available on BMP definitions and effectiveness estimates. The levels range from peer reviewed papers to factsheets without a stringent peer review. In order to determine the applicability and usefulness of the studies and data UMD/MAWP followed the following criteria.

Literature used to make efficiency estimate

UMD/MAWP established criteria for the amount of literature and type of literature used in efficiency estimation. For current BMP efficiencies that were developed with limited data or best professional judgment any new literature was considered in refining the efficiency. Reviews for applicability and credibility of the studies, however, were critical in these cases. Alternatively, for BMPs that had sufficient/adequate data used to develop current efficiencies, UMD/MAWP required a large body of consistent data to motivate a refinement to the BMP efficiency.

Another rule used by UMD/MAWP was that peer reviewed literature was given more weight than design standards/manuals, although both were considered in BMP development. Peer reviewed literature has undergone a robust critical screening before it is published; while non-peer reviewed literature is not submitted to the same screening process. Design manuals are written to result in aspirational BMP effectiveness. Designs often include additional components that increase the BMPs estimated median effectiveness. As such, more confidence lies in the peer reviewed literature.

In addition, UMD/MAWP utilized single site studies over multi-site analysis, as the former is a study of individual BMP projects, while the later is a collection of BMP projects. Multi site analysis often use design ratings for particular BMPs based on multiple BMP project sites or professional judgment. Multi site analyses are defined as a review of one particular BMP where an average or median performance is based on multiple sites.

Multi-site analysis may incorporate the efficiencies reported in the single site studies, thus counting some studies twice during statistical calculations if both single site and multi site results are compiled. The average or median reported in multi-site studies represents BMPs with sizing and design specifications that optimize conditions to increase removal efficiency. This high removal is not achieved at all sites and cannot be used unless the BMP definition includes the sizing and design specifications that increase pollutant removal. Furthermore, not only are multi-site analysis relying on design guidelines in their efficiency calculations, they primarily include positive removal efficiencies due to a tendency to under report or not publish negative or low performance results in design manuals.

Often location information is not available with multi-site studies. Understanding the climate, soils, and hydrology will determine the applicability of the study included in the analysis. In addition, multi-site studies often to not provide the details of the methodology used. Information on sampling and testing techniques and other characteristics of the study are not available for review and cannot be reviewed for errors or caveats. The studies used in a multi-site analysis may not represent one BMP, instead treatment trains, or multiple BMPs at the same site, may have been utilized so a direct comparison of an individual BMP performance is not possible. Also, multi site analysis may include applications of the BMP other than that which it is being studied and used for. During UMD/MAWP's literature search some urban stormwater BMP multi site analysis included agricultural waste treatment studies in the data results.

Some studies report negative efficiencies due to natural processes, or construction and operational related issues with the BMP. During the MAWP/UMD efficiency development process, negative efficiencies reported in literature were not omitted because situations where BMP systems sometimes act as a source and not as a sink occur in the real world. Errors in design, construction and maintenance can create a system that is not providing its expected pollutant removal. With some BMPs errors in design or construction can lead to flow bypassing the BMP, possibly resulting in negative efficiencies. Additionally, systems with permanent water pools will result in phosphorous saturated soils and may leach phosphorous into the water column, also producing negative efficiencies. Negative efficiencies often are not published and when they are, they have undergone rigorous scientific review so the reason for the negative efficiencies is understood.

Data Applicability

As with any literature review, data should be evaluated for its applicability. Before selecting a study for use in developing a BMP effectiveness estimate and definition, UMD/MAWP and panel members considered the questions below. The data used to develop effectiveness estimates was selected based on its applicability to the natural conditions of the Chesapeake Bay watershed, such as, soil type, hydrologic flow paths, and species composition. The studies were evaluated for their BMP design and implementation compatibility to those in the Chesapeake Bay watershed. Rates and timing of fertilizer applications, and the relationship between cultivation and planting dates, were evaluated to determine if the study was applicable to farming methods in the watershed.Studies were also reviewed to determine if the study duration accurately represents average effectiveness results. The time when removal rates are monitored may influence performance by under or overestimating effectiveness.

- Are natural characteristics (soil type, climate, flow paths, geology, vegetation, etc.) of the research site similar to conditions in the Chesapeake Bay watershed?
- Is the practice consistent with NRCS codes, jurisdictional stormwater design manuals? If not, how would effectiveness estimates be different?
- How critical is the duration of the experiment to the reported effectiveness results?
- Do results reflect changes in pollution reduction benefits over the lifetime of the BMP?
- Briefly explain the study method used?
- What parameters were sampled and monitored?
- Who conducted the research?
- How was the effectiveness estimate calculated?
- What was the scale of the study?
- What assumptions, outside of experimental results, were made in reaching the conclusions?

<u>Protocol for Effectiveness Development</u>

In addition to the aforementioned five guidelines and criteria for data selection experts were asked to complete a template detailing information on spatial and temporal factors that affect effectiveness estimates (see Appendix A for copy of the template). Uncertainty in nonpoint source pollution reduction estimates is due to variability in natural landscape conditions, degree of management, and spatial and temporal changes among BMPs and their location. Examples include precipitation, hydrology and geology, lag time between implementation of practices and full performance, and between implementation and observed water quality benefits. To minimize uncertainty in BMP efficiency estimation, and to more realistically estimate operational pollutant removals from BMPs, one must examine this suite of spatial and temporal factors. These factors should be used to adjust efficiencies estimated from research plots. Not every BMP will be subject to all the conditions, but a research project will not capture the entire suite of factors that determine efficiencies when practices are widely implemented across natural landscapes.

Factoring in Management Conditions of BMP:

Management conditions, including operation and maintenance of BMPs, design and construction supervision, and/or upland land use change will also impact efficiencies, usually making them lower than research scales. While there is little quantitative information on how BMP efficiencies should be adjusted to account for the impacts of improper maintenance on receiving waters, general adverse impacts on practice operation are understood. If maintenance is neglected a BMP may become impaired, no longer providing its designed functions. For example proper maintenance of outlet structures, flow splitters and clean out gates is key to achieving a stormwater BMPs designed efficiency (Koon, 1995).

Management and operation can be highly variable both between the research and operational scale, and between different managers within the operational scale. When practices are implemented across a large area on parcels managed by many different individuals, it is important to assume an "average" level of expertise, control and management in planning design, implementation and operation of any given BMP. The effect of "average" management has been considered in BMP effectiveness estimates, but validation of proper practice maintainance, andreplacement as needed was not included. These tend to be program management and compliance issues and should be addressed in considering the actual likely impact of implementation of a suite of BMPs as part of a watershed management plan. UMD/MAWP assumed the BMPs were implemented, operated and maintained as recommended for the practice. Reviews and audits of practice performance based on actual practice implementation, operation and maintainence are needed to better estimate effectiveness of reported practices.

Translating Research Studies to Operational Scale Efficiencies

Using research- and demonstration-site derived efficiencies for watershed-scale implementation efforts do not reflect the spatial variability of the entire watershed. Both the scale and management differences between a research plot and a BMP site will alter efficiencies.

The research-based estimates of best management practices need to be adjusted to provide more realistic estimates of efficiencies for widespread adoption of the practice. Virtually all research data is generated under excellent management conditions; meaning that studies are done on better than average soils (poorly drained soils avoided, plots easily worked in a day), agronomic management is optimal (timely planting, excellent farm management, high germination seed, etc.), and other hazards (goose grazing, deer grazing, etc) are eliminated. Hence, the research estimates represent a best-case scenario. This optimistic scenario needs to be adjusted to lower effectiveness when the efficiencies are being applied to widespread field implementation under "average condition" across the Chesapeake Bay watershed.

The nature of plot, field and watershed scale research introduces variability in BMP effectiveness. At the plot scale the researcher controls the land and typically only one experiment is carried out at a time. Varying levels of treatment, including controls, are easily carried out in a replicated experimental design. Research designs include approaches that reduce the likelihood of inconclusive results due to variations in natural factors such as soil, hydrology, topography, and other conditions. Most aspects of weather are consistent from plot to plot, and rainfall is often simulated, providing control over amount and intensity. Data is analyzed statistically to account for variability and significance of results.

At the field scale, research becomes more difficult as replication becomes less feasible or more expensive. Different levels of treatment are still feasible and each field receives a uniform treatment across its full extent. Heterogeneity in soils, topography, weather, and management introduce larger errors into the observations, obscuring the effects of the treatments to a greater extent than the plot scale. Rainfall is not simulated, and is natural, resulting in heterogeneous amounts and intensity across the research site.

At the watershed scale, the researcher becomes more of an observer than a manipulator of the research site. Most water quality research projects attempt to interpret the cumulative result of multiple changes in land management practices taking place at different times. Replication of experiments is rarely feasible. Implementation of specific practices usually cannot be targeted to specific places in the landscape, and is often limited to a small percentage of the total land area. Timing and intensity of climatic events is often the main determinant of fluctuations in water quality. Weather and the agricultural economy play a large role in crop choices, tillage practices, and fertilizer application. If a control watershed is available, the researcher often has little control over management. There may be lag times between land use change and a response in water quality. Given the high level of natural variability in water quality data, failure to detect a change is not an indication that BMPs did not work.

Alternatively, given the multitude of factors that influence water quality, detecting a change does not lead to the conclusion that the BMPs were responsible for the change unless other factors, such as management changes, can be ruled out. All these problems become more severe as watershed size increases. The scale of study should be taken into account and be reflected in efficiency adjustment as research and demonstration site derived efficiencies for watershed scale implementation do not reflect the spatial viability of the entire watershed.

As discussed, the expected spatial and temporal variability for a practice was estimated based on available science and knowledge of the geographic extent of implementation of the practice. Different reduction efficiencies were established for practice implementation across different physiographic, geomorphic or hydrologic settings. Where possible, efficiencies were adjusted for surface water and groundwater interactions (permeability), along with geology and soil types (slope, seeps, floodplain, etc.). BMP age, size, time to maturity and species composition are other site specific conditions that create variability in efficiencies. Data extrapolation to any scale is difficult and research, field and watershed scale efficiencies will differ. The variability that results from site specific and management conditions justified adjusting efficiencies between scales. Thus assuming all BMPs will produce the same efficiency at the operational scale as the research scale is erroneous.

Factoring in Time for BMP to be Implemented and Functioning

Implementation and hydrologic lag times were mentioned as factors that contribute to uncertainty and variability in efficiencies. Many practices are reported as implemented once the plan or design has been completed. In reality, the plan may call for phased implementation over as much as five to ten years. In addition, with agricultural land the farmer may not implement the practice as scheduled due to climatic, management or economic constraints. The time it takes for an implemented practice to reach its full potential may delay pollution reduction percentages. Efforts should be made to assure that reported implementation is close to actual, and to determine if implementation and operation is as rigorous as specified in the practice. Identifying possible lag times in reaching BMP pollution reductions due to phased-in implementation or time to maturity will more accurately estimate effectiveness.

Factoring in Hydrologic Lag Times

The loss pathways and hydrologic lag time associated with each practice should be examined to see if an adjustment in effectiveness should be made. Transport of pollutants occurs through a variety of environmental pathways that include the soil surface, vadose zone, saturated zone, tile drains, and streams. The time scale of this transport varies substantially depending on the pathway followed by water from the land surface to the stream. For example, surface runoff to a stream may take minutes to days, whereas leaching to groundwater followed by discharge to a stream may take months to decades.

When scaling-up BMPs from the research plot or small scale to widespread implementation across a watershed, it is important to account for the impact that expanded variability will have on practice performance. Several studies have shown that when BMPs are applied across even a small watershed the resulting improvement in water quality is far less than would have been projected based on research scale data. While some part of this may be due to “legacy” nutrients or sediments, this does not explain the majority of the difference. USGS research has suggested an average lag time of about 10 years in the Bay watershed to see the full impact of changes. However, they found that after one year about 50% of the change should have occurred and by 5-8 years 80-90% of the change should be observed. This addresses water flow and does not deal with other factors such as practice maturity.

Consistency among reviewers

As multiple experts provided efficiency recommends, their approach to efficiency development and adjustment varied. Thus some overview and adjustment of all recommendations must occur to be consistent among BMP evaluations. Some experts used the lack of data to justify not changing current efficiencies, while others used the lack of data to justify significantly reducing efficiencies. This was resolved by meeting with the experts and discussing the impact the lack of data had on effectiveness. UMD/MAWP was able to use supplemental data to fill these gaps. Also, UMD/MAWP reviewed recommendations to ensure all guidelines and criteria outlined for effiency development were used. When all guidelines and criteria were not employed UMD/MAWP walked experts through the process to ensure their full application. Following these excersises experts felt confident to recommend an efficiency and adjustments were made accordingly.

Using Best Professional Judgment and Adaptive Management

While literature was reviewed and experts were recruited to suggest BMP effectiveness estimates practices in the BMP project, there were several cases where it was necessary to use current "Best Professional Judgment" (BPJ). The most common reason for the application of BPJ was to adjust a BMP effectiveness estimate for spatial, temporal and management variability and resulting change in practice effectiveness at widespread "average" implementation across the Chesapeake Bay watershed. UMD/MAWP recommended efficiencies based on operational conditions that represented watershed-wide effectiveness . If the efficiency is not expected to occur uniformly across the watershed then an efficiency that was more reflective of operational conditions was recommended. As no quantified data on how much to adjust research values to reflect operational values exists, UMD/MAWP used best professional judgment based on known scientific processes to adjust the efficiency and make a recommendation.

Developing effectiveness estimates that reflect operational, real-world conditions requires a holistic view point and an adaptive management approach. An adaptive management approach recognizes our knowledge is incomplete but proposes a science based,,conservative approach to efficiencies that will be reviewed and updated at recurring intervals based on new research, monitoring and experience. The conservative approach is always advisable in adaptive management and is particularly warranted here. There is little if any data that suggests actual widespread implementation efficiencies as high as those in the research literature. A recent small watershed studies have indicated considerably lower reductions when groups of practices are applied than would have been expected based on old efficiencies (Brannon et al., 2000).

Policymakers and managers must better understand the use of adaptive management so they will accept changes as they are proposed. It is also important to make changes in BMP effectiveness estimates at planned intervals. It is difficult to implement policy and management programs if the impact estimation science is constantly changing, but that science must be incorporated over time. Experience in the Chesapeake watershed suggests three- to five-year intervals are manageable from a policy perspective and short enough that major changes in knowledge regarding the science of BMP effects is unlikely (Simpson and Weammert, 2007).

Conclusion

Most research studies cannot incorporate all the factors that influence operational reduction estimates. To account for this, research based efficiencies must be adjusted using the aforementioned guidelines, criteria and protocol. Applying conservative effectiveness estimates allows for easier future change because an increase in effectiveness estimates does not result in a reduction in modeled BMP implementation progress. Utilizing an adaptive management approach recognizes uncertainty and limitations in science, but does not impede implementation of management actions (Watzin, 2007). It is important to move forward using the best available science while being conservative enough to avoid overestimation of impacts that create unrealistic expectations.

It is also essential that adequate research be conducted on practice effects at field and watershed scales, spatial and management variability, and enhanced understanding of factors influencing adoption, implementation, operation, and maintenance of practices so that uncertainty in estimates of BMP effects can be reduced. Adaptive management is essential when applying science to policy, but use of adaptive management presents challenges at the interface between science and policy. Those challenges can be diminished, however, through expanded knowledge of the real effects of practices, systems, and programs.

Overall the definitions and effectiveness estimates revised and developed through this process are more accurate, realistic and defensible than old values. This is due to the thorough process developed by UMD/MAWP, complete with guidelines, critieria and protocol for data selection and effectiveness estimation. Also, many BMP specific experts were involved adding valuable expertise and confidence in definitions and effectiveness estimates.

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Individual BMP Reports

The completed reports for both year one and year two BMPs follow. Each report includes a one sentence definition of the practice and effectiveness estimate for total nitrogen, total phosphorous and total suspended sediment, where applicable. All data used to develop the definition and effectiveness estimate is provided along with an appendix of notes from meetings where the practice was discussed and decisions made.

Ammonia Emissions Reduction: Litter Treatment, BiofilterS, and Covers

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in Phase 5 of the Chesapeake Bay Watershed Model

Consulting Scientist

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Soil Scientist
ARS USDA Beltsville

Synthesis by

Tom Simpson
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary

Poultry Litter Treatment: a surface application of alum, an acidifier, to poultry litter to acidify poultry litter and maintain ammonia in the non-volatile ionized form (ammonium).

- Ammonia Emission Reduction of 50%

Poultry House Biofilters: are comprised of poultry housing ventilation systems that pass air through a biofilter media that incorporates a layer of organic material, typically a mixture of compost and wood chips or shreds, that supports a microbial population and reduces ammonia emissions by oxidizing volatile organic compounds into carbon diozide, water and inorganic salts.

- Ammonia Emission Reduction of 60%

Dairy Manure Covers: the use of a permeable plastic over liquid dairy manure storage that creates a physical barrier to prevent mass transfer of volatile chemical compounds from the liquid by decreasing wind velocity (decrease surface area), and reducing radiation onto the manure storage surface (lower temperature).

- Ammonia Emission Reduction of 15%

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project during 2007-2008 to develop the components or subcategories of the BMP, a corresponding definition(s) and effectiveness estimates. The BMPs developed have not been previously reported to the Chesapeake Bay Program. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of

BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

Attached to these definitions and efficiencies is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix A.

UMD/MAWP consulted Dr. Jack Meisinger to advise in the development of BMP definitions and effectiveness estimates. Discussions with Dr. Meisinger and state program managers, data available on ammonia emissions reductions, and best professional judgment was used to develop the definition and effectiveness estimate.

Guidelines. The following guidelines were used when selecting data to include in the data set:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.
- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.
- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process. As such, peer reviewed literature should be given more weight than design standards and manuals.
- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

Data applicability. As with any literature review, data should be evaluated for its applicability. Before selecting a study for use in developing a BMP effectiveness estimate and definition, UMD/MAWP and panel members considered the questions below. The data used to develop effectiveness estimates was selected based on its applicability to the natural conditions of the Chesapeake Bay watershed, such as, soil type, hydrologic flow paths, and species composition. The studies were evaluated for their BMP design and implementation compatibility to those in the Chesapeake Bay watershed. Rates and timing of fertilizer applications, and the relationship between cultivation and planting dates, were evaluated to determine if the study was applicable to farming methods in the watershed.Studies were also reviewed to determine if the study duration accurately represents average effectiveness results. The time when removal rates are monitored may influence performance by under or overestimating effectiveness.

- Are natural characteristics (soil type, climate, flow paths, geology, vegetation, etc.) of the research site similar to conditions in the Chesapeake Bay watershed?
- Is the practice consistent with NRCS codes, jurisdictional stormwater design manuals? If not, how would effectiveness estimates be different?
- How critical is the duration of the experiment to the reported effectiveness results?
- Do results reflect changes in pollution reduction benefits over the lifetime of the BMP?
- Briefly explain the study method used?
- What parameters were sampled and monitored?
- Who conducted the research?
- How was the effectiveness estimate calculated?
- What was the scale of the study?
- What assumptions, outside of experimental results, were made in reaching the conclusions?

After reviewing the literature on covers, alum and biofilters UMD/MAWP identified some issues with the study design and effectiveness calculations for alum treatment. In the studies the effectiveness was calculated using a timeframe not proportional to the time scale when the majority of ammonia is emitted. Studies typically averaged the effectiveness during 0-35 days of flocklife when alum is highly effective, averaged the effectiveness of the alum during the last seven days of flock life when alum is moderately effective, and would then average those two values to determine overall effectiveness. For example, Meisinger (unpublished) found over 42 day grow-out the alum treated litter reduced the ammonia concentrated in the exhaust air by 75% compared to the untreated control, with excellent control over the 0-35 day period (82% lower ammonia compared to the control) and moderate control (50% reduction) during the last 7 days when excretions were largest. This is not reflective of the time when the majority of ammonia emissions occur, during the last seven days of flock life (Carr, 2004a; Figure 1). This increase in emissions correlates to an increase in pH observed over flock life (Carr, 2004a; Figure 2), and as the pH increases the ammonia emissions also increase exponentially. Overall, alum is highly effective early on in flock life, but is less efficient over the total flock life (Carr, 2004a; Figure 3). Thus, UMD/MAWP averaged the literature values and then discounted the value as these values do not account for cumulative emissions over time.

Figure One.

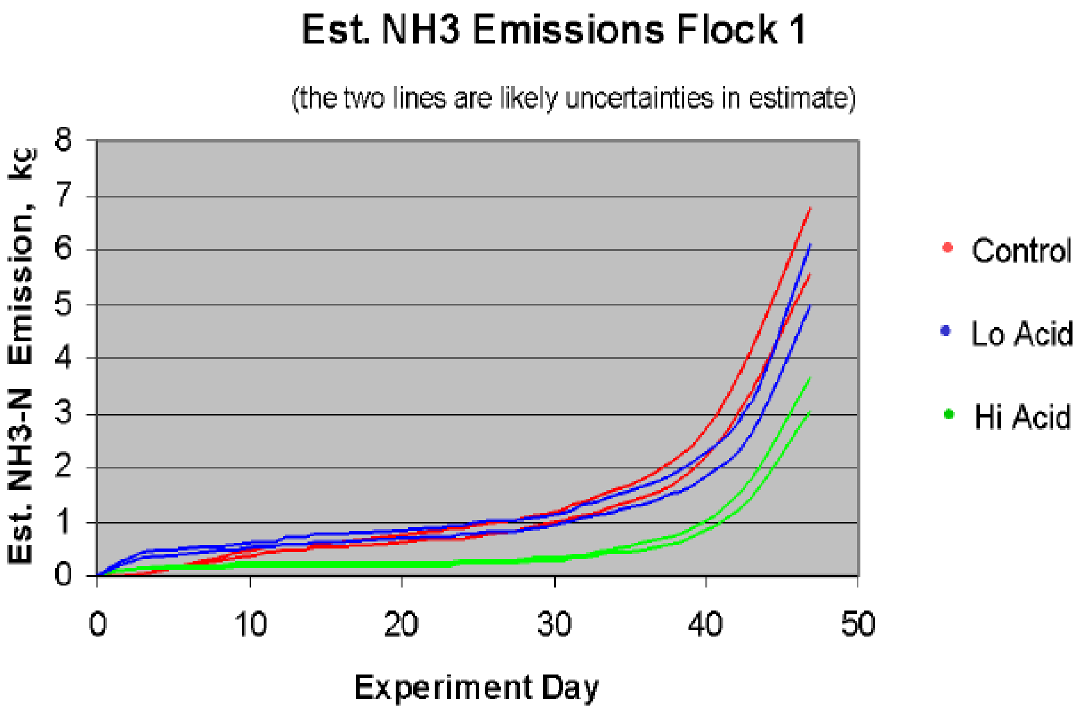


Figure Two. Litter pH Over Time

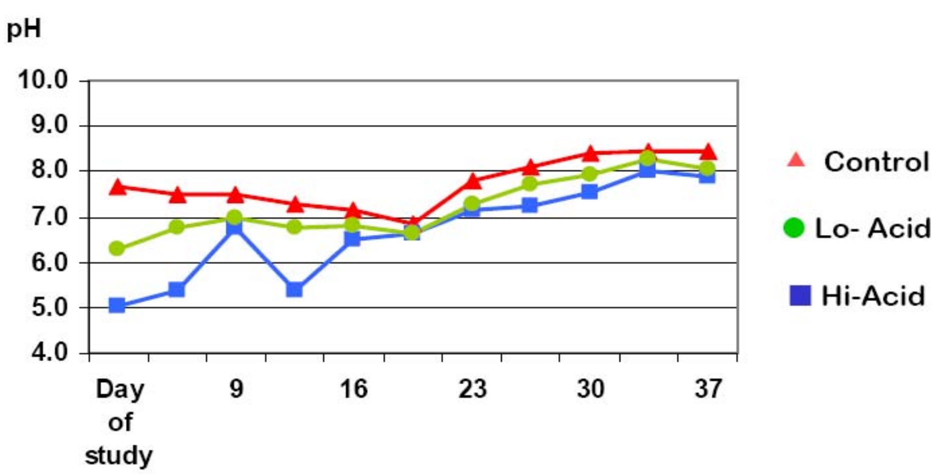
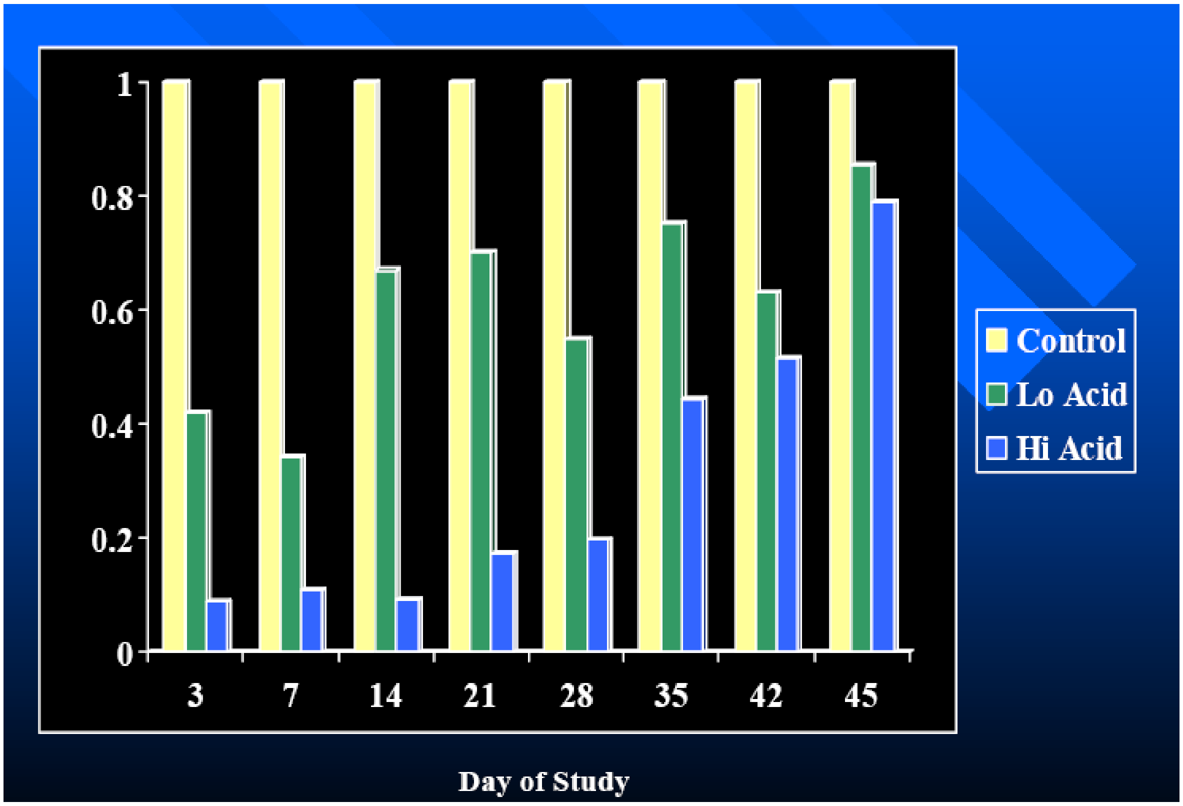


Figure Three. Exhaust Ammonia Concentration as Ratio to the Control



Description/Definition of BMP:
To determine this BMPs structure various sources of information were utilized, including experimental plot data provided by academic researchers and research articles published in peer reviewed journals, as well as consultation with recognized experts and jurisdictional Tributary Strategies. For this report ammonia emissions reduction techniques are defined as litter treatment (alum, etc.), biofilters and permeable plastic covers. Diet manipulation (pH, protein, amino acid control, urease inhibitors), moisture control (flooring, separator or belt conveyor, etc), vegetative environmental buffer, and land application techniques are not in this review. While these practices do reduce ammonia emissions, some are captured in other BMPs such as feed and nutrient management plans.

Litter treatment: a surface application of an acidifier to poultry litter to acidify poultry litter and maintain ammonia in the non-volatile ionized form (ammonium). One approach is to incorporate acidifying agents such as aluminum sulfate (alum), sodium bisulfate, acidified clay, calcium chloride, calcium sulfate, magnesium chloride, and magnesium sulfate. Litter treatments apply an acid that produces hydrogen ions that will attach to ammonia to form ammonium, which reacts with sulfate ions to form ammonium sulfate, a water-soluble fertilizer, reducing the ammonia emitted from the litter and increasing the nitrogen content of the litter. Alum will also reduce phosphorus runoff by precipitating soluble phosphorus. Alum is the most common litter treatment acidifier used in the Chesapeake Bay watershed and its performance is evaluated in this report. To receive ammonia emission reduction credit alum must be applied at a rate of 250lbs/1000 sq feet. Consult your local NRCS representative to determine local, state and federal laws to follow during application and help with application products, rates, methods, handling, storage and timing.

In addition to the nutrient benefits, litter treatment also has the potential to provide other co-benefits including:

- Improved air quality for poultry living and humans working in confined spaces leading to improved poultry health and performance as some amendments suppress bacterial pathogens and pests (darkling beetles) and expose to ammonia levels can damage the bird's respiratory system, and also result in poor body weight, feed efficiency and condemnation rate
- Reduced ventilation or altered ventilation strategies resulting in potential energy savings
- Increased proportion of nitrogen in the manure, creating a more valuable and balanced fertilizer
- Reduced leaching and runoff of soluble phosphorus and heavy metals from land applied litter (alum)

Biofilters: are comprised of housing ventilation systems that pass air through a biofilter media that incorporates a layer of organic material, typically a mixture of compost and wood chips or shreds that supports a microbial population and reduces ammonia emissions by oxidizing volatile organic compounds into carbon diozide, water and inorganic salts. A biofilter system can be, and is applied, to various species including poultry, swine and dairy.

Treatment effectiveness depends on many factors such as, moisture levels, filter median type/pore size, and detention time. Nicolai and Janni (1998) showed to achieve successful treatment, biofilters must have a sufficient detention time and fans that can accommodate pressure loss through the biofilter; moisture content of the filter media must remain between 40-70%; and biofilters must be composed of a media mixture range from 30:70 to 50:50 ratio by weight of compost and wood chips or other inert fill materials. Their research showed no difference between four second and six second detention times, or four seconds and eight seconds, but detention times below four seconds will impact performance. To incorporate a margin of safety UMD/MAWP recommends a 5 second detention time. Biofilters installed in poultry operations must include a mechanism for dust removal to achieve estimated ammonia emission reductions. UMD/MAWP also recommends a moisture content of 50-70% to add a margin of safety. Finally, UMD/MAWP recommends adding the proportions of media material suggested by Nicolai and Janni (1998), and incorporating this value into the definition along with the moisture content and detention time suggestions.

In addition to the nutrient benefits, biofilters also have the potential to provide other co-benefits including:

- Filters also retain or trap particles for particulate matter emission reduction
- Reduce odor, microbial bioaerosal and hydrogen sulfide emissions

Covers: There are two categories of covers, permeable and impermeable, each composed of various materials. Permeable covers include straw, geotextile, clay balls, perlite, rigid foam, oil, natural crust, and organic materials (corn stalks, sawdust, wood shavings, rice hulls, ground corncobs, and grass clippings). Impermeable covers include inflatable plastic (positively pressurized), floating plastic (negatively pressurized), floating plastic, suspended plastic, concrete, and wood/steel. A cover can be, and is applied, to various species including swine and dairy. This report focuses on permeable plastics that cover liquid lagoons, in particular geotextiles, as they are most widely implemented throughout the Chesapeake Bay watershed and are the most researched. A report evaluating the benefits of covering dry poultry manure will be published in November 2008 and will be submitted to the same evaluation process the liquid covers BMP here were subjected to and if approved will be added as a ammonia emission technique.

Using permeable plastics composed of nonwoven fabric, thermally bonded, continuous polypropylene filaments, covers create a physical barrier to prevent mass transfer of volatile chemical compounds from the liquid by covering manure storage facilities to decrease wind velocity (decrease surface area), and reduce radiation onto the manure storage surface (lower temperature). Permeable covers act as biofilters at the manure/air interface by physically limiting the emissions of ammonia and other gases from the surface of storage lagoons and create a biologically active zone where the emitted ammonia and other gases will be aerobically decomposed by microorganisms.

There are many advantages to geotextiles. They have low costs, are relatively effective at odor and gas reductions and are resistant to rot, moisture and chemical attack. Their disadvantages include a short lifetime, decreases in performance over time, costly disposal, can become submerged, and safety is a main issue during agitation and pumping.

Straw covers are not recommended because they cannot be managed in a way that does not result in the release of ammonia when land applied. Future development of straw covers should include application methods to overcome this barrier. Please note while there are active management systems that draw and trap green house gases (methane) this practice utilizes static covers that do not trap methane.

In addition to the water and air quality benefits, covers also have the potential to provide other co-benefits, such as reducing the transfer of hydrogen sulfide and other odorous compounds.

Applicable NRCS Codes
For all ammonia emission reduction techniques the following may apply. Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Cultural components consisting of shorter term conservation measures included in the Ammonia Emission Reduction definitions include, but may not be limited to the USDA-NRCS conservation practices listed below. When reporting ammonia emissions the applicable NRCS practice must be implemented to receive credit for either cover, biofilter or litter treatment as they are defined here. Meaning, credit is not given for litter treatment if only a 367 is implemented. You can only receive credit for the ammonia emission technique implemented. Utilizing only one technique, cover, treatment or biofilter, does not meet the criteria for any other technique and thus does not constitute implementation of the other techniques. If implementing Atmospheric Resource Quality Management (370) the actual technique (biofilter, cover, treatment, etc.) must be reported to receive the credit associated with that technique.

Amendments for treatment of agricultural waste (591) – (for litter treatment) Treatment of manure, process wastewater, storm water runoff from lots or other high intensity areas, and other wastes, with chemical or biological additives

Purpose:
To alter the physical and/or chemical characteristics of the waste stream to facilitate the implementation of a waste management system to:

- Improve or protect air quality
- Improve or protect water quality
- Improve or protect animal health
- Alter the consistency of the waste stream to facilitate implementation of a waste management system

Conditions where practice applies:
This practice applies where the use of a chemical or biological amendment will alter the physical and chemical characteristics of the waste stream as a part of a planned waste

management system. This practice does not include amendments added to the animal feed.
Waste facility cover (367) – A fabricated rigid, semi-rigid, or flexible membrane over a waste treatment or storage facility.

Purpose:
To cover a waste facility for:
- water quality improvement
- air quality improvement
- capture of biogas for energy production

Conditions where practice applies:
- Exclusion of precipitation from an animal waste storage or treatment facility will improve management of an existing or planned system.
- Capture and controlled release or flaring of emissions from an existing or planned agricultural waste storage will improve air quality.
- Bio-treatment of emissions from an existing or planned waste storage or treatment facility will improve air quality
- Biogas production and capture for energy are components of an existing or planned animal waste system.

Atmospheric Resource Quality Management (370) - A combination of treatments to manage resources that maintain or improve atmospheric quality.

Purpose:
- Minimize or reduce emissions of:
  - Particulate matter
  - Smoke
  - Odors
  - Greenhouse gases
  - Ozone
  - Chemical drift
- Maintain or increase visibility

Conditions where practice applies:
This practice applies to cropland, forest land, rangeland, roads, feedlots, dairies, poultry and swine operations and other CAFOs, equipment yards and staging areas, and other lands that contribute primary airborne particulates (dust, smoke, and chemicals), secondary airborne particulates (ammonia, nitrates (i.e. fertilizers, animal emissions, and animal waste emissions), organic products, odor, greenhouse gases [carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4)], (greenhouse gases, objectionable odors, and other gases that have a negative impact on air quality.

Effectiveness Estimate

Litter Amendments

For reasons discussed in the data applicability section of this report literature values for alum effectiveness are not representative of the majority of ammonia emissions and are thus discounted. UMD/MAWP also supports discounting these literature values as they do not capture the time between flocks when ammonia emissions are also occurring. As such, UMD/MAWP recommends assigning a 50% ammonia emission reduction to alum applied to poultry. Table 1 shows the literature values and their sources.

Table 1. Literature Ammonia Emission Effectiveness Estimates for Alum

Ammonia Emission Effectiveness Estimate (%)	Reference
28	Kithome et al 1999
50	Carr et al 2004b
75	Moore et al 2000
45	DeLaure et al 2004
75	Moore et al 1997
75	Meisinger, unpublished
Average (%) = 58	

Biofilter

The average literature values for biofilter ammonia emission reduction is 57%, however, UMD/MAWP recommends rounding this value to 60%. The literature values represent moisture contents slightly below and within our defined range, and media depths and residence times above, and within, our defined range, thus representing operational conditions where moisture levels and residence time may vary throughout the life of the practice. There is also a value representative of the time between the literature values, and the references, are found in table 2:

Table 2. Biofilter Ammonia Emissions Effectiveness

Ammonia Emission Effectiveness Estimate (%)	Reference
15*	Hartung et al 2001
36	Hartung et al 2001
6, 49, 81 (moisture content 27.6, 47.4, 54.7, respectively)	Nicolai and Janni, no date
82, 74 (12 in deep and 8s residence time, 6in deep and 4s residence time, respectively)	Nicolai and Janni, 1998
50	Nicolai and Janni, 1997
73.5	Sheridan et al 2002
62.5	Tymczyna et al 2003
98.5	Shah et al 2003
Average (%) = 57	

* No animals in stall when effectiveness sampled.

For poultry operations maintenance of the dust removal system is required. Maintenance of biofilters is critical in order for their removal effectiveness to remain as estimated. There are four maintenance requirements for biofilters, moisture control, weed control, rodent control and pressure maintenance (Schmidt et al 2004). Moisture content of the media must be regulated to determine if media is too dry or wet. Dampness should be maintained one half to three quarters of the way down through the depth of the media. If dampness is evident throughout the entire depth of the median then reduce watering time because the media is receiving too much water. Also, control weed growth on the biofilter to reduce roots and growth. Roots can clog the biofilter pores and root, stem and leaf growth on the media can reduce treatment effectiveness by causing air channeling and limiting oxygen exchange. Rodents may also cause channeling by burrowing into the biofilter, thus rodent control is necessary. Finally use a manometer to measure the maximum pressure drop across the filter during the maximum ventilation rate and replace the media if pressure drops over 50% of the design pressure. While no studies have been conducted to determine the life expectancy of a biofilter Schmidt et al (2004) estimate a biofilter can last 3-5 years.

<u>Covers</u>

UMD/MAWP recommends rounding the average literature value for ammonia emission reduction by covers to 15%. Table 3 lists the literature values and their references.

Table 3. Ammonia Emission Effectiveness Literature Values for Covers

Ammonia Effectiveness Estimate (%)	Reference
37.5	Bicudo et al 2004a
17.5	Bicudo et al 1999
-14.6	Clanton et al 2001
0	Nicolai et al 2002
37.5	Bicudo et al 2004b
Average (%) = 15.7	

Effectiveness is reduced with time as the fabric becomes plugged with biomass growth. Also, some types of covers require reapplication of the cover material after installation. Any tears, holes or punctures in the cover must be repaired. If manure is to be land applied installation and maintenance of an agitation and pumping system is required. Exhaust ventilation systems must also be maintained. Collect and removal ponded rain water from impermeable covers. Unwanted plastic and geotextile material must be properly disposed of and depending on your location high fees may be associated with collection, hauling and disposal. Finally, due to the increase in nutrient concentration in the manure, especially with impermeable covers, more land may be needed to apply manure at agronomic rates.

In some cases geotextile covers will release ammonia. The release in Clanton et al 2001 was in part due to the smooth texture on the underside of the fabric allowing gas bubbles to move laterally along the fabric. This lateral movement of gas is less likely to happen with larger surface areas. The addition of straw on the fabric creates a rougher surface which traps the gas bubbles forcing them through the fabric and allowing for adsorption of gases. The negative effectiveness is also due to the period of time spent stirring.

Level of Confidence

By employing a discounted value to alum to account for the entire flocklifes' emissions, and for time between flocks, using a margin of safety for the biofilter definition, and restricting the performance values to geotextiles, UMD/MAWP is confident these effectiveness estimates are representative of operational conditions.

How Modeled

UMD/MAWP recommends modeling ammonia emissions as follows. Of the total emitted ammonia, 40% randomly falls on the other land uses, proportional to the landuse in that watershed, while the remaining 60% is emitted to the atmosphere.

When a jurisdiction cannot report which ammonia reduction technique, alum, covers or biofilters, they need to tell the EPA Chesapeake Bay Program Office which technique was intended when their Tributary Strategy was developed. In MD it is assumed biofilters are implemented and on dairy farms in PA covers are assumed. If no guidance is provided the technique with the lowest effectiveness will be assigned, per Watershed Technical Workgroup policy.

Future Research Needs

Ammonia emissions between flocks are unknown and needs to be evaluated. In addition, if in-house composting of litter becomes widespread, effectiveness and an emission baseline needs to be reviewed.

<u>For litter treatment</u>

- Given the rate of ammonia emissions is rising exponentially, how effective is alum in the last week of flocklife? How much total ammonia loss occurs in the last week of flocklife?
- When birds are removed from the house and air is circulated to ventilate the house, how much ammonia is lost between flocks?
- Additional experiments are needed at different acid levels.
- Need to increase the longevity of litter treatments.
- Time release properties for the litter treatment need to be investigated

<u>Biofilter</u>

- How do you dispose or use (apply) spent material? Is it regulated under a nutrient management plan?

<u>Cover</u>

For straw covers, the literature is not clear on the ultimate fate of ammonia and the opportunity for release during land application. UMD/MAWP is unaware of literature that addresses this barrier to implementation and suggests the releases of ammonia during land application after straw covers be investigated.

<u>Ammonia Emission Technology and Phosphorus Removal</u>

If these practices become widely implemented research should be designed to quantify its ability to remove phosphorus. Self-Davis and Moore (1998) found with land application of alum treated litter to pasture, soluble reactive P concentrations in runoff were 87% lower compared to the control (untreated litter) for the first runoff event and 63% less for the second event.

Vegetated Environmental Buffer
The Agricultural Nutrient and Sediment Reduction Workgroup (AgNSRWG) recommends adding Vegetated Environmental Buffer as an ammonia emission BMP. Refer to the NRCS code and jurisdictional manuals for design specifications. However, this practice was not included in the UMD/MAWP recommendations as an ammonia emission reduction practice because in the limited gray literature on the practice no accounting or balancing of the fate of ammonia-nitrogen "knocked down" by the buffers was available.

However, the AgNSRWG may choose to develop a practice definition and effectiveness estimate in the future based on evolving data. The AgNSRWG will work to develop a definition and effectiveness estimate using the following reference materials:

Malone, G., VanWicklen, G., Collier, S., and D. Hansen. Efficacy of Vegetative Environmental Buffers to Capture Emissions from Tunnel Ventilated Poultry Houses. Workshop on Agricultural Air Quality, Washington, DC June 3-8, 2006.

The Benefits of Planting Trees Around Poultry Farms.
http://www.rec.udel.edu/Poultry/tree_buffer.pdf
VEB Tool-Kit. http://www.dpichicken.org/download/VEBTK.pdf

Using Shelterbelts to Reduce Odors Associated with Livestock Production Barns.
http://www.omafra.gov.on.ca/english/crops/facts/info_odours.htm

The University of Delaware received funding to support VEB research from the following
http://www.dpichicken.org/download/VEBTK.pdf

Citations

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Kithome, M., Paul, J.W., and A.A. Bomke. 1999. Reducing nitrogen losses during simulated composting of poultry manure using adsorbents or chemical amendment. *J. Env. Qual.* 28:194-201.

Meisinger, J. 2008. Alum treated litter to reduce ammonia concentrations. Unpublished raw data.

Moore, P.A., Huff, W.E. Jr., Daniel, T.C., Edwards, D.R., and T.C. Sauer. 1997. Effect of aluminum sulfate on ammonia fluxes from poultry litter in commercial houses. Pages 888-891 *in:* Proceedings of the 5th International Symposium on Livestock Environment Vol II. American Society of Agriculture.

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Nicolai, R.E. and K.A. Janni. 1997. Development of a Low Cost Biofilter on Swine Production Facilities. Paper No. 974040. ASAE, 2950 Niles Road, St. Joseph, MI 49085 USA.

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Tymczyna, L., Chmielowiec-Korzeniowska, A., and L. Saba. 2003. Biological Treatment of Laying House Air with Open Biofilter Use. Polish Journal of Environmental Studies, vol 13, no 4, pp 425-428.

APPENDIX A: MEETING MINUTES

Agricultural Nutrient and Sediment Reduction Workgroup Meeting Minutes
MD NRCS Office; Annapolis, MD
August 19, 2008

Ammonia Emissions Reduction: Litter Treatment, Biofilter, and Covers
Report: http://archive.chesapeakebay.net/pubs/calendar/ANRWG_08-19-08_Handout_2_9619.pdf

- For the ammonia emissions reduction practice, UMD/MAWP looked at three different practices: litter treatment, biofilters, and covers.
- Comments/Suggestions:
    - Some members thought that vegetated environmental buffers should have been looked at in this report.
        - UMD/MAWP said that the other practices are physically capturing ammonia and using it as a nutrient source, while the buffers are just knocking it down and are not using it for any type of nutrient balancing activity.
        - Bill Rohrer recommended that an efficiency be developed for vegetated buffers. He will contact Bud Malone to see if he has any information on this.
        - UMD/MAWP said that they will not be adding this practice into the report; however, the workgroup can still pursue this if they think that it would be beneficial.
        - UMD/MAWP agreed to acknowledge in the report that the workgroup raised questions about whether or not vegetated environmental buffers should be included in this report.
    - In order to make tracking these practices viable, will we need to have some buy-in from the poultry industry?
    - Add the NRCS practice code to the report.
    - In the description of litter treatment, aluminum sulfate should be changed to ammonium sulfate.
    - In Table 1, was there a consistent application rate used for the different effectiveness estimates?
        - The estimates in the table all had an application rate within the 200-250 range. However, they may have been reported at different times in the flock.
    - In the section on lagoon covers, it should be pointed out that some people are using active management systems that would draw the gases and trap them in order to reduce greenhouse gas (methane) concentrations. That is not what this report is about. The lagoon covers described in this report are static covers.
    - A sentence should be added to the report that says if the in-house composting of litter becomes more widespread, then the reduction efficiencies and the base emissions on which they are set need to be reviewed.
    - The report should mention that the losses between flocks, which are currently unknown, need to be better understood.

ACTION: Tom Simpson and Sarah Weammert will revise the livestock BMP reports based on today's discussion. The revised reports will be sent to workgroup members in advance of the September 3rd workgroup meeting.

ACTION: At the workgroup's September 3rd meeting, members will review the revised reports for all of the agricultural BMPs from Year 2 of the UMD/MAWP BMP Project and they will finalize their recommendations to the Nutrient Subcommittee.

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Minutes: Agricultural Nutrient and Sediment Reduction Workgroup
September 3, 2008

Ammonia Emissions Reduction

- Jeff needs to account for all of the ammonia emissions from every source. Jeff would need to find out the percent from poultry and apply the reductions to that load.
- Beth Horsey and Bill Rohrer proposed the addition of a vegetative buffer in the ammonia emissions reduction BMP.
- UMD/MAWP will write in the report that the AgNSRWG would like to include vegetative environmental buffers as a component of the ammonia emissions reduction BMP. There is no efficiency recommendation at this time.
- Tom Juengst raised concern about the effectiveness of buffers varying with age. The model does not represent differing effectiveness estimates according to age.

ACTION: Bill Rohrer will send Sarah Weammert a copy of the manual on ammonia emission reduction efficiencies, and Bud Malone's recommendations for vegetative environmental buffer benefits.

DECISION: The AgNSRWG agreed to move forward with the ammonia emissions reduction practice with the following changes:

- Vegetative environmental buffers will be added to the practice.
- Bud Malone's work will be researched to find an acceptable effectiveness estimate for vegetative environmental buffers.

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Minutes: Watershed Technical Workgroup
October 6, 2008

Ammonia Emission Reduction

- The ammonia emission reduction study included eight biofilters references and five covers references. The average value was discounted to account for cumulative emissions over time.
- Maryland and Pennsylvania have ammonia emission reduction in their Tributary Strategies.

    - Pennsylvania has ammonia emission reduction numbers for covers. Mark Dubin should be able to provide justification for those numbers.
- The Watershed Technical Workgroup approved the ammonia emission reduction practice.

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Chesapeake Bay Program Nutrient Subcommittee
October 22, 2008 Meeting

SUMMARY OF DECISION, ACTIONS AND ISSUES

Ammonia Emissions Reduction

- The ammonia emissions reduction BMP includes three practices: litter treatment, biofilter, and cover.
  - The cover practice is a liquid storage cover.
- The Agricultural Nutrient and Sediment Reduction Workgroup approved the practice and acknowledged that litter treatment for alum was the most common practice under this BMP. The Workgroup also added that vegetative buffers were another technique for ammonia emissions reduction.
  - The Agricultural Nutrient and Sediment Reduction Workgroup will be putting together a definition and effectiveness estimate for vegetative buffer practices for ammonia emissions reduction.
- The emissions reductions will be applied where there is a lack of emission controls.
- Ron Entringer opposed the ammonia emissions reduction BMP as written and will work to resolve the issues prior to the November Water Quality Steering Committee meeting.

ACTION: Sarah Weammert will clarify that the cover practice in the ammonia emission reduction BMP applies to liquid storage.

DECISION: The Nutrient Subcommittee members approved the ammonia emissions reduction BMP recommendations for final decision by the Water Quality Steering Committee. Concerns expressed by specific Subcommittee jurisdictional representatives were noted for the record.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
January 21, 2009

I. Review of Year 2 BMP Definitions and Effectiveness Estimates — Hansen

Attachment C: Year Two BMP Approval Status

- **Ammonia Emissions Reduction:** At the October NSC meeting, members requested that the report clarify that the cover practice in this BMP applies to liquid storage. This is now clarified in the report. In addition, the Agricultural Nutrient and Sediment Reduction Workgroup (AgNSRWG) recommended adding vegetated environmental buffers as an ammonia emissions BMP. The report now includes a section that states that the AgNSRWG will develop a definition and effectiveness estimate for this practice at a later date.

DECISION: The Nutrient Subcommittee approved the definition and effectiveness estimates for four Year 2 BMPs: mortality composting, dairy feed management, ammonia emissions reduction, and infiltration and filtration practices. These BMPs will go to the Water Quality Steering Committee for final approval.

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CHESAPEAKE BAY PROGRAM
WATER QUALITY STEERING COMMITTEE
January 26, 2009 Conference Call

SUMMARY OF DECISIONS, ACTIONS, AND ISSUES

Review and Approval of the Recommended Year 2 BMPs and Efficiencies

Dave Hansen, Nutrient Subcommittee Chair, reviewed Attachment A and updated the Steering Committee on the status of the review process for Year 2 University of Maryland Mid-Atlantic Regional Water Program (UMD/MAWP) BMPs.

Review of Year 2 UMD/MAWP BMP Effectiveness Estimates

- Four BMPs have gone through the review process from the panels up to the Workgroups and were approved (mortality composting, ammonia emissions reduction, dairy feed management, and infiltration/filtration practices. The Water Quality Steering Committee is asked to approve these four BMP definitions and effectiveness estimates.

DECISION: The Water Quality Steering Committee approved the Nutrient Subcommittee's recommended mortality composting, ammonia emissions reduction, dairy feed management, and infiltration/filtration BMP definitions and effectiveness estimates.

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CONSERVATION PLANNING:
FIELD AND PASTURE EROSION CONTROL PRACTICES

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in calibration and operation of the
Chesapeake Bay Program's Phase 5.0 Watershed Model

Synthesis by

Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary
Conservation Plans: are a combination of practices, other than conservation tillage or no-till, that reduces soil loss to or below tolerance, defined as the maximum amount of erosion at which the quality of a soil as a medium for plant growth can be maintained. Nutrient and sediment reductions vary by the land use, e.g. conventional tillage, conservation tillage, hayland or pastureland, in the model that a conservation plan is applied to.

Landuse	TN Reductions	TP Reductions	TSS Reductions
Conventional Tillage	8%	15%	25%
Conservation Tillage	3%	5%	8%
Hayland	3%	5%	8%
Pastureland	5%	10%	14%

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University Of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

Attached to these definitions and efficiencies is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix B.

Name Change

The original name of the Conservation Plans BMP will be changed to *Conservation Planning: Field and Pasture Erosion Control Practices* since the credited practices may encompass only a limited portion of the elements contained in a conservation plan.

Definition/Description

Conservation Planning: Field and Pasture Erosion Control Practices are a combination of practices, other than conservation tillage or no-till, that reduces soil loss to or below tolerance. Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. The practices help to control erosion and nutrient runoff by modifying cultural or structural practices. Cultural practices may change from year to year and include changes to crop rotations. This practice does not include reduction credits to certain cultural practice changes on crop or hay land, such as conservation tillage or cover crop practices which are credited as individual BMPs. However, cultural practice changes are reflected in pastureland reduction efficiencies. Structural components consisting of longer term conservation measures included in the *Field and Pasture Erosion Control Practices* include, but may not be limited to the following USDA-NRCS conservation practices. Note that credit cannot be taken for each practice implemented under a farm erosion and sediment plan or a NRCS Conservation Plan; the suite of practices listed in the plan are prescribed to meet a USDA-NRCS Revised Universal Soil Loss Equation, Version 2 (RUSLE2) prediction of soil losses at or below the soil loss tolerance value (T) for the accredited land acreage.

- Access Road (560)
- Alley Cropping (311)
- Animal Trails and Walkways (575)
- Conservation Cover (327)
- Conservation Crop Rotation (328)
- Contour Buffer Strips (332)
- Contour Farming (330)
- Critical Area Planting (342)
- Diversion (362)
- Field Border (386)
- Filter Strip (393)
- Grade Stabilization Structure (410)
- Grassed Waterway (412)
- Lined Waterway or Outlet (468)
- Residue Management, Seasonal (344)
- Rock Barrier (555)
- Row Arrangement (557)
- Sediment Basin (350)
- Stripcropping (585)
- Structure for Water Control (587)
- Terrace (600)
- Underground Outlet (620)
- Water and Sediment Control Basin (638)
- Windbreak/Shelterbelt Establishment (380)

EFFECTIVENESS ESTIMATE

The reduction credits attributed to structural practices in the *Field and Pasture Erosion Control Practices*, also including cultural practice changes for pasture only, are estimated as follows:

Landuse	TN Reductions	TP Reductions	TSS Reductions
Conventional Tillage	8%	15%	25%
Conservation Tillage	3%	5%	8%
Hayland	3%	5%	8%
Pastureland	5%	10%	14%

These effectiveness estimates are the same as the current efficiencies assigned to this practice. Effectiveness estimates were recently (2003) reviewed by the Chesapeake Bay Program's Agricultural Nutrient Reduction Workgroup and no new data is available that warrants a change. The effectiveness estimates are divided according to the different land uses conservation planning is applied to in the Chesapeake Bay Watershed Model. The first two land uses, conventional and conservation tillage, represent different levels of tillage where the impact of conservation planning varies due to the loading rates associated with the land use. The type of tillage technique applied to a land use will impact erosion rates. Erosion is reduce with less invasive tillage techniques (see report on conservation tillage). When combined with conservation tillage conservation planning has less soil to erode compared to conservation planning on conventionally tilled land (a clean inversion tillage). The next two land uses, pastureland and hayland, produce less nutrient runoff compared to cropland where tillage techniques such as conventional or conservation tillage are applied to. Thus, with less nutrients to reduce from the baseline conservation planning does not reduce the same percentage of nutrients on hayland or pastureland compared to cropland. For these reasons conservation planning is divided among the various land uses it can be applied to.

When reviewing the data and protocol used in 2003 to develop the conservation planning definitions and effectiveness estimates the CBP followed a rigourous scientific and technical review process. This defensible process, along with no new data to evaluate, lead to the decision to maintain the definition and effectiveness estimate for conservation planning.

Future Research Needs

The statement in the BMP description, "However, cultural practices changes are reflected in pastureland reduction efficiencies" may need to be revised based upon the final decisions on pasture management systems for Year 2 of the CBP/UMD BMP project. If these cultural practices are credited as stand-alone BMPs, their influence on the effectiveness of this practice will need to be considered.

Appendix A: Reviewer Comments

In an email response to Sarah Weammert, Russ Perkinson said the following, "I have reviewed the "conservation plan" BMP and find the recommended efficiency numbers and practice description to be reasonable."

Appendix B. Meeting Minutes

Agricultural Nutrient and Sediment Reduction Workgroup
Maryland Department of Agriculture
Annapolis, Maryland
May 10, 2007

Conservation Plans

- For conservation plans, UMD is not recommending any changes to the efficiencies because they feel that there is not enough data to warrant a change. Conservation plans were last reviewed and adjusted in 2003.
- Q: Is simply tracking that a farmer has a conservation plan, regardless of whether or not the plan is implemented, a good way to track this practice?
    - A: This is a broader issue that goes beyond just this BMP. Documenting the level and degree of implementation is important. However, this is not something that should be figured into this practice's efficiency. The efficiency number assumes that this practice is being implemented.
- Workgroup recommendations:
    - The definition of this practice should be modified so that it specifies exactly what is included in this efficiency. When finalizing this definition, it was suggested that the project team get input from NRCS.
    - The name of the practice should also be changed since the efficiency does not include all parts of a soil conservation plan, just the plan's erosion control practices.
    - This efficiency should be based on literature. It should include documentation on how the AgNSRWG determined this efficiency in 2003.
    - All practices have a lifespan that needs to be taken into account in tracking and reporting. This will be added to the future research needs list for this practice.

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Agricultural Nutrient and Sediment Reduction Workgroup
Conference Call
May 24, 2007
10:00 AM - 12:00 PM

Field and Pasture Erosion Control Practices

Questions raised by Beth Horsey are the following:

- How many of the NRCS practices must be implemented to count as field and pasture erosion control practice?
- How does this change in definition affect change in way states are tracking the BMP?

ACTION: Beth Horsey, MDA, asked for additional time to evaluate this practice and resolve the confusion.

ACTION: Sarah Weammert will send the former definition of the practice, before the name and definition change, to the workgroup electronically so that they can evaluate the differences.

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Herb Reed, UMD
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Sarah Weammert, UMD
Peter Tarby, PA DEP
Tom Juengst, PA DEP
Becky Thur, CRC
Mark Dubin, UMD MAWP/CBPO - could not get on call due to technical difficulties with conference line.

Minutes: Nutrient Subcommittee Meeting
June 6, 2007
10:00 AM to 3:00 PM
Fish Shack—Chesapeake Bay Program Office

Field and Pasture Erosion Control Practices

- Field and Pasture Erosion Control Practices received a major adjustment in 2003 and there are no additional data since then to consider. Efficiencies were therefore recommended to remain at their current levels.
- Jurisdictions at the AgNSRWG meeting requested the name and description change. Maryland was not supportive and has requested more time to review. The status of these practices is pending Maryland's review.
  - NRCS is on board with the name change.
  - UMD MAWP has no position on the name change.
  - Mark Dubin is leading the effort to ensure the list of practices is appropriate and tied to NRCS's practices.
  - The NSC will discuss this issue another time.

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Meeting Minutes
Agricultural Nutrient and Sediment Reduction Workgroup
Adams County Agricultural and Natural Resource Center
Gettysburg, Pennsylvania
July 12th, 2007

Field and Pasture Erosion Control Practices:

1. Keep title as "Farm Conservation Plans" with a subtitle of Field and Pasture Erosion Control Practices". Beth Horsey will provide some edits to the definition to clarify the components of the plans.

General Recommendation

1. Unless the scientific research indicates differently, as a general rule set phosphorus efficiencies 5% lower than sediment efficiencies to account for dissolved phosphorus losses not associated with soil losses.

Participants

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Becky Thur	CRC

Calling In

Tom Simpson	UMD

Agricultural Nutrient and Sediment Reduction Workgroup
Conference Call
August 2, 2007

- The workgroup recommended that phosphorus efficiencies be set 5% lower than sediment efficiencies as a general rule to account for dissolved phosphorus losses not associated with soil losses, unless the scientific research indicates differently.
    - UMD supports the recommendation that TP efficiencies be set lower than TSS efficiencies; however they suggest that the TP efficiencies be lowered by 10% rather than by 5%. They favor 10% because it implies that there is a significant difference and because it does not indicate a greater level of precision than we have. However, they will defer to the workgroup regarding what percentage is used.
    - Some members voiced concern that subtracting 10% from TP will affect some BMPs more than others. For example, if the original efficiency is 40% and it is lowered to 30% than it is only reduced by 25%, whereas if the original efficiency is 20% and it is lowered to 10% than it will be reduced by 50%.
    - DECISION: In order to make the reductions more proportional, UMD and the workgroup agreed to reduce TP by 25%, rather than simply subtracting 10%. This was based on research findings which suggest that 25% of TP are attributable to Dissolved Reactive Phosphorus (DRP) according to the UMD.

- The workgroup decided to accept the UMD recommendations with the agreed upon adjustments for the agricultural practices. The only exception was for the cover crop practices which will require additional revisions prior to final review by the workgroup.

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Minutes: Tributary Strategy Workgroup
August 6, 2007
Chesapeake Bay Program Office—Fish Shack

- DECISION: The TSWG has approved all of the AgNSRWG recommendations, with the exception of Cover Crops which is dependent upon further refinement and information.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
August 15, 2007

Highlights and Action Items

- Efficiency recommendations for urban, forestry, wetland, and agricultural BMPs were reviewed and approved by the Nutrient Subcommittee with the exception of the off-stream watering practices and cover crop BMPs. These two BMPs will be reviewed on a joint NSC, TSWG, AgNSRWG, MAWP conference call scheduled for August 24, 2007.

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Mary Lynn Wilhere, ACB

Chesapeake Bay Program
Water Quality Steering Committee
Conference Call
August 27, 2007

Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

DECISION: The Water Quality Steering Committee approved the 12 BMP definitions and efficiencies, described in the advance briefing papers, as recommended by the Nutrient Subcommittee and its workgroups for use in Phase 5 Chesapeake Bay Watershed Model.

Conference Call Participants

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CONSERVATION TILLAGE PRACTICES

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

**For use in calibration and operation of the
Chesapeake Bay Program's Phase 5.0 Watershed Model**

Synthesis by

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Project Manager**

And

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Summary

<u>Conservation Tillage:</u> involves the planting, growing and harvesting of crops with minimal disturbance to the soil surface through the use of minimum tillage, mulch tillage, ridge tillage, or no-till.

	% TN Reduction		% TP Reduction	% TSS Reduction
Separate surface and subsurface flow paths*	Surface 18	Subsurface 0	22	30
Combined surface and subsurface flow paths*	8		22	30

***** The separate values for flow path capture the different reductions to surface runoff and subsurface flow leaching. A combined flow path is provided if modeling efforts cannot separate the two flow paths.

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

Discussions with state program managers, data available on conservation tillage and best professional judgment was used to develop the definition and effectiveness estimates. Attached to the definitions and effectiveness estimate is a detailed summary of CBP's discussions on the BMP. This includes who was involved, how these recommendations were developed, including data, literature, data analysis results, and how BMP specific issues were addressed. All meeting minutes are included in Appendix D.

Definition/Description

Conservation tillage involves the planting, growing and harvesting of crops with minimal disturbance to the soil surface. Conservation tillage is designed to reduce erosion and maintain or improve soil health properties, conservation tillage increases infiltration by reducing surface sealing and enhancing macropore connectivity and flow. Conservation tillage techniques include minimum tillage, mulch tillage, ridge tillage, and no-till. No-till farming is a form of conservation tillage in which the crop is planted directly into vegetative cover or crop residue with little disturbance of the surface soil. Minimum tillage farming involves some disturbance of the soil, but uses tillage equipment that leaves much of the vegetation cover or crop residue on the surface. The Chesapeake Bay Watershed Model reports conservation tillage annually by acres and is modeled as a land use conversion.

Conservation tillage systems have traditionally required two standard components: (a) a minimum of 30 percent of the soil surface covered by crop residue and/or organic residues immediately following the planting operation; and (b) a non-inversion tillage method. Direct field measurements are relied upon to determine the percent residue covering the soil surface.

The Soil Conditioning Index (SCI) and Soil Tillage Intensity Rating (STIR) are planning tools that may be used in place of percent residue cover to determine organic matter trends and soil surface disturbances. The SCI predicts the effect of cropping systems on soil organic matter levels. A positive SCI indicates a cropping system that, if continued, is likely to result in increasing levels of soil organic matter. SCI is a Windows based model that can predict the consequences of cropping systems and tillage practices on the status of soil organic matter in a field. Soil organic matter is a primary indicator of soil quality and carbon sequestration. SCI has three main components including the amount of organic material returned to or removed from the soil, the effects of tillage and field operations on organic matter decomposition, and the effect of predicted soil erosion associated with the management system. Differences in crop residue fragility characteristics will also affect SCI values.

Soil Tillage Intensity Rating (STIR) is a calculation based on location of cropland and the crop management system that the producer employs on that land. It is an index used to evaluate the kind, severity, and number of ground disturbing tillage passes on soil quality.

Higher numbers indicate greater disturbance; lower numbers indicate less disturbance. The components of STIR are: operating speed of tillage equipment, tillage type, tillage depth, and the percent of surface area disturbed. Weights are assigned to each component to calculate a rating. This rating is useful in making residue management decisions.

The following methods can be used to determine if a practice meets the CBP definition of conservation tillage. They are tested in order of preference and it is recommended that CBP move to be multi-year rotational system approach (method 1) over time:

1. Measurement criteria based on a multi-year rotational system (a-c):

   (a) A USDA-NRCS Revised Universal Soil Loss Equation, Version 2 (RUSLE2) prediction of soil losses at or below the soil loss tolerance value (T); and

   (b) A positive USDA-NRCS Soil Conditioning Index (SCI) using RUSLE2; and

   (c) A USDA-NRCS Soil Tillage Intensity Rating (STIR) rotational value not to exceed the recommendations of the *USDA-NRCS Conservation Tillage Operations Guide for the Chesapeake Bay Region*.

2. Measurement criteria based on a one-year management system (a):

   (a) A USDA-NRCS Soil Tillage Intensity Rating (STIR) includes all field operations that are performed during a single crop interval between harvest of the previous crop and harvest or termination of the current crop (includes fallow periods). STIR values will be between 70 or less following non-fragile/ high residue crops (i.e. grain corn), and l0 or less following fragile/ low residue crops (i.e. soybeans). Maximum STIR values for individual crops and examples of tillage operations are provided in the recommendations of the *USDA-NRCS Conservation Tillage Operations Guide for the Chesapeake Bay Region*.

3. Measurement criteria based on field measurement (a):

   (a) Method 1 or 2 above are preferred but when direct field measurements are relied upon, at least 30 percent of the soil surface will be covered by crop residue and/or organic residues following planting.

Pollution reduction mechanisms for conservation tillage are (Dinnes, 2004):

- Reduced erosion and transport of nutrient enriched sediment and particulate
- Improved water infiltration and nutrient (phosphorous) adsorption to soil matrix
- Improved stabilization of soil surface to impede wind and water erosion detachment and transport of nutrient enriched sediment and particulates

- Reduced volume of runoff water reaching surface waters
- Temporary nutrient sequestration in soil organic matter

The secondary benefits of conservation tillage are (Dinnes, 2004):

- Decreased evaporation/increased moisture retention
- Reduced production costs; Reduced equipment requirements with no-till
- Carbon sequestration
- Yield increases in slight to moderate drought years
- Reduced loss of sediment-bound pesticides and chemicals

Conservation tillage, however, is limited on slopes that are too steep for row crops due to potential for erosion and unsafe equipment operations. No-till poses a management problem on fields with poor drainage in heavy soils due to low soil temperature in the spring. Finally, the benefits of no-till will increase incrementally during the transition period from conventional to conservation tillage systems with the improvement of soil physical properties.

Consistency with NRCS Practice Standards

Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Cultural components consisting of shorter term conservation measures included in the Conservation Tillage Practices definition include, but may not be limited to the following USDA-NRCS conservation practices:

- Residue and Tillage Management, Mulch Till (345)
- Residue and Tillage Management, No-Till/Strip Till/Direct Seed (329)
- Residue and Tillage Management, Ridge Till (346)

Effectiveness

Conservation tillage systems ability to reduce loss to TN and TP depends on many factors (Dinnes, 2004):

- Crop rotation and crop present at time of consideration
- Soil type
- Slope and slope length
- Climate
- Antecedent soil moisture content just prior to rainfall events
- Rate of N or P applications

- Surface vs. knife vs. tillage incorporation of commercial N or P, or manure, fertilizer applications
- Degree of soil disturbance from tillage system
- Large rainfall event soon after commercial P fertilizer or manure application in a soil environment having a continuous network of macropores may lead to elevated soluble P losses from reduced runoff and erosion; Large rainfall event soon after application of a N fertilizer containing nitrate-N in a soil environment having a continuous network of macropores may lead to elevated nitrate-N leaching losses via preferential flow
- Greater volume of drainage from increased infiltration rates with conservation tillage systems may lead to increased nitrate-N losses, but decrease ammonium-N losses from reduced runoff and erosion
- Reduced fraction of soil water percolating through the soil matrix diminishing contact and transport of soluble P, and soil nitrate-N, held within the soil matrix
- Potential for increased leaching losses
- Percentage of surface residue cover
- Amount of attached and detached residues
- Type of residue (i.e., corn with high C:N ratio and slow decomposition vs. soybean with low C:N ration and relatively fast decomposition)
- Soil aggregate stability

Load Reduction Benefits

Literature shows that higher nitrogen, specifically nitrate-N, leaching occurs when the dominate flow path is subsurface flow. The reduced soil-N mineralization and fraction of soil water that percolates through the soil matrix that reduces nitrate-N transport tends to be offset with greater drainage volumes in conservation tillage systems because these systems increase a soil's porosity, macrospores, and continuous macropores thus increasing water infiltration rates (Dinnes, 2004). A list of studies that show an increase in infiltration is included in Appendix B.

The literature does not support the older average TN reduction efficiency of 18% that results in the watershed model from conversion of 'hi-till' to 'lo-till'. Runoff and leaching can be addressed separately in Phase V of the WSM, TN reductions due to land use conversion should be 18% for surface runoff and 0% for subsurface losses (Table 2). If flow paths cannot be separated, the recommended median land use conversion effectiveness estimates for conservation tillage is 8% for TN. This TN efficiency attempts to average the N reductions that do occur in runoff with the near zero to negative reductions (increases in loss) observed in the literature on N leaching. As mentioned, leaching will influence the reduction in TN.

It was decided by project experts and the Nutrient Subcommittee that for all BMPs where specific phosphorous data is not available or very limited, TP reductions are calculated as 75% of the sediment reductions. Dissolved reactive phosphorous is assumed to be averaged around 25% of the total phosphorous load (Sharpley et al., 1993). Dissolved reactive phosphorous will not be reduced by practices whose reduction mechanisms is primarily sediment reduction. While the general assumption of 25% non-sediment bound phosphorous is an improvement over current approaches, it is important that the CBP continue to work with scientists to better understand and model the relative amounts and impacts of sediment versus dissolved reactive phosphorous.

Best professional judgment (BPJ) was used to estimate surface and subsurface flow proportions to estimate effectiveness. The previous BMP efficiencies were based on surface flow while the major loss pathway for N is subsurface flow. The previous reduction was applied to surface flow only, and, subsurface values were assumed to be zero (-10 to +10). For the revised calculations, it was assumed that about 60 to 75 % of flow was subsurface flow.

The values listed in Table 1 are for the combined losses of nutrients from surface runoff and leaching. This is not the correct way to evaluate conservation tillage effectiveness because these two processes are fundamentally different, for both N and P. These fundamental differences have been recognized by generations of soil scientists, it would be a serious error to combine them.

Table 1. Loads (lb/acre) associated with conventional and conservation tillage.

Land Use	TN Median (load)	TP Median (load)
Conventional Tillage for vegetable crops and tobacco	26	2
Conventional Tillage for agronomic crops w/ Manure	**23**	**1.8**
Conservation Tillage for agronomic crops w/ Manure	**19**	**1.2**

Bold = Phase 4.3 Estimates; Plain = Best Professional Judgment

Table 2. Land use conversion estimates associated with conservation tillage.

	% TN Reduction		% TP Reduction	% TSS Reduction
	Surface	Subsurface		
Separate Flow Paths	18	0	22	30
Combined Flow Paths	8		22	30

Land Use Conversion Estimates for Phase V Model

During discussions it was unclear if the new phase of the model could separate flow paths. The CBP partners reviewed land use conversion estimates for both separate and combined flow paths, but ultimately approved land use conversion estimates for combined flow paths:

TN reduction of 8%
TP reduction of 22%
TSS reduction of 30%

How Modeled

These land use conversion estimates will be applied to individual county land segments that have a specific load based on its soil, climate, amount of impervious surface, etc. resulting in loads that reflect area conditions. There will be no changes to the current modeling methodology for conservation tillage.

Future Research Needs

Tillage Technique Breakouts

UMD/ MAWP recommends that each conservation tillage technique be assigned its own reduction for TP and TS, but no difference between TN because there is no agreement within the literature or professional community on what the value should be. This is supported by a study conducted by Laflen and Colvin (1981) that compared the percent residue cover to soil erosion. The study produced a graph that can be used to estimate erosion based on the percent residue cover (Figure 1). This will result in different load reductions for minimal tillage and no till practices (Table 3). Currently the jurisdictions are unable to track and report conservation tillage versus no-till techniques and one efficiency is needed for the model. Jurisdictions should begin tracking and reporting tillage techniques as conservation tillage and no-till. As the ability to model effectiveness by technique would be more accurate.

Phosphorous Pathways

The MAWQ recommends the CBP refine the percent of sediment bound phosphorous versus dissolved reactive phosphorous (DRP). This project identified an improved method for representing DRP but additional research is warranted to further develop the accuracy of phosphorous transport.

Increased Chemical Use

Will the reduced loss of sediment-bound pesticides and chemicals be offset by higher chemical applications? This needs to be addressed in future reviews of the benefits of BMPs for decreased chemical runoff.

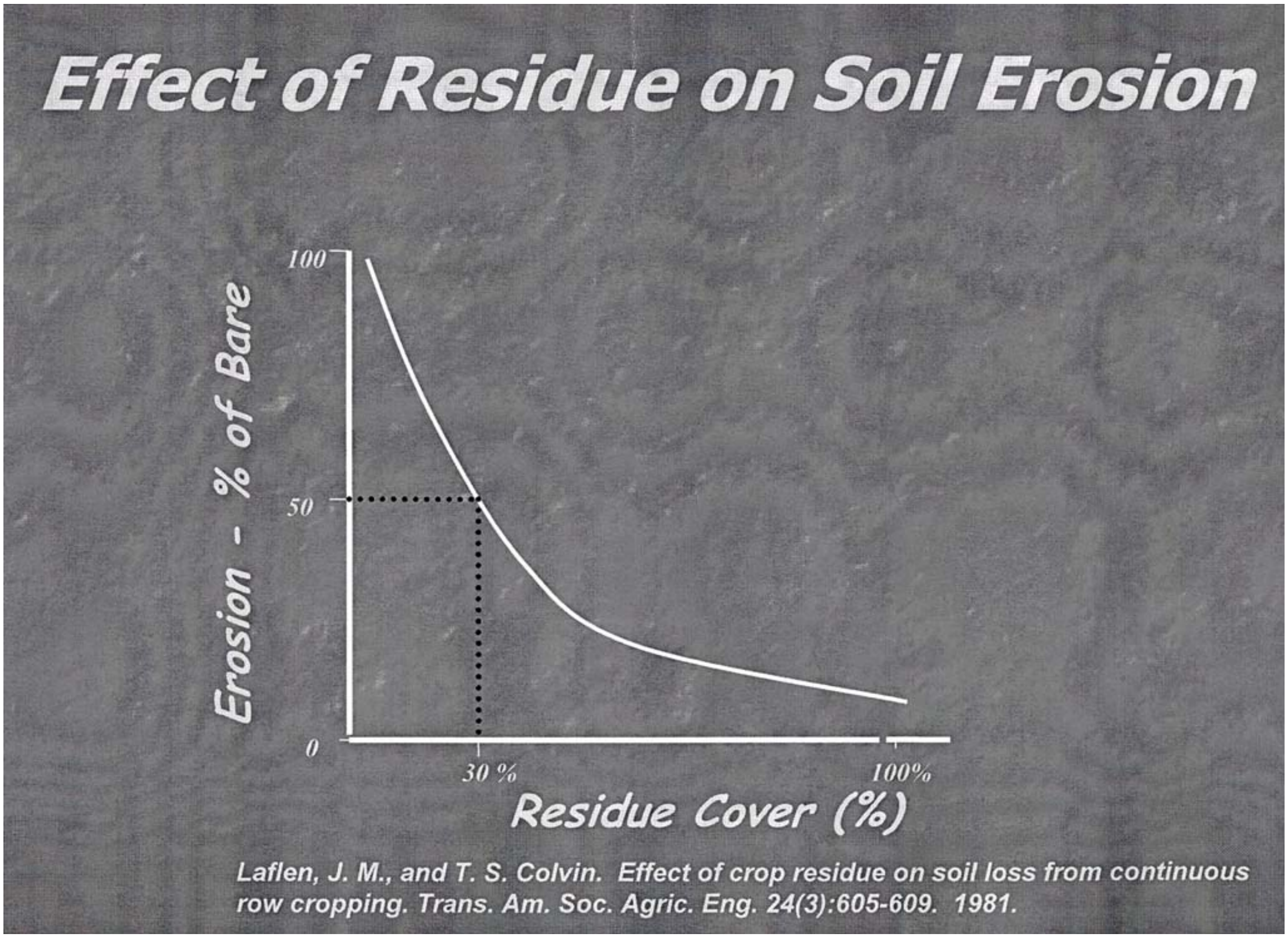


Figure 1. Relationship between percent residue cover and erosion. This graph supports one efficiency should not be used to estimate the soil and associated nutrient loss across all levels of residue cover.

Table 3. Efficiencies Based on Tillage Technique

Technique	TN	TP	TSS
Conservation tillage	Surface flow 18% Subsurface flow 0%	15%	20%
No-till	Surface flow 18% Subsurface flow 0%	30%	40%

Surface and Subsurface Flow Proportions

Future research studies should report TN and TP loss data from both surface and subsurface flow, so scientific data is determining flow proportions, not professional judgment and extrapolation . A report from Iowa (Dinnes, 2004) lists a general ratio of runoff TN loss to leaching TN loss for intensive, moderate and no till systems. While the numbers are a broad generalization, the trend shows increases of N loss through leaching on no till systems when compared to N loss through leaching on intensive and moderate tillage systems:

Intensive Tillage runoff TN: leaching TN = ~1:1
Moderate Tillage runoff TN: leaching TN = ~1:2
No-till runoff TN: leaching TN = ~1:5

We recognize these ratios need to be adjusted for the Chesapeake Bay Watershed. While absolute ratios may be different, there is no reason to believe the relative relationship will not remain the same. Please see Appendix B for a list of studies that show changes in leaching with various tillage techniques.

Follow-up Studies

The Chesapeake Bay Program should follow up on Dr. Josh McGraph's, UMD, no-till work on the Eastern Shore:

Project Title: Utilizing conservation tillage to minimize nutrient losses from poultry litter applied in grain production systems.

Project Director: Dr. Frank J. Coale, Professor, Department of Environmental Science and Technology, University of Maryland, College Park, 20742. Phone (301) 405 1306, fjcoale@umd.edu

Project Co-Director: Dr. Joshua McGrath, Assistant Professor, Department of Environmental Science and Technology, University of Maryland, Collage Park, 20742. Phone (301) 405 1351, mcgrathj@umd.edu

Objective: To demonstrate that commercially available conservation tillage technology can be successfully used to partially incorporate poultry litter in reduced tillage grain production systems preserving surface residue and soil conservation conditions, while reducing nitrogen and phosphorous losses in surface runoff and atmospheric ammonia emissions.

References:

Dinnes, D.L. 2004. Assessments of Practices to Reduce Nitrogen and Phosphorus Nonpoint Source Pollution of Iowa's Surface Waters. Iowa Department of Natural Resources, Des Moines, IA.

Laflen, J.M., and T.S. Colvin. 1981. Effect of Crop Residue on Soil Loss from Continuous Row Cropping. Trans. Am. Soc, Agric. Eng. 24(3):605-609.

Sharpley, A.N., Daniel, T.C., and D.R. Edwards. 1993. Phosphorus movement in the landscape. J. Prod. Agr. 6(4):492-500.

Appendix A:

Review notes/comments on "Conservation Tillage Nutrient and Sediment Reduction BMP Efficiencies" by J. J. Meisinger, USDA-ARS,
Beltsville, MD

My comments are focused on two primary issues:

1. The **values** listed (lbs N/P/TSS per acre) **are for the combined losses of nutrients from surface runoff *and* leaching. This is not the correct way to evaluate these BMPs** efficiencies because these two processes are fundamentally different, for both N and P. These fundamental differences have been recognized by generations of soil scientists, **it would be a serious error to combine them.**

a. Runoff is driven primarily by surface conditions, such as soil infiltration rate (infiltration limited), moisture content in the surface layers (moisture-storage limited), surface concentrations of N or P, surface residues, and other factors (crop leaf area index, rainfall intensity, frozen soil, etc.). Surface runoff of N is minimal, usually less than N inputs in rainfall; but surface runoff of P or TSS is a major loss pathway.

b. Leaching is primarily driven by the solubility of the nutrient (nitrate being totally soluble and P sparingly soluble), the quantity of surplus nutrient remaining in the soil before the fall-winter-spring water recharge season, and the quantity of percolate moving through the soil. Leaching of nitrate-N (totally soluble) is a major process amounting to maybe 10-30% of the applied N but dependant on many local factors (N removal by previous crop, denitrification loss, ammonia volatilization loss, etc.). Leaching of P is minimal (low water solubility), except in coarse soils with very high P levels, in tile drained settings, or where preferential flow is the dominant mechanism to transport recharge water (this is really surface runoff displaced down preferential flow channels).

c. Conservation tillage practices primarily affect surface runoff with minor impacts on quantity of percolate. There is a large volume of literature describing the benefits of conservation tillage on reduced surface runoff and associated reductions in P and TSS losses, but the reductions in N losses are usually substantially less. Conservation tillage can increase percolation due to reductions in runoff (where conservation tillage does not increase yields), or it can have little or no effect on percolation if the water conserved from runoff is devoted to higher crop evaporation-transpiration (higher yields).

I would strongly suggest separating surface runoff from leaching.

2. There is widespread **use of three tillage practices** in the watershed: **conventional low-residue** tillage leaving < 30% cover (moldboard plow, heavy disking, etc.), **minimal-tillage medium-residue** that leaves 30-60%(?) cover (chisel plow with subsequent disking, strip tillage leaving only between-row with residues, etc.), and **no-tillage high-residue** that leaves 60-100% cover (planter disturbance only, etc.). If we are intending to have the model reflect actual watershed conditions the **efficiencies should be structured to incorporate these three tillage practices.**

Tillage practices primarily impact surface runoff and secondarily impact leaching volumes (see above 1c). If we believe the Erosion vs. Residue Cover curve from Laflen & Colvin (1981, TASAE 24:605-609) then we could estimate that erosion would be about 75% of bare soil on conventionally tilled land, about 35% for minimal-tillage, and about 10% for no-tillage. These percentages would be OK for P and TSS, and maybe OK for N (since runoff is a minor loss for N anyway) *if* we separated surface runoff from leaching. However, it should be emphasized that it would be incorrect to apply the Laflen & Colvin figure to leaching losses because tillage has minimal impact on leaching (again, see above 1c). My suggested reductions were for a scenario of IF the Laflen & Colvin data were adopted as plotted. Their data is directly related to surface runoff losses of TSS and would only apply to the TP part of P and not soluble P; its application to N is uncertain but N losses to runoff are quite small and could be of 50% and still be to less than 5 lbs N/ac. Therefore, we conclude that in order **to properly incorporate the three tillage practices there is a corresponding need to separate runoff and leaching** in order to properly estimate the impact of these conservation practices.

3. Apparently the previous Bay model has been combining runoff and leaching into one "loading" estimate. If that is the case, one must ask the question: **Is it time to update the Bay model so it can accurately represent reality?** I see no reason to continue to estimate water quality impacts for agricultural practices that are not founded upon the understandings and principles of the individual processes delivering nutrients from agricultural land to the Bay.

Appendix B: List of Studies that show an increase in infiltration

Alley, M.M., Gaidos, J.M., and J.K.F. Roygard. no date given. No-till Wheat Grain Yields and Nitrate Leaching Losses Related to Early Season Fertilizer N Application Rates and Timings. Crop and Soil Environmental Sciences Department, Virginia Polytechnic Institute and State University.

Baker, J.L., and J.M. Laflen. 1983. Water Quality Consequences of Conservation Tillage. Journal of Soil and Water Conservation, May-June, pg. 186-193.

Blevins, R.L., Frye, W. W., Baldwin, P.L., and S.D. Roberston. 1990. Tillage effects on sediment and soluble nutrient losses from a Maury silt load soil. *Journal of Environmental Quality* 19(4): 683-696 IN Bosch, D.D., Potter, T.L., Truman, C.C., Bednarx, C.W., and T.C. Strickland. 2005. Surface runoff and lateral subsurface flow as a response to conservation tillage and soil-water conditions. *Transactions of the ASAE* 48(6): 2137-2144.

Bosch, D.D., Potter, T.L., Truman, C.C., Bednarz, W.W., and T.C. Strickland. 2005. Surface Runoff and Lateral Subsurface Flow as a Response to Conservation Tillage and Soil-Water Conditions. American Society of Agricultural Engineers. Vol 48(6):2137-2144.

Chichester, F.W., and C.W. Richardson. 1991. Sediment and Nutrient Losses as Affected by Tillage. Journal of Environmental Quality

Dillaha, T.A. 1990. "Role of BMP in Restoring the Health of the Chesapeake Bay: Assessment of Effectiveness" Chesapeake Bay Program, Perspectives on the Chesapeake Bay, 1990, Advances in Estuarine Sciences. pp. 57-81

Fawcett, R. and S. Caruana. 2001. Better Soil Better Yields: A Guidebook to Improving Soil Organic Matter and Infiltration with Continuous No-Till. Conservation Technology Information Center, West Lafayette, IN.

Forster, D. Lynn. 2002. Effects of Conservation Tillage on the Performance of Lake Erie Basin Farms. Journal of Environmental Quality 31, 32-37.

Langdale, G.W., Barnett, A.P., Leonard, R.A., and W.G. Fleming. 1979. Reduction of soil erosion by the no-till system in the Southern Piedmont. *Transactions of the ASAE* 22(1): 82-86, 92 IN Bosch, D.D., Potter, T.L., Truman, C.C., Bednarx, C.W., and T.C. Strickland. 2005. Surface runoff and lateral subsurface flow as a response to conservation tillage and soil-water conditions. *Transactions of the ASAE* 48(6): 2137-2144.

Logan, T.J., Davidson, J.M., Baker, J.L., and M.R. Overcash. 1987. Effects of Conservation Tillage on Groundwater Quality. Lewis Publishers, Inc., Chelsea, Michigan.

Menelik, G., Reneau, R.B., Martens, D.C., Simpson, T.W., Hagerdorn, C., and G.W. Hawkins. 1998. Nitrogen Leaching Losses in Corn Production on Soils in Chesapeake Bay Area as Influenced by Selected BMPs. 2nd Year Annual Report. Virginia Polytechnic Institute and State University, Department of Agronomy, Virginia Water Resources Center.

Romkens, M.J.M., Nelson, D.W., and J. V. Mannering. 1973. Nitrogen and phosphorous composition of surface runoff as affected by tillage method. *Journal of Environmental Quality* 2(2): 292-295 IN Bosch, D.D., Potter, T.L., Truman, C.C., Bednarx, C.W., and T.C. Strickland. 2005. Surface runoff and lateral subsurface flow as a response to conservation tillage and soil-water conditions. *Transactions of the ASAE* 48(6): 2137-2144.

Triplett, G.B., Jr., Van Doren, D. M., Jr., and B.L. Schmidt. 1968. Effect of corn (*Zea mays* L.) stover mulch on no-tillage corn yield and water infiltration. *Agron. J.* 60(1): 236-239 IN Bosch, D.D., Potter, T.L., Truman, C.C., Bednarx, C.W., and T.C. Strickland. 2005. Surface runoff and lateral subsurface flow as a response to conservation tillage and soil-water conditions. *Transactions of the ASAE* 48(6): 2137-2144.

Zhu, Y., Fox, R., and J. Toth. 2003. Tillage Effects on Nitrate Leaching Measured by Pan and Wick Lysimeters. Soil Science Society of America.

Appendix C: Notes from conservation tillage articles

ARTICLE 1.
BMP Name:
Conservation Tillage

Definition of BMP provided in article

Conservation tillage is a management practice designed to reduce soil erosion by leaving 30% or more of the soil surface covered with crop residue following tillage and planting (Galloway et al., 1981). In some cases, conservation tillage has also been shown to increase infiltration (Romkens et al., 1973; Blevins et al., 1990)

Efficiencies provided in article:
Surface runoff for strip till 81% less than conventionally tilled soil.
Shallow lateral subsurface flow increased 73% for strip tilled soil compared to conventionally tilled.
Overall strip tilling increased plant-available water, indicating decreased need for irrigation. Indicates beneficial results for reducing sediment, nutrient loss.

Location of study: soil, climate, hydrology
Tift County, Georgia.
Tifton loamy sand with 3 to 4% slope. Surface soil is well drained, sand horizon at immediate surface extends to 25cm. under surface horizon is loamy sand to sandy loam extending to 50cm, subsoil is sandy clay loam to about 2m. Clay fractions increase with depth 9.5% from 0-8cm to 20%, from 15-30cm. 75 to 92% sand in the top 30cm. sandy clay loam subsoil has reduced conductivity which is thought to restrict rooting depth and deep percolation, simultaneously inducing lateral subsurface flow.

BMP Characteristics: BMP age, date of construction, size, and species composition.

Constructed in 1999 on University of Georgia Gibbs Farm.
6 plots of 0.2 ha
1 plot of 0.4 ha on top of hillslope for rainfall simulation studies
Study 1999-2003, cotton crops grown each year except for 2002 when peanuts were grown as rotation crop.
3 of the 6 small plots were strip tilled, the other three were conventionally tilled, the downslope portion of plot 7 was strip tilled, the upslope portion was conventionally tilled.
Conventional tillage used chisel plowing to 20cm three weeks before planting and disk harrowing to form beds for planting. For strip tillage, a subsoiler was used to create 15m

strip for planting with tillage to 20cm. Planting, fertilization, and pesticide treatment was the same for all plots. Cotton and peanut residue was left on soil surface in all plots following harvest during which cotton stalks were mowed to 5cm. During fall all plots were planted with rye grain cover crop. 4.5Mg/ha of poultry litter was applied one month before planting in spring except in 2003 when no fertilizer was needed. Irrigation was used to supply water when necessary.

Watershed Management details: Does the BMP require high operation and maintenance, as well as monitoring? How technical is construction, does it require an engineer to install or can a farmer do it?

Tillage could be conducted by farmer.

How were the proposed efficiencies monitored? Type of equipment used, how often monitored, what tests were done (ex – if used EPA methods for testing for TN or some other organizations methods)

First 6 plots surrounded by earthen berms 0.6m in height to facilitate surface drainage to NW corner of each plot. Metal H flumes .46m with pressure transducers and data loggers were used to monitor flow depth every minute during flow events when flow through the H flumes exceeded 10mm in depth. Transducer readings were checked for accuracy twice per year. Daily and annual flow volumes were calculated, less than 1% of data had to be rejected due to faulty readings, etc. Missing data was supplemented using comparison to plots of the same tillage.
A tile drain was installed at 1.2m depth across the lower boundary of plot 7 to intercept lateral subsurface flow and direct it away from the lower plots. Tile drain loops were installed surrounding the remaining plots to capture lateral subsurface flow and an HS flume installed at each tile drain outlet to measure flow and conduct manual water sample collection. Manual samples were taken twice per week and used when logged flow readings were questionable.

Source of article
SURFACE RUNOFF AND LATERAL SUBSURFACE FLOW
AS A RESPONSE TO CONSERVATION TILLAGE
AND SOIL-WATER CONDITIONS
D. D. Bosch, T. L. Potter, C. C. Truman, C. W. Bednarz, T. C. Strickland
2005 American Society of Agricultural Engineers ISSN 0001-2351 Vol. 48(6) pages 2137-2144

USDA study, funding: grant from Georgia Cotton Commission and funds from USDA

ARTICLE 2
BMP Name: Conservation Tillage
A) Reduced Tillage
B) No-Till

Definition of BMP provided in article
A) Reduced tillage is defined as a practice where between 15 and 30 percent of the soil surface is covered with crop residue. With reduced tillage, the soil is disturbed prior to planting with chisels, field cultivators, disks, sweeps, or blades.
B) In a no-till system the soil is left undisturbed from harvest to planting except for nutrient injection, less than 25 percent of the row width is disturbed leaving the majority of crop residue on the surface.

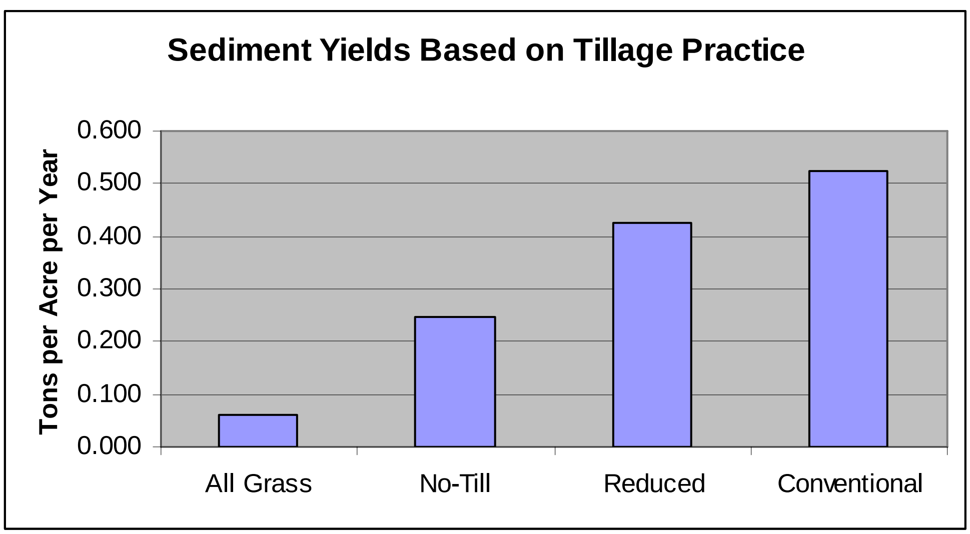
Efficiencies provided in article:
(no buffers)
A) a **reduced till** system **can reduce sediment** entering the ditch **by 19 percent** in comparison to a conventional tillage system.
B) a **no-till** system **can reduce sediment** entering the ditch **by 53 percent** in comparison to a conventional tillage system

Table 5.14: Sediment Yields in Tons per Acre per Year

	Buffer Widths	No-Till	Reduced	Conventional
	No Buffer	0.2456	0.4250	0.5235
20'	20' A	0.1671	0.2406	0.2837
	20' G	0.1337	0.1849	0.2250
	10' G, 10' T	0.1305	0.1797	0.2174
	13' G, 7' T	0.1305	0.1799	0.2167
35'	35' A	0.1522	0.2067	0.2382
	35' G	0.1158	0.1498	0.1774
	18' G, 17' T	0.1133	0.1452	0.1696
	24' G, 11' T	0.1130	0.1446	0.1692
120'	120' A	0.1202	0.1437	0.1521
	120' G	0.0838	0.0929	0.0999
	60' G, 60' T	0.0803	0.0889	0.0941
	80' G, 40' T	0.0799	0.0873	0.0929

Table 5.15: Sediment Reduction by Reduced and No-Till Systems over Conventional

Sediment Reduction over Conventional:	Reduced	No-Till
No Buffer	19%	53%
20' G	18%	41%
20' A	15%	41%
10' G, 10' T	17%	40%
13' G, 7' T	17%	40%
35' G	16%	35%
35' A	13%	36%
18' G, 17' T	14%	33%
24' G, 11' T	15%	33%
120' G	7%	16%
120' A	6%	21%
60' G, 60' T	6%	15%
80' G, 40' T	6%	14%



Location of study: soil, climate, hydrology
Location: Representative farms in the Matson Ditch Watershed, Northeastern Indiana
Hydrology: Matson Ditch is an open drainage channel that runs through the center of the 14-digit (HUC) watershed.

Soil: Soil types in the watershed were formed from compacted glacial till, predominately silt loams, silty clay loams, and clay loams. Erosion and over-saturation are major soil limitations.

Climate and Land Characteristics: The area receives approximately 39 inches of rainfall each year. The land is nearly level plains with an average slope of 3%, the maximum altitude above sea level is 360 meters. In the Matson Ditch study area 60.9% of the total land was devoted to crops, 88% to corn and soybean production with the remaining 12% in wheat, small grains, hay, and fallow cropland. According to the 2002 Census of Agriculture (NASS, 2002a), DeKalb County has 179,146 acres of land in farms, 85.4% is used for crops, 60.9% specifically for corn and soybean production. The average farm is size is 179 acres, down 3% from 1997

BMP Characteristics: BMP age, date of construction, size, and species composition. The average farm in the Matson Ditch area is less than 200 acres.

Three farm sizes were established based on norms of the Matson ditch watershed as described by farmers and farm service providers.

1) Small Farms cover 500 acres
2) Medium farms cover 1,000 acres
3) Large farms cover 2,500 acres.

Watershed Management details: Does the BMP require high operation and maintenance, as well as monitoring? How technical is construction, does it require an engineer to install or can a farmer do it?

A) For Reduced Tillage, the soil is disturbed prior to planting with chisels, field cultivators, disks, sweeps, or blades.

B) For No-Till, herbicides are the primary weed control practice in no-till systems.

In the Matson Ditch area a rolling harrow is typically used prior to planting to evenly distribute crop residue across the field with minimal soil disturbance.

No installation/construction of BMP involved.

How were the proposed efficiencies monitored? Type of equipment used, how often monitored, what tests were done (ex – if used EPA methods for testing for TN or some other organizations methods)

Method: Modeling

In this study average yearly sediment yields were calculated over a period of 30 years.

Cropland in the watershed was assumed to be split evenly between corn and soybean production to coincide with the economic model. Corn and soybean production accounted for 88% of cropland use in the watershed; the remaining 12% was dedicated to wheat, hay, small grains, and fallow lands.

The WEPP (Water Erosion Prediction Project) model predicted average yearly sediment yields (the amount of sediment that reaches water resources from the field) for no-till systems, conventional systems, and reduced tillage systems.

WEPP input parameters include rainfall amounts and intensity, soil textural qualities, plant growth parameters, residue decomposition parameters, effects of tillage implements on soil properties and residue amounts, slope shape, steepness and orientation, and soil erodibility.

Source of article (w/ full citation):
Master's Student Thesis: Cain, Zachary Thomas, M.S., Purdue University, May 2006. Examining the Economic and Environmental Impacts of Land Use Changes in the Matson Ditch Watershed. Major Professor: Stephen B. Lovejoy.

Appendix D. Meeting Minutes

Agricultural Nutrient and Sediment Reduction Workgroup
Maryland Department of Agriculture
Annapolis, Maryland
May 10, 2007

Conservation Tillage

- For this practice's efficiency, if it is possible to break out runoff and leaching in the model, then they recommend leaving TN runoff the same at 18% and assigning subsurface leaching an efficiency of zero. If surface and subsurface flow cannot be separated, then the recommended median land use conversion efficiency is 8% for TN.
- A change is not recommended in the efficiencies for TP and TSS.
- Workgroup recommendations:
    - Because Jack Meisinger was both the developer and the reviewer, it looks like this efficiency is based on just one person's opinion, when, in fact, there is a large set of supporting data to corroborate Meisinger's recommendation. It was suggested that UMD make this point in their final recommendation so that the reviewers understand the extent of data that back up this recommendation. The project team also will try to find additional sources of data from Josh McGraph's tillage study and the "Camacho table".

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Agricultural Nutrient and Sediment Reduction Workgroup
Conference Call
May 24, 2007
10:00 AM - 12:00 PM

Conservation Tillage

ACTION: Mark Dubin, UMD MAWP/CBPO, will continue to work with Tim Pilkowski, MD NRCS, and Elmer Dentler to ensure that conservation tillage definition is consistent with NRCS practice standard codes and propose revisions to UMD.

ACTION: Jeff Sweeney made a note that conservation tillage is not describe in the model as a pollutant efficiency reduction, but rather as a land use change. Sarah Weammert will revise their write-up to remove confusion caused by them mentioning that they are revising the 18% efficiency previously used in the model. For the calibration, each land use has a target range of what you would expect to come off the land. For conservation tillage, a value of 18% efficiency is used for the calibration. It is important to note that this efficiency isn't used in the simulation of the BMP performance. Sarah Weammert will revise the write-up to address the confusion.

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Herb Reed, UMD
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Kelly Shenk, EPA CBPO
Jeff Sweeney, UMD/CBPO
Kari Cohen, NRCS
Sarah Weammert, UMD
Peter Tarby, PA DEP
Tom Juengst, PA DEP
Becky Thur, CRC
Mark Dubin, UMD MAWP/CBPO - could not get on call due to technical difficulties with conference line.

Minutes: Nutrient Subcommittee Meeting
June 6, 2007
10:00 AM to 3:00 PM
Fish Shack—Chesapeake Bay Program Office

Conservation Tillage

- Conservation Tillage is categorized as a land use change, not as a BMP.
- The literature suggests a TN removal value of -10 to 10%. The reviewer and MAWP believe that if the model can separate conservation tillage into 2 categories—surface and subsurface flow—the efficiencies should be 18% TN removal for surface flow and 0% TN removal for subsurface flow. Otherwise, 8% TN removal was suggested for TN.
    - The AgNSRWG and TSWG agreed.
- The AgNSRWG suggested breaking this practice into 2 separate practices: conservation tillage and no-till.
    - The ability to do this will also be dependent on the ability to separately track and report conservation tillage and no-till.
- Russ Perkinson pointed out that TP and TSS probably should not be the same number.
    - ACTION: Tom will reexamine the TP and TSS numbers for conservation tillage.
- NEXT STEPS: The NSC and workgroups will work with NRSC in the future to determine if SCI and STIR values should be used to define Conservation Tillage rather than percent residue cover.
- NEXT STEPS: Conservation Tillage will go back to the AgNSRWG for another look before it's asked to be approved by the NSC.

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Meeting Minutes
Agricultural Nutrient and Sediment Reduction Workgroup
Adams County Agricultural and Natural Resource Center
Gettysburg, Pennsylvania
July 12th, 2007

V. Workgroup Recommendations:

The workgroup agreed on the following recommendations for the UMD and the CBP to address for the next Ag Workgroup conference call prior to the Tributary Strategy Workgroup meeting on August 6th regarding BMP definitions and efficiencies:

General Recommendation

1. Unless the scientific research indicates differently, as a general rule set phosphorus efficiencies 5% lower than sediment efficiencies to account for dissolved phosphorus losses not associated with soil losses.

Participants

Greg Albretcht	NYS SWCC CNMP
Bill Angstadt	DMAA
Renato Cuizon	MDA
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Becky Thur	CRC

Calling In

Tom Simpson	UMD

Agricultural Nutrient and Sediment Reduction Workgroup
Conference Call
August 2, 2007

- <u>Issue 3:</u> The workgroup recommended that phosphorus efficiencies be set 5% lower than sediment efficiencies as a general rule to account for dissolved phosphorus losses not associated with soil losses, unless the scientific research indicates differently.
    - UMD supports the recommendation that TP efficiencies be set lower than TSS efficiencies; however they suggest that the TP efficiencies be lowered by 10% rather than by 5%. They favor 10% because it implies that there is a

significant difference and because it does not indicate a greater level of precision than we have. However, they will defer to the workgroup regarding what percentage is used.
  - Some members voiced concern that subtracting 10% from TP will affect some BMPs more than others. For example, if the original efficiency is 40% and it is lowered to 30% than it is only reduced by 25%, whereas if the original efficiency is 20% and it is lowered to 10% than it will be reduced by 50%.
  - DECISION: In order to make the reductions more proportional, UMD and the workgroup agreed to reduce TP by 25%, rather than simply subtracting 10%. This was based on research findings which suggest that 25% of TP are attributable to Dissolved Reactive Phosphorus (DRP) according to the UMD.

- The workgroup decided to accept the UMD recommendations with the agreed upon adjustments for the agricultural practices. The only exception was for the cover crop practices which will require additional revisions prior to final review by the workgroup.

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Minutes: Tributary Strategy Workgroup
August 6, 2007
Chesapeake Bay Program Office—Fish Shack

Conservation Tillage Practices:

- The AgNSRWG recommended TP reductions reflect a 75% value of the TSS reductions due to dissolved reactive phosphorus losses.
- A rotational Soil Intensity Ratings (STIR) matrix will be developed tomorrow with NRCS. It will affect the BMP definition but not the efficiency. The language in the definition was reviewed and approved by NRCS across the region.
- DECISION: The TSWG accepted the AgNSRWG recommendations for Conservation Tillage Practices.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
August 15, 2007

- Efficiency recommendations for urban, forestry, wetland, and agricultural BMPs were reviewed and approved by the Nutrient Subcommittee with the exception of the off-stream watering practices and cover crop BMPs. These two BMPs will be reviewed on a joint NSC, TSWG, AgNSRWG, MAWP conference call scheduled for August 24, 2007.

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Emma Andrews, CRC
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Connie Musgrove, UMCES
Judy Okay, USFS

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Don VanHassent, FWG Chair
Jennifer Volk, DNREC
Sarah Weammert, UMD MAWP
Mary Lynn Wilhere, ACB

Chesapeake Bay Program
Water Quality Steering Committee
Conference Call
August 27, 2007

<u>Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies</u>

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

DECISION: The Water Quality Steering Committee approved the 12 BMP definitions and efficiencies, described in the advance briefing papers, as recommended by the Nutrient Subcommittee and its workgroups for use in Phase 5 Chesapeake Bay Watershed Model.

Conference Call Participants

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COVER CROP PRACTICES

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in the Phase 5.0 of the Chesapeake Bay Program Watershed Model

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Joel Blomquist
U.S. Geological Survey

Dr. Russ Brinsfield
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Synthesis by

Tom W. Simpson, PhD
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary

Cover Crops: Non-harvested winter cereal cover crops, including wheat, rye and barley, designed for nutrient removal.

Planting date	Cereal cover crop on conservation tillage (TP and TSS)	Cereal cover crop on conventional tillage		TN values based on planting date, species, location and seeding method
		TP	TSS	
Early	0%	15%	20%	See page 6 for table of values
Standard	0%	7%	10%	
Late	0%	0%	0%	

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

This document summarizes the recommended definition and nutrient and sediment reduction efficiencies for the Cereal Cover Crop practice. These recommendations were developed by a panel of soil and cover crop scientists and hydrologists convened specifically for this purpose. Effectiveness estimates assume timely planting and a good stand of the cereal grain. Attached to these definitions and effectiveness estimates is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix B.

Definition/Description

The pollutant reduction mechanisms of cover crops are (Dinnes, 2004):

- Improved stabilization of soil surface to impede wind and water erosion detachment and transport of nutrient enriched sediment and particulates
- Improved water infiltration and nutrient adsorption to soil matrix
- Increased crop growing season for greater utilization of available nutrients
- Reduced in-field volume of runoff water
- Reduced erosion and transport of nutrient enriched sediments and particulates
- Temporary nutrient sequestration in soil organic matter
- Trapping and retention of transported nutrient enriched sediments and particulates
- Vegetative assimilation

Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Components included in the Cover Crop Practices include, but may not be limited to the following USDA-NRCS conservation practice:

Cereal Cover Crops

This BMP refers to (non-harvested) cereal cover crops specifically designed for nutrient removal (Chesapeake Bay Program Nutrient Subcommittee Agricultural Nutrient Reduction Workgroup, 2004). This BMP is more prevalent in the lower Chesapeake Bay basin due to the longer growing season. The crops capable of nutrient removal include rye, wheat, barley, and to a much lesser extent, oats. There is no BMP reduction credit for legume cover crops such as clover and vetch that fix their own nitrogen from the atmosphere.

Significant amounts of nitrogen may remain in the soil after harvest of summer annual crops such as corn, soybeans, and vegetables. Nitrate nitrogen is particularly subject to leaching toward groundwater if substantial nitrogen remains in the soil as crop uptake of the summer annual crop ceases. Fall nitrate nitrogen levels in soils are more pronounced following years of less crop nutrient uptake due to drought conditions. The cereal cover crops trap nitrogen in their tissues as they grow, provided root growth is sufficient to reach the available soil nitrogen.

This BMP also provides some benefit for sediment erosion control, particularly when established after low residue crops. The BMP is less effective in reducing phosphorus than sediment losses since some phosphorous is transported in water soluble forms in addition to particulate forms. As corn does not sufficiently uptake nitrogen, cover crops are essential following moderate drought conditions. However, droughts may leave more nitrogen than the cover crop can trap. In years when rainfall has allowed excellent summer annual crop yields, cover crops are warranted because abundant soil nitrogen is available. Effectiveness is reduced when cover crops are established on very sandy soils where residual nitrate may have already migrated below the early rooting depth of a cover crop.

Small Grain Enhancement/Commodity Cover Crop

Commodity cereal cover crops differ from cereal cover crops in that they may be harvested for grain, hay or silage and may receive nutrient applications, but only on or after March 1 of the spring following their establishment. The intent of the practice is to modify normal small grain production practices by eliminating fall and winter fertilization so that the crops scavenge available soil nitrogen similarly to cover crops for part of their production cycle. This can encourage planting of more acreage of cereal grains by providing farmers with the flexibility of planting an inexpensive crop in the fall and delaying the decision to either kill or harvest the crop based on crop prices, silage needs, weather conditions, etc in the spring.

Although the panel discussed efficiencies for commodity cover crops/small grain enhancements, they do not yet have a clear enough understanding of how it is modeled to assign an efficiency. Since this practice has not been reported during the model calibration period, it is not necessary to complete the efficiency in time for the model calibration. The cover crop scientists and MAWP believe that through more discussions with the Chesapeake Bay Watershed modelers, they will be able to develop an efficiency before the model is used for management model runs.

Planting Date Categories

Original planting dates established by the CBP were refined and a new category added. Revised planting dates better reflect breakouts associated with jurisdictional cover crop programs. Early planting of a fall established cereal cover crop is critical in achieving substantial uptake of nitrogen in the fall. Research indicates that nitrogen uptake and trapping ability diminished rapidly when planting dates extend beyond optimum planting dates. To be eligible for level 1 reduction credit, referred to as early planting, the cover crop must be planted earlier than 14 days prior to the long-term published average date of the first killing frost in the fall. To be eligible for level 2 reduction credit, called standard planting, the cover crop must be planted 14 days prior to the average frost date up to the published long-term average date of the first killing frost in the fall.

There are benefits of planting cover crops later than the first frost that become evident in the spring. To capture this limited benefit a third planting date category, called late planting, that explores a cover crop BMP with a much discounted efficiency for planting from the first frost date and up to three weeks after is added. This BMP will provide a highly discounted efficiency to either late planted wheat or rye, based on that crops benefit during spring growth. This BMP would need to be incorporated with a no-till drill system to receive any reduction credit.

To illustrate the different planting dates, on the Eastern Shore of the average first frost date is October 15, thus, early planting occurs up to October 1, standard planting occurs from October 1 to October 15, and late planting occurs October 16 to November 5.

Planting dates were revised by the panel, and do not coincide with the original late and early planting dates used for reporting by the jurisdictions. Original planting dates were defined as up to seven days prior to published first frost date for early planted cover crops, and late planted cover crops were planted up to seven days after the published first frost date. Previous and future cover crop acres reported will need to be categorized into the new early, standard, and late planting dates.

Planting date timeframes are:
Level One Early: Anything prior to 2 weeks before average frost date
Level Two Standard: From 2 weeks prior to average frost date up to average frost date
Level Three Late: From average frost date plus 3 weeks

Efficiency recommendations

For TN and TP removal the effectiveness of cover crops depends on (Dinnes, 2004):

- Temperature either detrimental or beneficial for cover crop growth
- Inadequate or excessive precipitation that is detrimental to cover crop growth and impedes planting operations
- The degree of soil N removal by vegetative assimilation is dependent upon the type of plants species used
- Percentage of surface residue cover
- Crop rotation and previous primary crop
- Tillage program and associated degree and timing of soil disturbance
- Soil type
- Slope and slope length
- Antecedent soil moisture content just prior to rainfall events
- Rainfall and snowmelt duration and intensity
- Timing and rate of N fertilizer applications and succeeding rainfall event(s)
- Decomposition and mineralization of cover crop residue-N prior to established root system of subsequent primary crop may lead to increased N losses: though infrequent, is a risk with legume cover crops
- With good establishment of cover crop, adequate period (spring and/or fall) of warm temperatures, limited to no concentrated runoff flow, and limited to no concentrated runoff flow, Total Nitrogen (TN), ammonium-N, and nitrate-N removal can be substantial

<u>Total Nitrogen Effectiveness Estimate</u>

As the vast majority of nitrogen is transported via subsurface flow in agricultural systems, the surface flow reduction cover crops provide for nitrogen are not high. To capture this, the panel reviewed recent and established literature to estimate research scale subsurface nitrogen leaching efficiencies associated with cover crops. With the new recommendations from the cover crop panel the following categories are used to estimate nitrogen reductions from cover crops:
Cover Crop Type: Cereal Cover Crops
Planting Date: Early, Standard, Late
Seeding Technique: Drilled, Aerial, Other (e.g. surface broadcast or with stalk chopping or light disking)
Species: Rye, Wheat, Barley

A discussion of effectiveness estimate variations between planting dates and seeding techniques explains the revised total nitrogen effectiveness estimates (Table 1).

Table 1. New CBP Cover Crop Effectiveness Estimates

Total Nitrogen Estimates

Coastal Plain/Piedmont Crystalline/Karst Settings **Watershed scale = plot scale * .85 (subsurface edge of field) *.75 (landscape scale)**

Seeding method:	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn
Species:	Rye	Rye	Rye	Rye	Wheat	Wheat	Wheat	Wheat	Barley	Barley	Barley	Barley
Early planting	45	38	31	18	31	27	22	13	38	32	27	15
Normal planting	41	35	ne	ne	29	24	ne	Ne	29	24	Ne	ne
Late planting	19	16	ne	ne	13	11	ne	Ne	na	na	Ne	ne
Commodity SGE	*	na	ne	ne	*	na	ne	Ne	*	na	Ne	ne

Mesozoic Lowlands/Valley and Ridge Siliciclastic** **Watershed scale = plot scale * .65 (subsurface edge of field) *.75 (landscape scale)**

Seeding method:	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn
Species:	Rye	Rye	Rye	Rye	Wheat	Wheat	Wheat	Wheat	Barley	Barley	Barley	Barley
Early planting	34	29	24	14	24	20	17	10	29	25	20	12
Normal planting	31	27	ne	ne	22	18	ne	ne	22	19	ne	Ne
Late planting	15	12	ne	ne	10	9	ne	ne	na	na	ne	Ne
Commodity SGE	*	na	ne	ne	*	na	ne	ne	*	na	ne	Ne

na – not applicable

ne – Not eligible for credit. Aerial seeded grains require a significant rain event to germinate, and early aerial seeding is desirable because it increases the chance of experiencing significant rainfall prior to the end of the growing season.

* These effectiveness estimates will be finalized following further discussions between the cover crop scientists and modelers.

** Particulate nitrogen was not considered in developing the recommendation for the two settings.

The cover crop scientists and MAWP recommend analyzing particulate N in the future.

For the Mesozoic lowlands/valley and ridge siliciclastic settings the effects of cover crops on surface runoff N were not addressed.

Studying any impact that cover crops may have on surface runoff N losses is a topic for future research and discussion.

Table 2. Effectiveness Estimate Baseline for Early, Standard and Late Planting on Drilled Rye Conservation Tillage

To estimate effectiveness, baseline efficiencies for drilled rye on conservation tillage were determined, and then effectiveness estimates for the other cover crop categories were assigned. Based on the studies below, the average N effectiveness estimate for rye early planting was 70% and the average N effectiveness estimate for rye standard planting was 64%. Studies for late planting are discussed in the next section. The breakdown for early and standard planting is:

Cover Crop N Rec. Eff.	Cover Crop Species	Estimation Method	Experimental Scale/Unit	Brief Description of Study	Reference
Early Planting					
66%	Rye	Leached N	Lysimeters	Lysimeters were 20 in. diameter by 30 in. deep; grew tobacco with 200 lbs N per acre; covers established in mid-August after tobacco crop ; Connecticut well drained sandy loam soil; long-term study over 10 years.	Morgan et al., 1942
57%	Oats				
74%	Rye	Leached N	Lysimeters	Lysimeters were 22 n. diameter by 26 in. deep; grew unfertilized lespedesia then killed & plt. Covers, lespedesa residues produced 60 lb N /ac; planted covers in "early fall"; well drained Maury silt loam in Kentucky; long-term study over 11 years.	Karraker et al., 1950
70%	**Rye**	**Average of above**			
Standard Planting					
60%	Rye	Crop 15N Uptake	Research Plots	15N fertilizer to corn, fall residual 15N measured, cover crop 15N measured the next spring; calc % rec. of fall 15N including estimate of crop root N; done in MD Atl. Coastal Plain; moderately-well drained silt loam soil; two years of data	Shipley et al., 1991

65-75%	Rye	Rye N Uptake	Research Plots	Cover crop total N uptake as percentage of fall mineral N plus winter mineralization; high residual N from previous alfalfa residues and fert. N rates of 0-336 kg N/ha; VA Piedmont, well-drained silt loam, one year of data	Ditsch et al., 1992 Ditsch et al., 1993
67%	Rye	Ground Water Monitoring	Field Scale	Shallow groundwater monitoring wells and groundwater flow network, annual deep soil cores of vadose zone to water table, total N uptake of rye cover, MD Atl. Coastal Plain; well-drained loam soil; 6 years of data	Staver & Brinsfield, 2000
64%	Rye	Deep Soil Cores	Field Scale	Nitrate N in soil profile below root zone (60-240cm) below rye cover crop field vs. winter-fallow field, fields had cover vs no-cover for preceding 5 yrs, MD Atl. Coastal Plain; somewhat poorly-drained silt loam soil; 3 yrs of data	Staver & Brinsfield, 1995
60%	Rye	Rye N Uptake	Research Plots	Cover crop N uptake as percentage of fall mineral N plus winter mineralization; MD Atl. Coastal Plain; average of rye killed in mid-March and May 1; Moderately-well drained silt loam soil; one year of data	Clark et al., 2007
64%	**Rye**	**Average of above**			

Late Planting

Insufficient Data (i.e. no data)

How Baseline Was Used

The baseline efficiencies for drilled rye on conventional tillage are: 70% (early), 64% (standard), and 30% (late), (Table 2). Using these baseline efficiencies, effectiveness was calculated for the remaining cover crop categories. Multipliers to the baseline efficiencies reflective of that crops seeding technique, location, and a coefficient that represents operational effectiveness, were used to develop effectiveness estimates for all cover crop categories. The decision, justification, and data for these coefficients and final effectiveness estimates follow.

Late Planting Effectiveness

There is no fall benefit associated with late planted cover crops, instead the benefit occurs in the spring during cover crop growth when losses are high. This will reduce soil nitrate available for leaching.

Data displayed in Figures 1 (Hively, 2007) and 2 (Staver and Brinsfield, 1998) support a discounted efficiency for late planted cover crops. Hively's work evaluated the effects of cover crop implementation on nitrogen uptake in the Choptank and Chester River watersheds using farm program information, remote sensing, and on-farm research. The research concluded that this method can successfully estimate biomass production and nitrogen (N) uptake by cover crops in the real-world, real-time landscape and that species, planting date, and planting method significantly influenced fall biomass production.

Staver and Brinsfield investigated the effects of cereal grain winter cover crops on nitrate leaching rates, profile nitrate storage, and nitrate concentrations in shallow groundwater in two field-scale watersheds planted continuously in corn from 1984 through 1996. They found that cover crop growth reduced soil nitrate levels compared to winter-fallow areas, but this effect was greatly diminished when cover crop planting was delayed 30 days. Also, note that Figure 2 represents a crop planted on the last day of the late planting window, thus this is the lowest efficiency that would likely occur.

As Hively's (2007) data is from a very wet fall and Staver and Brinsfield (1998) data is from a very dry fall, it was suggested that the late planting efficiency number be determined by averaging a wet year, a dry year, and a good year: 16% (wet year, Hively 2007), 39% (dry year, Staver and Brinsfield 1998), 30% (good year, as estimated by Jack Meisinger). The average of these numbers is 28%. A decision was made to round this number to 30% because the dry year calculates for the end or two-thirds of the way through the planting period, thus the percentage could be higher before that.

Figure 1. Biomass calculated for all fields using satellite-derived Normalized Difference Vegetation Index (Hively, 2007)

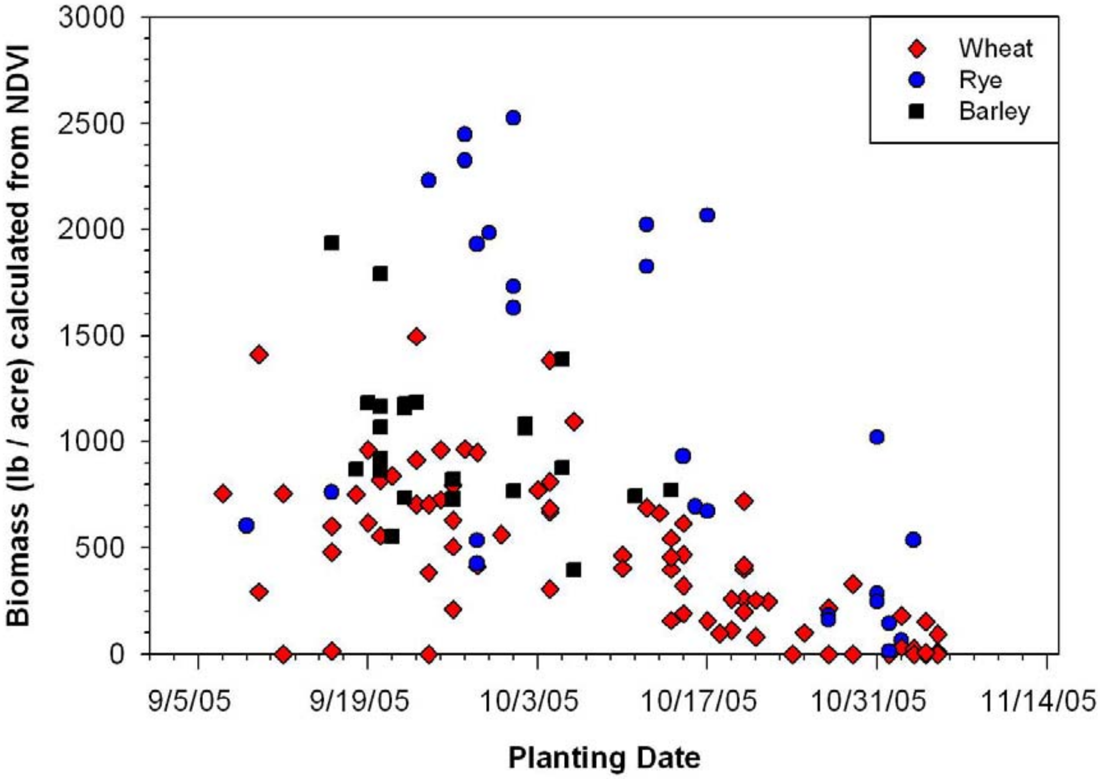
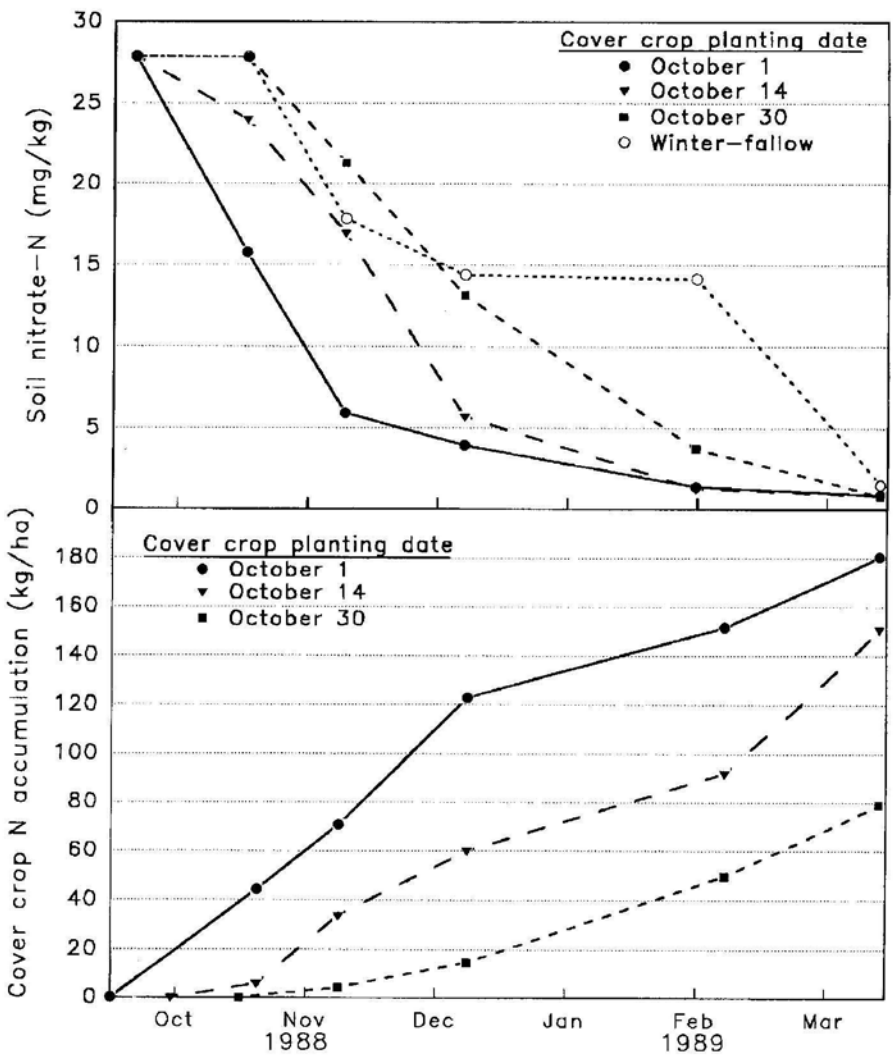


Figure 2. Nitrogen accumulation by a rye cover crop and changes in root zone (0 -30cm) nitrate as affected by cover crop planting date following 1988 corn harvest in a conventional tilled watershed (Staver and Brinsfield, 1998).



Reduction for Aerial Seeding

The cover crop scientists compiled data on aerial seeding and developed an approach that reduces the effectiveness of aerial seeded cover crops according to the species being seeded. Clear definitions for drilled, other, aerial seeding were provided:

Drilled – is planted with a seed drill, whether no-till or conventional till conditions

Other – includes any non-drilled seeding method where the seed is incorporated into the soil, e.g. broadcast and disked

Aerial – includes seeding by airplane as well as other broadcast seeding methods where the seed is not incorporated (including broadcast only, and broadcast / stalk chopped)

Aerial seeding can be quite successful under optimum weather conditions, but the chance of failure is high under sub-optimum (dry) weather conditions (Oplinger, 1994; Cooper, 1998; T. Kaspar, personal communication, September 2007; P. Porter, personal communication, September 2007) because aerial seeded grains require a significant rain event to germinate, unlike drilled grains, which can utilize soil moisture. Early-seeding is therefore desirable because it increases the chance of experiencing significant rainfall prior to the end of the growing season, (Jeffers and Beuerlein, 2001). Optimum practice is to seed immediately prior to rainy weather (P. Porter, personal communication, September 2007; Herbek and Murdock, 2004), or when moist soil conditions prevail (Herbek and Murdock, 2004).

Aerial seeding into soybeans is generally recommended, and is most successful if seeded during leaf-yellowing, prior to 10% leaf drop (OMAFRA staff, 2002; Center for Sustainable Agricultural Systems, 1998; P. Porter, personal communication, September 2007; T. Kaspar, personal communication, September 2007; Herbek and Murdock, 2004; Oplinger, 1994). This appears to result from a favorable (moist) microclimate under the soy canopy, followed by a light mulching of cover crop seed by falling soy leaves that increases seed-soil contact and protects from desiccation. Seeding after leaf-fall or in years with dry soil conditions results in poor performance. Seeding into soy at the proper time results in a good stand in 8 of 10 years (T. Kaspar, personal communication, September 2007).

Aerial seeding into corn is generally not recommended, because the drier microclimate under corn is unfavorable to establishment (Singer et al, 2005; T. Kaspar, personal communication, September 2007; P. Porter, personal communication, September 2007), because heavy corn residue can inhibit stand establishment (Jeffers and Beuerlein, 2001), and because seed is captured by the corn-leaf whorl. Aerial seeding into corn is heavily dependant on weather conditions (sufficient moisture following seeding) (T. Kaspar, personal communication, September 2007).

It is generally recommended that seeding rate be increased to compensate for reduced germination attributable to poor seed-soil contact. However, increased seeding rates do not compensate for effects of dry weather. Various advice is given on increasing seeding rates:

MDA - Increase by 25%

SARE - Increase by at least 30%

Mississippi - Increase by 75%

Kentucky - Increase by 40-50%

Wisconsin – no more than 15% based on field trials

Aerial seeding increases the risk of winter damage from frost-heaving and wind exposure, because the stem is weakly attached to the soil, root development is poor, and the crown is exposed (Oplinger, 1994; OMAFRA staff, 2002; Herbek and Murdock, 2004). This risk has been shown to decrease properly-timed aerial wheat seedings by 10% compared to drilled crops (OMAFRA staff, 2002)

If establishment is successful, aerially seeded cover crops perform well, due to their earlier seeding date, and can sometimes outperform cover crops that are drilled following row-crop harvest, (S. Conley, personal communication, September 2007; Herbek and Murdock, 2004; Oplinger, 1994), but if timing or weather are off, severe yield loss and/or complete failure should be expected (Herbek and Murdock, 2004; Oplinger, 1994). In a three-year study at Wooster, Ohio, yields of broadcast-seeded wheat were usually within 3 to 5 bu. per acre of the best drilled wheat as long as seeding rates were adequate (4bu/ac). At lower seeding rates (3 bu/ac) stands were only 70% the density and uniformity of drilled wheat. Yields of broadcast-seeded wheat were closely related to stand uniformity and density, with uniform, moderately dense stands yielding as well as drilled wheat (Jeffers and Beuerlein, 2001). Field trials in Wisconsin showed that aerial seeded wheat sowed prior to soy leaf drop outperformed both aerial seedings after leaf drop and drilled seedings after soy harvest (Oplinger, 1994).

Overall comparison of aerial seeding:

Benefits:

- Earlier planting dates (2-4 weeks earlier)
- Reduced labor and tractor time

Drawbacks:

- Highly weather dependant
- Higher seed cost and equipment fuel costs
- Patchy seed distribution if operators are not highly skilled
- Increased risk of disease due to earlier planting date
- Increased risk of winter damage to exposed crown

Seeding coefficients:

Early drilled rye = none

Early, standard and late other rye = .85

Early aerial soy/rye = .7

Early aerial corn/rye = .4

Early, standard and late drilled wheat = .7

Early, standard and late other wheat = .7

Early aerial soy/wheat = .7

Early aerial corn/wheat = .7

Early drilled barley = .85

Standard drilled barley = .7

Early other barley = .85

Standard other barley = .7

Early aerial soy/barley = .85

Early aerial corn/barley = .85

Species Breakouts

Rye is one of the easiest crops to grow. It has a wide range of adaptability due to its great winter hardiness and tolerance of different soil types (Johnny's Selected Seeds, 1983; Miller, 1984; Brinton, 1989; Bushuk, 1976) and marginal soils; outyielding other cereals on droughty, sandy, and infertile soils (Stoskopf, 1985). It can be grown in soils too poor to produce other grains or clover (McLeod, 1982), or too acidic for wheat (Evans and Scoles, 1976). Rye also has an extensive root system that enables it to be the most drought-tolerant cereal crops (Evans and Scoles, 1976).

The influence of both species type and seeding technique are accounted for in the calculations. For example, with the aerial seeding choices for either wheat or barley following corn, the 0.4 drilled rye coefficient is multiplied by the base value for drilled rye (70%), whereas the 0.7 for barley and wheat following soy is multiplied by the corresponding rye value. The multiplication of the additional factor of 0.7 for wheat and 0.85 for barley are a compensation for the species difference (rye outperforms wheat and barley) and has nothing to do with the aerial seeding as the aerial seeding is captured by the first coefficient calculation. Therefore aerial seeded wheat following soy is 0.7 * 0.7 = 0.49% as good as drilled rye, while aerial seeded wheat following corn is 0.7 * 0.4 = 0.28% as good as drilled rye. This is born out by the calculated figures (e.g., aerial wheat after corn equal to 19.6% = 0.7 * 0.4 * 70%; then the subsurface flow and landscape coefficient is applied).

Operational Effectiveness

The research-based estimates of cover crop efficiencies need to be adjusted to provide more realistic estimates of efficiencies for widespread adoption of this practice. Virtually all research data is generated under excellent management conditions; meaning that studies are done on better than average soils (poorly drained soils avoided, plots easily worked in a day), agronomic management is optimal (timely planting, excellent farm management, high germination seed, etc.), and other hazards (goose grazing, deer grazing, etc) are eliminated. Hence, the research estimates represent a best-case scenario. This optimistic scenario needs to be adjusted to lower effectiveness when the efficiencies are being applied to widespread field implementation under "average condition" across the Chesapeake Bay watershed.

Arriving at a value for translating the research data to widespread conditions, i.e. scaling-up, inevitably involves subjective judgment. This subjective judgment includes adjustment for non-optimal management (large acreages cannot all be managed optimally, farmers vary in management ability), soil spatial variability (trafficability, drainage), and weather variability (planting seasons with locally dry or wet conditions). The panel discussed these issues and arrived at a consensus that 75% of the literature values could be used for estimating the change in practice effectiveness under "average" implementation across the Chesapeake Bay watershed. There is little or no data to suggest that widespread implementation efficiencies are equal to those in the research literature, and several recent small watershed studies have indicated considerably lower reductions when groups of practices are applied. Thus, the panel proposed that research level efficiencies should be reduced by 25% to account for variability and loss in precision/control when going from research scale to widespread application. This still assumes that planting date and ground cover requirements are met.

Subsurface Flow Proportion

In the Chesapeake Bay Watershed, nitrogen flow pathways among the various hydrogeophysical regions are reasonably understood. The panel recommended 85% of TN would be transported via subsurface flow in the Coastal Plain, Piedmont Crystalline and Karst settings, while 65% of TN is transported via subsurface flow in the Mesozoic, Ridge and Valley, and Appalachian (See Appendix C for list of references).

The ratio of subsurface to surface flow nitrogen for the two recommended settings are:

Coastal plain/piedmont crystalline/Karst settings – 85/15

Mesozoic lowland/valley and ridge Siliciclastic – 65/35

Regional breakouts with corresponding subsurface and surface proportions as recommended by the panel are:

Coastal Plain Lowlands – 85/15

Coastal Plain Dissected Uplands -85/15

Coastal Plain Uplands -85/15

Piedmont Crystalline – 85/15

Blue Ridge – 65/35

Mesozoic Lowlands – 65/35

Piedmont Carbonate (karst)- 85/15

Valley and Ridge Carbonate (karst) -85/15

Valley and Ridge Siliciclastic – 65/35

Appalachian Plateau Siliciclastic -65/35

Barley as a cover crop

Data supports assigning a higher efficiency to barley than wheat for early planted crops (Hively, 2007). This is because barley is a more quickly maturing crop than wheat and has tendency to produce biomass at faster rate than wheat. For standard and late planting, however, no difference was observed between wheat and barley.

Corn as Silage

Where corn silage is harvested and cover crops are planted, that land should be considered to be under conventional tillage.

Final Calculation

The baseline calculation for drilled rye uses the baseline and multiples it by the subsurface flow proportion for the location and .75 to account for operational effectiveness. For the remaining rye calculations (other and aerial) and the drilled wheat and drilled barley calculations, the drilled rye baseline is multiplied against the individual species/corresponding seeding coefficient, and also multiplied by the subsurface flow proportion for the location and the scale coefficient. For each aerial or other wheat and barley calculation the base value is multiplied against the individual species/corresponding seeding coefficient, the seeding coefficient for the baseline species (drilled rye), the subsurface flow proportion for the location and also the scaling coefficient.

See Appendix D for a copy of the table with the individual cover crop coefficients. Calculations for each cover crop category are available as a spreadsheet at http://www.mawaterquality.org/bmp_reports.htm

Total phosphorous and total suspended sediment

The total phosphorous (TP) and total suspended sediment (TSS) reductions associated with cover crops are associated with surface flow and are recommended as:

Table 3. Surface and subsurface flow tp and tss effectiveness estimates

Planting date	Cereal cover crop on conservation tillage	Cereal cover crop on conventional tillage	
		TP	TSS
Early	0%	15%	20%
Standard	0%	7%	10%
Late	0%	0%	0%

The reduction in sediment bound phosphorous with conservation tillage is counterbalanced by the increased loss of soluble P from increased leaching. For this reason, cover crop practices on conservation tillage are assigned a zero percent reduction for TP and TSS. As cereal cover crops on conventional tillage will not increase leaching, and will not be fertilized in the spring, a reduction benefit is shown. This benefit decreases, however, as planting date is extended into the cold season. Since the adjustments made in 2003 to the cover crop efficiencies, no new data are available that warrant a change to the current efficiencies. For this reason reducing the current efficiencies by half between early and standard planting is a good estimate and no change is recommended to the existing efficiencies. It captures the reduction in erosion associated with establishing ground cover during various time periods. However, planting a cover crop beyond the standard planting date will result in the effectiveness being further reduced as the soil is tilled, consistent with the literature. The reduction with late planting is such that no benefit is observed and a zero percent reduction efficiency is assigned.

Future Research Needs

Jurisdictions should begin tracking acres of planted cover crops by species. To begin, evaluate species data used in the NRCS codes to determine if they support or recommend one species over another. This is a good indication of which species is planted more frequently.

There is also a need to better understand how aerial seeding and late planting dates alter effectiveness estimates. If cover crop reporting programs are performance based systems, then jurisdictions need to verify stand density. To be consistent with emerging research, this would also mean some years there would be minimal to no acres of aerial seeded cover crops reported as implemented.

It is recommended that continued research be done to show that this late planting effectiveness estimate is correct.

The kill by date in the spring needs to be determined and added to the cover crop definition.

Furthermore, the coefficients in the Mesozoic lowland/valley and ridge Siliciclastic category do not include any impact that cover crops may have on surface runoff nitrogen losses. The panel recommends that surface runoff nitrogen losses are analyzed in the future.

Finally, new species such as canola, radishes and mixes of small grains to break compaction should be evaluated and analyzed to determine if these species should be included for credit by the CBP.

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Appendix A: Changes Made Throughout the Practice Development Process

The following describes initial discussions between the Mid-Atlantic Regional Water Program, and a panel of scientists with expertise in cover crop Best Management Practices (BMP) on July 6, 2007. UMD/MAWP used the recommendations from the panel meeting, subsequent discussions with select panel members, along with professional judgment, to draft practice component and effectiveness estimations. A complete summary of the discussions on July 6, 2007 are included in Appendix B. While UMD/MAWP conceded to the efficiency calculation methods and categorical breakouts described previously, we think the initial recommendations provided by the panel at its first meeting need to be documented for future consideration since they differ significantly from their final recommendations. The following text highlights these first set of recommendations and discusses why changes were made.

Planting Date Timeframe

The panel originally recommended early planting be defined as greater than 7 days prior to the average frost date. Standard/late planting occurs 7 days prior, to 14 days after the average frost date. Efficiencies will be lower for the late planting dates as it drastically decreases past October, the time of the first frost date (Hively 2007; Staver and Brinsfield 1998; Figure 1 and 2). In addition there are benefits of late planting cover crops that become evident in the spring. To capture this the panel recommends adding a third category that explores a cover crop BMP, with a much discounted efficiency, for planting 14 days after the first frost, to around December 1 (when the ground becomes frozen). A late planted cover crop will provide a benefit, while highly discounted, based on that crop's growth during the spring.

The panel adjusted planting dates at a later meeting. The justification was based on the same data used to develop the original timeframes (Hively 2007; Brinsfield and Staver 1998).

Nutrient Efficiency Recommendations from July 6, 2007 Meeting

Subsurface Flow

The vast majority of nitrogen is transported via subsurface flow out of agriculture systems. To capture this, the panel reviewed recent and established literature to estimate research scale subsurface nitrogen leaching efficiencies associated with cover crops. The literature consulted includes:

Bowman, G., Shirley, C., and C. Cramer. 1998. Managing Cover Crop's Profitably Second Edition. Sustainable Agriculture Network. Beltsville, MD.

Clark, A.J., Meisinger, J.J., Decker, A.M., and F.R. Mulford. 2007 Effects of a Grass-Selective Herbicide in a Vetch-Rye Cover Crop System on Corn Grain Yield and Soil Moisture. Agro. J. 99:36-42.

Clark, A.J., Meisinger, J.J., Decker, A.M., and F.R. Mulford. 2007 Effects of a Grass-Selective Herbicide in a Vetch-Rye Cover Crop System on Nitrogen Management. Agro. J. 99:43-48.

Hively, W.D., Lang, M. McCarty, G. Sadeghi, A., McConnell, L., and J. Keppler. 2007. Remote Sensing of Cover Crop Nutrient Uptake Efficiency on Maryland's Eastern Shore. USDA-ARS Hydrology and Remote Sensing Laboratory, Maryland Department of Agriculture.

McCoy, J.L., Sigrist, M., and J. Rusko. No date given. Evaluating Agricultural BMPs in Maryland's Upper Pocomoke Watershed. Maryland Department of Natural Resources, Annapolis, MD.

Staver, K. and R. Brinsfield. 1998. Using Cereal Grain Winter Cover Crop to Reduce Groundwater Nitrate Contamination in the Mid-Atlantic Coastal Plain. Journal of Soil and Water Conservation 53:230-240.

During the first small group meeting to discuss effectiveness estimates TN reduction efficiencies associated with subsurface flow, as found in the aforementioned research, were assigned as follows based on original planting date timeframes:

	Cover crop rye	Cover crop wheat	Commodity wheat/barley
> 7 day (early)	65%	45%	25%
- 7 to +14 from First Frost date (standard)	50%	40%	20%
>14 day after (+ 14 day (late) until ground freezes up) 3rd category	10%	7%	4%

For conventional plow till, subtract 5% for all to account for mineralization of N due to tillage
For fly-on seeding, use 50% of all values
From cc rye to wheat, multiply by 0.8
From cc wheat to commodity wheat/barley, multiply by 0.5
From early to standard, multiply by 0.5
In the research numbers there is not enough difference between early and standard planting so the uptake should be cut in half.

As these loads represent research numbers, there are management conditions that alter the efficiencies. The panel felt there is no way to determine effectiveness at the watershed scale so they recommend using 75% of the literature values. This adjustment accounts for moving from more controlled settings of research plots to wide spread implementation. The resulting effectiveness estimates that reflect spatial and temporal variability with watershed-wide implementation are:

Planting date (compared to average frost date)	Cover crop rye	Cover crop wheat	Commodity wheat/barley
>7 day (early)	50%	35%	20%
-7 to +14 of (standard)	25%	20%	10%
+14 day (late)	8%	5%	3%

For conventional plow till subtract 5% for all to account for mineralization of N due to tillage.
For fly-on seeding use 50% of all values
From cc rye to wheat multiply by 0.8
From cc wheat to commodity wheat/barley multiply by 0.5
From early to standard multiply by 0.5, because the numbers in research data do not show enough of a difference between early and standard planting so the uptake should be cut in half

Surface flow

As the vast majority of nitrogen is transported via subsurface flow in agricultural systems, the surface flow reduction cover crops provide for nitrogen are not high. In the Chesapeake Bay Watershed, one can assume that 75% of TN is transported via subsurface flow in the Coastal Plain, while 60% of TN is transported via subsurface flow in the Piedmont, Ridge and Valley, and Appalachian (Bachman et al, 1998; Lindsey et al., 2003; Phillips et al., 1999). In addition under the best conditions the surface runoff reduction efficiency of TN is equal to surface runoff reduction efficiency of TP. UMD/MAWP recommends taking the weighted average of the two flow paths to determine TN removal broken out for non-coastal and coastal regions.

Nitrogen Reductions from Surface Flow

Planting date	Cereal cover crop on conservation tillage	Commodity on conservation tillage	Commodity on conventional tillage	Cereal cover crop on conventional tillage
Early	0%	0%	0%	15%
Standard	0%	0%	0%	7%
Late	0%	0%	0%	0%

Total Nitrogen Efficiency Recommendation

Using the assumption that on average across the Chesapeake Bay watershed 70% of nitrogen is transported via subsurface flow, and 30% is transported via surface flow total nitrogen reduction efficiencies can be calculated.

{[(subsurface nitrogen runoff reduction efficiency *0.70) + (surface nitrogen runoff reduction efficiency *0.30)] = Total Nitrogen Reduction Efficiency

Calculations for Total Nitrogen Reduction Efficiencies

Tillage:	Conventional	Conservation	Conventional	Conservation	Conventional	Conservation	Conventional	Conservation
Seeding Method:	Drilled/Other	Drilled/Other	Aerial	Aerial	Drilled/Other	Drilled/Other	Aerial	Aerial
Species:	Rye	Rye	Rye	Rye	Wheat/Barley	Wheat/Barley	Wheat/Barley	Wheat/Barley
Cereal Cover Crop Early Planting Date	40	35	20	12	26	25	13	12
Cereal Cover Crop Standard Planting Date	20	18	10	9	13	14	7	7
Cereal Cover Crop Late Planting Date	6	6	3	3	4	4	2	2
Commodity Early Planting Date	na	na	na	na	11	14	5	7
Commodity Standard Planting Date	na	na	na	na	4	7	2	3
Commodity Late Planting Date	na	na	na	na	2	2	1	1

Select members of the panel felt the spring benefit of late planted cover crops was not captured by the original efficiencies and higher efficiencies were later assigned. When the early to standard timeframe was changed the panel also adjusted efficiencies to reflect higher effectiveness. Even though the same data sets, and scientists conducting the research, were used to develop original efficiency estimates in July, new baselines were assigned in September. In the authors' opinion these higher efficiency values, coupled with an extended time frame for each planting date, results in efficiencies not reflective of actual effectiveness. These estimates are closer to reality compared to current efficiencies, but are optimistic. UMD/MAWP recommends revising the TN effectiveness estimates as more data becomes available.

Aerial Seeding Reduction
During the July panel meeting, using data (Hively 2007), observations, experience and best professional judgment, the panel recommended reducing effectiveness for fly-on seeding applications by 50%. This recommendation is based on a number of factors that combine to reduce nutrient uptake as aerial seeding results in a more difficult environment for germination and establishment. As discussed in the report above, when data became available the recommendation was refined to be science-based.

Barley Efficiency
Barley was originally assumed to be as effective as wheat. Upon further investigation (Hively 2007) the panel decided to assign efficiencies for barley that are higher than those assigned to wheat.

Original Commodity Cover Crop TP and TSS Effectiveness Estimates
Initial panel recommendations for TP and TSS reductions associated with commodity cover crops on conventional tillage were zero percent. This effectiveness estimate reflects the sediment and nutrient runoff associated with spring fertilizing that occurs on commodity cover crops.

Appendix B: Meeting Minutes

Cover Crop Panel Meeting
July 6, 2007
Introduction of attendees

Overview of Project
The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) will develop science-based draft definitions and efficiencies for new and innovative Best

Management Practices (BMPs) and evaluate efficiencies for selected existing practices. This will allow these practices to be incorporated into the Phase V of The Chesapeake Bay Watershed Model (WSM) for calibration and subsequent progress runs of Tributary Strategies. UMD will work with EPA and the Subcommittees and Workgroups of the Bay Program to modify and gain approval of proposed practice definitions and efficiencies using established Bay Program protocols. We will use the nearly 40 scientists involved in the MAWP and other scientists as needed, to lead development of definitions and efficiencies within their areas of expertise. This will assure the best available expertise for a specific BMP will be used to draft or refine each BMP definition and efficiency. For BMPs where a lead scientist is not identified UMD project staff will develop draft practice definitions and efficiencies. Project staff will use scientific literature searches, interviews and surveys, and demonstration sites and field tours to draft practice definitions and efficiencies.

When draft definitions and efficiencies are complete, scientists selected by the Chesapeake Bay Program's Scientific and Technical Assistance Committee (STAC) will review the definitions and efficiencies for the appropriateness of the proposed definitions and efficiencies, whether or not the efficiency is adequately conservative, credibility and applicability of referenced literature in the Chesapeake Bay watershed, specific concerns not addressed in the definition or efficiency that should be the focus of future research, and any other items not addressed. Following the STAC review the Chesapeake Bay Program's Tributary Strategy Workgroup and the appropriate source area workgroup will review the definitions and efficiencies and applicability to the WSM. They will also evaluate the relative effectiveness of different BMPs within each source area and between source areas. After TSWG review, UMD will provide the relative ranking of the BMP efficiencies to a STAC task group and charge them to ensure proposed efficiencies are consistent across sectors and are appropriately ranked.

After approval, all practice definitions will be compiled in a final report and submitted to the jurisdictions, CBPO, TMDL and watershed planning managers and EPA-Region III, USDA-NRCS, STAC and other interested parties. A one-day forum will be held to present the final definitions and efficiencies and discuss future directions and needs.

Objective of meeting

To determine efficiencies and definitions for the cover crop BMPs (cereal cover crop early planting, cereal cover crop late planting, commodity cover crop early planting, and commodity cover crop late planting) UMD contracted with Limnotech Inc. to run the Annualized Agricultural Nonpoint Source Pollution (AnnAGNPS) Model. The outputs, however, are not scientifically accurate because they show a 1% effectiveness for TN and TP. Limnotech Inc., could not determine why the output efficiencies were so low and UMD decided to convene this panel to evaluate literature values in order to estimate cover crop efficiencies. The efficiencies are to be represent average effectiveness with wide spread implementation. We are considering the average farmer across all soils and hydrologic regimes, along with broad implementation and spatial variability

Issues

To begin discussions the panel examined the current efficiencies and how cover crop BMPs are categorized. The first observation addressed the categories used to represent cover crop BMPs. The group stated that assigning one efficiency across the region is not ideal, while recognizing the load to the edge of segment is combined with the individual hydrology, soils and upland land uses of that segment, determine edge of stream loads. . Five categorical recommendations followed:

- Break out by physiographic province; coastal plain vs piedmont vs ridge and valley vs glaciated uplands.
- Use the first frost date to break out efficiencies.
- Use planting date.
- Break out by species.
- Or break out by climatic regime

RECOMMENDATION: Break BMP by frost date as it will capture regional differences and is trackable, because first frost dates are published.

RECOMMENDATION: Clarify the timeframe for the two planting dates as, greater than 7 days prior to the average frost date is early planting. Standard/late planting occurs 7 days prior, to 14 days after the average frost date. Efficiencies will be lower for the late planting dates as it drastically decreases past October (Hively remote sensing data presented to NSC 2007 and Brinsfield and Staver 1998 data). Some states already report cover crop implementation this way, while others use a planting timeframe between November 1-15 to determine late or early when reporting.

RECOMMENDATION: There are benefits of late planting cover crops that become evident in the spring. To capture this the panel recommends adding a third category that explores a cover crop BMP, with a much discounted efficiency, for planting 14 days after the first frost, to around December 1 (when the ground becomes frozen). A late planted cover crop will provide a benefit, while highly discounted, based on that crop's growth during the spring. This BMP would be a no-till drill system. Furthermore, the panel recommends evaluating this third planting date category in year two for a more accurate efficiency estimate. Late planting efficiencies need a kill by date established in its definition. To begin, split out how much of the efficiency is due to spring uptake (mid-march to Mid-April) and determine how that alters the efficiency. Late planted commodity cover crops would not receive credit, because once you fertilize in the spring the plant is no longer a cover crop.

Next the panel reviewed the current efficiencies and discussed places where they thought the current values deviate from scientific values and watershed-wide implementation. To estimate efficiencies, the panel stated one would need to know the amount of available nitrate. A possibility would be to look at yield at the first of August and create a sliding scale of payments that matches to the need. This is not currently possible so we could look across all years and determine the average impact.

Note: Land use (conservation and conventional) references the previous crop not the current

RECOMMENDATION: Should fall conventional tillage effectiveness be discounted? Depends on how this is modeled to get credit for land use change and BMP. A 5% reduction is recommended because of the loss of organic matter and the addition of N to system, unless accounted for in the model.

Research-scale cover crop N efficiency (What the crop will take up, subsurface flow, edge of field):

	Cover crop rye	Cover crop wheat	Commodity wheat/barley
> 7 day (early)	**65%**	**45%**	**25%**
- 7 to +14 from First Frost date (standard)	**50%**	**40%**	**20%**
>14 day after (+ 14 day (late) until ground freezes up) 3rd category	**10%**	**7%**	**4%**

For conventional plow till, subtract 5% for all to account for mineralization of N due to tillage
For fly-on seeding, use 50% of all values
From cc rye to wheat, multiply by 0.8
From cc wheat to commodity wheat/barley, multiply by 0.5
From early to standard, multiply by 0.5
In the research numbers there is not enough difference between early and standard planting so the uptake should be cut in half. Thus standard becomes 33% for cover crop rye, 26% for cover crop wheat and 13% for commodity wheat/barley.

Use root / vegetation ratio for surface flow
To be used in the CBP watershed model these numbers need to be translated to represent edge of field surface and subsurface flow. If the new load reduction is higher than current efficiencies the panel decided to reconvene and discuss why not seeing these high efficiencies operationally.

RECOMMENDATION: As these loads represent research numbers, are there management conditions that alter the efficiencies? The panel felt there is no way to determine effectiveness at the watershed scale so they recommend using 75% of the literature values. This adjustment accounts for moving from more controlled settings of research plots to wide spread implementation.

What numbers mean: research results showed x% of N could be taken up by the plant . In real world implementation (reference is Dean's sites), only 75% of what was expected was trapped in roots or leaves.

RECOMMEND: The current model is not process- based and CBP should use another model that is process-based or use a suite of models.

Early rye has a high efficiency, supported in literature referenced below; that is why rye to wheat is multiplied by 0.7

How will the watershed model simulate cover crop BMPs? This can be explored by putting values in Vortex and change efficiencies to represent different cover crops.

Phosphorous
The current efficiencies of 15% for early planting and 7 % for standard planting of cereal cover crops on conventional tillage is based on the erosion control aspects associated with the ground cover during that period planting period. If a farmer waited and planted at a later date there would be reduced effectiveness.

RECOMMENDATION: Zero effectiveness should be assigned to conservation tillage for cereal, commodity conventional and commodity conservation for all subcategories based on planting date. Cereal cover crop on conventional tillage will have a benefit for early and standard plantings but not with late planting. To reflect this, the panel recommends keeping the current TP and TSS efficiencies for early and standard planting and assigning a zero percent efficiency for late planting.

Should TP and TSS remain at zero for cover crops on conservation tillage for both early and standard planting?

Yes, because research (refs below) does not show a phosphorous or sediment reduction benefit associated with these two practices.

Is commodity cereal cover crop on conventional tillage zero currently? If conventionally tilled with either commodity or cereal cover crops produce a benefit?
The definition needs to state that for commodity no fertilizer is applied.

RECOMMENDATION: Leave current efficiency of zero, as the farmer works the soil with conventional tillage

Load reduction for TP and TSS panel recommended (no change from 2003 adjustments):

Planting date	Cereal cover crop on conservation tillage	Commodity on conservation tillage	Commodity on conventional tillage	Cereal cover crop on conventional tillage	
				TP	TSS
Early	0%	0%	0%	15%	20%
Standard	0%	0%	0%	7%	10%
Late	0%	0%	0%	0%	0%

Studies used as references:

Bowman, G., Shirley, C., and C. Cramer. 1998. Managing Cover Crop's Profitably Second Edition. Sustainable Agriculture Network. Beltsville, MD.

Clark, A.J., Meisinger, J.J., Decker, A.M., and F.R. Mulford. 2007 Effects of a Grass-Selective Herbicide in a Vetch-Rye Cover Crop System on Corn Grain Yield and Soil Moisture. Agro. J. 99:36-42.

Clark, A.J., Meisinger, J.J., Decker, A.M., and F.R. Mulford. 2007 Effects of a Grass-Selective Herbicide in a Vetch-Rye Cover Crop System on Nitrogen Management. Agro. J. 99:43-48.

Hively, W.D., Lang, M. McCarty, G. Sadeghi, A., McConnell, L., and J. Keppler. Remote Sensing of Cover Crop Nutrient Uptake Efficiency on Maryland's Eastern Shore. USDA-ARS Hydrology and Remote Sensing Laboratory, Maryland Department of Agriculture.

McCoy, J.L., Sigrist, M., and J. Rusko. No date given. Evaluating Agricultural BMPs in Maryland's Upper Pocomoke Watershed. Maryland Department of Natural Resources, Annapolis, MD.

Staver, K. and R. Brinsfield. 1998. Using Cereal Grain Winter Cover Crop to Reduce Groundwater Nitrate Contamination in the Mid-Atlantic Coastal Plain. Journal of Soil and Water Conservation 53:230-240.

Attendees:

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Meeting Minutes
Agricultural Nutrient and Sediment Reduction Workgroup
Adams County Agricultural and Natural Resource Center
Gettysburg, Pennsylvania
July 12th, 2007

- Beth Horsey inquired about the ability of states to track species of cover crops and if that was taken into account. States indicated that they do not currently track rye versus wheat cover crops. However, UMD recommended higher efficiencies for rye cover crops. In the absence of species specific data, Tom proposed that there could be a weighted average based on states knowledge of the percentage of cropland under rye versus wheat. If data does not exist, averages will have to be relied upon.
- Beth commented that while MD tracks planting dates of cover crops, they do not track species planted and would have capacity limitations for collecting this information. Tom suggested the CBP must resolve this issue and devise a means to weigh averages, perhaps assuming equal percentages for crops.
- Kelly Shenk interjected that the issue of cover crop implementation reporting based on species goes beyond the scope of Tom's project and that it was this workgroup's responsibility to find solutions to this issue. She indicated that the information UMD provided that shows that the cover crop efficiencies for rye are

significantly higher than wheat is very informative to states in how they refine their programs in the future. Beth mentioned that Maryland's cost share/funding is one of the best in the watershed. If they have limitations tracking this data, others surely will too. Russ Perkison felt Virginia was capable of tracking by species.

V. Workgroup Recommendations:

The workgroup agreed on the following recommendations for the UMD and the CBP to address for the next Ag Workgroup conference call prior to the Tributary Strategy Workgroup meeting on August 6th regarding BMP definitions and efficiencies:

Cover Crops:

1. No comment. Ag WG will comment once it receives final recommendation from UMD.

Participants

Greg Albretcht	NYS SWCC CNMP
Bill Angstadt	DMAA
Renato Cuizon	MDA
Mark Dubin	UMD-MARWP
Suzie Friedman	Environmental Defense
Beth Horsey	MDA
Peter Homyak	USC
Tom Juengst	PA DEP
Russ Perkinson	VA DCR
Tim Pilkowski	NRCS
Bill Rohrer	DNMC
Kevin Schabow	CRC-CBPO
Jennifer Shaafsma	MDA
Kelly Shenk	EPA-CBPO
Becky Thur	CRC

Calling In

Tom Simpson	UMD

Agricultural Nutrient and Sediment Reduction Workgroup
Conference Call
August 2, 2007

- Issue 4: In regards to cover crops, one workgroup concern is that the numbers in the table are just addressing ground water sources and they think that there needs to be some accounting for surface water.
  - UMD said that cover crops are no more effective at removing TN than TP. The TP numbers that are in the table are for surface and subsurface with the assumption that there is only a minimal subsurface component.

- They do not think that they can justify making the TN numbers any higher than the TP numbers for surface water.
- Although it does vary some across the region, overall about 75% of nitrogen tends to move through groundwater subsurface paths.
- UMD thinks that the most appropriate way to address this may be to contribute 75% of the subsurface TN reductions in the table; apply a 25% multiplier to the surface TP efficiencies, and then add the two values together so that you obtain a weighted average of surface and subsurface flow. Jack Meisinger agreed that this is a good way to go. UMD sent this idea to Ken Staver, but they have not heard back from him yet.
- In the current report, no distinction is made between soil association properties. The workgroup is concerned about this because there do tend to be differences between regional soil groups. Because of this, UMD will look into dividing the watershed up into three or four regions. Potential regional soil groupings are: 1) the coastal plain and karst soils at 80%; 2) the piedmont soils at 70%; and 3) glaciated and shale soils at 60%. Tom will email the workgroup the actual recommendations for the divided regions after he verifies whether or not the proposed groupings and percentages are correct.
- Q: Is this number a recharge number or a pollution number? We need to recognize that gully washers contribute to a significant amount of nutrient runoff.
  - A: They are basing it on a 1996 review that split out relative amounts of nitrogen transport by pathways. It looked at how nitrogen was being routed and not how water was being routed.
- Nitrogen and phosphorus have different sources of transport pathways.
- UMD is proposing that the table on page 4 of the cover crop recommendation document be used to deal with the subsurface component, and then a weighted average be done for surface loss.
- UMD will look back at the study that looked at this to see how they portioned out the subsurface vs. the surface pathways for various regions and to see how they looked at nitrogen transport compared to water transport. UMD will try to report their findings to the workgroup quickly.
- UMD agreed to add in citation information above the tables on pages 3 and 4.

- Issue 5: Today, the workgroup expressed concern over the variation in efficiency values for the different methods of cover crop seeding.
  - In the UMD recommendations, it says that for fly-on seeding, 50% of all efficiency values should be used (see page 4).
  - In MD, payments are only given for cover crops that have at least 80% vegetative cover. Therefore, since good coverage is required, the efficiencies should not vary based on whether or not it was flown over or drilled.
  - UMD said that their cover crop group had data that they felt showed that there tended to be less uptake with fly-on compared to drilling. Fly-on may be more variable because it is more dependent on good conditions.
  - Regarding the efficiencies on page 3 for late planting (2 weeks or more after the first frost), UMD explained that these were included because the cover crop group decided that some cover crops were better than no cover crops,

even though the literature showed that you were going to get limited growth and nutrient uptake.

  - The workgroup agreed that they were okay with the late planting numbers.
  - MD had concerns about basing the efficiencies on species of cover crops and their inability to track them at the present time. They would like to see some discussion in the results to indicate the discussion that the workgroup had at the July AgNSRWG meeting that looked at adjusting averages where species tracking is not available. Basically, this would reduce the defensibility of the watershed model's predictions.
  - Other workgroup recommendations for cover crops:
    - Provide an explanation in the paper as to why aerial seeding has lower efficiency values than drilling and cite the references.
    - Explain why they recommended using 75% of the literature values (above table on page 4).
    - Include more information on why late planting was included.
    - Have an 80% stand as a benchmark for efficiencies across all categories (drilling and fly-on). If fly-ons meet this stand percentage, then they could use this reduction. If they do not meet this, then they would need to use the other fly-on efficiency currently listed in the report, which is a 50% reduction. There would need to be documentation that there is an 80% ground cover by early December. Aerial seeding would be removed from the table. (UMD stipulation-Somewhere in the report it should say that getting consistent stands with aerial seeding is difficult and that aerial seeding can have very low uptake.)
  - UMD agreed to make the first three revisions. They are also okay with the fourth revision and will run it by the cover crop group.
  - DECISION: The workgroup will see what changes UMD makes to the cover crop report before they give their final recommendation for this practice.

- MD questioned why the majority of cover crop categories did not include TP and TSS efficiencies. The cover crop group did consider this question; however they decided to leave the efficiencies as they were. Mark will run this issue by Tom and Sarah since they are no longer on the call. This is an important message to bring up as a workgroup.
- As a general suggestion, the workgroup recommended that UMD continue to think about how we connect the reduction to the load. The efficiencies need to be relevant to the loads.
- The workgroup decided to accept the UMD recommendations with the agreed upon adjustments for the agricultural practices. The only exception was for the cover crop practices which will require additional revisions prior to final review by the workgroup.

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Minutes: Tributary Strategy Workgroup
August 6, 2007
Chesapeake Bay Program Office—Fish Shack

- ACTION: MARWP will explain the efficiency differences between planting techniques in the Cover Crops BMP report.
- ACTION: Before the NSC meeting, MARWP will provide the recommended (two or three) geographic regions to be used for Cover Crops and their respective efficiencies.
- ACTION: MARWP will document that in regard to Cover Crops, the issue of P reduction efficiencies in for surface flow conditions was addressed by the panel.
- ACTION: MARWP will more thoroughly document references used for the development of the Cover Crops BMP.
- DECISION: The TSWG has approved all of the AgNSRWG recommendations, with the exception of Cover Crops which is dependent upon further refinement and information.
    - ACTION: After MARWP consults with the Cover Crop panel, they will provide the requested information to the AgNSRWG who will then make their decisions and pass the information along to the TSWG for review and approval.

Cover Crop Practices:

- There were some modeling issues with developing Cover Crop Practices efficiencies, so a scientific review panel reviewed the practices.
- The panel had experience with highly variable cover and nutrient uptake with aerial seeding. They recommended that the efficiencies of aerial seeding of cover crops be reduced by half or that certification is provided showing that the 80% efficiency is achieved.
    - ACTION: MARWP will explain the efficiency differences between planting techniques in the Cover Crops BMP report.
- If cover crops are not separated out by species, it is recommended that either a weighted average of the percentage of crops be used or a default wheat efficiency to maintain conservatism unless a higher efficiency is demonstrated.

  - If programs are not able to track the data now, this stance will support the differentiated tracking and reporting in the future.
  - State NRCS standards do not break out by species in their data. Mark will look further into this.
- MARWP agrees with the AgNSRWG's recommendation to break out efficiencies by geographic region.
  - ACTION: Before the NSC meeting, MARWP will provide the recommended (two or three) geographic regions and their respective efficiencies.
- MARWP agrees with the AgNSRWG's recommendation to incorporate references into the recommendation document.
- MARWP agrees with number 5, 6
- MARWP has contacted Jack Meisinger, who suggested the 75% factor, for an explanation of why it was used for research versus field implementation efficiencies.
- In regard to the AgNSRWG's recommendation to reconsider the reduction efficiencies for surface flow conditions, the panel did not believe the P numbers needed to be changed.
  - ACTION: MARWP will document that the issue of P reduction efficiencies for surface flow conditions was addressed by the panel.
- ACTION: MARWP will more thoroughly document references used for the development of the Cover Crops BMP.
- DECISION: The TSWG has approved all of the AgNSRWG recommendations, with the exception of Cover Crops which is dependent upon further refinement and information.
  - ACTION: After MARWP consults with the Cover Crop panel, they will provide the requested information to the AgNSRWG who will then make their decisions and pass the information along to the TSWG for review and approval.
  - The Forestry and Wetlands BMPs will be reviewed later in the meeting.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
August 15, 2007

- Efficiency recommendations for urban, forestry, wetland, and agricultural BMPs were reviewed and approved by the Nutrient Subcommittee with the exception of the off-stream watering practices and cover crop BMPs. These two BMPs will be reviewed on a joint NSC, TSWG, AgNSRWG, MAWP conference call scheduled for August 24, 2007.

Agricultural BMPs **Kelly Shenk**

- The BMP efficiency for cover crops is still being developed but it is anticipated that a recommended efficiency will be made available to the TSWG and NSC by Friday for discussion via email or conference call.
  - A conference call will be scheduled for 8/23 or 8/24 to wrap-up the off-stream fencing and cover crop BMP efficiencies and to discuss consistency of the BMPs across sectors.

AgNSRWG, TSWG, and NSC Conference Call
August 24, 2007

- The AgNSRWG, the TSWG, and the NSC were given three options to choose from regarding the BMP efficiency for cover crops:
  - Option 1: Go forward with the final MAWP cover crop efficiency recommendation (dated August 27, 2007).
  - Option 2: Go forward with the cover crop panel original recommendation (presented at the July 12 AgNSRWG meeting).
  - Option 3: Keep the current efficiencies.
- The handout lists some of the pros and cons for each option.
- If the AgNSRWG, the TSWG, and the NSC cannot come to agreement on an option, then the Water Quality Steering Committee will be asked to make a decision at its August 27th conference call.
- Comments on Option 1:
  - This option, which was developed by MAWP in consultation with the cover crop panel, addresses a number of the issues brought up by the AgNSRWG. Although the cover crop panel was involved in crafting this option, this option does not have formal support from the full cover crop panel.

- This option has a surface and subsurface flow component (the original table from the cover crop panel lacked a surface flow component).

- Comments on Option 2:
  - This option looks only at the subsurface flow component and not the surface flow component.
  - Russ Perkinson, who was a member of the cover crop panel, objects with the statement that option 2 has the full support of the cover crop panel. He says that he never saw the final outcome from the panel session. He suggested that the panel be engaged again to review the final outcome. MAWP said that the table in the Option 2 handout and the session summary were sent to the entire cover crop panel one week after the July cover crop meeting.
  - Having the full agreement of the cover crop panel was never agreed on as part of this process. MAWP consulted the panel for advice.
- MDA is concerned about some of the proposed changes in Option 1 and Option 2. They feel that there is not enough scientific information to merit these changes and that more studies are needed in different hydrological years. MAWP said that when developing this efficiency they used the data that had accumulated over the past 12 years since 1994 and they consulted with a cover crop panel consisting of various soil and crop scientists.
- MDA proposed that we revisit this efficiency later when there is more information, potentially moving it to year 2 of the MAWP BMP project. CBP said that we don't have the option of delaying efficiencies for this BMP until year 2 because the Water Quality Steering Committee has requested the efficiencies for the most important BMPs in time for calibration this year.
- Each state agency was asked to vote for which option they were willing to support:
  - PA DEP: Option 1 or Option 2
  - VA DCR: Option 3
  - MDA: Option 3
  - DE DNREC: Option 3
  - WV DEP: Option 3
- DECISION: There is not consensus among the states, so this issue will be brought before the Water Quality Steering Committee on August 27th and they will be asked to make the final decision.
- It was suggested that we consider giving extra credit (a better efficiency than that in either option 1 or 2) to fields that are "above average" and have been certified on a field by field basis to have a higher stand. If this were done, some sort of standard would need to be set. In addition, the fields would need documentation to show that their stand percentage is above average.
- The makeup of the cover crop panel may need to be revisited if the Water Quality Steering Committee says that we can have more time on this efficiency.

Participants

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Chesapeake Bay Program
Water Quality Steering Committee
Conference Call
August 27, 2007

SUMMARY OF DECISIONS, ACTIONS AND ISSUES

<u>Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies</u>

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

Review of Cover Crops BMP

Kelly Shenk (EPA/CBPO) walked the Steering Committee through the three options for cover crop BMP efficiencies that were presented to them. These three options were presented to the AgNSRWG, the TSWG, and the NSC during the August 24, 2007 conference call, but the Nutrient Subcommittee did not reach full consensus on any of the options. The Steering Committee was asked to decide on the best option (see attached option paper for list of options and their pros and cons).

Option 2: Option 2 was taken off the table during the Steering Committee conference call because several cover crop panel members informed the Chesapeake Bay Program that it did not represent full consensus from the cover crop panel's July 6^{th} meeting.

Several AgNSRWG members wanted to give more time to the cover crop panel to evaluate the MAWP cover crop recommendation. However, due to the model calibration schedule deadlines set up by the WQSC, extending the timeframe without the WQSC's approval was not an option. Therefore, several partners voted for keeping the efficiencies the same rather than approving the MAWP final recommendation.

Cover Crop BMP Discussion

- The MAWP and the cover crop panel recommended separate efficiencies for species and planting date; however, not every state will be able to report down to this level of specificity. This issue was discussed, and the numbers will become a function of what the state does collect. Organizing the data in this manner will encourage this level of reporting and will encourage the best use of cover crops (e.g., early planting of Rye).
    - Beth McGee (CBF) and Rich Eskin (MDE) supported this method by clarifying that this is a great opportunity to use science to tweak our policies and make sure we get the most of out of the programs we're implementing. It's a good opportunity to show we're using the best science that we have to make decisions about what we should be implementing on the ground.
- Kenn Pattison (PA DEP) supported Option 1 because it was technically defensible. He would be hesitant to give credits for a BMP within a nutrient trading context that does not have a defensible efficiency.
    - Diana Esher added that defensibility is particularly important for Pennsylvania's trading program.
- Russ Perkinson (VA DCR) stated that Virginia is also interested in offset trading and wants the best possible BMP efficiencies; however, the agency has concerns with what was developed because a full consensus among states has not been reached to ensure we get the best answers we can. VA felt strongly that we need to go back to the MAWP convened cover crop panel and do a better job reaching consensus among the technical experts.
    - Rich Eskin added that if we go back to the cover crop panel it must happen quickly, but we should not fall back on the existing BMP efficiency numbers.

He emphasized that we can't let the perfect be the enemy of the good. Scientists always want more time and more data.

- The new cover crop BMP efficiencies would have to be agreed upon and incorporated into September calibration of Phase 5.0 of the Chesapeake Bay Watershed Model. Once the efficiency numbers are in the model, they cannot be changed without re-running a whole new model calibration
- Ron Entringer (NY DEC) suggested that Option 1 numbers be used for the watershed model calibration, and the cover crop panel should be given a reasonable amount of time to review the numbers. If they have strong suggestions or reach consensus that there should be a change from the numbers in Option 1, they would return to the WQSC for the final decision for crediting the BMPs in the future with a revised set of efficiencies.
  - Beth McGee raised concern that this option would open the door to do this into the future for all of the BMPs.
  - Rich Eskin expressed strong concerns over conducting watershed model-based progress runs if we calibrated the watershed model with one set of efficiencies and credited model-simulated progress with another set of efficiencies.
    - Lewis Linker confirmed that we would have to recalibrate the watershed model to get an accurate assessment of progress if a different set of BMP efficiencies were used. Given the time constraints and policy implications, this is not a doable option.
- Rich Eskin clarified that the cover crop panel is acting in an advisory capacity to the MAWP, not as a peer-reviewer or approval authority, and they have not posed any specific objections. Their input was given to and to be used by MAWP. This is how the process played out with the other 12 set of BMPs already approved by the Steering Committee. Therefore, unless some or all of the cover crop panel returns to the WQSC within one week with specific objections and data to support them, we should move forward with Option 1.
- Russ Perkinson suggested that when and if the panel reconvenes, it should have an impartial facilitator to run the meeting.
- Kelly Shenk emphasized the importance of determining who should provide the final recommendation to the WQSC and what process should be followed if they asked the cover crop panel to further evaluate the MAWP recommendation. Since the NSC couldn't resolve this issue and asked the WQSC to resolve it, it may not be necessary to have the NSC review of any further proposals, given time constraints.

DECISION: The Water Quality Steering Committee decided that given the time constraints, it was not necessary for the NSC to review the revised set of cover crop efficiencies at this point in the process.

- To stick to the review and approval process followed for all of the other BMPs, the WQSC would have to receive the cover crop panel's recommendations for review by September 12th for discussion and approval on the Steering Committee's September 17th conference call. The CBPO Modeling Team must receive the final set of cover crop BMP efficiencies on September 17th immediately following the call to proceed with the watershed model calibration.

- Mark Dubin informed the Steering Committee that through his experiences on the panel, he believes that the researchers on the panel were looking at the efficiencies from very narrow perspectives because they were struggling to adapt their research and recommendations to fit into the efforts of the Bay Program. He questioned whether the panel, alone, has the ability to adequately complete the task.
- There was a suggestion to include additional expertise on the panel to round out the panel's expertise on surface flow issues and cover crop effectiveness in other regions outside the coastal plain. There were no objections to this recommendation from any WQSC members, except Russ Perkinson, VADCR. Diana Esher suggested that they discuss this with Russ Perkinson off-line since the WQSC was running behind schedule and still needed to cover the TMDL issue on the conference call.

DECISION: The Water Quality Steering Committee decided that the MAWP will reconvene the cover crop panel with an objective facilitator to finalize a cover crop efficiency recommendation by September 12th for the WQSC. The WQSC will have until their conference call on September 17th to review the information and make a decision on September 17th conference call. The WQSC will provide the modeling team with the final efficiencies immediately following the call on the 17th so that they can get started in the model calibration.

ACTION: Tom Simpson will work with Kelly Shenk to contact the cover crop panel members to ask them to reconvene and review the cover crop efficiency recommendations, appoint additional members to ensure better Bay watershed representation and overland flow expertise, and appoint an objective facilitator to run the panel's meeting.

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Cover Crop Panel Meeting
September 5, 2007

Handouts

- Agenda
- MAWP Cover Crop Efficiencies Report
- PowerPoint presentation: Explanation of Methods and Calculations for MAWP Recommendation for Cover Crop Efficiencies (Tom Simpson and Sarah Weammert)
- CBP Cover Crop Studies Summary Table (Compiled by J.J. Meisinger, 9/5/07)
- Information Regarding Aerial Seeding of Cover Crops (Collected by Dean Hively, September 2007)

I. Overview of Charge and Process and Background — Sellner & Shenk

- Dr. Kevin Sellner, facilitator, began the meeting at 9:00 am. Introductions were made and the meeting's agenda and procedures were reviewed.
- The purpose of this meeting was to finalize a cover crop BMP efficiency recommendation for the Water Quality Steering Committee's final approval on September 17, 2007.

II. Summary of Cover Crop Efficiency Discussions — Simpson

- Tom Simpson presented an overview of how the previous MAWP cover crop efficiencies were developed. For more detailed information, see the handout of his PowerPoint presentation.

- The cover crop panel met on July 6th and came up with an efficiency table and a number of assumptions. (SLIDE 4 CORRECTION: The efficiency for cover crop wheat early planting should be 50%, not 45%.)
- After the July cover crop panel meeting, additional changes were made to the recommended efficiencies in response to a list of eight questions that the Agricultural Nutrient and Sediment Reduction Workgroup posed. Members of the panel were consulted when making these changes.
- The cover crop panel did not fully support the final MAWP efficiency recommendations. At their August 27th meeting, the Water Quality Steering Committee granted MAWP and its advisors on the cover crop panel more time to review the MAWP recommendation, resolve any outstanding issues, and to come up with a revised final recommendation. This is the purpose of today's panel meeting.

III. Identify and Issues to Resolve **All**

- The panel came up with a list of critical issues that need to be resolved:
    - Initial table of values
    - Operational efficiencies
    - Planting date
        - frost date
        - shift from frost date to heat units?
        - definition of early, standard, and late planting
        - effect of late planting
    - Surface v. subsurface
        - Regional differences (coastal plain v. piedmont v. karst)
    - Commodity grains
        - Relative to what?
    - Planting technique
        - How aerial seeding is categorized
    - Species
    - Conventional tillage
- It was noted that the baseline needs to be fully documented in the MAWP cover crop report.
- Q: Are the expected exports from a non-cover crop field equivalent to the discussions we're having on efficiencies and the expectations of the current watershed model?
    - A: Yes. This should be clarified in the MAWP cover crop report.
- ACTION: Send Gary Shenk an email and ask for a response to the following questions- How are cover crops modeled? What is the expected reduction? What is the time frame? The panel would also like to recommend to Gary that a dialogue occur between the modelers and this panel regarding how cover crops are modeled in the Phase 5 Chesapeake Bay Watershed Model and whether or not the cover crop efficiency is being applied correctly.
- Timeframe: Calibration of the Phase 5 watershed model was supposed to start on September 1st. The other twelve BMPS got final approval and were able to be used for calibration earlier this month; however, the WQSC granted MAWP and the cover crop panel an additional two weeks to come up with a revised final recommendation for the cover crop BMP. Once the WQSC approves the cover crop recommendation on September 17th, this efficiency will immediately be used for calibration.

IV. Discuss and Resolve Issues — All

- The panel discussed and resolved the issues listed above.

Subsurface v. Surface Flow

- Phase 5 of the watershed model is able to separate subsurface and surface flow components.
- In the previous MAWP recommendation, there was a 7:3 ratio for subsurface:surface nitrogen flow in all regions.
- Some panel members thought that there should be a fairly significant difference between coastal plain and non-coastal plain.
- Surface flow is more important in non-coastal plain.
- Concern was voiced that water may be an inappropriate surrogate for nitrogen. It is not a good surrogate for phosphorus or sediment.
  - A good reason to use water as a surrogate for nitrogen, accepting some flaw, is because there is data that compartmentalizes surface v. subsurface water flow for different settings, whereas there is not much data on N export in different settings.
- Kevin Sellner and Ken Staver mentioned that they have seen data that shows subsurface flow being more than 70% in the piedmont.
- Q: Does the panel have to come up with just one subsurface:surface ratio for the entire watershed?
  - A: No. The panel can give a different ratio for different regions (coastal plain and everything else; or coastal plain, piedmont, and karst) and they can say that they do not think that it is wise to use one number for the whole region, but if others choose to do so, then they recommend that X:X be used.
- Ken Staver showed several PowerPoint slides illustrating surface/subsurface water flow and nitrogen split.
- One panel member said that they would argue for a seasonal shift, however there is a lack of data to support this. Subsurface and surface numbers may differ seasonally based on the amount of excess nitrogen in the soil environment during each season. It was noted, however, that this difference decreases with the use of cover crops.
- Several members agreed that a 9:1 split is appropriate in the coastal plain, although this ratio may be too high to apply to the entire watershed.
- Tom Simpson proposed that 8:2 be used for the coastal plain because the efficiency is an annual efficiency and not a seasonal efficiency. Others think that there is defensible data to support 9:1 for the coastal plain. They also noted that data is collected over the full year, and not just seasonally.
- Since many members do not think that one number will work for the entire watershed, they decided to propose different ratios for the coastal plain, piedmont, and karst areas.
- DECISION: There was consensus among the panel (except for Tom Simpson) to adopt the following subsurface:surface ratios*:
  - Coastal Plain- 9:1
  - Piedmont- 8:2
  - Karst- ?

* Joel Blomquist and Kevin Sellner will talk to their colleagues at USGS and SERC to seek their opinion on these ratios and whether or not they are appropriate. A final decision will be made by the panel early next week once they get the opinion of others at USGS and SERC. If those at USGS and SERC agree with the panel's current decision, then no changes will be made.

Corn Silage

- ACTION: MAWP will make it clear in the cover crop report that where corn silage is harvested and cover crops are planted, that land should be considered to be under conventional tillage.

Late Planting

- One member was concerned that the spring benefit was not adequately being taken into account for late planting. Late planting efficiencies are lower than he thinks they should be.
- Q: Is the spring contribution captured in all of the numbers?
  - A: It is in the field data, so it should be in the base table.
- Q: What is the spring kill date used in the model?
  - A: Not sure. Need to check with the modelers. If panel members feel that the spring kill date used in the model should be different from the one that is currently being used, then the panel could recommend a different date (need data to backup this change).

Definitions for Planting Dates

- The panel decided to change the definitions of early, standard, and late planting from the definitions that were used during the July panel meeting.
- The previous definitions were as follows:
  - Early: >7 days before avg. 1st frost date
  - Standard: -7 to +14 days around avg. frost date
  - Late: >14 days after 1st frost to Dec. 1 (?)
- The MD program gives credit for up to November 5th for late planting, which is 3 weeks after the average frost.
- DECISION: The panel adopted the following definitions for planting dates-
  - Early: Anything prior to 2 weeks before average frost date
  - Standard: From 2 weeks prior to average frost date up to average frost date
  - Late: From average frost date plus 3 weeks

Cover Crop Efficiencies

- Jack Meisinger provided the panel with a handout summarizing several cover crop studies and their nitrogen efficiencies. Based on the studies in his table, the average N efficiency for rye early planting was 70% and the average N efficiency for rye standard planting was 64%. No studies were listed for late planting.
- Jack showed several PowerPoint slides illustrating three of the studies listed in the table.

- Some members recommended that the efficiency for standard planting be 65% and the efficiency for early planting be 75%. Even though the average in the table for early planting is 70%, some members felt that this number should be raised to 75% based on their best judgment, other studies they have seen, and the research scale issue. Others felt that the early planting efficiency should be 70% since there was data in the table to back this number up.
- The studies in the table are controlled research efforts on research scale plots.
- The group is comfortable with the studies in the handout. If anyone has additional studies that they would like to be included, they should send them to Jack.
- One reason that the group is arguing for percentages higher than the percentages that were proposed previously at the July cover crop meeting is because the definitions for early, standard, and late planting have been changed since then (see above).
- For the late planting efficiency, Dean Hively's calculations/data indicated that it should be 16%. His data is not research scale data, unlike the studies in Jack's table. Some members think that 16% is too low if the late planting date window starts on October 15th.
- Based on the graphs on page 4 and 5 of the MAWP report, some members think that the late efficiency should be about half of the standard efficiency. Also, it was noted that the graph on page 5 represents a crop planted on the last day of the late planting window, thus this is the lowest efficiency that would likely occur.
- Since Dean Hively's data is from a very wet fall and Ken Staver's data is from a very dry fall, it was suggested that the late planting efficiency number be determined by averaging a wet year, a dry year, and a good year: 16% (wet year, Dean's data), 39% (dry year, Ken's data), 30% (good year, Jack estimated).The average of these numbers is 28%. A decision was made to round this number to 30% because the dry year calculates for the end or 2/3s of the way through the planting period, thus the percentage could be higher before that.
- It is recommended that continued research be done to show that this late planting efficiency is correct.
- Dean placed the following efficiencies into a spread sheet to see what the end result would be when all of the assumptions are applied: 70% (early), 64% (standard), and 30% (late).
- DECISION: The panel accepted the following efficiencies for drilled rye conservation tillage: 70% (early), 64% (standard), and 30% (late).

Aerial Seeding

- Q: Does the model allow you to address aerial seed spreading following soy beans v. corn?
    - A: No. Also, this depends on the ability of the states to report this information. They currently do not report it. However, this does not mean that the panel cannot include this information in their matrix. Some members thought that this data was being recorded at least in MD, but not reported. Maybe they could hire a summer intern to gather this information. The owner would not need to be identified.
- Q: If the state does not report soy or corn for aerial seeding, should it be counted as corn since corn has the lower efficiency?

  - A: This is more of a programmatic question and it should be left up to other groups such as the Tributary Strategy Workgroup rather than this panel. If the states would have to automatically accept the lower efficiency, it may be an incentive for them to report differently.

Commodity Crops

- Q: What are we talking about when we use the term commodity crops?
  - A: Small grain enhancement that is not fertilized before March 1st. Between October and early March, you are clearly getting a cover crop effect; however, if you apply fertilizer in March that you would not have applied if it was a true cover crop, then this March fertilizer application is offsetting some of the benefit that had been accrued between October and March.
- By not applying fertilizer in the fall, you are typically not increasing spring application.
- Q: What are commodity crops being compared to?
  - A: They are being compared to winter fallow. The base for regular cover crops is also fallow.
- Some members don't agree with commodity crops being compared to winter fallow.
- Most small grain enhancement enrollment is in the late planning date window. Most commodity wheat would fall into this category.
- DECISION: There was consensus among the panel (except for Ken Staver) to adopt a 12% N efficiency for drilled wheat commodity crops, when comparing against fallow.
- DECISION: There was consensus among the panel (except for Ken Staver) to adopt a 20% N efficiency for drilled barley commodity crops, when comparing against fallow and assuming early planting.

V. Schedule and Next Steps

- The only outstanding issue at the close of this meeting was the ratio of subsurface:surface for coastal plain, piedmont, and karst areas.
  - Joel Blomquist and Kevin Sellner agreed to talk to their colleagues at USGS and SERC to seek their opinion on this issue. The input they gather from these other sources will be emailed to panel members later this week. Panel members will then have a chance to comment on this input. If they agree with any revisions that are proposed, then these revisions will be accepted. If panel members disagree, then a conference call will be held to discuss this issue further before a final decision is made.
- Schedule:
  - 9/7: Input from Joel and Kevin is due to Kelly Shenk
  - 9/7: Kelly will forward all input to full group and ask for final decision.
  - 9/10: All comments from panel are due to Kelly by close of business.
  - 9/12: If the panel is unable to reach consensus on the subsurface:surface item, a conference call will be held on September 12th at 12:00 pm to resolve.
  - 9/12: At close of business, Kelly will send the panel's final recommendation to the Water Quality Steering Committee (WQSC).

    - 9/17: WQSC will make the final decision.
- The panel decided that at least one panel member should be on the WQSC conference call to answer any technical questions. Jack Meisinger agreed to call in. The conference call will be held on September 17th from 2:00-4:00 pm.

VI. Adjourned
- The meeting was adjourned at 2:20 pm.

Participants

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Sally Bradley	CRC	sbradley@chesapeakebay.net
Russ Brinsfield	UMD-Wye	russb2@umd.edu
Mark Dubin	UMD	mdubin@chesapeakebay.net
Dave Hansen	UDE	djhansen@udel.edu
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Bob Kratochvil	UMD	rkratoch@umd.edu
Jack Meisinger	USDA	jmeising@anri.barc.usda.gov
John McCoy	MD-DNR	jmccoy@dnr.state.md.us
Kelly Shenk	EPA CBPO	shenk.kelly@epa.gov
Tom Simpson	UMD	tsimpson@umd.edu
Ken Staver	UMD-Wye	kstaver@umd.edu
Sarah Weammert	UMD	sweammer@umd.edu

Cover Crop Panel Conference Call
September 12, 2007

Minutes
- The conference call began at 12:00 pm.
- The purpose of this call was to come up with final recommendations for the subsurface:surface split and the issue of small grain enhancement cover crops.

Subsurface:Surface
- Q: Are we talking about an edge of field scale or a mixed land use watershed scale?
    - A: Edge of field scale.
- This split is being applied on a per acre basis, not on a watershed basis.
- A lower subsurface number would be expected from data on a mixed land use watershed scale than on an edge of field scale.
- USGS datasets are watershed scale.

- Tom Jordan's studies are at the watershed scale.
- The edge of field numbers are more appropriate when addressing this issue.
- The edge of field datasets that we have are relatively limited when looking at variations between regions. Thus the watershed datasets are important because they give us more information to look at.
- Q: How is this captured in the model?
    - A: Mixed land use and delivered loads are handled separately in the model from what we are talking about.
- There was concern that if we decreased the subsurface number simply in order to be conservative (thus increasing the surface number), then we increase the risk of overestimating effectiveness of surface flow practices.
- This apportionment is only relative to N, and not to any other species (P or sediment).
- N partitioning is not specific to cover crop practices.
- It was proposed that a 90:10 subsurface:surface ratio be used for TN.
    - MAWP had an objection to this proposal. They thought that the subsurface number should be lower. They would prefer Scott Phillips recommendation of 75:25.
- Q: What type of coastal plain settings are represented in Ken Staver's studies (which support a 90:10 split)? Are they extreme conditions?
    - A: His studies do not represent an extreme set of coastal plain conditions. The studies did not take place on a flat, sandy field and the soil was not highly porous. Also, water partitioning was 2.5 to 1.
- Q: Is an 85:15 split in the range of annual variability for Ken's data?
    - A: Yes, but it is going away from the mean.
- The panel agreed that separate ratios should be decided on to account for regional differences.
- If we decided on an 85:15 ratio for the coastal plain, would there be a big enough difference between that and the ratio for the piedmont?
- The ratio for karst should be closer to that of the coastal plain.
- USGS data suggest having two separate ratios: one for Mesozoic lowlands and siliciclastic settings and one for coastal plain, karst, and piedmont crystalline settings. In order to decide upon this, page 15 of the following reference was used as a guide:

  Bachman, L.J, B. Lindsey, J. Brakebill, and D.S. Powars. 1998. Ground-Water Discharge and Base-Flow Nitrate Loads of Nontidal Streams, and their Relation to a Hydrogeomorphic Classification of the Chesapeake Bay Watershed, Middle Atlantic Coast. Water-Resources Investigations Report 98-4059.
- The supporting USGS data for these regions would be a lower boundary. Also, the USGS data is on a watershed scale, not a field scale. This difference needs to be recognized.
- There are not enough data points from the USGS study to differentiate between karst and crystalline. Since we shouldn't force a difference, it was suggested that these regions have the same subsurface:surface ratio.
- In terms of water balance, the karst is certainly different; however, there are not enough data points in N balance to show a difference.
- DECISION: Everyone except for MAWP supported the proposal below. MAWP did not give an answer either way.

    - 65:35 subsurface:surface ratio for TN in Mesozoic lowlands and siliciclastic settings.
    - 85:15 subsurface:surface ratio for TN in karst, coastal plain, and piedmont crystalline settings.
- Lowering the ratio from 90:10 to 85:15 for coastal plain is somewhat appropriate since the coastal plain ratio now includes additional areas (karst and piedmont crystalline).
- At the last panel meeting, participants said that cover crop effects on overland flow were negligible. Is this still correct?
    - The .15 (surface component) goes in overland flow and cover crops don't effect overland flow, at least in the coastal plain.
    - The point was made that when cover crops are planted, there is less N for runoff to pick up. In theory this is a good point, but most overland flow of N occurs before cover crop planting has taken place.
- Clarify in report: (1) The ratios decided on are the % of N that goes into groundwater v. surface water and (2) the effectiveness only applies to subsurface. This was the approach that was decided on at the July 6th meeting.
- The panel agreed that in the coastal plain, the impact is minimal on surface runoff nutrient losses for conservation tillage. However, there was concern that surface runoff may have more of an effect in other areas such as the piedmont.
- DECISION: An asterisk will be placed by the efficiencies, stating something along the lines of: "particulate N reductions with surface water not addressed".

Small Grain Enhancement Cover Crops

- Although the panel discussed efficiencies for commodity cover crops/small grain enhancements, they do not yet have a clear enough understanding of how it is modeled to assign an efficiency. Since this practice has not been reported during the model calibration period, it is not necessary to complete the efficiency in time for the model calibration. The cover crop scientists and MAWP believe that through more discussions with the Chesapeake Bay Watershed modelers, they will be able to develop an efficiency in 2007 before the model is used for management model runs. They are not saying that it doesn't have potential value.
- DECISION: The panel would still like to consider this issue, thus they have decided not to make a recommendation at this time.

- The conference call was adjourned at 1:45 pm.

Participants

Joel Blomquist	USGS	jdblomqu@usgs.gov
Sally Bradley	CRC	sbradley@chesapeakebay.net
Mark Dubin	UMD	mdubin@chesapeakebay.net
Dean Hively	ARS	dean.hively@ars.usda.gov
John McCoy	MD DNR	jmccoy@dnr.state.md.us
Kelly Shenk	EPA CBPO	shenk.kelly@epa.gov

Tom Simpson	UMD	tsimpson@umd.edu
Ken Staver	UMD-Wye	kstaver@umd.edu
Sarah Weammert	UMD	sweammer@umd.edu

Appendix C. References for Subsurface Nitrogen Flow

Subsurface:Surface Nitrogen Ratios - Best Professional Judgment Based on References

Coastal Plain	Piedmont	Karst	Colleague	Reference	Comment
75:25	90:10		Tom Jordan, SERC	• Fisher, T.R., K.-Y. Lee, H. Berndt, J.A. Benitez, and M.M. Norton. 1998. Hydrology and chemistry of the Choptank River basin in the Chesapeake Bay drainage. Water Air Soil Poll. 105: 387-397. • Jordan, T.E., D.L. Correll, and D.E. Weller. 1997. Relating nutrient discharges from watersheds to land use and stream flow variability. Water Resources Research 33:2579-2590. • Jordan, T.E., D.L. Correll, and D.E. Weller. 1997 Effects of agriculture on discharges of nutrients from Coastal Plain watersheds of Chesapeake Bay. Journal of Environmental Quality 26: 836-848. • Jordan, T.E., D.L. Correll, and D.E. Weller. 1997. Nonpoint source discharges of nutrients from Piedmont watersheds of Chesapeake Bay. Journal of the American Water Resources Association 33:631-645.	• This is Tom Jordan's best professional judgment based on the references. • Base Flow Index (BFI) gives a relative measure. It's the proportion of base flow in total flow. The portion of baseflow is probably an underestimate of subsurface flow. • Most coastal plain watersheds studied: BFI 0.35 to 0.55; few lower Delmarva cp watersheds with sandy soil: BFI 0.6-0.8 • For piedmont: BFI ranging from 0.65 to 0.85
To discuss on conf. call	To discuss on conf. call		Joel Blomquist, USGS	• Bachman, L.J, B. Lindsey, J. Brakebill, and D.S. Powars. 1998. Ground-Water Discharge and Base-Flow Nitrate Loads of Nontidal Streams, and their Relation to a Hydrogeomorphic Classification of the Chesapeake Bay Watershed, Middle Atlantic Coast. Water-Resources Investigations Report 98-4059.	• Data in Bachman et al. indicate that the cover crop retention efficiency should be able to be attributed to groundwater and surface receiving waters differently based on hydrogeomorphic setting. • Bachman et al. also reports base-flow

					nitrate index (BFNI) values that range from 26 to 104 percent. These indexes are a potential surrogate for the desired apportioning cover-crop Nitrogen retention efficiencies. Piedmont crystalline BFNI were the highest (median 78) followed by Valley and ridge carbonate (3 sites, range 38-90), Valley and ridge siliciclastic (median 57), and Appalachian Plateau siliciclastic (median 47). Statistical analysis showed that the BFNI for Piedmont Crystalline streams were significantly higher than for the Appalachian plateau siliciclastic streams. One site from the Coastal Plain, Choptank R, had a BFNI or 72 percent; while two sites in the Mesozoic lowlands had indexes of 52 and 57 percent. • The BFNI presented by Bachman are entire watershed-scale measures and computed for an annual time frame. A preferred measure would be for a seasonal (winter) time frame at the field scale. such as the empirical data provided by Staver and others. Based on the documents that I've seen my judgment is that the appropriate apportionment GW should be higher for field-scale than one would see for basin scale--regardless of the setting.
90:10	85:15 or		Jack Meisinger	• N budgets from the Cochocton monolith lysimeters in eastern Ohio over 3 years	• Supports the general value of 90:10 (see references).

(approx. south of Baltimore)	80:20 (approx. north of Baltimor e)			(Chichester and Smith 1978 JEQ 7:227ff) • Ken Staver's direct measurements at Wye show the same split.	
	75:25		Adel Shirmohammadi, UMD	• Adel Shirmohammadi's piedmont studies. Dean Hively has asked Adel to send him names and locations of study watersheds, with citable references as appropriate.	• Based on his piedmont studies and accounting for N concentrations, Shirmohammadi estimates 75% on nitrate moving in groundwater. • His piedmont studies have observed 60-68% of water flow occurring as baseflow with the remainder as surface flow (this is a somewhat higher surface flow component than the 30% observed in the coastal plain).
	90:10		John Schmidt, ARS State College PA	Mahantango watershed studies: • Pionke, H.B., W.J. Gburek, R.R. Schnabel, A.N. Sharpley, and G.F. Elwinger. 1999. Seasonal flow, nutrient concentrations and loading patterns in stream flow draining an agricultural hill-land watershed. Journal of Hydrology 220: 62-73. • Pionke, H.B., W.J. Gburek, and G.J. Folmar. 1993. Quantifying stormflow components in a Pennsylvania watershed when ^{18}O input and storm conditions vary. Journal of Hydrology 148:169-187.	• Pionke et al. 1999, Table 2: 56% of the nitrate export is as base flow and elevated baseflow (both attributed to groundwater). • Pionke et al. 1993: Indicates that 80-90% of stormflow is from groundwater flow. • 80% of the 44% storm flow from Table 2 adds 35% to the 56% (>90%).

Summary of Emails:

From: Jordan, Thomas
Sent: Thu 9/6/2007 10:11 AM
To: Sellner, Kevin
Subject: RE: TN percentages

For watersheds that have high N loads, such as those with cropland, nitrate is the main component of total N discharge. Nitrate seems to move predominantly by leaching out of the rooting zone and traveling in the groundwater. This is suggested by the apparent dilution of nitrate concentration in stream water during high flow events when surface water is mixed with groundwater (Fisher et al. 1998). So, even if equal amounts of water traveled by surface and subsurface flows, most of the TN would travel by subsurface flow. But actually, there is probably more subsurface water flow than surface water flow from Chesapeake watersheds in general.

We don't have measurements of the relative amounts of surface and sub-surface flow but the base flow index (BFI) gives a relative measure. BFI is a measure of the proportion of base flow (slow flow) in total flow. Some of the storm flow (quick flow) is surface runoff and some is ground water flow that has been accelerated, so the proportion of base flow is probably an underestimate of the proportion of sub-surface runoff. Base flow presumably has negligible amounts of surface runoff. BFI for most of the Coastal Plain watersheds we studied ranges from 0.35 to 0.55. A few lower Delmarva Coastal Plain watersheds with sandy soil have higher BFI (0.6-0.8). Most of the Piedmont watersheds we studied (in silicaceous Piedmont on the MD-PA border) have BFI ranging 0.65 to 0.85 (see Jordan et al. 1997a, b, c).

You are asking for my guesstimate so I would guess that in the Coastal Plain about 75% TN discharge is sub-surface while in the Piedmont about 90% is sub-surface.

We are still working on our karst data for Piedmont and Appalachian provinces but so far it looks more like Piedmont than Coastal Plain.

Fisher, T. R., K.-Y. Lee, H. Berndt, J. A. Benitez, and M. M. Norton. 1998. Hydrology and chemistry of the Choptank River basin in the Chesapeake Bay drainage. Water Air Soil Poll. 105: 387-397.

Jordan, T. E., D. L. Correll, and D. E. Weller. 1997. Relating nutrient discharges from watersheds to land use and stream flow variability. Water Resources Research 33:2579-2590.

Jordan, T. E., D. L. Correll, and D. E. Weller. 1997. Effects of agriculture on discharges of nutrients from Coastal Plain watersheds of Chesapeake Bay. Journal of Environmental Quality 26:836-848.

Jordan, T. E., D. L. Correll, and D. E. Weller. 1997. Nonpoint source discharges of nutrients from Piedmont watersheds of Chesapeake Bay. Journal of the American Water Resources Association 33:631-645.

Thomas E. Jordan

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Fax: 443-482-2380

From: Joel D Blomquist [mailto:jdblomqu@usgs.gov]
Sent: Tuesday, September 11, 2007 2:55 PM
To: Sally Bradley
Subject: Cover crop reply from USGS
RE: ground-water / surface water apportionment of cover crop efficiencies--please distribute to the group.

Since I am a latecomer in the BMP efficiency process for CBP-WSM calibration purposes, I will address only the issue of apportioning the consensus efficiency methods to the extent that they affect groundwater and surface receiving waters.

DEFINITION: Based on my understanding of the documents and discussions, The efficiency estimates as discussed are defined as the percent of expected nitrogen losses that are reduced due to use of cover crop use. If empirically measured, a BMP with 80 percent nitrogen loss efficiency would retain 80 percent of the nitrogen in soil or biomass that would have been otherwise exported from fallow fields.

a) One of the charges to the group was to determine how to apportion these efficiencies to groundwater or surface receiving waters. Thus if ground-water receives 90% of the benefit and surface-water 10 % of the benefit-- then the reduction in amount of nitrogen reaching the aquifer is 90% of the total loss reduction for ground water, and 10% of the total loss reduction for surface water.

USGS SUPPORTING DATA: USGS has a number of documents that address annual and short-term separations of ground-water flow and run off flow in different parts of the Chesapeake Watershed. However, these studies are not a direct surrogate for the desired apportionment because this issue at hand is managing a nitrogen balance in a field setting and not a water balance in the watershed setting.

Bachman and others 1998 presents base flow separations for water exports and nitrogen exports from stations in a number of settings. Information on page 15 of this report clearly shows that the base-flow index (percentage of base flow to total streamflow) varies widely among streams in the CBW and median vbase-flow indexes are lowest in the Mesozoic lowlands than for streams in any other setting. (see figure 6) with Valley and Ridge Carbonate, Coastal Plain and Blue Ridge among the highest. Clearly these data indicate that the cover-crop retention efficiency should be able to be attributed to groundwater and surface receiving waters differently based on hydrogeomorphic setting.

Bachman 1989 also reports base-flow nitrate index (BFNI) values that range from 26 to 104 percent (pp19, Bachman and others, 1998). These indexes are a potential surrogate for the desired apportioning cover-crop Nitrogen retention efficiencies. Piedmont crystalline BFNI were the highest (median 78) followed by Valley and ridge carbonate (3 sites, range 38-90), Valley and ridge siliciclastic (median 57) , and Appalachian Plateau siliciclastic (median 47). Statistical analysis showed that the BFNI for Piedmont Crystalline streams were significantly higher than for the Appalachian plateau siliciclastic streams. One site from the Coastal Plain, Choptank R, had a BFNI or 72 percent; while two sites in the Mesozoic lowlands had indexes of 52 and 57 percent.

Again, the statistical differences in BFNI across hydrogeologic settings would tend to support an attempt to refine the apportionment across the CBW. However, the BFNI presented by Bachman are entire watershed-scale measures and computed for an annual time frame. A preferred measure would be for a seasonal (winter) time frame at the field scale. such as the empirical data provided by Staver and others. Based on the documents that I've seen my judgement is that the appropriate apportionment GW should be higher for field-scale than one would see for basin scale--regardless of the setting.

We can discuss how to include this information into the cover-crop document on the 12th. I hope this serves to support or add context to any final recommendations.

Joel

NOTE:

The documentation did not clearly state that the resulting coefficients are appropriate to only nitrogen loss / retention factors and have no direct relevance to phosphorus or sediment. It would be good to make that clear.

"Meisinger, John" <John.Meisinger@ars.usda.gov>
09/07/2007 04:13 PM

Folks,

The general value of 90% groundwater path for N loss & 10% for surface N looks good as I reviewed N budgets from the Coshocton monolith lysimeters in eastern Ohio over 3 years (Chichester and Smith 1978 JEQ 7:227ff). Also recall that Ken Staver's direct measurements at Wye also show the same split.

Since we have some data on this issue and since the model can accommodate some regional differences, I'd suggest using 90/10 for southern part of the watershed (say south of 39N lat or approx. south of Balt MD) and use 85/15 north of this latitude, although I'd also be comfortable with using a north value of 80/20.

Jack

From: Hively, Dean
Sent: Friday, September 07, 2007 3:17 PM
To: Shenk.Kelly@epamail.epa.gov; JMCCOY@dnr.state.md.us; djhansen@udel.edu; Meisinger, John; kstaver@umd.edu; mcgrathj@umd.edu; mdubin@chesapeakebay.net; rkratoch@umd.edu; russb2@umd.edu; Andy Clark; Sarah Weammert; mdubin@chesapeakebay.net; tsimpson@umd.edu; Joel D Blomquist; sbradley@chesapeakebay.net; fjcoale@umd.edu; dbb@psu.edu; sellnerk@si.edu
Cc: Sara Parr; Esher.Diana@epamail.epa.gov; Batiuk.Richard@epamail.epa.gov

Subject: Groundwater N component - some new data

Kelly and Sarah -

I have received two responses regarding groundwater partitioning of N in the Piedmont region of the Chesapeake Bay watershed.

1. John Schmidt, of the ARS group in State College, PA, provides solid evidence supporting 90% of N moving by groundwater, based on their Mahantango watershed studies. See his comments below, as well as attached papers.

2. I spoke with Adel Shirmohammadi, at UMD, who indicated that his piedmont studies have observed 60-68% of water flow occurring as baseflow with the remainder as surface flow (this is a somewhat higher surface flow component than the 30% observed in the coastal plain). Accounting for N concentrations, he estimates 75% on nitrate moving in groundwater. I have asked him to provide names and locations of his study watersheds, with citable references as appropriate. I will forward the information when I receive it.

Based on the evidence that I have seen (that presented at our meeting and the abovementioned) I would support 90% for coastal plain and 80-85% for piedmont.

Has any additional new supporting data been found?

Cheers, Dean

Dean,

For the Mahantango watershed, it seems that at least 90% of the nitrate leaves the watershed through the groundwater. If you look at the Pionke_1999 attachment, Table 2, 56% of the nitrate export is as base flow and elevated baseflow (which are both attributed to groundwater). In a previous Pionke paper, discussed on p. 69 (and attached, Pionke_1993), Pionke indicates that 80-90% of stormflow is from groundwater flow. Eighty percent of the 44% storm flow from Table 2 adds 35% to the 56% (>90%).

Attributing 90+% of N export to groundwater movement seems ok.

John

John P. Schmidt, Ph.D.
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W. Dean Hively, Associate Soil Scientist
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email: Dean.Hively@ars.usda.gov, phone: 301-504-9031

schnabel_1993.pdf Pionke_1993.pdf Pionke_1996.pdf pionke_1999.pdf

Appendix C. Information on Personal Communications Regarding Aerial Seeding

NSTL - Tom Kaspar, USDA-ARS National Soil Tilth Laboratory, Ames, Iowa, personal communication

UMN - Paul Porter, University of Minnesota Dept. of Agronomy, personal communication

UWI - Shawn Conley - University of Wisconsin Department of Agronomy, personal communication

Appendix D. Cover Crop Effectiveness Estimate Calculations

Items in gray represent values in calculations.

subsurf A	landscape	subsurf B
0.85	0.75	0.65

Plot scale:

Seeding method:	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn
Species:	Rye	Rye	Rye	Rye	Wheat	Wheat	Wheat	Wheat	Barley	Barley	Barley	Barley
Early planting	70	59.5	49.0	28.0	49.0	41.7	34.3	19.6	59.5	50.6	41.7	23.8
Normal planting	64	54.4	na	na	44.8	38.1	na	na	44.8	38.1	na	Na
Late planting	30	25.5	na	na	21.0	17.9	na	na	na	na	na	Na

Multiplicative factors employed:

	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn
	Rye	Rye	Rye	Rye	Wheat	Wheat	Wheat	Wheat	Barley	Barley	Barley	Barley
prior to av. Frost-14	Base Value	=.85drilled	=.7drilled	=.4drilled	=.7rye	=.7rye	=.7rye	=.7rye	=.85rye	=.85rye	=.85rye	=.85rye
up to av. first Frost	Base Value	=.85drilled	na	na	=.7rye	=.7rye	na	na	=.7rye	=.7rye	na	Na
to av. Frost +21	Base Value	=.85drilled	na	na	=.7rye	=.7rye	na	na	na	na	na	Na
		0.85	0.7	0.4	0.7	0.7	0.7	0.7	0.85	0.7	0.85	0.85

Coastal Plain/Piedmont Crystalline/Karst Settings

Watershed scale = plot scale * .85 (subsurface edge of field) *.75 (landscape scale)

Seeding method:	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn
Species:	Rye	Rye	Rye	Rye	Wheat	Wheat	Wheat	Wheat	Barley	Barley	Barley	Barley
Early planting	45	38	31	18	31	27	22	13	38	32	27	15
Normal planting	41	35	ne	ne	29	24	ne	ne	29	24	ne	ne
Late planting	19	16	ne	ne	13	11	ne	ne	na	na	ne	ne

Commodity SGE	*	na	ne	ne	*	Na	ne	ne	*	na	ne	ne

Mesozoic Lowlands/Valley and Ridge Siliciclastic**

Watershed scale = plot scale * .65 (subsurface edge of field) *.75 (landscape scale)

Seeding method:	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn	Drilled	Other	Aerial/soy	Aerial/corn
Species:	Rye	Rye	Rye	Rye	Wheat	Wheat	Wheat	Wheat	Barley	Barley	Barley	Barley
Early planting	34	29	24	14	24	20	17	10	29	25	20	12
Normal planting	31	27	ne	ne	22	19	ne	ne	22	19	ne	Ne
Late planting	15	12	ne	ne	10	9	ne	ne	na	na	ne	Ne
Commodity SGE	*	na	ne	ne	*	Na	ne	ne	*	na	ne	Ne

na - Not applicable
ne – Not eligible for credit. Aerial seeded grains require a significant rain event to germinate, and early aerial seeding is desirable
because it increases the chance of experiencing significant rainfall prior to the end of the growing season.

* These efficiencies will be finalized following further discussions between the cover crop scientists and modelers.

** Particulate nitrogen was not consider in developing the recommendation for the two settings.

Dairy Feed Management

Definition and Nutrient and Sediment Reduction Effectiveness Estimates
For use in Phase 5 of the Chesapeake Bay Program Watershed Model

Consulting Scientists

Mark Dubin
Agricultural Technical Coordinator
Chesapeake Bay Program/Mid-Atlantic Water Program

Dr. Virginia Ishler
Dairy and Animal Scientist
Pennsylvania State University

Dr. Rick Kohn
Professor, Animal and Avian Sciences
University of Maryland

Dr. Kathy Soder
Animal Scientist
USDA-ARS-Pasture Systems and Watershed Management Research Unit

Dr. Charlie Stallings
Dairy Scientist
Virginia Tech

and

Synthesis by
Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary

Dairy Precision Feeding: reduces the quantity of phosphorous and nitrogen fed to livestock by formulating diets within 110% of Nutritional Research Council recommended level in order to minimize the excretion of nutrients without negatively affecting milk production.

- Effectiveness Estimates are determined via direct testing, however, without test results TP reduction is assumed to be 25% and TN reductions are assumed to be 24% with no TSS associated with dairy precision feeding.

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project during 2007-2008 to develop the components or subcategories of the BMP, a corresponding definition(s) and effectiveness estimates. The BMPs developed have not been previously reported to the Chesapeake Bay Program. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

Attached to these definitions and efficiencies is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. Meeting minutes are included in Appendix A.

UMD/MAWP consulted a panel of experts from the academic, industrial, state agency and non-profit sectors to advise in the development of BMP definitions and effectiveness estimates. Discussions during panel meetings, data and best professional judgment was used to craft the recommendations presented here. While their input strongly influenced the recommendations, inclusion of panel members name does not constitute endorsement.

Guidelines. The following guidelines were used when selecting data to include in the data set:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.

- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.

- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process. As such, peer reviewed literature should be given more weight than design standards and manuals.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

Data applicability. As with any literature review, data should be evaluated for its applicability. Before selecting a study for use in developing a BMP effectiveness estimate and definition, UMD/MAWP and panel members considered the questions below. The data used to develop effectiveness estimates was selected based on its applicability to the natural conditions of the Chesapeake Bay watershed, such as, soil type, hydrologic flow paths, and species composition. The studies were evaluated for their BMP design and implementation compatibility to those in the Chesapeake Bay watershed. Rates and timing of fertilizer applications, and the relationship between cultivation and planting dates, were evaluated to determine if the study was applicable to farming methods in the watershed.Studies were also reviewed to determine if the study duration accurately represents average effectiveness results. The time when removal rates are monitored may influence performance by under or overestimating effectiveness.

- Are natural characteristics (soil type, climate, flow paths, geology, vegetation, etc.) of the research site similar to conditions in the Chesapeake Bay watershed?
- Is the practice consistent with NRCS codes, jurisdictional stormwater design manuals? If not, how would effectiveness estimates be different?
- How critical is the duration of the experiment to the reported effectiveness results?
- Do results reflect changes in pollution reduction benefits over the lifetime of the BMP?
- Briefly explain the study method used?
- What parameters were sampled and monitored?
- Who conducted the research?
- How was the effectiveness estimate calculated?
- What was the scale of the study?
- What assumptions, outside of experimental results, were made in reaching the conclusions?

After considering these questions, the panel and UMD/MAWP determine if a study should be included in the data set to be used in effectiveness estimation.

BMP Structure/Subcategories

To determine this BMPs structure various sources of information were utilized, including experimental plot data provided by academic researchers and research articles published in peer reviewed journals, as well as consultation with recognized experts.

Description/Definition of BMP:

After adopting feed management practices manure testing may result in an elevated manure nutrient content. For example, a switch to a more digestible forage, an encouraged feed management practice, may result in elevated manure P content. This improves net farm income by feeding nutrients more efficiently, one intent of feed management. The other purpose of feed management is to reduce the quantity of nutrients excreted in manure by minimizing the over-feeding of nutrients. It is this purpose, decreased manure nutrient content for improved water quality, which this report focuses. To receive credit for dairy precision feeding as a water quality BMP the ultimate goal is to demonstrate decreased manure nutrient content.

Dairy precision feeding reduces the quantity of phosphorous and nitrogen fed to livestock by formulating diets within 110% of NRC recommended level in order to minimize the excretion of nutrients without negatively affecting milk production. The National Research Council (NRC) recommended rate for P in dairy diets is .32 to .38% P, depending on milk production (Dou et al 2003). A survey and sampling of NY, PA, DE, MD and VA found P diets are being feed 34% above the NRC recommendations (Dou et al 2007). Milk Urea Nitrogen (MUN) and fecal tests for nitrogen (N), and total mixed ration (TMR) and fecal P analysis for phosphorous (P) is the preferred approach to determine changes in nutrient content to estimate N and P reductions from implementing dairy precision feeding. If a jurisdiction would like to use another tool to predict nutrient excretion it must be independently reviewed and approved by the Chesapeake Bay Program. When MUN and fecal N analysis, or TMR and fecal P analysis results are not available, average literature values will be assigned to estimate performance. Farmers must achieve 110 percent of the NRC recommendation to be credited for this BMP efficiency.

Other benefits:
Manipulation on manure odors, pathogens, animal health and well-being

Possible NRCS codes:
Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Cultural components consisting of shorter term conservation measures included in the Dairy Precision Feeding definitions include, but may not be limited to the USDA-NRCS conservation practices listed below.
Feed Management (592) - Managing the quantity of available nutrients fed to livestock and poultry for their intended purpose.

Purpose:

- Supply the quantity of available nutrients required by livestock and poultry for maintenance, production, performance, and reproduction; while reducing the quantity of nutrients, especially nitrogen and phosphorus, excreted in manure by minimizing the over-feeding of these and other nutrients.
- Improve net farm income by feeding nutrients more efficiently

Conditions where practice applies:

- Confined livestock and poultry operations with a whole farm nutrient imbalance, with more nutrients imported to the farm than are exported and/or utilized by cropping programs.
- Confined livestock and poultry operations that have a significant build up of nutrients in the soil due to land application of manure.
- Confined livestock and poultry operations that land apply manure and do not have a land base large enough to allow nutrients to be applied at rates recommended by soil test and utilized by crops in the rotation.
- Livestock and poultry operations seeking to enhance nutrient efficiencies.

Effectiveness Estimate

As excreted fecal testing and MUN or TMR testing for N and P, respectively, will be utilized to determine reductions in manure nutrient content. P feeding after the NRC requirement is met results in a direct increase in the excreted P in the manure. Therefore, reductions in the feed will result in reduced P in the manure in a proportional manner as long as dry matter intake stays the same. However, feed testing alone does not guarantee that the cows are consuming the recommended levels or that something in the feed(s) has not changed. CBP recommends taking "fecal samples" to document the specific group of animals versus manure samples from the storage structure. A significant barrier to obtaining an as excreted fecal sample is that it is difficult in production systems, while it is easier in research projects. With traditional storage structures one cannot get a representative sample in the lagoon, pit, etc. as manure is exposed to contamination from other sources and subject to volatilization. While both MUN and TMR have their limitations they are valuable monitoring tools and UMD/MAWP and CBP recommends requiring both for monitoring manure nutrient changes when as excreted fecal sampling may be difficult or impossible to obtain.

In addition to using fecal tests to determine P content, TMR is also used. A TMR consists of a complete ration that provides adequate nourishment to help dairy cows achieve maximum performance. All forage grains, protein supplements, minerals and vitamins are thoroughly mixed resulting in greater utilization of nutrients and thus less nutrient accumulation. Using a TMR can identify imbalances in nutrient uptake and help decrease nutrient overfeeding. With a pasture-based system, nutrient analyses of pastures should be conducted to avoid feeding excess crude protein which could lead to increased nitrogen leaching. Formulations of TMR should complement the nutrients in pasture.

MUN, a rapid, simple and noninvasive process, can be used to predict nitrogen excretion in dairy cows (Jonker et al., 1998; Figure 1), and target MUN concentrations can be derived by predicting urinary nitrogen excretion for cows consuming ideal diets (Jonker et al., 1999). MUN will be tested by milk cooperatives as there is a strong correlation between MUN and manure N content that can be used to determine the reduction in manure N content by feeding a diet within 110% of the NRC recommended rate. If manure testing is conducted, interested parties can accumulate a database of results to determine general manure N content changes and with time note trends in reduction. This data can be expanded to determine actual reductions in nitrogen.

While Jonker et al's (1998) equation, 12.54 ± 0.24 (Figure 1), fits data collected before DHIA laboratories changed its standards, Kohn et al. (2002) concluded the amount of nitrogen excreted should now be estimated as 0.026 x body weight (kg) x MUN (mg/dl). The close relationship between MUN and excreted urinary nitrogen (UN) remains.

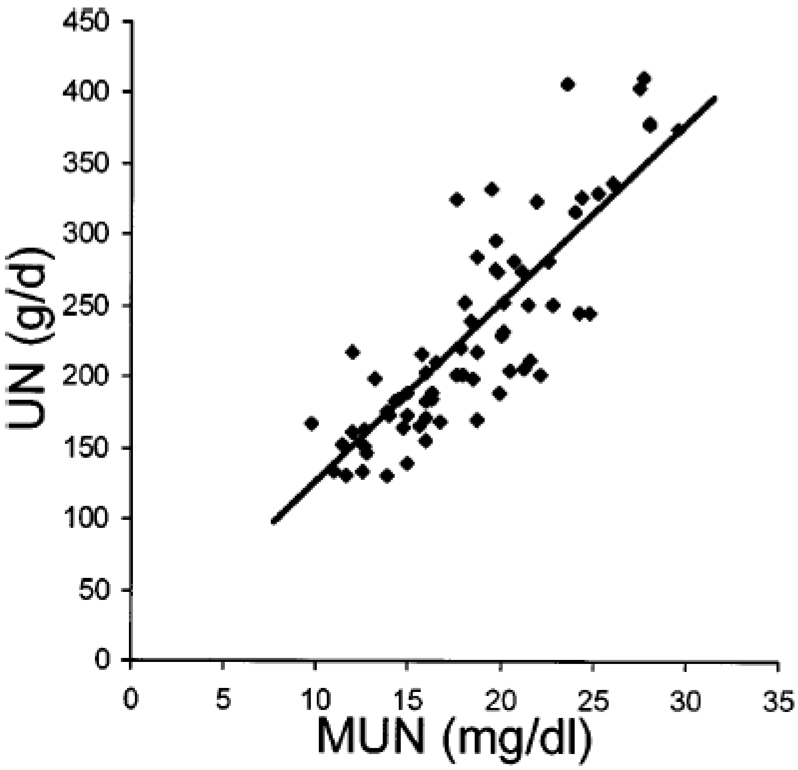

Figure 1. Relationship between milk urea N (MUN; milligrams per deciliter) and urinary N excretion (UN; grams per day); slope = 12.54 ± 0.24 (Jonker et al 1998).

Milk Urea Nitrogen (MUN) will be tracked to ensure it is within the range of 8 to 12, while remaining consistent throughout the year, thus maintained below 12 at all times. MUN is a tool that reflects the amount of urea found in milk and these values closely correlate with the concentration of urea found in the blood of dairy cows. MUN will be tested during the winter months (November – March) and before and after comparisons will be made to assure MUN is maintained. Winter months were chosen because winter sampling is the most consistent and avoids factors that introduce variability. During the summer high MUN is observed due to high temperature and humidity. The November through March timeframe will hopefully avoid peaks in MUN levels, as this time frame avoids the natural variables that may result in peaks. If peaks are the result of management then credit should not be given. One future research need is to determine if MUN peaks are a result of management or natural cycles.

If results from the paired sampling (feed versus fecal) do not correlate additional sampling is warranted. In this case repeat the manure testing with a much larger number of cows, or average slurry analysis across rolling yearly time periods to correct for seasonal effects and other factors of variability. Fecal samples should be taken every season and timed to ration adjustments.

If TMR or MUN and fecal testing is not available average literature values will be used to estimate the effectiveness of dairy precision feeding. A precision feeding management system reduces the on-farm P imbalance by using more accurate feeding of P (based on P required in animal diets), as P intake significantly impacts P excretion, integrated with increased productivity of grass forage and increased proportion of forage in the diet, along with the conversion of corn to grassland. The conversion of corn to grassland is not part of the dairy feeding BMP reported here, but model runs by Ghebremichael et al 2007 showed a 5.8 and 9.3 kg/ha reduction in sediment bound P in erosion loss each year. The Chesapeake Bay Program (CBP) Watershed Model (WSM) can predict load decreases for land use changes and credit for this practice will be accounted using this approach. Any testing of manure excreted in confinement should show nutrient changes that occurred based on reduction in supplement and/or increases in forage. Any reduction in supplement or increase in forage quality will be captured in a manure test. To estimate its effect, feed supplement purchases declined 7.5 kg/cow/year for dietary mineral P, and protein concentration declined 1.04 and 1.29 tons/cow/year through adaption of a precision feed management system that increased the high-quality homegrown forage production (Ghebremichael et al 2007).

A dairy herd's feed input may vary monthly due to fluctuations in market price, feed supplier and nutritionist recommendations and seasonal access to pasture. The panel recommends testing feed and as excreted fecal testing and measure the change in P and N content to determine effectiveness. If manure testing for P is unavailable UMD/MAWP recommends a 25% reduction in manure P excretions be assigned if it can be demonstrated that feeding occurred at 110% the NRC recommendation. This value is slightly lower than the average literature value found for manure P content at 111% NRC recommendation, and higher than the average found at 100% the NRC recommendation, see table one for a list of values and references. The average literature value for N reduction is 24% (table 2).

Dou et al 2007 surveyed over 600 dairy commercial farms in the Chesapeake Bay watershed and results showed a lower dietary P content, 34% reduction, equaled a reduction of 8-10 kg of P in feces per cow per year. Extrapolating to the whole Chesapeake Bay watershed results in a 5000 kg of P per year reduced, approximately 30% of total manure P produced by all dairy cattle or 4% of total manure P by all livestock animals in the watershed.

Table 1. Literature Values of Manure Phosphorous Reductions

P Effectiveness Estimate (%)	Reference
At 111% NRC recommendation:	
33	Cerosaletti et al 2004
23	Wu et al 2000
Average (%) = 28	
At 100% NRC recommendation:	
25	Ghebremichael et al 2008
25	Wu et al 2003
16	Hristov et al 2006
Average (%) = 22	

Table 2. Literature Values of Manure Nitrogen Reductions

N Effectiveness Estimate (%)	Reference	Notes
Klausner et al 1998	34	From another source, cannot find original article
Tylutki, 2004	17	Less load rate (kg/ha) with greater home grown forage diets
Kohn et al 1997	38	With 50% increase in feed N converted to animal product results in a 36-40% reduction in N losses per product
Jonker et al 2002a	8	Improve herd by 10% to reduce N losses to environment by 8%
	Average (%) = 24	

Preliminary Results from the Milk Urea Nitrogen Program

The Natural Resources Conservation Service and the University of Maryland cooperated on a project to institutionalize the measurement of milk urea nitrogen on dairy farms. Cooperatives were paid to analyze and report MUN on milk statements along with milk volume, fat, protein, solids and somatic cell counts. The analyses have been evaluated to insure accuracy and consistency. Information on how to interpret MUN has been provided to nutritionists and farmers over the course of the past three years.

The results in this report summarize milk urea nitrogen (MUN) analyses reported by cooperatives participating in the program. Although cooperatives were only paid for analyses of milk for farms in MD and VA, once the equipment was installed and calibrated, the results could be expanded to all members of the cooperative without additional cost. Therefore, results from other states were also provided.

The average MUN for the Chesapeake Bay states has remained about 12.5 mg/dl (SD = 3.5) annually for the participants in the project.

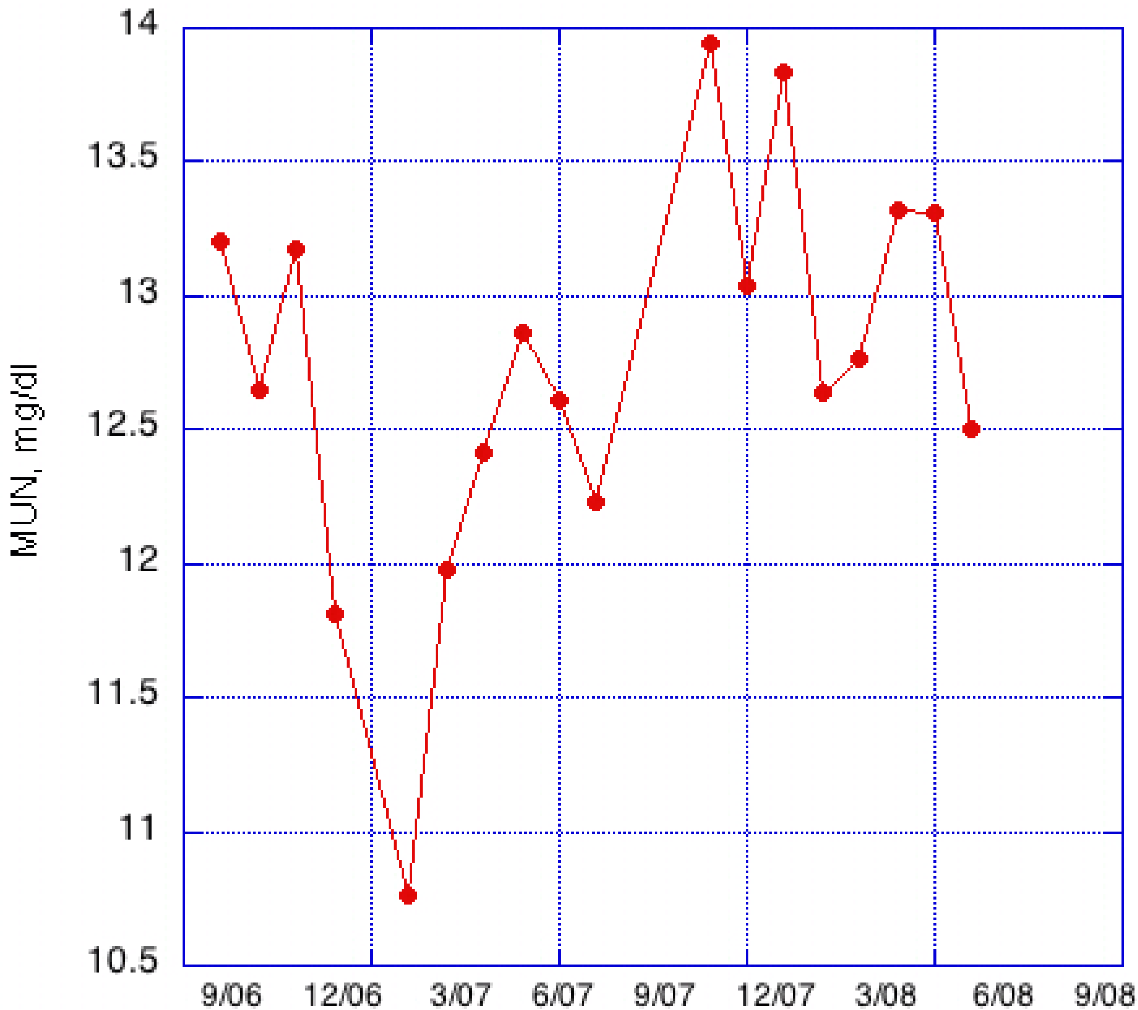

Figure 2. Change in MUN (mg/dl) for all observed farms in project.

Although MUN appeared to decline initially, the overall average increased in the spring of 2007 and did not decline in the subsequent fall (Figure 2). A major reason MUN increases in the spring is the substitution of ingredients in rations as producers run out of some ingredients and substitute farm-grown ingredients that are available. The drought in 2007 and the price increases on corn grain may have resulted in the higher MUN in the fall of 2007.

Table 3. Mean bulk-tank MUN (mg/dl) by state for a subset of samples analyzed as part of the NRCS MUN project from Sep 2006 to May 2008.

State	Samples	Mean	SD
DE	2226	12.7	3.4
GA	9313	14.3	3.7
KY	6047	13.2	3.3
MD	54124	12.6	3.4
NC	19175	13.6	3.3
OH	234	14.3	1.5
PA	166058	12.6	3.1
SC	6615	13.3	2.8
TN	15787	14.6	3.3
VA	40506	12.8	3.8
WV	1643	12.8	2.7

Mean MUN by state (Table 3) over the course of the project showed that on average many farmers still feed more protein than necessary. The target MUN would be about 11.0 mg per dl. The Chesapeake Bay states (e.g. DE, MD, PA, VA) have lower MUN than other states (e.g GA, KY, NC, SC, TN).

These results suggest that farmers continue to feed more than adequate protein to their herds. In Jan and Feb of 2007, NRCS made $150 payments to farmers who were able to keep their MUN below 12 mg/dl. A total of 46 dairy farmers applied for and received the award. The incentive program increased our inquiries about MUN from both nutritionists and farmers, and initiated interest among several farmers who had not contacted us earlier. We would like to offer this program again in the upcoming year, and would like to survey farmers and nutritionists to better understand why they did not participate.

On average, the results were similar to those observed by Jonker et al. (2002a,b). In that case, about 70% of dairy farmers oversupplied protein to their herds, and MUN also averaged 12.5 mg/dl. In that case, providing interpretive information and MUN results decreased MUN on participating farms compared to non-participants. However, in the present case, results were provided to all farms regardless of whether or not they requested them. Therefore, we could not differentiate farmers who used the results from those who did not. Many factors influence feeding choices from month to month and year to year making it difficult to determine why MUN has not decreased to closer to target values. We would like to better understand these changes by surveying farmers as well.

Modeling Reductions of Land Applied Manure

To help understand the reductions associated with applying manure with less P content some modeling exercises have been conducted. They show the expected soluble P (sol P) and particulate P (PP) reductions with feed inputs at the 100% NRC recommended rate (Table 4). Modeled P reductions with diet manipulation and forage management are show in table 5, and for diet manipulation, forage and land use conversion in table 6. Sediment (S) reductions (Table 7) are also available comparing baseline conditions (no precision feeding management such as diet manipulation, forage productivity) and compared to diet manipulation alone (the BMP reported here).

Table 4. Modeled Values for the Relationship between Reduction in Manure P Content (100% NRC Recommendation) Land Applied to Reductions in Soluble P and Particulate P Runoff (Ghebremichael et al 2008).

Parameter	Land Use Application	Effectiveness (%)
Sol P	Cropland	12
Sol P	Pasture	14
Sol P	Watershed wide	11
PP	Cropland	8
PP	Pasture	10
PP	Watershed wide	7

Table 5. Three Year Average Modeled Values for the Relationship Between Land Applied Manure with P Content Reduced via Diet Manipulation (100% NRC Rate) and Forage Management to Reductions in Soluble P and Particulate P Runoff (Ghebremichael et al 2008).

Parameter	**Comparison**	**Land Use App**	**% Reduct.**
PP	Baseline – no feed manipulation or forage management	Cropland	22
PP	Baseline – no feed manipulation or forage management	Entire watershed	16
PP	Baseline – no feed manipulation or forage management	Grassland	44
PP	Diet manipulation alone	Grassland	40
Sol P	Baseline – no feed manipulation or forage management	Cropland	12
Sol P	Baseline – no feed manipulation or forage management	Entire Watershed	13
Sol P	Baseline – no feed manipulation or forage management	Grassland	15
Sol P	Diet manipulation alone	Grassland	3

Table 6. Three Year Average Predicted Values for the Relationship Between Reduction in Manure P Content (100% NRC Rate), Forage Management, and Land Use Conversion to Reductions in Soluble P and Particulate P Runoff (Ghebremichael et al 2008).

Parameter	Comparison	Land Use App	% Reduct.
PP	Baseline – no feed manipulation, forage management or land use conversion	corn to grass land	48
PP	Diet and forage mgt	cropland	26
PP	Diet and forage mgt	watershed	16
sol P	Baseline – no feed manipulation, forage management or land use conversion	corn to grass land	8
sol P	Diet and forage mgt	cropland	-4
sol P	Diet and forage mgt	watershed	-2

Table 7. Three Year Average Modeled Sediment Reductions (Ghebremichael et al 2008).

Average Sediment Loss Reduced through diet manipulation (100% NRC recommendation) and forage management	**Comparison**	**Applied Land Use**
34%	Baseline – no feed manipulation or forage management	Cropland
63%	Baseline – no feed manipulation or forage management	Grassland
25%	Baseline – no feed manipulation or forage management	Entire Watershed
Average Sediment Loss Reduced through diet manipulation (100% NRC recommendation), forage management, land use conversion	**Comparison**	**Land Use**
89%	Baseline – no feed manipulation, forage management or land use conversion	Corn to Grass
49%	Diet and forage management alone, no land use conversion	Entire Watershed

Level of Confidence

UMD/MAWP does not have confidence in the modeled scenarios capturing forage productivity and conversion of corn land to grass as the data set is limited and inconsistent. The manure N and P content values are research based, not modeled, and are a good estimate of average N and P reductions but not as accurate as manure testing.

Factors that Create Variability.

Uncontrollable conditions may hinder the production of the required forage amounts and quality to achieve a zero P balance. For example, weather conditions, such as drought, contribute to crop losses. Weather also affects harvesting and feed storage, thus affecting forage production and quality. Crop losses to pest damage may require the import of forage. Reductions are also highly variable due to the forage P content and variable levels of dietary P intake. The willingness of farmer to adopt reduced P diets will also create variability in reductions.

Identify outstanding issues to be resolved in the future

Assess whole-farm mass nutrient balances over several years to provide data from representative, not extreme years.

We need to use BMPs that control P losses while simultaneously matching N availability to crops needs in order to control N losses and increase N use efficiency for forage production.

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Appendix A. Meeting Minutes

Dairy Feed Management

May 14, 2008

Ginny Ishler
Kathy Soder
Rick Kohn
Tom Simpson
Sarah Weammert
Mark Dubin

Action Items

ACTION: Sarah will search our data set for P reductions in excreted manure; send strawman out to group for review. Recommend fecal monitoring to identify actual change (like poultry phytase monitoring)

ACTION: Use Rick's data to determine representative value of pre BMP condition Timeline – has mean and deviation soon; hire summer student to do this work

Kathy ACTION: Pasture lab may have numbers on manure deposited depending on time in confinement/pasture and confinement alone

Overview of Project

Estimates of BMP performance will be used in TMDL implementation plans, trading permits and WSM modeling, and for continued use in Tributary Strategies. While our scope dictates that we quantify the nutrient and sediment reductions, UMD/MAWP recognizes there are additional co-benefits (social, economic, etc.). UMD/MAWP is asking panel members to help create a list of all co-benefits.

Our most important task is to estimate BMP performance at the operational, average watershed wide scale. UMD/MAWP's job is to ensure panel decisions, scientific justification, and best professional judgment are within the framework of our guidelines designed to estimate operational, average watershed wide conditions:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.

- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.

- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process. As such, peer reviewed literature should be given more weight than design standards and manual.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

UMD/MAWP will ask detailed questions about the BMP, not to discredit the performance of the BMP, but to arrive at operational conditions.

Panel members' primary task is to develop a report for the BMP using the guidelines, decision matrix, and factors of variability found in the template. A final report from the panel is due to the Chesapeake Bay Program by July 15, 2008 so partners can begin their technical review process. Bay Program partners are made up of jurisdictional agencies, the EPA and the Chesapeake Bay Commission. During technical review (mid-July to September) workgroups may bring specific question to panel/scientists for discussion.

Questions Posed to Panel
Feed Management Goal for P?
Feed Management Goal for N (MUN value to x level)?

Define the practice, is there enough before and after samples for reasonable change?

Framework suggestion: Two levels one at 110% of the recommended NRC level; some percent below 100% of the recommended value
Pushing as low as can while maintaining level of production (fat content, etc.); don't want to harm cow.

How ammonia ties into N feed mgt? Not evaluating individual ammonia control, but when doing N feed management what is the NH4 reduction?

Discussion

<u>BMP Framework</u>
Framework suggestion: Two levels one at 110% of the recommended NRC level; some percent below 100% of the recommended value
Pushing as low as can while maintaining level of production (fat content, etc.); don't want to harm cow.
Two tier with standard at 110% of 80th percentile; offered additional incentive to go to some level below that, provide warranty against lost.

Need to talk about the same number:
NRC makes recommendation for individual cows, but cows are fed in groups. In MD 110%, means 110% for one standard deviation above average cow in group (not 110% of average requirement, but of 80th percentile cow requirement). Thus, in MD feeding better than the average cow, allowing for a 10% buffer (safety requirement). Many producers are above 110% of the recommended NRC level.

With amino acid (Schwab) work, if balance for amino acid and reduce protein, 90% below recommended rate.

Ginny: P reduction not a big deal to lower, but for protein not comfortable reducing feed levels that low due to variability in feed. We'll have a hard sell go below 100%. Do have enough research to document go a certain duration at a lower level? Nutritionists will not be comfortable going below NCS rate.
Rick agrees

In VA feeding levels are 5% above NRC recommended rate, 5-15% above recommended rate, and above 15% of average cow without one standard deviation. In terms of implementation very few producers are below 105%; less than 10% of the population is below 110% of the recommended rate, and the vast majority are 15% above the NRC recommended rate.

Lead factor: Protein need lead factor
Lead factor defined as one standard deviation

PA aiming for 110% and below, narrowing down to 100% (on average) of the NRC recommended rate.

How do jurisdictional feed rates relate now? Reporting between VA, PA, MD requirements (lead factor; percent). Logical explainable consistency:

MD's 110% is higher compared to VA and PA because MD estimates its rate based on the 80th percentile cow.

Management Intensity Framework:

Only getting few percent of operations at 100%, and it is a struggle to get to that level. Not opportunity for credible practice below 100%?
Ginny: combined variability and error in nutritionists feed ration and forage management; can't compensate for loss in milk production with high milk prices
Kathy: with protein and pasture forage hard to get to 100%

100% of 80th percentile cow or average cow?
Use average cow.

Nitrogen Framework
Should BMP be 105 or 110% of average cow? (Just one practice, either 105 or 110):
Charlie: Support one BMP with the caveat that MUN is tracked and didn't fall below a certain threshold
Ginny: agrees, add monitoring intakes and tracking milk production in addition to MUN to BMP requirements
Rick: agree, one level is best; if plot MUN vs herd production per cow don't see low MUN associated with low production, see reverse. Herds with low MUN could get response to adding protein to the diet.
Future Research Need: below 100%

How much risk is there to under feeding protein?
Very little as most herds too much protein.
Negatives of under feeding protein:
With variability in distillers may see more farms deficient in protein.

What is the timeframe for compensation? Will there be abuse?
No, because the BMP is compared against a baseline with a proof ration still balanced for types of protein. Payment is received if you follow the plan as written and get yield reduction. With crops use test strips (with big herds could have test cows).
Think about for future.

Real reluctance to go below NRC standard even though data does not show high impacts to milk yield. But nutritionists still reluctant to formulate rations to get to lower MUN level.
Rick: MD MUN level go below 12; seeing response with regulation, some nutritionists

always below 12 some can't get below 15. HIGHLIGHT: We will be more effective in rewriting NRC, update requirements, then going below NRC. Ginny, Kathy and Charlie agree.

<u>Grazing herds</u>
How handle herds that are grazing?
Kathy: With grazing hard time staying below 100%; study in PA found that no one was below 100%, all above. Study evaluated cows plus total mixed ration (TMR) in barn; some sites changed TMR for season but it made no difference, all above 100%.

In pasture grasses P content is not deficient. May be high, but how high? Most P in root system, doesn't make it into forage level.

VA has some grazing herds on P study. Not lowest P feeding because certain amount of P is available from the forage. Pasture based herds not necessarily best herd to evaluate low level of P achievable without harming animal health or compromising milk yield.

Pasture Based vs Confined
Separate out forage systems for pasture based vs dominantly confined?
All: separate programs, strategies different for two groups.

More controllable feed source for confined herds

N: 105-110% standard
Future Research Need: below 100%

For P, recommended compared to NRC? Is there opportunity for high management intensity or lower level:
Standard: 100% of NRC for average cow for P with no lead factor

What are the risks to production and cow health if P in feed is below 100% if the recommended NRC rate?
Very difficult get down to 100% let alone 90%.
May have to pay more for ingredients to get to any percent below 100. Distillers grains very high in P.
Incentive to pay for additional feed costs (ingredients).

HIGHLIGHT Goal is consistency:
Maintaining over time is key because at one time feed is 100% of the recommended rate while at another time during the year feed is at 115% of the recommended rate.

What is the optimal range?
Account for seasonal effects, cows on pasture, equipment issues, weather, etc.. The BMP will capture the average over time with adaptability to adjust feed rations.

When analyzing MUN range data Rick took out high outliers that couldn't be explained.

The BMP can be the average of 100%, providing allowance for going over one hundred percent certain months. This approach eliminates high outliers that are not able to be explained. Use one level for P, recognizing variability with limits to how variable you can be to encourage consistency in ration.

P content of feed is .35% with no byproduct ingredients; rare go below that.

What is the reduction in ammonia emissions from N feed management?
Fecal part slowly degrades protein, while urea is readily degraded to protein. Urea decreases with feed reductions. MUN directly related to excreted urea.
Is there a significant reduction in ammonia associated with MUN?
Direct correlation with no intercept, the urine a cow excretes is equal to its body weight times a coefficient times MUN.
Need figure out in future how starting, target, animal size, volatilization losses under different settings (weather, etc.) influence emission reductions. Will get some ammonia volatilization benefits from reducing urea excreted.
Rick – quantify reductions as a percentage of the urea produced. Reducing MUN by x% reduces volatilization by the same percent because not changing any other manure or feed management. Reduce amount urea produced, same fraction in the environment is reduced.
N reduction in milk itself is negligible

Total volatilization number not determined, EPA is testing now, so the percent of ammonia emissions reduced via feed management cannot be calculated at this time.
FUTURE RESEARCH NEED

Are we improving N efficiency of cows in general?
Larry Chase created an equation that shows when a cow is more efficient with N then it is excreting less. As efficiency goes up MUN goes down. As N use increases it reaches a threshold and no longer increases.

Tracking and Reporting – reductions in manure N?
With MUN, milk production per cow, number cows, can calculate on a farm

Can report number of cows in this program per county, then use average change to determine average reduction in loss. Local enough level to capture right size of operation.

Give base value, if go beyond must have more detailed reporting to receive additional reductions.

Regional variability:
Further north more time in confinement rather than pasture
Further south more forage production at longer period of time

Make average change in feeding program but manure handling systems vary, effecting overall result of farm pollution.

Baseline
Rick has average tally of MUN's by zipcodes and date (over 3 years); can document feed management changes with MUN.
How different is starting point in feed management? Look at county high and low and with change over time. Is there enough of an impact over the 3 years for it to show up?
ACTION: review Rick's data; representative data of pre BMP condition
Timeline – has mean and deviation soon; hire summer student to do this work

There are substantial differences in starting points within the different regions of the watershed. Amish dominated areas may jump out; larger operations; grazing duration.

Forage:
Can we grow different forages, or change forage management, to give better feed stock for the ration?
Weed control, insect damage: effects quality of feed and how efficient cow uses nutrients
How do nutritionists determine what nutrients the cow gets out of the forage?
Testing pasture. Looking at hay shed, utilizing what they have. Reactionary. Can't supplement lousy forage and get good milk production.

HIGHTLIGHT
Can we improve forage quality to optimize feed management?
More of recommendation to work with forage management program within NRCS. Urge NRCS to work with land grant forage specialist.
If forage is improved (via weed control, insect damage) and feed then the P and N in feed ration is reduced. This will be reflected in the precision feeding level. Not individual BMP; feed ration management and forage production work together.

Our BMP is to achieve N and P percent feeding at a certain level. Whether achieved through less intake via feed or forage is not credit producer, the overall decrease in nutrient intake will be what provides environmental benefit.

Review:

N: *105-110% of NRC*; use MUN as standard
MUN is performance standard (how good the ration is) opposed to technology analysis. MUN is standard across the states. Target of MUN (average 14 nationally) varies. If formulate for NRC get MUN closer to 8-10; basing target on average is not way to do this.
We are trying to encourage improvement, if use MUN, just getting to 12-14 doesn't mean efficiently feeding NRC ration. Herd production determines MUN (12-14 for high production herds vs 8-10 for low production herds). *Target/goal is 8-12 to cover everyone.*

Know average starting point, target for 8-12 (below 12 get payment), and number of cows succeeding in making that reduction = reduction in nitrogen excretion

What year begin determining starting point for MUN?
Go back 2 years of regionally coordinated data, use that data to give BMP its maximum credit.

How BMP express 100% of NRC?
VA – inputs: average milk production for x month, average body weight, sample TMR (analyze for nutrients), dry matter intake

P measurements:
ACTION: Search our data set for P reductions in excreted manure; send strawman out to group for review. Recommend fecal monitoring to identify actual change (like poultry phytase monitoring)

Consistency:
12 month with 3 month intervals
Winter sampling most consistent; November – March avoids factors that introduce variability
Misrepresenting? Theoretically could lower MUN in just winter but show economic benefit so see lower MUN year round.

Year to year comparison based on season. Don't know how controllable spikes in MUN are. High MUN in summer metabolism not as efficient due to high temperature and humidity. Don't want to penalize producers for this.

Higher milk production in spring.
In beginning of spring see end of silage (usually less quality silage) so begin doing weird things to provide food.

Put out on pasture where have high protein.

If don't account for variability (which is all on high side, higher MUN) in winter baseline

EQUP credit: 12 quarterly eliminating high peaks that can't be explained

If peaks are based on management then can penalize, but don't know for sure so we have to leave peaks out. Peaks may be result of one of the natural variables.

HIGHLIGHT Before and after comparison are winter months.

Future Research Need: determine cause of peaks, is it management or natural cycles?

Mean, yearly: 15 MUN

Cool weather 6 month average
Warm weather 6 month average

Items that haven't been discussed:

Need for <u>further research</u> to refine effectiveness estimates –

How time in confinement/pasture management relates to type of animals:
Some state by state numbers (NY, Wisconsin) but not sure other states recording this

Percent time confined vs pasture; or percent nutritional intake?
Access to pasture vs actual pasture intake (dry matter intake); what getting off pasture vs being outside

What percent of the manure is captured in confinement for 3 systems (100% confinement, pasture/confinement percent time variation)?
6 months in barn in PA so decrease by half;

Pasturing may be spring/fall w/ keeping in during summer; or

Kathy ACTION: Pasture lab may have numbers on manure deposited depending on time in confinement/pasture and confinement alone

Agricultural Nutrient and Sediment Reduction Workgroup Meeting Minutes
MD NRCS Office; Annapolis, MD
August 19, 2008

Dairy Feed Management

Report: http://archive.chesapeakebay.net/pubs/calendar/ANRWG_08-19-08_Handout_3_9619.pdf

- Dairy feed management reduces the quantity of phosphorus and nitrogen fed to livestock by formulating diets within 110% of NRC recommended levels in order to minimize the excretion of nutrients without negatively affecting milk production.
- UMD/MAWP describes two ways to determine reductions in manure nutrient content. The first option is to use manure testing. To do this, a database of manure tests could be built that would show what the change in manure content is over time, similar to what was done for poultry litter phytase. In the interim while this database is being built, however, they suggest that a milk urea nitrogen (MUN) value of 8-12 be used for N and that a 25% reduction in manure P excretions at 110% of the NRC recommendation be used for P.
- UMD/MAWP is not suggesting that we track specific farms. Instead, they are suggesting that we use information to determine the average reduction seen over all of the farms in a specific area over a specific time period. Since this information is not available yet, we could start by using a generalized reduction estimate. Overtime though, it would be beneficial if we could quantity reductions based on actual samples.
- There is a very strong correlation between MUN and manure nitrogen, thus MUN can be used to estimate manure N content. MUN is already analyzed by milk coops, so it would not be a new test requirement.
- The proposed P reduction is based off of literature values.
- The BMP panel was concerned about going below 110% at this time. At 100%, some cows in the group would actually be fed below 100%.
- Comments/Suggestions:
    - Change the title of Table 1 from "phosphorus levels" to "phosphorus reduction effectiveness"
    - In the paragraph before Table 1, there is a unit error. 5000 mg should be changed to 5000 kg.
    - A paragraph should be added that discusses the relationship between MUN and manure N content. A graph from Rick Kohn's 2002 paper will be added to support this.
    - The NRCS practice standard should be added to the report.
    - An effectiveness value should be provided for N (a value was already

provided for P).

- When MD NRCS started their feed management program several years ago, the recommendation that they received from the group of experts that they assembled was that feed analysis, rather than manure analysis, should be used since manure analysis is so variable. MD NRCS agrees that MUN should be used for N, but their program looks at TMRs for P.
  - Several members from the MD NRCS panel also served on the panel for the UMD/MAWP project; however, at the panel meeting conducted for this BMP project, the minutes reflect that the panel members supported the use of manure analysis rather than feed analysis.
  - UMD/MAWP agreed to contact panel members regarding this issue.

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Minutes: Agricultural Nutrient and Sediment Reduction Workgroup
September 3, 2008

Dairy Feed Management

- Since the last AgNSRWG meeting, Sarah Weammert talked to the members of the panel and many changed their minds to compromise on doing TMRs to measure the ration and the manure.

- The AgNSRWG members were in favor of testing the Milk Urea Nitrogen (MUN), as it is a proven method and widely used.
- Tom suggested MUN for nitrogen and TMR and manure, as excreted, for phosphorus. This will be clearly stated in report.
- UMD/MAWP will review their references and look for nitrogen book values. If they do not exist, MUN is an acceptable alternative.
- Jeff Sweeney needs a percent reduction from the pre-BMP load.
- Tom Juengst suggested talking to New York because they have a good understanding of tracking and reporting dairy feed management.

DECISION: The AgNSRWG agreed to move forward with the dairy feed management recommendations with the following changes:

- For nitrogen, book values will be used when available, followed by MUN. For phosphorus, TMR and manure, as excreted, will be used when available.
- On page 5 of the report, Sarah Weammert will delete "which is done in Maryland."

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Dairy Precision Feeding

- The dairy precision feeding will use direct testing of what's going in and what's coming out of the animal. Average literature values will be used as a back-up.
- Five phosphorus studies and four nitrogen studies were reviewed. Sarah is looking for more literature on the average nitrogen reductions expected from precision feeding.
- Pennsylvania and New York include diary feed management in their Tributary Strategies, at high levels.
- The Workgroup approved the dairy precision feeding practice.

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Chesapeake Bay Program Nutrient Subcommittee
October 22, 2008 Meeting

SUMMARY OF DECISION, ACTIONS AND ISSUES

Dairy Feed Management

- MUN and TMR are used to estimate changes in manure nutrient content. If this data are not available, the default is the average N and P literature values.
- The Agricultural Nutrient and Sediment Reduction Workgroup stated that programs already exist for this BMP, and these issues were captured in the report.
- Tom Simpson suggested adding language to capture that dried distillers are not used at a level that would offset other reductions.
- Russ Perkinson has experienced some difficulties tracking dairy feed management. He believes the 25% TP reduction is optimistic.
- Fred Samadani questioned whether or not dairy feed management was a legitimate BMP due to continued concerns about manure.
  - Dave Kindig clarified that dairy feed management does not address the volume of manure but the phosphorus levels in the manure.
  - Tom Simpson added that its benefit is that it reduces continued build-up of nutrients.
- The Phase 5 watershed model simulates dairy feed management by reducing the amount of nutrients produced by the animals' manure and, therefore, reducing the amount of manure being applied to the land.
  - Olivia Devereux cautioned that just because there is less nutrient content per unit of manure as a result of dairy feed management, doesn't mean less nutrients will be applied to the land. Farmers will apply manure on their fields based upon the concentration of nutrients in the manure, not upon the volume of manure.
- Kenn Pattison clarified that the Phase 5 watershed model does not apply manure; it applies nitrogen and phosphorus loads from manure.
- Tom Simpson explained that in the model, if a segment has a nutrient imbalance it moves you toward a nutrient balance. If you are already in balance, you shift your source from manure to organic. In the real world, it does the same thing, but it also reduces the buildup of soil phosphorus levels that may currently be at acceptable levels but are moving toward being way beyond agronomic needs.
- Ron Entringer pointed out that if there is a lot less nitrogen coming out of the animal, there is less nitrogen that will volatilize. There are ancillary benefits beyond what the report captures.
- Russ Perkinson is okay with the practice if farmers achieve 110% of NRC recommendation.

DECISION: The Nutrient Subcommittee approved the proposed dairy feed management BMP recommendations, for final decision by the Water Quality Steering Committee, with the revision that farmers must achieve 110 percent of the NRC recommendation to be credited for this BMP efficiency.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
January 21, 2009

II. Review of Year 2 BMP Definitions and Effectiveness Estimates Hansen

Attachment C: Year Two BMP Approval Status

- The Nutrient Subcommittee reviewed the proposed definitions and effectiveness estimates for the Year 2 BMPs.
- These BMPs were also reviewed at last October's NSC meeting, during which four of the eight BMPs were approved with the condition that the requested changes be made. At today's meeting, members heard how these changes were addressed:
  - **Dairy Feed Management:** At the October NSC meeting, members requested that the report state that farmers must achieve 110 percent of the NRCS recommendation to be credited for this BMP efficiency. This statement is now included in the report.

DECISION: The Nutrient Subcommittee approved the definition and effectiveness estimates for four Year 2 BMPs: mortality composting, dairy feed management, ammonia emissions reduction, and infiltration and filtration practices. These BMPs will go to the Water Quality Steering Committee for final approval.

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CHESAPEAKE BAY PROGRAM
WATER QUALITY STEERING COMMITTEE
January 26, 2009 Conference Call

SUMMARY OF DECISIONS, ACTIONS, AND ISSUES

Review and Approval of the Recommended Year 2 BMPs and Efficiencies

Dave Hansen, Nutrient Subcommittee Chair, reviewed Attachment A and updated the Steering Committee on the status of the review process for Year 2 University of Maryland Mid-Atlantic Regional Water Program (UMD/MAWP) BMPs.

Review of Year 2 UMD/MAWP BMP Effectiveness Estimates

- Four BMPs have gone through the review process from the panels up to the Workgroups and were approved (mortality composting, ammonia emissions reduction, dairy feed management, and infiltration/filtration practices. The Water Quality Steering Committee is asked to approve these four BMP definitions and effectiveness estimates.

DECISION: The Water Quality Steering Committee approved the Nutrient Subcommittee's recommended mortality composting, ammonia emissions reduction, dairy feed management, and infiltration/filtration BMP definitions and effectiveness estimates.

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Dry Detention Ponds and Hydrodynamic Structures Best Management Practice

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in the Chesapeake Bay Program's Phase 5.0 Watershed Model

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Department of Environmental Science and Technology

Synthesis by
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University of Maryland/Mid-Atlantic Water Program

Project Manager

And

Sarah E. Weammert

University of Maryland/Mid-Atlantic Water Program

Project Leader

Summary

Dry Detention Ponds are depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms.

Hydrodynamic Structures are devices designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads that are designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.

- Effectiveness Estimates are 5% TN, 10% TP, and 10% TSS

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of

BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

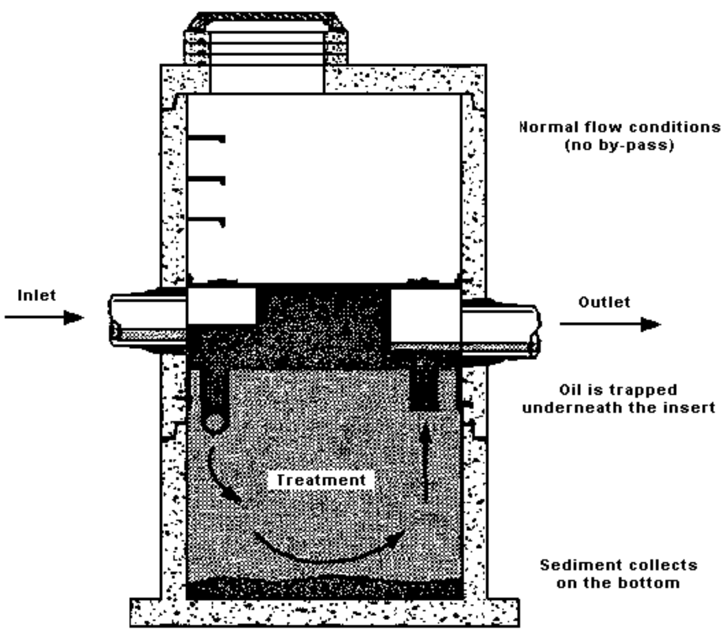
To review efficiencies MAWQ contracted an expert, Dr. Andy Baldwin, and asked him to review applicable literature and propose an efficiency for model calibration based on the literature and their experience. See Appendix A for his report. The objective of this project is to estimate efficiencies that reflect operational conditions and consequently the CBP adopted Andy Baldwin's research scale recommendations. Attached to these definitions and efficiencies is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix B.

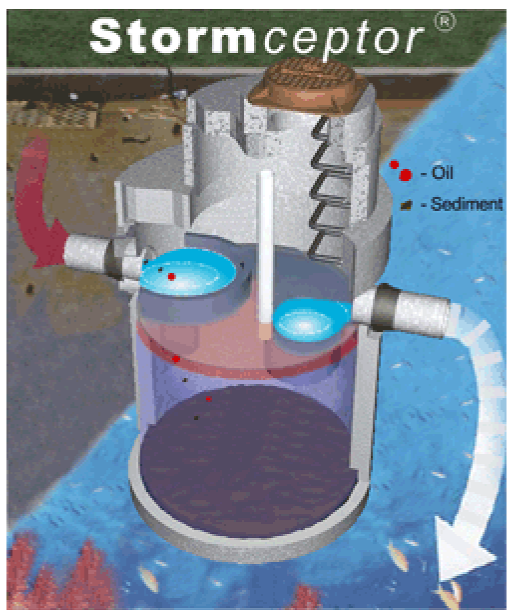
Our workplan included categories determined by the Nutrient Subcommittee (NSC) Urban Stormwater Workgroup (USWG) that included dry detention ponds and hydrodynamic structure as one BMP. During the USWG review process it became apparent that these should be separated into two practices. This report remains consistent with the workplan agreed upon by UMD/MAWP and the CBP and thus describes dry detention ponds and hydrodynamic structures as one BMP. UMD/MAWP agrees with the USWG, the BMP should be separated into two practices. Table 3 in Dr. Baldwin's report provides values the USWG can use to begin estimating the effectiveness for the individual BMPs.

Photograph of BMP

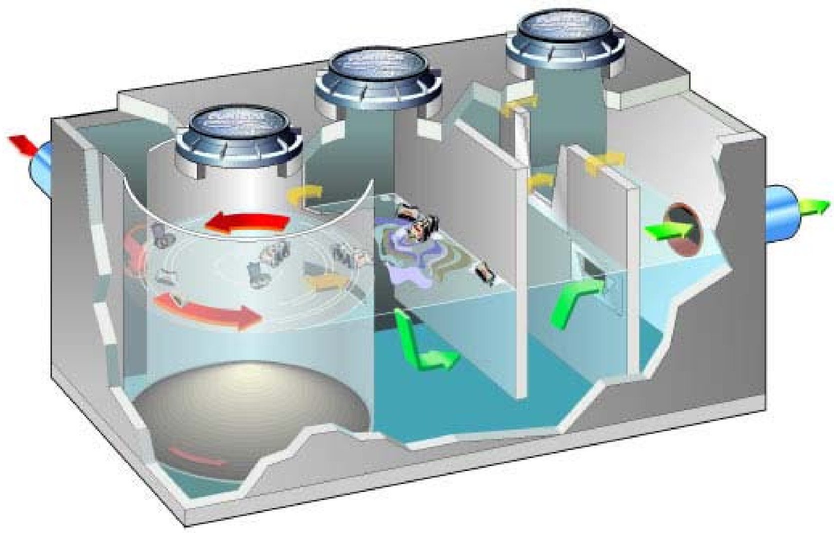
Dry detention pond with grass surface. Source: Chesapeake Bay Program 2006

Dry detention basin. Source: http://www.colonial-heights.com/assets/images/009.jpg





Stormceptor® hydrodynamic device. The unit is installed below grade surface and accessed via a manhole; note ladder in upper chamber for scale. Source: http://www.fhwa.dot.gov/environment/ultraurb/3fs14.htm *and* http://www.rinkerstormceptor.com/images/flow_l.gif.



Vortechs® hydrodynamic device. This is a multi-chambered device installed below-ground that is accessed via manholes. Source: http://www.epa.gov/NE/assistance/ceitts/images/techsimgs/vortechs2.jpg.

Description/Definition

Dry detention basins are depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. Dry detention ponds are designed to dry out between storm events, in contrast with wet ponds, which contain standing water permanently. The surface of the detention basin itself often consists of planted grass, as seen in the photographs above, or can consist of concrete or some other liner. The grassed surfaces require periodic mowing, but may improve trapping of sediments compared with smooth surfaces such as concrete, and may also allow infiltration of stormwater if the underlying soil is permeable. Structures to reduce flow velocity such as rock berms may also be included, for example as seen in the second photograph above. Dry detention basins can also consist of belowground tanks or vaults that temporarily store stormwater.

Hydrodynamic structures are devices designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads that are designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff. These are generally proprietary devices such as Stormceptor®, StormVault®, and Vortechs® that are installed belowground, thereby allowing use of aboveground space for parking or other uses. They also may be effective in removing contaminants that are not removed by less highly-engineered systems. However, they may also require greater maintenance than other BMPs and may not be economical for large runoff volumes.

The water quality functions of dry detention ponds operate primarily by removing suspended particles via settling due to decreased water velocity. If plants such as grasses are present they may further reduce velocity by increasing roughness of the surface. Nitrogen and phosphorus may be removed via settling of particulate forms and plant and microbial uptake. Phosphorus may also sorb to soil particles. Significant removal of nitrate is unlikely because the aerobic soil conditions are not favorable to microbial denitrification. These stormwater BMPs are designed to store surface runoff water and release it slowly to streams, attenuating flood peaks resulting from storms. This hydrologic function of detention basins is often considered a water quality function that helps to reduce stream channel incision, bank erosion, and loss of instream habitat structures that is typical of streams in urban areas with extensive watershed areas covered by impervious surfaces such as building, roads, and parking lots (Schueler 1994).

Detention basins provide little habitat value for organisms other than soil invertebrates, and if they are constructed from cement, even that function is negligible. Hydrodynamic structures provide essentially zero habitat other than for microbial communities.

A number of definitions of various configurations of urban dry detention basin and hydrodynamic structure BMPs have been developed. These include:

- Dry detention ponds and hydrodynamic structure practices are used to moderate flows and remain dry between storm events. These are storm water design features that provide a gradual release of water in order to increase the settling of pollutants and protect downstream channels from frequent storm events. A variety of products for these storm water inlets known as swirl separators, or hydrodynamic structures, are modifications of the traditional oil-grit separator and include an internal component that creates a swirling motion as storm water flows through a cylindrical chamber. These designs allow sediment to settle out as storm water moves in this swirling path. Additional compartments or chambers are sometimes present to trap oil and other floatables. (Chesapeake Bay Program 2006)

- Dry Pond: Designed to moderate influence on peak flows and drains completely between storm events (Idaho Department of Environmental Quality 1998).

- Underground Dry Detention Facility: Designed to dry out between storms and provides storage below ground in tanks and vaults (Idaho Department of Environmental Quality 1998).

- Hydrodynamic structures are not considered a stand alone BMP. They act similar to a dry detention pond and therefore are included in this group.

Efficiency

The removal efficiencies for dry detention basins and hydrodynamic structures used in the Chesapeake Bay watershed model are currently 5%, 10%, and 10% for nitrogen (N), phosphorus (P), and sediment, respectively. To evaluate the validity of these numbers, a review of peer-review and gray literature was conducted. Removal efficiencies found in the literature were summarized and used as a basis for validating or changing currently used efficiencies.

Literature Review and Data Analysis Methods

Gray literature such as reports, web sites, and other information not subjected to the peer-review process was obtained through material already in hand, contacts with the Center for Watershed protection, references listed in refereed and gray literature already in hand, and web searches. Literature in peer-reviewed journals was identified using electronic databases such as ISI Web of Science.

Literature was reviewed to find removal efficiency data for suspended solids (generally Total Suspended Solids, TSS) and various forms of nitrogen and phosphorus (including total nitrogen, ammonia/ammonium, nitrate/nitrite, total phosphorus, and phosphate). Data for other measures or forms of solids, nitrogen, and phosphorus were occasionally reported (e.g. dissolved solids, organic N and P), and these are included in the appendix . Occasionally there were slightly different analyses (e.g. total N versus total Kjeldahl N; nitrate and nitrite analyzed separately or combined), but in general it was possible to lump results under six primary headings (each abbreviated here as shown in parentheses): Total Suspended Solids (TSS); Total Nitrogen (TN); nitrate and/or nitrite nitrogen (NO3); ammonium or ammonia nitrogen (NH4); Total Phosphorus (TP); and ortho-phosphate or reactive/soluble phosphate (PO4). For the purposes of this report, however, statistical analyses were performed only for TN, TP, and TSS.

While the goal of this review is to develop or validate specific removal rating values, it is important to keep in mind that considerable variation exists between studies in methods for sample collection, chemical or physical analysis, experimental design, and data analysis. Even the calculation of removal efficiency, a seemingly straightforward concept, can be approached using at least four different methods (Strecker et al. 2001). In this review, the two primary methods were calculation of efficiency based on either 1) change in parameter concentration between inflow and outflow, or 2) percentage of mass of influent pollutants removed, which can result in markedly different efficiency removal efficiency values, even for the same data set. In many cases in this review, removal efficiencies were not reported, but influent and effluent concentration data (e.g., Event Mean Concentration, EMC) were presented that were used to calculate percent removal.

Recently, the concept of removal efficiencies itself has been questioned, and the use of "effluent quality," or the concentrations of pollutants in BMP effluent, has been recommended as a more robust measure of the effectiveness of BMPs for water quality improvement than removal efficiency values (Strecker 2001). A recent comprehensive review of the International BMP Database (BMP Database 2007), Rea and Traver (2005) report well-analyzed effluent concentration data for various BMPs, but present no removal efficiency values, indicating a shift in the state-of-the-art method for evaluating BMPs.

The literature found in this review was divided into two groups: a) studies of individual BMP project sites ("single-site" studies); and b) studies that reviewed or averaged performance for multiple sites or design ratings for particular BMPs based on multiple sites or professional judgment ("multi-site" studies). The studies of individual sites were analyzed separately from the multi-site studies because the latter typically relied on studies of some of the single sites. Single-site studies were limited to those that occurred in the eastern U.S., defined as those sites east of the Mississippi River. Some of the multi-site studies likely include some sites from elsewhere in the U.S., and possibly Canada.

Removal efficiencies were first summarized in tabular format for single-site studies (Appendix A) and multi-site studies. Summary statistics for TN, TP, and TSS were then calculated and tabulated (mean, standard error (SE), median, minimum, maximum, and number of values (N)). Statistics were not calculated for multi-site studies since only two studies were found. Finally, a frequency analysis of removal efficiencies was performed for single- site studies to graphically present the distribution of efficiencies.

Results of Literature Review

Removal efficiency information was found for a range of different individual dry detention basins and hydrodynamic structures across the eastern U.S. (Appendix B). Average removal was about 50%, 10%, and 40% for TSS, TN, and TP, respectively (Table 1). Median values were considerably higher than the mean for TSS, indicating skewing toward low removal efficiencies (i.e., there were a few sites with very low efficiencies that disproportionately reduced the average). Skewing is also reflected in Fig. 1, which shows a clumping of sites with removal efficiencies in the range of 60-100% and few studies with low or negative efficiencies. The median efficiency for TN is also higher than the mean, but there are so few data points that meaningful inference cannot be made. In contrast, removal efficiencies for TP are skewed somewhat positive, as reflected in an average above the median (Table 1) and a clumping of sites with efficiencies of 10-70% and a group with efficiencies of 70-80%.

There was considerably variability in removal efficiency as reflected by high standard deviations, particularly for TSS and TN, which had standard deviations greater than the mean. Removal rates for TSS ranged from extremes of about -50 to almost 100%.

In interpreting removal efficiency results, it is important to bear in mind that a large positive or negative efficiency value can result from very small changes in chemical concentration (e.g., a change from 0.01 mg/L TP at the inflow to 0.03 mg/L at the outflow results in a removal efficiency of -200%, but these low concentrations are within ranges occurring in many natural waters).

The average removal efficiencies calculated for individual sites are within the range of those reported by multiple-site review or design guideline studies for TSS, although the median removal rate for individual sites was higher (Table 2). Removal of TN for single sites was below multi-site efficiencies, but again there were few single-site studies of TN removal. Total phosphorus removal for single sites was about twice as high (about 40%) as values reported in multi-site studies (about 20%).

The higher removal efficiencies for the single-site studies for TP and TSS are possibly because hydrodynamic structures were not included in the Winer (2000) and Schueler (1997) multi-site studies presented in Table 2. Calculation of summary statistics separately for dry detention basins and hydrodynamic structures (Table 3) indicates that median removal efficiencies for TSS and particularly TP by hydrodynamic devices are greater than for dry detention ponds. The opposite is true for TN; hydrodynamic devices appear to result in negative removal efficiencies of nitrogen (possibly due to a lack of vegetation for nutrient uptake).

Recommended Removal Efficiencies for Model

The results of this literature indicate that the removal efficiencies currently used in the Chesapeake Bay model are too low. The CBP, however, feels the current effectiveness estimates should not be increased. The justification is based on the Urban Stormwater Workgroup statements that dry detention ponds/basins and hydrodynamic structures are not effective practices when compared to other stormwater practices such as wet ponds and wetlands. After reviewing all the effectiveness estimates for the urban stormwater practice it became evident that the estimates for dry detention ponds/basins and hydrodynamic structures recommended by Dr. Baldwin were more reflective of conditions in wet ponds and wetlands. The CBP lowered the effectiveness estimates for dry detention ponds/basins and hydrodynamic structures so the estimates for wet ponds and wetlands are higher. One concern is that the review process should have focused on new literature; however, the weight of evidence is from the 1980s. There is also concern that raising the effectiveness estimate will encourage the use of this practice over other urban stormwater practices such as wetlands and wet ponds that provide other benefits in addition to water quality improvement.

The CBP approved effectiveness estimates for Dry Detention Ponds/Basins and Hydrodynamic Structures were not changed based on the recommendation of the USWG. However, the function and actual effectiveness of these structures needs further evaluation since available literature does suggest somewhat higher removal rates than those supported by the USWG:

TN 5%
TP 10%
TSS 10%

Variability in Effectiveness

Changes in factors relating to soil, vegetation, or hydrologic conditions may alter the effectiveness of dry detention ponds and hydrodynamic structures or removal of suspended solids or nutrients. For example, longer detention times will in general tend to improve efficiency due to increased contact between water and soil or microbial surfaces and vegetation, as well as longer times for settling of particulates. Longer detention times can be created by increasing the area or volume of dry detention ponds and hydrodynamic structures relative to drainage area entering the system, or conversely by reducing the volume of runoff entering the pond or structure. Efficiency can also be affected by the geomorphology of the unit; designs that maximize the area of contact between water and soil, vegetation, or microbial surfaces should in general increase efficiency (e.g., long, linear ponds with shallow water depth are likely to be more effective than deep, concave basins of the same volume). Increased vegetation density and biomass is also likely to improve efficiency because of greater uptake, more microbial surface area, and increased oxidation of the root zone. Because vegetation structure and composition are temporally dynamic, efficiency may also vary, but should approach a dynamic equilibrium after some period of time, probably measured in years. While microbial removal processes that affect nitrogen removal are sustainable indefinitely under relative constant environmental conditions, soil surfaces may become phosphorus-saturated, and further phosphorus sorption is therefore not possible. Depending on the soil type and phosphorus loading rates, saturation may take many years, if it occurs at all. Capacity for sediment removal may also be impeded if high loading rates result in clogging or burial of vegetation. Additionally, high flow rates may lead to the formation of preferential flow pathways that reduce contact between water and microbes, soil, or vegetation. These and other variables may lead to changes in the efficiency of dry detention ponds or hydrodynamic structures for stormwater quality improvement over time. Some processes may increase efficiency (e.g. peat formation) while other processes may simultaneously decrease efficiency (e.g. channel formation).

Climatic variables may also affect BMP performance over time, either positively or negatively. Periods of greater precipitation will likely result in shorter residence times, or even bypassing of the BMP due to high flow volumes, both of which will reduce performance. On the other hand, higher temperatures should increase metabolic rates, increasing growth of microbes and plants and facilitating greater transformation and uptake of nutrients. Global climate change may therefore affect performance by changing precipitation patterns and temperature in unpredictable ways. An additional factor is higher CO2 concentrations, which may result in shifts toward species competitively favored under high atmospheric CO2 levels. Changes in species composition may have some effect on performance, although effects are likely to be small unless there are large changes in stem density or biomass.

As mentioned previously, there is considerable variation in the performance of dry detention basins and hydrodynamic structures. Performance may vary over time, and in some cases high volume runoff events may bypass the system, resulting in little removal for large volumes of runoff. Maintenance of these BMPs is important, particularly for the hydrodynamic structures, which require periodic cleanout of sediment and absorbent materials, if present. The low or negative removal rates for TN reported for hydrodynamic structures compared with the comparatively higher rates for detention ponds suggest that vegetation plays an important role in removing nitrogen. Detention ponds should continue to function effectively for years without any significant maintenance other than mowing (which may not be critical for optimum performance).

Periodic inspections should be performed to identify changes in hydrology, vegetation, or soils like those described above so that remedial measures can be taken in necessary. Particularly when systems are new, it is important to make sure water levels along the surface of the detention basin are suitable for the growth and persistence of vegetation. Development of channels or other evidence of erosion should be dealt with expeditiously, for example by diverting some portion of the runoff, installing rock berms, or otherwise decreasing flow velocities in the BMP.

While no studies have specifically evaluated how BMP efficiencies should be adjusted to account for the impacts of improper maintenance on receiving waters, some general adverse effects to water quality are understood. If maintenance is neglected a BMP may become impaired, no longer providing its designed functions. Proper maintenance of outlet structures, flow splitters and clean out gates is key to achieving a BMPs designed efficiency (Koon 1995).

In addition, sediment accumulation is one maintenance concern that if not addressed may adversely affect the BMPs effectiveness. As sediment accumulates it decreases storage volume and detention time, bypassing the intended functions of the BMP and increasing discharge of nutrient and sediment rich stormwater (Livingston et al. 1997). Increased discharge will lead to decreased downstream channel stability, resulting in an increase of sediment loads and a reduction in available aquatic habitat. The consequences of increased stormwater discharges from sediment filled BMPs, are a reduction in the BMPs pollution removal efficiencies, and ultimately, increased ecological impairments. The uncertainty in how improper maintenance will adjust BMP efficiencies supports the recommendation to use a more conservative percent removal estimate.

Future Research Needs

It is recommended that this BMP be separated into two practices. The definition and designs of these practices are not similar and to better represent their individual functions and benefits the practices should be separated into 1. dry detention ponds and 2. hydrodynamic structures. In addition, the USWG believes the individual BMPs are probably appropriate for the calibration period of 1985 to 2002, but from now on, the workgroup would like to move toward a systems approach.

The fact that the Best Management Practice (BMP) project conducted by the Mid-Atlantic Water Quality Program-University of Maryland (MAWQ-UMD) did not address "treatment trains" has been brought up on several occasions. The MAWQ-UMD conducted its review as instructed in the scope of work provided and approved by both MAWQ-UMD and the Chesapeake Bay Program. The workplan identified the BMPs to be reviewed and stated that TN, TP and TSS percent removal efficiencies should be reviewed for inclusion in calibration of the watershed model. The workplan, however, also instructed project staff to compile a list of future research needs. Upon review of the urban stormwater BMPs it became obvious that the current practice categories and the individual treatment of effectiveness is not appropriate. However, there was not enough time or funding in the current project to determine effectiveness for treatment systems/trains but this should be done in the future.

As mentioned previously, the concept of "effluent quality" has been recommend over the use of removal efficiencies such as those that have been presented here and upon which the recommended values for the Chesapeake Bay model were based (Strecker et al. 2001). While the use of removal efficiencies in a modeling landscape or watershed transformation or removal or nutrients and sediments makes sense in theory, in practice problems arise due to the different methods used in calculating removal (e.g. load- vs. concentration-based) and small absolute changes in concentration or load resulting in large percentage changes, to name two examples. Furthermore, it is currently recognized (e.g., Kadlec and Knight 1996) that "natural" systems such as dry detention ponds constructed with vegetation and not concrete or liners, are not capable of removal of pollutants below a certain "background" concentration, a phenomenon not often considered when removal efficiencies are used in modeling or design efforts. Adoption of an "effluent quality" approach however, recognizes that for a specific flow volume and above a certain minimum design size, most BMPs will remove pollutants to some constant background concentration, irregardless of additional increased in BMP area or volume. This approach could be applied in the Bay model by assigning the same effluent concentrations to BMPs of certain watershed:BMP size ratio. In addition to using effluent quality as a measure of BMP performance rather than removal efficiencies, Strecker et al. (2001) recommends using living resource restoration indicators, such as aquatic invertebrate sampling and habitat classification, in addition to calculating effectiveness by using chemical measures.

Strecker et al (2001) recommend parameters that all studies should include, but are often missing. These include transferable measures of storage volume, surcharge detention volumes, stage/storage data, watershed characteristics, and land use information. Winer (2000) also recommends incorporating individual storm parameters, specifically bacteria, hydrocarbons, dissolved metals, as they correlate with human health, recreation and aquatic toxicity and are often not reported. Not only do many studies lack the aforementioned parameters, studies also make translation of available design parameters difficult. To ensure studies begin using these recommendations Strecker et al. state that the EPA require all federally funded projects that will evaluate BMP effectiveness employ standard methods they discuss, and in addition, that the EPA provide detailed guidance on data collection and sampling methods to improve data transferability (2001).

No Impact Development

The concept of low impact development (LID), the use of proper site design techniques that reduces stormwater volume and pollution runoff, has been implemented across the Chesapeake Bay watershed for close to two decades. A refined version of LID, no impact development (NID), is currently being recommended as the new approach to urban development. NID claims to result in hydrologic and nutrient and sediment losses comparable to forest or natural meadows. UMD/MAWQ cautions against the adoption and assumption of effectiveness estimates for NID without further research to quantify its actual ability to reduce stormwater runoff and nutrient pollution. Current literature and practice implementation does not support the achievement of forest or natural meadow like conditions. Substantial research should be conducted before forest or meadow like hydrologic and pollution losses are assumed to be implemented on developed lands.

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Table 1. Summary of removal efficiency (%) for dry detention basins and hydrodynamic structures. Mean and standard error are plotted in Fig. 1. Results of all studies reviewed and for different forms of nitrogen and phosphorus are included in Appendix A.

Statistic	TSS (Total Suspended Solids)	TN (Total Nitrogen)	TP (Total Phosphorus)
Average	54	13	43
Standard Deviation	47.6	31.2	27.8
Standard Error	10.9	12.7	7.2
Median	75	18	38
Minimum	-52	-30	-3
Maximum	98	44	88
N	9	6	15

Table 2. Multi-site studies reporting removal efficiencies (%) for dry detention basins. No multi-site studies were found for hydrodynamic structure efficiencies.

TSS (Total Suspended Solids)	TN (Total Nitrogen)	TP (Total Phosphorus)	Reference
47	25	19	Winer 2000
61	31	19	Schueler (1997) in USEPA 2007

Table 3. Summary statistics calculated separately for dry detention basins and hydrodynamic structures.

Parameter	**Statistic**	**Dry detention basins**	**Hydrodynamic structures**
TSS	Average	52	55
	Standard deviation	51.9	46.9
	Standard error	18.3	14.1
	Median	72	76
	Minimum	-52	-42
	Maximum	96	98
	N	8	11
TN	Average	27	-14
	Standard deviation	26.2	22.6
	Standard error	13.1	15.9
	Median	38	-14
	Minimum	-12	-30
	Maximum	44	1
	N	4	2
TP	Average	45	42
	Standard deviation	27.1	30.8
	Standard error	9.6	11.6
	Median	35	46
	Minimum	12	-3
	Maximum	85	88
	N	8	7

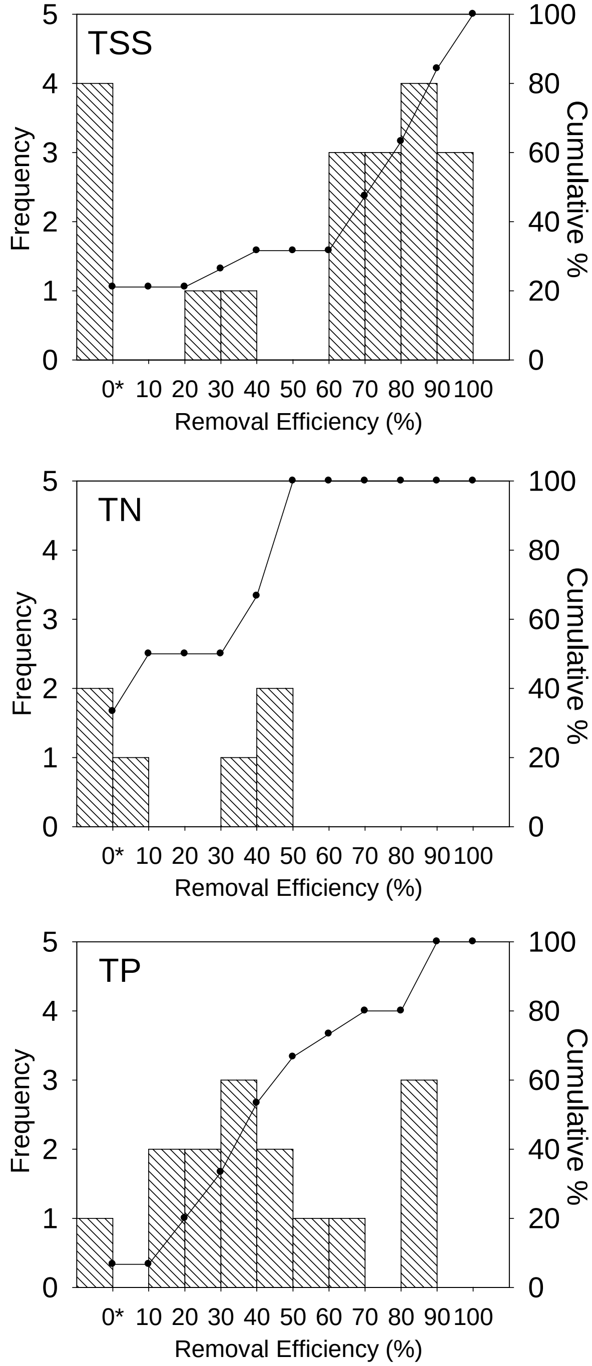

Fig. 1. Frequency analysis of removal efficiencies for single-site studies. Frequency (number of reported values) in removal-efficiency increments of 10 % (e.g. 10-20%, 20-30%, etc.) is plotted on the left axis and as bars. The cumulative percentage of studies reporting values within each removal-efficiency increment is plotted on the right axis as circular symbols connected by lines. The 0* category includes any studies reporting efficiencies of 0% or less (i.e. net efflux)

Appendix B . Summary of literature on the pollutant removal effectiveness (%) of individual dry detention basins (DDB) and hydrodynamic structures (HS) as Best Management Practices for urban and mixed open land uses. TSS = Total Suspended Solids, TN = Total Nitrogen, NO3 = Nitrate and/or nitrite, NH4 = Ammonia or ammonium, TP = Total Phosphorus, PO4 = reactive or ortho-phosphate. Calculation method:C = concentration-based; L = Load-based; NS = Not specified; O = Other.

Type	System name	Location	TSS	TN	NO3	NH4	TP	PO4	Calc. Method	Comments	Refer
DDB	Massie Pond	Charlottesville, VA	64				59		C	Average of 11 storms	Shoen
DDB	Sussex Basin		-52	41			38	-6	L	Average of 4 storms	Barton 1999
DDB	Greenville Pond		68						L	Mean pond treatment efficiency	Stanle
DDB	Brooke Detention Pond	Brooke, VA					12	19	C	Generally based on several storm events	BMP (2007
DDB	Greenville Pond	Greenville, NC	75	35	6		27	8	C	Generally based on several storm events	BMP (2007
DDB	Oakhampton Dry Basin	Hampton, MD	88		9	44	33	-47	C	Generally based on several storm events	BMP
DDB	Twin Towers Dry Pond	Tallahassee, FL	-4	-12	5	-78	23	26	C	Generally based on several storm events	BMP (2007
HD	CDS Unit	Williams Point, FL	-9				12		C	Generally based on several storm events	BMP
HD	MCTT Catchbasin	Birmingham, AL	24		0	9		-5	C	Generally based on several storm events	BMP
HD	MCTT Main Settling Chamber	Birmingham, AL	88		-11	-41		5	C	Generally based on several storm events	BMP (2007
HD	MCTT Milwaukee	Milwaukee, WI	98		33	36	88	74	C	Generally based on several storm events	BMP (2007
HD	MCTT Minocqua	Minocqua, WI	94				47		C	Generally based on several storm events	BMP
HD	Stormceptor STC 3600	Charlottesville, VA	76	-30			65		C	Generally based on several storm events	BMP
HD	Sunset Park Baffle Box #2	Indialantic, FL	67				46		C	Generally based on several storm events	BMP (2007
HD	Urban Storm treatment unit	Madison, WI	-42		10	8		31	C	Generally based on several storm events	BMP (2007
HD	UVA Stormvault Phase I	Charlottesville, VA	32						C	Generally based on several storm events	BMP (2007
HD	UVA Stormvault Phase II	Charlottesville, VA	85				38		C	Generally based on several storm events	BMP (2007
HD	Vortechs Stormwater Treatment System	Lake George, NY	88	1			-3		C	Generally based on several storm events	BMP (2007
DDB	Dry detention pond	NS	80				85		NS	Midpoint of range	Yu et Shoen
DDB	Dry detention pond	NS	96	44	64		81		NS		Yu et Shoen

Appendix A. Original Report Submitted by Andy Baldwin

Dry Detention Ponds and Hydrodynamic Structures Best Management Practice Definition and Nutrient and Sediment Reduction Efficiencies For use in calibration of the Chesapeake Bay Program's Phase 5.0 Watershed Model

Recommendations for Formal Approval by the Nutrient Subcommittee's Tributary Strategy and Urban Stormwater Workgroups

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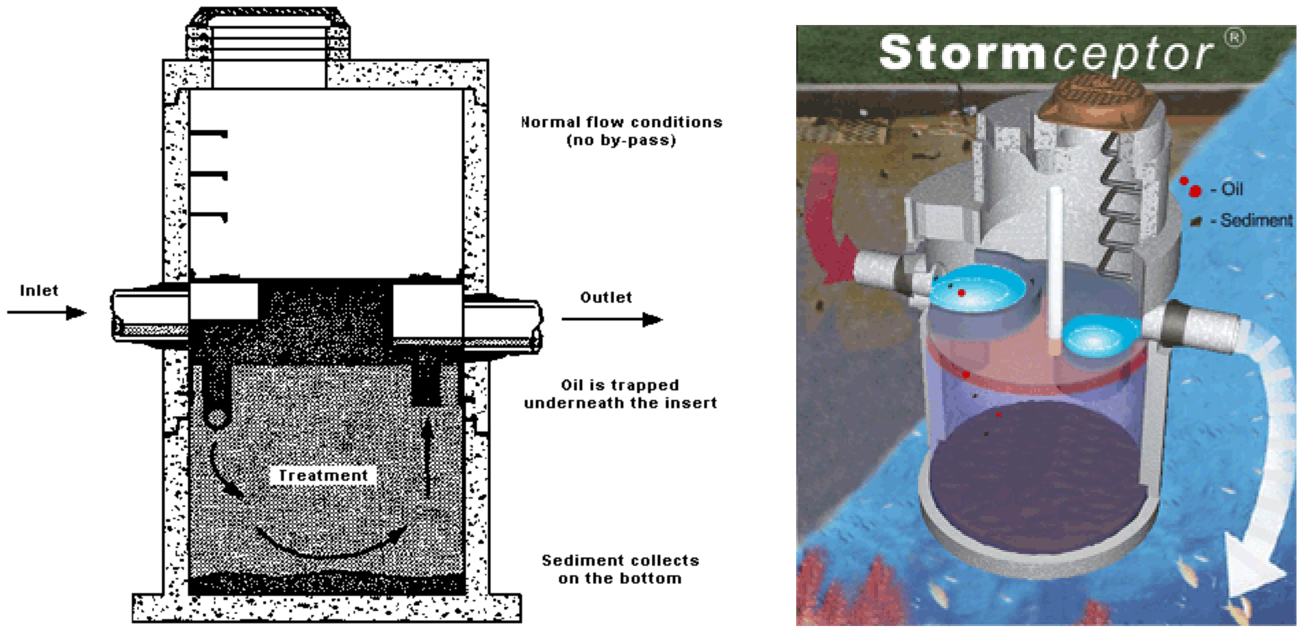
Introduction

This document summarizes the recommended definition and nutrient and sediment reduction efficiencies for the Urban Dry Detention Ponds and Hydrodynamic Structures Best Management Practice for review and final approval by the Tributary Strategy Workgroup and Urban Stormwater Workgroup. Included in these recommendations is a full accounting of the Chesapeake Bay Program's discussions on this BMP and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed.

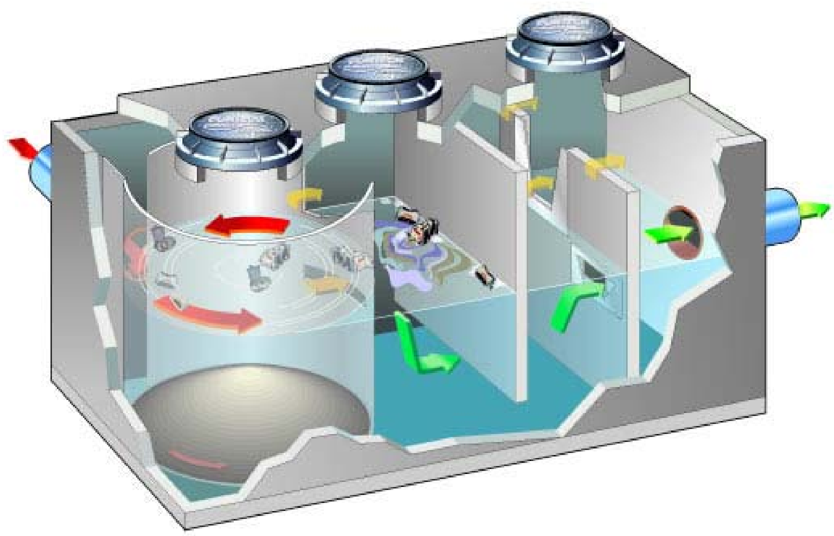
Photograph of BMP

Dry detention pond with grass surface. Source: Chesapeake Bay Program 2006

Dry detention basin. Source: http://www.colonial-heights.com/assets/images/009.jpg



Stormceptor® hydrodynamic device. The unit is installed below grade surface and accessed via a manhole; note ladder in upper chamber for scale. Source: http://www.fhwa.dot.gov/environment/ultraurb/3fs14.htm *and* http://www.rinkerstormceptor.com/images/flow_1.gif.



Vortechs® hydrodynamic device. This is a multi-chambered device installed below-ground that is accessed via manholes. Source: http://www.epa.gov/NE/assistance/ceitts/images/techsimgs/vortechs2.jpg.

Description/Definition

Dry detention basins are depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. Dry detention ponds are designed to dry out between storm events, in contrast with wet ponds, which contain standing water permanently. The surface of the detention basin itself often consists of planted grass, as seen in the photographs above, or can consist of concrete or some other liner. The grassed surfaces require periodic mowing, but may improve trapping of sediments compared with smooth surfaces such as concrete, and may also allow infiltration of stormwater if the underlying soil is permeable. Structures to reduce flow velocity such as rock berms may also be included, for example as seen in the second photograph above. Dry detention basins can also consist of belowground tanks or vaults that temporarily store stormwater.

Hydrodynamic structures are devices designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads that are designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff. These are generally proprietary devices such as Stormceptor®, StormVault®, and Vortechs® that are installed belowground, thereby allowing use of aboveground space for parking or other uses. They also may be effective in removing contaminants that are not removed by less highly-engineered systems. However, they may also require greater maintenance than other BMPs and may not be economical for large runoff volumes.

The water quality functions of dry detention ponds operate primarily by removing suspended particles via settling due to decreased water velocity. If plants such as grasses are present they may further reduce velocity by increasing roughness of the surface. Nitrogen and phosphorus may be removed via settling of particulate forms and plant and microbial uptake. Phosphorus may also sorb to soil particles. Significant removal of nitrate is unlikely because the aerobic soil conditions are not favorable to microbial denitrification. These stormwater BMPs are designed to store surface runoff water and release it slowly to streams, attenuating flood peaks resulting from storms. This hydrologic function of detention basins is often considered a water quality function that helps to reduce stream channel incision, bank erosion, and loss of instream habitat structures that is typical of streams in urban areas with extensive watershed areas covered by impervious surfaces such as building, roads, and parking lots (Schueler 1994).

Detention basins provide little habitat value for organisms other than soil invertebrates, and if they are constructed from cement, even that function is negligible. Hydrodynamic structures provide essentially zero habitat other than for microbial communities.

A number of definitions of various configurations of urban dry detention basin and hydrodynamic structure BMPs have been developed. These include:

- Dry detention ponds and hydrodynamic structure practices are used to moderate flows and remain dry between storm events. These are storm water design features that provide a gradual release of water in order to increase the settling of pollutants and protect downstream channels from frequent storm events. A variety of products for these storm water inlets known as swirl separators, or hydrodynamic structures, are modifications of the traditional oil-grit separator and include an internal component that creates a swirling motion as storm water flows through a cylindrical chamber. These designs allow sediment to settle out as storm water moves in this swirling path. Additional compartments or chambers are sometimes present to trap oil and other floatables. (Chesapeake Bay Program 2006)

- Dry Pond: Designed to moderate influence on peak flows and drains completely between storm events (Idaho Department of Environmental Quality 1998).

- Underground Dry Detention Facility: Designed to dry out between storms and provides storage below ground in tanks and vaults (Idaho Department of Environmental Quality 1998).

- Hydrodynamic structures are not considered a stand alone BMP. They act similar to a dry detention pond and therefore are included in this group.

Efficiency

The removal efficiencies for dry detention basins and hydrodynamic structures used in the Chesapeake Bay watershed model are currently 5%, 10%, and 10% for nitrogen (N), phosphorus (P), and sediment, respectively. To evaluate the validity of these numbers, a review of peer-review and gray literature was conducted. Removal efficiencies found in the literature were summarized and used as a basis for validating or changing currently used efficiencies.

Literature Review and Data Analysis Methods

Gray literature such as reports, web sites, and other information not subjected to the peer-review process was obtained through material already in hand, contacts with the Center for Watershed protection, references listed in refereed and gray literature already in hand, and web searches. Literature in peer-reviewed journals was identified using electronic databases such as ISI Web of Science.

Literature was reviewed to find removal efficiency data for suspended solids (generally Total Suspended Solids, TSS) and various forms of nitrogen and phosphorus (including total nitrogen, ammonia/ammonium, nitrate/nitrite, total phosphorus, and phosphate). Data for other measures or forms of solids, nitrogen, and phosphorus were occasionally reported (e.g. dissolved solids, organic N and P), and these are included in the appendix . Occasionally there were slightly different analyses (e.g. total N versus total Kjeldahl N; nitrate and nitrite analyzed separately or combined), but in general it was possible to lump results under six primary headings (each abbreviated here as shown in parentheses): Total Suspended Solids (TSS); Total Nitrogen (TN); nitrate and/or nitrite nitrogen (NO3); ammonium or ammonia nitrogen (NH4); Total Phosphorus (TP); and ortho-phosphate or reactive/soluble phosphate (PO4). For the purposes of this report, however, statistical analyses were performed only for TN, TP, and TSS.

While the goal of this review is to develop or validate specific removal rating values, it is important to keep in mind that considerable variation exists between studies in methods for sample collection, chemical or physical analysis, experimental design, and data analysis. Even the calculation of removal efficiency, a seemingly straightforward concept, can be approached using at least four different methods (Strecker et al. 2001). In this review, the two primary methods were calculation of efficiency based on either 1) change in parameter concentration between inflow and outflow, or 2) percentage of mass of influent pollutants removed, which can result in markedly different efficiency removal efficiency values, even for the same data set. In many cases in this review, removal efficiencies were not reported, but influent and effluent concentration data (e.g., Event Mean Concentration, EMC) were presented that were used to calculate percent removal.

Recently, the concept of removal efficiencies itself has been questioned, and the use of "effluent quality," or the concentrations of pollutants in BMP effluent, has been recommended as a more robust measure of the effectivness of BMPs for water quality improvement than removal efficiency values (Strecker 2001). A recent comprehensive review of the International BMP Database (BMP Database 2007), Rea and Traver (2005) report well-analyzed effluent concentration data for various BMPs, but present no removal efficiency values, indicating a shift in the state-of-the-art method for evaluating BMPs.

The literature found in this review was divided into two groups: a) studies of individual BMP project sites ("single-site" studies); and b) studies that reviewed or averaged performance for multiple sites or design ratings for particular BMPs based on multiple sites or professional judgment ("multi-site" studies). The studies of individual sites were analyzed separately from the multi-site studies because the latter typically relied on studies of some of the single sites. Single-site studies were limited to those that occurred in the eastern U.S., defined as those sites east of the Mississippi River. Some of the multi-site studies likely include some sites from elsewhere in the U.S., and possibly Canada.

Removal efficiencies were first summarized in tabular format for single-site studies (Appendix A) and multi-site studies. Summary statistics for TN, TP, and TSS were then calculated and tabulated (mean, standard error (SE), median, minimum, maximum, and number of values (N)). Statistics were not calculated for multi-site studies since only two studies were found. Finally, a frequency analysis of removal efficiencies was performed for single- site studies to graphically present the distribution of efficiencies.

Results of Literature Review

Removal efficiency information was found for a range of different individual dry detention basins and hydrodynamic structures across the eastern U.S. (Appendix A). Average removal was about 50%, 10%, and 40% for TSS, TN, and TP, respectively (Table 1). Median values were considerably higher than the mean for TSS, indicating skewing toward low removal efficiencies (i.e., there were a few sites with very low efficiencies that disproportionately reduced the average). Skewing is also reflected in Fig. 1, which shows a clumping of sites with removal efficiencies in the range of 60-100% and few studies with low or negative efficiencies. The median efficiency for TN is also higher than the mean, but there are so few data points that meaningful inference cannot be made. In contrast, removal efficiencies for TP are skewed somewhat positive, as reflected in an average above the median (Table 1) and a clumping of sites with efficiencies of 10-70% and a group with efficiencies of 70-80%.

There was considerably variability in removal efficiency as reflected by high standard deviations, particularly for TSS and TN, which had standard deviations greater than the mean. Removal rates for TSS ranged from extremes of about -50 to almost 100%.

In interpreting removal efficiency results, it is important to bear in mind that a large positive or negative efficiency value can result from very small changes in chemical concentration (e.g., a change from 0.01 mg/L TP at the inflow to 0.03 mg/L at the outflow results in a removal efficiency of -200%, but these low concentrations are within ranges occurring in many natural waters).

The average removal efficiencies calculated for individual sites are within the range of those reported by multiple-site review or design guideline studies for TSS, although the median removal rate for individual sites was higher (Table 2). Removal of TN for single sites was below multi-site efficiencies, but again there were few single-site studies of TN removal. Total phosphorus removal for single sites was about twice as high (about 40%) as values reported in multi-site studies (about 20%).

The higher removal efficiencies for the single-site studies for TP and TSS are possibly because hydrodynamic structures were not included in the Winer (2000) and Schueler (1997) multi-site studies presented in Table 2. Calculation of summary statistics separately for dry detention basins and hydrodynamic structures (Table 3) indicates that median removal efficiencies for TSS and particularly TP by hydrodynamic devices are greater than for dry detention ponds. The opposite is true for TN; hydrodynamic devices appear to result in negative removal efficiencies of nitrogen (possibly due to a lack of vegetation for nutrient uptake).

Recommended Removal Efficiencies for Model

The results of this literature indicate that the removal efficiencies currently used in the Chesapeake Bay model are too low. Specifically, the following removal efficiencies are justified by this review of scientific and technical literature:

Sediment (TSS):	50%	(currently 10%)
Nitrogen (TN):	15%	(currently 5%)
Phosphorus (TP):	35%	(currently 10%)

These values are considerably higher than those currently used in the model. The value for TP is supported by the most references from the literature (15), while that of TN is supported the least (6 references).

Changes in factors relating to soil, vegetation, or hydrologic conditions may alter the effectiveness of dry detention ponds and hydrodynamic structures or removal of suspended solids or nutrients. For example, longer detention times will in general tend to improve efficiency due to increased contact between water and soil or microbial surfaces and vegetation, as well as longer times for settling of particulates. Longer detention times can be created by increasing the area or volume of dry detention ponds and hydrodynamic structures relative to drainage area entering the system, or conversely by reducing the volume of runoff entering the pond or structure. Efficiency can also be affected by the geomorphology of the unit; designs that maximize the area of contact between water and soil, vegetation, or microbial surfaces should in general increase efficiency (e.g., long, linear ponds with shallow water depth are likely to be more effective than deep, concave basins of the same volume). Increased vegetation density and biomass is also likely to improve efficiency because of greater uptake, more microbial surface area, and increased oxidation of the root zone. Because vegetation structure and composition are temporally dynamic, efficiency may also vary, but should approach a dynamic equilibrium after some period of time, probably measured in years. While microbial removal processes that affect nitrogen removal are sustainable indefinitely under relative constant environmental conditions, soil surfaces may become phosphorus-saturated, and further phosphorus sorption is therefore not possible. Depending on the soil type and phosphorus loading rates, saturation may take many years, if it occurs at all. Capacity for sediment removal may also be impeded if high loading rates result in clogging or burial of vegetation. Additionally, high flow rates may lead to the formation of preferential flow pathways that reduce contact between water and microbes, soil, or vegetation. These and other variables may lead to changes in the efficiency of dry detention ponds or hydrodynamic structures for stormwater quality improvement over time. Some processes may increase efficiency (e.g. peat formation) while other processes may simultaneously decrease efficiency (e.g. channel formation).

Climatic variables may also affect BMP performance over time, either positively or negatively. Periods of greater precipitation will likely result in shorter residence times, or even bypassing of the BMP due to high flow volumes, both of which will reduce performance. On the other hand, higher temperatures should increase metabolic rates, increasing growth of microbes and plants and facilitating greater transformation and uptake of nutrients. Global climate change may therefore affect performance by changing precipitation patterns and temperature in unpredictable ways. An additional factor is higher CO2 concentrations, which may result in shifts toward species competitively favored under high atmospheric CO2 levels. Changes in species composition may have some effect on performance, although effects are likely to be small unless there are large changes in stem density or biomass.

As mentioned previously, there is considerable variation in the performance of dry detention basins and hydrodynamic structures. Performance may vary over time, and in some cases high volume runoff events may bypass the system, resulting in little removal for large volumes of runoff. Maintenance of these BMPs is important, particularly for the hydrodynamic structures, which require periodic cleanout of sediment and absorbent materials, if present. The low or negative removal rates for TN reported for hydrodynamic structures compared with the comparatively higher rates for detention ponds suggest that vegetation plays an important role in removing nitrogen. Detention ponds should continue to function effectively for years without any significant maintenance other than mowing (which may not be critical for optimum performance).

Periodic inspections should be performed to identify changes in hydrology, vegetation, or soils like those described above so that remedial measures can be taken in necessary. Particularly when systems are new, it is important to make sure water levels along the surface of the detention basin are suitable for the growth and persistence of vegetation. Development of channels or other evidence of erosion should be dealt with expeditiously, for example by diverting some portion of the runoff, installing rock berms, or otherwise decreasing flow velocities in the BMP.

While no studies have specifically evaluated how BMP efficiencies should be adjusted to account for the impacts of improper maintenance on receiving waters, some general adverse effects to water quality are understood. If maintenance is neglected a BMP may become impaired, no longer providing its designed functions. Proper maintenance of outlet structures, flow splitters and clean out gates is key to achieving a BMPs designed efficiency (Koon 1995).

In addition, sediment accumulation is one maintenance concern that if not addressed may adversely affect the BMPs effectiveness. As sediment accumulates it decreases storage volume and detention time, bypassing the intended functions of the BMP and increasing discharge of nutrient and sediment rich stormwater (Livingston et al. 1997). Increased discharge will lead to decreased downstream channel stability, resulting in an increase of sediment loads and a reduction in available aquatic habitat. The consequences of increased stormwater discharges from sediment filled BMPs, are a reduction in the BMPs pollution removal efficiencies, and ultimately, increased ecological impairments. The uncertainty in how improper maintenance will adjust BMP efficiencies supports the recommendation to use a more conservative percent removal estimate.

Statement of Conservatism

The level of uncertainty surrounding the recommended efficiency values is affected by, at a minimum, the number of studies available for a given parameter, the methods used to determine efficiency (e.g. number of replicates, analytical methods), the location of the studies, and the method used to calculate efficiency (e.g., load- vs. concentration-based). For the purposes of this review, the most-reported parameters in single- and multi-site studies were TSS, TN, and TP, which is fortunate for developing recommendations for sediment, nitrogen, and phosphorus removal efficiencies. However, the review of the single-site studies shows tremendous variability in the efficiency of any given site in improving water quality. For the purposes of modeling water quality in the Chesapeake Bay watershed, however, these between site differences should average out, assuming that locations outside the Bay Watershed that were included in the review have similar efficiencies to those in the watershed.

While peer-reviewed literature may in general be assumed to have greater reliability than gray literature, a number of the reported results here were based on extensive monitoring data, some of it not even published in a gray-literature report (e.g., some of the sites in the International BMP database). However, it was also clear that some gray and peer-reviewed studies were based on relatively few measurements, or on grab samples rather than flow-weighted sampling. Only two articles in peer-reviewed journals were found, and these were both for dry detention basins.

The recommended values are near the lower end of the average and median values reported for the single-site studies. Given the variability between sites and relative paucity of monitoring data, these values represent a realistic assessment of removal efficiencies across a wide geographic region.

Future Research Needs

It is recommended that this BMP be separated into two practices. The definition and designs of these practices are not similar and to better represent their individual functions and benefits the practices should be separated into 1. dry detention ponds and 2. hydrodynamic structures.

As mentioned previously, the concept of "effluent quality" has been recommend over the use of removal efficiencies such as those that have been presented here and upon which the recommended values for the Chesapeake Bay model were based (Strecker et al. 2001). While the use of removal efficiencies in a modeling landscape or watershed transformation or removal or nutrients and sediments makes sense in theory, in practice problems arise due to the different methods used in calculating removal (e.g. load- vs. concentration-based) and small absolute changes in concentration or load resulting in large percentage changes, to name two examples. Furthermore, it is currently recognized (e.g., Kadlec and Knight 1996) that "natural" systems such as dry detention ponds constructed with vegetation and not concrete or liners, are not capable of removal of pollutants below a certain "background" concentration, a phenomenon not often considered when removal efficiencies are used in modeling or design efforts. Adoption of an "effluent quality" approach however, recognizes that for a specific flow volume and above a certain minimum design size, most BMPs will remove pollutants to some constant background concentration, irregardless of additional increased in BMP area or volume. This approach could be applied in the Bay model by assigning the same effluent concentrations to BMPs of certain watershed:BMP size ratio. In addition to using effluent quality as a measure of BMP performance rather than removal efficiencies, Strecker et al. (2001) recommends using living resource restoration indicators, such as aquatic invertebrate sampling and habitat classification, in addition to calculating effectiveness by using chemical measures.

Strecker et al (2001) recommend parameters that all studies should include, but are often missing. These include transferable measures of storage volume, surcharge detention volumes, stage/storage data, watershed characteristics, and land use information. Winer (2000) also recommends incorporating individual storm parameters, specifically bacteria, hydrocarbons, dissolved metals, as they correlate with human health, recreation and aquatic toxicity and are often not reported. Not only do many studies lack the aforementioned parameters, studies also make translation of available design parameters difficult. To ensure studies begin using these recommendations Strecker et al. state that the EPA require all federally funded projects that will evaluate BMP effectiveness employ standard methods they discuss, and in addition, that the EPA provide detailed guidance on data collection and sampling methods to improve data transferability (2001).

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Table 1. Summary of removal efficiency (%) for dry detention basins and hydrodynamic structures. Mean and standard error are plotted in Fig. 1. Results of all studies reviewed and for different forms of nitrogen and phosphorus are included in Appendix A.

Statistic	TSS (Total Suspended Solids)	TN (Total Nitrogen)	TP (Total Phosphorus)
Average	54	13	43
Standard Deviation	47.6	31.2	27.8
Standard Error	10.9	12.7	7.2
Median	75	18	38
Minimum	-52	-30	-3
Maximum	98	44	88
N	9	6	15

Table 2. Multi-site studies reporting removal efficiencies (%) for dry detention basins. No multi-site studies were found for hydrodynamic structure efficiencies

TSS (Total Suspended Solids)	TN (Total Nitrogen)	TP (Total Phosphorus)	Reference
47	25	19	Winer 2000
61	31	19	Schueler (1997) in USEPA 2007

Table 3. Summary statistics calculated separately for dry detention basins and hydrodynamic structures.

Parameter	Statistic	Dry detention basins	Hydrodynamic structures
TSS	Average	52	55
	Standard deviation	51.9	46.9
	Standard error	18.3	14.1
	Median	72	76
	Minimum	-52	-42
	Maximum	96	98
	N	8	11
TN	Average	27	-14
	Standard deviation	26.2	22.6
	Standard error	13.1	15.9
	Median	38	-14
	Minimum	-12	-30
	Maximum	44	1
	N	4	2
TP	Average	45	42
	Standard deviation	27.1	30.8
	Standard error	9.6	11.6
	Median	35	46
	Minimum	12	-3
	Maximum	85	88
	N	8	7

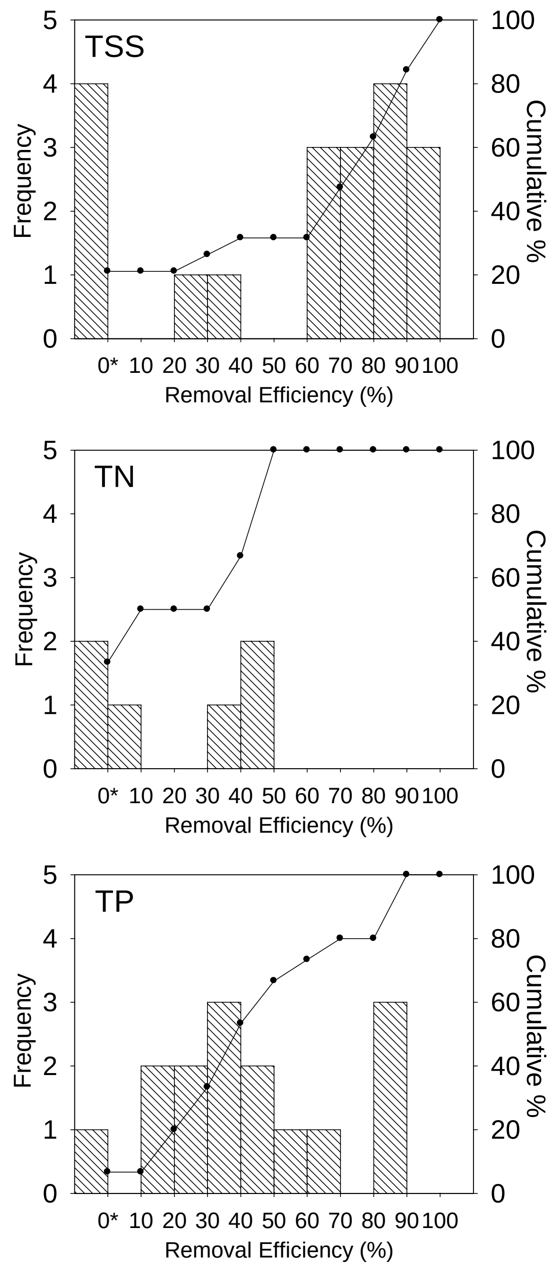

Fig. 1. Frequency analysis of removal efficiencies for single-site studies. Frequency (number of reported values) in removal-efficiency increments of 10 % (e.g. 10-20%, 20-30%, etc.) is plotted on the left axis and as bars. The cumulative percentage of studies reporting values within each removal-efficiency increment is plotted on the right axis as circular symbols connected by lines. The 0* category includes any studies reporting efficiencies of 0% or less (i.e. net efflux)

Summary of literature on the pollutant removal effectiveness (%) of individual dry detention basins (DDB) and hydrodynamic structures (HS) as Best Management Practices for urban and mixed open land uses. TSS = Total Suspended Solids, TN = Total Nitrogen, NO3 = Nitrate and/or nitrite, NH4 = Ammonia or ammonium, TP = Total Phosphorus, PO4 = reactive or ortho-phosphate. Calculation method:C = concentration-based; L = Load-based; NS = Not specified; O = Other.

Type	System name	Location	TSS	TN	NO3	NH4	TP	PO4	Calc. Method	Comments	Reference
DDB	Massie Pond	Charlottesville, VA	64				59		C	Average of 11 storms	Shoemaker et al (2002)
DDB	Sussex Basin		-52	41			38	-6	L	Average of 4 storms	Bartone and Uchrin 1999
DDB	Greenville Pond		68						L	Mean pond treatment efficiency	Stanley (1996)
DDB	Brooke Detention Pond	Brooke, VA					12	19	C	Generally based on several storm events	BMP Database (2007a,b)
DDB	Greenville Pond	Greenville, NC	75	35	6		27	8	C	Generally based on several storm events	BMP Database (2007c,d)
DDB	Oakhampton Dry Basin	Hampton, MD	88		9	44	33	-47	C	Generally based on several storm events	BMP Database (2007e,f)
DDB	Twin Towers Dry Pond	Tallahassee, FL	-4	-12	5	-78	23	26	C	Generally based on several storm events	BMP Database (2007g,h)
HD	CDS Unit	Williams Point, FL	-9				12		C	Generally based on several storm events	BMP Database (2007i,j)
HD	MCTT Catchbasin	Birmingham, AL	24		0	9		-5	C	Generally based on several storm events	BMP Database (2007k,l)
HD	MCTT Main Settling Chamber	Birmingham, AL	88		-11	-41		5	C	Generally based on several storm events	BMP Database (2007m,n)
HD	MCTT Milwaukee	Milwaukee, WI	98		33	36	88	74	C	Generally based on several storm events	BMP Database (2007o,p)
HD	MCTT Minocqua	Minocqua, WI	94				47		C	Generally based on several storm events	BMP Database (2007q,r)
HD	Stormceptor STC 3600	Charlottesville, VA	76	-30			65		C	Generally based on several storm events	BMP Database (2007s,t)
HD	Sunset Park Baffle Box #2	Indialantic, FL	67				46		C	Generally based on several storm events	BMP Database (2007u,v)

Type	System name	Location	TSS	TN	NO3	NH4	TP	PO4	Calc. Method	Comments	Reference
HD	Urban Storm treatment unit	Madison, WI	-42		10	8		31	C	Generally based on several storm events	BMP Database (2007w,x)
HD	UVA Stormvault Phase I	Charlottesville, VA	32						C	Generally based on several storm events	BMP Database (2007y,z)
HD	UVA Stormvault Phase II	Charlottesville, VA	85				38		C	Generally based on several storm events	BMP Database (2007aa,bb)
HD	Vortechs Stormwater Treatment System	Lake George, NY	88	1			-3		C	Generally based on several storm events	BMP Database (2007cc,dd)
DDB	Dry detention pond	NS	80				85		NS	Midpoint of range	Yu et al. (1993) in Shoemaker et al (2007)
DDB	Dry detention pond	NS	96	44	64		81		NS		Yu et al. (1994) in Shoemaker et al (2007)

Appendix B. Meeting Minutes

URBAN STORMWATER WORKGROUP CONFERENCE CALL
May 29, 2007

Dry Detention Ponds and Hydrodynamic Structures

- Dry detention ponds and hydrodynamic structures were previously lumped together by the Bay Program because it was thought that they had similar efficiencies, not similar definitions.
- Q: Does this analysis support lumping these two practices together, or should they be separated?
    - A: Table 3 in Andy's document shows the summary statistics calculated separately for dry detention basins and hydrodynamic structures. According to these statistics, TSS and TP efficiencies are similar for both practices, while the TN efficiency appears to be lower for hydrodynamic structures.
- It was suggested that a statement be included in the report that says that the Bay Program does not enforce any particular hydrodynamic structure brand and that they are assigning an efficiency as a whole to the entire group.
- Q: Why are the proposed efficiencies for hydrodynamic structures so much higher than the current efficiencies? The current efficiencies for TSS, TN, and TP are 10%, 5%, and 10%, respectively, whereas the proposed efficiencies are 50%, 15%, and 35%.
    - A: The proposed efficiencies are based off of the literature synthesis in Andy's report. The results of the literature indicate that the removal efficiencies currently used in the model are too low. The recommended efficiencies for TN and TP are close to the median efficiencies shown in Table 1, whereas the recommended efficiency for TSS is a more conservative recommendation that is below the median efficiency.
- For dry detention ponds, the recommended efficiencies are slightly lower than the efficiencies in PA's BMP manual. This manual does not include an efficiency for hydrodynamic structures.
- Several workgroup members voiced their concern about substantially increasing the efficiencies for hydrodynamic structures.
- It was proposed that dry detention ponds and hydrodynamic structures be separated and given different efficiencies. In order to address the workgroup's concerns, it was suggested that UMD's proposed efficiencies be used for dry detention ponds and that the current efficiencies for hydrodynamic structures remain unchanged. Justification for keeping the current hydrodynamic structure efficiencies includes limited data, maintenance issues, and uncertainty.
- Q: Based on the tracking and reporting that we have now, is it possible to separate these two practices?
    - A: Yes, it is possible. PA said that they already track these practices separately.
- One reason that the current TSS efficiency for hydrodynamic structures is so conservative is because maintenance on these structures has a bad track record.

- Q: Is there any literature on maintenance that could be used in this analysis?
    - A: Long-term maintenance is not mentioned in most of these studies. Sarah and Andy have a few documents from local governments that discuss maintenance; however, there are no numbers on how maintenance affects the efficiency.
- DECISION: The USWG recommends that dry detention ponds and hydrodynamic structures be separated and given different efficiencies. The workgroup recommends that UMD's proposed efficiencies be used for dry detention ponds and that the current efficiencies for hydrodynamic structures remain unchanged.

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Minutes: Tributary Strategy Workgroup Meeting
June 4, 2007
10:00 AM to 3:00 PM
NRCS MD State Office, Annapolis

Urban BMPs

- ACTION: The USWG will write up a formal recommendation for their proposed reduction efficiencies of urban wetlands and wet ponds, and any other urban BMPs, with documented reasoning. The USWG and the MARWP will present their different recommendations to the TSWG and/or the NSC when it is time to make the final decision.
- ACTION: Andy Baldwin, the expert efficiency developer for urban BMPs, will provide a short piece to the workgroups that clearly explains why he his recommended efficiency for dry ponds is very close to his proposed efficiency for wetponds.

- ACTION: The MARWP will ensure that their analysis included studies and data used by the states in their stormwater manuals and handbooks.
    - DECISION: The TSWG will wait to make a decision until the USWG formally presents their proposed recommendations and Andy Baldwin provides additional information requested by the TSWG.

Dry Detention Ponds and Hydrodynamic Structures

- The USWG accepted the MARWP's recommended efficiencies and recommended splitting this BMP into 2 separate ones.

DECISION: The TSWG had no objections to splitting the dry detention ponds and hydrodynamic structure BMP into 2 separate BMPs.

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- The USWG recommended this BMP be split into its 2 separate parts. The workgroup can address this in the future but it is beyond the scope of the BMP review project.
- The USWG accepted UMD's efficiency recommendation.

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URBAN STORMWATER WORKGROUP CONFERENCE CALL
June 26, 2007

- At their May 29th conference call, the USWG reviewed the year-one urban BMP definitions and efficiencies that MAWP/UMD is proposing as part of an EPA-CBP funded project.
- Following are the decisions made by the workgroup during the May conference call:
  - Dry Detention Ponds & Hydrodynamic Structures: The USWG recommended that these practices be separated and that MAWP's proposed efficiencies be used for dry detention ponds and that the current CBP adopted efficiencies be used for hydrodynamic structures.
- Based on their review during the May conference call, workgroup members felt that the proposed efficiencies for these practices did not take into account all relevant studies. In order to address these concerns, members were given until June 8th to submit additional references to MAWP.
- After reviewing the additional information provided by workgroup members, MAWP has decided that their recommendations for the year-one urban BMPs will remain unchanged. At today's conference call, Tom Simpson, UMD, and Sarah Weammert, UMD, explained their reasoning for this decision. The handout that was distributed to the group explains their approach for BMP efficiency development. It can be accessed at http://www.chesapeakebay.net/calendar.cfm?EventDetails=8034&DefaultView=2 .
- The main pieces of literature that USWG members asked MAWP to look at were the design manuals for the different jurisdictions, NERP data, and the Center for Watershed Protection (CWP) database. MAWP found that all of these sources were included in Andy Baldwin's BMP reports (Andy Baldwin developed the proposal documents for each of these practices).
- BMP projects from the CWP database were used to develop VA draft regulations and MD and PA stormwater design manuals. Upon further evaluation of all sources considered in the development of the urban wetland and wet pond practices, it was found that the developer had included the sources from the design manuals in his multi-site analyses. The analysis by the database developer includes the median values for all 145 studies used in the 2000 version of the Center for Watershed Protection database. In addition, some single site studies from the database are also included in the developers single site analyses. The 2007 CWP database will not be published until later this summer.
- ISSUES: Two concerns that the USWG had at the May conference call were: (1) MAWP's proposed efficiencies are based on single-site studies rather than multi-site studies and (2) the analysis includes studies with negative efficiencies. The

USWG would instead like to base the efficiencies on multi-site studies and omit studies with negative efficiencies.

- MAWP decided that they would not change their recommended efficiencies based on the above two concerns. The developer and the STAC reviewer stated that the values closer to the mean and median efficiencies of the single-site studies should be used to determine effectiveness rather than those of the multi-site studies. In regards to negative efficiency studies, MAWP thinks that they should be included because these situations do occur operationally in real world situations. Also, negative efficiencies that have been published have undergone a rigorous scientific review.
- At the WQSC meeting it was suggested that statistics be provided for the studies in the analyses. These statistics are already listed in the reports for the year-one urban BMPs.
- ACTION: Workgroup members should submit ideas for future Bay Program needs (such as additional practices, changes in the overall approach to practices, ect.) to MAWP. It is beyond the scope of their project to address these needs, but they will include a list of issues that need to be addressed in their report.
- This project is not trying to define an efficiency for the perfect example of this practice. It is instead trying to identify an efficiency that characterizes this practice as it functions on broad application in the landscape and reflects real-world operational conditions.
- The workgroup needs to look at the definitions for wetlands & wet ponds and urban erosion & sediment control because there seems to be conflicting opinions between the developer, the reviewer, and the workgroup.
- ACTION: Sarah Weammert requested that the workgroup provide her with guidance for year-two urban BMPs. Specifically, she would like guidance on infiltration and filtration practices. What are the specific practices that need to be looked at? Are there 3-5 major groups of practices? What should the subcategories be? This will be on the agenda for the next workgroup meeting. Sarah needs this information by September.
- The workgroup discussed what their next steps should be and whether or not they would like to approve the MAWP recommendations or submit their own separate recommendations to the Tributary Strategy Workgroup on July 9th.
- Q: What does the rest of the review process look like for these BMPs?
    - A: MAWP's recommendations and the source workgroup recommendations will be presented to the TSWG on July 9th, to the NSC on August 15th, and to the WQSC in mid to late August. STAC is also concurrently reviewing MAWP's work. They will provide two reports for the TSWG to review at their August 6th meeting. One report will look at the process MAWP is using to come up with these efficiencies and whether or not it is sound and the second report will look at whether or not the BMP efficiencies make sense when you look at them across the board. Essentially, STAC is evaluating whether or not this combination of science and judgment is appropriate for what we are doing and if it is consistent, logical, and valid. They are not evaluating the efficiency number.

- The proposed efficiencies are based on both science and best professional judgment. We need to know where the science ends and where the best professional judgment begins. This is addressed in the individual BMP reports.
- ISSUE: Concern was voiced over the difference between the MAWP efficiencies and the efficiencies used in state regulations and programs.
  - DE is not including efficiencies in their regulations, however other states, such as VA, need to include efficiencies.
  - CWP is developing efficiencies for the VA regulations. It would be helpful if VA could provide the workgroup with their proposed state regulation efficiencies before the July TSWG meeting.
  - MD's efficiencies were also developed by CWP and they differ from MAWP's recommendations.
  - Some of the states feel that they can not support the MAWP proposed efficiencies if they are different from their state efficiencies.
  - The efficiencies used in the CBP model and the efficiencies in the state regulations are different because the efficiencies were developed with different assumptions and are intended for different purposes. The state efficiencies describe what a BMP is capable of achieving if operation, design, and maintenance are optimal (best case scenario), whereas the efficiencies used in the Bay Program model describe what is happening operationally across the watershed from a realistic standpoint, taking into account maintenance issues, errors in design, etc.
  - There is currently no information that shows that the Bay region is operating at a much more effective rate than the rest of the country. Inspection reports and monitoring data are not available. If this type of data did exist, then MAWP could have factored it into their analysis.
  - It was pointed out that the state efficiencies and the MAWP proposals were developed using essentially the same data, however they are both looking at it differently from a statistical analysis standpoint.
  - It was suggested that the USWG write an issue paper that discusses this need for consistency with state stormwater programs and how it may play out. This paper could explain what the workgroup would ideally like to see and how it is backed up by the data.
  - It was also suggested that the different objectives and assumptions for state efficiencies and Bay Program efficiencies be documented.
- Q: Who is going to make the final decision regarding what efficiencies are used in the Bay Program model?
  - A: Ideally, the TSWG and the NSC will make the final decision. However, if a decision cannot be reached by these groups, then the decision will have to be made by the WQSC.
- ISSUES: As mentioned earlier, the USWG thinks that multi-site studies rather than single-site studies should be used and that studies with negative efficiencies should be omitted.
- STAC has been made aware of the USWG's concerns and they are looking closely at the above two issues.

- Q: Why do we still track individual BMP practices in the watershed model? Instead, could we look at the number of acres meeting performance standards?
  - A: Individual BMP practices are tracked in the model due to a previous decision made by the workgroup. The model could be based more on performance standards if monitoring information and data were available. We need to have a way to monitor the performance standard. You can't make a blanket assumption that you have 100% performance standard compliance.
- It was suggested that the USWG's argument may be stronger if it was more technical. For example, the workgroup could explain why the states didn't use all of the studies that MAWP used, why they omitted negative efficiencies, why their numbers are better, etc. It would be useful if the argument was linked to MAWP's recommendations.
- ACTION: Representatives from the USWG need to attend the July 9th TSWG meeting in order to present the workgroup's argument and recommendations. Norm Goulet, workgroup chair, will be unable to attend. Sally Bradley will send workgroup members the agenda for the July 9th TSWG meeting when it is available.
- ACTION: It would also be helpful if someone would write down the workgroup's concerns and the justification for their proposed approach. This draft document could then be emailed to the workgroup for comments.

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MINUTES: TRIBUTARY STRATEGY WORKGROUP MEETING
July 9, 2007
10:00 AM – 1:30 PM
NRCS MD State Office

Urban BMPs

- Reggie Parrish updated the TSWG on the status of the urban BMPs review process.
- The USWG has been addressing three areas of discrepancy:
    - Wetlands and Wet Ponds: The USWG believed the proposed efficiencies were too low.
    - Dry Detention Ponds and Hydrodynamic Structures: The USWG accepted the proposed Dry Detention Ponds efficiencies but wanted to separate out Hydrodynamic Structures into its own BMP. The workgroup believed the existing efficiencies should remain unchanged for Hydrodynamic Structures.
    - Urban Erosion and Sediment Control: The USWG rejected the proposed efficiencies and requested more work in this area before it is revisited.
- The USWG has been preparing their own recommendations for urban BMPs and providing Tom and Sarah with additional information that they believe should be considered.
- The USWG made various suggestions for the literature review process. First, the USWG suggested that the literature that finds negative efficiencies from the BMPs be eliminated in the review. The USWG also suggested that only multiple-site studies be used in the literature review, not single-site studies. Finally, the USWG did not believe enough attention was given to the state stormwater manual efficiencies.
    - Tom and WQSC members believed studies with negative efficiencies should be factored into the literature review.
    - Tom explained that all of the data behind the state stormwater manuals was used, and more, in the literature review process. The suggested efficiencies given in the manuals were not directly used, however, because they represent a target efficiency to shoot for, not an actual average widespread implementation efficiency.
    - ACTION: Tom and Sarah will clarify in their report that although the state stormwater manuals "target" efficiency was not directly used in the literature review, the data behind the state stormwater manuals, and more, were used in developing the recommended efficiencies.
- Reggie proposed 3 options on behalf of the USWG (who had not yet reviewed the document) for moving forward with the urban BMPs:
    - Option 1: Proceed with a different set of efficiencies for state/local and CBP.
        - Kelly Shenk thought it would be useful to understand the different purposes that the partnership uses the BMP efficiencies for. For

example, CBP is interested in showing the average reduction of loads across the watershed, by using the model as a projection tool for necessary management actions.

        - Reggie explained that local governments have a scale issue with the BMP information, as some states are looking at a series of BMPs and how they function rather than just looking at a single BMP.

    - Virginia is in the process of developing regulations based on their BMP efficiencies. VA was in favor of Option 1 for defensibility reasons as they more forward with their regulations.
    - Helen did not wish for Option 1 to move forward because she believed consistency is necessary. MD's local governments demand consistency.

- Option 2: Work with modelers to determine feasibility and possibility of not changing the urban BMP efficiencies until year 2 BMPs are revised in the model.
    - Helen confirmed that the BMP efficiencies won't make a dent in the model but are important for planning options, TMDLs, trading, etc.
    - Kelly thought this option may be worth exploring but that more time may not provide more data to inform our decision, it would just prolong the deadline for making a decision. Likewise, we're given the opportunity make these changes in the model simultaneously right now. Waiting until year 2 may be impossible politically.
- Option 3: Shift from a single BMP efficiency approach to a systems approach.
    - Most states are looking at this issue holistically, so the USWG is asking if this review process is our opportunity to change course and start to look at BMP efficiencies holistically.
    - Ken Pensyl informed the workgroup that some BMPs do not get accounted for because they have no drainage area associated with them, however the broad spectrum of runoff from development could be addressed using a systems approach.
    - DECISION: The workgroup agreed that moving to a systems approach as outlined in Option 3 is the best way to move forward.
        - Tom confirmed that they could support a systems approach but that data to document the hydrology of the landscape are necessary.
        - The systems approach would factor in landscape conditions such as slope and soil type.
        - Kelly agreed by saying that a lot of states are heading in this direction of performance-based approaches. We will still need to determine what the realistic reduction is that we can expect to achieve with the performance-based approach.
        - The USWG wants to collect performance data on different types of land uses across the region.

- Although the workgroup agreed to pursue Option 3, this shift to a systems approach could take years, so a more immediate solution is still needed for proceeding with the BMP efficiencies for the model.
  - Kelly suggested that the efficiencies be developed by first starting with the state stormwater manuals as the design standards for the BMPs and then applying a margin of safety based on the data collected by the MARWP.
  - Referring back to our adaptive management approach, Kelly suggested we use the MARWP's recommended efficiencies as the conservative estimate to be fed into the model until we have monitoring data and can make adjustments.
  - DECISION: The USWG will discuss the options for moving forward in the short-term with the urban BMP efficiencies, considering the TSWG's input.
  - Helen suggested that looking at each BMP's margin of safety could help us to decide the appropriate margin of safety to use for the urban BMPS.
  - ACTION: Per Tom's suggestion, the USWG will figure out a way to include the negative efficiency studies in their efficiency recommendations because their dismissal cannot be justified.

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Urban Stormwater Workgroup Conference Call
July 25, 2007
Minutes

- Reggie Parrish, workgroup coordinator, began the meeting at 10:10 am. Introductions were made and the meeting's agenda was reviewed.
- At the July 9th Tributary Strategy Workgroup meeting, Reggie presented the USWG's concerns regarding the UMD/MAWP proposed efficiencies to the TSWG. Three potential options were suggested that were based on previous USWG conference calls.
- Based on the discussion at the TSWG meeting, two additional options have also been proposed. All five of the options are listed in the handout for today's call, which can be accessed at: http://www.chesapeakebay.net/calendar.cfm?EventDetails=9014&DefaultView=2. The TSWG strongly supported option C, but recognized that the workgroup would need to propose a short-term solution if this option were chosen.
- At the July 9th TSWG meeting, the TSWG asked the USWG to develop a specific position that they can formally submit to the TSWG, the Nutrient Subcommittee and ultimately the Water Quality Steering Committee.
- During today's conference call, we had hoped to come up with a specific position supported by the USWG; however, since many key players were unable to participate in today's call, conference call participants decided that the call should be rescheduled for sometime next week and that we should postpone making a decision on the workgroup's position until that time.
- The USWG needs to decide on a position before the next TSWG meeting, which is being held on August 6th.
- Q: How do our no net increase efforts relate to the BMP efficiency efforts?
    - A: We are not sure exactly how these efforts are related yet. The performance based systems approach, which is one of the proposed BMP efficiency options, seems like it would be relevant to no net increase efforts.
- Q: What is the definition of no net increase?
    - A: In PA, they are trying to move forward with the concept of no net change rather than no net increase. The Stormwater and New Development Taskgroup did not define no net increase at their last meeting. It is important to point out, however, that we do not want the efficiencies to get bogged down with the no net increase issue. We still need the efficiencies in the more short term timeframe.
- Q: Right now, the states are only providing the Bay Program with data on implementation. What data would need to be provided for option E (see handout) to show that the BMP is properly designed, inspected, maintained and operating? It seems like a lot of data would be needed. Do we have this information?
    - A: We are not exactly sure yet what data would be needed for this option. One suggestion was that if a state could ensure that a good O and M plan was in place, then maybe this could ensure a higher efficiency. Before choosing this option, the workgroup would really need to explore it further.

- Workgroup members were interested in how the other sectors chose their efficiencies in the Bay model and what data they used to do this.
- In other sectors, it is not assumed that the BMPs reported meet design standards and are properly maintained. Essentially, they apply a safety factor for long-term maintenance. This is also why UMD/MAWP adjusted their efficiencies down.
- It was pointed out that there is not long-term data available for most BMPs. It is just a matter of ensuring implementation. In PA, there is an inspection program to ensure that BMPs are properly installed.
- Compared to focusing on individual BMPs, a systems approach would be more in line with state design manuals.
- Q: Is there any documentation of the discussion that took place to develop PA's BMP manual?
    - A: There is some documentation, however it is not very detailed.
- Some participants thought that implementation information and water quality monitoring (to show that you are getting the expected results) should be all of the data that is needed.
- Option D (see handout) says that state manuals use efficiencies that describe optimal performance, but that Bay Program and UMD/MAWP efficiencies acknowledge that BMPs do not work optimally all of the time in the real world.
- PA pointed out, however, that the Bay Program and UMD/MAWP efficiencies are based on single BMPs and in PA they use a combination of BMPs that this approach does not capture. In reality, these are being looked at as systems and multiple BMPs are being relied on to achieve results. Using a systems approach is option C in the handout.
- Could the urban sector use an approach similar to the ag sector's conservation plans, which is essentially a suite of BMPs?
- A systems approach could develop different efficiencies for various tiers of a system.
- It was suggested that we default to state standards and then add some sort of qualifier on that shows that they are not achieving their goals 100%.
- Some participants felt that option E (see handout) is sort of the "do nothing option" and that it pushes the decision to a later point in time.
- The model calibration period is from 1985 to 2004. For stormwater management in PA, the Bay Program has one number for each year that covers the entire watershed portion of the state. Jeff Sweeney needs to know what efficiency should be applied to these stormwater management acres. PA agreed to follow up on this issue for Jeff.
- Essentially there appear to be two issues: 1) what we need immediately for calibration, and 2) what we will use in the future.
- Q: If we come up with some numbers for calibration and then we come up with different efficiencies to be used for future planning, we would have to revise those efficiencies in the model, correct?
    - A: Yes. Jeff said that this could be done though.

- One concern that was voiced was that members do not want to see efficiencies lowered based on historic expectations, compared to future expectations. It was suggested that we have two separate efficiencies for 1985-2000 and 2000 and beyond.
- For whatever position they choose, the USWG needs to provide supporting documentation equivalent to what UMD/MAWP provided for all of the other BMPs.
- Q: Did UMD/MAWP separate out dry detention ponds and hydrodynamic structures, as was proposed at the May 29th conference call?
    - A: These practices were combined based on the categories created previously by the USWG. As far as Reggie and Sally know, UMD/MAWP did not make any revisions to their proposals to separate out these practices. Reggie will contact Sarah Weammert, UMD/MAWP, to find out whether or not they made this change.
- During today's conference call, there seemed to be general agreement that we need to look at a systems approach on a more long-term basis. However, in the short-term we really need to decide on some way to assess BMP efficiency for model calibration.
- Reggie Parrish will set up a call for sometime this week between Ken Murin and Norm Goulet so that they can further discuss a potential USWG position on BMP efficiencies.
- The meeting was adjourned at 11:30 am. A date for next week's conference call will be sent out to workgroup members as soon as it is selected.

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Urban Stormwater Workgroup Conference Call
August 1, 2007

- Norm Goulet, USWG chair, began the conference call at 9:30 am. Introductions were made and the meeting's agenda was reviewed.
- All of the handouts for today's conference call can be accessed at: http://www.chesapeakebay.net/calendar.cfm?EventDetails=9016&DefaultView=2

- The purpose of this conference call was to come up with a workgroup position on urban BMP efficiencies. This position needs to be presented by the workgroup at the next Tributary Strategy Workgroup Meeting, which is being held on August 6th.
- Highlights from the STAC review of the UMD/MAWP BMP efficiency process include:
  - STAC agreed with UMD/MAWP on the use of negative efficiencies. They said that the Chesapeake Bay model must be calibrated to function with operational rather than research BMP efficiencies. Hence, if reported negative efficiencies reflect operational conditions, STAC felt that they should be considered in an assessment of the BMP efficiency literature.
  - STAC stated that peer-reviewed literature should be given more weight than state BMP manuals. They do not consider state manuals to be peer-reviewed since they were not subjected to independent examination.
  - STAC commented on the fact that some experts used the lack of research data to justify deep discounts of the few reported efficiencies, while other experts refused to change current efficiencies because of the lack of research data. STAC said that they hope that such a situation was anticipated, and that the charge to the expert specifically stated how such situations were to be handled.
- In the workgroup's draft position paper, the following three specific concerns are listed: 1) negative studies should be eliminated, 2) single site studies should not be used, and 3) state manual BMP efficiencies not appropriately considered.
- It was thought by some members that the biggest workgroup concern, which is not listed, is that the efficiencies are based on historic data. More recently, the states have increased volumes, changed their strategies, added pre-treatment, and changed BMP design criteria. These changes are not reflected in the studies that UMD/MAWP used to come up with their efficiencies. Members thought that the efficiencies that UMD/MAWP proposed may be good for BMPs that were put on the ground between 1984 and 2000, but not for more recent BMPs.
- The calibration period for the CBP model is from 1985-2002. Thus, based on the above comments, it seems that the efficiencies from UMD/MAWP would be appropriate to use for model calibration. This is our immediate need.
- Post-construction BMPs are a bigger issue than construction BMPs. They should be the focus of the information that states report to the CBP office.
- Norm proposed that the following modifications be made to the USWG's position paper:
  - Acknowledge that the UMD/MAWP numbers are incorrect for a variety of reasons.
  - State that the workgroup will, however, accept the efficiencies from UMD/MAWP with the stipulation that they have the option to increase the efficiencies later if sufficient data is available to show that they are achieving higher efficiencies.
  - The UMD/MAWP numbers will be used in the upcoming model calibration.
  - The UMD/MAWP efficiencies will only be used for one year. During that time, we will work towards switching to a systems approach.

    - If a systems approach is not developed within one year, then the default is still the UMD/MAWP numbers.
- It was suggested that we have an on-going evaluation of the BMPs to determine how they actually function in the long-term.
- Ideas for how we could develop a systems approach include:
    - Two systems could be developed: ultra-urban and a more suburban approach. Each of these would have different values.
    - Gather information from each state since different states have different soils, slopes, etc. Maybe a research group could look at this and come up with calculated values for the land use. This would be similar to what UMD did for the BMP efficiencies.
    - Unfortunately, there is not much monitoring data out there.
    - Right now, CBP efforts should focus on just sediments and nutrients. Maybe later they could expand this effort to include other pollutants.
    - The systems must be something that we know we can track in the future.
- The workgroup will develop a funding proposal for a project that will research and potentially develop a systems approach. In addition, the workgroup may need to develop its own report that they will pass up to the Tributary Strategy Workgroup and the Nutrient Subcommittee.
- There is a protocol for peer review on the Bay Program website.
- Q: Will we be able to get CBP funding for this project?
    - A: After a proposal is developed, it can be taken to the Budget Steering Committee. However, there is unlikely to be money available from the CBPO at this time due to a budget shortfall. Therefore, we may need to be creative and look for other funding sources. It was pointed out that there was no CBPO money available for the UMD BMP efficiency project either, but we were able to gain the Budget Steering Committee's support for this project and another source of funding was found.
- Q: Can UMD's scope of work be modified so that they look at the systems approach in year 2 of their BMP project?
    - A: It is unlikely, but Kelly Shenk will look into this just in case. It will depend on how much of a departure this is from the project's original scope. Even if we can get them to look at the systems approach in year 2, their review will not be as extensive as what the workgroup was discussing earlier. If we are going to switch to a systems approach, maybe we no longer need UMD to look at infiltration practice efficiencies in year 2. Perhaps we could replace this with gathering data on the systems approach.
- Q: Could we use the UMD efficiencies for the model calibration period, and then use the state BMP manual numbers when we do implementation runs later?
    - A: No. The state BMP manual numbers cannot be used.
- Q: What do we do in the mean time while we are developing this systems approach?
    - A: It was suggested that we use the UMD efficiencies unless the states have data that shows that they are achieving a higher efficiency.
- Workgroup members decided to accept the position laid out in today's handout once Norm's proposals (see above) are included. Reggie will revise the handout so

that it includes Norm's proposals and text on model calibration and historic vs. future values.

- Norm and Reggie will present the workgroup's position at the August 6th Tributary Strategy Workgroup meeting. Information on this meeting can be found at http://www.chesapeakebay.net/calendar.cfm?EventDetails=8816&DefaultView=2.
- The meeting was adjourned at 10:45 am.

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Minutes: Tributary Strategy Workgroup
August 6, 2007
Chesapeake Bay Program Office—Fish Shack

- The USWG does not concur with the report's findings. Sarah and Tom tried to address the workgroup's concerns.
- The USWG's main concerns are that the literature do not reflect current design requirements, the literature is dated, negative studies and single site studies are included, and that state manual BMP efficiencies are not appropriately considered.
    - Some of the urban BMPs use single site studies while others use multi and single site studies.

Dry Detention Ponds/Basins and Hydrodynamic Structures:

- The USWG would like the Dry Detention Ponds to be separated from the Hydrodynamic Structures.
- Norm said that Dry Ponds are not that efficient and are recommended by MARWP to be more efficient than Wet Ponds which we know is not true.
- The USWG would like the Dry Ponds efficiencies to remain where they currently are.
- The developer has tables with efficiencies for these two BMPs separated out, and the efficiencies were fairly similar.
    - After reviewing the tables over lunch with the separated data for this combined BMP, Norm confirmed that the numbers for the Dry Ponds and

Hydrodynamic Structures are very similar and recommended that the efficiencies remain where they are.

- DECISION: The TSWG and MARWP are willing to support the USWG decision to keep the efficiencies as they are, with the commitment to return to the developer for explanation.
  - ACTION: MARWP will ask Andy for an explanation of his recommended efficiencies, including why they are as close to Wet Ponds as they are and why they are so different from what is believed to be realistic.

- The review process should have focused on new literature; however, the weight of evidence is from the 1980s.
- The USWG believes the individual BMPs are probably appropriate for the calibration period of 1985 to 2002, but from now on, the workgroup would like to move toward a systems approach.
  - The USWG will follow through with moving to a systems approach. The timeline will be dependent on funding and who is available to work on the issue but will ideally be done within a year.
  - Kelly mentioned that although we all agree that we need to move toward a systems approach for the model, we need to be sure we will have the necessary data in the next year to back-up the effort.
  - The TSWG will follow up with the USWG on their effort to move toward a systems approach.
  - Kelly suggested that for Year 2, MARWP should accumulate state agency monitoring data and permits for a data acquisition process that would acclimate moving toward a systems approach.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
August 15, 2007

- Norm Goulet, Urban Stormwater Workgroup Chair, presented the recommended BMP efficiencies for urban wetlands and wet ponds, urban erosion and sediment control, dry extended detention basins, and dry detention ponds/basins and hydrodynamic structures.
- The USWG is recommending these efficiencies with some caveats. The way urban BMPs are modeled needs to change from stand alone BMPs to a systems approach. Until that can be accomplished, these BMP recommendations should be used to calibrate the model along with additional data from the jurisdictions.
- There is also concern that the CBP recommended efficiencies are not always consistent with the efficiencies provided in state handbooks. If facilities can provide documentation regarding implementation, maintenance, and inspection processes, are the handbook efficiencies acceptable? Will this cause confusion?
- It was noted that there is also a difference in efficiency if a jurisdiction has a strong enforcement program. Stronger enforcement leads to more maintenance at facilities and higher efficiencies.
- Was consideration given to splitting dry ponds and hydrodynamic structures since they behave differently? Consideration was given; however, there is not a lot of recent information available regarding hydrodynamic structures and each state handles these structures differently which makes it difficult to develop a stand alone BMP efficiency rating.
- A concern was raised regarding super-load areas in the Phase 5 model. They seem reasonable in applied to highly disturbed areas only; however, they would not be accurate if applied to whole acreages. The Tributary Strategies Workgroup will take a look at this issue and report back to the NSC.
- It will be necessary to update the CBP website to clearly link urban BMPs with their efficiencies and to explain the transition from Phase 4.3 to Phase 5 of the CBP model to make it more understandable to users.
- Infiltration and filtering processes were omitted from the MAWP year 1 project scope but will be included in year 2. It is valuable to examine these BMPs even if the model eventually moves to a systems-based approach as it will take time to make the needed changes to the model and the jurisdictions are currently implementing these BMPs.
- What about N and P speciation? How effective are BMPs at treating various forms of N and P? There is not enough information available to develop general

rules about the various N and P species; however, this issue will be highlighted in the MAWP report as a research need.

- The recommended urban BMPs were approved.

Efficiency Recommendation	**TN**	**TP**	**TSS**
Urban Wetlands and Wet Ponds	20	45	60
Urban Erosion and Sediment Control	25	40	40
Dry Extended Detention Basins	20	20	60
Dry Detention Ponds/Basins and Hydrodynamic Structures	5	10	10

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Chesapeake Bay Program
Water Quality Steering Committee
Conference Call
August 27, 2007

SUMMARY OF DECISIONS, ACTIONS AND ISSUES

Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

DECISION: The Water Quality Steering Committee approved the 12 BMP definitions and efficiencies, described in the advance briefing papers, as recommended by the Nutrient Subcommittee and its workgroups for use in Phase 5 Chesapeake Bay Watershed Model.

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Dry Extended Detention Basins Best Management Practice

Definition and Nutrient and Sediment Reduction Efficiencies

For use in calibration of the Chesapeake Bay Program's Phase 5.0 Watershed Model

Consulting Scientist

Andrew H. Baldwin, Ph.D.
University of Maryland
Department of Environmental Science and Technology

Synthesize and Consensus Agreement by

Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

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Summary

Dry Extended Detention Basins: depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms using a low flow control outlet that releases water over time drying out between storm events.

- Effectiveness Estimates: TSS 60%, TN 20%, TP 20%

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University Of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. Previously, BMP documentation was limited and the CBP has been criticized for this in the press and in governmental reviews. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

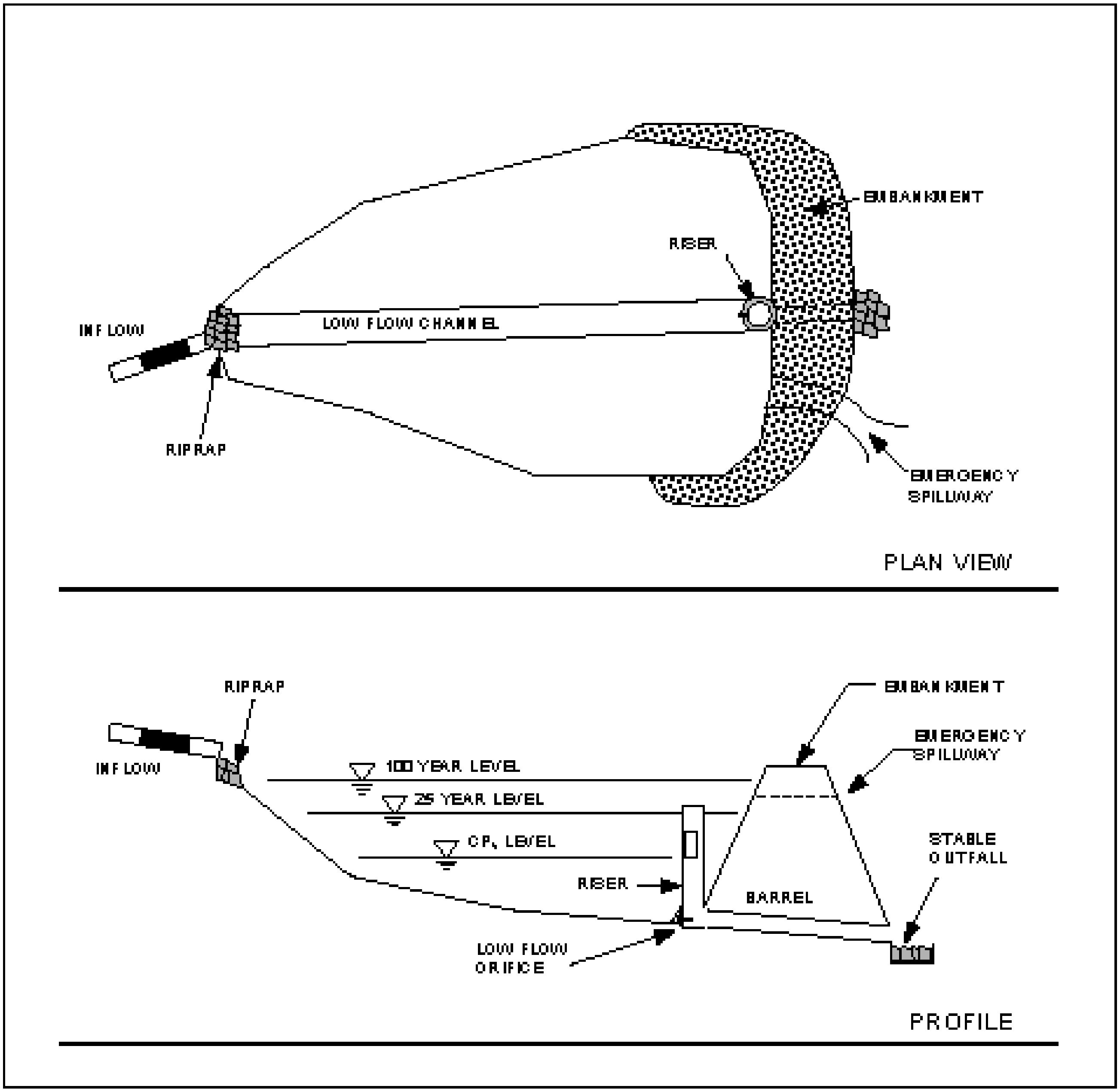
To review efficiencies MAWQ contracted an expert, Dr. Andy Baldwin, and asked him to review applicable literature and propose an efficiency for model calibration based on the literature and their experience. The CBP adopted Dr. Baldwin's recommendations and the practice report follows. Attached to these definitions and efficiencies is a full accounting of the CBP's discussions on this BMP, who was involved, and how recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix A.

Photograph of BMP

Dry extended detention pond with grass surface. Source: MDE Water Management Administration, dnrweb.dnr.state.md.us/watersheds/surf/bmp/info/drydetentionponds_ex.html. Note the presence of a riser as well as a low-flow orifice structure.

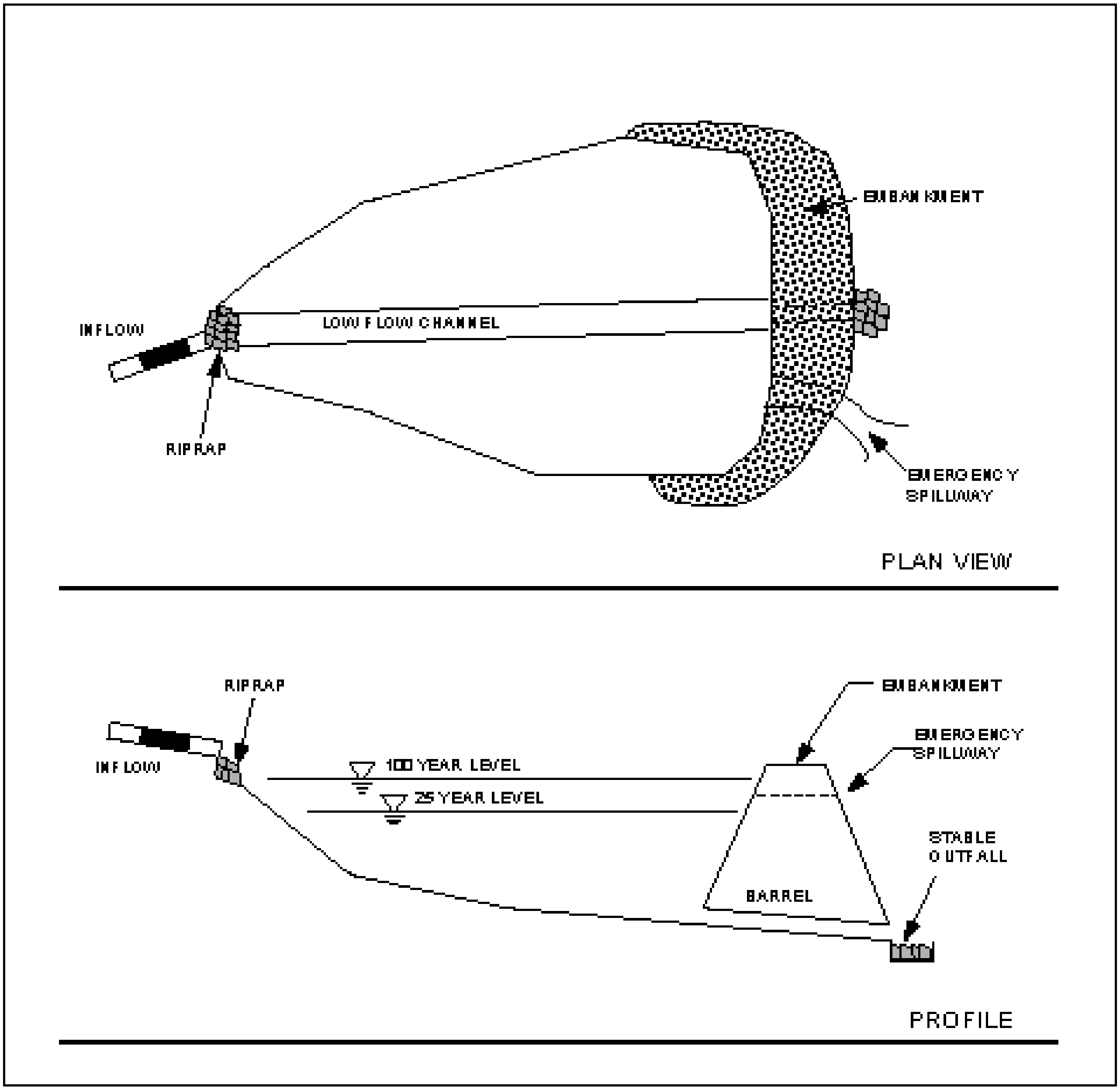
Comparison of Dry Extended Detention Basin and Dry Detention Basin

Dry Extended Detention (ED) Basin. In the lower panel, note the riser that will store "Channel Protection Volume" (CPv), and release that water over at least a 24-hour period through the low-flow orifice.



Source: Haubner et al. 2001.

Dry Detention Basin. Note the lack of a low-flow orifice; stormwater will therefore be directly discharge to the stream, retained for a shorter period of time than in the Dry ED Basin design.



Source: Haubner et al. 2001.

Description/Definition

The author recommends renaming this BMP dry extended detention basin, instead of dry extended detention ponds, as this BMP does not hold or pond water for a significant period of time. Dry extended detention (ED) basins are depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. Dry ED basins are designed to dry out between storm events, in contrast with wet ponds, which contain standing water permanently. As such, they are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, theoretically improving treatment effectiveness. In the literature, dry ED basins are often lumped together with or considered as dry detention basins (evaluated in a separate report). However, some sources clarify that dry ED basins have specific structures that act to retain stormwater for some minimum period of time (e.g. 24 hr) following a storm event, using a secondary low-flow orifice feature such at that illustrated in the schematic above. Dry detention basins are distinguished from dry extended detention basins in that the design of the later uses a control low flow outlet that releases water over a given period of time. A dry detention basin does not use a low flow outlet directly discharging to the stream and retaining water for a shorter period of time than the dry extended basin design.

The surface of the detention basin itself often consists of planted grass, as seen in the photograph above, or can consist of concrete or some other liner. The grassed surfaces require periodic mowing, but may improve trapping of sediments compared with smooth surfaces such as concrete, and may also allow infiltration of stormwater if the underlying soil is permeable. Ancillary treatment structures such as wetlands or permanent pools may also be built in series with dry ED basins, an arrangement sometimes referred to as a "treatment train."

The water quality functions of dry extended detention ponds operate primarily by removing suspended particles via settling due to decreased water velocity. If plants such as grasses are present they may further reduce velocity by increasing roughness of the surface. Nitrogen and phosphorus may be removed via settling of particulate forms and plant and microbial uptake. Phosphorus may also sorb to soil particles. Significant removal of nitrate is unlikely because the aerobic soil conditions are not favorable to microbial denitrification. These stormwater BMPs are designed to store surface runoff water and release it slowly to streams, attenuating flood peaks resulting from storms. This hydrologic function of detention basins is often considered a water quality function that helps to reduce stream channel incision, bank erosion, and loss of instream habitat structures that is typical of streams in urban areas with extensive watershed areas covered by impervious surfaces such as building, roads, and parking lots (Schueler 1994). Detention basins provide little habitat value for organisms other than soil invertebrates, and if they are constructed from cement, even that function is negligible.

A number of definitions of various configurations of urban dry extended detention basin BMPs have been developed. These include:

- A storm water design feature that provides gradual release of volume of water in order to increase settling of pollutants and protects downstream channels from frequent storm events.

- Dry extended detention pond (peak quantity control only): Dry extended detention ponds (a.k.a dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets are designed to detain the stormwater runoff from a water quality "storm" for some minimum duration (e.g., 24 hours) which allow sediment particles and associated pollutants to settle out. Unlike wet ponds, dry extended detention ponds do not have a permanent pool. However, dry extended detention ponds are often designed with small pools at the inlet and outlet of the pond, and can also be used to provide flood control by including additional detention storage above the extended detention level (www.stormwatercenter.net)

- Extended detention basin: An impoundment that temporarily stores runoff for a specified period and discharges it through a hydraulic outlet structure to a downstream conveyance system. An extended detention basin is usually dry during non-rainfall periods (VA DCR website).

- Enhanced extended detention basins: An enhanced extended detention basin has a higher efficiency than an extended detention basin because it incorporates a shallow marsh in the bottom. The shallow marsh provides additional pollutant removal and helps to reduce the resuspension of settled pollutants by trapping them (VA DCR website).

- Dry detention and dry extended detention (ED) basins are surface facilities intended to provide for the temporary storage of stormwater runoff to reduce downstream water quantity impacts. These facilities temporarily detain stormwater runoff, releasing the flow over a period of time. They are designed to completely drain following a storm event and are normally dry between rain events. Dry detention basins are intended to provide overbank flood protection (peak flow reduction of the 25-year storm, Qp25) and can be designed to control the extreme flood (100-year, Qf) storm event. Dry ED basins provide downstream channel protection through extended detention of the channel protection volume (CP_v), and can also provide Qp25 and Qf control. For a dry ED basin, a low flow orifice capable of releasing the channel protection volume over 24 hours must be provided (Haubner et al 2001). (The channel protection volume (CP_v) is defined in the Code of Maryland Regulations 26.17.02 as "…the volume used to design structural management practices to control stream channel erosion." The rationale for this criterion is that runoff will be stored and released in such a gradual manner that critical erosive velocities during bankfull and near-bankfull events will seldom be exceeded downstream. Source: http://www.mde.state.md.us/assets/document/Channel%20Protection%20Volume%20Implementation.pdf).

Efficiency

The removal efficiencies for dry extended detention basins used in the Chesapeake Bay watershed model are currently 30%, 20%, and 60% for nitrogen (N), phosphorus (P), and sediment, respectively. These values are higher than those currently used for dry detention basins in the model, which is appropriate given the presumably longer detention times (due to low-flow outlet structures) and enhancements such as ponds or wetlands that are sometimes built in conjunction with dry extended detention basins. To evaluate the validity of these numbers, a review of peer-review and gray literature was conducted. Removal efficiencies found in the literature were summarized and used as a basis for validating or changing currently used efficiencies.

Literature Review and Data Analysis Methods

Gray literature such as reports, web sites, and other information not subjected to the peer-review process was obtained through material already in hand, contacts with the Center for Watershed protection, references listed in refereed and gray literature already in hand, and web searches. Literature in peer-reviewed journals was identified using electronic databases such as ISI Web of Science.

Literature was reviewed to find removal efficiency data for suspended solids (generally Total Suspended Solids, TSS), Total Nitrogen (TN), and Total Phosphorus (TP). Data for other measures or forms of solids, nitrogen, and phosphorus were occasionally reported (e.g. dissolved solids, nitrate, ortho-phosphate, organic N and P), but these data were not necessary for the purpose of this report.

While the goal of this review is to develop or validate specific removal rating values, it is important to keep in mind that considerable variation exists between studies in methods for sample collection, chemical or physical analysis, experimental design, and data analysis. Even the calculation of removal efficiency, a seemingly straightforward concept, can be approached using at least four different methods (Strecker et al. 2001). In this review, the two primary methods were calculation of efficiency based on either 1) change in parameter concentration between inflow and outflow, or 2) percentage of mass of influent pollutants removed, which can result in markedly different efficiency removal efficiency values, even for the same data set. In many cases in this review, removal efficiencies were not reported, but influent and effluent concentration data (e.g., Event Mean Concentration, EMC) were presented that were used to calculate percent removal.

Recently, the concept of removal efficiencies itself has been questioned, and the use of "effluent quality," or the concentrations of pollutants in BMP effluent, has been recommended as a more robust measure of the effectiveness of BMPs for water quality improvement than removal efficiency values (Strecker 2001). A recent comprehensive review of the International BMP Database (BMP Database 2007), Rea and Traver (2005) report well-analyzed effluent concentration data for various BMPs, but present no removal efficiency values, indicating a shift in the state-of-the-art method for evaluating BMPs.

The literature found in this review was divided into two groups: a) studies of individual BMP project sites ("single-site" studies); and b) studies that reviewed or averaged performance for multiple sites or design ratings for particular BMPs based on multiple sites or professional judgment ("multi-site" studies). The studies of individual sites were analyzed separately from the multi-site studies because the latter typically relied on studies of some of the single sites. Single-site studies were limited to those that occurred in the eastern U.S., defined as those sites east of the Mississippi River. Some of the multi-site studies likely include some sites from elsewhere in the U.S., and possibly Canada.

Removal efficiencies were summarized in tabular format for single-site studies and multi-site studies. Summary statistics for TN, TP, and TSS removal efficiency such as mean and standard deviation were not calculated for since only two single-site and three multi-site studies were found.

Results of Literature Review

Only two studies of individual sites were found in the literature review (Table 1).These studies suggest a wide range of efficiency between the two sites, e.g. 30-70% for TSS, 15-50% for TN, and 40-60% for TP. While these individual studies appear to be reasonably rigorous assessments of the sites, there are too few studies to assess the mean or range of performance efficiencies of these systems. As noted previously, the literature for dry detention basins likely includes some dry ED basin studies as well.

The range of efficiencies reported for multi-site studies is somewhat small than that for individual studies (Table 2), indicating efficiencies of 60-85% for TSS, 15-30% for TN, and 15-25% for TP. In interpreting removal efficiency results, it is important to bear in mind that a large positive or negative efficiency value can result from very small changes in chemical concentration (e.g., a change from 0.01 mg/L TP at the inflow to 0.03 mg/L at the outflow results in a removal efficiency of -200%, but these low concentrations are within ranges occurring in many natural waters).

Given the variability of performance among different sites, it is not surprising that some of the values for the two sites are far from those of the multi-site studies. In particular, the TP removal efficiencies of the individual sites are considerably higher than those of the multi-site studies.

Recommended Removal Efficiencies for Model

The results of this literature indicate that the removal efficiencies currently used in the Chesapeake Bay model are appropriate for TSS and TP, but too high for TN. Specifically, the following removal efficiencies are justified by this review of scientific and technical literature:

Sediment (TSS):	60%	(no change)
Nitrogen (TN):	20%	(currently 30%)
Phosphorus (TP):	20%	(no change)

In determining these ratings, the multi-site studies were weighted higher than the single-site studies. Additionally, upward adjustment of the currently-used rate was not considered justified given the few studies available.

The current value for TSS seems appropriate based on the range of multi-site studies and the single-site studies (one multi-site value of 85% and one single-site value of 30% together do not justify a downward adjustment of the efficiency value). Furthermore, the removal rate of 60% for dry ED basins is slightly higher than the value I recommended for dry detention basins (50%), which makes sense given the theoretically higher removal rates due to longer detention times in dry ED basins.

Reducing the value for TN from 30% to 20% is justified given the low removal rates indicated by two of the multi-site studies and one of the single-site studies. Nonetheless, this value of 20% removal is higher than that which I recommended for dry detention basins of 15%.

For TP, the reported results for multi-site studies do not justify changing the efficiency. The two individual studies did report considerably higher values, but these are insufficient justification to increase the efficiency for the model. The value I recommended for TP removal in dry detention basins was 35% (currently 20% is used in the Bay model). Given the longer detention time in dry ED basins, one might ask why the value recommended for dry ED basins is not higher. For phosphorus sorbed to suspended particles that could be removed via sedimentation, higher rates might be justified. However, prolonged inundation in dry ED basins may result in anaerobic, chemically-reducing conditions in their soils, leading to the chemical reduction of iron and release of iron-bound phosphate from the soil (Mitsch and Gosselink 2000), resulting in lower phosphorus removal in dry ED basins than in dry detention basins.

Changes in factors relating to soil, vegetation, or hydrologic conditions may alter the effectiveness of dry ED ponds for removal of suspended solids or nutrients. For example, longer detention times will in general tend to improve efficiency due to increased contact between water and soil or microbial surfaces and vegetation, as well as longer times for settling of particulates. Longer detention times can be created by increasing the area or volume of dry ED ponds and hydrodynamic structures relative to drainage area entering the system, or conversely by reducing the volume of runoff entering the pond or structure. Efficiency can also be affected by the geomorphology of the unit; designs that maximize the area of contact between water and soil, vegetation, or microbial surfaces should in general increase efficiency (e.g., long, linear ponds with shallow water depth are likely to be more effective than deep, concave basins of the same volume). Increased vegetation density and biomass is also likely to improve efficiency because of greater uptake, more microbial surface area, and increased oxidation of the root zone. Because vegetation structure and composition are temporally dynamic, efficiency may also vary, but should approach a dynamic equilibrium after some period of time, probably measured in years. While microbial removal processes that affect nitrogen removal are sustainable indefinitely under relatively constant environmental conditions, soil surfaces may become phosphorus-saturated, and further phosphorus sorption is therefore not possible. Depending on the soil type and phosphorus loading rates, saturation may take many years, if it occurs at all. Capacity for sediment removal may also be impeded if high loading rates result in clogging or burial of vegetation. Additionally, high flow rates may lead to the formation of preferential flow pathways that reduce contact between water and microbes, soil, or vegetation. These and other variables may lead to changes in the efficiency of dry ED ponds for stormwater quality improvement over time. Some processes may increase efficiency (e.g. development of vegetation) while other processes may simultaneously decrease efficiency (e.g. channel formation).

Climatic variables may also affect BMP performance over time, either positively or negatively. Periods of greater precipitation will likely result in shorter residence times, or even bypassing of the BMP due to high flow volumes, both of which will reduce performance. On the other hand, higher temperatures should increase metabolic rates, increasing growth of microbes and plants and facilitating greater transformation and uptake of nutrients. Global climate change may therefore affect performance by changing precipitation patterns and temperature in unpredictable ways. An additional factor is higher CO_2 concentrations, which may result in shifts toward species competitively favored under high atmospheric CO_2 levels. Changes in species composition may have some effect on performance, although effects are likely to be small unless there are large changes in stem density or biomass.

The few studies available suggest considerable variation in the performance of dry ED basins. Performance may vary over time, and in some cases high volume runoff events may bypass the system, resulting in little removal for large volumes of runoff. Detention ponds should continue to function effectively for years without any significant maintenance other than mowing (which may not be critical for optimum performance). Periodic inspections should be performed to identify changes in hydrology, vegetation, or soils like those described above so that remedial measures can be taken in necessary. Particularly when systems are new, it is important to make sure water levels along the surface of the detention basin are suitable for the growth and persistence of vegetation. Development of channels or other evidence of erosion should be dealt with expeditiously, for example by diverting some portion of the runoff, installing rock berms, or otherwise decreasing flow velocities in the BMP.

While no studies have specifically evaluated how BMP efficiencies should be adjusted to account for the impacts of improper maintenance on receiving waters, some general adverse effects to water quality are understood. If maintenance is neglected a BMP may become impaired, no longer providing its designed functions. Proper maintenance of outlet structures, flow splitters and clean out gates is key to achieving a BMPs designed efficiency (Koon 1995).

In addition, sediment accumulation is one maintenance concern that if not addressed may adversely affect the BMPs effectiveness. As sediment accumulates it decreases storage volume and detention time, bypassing the intended functions of the BMP and increasing discharge of nutrient and sediment rich stormwater (Livingston et al. 1997). Increased discharge will lead to decreased downstream channel stability, resulting in an increase of sediment loads and a reduction in available aquatic habitat. The consequences of increased stormwater discharges from sediment filled BMPs, are a reduction in the BMPs pollution removal efficiencies, and ultimately, increased ecological impairments. The uncertainty in how improper maintenance will adjust BMP efficiencies supports the recommendation to use a more conservative percent removal estimate.

Statement of Conservatism

The level of uncertainty surrounding the recommended efficiency values is affected by, at a minimum, the number of studies available for a given parameter, the methods used to determine efficiency (e.g. number of replicates, analytical methods), the location of the studies, and the method used to calculate efficiency (e.g., load- vs. concentration-based).

For the purposes of this review, the most-reported parameters in single- and multi-site studies were TSS, TN, and TP, which is fortunate for developing recommendations for sediment, nitrogen, and phosphorus removal efficiencies. However, the review of the single-site studies shows tremendous variability in the efficiency of any given site in improving water quality. For the purposes of modeling water quality in the Chesapeake Bay watershed, however, these between site differences should average out, assuming that locations outside the Bay Watershed that were included in the review have similar efficiencies to those in the watershed.

While peer-reviewed literature may in general be assumed to have greater reliability than gray literature, a number of the reported results here were based on extensive monitoring data, some of it not even published in a gray-literature report (e.g., some of the sites in the International BMP database). However, it was also clear that some gray and peer-reviewed studies were based on relatively few measurements, or on grab samples rather than flow-weighted sampling. Only two articles in peer-reviewed journals were found, and these were both for dry detention basins.

The recommended values are near the lower end of the average and median values reported for the single-site studies. Given the variability between sites and relative paucity of monitoring data, these values represent a realistic assessment of removal efficiencies across a wide geographic region.

Given the numerous variables that may influence the performance of individual dry extended detention basins, any single numerical removal efficiency will not apply to all situations. Because only two single-site and three multi-site studies were found (the latter presumably also not including a large sampling of studies; e.g., Winer 2000 found only 3 studies that included concentration data), the reported studies do not incorporate a range of BMP designs of different ages across a wide geographic area. Therefore, there is considerable uncertainty in predicting the performance of actual BMPs across the Chesapeake Bay watershed. Using a confidence scale of low, medium-low, medium, medium-high, and high, I would rate the degree of confidence in the recommended values as medium-low.

Future Research Needs

As mentioned previously, the concept of “effluent quality” has been recommend over the use of removal efficiencies such as those that have been presented here and upon which the recommended values for the Chesapeake Bay model were based (Strecker et al. 2001). While the use of removal efficiencies in a modeling landscape or watershed transformation or removal or nutrients and sediments makes sense in theory, in practice problems arise due to the different methods used in calculating removal (e.g. load- vs. concentration-based) and small absolute changes in concentration or load resulting in large percentage changes, to name two examples. Furthermore, it is currently recognized (e.g., Kadlec and Knight 1996; Schueler 1999 in Winer 2001) that "natural" systems such as dry ED ponds constructed with vegetation and not concrete or liners, are not capable of removal of pollutants below a certain "background" concentration, a phenomenon not often considered when removal efficiencies are used in modeling or design efforts. Adoption of an "effluent quality" approach however, recognizes that for a specific flow volume and above a certain minimum design size, most BMPs will remove pollutants to some constant background concentration, regardless of additional increased in BMP area or volume. This approach could be applied in the Bay model by assigning the same effluent concentrations to BMPs of certain watershed:BMP size ratio. In addition to using effluent quality as a measure of BMP performance rather than removal efficiencies, Strecker et al. (2001) recommends using living resource restoration indicators, such as aquatic invertebrate sampling and habitat classification, in addition to calculating effectiveness by using chemical measures. These measures may not be applicable to systems such as dry ED basins, however.

Strecker et al (2001) recommend parameters that all studies should include, but are often missing. These include transferable measures of storage volume, surcharge detention volumes, stage/storage data, watershed characteristics, and land use information. Winer (2000) also recommends incorporating individual storm parameters, specifically bacteria, hydrocarbons, dissolved metals, as they correlate with human health, recreation and aquatic toxicity and are often not reported. Not only do many studies lack the aforementioned parameters, studies also make translation of available design parameters difficult. To ensure studies begin using these recommendations Strecker et al. state that the EPA require all federally funded projects that will evaluate BMP effectiveness employ standard methods they discuss, and in addition, that the EPA provide detailed guidance on data collection and sampling methods to improve data transferability (2001).

The fact that the BMP project conducted by UMD/MAWP did not address "treatment trains" has been brought up on several occasions. Please understand that UMD/MAWP conducted its review as instructed in the scope of work provided and approved by both UMD/MAWP and the Chesapeake Bay Program. The workplan identified the BMPs to be reviewed and stated that TN, TP and TSS percent removal efficiencies should be reviewed for inclusion in calibration of the watershed model. The workplan, however, also instructed project staff to compile a list of future research needs. Upon review of the urban stormwater BMPs it became obvious that the current practice categories and the individual treatment of effectiveness is not appropriate. However, there was not enough time or funding in the current project to determine effectiveness for treatment systems/trains but this should be done in the future.

No Impact Development

The concept of low impact development (LID), the use of proper site design techniques that reduces stormwater volume and pollution runoff, has been implemented across the Chesapeake Bay watershed for close to two decades. A refined version of LID, no impact development (NID), is currently being recommended as the new approach to urban development. NID claims to result in hydrologic and nutrient and sediment losses comparable to forest or natural meadows. UMD/MAWQ cautions against the adoption and assumption of effectiveness estimates for NID without further research to quantify its actual ability to reduce stormwater runoff and nutrient pollution. Current literature and practice implementation does not support the achievement of forest or natural meadow like conditions. Substantial research should be conducted before forest or meadow like hydrologic and pollution losses are assumed to be implemented on developed lands.

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Table 1. Summary of literature on the pollutant removal effectiveness (%) of individual dry extended detention (ED) basins as Best Management Practices for urban and mixed open land uses. TSS = Total Suspended Solids, TN = Total Nitrogen, TP = Total Phosphorus. Calculation method: C = concentration-based; L = Load-based.

System name	Location	TSS	TN	TP	Calc. Method	Comments	Reference
Virginia Tech Extended Dry Detention Pond	Blacksburg, VA	73	47	42	L	Concentration-based removals were 66% (TSS), 34% (TN), and 28% (TP)	Hodges 1997
Cedar Lake Extended Detention Pond	Northville Township, MI	30	15	57	C		Wayne County 2000

Table 2. Multi-site studies reporting removal efficiencies (%) for dry extended detention basins as Best Management Practices for urban and mixed open land uses. Calculation method: NS = not specified.

System name	TSS	TN	TP	Calc. Method	Comments	Reference
Multiple sites	61	31	20	NS		Winer 2000
Several studies	60	15	15	NS	Mid-point of ranges	Olson Environmental Sciences and Wright Water Engineers 2004
Various studies	85	15	25	NS	Mid-point of ranges	Wayne County 2000

Appendix A.

URBAN STORMWATER WORKGROUP CONFERENCE CALL
May 29, 2007

- In his report, Andy recommended renaming this BMP "dry extended detention basin", instead of "dry extended detention pond", as this BMP does not hold or pond water for a significant period of time.
- The results of this literature analysis indicate that the removal efficiencies currently used in the Chesapeake Bay model are appropriate for TSS and TP, but too high for TN. Therefore, UMD proposes that no change be made to the TSS and TP efficiencies and that the TN efficiency be reduced from 30% to 20%.
- Q: How is a dry extended detention basin different from a dry detention pond?
    - A: Many of the studies did not differentiate between dry extended detention basins and dry detention ponds. However, some of the sources did clarify that dry extended detention basins have specific structures, such as low-flow orifices, that act to retain stormwater for some minimum period of time following a storm event.
- Q: Why is the TP efficiency less for the dry extended detention basin than it is for the dry detention pond?
    - A: Two possible explanations are that (1) the prolonged inundation in dry extended detention basins may result in anaerobic, chemically-reducing conditions in their soils, leading to the chemical reduction of iron and release of iron-bound phosphate from the soil, resulting in lower phosphorus removal in dry extended detention basins than in dry detention basins, or (2) there were too few studies on dry extended detention basins.
- In the PA BMP manual, the efficiencies for this practice are 20% for TN, 50% for TP, and 60% for TSS. Note that the efficiency for TP (50%) is much higher than the proposed 20%.
- Each of the jurisdictions have different criteria and different conditions that may not be reflected in these studies.

DECISION: The USWG accepted UMD's proposed efficiencies, with the following stipulation for TP. Sarah and Andy will evaluate the PA data used to develop the TP efficiency for this practice in the PA BMP manual. If they feel that a change is then warranted, it will be discussed at the June 6th NSC meeting.

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Minutes: Tributary Strategy Workgroup Meeting
June 4, 2007
10:00 AM to 3:00 PM
NRCS MD State Office, Annapolis

Urban BMPs

- ACTION: The USWG will write up a formal recommendation for their proposed reduction efficiencies of urban wetlands and wet ponds, and any other urban BMPs, with documented reasoning. The USWG and the MARWP will present their different recommendations to the TSWG and/or the NSC when it is time to make the final decision.
- ACTION: Andy Baldwin, the expert efficiency developer for urban BMPs, will provide a short piece to the workgroups that clearly explains why he his recommended efficiency for dry ponds is very close to his proposed efficiency for wetponds.
- ACTION: The MARWP will ensure that their analysis included studies and data used by the states in their stormwater manuals and handbooks.
- DECISION: The TSWG will wait to make a decision until the USWG formally presents their proposed recommendations and Andy Baldwin provides additional information requested by the TSWG.

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Minutes: Nutrient Subcommittee Meeting
June 6, 2007
10:00 AM to 3:00 PM
Fish Shack—Chesapeake Bay Program Office

Dry Extended Detention Basins
The USWG accepted MAWP's efficiency recommendations.

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URBAN STORMWATER WORKGROUP CONFERENCE CALL
June 26, 2007

- At their May 29th conference call, the USWG reviewed the year-one urban BMP definitions and efficiencies that MAWP/UMD is proposing as part of an EPA-CBP funded project.
- Following are the decisions made by the workgroup during the May conference call:
    - Dry Detention Ponds & Hydrodynamic Structures: The USWG recommended that these practices be separated and that MAWP's proposed efficiencies be used for dry detention ponds and that the current CBP adopted efficiencies be used for hydrodynamic structures.
    - Dry Extended Detention Basins: The USWG accepted UMD's proposed efficiencies, with the following stipulation for TP- MAWP should evaluate the data used to develop the TP efficiency for this practice in the PA BMP manual.
    - Wetlands and Wet ponds: The USWG rejected both Andy Baldwin's and MAWP's recommendations, citing that efficiencies were too low.
    - Urban Erosion and Sediment Control: The USWG rejected MAWP's proposal.
- Based on their review during the May conference call, workgroup members felt that the proposed efficiencies for these practices did not take into account all relevant studies. In order to address these concerns, members were given until June 8th to submit additional references to MAWP.

- After reviewing the additional information provided by workgroup members, MAWP has decided that their recommendations for the year-one urban BMPs will remain unchanged. At today's conference call, Tom Simpson, UMD, and Sarah Weammert, UMD, explained their reasoning for this decision. The handout that was distributed to the group explains their approach for BMP efficiency development. It can be accessed at http://www.chesapeakebay.net/calendar.cfm?EventDetails=8034&DefaultView=2 .
- The main pieces of literature that USWG members asked MAWP to look at were the design manuals for the different jurisdictions, NERP data, and the Center for Watershed Protection (CWP) database. MAWP found that all of these sources were included in Andy Baldwin's BMP reports (Andy Baldwin developed the proposal documents for each of these practices).
- BMP projects from the CWP database were used to develop VA draft regulations and MD and PA stormwater design manuals. Upon further evaluation of all sources considered in the development of the urban wetland and wet pond practices, it was found that the developer had included the sources from the design manuals in his multi-site analyses. The analysis by the database developer includes the median values for all 145 studies used in the 2000 version of the Center for Watershed Protection database. In addition, some single site studies from the database are also included in the developers single site analyses. The 2007 CWP database will not be published until later this summer.
- ISSUES: Two concerns that the USWG had at the May conference call were: (1) MAWP's proposed efficiencies are based on single-site studies rather than multi-site studies and (2) the analysis includes studies with negative efficiencies. The USWG would instead like to base the efficiencies on multi-site studies and omit studies with negative efficiencies.
- MAWP decided that they would not change their recommended efficiencies based on the above two concerns. The developer and the STAC reviewer stated that the values closer to the mean and median efficiencies of the single-site studies should be used to determine effectiveness rather than those of the multi-site studies. In regards to negative efficiency studies, MAWP thinks that they should be included because these situations do occur operationally in real world situations. Also, negative efficiencies that have been published have undergone a rigorous scientific review.
- At the WQSC meeting it was suggested that statistics be provided for the studies in the analyses. These statistics are already listed in the reports for the year-one urban BMPs.
- ACTION: Workgroup members should submit ideas for future Bay Program needs (such as additional practices, changes in the overall approach to practices, ect.) to MAWP. It is beyond the scope of their project to address these needs, but they will include a list of issues that need to be addressed in their report.
- This project is not trying to define an efficiency for the perfect example of this practice. It is instead trying to identify an efficiency that characterizes this practice as it functions on broad application in the landscape and reflects real-world operational conditions.

- The workgroup needs to look at the definitions for wetlands & wet ponds and urban erosion & sediment control because there seems to be conflicting opinions between the developer, the reviewer, and the workgroup.
- ACTION: Sarah Weammert requested that the workgroup provide her with guidance for year-two urban BMPs. Specifically, she would like guidance on infiltration and filtration practices. What are the specific practices that need to be looked at? Are there 3-5 major groups of practices? What should the subcategories be? This will be on the agenda for the next workgroup meeting. Sarah needs this information by September.

II. Workgroup Recommendations **All**

- The workgroup discussed what their next steps should be and whether or not they would like to approve the MAWP recommendations or submit their own separate recommendations to the Tributary Strategy Workgroup on July 9th.
- Q: What does the rest of the review process look like for these BMPs?
    - A: MAWP's recommendations and the source workgroup recommendations will be presented to the TSWG on July 9th, to the NSC on August 15th, and to the WQSC in mid to late August. STAC is also concurrently reviewing MAWP's work. They will provide two reports for the TSWG to review at their August 6th meeting. One report will look at the process MAWP is using to come up with these efficiencies and whether or not it is sound and the second report will look at whether or not the BMP efficiencies make sense when you look at them across the board. Essentially, STAC is evaluating whether or not this combination of science and judgment is appropriate for what we are doing and if it is consistent, logical, and valid. They are not evaluating the efficiency number.
- The proposed efficiencies are based on both science and best professional judgment. We need to know where the science ends and where the best professional judgment begins. This is addressed in the individual BMP reports.
- ISSUE: Concern was voiced over the difference between the MAWP efficiencies and the efficiencies used in state regulations and programs.
    - DE is not including efficiencies in their regulations, however other states, such as VA, need to include efficiencies.
    - CWP is developing efficiencies for the VA regulations. It would be helpful if VA could provide the workgroup with their proposed state regulation efficiencies before the July TSWG meeting.
    - MD's efficiencies were also developed by CWP and they differ from MAWP's recommendations.
    - Some of the states feel that they can not support the MAWP proposed efficiencies if they are different from their state efficiencies.
    - The efficiencies used in the CBP model and the efficiencies in the state regulations are different because the efficiencies were developed with different assumptions and are intended for different purposes. The state efficiencies describe what a BMP is capable of achieving if operation, design, and maintenance are optimal (best case scenario), whereas the

efficiencies used in the Bay Program model describe what is happening operationally across the watershed from a realistic standpoint, taking into account maintenance issues, errors in design, etc.
    - There is currently no information that shows that the Bay region is operating at a much more effective rate than the rest of the country. Inspection reports and monitoring data are not available. If this type of data did exist, then MAWP could have factored it into their analysis.
    - It was pointed out that the state efficiencies and the MAWP proposals were developed using essentially the same data, however they are both looking at it differently from a statistical analysis standpoint.
    - It was suggested that the USWG write an issue paper that discusses this need for consistency with state stormwater programs and how it may play out. This paper could explain what the workgroup would ideally like to see and how it is backed up by the data.
    - It was also suggested that the different objectives and assumptions for state efficiencies and Bay Program efficiencies be documented.
- Q: Who is going to make the final decision regarding what efficiencies are used in the Bay Program model?
    - A: Ideally, the TSWG and the NSC will make the final decision. However, if a decision cannot be reached by these groups, then the decision will have to be made by the WQSC.
- ISSUES: As mentioned earlier, the USWG thinks that multi-site studies rather than single-site studies should be used and that studies with negative efficiencies should be omitted.
- STAC has been made aware of the USWG's concerns and they are looking closely at the above two issues.
- Q: Why do we still track individual BMP practices in the watershed model? Instead, could we look at the number of acres meeting performance standards?
    - A: Individual BMP practices are tracked in the model due to a previous decision made by the workgroup. The model could be based more on performance standards if monitoring information and data were available. We need to have a way to monitor the performance standard. You can't make a blanket assumption that you have 100% performance standard compliance.
- It was suggested that the USWG's argument may be stronger if it was more technical. For example, the workgroup could explain why the states didn't use all of the studies that MAWP used, why they omitted negative efficiencies, why their numbers are better, etc. It would be useful if the argument was linked to MAWP's recommendations.
- ACTION: Representatives from the USWG need to attend the July 9th TSWG meeting in order to present the workgroup's argument and recommendations. Norm Goulet, workgroup chair, will be unable to attend. Sally Bradley will send workgroup members the agenda for the July 9th TSWG meeting when it is available.

- ACTION: It would also be helpful if someone would write down the workgroup's concerns and the justification for their proposed approach. This draft document could then be emailed to the workgroup for comments.

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MINUTES: TRIBUTARY STRATEGY WORKGROUP MEETING
July 9, 2007
10:00 AM – 1:30 PM
NRCS MD State Office

Urban BMPs

- Reggie Parrish updated the TSWG on the status of the urban BMPs review process.
- The USWG has been addressing three areas of discrepancy:
    - Wetlands and Wet Ponds: The USWG believed the proposed efficiencies were too low.
    - Dry Detention Ponds and Hydrodynamic Structures: The USWG accepted the proposed Dry Detention Ponds efficiencies but wanted to separate out Hydrodynamic Structures into its own BMP. The workgroup believed the existing efficiencies should remain unchanged for Hydrodynamic Structures.
    - Urban Erosion and Sediment Control: The USWG rejected the proposed efficiencies and requested more work in this area before it is revisited.

- The USWG has been preparing their own recommendations for urban BMPs and providing Tom and Sarah with additional information that they believe should be considered.
- The USWG made various suggestions for the literature review process. First, the USWG suggested that the literature that finds negative efficiencies from the BMPs be eliminated in the review. The USWG also suggested that only multiple-site studies be used in the literature review, not single-site studies. Finally, the USWG did not believe enough attention was given to the state stormwater manual efficiencies.
    - Tom and WQSC members believed studies with negative efficiencies should be factored into the literature review.
    - Tom explained that all of the data behind the state stormwater manuals was used, and more, in the literature review process. The suggested efficiencies given in the manuals were not directly used, however, because they represent a target efficiency to shoot for, not an actual average widespread implementation efficiency.
    - ACTION: Tom and Sarah will clarify in their report that although the state stormwater manuals "target" efficiency was not directly used in the literature review, the data behind the state stormwater manuals, and more, were used in developing the recommended efficiencies.
- Reggie proposed 3 options on behalf of the USWG (who had not yet reviewed the document) for moving forward with the urban BMPs:
    - Option 1: Proceed with a different set of efficiencies for state/local and CBP.
        - Kelly Shenk thought it would be useful to understand the different purposes that the partnership uses the BMP efficiencies for. For example, CBP is interested in showing the average reduction of loads across the watershed, by using the model as a projection tool for necessary management actions.
            - Reggie explained that local governments have a scale issue with the BMP information, as some states are looking at a series of BMPs and how they function rather than just looking at a single BMP.
        - Virginia is in the process of developing regulations based on their BMP efficiencies. VA was in favor of Option 1 for defensibility reasons as they more forward with their regulations.
        - Helen did not wish for Option 1 to move forward because she believed consistency is necessary. MD's local governments demand consistency.
    - Option 2: Work with modelers to determine feasibility and possibility of not changing the urban BMP efficiencies until year 2 BMPs are revised in the model.
        - Helen confirmed that the BMP efficiencies won't make a dent in the model but are important for planning options, TMDLs, trading, etc.
        - Kelly thought this option may be worth exploring but that more time may not provide more data to inform our decision, it would just prolong the deadline for making a decision. Likewise, we're given the

opportunity make these changes in the model simultaneously right now. Waiting until year 2 may be impossible politically.

- Option 3: Shift from a single BMP efficiency approach to a systems approach.
  - Most states are looking at this issue holistically, so the USWG is asking if this review process is our opportunity to change course and start to look at BMP efficiencies holistically.
  - Ken Pensyl informed the workgroup that some BMPs do not get accounted for because they have no drainage area associated with them, however the broad spectrum of runoff from development could be addressed using a systems approach.
  - DECISION: The workgroup agreed that moving to a systems approach as outlined in Option 3 is the best way to move forward.
    - Tom confirmed that they could support a systems approach but that data to document the hydrology of the landscape are necessary.
    - The systems approach would factor in landscape conditions such as slope and soil type.
    - Kelly agreed by saying that a lot of states are heading in this direction of performance-based approaches. We will still need to determine what the realistic reduction is that we can expect to achieve with the performance-based approach.
    - The USWG wants to collect performance data on different types of land uses across the region.
- Although the workgroup agreed to pursue Option 3, this shift to a systems approach could take years, so a more immediate solution is still needed for proceeding with the BMP efficiencies for the model.
  - Kelly suggested that the efficiencies be developed by first starting with the state stormwater manuals as the design standards for the BMPs and then applying a margin of safety based on the data collected by the MARWP.
  - Referring back to our adaptive management approach, Kelly suggested we use the MARWP's recommended efficiencies as the conservative estimate to be fed into the model until we have monitoring data and can make adjustments.
  - DECISION: The USWG will discuss the options for moving forward in the short-term with the urban BMP efficiencies, considering the TSWG's input.
  - Helen suggested that looking at each BMP's margin of safety could help us to decide the appropriate margin of safety to use for the urban BMPS.
  - ACTION: Per Tom's suggestion, the USWG will figure out a way to include the negative efficiency studies in their efficiency recommendations because their dismissal cannot be justified.

- Kelly reminded the TSWG that we would ideally like to have all decisions made at the workgroup and NSC level by mid-August, before the WQSC reviews the recommendations.
    - The WQSC members are interested in knowing who their workgroup representatives are in order for the workgroups to take the authority to make the decisions before the process goes to the steering committee.

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Urban Stormwater Workgroup Conference Call
July 25, 2007

Minutes

- Reggie Parrish, workgroup coordinator, began the meeting at 10:10 am. Introductions were made and the meeting's agenda was reviewed.
- At the July 9th Tributary Strategy Workgroup meeting, Reggie presented the USWG's concerns regarding the UMD/MAWP proposed efficiencies to the TSWG. Three potential options were suggested that were based on previous USWG conference calls.

- Based on the discussion at the TSWG meeting, two additional options have also been proposed. All five of the options are listed in the handout for today's call, which can be accessed at: http://www.chesapeakebay.net/calendar.cfm?EventDetails=9014&DefaultView=2. The TSWG strongly supported option C, but recognized that the workgroup would need to propose a short-term solution if this option were chosen.
- At the July 9th TSWG meeting, the TSWG asked the USWG to develop a specific position that they can formally submit to the TSWG, the Nutrient Subcommittee and ultimately the Water Quality Steering Committee.
- During today's conference call, we had hoped to come up with a specific position supported by the USWG; however, since many key players were unable to participate in today's call, conference call participants decided that the call should be rescheduled for sometime next week and that we should postpone making a decision on the workgroup's position until that time.
- The USWG needs to decide on a position before the next TSWG meeting, which is being held on August 6th.
- Q: How do our no net increase efforts relate to the BMP efficiency efforts?
  - A: We are not sure exactly how these efforts are related yet. The performance based systems approach, which is one of the proposed BMP efficiency options, seems like it would be relevant to no net increase efforts.
- Q: What is the definition of no net increase?
  - A: In PA, they are trying to move forward with the concept of no net change rather than no net increase. The Stormwater and New Development Taskgroup did not define no net increase at their last meeting. It is important to point out, however, that we do not want the efficiencies to get bogged down with the no net increase issue. We still need the efficiencies in the more short term timeframe.
- Q: Right now, the states are only providing the Bay Program with data on implementation. What data would need to be provided for option E (see handout) to show that the BMP is properly designed, inspected, maintained and operating? It seems like a lot of data would be needed. Do we have this information?
  - A: We are not exactly sure yet what data would be needed for this option. One suggestion was that if a state could ensure that a good O and M plan was in place, then maybe this could ensure a higher efficiency. Before choosing this option, the workgroup would really need to explore it further.
- Workgroup members were interested in how the other sectors chose their efficiencies in the Bay model and what data they used to do this.
- In other sectors, it is not assumed that the BMPs reported meet design standards and are properly maintained. Essentially, they apply a safety factor for long-term maintenance. This is also why UMD/MAWP adjusted their efficiencies down.
- It was pointed out that there is not long-term data available for most BMPs. It is just a matter of ensuring implementation. In PA, there is an inspection program to ensure that BMPs are properly installed.
- Compared to focusing on individual BMPs, a systems approach would be more in line with state design manuals.

- Q: Is there any documentation of the discussion that took place to develop PA's BMP manual?
  - A: There is some documentation, however it is not very detailed.
- Some participants thought that implementation information and water quality monitoring (to show that you are getting the expected results) should be all of the data that is needed.
- Option D (see handout) says that state manuals use efficiencies that describe optimal performance, but that Bay Program and UMD/MAWP efficiencies acknowledge that BMPs do not work optimally all of the time in the real world.
- PA pointed out, however, that the Bay Program and UMD/MAWP efficiencies are based on single BMPs and in PA they use a combination of BMPs that this approach does not capture. In reality, these are being looked at as systems and multiple BMPs are being relied on to achieve results. Using a systems approach is option C in the handout.
- Could the urban sector use an approach similar to the ag sector's conservation plans, which is essentially a suite of BMPs?
- A systems approach could develop different efficiencies for various tiers of a system.
- It was suggested that we default to state standards and then add some sort of qualifier on that shows that they are not achieving their goals 100%.
- Some participants felt that option E (see handout) is sort of the "do nothing option" and that it pushes the decision to a later point in time.
- The model calibration period is from 1985 to 2004. For stormwater management in PA, the Bay Program has one number for each year that covers the entire watershed portion of the state. Jeff Sweeney needs to know what efficiency should be applied to these stormwater management acres. PA agreed to follow up on this issue for Jeff.
- Essentially there appear to be two issues: 1) what we need immediately for calibration, and 2) what we will use in the future.
- Q: If we come up with some numbers for calibration and then we come up with different efficiencies to be used for future planning, we would have to revise those efficiencies in the model, correct?
  - A: Yes. Jeff said that this could be done though.
- One concern that was voiced was that members do not want to see efficiencies lowered based on historic expectations, compared to future expectations. It was suggested that we have two separate efficiencies for 1985-2000 and 2000 and beyond.
- For whatever position they choose, the USWG needs to provide supporting documentation equivalent to what UMD/MAWP provided for all of the other BMPs.
- Q: Did UMD/MAWP separate out dry detention ponds and hydrodynamic structures, as was proposed at the May 29th conference call?
  - A: These practices were combined based on the categories created previously by the USWG. As far as Reggie and Sally know, UMD/MAWP did not make any revisions to their proposals to separate out these practices. Reggie will contact Sarah Weammert, UMD/MAWP, to find out whether or not they made this change.

- During today's conference call, there seemed to be general agreement that we need to look at a systems approach on a more long-term basis. However, in the short-term we really need to decide on some way to assess BMP efficiency for model calibration.
- Reggie Parrish will set up a call for sometime this week between Ken Murin and Norm Goulet so that they can further discuss a potential USWG position on BMP efficiencies.
- The meeting was adjourned at 11:30 am. A date for next week's conference call will be sent out to workgroup members as soon as it is selected.

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Urban Stormwater Workgroup Conference Call
August 1, 2007

- Norm Goulet, USWG chair, began the conference call at 9:30 am. Introductions were made and the meeting's agenda was reviewed.
- All of the handouts for today's conference call can be accessed at: http://www.chesapeakebay.net/calendar.cfm?EventDetails=9016&DefaultView=2
- The purpose of this conference call was to come up with a workgroup position on urban BMP efficiencies. This position needs to be presented by the workgroup at the next Tributary Strategy Workgroup Meeting, which is being held on August 6th.
- Highlights from the STAC review of the UMD/MAWP BMP efficiency process include:
    - STAC agreed with UMD/MAWP on the use of negative efficiencies. They said that the Chesapeake Bay model must be calibrated to function with operational rather than research BMP efficiencies. Hence, if reported negative efficiencies reflect operational conditions, STAC felt that they should be considered in an assessment of the BMP efficiency literature.
    - STAC stated that peer-reviewed literature should be given more weight than state BMP manuals. They do not consider state manuals to be peer-reviewed since they were not subjected to independent examination.

- STAC commented on the fact that some experts used the lack of research data to justify deep discounts of the few reported efficiencies, while other experts refused to change current efficiencies because of the lack of research data. STAC said that they hope that such a situation was anticipated, and that the charge to the expert specifically stated how such situations were to be handled.

- In the workgroup's draft position paper, the following three specific concerns are listed: 1) negative studies should be eliminated, 2) single site studies should not be used, and 3) state manual BMP efficiencies not appropriately considered.
- It was thought by some members that the biggest workgroup concern, which is not listed, is that the efficiencies are based on historic data. More recently, the states have increased volumes, changed their strategies, added pre-treatment, and changed BMP design criteria. These changes are not reflected in the studies that UMD/MAWP used to come up with their efficiencies. Members thought that the efficiencies that UMD/MAWP proposed may be good for BMPs that were put on the ground between 1984 and 2000, but not for more recent BMPs.
- The calibration period for the CBP model is from 1985-2002. Thus, based on the above comments, it seems that the efficiencies from UMD/MAWP would be appropriate to use for model calibration. This is our immediate need.
- Post-construction BMPs are a bigger issue than construction BMPs. They should be the focus of the information that states report to the CBP office.
- Norm proposed that the following modifications be made to the USWG's position paper:
  - Acknowledge that the UMD/MAWP numbers are incorrect for a variety of reasons.
  - State that the workgroup will, however, accept the efficiencies from UMD/MAWP with the stipulation that they have the option to increase the efficiencies later if sufficient data is available to show that they are achieving higher efficiencies.
  - The UMD/MAWP numbers will be used in the upcoming model calibration.
  - The UMD/MAWP efficiencies will only be used for one year. During that time, we will work towards switching to a systems approach.
  - If a systems approach is not developed within one year, then the default is still the UMD/MAWP numbers.
- It was suggested that we have an on-going evaluation of the BMPs to determine how they actually function in the long-term.
- Ideas for how we could develop a systems approach include:
  - Two systems could be developed: ultra-urban and a more suburban approach. Each of these would have different values.
  - Gather information from each state since different states have different soils, slopes, etc. Maybe a research group could look at this and come up with calculated values for the land use. This would be similar to what UMD did for the BMP efficiencies.
  - Unfortunately, there is not much monitoring data out there.

- Right now, CBP efforts should focus on just sediments and nutrients. Maybe later they could expand this effort to include other pollutants.
- The systems must be something that we know we can track in the future.

- The workgroup will develop a funding proposal for a project that will research and potentially develop a systems approach. In addition, the workgroup may need to develop its own report that they will pass up to the Tributary Strategy Workgroup and the Nutrient Subcommittee.
- There is a protocol for peer review on the Bay Program website.
- Q: Will we be able to get CBP funding for this project?
    - A: After a proposal is developed, it can be taken to the Budget Steering Committee. However, there is unlikely to be money available from the CBPO at this time due to a budget shortfall. Therefore, we may need to be creative and look for other funding sources. It was pointed out that there was no CBPO money available for the UMD BMP efficiency project either, but we were able to gain the Budget Steering Committee's support for this project and another source of funding was found.
- Q: Can UMD's scope of work be modified so that they look at the systems approach in year 2 of their BMP project?
    - A: It is unlikely, but Kelly Shenk will look into this just in case. It will depend on how much of a departure this is from the project's original scope. Even if we can get them to look at the systems approach in year 2, their review will not be as extensive as what the workgroup was discussing earlier. If we are going to switch to a systems approach, maybe we no longer need UMD to look at infiltration practice efficiencies in year 2. Perhaps we could replace this with gathering data on the systems approach.
- Q: Could we use the UMD efficiencies for the model calibration period, and then use the state BMP manual numbers when we do implementation runs later?
    - A: No. The state BMP manual numbers cannot be used.
- Q: What do we do in the mean time while we are developing this systems approach?
    - A: It was suggested that we use the UMD efficiencies unless the states have data that shows that they are achieving a higher efficiency.
- Workgroup members decided to accept the position laid out in today's handout once Norm's proposals (see above) are included. Reggie will revise the handout so that it includes Norm's proposals and text on model calibration and historic vs. future values.
- Norm and Reggie will present the workgroup's position at the August 6th Tributary Strategy Workgroup meeting. Information on this meeting can be found at http://www.chesapeakebay.net/calendar.cfm?EventDetails=8816&DefaultView=2.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
August 15, 2007

- Norm Goulet, Urban Stormwater Workgroup Chair, presented the recommended BMP efficiencies for urban wetlands and wet ponds, urban erosion and sediment control, dry extended detention basins, and dry detention ponds/basins and hydrodynamic structures.
- The USWG is recommending these efficiencies with some caveats. The way urban BMPs are modeled needs to change from stand alone BMPs to a systems approach. Until that can be accomplished, these BMP recommendations should be used to calibrate the model along with additional data from the jurisdictions.
- There is also concern that the CBP recommended efficiencies are not always consistent with the efficiencies provided in state handbooks. If facilities can provide documentation regarding implementation, maintenance, and inspection processes, are the handbook efficiencies acceptable? Will this cause confusion?
- It was noted that there is also a difference in efficiency if a jurisdiction has a strong enforcement program. Stronger enforcement leads to more maintenance at facilities and higher efficiencies.
- Was consideration given to splitting dry ponds and hydrodynamic structures since they behave differently? Consideration was given; however, there is not a lot of recent information available regarding hydrodynamic structures and each state handles these structures differently which makes it difficult to develop a stand alone BMP efficiency rating.
- A concern was raised regarding super-load areas in the Phase 5 model. They seem reasonable in applied to highly disturbed areas only; however, they would not be accurate if applied to whole acreages. The Tributary Strategies Workgroup will take a look at this issue and report back to the NSC.
- It will be necessary to update the CBP website to clearly link urban BMPs with their efficiencies and to explain the transition from Phase 4.3 to Phase 5 of the CBP model to make it more understandable to users.
- Infiltration and filtering processes were omitted from the MAWP year 1 project scope but will be included in year 2. It is valuable to examine these BMPs even if the model eventually moves to a systems-based approach as it will take time to

make the needed changes to the model and the jurisdictions are currently implementing these BMPs.

- What about N and P speciation? How effective are BMPs at treating various forms of N and P? There is not enough information available to develop general rules about the various N and P species; however, this issue will be highlighted in the MAWP report as a research need.
- The recommended urban BMPs were approved.

Efficiency Recommendation	**TN**	**TP**	**TSS**
Urban Wetlands and Wet Ponds	20	45	60
Urban Erosion and Sediment Control	25	40	40
Dry Extended Detention Basins	20	20	60
Dry Detention Ponds/Basins and Hydrodynamic Structures	5	10	10

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Chesapeake Bay Program
Water Quality Steering Committee

Conference Call

August 27, 2007

SUMMARY OF DECISIONS, ACTIONS AND ISSUES

Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

DECISION: The Water Quality Steering Committee approved the 12 BMP definitions and efficiencies, described in the advance briefing papers, as recommended by the Nutrient Subcommittee and its workgroups for use in Phase 5 Chesapeake Bay Watershed Model.

Conference Call Participants

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Forest Harvesting Practices

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in the Chesapeake Bay Program's Phase 5.0 Watershed Model

Consulting Scientists

Pamela Edwards
Research Hydrologist
USDA Forest Service

And

Karl Williard
Associate Professor of Forest Hydrology/Watershed Mgmt.
Southern Illinois University Carbondale
Department of Forestry

Synthesis by

Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary

Forest Harvesting Practices: a suite of practices that reduce sediment and nutrient pollution to water bodies originating from forest management activities to acceptable levels.

- Effectiveness Estimate: 60% TSS, 60% TP and 50% TN

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University Of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

To review efficiencies MAWQ contracted experts, Pam Edwards and Karl Williard, and asked them to review applicable literature and propose an efficiency for model calibration based on the literature and their experience. See Appendix A for their report. The objective of this project is to estimate efficiencies that reflect operational conditions, and consequently the CBP modified the experts' research level recommendations to reflect actual conditions. Attached to these definitions and efficiencies is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix C.

Description/Definition

Specific, individual forestry BMPs focus primarily on controlling water quantity and energy because water movement serves as a primary mechanism for sediment and associated nutrient detachment and transport. Dissolved nutrients tend to be less impacted by typical forestry BMPs. Though, riparian BMPs, such as streamside buffer strips, may have a significant effect on dissolved nutrient loads

The definition for forest harvesting practices are a suite of practices that reduce sediment and nutrient pollution to water bodies originating from forest management activities to acceptable levels. These activities include: road, trail, and landing construction, use, and closure; harvesting and log removal activities; and site preparation or within-rotation treatments.

Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Components consisting of conservation measures included in the Forest Harvesting Practices definition include, but may not be limited to the following USDA-NRCS conservation practices:

- Forest Trails and Landings (655)
- Forest Slash Treatment (384)

Efficiency

To develop effectiveness estimates a literature review and discussions aimed at estimating the operational effectiveness with watershed wide spatial and temporal variability were conducted. These efficiencies assume they will be applied against typical forest loads. If a high loading land use is developed for disturbed forest then efficiencies should be re-evaluated and would likely be lower.

Literature Review and Data Analysis Methods

BMP efficiencies for sediment and nutrient reductions from forestry operations are based on studies in which paired watershed comparisons were made. One watershed was harvested (and also may have had site preparation) with BMPs while the second was harvested without BMPs. While many other studies in the literature compare sediment and nutrient loads between reference (undisturbed) watersheds and managed watersheds employing BMPs, BMP efficiencies cannot be determined from those types of studies. Sediment and nutrient reductions were based on in-stream water-column loadings, as there are no published studies to-date in the East that have measured to-stream or to-lake (i.e., actual hillside contributions) concentrations or loadings.

The data used to calculate sediment and nutrient reductions for this document were extracted from the papers listed in Table 1. Only data collected from regions that we deemed applicable to landscapes present in some part of the Chesapeake Bay watershed (i.e., physiography, topography, soils, hydrology and climate) are included; however, because there are so few BMP vs. no BMP comparisons, in reality few BMP vs. no BMP data have been excluded.

Data used in the calculation of BMP efficiencies for sediment are shown in Table 2. Loads for sediment from the study by Arthur et al. (1998) were presented in bar graph form, so an engineering ruler was used to measure the height of each bar and the loadings were calculated from those measurements. All other sediment and nutrient data were provided as tabular values.

Table 1. Studies from which sediment and nutrient data were obtained for forestry BMP efficiencies.

Reference	Treatment/Watershed Description	Location	Sediment Measured?	Nitrogen Measured?	Phosphorus Measured?
Kochenderfer and Hornbeck (1999)	One watershed (38.8 ha) diameter limit cut to 35.6-cm dbh with BMPs, one watershed (29.9 ha) clearcut to 12.7-cm dbh without BMPs. Hillsides averaged 40% slope in both watersheds.	Central Appalachians, north central WV	Yes	No	No
Wynn et al. (2000)	One watershed (8.5 ha) clearcut with BMPs, one watershed (7.9 ha) clearcut without BMPs. Firelines installed, herbicide applied, controlled burn and hand planting followed. Slopes average 2% over most of harvested areas except up to 30% slope along deeply incised streams.	Coastal Plain, VA	Yes	Yes	Yes
Arthur et al. (1998)	One watershed clearcut with BMPs, one watershed clearcut without BMPs. On both watersheds all stems > 35.5 cm, cut and left all stems < 5 cm dbh. Hillsides average 45% slope. Watershed sizes not given	Cumberland Plateau, eastern KY	Yes	Yes	Yes

Table 2. Efficiencies (i.e., percent reduction) for sediment loads gained from using forestry BMPs

Reference	Time Period	Sediment Load		Calculated Efficiency
		No BMPs	BMPs	
Kochenderfer and Hornbeck (1999)	1st yr after harvest 2nd yr after harvest	3227 kg/ha 323 kg/ha	123 kg/ha 77 kg/ha	96% 76%
Wynn et al. (2000)	Post harvest Post site-prep	9760 kg/ha/yr 7670 kg/ha/yr	560 kg/ha/yr 620 kg/ha/yr	94% 91%
Arthur et al. (1998)	During Harvest 1st yr post harvest 2nd yr post harvest 4th yr post harvest[1] 5th yr post harvest 6th yr post harvest	1180 kg/ha 640 kg/ha 376 kg/ha 100 kg/ha 200 kg/ha 307 kg/ha	553 kg/ha 420 kg/ha 367 kg/ha 47 kg/ha 387 kg/ha 67 kg/ha	53% 34% 2% 53% 94% 78%

[1] 3rd year post harvest figures were not collected.

Table 3. Efficiencies (i.e., percent reduction) for total nitrogen loads gained from using forestry BMPs

Reference	Time Period	Total Nitrogen Load		Calculated Efficiency
		No BMPs	BMPs	
Wynn et al. (2000)	Post harvest Post site-prep	104.7 kg/ha/yr 85.4 kg/ha/yr	41.8 kg/ha/yr 17.1 kg/ha/yr	60% 80%
Arthur et al. (1998)	1st yr post harvest	1.45 kg/ha/yr[1] a	1.27 kg/ha/yr A	12%

[1]Authur et al. (1998) measured nitrate-N loads, not total nitrogen. The authors do not state whether the nitrate analysis was conducted on filtered or unfiltered samples.

Table 4. Efficiencies (i.e., percent reduction) for total phosphorus loads gained from using forestry BMPs

Reference	Time Period	Total Phosphorus Load		Calculated Efficiency
		No BMPs	BMPs	
Wynn et al. (2000)	Post harvest Post site-prep	12.61 kg/ha/yr 10.82 kg/ha/yr	1.72 kg/ha/yr 1.60 kg/ha/yr	86% 85%
Arthur et al. (1998)	1st yr post harvest	0.36 kg/ha/yr[1]	0.20 kg/ha/yr	44%

[1]Authur et al. (1998) measured phosphate loads, not total phosphorus. The authors do not state whether the phosphate analysis was conducted on filtered or unfiltered samples.

Recommended Efficiencies for Model

Sediment

Two of the studies (Kochenderfer and Hornbeck 1999, Wynn et al. 2000) resulted in efficiencies values of 94 and 96 percent for sediment during at least the first year after treatment, even though they were in very different physiographic regions with different topographic conditions. The study by Arthur et al. (1998) had efficiencies of only 53 percent during harvesting; however, they noted that they probably would have had greater increases in sediment in the watershed with no BMPs had their logging crew not been well trained in BMPs. That is, they employed recommended logging techniques in some instances even though they were not required to. For example, the Kentucky crews never skidded logs downhill, even though this is a common practice when BMPs are ignored (e.g., Kochenderfer and Hornbeck 1999, Reinhart et al. 1963).

At a local (i.e., small watershed scale) level, the Chesapeake Bay Program (CBP) uses a more conservative efficiency sediment reduction value of **60 percent**. Research level evaluations suggest higher reductions but CBP does not think adequate operational data is available to justify increasing the efficiency.

Nutrients

Only two studies applicable to the Chesapeake Bay region directly measured percent reduction in nutrients due to BMP implementation in forested watersheds (Authur et al. 1998, Wynn et al. 2000). There is a multitude of studies in the eastern United States that examined the impacts of forest harvesting on dissolved nutrient leaching by comparing a treated (harvested) watershed to a control or reference watershed (Aubertin and Patric 1974, Hornbeck et al. 1986, Lynch and Corbett 1990, Martin et al. 2000, Swank et al. 2001). Most of these studies showed that dissolved nutrient concentrations and loads increased in the first one to three years following harvesting due to loss of biotic immobilization and increases in microbial mineralization rates. However, the studies demonstrated that nutrient concentrations and loads decreased in subsequent years following harvesting until reaching pre-harvest levels, generally after year five to ten years.

Total Nitrogen

Wynn et al. (2000) found a 60 to 80% efficiency for TN, with the higher percentage following post site-prep (herbicide and burning). Given that this is the only study specifically addressing TN efficiency, the more conservative current efficiency value of

50 percent for TN is assigned. The research data shows an extremely high efficiency and again CBP does not feel the research is adequate to increase the efficiency.

Total Phosphorus

Total phosphorus (TP) includes all orthophosphates and condensed phosphates, both dissolved and particulate, organic and inorganic. The majority of phosphorus (P) is transported in the particulate form, bound to sediment. Thus, the efficiencies for P should approach those for sediment, which they did (44 to 86%). The Arthur et al. (1998) study (44% efficiency) stated that they analyzed phosphate on a spectrophotometer, so only the inorganic fraction of P was measured. They did not state whether their water samples were filtered or unfiltered prior to analysis. This is especially important for P analysis, since much of the P is sediment bound. Given the relatively low P loads and efficiency compared to the Wynn et al. (2000) study, one could speculate that only dissolved P from filtered samples was measured. Given the uncertainties in the Arthur et al. (1998) analysis and that adequate research does not exist to justify an increase in the efficiency, MAWQ project staff recommends an efficiency for **TP of 60% percent**. This is similar to the recommended sediment efficiency, which is logical given the similar modes of transport. Other BMPs UMD/MAWP refined during their review used a 75 to 25, particulate to dissolved P ratio to determine TP effectiveness estimates. However, in forest settings, most P is particulate so using 75 to 25, particulate to dissolved P ratio used on agricultural levels is not appropriate.

It is important to point out that nutrients that commonly travel subsurface in the dissolved phase, such as nitrate, will likely have lower efficiencies. Most forestry BMPs were developed to control energy and water movement on the surface of the landscape and may not impact subsurface processes to a large extent.

The developers, Pam Edwards and Karl Williard, proposed efficiencies substantially higher than current ones based primarily in two coastal plain studies. CBP felt that these two studies were likely to be optimistic when applied across the watershed particularly when given the variability in terrain and expertise of the harvester in BMPs application. CBP kept efficiencies close to where they are currently but reduced N slightly to account for losses through subsurface flow that do not appear to have been acknowledged in the current efficiency. For other BMPs research level efficiencies were reduced by 25% to account for variability and loss in precision/control when going from research scale to widespread application. The Forestry Workgroup felt this was too severe of a reduction because of the regulatory program governing forest harvesting practices. To accommodate limitations in the data, wide spread implementation, and the current regulatory program, forest harvesting BMPs were only discounted by 20%, relatively.

BMP Efficiency Development

Most investigations of BMP effectiveness, including those from which data have been extracted for this report, used indirect measurements of in-stream suspended sediment exports as a surrogate of actual sediment delivery to water bodies (Edwards 2003). Indirect measurements using suspended sediment measured typically at the mouth of watersheds ignore several spatial and temporal factors concerning sediment delivery. These include:

1) some eroded sediment originating from the forest operation and associated activities may still be stored on the hillside at the time the monitoring was performed;
2) delivered sediment can be stored in the channel for decades and perhaps hundreds of years before being flushed out (Reid 1982, Trimble 1981);
3) some erosion resulting from forest management operations may begin or continue after monitoring has ceased (e.g., washouts of roads constructed for the forest operation). These may be short-term inputs or they may become chronic long-term inputs, depending upon the sources;
4) bedload inputs to the water bodies are not accounted for by measurements of suspended sediment.

In the East, including the Chesapeake Bay watershed, bedload inputs are generally not considered large since the landscape is old and most bedload materials from the hillside were eroded and transported very long ago. Contemporary bedload inputs probably are associated most commonly with stream crossing construction. Thus, even though this part of the sediment budget generally is not measured, it probably is not very important, especially on a basin-wide scale.

By contrast, volumes of sediment stored in-stream can be large, especially if in-stream structures are present that serve as dams (Bill 2005). Consequently, the in-stream storage term is a very important unknown when determining BMP efficiencies because only a portion of contributions at any point in time may be measurable at a downstream monitoring site. It also adds an additional, unknown lag time to delayed hillside deliveries or new sources of sediment and associated nutrients. Thus, in-stream water-column measures of suspended sediment underestimate total suspended sediment delivery, and may therefore result in overestimations of BMP efficiencies based on simple comparisons of watershed exports.

Stored in-channel sediment primarily is flushed through and out of a watershed by stormflow. However, every storm behaves differently with respect to its ability to suspend and transport sediment. While the size of the storm is an important component of sediment transport potential, it is only one of several important variables (Stuart and Edwards 2006). The structure and complexity of the channel, locations and types of sediment, time since the last storm(s), antecedent flow, intensity and duration characteristics of the storm, source of stormflow (i.e., rainfall or snowmelt), rising and falling limb hysteresis, and other factors all influence the degree of in-channel sediment displacement and transport potential (Walling 1977, Rieger and Olive 1986, Beschta 1987, Goodwin and Denton 1991, Bunte and McDonald 1998, Stuart and Edwards 2006). As a result, it is impossible to predict how and when contemporary sediment additions from forestry operations will be flushed out to obtain a measure of total sediment delivery during a given time period. Likewise, while it is assumed that all of the sediment measured in the stream following a forest operation (above background or pretreatment levels) is from that operation it is impossible to ensure that is the case.

One would expect that sediment delivery would vary geographically in a catchment like the Chesapeake Bay watershed because of the extreme differences in topographic and soil conditions that exist. Generally, sediment delivery to surface waters would be higher in watersheds with one or more of the following features: steep slopes, soils with high erodibilities or lower cohesiveness (e.g., sands), high total rainfall and/or high intensity storms, high road density (especially with stream crossings), and high stream channel density (including ephemerals).

However, sediment delivery cannot be predicted well by considering each of these variables individually as they all are strongly interrelated to one another. For example, one would have interpreted incorrectly that sediment exports would be greater in the Appalachians because of steep hillslopes stream gradients compared to the flatter Coastal Plain (Table 2). The Coastal Plain soils were sandier and intense storms tend to occur somewhat more regularly throughout the Coastal Plain because of tropical storms.

The actual sediment loading from the watersheds reported in Table 2 suggest that there were clearly differences in the amount of mineral sediment delivered to the stream channels. Post harvesting sediment exports with no BMPs at the Coastal Plain site were 3 times as great from the Appalachian site, while with BMPs the Coastal Plain site was 4.5 times as great as the Appalachian site. Sediment exports with no BMPs were 2.4 times less from the Cumberland Plateau site than from the Appalachian site, while with BMPs the Cumberland Plateau site was abut 5 times as great as the Appalachian site. The pattern of these Kentucky results do suggest that the sediment losses were somewhat ameliorated on the no BMP watershed by more-careful logging practices, as Arthur et al. (1998) suspected.

Watersheds dominated by karst geology probably are some of the least likely to receive substantial inputs of sediment from forestry activities because these lands tend to be in valley segments that are dominated by other land uses and stream density is low. Unless sediment enters a pothole and goes directly into groundwater, there is little connectivity between sedimentation and groundwater. This, however, is not the case for dissolved nutrients. Relatively mobile ions such as nitrate can commonly leach to groundwater aquifers. But forests are less likely to be found on limestone geology in the Chesapeake Bay watershed than on other less fertile and upland geology.

BMP implementation lag times will vary somewhat among states because each State defines its own set of forestry BMPs (Edwards and Stuart 2002). However, typically forestry BMP implementation is required during or soon after an activity is implemented or ceases. For example, water barring and seeding of skid roads cannot be performed until after skid road use has ended, so most states require or recommend water barring and seeding soon after the road is no longer needed, or at least before the start of the wet season. Lengthy delays in implementation of forestry BMP would be unusual; instead, the total lack of BMP implementation would probably be a more common problem.

If implemented properly, forestry BMPs typically are fully functioning immediately or become so quickly. Vegetative covering of bare soil is probably the BMP that takes longest to become fully functioning simply due to the time needed for seeds or sprouts to become well established. This can occur in several weeks or in some cases can take a year or more if initial seed did not become established and native vegetation establishment becomes the fallback alternative.

Forestry BMPs are not designed specifically for extreme events, even though extreme events often are responsible for the largest additions of sediment and nutrients. For example, sediment exports from single extreme (flood) events on forested watersheds have been shown to dominate annual sediment loadings (Beasley 1979, Edwards and Owens 1991) and they can far exceed multiple years of accumulated sediment exports during more normal years (Kochenderfer and Edwards 1991). In these extreme events, the presence of BMPs to control sediment and associated nutrient losses in the watershed is overwhelmed by the energy of in-stream flows as well as concentrated overland flows in areas where subsurface flows typically only occur. The exception to planning for extreme events is that the diameter of some cross drain culverts on roads may be designed to handle estimated flows from precipitation events with given return intervals.

Possible adjustments that may improve forestry BMPs by reducing overland flow and sediment transport during these large events would be: requiring forester involvement with road and trail planning and layout and BMP implementation, reducing the allowable length between cross drain structures on roads, ensuring that all roads and trails are fully graveled (or re-vegetated), and improving cross drain outlet resistance to erosion and increasing infiltration. In some cases, increasing filter or buffer strips may help reduce sediment inputs, but in steep terrain with erodible soils, buffer strips as wide as 250 ft do not prevent overland flow originating at cross drain outlets from reaching streams; thus, more attention to reducing the amount of water passed through each cross drain may provide more sediment reduction than wider buffer strips. Also, the presence of stream crossings necessitates that buffers become progressively narrower as the road approaches the stream. In these situations, water and sediment control by other means is the best way to reduce additional sediment inputs. However, all of these recommendations involve additional costs and it is unlikely that few states will drastically change their current set of BMPs during future revisions to address large events. The very nature of nonpoint source BMPs makes it technologically difficult, if not impossible, to increase their efficiency for large events without similarly increasing implementation costs substantially.

Stream crossings by roads cut for forest harvesting are the single largest source of sediment in most watersheds. Large amounts can be mechanically pushed into the stream during crossing construction and adjacent fillslope construction. In the longer-term, crossings provide conduits for chronic inputs of sediment as water moves down the road toward the stream. Often stream crossings are at lower elevations than adjacent approaches, which exacerbate sediment delivery to streams. When possible, less invasive crossing structures, such as temporary bridges, should be used to reduce mechanical sediment deposition to streams. If crossing elevations must be lower than approaches, the road should be designed to bleed road drainage off before the crossing is reached. However, even if a road is constructed using all proper BMPs and all additional forestry BMPs are employed, if one or more crossing is included in the design, some sediment will be mechanically added to the channel during construction. Furthermore, mechanical additions can exceed that from all other sources in the watershed; thus, crossings should be avoided if possible. If crossings are used, calculated BMP efficiency based on total sediment exports will be less than that where crossings are not needed and specified bufferstrip widths can be maintained.

There is essentially no research or modeling that has been done and validated that examines BMP effectiveness for sediment and nutrients at the basin scale. Furthermore, because of cumulate downstream issues of sediment storage, flushing, and lag times in sediment routing on both the hillside and in-channel, understanding what effect forestry BMPs have at that landscape scale is probably not a task that will be solved in the foreseeable future. However, from analyses done by Edwards et al. (2004), the natural variability of in-stream suspended sediment observed for Appalachian watersheds was so great that it suggested that effectiveness of BMPs downstream would largely be unmeasurable or undetectable. It is unknown whether one or multiple forest operations done without BMPs could result in sediment increases downstream that would be large enough to influence BMP efficiency measurements, particularly as the effects of dilution, settling/storage, and various routing rates come into play. Because forestry operations in the mid-Atlantic region are usually done on fairly small parcels of land at any one time, and the number of operations in a given watershed are probably small relative to the land base and spatially dispersed, it is likely that the actual contribution that forestry BMP efficiencies has on total basin-wide efficiencies for all land uses will be negligible.

Outstanding issues to resolve in the future

Most states have records documenting BMP implementation for forestry operations. Those data typically are collected by the State agency responsible for BMP enforcement or compliance. Those data do not measure sediment or nutrient delivery, but they do provide specific information about percentages of sites in which BMPs were implemented and effective, and often other information that can be used to further identify where/when problems with BMP effectiveness exist. These data should be used to further refine estimates of BMP efficiencies in the Chesapeake Bay watershed.

There is a substantial need to understand how in-stream suspended sediment and dissolved nutrient values relate to actual hillside delivery of sediment and nutrients from forest operations. The relationships may be more direct and less complicated for dissolved nutrients, unless they are strongly bound to sediment (i.e., clay particles). For sediment itself and sediment-controlled nutrients, confidence in BMP efficiency values (based on in-stream measurements) will be possible only if the relationships between delivery and suspension can be estimated with some degree of certainty. While measurements of hillside deliveries of sediment and nutrients probably would be more desirable and directly applicable to determining BMP efficiencies, these types of studies are rare because they are quite expensive and labor intensive. However, they would provide data that would be a welcome addition for many uses applicable to BMP effectiveness.

There also needs to be further study of sediment routing and storage in high gradient streams in the East. To-date, most of this work has been done in Western streams that have very different sediment dynamics than the East. It is known that forest management generally does not directly or indirectly (through flow augmentation after harvesting) change stream morphology significantly (Bill 2005, Phillips 2005), but there may be subtle changes to channel erosion that are not yet understood, and this is an area of investigation that would be important to modeling sediment routing.

Applicable on-going studies

A 9-year study of hillside sediment delivery to streams in two whole watersheds in the central Appalachians in West Virginia is in its last year of data collection. One watershed has remained undisturbed, and a second has had discrete periods of pretreatment, road construction, forest harvesting, and recovery. Sample processing of the 2007 samples should be completed by late spring 2008. While the watershed is outside of the boundaries of the Chesapeake Bay watershed, the results should have application to the Bay watershed. All results from this study should be published in the next 3 to 5 years. Contact: Pam Edwards, Research Hydrologist, US Forest Service, Parsons, WV 304-478-2000 ext. 129, pjedwards@fs.fed.us.

Future Research Need

It would be useful to have discussion of impacts of potential harvesting buffers for bioenergy production. Likely two countervailing influences: a) Removal of nutrient from the buffer such that nutrient saturation becomes less likely. b) Periodic reduction in effectiveness of buffers associated with periodic disturbance.

How Modeled

The effectiveness estimate assigned to forest harvesting assumes the practice will be applied to a forested land use category that represents average, natural forests with low nutrient loading rates. Degraded land uses proposed for use in Phase 5 of WSM have increased nutrient loads compared to average forests. If the effectiveness estimates are applied to a degraded forest than estimates need to be revised to account for the higher nutrient loading rates from the degraded land use category. There may be a limit to the nutrient and hydrologic treatment capacity of the BMP that will exceed its ability to achieve the proposed effectiveness estimates on a degraded land use.

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Appendix A. Report on Forest Harvesting Practices by Pam Edwards and Karl Williard

<u>Forest Harvesting Practices</u>
Definition and Nutrient and Sediment Reduction Efficiencies

For use in calibration of the Phase 5 of the Chesapeake Bay Program Watershed Model

Recommendations for Formal Approval by the Nutrient Subcommittee's Tributary Strategy and Forestry and Tributary Strategy Workgroups

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Introduction

This document summarizes the recommended definition and nutrient and sediment reduction efficiencies for forest harvesting practices for review and final approval by the Tributary Strategy Workgroup and Forestry Workgroups.

Photograph of BMP

Forestry BMP effectiveness traditionally has been evaluated within the full set of BMPs employed on the watershed. As a result, it is impossible to evaluate the efficiency of any individual forestry BMP, so no photograph is included here.

Description/Definition

Definition: *Forestry BMPs are a suite of practices that reduce sediment and nutrient pollution to water bodies originating from forest management activities to acceptable levels at acceptable costs. These activities include: road, trail, and landing construction, use, and closure; harvesting and log removal activities; and site preparation or within-rotation treatments.*

Specific, individual forestry BMPs focus primarily on controlling water quantity and energy because water movement serves as a primary mechanism for sediment and associated nutrient detachment and transport. Dissolved nutrients tend to be less impacted by typical forestry BMPs. Though, riparian BMPs, such as streamside buffer strips, may have a significant effect on dissolved nutrient loads

Efficiency

Literature Review and Data Analysis Methods

BMP efficiencies for sediment and nutrient reductions from forestry operations are based on studies in which paired watershed comparisons were made. One watershed was harvested (and also may have had site preparation) with BMPs while the second was harvested without BMPs. While many other studies in the literature compare sediment and nutrient loads between reference (undisturbed) watersheds and managed watersheds employing BMPs, BMP efficiencies cannot be determined from those types of studies. Sediment and nutrient reductions were based on in-stream water-column loadings, as there are no published studies to-date in the East that have measured to-stream or to-lake (i.e., actual hillside contributions) concentrations or loadings.

The data used to calculate sediment and nutrient reductions for this document were extracted from the papers listed in Table 1. Only data collected from regions that we deemed applicable to landscapes present in some part of the Chesapeake Bay watershed (i.e., physiography, topography, soils, hydrology and climate) are included; however, because there are so few BMP vs. no BMP comparisons, in reality few BMP vs. no BMP data have been excluded.

Data used in the calculation of BMP efficiencies for sediment are shown in Table 2. Loads for sediment from the study by Arthur et al. (1998) were presented in bar graph form, so an engineering ruler was used to measure the height of each bar and the loadings were calculated from those measurements. All other sediment and nutrient data were provided as tabular values.

Percent efficiency (i.e., the % reduction in sediment or nutrients achieved by using BMPs) for each year of data were calculated from the following equation:

$$\% \text{ Efficiency} = 100\ (\textit{without BMP} - \textit{with BMP})/(\textit{without BMP}),$$

where *without BMP* represents the load measured from the watershed in which BMPs were not employed, and *with BMP* represents the load measured from the watershed in which BMPs were employed.

Table 1. Studies from which sediment and nutrient data were obtained for forestry BMP efficiencies.

Reference	Treatment/Watershed Description	Location	Sediment Measured?	Nitrogen Measured?	Phosphorus Measured?
Kochenderfer and Hornbeck (1999)	One watershed (38.8 ha) diameter limit cut to 35.6-cm dbh with BMPs, one watershed (29.9 ha) clearcut to 12.7-cm dbh without BMPs. Hillsides averaged 40% slope in both watersheds.	Central Appalachians, north central WV	Yes	No	No
Wynn et al. (2000)	One watershed (8.5 ha) clearcut with BMPs, one watershed (7.9 ha) clearcut without BMPs. Firelines installed, herbicide applied, controlled burn and hand planting followed. Slopes average 2% over most of harvested areas except up to 30% slope along deeply incised streams.	Coastal Plain, VA	Yes	Yes	Yes
Arthur et al. (1998)	One watershed clearcut with BMPs, one watershed clearcut without BMPs. On both watersheds all stems > 35.5 cm, cut and left all stems < 5 cm dbh. Hillsides average 45% slope. Watershed sizes not given	Cumberland Plateau, eastern KY	Yes	Yes	Yes

Table 2. Efficiencies (i.e., percent reduction) for sediment loads gained from using forestry BMPs

Reference	Time Period	Sediment Load		Calculated Efficiency
		No BMPs	BMPs	
Kochenderfer and Hornbeck (1999)	1st yr after harvest 2nd yr after harvest	3227 kg/ha 323 kg/ha	123 kg/ha 77 kg/ha	96% 76%
Wynn et al. (2000)	Post harvest Post site-prep	9760 kg/ha/yr 7670 kg/ha/yr	560 kg/ha/yr 620 kg/ha/yr	94% 91%
Arthur et al. (1998)	During Harvest 1st yr post harvest 2nd yr post harvest 4th yr post harvest[1] 5th yr post harvest 6th yr post harvest	1180 kg/ha 640 kg/ha 376 kg/ha 100 kg/ha 200 kg/ha 307 kg/ha	553 kg/ha 420 kg/ha 367 kg/ha 47 kg/ha 387 kg/ha 67 kg/ha	53% 34% 2% 53% 94% 78%

[1] 3rd year post harvest figures were not collected.

Table 3. Efficiencies (i.e., percent reduction) for total nitrogen loads gained from using forestry BMPs

Reference	Time Period	Total Nitrogen Load		Calculated Efficiency
		No BMPs	BMPs	
Wynn et al. (2000)	Post harvest Post site-prep	104.7 kg/ha/yr 85.4 kg/ha/yr	41.8 kg/ha/yr 17.1 kg/ha/yr	60% 80%
Arthur et al. (1998)	1st yr post harvest	1.45 kg/ha/yr[1] A	1.27 kg/ha/yr a	12%

[1]Authur et al. (1998) measured nitrate-N loads, not total nitrogen. The authors do not state whether the nitrate analysis was conducted on filtered or unfiltered samples.

Table 4. Efficiencies (i.e., percent reduction) for total phosphorus loads gained from using forestry BMPs

Reference	Time Period	Total Phosphorus Load		Calculated Efficiency
		No BMPs	BMPs	
Wynn et al. (2000)	Post harvest Post site-prep	12.61 kg/ha/yr 10.82 kg/ha/yr	1.72 kg/ha/yr 1.60 kg/ha/yr	86% 85%
Arthur et al. (1998)	1st yr post harvest	0.36 kg/ha/yr[1]	0.20 kg/ha/yr	44%

[1]Authur et al. (1998) measured phosphate loads, not total phosphorus. The authors do not state whether the phosphate analysis was conducted on filtered or unfiltered samples.

Sediment

Two of the studies (Kochenderfer and Hornbeck 1999, Wynn et al. 2000) resulted in efficiencies values of 94 and 96 percent for sediment during at least the first year after treatment, even though they were in very different physiographic regions with different topographic conditions. The study by Arthur et al. (1998) had efficiencies of only 53 percent during harvesting; however, they noted that they probably would have had greater increases in sediment in the watershed with no BMPs had their logging crew not been well trained in BMPs. That is, they employed recommended logging techniques in some instances even though they were not required to. For example, the Kentucky crews never skidded logs downhill, even though this is a common practice when BMPs are ignored (e.g., Kochenderfer and Hornbeck 1999, Reinhart et al. 1963).

While the two studies that had true "no BMP" operations showed efficiencies of approximately 95 percent, this is probably too high to recommend because of the limitations associated with using only suspended sediment values and the small number of studies. So at a local (i.e., small watershed scale) level, I would recommend using a more conservative efficiency value of **75 percent**.

Statement of Conservatism

Because of all of the unknowns related to sediment delivery, storage, and routing, the estimate of 75 percent is really a best guess based on professional judgment.
Research studies clearly show that sediment inputs to surface waters can be reduced by using BMPs, and in many cases in-stream sediment levels reported from undisturbed watersheds are much higher than from well managed forests. Worst case studies, such as Reinhart et al. (1963) used in the analysis by Kochenderfer and Hornbeck (1999) indicate that poor management can lead to substantial sediment delivery, even if it is measured indirectly by in-stream surrogates. Thus, the expectation of generally high BMP efficiencies is realistic, and we would not consider the value of 75 percent to be overreaching.

Nutrients

Only two studies applicable to the Chesapeake Bay region directly measured percent reduction in nutrients due to BMP implementation in forested watersheds (Authur et al. 1998, Wynn et al. 2000). There is a multitude of studies in the eastern United States that examined the impacts of forest harvesting on dissolved nutrient leaching by comparing a treated (harvested) watershed to a control or reference watershed (Aubertin and Patric 1974, Hornbeck et al. 1986, Lynch and Corbett 1990, Martin et al. 2000, Swank et al. 2001). Most of these studies showed that dissolved nutrient concentrations and loads increased in the first one to three years following harvesting due to loss of biotic immobilization and increases in microbial mineralization rates.

However, the studies demonstrated that nutrient concentrations and loads decreased in subsequent years following harvesting until reaching pre-harvest levels, generally around year five to ten.

Total Nitrogen

Wynn et al. (2000) defines total nitrogen (TN) as the sum of total Kjedahl nitrogen (TKN) and ammonium. TKN is a measure of organic nitrogen compounds and ammonium. In forested watersheds that have been harvested, the majority of organic nitrogen in water is found in the particulate form.

Wynn et al. (2000)found a 60 to 80% efficiency for TN, with the higher percentage following post site-prep (herbicide and burning). Given that this is the only study specifically addressing TN efficiency, I would recommend the more conservative efficiency value of **60% for TN**.

Nitrate-N

Of the inorganic nitrogen species (ammonium, nitrite, and nitrate), nitrate is the dominant form that leaches to receiving waters. It is considered a mobile anion, because of its exclusive non-specific adsorption characteristics. Authur et al. (1998) showed that nitrate loads were reduced by 12%, when BMPs were implemented during the harvesting operation. Since the Authur et al. (1998) study may not have had a true "no BMP" application, I would expect that the efficiency for nitrate-N could be greater than their results. Therefore, I would recommend an efficiency of **20% for nitrate-N**.

Total Phosphorus and Phosphate

Total phosphorus (TP) includes all orthophosphates and condensed phosphates, both dissolved and particulate, organic and inorganic. The majority of phosphorus (P) is transported in the particulate form, bound to sediment. Thus, the efficiencies for P should approach those for sediment, which they did (44 to 86%). The Arthur et al. (1998) study (44% efficiency) stated that they analyzed phosphate on a spectrophotometer, so only the inorganic fraction of P was measured. They did not state whether their water samples were filtered or unfiltered prior to analysis. This is especially important for P analysis, since much of the P is sediment bound. Given the relatively low P loads and efficiency compared to the Wynn et al. (2000) study, one could speculate that only dissolved P from filtered samples was measured. Given the uncertainties in the Arthur et al. (1998) analysis, I would recommend an efficiency for **TP of 75%**, which is more in line with the Wynn et al. (2000) study. This is similar to the recommended sediment efficiency, which is logical given the similar modes of transport.

It is important to point out that nutrients that commonly travel subsurface in the dissolved phase, such as nitrate, will likely have lower efficiencies. Most forestry BMPs were developed to control energy and water movement on the surface of the landscape and may not impact subsurface processes to a large extent. The primary exception would be streamside buffer strips, which can significantly impact nitrate concentrations and loads through processes such as plant uptake and denitrification.

Sediment

I reiterate the comments made above in the sediment section. The recommended efficiencies for nutrients are really a best guesstimate based on professional judgement, given the lack of studies that directly measure the abilities of BMP's to reduce nutrient delivery to receiving waters at the watershed scale. Since TP is so similar in its mode of transport to sediment, I am relatively comfortable with the TP efficiency of 75%. I would expect that the TN and nitrate-N efficiencies would be lower than TP, given that nitrogen is more commonly transported subsurface in the dissolved phase. Most applied BMPs are expected to have less of an impact on subsurface modes of transport. Also, the TN efficiency of 60% compared to the nitrate efficiency of 20% follows this reasoning, as TN has a greater likelihood to be transported on the surface in the particulate phase. Thus, I am comfortable that the nitrogen efficiencies are lower than the TP, but I feel there is a wider range of possible efficiencies for nitrogen, given its variable modes of transport.

BMP Efficiency Development

Most investigations of BMP effectiveness, including those from which data have been extracted for this report, used indirect measurements of in-stream suspended sediment exports as a surrogate of actual sediment delivery to water bodies (Edwards 2003). Indirect measurements using suspended sediment measured typically at the mouth of watersheds ignore several spatial and temporal factors concerning sediment delivery. These include:

1) some eroded sediment originating from the forest operation and associated activities may still be stored on the hillside at the time the monitoring was performed;
2) delivered sediment can be stored in the channel for decades and perhaps hundreds of years before being flushed out (Reid 1982, Trimble 1981);
3) some erosion resulting from forest management operations may begin or continue after monitoring has ceased (e.g., washouts of roads constructed for the forest operation). These may be short-term inputs or they may become chronic long-term inputs, depending upon the sources;
4) bedload inputs to the water bodies are not accounted for by measurements of suspended sediment.

In the East, including the Chesapeake Bay watershed, bedload inputs are generally not considered large since the landscape is old and most bedload materials from the hillside were eroded and transported very long ago. Contemporary bedload inputs probably are associated most commonly with stream crossing construction. Thus, even though this part of the sediment budget generally is not measured, it probably is not very important, especially on a basin-wide scale.

By contrast, volumes of sediment stored in-stream can be large, especially if in-stream structures are present that serve as dams (Bill 2005). Consequently, the in-stream storage term is a very important unknown when determining BMP efficiencies because only a portion of contributions at any point in time may be measurable at a downstream monitoring site. It also adds an additional, unknown lag time to delayed hillside deliveries or new sources of sediment and associated nutrients. Thus, in-stream water-column measures of suspended sediment underestimate total suspended sediment delivery, and may therefore result in overestimations of BMP efficiencies based on simple comparisons of watershed exports.

Stored in-channel sediment primarily is flushed through and out of a watershed by stormflow. However, every storm behaves differently with respect to its ability to suspend and transport sediment. While the size of the storm is an important component of sediment transport potential, it is only one of several important variables (Stuart and Edwards 2006). The structure and complexity of the channel, locations and types of sediment, time since the last storm(s), antecedent flow, intensity and duration characteristics of the storm, source of stormflow (i.e., rainfall or snowmelt), rising and falling limb hysteresis, and other factors all influence the degree of in-channel sediment displacement and transport potential (Walling 1977, Rieger and Olive 1986, Beschta 1987, Goodwin and Denton 1991, Bunte and McDonald 1998, Stuart and Edwards 2006). As a result, it is impossible to predict how and when contemporary sediment additions from forestry operations will be flushed out to obtain a measure of total sediment delivery during a given time period. Likewise, while it is assumed that all of the sediment measured in the stream following a forest operation (above background or pretreatment levels) is from that operation it is impossible to ensure that is the case.

One would expect that sediment delivery would vary geographically in a catchment like the Chesapeake Bay watershed because of the extreme differences in topographic and soil conditions that exist. Generally, sediment delivery to surface waters would be higher in watersheds with one or more of the following features: steep slopes, soils with high erodibilities or lower cohesiveness (e.g., sands), high total rainfall and/or high intensity storms, high road density (especially with stream crossings), and high stream channel density (including ephemerals).

However, sediment delivery cannot be predicted well by considering each of these variables individually as they all are strongly interrelated to one another. For example, one would have interpreted incorrectly that sediment exports would be greater in the Appalachians because of steep hillslopes stream gradients compared to the flatter Coastal Plain (Table 2). The Coastal

Plain soils were sandier and intense storms tend to occur somewhat more regularly throughout the Coastal Plain because of tropical storms.

The actual sediment loading from the watersheds reported in Table 2 suggest that there were clearly differences in the amount of mineral sediment delivered to the stream channels. Post harvesting sediment exports with no BMPs at the Coastal Plain site were 3 times as great from the Appalachian site, while with BMPs the Coastal Plain site was 4.5 times as great as the Appalachian site. Sediment exports with no BMPs were 2.4 times less from the Cumberland Plateau site than from the Appalachian site, while with BMPs the Cumberland Plateau site was abut 5 times as great as the Appalachian site. The pattern of these Kentucky results do suggest that the sediment losses were somewhat ameliorated on the no BMP watershed by more-careful logging practices, as Arthur et al. (1998) suspected.

Watersheds dominated by karst geology probably are some of the least likely to receive substantial inputs of sediment from forestry activities because these lands tend to be in valley segments that are dominated by other land uses and stream density is low. Unless sediment enters a pothole and goes directly into groundwater, there is little connectivity between sedimentation and groundwater. This, however, is not the case for dissolved nutrients. Relatively mobile ions such as nitrate can commonly leach to groundwater aquifers. But forests are less likely to be found on limestone geology in the Chesapeake Bay watershed than on other less fertile and upland geology.

BMP implementation lag times will vary somewhat among states because each State defines its own set of forestry BMPs (Edwards and Stuart 2002). However, typically forestry BMP implementation is required during or soon after an activity is implemented or ceases. For example, water barring and seeding of skid roads cannot be performed until after skid road use has ended, so most states require or recommend water barring and seeding soon after the road is no longer needed, or at least before the start of the wet season. Lengthy delays in implementation of forestry BMP would be unusual; instead, the total lack of BMP implementation would probably be a more common problem.

If implemented properly, forestry BMPs typically are fully functioning immediately or become so quickly. Vegetative covering of bare soil is probably the BMP that takes longest to become fully functioning simply due to the time needed for seeds or sprouts to become well established. This can occur in several weeks or in some cases can take a year or more if initial seed did not become established and native vegetation establishment becomes the fallback alternative.

Forestry BMPs are not designed specifically for extreme events, even though extreme events often are responsible for the largest additions of sediment and nutrients. For example, sediment exports from single extreme (flood) events on forested watersheds have been shown to dominate annual sediment loadings (Beasley 1979, Edwards and Owens 1991) and they can far exceed multiple years of accumulated sediment exports during more normal years (Kochenderfer and Edwards 1991). In these extreme events, the presence of BMPs to control sediment and associated nutrient losses in the watershed is overwhelmed by the energy of in-stream flows as well as concentrated overland flows in areas where subsurface flows typically only occur. The exception to planning for extreme events is that the diameter of some cross drain culverts on roads may be designed to handle estimated flows from precipitation events with given return intervals.

Possible adjustments that may improve forestry BMPs by reducing overland flow and sediment transport during these large events would be: requiring forester involvement with road and trail planning and layout and BMP implementation, reducing the allowable length between cross drain structures on roads, ensuring that all roads and trails are fully graveled (or re-vegetated), and improving cross drain outlet resistance to erosion and increasing infiltration. In some cases, increasing filter or buffer strips may help reduce sediment inputs, but in steep terrain with erodible soils, buffer strips as wide as 250 ft do not prevent overland flow originating at cross drain outlets from reaching streams; thus, more attention to reducing the amount of water passed through each cross drain may provide more sediment reduction than wider buffer strips. Also, the presence of stream crossings necessitates that buffers become progressively narrower as the road approaches the stream. In these situations, water and sediment control by other means is the best way to reduce additional sediment inputs. However, all of these recommendations involve additional costs and it is unlikely that few states will drastically change their current set of BMPs during future revisions to address large events. The very nature of nonpoint source BMPs makes it technologically difficult, if not impossible, to increase their efficiency for large events without similarly increasing implementation costs substantially.

Stream crossings by roads are the single largest source of sediment in most watersheds. Large amounts can be mechanically pushed into the stream during crossing construction and adjacent fillslope construction. In the longer-term, crossings provide conduits for chronic inputs of sediment as water moves down the road toward the stream. Often stream crossings are at lower elevations than adjacent approaches, which exacerbate sediment delivery to streams. When possible, less invasive crossing structures, such as temporary bridges, should be used to reduce mechanical sediment deposition to streams. If crossing elevations must be lower than approaches, the road should be designed to bleed road drainage off before the crossing is reached. However, even if a road is constructed using all proper BMPs and all additional forestry BMPs are employed, if one or more crossing is included in the design, some sediment will be mechanically added to the channel during construction. Furthermore, mechanical additions can exceed that from all other sources in the watershed; thus, crossings should be avoided if possible. If crossings are used, calculated BMP efficiency based on total sediment exports will be less than that where crossings are not needed and specified bufferstrip widths can be maintained.

There is essentially no research or modeling that has been done and validated that examines BMP effectiveness for sediment and nutrients at the basin scale. Furthermore, because of cumulate downstream issues of sediment storage, flushing, and lag times in sediment routing on both the hillside and in-channel, understanding what effect forestry BMPs have at that landscape scale is probably not a task that will be solved in the foreseeable future. However, from analyses done by Edwards et al. (2004), the natural variability of in-stream suspended sediment observed for Appalachian watersheds was so great that it suggested that effectiveness of BMPs downstream would largely be unmeasurable or undetectable. It is unknown whether one or multiple forest operations done without BMPs could result in sediment increases downstream that would be large enough to influence BMP efficiency measurements, particularly as the effects of dilution, settling/storage, and various routing rates come into play. Because forestry operations in the mid-Atlantic region are usually done on fairly small parcels of land at any one time, and the number of operations in a given watershed are probably small relative to the land base and spatially dispersed, it is likely that the actual contribution that forestry BMP efficiencies has on total basin-wide efficiencies for all land uses will be negligible.

Outstanding issues to resolve in the future

Most states have records documenting BMP implementation and effectiveness for forestry operations. Those data typically are collected by the State agency responsible for BMP enforcement or compliance. Those data do not measure sediment or nutrient delivery, but they do provide specific information about percentages of sites in which BMPs were implemented and effective, and often other information that can be used to further identify where/when problems with BMP effectiveness exist. These data could be used to further refine estimates of BMP efficiencies in the Chesapeake Bay watershed.

There is a substantial need to understand how in-stream suspended sediment and dissolved nutrient values relate to actual hillside delivery of sediment and nutrients from forest operations. The relationships may be more direct and less complicated for dissolved nutrients, unless they are strongly bound to sediment (i.e., clay particles). For sediment itself and sediment-controlled nutrients, confidence in BMP efficiency values (based on in-stream measurements) will be possible only if the relationships between delivery and suspension can be estimated with some degree of certainty. While measurements of hillside deliveries of sediment and nutrients probably would be more desirable and directly applicable to determining BMP efficiencies, these types of studies are rare because they are quite expensive and labor intensive. However, they would provide data that would be a welcome addition for many uses applicable to BMP effectiveness.

Of course, there also needs to be further study of sediment routing and storage in high gradient streams in the East. To-date, most of this work has been done in Western streams that have very different sediment dynamics than the East. It is known that forest management generally does not directly or indirectly (through flow augmentation after harvesting) change stream morphology significantly (Bill 2005, Phillips 2005), but there may be subtle changes to channel erosion that are not yet understood, and this is an area of investigation that would be important to modeling sediment routing.

Applicable on-going studies

A 9-year study of hillside sediment delivery to streams in two whole watersheds in the central Appalachians in West Virginia is in its last year of data collection. One watershed has remained undisturbed, and a second has had discrete periods of pretreatment, road construction, forest harvesting, and recovery. Sample processing of the 2007 samples should be completed by late spring 2008. While the watershed is outside of the boundaries of the Chesapeake Bay watershed, the results should have application to the Bay watershed. All results from this study should be published in the next 3 to 5 years. Contact: Pam Edwards, Research Hydrologist, US Forest Service, Parsons, WV 304-478-2000 ext. 129, pjedwards@fs.fed.us.

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Appendix B. Comments from STAC Reviewers

I. Bob Shaffer. Email correspondence follows:

Sarah: I believe 70% for sediment and 60% for TN and TP are reasonable from an observed operational viewpoint, as well as being supported by the relevant studies. Also, please note that the Wynn et al. study was conducted in the coastal plain of Virginia, not NC.

Bob Shaffer
-----Original Message-----
From: Sarah Weammert [mailto:sweammer@umd.edu]
Sent: Monday, April 23, 2007 3:13 PM
To: Shaffer, Robert
Subject: RE:
Thank you Bob for your comments! Can you recommend an efficiency that you feel is not conservative but is also reflective of effectiveness found on operational lands (versus research plots)?

Sarah

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Sarah Weammert
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BMP Project Leader
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Fax: (301)-314-9023
Email: sweammer@umd.edu

From: Shaffer, Robert [mailto:rshaffer@vt.edu]
Sent: Monday, April 23, 2007 1:42 PM
To: Sarah Weammert
Subject: RE:

Sarah: I have reviewed your proposed efficiencies for forest harvesting BMPs. My comments are:
1. definition is accurate
~~~~~~~~~~~~~~~~~~~~~~~~~~~~

2. proposed efficiencies are overly conservative based on results from the studies cited as well as my best professional judgment.

Sincerely,

Bob Shaffer
-----Original Message-----
From: Sarah Weammert [mailto:sweammer@umd.edu]
Sent: Monday, April 23, 2007 10:23 AM
To: Shaffer, Robert
Subject:
Good morning,

My name is Sarah Weammert and I'm working with Tom Simpson at the University of Maryland on a review of definitions and efficiencies for a select list of BMPs. This project is being funded by the Chesapeake Bay Program and proposed efficiencies will be used for calibration of Phase 5 of the Watershed Model. To review efficiencies UMD contracted an expert and asked them to review applicable literature and propose an efficiency for model calibration based on the literature and their experience. The objective of this project is to estimate efficiencies that reflect operational conditions. We are not looking for the efficiency one would expect at a research plot.

All BMP efficiencies are going through a robust review process. The next step is to ask scientists to review the proposed efficiencies. Jim Pease recommended I ask you to review the proposal for forest harvesting. We ask that you read the attached review with particular attention to the definition and determine if the definition reflects how the BMP is implemented in practice. Please also review the proposed efficiency and based on your best professional judgment state if you feel the efficiency is a reasonable estimate. While doing this keep in mind the following constraints. We must have one efficiency for bay-wide application. However, this efficiency will be applied to individual county land segments that have a specific load based on its soil, climate, amount of impervious surface, etc. Any additional editorial comments are welcome. We guess the review taking one to two hours.

If you see any major problems with the proposal please contact me ASAP. We need reviews back so they can be submitted to the Bay Program's source area workgroups for review. Please send me your review by COB May 1st. I really appreciate your time and energy, thank you for your help!

II. Daniel Rider. Email correspondence follows:

Good Afternoon,

I am pleased to provide you with my professional opinion regarding the suitability of the proposed Forestry BMP efficiencies to be used in the Bay Model. I will be brief in my comments.

1. The definition accurately reflects the purpose and applicability of forestry BMPs.

2. I suggest that the efficiencies of 50%, 40%, and 50% for sediment, total nitrogen and total phosphorus (respectively) are set too low. The UMD staff cited a lack of scientific evidence to warrant assigning higher efficiencies. However, the body of science available clearly indicated much higher efficiencies realized. Therefore, I fail to understand how the staff concluded that efficiencies lower than those reported is justifiable. While I am not familiar with the Arthur study, I am familiar with both the Kochenderfer and Wynn studies: both of these studies utilized harvesting protocols just as they would be implemented in a practical setting. I suspect that these two studies reflect the actual impacts of BMPs as they are implemented on the ground.

Thank you for the opportunity to respond and I hope my comments are viewed as constructive review. Please feel free to contact me should you have any questions.

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III. Mary Beth Adams. Email correspondence follows:

It still looks pretty good to me, after a mroe thorough read through. i think we can progress with it. MBa Mary Beth Adams USDA Forest Service Timber and Watershed Laboratory Parsons, WV 26287 304-478-2000, X-130 mbadams@fs.fed.us

Appendix C. Meeting Minutes

Minutes: Tributary Strategy Workgroup Meeting
June 4, 2007
10:00 AM to 3:00 PM
NRCS MD State Office, Annapolis

- The MARWP recommended more conservative efficiencies than the experts. It was a concern that the efficiencies would not be achieved when applied to future disturbed forest land uses.
- ACTION: In order for the MARWP to determine if the efficiencies apply to the degraded forest land uses in the model, Jeff Sweeney will provide Tom with explanations of what degraded land uses are and how much loading is associated with them in the model.
- Judy Okay suggested that the MARWP look at state audits because states audit BMPs and have a certain percentage of compliance. They also have an idea on what goes on outside of the audits.
- Next Steps: The MARWP will factor in state audits and the model's definition and loads from degraded forest land use. The Forestry Workgroup will be reviewing this practice on June 12th.

Participants

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Minutes: Nutrient Subcommittee Meeting
June 6, 2007

10:00 AM to 3:00 PM
Fish Shack—Chesapeake Bay Program Office

- The Forest Harvesting numbers were suggested based on limited studies and are generally not believed to be reflective of widespread implementation conditions by the average harvester.
- MAWP reduced the developer's recommendations. Mary Beth Adams, a reviewer, supported MAWP's recommendations.
- There is an issue with applying these numbers to disturbed forests that must be addressed.

Participants

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Forestry Workgroup Meeting
Chesapeake Bay Program Office; Annapolis, MD
June 12, 2007

- The BMP proposal for forest harvesting was developed by Pam Edwards and Karl Williard and it was reviewed by Mary Beth Adams, Dan Rider and Bob Scaffer.
- The current efficiencies are a 50% TN reduction, 50% TP reduction, and 50% TSS reduction. Edwards and Williard proposed raising these efficiencies to 60% TN, 75% TP, and 75% TSS. UMD is proposing efficiencies that are lower than Edwards and Williard's efficiencies: 40% TN, 50% TP, and 50% TSS.
- UMD recommends more conservative efficiencies than the experts for the following reasons:
    - Authors note that loggers with BMP implementation experience may have biased results
    - Limited number of studies
    - Research scale vs. operational conditions
- Sarah did not provide the developers with the current efficiencies, however she does not know if they looked at them on their own.
- It is important to note that these efficiencies must only be applied to typical forest loads, not to any future "disturbed forest" land use. Before application to a disturbed forest land use, efficiencies must be adjusted.
- This practice is only applied to 1% of forest acreage.
- ACTION: Email comments on the proposed efficiencies for forest harvesting to Gene Odato (godato@state.pa.us) and comments on the proposed efficiencies for forest buffers to Judy Okay (jokay@chesapeakebay.net) during the next two weeks (June 26 deadline). These comments will summarize the FWG's recommendations for these efficiencies to the Tributary Strategy Workgroup and may override the contractor's (UMD) recommendations.

Participants

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Minutes: Tributary Strategy Workgroup
August 6, 2007
Chesapeake Bay Program Office—Fish Shack

- The FWG believes the BMPs are put in place for subsurface flow so the efficiencies should reflect that.
- The FWG recommends a margin of safety between 20% and 30% and supported by scientific literature.
- MARWP recommends 40% reduction for TN, 50% for TP, and 50% for TSS.
- The FWG recommends a 60% reduction for TN, 75% for TP, and 75% for TSS.
- Judy mentioned that forest harvesting is regulated which provides more confidence in the efficiencies. Therefore, the margin of safety reduction should be on the lower side.
- Tom added that giving regulated BMPs a higher efficiency would be making the assumption that just because they are regulated they are performing effectively.
- If a 20% margin of safety is applied to the FWG recommendations, they would closely reflect MARWP's recommendations.
- Helen mentioned that the loading rate for forest harvesting is very high and may need to be readdressed. The TSWG should look into if the entire harvested forest area is considered a disturbed forest land use.
    - ACTION: The TSWG will work with the modelers to determine how forest harvesting and disturbed forests are applied in the model.
- The FWG would like the numbers to go back to the developers for their opinion on the appropriate margin of safety reduction.
- DECISION: The TSWG agreed to support the FWG recommendation with a 20% relative reduction, making the efficiencies 50% for TN, 60% for TP, and 60% for TSS.
    - ACTION: MARWP will work with the developers to review the proposed 20% margin of safety and get their opinion.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
August 15, 2007

- The TSWG asked the Forestry Workgroup and MAWP to work together to develop a consensus final recommendation for consideration by the NSC. The FWG and MAWP were able to accomplish this task and presented the final recommendation to the NSC for its approval.
- Two issues were raised during the course of this discussion that warranted significant consideration:
    1.) There is concern about how the BMP efficiency was developed regarding uniform flow versus concentrated flow. After reviewing the research, this is an emerging issue and there is not consensus within the research community about how to address this in BMP efficiencies. However, the FWG considered this issue and addressed it as best they could in developing the efficiencies.
    2.) There is concern over how land conversion reductions are handled in the model and if they are already accounted for the BMP efficiencies. After lengthy discussion it was decided that the efficiencies are correct with regards to this concern but the way the efficiencies are calculated in the model needs to be clarified.
- The FWG considered the above issues at length during the development of the forestry efficiencies and built them into the recommendations presented at today's meeting.

Improvements can be made in the future to refine these efficiencies further as new information becomes available.

- The recommended forestry BMPs were approved, with the understanding that the values will be rounded to the nearest 5 or 0.
- TN 50%, TP 60%, TSS 60%

Participants

Emma Andrews, CRC
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Collin Burrell, DCDOH
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Melissa Fagan, CRC
Norm Goulet, NOVRC
Mike Langland, USGS
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Connie Musgrove, UMCES
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Becky Thur, CRC
Don VanHassent, FWG Chair
Jennifer Volk, DNREC
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Mary Lynn Wilhere, ACB

Chesapeake Bay Program
Water Quality Steering Committee

Conference Call
August 27, 2007

SUMMARY OF DECISIONS, ACTIONS AND ISSUES

<u>Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies</u>

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

DECISION: The Water Quality Steering Committee approved the 12 BMP definitions and efficiencies, described in the advance briefing papers, as recommended by the Nutrient Subcommittee and its workgroups for use in Phase 5 Chesapeake Bay Watershed Model.

Conference Call Participants

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INFILTRATION AND FILTRATION PRACTICES

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in Phase 5 of the Chesapeake Bay Program Watershed Model

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Summary

For purposes of this report the infiltration BMPs include bioretention, permeable pavement and pavers, and infiltration trenches and basins. The filtration BMPs in this report are categorized as filters and vegetated open channels. These techniques are not all the infiltration and filtration practices available for implementation or credit. For purposes of this report the authors selected the most implemented with data to develop their effectiveness estimates.

Bioretention: An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants.

Permeable Pavement and Pavers: Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain.

Infiltration Trenches and Basins: A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration.

Filters: Filters capture and treat runoff by filtering through a sand or organic media.

Vegetated Open Channels: Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils.

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project during 2007-2008 to develop the components or subcategories of certain best management practices (BMP), a corresponding definition(s), and effectiveness estimates. The BMPs developed have not been previously reported to the Chesapeake Bay Program. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions, modeling scenarios and watershed plans will better reflect monitored data.

Management and operation can be highly variable both between the research and operational scale and between different managers within the operational scale. When practices are implemented across a large area on parcels managed by many different individuals, it is important to assume an "average" level of expertise, control and management in planning design, implementation and operation of any given BMP. While there may be limited data quantifying the difference between research and "average" management, it is recognized that widespread implementation rarely has the same level of oversight and control that is essential to get statistically meaningful results observed at research scale. As a result, there is a need to lower effectiveness from the research scale when widespread implementation occurs.

One important outcome of the project is the wealth of documentation compiled on the infiltration and filtration BMPs reported here. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. A limited number of performance studies, along with the variability associated with field monitoring, resulted in small data sets for pollutant removal efficiencies. As a result, best professional judgment was often used to determine BMP effectiveness. It should be noted that these numbers are provisional, but represent our best professional judgment based on the available data. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

Performance information for all of these practices was derived from their use in urbanized/high-impervious land use areas. The recommendations should not be applied to other land uses. The use of percent pollutant mass removals can be misleading because of the variability in drainage areas, hydrology, and practice design. Caution must be used if the drainage area characteristics are different from that typical to the practice. DO NOT combine percent removals for BMPs in series.

Attached to these definitions and efficiencies is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix A.

UMD/MAWP consulted a panel of experts from the academic, industrial, state agency and non-profit sectors to advise in the development of BMP definitions and effectiveness estimates. Discussions during panel meetings, data and best professional judgment was used to craft the recommendations presented here. While their input strongly influenced the recommendations, inclusion of panel members name does not constitute endorsement.

Finally, this report does not encompass all the stormwater BMPs available for credit by the CBP. UMD/MAWP was contracted to develop a definition and effectiveness estimate for infiltration and filtration techniques and the five subcategories here were selected based on jurisdictional Tributary Strategies, recommended by the panel and supported by the Urban Stormwater Workgroup. Other urban stormwater BMPs were evaluated by UMD/MAWP in 2007 and are available at www.mawaterquality.org/bmp_reports.htm. Visit http://www.chesapeakebay.net/tributarystrategy_tools.aspx?menuitem=20839 for a list of all urban stormwater practices.

Guidelines. The following guidelines were used when selecting data to include in the data set:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.

- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.

- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process. As such, peer reviewed literature should be given more weight than design standards and manuals.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

Design Considerations, Objectives and Criteria

All infiltration BMPs are designed for the following objectives:

- Reduction of urban runoff impacts
- Groundwater recharge
- Water quality control
- Stream channel protection
- Peak discharge control for both small and large storms

Filtration BMPs will address these objectives, with the exception of groundwater recharge.

All practices must be designed, constructed and maintained, at least to the degree specified in all applicable codes and regulations. Design calculations must be done by a qualified engineer familiar with hydrology and hydraulics. For all urban stormwater practices general design criteria are recommended. Each individual practice will have detailed design standards for slope, velocity, infiltration rates, width, residence time, manning n value, maintenance, pipe placement, soil amendments, and various other design elements, and jurisdictional stormwater design manuals should be consulted. UMD/MAWP recommends the following considerations to enhance urban stormwater BMP pollution reduction:

- Require pretreatment cells.
- Prior to design and construction require stringent testing of natural and engineered media used on site.
- Train public works crews on the best techniques for maintaining the long-term performance of practices. Some practices require routing mowing to keep grass in an active growth stage to maintain a dense cover for erosion control and facilitate nutrient uptake.
- Use of media with high fertilizer content should not be used to establish ground cover during practice construction.
- Where vegetation is incorporated in the design, plant placement should be carefully considered when designing a practice, but placement is critical to avoid shading or clogging of the system.
- Where vegetation is used, plant selection should be based on moisture condition, species density (height and cover), soil content, and other climatic factors. Native species should be utilized over non-native species as natives are well adopted to local climate and soil types resulting in minimal watering, fertilization and pesticide applications.

BMP Structure/Subcategories

To determine this BMPs structure various sources of information were utilized, including experimental plot data provided by academic researchers and research articles published in peer reviewed journals, as well as consultation with recognized experts.

There are 5 subcategories of infiltration and filtration practices described here. Each of those subcategories are broken down to account for design elements, such as the presence of underdrains, liners, vegetation, filter media characteristics and natural conditions, such as soil type, that influence performance of practices.

The breakdown for infiltration and filtration practices are:

1. Bioretention – lined or unlined in a C or D soil with underdrain; A or B soil with underdrain; A or B soil and no underdrain
2. Filters
3. Open Channel – in C or D soil without underdrain; in A or B soil without underdrain; in A or B soil with underdrain
4. Permeable Pavement and Pavers – C or D soil with underdrain; A or B soil with underdrain; A or B soil without underdrain. Each subcategory is further broken down to represent designs with sand and/or vegetation layers, and those without either.
5. Infiltration Basins and Trenches – With sand layer or vegetation layer; without sand or vegetation incorporated in design

Lined projects are often constructed on brownfields, to prevent the leaching of toxic material to groundwater, and in highly urbanized areas, to protect underground utilities or to allow drainage of compacted urban soils. In addition to brownfields and urbanized areas, sites situated in tight clay soils can be treated as lined sites, due to the fact that they will not allow for rapid subsurface infiltration of runoff and will often need to be drained. Sites with these characteristics should be categorized separately.

Classification of A, B, C or D soils is determined from soil type, land use, moisture condition, and hydrologic condition. Soil type A has a high infiltration rate whereas soil type D usually consists of clays that are nearly impermeable (low infiltration) and produce higher volumes of runoff. USDA NRCS has soil type data maps.

Underdrains are typically included in a design to help drain water. Therefore, more surface runoff and subsurface drainage will discharge from BMPs designed with underdrains than from those without. Sites on C and D soils and on highly urbanized areas often have underdrains to allow for adequate drainage.

Nitrate
Literature shows that higher nitrogen, specifically nitrate-N, leaching to groundwater occurs when the dominate flow path is subsurface flow. The reduced soil-N mineralization and fraction of soil water that percolates through the soil matrix that reduces nitrate-N transport tends to be offset with greater drainage volumes because these systems increase a soil's porosity, macrospores, and continuous macropores thus increasing water infiltration rates (Dinnes, 2004). This has been documented for conservation tillage, but not specifically for infiltration practices. However, the increase in infiltration rates that conservation tillage creates is comparable to urban practices that promote infiltration. A list of studies that show an increase in infiltration is included in Appendix B.

Total Nitrogen (TN) removal is low for many infiltration and filtration practices, with the proportion of nitrate removal extremely low. Designers are using these practices to move water, not remove nutrients. Within these systems TN enters as nitrate or has time to mineralize and with the next infiltration event will leave the system as nitrate. The fate after nitrate is leached is unknown. In model scenarios the CBP Watershed Model has decent estimates of transport once nitrate is below the biologically active zone and moves to the edge of stream with proximity to the stream factored in.

Unlike nitrogen, leaching of TP and TSS to groundwater is low, due to filtering by soil media (TSS) or sorption to soil particles (TP). Therefore, TP and TSS removal is very high with properly designed and maintained infiltration and filtration systems.

Effectiveness estimates:
Effectiveness estimates are presented as total mass removal, capturing both reductions in overall runoff volume (runoff reduction) and pollutant concentrations (pollutant removal). Rates are applied to the runoff from acres treated. The equation used to determine total removal is:
TR = RR + {(100-RR) * PR}
TR – total removal is the nutrient mass reduction, which is the product of both runoff reduction and pollutant removal.
RR – runoff removal is defined as the total annual runoff volume reduced through canopy interception, soil infiltration, evaporation, transpiration, rainfall harvesting, engineered infiltration, or extended filtration.
PR – pollutant removal is defined as the change in event mean concentration as runoff flows into and out of a BMP. Pollutant removal is accomplished via processes such as settling, filtering, adsorption, and biological uptake. This does not account for changes in the overall volume of runoff entering and leaving the BMP. PR values are event mean concentration based (defined as the average concentration of a pollutant in runoff for a monitored storm event).

This system was developed by the Center for Watershed Protection (CWP) and Chesapeake Stormwater Network in the Technical Memorandum: The Runoff Reduction Method released on April 18, 2008. An extensive literature search was conducted and used to determine the values presented in the Technical Memo. The values in the memo are used to begin developing the recommendations here. A table with the effectiveness estimates and range in values recommended is below, and the calculations and methods used to develop these values are included in the following sections.

	EMC Based Removal (PR)			Runoff Reduction (RR)	**Mass Based Removal (TR)** expressed as removal from collection area (acres)		
	TP	TN*	TSS		**TP**	**TN**	**TSS**
Bioretention							
C/D soils, underdrain	37	10	50	15	**45**	**25**	**55**
A/B soils, underdrain	37	10	50	65	**75**	**70**	**80**
A/B soils, no underdrain	37	10	50	80	**85**	**80**	**90**
					± 15	± 20	± 15
Filters							
All (sand, organic, peat)	60	40	80	0	**60**	**40**	**80**
					± 15	± 10	± 10
Vegetated Open Channels							
C/D soils, no underdrain	10	10	50	0	**10**	**10**	**50**
A/B soil, no underdrain	10	10	50	40	**45**	**45**	**70**
					± 20	± 20	± 30
Bioswale	37	10	50	65	**75**	**70**	**80**
					± 15	± 20	± 15
Permeable Pavement (no							

sand/veg)							
C/D soils, underdrain	10	0	50	10	**20**	**10**	**55**
A/B soils, underdrain	10	0	50	45	**50**	**45**	**70**
A/B soils, no underdrain	10	0	50	75	**80**	**75**	**85**
					± 15	± 20	± 15
Permeable Pavement (with sand, veg)							
C/D soils, underdrain	10	10	50	10	**20**	**20**	**55**
A/B soils, underdrain	10	10	50	45	**50**	**50**	**70**
A/B soils, no underdrain	10	10	50	75	**80**	**80**	**85**
					± 15	± 20	± 15
Infiltration Practices (no sand/veg)							
A/B soils, no underdrain	25	0	95	80	**85**	**80**	**95**
					± 15	± 15	± 10
Infiltration Practices (with sand/veg)							
A/B soils, no underdrain	25	15	95	80	**85**	**85**	**95**
					± 15	± 10	± 10

* The proportion of nitrate removal from infiltration and filtration practices is extremely low and the fate of leached nitrate is unknown. Thus, TN removal is low to account for the lack of nitrate removal via infiltration.

Bioretention -

Definition: Bioretention refers to an area where an excavated pit is filled with an engineered soil media, and then often topped with topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, biological and biochemical reactions within the soil matrix and around the root zones of the plants. Filtered runoff may be collected and returned to the conveyance system via an underdrain or completely infiltrated into the underlying soils. The P-index of the fill media must range between 10-30. A high P-index fill media should not be used because it will increase P loads in the effluent drainage. The engineered soil material, consists of sand (approximately 50%), sandy topsoil (approximately 20-30%) and an organic component (20-30%), all by **volume**.

Other benefits:

- Effective at removing metals, pathogens, oil and grease
- Reduces runoff volumes, time to peak
- Creates habitat, aesthetic benefit
- Can be used for landscaping

Effectiveness (applied to the runoff from acres treated):

Total Phosphorous (TP):

Runoff Reduction (RR):
Category 1: runoff reduction of 15%, lined cell, or unlined in a C or D soil with an underdrain
Category 2: runoff reduction of 65%, A or B soil with underdrain, no liner
Category 3: runoff reduction of 80%, best case, A or B soil and no underdrain, no liner

Pollutant reduction (PR) is 37% for all three categories as it is the median value from the literature; 25-50% (CWP, 2008).

Category 1: .37*85 = 30 + 15 = 45%
Category 2: .37*35 = 13 + 65 = 77%
Category 3: .37*20 = 74 + 80 = 87%

When values are rounded to the nearest factor of 5 TP Bioretention TR becomes:
45% for category 1
75% category 2
85% category 3
All levels have error bars equal to 15

Total Nitrogen (TN):

Runoff reduction (RR) remains the same:
15% for category 1
65% for category 2
80% for category 3

PR of 10%: The 10% TN concentration reduction a conservative judgment based on the studies listed in the CWP (2008) report. This report did not take into account subsurface leaching of nitrate to groundwater, therefore a more conservative number was used.

Category 1: .10*85 = 8.5 + 15 = 23.5
Category 2: .10*35= 3.5 + 65 = 68.5
Category 3: .10*20= 2.0 + 80 = 82

When values are rounded to the nearest factor of 5 Bioretention TN TR is:
25% for sites with no infiltration (category 1)
70% for sites with poor infiltration (category 2)
80% for sites with good infiltration (category 3)
With error bars of 20

Total Suspended Solids (TSS):
Using a conservative 50% for TSS PR (it is in line with load reduction numbers in Hunt et. al., 2006 and CWP, 2008 data, and the same RR as other calculations:
15% for category 1
65% for category 2
80% for category 3

Category 1: .50 * 85 = 42.5 + 15 = 57.5
Category 2: .50 * 35 = 17.5 + 65 = 82.5
Category 3: .50 * 20 = 10 + 80 = 90

When values are rounded to the nearest factor of 5 Bioretention TSS TR:
Category 1: 55%
Category 2: 80%
Category 3: 90%

There is less variability with TSS than nutrients so the error bars should not be greater than the nutrient error bars. A site will achieve better TSS percent removal with a higher input than lower input, so to be conservative, while not assigning error bars greater than those for nutrients, use error bars equal to 15. However, lop off error bars at +10 for Category 3 as TR is equal to 90% (to avoid a value of 105%).

<u>Range in values:</u>
Error bars are large because there is a lot of variability among project sites. The values selected capture the majority of the range found. The high range is due to the approach CWP took by looking at annual runoff, which captures a lot of smaller storms.

Bioretention maintenance (Hunt and Lord, 2006):

- Pruned 1-2 times a year
- Mulched 1-2 times a year
- Initially watered (frequency depends on climate) and limed (one time application) to establish vegetation quickly.
- Grass bioretention cells are usually mowed 2 to 12 times a year.
- Initially spot-fertilize vegetation to ensure growth and survival in low P soils for first year vegetation.
- Occasional (2 to 3 times a year) removal of mulch and top layer of fill soil because clogging occurs most frequently at the top of the soil column. Complete excavation may be necessary when bioretention cells are located in an unstable drainage area (soil type C).
- Remove and replace dead plants one time a year. Within the first year 10% of plans may die, however, survival rates increase with time. This supports a tiered effectiveness approach to nutrient removal.
- Miscellaneous upkeep (12 times a year) includes trash removal, spot weeding, and removing mulch from overflow device.

Filters –

Definition:

Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter. These systems require yearly inspection and maintenance to receive pollutant reduction credit.

If media is periodically removed and replaced effectiveness is maintained, if filters are not replaced they will likely clog or leach pollutants. Organic filters are more effective at removing heavy metals but can leach nutrients if the organic matter begins to break down. Research shows sand filters have negligible retention (Strecker et al, 2004). With organic filters sites may achieve higher retention. Therefore, no runoff reduction is associated with filters. These systems filter materials and then water is returned to the conveyance system. If runoff is first filtered and then infiltrated the BMP becomes an infiltration BMP.

Other Benefits:

- heavy metal removal with organic media

Effectiveness (applied to the runoff from acres treated):
Since there is no runoff reduction associated with filters thus the TR value is equal to the PR value. TN and TP removal numbers were derived from the CWP technical memo with wide error bars beyond CWP's range to account for Urbonas data (1999). The TSS value is based on values obtained from the CWP technical memo appendix F (2008).

TN 40% with error bars of 10
TP 60% with error bars of 15
TSS 80% with error bars of 10

Maintenance: Filter performance will become zero without maintenance. They can clog within 6 months, and the pollutant removal values used here are based on at least annual inspection and maintenance to ensure proper performance. Filters require at least yearly inspection. Sediment and floatable contaminants should be removed, and periodic replacement of filter media is needed.

Vegetated Open Channel –

Definition:
Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils. Some are designed to infiltrate water, but typically channels are constructed for conveyance with treatment occurring as water is conveyed. Open channels will be categorized between infiltration and conveyance (non infiltration), providing an incentive to design for infiltration over a conveyance system. These channels designed for infiltration are termed bioswales. With these practices no fertilization of the channel should occur. Removal of collected sediments, as needed, is required as these systems are prone to sedimentation and erosion, and in-system erosion can lead to failure and/or export of sediment and phosphorous.

Open channels are also referred to as biofilters, grass swales, or water quality swales.
3 subcategories:
Category 1: Open channel in C or D soil without underdrain
Category 2: Open channel in A or B soil without underdrain
Category 3: Open channel in A or B soil with underdrain; Design with complete infiltration like bioswale

Other Benefits:

- Aesthetics (may replace open ditch systems)
- Treat heavy metals

Effectiveness (applied to the runoff from acres treated):
To achieve high infiltration, conditions similar to a bioretention cell are needed. Drainage swales are designed for conveyance, and thus the media in a dry swale is not as deep compared to a bioretention cell, and grass is found in a dry swale instead of shrubs and other vegetation in bioretention areas. Vegetative cover will influence sediment loads. In addition, swale design parameters will influence slopes, vegetative height, soils, vermin, etc. which introduces a lot of variability.

CWP recommends a RR for grass channels of 10-20%. Their literature review shows a range of 0-41% over four studies with two of those showing 0% runoff reduction. Strecker, et al (2004) reviewed 32 grass swales and filter strips and showed 40% RR and TSS of 45-75%. Liptan and Murase (2000) studied grass channels in Oregon and reported runoff reductions between 27 and 41 percent.

RR:
Category 1: Open channel in C or D soil with no underdrain – 0%
Category 2: Open channel in A or B soil with no underdrain – 40%
Category 3: Bioswale - Open channel in A or B soil with underdrain – 65%. (designed like long liner bioretention)

RR is influenced by soil type, slope, vegetative cover, and the length of the channel. Native soil is sometimes used to build swales, they are also built on engineered soils.

PR values will be 10% for TN and TP and 50% for TSS. The TN and TP values are based on the values CWP assigned to grass channels in the technical memo (TN 20% and TP of 15%). The range in the literature values for TP are negative to 45%, and negative to 38% for TN. A more conservative value from the CWP estimate was selected as the location of the studies is nation wide and the range is so variable. Strecker et al. (2004) found a TSS removal ranging from 45-75%. 50% was selected as it is within the low end of the range.

These values coincide with those for dry swales, RR of 40% (40-60), which were derived from 3 studies varying in location. The first is located in Washington State on a site with very permeable soils, was lined and underdrained, and only small storms were monitored. The second was in MD with no underdrain, a grass swale on permeable soil. The third is located in TX.

TR= RR + {(100-RR) * PR}
Total Removal for standard grass channels located in C and D soils without underdrain:
0% RR, 10% TN, 10% TP and 50% TSS
TN: (.10*100) + 0 = 10
TP: (.10*100) + 0 = 10

TSS: (.50*100) + 0 = 50

Total Removal for standard grass channels located in A and B soils without underdrain:
40% RR, 10% TN, 10% TP and 50% TSS
TN: (.10 * 60) + 40 = 45
TP: (.10*60) + 40 = 45
TSS (.50 * 60) + 40 = 70

Values are rounded to the nearest factor of five. With TSS and TP error bars of +-15, and TN error bars equal to +-20.

Explanation of lower nutrient removal compared to CWP:
CWP studies have a good vegetative cover, however, in real world implementation drought will result in die off of vegetation. In addition, fertilization and resuspension of materials should reduce nutrient removal and the young sites captured by CWP review will not include these aspects. During certain times of the year nitrogen export occurs. As all literature in the CWP (2008) memo did not monitor year round, this should be considered when estimating nitrogen effectiveness. Also, there is high data variability so high error bars should be used.

Category 3, open channel in A or B soil with an underdrain, will be referred to as a bioswale. With a bioswale the load is reduced because unlike other open channel designs there is now treatment through the soil. A bioswale is designed to function as a bioretention area so RR and PR for bioswales should be equal to bioretention values in A or B soils with an underdrain. A 65% RR value is thus selected to be consistent with the value assigned to bioretention. The TN PR (10%), TP PR (37%), and TSS PR (50%) values from bioretention are also reflected for bioswales.

TR:
TN = 70%
TP = 75%
TSS = 80%
With error bars of 15 for TP, 20 for TN and 15 for TSS to capture the range in data values.

<u>Maintenance:</u>
Some maintenance is required for these systems. Inspection for erosion and channel destabilization is needed along with removal of trash, leaves and other natural debris, and sediment buildup. Some may require periodic mowing.

Permeable Pavement and Pavers – Name change from porous pavement because porous means the media has holes, not necessarily infiltration. The word pavers will be added to the name because pavement may restrict the use of pavers.

Definition: Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. Proper mix production, construction, and installation are required and verification of proper design specifications is required. Regular maintenance of these systems is imperative for proper and long-term function.

Permeable pavements can effectively reduce TSS and TP by trapping particles in the open surface voids. However, to avoid clogging and subsequent failure, permeable pavements should not be used to treat runoff with high concentration of TSS. As such, it is important that they be sited in stable watersheds away from disturbed soils.

Studies have also suggested that permeable pavements may reduce TN, particularly those designed with a sand layer or vegetation (Collins et al, 2007). Nitrogen is typically removed through microbial or plant uptake.

Permeable pavements should not be given credit if used in areas where their performance typically is poor. This includes high traffic areas and areas where high TSS loads are expected on the pavement.

Other Benefits:

- May reduce the salt needed for deicing in winter conditions reducing chloride pollution
- In the filter course sorption binds contaminants like heavy metals, petroleum hydrocarbons, oil and grease
- Reduce runoff
- Remove heavy metals, oils, grease
- May reduce surface temperatures

Categories:

1- C/D with underdrain
2- A/B with underdrain
3- A/B no underdrain

Permeable pavement and pavers are further categorized for sites with sand and/or vegetation, and those without.

Runoff reduction numbers used here are assumed to be for normal, well functioning system. If systems are not maintained, then runoff removal should be reduced to zero within the first year as they are now only pushing water through the system. To receive credit over the longer term, jurisdictions must conduct yearly inspections to determine if permeable pavement and pavers are still infiltrating runoff.

Effectiveness (applied to the runoff from acres treated):
Average TP and TN numbers are from a very small number of studies, ranging from -54 to 97% for TP and -2.2 to 95% for TN (CWP, 2008). The highest value for TN and TP are from the same study that experienced low loads. The technical memo, using best professional judgment, recommended TP and TN pollutant removal values of 25%. As there are a limited number of study sites and high variability the conservative value 10% for TP is used for this report. Some pavements can achieve some organic N uptake if microbial communities are present and/or vegetation growing. To account for this, sites with vegetation or sand filled systems receive a 10% pollutant removal credit for TN (Collins et al., 2007). Without sand or vegetation 0% is used. TSS removal is a lot higher, trapping 50% of the solids in top layer of pavement (CWP, 2008). Newly constructed, maintained systems range between 55-85% TSS removal; here 50% is used to be conservative. Keep in mind with more TSS capture, the faster the system is going to clog.

The runoff reduction values associated with permeable pavement and pavers will be lower than the runoff reduction assigned to bioretention because soil can hold more water than gravel. The values assigned in the CWP technical memo are 75% for systems with full infiltration and 45% for C and D soils with underdrains. The full infiltration value is used here but the 45% is assigned to category 2, A or B soils with underdrains, while a 10% value is assigned to sites on C or D soils with an underdrain. With permeable pavement and pavers there is less runoff reduction than with bioretention due to coarser medium and the absence of water in the soil. To be conservative, and comparative to the value assigned to bioretention, 10% is assigned to be lower than bioretention.

Total Removal:
TP and TN (with sand or vegetation) TR C or D soil with underdrain: 20%
TP and TN (with sand or vegetation) TR A or B soil with underdrain: 50%
TP and TN (with sand or vegetation) TR A or B soil with no underdrain: 80%
TN (without sand or vegetation) TR C or D soil with underdrain: 10%
TN (without sand or vegetation) TR A or B soil with underdrain: 45%
TN (without sand or vegetation) TR A or B soil with no underdrain: 75%
TP (without sand or vegetation) TR C or D soil with underdrain: 20%
TP (without sand or vegetation) TR A or B soil with underdrain: 50%
TP (without sand or vegetation) TR A or B Soil with no underdrain: 80%

TSS TR C or D soil with underdrain: 55%
TSS TR A or B soil with underdrain: 70%
TSS TR A or B soil with no underdrain: 85%
Effectiveness estimates are rounded to the near value of 5.

Error Bars:
TN error bars of 20
TP error bars of 15
TSS error bars of 15

Maintenance:
Permeable pavement and pavers require HIGH operation and maintenance or they will clog. Clogging happens when suspended solids are trapped in the surface. In the event clogging occurs the system will leach out the sediment already collected, and discontinue trapping sediment in the current runoff. Runoff reduction will fall off drastically when this occurs. After the first year maintenance is critical (Balades et al 1995). Balades et al (1995) found rapid decline in the underseepage rate after year one, reaching 50% by year two or three. Immediately after implementation, filters will only capture coarser materials, forming a matrix that with time filters out the finer sediment. With maintenance this cycle starts over again capturing only coarser material.

Many permeable pavement and pavers are not maintained. Even with maintenance there is disagreement that the maintenance techniques will completely recover the permeable pavement and pavers back to the level of degree of performance they once achieved. There will be a certain amount of decline in performance as maintenance techniques cannot remove all accumulated sediment. To reflect this, and the limited number of studies used to calculate effectiveness values, a conservative approach is taken to estimating permeable pavement and paver performance.

Some kinds of permeable pavement are difficult to produce properly and the mixture may require the use of certified producers to obtain and mix the material, as well as certified workers to apply it. In some areas, such certified professionals have been in short supply causing some potential customers to choose other BMPs.

Infiltration Basins and Trenches -
Definition: A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be build in good soil, they are not constructed on poor soils, such as C and D soil types. Engineers are required to test the soil before approved to build is

issued. To receive credit over the longer term, jurisdictions must conduct yearly inspections to determine if the basin or trench is still infiltrating runoff.

<u>Other Benefits:</u>

- Heavy metal removal
- Runoff Reduction
- Groundwater recharge

<u>Effectiveness (applied to the runoff from acres treated):</u>
From a removal perspective, infiltration basins and trenches function like sand filters.
It is difficult to monitor actual pollutant removal because the water is infiltrating below the surface and only a portion of it is captured. The pollutant removal for infiltration basins and trenches is equated to the sand filter value.

Some basins/trenches are lined with rocks, while some have vegetation. Systems solely lined with rocks have some TSS and TP removal. Rock lined basins have a layer of soil thus TP is removed, but without vegetation TN is not removed. The ideal basin has no surface discharge, with 100% infiltration. With larger events some surface overflow or bypass occurs and no treatment results for the overflow. What is infiltrated captures most of the TSS moving through the system, some TP removal occurs, but very little TN is removed.

Runoff reduction is estimated to be 80%, based on CWP (2008) memo. The table shows a runoff reduction range of 60-90% with CWP BPJ range of 50-90%. The 50%, however, is for sites where an underdrain must be utilized. We are assuming that basins and trenches are not constructed on sites needing to utilize an underdrain, given the intent of the practice. Assuming the practice is designed with adequate pretreatment and soil infiltration testing, 80% RR is used and is a more conservative value than the 90% assigned by CWP (2008).

The CWP technical memo recommends 25% for TP and 15% for TN, a 15% reduction in TN is used here for systems with sand or vegetation, and 0% TN removal for systems without sand and/or vegetation, to be consistent with the other infiltration and filtration BMPs in this report and to be conservative.

A PR of 95% for TSS is assigned based on infiltration numbers from the University of New Hampshire Stormwater Center 2007 annual report.

TR = RR + {(100-RR) *PR}

Total removal:
TSS: 80 + {(100-80) * .95}= 95
TP: 80 + {(100-80) * .25} = 85
TN with sand and/or vegetation: 80 + {(100-80) * 15} = 85
TN without sand and/or vegetation: 80 + {(100-80) * 0} = 80
Values are rounded down to the nearest factor of 5

Error Bars:
Due to the lack of research on infiltration basins and trenches compared to other infiltration techniques, sand filter error bar values are used as infiltration basins and trenches function like a sand filter:
TN 10
TP 15
TSS 10 – as the TR value is 95%, crop the +10 to +5 so TR is not above 100%

Maintenance:
As infiltration is the main mechanism that reduces runoff and pollutants, maintaining infiltration is critical. As clogging occurs flow begins to bypass the BMP. These systems will capture a lot of sediment so maintenance is key.

Factors that Create Variability in Performance

Shut off event for all infiltration and filtration practices:
Most BMPs are designed for a 1 inch storm event to capture the water quality volume. With a 1.5 inch to 2 inch rain event all practice begin to show bypass flow or overflow. Some sites can handle more runoff but after one inch most sites become inundated. To determine the sizing criteria and water quality rainfall depth, engineers work backwards starting with the total impervious area. The CBP WSM will shut down treatment for all flow beyond 1 inch.

Effectiveness Estimate – Range of values
Equation Used to Determine Effectiveness Estimates:
TR = RR + {100-RR) * PR}
TR – total removal
RR – runoff removal
PR – pollutant removal

Tiered approach to range:

Starting with year 2 and continuing on, use a random sampling of the range as done for the range of performance values for nutrients.

For TSS pollutant removal, initial (first year) instillations will be at the low end of range and up (bottom of error bar) to the median. For nutrient removal use random sampling of the range because we don't have an understand of vegetative management and its effect on nutrient removal and cycles. While some locations cut vegetation back, some let it grow wild. By using random sampling within the range this accounts for time needed to establish vegetation and the variability in managing vegetation once it becomes established.

How Modeled:

When a jurisdiction cannot report which soil type or if an underdrain is present the value with the lowest mass removal is used (per WTWG policy). For example, when soil type and the presence of underdrains cannot be determined for bioretention the C/D soil with underdrain estimates (TP 45%, TN 25%, and TSS 55%) are assigned as these are the lowest effectiveness estimates. For vegetated open channels the C/D soils without an underdrain (TP 10%, TN 10%, and TSS 50%) is assigned. The values for C/D soil with an underdrain and no sand or vegetation are assigned (TP 20%, TN 10% and TSS 55%) to permeable pavement and pavers. The infiltration trenches and basins default values are A/B soils with no underdrain and no sand or vegetation (TP 85%, TN 80%, and TSS 95%).

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APPENDIX A: MEETING NOTES AND MINUTES

Infiltration and Filtration Meeting Minutes for April 23, 2008

Attendees:
Allen Davis
Chris Kloss
Kelly Collins
Sarah Weammert

<u>Action Items</u>
Proprietary BMPs, how should the CBP evaluate them? ACTION: Kelly mentioned CWP staff are working creating an evaluation process. Sarah will contact Kelly for more details. Sarah will also contact Bob Pitt and UH staff for information on their attempt to create an evaluation process.

Where does the model get its runoff values? Hydrology (runoff) – is it accounting for runoff reduction? ACTION: Sarah will ask Jeff Sweeney

Allen has tables with bioretention percent removal from various studies (Davis, Hunt, etc.) – infiltration was occurring in all but one site (one site lined). ACTION: Allen will provide copies of these tables for the report.

ACTION: Can the model use mass (total removal)? Sarah will contact the CBP modelers for assistance.

ACTION: Kelly and Sarah will look up organic filter data to use in our second meeting.

Question: Should we add language to the definition of bioretention that says, "outflow volume reduction must be achieved."?
In addition, should the definition also include, "Use low P-index fill soils to reduce P loads (P-index ranging between 10-30). Do not use a high P-index fill soil because it will increase P loads in the effluent drainage."

Question: What is the basis for back calculating TN removal in bioretention and not for TP? For TP pollution removal we used the median of the range found in CWP's data. For TN we used 10% while the CWP range was 40-60%.

ACTION: Kelly has lit review on pervious pavement and pavers she will send out to group

Question: Should we add a sentence to the definition that mandates maintenance. If so how often should pervious pavement and pavers be serviced?

<u>Overview of Project</u>
Estimates of BMP performance will be used in TMDL and trading permits and WSM modeling, and for continued use in Tributary Strategies. While our scope dictates that we quantify the nutrient and sediment reductions, UMD/MAWP recognizes there are additional co-benefits (social, economic, etc.). UMD/MAWP is asking panel members to help create a list of all co-benefits.

Our most important task is to estimate BMP performance at the operational, average watershed wide scale. UMD/MAWP's job is to ensure panel decisions, scientific justification, and best professional judgment are within the framework of our guidelines designed to estimate operational, average watershed wide conditions:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.

- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.

- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process. As such, peer reviewed literature should be given more weight than design standards and manual.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

UMD/MAWP will ask detailed questions about the BMP, not to discredit the performance of the BMP, but to get to operational conditions.

Panel members' primary task is to develop a report for the BMP using the guidelines, decision matrix, and factors of variability found in the template. A final report from the panel is due to the Chesapeake Bay Program by July 15, 2008 so partners can begin their technical review process. Bay Program partners are made up of jurisdictional agencies, the EPA and the Chesapeake Bay Commission. During technical review (mid-July to September) workgroups may bring specific question to panel/scientists for discussion.

Questions Posed to Panel:
Infiltration: What practices can be included? Can we deal with breakouts simply?
How much water are you infiltrating, can it be event based? For example, the standard states the practice is designed to catch x amount of rain in x amount of time, then when meet design criteria group into infiltration category?
How common is bypass flow?
How do we account for research plot data representing operational conditions?
What level of operation and maintenance (O&M) do these sites require? How likely is it that a site will receive the level of O&M required?

Proprietary devices? How handle? Procedure for evaluating (minimum information required to give effectiveness estimate).
ACTION: Kelly mentioned CWP staff are working on this. Sarah will contact Kelly for more details. New Hampshire and Bob Pitt have also been addressing this.

Filtration: Percent pollutants removed by media, can they be categorized? Ex – 25-50% category then a 50-75%?
How function over time, clogging?
How high is O&M? Published effectiveness versus average operational (filter needs to be cleaned)

For infiltration and filtration, how do we define/track the drainage area?

What specific design standards exists that will ensure sustainable results?

What are the long-term effects of concentrated pollutants in filter median?

In addition to the life cycle changes in pollutant removal rates, do infiltration rates also decline with age? Is the degree to which the performance may degrade dependent upon the level of maintenance performed?

What standards of performance should be used for privately owned systems?

How is the effectiveness of raingardens and infiltration practices affected in the winter season when the ground is frozen and there is a need to consider frost depth when designing these practices? What about clogging in general, what are the other items that cause clogging?

Should soils be a limiting design factor to infiltration? How does soil matrix composition influence desired infiltration rates while also supporting vegetative growth needed?

What inspection requirements can a local jurisdiction except to ensure designed performance? What is the performance curve without maintenance for each technique?

Discussion:

Where does the model get its runoff values? Hydrology (runoff) – is it accounting for runoff reduction? ACTION: Sarah will ask Jeff Sweeney

Filter practices: particle size captured depends on filter media

Bioretention: standards between counties and states varies, some designs incorporate underdrains and/or liners, while some do not. An underdrain or liner will influence in filtration rates and ultimately performance of the BMP.

Should there be minimum design standards?: Yes, by actual BMP (swale, sand filter, organic filter, trench, basin, open channel, etc.) and not for the broad category of infiltration and filtration.

Dry swale and swale have different volume reductions due to infiltration, while grass channels funnel water to stormdrains. CWP defines dry swales as practices that include an engineered media, and a wet swale is defined as a grass channel with standing water.

How much will performance differ? Treatment versus treatment *and* infiltration will determine variability in performance. A BMP with treatment and infiltration will reduce a greater portion of runoff.

What makes a good performer?

For bioretention a soil P test is required (P reductions depend on soil P content).
Allen has tables with percent removal based on list of studies (Davis, Hunt, etc.) – infiltration was occurring in all but one site (one site lined). ACTION: Allen will provide copies of these tables for the report.

Use CWP Table 2 and 3 breakouts. Range level 1 and 2 – level one is minimum design criteria. In order to receive a higher credit (level 2) sites need to provide adequate pre treatment.

<u>Framework/Breakouts:</u>
Current CBP subcategories for infiltration and filtration are:
Infiltration (trench, basin, porous pavement)
Filtration (open channel, sand filters, organic media filters, raingarden, swales, and dry wells)

Allen suggested two subcategories should be developed for each filtration technique. If infiltration occurred with the filtering practice the site would receive additional credit, those without infiltration would not:
Bioretention (level 1) and then bioretention with infiltration (level 2)

Designs with a liner will loss 20% of ponded water to evapotranspiration, however, most projects are not lined. Lined projects are most often constructed on brownfields and highly urbanized areas, because sites on brownfields must address leaching of toxic soils, and projects in urbanized areas are competing with utilities and constructed on poor soils. In addition to brownfields and urbanized areas, clay soils will act like a liner, so sites with these soils should be categorized.

ACTION: Can the model use mass (total removal)? Sarah will inquire.

Decision:
Break out practices with treatment and treatment with infiltration. Also categorize lined projects or projects constructed on various soil types (A and B, or C and D). Classification of A, B, C or D soils is determined from soil type, land use, moisture condition, and hydrologic condition. Soil type A has a high infiltration rate whereas soil type D usually consists of clays that are nearly impermeable (low infiltration) and produce higher volumes of runoff. USDA NRCS has soil type data maps.

With the breakout groups determined, the question now becomes how to define poor and good infiltration?
Underdrain (poor infiltration, only able to partially contain the runoff) versus no underdrain (good infiltration, able to fully contain all the runoff from a given design storm):
C and D soils have underdrain

Highly urbanized have drain

Category 1: Lined or unlined in C or D soils with underdrain
Category 2: A or B soil with underdrain
Category 3: A or B soil and no underdrain

<u>Equation Used to Determine Effectiveness Estimates</u>:
TR = RR + {100-RR) * PR}
TR – total removal
RR – runoff removal
PR – pollutant removal

<u>Shut off event</u>
1.5in to 2in rain all practices: most BMP designed for 1 in storm. Some sites can handle more runoff but after one inch most sites become inundated.

<u>Bioretention:</u>

The error bar value of 15 captures the majority of the range found within the CWP sites (n=? ACTION: Sarah to fill in based on single-site, multi-site; with underdrain, without underdrain; lab, field tests)

Question: Should we add language to the definition of bioretention that says, "outflow volume reduction must be achieved."?
In addition, should the definition also include, "Use low P-index fill soils to reduce P loads (P-index ranging between 10-30); do not use a high P-index fill soil because it will increase P loads in the effluent drainage."

Error bars are large, a lot of variability among project sites.

CWP looked at annual runoff, which captures a lot of smaller storms.

<u>TP</u>

RR (infiltration fraction):
Category 1: runoff reduction of 15%, lined or unlined in C/D with underdrain
Category 2: runoff reduction of 65%, A or B soil with underdrain
Category 3: runoff reduction of 80%, best case, A or B soil and no underdrain

Concentration reduction is 37% for all three categories median 25-50 (see table 2 on page 10 of CWP technical memo).

Category 1: .37*85 = 30 + 15 = 45%
Category 2: .37*35 = 13 + 65 = 77%
Category 3: .37*20 = 74 + 80 = 87%

Values are rounded to the nearest factor of 5.

TP Bioretention Total Removal (TR):
45% for category 1
75% category 2
85% category 3
All levels have error bars equal to 15

<u>TN</u>
Note: Some N removal in lined cells through plant uptake, but need a good vegetative stand.

Runoff reduction (RR):
15% for category 1
65% for category 2
80% for category 3
With error bars of 20

PR of 10%: The 10% TN concentration reduction is backed out from the load calculations because studies in the CWP report are skewed towards higher performance sites (Table 3 of technical memo shows BPJ of 40-60%).
Why back calculated here and not for TP?

Category 1: .10*85 = 8.5 + 15 = 23.5
Category 2: .10*35= 3.5 + 65 = 68.5
Category 3: .10*20= 2.0 + 80 = 82
Values are rounded to the nearest factor of 5.

TN Bioretention Total Removal (TR):
25% for sites with no infiltration (category 1)
70% for sites with poor infiltration (category 2)
80% for sites with good infiltration (category 3)

<u>TSS</u>:

Use 50% concentration based removal – conservative, in line with load reduction number to match Hunt and CWP data.

Same RR as other calculations:
15 for category 1
65 for category 2
80 for category 3

Category 1: .50 * 85 = 42.5 + 15 = 57.5
Category 2: .50 * 35 = 17.5 + 65 = 82.5
Category 3: .50 * 20 = 10 + 80 = 90
Values are rounded to the nearest factor of 5.

TSS Bioretention TR:
55 for category 1
80 for category 2
90 for category 3
With error bars of 15, to factor in age. There is less variability with TSS than nutrients so the error bars should not be greater than the nutrient error bars. A site will achieve better TSS percent removal with a higher input than lower input, so to be conservative, while not assigning error bars greater than those for nutrients, use error bars equal to 15. However, lop off error bars at +10 for Category 3 as TR is equal to 90% (to avoid a value of 105%).

<u>Tiered approach:</u>
For TSS pollutant removal, initial (first year) instillations will be at the low end of range (bottom of error bar) to median.
Starting with year 2 and continuing on, use a random sampling of the range as done for the range of performance values for nutrients.

For nutrient removal use random sampling of the range because we don't have an understand of vegetative management and its effect on nutrient removal and cycles. While some locations cut vegetation back, some let it grow wild. By using random sampling within the range this accounts for time needed to establish vegetation and the variability in managing vegetation once it becomes established.

<u>Conservatism from scientific values:</u>
Most studies focused on BMPs that were constructed within three years of monitoring.
In the CWP BMP review, bioretention sites with **negative effectiveness** were eliminated because CWP uses higher design specifications for soil P than the studies with the negative performance. This is reflected in CWP definition/description of bioretention.

Projects not constructed to specifications is not uncommon, and to further complicate performance BMP design specifications are different for each jurisdiction.

Kelly stated the sites included in the CWP review represent practices with high levels of management as most testing was conducted on new facilities. This leads to results skewed towards higher performance, where oversight is high and sites are maintained. Chris and Allen agreed with this.

<u>Bioretention maintenance</u> (Hunt and Lord, 2006):
Pruned 1-2 times a year
Mulched 1-2 times a year
Initially watered (frequency depends on climate) and limed (one time application) to establish vegetation quickly.
Grass bioretention cells are usually mowed 2 to 12 times a year.
Initially spot-fertilize vegetation to ensure growth and survival in low P soils for first year vegetation.
Occasional (2 to 3 times a year) removal of mulch and top layer of fill soil because clogging occurs most frequently at the top of the soil column. Complete excavation may be necessary when bioretention cells are located in an unstable drainage area (soil type C).
Remove and replace dead plants one time a year. Within the first year 10% of plans may die, however, survival rates increase with time. This supports a tiered effectiveness approach to nutrient removal.
Miscellaneous upkeep (12 times a year) includes trash removal, spot weeding, and removing mulch from overflow device.

Breakouts/Framework:
Filters are their own category (both sand and organic), maybe condensing open channel systems down into one, with infiltration and non infiltration subcategories, like bioretention. Permeable pavement will also be its own category. Infiltration trenches and basins will be quantified as one category.

5 total categories:
Bioretention with subcategories
Filters
Open Channel with subcategories
Permeable Pavement
Infiltration Basins and Trenches

Definition:

Filters:
Sand and organic media; but apply age coefficient to organic (ACTION: Sarah and Kelly will look at The Practice for values). If media is periodically removed and replaced effectiveness is maintained, if filters are not replaced they will keep leaching. Organic filters are more effective at removing heavy metals. Using best professional judgment (BPJ), panel members assume that sand filters have negligible retention. With organic filters sites may achieve higher retention. Need to determine if these sites experience high evaporation.

HIGH MAINTENANCE: go to zero with no maintenance. Can clog within 6 months. Very minimum need to be replaced every 3 years. At least yearly inspection, add to definition, "pollution removal based on at least annual inspection and maintenance to ensure proper performance." ACTION ITEM

No runoff reduction is associated with filters. These systems filter materials and then water is returned to the conveyance system. If runoff is first filtered and then infiltrated the BMP becomes an infiltration BMP.

Open channel systems:
Some are designed to infiltrate water but typically channels are constructed for conveyance with treatment occurring as water is conveyed. Open channels will have two subcategories: Infiltration and conveyance (non infiltration) providing an incentive to design bioswales over a grass channel.

Add to definition, "no fertilizer of channel and remove grass clippings."

Pervious pavement and pavers:
Name change from porous pavement because porous means the media has holes, not necessarily infiltration. The word pavers will be added to the name because pavement may restrict the use of pavers. With pavement and pavers water infiltrates through the surface or exits via an underdrain. Water also filters through open voids in the surface.
Retention occurs in the voids (storage of couple cm that evaporates). Thus pervious pavement and pavers is a combination of both infiltration and filtration.

HIGH operation and maintenance or will clog.
Question: Should we add a sentence to the definition that mandates maintenance. If so how often should pervious pavement and pavers be serviced?

Handle subcategories like bioretention: move to filtration category but subcategorize infiltration versus no infiltration. This captures sites in the piedmont that must contain an underdrain so water has somewhere to go.

Pollution reduction occurs by removing TSS. Nutrient removal is 0% with no infiltration subcategory. Nutrient removal only occurs if infiltrating along with the pavement or pavers. In terms of runoff reduction, this is not end of pipe treatment; the surface is BMP. This practice is not reducing the load coming to it, it reduces the load once it reaches the practice.
ACTION: Kelly has lit review send out to group

Infiltration basins and trenches:
What is adequate infiltration? Definition should include "infiltration rate greater than .5 in an hour" because the excavated area designed to infiltrate with soil underlying the infiltration basin must be greater than .5 inches an hour to provide adequate infiltration.

Bioretention:
Eliminate 1st sent in current definition. At end, add "or returned to conveyance system via underdrain."

Performance values:

Filter:
RR - No runoff reduction with filter

TN and TP (EMC based) removal numbers from CWP – total removal (mass based) and EMC number's, assumed.
Widen error bars with CWP numbers's to also account for Ben Urbonas data (1999 Design of a sand filter for SW Quality Enhancement)

TN 40 with error bars of 10 (CWP range 30-45)
TP 60 with error bars of 15 (CWP range 60-65)
TSS 90 (based on Urbonas) with error bars of 10

Open channel:
3 subcategories – infiltration, underdrain, no infiltration
To achieve complete infiltration need conditions like bioretention cell.
Dry swale – media not as deep, grass instead of shrubs and other vegetation to compared to bioretention. Permeability of soil
Drainage swales (designed for conveyance) - grass channels. CWP number's are BPJ.

ACTION for open channel: CWP number's high based on Allen's data. Revisit with Allen's data; No runoff reduction or little?

TSS number: 75-85. 50% Michael Barrett in TX. Lipton and Marosie 70% on turf. 45-75% mass removal Strecker did review of many grass swales and vegetative filter strip n of 32 (average runoff was 40% so some infiltration).

ACTION: Use appendix F loads with Table C-3 concentrations to back out.

Vegetative cover will influence sediment loads.
Swales design parameters will influence slopes, vegetative height, soils, vermin, etc. which introduces a lot of variability so need wide error bars.

Length? When does swale become a swale or a ditch? Are there guidelines? Yes and model will use the drainage area to determine if swale or ditch

4 subcategories:
Category 1: Grass channel in C or D soil – 0% RR, no additional credit for infiltration
Category 2: Grass channel in A or B soil – 40% more runoff removal (Barrett saw 50%)
Category 3: Design with underdrain
Category 4: Design with complete infiltration like bioswale

CWP appendix B has RR for grass channels of 10-20%
Strecker 2004. review of 32 grass swales and filter strips showed 40% RR and TSS of 45-75%

A or B soil: 40% average with little storms 100% big storms very little. CHECK WITH ALLEN'S DATA

RR:
C and D – 0%
A and B – 40%; soils used for swales not native soil (swales built on engineered soils unlike bioretention)

TR = RR [(100-RR) * PR]

Explanation of lower nutrient removal compared to CWP:
CWP studies have a good vegetative cover, however, in real world drought results in vegetation dying. In addition, fertilization and resuspension of materials should reduce nutrient removal and the young sites captured by CWP review will not include these aspects. During certain times

of the year nitrogen export occurs. Also, there is high data variability so high error bars should we used.

TSS error bars +-30
TP and TN +-20

PR:
TN and TP 10/10 (CWP BPJ TN 20% and TP of 15% for grass channels)
TSS 50 (Strecker et al. 2004)

Total Removal for standard grass channels:
Located in C and D: 0 RR TN and TP 10 TSS 50 concentration
TN: (.10*100) + 0 = 10
TP: (.10*100) + 0 = 10
TSS: (.50*100) + 0 = 50

Located in A and B: 40RR TN and TP 10 and TSS 50
TN: (.10 * 60) + 40 = 45
TP: (.10*60) + 40 = 45
TSS (.50 * 60) + 40 = 70

Values are rounded to the nearest factor of five.

3 studies on dry swales (located in Washington State with very permeable soils and small storms, lined and underdrained; MD with no underdrain just grass swale and permeable soil; and the third in TX). Data matches standard grass swale RR of 40 (range 40 – 60)
NEED TO COMPLETE

Bioswale equal to bioretention A or B with underdrain: use 65 RR middle value. Load changes because now treatment through the soil.

TN: (.10 * 35) + 65 = 68.5
TP: (.37 * 35) + 65 = 77.95
TSS: (.50 * 35) + 65 = 82

TR:
TN = 70
TP = 75
TSS = 80
With error bars of 15 for P, 20 for N and 15 for S.

INFILTRATION AND FILTRATION CONFERENCE CALL JUNE 18, 2008

Participants:
Allen Davis
Kelly Collins
Sarah Weammert
Tom Simpson

Questions posed:

Nitrate – the total removal equation assumes that all the nutrients infiltrated are removed. We have studies that show with increased infiltration you decrease nitrate removal. The model can break out surface and subsurface flow, should we reduce the pollutant removal value for nitrogen by a certain amount to account for nitrate removal rates in subsurface flow? With both underdrain (rapid) and no underdrain (rapid too) too quick for Denitrification to occur? Now, if it is not and an anaerobic condition does exist then wouldn't phosphorous be released?

P-index range of 10-30. how assure have that in the first place? Can we assure its tested? And can we assure it does not increase with time?
Number from Bill Hunt's work where a bioretention BMP was build with soil from pig farm.
With time -

We said that practices are designed to handle one inch of rain, what intensity are we talking (24-hr, 6-hr, 1-hr)? And if the BMP is functioning at 100% during the one inch storm and then at the 1.5 inch are we at 0%? Is this linear?

Sediment size – with retention is the sediment coming in the native soil? Is it active erosion or is resuspension also occurring? Both?
Bioretention – for first few months some leaching of fines from original media. Afterwards no evidence of wash thur, stays at surface.
Swales – some resuspension BPJ, no documentation
Filtration – no, designed

Also can you assume with discharge that the sediment distribution is no sand, 2/3clay, and 1/3 silt? If doing infiltration at the one inch storm not enough velocity to move the sand.
ACTION: Kelly has paper from France. Capture coarser over time, form a matrix then filter out finer. But with maintenance start over again capturing only coarser.

Pervious pavement and pavers
Same breakout by bioretention: a/b soils with underdrain/ complete infiltration/ and c/d soils with underdrain

Runoff reduction:
75% a/b soil no underdrain
45 a/b with undrain
c/d no underdrain – less runoff reduction than bioretention , coarser median, water not in soil, conservative at or less than c/d soil with bioretention – 10 or 15; go with 10 to be lower than bioretention

bioretention higher b/c soil can hold more water than gravel.

Pollutant removal (concentration): TP and TN number from very small n – to be conservative go with 10% for TP and TN – no nitrogen, maybe organic, but would leak through at some point. Some pavement can get some organic N uptake if have microbial communities and vegetation growing.

Break out by vegetation and/or sand filled. Filled with sand, saw significant nitrogen removal due to microbrial growth on sand (none other pavements)
With vegetation or sand filled use 10% TN (NC state research)
Without: use 0%
ACTION: Kelly email Sarah the link to paper that captures this

TSS a lot higher – trap solids in top of pavement 50%; not maintained they clog and fail. Clogging due to suspended solids trapped in surface. Even if fail not leaching out already collected, but not trapping current runoff. **Runoff reduction will fall off drastically. Numbers you assume would be for normally well functioning system. Not maintained reducing runoff numbers go to zero within first year.** Pushing water through
Ref: memo appendices are some tables (appendix F) summarized studies.

Newly constructed, maintained. 55-85% TSS removal; use 50% to be conservative. More TSS capture, faster going to clog. Complete infiltration 85% TSS removal.

Many not maintained. Within maintaence disagreement that the main techniques will completely recover back to way it was. Certain amount of decline in performance can't get all sediment back.

TR: 25%, for c/d
TR: 75% for a/b soil no underdrain

Recalculate

Most pollutant removal through infiltration **majority reducing runoff and increasing infiltration**

Nutrient removal of 25% based on best guess. So
TN error bar of 20
TP 15
TSS 15

<u>Infiltration basins and trenches</u>
Not underdrained b/c by definition infiltration trenches. Wouldn't even build in poor soil. Need .5 inch per hour infiltration. Have to test soil before approved to put one in. soils in design specs.

From removal perspective function like sand filter. Use sand filter numbers,
Difficult to monitor actual pollutant removal b/c water infiltrating. Only capturing portion of it.
Infiltration runoff, equate pollutant removal with infiltration number. Is nitrate leaching into groundwater? Is it trapped in soil?

Performance vs infiltration:
Performance take sand filter numbers. From that work in infiltration numbers.
Some basins/trenches are rocks, some have vegetation. Just rocks little TSS but not much else.
Even rock lined basins have soil underlined so some TP removal, no TN without vegetation.
Ideal basin – no surface discharge, everything infiltrated. Larger events some surface overflow or bypass, no treatment. What is infiltrated get most TSS captured, some TP very little TN.
Filter out solids. Once water hits groundwater, need to address nitrate.

Runoff reduction around 80%,
MD manual defines; water quality volume; .52 inch/hour

60% of TP; sand filter number
Total removal 95% TSS, 81% TP, (ref: Univ of NH stormwater center, 2007 annual report) mass removal numbers
80% runoff reduction with sand filter pollutant 90% TP and 95% for TSS – match Univ of NH numbers

Two subcategories: with sand and/or vegetative cover use 10% TN removal. Without 0% TN removal. Which is dominant? Check MD manual. ACTION

Basins – no outlet. By definition

Use sand filter error bars:
TN 15 – due to lack of research
TP 60
TSS 10

Maintenance: maintain infiltration, similar to permeable pavement. With clogging get bypass. Do capture a lot of sediment. ADD TO DEFINITION – to receive credit over longer term must do yearly inspection (like permeable pavement)
Inspection – is it infiltrating or not?
ACTION: find more details on maintenance

All
Design storm – water quality volume. Not intensity. Total impervious area; work backwards

Nitrate
TN low, with nitrate removal pretty low. Using practice to move water. Enter as nitrate or has time to mineralize and with next infiltration event leaving as nitrate. Fate from there? Decent estimates of once below biologically active zone, from there to edge of stream in model scenarios. Proximity to stream factored in.
TP and TSS very high.

Literature shows that higher nitrogen, specifically nitrate-N, leaching occurs when the dominate flow path is subsurface flow. The reduced soil-N mineralization and fraction of soil water that percolates through the soil matrix that reduces nitrate-N transport tends to be offset with greater drainage volumes in conservation tillage systems because these systems increase a soil's porosity, macrospores, and continuous macropores thus increasing water infiltration rates (Dinnes, 2004). A list of studies that show an increase in infiltration is included in Appendix B.

The literature does not support the older average TN reduction efficiency of 18% that results in the watershed model from conversion of 'hi-till' to 'lo-till'. Runoff and leaching can be addressed separately in Phase V of the WSM, TN reductions due to land use conversion should be 18% for surface runoff and 0% for subsurface losses (Table 2). If flow paths cannot be separated, the recommended median land use conversion effectiveness estimates for conservation tillage is 8% for TN. This TN efficiency attempts to average the N reductions that do occur in runoff with the near zero to negative reductions (increases in loss) observed in the literature on N leaching. As mentioned, leaching will influence the reduction in TN.

Level of Confidence

Panel members were asked to provide their confidence in the effectiveness estimates as average, operational conditions. Kelly Collins said,

"I have a med-high level of confidence in these numbers. We took a conservative approach to the monitoring studies, which as you pointed out earlier, tend to be well designed, carefully monitored, newly installed, and well maintained. The problem is that there are very little case study data that assess true field performance. Because of our conservative approach, I believe these numbers are more closely representative of operational conditions than optimal conditions. I feel they are our most accurate estimates, based on the currently available research."

Allen Davis also has high confidence in these recommendations based on the data, but less confidence in their ability to capture true performance. He stated,

"I agree that the numbers are valid based on the best information that we have and from that perspective, my confidence is high. Nonetheless, I still have doubts that they may represent true field performance in all Bay situations over long periods. Our database is still very small, we study sites that are maintained, and the sites are still new. Performance is highly variable (even under controlled conditions), and the collected data will depend on whether you have a wet/dry year, the land use treated, different designs, etc. Load performance calculations require accurate measurement of both pollutant concentrations AND corresponding flows. As far as capturing the true performance throughout the watershed under all possible conditions, my confidence is medium/low."

Appendix A: Meeting Minutes

Urban Stormwater Workgroup Conference Call
August 26, 2008

Highlights and Action Items

- Workgroup members reviewed the UMD/MAWP definition and effectiveness estimate recommendation for infiltration and filtration practices.
- **ACTION:** Jeff Sweeney and Gary Shenk will figure out if the total reduction values that were developed using the runoff reduction method can be used in the Watershed Model.
- **ACTION:** Sarah Weammert, UMD/MAWP, will revise the Infiltration and Filtration Practices report based on today's discussion.
- **ACTION:** Workgroup members will review the revised Infiltration and Filtration Practices report and provide feedback. A conference call will likely be held next week to resolve any

additional issues. The workgroup's recommendations are due to the Watershed Technical Workgroup prior to their October 6th meeting.

Handouts

Meeting Website: http://archive.chesapeakebay.net/calendar.cfm?eventdetails=9234

- Infiltration and Filtration Practice Recommendations from Year 2 of the UMD/MAWP BMP Project
- Comments on the Infiltration/Filtration BMP Report from Glynn Rountree, National Association of Home Builders
- Comments on the Infiltration/Filtration BMP Report from Randy Greer, DE Sediment and Stormwater Program

Minutes

- Reggie Parrish, USWG Coordinator, began the conference call at 10:00 am. Introductions were made and the conference call's agenda was reviewed.
- The purpose of this conference call was to review the UMD/MAWP definition and effectiveness estimate recommendations for infiltration and filtration practices. The recommendations are described in detail in the report that was distributed to the workgroup prior to today's call.
- Tom Simpson and Sarah Weammert presented the recommendations to the workgroup.
- The workgroup's final recommendations must be submitted to the Watershed Technical Workgroup (formerly the Tributary Strategy Workgroup) prior to their October 6th meeting.
- These practices were not in the original scope of work for this project. The workgroup had requested that they be added.
- In this report, the breakdown for infiltration and filtration practices is as follows:
    - Bioretention: lined or unlined in a C or D soil with underdrain; A or B soil with underdrain; A or B soil and no underdrain
    - Filters
    - Open Channel: In C or D soil without underdrain; in An or B soil without underdrain; in A or B soil with underdrain
    - Permeable Pavement and Pavers: C or D soil with underdrain; A or B soil with underdrain; A or B soil without underdrain. Each subcategory is further broken down to represent designs with sand and/or vegetation layers, and those without either
    - Infiltration Basins and Trenches: With sand layer or vegetation layer; without sand or vegetation incorporated in design
- The expert panel for this set of practices consisted of Kelly Collins (Center for Watershed Protection), Allen Davis (UMD), and Chris Kloss (Low Impact Development Center).
- In order to determine the effectiveness estimates, this panel decided to use the runoff reduction method that was developed by the Center for Watershed Protection and the Chesapeake Stormwater Network in their technical memorandum that was released on April 18, 2008. This method was developed for use by Virginia.
- The runoff reduction method captures both reductions in overall runoff volume (runoff reduction) and pollutant concentrations (pollutant removal).
- The effectiveness estimates for all of the categories of practices are listed in the table on page 6 of this report. This table includes pollutant removal estimates (PR), runoff reduction

estimates (RR), and total removal (TR). TR is based on both runoff reduction and pollutant removal. UMD/MAWP is recommending that the TR values be used in the watershed model.

- Values are rounded to the nearest factor of 5.
- The report includes maintenance information from the literature for each of the practice categories, as requested last year.
- Bioretention
  - Function would cease for a rain event with more than 1 inch of runoff. For a 0-1 inch runoff event, UMD/MAWP recommends that the TR values be applied. Some structures are designed to deal more with peak control; however, the panel felt that the standard design is for a one inch runoff event over 24 hours.
  - MD cautioned that not having an underdrain is actually discouraged.
- If information that enables us to determine which subcategory a practice falls into is not reported (soil type, underdrain), then the most conservative value will be used.
- It was pointed out that for TSS, soil type should not factor in. This should just be based on whether or not there is an underdrain. Sarah said that this is just the nature of the equation that was used.
- Filters:
  - For filters, TR is equal to the PR values since there is no runoff reduction associated with this category of practices.
  - One of the maintenance requirements that is included in this report is that filters be inspected at least on a yearly basis. Can this be tracked and reported?
    - DC inspections generally occur at intervals of 6 months – 2 years.
    - MD's practices must be inspected once every three years.
    - In DE, there are varying degrees of maintenance and inspection frequency from the northern to the southern end of the state.
    - PA has varying degrees of operation and maintenance requirements. All of the municipalities that have adopted ordinances have a responsibility to make sure that BMPs are being maintained and they have the ability to do inspections. Inspections are performed at the state level to assist municipalities on a case-by-case basis. PA does not have any long-term permit mechanism to ensure that operation and maintenance is being maintained after the NPDES permit, although they would like to add this in the future if possible.
- Do the effectiveness estimates proposed by UMD/MAWP look reasonable to workgroup members?
  - Ken Pensyl said that the report's TR values meet the minimum requirements that were established by MD.
- Are these numbers possibly higher than what's actually happening on the ground?
  - The TR value looks reasonable for BMPs that are designed properly, constructed properly, and maintained properly. In reality though, a lot of the BMPs need maintenance in order to function properly. How should this be factored in?
- How are the agricultural BMPs taking into account maintenance issues?
  - Sarah said that for the agricultural practices, they reduced the effectiveness when they moved from a research plot scale to a watershed scale.
  - Tom said that they considered whether or not each of the ag practices had an operation and maintenance requirement. For many of the practices, this raised the bigger issue of the need to verify implementation.

    - It was pointed out that the urban sector has a regulatory program, thus maintenance and implementation should be more certain than on the agricultural side.
- CBP gave UMD/MAWP a scope of work that instructed them to look at individual BMPs. MD, however, is beginning to move away from focusing on individual BMPs and is instead beginning to focus on a treatment train approach. This is something that will need to be addressed in the future.
- UMD/MAWP tried to keep the practice definitions rather general so that they could work across the jurisdictions.
- Are there other sources of information that could help us come up with more accurate values?
    - PA said that Villanova has some research on bioretention facilities. Sarah said that this research was already included in the Center for Watershed Protection's technical memo.
- Infiltration Practices
    - In the report, an infiltration rate of greater than ½ inch per hour is required to provide adequate infiltration. Does this mesh with the design standards in the jurisdictions?
        - MD: minimum infiltration rate of 0.52 inches
        - DC: minimum infiltration rate of 0.5 inches
        - PA: minimum infiltration rate of 0.1 inches and a maximum of 10 inches per hour (anything over 6 inches needs additional buffering and/or pre-treatment)
        - The report's current definition would not capture PA's reporting. UMD/MAWP will take this requirement out of the definition.
    - Randy Greer of the DE Sediment and Stormwater Program provided comments in advance of the call that deal with infiltration practices (see handout). Sarah said that she thinks that many of his comments are the result of some confusion over the equation that was used. She agreed to touch base with him to discuss these issues.
- Jeff Sweeney said that the group will need to make a decision on what is actually used in the model. For example, while soil type can be determined from the model, none of the jurisdictions are currently reporting whether or not there is an underdrain. If this is not reported, then the lowest effectiveness value will be used.
    - In MD, all bioretention practices are required to have an underdrain. In this case, Jeff said that MD would need to submit this comment in writing when they submit their data to CBP. Once this written statement was received, all of MD's reported bioretention practices would be considered to have an underdrain.
- Another model issue is that this report calls for the use of several different filtration categories. Up to this point, there has just been one filtration category. How will data from previous years be handled?
    - The default could be to put all of the historic reporting information into one of the new filtration categories, such as filters.
    - If possible, MD would try to resubmit specifics on the data for previous years.
- If a jurisdiction doesn't specify which filtration category a practice falls under when they report their information to CBP, how will this be handled?
    - USWG members agreed that when jurisdictions don't specify what filtration category a practice falls into, then the filters category will just be used.
- Do UMD/MAWP's recommended effectiveness estimates for this practice make sense when compared to the effectiveness estimates for the urban BMPs in Year 1 of this project?

- The approved effectiveness estimates for the urban BMPs in Year 1 are as follows:
  - Urban wetlands and wetponds: 60% TSS, 20% TN, 45% TP
  - Urban erosion and sediment control: 40% TSS, 25% TN, 40% TP
  - Dry extended detention basins: 60% TSS, 20% TN, 20% TP
  - Dry detention ponds/basins: 10% TSS, 5% TN, 10% TP
- When making this comparison, Sarah recommends comparing the Year 1 values to the pollutant removal (PR) values for the Year 2 infiltration/filtration practices, and not the total removal (TR) values since the runoff reduction method was not used for the Year 1 practices, and thus the values for these practices are only based on the PR value.

- Does the workgroup agree with the use of the runoff reduction approach in determining the Year 2 effectiveness values?
  - Urban BMPs are designed primarily for quantity control. This method takes this into account.
  - The runoff reduction approach is a new approach that was developed by the Center for Watershed Protection for use in Virginia. Sarah said that the reason that this approach was not used in Year 1 of the project was because it had not been developed yet.
  - Concern was voiced by MD and DE about using this method.
  - The other jurisdictions calculate runoff reduction differently. For example, this method does not reflect the program that is being implemented in MD.
  - DE uses a model developed by Bill Lucas. This model considers site by site conditions and each BMP is calculated differently. To find out more information on this, contact Randy Greer.
- If we were to decide to do this state-by-state, instead of using the single approach recommended by UMD/MAWP, then it would be the workgroup's responsibility to provide documentation on the decision-making process and why the specific values were selected.
- Can the TR numbers be used in the model?
  - Jeff Sweeney will need to sit down with Gary Shenk to figure this out.
- If the decision is made not to use the runoff reduction method, then UMD/MAWP would recommend that the PR values be used.
- Members were concerned that some of the PR values recommended in the report were too low.

ACTION: Jeff Sweeney and Gary Shenk will figure out if the total reduction values that were developed using the runoff reduction method can be used in the Watershed Model.

ACTION: Sarah Weammert, UMD/MAWP, will revise the Infiltration and Filtration Practices report based on today's discussion.

ACTION: Workgroup members will review the revised Infiltration and Filtration Practices report and provide feedback. A conference call will likely be held next week to resolve any additional issues. The workgroup's recommendations are due to the Watershed Technical Workgroup prior to their October 6th meeting.

- The conference call was adjourned at 12:00 pm.

Participants

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Urban Stormwater Workgroup Conference Call Minutes
September 23, 2008

Highlights and Action Items

- **DECISION:** The Urban Stormwater Workgroup approved the infiltration and filtration practice recommendations as proposed by UMD/MAWP. Members agreed that we should move forward with using the mass-based total removal values (TR values) for these practices.
- **ACTION:** The Urban Stormwater Workgroup's recommendation will be submitted to the Watershed Technical Workgroup for review in advance of their October 6th meeting.

Handouts

Meeting Website: http://archive.chesapeakebay.net/calendar.cfm?eventdetails=9797

- UMD/MAWP Recommendations for Infiltration and Filtration Practices
- Infiltration and Filtration Practices Panel Response, 9-4-08
- Center for Watershed Protection Technical Memorandum: The Runoff Reduction Method
- Center for Watershed Protection Technical Memorandum: Appendix F

Minutes

- Reggie Parrish, USWG Coordinator, began the conference call at 1:00 pm. Introductions were made and the conference call's agenda was reviewed.

- The purpose of this conference call was to finalize the workgroup's recommendation for effectiveness estimates for infiltration and filtration practices. This recommendation will be based on the infiltration and filtration report developed by UMD/MAWP as part of year two of their BMP project.
- At the August 26th USWG conference call, workgroup members expressed concern that UMD/MAWP used the runoff reduction method to determine effectiveness numbers, when not all of the watershed states use this method. The runoff reduction method was developed by the Center for Watershed Protection for use in VA.
- Since the August 26th call, Sarah Weammert, UMD/MAWP, brought this issue up with the expert panel that had assisted in developing UMD/MAWP's original recommendation. UMD/MAWP and the panel decided that they still recommend the use of the total removal (TR) values that were already presented, which were calculated using the runoff reduction method.
- If the USWG decides not to use the TR values, then pollutant removal (PR) values could be used. The PR values that are proposed by UMD/MAWP are found on page 2 of the panel response document.
- Today, one of the decisions that the workgroup had to make was whether to use the TR values or the PR values.

Discussion

- Kate Bennett was concerned that the jurisdictions were being asked to try to account for the maintenance of individual facilities, when in some cases they don't even have a good idea of where all of the facilities are located. Trying to track whether these facilities are properly maintained would be difficult.
  - Jeff Sweeney explained that for all of the BMPs evaluated in this project, including those in other sectors, UMD/MAWP chose values lower than the average literature values to account for factors such as improper maintenance.
- UMD/MAWP and the panel still recommend using the TR values, which were calculated using the runoff reduction method. Workgroup members were asked whether they had any objections to using these numbers.
  - Ken Pensyl: If we decide to use the TR numbers, how will we determine whether the practices were installed on either a/b soil or c/d soil?
    - Jeff Sweeney said that CBP will use the predominant soil type in that land segment.
  - How will Jeff Sweeney know whether or not there is an underdrain?
    - For bioretention, the default will be that there is an underdrain.
    - If there is no underdrain, it becomes an infiltration practice.
  - In addition to VA, DC is also planning to use CWP's runoff reduction method. This method is included in DC's updated stormwater regulations, which still need to be approved.
  - MD is not using the runoff reduction method. They are using a different approach in which they are moving away from individual BMP tracking.
  - Workgroup members decided to recommend the use of the TR values, and not the PR values.
- Jeff Sweeney said that the jurisdictions are currently only reporting practices as either infiltration practices or filtration practices. They are not reporting what category their

filtration practices fall into (the UMD/MAWP provides effectiveness estimates for several different categories of filtration practices). If a jurisdiction doesn't specify which filtration category a practice falls under when they report their information to CBP, how should this be handled?
  - It was suggested that there be a default value.
  - At the August 26th meeting, USWG members agreed that when jurisdictions do not specify which filtration category a practice falls into, then the filters category will be used.
- Jeff McKay asked how UMD/MAWP came up with the effectiveness estimates for TSS in bioretention practices.
  - Jeff Sweeney said that UMD/MAWP used the same protocols for all of the BMPs in this project. Essentially, they took an average of all of the literature values that they could substantiate, and then they backed it off a little. They also rounded the number to the nearest zero or five.
- In year 1 of this BMP project, an effectiveness estimate of 60% for TSS was approved for wet ponds. Does this make sense when compared to the effectiveness estimates that are being recommended for infiltration and filtration practices?
- Reggie Parrish said that the guidance for tracking and reporting that is posted on the CBP website will need to be revised based on this document.

DECISION: The Urban Stormwater Workgroup approved the infiltration and filtration practice recommendations as proposed by UMD/MAWP. Members agreed that we should move forward with using the mass-based total removal values (TR values) for these practices.

ACTION: The Urban Stormwater Workgroup's recommendation will be submitted to the Watershed Technical Workgroup for review in advance of their October 6th meeting.

- The conference call was adjourned at 1:35 pm.

Participants

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Minutes: Watershed Technical Workgroup
October 6, 2008

Infiltration and Filtration Practices

- The Urban Stormwater Workgroup recommends using mass-based removal.
- The Workgroup approved the infiltration and filtration practices.

Participants

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Chesapeake Bay Program Nutrient Subcommittee
October 22, 2008 Meeting

SUMMARY OF DECISION, ACTIONS AND ISSUES

Infiltration and Filtration

- Norm Goulet, Chair of the Urban Stormwater Workgroup that reviewed the infiltration and filtration BMP, stated that states are moving away from the tracking of individual BMP facilities and moving towards reporting on systems. Norm encouraged the Nutrient Subcommittee to start looking at the runoff reduction capabilities of these facilities and how that will be looked at in terms of nutrient reductions. There are concerns about the lack of clarity on the movement of the nutrients through groundwater. The Urban Stormwater Workgroup approved the UMD/MAWP recommendations, with the above comments.

- Jeff Sweeney informed states that they need to take the initiative to propose new BMPs, based on the CBP protocol, and their requests will be acted on. This would address the way that Maryland is moving in terms of urban BMPs.
- Jeff Sweeney pointed out that in order to get credit for the various practices that fall under infiltration and filtration, they need to track and report these specific practices. If the states do not specify the details of the implemented practice, the lowest removal reduction will be used in the watershed model.
- Ron Entringer would like to work more closely with the Urban Stormwater Workgroup on how to capture urban loads and BMP reductions for WLAs and LAs within the Bay TMDL.
- Bill Keeling reiterated that we now have multiple levels of BMPs in the Phase 5 watershed model so we need to be careful about reporting.
    - Rich Batiuk clarified that the lowest efficiency number for each BMP practice will be used if the states provide specific information on the reported practices. However, states that report their specific practices that fall under a BMP with multiple practices and higher efficiencies, will be rewarded.
- Collin Burrell commented that this approach--multiple efficiencies matched up with various practices under a BMP--will encourage jurisdictions to improve their tracking and reporting practices.
- Russ Perkinson was concerned with the nitrogen reduction numbers on A/B soils.
- Ron Entringer said that he will vote 'no,' because he is uncomfortable with how the infiltration/filtration BMP will work in the Phase 5 watershed model and he believes the numbers seem too high. Ron will try to get some more input from people before the Water Quality Steering Committee meeting in November.
    - Sarah Weammert explained that the reduction values are so high because the definitions for the individual infiltration and filtration practices were very stringent.
    - Dave Hansen added that for a jurisdiction to take credit for this BMP, it is understood that the practice must meet all of the requirements of the individual practice as listed.
    - Bill Keeling reiterated that jurisdictions will not receive credit for a reported BMP unless the practice meets all of the requirements.
- Sarah Weammert clarified that the removal values are applied to acres treated.

ACTION: Sarah Weammert will add the necessary documentation to the infiltration and filtration BMP efficiency table to clarify that the removal values are applied to the runoff from acres treated.

DECISION: The Nutrient Subcommittee approved the infiltration and filtration recommendations for final decision by the Water Quality Steering Committee. Concerns expressed by specific Subcommittee jurisdictional representatives were noted for the record.

Participants

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Appendix B: List of Studies that show an increase in infiltration

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Mortality Composting

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in Tributary Strategy runs of Phase 5 of the Chesapeake Bay Program Watershed Model

Recommendations for Endorsement by the Chesapeake Bay Program Nutrient Subcommittee and its Workgroups

Consulting Scientists

Gary Felton
Associate Professor
University of Maryland

Jennifer Timmons
Regional Poultry Specialist
University of Maryland

Jactone Oregjo
Assistant Professor
Virginia Tech

Synthesize and Recommendation by

Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary

Mortality Composters: Composting routine mortality in a designed, on-farm facility, with subsequent land application of the compost.

- Effectiveness Estimates: TN 40%, TP 10%, 0% TSS

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project during 2007-2008 to develop the components or subcategories of the BMP, a corresponding definition(s) and effectiveness estimates. The BMPs developed have not been previously reported to the Chesapeake Bay Program. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

Attached to these definitions and efficiencies is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix A.

UMD/MAWP consulted a panel of experts from the academic, industrial, state agency and non-profit sectors to advise in the development of BMP definitions and effectiveness estimates. Discussions during panel meetings, data and best professional judgment was used to craft the recommendations presented here. While their input strongly influenced the recommendations, inclusion of panel members name does not constitute endorsement.

Guidelines. The following guidelines were used when selecting data to include in the data set:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.

- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.

- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process by independent scientists. As such, peer reviewed literature should be given more weight than design standards and manuals. For this BMP, however, no peer reviewed literature was available and gray literature, or limited research scale type publications, and best professional judgment was used.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

BMP Definition

Mortality composters involve composting routine mortality in a designed, on-farm facility, with subsequent land application of the compost. This prevents the necessity to bury dead animals that could result in nutrient leachate, or rendering of dead animals for processing into animal feeds or incineration. Mortality composting can be, and is applied, to various species including poultry, swine and dairy calves.

While there are many objectives to mortality composting this report only evaluates its water quality benefit compared to burial. Mortality composting reduces the risk of disease transmission, prevents nuisances such as flies, vermin and scavenging animals, and combats odor resulting from the anaerobic breakdown of proteins. In addition to water quality benefits, mortality composting benefits both human and animal health.

BMP Subcategories

Mortality composting effectiveness is categorized by broilers, layers, hens, turkeys, swine and dairy calves.

Applicable NRCS Code

Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Cultural components consisting of shorter term conservation measures included in the Mortality Composting definition include, but may not be limited to the USDA-NRCS conservation practices listed below.

Animal Mortality Facility (316) An on-farm facility for the treatment or disposal of livestock and poultry carcasses.

Purpose

This practice may be applied as part of a conservation management system to support one or more of the following purposes:

- Decrease non-point source pollution of surface and groundwater resources
- Reduce the impact of odors that result from improperly handled animal mortality
- Decrease the likelihood of the spread of disease or other pathogens that result from the interaction of animal mortality and predators
- To provide contingencies for normal and catastrophic mortality events

Conditions where practice applies:

This practice applies where animal carcass treatment or disposal must be considered as a component of a waste management system for livestock or poultry operations. It applies where on-farm carcass treatment and disposal are permitted by federal, State, and local laws, rules, and regulations. It also applies where a waste management system plan as described in the National Engineering Handbook (NEH), Part 651, Agricultural Waste Management Field Handbook (AWMFH) has been developed that accounts for the end use of the product from the mortality facility. This practice includes disposal of both normal and catastrophic animal mortality; however, it does not apply to catastrophic mortality resulting from disease.

Effectiveness Estimate

The pollution reductions associated with mortality composting is calculated using a set of equations incorporating the average mortality weight, nitrogen and phosphorus composition, percent mortality, the number of animals each year, and an effectiveness estimate (Table 1). Mortality is not consistent, it increases with animal weight. To account for this average mortality weight is within the 70^{th} weight percentile. The average nutrient composition, percent mortality and number of animals each year is dependent on each animal type. The effectiveness estimate remains the same regardless of species with 40% reduction for N and a 10% reduction for P when compared to burial.

The effectiveness estimate is calculated using knowledge of septic systems, nitrification, denitrification, and composting operations. While there is information available on mortality composting construction and implementation, no direct data is available on the pollution reduction benefits of mortality compositing, and one value for nitrogen and one value for phosphorus reduction is assigned for all animal types. To determine effectiveness the loss of N and P prior to composting is needed. With burial the majority of phosphorus is bound in the soil, comparable to a septic system, but oozing to the surface and overland flow negates a 0% P loss. Panel members estimated available P loss from burial is between 10 and 15%, and 12% is assigned. Composting operations will result in some loss of P so the effectiveness of mortality composting for available P is rounded down to 10%. When burying carcasses 80% of the N is potentially available for loss. After composting only 60% of that 80% remains, as 40% is lost to the air as ammonia. 60% of 80 is 48%, however, some additional N is lost during composting operation (handling, storage, etc.) so 48% is reduced to 40%.

Currently, the load calculated here is taken from the manure load. In the future a specific load for mortality composting may be assigned.

Effectiveness Estimates:
40% N
10% P

Body Composition:
Hen: 3.5% N and .76% P (Scheideler, 1998)
Broiler and Layer: 2.9% N (See Table 2), .49% P (Ken Staver, personal communication, January 6, 2009)
Turkey: Sarah Weammert is researching
Swine: Sarah Weammert is researching
Dairy (mature): 2.5% N, .72% P
Dairy (heifers): 2.9% N, .83% P

Nitrogen and phosphorus body composition for turkeys and swine is not available at this time.

Generally, layers will have more feather weight that broilers (on average feathers make up 5% of the body weight). Otherwise body P and N should not vary greatly between the types of poultry and are assumed equal at this time.

Average number of animals (total animals, not capacity) will vary each year depending on location.

Percent mortality:
Hen: 10% (Timmons, personal communication, May 22, 2008)
Broiler: 5% (Doerr, personal communication, May 16, 2008)
Layer: 10% (panel recommendation)
Turkey (male): 9% (panel recommendation)
Turkey (female) 5% (panel recommendation)
Swine: Sarah Weammert is researching
Dairy: 6% (Stallings, personal communication, December 30, 2008)

Male turkeys are not as hardy as female birds and their growth rate is faster resulting in higher mortality rates over females.

Average mortality weight:
Average mortality weight is calculated as the 70th weight percentile of designed weight.
Hen: 7.5 to 8 lbs average hen weight, average mortality weight of 6lbs (Timmons, personal communication, May 22, 2008)
Broiler: 5lbs average weight, 3.5lbs average mortality rate (panel recommendation)
Layer: average weight is 5lbs so average mortality weight is 3.5lbs (panel recommendation)
Turkey (male): average designed weight 24 lbs, average mortality weight of 17 (panel recommendation)
Turkey (female): average designed weight 14lbs, average mortality weight of 10(panel recommendation)
Swine: Sarah Weammert is researching
Dairy (mature): average mature weight is 1500 lbs, average mortality weight is 1050lbs (Stallings, personal communication, December 30, 2008)

Broiler and layer average weight and mortality weight are equal regardless of protein intake because layers live 440 days while broilers live 45 days.

Table 1. Equations used to calculate effectiveness of mortality composting

Equation 1	Average number of animals * percent mortality = number of animals that die
Equation 2	Number of animals that die * average mortality weight = lbs of dead animals
Equation 3a	lbs of dead animals * percent N composition = total lbs of N available for loss
Equation 3b	lbs of dead animals * percent P composition = total lbs of P available for loss
Equation 4a	Total lbs available for N loss * .60 = lbs of N reduced
Equation 4b	Total lbs available for P loss * .90 = lbs of P reduced

For example, Delmarva Broilers have average mortality weight of 3.5lbs, 5% mortality rate, an average of 575 million birds a year, and 8% nitrogen composition:

Equation 1: 575,000,000 x .05 = 28750000 bird deaths
Equation 2: 2875000 x 3.5 = 10062500 lbs of dead birds
Equation 3a: 10062500 x .08 = 8005000 total lbs of N available for loss
Equation 4a: 8005000 x .60 = 4803000 lbs of N reduced

Table 2. Average Body Composition for Nitrogen in Poultry

Source:	**Nitrogen Body Composition:**
Ken Staver, personal communication, January 6, 2009	2.9%
Angel, no date	3.1%
Pesti and Bakalli, 1997	2.8%
Average	**2.9%**

On-going studies

EPA Region 2 – On-Farm Mortality Composting Demonstration Project Request for Proposals. Funding Opportunity Number EPA-R2DEPP-FO-07-04.

Identify outstanding issues to be resolved in the future

As previously mentioned, direct calculations on the nutrient removal performance of mortality composting is not available. Future studies of this practice should evaluate nutrient removal.

Citations

Angel, R. no date. Phosphorous and Calcium Requirements in Broilers and Broiler Nutrient Excretion Based on Balance Studies.

Pesti, G.M., and R.I. Bakalli. 1997. Estimation of the Composition of Broiler Carcasses from their Specific Gravity. *Poultry Science* 76:948-951.

Scheideler, S.E. 1998. Rendered Spent Hen Meal Utilization in Layer Rations. University of Nebraska Cooperative Extension MP 70. http://ianrpubs.unl.edu/poultry/mp70/mp70-03.htm

Appendix A. Panel meeting minutes

Mortality composters
May 15, 2008

In attendance:
Jactone Oregjo
Jennifer Timmons
Sarah Weammert
Gary Felton
Tom Simpson

Action Items
ACTION: Does VA cost share mortality composting, or just rendering? Sarah will check

ACTION Gary will check what meant by 440 days of flock life for egg layers.

ACTION Jennifer will check what is meant by 440 days of flock life for breeding hens.

ACTION: Designed weight (whole bird). What is average size of hen versus tom turkeys? Also find a turkey expert (Sarah will find).

ACTION: Find data on septic tank phosphorous discharge (Sarah)

ACTION: What is the before swine condition, is it burial or incineration? Jennifer will ask her husbands family.

ACTION: ask state cost share programs for # poultry mortality composters in last 5 years, bin versus channel (all but DC, pose to ag workgroup - Sarah)

Overview of Project
Estimates of BMP performance will be used in TMDL implementation plans, trading permits and WSM modeling, and for continued use in Tributary Strategies. While our scope dictates that we quantify the nutrient and sediment reductions, UMD/MAWP recognizes there are additional co-benefits (social, economic, etc.). UMD/MAWP is asking panel members to help create a list of all co-benefits.

For mortality composting in particular why practice itself is primary benefit in animal health and disease control.

Our most important task is to estimate BMP performance at the operational, average watershed wide scale. UMD/MAWP's job is to ensure panel decisions, scientific justification, and best professional judgment are within the framework of our guidelines designed to estimate operational, average watershed wide conditions:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.
- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.
- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process. As such, peer reviewed literature should be given more weight than design standards and manual.
- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

UMD/MAWP will ask detailed questions about the BMP, not to discredit the performance of the BMP, but to get to operational conditions. Farmer may not operate composter at all, or at lower levels than required by definition. Need to make judgment call on what is implementation in real world.

Panel members' primary task is to develop a report for the BMP using the guidelines, decision matrix, and factors of variability found in the template. A final report from the panel is due to the Chesapeake Bay Program by July 15, 2008 so partners can begin their technical review process. Bay Program partners are made up of jurisdictional agencies, the EPA and the Chesapeake Bay Commission. During technical review (mid-July to September) workgroups may bring specific question to panel/scientists for discussion.

Definition:

From Agricultural BMP Descriptions –
Poultry mortality composters involve composting routine mortality in a designed facility, with subsequent land application of the compost. This prevents the necessity to bury dead animals that could result in nutrient leachate. Rendering of dead animals for processing into animal feeds or incineration are also alternatives to burial.

Questions posed to panel:

What is the efficiency for use as compost, what is the nutrient content?

What is the efficiency for processing into animal feed? What is the nutrient content? How well are the nutrient taken up by the animal and thus how much is excreted?

For incineration, what is the emission?

Is there a nutrient reduction associated with mortality composting?

If so, what baseline are we using to determine the effectiveness of composting? If it is incineration, what is the air emission?

If it is feed processing, what is the nutrient content after processing carcasses into animal feed? How effectively do the animals digest the nutrient content of the feed, and how much nutrients are excreted?

What is the nutrient content of the compost?

As the nutrient content of mortality compost is lower than that in inorganic fertilizer, will this lead to increased pollution loads due to higher application rates of compost? How will the timing of compost effect crop nutrient uptake? Will this compensate for increased application?

Discussion:

For this BMP we are evaluating mortality composting, not rendering or general compost.

With animal waste management and nutrient management land application of compost is accounted for. Real impacts from mortality composting occurs when dead animals have not been properly disposed of.

Bay wide, what is standard practice without mortality composter? Throw in woods, bury it in a hole in the ground. Rendering not common anymore in MD, however, VA freeze carcasses and send to rendering plant. Percent that does this is in VA unknown.

What would have been the loss from burying and disgarding vs composting it, and then using the compost? Most farmers use the animal carcasses compost in their animal waste management plan, thus the nutrients from animal carcasses compost is captured in animal waste management plan.

There are extra restrictions on animal mortality compost due to public health concerns, taking off farm is not encouraged. Incorporated in litter and then land applied on farm is common. Production systems without own animal operations that apply litter the composted carcasses is included. Nutrient management done on that litter in same proportion as other litter plans.

What is the N and P reduction to water from composting? (done considering its loss after composting because captured in animal waste management plan) Is there any data on improper disposal?

Improper composting more common than improper disposal.

Birds to rendering have no potential for loss.

Burying poultry is illegal in the coastal plain because can't bury within 2 feet of water table.

Can calculate mass of N and P of birds, how much lost to water?

ACTION: Does VA cost share mortality composting, or just rendering?

Purdue pushes compost.

Incineration is infrequently occurring.

Look at mass of dead birds compared to mass of litter.

Delmarva - One bird per thousand per day is normal loss. 110 million birds in ground any given day thus a 120,000 died a day.

Mortality Nationally:
4.2% per flock life for broilers
8-10% for roasters and bigger birds

5% for bay wide use – Broilers (all types: roasters,) per flock
5.5 flocks per year; 5lbs average designed weight

Egg Layers:
National # showed 14% per flock with 440 days of flock life; roughly 10% per year
John Door – Gary knows – knowledge of layers – ACTION Gary will check
what meant by 440 days ?
Designed weight ? ask John (national 5lbs)

Breeding hens 10-12% at 440 days; ACTION – Jennifer will check
With 8lbs designed weight

Turkey males 9% (not as hardy as female birds, growth rate faster in males); 24lbs designed weight
Females 4-6%; 14lbs average designed weight
ACTION – overview of turkey industry; grown separately? Find turkey specialist
If separate use different mortality.
VA major turkey producing state.

ACTION: Designed weight (whole bird). What is average size of hen versus tom turkeys?

Is this trackable?

Whole bird N and P content?
Have book values in my data set

% loss
Avg size
% TN and TP

If composted hot 40% ammonia (130 degrees needed and see in every correctly operated bird composter).

130 degrees for x amount of days should be added to definition. Use NRCS design standards as our definition.

MD cost shares channel composters.
Bin composters are no longer appropriate for big operations.

What percent of cost shared is bin? Have to look at cost share program between this year and last, it has changed that dramatically.

Minimum number of houses to go to channel: 4 houses (new house size 60ft x 600ft, keeping density the same).

60% of N remains
100% of P remains (of what is in bird 100%)

Nitrogen in compost in form much more slow release. Slow release is good if have crop that has long uptake periods (corn short uptake periods).
Compost N very small amount compared to overall litter.
If applied litter see high leaching, not with compost. Loss spring leach
Less than 5%
Additional benefit can't quantify. ADD TO REPORT LANGUAGE

When composting including oxygen, aerobic composter, how much nitrification?

Loss 40% of TN during composting, nitrate in other 60% (reference our data set)

40% goes off as ammonia; majority left in organic farms; have 60% of N

What loss of N and P prior to composting?
Burial:
Gary - Burying 0% P loss, bound in soil like septic tank ; all N lost to environment (100%)
When bury how much is denitrified? Don't know if have bacteria there to denitrify. With decomposition assume some ammonia loss.

Discarding (using woods and other land areas to discard carcasses):
So uncommon now, by 1993 (cost sharing began) mostly doing composting, discard discarding.
Loss 100% of nitrogen to environment
Some P loss if just throw on surface

With P, using upside down cans, how many had leachate issues (not precipitation leachate)? Opportunity for soluble P movement, not sure how far? How long before those enabling conditions change?

Use P septic tank number? ACTION find data

10% of P of burial chickens was eligible for loss; 20% too high

Is 100% of N is available for loss? no b/c mobilize some in soil, and denitrify some before reaches groundwater. Majority decomposition, small portion is denitrified.
More than one mechanism, so dynamic. No nitrification b/c anaerobic, so how does it denitrify?
Add time element to determine how long it takes proteins to degrade?
80-90% of dead birds buried 80-90% available for loss? BPJ, so little reach on grain bins can't
C:N ratio of carcasses is 5 so carbon isn't available to denitrify

When go to composting:
Loss goes to zero; handled in nutrient management
Materials in food bin never eligible for land application

60% left goes into litter storage (application)
40% into air (ammonia)
10% potential of loss for P
Just for chickens

Sediment component? Not with compost.

Swine:
Pre-condition: rendering
Phil - Jactone ask about swine ACTION what is the before (incineration, burial, other)? Jen will also ask her husbands family
10 degrees F lower in swine compost, will shift population of microbes that are active, how significant is that? Not sure

Mortality composting designed for disease and odor suppression, and disposal. While it has a very small water quality benefit it is not significant enough to warrant separating swine from poultry.

Dairy mortality is so low comparable to poultry due to high level of dairy health management. Diary estimates will also be comparable to poultry.

Horses?

Calves and heefers mortality? See national data
Lose 8 calves equals one adult – mass

Knowledge gaps/Future research needs:

Nutrient balance of N and P for mortality composter

Survey of type of mortality composters used and how they are used

Work on design of channel composters – give producer more control – more flexibility in design process to encourage implementation.

What results from in the shed composting? Expenditures versus benefit.

ACTION: ask state cost share programs for # poultry mortality composters in last 5 years, bin versus channel (all but DC, pose to ag workgroup)

Ammonia emissions:
Richard Gates, Kentucky

Treating litter (alum, etc.) to reduce emissions; loss effectiveness of alum at maximum generation

control

Wind breaks, trees- no data; if knocking down to ground b/c trees don't take up a lot of nutrients.

Data: Philmore in arkansas
John chastane; Clemens, modeling
Gary Van Wickling: Georgetown
Steve Hoff at Iowa State: biomass filters
Lou Carr did study with 3 additives

Research need:

how control ammonia through flock production? Delayed release agent for ammonia (alum does great job for P, but

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Information supplied after the meeting:

Sheep:
lamb mortality is about 10% per year; lamb weight is about 10 pounds
sheep mortality is something less than 5% per year: sheep weight is between 150 and 250, depending on breed
Maryland has 23,000 sheep and lambs (Maryland Ag Statistics Service)

Life span of sheep:
Meat market takes 8 months to market size Market weight is about 150 lbs
Lambs take 2-3 months and all seem to get sold in mid spring (Easter). Market weight is about 50 lbs

I suggest we ask about road kill of deer. If any species has less mass than road kill of deer, we shouldn't worry about it for this task.

Chickens:

Leghorns from hatch to onset of puberty probably have a mortality rate akin to broilers (maybe a little less since they are a slower growing bird). So I am going to guess that from 0 - 16 weeks a flock might see 3-7% mortality, much of that in the first week to 10 days. Mind you, that is truly a guess - my reference text for layers is packed!!
Pullets are put onto a layer ration as they approach 16 weeks and by 18 weeks should be starting to lay. First lay may go to as much as 70 weeks (this is a producer decision based on the shell quality toward end of the first year's cycle) but usually is more like 62 weeks.
They'll be down for a period of 4-6 weeks in molt and then come back into lay again. 2nd lay may be another 45 weeks (but these are all individual producer decisions that are based on what the egg market is doing ...e.g., is it more profitable to molt a bird and get a new year of lay or pay for a new replacement pullet and cull the year old layer?). Some may molt a second time and go another 40 weeks of lay.

A large operation (houses of 100K birds each in large complexes under reasonable management) expect about 1-1.5% mortality per month. Hens in lay weigh about 3.75 - 4 lbs to start and probably 3 - 3.25 at the end of first year lay. A small percentage (?) of "spent fowl" are deboned for USDA's sponsored school lunch program.
Most producers have to pay to have a company come in, remove birds from cages, euthanize them and take them to a landfill or other disposal arrangement. Today, spent fowl represent a cost for producers.

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Average breeder hen life span (including pullet stage) and average mortality of these birds and average breeder hen weight:

1) 65 weeks total.. Industry standard. 21 weeks in pullet house, 44 weeks in lay or production house.

Mortality day old to life of flock

Pullet 0 - 21 weeks - 5%........Lay 22 - 65 weeks - 8%...... Totals 13%

Average hen weight... 7 - 7.5 lbs

2) The sale age of a hen is about 65 weeks. However, this can be 2-3 weeks longer or shorter depending on market conditions. Currently we are at 62 weeks.

Our mortality goals are 6.5% in the pullet stage and 9% in the hen stage.

The weight goal for our female is 7.8lbs at 60 weeks.

3) industry average for hens is closer to 8lbs. Their average hen weight runs a little lighter than industry average.

Swine:

Burial is the disposal method.

Agricultural Nutrient and Sediment Reduction Workgroup Meeting Minutes
MD NRCS Office; Annapolis, MD
August 19, 2008

Mortality Composting
Report: http://archive.chesapeakebay.net/pubs/calendar/ANRWG_08-19-08_Handout_4_9619.pdf

- In this report, UMD/MAWP proposes an effectiveness estimate of 40% for N and 10% for P.
- The litter is not considered in this reduction, only the bird carcass. It is assumed that the litter is being land applied and is already counted.
- This practice was compared to the practice of mortality burial.
- The panel's logic was that when the mortality is buried, the P is mostly tied up by the soil. However, there are significant opportunities for denitrifiaction.
- Although mortality composting would result in some reduction in N loss, increases in ammonia emissions should also be accounted for.
- Comments/Suggestions:

- The description section of this report should include a statement that says that this report does not take into account bacteria concerns.
- The report needs to be clear that burying mortality has environmental and bird and human health implications.

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Minutes: Agricultural Nutrient and Sediment Reduction Workgroup
September 3, 2008

Mortality Composting

- Because there is no land use on which to apply the mortality composting BMP, Jeff Sweeney has been taking it from the manure load. He will continue to do this until more jurisdictions are reporting and numbers increase, at which point a new load may be assigned.

DECISION: The AgNSWRG agreed to approve the mortality composting practice as written.

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Minutes: Watershed Technical Workgroup
October 6, 2008

Mortality Composting

- Most of the studies on mortality composting are about how to design the practice, not on the performance. More research is needed on the efficiency of the practice.
- Nitrogen is reduced by 40% and phosphorus by 10%.
- Deceased animals will be put in the model as a nutrient source. Jurisdictions will then have the opportunity to adopt the mortality composting practice to reduce the load.
- Beth Horsey pointed out that farmers may be reporting the number of animal units purchased, or the number of animals that the house can hold, rather than the actual current inventory, when 5-10% of animals die each year in concentrated operations.
- The Workgroup approved the mortality composting BMP.

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Chesapeake Bay Program Nutrient Subcommittee
October 22, 2008 Meeting

SUMMARY OF DECISION, ACTIONS AND ISSUES

Mortality Composting

- UMD/MAWP recommended a 40% N reduction and 10% P reduction for mortality composting of bird carcasses. The Agricultural Nutrient and Sediment Reduction Workgroup and Watershed Technical Workgroup approved the UMD/MAWP's recommendations.
- The methodology for generating the reductions from mortality composting will work for all types of animals; however, at this point data on body composition (from which the reductions are taken) are only available for layers and hens.
- Jeff Sweeney needs to know the number of animals that were composted, not the number of composters from each state.

DECISION: The Nutrient Subcommittee approved the recommendations for the mortality composting BMP for a final decision by the Water Quality Steering Committee.

ACTION: Sarah Weammert will continue to research body composition data for the remaining animal types so that the mortality composting BMP can be applied to all animal types. The resultant data will be incorporated into the final BMP efficiencies report.

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Off-stream Watering with Fencing and Off-stream Watering without Fencing Practices

Definitions and Nutrient and Sediment Reduction Effectiveness Estimates

For use the Chesapeake Bay Program's Phase 5.0 Watershed Model

Consulting Scientist

Theo A. Dillaha, Ph.D.
Virginia Tech
Department of Biological Systems Engineering

Synthesis by

Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary

Offstream watering with fencing: This BMP excludes animals from streams. It incorporates both alternative watering and installation of fencing that eliminates livestock access to narrow strips of land along stream. The implementation of stream fencing should substantially limit livestock access to streams, eliminating direct manure deposition to streambeds and banks and reducing erosion and nutrient deposition to riparian areas.

- Effectiveness Estimates: 25% TN, 30% TP and 40% TSS

Offstream watering without fencing: This BMP requires the use of alternative drinking water sources away from streams to reduce the time livestock spends near and in streams and streambanks reducing direct manure deposition to streambeds and banks and also reducing erosion and nutrient deposition to riparian areas.

- Effectiveness Estimates: 15% TN, 22% TP and 30% TSS

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University Of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

To review efficiencies MAWQ contracted with an expert, Dr. Theo Dillaha, and asked him to review applicable literature and propose an efficiency for model calibration based on the literature and their experience. See Appendix A for his report. MAWP in consultation with the Nutrient Subcommittee (NSC) workgroups adapted Dillaha's recommendations to reflect average expected performance of stream protection measures. Attached to these definitions and efficiencies is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix F.

Off-stream Watering with Fencing Practices

Definition

This BMP incorporates both alternative watering and installation of fencing that excludes narrow strips of land along streams from pastures and livestock. The implementation of stream fencing should substantially limit livestock access to streams but can allow for the use of limited hardened crossing areas where necessary to accommodate access to additional pastures or for livestock watering.

The fenced areas may be planted with trees or grass, but are typically not wide enough to provide the full benefits of buffers. When a fencing system is installed, the excluded land is not considered a buffer unless specific buffer installation criteria are met, as outlined by the National Resource Conservation Service (see Riparian Forest Buffer and/or Grass Buffer BMP reports for details). In situations where installation criteria are met jurisdictions are eligible to receive credit for off-stream watering with fencing and a riparian buffer on pasture land. Buffers are reported as a separate practice from off-stream watering with fencing, and are currently implemented between cropland and receiving waterways. While stream protection may provide some buffer like function when vegetated at a specified width, it is buffering a very low loading land use and the major benefit is from keeping cows out of creeks and streambanks. Fencing or stream protection is a pasture management practice. UMD/MAWP recommends developing effectiveness estimates for buffers implemented on pastureland.

Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Components included in the Off-stream Watering with Fencing Practices include, but may not be limited to the following USDA-NRCS conservation practices:

- Fence (382)
- Heavy Use Area Protection (561)
- Pipeline (516)
- Pond (378)
- Pumping Plant (533)
- Spring Development (574)
- Streambank and Shoreline Protection (580)

- Stream Crossing (578)
- Use Exclusion (472)
- Water Harvesting Catchment (636)
- Water Well (642)
- Watering Facility (614)

Note that credit cannot be taken for each practice; one or a suite of practices may be required to meet the definition of Off-stream Watering without Fencing Practices for the credited land acreage.

Future Research Need
For the future, when jurisdictions report the cumulative effects of stream protection with fencing and functional buffers, UMD/MAWP recommends defining and evaluating the effectiveness of pasture buffers as an individual BMP. Pasture buffers should be assigned their own efficiency and not rely on cropland buffer efficiency estimates to represent pasture buffer effectiveness.

Follow-up study
National Fish and Wildlife Foundation study in Virginia for Shenandoah County

Off-Stream Watering without Fencing Practices

Definition

This BMP requires the use of alternative drinking water sources away from streams. The BMP may also include options to provide off-stream shade for livestock, and implementing a shade component is encouraged where applicable. The hypothesis on which this practice is based is that, given a choice between a clean and convenient off-stream water source and a stream, cattle will preferentially drink from off-stream water source and reduce the time they spend near and in streams and streambanks. The net effectiveness of the practice must reflect partial removal of livestock from near stream areas and relocation of animal waste deposition areas and heavy traffic areas surrounding water sources to more upland locations. (Source: Chesapeake Bay Program Nutrient Subcommittee Agricultural Nutrient Reduction Workgroup. Agricultural BMP Descriptions as Defined for the Chesapeake Bay Program Watershed Model. March 31, 2004, http://www.chesapeakebay.net/pubs/waterqualitycriteria/doc-Ag_BMP_Defns.pdf (Accessed August 28, 2006)).

Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Components included in the Off-stream Watering Without Fencing Practices include, but may not be limited to the following USDA-NRCS conservation practices:

- Heavy Use Area Protection (561)
- Pipeline (516)
- Pond (378)
- Pumping Plant (533)
- Spring Development (574)
- Water Harvesting Catchment (636)
- Water Well (642)
- Watering Facility (614)

Note that credit cannot be taken for each practice; one or a suite of practices may be required to meet the definition of Off-stream Watering without Fencing Practices for the credited land acreage.

Future Research Need

UMD/MAWP recommends the Chesapeake Bay Program explore the extra benefit of adding shaded areas for livestock to pastures with off-stream watering without fencing. Some emerging literature shows how efficiencies change by adding structures that provide shade. The idea is that livestock will enter the stream less frequently on hot days if off-stream watering and shade are both provided.

Recommended Efficiency

Off-stream Watering with Fencing

The primary benefit of this BMP is exclusion of livestock from the stream and stream corridor delineated by the fencing. Livestock either drink from tanks, troughs, or similar systems away from the stream or from narrow hardened access points along the stream, which allows livestock to drink but not loiter in the stream.

Potential Environmental Benefits and Methods of Action:

- Livestock exclusion from stream. Direct deposition of livestock manure into streams is immediately eliminated (or greatly reduced if cattle have access to a few hardened access points for drinking). Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Livestock exclusion from riparian zone. Livestock do not have access to the riparian zone protected by the fence, which decreases streambank disturbance and potential nutrient and sediment loadings from the fenced riparian area during stormflow events. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Protection of stream substrate. Livestock do not disturb the stream bottom when drinking, loitering in the stream, or crossing the stream, Depending on the type of stream substrate, this eliminates sediment and nutrient resuspension from bottom sediments and substrate.

- Regeneration of riparian zone vegetation. Exclusion of livestock from a portion of the riparian zone allows the fenced portion of the riparian zone to revegetate and act as a full or partial buffer.

Potential Negative Environmental Consequences and Methods of Action:

- Pollutant losses from watering sites. If not designed and maintained properly, off-stream watering sites can become a concentrated source of nutrients and sediments that can be carried to streams during surface runoff events and/or can contribute dissolved nutrient loadings to interflow and groundwater. The area around the watering points must be hardened and properly drained so that it is not continuously wet and muddy. In addition, accumulated manure must be regularly collected and spread in adjacent pastures. There should not be a well defined drainageway leading from the watering site as this would facilitate transport of sediment and nutrients to down slope streams during runoff events. Down slope, adjacent pasture should be maintained in good condition so that it acts as a buffer zone, with shallow uniform flow, to traps sediments and nutrients that may be washed from the watering site.

Off-stream Watering without Fencing

With off-stream watering without fencing, the benefits are similar to off-stream watering with fencing except that exclusion of livestock from the stream and stream corridor is only partial. The hypothesis on which this practice is based is that, given a choice between a clean and convenient off-stream water source and a stream, cattle will preferentially drink from off-stream water source and reduce the time they spend near and in streams. Off-stream watering without fencing may include off-stream shade, and is recommended, if the only other shade is in the riparian zone.

Potential Environmental Benefits and Methods of Action:

- Partial livestock exclusion from stream. Direct deposition of livestock manure into streams is reduced. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Partial livestock exclusion from riparian zone. Livestock spend less time moving through the riparian zone when going to drink, reducing streambank disturbance and potential nutrient and sediment loadings from the riparian area during stormflow events. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Partial protection of stream substrate. Stream bottom disturbance is reduced because cattle do not drink, loiter in, or cross the stream as much. Depending on the type of stream substrate, this reduces sediment and nutrient resuspension from bottom sediments and substrate.
- Partial regeneration of riparian zone vegetation. Reduced livestock activity in the riparian zone allows partial restoration of the riparian zone and its buffer functions.

Potential Negative Environmental Consequences and Methods of Action:

- The potential for pollutant losses from watering sites, as discussed for off-stream watering with fencing, is also true for off-stream watering without fencing.

UMD/MAWP contracted with Dr. Theo Dillaha, Virginia Tech, to conduct a literature review of off-stream watering practices and provide a report on the practice definitions and efficiencies. He used two journal articles and a research report to develop his proposed BMP efficiencies:

- Galeone, Daniel G., Robin A. Brightbill, Dennis J. Low, and David L. O'Brien. 2006. Effects of Streambank Fencing of Pasture Land on Benthic Macroinvertebrates and the Quality of Surface Water and Shallow Ground Water in the Big Spring Run Basin of Mill Creek Watershed, Lancaster County, Pennsylvania, 1993-2001. Scientific Investigations Report 2006–5141. U.S. Geological Survey, Reston, Virginia.
- Line, D.E., W.A. Harman, G.D. Jennings, E.J. Thompson, and D.L. Osmond. 2000. Nonpoint-Source Pollutant Load Reductions Associated with Livestock Exclusion. *Journal of Environmental Quality*. 29(6):1882-1890.
- Sheffield, R.E., S. Mostaghimi, D.H. Vaughan, E.R. Collins Jr., and V.G. Allen. 1997. Off-Stream Water Sources for Grazing Cattle as a Stream Bank Stabilization and Water Quality BMP. *TRANSACTIONS of the ASAE*, 40(3):595-604.

Dillaha recommended reducing the reported literature efficiency values by 50%. He stated his justifications for reducing the efficiencies as:

- ***Off-stream watering with fencing:*** To be conservative, since the results are from a single study, Theo Dillaha recommended reducing the reported reduction values by 50%.
- ***Off-stream watering without fencing:*** Data from two studies are used and are compared with data with fencing. To be conservative Theo Dillaha recommended reducing the reported reduction values by 50%. He also required the reductions to be less than those for off-stream watering with fencing because the literature review indicated that off-stream watering reduced but did not eliminate livestock activities in streams (80-90% reduction) and riparian areas (50% reduction).

After conducting a ranking exercise it became apparent the 50% reduction in effectiveness for off-stream watering was too severe after comparing the efficiencies to other agricultural BMPs. Using the 50% reduction for off-stream watering with fencing would equate it to Total Phosphorous (TP) reductions associated with conservation plans field and pasture erosion control practices. Conservation plans reduce nutrients and sediment by increased vegetative assimilation, increased trapping and retention of transported nutrient enriched sediment and particulates, improved water infiltration and nutrient adsorption to the soil matrix, and reduced erosion and transport of nutrient enriched sediment and particulates. Fencing practices will also

reduce TP by the same mechanisms described above, and will also regenerate riparian zone vegetation allowing buffers to grow, providing some filtering benefits of buffers. In addition, fencing has the potential to further reduce nutrients and sediment compared to conservation plans primarily by eliminating or hindering direct deposition of livestock manure into streams, nutrient and sediment loadings from riparian area during stormflow are reduced, and sediment and nutrient resuspension from bottom sediments and substrate is eliminated.
These benefits are considered mechanisms that greatly reduce nutrient and sediment loadings and will have a greater ability to reduce pollutant loadings than field and pasture erosion control plans.

In this case, the literature did not support the current reduction efficiencies, so some adjustment to current estimates was warranted. However, the developer used a conservative view of the literature values and then reduced them by 50% based on his experience to account for variability and uncertainty. While the literature made it evident that some reductions were needed, UMD/MAWP and Chesapeake Bay Program (CBP) partners felt the developer had reduced the efficiencies further than warranted, and effectiveness estimates selected should be closer to the conservative literature base that the developer cited (Appendix A).

As a general rule during the BMP efficiency development process, for all TP efficiencies where specific data is not available on phosphorous the TP load reductions were calculated to be 75% of the sediment reductions to account for soluble phosphorous losses. In the Chesapeake Bay watershed dissolved reactive phosphorous is assumed to be 25% and sediment bound phosphorous is 75% of the total phosphorous load (Sharpley et al 1993). Thus 75% of the TSS load reduction is an estimate of the sediment bound phosphorous reductions. Dissolved reactive phosphorous will not be reduced with a sediment reduction.

BMP	TN Reduction	TP Reduction	TSS Reduction
Off-stream watering w/ fencing	25%	30%	40%
Off-stream watering w/out fencing	15%	22%	30%

Off-stream Watering with Fencing and Rotational Grazing Practices

The review of the definition of this practice has been delayed until the Year 2 portion of the BMP Project due to the following reasons:

- Rotational grazing is a stand alone BMP that should be considered for its overall impact on forage and livestock management. It should not be solely compared to pasture losses, as was done when linked with stream protection measures and rotational grazing should be encouraged broadly, not just when pastures are in stream.
- The development of additional grazing management practices in Year 2 of the project will be reflective of the review of this practice. Both sets of practices should be developed in unison to enable compatible definitions and efficiencies.
- CBP partners, including New York State, Pennsylvania, and USDA-NRCS have requested that a final definition and efficiency be developed with additional research sources.

From this review it became apparent that rotational grazing should be separated into a stand alone BMP. It may be necessary to have different management levels or intensities for rotational grazing. MAWQ recommends:

- That the CBP separate Rotational Grazing from the other Year 1 pasture BMPs for further refinement in Year 2 of the BMP project.
- That additional research data be obtained to develop definitions and efficiencies for pasture management systems including Rotational Grazing and Precision Rotational Grazing BMPs that are separate from stream corridor management.

How Modeled

The effectiveness estimate assigned to off-stream watering with fencing and off-stream watering without fencing assumes the practice will be applied to a stream corridor land use category that represents average, natural stream segments with low nutrient loading rates. Degraded land uses proposed for use in Phase 5 of WSM have increased nutrient loads compared to average pasture lands. If the effectiveness estimates are applied to a degraded stream corridor land use than estimates need to be revised to account for the higher nutrient loading rates from the degraded land use category. There may be a limit to the nutrient and hydrologic treatment capacity of the BMP that will exceed its ability to achieve the proposed effectiveness estimates on a degraded land use.

Reference:

Sharpley, A.N., Daniel, T.C., and D.R. Edwards. 1993. Phosphorus movement in the landscape. J. Prod. Agr. 6(4):492-500.

Appendix A: Report by Theo Dillaha

Off-stream Watering with Fencing, Off-stream Watering without Fencing, Off-stream Watering with Fencing and Rotational Grazing

Strategies for Estimating Nutrient and Sediment Reduction Efficiencies

For use in calibration and operation of the Chesapeake Bay Program's Phase 5.0 Watershed Model

Prepared By:

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March 26, 2007

INTRODUCTION

This document summarizes the recommended definitions, nutrient and sediment reduction efficiencies, and strategies for simulating the effects of BMPs involving off-stream watering. The BMPs considered include:

- Off-stream watering with fencing.
- Off-stream watering without fencing.
- Off-stream watering with fencing and rotational grazing.

The recommendations contained within are proposed for review and approval by the Tributary Strategy and Source Area Workgroups. Attached to this report are the BMP definitions and efficiencies found in literature that were provided by the University of Maryland as the basis for this review. This report describes (1) a proposed procedure for using HSPF to directly simulate the effects of reduced cattle access to streams and (2) recommended changes in the provided reduction efficiencies and the scientific basis for the proposed changes. It should be noted that the proposed efficiencies have an unusually high degree of uncertainty because they are based on only three field studies, and, as described in this report, each of these field studies had significant experimental limitations and/or problems. It is highly recommended that the Bay Program sponsor field research to provide better estimates of the effectiveness of these BMPs.

BASIS FOR REVIEW

The following material was provided by the University of Maryland as the basis for this review:

1. Review instructions/contract (Appendix A).
2. BMP definitions.
3. BMP efficiencies found in two journal articles and one research report. (Appendices B to D).
4. The two journal articles and research report used in developing the proposed BMP efficiencies:
   - Galeone, Daniel G., Robin A. Brightbill, Dennis J. Low, and David L. O'Brien. 2006. Effects of Streambank Fencing of Pasture Land on Benthic Macroinvertebrates and the Quality of Surface Water and Shallow Ground Water in the Big Spring Run Basin of Mill Creek Watershed, Lancaster County, Pennsylvania, 1993-2001. Scientific Investigations Report 2006–5141. U.S. Geological Survey, Reston, Virginia.
   - Line, D.E., W.A. Harman, G.D. Jennings, E.J. Thompson, and D.L. Osmond. 2000. Nonpoint-Source Pollutant Load Reductions Associated with Livestock Exclusion. *Journal of Environmental Quality*. 29(6):1882-1890.
   - Sheffield, R.E., S. Mostaghimi, D.H. Vaughan, E.R. Collins Jr., and V.G. Allen. 1997. Off-Stream Water Sources for Grazing Cattle as a Stream Bank Stabilization and Water Quality BMP. *TRANSACTIONS of the ASAE*, 40(3):595-604.
5. A report on the long-term effectiveness of BMPs:
   - Rosenthal, Alon, and Don Urban. 1989. *BMP Longevity: A Pilot Study.* Submitted to U.S. EPA, Chesapeake Bay Liaison Office, Office of Program Policy and Evaluation, Office of Water.

BMPS CONSIDERED AND DEFINITIONS

The BMPs considered in this report include:

- Off-stream watering with fencing.
- Off-stream watering with fencing and rotational grazing.
- Off-stream watering without fencing.

Definitions of the BMPs provided by the University of Maryland with recommended changes are:

Off-stream Watering with Fencing

Definition: ~~From Agricultural BMP Descriptions As Defined For The Chesapeake Bay Program Watershed Model – Direct contact of pastured animals with surface water results in direct~~

~~deposition of animal waste, streambank erosion, and re-suspension of sediments and associated nutrients held in streambeds. There are three unique systems that are variations to this BMP. The variations include off stream watering: (1) without stream fencing, (2) with stream fencing, and (3) with stream fencing and rotational grazing. The systems are mutually exclusive, so reduction efficiencies are not additive. With fencing –~~ This BMP incorporates both alternative watering and installation of fencing that ~~involves~~ *excludes* narrow strips of land along streams ~~to exclude~~ *from pastures and* livestock. The fenced areas may be planted with trees or grass, but are typically not wide enough to provide *the full* benefits of buffers. The implementation of stream fencing should substantially limit livestock access to streams but can allow for the use of limited hardened crossing areas where necessary to accommodate access to additional pastures or for livestock watering. (Source: Agricultural BMP Descriptions As Defined For The Chesapeake Bay Program Watershed Model ?)

Off-stream Watering with Fencing and Rotational Grazing

Description: Off-stream watering with stream fencing and rotational grazing (pasture) combines stream fencing and alternative watering with cross fencing systems, creating paddocks to enable rapid grazing of small areas in sequence. Once *the vegetation in a paddock is grazed to a height of approximately 5 cm* ~~an area is intensively grazed of most vegetative matter~~, the animals are moved to another paddock to enable *rapid* recovery of the *paddock vegetation* ~~pasture grasses~~. This BMP is beneficial in removing animals from stream areas *and in improving vegetative cover, which can increase vegetative uptake of nutrients, decrease surface runoff by promoting increased infiltration, and reduce erosion. However, these benefits may be offset in part or whole by increased stocking densities.* ~~but may be offset by an increased animal stocking rate per acre. This increases the concentration of~~ *Increased stocking densities can increase unit area loadings of livestock manure to adjacent pastures* ~~animal manure *loadings* per acre~~ and may adversely affect the quality of surface water runoff. (Source: Chesapeake Bay Program Agriculture Nutrient Reduction Workgroup, Agricultural BMP Descriptions, 11/3/03.)

Examples: Managing forage height through ~~mechanical means,~~ stocking rates, *limiting grazing time,* supplemental feeding and other methods.

Off-Stream Watering without Fencing

Definition: This BMP requires the use of alternative drinking water *sources* ~~troughs or tanks~~ away from streams. The BMP may also include options to provide *off-stream* shade for livestock. ~~away from streams. Limited research has been conducted for this practice that documents changes in livestock behavior resulting in significantly less time spent~~ *The hypothesis on which this practice is based is that, given a choice between a clean and convenient off-stream* *water source and a stream, cattle will preferentially drink from off-stream water source and reduce the time they spend* near ~~streambanks~~ and in streams. The net effectiveness of the practice must reflect partial removal of livestock from near stream areas and relocation of animal waste deposition areas and heavy traffic areas surrounding water sources to more upland locations. (Source: Chesapeake Bay Program Nutrient Subcommittee Agricultural Nutrient Reduction Workgroup. Agricultural BMP Descriptions as Defined for the Chesapeake Bay Program Watershed Model. March 31, 2004, http://www.chesapeakebay.net/pubs/waterqualitycriteria/doc-Ag_BMP_Defns.pdf (Accessed August 28, 2006)).

PROCESSES AND FACTORS AFFECTING BMP PERFORMANCE

Off-stream Watering with Fencing

The primary benefit of this BMP is exclusion of livestock from the stream and stream corridor delineated by the fencing. Livestock either drink from tanks, troughs, or similar systems away from the stream or from narrow hardened access points along the stream, which allows livestock to drink but not loiter in the stream.

Potential Environmental Benefits and Methods of Action:

- Livestock exclusion from stream. Direct deposition of livestock manure into streams is immediately eliminated (or greatly reduced if cattle have access to a few hardened access points for drinking). Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Livestock exclusion from riparian zone. Livestock do not have access to the riparian zone protected by the fence, which decreases streambank disturbance and potential nutrient and sediment loadings from the fenced riparian area during stormflow events. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Protection of stream substrate. Livestock do not disturb the stream bottom when drinking, loitering in the stream, or crossing the stream, Depending on the type of stream substrate, this eliminates sediment and nutrient resuspension from bottom sediments and substrate.
- Regeneration of riparian zone vegetation. Exclusion of livestock from a portion of the riparian zone allows the fenced portion of the riparian zone to revegetate and act as a full or partial buffer.

Potential Negative Environmental Consequences and Methods of Action:

- Pollutant losses from watering sites. If not designed and maintained properly, off-stream watering sites can become a concentrated source of nutrients and sediments that can be carried to streams during surface runoff events and/or can contribute dissolved nutrient loadings to interflow and groundwater. The area around the watering points must be hardened and properly drained so that it is not continuously wet and muddy. In addition, accumulated manure must be regularly collected and spread in adjacent pastures. There should not be a well defined drainageway leading from the watering site as this would facilitate transport of sediment and nutrients to down slope streams during runoff events. Down slope, adjacent pasture should be maintained in good condition so that it acts as a buffer zone, with shallow uniform flow, to traps sediments and nutrients that may be washed from the watering site.

Off-stream Watering with Fencing and Rotational Grazing

With off-stream watering and fencing and rotational grazing, the benefits of this BMP are the same as with off-stream watering and fencing described above (exclusion of livestock from the stream and stream corridor delineated by the fencing). There should be additional benefits due to increased vegetative cover and activity in the adjacent paddocks. These additional benefits may be offset in part or whole by increased stocking densities, which can increase unit area loadings of livestock manure to adjacent pastures and may adversely affect the quality of surface water runoff. With good rotational grazing management, stocking densities may be increased by a factor of two or more. Whether stocking densities increase or not is a site-specific landowner decision.

Environmental Benefits and Methods of Action:

- Livestock exclusion from stream.
- Livestock exclusion from riparian zone.
- Protection of stream substrate.
- Regeneration of riparian zone vegetation.
- Reduced sediment and nutrient transport from adjacent pastures: Increased vegetative cover in adjacent pastures will promote increased vegetative uptake of nutrients, decreased surface runoff by promoting increased infiltration, and decreased erosion.

Potential Negative Environmental Consequences and Methods of Action:

- Pollutant losses from watering sites.
- The benefits of increased vegetative cover and growth may be offset in part or whole by increased stocking densities, which increase unit area loadings of livestock manure to adjacent pastures.

Off-stream Watering without Fencing

With off-stream watering without fencing, the benefits are similar to off-stream watering with fencing except that exclusion of livestock from the stream and stream corridor is only partial.

The hypothesis on which this practice is based is that, given a choice between a clean and convenient off-stream water source and a stream, cattle will preferentially drink from off-stream water source and reduce the time they spend near and in streams. To further enhance the effectiveness of off-stream watering without fencing, off-stream shade must be provided if the only available shade is in the riparian zone.

Potential Environmental Benefits and Methods of Action:

- Partial livestock exclusion from stream. Direct deposition of livestock manure into streams is reduced. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Partial livestock exclusion from riparian zone. Livestock spend less time moving through the riparian zone when going to drink, reducing streambank disturbance and potential nutrient and sediment loadings from the riparian area during stormflow events. Pollutant loadings that are not deposited in the stream are redirected/deposited in adjacent pastures.
- Partial protection of stream substrate. Stream bottom disturbance is reduced because cattle do not drink from the stream as much. Sediment and nutrient resuspension from bottom sediments and substrate is reduced.
- Partial regeneration of riparian zone vegetation. Reduced livestock activity in the riparian zone allows partial restoration of the riparian zone and its buffer functions.

Potential Negative Environmental Consequences and Methods of Action:

- Pollutant losses from watering sites.

LITERATURE REVIEW BMP EFFICIENCIES

Galeone et al. (2006) Study

Galeone et al. (2006) conducted a seven- to eight-year study in Lancaster, Pennsylvania, on the effects of streambank fencing on stream water quality. Effects of fencing on benthic macroinvertebrates and the quality of surface and shallow ground water were investigated. The study consisted of a nested experimental design including paired watersheds, and upstream/downstream and pre- and post-BMP implementation comparisons. The pre-BMP monitoring lasted three to four years, and the post-BMP monitoring period lasted four years. Approximately 2 miles of stream were fenced in the 1.42 mi^2 treatment watershed. Fencing created buffer strips 5 feet to 12 feet wide on each side of the stream. Off-stream watering sources were not provided. Each pasture was supplied with a cattle crossing at which livestock could drink or cross to pastures on the other side of the stream. The type of stream cattle crossing was not described, but because cattle could drink from the stream at the crossing, it would not have been elevated. Monitoring was conducted at the locations indicated in Table 1. In addition, a system of shallow groundwater wells was sampled.

Table 1. Galeone et al. monitoring sites with base-flow and stormflow sampling

Site	Description	Area, mi^2	Data use
C-1	Outlet of control basin	1.77	Compare to T-1 and T-2 for paired basin analysis
T-1	Outlet of treatment basin	1.42	Compare to C-1 for paired basin analysis and T-3 for upstream-downstream analysis
T-2	Upstream tributary in treatment basin	0.36	Compare to C-1 for paired basin analysis and T-4 for upstream-downstream analysis
T-4	Upstream tributary above all pasture in treatment basin	0.32	Compare to T-2 for upstream-downstream analysis

Baseflows were sampled 25 to 30 times per year and 35 to 60% of storm events were sampled. Water quality samples were analyzed for: nitrate, nitrite, dissolved ammonia, dissolved Kjeldahl nitrogen, TKN, dissolved P, Total P, and suspended sediment. The research encountered several significant problems, which introduce significant uncertainty into the reported results:

1. Precipitation was 5-in/year higher during the pre-treatment period than the post-treatment period. This resulted in a decrease in streamflow during the post-treatment period of 56 to 63%. This decrease in runoff would have greatly reduced NPS loadings from pervious land segments during the post-treatment phase and falsely contributed to reported BMP efficiencies.
2. Nitrogen and P fertilizer applications decreased 27 to 33%, respectively, in the treatment basin from the pre- to post-BMP treatment periods. In contrast, in the control basin, N and P applications decreased by 3% and increased by 7%, respectively. These differences would tend to contribute to an overestimation of treatment effectiveness.
3. The number of cattle in the control and treatment basins decreased by approximately 50% between the pre- and post-BMP periods. In the control watersheds, the cattle populations decreased over the last two years. In the treatment watershed, the decrease occurred during the last year of the study. These differences would tend to contribute to an overestimation of treatment effectiveness.

Because of the research problems encountered above, comparison of pre- and post-BMP implementation is of little value. Results based on differences in constituent yields between the control (C-1) and treatment watersheds (T-1 and T-2) during the post-BMP period are reported in Table 2 but should be used with caution because of the problems cited above. As shown in Table 2, there are substantial differences in results for the T-1 and T-2 watersheds. For the larger T-1 treatment watershed, which is comparable in size to the C-1 control watershed, streamside fencing without cattle access to the stream at cattle crossings for drinking decreased all nutrient loadings by 18 to 36% except for dissolved P, which increased by 19%. In contrast, for the smaller treatment watershed, nutrient losses were higher than those from the treatment watershed. The only consistent reduction was in suspended sediment, where sediment yields were reduced by 37 to 44% for the T-1 and T-2 watersheds, respectively.

Table 2. Constituent yields for the treated sites (T-1 and T-2) for the post-treatment period compared with the control basin (C-1) based on analysis of covariance (ANCOVA).

Constituent	T-1 to C-1 Comparison	T-2 to C-1 Comparison
Dissolved nitrate	-18%	+15%
Dissolved nitrite	-28%	+15%
Dissolved ammonia	-36%	+10%
Dissolved TKN	-20%	+30%
TKN	-26%	+43%
Dissolved phosphorus	+19%	+94%
Total phosphorus	-14%	+51%
Suspended sediment	-37%	-44%

In summary, while this study is the most comprehensive in terms of the effects of stream-side fencing available, its results have a high degree of uncertainty because of the extreme changes that occurred between the pre-and post-BMP implementation periods. In addition, results based on comparison of the treatment and control watersheds during the post-BMP implementation period are contradictory. The study does suggest that stream-side fencing and limiting cattle access to streams decrease sediment yields.

Line et al. (2000) Study

Line et al. (2000) conducted a four-year study in the Piedmont Region of North Carolina on the effects of off-stream watering, with and without stream-bank fencing, on surface water quality. The study consisted of a nested experimental design with upstream/downstream and pre- and post-BMP implementation comparisons. The pre-BMP monitoring period lasted 81 weeks, and the post-BMP monitoring period lasted 137 weeks. There were two monitoring sites on Kiser Branch. Site E was at the watershed outlet and drained approximately 56.7 ha. Site D was located approximately 355 m upstream of site E on Kaiser Branch and drained 41.8 ha (designated as Subwatershed D).

BMP Installation: The 355 m of stream between sites D and E (subwatershed D-D) was fenced along both sides of the stream, and a buffer zone 10 m to 16 m wide was created along each side of the stream. A 94-m long intermittent stream in subwatershed D-E was also fenced, and a 3-m buffer was created on each side of the intermittent drainageway. Fencing separated subwatershed D-E from subwatershed E. A severely eroding section of the stream bank between sites D and E was graded and seeded after fencing was installed. In addition, the riparian buffer between D and E was planted with soft and hardwood trees 3-m on center. A low-water cattle crossing was installed across the stream, but it was unclear if cattle could drink at the crossing.

Off-stream watering sources were provided in the pastures of both subwatersheds D-E and E, so the treatment difference between the two watersheds was fencing. Subwatershed E was lightly grazed and was not a good control for subwatershed D-E, which was intensively grazed and contained a farmstead with a dairy, numerous structures, manure storage facilities, etc. Approximately one-half the area of subwatershed D-E was estimated to be denuded or covered with impervious areas.

Discharge was measured continuously at sites D and E by USGS. Grab samples were collected weekly for water quality analysis, and three samples were collected with automated samplers during stormflow events to characterize stormwater flow. Total precipitation on an annual basis was similar during the pre- and post-BMP periods. Water quality samples were analyzed for: nitrate-nitrite, TKN, Total P, TSS, and total solids. The research had several significant problems, which introduce significant uncertainty into the reported results:

1. Although precipitation on an annual basis was similar during the pre- and post-BMP periods, there were four major storms (>100 mm) during the pre-BMP implementation phase and no similar storms during the post-BMP period. The larger storms during the pre-BMP period would be expected to produce more runoff, which they did (≈28% more on an annual basis), and greater NPS loadings to the streams than during the post-BMP implementation period. This would probably result in reported efficiencies that are too low.
2. The stormwater sampling methodology was rather coarse, three samples per storm event, and probably inaccurately represented stormwater flow concentration and yields.
3. There was no control treatment since the land uses in the two subwatersheds were so different.
4. The riparian buffers created in subwatershed D-E, are 10 to 16-m wide and thus constitute functional buffers, which would be expected to reduce pollutant loading to the stream. Channel regarding and stabilization, another structural BMP implement, also would have reduced sediment and contaminant losses. In addition, during the pre-BMP period, additional BMPs were installed, including improved stock trails, heavy use area protection, a large waste-holding pond, and a waste irrigation system. This experiment evaluated the combined effects of all of these BMPs in subwatershed D-E.

The results of this experiment, with its associated uncertainties, are presented in Table 3. Comparison of the pre- and post-BMP results for Site D, which represented the effects of off-stream watering without fencing in a pasture with low stocking density, shows that off-stream watering reduced nitrate-nitrate, TSS, and total solids loadings by 41, 38, and 44% respectively, and increased TKN and Total-P loadings by 27 and 13%, respectively. These results are somewhat surprising because one would have expected the TKN and Total-P loadings to decrease with the lower sediment yields if they were sediment bound, or to infiltrate and decrease like nitrate-nitrite if they were predominantly dissolved like nitrate-nitrite.

Subtracting the loadings at site D from those of site E theoretically gives the changes in loadings from subwatershed D-E. The system of BMPs in this subwatershed significantly reduced all pollutant loadings except nitrate-nitrite. Nitrate-nitrite, TKN, Total-P, TSS, and TS were reduced by 33, 79, 76, 82, and 83%, respectively. As indicated previously, fencing was just one of the BMPs that contributed to these reductions.

Table 3. Mean weekly discharge and pollutant loads for monitoring sites D and E

Site/Period	Discharge	Nitrate-nitrite	TKN	Total-P	TSS	Total solids
	m^3/wk	kg/wk				
Site D, Upstream subwatershed (effects of off-stream watering without fencing on water quality in low stocking density pastures)						
Pre-BMP	3,594a[#]	8.2a	11.8a	3.9a	1,657a	2,736a
Post-BMP	2,612a	4.8a	15.0a	4.4a	1,031a	1,531a
Reduction	27%	41%	-27%	-13%	38%	44%
Site E, Entire watershed (effects of a system of many BMPs)						
Pre-BMP	6,997a	18.7a	127.8a	54.2a	12,733a	17,846a
Post-BMP	4,135b	11.8b	39.9b	16.6b	2,988b	4,302b
Reduction	41%	37%	69%	69%	77%	76%
Between Site D and E, Downstream subwatershed (effects of a system of many BMPs)						
Pre-BMP	3,403a	10.5a	116.0a	50.3a	11,076a	15,110a
Post-BMP	1,523b	7.0a	24.9b	12.2b	1,957b	2,771b
Reduction	55%	33%	79%	76%	82%	82%

[#] Within factors and sites, means followed by the same letter are not statistically different at the 0.05 level.

Sheffield et al. (1997) Study

Sheffield et al. (1997) conducted a 15-month study on the effects of off-stream watering on cattle behavior and water quality in the Ridge and Valley region of southwest Virginia. Cattle behavior was observed at three locations. Water quality data was collected only at one location: River Ridge Farm in Independence, Virginia. During the first seven months of the study (pre-BMP), cattle drank from a stream at each site. Water troughs were then installed in the pastures, and the cattle had access to either the troughs or the streams for drinking. The experimental design was for pre- and post-BMP implementation comparison. No mention was made of collection of stormwater samples. The site with water-quality monitoring had a recording rain gauge, and stream flow measurements were made with a bucket and stopwatch at a pond outlet pipe. Grab water quality samples were collected at two-week intervals. Samples were tested for: total suspended solids (TSS), nitrate-nitrogen (NO_3-N), ammonium (NH_4-N), total nitrogen (TN), orthophosphorus (PO_4-P), total phosphorus (TP), fecal coliform (FC), fecal streptococci (FS), and total coliform (TC).

Cattle Behavior: Cattle were observed at each of the three field sites for a day during both the pre- and post-BMP periods. The time that the cattle spent drinking from the stream and trough and the time that the cattle spent in the stream or trough areas (defined as time spent within 4.6 m of the center of the stream or from the edge of the trough) were recorded at five-minute intervals through the day (presumably just daylight hours). The pre-BMP observations occurred in the winter and the post-BMP observations in the summer.

The research had several significant problems, which introduce significant uncertainty into the reported results:

1. Precipitation during the pre-BMP period (Aug. 17, 1994, to March 17, 1995) was fairly normal, 70 cm, which is about 3 cm above the long-term average. In contrast, the post-BMP period (March 18, 1995 to October 15, 1996) was 107 cm (Sheffield, 1996) and about 42 cm above normal. There was thus a 54% increase in precipitation between the pre- and post-BMP periods, which would greatly increase runoff, channel erosion, and non-point loadings during the post-BMP implementation phase. Precipitation and runoff differences between the pre- and post-BMP periods were not reported or discussed in the journal article. Loadings were adjusted for precipitation by converting and reporting all loadings with units of kg/cm rain. This is not the best way of accounting for differences between the pre- and post-BMP periods.
2. Sampling was conducted bi-weekly, and no sampling of stormwater flows was reported. It is likely that the samples collected are more representative of yields and concentration during baseflow conditions rather than combined baseflow and storm water yields. It is probably best to assume that the reported flow-weighted concentrations and loadings are only representative of baseflow conditions and not storm water flows. If this is the case, the extremely high reduction efficiencies make more sense scientifically.
3. Pre-BMP cattle observations were made in the winter. Post-BMP cattle observations were made in the summer. One would suspect that changes in temperature would also influence cattle behavior. The times cattle spent drinking from streams or were in stream areas were reported, but times cattle spent drinking from troughs or near troughs were not reported. It is difficult to evaluate the significance of seasonal patterns because the trough data is not reported.

As indicated in Table 4, installation of off-stream watering troughs decreased the average time cattle spent drinking from streams and being in the stream area by 89 and 51%, respectively. The table also reports the time that cattle spent in the stream area, which probably best represents the time that cattle would be disturbing the stream bottom and adjacent riparian area. The time spent in the riparian area is likely a good approximation of the time that cattle would likely be depositing manure in the riparian area. If this is the case and if one supposes that the fraction of time spent in the stream area can be used to estimate the fraction of daily manure production deposited in the stream area and consequently has a high probability of affecting the stream, then the fraction of daily manure production reaching the stream, $L_{m,}$ is:

$$L_m = \frac{12.69\,\text{min}/\,day}{1440\,\text{min}/\,day} = 0.009$$

and the fraction of manure reaching the stream with off-stream watering would be 0.51*0.009 = 0.004. In bacterial TMDLs developed in the Chesapeake Bay region, cattle in fields with streams and no fencing are typically assumed to spend much more time in the stream area.

Table 4. Observed cattle behavior with and without off-stream watering

	Pre-BMP Time, min/day	Post-BMP Time, min/day	Post BMP reduction, %
Time spent in stream drinking	6.62	0.72	89
Time spent in stream area	12.69	6.19	51

The reported efficiencies of the off-stream watering BMP without fencing in reducing flow-weighted pollutant concentrations are reported in Table 5. I am suspicious of the reported loading values because I was unable to derive them from the reported flow-weighted mean concentrations. Assuming that the flow-weighted concentrations are correct, they suggest that for baseflow conditions, off-stream watering reduced total suspended solids, ammonium, Total-P, and sediment bound P by 89.2, 72.1, 64.6, and 42.9%, respectively. The contaminants that are typically predominately adsorbed to sediments appeared to be reduced. More soluble contaminants such as nitrate and orthophosphorus increased. There is an error in the reported Total N values as the reduction in ammonium, which is a sub-component of Total N, is greater than the reported reduction in Total N. This suggests that either the pre- or post-BMP, or both concentrations for total N or ammonium are in error. Because of these errors and suspected errors in the reported loadings discussed previously, I hesitate to use any of the reported reductions to estimate the efficiencies of off-stream watering in reducing pollutant loadings.

Table 5. Reductions in pollutants due to off-stream watering without fencing (Sheffield et al., 1997)

Parameter	Flow-weighted Concentration (mg/L)		% Change
	Pre-BMP	Post-BMP	
Total Suspended Solids	132.35	14.28	-89.2
Total Nitrogen	1.34	1.24	-7.7
Ammonium (NH_4-N)	0.32	0.09	-72.1
Nitrate (NO_3-N)	0.17	0.23	37.1
Sediment Bound N	0.47	0.47	-0.7
Total Phosphorus (TP)	0.20	0.07	-64.6
Orthophosphates (PO_4-P)	0.00	0.01	98.5
Sediment Bound P	0.12	0.07	-42.9
	Loadings (kg/cm rain)		% Change
	Pre-BMP	Post-BMP	
Total Suspended Solids	~~292.84~~#	~~11.06~~	~~-96.2~~
Total Nitrogen	~~3.02~~	~~1.34~~	~~-55.6~~
Ammonium (NH_4-N)	~~0.52~~	~~0.12~~	~~-76.9~~
Nitrate (NO_3-N)	~~0.31~~	~~0.35~~	~~12.9~~
Sediment Bound N	~~1.05~~	~~0.55~~	~~-47.6~~
Total Phosphorus (TP)	~~3.25~~	~~0.08~~	~~-97.5~~
Orthophosphates (PO_4-P)	~~0.04~~	~~0.01~~	~~-75.0~~
Sediment Bound P	~~0.93~~	~~0.07~~	~~-92.5~~

These values could not be derived from the reported flow-weighted concentrations. Suspected error in reported values of either the flow-weighted concentrations or the loadings.

Rosenthal and Urban (1989) Study

Rosenthal and Urban (1989) conducted a study titled "BMP Longevity: A Pilot Study to Assess the Long-term Effectiveness of Various BMPs (terraces/diversions, animal waste storage, vegetative strips, grassed waterways, and conservation tillage)." The study had three components: a survey of SCS and conservation district personnel in 11 states concerning their judgment of the short- and long-term effectiveness of the BMPs; on-site evaluations of 120 BMPs in three states; and anecdotal and empirical information from discussions, observations, and literature. The results of this study did not provide any information on the longevity or maintenance of fencing and off-stream watering systems and consequently was not used in this review.

Literature Review Summary

All of the studies provided had significant experimental limitations but did provide some relevant information that can be used in estimating the effectiveness of off-stream watering systems with and without fencing. None of the studies provided any information on controlled grazing. The results of the studies are summarized in Table 6.

Table 6. Summary of reported BMP efficiencies

BMP and Study	Percentage Reduction												
	NO_3	NO_2	NO_3+ NO_2	NH_4	Dissolved TKN	TKN	Total N	Sediment Bound N	Dissolved P	Total P	Sediment Bound P	TSS	Flow
Off-stream watering with fencing													
Galeone et al. (2006)													
Watershed T-1	18	28		36	20	26			-19	14		37	
Watershed T-2	-15	-15		-10	-30	-43			-94	-51		44	
Off-stream watering without fencing													
Line et al. (2000)			41			-27				-13		38	27
Sheffield et al. (1987)	-37			72			8		-99	65		89	

Galeone et al. (2006) investigated the effects of stream-side fencing, which restricted cattle access to the stream except at a few controlled points for drinking. The results of the study probably best represent the ***off-stream watering with fencing*** BMP. The study had some experimental problems that were discussed previously that make comparisons of the pre- and post-BMP periods problematic. The more reliable results came from the paired watershed comparisons. As shown in Table 2 for the main watershed (T-1 and C-1 comparison), sediment loss was reduced by 37%, dissolved P loss increased by 19%, and other nutrient losses decreased by 14 to 36%. These results seem reasonable except for the increase in dissolved P loss. For the small watershed (T-2 and C-1 comparison), all nutrient losses increased, but there was a 44% reduction in sediment loss. These results do not seem to be reasonable and are attributed to the large differences between the control and T-2 treatment watershed. The combined results suggest that the likely effectiveness of fencing with limited access to streams is highly variable.

Line et al. (2000) evaluated BMPs in two subwatersheds. The study had a good baseflow water quality sampling protocol, but stormflow water quality sampling protocol was less than optimal.

Runoff decreased significantly between the subwatershed with fencing and off-stream watering and other BMPs installed during the pre-BMP period, so it is difficult to attribute the reported pollutant reductions solely to fencing and off-stream watering. Thus the results were judged to be inappropriate for use in this study. The second sub-watershed (Table 3, Site D) had ***off-stream watering with no fencing*** in a low stocking-density pasture. Reported reductions between the pre- and post-BMP periods in discharge, nitrate-nitrite, TKN, Total-P, and TSS were 27, 41, -27, -13, and 38%, respectively. TKN and Total-P losses increased.

The Sheffield et al. (1997) study investigated the effects of ***off-stream watering without fencing*** on water quality and cattle behavior. Some limitations were noted with the results due to the 42% increase in precipitation in the post-BMP period compared to the pre-BMP period and due to suspected errors some of the reported data values. Reported BMP efficiencies were generally higher than in the two longer-term studies; however, nitrate and dissolved P (orthophosphorus) losses were higher (Table 6).

TIME LAGS, LONGEVITY, MAINTENANCE, AND OTHER ISSUES

These issues were not addressed in the research articles provided, so I am simply sharing my best professional judgments. These deserve critical discussion and collective modification. My judgments are based on my mental model of what happens when livestock are removed from streams. In my model, water quality improves because of:

1. Direct Deposition. Manure is no longer directly deposited in the stream,.
2. Stream Substrate Disturbance. Cattle do not stir up stream sediments and/or degrade the stream substrate.
3. Indirect Deposition in Riparian Areas. Manure is no longer deposited in riparian zones where it has a greater chance of being transported to streams during runoff events.
4. Streambank Degradation. Livestock no longer degrade streambanks and riparian vegetation, which makes the streambanks more susceptible to channel erosion and loss of nutrients with the resulting soil loss.
5. Riparian Zone Regeneration. Previously degraded riparian areas may revegetate and start to function as buffers.

Time Lags

The effect of fencing and off-stream watering on manure constituent loads to streams is immediate for:

1. Direct Deposition
2. Stream Substrate Disturbance
3. Indirect Deposition in Riparian Areas
4. Streambank Degradation

The effect of fencing and off-stream watering on manure constituent loads to streams is takes time for:

5. Riparian Zone Regeneration

I would presume that full buffer-function recovery takes 10 years; and that the recovery is 0% the first year and increases by 10% per year until it is fully functioning.

Longevity

Fencing and off-stream watering should be effective indefinitely if maintained. The only concern is flood events that may destroy the fencing. At issue is whether it will be replaced/repaired. Fences should be designed with potential flooding in mind. For example, high tensile fencing might be more appropriate than woven wire in flood-prone areas. I have some concern that off-stream watering over time may lead to pollutant build-up in the watering area and that at some point this build-up may become a potential point source. This could be avoided/reduced with proper design (mobile watering troughs, proper drainage and hardening, etc.) and maintenance.

Practice Maintenance

With fences, one supposes that they will be maintained to contain the livestock. If stream-side fencing is not maintained but off-stream watering is still available, the majority of the benefits occur in terms of reduced livestock in streams/riparian areas. Watering systems must be maintained, or they will fail and force livestock back to the stream if unfenced. They also can become a pollutant source if there are excessive water leakage/overflow, poor drainage, and excessive accumulation of manure. They must be checked and maintained regularly to ensure adequate water flow for livestock, prevent overflows, redistribute accumulated manure to pastures, etc.

Variability and Uncertainty in BMP Effectiveness

This is difficult to evaluate because there has been so little research on these practices, but I would presume that the effectiveness of these BMPs is highly site-specific. Variability and uncertainty in the effectiveness of fencing and off-stream watering systems is very high, as demonstrated in the research studies reviewed. Variability and uncertainty in effectiveness factors could be reduced with modeling studies.

Effects of Extreme Events

This is significant only where off-stream watering is in the flood zone. It is a problem if located in the flood plain. It is a major concern for fencing systems in flood plains, where many are located. Fencing BMPs in flood plains requires some sort of insurance program that will assist landowners in replacing and repairing damaged fences after floods. Without such provisions, landowners who installed fences through a cost-share program are liable if a flood destroys the fences. They must either replace it at their own expense or return all or a portion of the cost-share expenses. This liability makes some landowners reluctant to install stream-side fencing.

Scale Issues

Reviewed research was conducted at the small watershed scale (<600 ha in the largest study). With fairly intensive implementation, reductions were variable across studies. I am not sure how results from these studies can be scaled up. The recommended approach is to scale up with modeling studies as proposed below.

PROPOSED PROCEDURE FOR ESTIMATING NUTRIENT REDUCTION FACTORS

As indicated in the review of the articles and reports provided on the effectiveness of fencing, off-stream watering and related practices, inadequate research has been conducted on these BMPs to estimate their effectiveness with any degree of scientific confidence. However, there are two alternative ways in which their effectiveness could be estimated with a higher degree of confidence. These are described below.

The fencing and off-stream watering BMPs improve water quality by reducing or eliminating livestock access to streams and riparian areas. When livestock are removed from streams, water quality improves because:

1. Manure is no longer directly deposited in the stream.
2. Cattle do not stir up stream sediments and/or degrade the stream substrate.
3. Manure is no longer deposited in riparian zones where it has a greater chance of being transported to streams during run-off events.
4. Livestock no longer degrade streambanks and riparian vegetation, which makes the streambanks more susceptible to channel erosion and loss of nutrients with the resulting soil loss.
5. Previously degraded riparian areas may revegetate and start to function as buffers.

My understanding is that the Bay Watershed Model/HSPF has been modified to simulate buffers, so the developing buffers (5) could be simulated with the new buffer simulation routines.

I am not sure how HSPF can simulate the effects of livestock on items (2) and (4), above, but HSPF can simulate the effects of removing livestock from streams and riparian zones. This is routinely done in bacterial TMDLs in Virginia and elsewhere using HSPF. The approach makes the following which can then be implemented in HSPF:

1. Livestock contributions of manure (bacteria and nutrients) to streams can be simulated in HSPF as point source contributions to the applicable stream reach.
2. The manure production rate and composition (bacteria, nutrients, COD, etc.) of manure is known.
3. The magnitude of the point source contribution of manure constituents is a function of daily manure production for different types of livestock and the fraction of the day (which varies seasonally) that livestock spend in the stream/riparian area. Seasonal data on the estimated time that livestock spend in streams/riparian zones are available from the Center for TMDL and Watershed Studies.
4. Available county livestock census and land use data can be used to estimate livestock populations in pastures adjacent to streams with and without fencing.

5. Software can then be used to apportion the manure loadings between the stream/riparian area and adjacent pastures, animal waste storage systems, etc. An example of such software is the Bacteria Source Load Calculator (http://www.tmdl.bse.vt.edu/outreach/C85/) developed by the Center f or TMDL Studies. This program currently only simulates bacteria in manure, but it could easily be modified to simulate manure nutrients, COD, TSS, etc. The software outputs WDM files that can be used to input point-source bacterial loadings into HSPF and bacterial loadings to pervious land segments (PLSs). Modified software could do the same for nutrients and other manure constituents. All consulting firms and organizations developing bacterial TMDLs use similar software to develop the HSPF data files.
6. In bacteria TMDLs, the effects of fencing and off-stream watering are simulated by varying the amount of time that cattle spend in the stream/riparian zone. Seasonal estimates of the time that various livestock species spend in the stream/riparian zone without fencing and off-stream watering have been estimated.
    a. To simulate fencing with total livestock exclusion, the time that livestock spend in the stream/riparian area is reduced to zero, and all manure and its constituents are apportioned between PLSs adjacent to the stream reach, animal waste storage structures and other areas where livestock spend their time.
    b. To simulate fencing with partial exclusion (livestock drinking at controlled locations where their access is limited) or off-stream watering, the time that the livestock spend in the stream/riparian area is reduced, which shifts a portion of the manure constituents, previously deposited in the stream/riparian area, to other pools.
    c. This is currently implemented in HSPF for bacteria and could be done for nutrients.
7. In the above manner, HSPF can then be used to simulate bacteria/nutrient losses without fencing and off-stream watering, then rerun with cattle spending less time in stream/riparian areas to simulate the effects of off-stream watering with or without fencing.

Method 1: Direct Application in Bay Watershed Model

I do not know exactly how the Bay Watershed Model nutrient loadings to PLS are currently generated. Ideally nutrient loadings from commercial fertilizer, atmospheric deposition and livestock manure are handled separately. If this is the case, then the procedure described above could be used to reapportion manure loadings between PLSs and direct point source loadings to simulate the effects of stream side fencing and off-stream watering. If nutrient loadings to PLSs are lumped by land use or in some other method, it would be a major undertaking to separate out the manure loadings. This might not be practical but it is definitely technically feasible.

Method 2: Reference Watershed Approach

An alternative to incorporating the above approach into the Bay Watershed Model would be to apply it to a representative range of reference watersheds across the Bay watershed and to then use the results of these simulations to estimate reduction efficiencies for nutrients and other manure constituents for different combinations of livestock riparian zone exclusion, watershed conditions, seasons, types of livestock, buffer widths, etc. This could be done fairly quickly, and I recommend this approach. It would be an order of magnitude quicker and less expensive than conducting the field research required to obtain equivalent information. This would provide information on the uncertainties associated with specific reduction efficiencies.

RECOMMENDED BMP EFFICIENCIES BASED ON REVIEWED ARTICLES

I personally do not have a high degree of confidence in the efficiencies reported in the reviewed articles, but using them, I would recommend the following BMP reduction efficiencies. I am not considering the results of the Galeone et al. (2006) T-2 watershed study, for they do not appear to be scientifically logical (removing cattle from streams increases pollutant loadings).

- ***Off-stream watering with fencing:*** Only the efficiencies for the Galeone T-1 watershed are applicable. To be conservative, since the results are from a single study, I recommend reducing the reported reduction values by 50%. The resulting recommended efficiencies, based on a single study, are given in Table 7.
- ***Off-stream watering without fencing:*** Data from two studies are used and are compared with data with fencing. To be conservative I intended to reduce the reported reduction values by 50%. I also required the reductions to be less than those for off-stream watering with fencing because the literature review indicated that off-stream watering reduced but did not eliminate livestock activities in streams (80-90% reduction) and riparian areas (50% reduction). Since the study with fencing had lower efficiencies than the studies without fencing, the recommended reduction efficiencies for off-stream watering with and without fencing are essentially the same.
- ***Off-stream watering with fencing and rotational grazing:*** These are presumed to be the same as off-stream watering with fencing because no information was available on the effects of rotational grazing. Also, there was concern that stocking density increases due to higher forage production with rotational grazing would offset the water quality benefits of increased vegetative cover in pastures.

Table 7. Reported and recommended BMP efficiencies

BMP and Study	Percentage Reduction												
	NO_3	NO_2	NO_3+ NO_2	NH_4	Dissolved TKN	TKN	Total N	Sediment Bound N	Dissolved P	Total P	Sediment Bound P	TSS	Flow
Off-stream watering with fencing													
Galeone et al. (2006)													
Watershed T-1	18	28		36	20	26			-19	14		37	
Watershed T-2	-15	-15		-10	-30	-43			-94	-51		44	
Recommended Efficiency	*9*	*14*		*18*	*10*	*13*			*0*[1]	*7*		*19*	
Off-stream watering without fencing													
Line et al. (2000)			41			-27				-13		38	27
Sheffield et al. (1987)	-37			72			8		-99	65		89	
Recommended Efficiency	*5*[2]		*5*[2]	*18*[2]		*7*[2]	*4*		*0*[1]	*7*[2]		*19*[2]	

[1] 50% safety factor for reductions ignored and best professional judgment used to estimate a reduction of 0%.

[2] Assumed that it was impossible for off-stream watering without fencing to be more effective than with fencing so off-stream without fencing was assumed to be the same as with fencing if the reported efficiency was higher.

STUDIES TO FOLLOW-UP ON UPON COMPLETION:

"Streamside Livestock Exclusion: A tool for increasing farm income and improving water quality" *Authors: R. Zeckoski, B. Benham, C. Lunsford.* Contact: Brian Benham, Virginia Tech

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Sheffield, R.E. 1996. Off-stream water sources for grazing cattle as a stream bank stabilization and water quality BMP. M.S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg.

APPENDIX B: BMP EFFICIENCY REVIEW STATEMENT OF WORK

The University of Maryland will provide the BMP definition and efficiency found in literature for contractor to provide feedback. Specifically, the contractor will discuss the accuracy of the efficiency and comment on any adjustments that should be made to the efficiency. For example, mention that the BMP takes high operation and maintenance to achieve and maintain the proposed efficiency but you cannot provide the resulting adjusted reduction efficiency percent. If an adjustment value is not available contractor is not required to suggest the efficiency change. However, contractor will comment on whether or not the literature value should be adjusted based on the following considerations:

- Identify the loss pathways and estimate the hydrologic lag time associated with the practice.
- The expected spatial variability for a practice should be estimated based on available science and knowledge of the expected geographic extent of implementation of the practice. Different reduction efficiencies should be established for practice implementation across different physiographic, geomorphic or hydrologic settings. Where possible, discuss how surface water and groundwater interactions (permeability), along with geology and soil types (slope, seeps, floodplain, etc.) alter efficiencies.
- Implementation lag times - BMP efficiencies should match the practice implementation schedule. Many practices are reported as implemented once the plan or design has been completed. In reality, the plan may call for phased implementation over as much as five to ten years. In addition, the farmer may not implement the practice as scheduled due to climatic, management or economic constraints. The time it takes for an implemented practice to reach its full potential may also delay pollution reduction percentages. Identify possible lag times in reaching BMP pollution reductions due to phased-in implementation or time to maturity of BMP.
- Define the impact of extreme climatic events on the BMP and discuss the BMPs efficiency function in events above its designed maximum. Where data is available, please discuss how the practice efficiency should be adjusted for events approaching, but within, the design maximum.
- Where applicable explain how different lengths or widths of the BMP will alter efficiencies.
- Discuss how the efficiency of the BMP will change with various watershed management conditions, including operation and maintenance of BMP, construction supervision, and/or upland land use change, among others.
- Discuss how the efficiency will change from the research/demonstration scale to the watershed/basin scale application. This does not have to be a quantified answer, but please identify issue with adjusting the efficiency at various scales. For example if the BMP requires high operation and maintenance to work properly please explain that here.

Finally please provide the efficiency you recommend the Chesapeake Bay Program uses for its Watershed Model and Tributary Strategies.

Appendix C: Univ. of Maryland Literature Review of Galeone et al., 2006

BMP Name: Offstream watering

Definition of BMP provided in article:

Efficiencies provided in article:

Overall water-quality changes in constituent yields for the treated sites (T-1 and T-2) of the Big Spring Run Basin, Lancaster County, Pa., for the post-treatment period based on analysis of covariance (ANCOVA) results and the separation of constituent yields into base-flow and stormflow components. [DKN, dissolved ammonia plus organic nitrogen; TKN, total ammonia plus organic nitrogen]

Constituent	T-1 change	T-2 change
Dissolved nitrate	-18%	+15%
Dissolved nitrite	-28%	+15%
Dissolved ammonia	-36%	+10%
DKN	-20%	+30%
TKN	-26%	+43%
Dissolved phosphorus	+19%	+94%
Total phosphorus	-14%	+51%
Suspended sediment	-37%	-44%

Improvements relative to control or untreated sites in surface-water quality (nutrients and suspended sediment) during the post-treatment period were evident at the outlet (T-1) of the treatment basin; however, a tributary site (T-2) (0.36 mi2 drainage) showed reductions only in suspended sediment.

The average reduction in suspended-sediment yield for the treated sites was about 40 percent.

The results indicated that effects on suspended sediment were fairly consistent in the treatment basin, but this was not true for nutrients.

Two factors were evident at T-2 that helped to overshadow any positive effects of fencing on nutrient yields. One was the increased concentration of dissolved P in shallow ground water. This influx of P through the ground-water system partially helped to increase P yield during the post-treatment period at T-2. This indicates that nutrient management in a basin is critical to reducing P yields, and that streambank fencing with small buffer widths cannot compensate for increased dissolved P moving to the stream system through shallow subsurface zones. Another factor that appeared to affect water quality at T-2 was that the cattle crossings were embedded in the stream, which was necessary for a drinking-water supply for the cattle and was less costly than installation of culverts and raising the crossing above the stream. Cattle excretions at the crossings appeared to increase concentrations of dissolved ammonia plus organic N and dissolved P. This factor would be one reason to install crossings using culverts if at all possible, but an alternative water supply would need to be provided for the animals.

Location of study:
Study area was predominantly agricultural land, about 90%. Agricultural use consisted of primarily row crop (corn and alfalfa), with most remaining agricultural land for pasture and hay fields, with dairy-cattle husbandry as the predominant form of animal agriculture.

The Mill Creek Basin lies within the Susquehanna River Basin. The broad valleys in northern Lancaster County are drained by an elaborate, branched network of meandering streams. A ridge formation occurs within the study area with Big Spring Run and an unnamed tributary to Big Spring Run in the treatment basin bisecting the ridge with little or no deviation in their flow direction.

Geology consists of carbonate and siliciclastic Cambrian rocks covered by thin layer of soil and a mantle of regolith derived from weathered bedrock. The ground-water/surface-water system that has developed is complex. This system is controlled by the bedrock geology but is driven by the timing, duration, and intensity of precipitation events

Soils in the two study basins are generally similar composed of six soil types. Soils along the ridges and adjacent side slopes are predominantly of the Conestoga series (fine-loamy, mesic Typic Hapludalf), followed by Penlaw (fine-silty, mixed, mesic, Aquic Fragiudalf) and Pequea (coarse-loamy, mixed, mesic Typic Eutrochrept) series. Soils of the Hollinger series (fine-loamy, mixed, mesic Typic Hapludalf) were identified only on the side slopes. The most common series identified in the basins was the Lehigh series (fine-loamy, mixed, mesic Aquic Hapludalf), which was along the lower and middle slopes.

Gentle sloping terrain is the most common topography in the basin. The soils adjacent to the stream channel were identified as the Clarksburg series (fine-loamy, mixed, mesic Typic Fragiudalf). Most soils are deep and moderately to well drained. The reported soil depths range from 50 to 75 in. (Custer, 1985). Slopes are low to moderate, primarily between 3 and 8 percent.

BMP Characteristics:
Fence was installed in the treatment basin from May 1997 through July 1997. All pasture areas in the treatment basin along the stream network were fenced. One- or two-strand high-tensile wire was used with an electrical current supplied by solar power. On either side of the stream, the distance between the streambank and the fence was anywhere from 5 to 12 ft. For each pasture fenced, approximately two cattle crossings were installed to allow the animals to access pasture and also to supply the cows with an area for water consumption. After fence installation, a variety of brushy, herbaceous vegetation was naturally established.

Watershed Management details:
Fencing installed included electrical current which was supplied through solar power. This particular type of fencing would probably require expert installation. Maintenance of fencing and cow crossing would require periodic monitoring to ensure fencing and crossing were functioning properly. Establishment of vegetation between fencing and stream was important as it provided stream buffer capacity.

How were the proposed efficiencies monitored?
The paired-basin monitoring design requires the use of two relatively similar basins with one basin used as a control and a second basin in which treatment is applied. Basins selected were similar physical characteristics. Eight surface-water locations were sampled; four were continuous-recording stations (C-1, T-1, T-2, and T-4) and four were intermittent stations (C1-2, T1-3, T2-3, and T-3)

A nested experimental design including paired-basin and upstream/downstream components was used to study the effects of fencing on surface-water quality and benthic-macroinvertebrate communities. Five surface-water sites, one at the outlet of a 1.77-mi2 control basin (C-1), two sites in the treatment basin (T-3 and T-4) that were above any fence installation, and two sites (one at an upstream tributary site (T-2) and one at the outlet (T-1)) that were treated, were sampled intensively.

The ground-water system in the study area was characterized on the basis of water levels, flow directions, age dating, and chemical quality. Wells and piezometers were used to measure water level and ground water flow direction.

Pre-treatment data were collected primarily from October 1993 until July 15, 1997.
Post-treatment data collection was mostly discontinued by the end of June 2001.

Farm operators provided data on the dairy-cow activity in the pastures and the loading of inorganic and organic fertilizers within the study area. Prior to and during early parts of the study, each farmer had developed nutrient-management plans with the Lancaster County Conservation District (LCCD) and Natural Resource Conservation Service (NRCS). One aspect of the plan was to calibrate manure spreaders. The information from these calibrations was used to determine the weight of each “load” of manure applied by each farmer which was converted to pounds of N and P based on published values for concentrations of nutrients in different sources and forms of animal manure. The time that cows were in pasture was used to estimate the amount of waste excreted by the animals. These estimates were then added to manure-application data supplied by the farmers so that a total amount of N and P applied to the landscape could be estimated. The nutrient-application data were used to estimate the loading of N and P to both basins over time.

Water samples for analyses of nutrients and suspended sediment were collected at a fixed-time interval and during storm events. Samples were analyzed for dissolved forms of ammonia, nitrite, ammonia plus organic N (DKN), nitrite plus nitrate, P, and orthophosphate. Analyses also included total forms of ammonia plus organic N (TKN) and P, and suspended sediment. Fixed-time interval (grab) samples were collected every 10 days (regardless of flow conditions) from April through November and on a monthly basis during a low-flow period from December through March. These fixed-time samples were collected at four sites in the treatment basin (T-1, T-2, T-3, and T-4) and one site in the control basin.

Chilled samples were shipped to the USGS National Water Quality Laboratory (NWQL) in Arvada, Colo., for nutrient analysis. Analyses were performed according to techniques described in Fishman and Friedman (1989). Suspended-sediment concentration analyses were conducted by the USGS Sediment Laboratory in Pennsylvania through water year 1995 and thereafter at the USGS Sediment Laboratory in Kentucky. Both sediment laboratories used procedures described by Guy (1969) to determine suspended-sediment concentrations.

Nutrient and suspended-sediment yields for low-flow and stormflow samples were determined for each sample collected so that pre- and post-treatment comparisons could be conducted.

Source of article:
Government agency – USGS

Effects of Streambank Fencing of Pasture Land on Benthic Macroinvertebrates and the Quality of Surface Water and Shallow Ground Water in the Big Spring Run Basin of Mill Creek Watershed, Lancaster County, Pennsylvania, 1993-2001
Daniel G. Galeone, Robin A. Brightbill, Dennis J. Low, and David L. O'Brien
In cooperation with the Pennsylvania Department of Environmental Protection
Scientific Investigations Report 2006–5141
U.S. Department of the Interior
U.S. Geological Survey

Appendix D: Univ. of Maryland Literature Review of Line et al., 2000

BMP Name:
Off stream watering w/ fencing (and riparian vegetation planting)
Off stream watering w/out fencing

Definition of BMP provided in article
Livestock Exclusion Fencing – The fencing keeps livestock away from streambanks, thereby preventing the mechanical breakdown of banks by livestock hooves and facilitating the establishment of a vegetative filter along the streams. For this BMP site riparian vegetation was planted.

Alternate Watering System w/ out fencing – Providing an off-stream watering supply w/out fencing.

Efficiencies provided in article:
Difference between sites D and E (captures alt watering system with fencing):
32.6% nitrate-nitrite
78.5% TKN
75.6% TP
81.7% TSS
Mean weekly loads post-fencing were significant ($P < 0.05$) for all pollutants except nitrate-nitrite.
The nitrite and nitrate load will probably decrease in the future as the trees become established and denitrification and nutrient uptake in the riparian corridor increase. Thus, the BMPs were effective at reducing loads of TKN, TP, and TSS, but were much less effective at reducing the nitrate and nitrite load.

At site D (captures only the alternative watering system):
No reductions in loads are statistically significant at the 0.05 level; results of this study indicate that the effect of this BMP by itself is not significant.

Location of study: soil, climate, hydrology
Piedmont region of North Carolina

56.7 ha watershed, predominantly pasture for dairy cows and replacement heifers. The upper pasture (41.8 ha upstream of Site D) is lightly grazed by 75 to 100 heifers and calves and a lower pasture (14.9 ha between sites D and E) that was heavily grazed by adult cows. The dairy farm has been at this location for at least 100 years. In both pastures animals had unlimited stream access.

Stream is Kiser Branch, originates in the upper pasture and flows about 180 meters before entering the lower pasture. There is degradation along the streambanks and channel bed.

Typical nonstorm daily mean Q at both upstream and downstream monitoring sites was 8 L/s w/ peak instantaneous Q as high as 3100 L/s during some storm events. Average annual rainfall for the general area around the study watershed is 1090 mm. The watershed geology is typical of the western Piedmont region of NC w/ a saprolite layer of varying thickness overlaying fractured igneous and metamorphic rock. The predominant soils were Tatum silt loam and Vance sandy loam, which are generally well drained and moderately to slowly permeable. Both soils have a loamy A horizon and a predominantly clayey Bt horizon that extend to a depth of between 36 to 100 cm. The depth to bedrock for these soils was typically 1.1 to 1.8 m. The watershed area was hilly w/ land slopes of 5 to 15% w/ a few flatter areas on the tops of ridges and along the stream. Average slope of the channel was 1.3%.

Vegetation in the 41.8 ha upper pasture was primarily common bermudagrass. Grass lightly grazed. The 14.9 ha lower pasture was grazed regularly

BMP Characteristics: BMP age, date of construction, size, and species composition.

Design: Following the collection of 81 wk of monitoring data (August 1994 to February 1996) an alternate watering system was installed in both pasture areas. Watering tanks were installed at upland locations at least 50 m away from the stream and were surrounded by a geotextile fabric overlain w/ gravel. Additionally, livestock exclusion fencing was installed in the lower pasture in February 1996. The fence excluded cows from a 10 to 16 meter wide and 335 meter long section of pasture along either side of Kiser Branch between Sites D and E.

Shortly after fence construction, various hard and softwood trees were planted in the riparian corridor and a severely eroding section of streambank was reshaped and seeded.

Fencing to exclude cows from a 6 meter wide riparian corridor containing a major tributary to Kiser Branch also was installed in February 1996. The volunteer vegetation inside the fenceline provided about a 3 meter grassed filter strip alog either side of the 94 meter long intermittent channel.

Species composition: In a zone w/in 3 m of the Branch, button bush, hazel alder, red maple, and bald cypress trees were planted while on the drier upland areas green ash, red and white oak and loblolly pine trees were planted. All trees were planted in rows on a 3 m centers in holes drilled w/ a post hole digger, except for loblolly pine, which were planted by a dibble. Volunteer vegetation has grown in the riparian corridor. Along and in the stream, willows and cattails have proliferated while on the banks a variety of weeds and grasses have become established.

Watershed Management details: Does the BMP require high operation and maintenance, as well as monitoring? How technical is construction, does it require an engineer to install or can a farmer do it?

Maintenance:
One application of herbicide around the trees, to release them from the competition of volunteer vegetation, was the only follow up work performed after planting the trees.

No info on fencing or watering system maintenance or construction was mentioned.

How were the proposed efficiencies monitored? Type of equipment used, how often monitored, what tests were done (ex – if used EPA methods for testing for TN or some other orgs methods)

Continuous Q measurements were made at upstream (Site D) and downstream (Site E) monitoring stations from August 1994 through September 1998 by the USGS. Two recording raingages measured rainfall continuously. Grab samples from the overall of a V-notch weir at Site D and a large culvert at Site E were collected weekly, iced w/in 15 min and transported to a nearby USEPA-certified laboratory. Samples were analyzed for nitrate + nitrite nitrogen, TKN, TP, TSS and TS concentrations using Methods 353.1, 351.2 and 35.4 from the USEPA for nitrate and nitrite, TKN, and TP and 2540D and 2540B from Anonymous for TSS and TS. Split, blank, and spiked samples were prepared and analyzed to verify the quality and representativeness of the samples.

Samples were collected during storm events at Sites D and E using automated samplers activated by the stage recording equipment. Samplers were programmed to collect two samples on the rising limb, one near the peak, and one at a stage approximately halfway between the first grab sample collected on the rising limb and the peak of they hydrograph. Each sample was placed in two bottles, one that was pre-acidified for preservation of nitrogen and phosphorus forms and one that was non-acidified for storage of the solids or sediment. Samples were transported to the lab as soon after the events as possible and analyzed using the same methods as those used for grab samples.

However due to irregular hydrographs from extended-duration storms or storms w/ multiple peak Q's and equipment malfunction, significant portions of storm flows were not sampled.

Source of article (w/ full citation): Please note if it is a NGO or gov't agency.

Line, D.E.; Harman, W.A.; Jennings, G.D.; Thomposn, E.J., and D.L. Osmond. 2000. Nonpoint-Source Pollutant Load Reductions Associated with Livestock Exclusion. *Journal of Environmental Quality*. 29(6):1882-1890.

Appendix E: Univ. of Maryland Literature Review of Sheffield et al., 1997

BMP Name:

OFF-STREAM WATER SOURCES FOR GRAZING CATTLE AS A STREAM BANK STABILIZATION AND WATER QUALITY BMP

Definition of BMP provided in article:

The overall goal of this study was to evaluate the feasibility of using water troughs as a Best Management
Practice (BMP) to reduce the losses of soil, nutrients, and bacteria from pasture lands.

Efficiencies provided in article:

	Flow-weighted Concentration (mg/L)		
	Pre-BMP	**Post-BMP**	**% Change**
TSS	132.35	14.28	-89.21
Total Nitrogen (TN)	1.340	1.237	-7.72
Ammonium (NH4)	0.321	0.090	-72.06
Nitrate (NO3)	0.167	0.229	37.05
Sediment Bound Nitrogen	0.472	0.468	-0.66
Total Phosphorus (TP)	0.203	0.072	-64.56
Orthophosphates (PO4)	0.004	0.007	98.47
Sediment Bound Phosphorus	0.120	0.068	-42.87

	Loading (kg/cm rain)		
	Pre-BMP	**Post-BMP**	**% Change**
TSS	292.84	11.06	-96.22*
Total Nitrogen (TN)	3.02	1.34	-55.63*
Ammonium (NH4)	0.52	0.12	-76.92*
Nitrate (NO3)	0.31	0.35	12.90
Sediment Bound Nitrogen	1.05	0.55	-47.62
Total Phosphorus (TP)	3.25	0.08	-97.54*
Orthophosphates (PO4)	0.04	0.01	-75.00
Sediment Bound Phosphorus	0.93	0.07	-92.47*

* Significant difference between means at a = 0.05 level

Location of study:
This study was conducted on two commercial cow-calf operations in the Ridge and Valley region of southwest Virginia which used rotational stocking. One study pasture (14.2 ha) was located on the River Ridge Farm in Independence, Virginia (fig. 1), and two additional study pastures (16.6 and 22.3 ha) were located on the Bender
Farm in Floyd, Virginia (fig. 2). The River Ridge Farm produces Brahma-Angus calves using high stocking density and stocking rates of 200 cows and 170 calves on eight pastures totaling 136 ha. The Bender Farm produces Angus-Hereford calves at a stocking rate of 150 cows and 60 calves on eight pastures totaling 187 ha. The Bender Farm used first-last grazing during the spring and fall, rotating yearlings onto paddocks for three days before grazing lactating cows and calves.

The three study pastures were chosen for several reasons. First, a spring-fed first-order stream originates in each pasture. Second, spring-developments provide water to a three-trough system on the River Ridge Farm, and a single trough system provides water for cattle on each of the pastures on the Bender Farm. Lastly, tall fescue (*Festuca arundinacea* L.) was the dominant grass on both farms among a mix of orchardgrass (*Dactylis glomerata*), Kentucky bluegrass (*Poa pratensis*), red clover (*Trifolium pratense*) and white clover (*Trifolium repens*). A more detailed description of the study sites is given by Sheffield (1996).

The tall fescue present in the River Ridge and two Bender pastures was found to be highly infected (77%, 72%, and 78%, respectively) by the fungal endophyte (*Acremonium coenophialum* Morgan, James and Gams). The endophyte has long been identified with three syndromes among cattle (Ball et al., 1991). Cattle grazing toxic tall fescue and suffering from the effects of fescue toxicosis or "summer slump" have been observed to have a tendency to wallow in mud (Bowman et al., 1973) or stand in ponds or creeks during hot portions of the day. Fescue toxicosis causes the body temperature of cattle to elevate and subsequently the cattle spend more time within the stream areas. Therefore, it can be expected that the level of impact (erosion, degraded water quality) upon these areas would increase in pastures where high levels of the endophyte are present.

BMP Characteristics:
Off-stream water sources, as suggested by Smith et al. (1992) and Marlow and Pogacnik (1986), is a water quality management practice which has been noted by farmers and conservationists to be quite effective in reducing cattle impact upon stream environments.

pre-BMP period: Aug. 1994 through Apr. 1995: cattle had access to only one stream in the observed pasture as their source of water.

post-BMP period: Apr. 1995 through Oct. 1995: water troughs were installed in the pastures and cattle had continued access to streams. To provide water for the troughs, springs were developed according to design specifications of the Natural Resources Conservation Service (1992). At no time during the study were cattle excluded from the stream by fencing.

Watershed Management details:
The BMP required troughs to be built. The sample farms had springs that were used.

How were the proposed efficiencies monitored?
Prior to the study, various monitoring equipment were installed on the River Ridge Farm, and surveys were conducted in preparation of this project. A weighing raingauge and a standard raingauge were installed. The standard and weighing raingauges were read by the farm operator. Surveys for stream length and slope were conducted prior to the start of the project. Stream flow data were obtained by measuring the time to collect a known volume of water (3.785 L or 18.925 L) at the pond outlet.

The following water quality parameters were measured from semi-monthly water quality samples: total suspended solids (**TSS**), nitrate-nitrogen (**NO3-N**), ammonium (**NH4-N**), total nitrogen (**TN**), sediment-bound nitrogen (**SBN**), ortho-phosphorus (**PO4**), total phosphorus (**TP**), sedimentbound phosphorus (**SBP**), fecal coliform (**FC**), fecal streptococci (**FS**), and total coliform (**TC**).

Due to the skewness of the data, the nonparametric Wilcoxon sign-rank sum test was used to evaluate each parameter.

Source of article (w/ full citation): Please note if it is a NGO or gov't agency.
Authors: R. E. Sheffield, S. Mostaghimi, D. H. Vaughan, E. R. Collins Jr., V. G. Allen
Title: OFF-STREAM WATER SOURCES FOR GRAZING CATTLE AS A STREAM BANK STABILIZATION AND WATER QUALITY BMP
Journal: TRANSACTIONS OF THE ASAE, VOL. 40(3):595-604

Appendix F. Meeting Minutes

Agricultural Nutrient and Sediment Reduction Workgroup

Maryland Department of Agriculture
Annapolis, Maryland
May 10, 2007

Off-Stream Watering BMPs

- Off-stream watering BMPs include: 1) off-stream watering with fencing, 2) off-stream watering without fencing, and 3) off-stream watering with fencing and rotational grazing.
- The proposed efficiencies for the off-stream watering BMPs are much lower than the current efficiencies.
- For the off-stream watering with fencing BMP, the efficiencies recommended in the handouts are: 12% TN reduction, 10% TP reduction, and 20% TSS reduction. Concern was voiced by workgroup members that these efficiencies are too low. Tom Simpson indicated that they made an error in how they treated the data and agreed that they were too low. He proposed changing these efficiencies to 24% TN, 40% TP, and 40% TSS. Tom says he believes that the data can support this change, but increasing the efficiencies even more would require additional data for support. If workgroup members know of data that would support higher efficiencies for this practice, they can send it to Tom and Sarah.
- Workgroup recommendations:
    - One criticism was that the definitions for these practices do not reflect what farmers are actually doing.
    - It was suggested that rotational grazing be taken out of this practice since we do not have the data. Tom Simpson said that they will try to segregate this out and that they will suggest that it be a separate practice.
- It was recommended that workgroup members look at the STAC white paper entitled *Innovation in Agricultural Conservation for the Chesapeake Bay: Evaluating Progress and Addressing Future Challenges*. This paper can be accessed at: http://www.chesapeake.org/stac/Pubs/STACAgWhitepaper.pdf.

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Agricultural Nutrient and Sediment Reduction Workgroup
Conference Call
May 24, 2007
10:00 AM - 12:00 PM

Off-Stream Watering with Fencing:
Jeff Sweeney commended UMD for developing such thorough documentation for this BMP.

ACTION: Mark Dubin will work with NRCS to insert codes and continue to work with NRCS in refining this BMP.

DECISION: UMD decided that they would separate out rotation grazing and deal with this BMP in Year 2 of their project.

ACTION: The workgroup asked UMD to address the nutrient balance in defining rotation grazing with respect to manure storage, feed imports, etc. The workgroup agreed to provide guidance to UMD on how to address year 2 BMPs and what factors to consider at the July workgroup meeting. NY needs to be consulted about this.

ACTION: MDA requested more time to evaluate the science behind this recommendation.

DECISION: The workgroup recommended pulling out critical area planning from this BMP since it constitutes the buffer component of fencing and is covered under the buffer BMP.

DECISION: UMD will clarify how buffers relate to this BMP and how fence set backs are addressed.

Offstream watering without fencing:
The assumption with this BMP is that shade will be provided near the watering source so that cows don't seek shade in streams. Having an offstream watering site won't prevent cows from going into streams to get away from the heat or flies. Have we factored in that level of uncertainty into the efficiency? MDA says that their BMP focuses just on watering source, not on a shade requirement.

ACTION: Sarah Weammert, UMD, will determine whether or not the studies they used for developing the efficiency factored in shade.

Workgroup ideas for how to address this issue:

- Option 1: Propose name change to "offstream watering without fencing but with shade". However, this may be impossible to define and track.
- Option 2: Adjust the efficiency to be lower to account for situations where cows may seek refuge in streams to cool down, to get away from flies, etc.
- Option 3: Carry out option 2 AFTER we line up all ag BMPs to see if their efficiencies make sense compared to one another. At that time, it may be clear whether or not we need to reduce the efficiency.
- Other options?

Participants:
Herb Reed, UMD
Beth Horsey, MDA
Kelly Shenk, EPA CBPO
Jeff Sweeney, UMD/CBPO
Kari Cohen, NRCS
Sarah Weammert, UMD
Peter Tarby, PA DEP
Tom Juengst, PA DEP
Becky Thur, CRC
Mark Dubin, UMD MAWP/CBPO - could not get on call due to technical difficulties with conference line.

Minutes: Tributary Strategy Workgroup Meeting
June 4, 2007
10:00 AM to 3:00 PM
NRCS MD State Office, Annapolis

Off-Stream Watering Practices
Off-Stream Watering Practices

- The expert reviewer recommended a 50% reduction from the literature numbers because of the limitation of literature and the fact that it wasn't spatially representative.
- The MARWP did not agree with the suggested 50% reduction and suggested efficiencies between the current efficiencies and the expert-suggested efficiencies. The AgNSRWG agreed that the expert-recommended efficiencies were too low but wanted more time to review the MARWP's recommendations.
- The TSWG suggested that shade play a part in the efficiency of off-stream watering without fencing because if there is shade, this practice could be 75 to 90% more effective because the animal won't have as a great an urge to go down to the water to cool off.

- For off-stream watering with fencing, the workgroup discussed how riparian buffers should fit into this practice. The reviewer suggested a new BMP called 'off-stream watering with fencing with a minimum width,' but the MARWP did not support that proposal. The AgNSRWG called for fencing and buffers to be reported separately.
  - If NEIEN is successful, off-stream watering with fencing and buffers should be able to be reported separately.
- ACTION: The reviewer's comments were not yet incorporated into the recommendation document, so Sarah Weammert will incorporate the reviewer, Mary Leigh Wolfe's, comments into the off-stream watering practices document.
- Consistency across states' BMP definitions is greatly needed.
- DECISION: The AgNSRWG is further reviewing the MARWP's proposed efficiencies for off-stream watering with and without fencing. The TSWG will wait for the AgNSRWG's comments before making a decision.
- DECISION: The MARWP and the TSWG agreed to separate rotational grazing from off-stream watering practices because it operates a separate practice and may have a separate efficiency. Rotational grazing and off-stream watering practices will be reported separately. Rotational grazing will be reviewed in the 2nd year of the BMP Project within a suite of pasture management BMPs.
- ACTION: Sarah Weammert will incorporate Mary Leigh Wolfe's comments into the off-stream watering practices recommendation document.
- Consistency across states' BMP definitions of off-stream watering practices is greatly needed.
- ACTION: States will tell Jeff Sweeney how to treat all pasture BMPs in the model within the next month. If buffers are implemented along with off-stream watering practices, they need to reported. If states can determine how much of their pasture land use is degraded, that should also be reported.
- DECISION: The AgNSRWG is further reviewing the MARWP's proposed efficiencies for off-stream watering with and without fencing. The TSWG will wait for the AgNSRWG's comments before making a decision.
- DECISION: The MARWP and the TSWG agreed to separate rotational grazing from off-stream watering practices. Rotational grazing and off-stream watering practices will be reported separately. Rotational grazing will be reviewed in the 2nd year of the BMP Project within a suite of pasture management BMPs.

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Minutes: Nutrient Subcommittee Meeting
June 6, 2007
10:00 AM to 3:00 PM
Fish Shack—Chesapeake Bay Program Office

Off-Stream Watering Practices

- The current numbers for the off-stream watering with fencing BMP are not supported by much data according to Tom, who helped to develop them.
- The existing literature is limited, and the developer believed to be overly optimistic, so the developer's suggested numbers are half of what the literature suggested. Roughly, MAWP doubled and adjusted the developer's recommendations.
- The issue of whether or not buffers were included in Off-stream Watering with Fencing was discussed. It was believed that if requiring a sufficient setback in state cost-share programs, then it would constitute a buffer and we need to work on a buffer against pastureland. Buffers and Off-stream Watering remain 2 separate practices. Jeff Sweeney needs to know if buffers are implemented in addition to the Off-stream Watering with Fencing.
- The Off-stream Watering suite of BMPs may include a new land use called "degraded stream corridor" which would have a nutrient load equal to 9.5 times the load from the average pastureland. This figure is based on calculations done by Russ Mader.
  - The AgNSRWG and TSWG are still reviewing this issue.
- The issue of shade in the Off-stream Watering without Fencing BMP was raised. It was suggested that providing shade is required to make this BMP work.
- The numbers for TP and TSS percent reduction of 30 for Off-stream Watering without Fencing and 40 for Off-stream Watering with Fencing appeared to be too close to Russ Perkinson.
  - ACTION: Tom will review the TP and TSS numbers for Off-stream Watering with and without fencing and will discuss the issue further with Russ. The issue will go back to the AgNSRWG if necessary.
- NRCS grazing specialists wish to weigh in to this discussion as well.
- For Off-stream Watering with Rotational Grazing, MAWP recommends that further review be delayed until Year Two. This practice is under consideration to be separated into its own BMP.

Participants

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Minutes: Tributary Strategy Workgroup Meeting
July 9, 2007
10:00 AM – 1:30 PM
NRCS MD State Office

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- Pasture Management has been discussed in terms of whether or not Off-Stream Watering Without Fencing should include shade. NRCS does not recognize this as a separate practice, and some believe that it could be detrimental because of a lack of management.

- Rotational Grazing has been moved to year 2 of the BMP Project. In year 2, the MARWP will look into how to deal with differences between rotational and intensive grazing and the conjunction of rotational grazing with streams which is likely to be separated.

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Meeting Minutes
Agricultural Nutrient and Sediment Reduction Workgroup
Adams County Agricultural and Natural Resource Center
Gettysburg, Pennsylvania
July 12th, 2007

- Russ Perkinson raised concerns that dissolved reactive phosphorus (DRP) were not factored into efficiencies. Tom replied that that no known literature on DRP and its impact on BMPs existed, and could not find expert opinion to quantify differences between DRP and soluble P. Tom did feel that DRP was a bigger issue on cropland than stream protection.
- Russ Perkinson indicated that he struggled with the pasture exclusion figures (with and w/o fencing) and could not endorse the numbers as presented for the state of VA. The biggest point of contention for him was the limited efficiency increase between the practice with fencing versus without. A greater benefit should be expressed with the addition of stream bank fencing.

- Mark Dubin explained that the efficiencies associated with fence and w/o are only looking at reductions from exclusion, and do not factor in buffers. The exclusion of livestock from the stream would only account for a portion of the nutrient/sediment reductions gained. Additional reductions would be associated with the land use change of the area in the exclusion, as well as the reductions from functional riparian buffers of 35 feet or greater under the riparian buffer practice.
- Russ pointed out that in order to qualify for a cost share in VA, a fence BMP is always done in conjunction with a buffer, which would account for greater than a 10% difference compared to the w/o fencing BMP. He sees a 50%:25% split as being a much more accurate portrayal of these efficiencies.
- Workgroup members felt that the livestock shading provision in the Off-Stream Watering w/o Fencing practice should not be required since it was not consistent with NRCS standards and has not been a cost shared practice under state conservation implementation programs.

Participants

Greg Albretcht	NYS SWCC CNMP
Bill Angstadt	DMAA
Renato Cuizon	MDA
Mark Dubin	UMD-MARWP
Suzie Friedman	Environmental Defense
Beth Horsey	MDA
Peter Homyak	USC
Tom Juengst	PA DEP
Russ Perkinson	VA DCR
Tim Pilkowski	NRCS
Bill Rohrer	DNMC
Kevin Schabow	CRC-CBPO
Jennifer Shaafsma	MDA
Kelly Shenk	EPA-CBPO
Becky Thur	CRC

Calling In

Tom Simpson	UMD

Agricultural Nutrient and Sediment Reduction Workgroup
Conference Call
August 2, 2007

- Issue 1: For the off-stream watering with/without fencing BMP, the workgroup recommended that the livestock shading requirement be removed from the stream protection without fencing definition.

- DECISION: UMD accepted the workgroup's recommendation. Shade should not be a requirement for this practice, although they suggested saying in the definition that shading should be encouraged where applicable.

- Issue 2: For the off-stream watering with/without fencing BMP, the workgroup recommended that the efficiencies for the without-fencing category be reduced to increase the difference between this category and the with-fencing category. A higher efficiency is primarily proposed for this category because some states require at least a 35-foot setback for the fencing.
  - VA requires a 35-foot setback.
  - A 35-foot setback is not in MD's requirements. It is site specific.
  - A 35-foot setback is standard now in PA, but in the past it was 12 or 15 feet.
  - UMD stated that off-stream fencing has been used to refer to the act of simply fencing cattle out of the stream and it isn't tied to width.
  - DECISION: UMD will not change their recommended efficiencies for the off-stream watering practices. However, in order to address the workgroup's concerns, they agreed to recognize that when a wide area is fenced off (such as with a 35-foot setback), it should qualify as two practices: stream protection and a buffer for pasture. The workgroup accepts this suggestion, unless Russ Perkinson (who brought up this issue at the last meeting and is not in attendance today) has any objections. If he does, then this issue will be brought back to the workgroup at a later date.

- Issue 3: The workgroup recommended that phosphorus efficiencies be set 5% lower than sediment efficiencies as a general rule to account for dissolved phosphorus losses not associated with soil losses, unless the scientific research indicates differently.
  - UMD supports the recommendation that TP efficiencies be set lower than TSS efficiencies; however they suggest that the TP efficiencies be lowered by 10% rather than by 5%. They favor 10% because it implies that there is a significant difference and because it does not indicate a greater level of precision than we have. However, they will defer to the workgroup regarding what percentage is used.
  - Some members voiced concern that subtracting 10% from TP will affect some BMPs more than others. For example, if the original efficiency is 40% and it is lowered to 30% than it is only reduced by 25%, whereas if the original efficiency is 20% and it is lowered to 10% than it will be reduced by 50%.
  - DECISION: In order to make the reductions more proportional, UMD and the workgroup agreed to reduce TP by 25%, rather than simply subtracting 10%. This was based on research findings which suggest that 25% of TP are attributable to Dissolved Reactive Phosphorus (DRP) according to the UMD.

The workgroup decided to accept the UMD recommendations with the agreed upon adjustments for the agricultural practices. The only exception was for the cover crop practices which will require additional revisions prior to final review by the workgroup.

Participants

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Minutes: Tributary Strategy Workgroup
August 6, 2007
Chesapeake Bay Program Office—Fish Shack

Off-Stream Watering With Fencing Practices:

- The AgNSRWG is comfortable with MARWP's proposed recommendations, with a couple of caveats.
    - The AgNSRWG recommended TP reductions reflect a 75% value of the TSS reductions due to dissolved reactive phosphorus losses.
    - There would be an accumulative effect of N, P, and S reductions for riparian buffers of 35 feet or greater.
- DECISION: The TSWG agreed with the Off-Stream Watering with Fencing Practices recommendations.

Off-Stream Watering without Fencing Practices:

The AgNSRWG recommended TP reductions reflect a 75% value of the TSS reductions due to dissolved reactive phosphorus losses.

- NRCS does not have a national standard for livestock shading which causes concern with AgNSRWG members. The workgroup decided to address shading by leaving the language in the definition and noting that it is an optional aspect that is encouraged and may be more formally addressed in the future.
- The AgNSRWG believed the practice would be more effective with shading.
    - Peter Freehafer asked if additional credit could be given if shading is addressed.
    - The AgNSRWG believed the language worked with current circumstances and would support a more formal crediting process in the future.
    - Kelly Shenk mentioned that more research would be needed to more formally address the impacts of shading.
- The AgNSRWG wishes to delay Rotational Grazing to Year 2 of the BMP project.
    - There are many opportunities and management methods available that could call for changes in efficiencies.

- DECISION: The TSWG agreed with the Off-Stream Watering Without Fencing recommendations.

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AgNSRWG, TSWG, and NSC Conference Call
August 24, 2007

- Jeff Sweeney, UMD-CBPO, gave a presentation on the effectiveness of pasture fencing in the Phase 5 watershed model. His presentation can be accessed at: http://www.chesapeakebay.net/pubs/calendar/ANRWG_08-24-07_Presentation_1_9035.pdf.
- At the last NSC meeting, the states requested that Jeff explain how we credit this BMP in the watershed model.
- For the Phase 5 watershed model, Jeff is proposing that the method used for crediting pasture fencing be changed. Currently in the Bay model, they credit the pasture protected area with an efficiency. For Phase 5, however, they are proposing a land use conversion that would convert land in the high-loading corridor to the "hay without nutrients" land use. In Phase 5, pasture would be divided into pasture corridor and non-corridor pasture.
- The amount of pasture protected area (phase 4.3) and the amount of total pasture land designated as a pasture corridor (phase 5.0) are based on state Tributary Strategies. Pasture corridor designated land assumes a 35-foot width between the stream and the fence.

- The PowerPoint presentation includes graphs that compare the projected nitrogen, phosphorus, and sediment loads in the Phase 5 model for four different options: (1) current efficiency/ current method, (2) current efficiency/ proposed method, (3) proposed efficiency/ current method, and (4) proposed efficiency/ proposed method. The proposed efficiency refers to the efficiency recommended by MAWP and the proposed method refers to the land use conversion discussed above.
- An issue that needs to be discussed further by the workgroups in the future is what will happen to this corridor land over time. Will it become grass? Will it grow into forest?
- DECISION: The AgNSRWG agreed that we should move forward with the proposed method (making a land use change) and that we should accept MAWP's proposed efficiencies. The TSWG and the NSC approved of this decision.

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Chesapeake Bay Program

Water Quality Steering Committee
Conference Call
August 27, 2007

SUMMARY OF DECISIONS, ACTIONS AND ISSUES

Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

- Bill Brannon (WV DEP) questioned the Off-Stream Watering BMP efficiencies, noting the significant decrease in efficiency between the current and recommended numbers. He noted that his WV representation on the Nutrient Subcommittee raised this as an issue and he just wanted to make sure that the NSC addressed this issue in its final recommendation.
    - Mark Dubin (UMD/CBPO) informed the group that this issue was discussed on Friday's (August 24) Nutrient Subcommittee conference call with the Agricultural Nutrient and Sediment Reduction Workgroup (AgNSRWG) and the Tributary Strategy Workgroup. Jeff Sweeney (UMD/CBPO) had been looking into the work done previously by Russ Mader on pasture loads through riparian forest buffers. Jeff and Mark made some assumptions based on this work and discussed them with the AgNSRWG. The workgroup believed their work was a good first step in the process and that the assumptions will continue to be studied to ensure they are correct. The workgroup recommended moving forward with the recommended efficiencies for use in Phase 5 of the Watershed Model based on the agreement on August 24 conference call that what we have so far is a good first step. The workgroup recommended the partners continue to work on looking at how to model the loads the recommended efficiencies will be applied to.

ACTION: Water Quality Steering Committee members with further questions about the off-stream watering BMP efficiencies should contact Mark Dubin.

DECISION: The Water Quality Steering Committee approved the 12 BMP definitions and efficiencies, described in the advance briefing papers, as recommended by the Nutrient Subcommittee and its workgroups for use in Phase 5 Chesapeake Bay Watershed Model.

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Riparian Forest Buffer Practice (Agriculture) and
Riparian Grass Buffer Practice

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in the Phase 5.0 of the Chesapeake Bay Program Watershed Model

Synthesis by

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Project Manager

And

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Summary

Riparian Forest Buffers: an area of trees at least 35 feet wide on one side of a stream, usually accompanied by trees, shrubs and other vegetation, that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals.

Riparian Forest Buffers - Nutrient and Sediment Reduction Efficiencies			
	TN	TP	TSS
Inner Coastal Plain	65	42	56
Outer Coastal Plain Well Drained	31	45	60
Outer Coastal Plain Poorly Drained	56	39	52
Tidal Influenced	19	45	60
Piedmont Scnist/Gneiss	46	36	48
Piedmont Sandstone	56	42	56
Valley and Ridge - marble/limestone	34	30	40
Valley and Ridge - Sandstone/Shale	46	39	52
Appalachian Plateau	54	42	56

Riparian Grass Buffers: an area of grasses that is at least 35 feet wide on one side of a stream that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals.

Riparian Grass Buffers - Nutrient and Sediment Reduction Efficiencies			
	TN	TP	TSS
Inner Coastal Plain	46	42	56
Outer Coastal Plain Well Drained	21	45	60
Outer Coastal Plain Poorly Drained	39	39	52
Tidal Influenced	13	45	60
Piedmont Scnist/Gneiss	32	36	48
Piedmont Sandstone	39	42	56
Valley and Ridge - marble/limestone	24	30	40
Valley and Ridge - Sandstone/Shale	32	39	52
Appalachian Plateau	38	42	56

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University Of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

Attached to this report is a full accounting of the Chesapeake Bay Program's discussions on this practice and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed (Appendix A).

Definition

Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Components included in the Riparian Forest Buffer Practices include, but may not be limited to the following USDA-NRCS conservation practices:

- Channel Bank Vegetation (322)
- Tree/Shrub Establishment (612)
- Tree/Shrub Site Preparation (490)
- Riparian Forest Buffer (391)

Riparian forest buffers are defined as an area of trees, usually accompanied by shrubs and other vegetation, that is adjacent to a body of water which is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals, to supply food, cover, and thermal protection to fish and other wildlife (Todd, 2002). The recommended buffer width for riparian forest buffers (agriculture) is 100 feet, with a 35 feet minimum width required for credit in the model (MD Department of Natural Resources, 2003).

UMD/MAWP was tasked with refining our understanding of the water quality benefits associated with buffers, and as such is the focus of this report. Air quality, wildlife habitat and aesthetic values are extremely important benefits of buffers, but are not discussed in this report.

Data
Current efficiencies are based on a large number of studies and the Forestry Workgroup (FWG) has added literature to this list and shared it with UMD/MAWP. This collection of literature was used in efficiency development, and UMD/MAWP also considered literature from Beltsville, MD, North Carolina, along with several small watershed studies referenced in a book chapter on adaptive management. Using all of the sources, the following efficiency estimations are recommended for riparian buffers.

There was considerable variability in the literature on buffer effectiveness. Some recent work looking at small watersheds, as opposed to transects that have been traditional utilized to estimate effectiveness, have not shown the levels of reduction that we currently assume. For optimal effectiveness the location of buffer zones must be considered. In addition site conditions, such as slope, soil permeability, buffer age and width, depth to water table, specie composition and biomass, and amounts of upland nutrient inputs will also influence a buffers ability to reduce pollution.

A literature evaluation conducted by the FWG contains a number of studies with a range of expected nutrient and sediment reduction of 32 to 95% for TN and 20 to 96% for TP (Appendix B). The concern with these high efficiencies is that they are based on field scale studies with controlled implementation and oversight, as discussed in the UMD/MAWP process paper. The FWG agrees that an appropriate efficiency discount to accommodate these concerns is warranted. Studies with lower efficiency estimates are not as frequent as studies with higher efficiencies, but are emerging and should be incorporated into efficiency estimation. These studies are discussed below.

Deanna Osmond from North Carolina State University provided information on buffer efficiency studies conducted in North Carolina (Osmond et al 2007). The buffer experiment at the Center for Environmental Farming Systems (CEFS) in Goldsboro, NC was planned with replicated treatments (different buffer types and widths) and controls. The experiment was planted in 1996 and it has been monitored for almost ten years.

Riparian forest buffer nitrogen reductions in North Carolina were originally estimated at 75-85%. However, based on the long-term research they were changed to 20-60%, varying by width, in 2006. The data support a 30% net reduction due to the hydrology and soil conditions. Vegetation type did not have as much of an impact as hydrology and soil. The data does not support efficiencies higher than 30%; the wide range in final efficiencies, and higher efficiency for 100ft buffers, was a policy decision to promote wider buffers for their additional habitat benefits.

UMD/MAWP also reviewed data from Beltsville Agricultural Research Center (BARC) that investigated buffer effectiveness with regard to variability in hydrology and contaminant export (Angier et al 2005). This site contains an upwelling zone/secondary channel system that supplied nearly half (2.4 mg-N/s) of the total N flux (5.2 mg-N/s) on one sampling date. One particular upwelling site contributed 10-15% of the total stream flow and 30-40% of the total stream nitrate load, yet comprised only 0.06% of the total riparian land area. While the OPE-3 site may not be representative of the dominant flow patterns in the Chesapeake Bay watershed, sites with upwelling and non-uniform flow are common and are a recognized problem on the landscape, and thus need to be considered in effectiveness estimations. UMD/MAWP believes the OPE-3 study and the NC work suggest non-uniform flow is important, but the frequency of this trend is not certain.

Other data sources considered in effectiveness estimates were small watershed studies. Recent watershed studies show that even when riparian buffers were assumed to reduce nutrient concentrations as effectively as in published studies, most watersheds showed buffer patterns that would not lead to a substantial reduction in nutrient discharges (Gregory et al 2007). Spatial and temporal variations in buffer effectiveness suggest that the water quality benefits of any buffer restoration are likely to be conditional rather than universal (Jordan et al, 1993; Hill, 1996; Correll et al, 1997; Vidon and Hill, 2004; Hefting et al., 2004).

In a book chapter on adaptive management by Dr. Mary Watzin she mentions seven studies that address riparian buffer pollutant removal efficiencies (Schnepf and Cox 2007). One study from Pennsylvania showed no reduction in nitrate movement across the buffer for the initial 10-year period (Szpir et al, 2005). This study and another (Udawatta et al., 2002) shows that plants need to become established before full effectiveness is evident. With established buffers nutrient removal often decreases with time (Sheppard et al., 2006). Watzin also lists three studies that suggest filter strips and buffers can become saturated with phosphorous and no longer effectively remove nutrients over time (Dillaha et al., 1989; Reed and Carpenter, 2002; Watzin et al., 2003). Polyakov et al. (2005) suggest spatial variation in local conditions explain why some buffer sites show high nutrient removal efficiencies and others low nutrient removal efficiencies. These studies illustrate that time to maturity, saturation, and site specific conditions influence pollutant removal efficiencies and need to be considered in efficiency estimations

By solely focusing on the BARC, North Carolina, and small watershed studies efficiency estimates would be extremely low to negative. Incorporating literature provided by the FWG, along with the BARC, NC and small watershed studies, is more representative of the entire watershed, so all were considered in effectiveness estimation. Efficiency estimates should incorporate spatial variation in local conditions, including but not limited to, non-uniform upflow for nitrogen, and dissolved reactive phosphorous (DRP) contributions to the load exiting riparian buffers.

Riparian Forest Buffer Effectiveness Estimates

Based on discussions with researchers and literature reviews, a 20% reduction in the effectiveness values is applied to efficiencies from literature sources to account for spatial, temporal and management variability with widespread implementation and is supported by the recent results from small watershed studies that recommend lower effectiveness. This adjustment also accounts for landscapes where non-uniform flow is present. It should be noted that this is also consistent with the adjustments applied to other practices to account for spatial, temporal and management variability with widespread implementation.

Total Nitrogen

Based on the North Carolina, BARC studies and the past approved studies used for the current efficiencies, effectiveness estimates are based on geomorphic region, because groundwater flow through buffer systems will have a strong influence on effectiveness and hydrogeomorphic regions help identify different groundwater flow patterns. A baseline of 65%, reduced from the 85% median value in the literature, is assigned to nitrogen and is proportionally distributed among hydrogeomorphic regions.

Total Phosphorous

The North Carolina study viewed phosphorous as a source, not a sink, however, applying a zero percent efficiency to phosphorous, is not reflective of all sites in the watershed, or wide-spread implementation. A baseline of 45%, reduced from the 65% median value in the literature, is assigned to phosphorous and again proportionally distributing the range over hydrogeomorphic regions.

Total Suspended Solids

It was decided by project experts and the Nutrient Subcommittee that for all BMPs where specific phosphorous data is not available or very limited, TP reductions are calculated as 75% of the sediment reductions. Dissolved reactive phosphorous is assumed to be averaged around 25% of the total phosphorous load (Sharpley et al., 1993). Dissolved reactive phosphorous will not be reduced by practices whose reduction mechanisms is primarily sediment reduction. While the general assumption of 25% non-sediment bound phosphorous is an improvement over current approaches, it is important that the CBP continue to work with scientists to better understand and model the relative amounts and impacts of sediment versus dissolved reactive phosphorous.

Hydrogeomorphic Breakouts

When calculating efficiencies for each hydrogeomorphic region all numbers were rounded to the nearest whole number. This was done to avoid implying that the scientific community has an understanding of buffer effectiveness that our current knowledge base does not support.

Riparian Forest Buffers - Nutrient and Sediment Reduction Efficiencies			
	TN	TP	TSS
Inner Coastal Plain	65	42	56
Outer Coastal Plain Well Drained	31	45	60
Outer Coastal Plain Poorly Drained	56	39	52
Tidal Influenced	19	45	60
Piedmont Scnist/Gneiss	46	36	48
Piedmont Sandstone	56	42	56
Valley and Ridge - marble/limestone	34	30	40
Valley and Ridge - Sandstone/Shale	46	39	52
Appalachian Plateau	54	42	56

Grass buffer efficiencies

Grass buffers have been assumed to be 70% as efficient at reducing total nitrogen (TN) than forest buffers. The efficiency derived for TP is assumed to be 75% of the TSS efficiency. Although emerging literature is raising questions about this, we will continue to use that relationship but suggest that it be re-evaluated as new data becomes available.

Riparian Grass Buffers - Nutrient and Sediment Reduction Efficiencies			
	TN	TP	TSS
Inner Coastal Plain	46	42	56
Outer Coastal Plain Well Drained	21	45	60
Outer Coastal Plain Poorly Drained	39	39	52
Tidal Influenced	13	45	60
Piedmont Scnist/Gneiss	32	36	48
Piedmont Sandstone	39	42	56
Valley and Ridge - marble/limestone	24	30	40
Valley and Ridge - Sandstone/Shale	32	39	52
Appalachian Plateau	38	42	56

How Modeled

Note: we do not recommend any change to how buffers are applied in the model.

The nutrient reduction with this practice occurs both from the land use conversion of planting an acre (presumed to be cropland) with a forest buffer and the ability of the buffer to treat upgradient surface and subsurface flow from an assumed area of 4 acres for each acre of buffer.

the efficiencies represent the level of treatment of the upgradient flow. The bay program has divided the basin into different hydrogeomorphic regions to reflect different proportions of surface versus ground water flow and different groundwater flow paths based on the work of lowrance, et al from about 1995.

A ratio of 2 to 1 is used for P as this pollutant will be far more dependent on sediment delivery and storm flow. Hence, using a 4 to 1 treated area to buffer area ratio for N, each buffer mile (12 acres) represents 48 acres (one side) of land on which the proposed level of N removal effectiveness will be applied. P removal efficiencies would be applied on only 24 acres. Treated acreage is approximated as a percentage of all the non-urban land uses in the corresponding watershed. In other words in a watershed where the remaining 100 acres is 60% forested and 40% agriculture, for each acre of buffer established, the appropriate load reduction % would be applied to the total load of N from 2.4 forest acres and 1.6 agriculture acres. For P removal, the load from 1.2 acres of forest and .8 acres of agriculture would receive the benefit.

Future Research Needs

Preferential flow and groundwater flow greatly influencing riparian forest and grass buffer nutrient reduction efficiency; however, it is an issue that has many variables. The incidence and frequency of preferential subsurface flow is not known and likely differs for the various hydrogeomorphic provinces. Because preferential subsurface flow cited is only active through a relatively short season of high precipitation/ high water table, but groundwater flow persists throughout the year, the influence of preferential flow on overall nutrient reduction values remains uncertain. Facts that further confound the issue of sources and reductions of N and P in other than surface flow are captured in scientific literature:

- Concentrations of nitrate in ground water are affected more strongly by soil, land use and topography than by the presence of forest buffers. Riparian plantings perched atop of terraced stream banks lack the interface contact between the roots and water for nutrient uptake (Speiran 2003).
- Concentrations of phosphate in streams vary with bedrock material. Igneous bedrock has a much higher phosphate concentration than glacial till parent materials (Binkley et al. 2004).
- Nitrate concentration reductions fluctuate between the dormant and the growing season making wetlands and transition zones between uplands sinks for groundwater nitrate (Simmons et al 1992).
- In some instances, tiled and ditched fields facilitate the bypass of buffers by pollutant rich agricultural runoff (Puckett 2004).

The facts given are current knowledge, but do not carry us to a clear conclusion about the discount rate that should be considered for concentrated flow. Future studies on buffer effectiveness should investigate how sheet flow versus concentrated flow alters pollution removal. Studies should also begin to address the number of areas in the watershed that have upland, concentrated and sheet flow conditions and determine their influence on performance. Emerging studies with non-uniform flow show lower efficiencies than estimated efficiencies, but how pervasive are non-uniform flow areas? The Bay community needs to determine the pervasiveness of these areas in the watershed to determine the applicability of the emerging literature to the Chesapeake Bay Watershed.

Furthermore future studies should consider upland land use and how buffer effectiveness estimates differ between cropland and pasture land.

Need to Re-evaluate Efficiencies

Past effectiveness estimates were based largely on results from buffer transects with uniform flow where very high N and P efficiencies were reported. Emerging research and experience are indicating that factors such as non-uniform flow, buffer maturity and saturation may impact buffer performance over the long term at the field scale. It is recommended that buffer effectiveness be reviewed as new research is published and efficiencies be adjusted as needed. The CBP or STAC may want to convene a panel in the near future to further review buffer efficiencies. However, while efficiencies may need further revision, it is important not to lose sight of the many habitat, biotic and other benefits of buffers, particularly forest buffers.

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Appendix A. Meeting Minutes

Agricultural Nutrient and Sediment Reduction Workgroup
Conference Call
May 24, 2007
10:00 AM - 12:00 PM

Forest and Grass Buffer BMPs:
The recommendations were sent to STAC and the Forestry Workgroup, as well as the Ag workgroup.

It is clear that further analysis is merited on this BMP. The USFS has provided preliminary reactions to Kelly Shenk on the proposed BMP efficiency. They talked to Rich Lowrance, the creator of the REMM model that was used to evaluate the efficiencies. Rich is working directly with Carrie Graff who ran the analysis to evaluate the work and make recommendations for further analyses to address some of the USFS concerns. A few concerns mentioned in USFS preliminary response are the following:

- Need to make sure that we understand how subsurface flow was treated in the model runs since it will drive efficiency numbers.
- Need more model runs to enhance rigor.
- Need more documentation to back up recommendations.
- Need better understanding of field inputs used for different geomorphic regions.
- Need statistical analysis to justify treating grass and forest buffers together.

Ag Workgroup comments:

- The efficiency of grass buffers will vary depending on whether they are warm season grasses (deeper rooting) or cold season grasses.
- Weammert did not know if these differences were factored into analysis.
- Sweeney indicated that states do not indicate the grass type in their CBPO reporting.
- Horsey said it was probably not possible to track.

DECISION: Ask that UMD and the Forestry Workgroup evaluate the data to determine whether there is a significant difference in pollution reduction efficiency between warm and cold season grasses. If there is a difference, consider including the distinction in the BMP efficiencies to help drive more detailed reporting in the future. In the event that a state does not report the type of grass, consider assuming that it cold season grass (since they are easier to plant and more common).

ACTION: Jeff Sweeney suggested that we make sure that the Forestry Workgroup recognizes that the efficiency of buffers is reflected not only in the % reduction efficiency, but also in benefits given to upland acres (not previously quantified), and land use conversion. Therefore, even though UMD is proposing a reduction in the efficiency, this is being offset by quantifying upland benefits.

DECISION: The Ag Workgroup comments will be conveyed to both the UMD and the Forestry Workgroup in advance of its May 30 meeting. Anyone who would like to be involved in the Forestry Workgroup discussions, contact Sara Parr for meeting information at sparr@chesapeakebay.net.

Participants:
Herb Reed, UMD
Beth Horsey, MDA
Kelly Shenk, EPA CBPO
Jeff Sweeney, UMD/CBPO
Kari Cohen, NRCS
Sarah Weammert, UMD
Peter Tarby, PA DEP
Tom Juengst, PA DEP
Becky Thur, CRC
Mark Dubin, UMD MAWP/CBPO - could not get on call due to technical difficulties with conference line.

Minutes: Tributary Strategy Workgroup Meeting
June 4, 2007
10:00 AM to 3:00 PM
NRCS MD State Office, Annapolis

Riparian Forest and Grass Buffers

- The buffer recommendations are still under review by the Forestry Workgroup. The workgroup said that they did not think the MARWP review was complete enough.

Next Steps: The MARWP will review Al Todd's paper on on-the-ground reduction levels. Judy Okay will ensure the MARWP has this paper and other relevant papers. The Forestry Workgroup will be reviewing buffers on June 12th.

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Minutes: Nutrient Subcommittee Meeting
June 6, 2007
10:00 AM to 3:00 PM
Fish Shack—Chesapeake Bay Program Office

- The primary support behind the suggested buffer efficiencies comes from minimal model runs. The model assumes perfect construction, operation, and maintenance of the buffers. Therefore, calculated efficiencies are the absolute highest reduction observed from a buffer.
- The Forestry Workgroup will be reviewing Buffers are their June 12th meeting at which Carrie Graff, the developer, will be present. If the FWG wishes to propose a different efficiency, they will have to build a case for their recommendations based on the literature.

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Forestry Workgroup Meeting
Chesapeake Bay Program Office; Annapolis, MD
June 12, 2007

Review of the Mid-Atlantic Water Quality Program Forestry BMP Definitions and Efficiencies

- The workgroup reviewed the BMP definitions and efficiencies that the University of Maryland is proposing as part of an EPA-CBP funded project. Sarah Weammert, UMD, and Carrie Graff, Limno-Tech, presented the project's recommendations and answered questions from workgroup members. The BMPs that are being reviewed by the FWG for year 1 of this project are riparian grass buffers, riparian forest buffers, and forest harvesting practices.
- The BMP project has four steps: 1) scientific literature search, 2) development of practice definition and efficiency, 3) review, and 4) documentation and reporting. They are currently in the review phase for year 1 BMPs.
- Scientists with expertise on specific BMPs, when available, took the lead in drafting practice definitions and proposing efficiencies.
- When developing the proposed efficiencies, they did not try to assess implementation (level or degree), O&M, replacement or tracking, and reporting.
- After the FWG reviews these proposals, the proposals will be reviewed by the Tributary Strategy Workgroup, the Nutrient Subcommittee, STAC, and the Water Quality Steering Committee. The timeline for the review has been extended and the TSWG will now review July 9. The Water Quality Steering Committee will review the proposals in August.

Riparian Forest Buffers and Riparian Grass Buffers

- The proposals for riparian forest buffers and riparian grass buffers were developed by Carrie Graff and reviewed by Richard Lowrance and Judy Okay.

- UMD contracted with Carrie Graff from Limno-Tech Inc. to run the Riparian Ecosystem Management Model (REMM) for these practices. Input data provided by the Chesapeake Bay Program was significantly delayed, so model runs began two months late. Consequently, STAC and technical review are taking place concurrently.
- REMM models a three zone buffer system. Required inputs for REMM include upland inputs, daily weather data, site description, soil characteristics, erosion factors, and vegetation characteristics. Outputs from REMM include depth to water table, water fluxes, sediment yields, N-fluxes, P-fluxes, and groundwater N and P contents.
- Q: Is biological activity in the soil taken into account in REMM?
  - A: No, but REMM does include a higher organic content in the top soil layer.
- Q: Is there any way to validate some of the model output?
  - A: REMM has not been validated for the climate in the Chesapeake Bay region. It has, however, been validated in an area with a different climate.
- Carrie thinks that the Bay Program may have given her the wrong value for inner flow. She would like to run REMM with the correct numbers before she signs off on the project.
- REMM assumes perfect construction, operation and maintenance and simulates sheet flow across the buffer. For these reasons, calculated efficiencies are the absolute highest reduction observed from a riparian grass buffer.
- Based on these model runs, there was no apparent hydrogeomorphic region effect, and one would be expected based on the literature.
- Nitrogen reductions from grass buffers were estimated to be about 75% of reductions from forest buffers which is consistent with the 70% used in the past.
- Phosphorus reductions averaged 35% and 31% respectively for grass and forest buffers.
- Buffer maturity was not addressed in this project. Forest buffers are assumed to be fully functional once established but may take 7-10 years or more to reach full potential. It is beyond the scope of this project to determine how buffer maturity should be addressed in the Bay Program but it is a topic that should receive additional discussion.
- UMD recommended that grass and forest buffer efficiencies be considered together.
- UMD laid out three options for the workgroup for riparian buffer nitrogen efficiencies:
  1. Use efficiencies from the REMM results from the two regions and make all other hydrogeomorphic regions proportionally the same as they are currently.
  2. Do not change current N efficiencies.
  3. Either option 1 or 2 but reduce efficiencies for both N and P by 20% to 33% to offset REMM assumption of sheet flow, no channelized surface flow and no subsurface flow bypass of the buffer.
- The UMD project team supports approach #3 as the most realistic and defensible option since it recognizes hydrogeomorphic regions, corrects the phosphorus estimate (as they all do), and recognizes non-uniformity of surface or subsurface flow across buffers.
- Doing another REMM run based on different parameters may be an option. Carrie said that it would take up to a week to make the changes, however money may be an issue because UMD has already spent their budget for this practice.
- Sarah Weammert is working with Judy Okay to collect literature on buffers in order to put a literature synthesis together. Literature from other areas, such as west of the Mississippi River and Florida, will not be used. They will look at how the literature compares to the proposed efficiency and the model runs. If they find that there are a few parameters that are missing, perhaps they could ask for additional model runs.

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Minutes: Tributary Strategy Workgroup Meeting
July 9, 2007
10:00 AM – 1:30 PM
NRCS MD State Office

Review of the Mid-Atlantic Water Quality Program Phase I BMP Definitions and Efficiencies

- The Riparian Forest Buffer BMP was also reviewed be a group of experts. Richard Lowrance, one of the reviewers, believed the groundwater flux input for the model that the developer, Carrie Graff, ran, was too high.
- Richard Lowrance also believed that N should be higher than the proposed 30-40% and should vary by geomorphic region, similarly to the current situation.

- North Carolina research supported a 30% N reduction efficiency and suggests buffers are a source of P over time, not a sink. These researchers suggested not giving buffers an efficiency for P.
- Researchers at Beltsville Agricultural Research Service were very concerned about the issue of non-uniform flow that is more and more appearing to be a serious issue on a landscape scale.
- The model runs by Carrie Graff resulted in varied N reduction efficiencies, so the MARWP is reluctant to use these numbers.
- In lieu of the above issues, the MARWP recommended adjusting the current efficiencies by 20-30% and use an adaptive management approach to incorporating non-uniform flow while more data on this issue are collected. MARWP suggested we adapt the current hydrogeomorphic region buffer N efficiencies to account for spatial and temporal variability as well as non-uniform flow. P efficiencies were recommended to be between 25-40%, in between the research scale and watershed scale efficiencies.
- ACTION: Sarah Weammert will finalize the reports on the new buffer information and send them to the TSWG. The reports will clarify how the efficiencies will be incorporated into the model.
- The recommended buffer efficiencies will go to the Forestry Workgroup for review at their next conference call.

Source Workgroup Status Reports on BMP Review

Forest BMPs

- After holding a workgroup meeting with Sarah Weammert and the Forest Buffer BMP developer, Carrie Graff, a number of questions and issues were generated. The workgroup nominated Judy Okay to pull together the comments from the workgroup on buffers and Gene Odato to pull together the comments on Forest Harvesting and to present the response to MARWP. After MARWP responds, the information will be sent to the FWG for additional comment.
- The FWG will be holding a conference call in the next couple of days, allowing enough time post-call to present their proposals to the TSWG by July 23rd, two weeks in advance of their August 6th meeting.
- For Forest Harvesting, Sally Claggett raised concern that the reviewers recommended raising the efficiency but the MARWP recommended lowering the efficiency based on the reviewers' recommendations.
    - Tom explained that the reviewers assumed Harvesting BMPs were always implemented. Harvesting BMPs only make up 1% of the landscape and are already accounted for to some degree in Phase 5. In addition, Phase 5 will have a new land use category—disturbed forest—which will already consider efficiencies applied to that land use category, drowning out how it is currently applied.
    - This issue will be discussed with the modelers but should not big a big deal to resolve one way or another due to the insignificance of the Forest Harvesting BMP.
- Sally Claggett explained that the FWG found the model runs for buffers to be helpful but not as favorable as a literature review in determining efficiencies, especially considering buffers may be one of the most well-documented/researched BMP efficiency.
- Although there had been mention of conjoining grass and forest buffers, the two buffers will remain separate.

- The FWG plans to come up with a recommendation based on the literature and then reduce it to some extent to allow for a margin of safety. How much of a margin of safety is expected to be a point of debate.
    - Tom clarified to the workgroup that there is science on non-uniform flow, and other issues that would discount research-scale efficiencies, that could help in deciding the appropriate margin of safety to use.
- Helen mentioned that Phase 5 shows that forests are N saturated. She suggested that the FWG set up a meeting with Gary Shenk to understand and weigh in on the forestry decisions being made in the model.
    - Tom agreed that all of the NSC workgroups should understand what is being done in the model and how it differs from what was done in Phase 4.3.
- ACTION: Sara Parr will let the TSWG know when the FWG's next conference call is for those who want to participate in the forest BMP discussions.

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Meeting Minutes
Agricultural Nutrient and Sediment Reduction Workgroup
Adams County Agricultural and Natural Resource Center
Gettysburg, Pennsylvania
July 12th, 2007

- Russ Perkinson raised concerns that dissolved reactive phosphorus (DRP) was not factored into efficiencies. Tom replied that that no known literature on DRP and its impact on BMPs existed, and could not find expert opinion to quantify differences between DRP and soluble P. Tom did feel that DRP was a bigger issue on cropland than stream protection.
- Kelly inquired if it was possible to investigate the issue of DRP in buffers. While Tom thought it was indeed possible, he didn't think a legitimate answer was feasible by August. Kelly proposed a disclaimer on regarding DRP in the report be added acknowledging further research is needed on DRP to calculate more accurate efficiencies. Tom concurs that it is more important than what's currently being accounted for.

Workgroup Recommendations:

No comment. Ag WG will defer to Forestry Workgroup.

Participants

Greg Albretcht	NYS SWCC CNMP
Bill Angstadt	DMAA
Renato Cuizon	MDA
Mark Dubin	UMD-MARWP
Suzie Friedman	Environmental Defense
Beth Horsey	MDA
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Tom Juengst	PA DEP
Russ Perkinson	VA DCR
Tim Pilkowski	NRCS
Bill Rohrer	DNMC
Kevin Schabow	CRC-CBPO
Jennifer Shaafsma	MDA
Kelly Shenk	EPA-CBPO
Becky Thur	CRC

Calling In

Tom Simpson	UMD

Minutes: Forestry Workgroup Conference Call
July 16, 2007
2:00 PM to 3:30 PM

- Tom Simpson, UMD Mid-Atlantic Regional Water Program (MARWP), presented the status of the forest harvesting and riparian buffer BMP efficiencies.
- Tom explained that the riparian forest buffer BMP review took a different route than the other BMPs under review in that model runs were done to determine buffer efficiencies rather than literature reviews but that this method may not have been the best.
- Tom clarified the purpose of the BMP review project: to develop BMP definitions and efficiencies that reflect field implementation under average operation, management, and maintenance with widespread adoption, accounting for temporal and spatial variability. Once the efficiencies are generated, they will be used in Phase 5 of the Watershed Model to estimate progress and scenario reductions as close as possible to what will actually occur.
- Tom emphasized that the BMP efficiencies will not just be used in the model, but will have a place in regulatory and market-based programs, such as water quality trading programs, TMDLs, and MS4 permits. Their implications in these programs underline the need for a scientific and defensible review.
    - When adequate data are lacking for efficiencies, an adaptive management approach will be taken to move forward with the information we have available while continuing to enhance our scientific knowledge and reducing our uncertainty to be able to make changes in the future as data allow.

Riparian Buffers

- The results of the Riparian Ecosystem Management Model (REMM) runs done by Carrie Graff, Limnotech Inc, were questioned due to problems with the input hydrology.
- The REMM runs showed high variability for grass riparian buffers' nitrogen reduction efficiencies but more consistent results for phosphorus reduction efficiencies.
- Tom reached out to additional people in the field to discuss the results and where to go from here.
    - Richard Lowrance, ARS-Tifton, initially agreed that N should be 30-40% and P 20-30%, varied by geographic region, but he later changed his mind and suggested the efficiencies be similar to the current numbers based on his research with RFBs.
    - Deanna Osmond, NC State, explained that NC data supports a 30% N reduction but state efficiencies say 20-60% for programmatic reasons. NC data suggest buffers are a source, not a sink, of P and recommend not giving buffers a P efficiency.
    - Greg McCarty, Dean Hively, and others at ARS-Beltsville found non-uniform groundwater and surface water flow issues through their research buffers. Upwelling in buffers represented major discharge areas.
        - Although properly designed 3-zone buffers help to prevent channelization, most buffers implemented, through CREP for example, are not 3-zone buffers.
- Buffer efficiencies are currently not scaled according to buffer width.
- Based on the new information, MARWP made new recommendations for buffer efficiencies:
    - Adjust current efficiencies by 20-33% as an interim measure.
    - Keep grass as 70% of forest for N.

    - Make P efficiencies the same for grass and forest buffers with a range of 25-40% across the regions.
- Gary Moore raised the issue of how P is stored and mobilized in future inputs.

II. FWG Response to the MARWP's Proposed Buffer Efficiencies

- Judy Okay presented some key points in response to MARWP's buffer efficiency recommendations.
    - Groundwater is considered with surface and subsurface flow in the model.
        - Gary Shenk has previously stated that the model can separate flow.
        - ACTION: Judy will talk to Gary Shenk and Jeff Sweeney to figure out if, and to what extent, the model can separate surface and groundwater flow.
    - Literature suggests that groundwater upwelling has a general residence time of 40-50 years, and a long residence time may allow for a complete N reduction.
    - The NC study used by the MARWP involved buffers of 4.5 and 9 meters, all less than the Bay Program's minimum requirement of 35 feet, and much less than the average reported buffer width of 105 feet. Judy recommended width be given more attention.
    - Most plantings are done by trained professionals. In PA, only 3% were done by volunteer groups.
    - Tracked buffer plantings have a 77% survival rate.
    - Buffers are planted on the landscape primarily to intercept surface flow and area also effective at plant uptake at shallow groundwater depths. There are no BMPs that can reach into deep groundwater that upwells years from now.
- Judy Okay and the FWG recommended the RFB BMP efficiencies to be 67% for N and 44% for P, numbers that are supported by the literature and discounted for survival and placement uncertainty.

Discussion

- Tom stated that the next step would be to take the separate MARWP and FWG recommendations to the TSWG, and if necessary up the line to the NSC, for them to decide.
- ACTION: Judy Okay will send Tom Simpson a 1992 study by Bryce Cooper for his reference.
- Anne Hairston-Strang requested additional documentation to provide better scientific backing.
- Judy brought up a concern that Richard Lowrance mentioned in regard to the REMM P readings. The model may have been overwhelmed with waters, causing seepage and resultant decreased reductions.
- Because the BMP efficiencies will likely be in effect for at least 5 years, it's necessary to provide adequate scientific backing. Eileen McLellan, Environmental Defense, suggested it's better to err on the side of conservatism.
    - Sally Claggett believed that if new data become available, it should be able to be incorporated into the model without having to wait.
        - The model does not allow for this, however, Judy agreed with Sally in that the efficiencies need to be science not policy-based.
- Judy mentioned that there is a longevity with buffers that isn't seen with other BMPs, such that after 5 years, they are fully functional and their efficiency increases for another 30 to 40 years. The FWG would like to consider the possibility of giving buffers a higher efficiency as they age.

- Issues left to be resolved include:
  - Non-uniform flow
  - Modeling preferential flow
  - RFB effects on deep groundwater
  - Whether or not the model can separate surface and groundwater flow.
  - Significance of evapotranspiration
  - Buffer longevity and associated efficiency
  - How P is stored in buffers and mobilized in future inputs
- ACTION: FWG members will write a paragraph on their comfort level with the proposed BMP efficiencies and any other issues they have. Comments will be sent to Judy by Thursday, July 19th.
- Tom Simpson informed the FWG that Deanna Osmond will be visiting the Bay on the 25th and 26th of September to share her buffer research. She would be glad to arrange a time to meet with the FWG.

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Minutes: Tributary Strategy Workgroup
August 6, 2007
Chesapeake Bay Program Office—Fish Shack

DECISION: The TSWG could not reach consensus on the Riparian Forest Buffer BMP, so it will pass the BMP up to the Nutrient Subcommittee for a decision.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
August 15, 2007

Forestry BMPs **Judy Okay**

- The TSWG asked the Forestry Workgroup and MAWP to work together to develop a consensus final recommendation for consideration by the NSC. The FWG and MAWP were able to accomplish this task and presented the final recommendation to the NSC for its approval.
- Two issues were raised during the course of this discussion that warranted significant consideration:
  1.) There is concern about how the BMP efficiency was developed regarding uniform flow versus concentrated flow. After reviewing the research, this is an emerging issue and there is no consensus within the research community about how to address this in BMP efficiencies. However, the FWG considered this issue and addressed it as best they could in developing the efficiencies.
  2.) There is concern over how land conversion reductions are handled in the model and if they are already accounted for the BMP efficiencies. After lengthy discussion it was decided that the efficiencies are correct with regards to this

concern but the way the efficiencies are calculated in the model needs to be clarified.

- The FWG considered the above issues at length during the development of the forestry efficiencies and built them into the recommendations presented at today's meeting. Improvements can be made in the future to refine these efficiencies further as new information becomes available.
- The recommended forestry BMPs were approved, with the understanding that the values will be rounded to the nearest 5 or 0.

Efficiency Recommendation	**TN**	**TP**	**TSS**
Riparian Forest Buffers			
Inner Coastal Plain	65	42	56
Outer Coastal Plain Well Drained	31	45	60
Outer Coastal Plain Poorly Drained	56	39	52
Tidal Influenced	19	45	60
Piedmont Scnist/Gneiss	46	36	48
Piedmont Sandstone	56	42	56
Valley and Ridge – Marble/Limestone	34	30	40
Valley and Ridge – Sandstone/Shale	46	39	52
Appalachian Plateau	54	42	56
Riparian Grass Buffers			
Inner Coastal Plain	46	42	56
Outer Coastal Plain Well Drained	21	45	60
Outer Coastal Plain Poorly Drained	39	39	52
Tidal Influenced	13	45	60
Piedmont Scnist/Gneiss	32	36	48
Piedmont Sandstone	39	42	56
Valley and Ridge – Marble/Limestone	24	30	40
Valley and Ridge – Sandstone/Shale	32	39	52
Appalachian Plateau	38	42	56
Forest Harvesting	50	60	60

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Chesapeake Bay Program
Water Quality Steering Committee
Conference Call
August 27, 2007

SUMMARY OF DECISIONS, ACTIONS AND ISSUES

Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

Approval of 12 Consensus-Supported BMPs

- Beth McGee (CBF) clarified that page 5 of the "Consensus BMP Efficiency Recommendations For Agricultural, Forest, and Wetland BMPs" briefing paper should read that grass buffers are 70% as efficient at reducing total nitrogen (TN) than forest buffers.

ACTION: The MAWP will rephrase the information on page 5 of "Consensus BMP Efficiency Recommendations For Agricultural, Forest, and Wetland BMPs" to reflect that grass buffers are 70% as efficient at reducing TN as forest buffers.

DECISION: The Water Quality Steering Committee approved the 12 BMP definitions and efficiencies, described in the advance briefing papers, as recommended by the Nutrient Subcommittee and its workgroups for use in Phase 5 Chesapeake Bay Watershed Model.

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Appendix B: Riparian Buffer Effectiveness Reports from the Forestry Workgroup
Riparian Forest Buffer Efficiency Recommendations
Submitted by Dr. Judy Okay for the Forestry Workgroup

Introduction

In an effort to develop new efficiencies for riparian forest buffers in the Chesapeake Bay watershed, the University of Maryland Mid-Atlantic Water Quality Program (UMD/MAWQ P) and the Chesapeake Bay Forestry Workgroup have had presentations and information exchanges. The UMD team presented results from the Riparian Ecosystem Management Model (REMM) runs by Dr. Carrie Graff as well as results of Dr. Deanna Osmond's North Carolina research and OPE 3 data (Angier et al 2005) from the Beltsville Agriculture Research Center(BARC). Although the UMD efforts present current information giving nutrient reduction efficiencies for riparian forest buffers, the manner in which the research results should be applied is not clear. Consequently the Forestry Workgroup is not confident in the conclusions drawn by the UMD team because it is difficult to follow the logic used to develop the recommended nutrient reduction efficiencies. The development of the new efficiencies for riparian forest buffer nutrient reductions presents an opportunity to evaluate current efficiencies used in the Chesapeake Bay Model to predict nutrient reductions by riparian buffers. It also presents an opportunity to improve the efficiency based on what we know about the buffers that are being planted in the Bay watershed.

UMD/MAWQP is concerned that the current buffer efficiencies are based on a perfect implementation, perfect maintenance scenario and surface flow is the only hydrology considered. For this reason it is proposed by UMD/MAWQP that established efficiencies should be discounted to compensate for the conceivable imperfections encountered in reality. The Forestry Workgroup generally agrees with an appropriate efficiency discount to accommodate the concerns. A study of National Fish and Wildlife Foundation grant - supported riparian projects indicates that 80% of the projects were not performing up to expectations and in some cases could be considered failures. Results of this study differ significantly from other studies done in the Chesapeake Bay watershed. The following information has been compiled to give an idea of what the other studies show regarding riparian forest buffer establishment in the Bay watershed.

- **Most forest buffers are planted by trained professionals working with a state agency**. As an example, out of 3,439 plantings in Pennsylvania 73 were done by volunteer groups (less than 3% of state total taken from CBP data base).
- **All riparian forest buffers planted under cost share programs have the guidance and prescription of the agency providing the cost share.** In the Pennsylvania example that would be 97% of the plantings.

- **Soil types that are not conducive to growing trees are not eligible for enrollment in cost share programs.** Thus, riparian buffers will not be planted in areas that would culminate in project failure.
- **Forest buffers begin to show site influence at about 5 years (**Orzetti 2005) and this function will be **maximized as the tree matures and can be expected to persist for 30-40 years or longer.**
- **The mean survival rate is 77 percent for trees in riparian forest buffer plantings in the Bay watershed** (see Table 1 for sources of information).

The Forestry Workgroup is confident that a high percentage of riparian forest buffers being planted within the Chesapeake Bay watershed are being planted by experienced individuals, in appropriate places and the buffers are surviving at a sustainable level.

Table 1. Studies of riparian forest restoration efforts.

Author/s	# sites	Year of study	Locat ion	Age of planting	% survival
Sweeney, Czapka,Yerkes	2	2002	MD	4 years	88.8%
Pannill, Hairston – Strang, Bare, Robbins	130	2001	MD		67% mean
Starr	84	2006	VA	3-8 years	61-70%
Jackson	1	2006	PA	2 years	85-95%
Okay	1	2006	VA	4 years	76%
Mean for all studies					77.3%

Concerns about the hydrology related to riparian forest buffer sites have surfaced as another issue prompting a further discount in UMD/MAWQ recommended efficiencies. Preferential sub-surface flow and groundwater flow paths are the primary concerns. In the UMD report, there is reference to the BARC study that showed an upwelling site that contributed 10-15% of the total stream flow and 30-40% of the total stream nitrate load). The take home messages to address the hydrologic issues are:

- UMD states that it does not consider the OPE 3 BARC sites as typical.
- Others have found that on average about 50% of total stream water originates from groundwater (Phillips and Lindsey 2003 from Bachman 1998). However Howarth et al. (Scope 54, 2007) in explaining hydrologic contributions to aquatic systems state that less than 10% of total P transported is contributed by groundwater, the bulk is

contributed by surface flow and soil water. This is a significant difference from the BARC study.

- In a watershed with permanent forest or pasture cover the primary source of phosphorus is stream bank erosion (Hobie and Likens 1973). Runoff is the dominant source (about 80%) of nutrients for streams and rivers of the Chesapeake Bay watershed (Phillips and Lindsey 2003; Milak, Scope 54 , 2007).

Preferential flow and groundwater flow greatly influencing riparian forest buffer nutrient reduction efficiency is an issue that has many variables and the Forestry Workgroup does not think the science to support and justify the assertion is adequate. There are some nutrient reduction values for subsurface flow entered in Table 2. The incidence and frequency of preferential subsurface flow is not known and likely differs for the various hydro-geomorphic provinces. Because preferential subsurface flow cited is only active through a relatively short season of high precipitation/ high water table, but groundwater flow persists throughout the year, the influence of preferential flow on overall nutrient reduction values remains uncertain. Facts that further confound the issue of sources and reduction of N and P in other than surface flow are captured in scientific literature:

- Concentrations of nitrate in ground water are affected more strongly by soil, land use and topography than by the presence of forest buffers. Riparian plantings perched atop of terraced stream banks lack the interface contact between the roots and water for nutrient uptake (Speiran 2003).
- Concentrations of phosphate in streams vary with bedrock material. Igneous bedrock has a much higher phosphate concentration than glacial till parent materials (Binkley et al. 2004).
- Nitrate concentration reductions fluctuate between the dormant and the growing season making wetlands and transition zones between uplands sinks for groundwater nitrate (Simmons et al 1992).
- In some instances, tiled and ditched fields facilitate the bypass of buffers by pollutant rich agricultural runoff (Puckett 2004).

The facts given are current knowledge, but do not carry us to a clear conclusion about the discount rate that should be considered for the nutrient reduction efficiency. The Forestry Workgroup suggests that this issue be tabled and taken up by the scientific community and supported by the Forestry Workgroup, so that when efficiencies are revised in the future, the scientific evidence will better show the impact of preferential flow and groundwater influence over riparian buffer effectiveness. At that time the appropriate adjustment of the efficiencies can be made. Although the Chesapeake Bay model can be programmed to consider various hydrologic flow (surface, subsurface and groundwater) separately, the flows are currently batched in the model runs (per Jeff Sweeney). In the current Bay Model, there are discounts associated with buffer performance according to hydro-geomorphic province.

Discussion

The UMD/MAWQ team has listened to the Forestry Workgroup and considered current research regarding the effectiveness of riparian forest buffers for nutrient reduction. That action is appreciated. Within the Forestry Workgroup individuals have also reviewed the body of literature available. Additional benefits of riparian forest buffers are presented in Table 2. Nutrient reduction is often the focus when discussing the functions of riparian forest buffers. The multiplicity of buffer benefits to aquatic and terrestrial ecosystems do include biological processing of nutrients and enhanced rates of reduction that are often overlooked. Although these benefits are not captured in the Bay model the benefits exist. The gap between the UMD recommendations and the Forestry Workgroup expectations about nutrient reduction efficiencies for riparian buffers has narrowed, but the differences are still considerable. The gaps in reduction efficiencies are represented in graphs (Figs. 1 and 2) showing various studies and recommendations by UMD and the Forestry Workgroup. The information included in this paper presents the issues raised by the UMD team and attempts to clarify the reality as represented by information available from the Chesapeake Bay riparian forest buffer initiative and the compilation of related literature. All of the information indicates a need to consider a "conservation discount" for riparian forest buffer nutrient reduction efficiencies.

Information to consider when developing the "conservation discount" of nutrient reduction efficiencies for riparian buffers is: (1) the nutrient reduction values represented by scientific study, (2) the real life scenario of survival for on the ground projects, (3) the safeguards for success built into the programs fostering riparian plantings reported to the Chesapeake Bay Program. (4) The mean forest buffer width tracked through the Bay Program forest buffer database is 105 ft. The longevity of forest buffers should also be considered in the scheme of buffer performance. A survey of landowners in Pennsylvania showed that most (80-85%) with forest buffers planted through CREP, plan to leave the buffers in place after their contract expires in 10/15 years. Historically tree plantings done within cost share programs in the 1956 timeline have remained almost completely in forest production. Surveys completed by Conservation Reserve Program (CRP) participants indicate that 90% of the tree acres would be retained (Emily Cooper 2005; Okwudili, et al. 1999; Moorhead and Dangerfield 1998).

The following are options representative of the Chesapeake Bay Program Forestry Workgroup consensus.

Option 1. Retain the current CBP model efficiencies for riparian forest buffers until results in the scientific literature clearly support specific reductions that can be applied to the variety of landscapes in the Chesapeake Bay Watershed.

Option 2. Apply a 65% N reduction and a 45% P reduction as the baseline riparian forest buffer efficiency reduction (a 20% discount from scientific literature values). This is based on known project conditions of riparian forest buffers reported to the CBP.

Option 2 +. Supplement the reductions in Option 2. which are 20-30% lower than values represented in literature with a compensation for increases in efficiencies related to forest buffer maturity. There are signs of buffer influence after 5 years. It is suggested that a 5% compensation be given at that time and an additional 5% for each 5 year increment of maturity up to 15 years. The final efficiency will be capped at 80% for N and 60% for P which is what is expected from a mature buffer according to scientific literature values per Table 2. Through a conversation with Jeff Sweeney, this scheme can be incorporated into Phase V model.

The Forestry Workgroup prefers **Option 2 and Option 2+** as a combination efficiency. **Option 2** is a conservative recommendation. The use of **Option 2+,** takes into account the first 5 years after implementation when there are site improvements just because land management has changed, but the trees are not functioning at an effective level. After 5 years up to 15 years nutrient uptake efficiency increases, as well as ecosystem functions improve (Binkley et al. 2004).

Table 2. Riparian Forest Buffer Widths and Related Functions

Function	Width		Expected Reduction	Scientific Support
Sediment	Meters	Feet		
	19	62.7	89.90%	Lowrance et al., 1995
	21.3	70.3	75- 81% TSS	Young et al., 1980
	60	198	90 – 94% TSS	Peterjohn & Correll 1984
Air Temp	0-30	0-100	1.6◦C/ 10m increase	Ledwith 1996
	30-150	100-495	0.2◦C/10m increase	Ledwith 1996
Relative Humidity	0-30	0-100	3.8%10m decrease	Ledwith 1996
	30 -150	100-594	0.6%/10m decrease	Ledwith 1996
Habitat				
Small mammals	67-93	221-369		Jones et al. 1988

Birds	75-200	247-660		Jones et al. 1988; Allen 1983
Large mammals	100+	330 +		Jones et al. 1988; Allen 1983; Fischnesch 2006
Aquatic & Terrestrial	15-30	50-100		Spackman 1992
Healthy Biota	30	100		Castelle 1993
Channel Protection				
Channel Stability	15-30	50-100		Spackman 1992
Fl. Plain & Stream	15	49.5		Castelle et al. 2002
Nutrient reduction				
Phosphorus	5 – 18	15-60	20 – 85% reduction	Maggette 1987,1989; Mander 1997,
		15-55	96% reduction	Vought 1994
	19	63	70% reduction	Lowrance et al. 1995
			24-80% reduction	Peterjohn & Correll 1984; Lowrance et al. 1983
	23.6	78	78.5% reduction	Lowrance 1995
	28.2	93	77.2% reduction	Lowrance 1995
Nitrogen	50	165	86% surface runoff red.	Correll 1985 reported by Wenger
			80% overland 85% shallow gr. Water	Correll et al. 1992
	31	102	94% shallow gr. Water	Hanson et al. 1994 rep. by Wenger
	60	197	95% subsurface reduction	Jordan et al. 1993 rep. by Wenger
	19	63	74.3% reduction	Lowrance et al. 1995
			70% in loam 32% in sand	Pinay et al. 1995
		25-60	>80% subsurface	Simmons et al. 1992

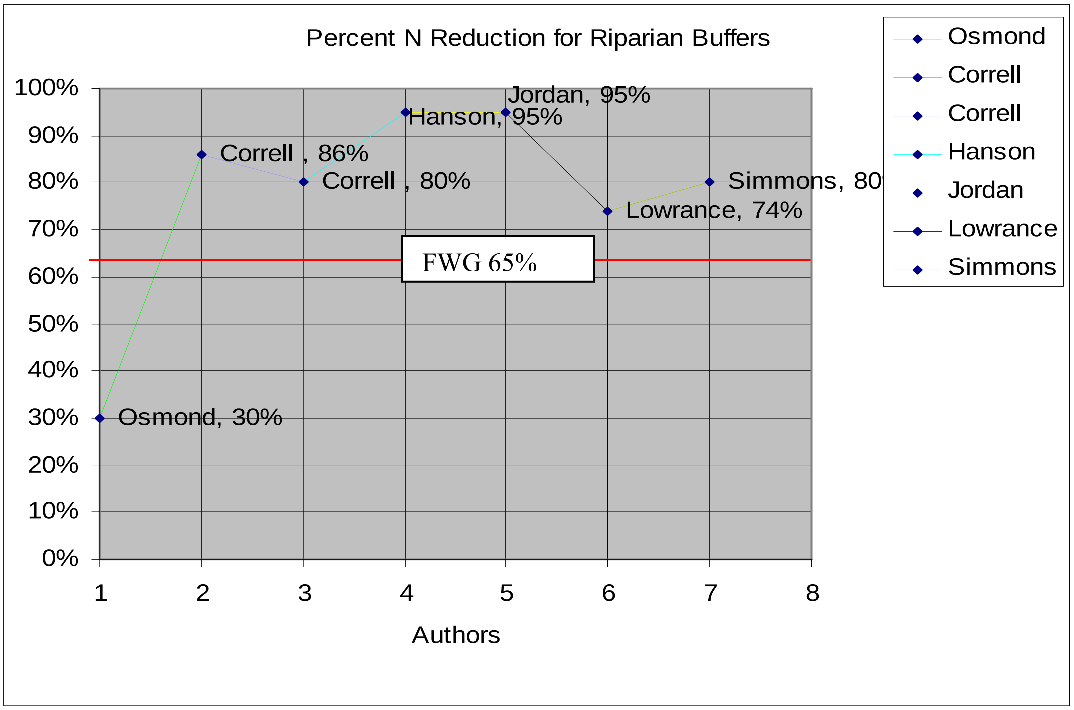

Figure 1. Percent N nutrient reduction for riparian forest buffers.

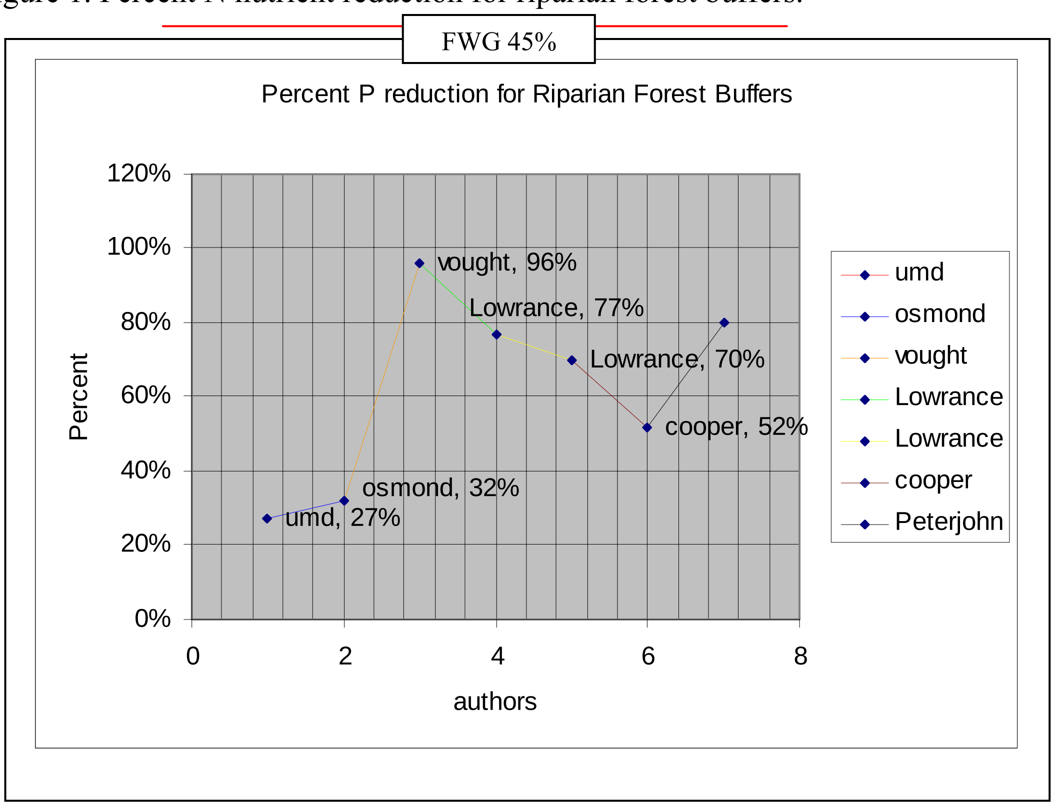

Figure 2. Percent P nutrient reduction for riparian forest buffers.

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Urban Erosion and Sediment Control Best Management Practice

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use the Chesapeake Bay Program's Phase 5.0 Watershed Model

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Summary

Urban Erosion and Sediment Control: protecting water resources from sediment pollution and increases in runoff associated with land development activities by retaining soil on-site so sediment and attached nutrients are prevented from leaving disturbed areas and polluting streams.

- Effectiveness Estimates are 25% TN, 40% TP and 40% TSS

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University Of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

To review efficiencies MAWQ contracted an expert, Dr. Andy Baldwin, and asked him to review applicable literature and propose an efficiency for model calibration based on the literature and their experience. The objective of this project is to estimate efficiencies that reflect operational conditions. Attached to these definitions and efficiencies is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix B.

Dr. Baldwin recommended a reduction in current efficiencies because findings show that small particles (silts and clays) are probably not effectively removed via many BMPs and another study concluded that construction site BMPs are often not implemented correctly (or even at all).

As a result Dr. Baldwin concluded that efficiencies were too high based on the literature but he was not comfortable with assigning a specific reduced value due to insufficient data. The CBP made slight reductions from the current efficiencies to reflect Dr. Baldwin's recommendation..

Using Dr. Baldwin's report and best professional judgment CBP apply the following pollutant removal efficiencies:

TN	25%
TP	40%
TSS	40%

Description/Definition

Development of land for industrial, commercial, or residential includes activities such as forest clearing and grading. The removal of vegetation and disturbance of soil from development and construction leave soil particles exposed and susceptible to erosion by wind and water. Nitrogen and phosphorus may also be transported from development sites via adsorption to eroded soil particles or dissolution in runoff from exposed areas. Erosion and sediment control practices protect water resources from sediment pollution and increases in runoff associated with land development activities. By retaining soil on-site, sediment and attached nutrients are prevented from leaving disturbed areas and polluting streams.

The goal of the erosion and sediment control practices evaluated in this document is the same as those of other BMPs designed to reduce transport of sediment and nutrients to aquatic downstream water bodies, such as wet ponds and constructed wetlands. Some of the technologies used to control erosion and sediment loss at development sites share the design and function of BMPs receiving runoff from existing developments (e.g. sediment detention ponds such as the one pictured above are the same as wet ponds, with the exception that one receives runoff from construction sites and the other from roads, buildings, or lawns). Another distinction from BMPs for existing developments is that typically a range of sediment and erosion control technologies and management practices is applied at a given development site (again as depicted in the photograph above). Furthermore, land development activities have the potential to generate much higher concentrations of sediment in runoff than do developed lands where vegetation has been established.

The water quality functions of erosion and sediment control BMPs result from diversion of surface runoff treatment areas (e.g. using terracing, berms, or swales), reducing water velocity (e.g., using check dams), filtration (e.g., by silt fences), and by removing suspended particle via settling or infiltration. Grasses are often planted on exposed soils, sometimes stabilized with nets or mats, to reduce erosion, and in swales to reduce velocity by increasing roughness of the surface. Nitrogen and phosphorus may be removed via settling of particulate forms and plant and microbial uptake. Phosphorus may also sorb to soil particles. Significant removal of nitrate is unlikely because the aerobic soil conditions are not favorable to microbial denitrification (an exception would be sediment ponds with permanent standing water). The combined effect of these types of BMPs are likely to promote infiltration, reduce runoff velocity, and store surface runoff water, attenuating flood peaks resulting from storms. This hydrologic function is considered a water quality function that helps to reduce stream channel incision, bank erosion, and loss of instream habitat structures that is typical of streams in urban areas with extensive watershed areas covered by impervious surfaces such as building, roads, and parking lots (Schueler 1994).

Erosion and sediment control BMPs provide little habitat value for organisms other than soil invertebrates

A number of definitions of various configurations of urban erosion and sediment control BMPs have been developed. Descriptions of these methods, abbreviated from USEPA (1993), include:

Sediment Basins. Sediment basins, also known as silt basins, are engineered impoundment structures that allow sediment to settle out of the urban runoff. They are installed prior to full-scale grading and remain in place until the disturbed portions of the drainage area are fully stabilized. They are generally located at the low point of sites, away from construction traffic, where they will be able to trap sediment-laden runoff.

Sediment Trap. Sediment traps are small impoundments that allow sediment to settle out of runoff water. Sediment traps are typically installed in a drainageway or other point of discharge from a disturbed area. Temporary diversions can be used to direct runoff to the sediment trap.

Filter Fabric Fence [“silt fence”]. Filter fabric fence is available from many manufacturers and in several mesh sizes. Sediment is filtered out as urban runoff flows through the fabric. Such fences should be used only where there is sheet flow (i.e., no concentrated flow).

Straw Bale Barrier. A straw bale barrier is a row of anchored straw bales that detain and filter urban runoff. Straw bales are less effective than filter fabric, which can usually be used in place of straw bales. However, straw bales have been effectively used as temporary check dams in channels. As with filter fabric fences, straw bale barriers should be used only where there is sheet flow.

Inlet Protection. Inlet protection consists of a barrier placed around a storm drain drop inlet, which traps sediment before it enters the storm sewer system. Filter fabric, straw bales, gravel, or sand bags are often used for inlet protection.

Construction Entrance. A construction entrance is a pad of gravel over filter cloth located where traffic leaves a construction site. As vehicles drive over the gravel, mud, and sediment are collected from the vehicles' wheels and offsite transport of sediment is reduced.

Vegetated Filter Strips. Vegetated filter strips are low-gradient vegetated areas that filter overland sheet flow. Runoff must be evenly distributed across the filter strip. Channelized flows decrease the effectiveness of filter strips.

Additional guidelines for effective sediment erosion control, again from USEPA (1993) include:

Wind erosion controls. Wind erosion controls limit the movement of dust from disturbed soil surfaces and include many different practices. Wind barriers block air currents and are effective in controlling soil blowing. Many different materials can be used as wind barriers, including solid board fence, snow fences, and bales of hay.

Earth dikes, perimeter dikes or swales, or diversions can be used to intercept and convey runoff above disturbed areas. These practices should be used to intercept flow from denuded areas or newly seeded areas to keep the disturbed areas from being eroded from the uphill runoff.

Pipe slope drain. Also known as a pipe drop structure, this a temporary pipe placed from the top of a slope to the bottom of the slope to convey concentrated runoff down the slope without causing erosion (Delaware DNREC, 1989 in USEPA 1993).

Benches, terraces, or ditches break up a slope by providing areas of low slope in the reverse direction. This keeps water from proceeding down the slope at increasing volume and velocity. Instead, the flow is directed to a suitable outlet, such as a sediment basin or trap.

Retaining walls. Often retaining walls can be used to decrease the steepness of a slope. If the steepness of a slope is reduced, the runoff velocity is decreased and, therefore, the erosion potential is decreased.

Linings for urban runoff conveyance channels. Often construction increases the velocity and volume of runoff, which causes erosion in newly constructed or existing urban runoff conveyance channels. If the runoff during or after construction will cause erosion in a channel, the channel should be lined or flow control BMPs installed. The first choice of lining should be grass or sod since this reduces runoff velocities and provides water quality benefits through filtration and infiltration. If the velocity in the channel would erode the grass or sod, then riprap, concrete, or gabions can be used.

Check dams. Check dams are small, temporary dams constructed across a swale or channel (see photo above). They can be constructed using gravel or straw bales. They are used to reduce the velocity of concentrated flow and, therefore, to reduce the erosion in a swale or channel.

Seeding, mulching/matting/netting, and sods. Seeding establishes a vegetative cover on disturbed areas. Seeding is very effective in controlling soil erosion once a dense vegetative cover has been established. However, often seeding and fertilizing do not produce as thick a vegetative cover as do seed and mulch or netting. Mulching involves applying plant residues or other suitable materials on disturbed soil surfaces. Mulches/mats used include tacked straw, wood chips, and jute netting and are often covered by blankets or netting. The mulching/mats protect the disturbed area while the vegetation becomes established. Mulching and/or sodding may be necessary as slopes become moderate to steep, as soils become more erosive. Plastic mats should be avoided.

Wildflower cover. Because of the hardy drought-resistant nature of wildflowers, they may be more beneficial as an erosion control practice than turf grass. While not as dense as turfgrass, wildflower thatches and associated grasses are expected to be as effective in erosion control and contaminant absorption.

Efficiency

Gray literature such as reports, web sites, and other information not subjected to the peer-review process was obtained through material already in hand, contacts with the Center for Watershed protection, references listed in refereed and gray literature already in hand, and web searches. Literature in peer-reviewed journals was identified using electronic databases such as ISI Web of Science. Literature was reviewed to find removal efficiency data for suspended solids (generally Total Suspended Solids, TSS), Total Nitrogen (TN), and Total Phosphorus (TP).

Little quantitative information was found on the removal efficiency of erosion and sediment control BMPs (Tables 1 and 2). This was surprising given the widespread use of these BMPs throughout the US and elsewhere, and the high concentrations of suspended sediment that can occur in runoff from exposed soils at land development sites relative to runoff from existing developments. No reports of any study that evaluated nitrogen were found, and only one study was found that examined phosphorus removal. All of the rest examined only suspended solids or effectiveness “in controlling erosion on construction sites”, which was equated with solids removal even though the two parameters may not be identical.

The studies of individual sites showed a wide range of treatment effectiveness (Table 1). One study (Barrett et al. 1998; Barrett and Malina 2006) found 0% removal in field studies of silt fence effectiveness (range of -61% to 26%), which involved sampling water in the pond immediately upstream of the fence and in the effluent immediately downstream of the silt fence. This low removal rate was attributed to the small size of particles (silt and clay) that comprised the majority of suspended solids, which passed unfiltered through the fence. Most of the larger particles settled in the pond upgradient of the silt fence. In laboratory studies by the same authors, higher removal efficiencies were noted (68-90%), but again much of the removal settled out in the flume chamber upgradient of the fence; even flumes with no fence resulted in 34% removal. Studies of sediment traps at two North Carolina construction sites (Line and White 2001) found higher removal efficiencies of sediment (59-69%). This study also found the traps were not as effective in removing fine particles (silt and clay) as coarser particles (sand). This study also found phosphorus removal rates of 9-30%.

Twenty removal efficiency values were reported for multi-site studies on various sediment and erosion control BMPs (Table 2), even though these were reported in only two references (USEPA 1990 and 1993). These studies only included information on suspended solids or on "controlling erosion." Because little or no methological information was included in the references, it is not possible to determine if the studies are based on quantitative sampling and analysis or best professional judgment. Measures that rapidly establish dense grass vegetation or cover material on exposed soils (sods, seeding, mulch) appear to have removal efficiencies >75% (Table 2). Sediment traps and basins appear to have removal rates of 50-70%, while silt fences and straw bales appear somewhat more effective in these multi-site studies (but recall low removals by silt fences in the field described for single-site studies. The average removal of these multi-site studies is 78%, somewhat higher than would be that of the single-site studies (0, 64, and 79%).

In addition to quantitative measures of removal efficiency, one study performed a semi-quantitative assessment of 30 Michigan construction sites to evaluate the implementation of BMPs in accordance with guidelines developed by the Michigan Department of Environmental Quality (Kaufman 2000). This study concluded that "performance of erosion control measures was poor" because the BMPs were not implemented correctly in relation to the guidelines or were inappropriate for the topography, hydrology, and soil characteristics of the site. Specifically, the study found that slope stabilization BMPs (mulching, seeding, and staging, i.e. working on different areas at different times) were particularly poor performers, with water management BMPs (buffer strips, filter fences, and sediment basins) only slightly better. BMPs for stabilizing soils (grading, access roads, spoil piles) performed the best. The study concludes that developers are not following recommended BMP practices and/or the laws requiring BMPs at construction sites are not being enforced, reflecting "a failure to integrate science and policy." This study suggests that while sediment and erosion control BMPs may function effectively when properly installed, a majority of these BMPs may not be functioning effectively due to incorrect installation.

Recommended Removal Efficiencies for Model

The current values used in the Chesapeake Bay model are not supported by the literature found in this review (although there is likely to be additional information in the gray literature that could not be obtained). No information was found for nitrogen removal, so the validity of the 30% removal efficiency currently in the model cannot be assessed. Only one study evaluated phosphorus removal, and the value reported (20%) suggest the currently used value of 50% is too high.

For suspended solids, the current value of 50% appears somewhat reasonable, although it is difficult to revise the number more specifically because the efficiency of different BMPs for sediment and erosion control varies widely and there have been few, if any studies of the combined effect of multiple BMPs on construction sites, even though that is the typical situation encountered in practice. Given the finding that small particles (silts and clays) are probably not effectively removed via many BMPs, increasing the number is not justified. Furthermore, the Michigan study's (Kaufman 2000) conclusion that construction site BMPs are often not implemented correctly (or even at all), if anything the 50% value should be reduced. With this limited information Andy Baldwin felt insufficient data exist at this time to warrant a reduction. The CBP feels operational conditions should be reflected in efficiencies and suggest the following:

TN	25%
TP	40%
TSS	40%

Efficiency Adjustment Discussion

Fifield (2002) states that there is little documentation of sediment-trapping systems for construction sites, and that conflicting opinions exist about the actual effectiveness of these systems. Fifield (2002) summarizes USEPA (1976) field studies, which noted that:

- Poor construction and maintenance were the most important factors leading to ineffective treatment;
- Predicted efficiency was higher than observed efficiency; and
- Cleaning out of sediment is necessary to maintain effectiveness.

The general concept of erosion and sediment control, according to Fifield (2002) is that properly designed, constructed, and maintained systems are always effective in trapping some sediment.

Changes in factors relating to soil, vegetation, topography, or hydrologic conditions may alter the effectiveness of erosion and sediment control BMPs for removal of suspended solids or nutrients. For example, longer detention times behind silt fences will in general tend to improve efficiency due to longer times for settling of particulates (Barrett and Malina 2006). Efficiency can also be affected by the geomorphology of the unit; designs that maximize the area of contact between water and soil, vegetation, or microbial surfaces should in general increase efficiency. Increased vegetation density and biomass in swales or buffers is also likely to improve efficiency because of greater roughness, nutrient uptake, and more microbial surface area. While microbial removal processes that affect nitrogen removal are sustainable indefinitely under relatively constant environmental conditions, soil surfaces may become phosphorus-saturated, and further phosphorus sorption is therefore not possible. Depending on the soil type and phosphorus loading rates, saturation may take many years, if it occurs at all. Capacity for sediment removal may also be impeded if high loading rates result in clogging or burial of vegetation. Additionally, high flow rates may lead to the formation of preferential flow pathways that reduce contact between water and microbes, soil, or vegetation. These and other variables may lead to changes in the efficiency of BMPs over time. Some processes may increase efficiency (e.g. development of vegetation) while other processes may simultaneously decrease efficiency (e.g. channel formation).

Climatic variables may also affect BMP performance over time, either positively or negatively. Periods of greater precipitation will likely result in shorter residence times, or even bypassing of the BMP due to high flow volumes, both of which will reduce performance. On the other hand, higher temperatures should increase metabolic rates, increasing growth of microbes and plants and facilitating greater transformation and uptake of nutrients. Global climate change may therefore affect performance by changing precipitation patterns and temperature in unpredictable ways. An additional factor is higher CO_2 concentrations, which may result in shifts toward species competitively favored under high atmospheric CO_2 levels. Changes in species composition may have some effect on performance, although effects are likely to be small unless there are large changes in stem density or biomass.

The few studies available suggest considerable variation in the performance of erosion and sediment control BMPs. Performance may vary over time, and in some cases high volume runoff events may bypass the system, resulting in little removal for large volumes of runoff. While some erosion and sediment control measures are temporary (e.g. silt fences), others are often left in place or modified into permanent structures (e.g., sediment traps and basins). Detention ponds should continue to function effectively for years without any significant maintenance other than mowing (which may not be critical for optimum performance). Periodic inspections should be performed to identify changes in hydrology, vegetation, or soils like those described above so that remedial measures can be taken in necessary. Development of channels or other evidence of erosion should be dealt with expeditiously, for example by diverting some portion of the runoff, installing rock berms, or otherwise decreasing flow velocities in the BMP.

While no studies have specifically evaluated how BMP efficiencies should be adjusted to account for the impacts of improper maintenance on receiving waters, some general adverse effects to water quality are understood. If maintenance is neglected a BMP may become impaired, no longer providing its designed functions.

In addition, sediment accumulation is one maintenance concern that if not addressed may adversely affect BMP effectiveness. As sediment accumulates it decreases storage volume and detention time, bypassing the intended functions of the BMP and increasing discharge of nutrient and sediment rich stormwater (Livingston et al. 1997). Increased discharge will lead to decreased downstream channel stability, resulting in an increase of sediment loads and a reduction in available aquatic habitat. The consequences of increased stormwater discharges from sediment filled BMPs, are a reduction in the BMPs pollution removal efficiencies, and ultimately, increased ecological impairments. The uncertainty in how improper maintenance will adjust BMP efficiencies supports the recommendation to use a more conservative percent removal estimate.

Statement of Conservatism

The level of uncertainty surrounding the recommended efficiency value for TSS is affected by, at a minimum, the number of studies available for a given parameter, the methods used to determine efficiency (e.g. number of replicates, analytical methods), the location of the studies, and the method used to calculate efficiency (e.g., load- vs. concentration-based). For the purposes of this review, the most-reported parameters in single- and multi-site studies was TSS, which is fortunate for developing recommendations for sediment efficiencies (only one study reported TP efficiency and none reported TN efficiency).

Given the numerous variables that may influence the performance of individual BMPs for erosion and sediment control, any single numerical removal efficiency will not apply to all situations. Because only a few studies were found, the reported studies do not incorporate a range of BMP designs of different ages across a wide geographic area. Therefore, there is considerable uncertainty in predicting the performance of actual BMPs across the Chesapeake Bay watershed. Furthermore, the degree to which BMPs are installed correctly in accordance with erosion control regulations across the Bay watershed is unknown. Using a confidence scale of low, medium-low, medium, medium-high, and high, Dr. Andy Baldwin rated the degree of confidence in the recommended values as low.

Future Research Needs

The fact that the Best Management Practice (BMP) project conducted by the Mid-Atlantic Water Quality Program-University of Maryland (MAWQ-UMD) did not address "treatment trains" has been brought up on several occasions. Please understand that MAWQ-UMD conducted its review as instructed in the scope of work provided and approved by both MAWQ-UMD and the Chesapeake Bay Program. The workplan identified the BMPs to be reviewed and stated that TN, TP and TSS percent removal efficiencies should be reviewed for inclusion in calibration of the watershed model. The workplan, however, also instructed project staff to compile a list of future research needs. Upon review of the urban stormwater BMPs it became obvious that the current practice categories and the individual treatment of effectiveness is not appropriate. However, there was not enough time or funding in the current project to determine effectiveness for treatment systems/trains but this should be done in the future.

No Impact Development

The concept of low impact development (LID), the use of proper site design techniques that reduces stormwater volume and pollution runoff, has been implemented across the Chesapeake Bay watershed for close to two decades. A refined version of LID, no impact development (NID), is currently being recommended as the new approach to urban development. NID claims to result in hydrologic and nutrient and sediment losses comparable to forest or natural meadows. UMD/MAWQ cautions against the adoption and assumption of effectiveness estimates for NID without further research to quantify its actual ability to reduce stormwater runoff and nutrient pollution. Current literature and practice implementation does not support the achievement of forest or natural meadow like conditions. Substantial research should be conducted before forest or meadow like hydrologic and pollution losses are assumed to be implemented on developed lands.

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Table 1. Summary of literature on the pollutant removal effectiveness (%) of single-site studies of urban erosion and sediment controls as Best Management Practices for urban and mixed open land uses. TSS = Total Suspended Solids, TN = Total Nitrogen, TP = Total Phosphorus. Calculation method: C = concentration-based; L = Load-based.

System name	Type	Location	TSS	TN	TP	Calc. Method	Comments	Reference
Highway construction projects	Silt fences	Austin, TX vicinity	0			C	Median removal; range= -61% to 54%; SD=26%; Included even though West of Miss R due to low availability of rigorous studies	Barrett and Malina 2006; Barrett et al. 1998
Laboratory tests	Silt fences	Austin, TX	79			C	Midpoint of range of 68-90%; much of removal due to settling in chamber or pond before reaching fence (34% removal with no fence); detention time more important than filtration capacity; Location not relevant for lab studies	Barrett and Malina 2006; Barrett et al. 1998
Construction sites	Sediment traps	North Carolina	64		20	NS	Midpoint of range	Line and White 2001

Table 2. Multi-site studies reporting removal efficiencies (%) for dry extended detention basins as Best Management Practices for urban and mixed open land uses. Calculation method: NS = not specified.

Type	TSS	TN	TP	Calc. Method	Comments	Reference
Sod	99			NS	Average	References cited in USEPA 1993 Table 4-15
Seed	90			NS	Average after vegetation establishment	References cited in USEPA 1993 Table 4-15
Seed and mulch	90			NS	Average after vegetation establishment	References cited in USEPA 1993 Table 4-15
Mulch (various)	75			NS	Midpoint of observed ranges	References cited in USEPA 1993 Table 4-15
Terraces	63			NS	Midpoint of observed range	References cited in USEPA 1993 Table 4-15
All erosion controls	85			NS	Average	Schueler 1990 in USEPA 1993 Table 4-15
Sediment basin	70			NS	Average	References cited in USEPA 1993 Table 4-16
Sediment trap	60			NS	Average	References cited in USEPA 1993 Table 4-16
Filter fabric fence	70			NS	Average	References cited in USEPA 1993 Table 4-16
Straw bale barrier	70			NS	Average	References cited in USEPA 1993 Table 4-16
Vegetative filter strip	70			NS	Average	References cited in USEPA 1993 Table 4-16
Seeding--permanent	99			NS	Effectiveness "in controlling erosion on construction sites"	USEPA 1990
Seeding--temporary	99			NS	Effectiveness "in controlling erosion on construction sites"	USEPA 1990
Mulching	87			NS	Midpoint of range; Effectiveness "in controlling erosion on construction sites"	USEPA 1990
Sod stabilization	99			NS	Effectiveness "in controlling erosion on construction sites"	USEPA 1990
Vegetative buffer strip	87			NS	Midpoint of range; Effectiveness "in controlling erosion on construction sites"	USEPA 1990
Straw bale dike	67			NS	Removal of this percent of sediment in site runoff	USEPA 1990
Silt fence	97			NS	Removal of this percent of sediment in site runoff	USEPA 1990
Sediment trap	46			NS	Removal of this percent of sediment in site runoff	USEPA 1990
Temporary sediment basin	46			NS	Removal of this percent of sediment in site runoff	USEPA 1990
Average	78					

SD	17
N	20
Minimum	46
Maximum	99

Appendix A: STAC Reviewer Comments

I have looked over the document you sent to me and only have a few comments that I would like to pass along to you.

First I'm in complete agreement with Andy Baldwin's synthesis of the existing literature, or lack there of, concerning values that should be used for the three efficiency's of interest (TN, TP, TSS) . I endorse his statements about the need to be more conservative going forward with the use these efficiencies in any modeling endeavor. Beyond that I am not comfortable giving you any advice on what a realistic value would be for each efficiency.

In terms of definitions provided in the report, I suggest the following changes be made to the document.

1) Add the following statement to the end of the "**Linings for urban runoff conveyance channels**"definition - *Plastic type turf reinforcement mats are often used to extend the use of grass in channels periodically subjected to high velocity flows.*

2) Replace the wording for **"seedling, mulching/matting/netting, and sod"** definition with the following:

Seeding, mulching/blankets/mats and sod. *Seeding establishes a vegetative cover on disturbed areas. Seedling is very effective in controlling soil erosion once a dense vegetative cover has been established. Seed washout is reduced and germination and seedling vigor are improved when plant residues, paper based products or wood fiber type mulches are used to cover or incased seed. Blankets of netted straw, coconut and wood fibers, or jute, are often used in place of mulch and tack to prevent seedling washout on moderately sloped hillsides. Interwoven natural material mats are used to anchor plants on steeply sloped hillsides and in channels periodically subjected to high velocity flows. Sod is used when an instant dense vegetative cover is desired.*

3) The definition provided for "**Wildflower cover**" is inconsistent with the other terms that have been defined. It appears that a position is being advocated rather than a working definition being provided for this term. Moreover, most of what is being stated in the first half of the definition is wholly speculative.. I don't think anything would be lost if this definition was omitted from the

document. No reference is made to this definition in either of the two tables present in the document.

Thanks for the opportunity to look this over.

Mark Carroll

Appendix B. Meeting Minutes

URBAN STORMWATER WORKGROUP CONFERENCE CALL
May 29, 2007

Urban Erosion and Sediment Control

- The current efficiencies in the Chesapeake Bay model are 33% for TN, 50% for TP, and 50% for TSS. UMD proposes lowering these efficiencies to 25%, 40%, and 40%.
- There was concern that the studies used in this analysis didn't show new design standards.
- Sarah will look at the new information provided by workgroup members.

DECISION: The USWG rejected UMD's proposal and recommended that no change be made to the current efficiencies.

Participants

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Minutes: Tributary Strategy Workgroup Meeting
June 4, 2007
10:00 AM to 3:00 PM
NRCS MD State Office, Annapolis

Urban Erosion and Sediment Control

- The expert reviewer did not feel comfortable assigning efficiency numbers to this BMP. Instead, he suggested that the current numbers were either too high or there was not enough information. The MARWP used their best professional judgment to develop an efficiency that was lower than the current efficiencies.

DECISION: Current numbers for Urban Erosion and Sediment Control will be used for now in the calibration. The MARWP will continue to work with the workgroups and the states to get supporting data for state numbers on new land use (construction) loads and to examine if TP and TSS efficiencies should differ.

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Minutes: Nutrient Subcommittee Meeting
June 6, 2007
10:00 AM to 3:00 PM
Fish Shack—Chesapeake Bay Program Office

- The developer did not believe there was sufficient literature available to recommend numbers for efficiencies. Based on the developer's general recommendations, MAWP proposed numbers slightly lower than the current efficiencies.
- The USWG did not agree with the proposed numbers and will be developing their own literature-supported efficiencies to be considered.

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- At their May 29th conference call, the USWG reviewed the year-one urban BMP definitions and efficiencies that MAWP/UMD is proposing as part of an EPA-CBP funded project.
- Following are the decisions made by the workgroup during the May conference call:
    - Dry Detention Ponds & Hydrodynamic Structures: The USWG recommended that these practices be separated and that MAWP's proposed efficiencies be used for dry detention ponds and that the current CBP adopted efficiencies be used for hydrodynamic structures.
    - Dry Extended Detention Basins: The USWG accepted UMD's proposed efficiencies, with the following stipulation for TP- MAWP should evaluate the data used to develop the TP efficiency for this practice in the PA BMP manual.
    - Wetlands and Wet ponds: The USWG rejected both Andy Baldwin's and MAWP's recommendations, citing that efficiencies were too low.
    - Urban Erosion and Sediment Control: The USWG rejected MAWP's proposal.
- Based on their review during the May conference call, workgroup members felt that the proposed efficiencies for these practices did not take into account all relevant studies. In order to address these concerns, members were given until June 8th to submit additional references to MAWP.
- After reviewing the additional information provided by workgroup members, MAWP has decided that their recommendations for the year-one urban BMPs will remain unchanged. At today's conference call, Tom Simpson, UMD, and Sarah Weammert, UMD, explained their reasoning for this decision. The handout that was distributed to the group explains their approach for BMP efficiency development. It can be accessed at http://www.chesapeakebay.net/calendar.cfm?EventDetails=8034&DefaultView=2.
- The main pieces of literature that USWG members asked MAWP to look at were the design manuals for the different jurisdictions, NERP data, and the Center for Watershed Protection (CWP) database. MAWP found that all of these sources were included in Andy Baldwin's BMP reports (Andy Baldwin developed the proposal documents for each of these practices).
- BMP projects from the CWP database were used to develop VA draft regulations and MD and PA stormwater design manuals. Upon further evaluation of all sources considered in the development of the urban wetland and wet pond practices, it was found that the developer had included the sources from the design manuals in his multi-site analyses. The analysis by the database developer includes the median values for all 145 studies used in the 2000 version of the Center for Watershed Protection database. In addition, some single site studies from the database are also included in the developers single site analyses. The 2007 CWP database will not be published until later this summer.
- ISSUES: Two concerns that the USWG had at the May conference call were: (1) MAWP's proposed efficiencies are based on single-site studies rather than multi-site studies and (2) the analysis includes studies with negative efficiencies. The USWG would instead like to base the efficiencies on multi-site studies and omit studies with negative efficiencies.

- MAWP decided that they would not change their recommended efficiencies based on the above two concerns. The developer and the STAC reviewer stated that the values closer to the mean and median efficiencies of the single-site studies should be used to determine effectiveness rather than those of the multi-site studies. In regards to negative efficiency studies, MAWP thinks that they should be included because these situations do occur operationally in real world situations. Also, negative efficiencies that have been published have undergone a rigorous scientific review.
- At the WQSC meeting it was suggested that statistics be provided for the studies in the analyses. These statistics are already listed in the reports for the year-one urban BMPs.
- ACTION: Workgroup members should submit ideas for future Bay Program needs (such as additional practices, changes in the overall approach to practices, ect.) to MAWP. It is beyond the scope of their project to address these needs, but they will include a list of issues that need to be addressed in their report.
- This project is not trying to define an efficiency for the perfect example of this practice. It is instead trying to identify an efficiency that characterizes this practice as it functions on broad application in the landscape and reflects real-world operational conditions.
- The workgroup needs to look at the definitions for wetlands & wet ponds and urban erosion & sediment control because there seems to be conflicting opinions between the developer, the reviewer, and the workgroup.
- ACTION: Sarah Weammert requested that the workgroup provide her with guidance for year-two urban BMPs. Specifically, she would like guidance on infiltration and filtration practices. What are the specific practices that need to be looked at? Are there 3-5 major groups of practices? What should the subcategories be? This will be on the agenda for the next workgroup meeting. Sarah needs this information by September.

III. Workgroup Recommendations **All**

- The workgroup discussed what their next steps should be and whether or not they would like to approve the MAWP recommendations or submit their own separate recommendations to the Tributary Strategy Workgroup on July 9th.
- Q: What does the rest of the review process look like for these BMPs?
    - A: MAWP's recommendations and the source workgroup recommendations will be presented to the TSWG on July 9th, to the NSC on August 15th, and to the WQSC in mid to late August. STAC is also concurrently reviewing MAWP's work. They will provide two reports for the TSWG to review at their August 6th meeting. One report will look at the process MAWP is using to come up with these efficiencies and whether or not it is sound and the second report will look at whether or not the BMP efficiencies make sense when you look at them across the board. Essentially, STAC is evaluating whether or not this combination of science and judgment is appropriate for what we are doing and if it is consistent, logical, and valid. They are not evaluating the efficiency number.
- The proposed efficiencies are based on both science and best professional judgment. We need to know where the science ends and where the best professional judgment begins. This is addressed in the individual BMP reports.
- ISSUE: Concern was voiced over the difference between the MAWP efficiencies and the efficiencies used in state regulations and programs.

- DE is not including efficiencies in their regulations, however other states, such as VA, need to include efficiencies.
- CWP is developing efficiencies for the VA regulations. It would be helpful if VA could provide the workgroup with their proposed state regulation efficiencies before the July TSWG meeting.
- MD's efficiencies were also developed by CWP and they differ from MAWP's recommendations.
- Some of the states feel that they can not support the MAWP proposed efficiencies if they are different from their state efficiencies.
- The efficiencies used in the CBP model and the efficiencies in the state regulations are different because the efficiencies were developed with different assumptions and are intended for different purposes. The state efficiencies describe what a BMP is capable of achieving if operation, design, and maintenance are optimal (best case scenario), whereas the efficiencies used in the Bay Program model describe what is happening operationally across the watershed from a realistic standpoint, taking into account maintenance issues, errors in design, etc.
- There is currently no information that shows that the Bay region is operating at a much more effective rate than the rest of the country. Inspection reports and monitoring data are not available. If this type of data did exist, then MAWP could have factored it into their analysis.
- It was pointed out that the state efficiencies and the MAWP proposals were developed using essentially the same data, however they are both looking at it differently from a statistical analysis standpoint.
- It was suggested that the USWG write an issue paper that discusses this need for consistency with state stormwater programs and how it may play out. This paper could explain what the workgroup would ideally like to see and how it is backed up by the data.
- It was also suggested that the different objectives and assumptions for state efficiencies and Bay Program efficiencies be documented.

- Q: Who is going to make the final decision regarding what efficiencies are used in the Bay Program model?
  - A: Ideally, the TSWG and the NSC will make the final decision. However, if a decision cannot be reached by these groups, then the decision will have to be made by the WQSC.
- ISSUES: As mentioned earlier, the USWG thinks that multi-site studies rather than single-site studies should be used and that studies with negative efficiencies should be omitted.
- STAC has been made aware of the USWG's concerns and they are looking closely at the above two issues.
- Q: Why do we still track individual BMP practices in the watershed model? Instead, could we look at the number of acres meeting performance standards?
  - A: Individual BMP practices are tracked in the model due to a previous decision made by the workgroup. The model could be based more on performance standards if monitoring information and data were available. We need to have a

way to monitor the performance standard. You can't make a blanket assumption that you have 100% performance standard compliance.

- It was suggested that the USWG's argument may be stronger if it was more technical. For example, the workgroup could explain why the states didn't use all of the studies that MAWP used, why they omitted negative efficiencies, why their numbers are better, etc. It would be useful if the argument was linked to MAWP's recommendations.
- ACTION: Representatives from the USWG need to attend the July 9th TSWG meeting in order to present the workgroup's argument and recommendations. Norm Goulet, workgroup chair, will be unable to attend. Sally Bradley will send workgroup members the agenda for the July 9th TSWG meeting when it is available.

ACTION: It would also be helpful if someone would write down the workgroup's concerns and the justification for their proposed approach. This draft document could then be emailed to the workgroup for comments.

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MINUTES: TRIBUTARY STRATEGY WORKGROUP MEETING
July 9, 2007
10:00 AM – 1:30 PM
NRCS MD State Office

Urban BMPs

- Reggie Parrish updated the TSWG on the status of the urban BMPs review process.
- The USWG has been addressing three areas of discrepancy:

    - Wetlands and Wet Ponds: The USWG believed the proposed efficiencies were too low.
    - Dry Detention Ponds and Hydrodynamic Structures: The USWG accepted the proposed Dry Detention Ponds efficiencies but wanted to separate out Hydrodynamic Structures into its own BMP. The workgroup believed the existing efficiencies should remain unchanged for Hydrodynamic Structures.
    - Urban Erosion and Sediment Control: The USWG rejected the proposed efficiencies and requested more work in this area before it is revisited.
- The USWG has been preparing their own recommendations for urban BMPs and providing Tom and Sarah with additional information that they believe should be considered.
- The USWG made various suggestions for the literature review process. First, the USWG suggested that the literature that finds negative efficiencies from the BMPs be eliminated in the review. The USWG also suggested that only multiple-site studies be used in the literature review, not single-site studies. Finally, the USWG did not believe enough attention was given to the state stormwater manual efficiencies.
    - Tom and WQSC members believed studies with negative efficiencies should be factored into the literature review.
    - Tom explained that all of the data behind the state stormwater manuals was used, and more, in the literature review process. The suggested efficiencies given in the manuals were not directly used, however, because they represent a target efficiency to shoot for, not an actual average widespread implementation efficiency.
    - ACTION: Tom and Sarah will clarify in their report that although the state stormwater manuals "target" efficiency was not directly used in the literature review, the data behind the state stormwater manuals, and more, were used in developing the recommended efficiencies.
- Reggie proposed 3 options on behalf of the USWG (who had not yet reviewed the document) for moving forward with the urban BMPs:
    - Option 1: Proceed with a different set of efficiencies for state/local and CBP.
        - Kelly Shenk thought it would be useful to understand the different purposes that the partnership uses the BMP efficiencies for. For example, CBP is interested in showing the average reduction of loads across the watershed, by using the model as a projection tool for necessary management actions.
            - Reggie explained that local governments have a scale issue with the BMP information, as some states are looking at a series of BMPs and how they function rather than just looking at a single BMP.
        - Virginia is in the process of developing regulations based on their BMP efficiencies. VA was in favor of Option 1 for defensibility reasons as they more forward with their regulations.
        - Helen did not wish for Option 1 to move forward because she believed consistency is necessary. MD's local governments demand consistency.
    - Option 2: Work with modelers to determine feasibility and possibility of not changing the urban BMP efficiencies until year 2 BMPs are revised in the model.
        - Helen confirmed that the BMP efficiencies won't make a dent in the model but are important for planning options, TMDLs, trading, etc.

        - Kelly thought this option may be worth exploring but that more time may not provide more data to inform our decision, it would just prolong the deadline for making a decision. Likewise, we're given the opportunity make these changes in the model simultaneously right now. Waiting until year 2 may be impossible politically.
    - Option 3: Shift from a single BMP efficiency approach to a systems approach.
        - Most states are looking at this issue holistically, so the USWG is asking if this review process is our opportunity to change course and start to look at BMP efficiencies holistically.
        - Ken Pensyl informed the workgroup that some BMPs do not get accounted for because they have no drainage area associated with them, however the broad spectrum of runoff from development could be addressed using a systems approach.
        - DECISION: The workgroup agreed that moving to a systems approach as outlined in Option 3 is the best way to move forward.
            - Tom confirmed that they could support a systems approach but that data to document the hydrology of the landscape are necessary.
            - The systems approach would factor in landscape conditions such as slope and soil type.
            - Kelly agreed by saying that a lot of states are heading in this direction of performance-based approaches. We will still need to determine what the realistic reduction is that we can expect to achieve with the performance-based approach.
            - The USWG wants to collect performance data on different types of land uses across the region.
    - Although the workgroup agreed to pursue Option 3, this shift to a systems approach could take years, so a more immediate solution is still needed for proceeding with the BMP efficiencies for the model.
        - Kelly suggested that the efficiencies be developed by first starting with the state stormwater manuals as the design standards for the BMPs and then applying a margin of safety based on the data collected by the MARWP.
        - Referring back to our adaptive management approach, Kelly suggested we use the MARWP's recommended efficiencies as the conservative estimate to be fed into the model until we have monitoring data and can make adjustments.
        - DECISION: The USWG will discuss the options for moving forward in the short-term with the urban BMP efficiencies, considering the TSWG's input.
        - Helen suggested that looking at each BMP's margin of safety could help us to decide the appropriate margin of safety to use for the urban BMPS.
        - ACTION: Per Tom's suggestion, the USWG will figure out a way to include the negative efficiency studies in their efficiency recommendations because their dismissal cannot be justified.

- Kelly reminded the TSWG that we would ideally like to have all decisions made at the workgroup and NSC level by mid-August, before the WQSC reviews the recommendations.

- The WQSC members are interested in knowing who their workgroup representatives are in order for the workgroups to take the authority to make the decisions before the process goes to the steering committee.

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Urban Stormwater Workgroup Conference Call
July 25, 2007

- Reggie Parrish, workgroup coordinator, began the meeting at 10:10 am. Introductions were made and the meeting's agenda was reviewed.
- At the July 9th Tributary Strategy Workgroup meeting, Reggie presented the USWG's concerns regarding the UMD/MAWP proposed efficiencies to the TSWG. Three potential options were suggested that were based on previous USWG conference calls.
- Based on the discussion at the TSWG meeting, two additional options have also been proposed. All five of the options are listed in the handout for today's call, which can be accessed at: http://www.chesapeakebay.net/calendar.cfm?EventDetails=9014&DefaultView=2. The TSWG strongly supported option C, but recognized that the workgroup would need to propose a short-term solution if this option were chosen.

- At the July 9th TSWG meeting, the TSWG asked the USWG to develop a specific position that they can formally submit to the TSWG, the Nutrient Subcommittee and ultimately the Water Quality Steering Committee.
- During today's conference call, we had hoped to come up with a specific position supported by the USWG; however, since many key players were unable to participate in today's call, conference call participants decided that the call should be rescheduled for sometime next week and that we should postpone making a decision on the workgroup's position until that time.
- The USWG needs to decide on a position before the next TSWG meeting, which is being held on August 6th.
- Q: How do our no net increase efforts relate to the BMP efficiency efforts?
  - A: We are not sure exactly how these efforts are related yet. The performance based systems approach, which is one of the proposed BMP efficiency options, seems like it would be relevant to no net increase efforts.
- Q: What is the definition of no net increase?
  - A: In PA, they are trying to move forward with the concept of no net change rather than no net increase. The Stormwater and New Development Taskgroup did not define no net increase at their last meeting. It is important to point out, however, that we do not want the efficiencies to get bogged down with the no net increase issue. We still need the efficiencies in the more short term timeframe.
- Q: Right now, the states are only providing the Bay Program with data on implementation. What data would need to be provided for option E (see handout) to show that the BMP is properly designed, inspected, maintained and operating? It seems like a lot of data would be needed. Do we have this information?
  - A: We are not exactly sure yet what data would be needed for this option. One suggestion was that if a state could ensure that a good O and M plan was in place, then maybe this could ensure a higher efficiency. Before choosing this option, the workgroup would really need to explore it further.
- Workgroup members were interested in how the other sectors chose their efficiencies in the Bay model and what data they used to do this.
- In other sectors, it is not assumed that the BMPs reported meet design standards and are properly maintained. Essentially, they apply a safety factor for long-term maintenance. This is also why UMD/MAWP adjusted their efficiencies down.
- It was pointed out that there is not long-term data available for most BMPs. It is just a matter of ensuring implementation. In PA, there is an inspection program to ensure that BMPs are properly installed.
- Compared to focusing on individual BMPs, a systems approach would be more in line with state design manuals.
- Q: Is there any documentation of the discussion that took place to develop PA's BMP manual?
  - A: There is some documentation, however it is not very detailed.
- Some participants thought that implementation information and water quality monitoring (to show that you are getting the expected results) should be all of the data that is needed.
- Option D (see handout) says that state manuals use efficiencies that describe optimal performance, but that Bay Program and UMD/MAWP efficiencies acknowledge that BMPs do not work optimally all of the time in the real world.

- PA pointed out, however, that the Bay Program and UMD/MAWP efficiencies are based on single BMPs and in PA they use a combination of BMPs that this approach does not capture. In reality, these are being looked at as systems and multiple BMPs are being relied on to achieve results. Using a systems approach is option C in the handout.
- Could the urban sector use an approach similar to the ag sector's conservation plans, which is essentially a suite of BMPs?
- A systems approach could develop different efficiencies for various tiers of a system.
- It was suggested that we default to state standards and then add some sort of qualifier on that shows that they are not achieving their goals 100%.
- Some participants felt that option E (see handout) is sort of the "do nothing option" and that it pushes the decision to a later point in time.
- The model calibration period is from 1985 to 2004. For stormwater management in PA, the Bay Program has one number for each year that covers the entire watershed portion of the state. Jeff Sweeney needs to know what efficiency should be applied to these stormwater management acres. PA agreed to follow up on this issue for Jeff.
- Essentially there appear to be two issues: 1) what we need immediately for calibration, and 2) what we will use in the future.
- Q: If we come up with some numbers for calibration and then we come up with different efficiencies to be used for future planning, we would have to revise those efficiencies in the model, correct?
    - A: Yes. Jeff said that this could be done though.
- One concern that was voiced was that members do not want to see efficiencies lowered based on historic expectations, compared to future expectations. It was suggested that we have two separate efficiencies for 1985-2000 and 2000 and beyond.
- For whatever position they choose, the USWG needs to provide supporting documentation equivalent to what UMD/MAWP provided for all of the other BMPs.
- Q: Did UMD/MAWP separate out dry detention ponds and hydrodynamic structures, as was proposed at the May 29th conference call?
    - A: These practices were combined based on the categories created previously by the USWG. As far as Reggie and Sally know, UMD/MAWP did not make any revisions to their proposals to separate out these practices. Reggie will contact Sarah Weammert, UMD/MAWP, to find out whether or not they made this change.
- During today's conference call, there seemed to be general agreement that we need to look at a systems approach on a more long-term basis. However, in the short-term we really need to decide on some way to assess BMP efficiency for model calibration.
- Reggie Parrish will set up a call for sometime this week between Ken Murin and Norm Goulet so that they can further discuss a potential USWG position on BMP efficiencies.
- The meeting was adjourned at 11:30 am. A date for next week's conference call will be sent out to workgroup members as soon as it is selected.

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Urban Stormwater Workgroup Conference Call
August 1, 2007

- Norm Goulet, USWG chair, began the conference call at 9:30 am. Introductions were made and the meeting's agenda was reviewed.
- All of the handouts for today's conference call can be accessed at: http://www.chesapeakebay.net/calendar.cfm?EventDetails=9016&DefaultView=2
  - The purpose of this conference call was to come up with a workgroup position on urban BMP efficiencies. This position needs to be presented by the workgroup at the next Tributary Strategy Workgroup Meeting, which is being held on August 6th.
  - Highlights from the STAC review of the UMD/MAWP BMP efficiency process include:
    - STAC agreed with UMD/MAWP on the use of negative efficiencies. They said that the Chesapeake Bay model must be calibrated to function with operational rather than research BMP efficiencies. Hence, if reported negative efficiencies reflect operational conditions, STAC felt that they should be considered in an assessment of the BMP efficiency literature.
    - STAC stated that peer-reviewed literature should be given more weight than state BMP manuals. They do not consider state manuals to be peer-reviewed since they were not subjected to independent examination.
    - STAC commented on the fact that some experts used the lack of research data to justify deep discounts of the few reported efficiencies, while other experts refused to change current efficiencies because of the lack of research data. STAC said that they hope that such a situation was anticipated, and that the charge to the expert specifically stated how such situations were to be handled.
  - In the workgroup's draft position paper, the following three specific concerns are listed: 1) negative studies should be eliminated, 2) single site studies should not be used, and 3) state manual BMP efficiencies not appropriately considered.
  - It was thought by some members that the biggest workgroup concern, which is not listed, is that the efficiencies are based on historic data. More recently, the states have increased volumes, changed their strategies, added pre-treatment, and changed BMP design criteria. These changes are not reflected in the studies that UMD/MAWP used to come up with their efficiencies. Members thought that the efficiencies that UMD/MAWP proposed may be good for BMPs that were put on the ground between 1984 and 2000, but not for more recent BMPs.
  - The calibration period for the CBP model is from 1985-2002. Thus, based on the above comments, it seems that the efficiencies from UMD/MAWP would be appropriate to use for model calibration. This is our immediate need.

- Post-construction BMPs are a bigger issue than construction BMPs. They should be the focus of the information that states report to the CBP office.
- Norm proposed that the following modifications be made to the USWG's position paper:
    - Acknowledge that the UMD/MAWP numbers are incorrect for a variety of reasons.
    - State that the workgroup will, however, accept the efficiencies from UMD/MAWP with the stipulation that they have the option to increase the efficiencies later if sufficient data is available to show that they are achieving higher efficiencies.
    - The UMD/MAWP numbers will be used in the upcoming model calibration.
    - The UMD/MAWP efficiencies will only be used for one year. During that time, we will work towards switching to a systems approach.
    - If a systems approach is not developed within one year, then the default is still the UMD/MAWP numbers.
- It was suggested that we have an on-going evaluation of the BMPs to determine how they actually function in the long-term.
- Ideas for how we could develop a systems approach include:
    - Two systems could be developed: ultra-urban and a more suburban approach. Each of these would have different values.
    - Gather information from each state since different states have different soils, slopes, etc. Maybe a research group could look at this and come up with calculated values for the land use. This would be similar to what UMD did for the BMP efficiencies.
    - Unfortunately, there is not much monitoring data out there.
    - Right now, CBP efforts should focus on just sediments and nutrients. Maybe later they could expand this effort to include other pollutants.
    - The systems must be something that we know we can track in the future.
- The workgroup will develop a funding proposal for a project that will research and potentially develop a systems approach. In addition, the workgroup may need to develop its own report that they will pass up to the Tributary Strategy Workgroup and the Nutrient Subcommittee.
- There is a protocol for peer review on the Bay Program website.
- Q: Will we be able to get CBP funding for this project?
    - A: After a proposal is developed, it can be taken to the Budget Steering Committee. However, there is unlikely to be money available from the CBPO at this time due to a budget shortfall. Therefore, we may need to be creative and look for other funding sources. It was pointed out that there was no CBPO money available for the UMD BMP efficiency project either, but we were able to gain the Budget Steering Committee's support for this project and another source of funding was found.
- Q: Can UMD's scope of work be modified so that they look at the systems approach in year 2 of their BMP project?
    - A: It is unlikely, but Kelly Shenk will look into this just in case. It will depend on how much of a departure this is from the project's original scope. Even if we can get them to look at the systems approach in year 2, their review will not be as extensive as what the workgroup was discussing earlier. If we are going to switch

to a systems approach, maybe we no longer need UMD to look at infiltration practice efficiencies in year 2. Perhaps we could replace this with gathering data on the systems approach.

- Q: Could we use the UMD efficiencies for the model calibration period, and then use the state BMP manual numbers when we do implementation runs later?
    - A: No. The state BMP manual numbers cannot be used.
- Q: What do we do in the mean time while we are developing this systems approach?
    - A: It was suggested that we use the UMD efficiencies unless the states have data that shows that they are achieving a higher efficiency.
- Workgroup members decided to accept the position laid out in today's handout once Norm's proposals (see above) are included. Reggie will revise the handout so that it includes Norm's proposals and text on model calibration and historic vs. future values.
- Norm and Reggie will present the workgroup's position at the August 6th Tributary Strategy Workgroup meeting. Information on this meeting can be found at http://www.chesapeakebay.net/calendar.cfm?EventDetails=8816&DefaultView=2.

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Minutes: Tributary Strategy Workgroup
August 6, 2007
Chesapeake Bay Program Office—Fish Shack

Urban Erosion and Sediment Control:

DECISION: The USWG did not have any issues with the recommended Urban Erosion and Sediment Control BMP efficiencies.

Participants

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
August 15, 2007

- Norm Goulet, Urban Stormwater Workgroup Chair, presented the recommended BMP efficiencies for urban wetlands and wet ponds, urban erosion and sediment control, dry extended detention basins, and dry detention ponds/basins and hydrodynamic structures.
- The USWG is recommending these efficiencies with some caveats. The way urban BMPs are modeled needs to change from stand alone BMPs to a systems approach. Until that can be accomplished, these BMP recommendations should be used to calibrate the model along with additional data from the jurisdictions.
- There is also concern that the CBP recommended efficiencies are not always consistent with the efficiencies provided in state handbooks. If facilities can provide documentation regarding implementation, maintenance, and inspection processes, are the handbook efficiencies acceptable? Will this cause confusion?
- It was noted that there is also a difference in efficiency if a jurisdiction has a strong enforcement program. Stronger enforcement leads to more maintenance at facilities and higher efficiencies.
- Was consideration given to splitting dry ponds and hydrodynamic structures since they behave differently? Consideration was given; however, there is not a lot of recent information available regarding hydrodynamic structures and each state handles these structures differently which makes it difficult to develop a stand alone BMP efficiency rating.
- A concern was raised regarding super-load areas in the Phase 5 model. They seem reasonable in applied to highly disturbed areas only; however, they would not be accurate

if applied to whole acreages. The Tributary Strategies Workgroup will take a look at this issue and report back to the NSC.

- It will be necessary to update the CBP website to clearly link urban BMPs with their efficiencies and to explain the transition from Phase 4.3 to Phase 5 of the CBP model to make it more understandable to users.
- Infiltration and filtering processes were omitted from the MAWP year 1 project scope but will be included in year 2. It is valuable to examine these BMPs even if the model eventually moves to a systems-based approach as it will take time to make the needed changes to the model and the jurisdictions are currently implementing these BMPs.
- What about N and P speciation? How effective are BMPs at treating various forms of N and P? There is not enough information available to develop general rules about the various N and P species; however, this issue will be highlighted in the MAWP report as a research need.
- The recommended urban BMPs were approved.

Efficiency Recommendation	**TN**	**TP**	**TSS**
Urban Wetlands and Wet Ponds	20	45	60
Urban Erosion and Sediment Control	25	40	40
Dry Extended Detention Basins	20	20	60
Dry Detention Ponds/Basins and Hydrodynamic Structures	5	10	10

Participants

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Chesapeake Bay Program
Water Quality Steering Committee
Conference Call
August 27, 2007

SUMMARY OF DECISIONS, ACTIONS AND ISSUES

Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

DECISION: The Water Quality Steering Committee approved the 12 BMP definitions and efficiencies, described in the advance briefing papers, as recommended by the Nutrient Subcommittee and its workgroups for use in Phase 5 Chesapeake Bay Watershed Model.

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Urban Wet Ponds and Wetlands Best Management Practice

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in the Chesapeake Bay Program's Phase 5.0 Watershed Model

Consulting Scientist

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Synthesis by

Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
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Project Leader

Summary

Urban Wetponds: depressions or basins created by excavation or berm construction that receive sufficient water via runoff, precipitation, and groundwater to contain standing water year-round at depths too deep to support rooted emergent or floating-leaved vegetation (in contrast with dry ponds, which dry out between precipitation events). Nutrients and suspended particles are removed via settling. Nitrogen is further removed primarily via plant and microbial uptake and nitrification-denitrification reactions, while phosphorus is further removed by soil sorption.

- Effectiveness Estimates: 60% TSS, 20% TN, 45% TP

Urban Wetlands: Wetlands have soils that are saturated with water or flooded with shallow water that support rooted floating or emergent aquatic vegetation (e.g. cattails). Nutrients and suspended particles are removed via settling. Nitrogen is further removed primarily via plant and microbial uptake and nitrification-denitrification reactions, while phosphorus is further removed by soil sorption.

- Effectiveness Estimates: 60% TSS, 20% TN, 45% TP

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University Of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

To review efficiencies MAWQ contracted an expert, Dr. Andy Baldwin, and asked him to review applicable literature and propose an efficiency for model calibration based on the literature and their experience. The CBP adopted Dr. Baldwin's recommendations and his report follows. Attached to these definitions and efficiencies is a full accounting of the Chesapeake

Bay Program's discussions on this BMP, who was involved, and how recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix E.

Photograph of BMP

Stormwater wetland at the University of Maryland, College Park. Runoff from the parking lot enters the wetland from the left, flows in a roughly U-shaped counterclockwise pattern, and discharges via a riser a the top center of the wetland. Photo by A.H. Baldwin.

Wet pond receiving stormwater runoff from parking lots serving the Comcast Center sports arena and other facilities at the University of Maryland, College Park. Emergent wetland vegetation (cattails and other species) is visible in shallow waters along the shoreline. Photo by A.H. Baldwin.

Description/Definition

Wet ponds and wetlands used as a Best Management Practice (BMP) for management of urban stormwater runoff are man-made landscape features that have characteristics and functions similar to their natural counterparts. Wet ponds are depressions or basins created by excavation or berm construction that receive sufficient water via runoff, precipitation, and groundwater to contain standing water year-round at depths too deep to support rooted emergent or floating-leaved vegetation (in contrast with dry ponds, which dry out between precipitation events). Wetlands, on the other hand, have soils that are saturated with water or flooded with shallow water that support rooted floating or emergent aquatic vegetation (e.g. cattails). Some systems may contain submergent vegetation, or emergent vegetation along the shorelines, blurring the distinction between the two.

While there are similarities between natural and stormwater wetlands or wet ponds, there are also differences. In general, stormwater systems have a water balance dominated by surface runoff (rather than groundwater), "flashy" hydroperiods, well-defined boundaries, low species diversity and habitat value, and elevated contaminant and sediment concentrations compared with their natural counterparts (Schueler 1992a).

The water quality functions of urban wet ponds and wetland BMPs operate via similar mechanisms to those occurring in natural systems. Suspended particles are removed via settling resulting from low water velocities in the systems (and physical filtration by plants if present), a process called sedimentation (Schueler 1992a; Brix 1993). Nitrogen is removed primarily via plant and microbial uptake, the nitrification-denitrification reactions, and particulate settling, while phosphorus is removed primarily via soil sorption and settling of phosphorus sorbed to particulate matter. Wetlands and wet ponds may also remove, transform, or retain metals, pesticides, pathogens, oils, and other organic and inorganic constituents of surface runoff (Kadlec and Knight 1996; Mitsch and Gosselink 2000a; BMP Database 2007). Furthermore, many stormwater BMPs are designed to store surface runoff water, releasing it slowly to streams with the goal of attenuating flood peaks resulting from storms. This hydrologic function of wet ponds and wetlands is often considered a water quality function that helps to reduce stream channel incision, bank erosion, and loss of instream habitat structures that is typical of streams in urban areas with extensive watershed areas covered by impervious surfaces such as building, roads, and parking lots (Schueler 1994).

In addition to water quality functions, wetland, and to a lesser extent wet pond, BMPs provide habitat for fish, aquatic invertebrates, birds, mammals, reptiles, and amphibians (Schueler 1992a; Baldwin, personal observation). However, if not designed properly these structures may also provide habitat for disease vectors such as mosquitoes (NC State 2005). Wet ponds and wetland BMPs can also be important for human quality of life, providing aesthetic or recreational value. Because they are often small and isolated from other habitats such as forests and streams, plant and wildlife species diversity may be low. Nonetheless, their presence in otherwise highly developed landscapes may increase their value as habitat for wildlife as well as use by humans (Mitsch and Gosselink 2000b).

A number of definitions of various configurations of urban wet pond and wetland BMPs have been developed. The following were taken from the Chesapeake Bay Programs (CBP) trib tools webpage, and are the CBP's current definitions of BMP categories and types developed by its Urban Stormwater Workgroup (2002):

Wet pond: A stormwater management pond designed to obtain runoff and always contains water (Prince George's LID Report 1999)

Wet extended detention pond: Combines the pollutant removal effectiveness of a permanent pool of water with the flow reduction capabilities of an extended storage volume (Idaho Department of Environmental Quality 1998).

Multiple pond system: A group of ponds that collectively treat the water quality volume (Center for Watershed Protection 2003).

“Pocket” pond: A wetland that has such a small contributing drainage area where little or no baseflow is available to sustain water elevations during dry weather. Water elevations are highly influenced, and in some cases, maintained by a locally high water table (Center for Watershed Protection 1996).

Practices that have a combination of a permanent pool, extended detention or shallow wetland equivalent to the entire water quality storage volume. Practices that include significant shallow wetland areas to treat urban stormwater but often incorporate small permanent pools and/or extended detention storage (Center for Watershed Protection and Maryland Department of the Environment 2000).

Shallow wetland: A wetland that provides water quality treatment entirely in a wet shallow marsh (Center for Watershed Protection 2003).

Extended detention wetland: A wetland system that provides some fraction of the water quality volume by detaining storm flows above the marsh surface (Center for Watershed Protection 2003).

Pond/wetland system: A wetland system that provides a portion of the water quality volume in the permanent pool of a wet pond that precedes the marsh for a specified minimum detention time (Center for Watershed Protection 2003).

“Pocket” wetland: A stormwater wetland design adapted for the treatment of runoff from small drainage areas (<5 acres) and which has little or no baseflow available to maintain water elevations and relies on groundwater to maintain a permanent pool (Center for Watershed Protection and Maryland Department of the Environment 2000).

Submerged gravel wetland: One or more treatment cells that are filled with crushed rock designed to support wetland plants. Stormwater flows subsurface through the root zone of the constructed wetland where pollutant removal takes place (Haubner et al. 2001)

Constructed wetland: Constructed wetlands are systems that perform a series of pollutant removal mechanisms including sedimentation, filtration, absorption, microbial decomposition and vegetative uptake to remove sediment, nutrients, oil and grease, bacteria and metals. Wetland systems reduce runoff velocity thereby promoting settling of solids. Plant uptake accounts for removal of dissolved constituents. In addition, plant materials can serve as an effective filter medium and Denitrification in the wetland can remove nitrogen (EPA 1993).

Retention pond (wet): Surface pond with a permanent pool.

Wetland basin with open water surfaces: Similar to retention ponds except that a significant portion (usually 50% or more) of the permanent pool volume is covered by emergent wetland vegetation (Best Management Practice database).

Retention basin: Capture a volume and retain that volume until it is displaced in part or in total by the next runoff event. Maintains a significant permanent pool volume of water between runoff events (EPA 1999)

Efficiency

The removal efficiencies for wet ponds and wetlands used in the Chesapeake Bay watershed model are currently 30%, 50%, and 80% for nitrogen (N), phosphorus (P), and sediment, respectively. To evaluate the validity of these numbers, a review of peer-review and gray literature was conducted. Removal efficiencies found in the literature were summarized and used as a basis for validating or changing currently used efficiencies.

Literature Review and Data Analysis Methods

Gray literature such as reports, web sites, and other information not subjected to the peer-review process were obtained through material already in hand, contacts with the Center for Watershed protection, references listed in refereed and gray literature already in hand, and web searches. Literature in peer-reviewed journals were identified using electronic databases such as ISI Web of Science.

Literature was reviewed to find removal efficiency data for suspended solids (generally Total Suspended Solids, TSS) and various forms of nitrogen and phosphorus (including total nitrogen, ammonia/ammonium, nitrate/nitrite, total phosphorus, and phosphate). Data for other measures or forms of solids, nitrogen, and phosphorus were occasionally reported (e.g. dissolved solids, organic N and P). Occasionally there were slightly different analyses (e.g. total N versus total Kjeldahl N; nitrate and nitrite analyzed separately or combined), but in general it was possible to lump results under six primary headings (each abbreviated here as shown in parentheses): Total Suspended Solids (TSS); Total Nitrogen (TN); nitrate and/or nitrite nitrogen (NO3); ammonium or ammonia nitrogen (NH4); Total Phosphorus (TP); and ortho-phosphate or reactive/soluble phosphate (PO4).

While the goal of this review is to develop or validate specific removal rating values, it is important to keep in mind that considerable variation exists between studies in methods for sample collection, chemical or physical analysis, experimental design, and data analysis. Even the calculation of removal efficiency, a seemingly straightforward concept, can be approached using at least four different methods (Strecker et al. 2001). In this review, the two primary methods were calculation of efficiency based on either 1) change in parameter concentration between inflow and outflow, or 2) percentage of mass of influent pollutants removed, which can result in markedly different efficiency removal efficiency values, even for the same data set. In many cases in this review, removal efficiencies were not reported, but influent and effluent concentration data (e.g., Event Mean Concentration, EMC) were presented that were used to calculate percent removal.

Recently, the concept of removal efficiencies itself has been questioned, and the use of "effluent quality," or the concentrations of pollutants in BMP effluent, has been recommended as a more robust measure of the effectiveness of BMPs for water quality improvement than removal efficiency values (Strecker et al. 2001). A recent comprehensive review of the International BMP Database (BMP Database 2007), Rea and Traver (2005) report well-analyzed effluent concentration data for various BMPs, but present no removal efficiency values, indicating a shift in the state-of-the-art method for evaluating BMPs.

The literature found in this review was divided into two groups: a) studies of individual BMP project sites ("single-site" studies); and b) studies that reviewed or averaged performance for multiple sites or design ratings for particular BMPs based on multiple sites or professional judgment ("multi-site" studies). The studies of individual sites were analyzed separately from the multi-site studies because the latter typically relied on studies of some of the single sites. Single-site studies were limited to those that occurred in the eastern U.S., defined as those sites east of the Mississippi River. Some of the multi-site studies likely include some sites from elsewhere in the U.S., and possibly Canada.

Removal efficiencies were first summarized in tabular format for single-site studies (Appendix A) and multi-site studies (Appendix B). Summary statistics for each parameter were then calculated and tabulated (mean, standard error (SE), median, minimum, maximum, and number of values (N)). Mean and SE for single- and multi-site studies were also plotted together to examine the relationship between the results of this and other review studies. Finally a frequency analysis of removal efficiencies was performed for both single- and multi-site studies to present graphically the distribution of efficiencies.

Results of Literature Review

Removal efficiency information was found for a range of different individual wet pond and wetland systems across the eastern U.S. (Appendix A). Removal averaged 40-60% for TSS, NO3, TP, and PO4 (Table 1). Mean removal was considerably lower for TN and NH4. Median values were generally near the mean, indicating a fairly equitable distribution around the mean (i.e., data were not highly skewed). There was considerable variability in removal efficiency as reflected by high standard deviations (particularly for TN and NH4) and large range in removal efficiency (e.g., -300 to 100% for NH4). Standard errors were also high for NH4 due to its comparatively smaller sample size.

In interpreting removal efficiency results, it is important to bear in mind that a large positive or negative efficiency value can result from very small changes in chemical concentration (e.g., a change from 0.01 mg/L PO4 at the inflow to 0.03 mg/L at the outflow results in a removal efficiency of -200%, but these low concentrations are within ranges occurring in many natural waters).

The average removal efficiencies calculated for individual sites are lower than those reported by multiple-site review or design guideline studies for all parameters except PO4 (Table 2 and Fig. 1). Based on standard error bars, results for single sites may be significantly lower for TSS and TN. The lower removal efficiencies for the single-site studies is likely because of the low or negative removal efficiencies reported or calculated for the single-site studies. Multi-site studies may have: 1) included primarily positive removal efficiencies (due to a tendency to underreport or not publish in refereed journals negative or low-performance results); 2) were averages that reduced the visibility of low or negative removal efficiencies; or 3) were design recommendations based on optimal operational and maintenance conditions not achieved at some sites.

The pattern of lower removal efficiencies for the single-site studies is also reflected in the frequency analyses (Figs. 2 and 3). For example, no multi-site reviews documented removal efficiencies below 60% (Fig. 3), while approximately 40% of the single-site studies reviewed had lower removal efficiencies. Not surprisingly, the range of efficiencies for single-site studies was broader than that for multi-site studies, many of which were based on average removal efficiencies that therefore reduced the impact of extreme values.

Recommended Removal Efficiencies for Model

The results of this literature indicate that the removal efficiencies currently used in the Chesapeake Bay model should be reduced. Specifically, the following removal efficiencies are justified by this review of scientific and technical literature:

Sediment (TSS):	60%	(currently 80%)
Nitrogen (TN):	20%	(currently 30%)
Phosphorus (TP):	45%	(currently 50%)

These values are closer to the mean and median efficiencies of the single-site studies than they are to the multi-site studies. The justification for these numbers takes into consideration the likelihood that multi-site studies may not reflect the low efficiencies of some BMP projects, as discussed previously. The recommended values for nitrogen and phosphorus are nonetheless well within the range of efficiencies found in multi-site studies (Fig. 3). The recommended value for sediments is at the low end of the range of reported multi-state studies, but approximately in the center of the range of efficiencies for single-site studies.

Removal efficiencies for NO3 and NH4 were higher than those for TN, but these forms of nitrogen are a subset of total nitrogen (e.g., organic nitrogen). Phosphate removal, on the other hand, was lower than that for TP, presumably because much phosphorus is in particulate form and removed via settling.

Changes in factors relating to soil, vegetation, or hydrologic conditions may alter the effectiveness of wetlands or wet ponds for removal of suspended solids or nutrients. For example, longer detention times will in general tend to improve efficiency due to increased contact between water and soil or microbial surfaces and vegetation, as well as longer times for settling of particulates. Longer detention times can be created by increasing the area or volume of wet ponds or wetlands relative to drainage area entering the system, or conversely by reducing the volume of runoff entering the wetland. Efficiency can also be affected by the geomorphology of the unit; designs that maximize the area of contact between water and soil, vegetation, or microbial surfaces should in general increase efficiency (e.g., long, linear wetlands with shallow water depth are likely to be more effective than deep, concave basins of the same volume). Increased vegetation density and biomass is also likely to improve efficiency because of greater uptake, more microbial surface area, and increased oxidation of the root zone. Because vegetation structure and composition are temporally dynamic, efficiency may also vary, but should approach a dynamic equilibrium after some period of time, probably measured in years. While microbial removal processes that affect nitrogen removal are sustainable indefinitely under relative constant environmental conditions, soil surfaces may become phosphorus-saturated, and further phosphorus sorption is therefore not possible. Depending on the soil type and phosphorus loading rates, saturation may take many years, if it occurs at all. Phosphorus can also be sequestered in undecomposed plant material (i.e., peat) under certain waterlogged conditions in wetlands; however, if hydrology is altered, oxidation and decomposition of plant parts may release the phosphorus (and nitrogen) they contain. Capacity for sediment removal may also be impeded if high loading rates result in clogging or burial of vegetation. Additionally, high flow rates may lead to the formation of preferential flow pathways that reduce contact between water and microbes, soil, or vegetation. These and other variables may lead to changes in the efficiency of wetlands or wet ponds for stormwater quality improvement over time. Some processes may increase efficiency (e.g. peat formation) while other processes may simultaneously decrease efficiency (e.g. channel formation).

Climatic variables may also affect BMP performance over time, either positively or negatively. Periods of greater precipitation will likely result in shorter residence times, or even bypassing of the BMP due to high flow volumes, both of which will reduce performance. On the other hand, higher temperatures should increase metabolic rates, increasing growth of microbes and plants and facilitating greater transformation and uptake of nutrients. Global climate change may therefore affect performance by changing precipitation patterns and temperature in unpredictable ways. An additional factor is higher CO2 concentrations, which may result in shifts toward species competitively favored under high atmospheric CO2 levels. Changes in species composition may have some effect on performance, although effects are likely to be small unless there are large changes in stem density or biomass.

Properly designed wet ponds or wetlands should require little or no maintenance for long-term treatment. However, periodic inspections should be performed to identify changes in hydrology, vegetation, or soils like those described above so that remedial measures can be taken in necessary. Particularly when systems are new, it is important to make sure water levels are suitable for the growth and persistence of wetland vegetation (in wetlands or on the shores of wet ponds). Development of channels or other evidence of erosion should be dealt with expeditiously, for example by diverting some portion of the runoff, installing rock berms, or otherwise decreasing flow velocities in the BMP.

While no studies have specifically evaluated how BMP efficiencies should be adjusted to account for the impacts of improper maintenance on receiving waters, some general adverse effects to water quality are understood. If maintenance is neglected a BMP may become impaired, no longer providing its designed functions. Proper maintenance of outlet structures, flow splitters and clean out gates is key to achieving a BMPs designed efficiency (Koon 1995).

In addition, sediment accumulation is one maintenance concern that if not addressed may adversely affect the BMPs effectiveness. As sediment accumulates it decreases storage volume and detention time, bypassing the intended functions of the BMP and increasing discharge of nutrient and sediment rich stormwater (Livingston et al. 1997). Increased discharge will lead to decreased downstream channel stability, resulting in an increase of sediment loads and a reduction in available aquatic habitat. The consequences of increased stormwater discharges from sediment filled BMPs, are a reduction in the BMPs pollution removal efficiencies, and ultimately, increased ecological impairments. The uncertainty in how improper maintenance will adjust BMP efficiencies supports the recommendation to use a more conservative percent removal estimate.

Statement of Conservatism

The level of uncertainty surrounding the recommended efficiency values is affected by, at a minimum, the number of studies available for a given parameter, the methods used to determine efficiency (e.g. number of replicates, analytical methods), the location of the studies, and the method used to calculate efficiency (e.g., load- vs. concentration-based). For the purposes of this review, the most-reported parameters in single- and multi-site studies were TSS, TN, and TP (Tables 1 and 2), which is fortunate for developing recommendations for sediment, nitrogen, and phosphorus removal efficiencies. However, the review of the single-site studies shows tremendous variability in the efficiency of any given site in improving water quality. For the purposes of modeling water quality in the Chesapeake Bay watershed, however, these between site differences should average out, assuming that locations outside the Bay Watershed that were included in the review have similar efficiencies to those in the watershed.

While peer-reviewed literature may in general be assumed to have greater reliability than gray literature, a number of the reported results here were based on extensive monitoring data, some of it not even published in a gray-literature report (e.g., some of the sites in the International BMP database). However, it was also clear that some gray and peer-reviewed studies were based on relatively few measurements, or on grab samples rather than flow-weighted sampling.

The recommended values are similar to the average and median values reported for the single-site studies. While not conservative, these values represent a realistic assessment of removal efficiencies across a wide geographic region, based on available monitoring information. These values are lower than those reported in a majority of other multi-site studies, but again this is justified for reasons discussed previously.

Given the numerous variables that may influence the performance of individual wet ponds or wetlands, any single numerical removal efficiency will not apply to all situations. However, a fairly substantive body of gray and refeered literature was used in developing the removal efficiency values for the Chesapeake Bay model, encompassing a range of different BMP designs of different ages across a wide geographic area. Therefore, it is likely that the recommended values are a realistic measure of the performance of actual BMPs across the Chesapeake Bay watershed. Using a confidence scale of low, medium-low, medium, medium-high, and high, I would rate the degree of confidence in the recommended values as medium-high.

Future Research

As mentioned previously, the concept of “effluent quality” has been recommend over the use of removal efficiencies such as those that have been presented here and upon which the

recommended values for the Chesapeake Bay model were based (Strecker et al. 2001). While the use of removal efficiencies in a modeling landscape or watershed transformation or removal or nutrients and sediments makes sense in theory, in practice problems arise due to the different methods used in calculating removal (e.g. load- vs. concentration-based) and small absolute changes in concentration or load resulting in large percentage changes, to name two examples. Furthermore, it is currently recognized (e.g., Kadlec and Knight 1996) that "natural" systems such as wetland or wet ponds are not capable of removal of pollutants below a certain "background" concentration, a phenomenon not often considered when removal efficiencies are used in modeling or design efforts. Adoption of an "effluent quality" approach however, recognizes that for a specific flow volume and above a certain minimum design size, most BMPs will remove pollutants to some constant background concentration, irregardless of additional increases in BMP area or volume. This approach could be applied in the Bay model by assigning the same effluent concentrations to BMPs of certain watershed:BMP size ratio.
In addition to using effluent quality as a measure of BMP performance rather than removal efficiencies, Strecker et al. (2001) recommends using living resource restoration indicators, such as aquatic invertebrate sampling and habitat classification, in addition to calculating effectiveness by using chemical measures.

Strecker et al (2001) recommend parameters that all studies should include, but are often missing. These include transferable measures of storage volume, surcharge detention volumes, stage/storage data, watershed characteristics, and land use information. Winer (2000) also recommends incorporating individual storm parameters, specifically bacteria, hydrocarbons, dissolved metals, as they correlate with human health, recreation and aquatic toxicity and are often not reported; and in addition recommends investigating internal factors, such as geometry and sediment/water column interactions, of wetlands and wet ponds as they may be responsible for the wide range of effectiveness found in studies. Not only do many studies lack the aforementioned parameters, studies also make translation of available design parameters difficult. To ensure studies begin using these recommendations Strecker et al. state that the EPA require all federally funded projects that will evaluate BMP effectiveness employ standard methods they discuss, and in addition, that the EPA provide detailed guidance on data collection and sampling methods to improve data transferability (2001).

The fact that the Best Management Practice (BMP) project conducted by the Mid-Atlantic Water Quality Program-University of Maryland (MAWQ-UMD) did not address "treatment trains" has been brought up on several occasions. Please understand that MAWQ-UMD conducted its review as instructed in the scope of work provided and approved by both MAWQ-UMD and the Chesapeake Bay Program. The workplan identified the BMPs to be reviewed and stated that TN, TP and TSS percent removal efficiencies should be reviewed for inclusion in calibration of the watershed model. The workplan, however, also instructed project staff to compile a list of future research needs. Upon review of the urban stormwater BMPs it became obvious that the current practice categories and the individual treatment of effectiveness is not appropriate. However, there was not enough time or funding in the current project to determine effectiveness for treatment systems/trains but this should be done in the future.

No Impact Development

The concept of low impact development (LID), the use of proper site design techniques that reduces stormwater volume and pollution runoff, has been implemented across the Chesapeake Bay watershed for close to two decades. A refined version of LID, no impact development (NID), is currently being recommended as the new approach to urban development. NID claims to result in hydrologic and nutrient and sediment losses comparable to forest or natural meadows. UMD/MAWQ cautions against the adoption and assumption of effectiveness estimates for NID without further research to quantify its actual ability to reduce stormwater runoff and nutrient pollution. Current literature and practice implementation does not support the achievement of forest or natural meadow like conditions. Substantial research should be conducted before forest or meadow like hydrologic and pollution losses are assumed to be implemented on developed lands.

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Yu, S.L., and D.E. Benelmouffok. 1988. Field Testing of Selected Urban BMPs in Critical Water Issues and Computer Applications. In Proceedings of the 15th Annual Water Resources Conference. American Society of Civil Engineers, New York, NY. IN Shoemaker, L., Lahlou, M., Doll, A., and P. Cazenas. 2002. Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring; Fact Sheet Detention Ponds. Federal Highway Administration, Landover, Maryland. http://www.fhwa.dot.gov/environment/ultraurb/index.htm

Table 1. Summary of removal efficiency (%) for stormwater wetlands and wet ponds evaluated in single-site studies. Mean and standard error are plotted in Fig. 1. Results of all studies reviewed are included in Appendix A.

Statistic	TSS (Total Suspended Solids)	TN (Total Nitrogen)	NO3 (Nitrate and/or Nitrite)	NH4 (Ammonium or Ammonia Nitrogen)	TP (Total Phosphorus)	PO4 (Ortho-phosphate or Reactive Phosphate)
Mean	56	17	44	13	45	41
Standard deviation	36.5	29.3	39.8	91.7	25.7	43.0
Standard error	4.5	4.5	6.2	21.0	3.3	11.5
Median	64	20	55	35	45	51.5
Minimum	-78	-81	-83	-300	-42	-76
Maximum	99	65	97	100	86	90
N	62	40	39	19	58	14

Table 2. Summary of removal efficiency (%) for stormwater wetlands and wet ponds evaluated in multi-site studies. Mean and standard error are plotted in Fig. 1. Results of all studies reviewed are included in Appendix B.

Statistic	TSS (Total Suspended Solids)	TN (Total Nitrogen)	NO3 (Nitrate and/or Nitrite)	NH4 (Ammonium or Ammonia Nitrogen)	TP (Total Phosphorus)	PO4 (Ortho-phosphate or Reactive Phosphate)
Mean	75	31	52	26	47	34
Standard deviation	7.9	11.1	18.0	--	11.9	22.8
Standard error	1.9	2.4	5.7	--	2.5	8.6
Median	75.5	30	49	26	47.5	36
Minimum	61	19	24	26	16	-10
Maximum	91	56	81	26	69	66
N	18	21	10	1	22	7

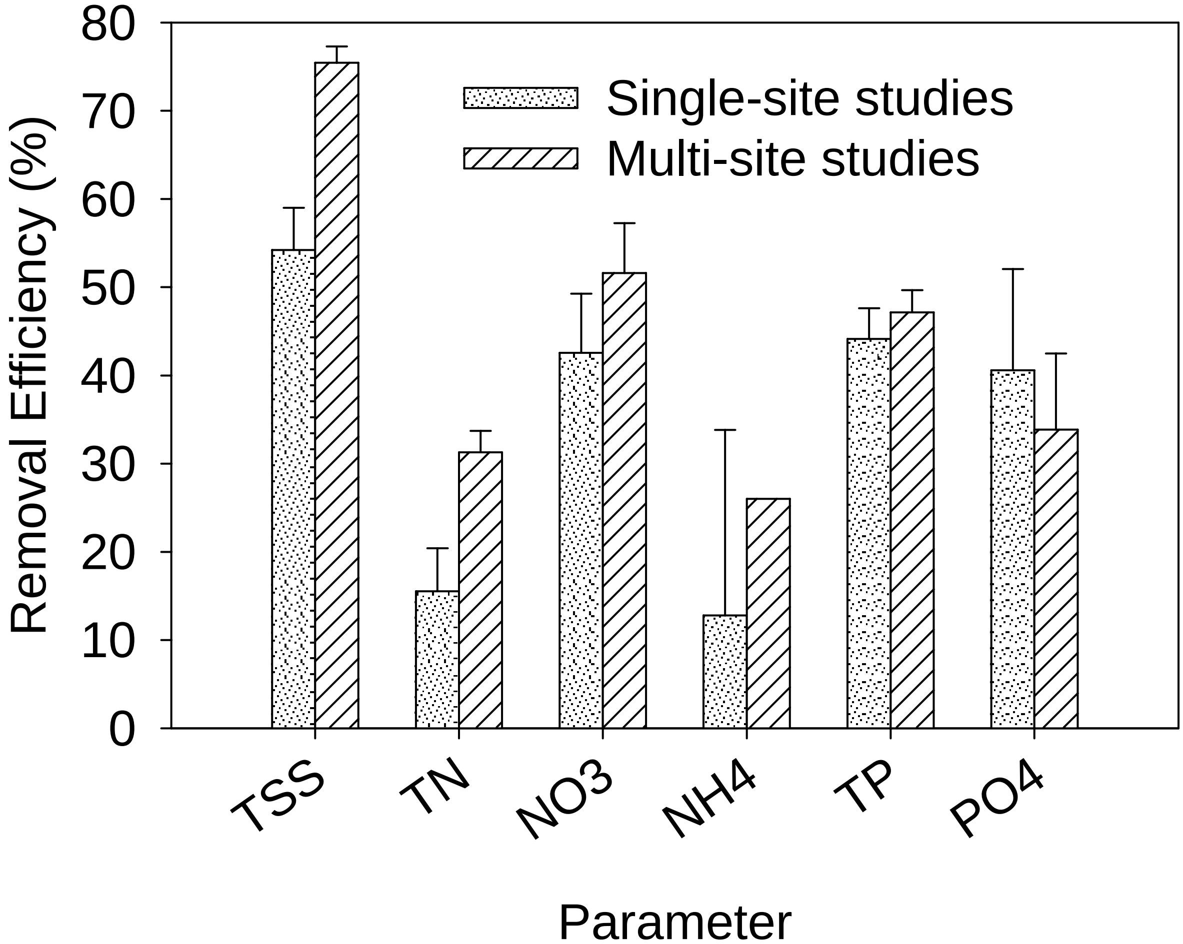

Fig. 1. Summary of removal efficiencies for single- and multi-site studies. Plotted values are mean + SE (see Tables 1 and 2). TSS = Total Suspended Solids, TN = Total Nitrogen, NO3 = Nitrate and/or nitrite, NH4 = Ammonia or ammonium, TP = Total Phosphorus, PO4 = reactive or ortho-phosphate.

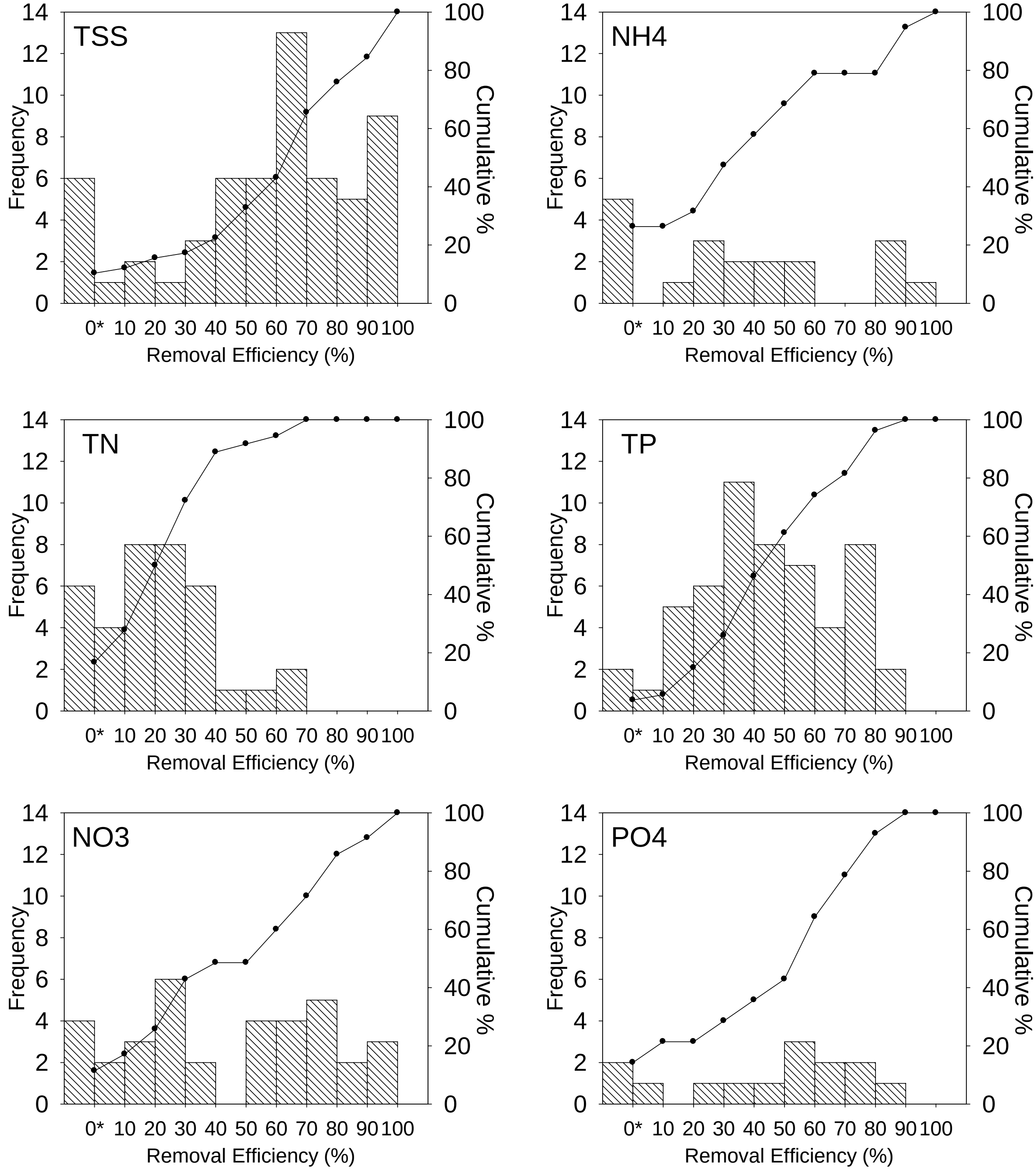

Fig. 2. Frequency analysis of removal efficiencies for single-site studies. Frequency (number of reported values) in removal-efficiency increments of 10 % (e.g. 10-20%, 20-30%, etc.) is plotted on the left axis and as bars. The cumulative percentage of studies reporting values within each removal-efficiency increment is plotted on the right axis as circular symbols connected by lines. The 0* category includes any studies reporting efficiencies of 0% or less (i.e. net efflux).

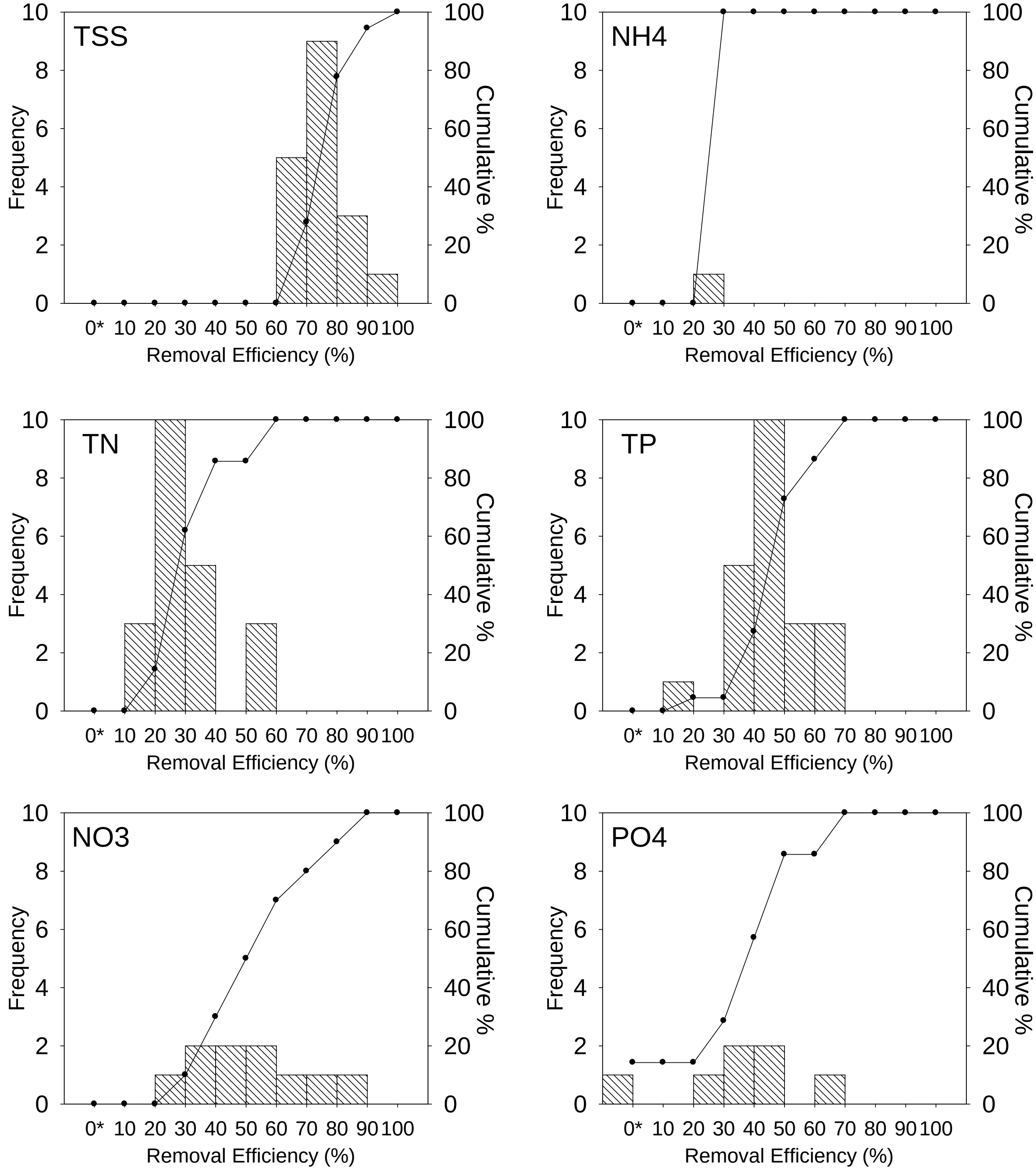

Fig. 3. Frequency analysis of removal efficiencies for multi-site studies. Frequency (number of reported values) in removal-efficiency increments of 10 % (e.g. 10-20%, 20-30%, etc.) is plotted on the left axis and as bars. The cumulative percentage of studies reporting values within each removal-efficiency increment is plotted on the right axis as circular symbols connected by lines. The 0* category includes any studies reporting efficiencies of 0% or less (i.e. net efflux).

Appendix A . Summary of literature on the pollutant removal effectiveness (%) of individual wet ponds and wetlands as Best Management Practices for urban and mixed open land uses. TSS = Total Suspended Solids, TN = Total Nitrogen, NO3 = Nitrate and/or nitrite, NH4 = Ammonia or ammonium, TP = Total Phosphorus, PO4 = reactive or ortho-phosphate. Calculation method:C = concentration-based; L = Load-based; NS = Not specified; O = Other.

System description	TSS	TN	NO3	NH4	TP	PO4	Calc. Method	Comments	Reference
Constructed wetlands					43		NS	Midpoint of range	Lakatos and McNemer (1987) in Olsson Environmental Sciences and Wright Water Engineers (2004)
Extended detention wet pond	76	65	75		70		NS		Yu and Benelmoufook (1988) in FHWA (2007)
In-line wet detention pond	78				20		NS	Pretreatment for wetland system	Martin and Smoot (1986) in FHWA (2007)
Wet pond	54	16	24		30		NS	Pretreatment for wetland system	Gain (1996) in FHWA (2007)
Wet detention pond	85	26	92		54		NS		Harper and Herr (1993) in FHWA (2007)
Wet pond	81	37			54		NS	Westleigh, MD	Driscoll (1983) in USEPA (2007)
Wet pond	91	62	66		79		NS	WaverlyHills, MI	Driscoll (1983) in USEPA (2007)
Wet pond	60				45		NS	Unqua, NY	Driscoll (1983) in USEPA (2007)
Wet pond	64	15	80		60		NS	TimberCreek, FL	Cullum (1985) in USEPA (2007)
Wet pond	45		36		45		NS	SaintJoe'sCreek, FL	Kantrowitz and Woodham (1995) in USEPA (2007)
Wet pond	62				36		NS	RunawayBay, NC	Wu (1989) in USEPA (2007)
Wet pond	32		7		18		NS	Pitt-AA, MI	Driscoll (1983) in USEPA (2007)
Wet pond	93				45		NS	LakesidePond, NC	Wu (1989) in USEPA (2007)
Wet pond	54		97		69		NS	I-4, FL	Dorman et al. (1989) in USEPA (2007)
Wet pond	83	30	28		37		NS	HighwaySite, FL	Martin (1988) in USEPA (2007)
Wet pond	32	6	-1		12		NS	GraceStreet, MI	Driscoll (1983) in USEPA (2007)
Wet pond	85	34			86		NS	FarmPond, VA	Occoquan Watershed Monitoring Laboratory (1983) in USEPA (2007)
Wet pond	-33.3	32			39		NS	Burke, VA	Occoquan Watershed Monitoring Laboratory (1983) in USEPA (2007)

System description	TSS	TN	NO3	NH4	TP	PO4	Calc. Method	Comments	Reference
Wet pond	61		22		45		NS	Buckland, CT	Dorman et al. (1989) in USEPA (2007)
Wet pond	91		87		76		NS	BoyntonBeachMall, FL	Holler (1989) in USEPA (2007)
Wet pond	54	16	24		30		NS	FL	Gain (1996) in USEPA (2007)
Wet extended detention pond	19.6	35.1	65.9		36.5		NS	Piedmont, NC	Borden et al. (1996) in USEPA (2007)
Wet extended detention pond					85		NS	LakeTohopekaligaDistrict, FL	Holler (1990) in USEPA (2007)
Wet extended detention pond	60.4	16	18.2		46.2		NS	Davis, NC	Borden et al. (1996) in USEPA (2007)
Shallow Marsh*	83	26	73		43		NS	Mean removal	Winer (2000) in USEPA (2007)
Extended Detention Wetland*	69	56	35		39		NS		Winer (2000) in USEPA (2007)
Pond/Wetland System*	71	19	40		56		NS	Mean removal	Winer (2000) in USEPA (2007)
Submerged Gravel Wetland*	83	19	81		64		NS		Winer (2000) in USEPA (2007)
Wetland			67	87		62	L	Mesocosm study	Johengen and LaRock (1993)
Wet pond	54						C	Estimated from average of three system designs	Strecker et al. (2001)
Wet detention pond	-37	40	63	83	57	77	C	Silver Stream site	Mallin et al. (2002)
Wet detention pond	-22	-41	-83	-300	-35	-76	C	Echo Farms--golf course site	Mallin et al. (2002)
Wet detention pond	65	-4	5	29	23	7	C	Ann McCrary Site	Mallin et al. (2002)
Wet ponds			87	82		90	NS		Yousef et al. (1986) in Olsson Environmental Sciences and Wright Water Engineers (2004)
Constructed wetlands	67	12					NS	Midpoint of range	USGS (1986) in Olsson Environmental Sciences and Wright Water Engineers (2004)

System description	TSS	TN	NO3	NH4	TP	PO4	Calc. Method	Comments	Reference
Wet detention pond	41	22			29		L	Pond WF	Wu et al. (1996)
Wet detention pond	62	21			36		L	Pond RB	Wu et al. (1996)
Wet detention pond	93	32			45		L	Pond LS	Wu et al. (1996)
Constructed wetland	0		97	100	74		L	Urban golf course runoff	Kohler et al. (2004)
Stormwater wetland	47				38	32	C	Avg of a series of storm events	Rea and Traver (2005)
Detention pond	65						L	Pond/wetland system ("Silver Star Rd")	BMP Database (2007t, u)
Wetland basin	66						L	Pond/wetland system ("Silver Star Rd")	BMP Database (2007v, w)
Wetland basin	72	8.7	57	49	29	48	C	Prince George's Pond, Clinton, MD, N =19-22 storm measurements; calculated from inflow and outflow mean EMCs	BMP Database (2007i, j)
Wetland basin	65	23	55	56	39	69	C	Queen Anne's Pond, Centreville, MD; mistake in analysis reports; this may be PG pond and vice-versa	BMP Database (2007l, m)
Wetland basin	46		23	51	26	52	C	Storm removals reported only; base flow lower removals; May's Chapel Wetland Basin, May's Chapel, MD	BMP Database (2007k)
Wetland basin	22				32		C	Rt 211 Wetland, Sperryville, VA--calculated from mean inflow and outflow EMCs	BMP Database (2007e, f)
Wetland basin	50				65	77	C	Rt 288 Mitigated wetland, Chesterfield, VA--Calculated from stat report Inflow and outflow EMCs	BMP Database (2007a, b)
Wetland basin	75				-42	28	C	Bower's mitigated wetland, Chesapeake, VA--calculated from inflow and outflow mean EMCs	BMP Database (2007g, h)

System description	TSS	TN	NO3	NH4	TP	PO4	Calc. Method	Comments	Reference
Wetland basin	19				20	-6	C	Rio Hill Detention basin, Charlottesville, VA	BMP Database (2007c, d)
Detention pond	-78		-42	14	40		C	Pinellas Detention Pond (FL)	BMP Database (2007x, y)
Detention pond		-1	0	25			C	Duvall County Pond 1 (FL); TP neg but very low conc	BMP Database (2007z, aa)
Wetland	85	55	58	50	75		C	Meggins Creek Marsh (FL)	BMP Database (2007r, s)
Detention pond	-3	2	30	-21	57		C	Waverly Retention Pond (MI)	BMP Database (2007nn, oo)
Detention pond	99						C	SE Landfill Pond (AL)--calculated from mean EMCs	BMP Database (2007jj, kk)
Detention pond	56						C	SE Landfill Pond Small (AL)--calculated from mean EMCs	BMP Database (2007ll, mm)
Detention pond	99	13	56	-126	72		C	DeBary Detention with Filtration Pond (FL)--calculated from mean EMCs	BMP Database (2007hh, ii)
Detention pond	66		76	35	74		C	Tampa Office Rd (FL)--calculated from mean EMCs	BMP Database (2007zz, aaa, bbb, ccc, ddd, eee)
Detention pond	97	47	18	-7	78		C	Lake Munson (FL)--calculated from mean EMCs	BMP Database (2007ff, gg)
Detention pond	35	1	71	39	64	51	C	Cockroach Wet Pond (FL)--calculated from mean EMCs	BMP Database (2007bb, cc)
Detention pond	62	-32	36	-31	54		C	South Central Stormwater Facility (FL)--calculated from mean EMCs	BMP Database (2007dd, ee)
Wetland	73	-47	76	28	55		C	Hidden River Wetland (FL)--calculated from mean EMCs	BMP Database (2007n, o)
Detention pond	94	28	18		73	57	C	Shawnee Ridge Retention Pond (GA)--calculated from mean EMCs	BMP Database (2007tt, uu)
Detention pond	4	21			40		C	Trevor Creek Retention Pond (MI)--calculated from mean EMCs	BMP Database (2007pp, qq)
Detention pond	46	14			7		C	Pittsfield Retention Pond (MI)--calculated from mean EMCs	BMP Database (2007rr, ss)
Wetland	75	-81			46		C	Swift Run Wetland (MI)--calculated from mean EMCs	BMP Database (2007p, q)

System description	TSS	TN	NO3	NH4	TP	PO4	Calc. Method	Comments	Reference
Detention pond	92	14			32		C	Lakeside Pond (NC)--calculated from mean EMCs	BMP Database (2007vv, ww)
Detention pond	64	21			19		C	Runaway Bay Pond (NC)--calculated from mean EMCs	BMP Database (2007xx, yy)

Appendix B . Summary of review studies and design recommendations on the pollutant removal effectiveness (%) of multiple wet pond and wetland sites as Best Management Practices for urban and mixed open land uses. TSS = Total Suspended Solids, TN = Total Nitrogen, NO3 = Nitrate and/or nitrite, NH4 = Ammonia or ammonium, TP = Total Phosphorus, PO4 = reactive or ortho-phosphate. Calculation method: C = concentration-based; L = Load-based; NS = Not specified; O = Other.

System description	TSS	TN	NO3	NH4	TP	PO4	Calc. Method	Comments	Reference
Wet ponds	67	31	24		48		NS	Typical values--N not specifed	Schueler (1997) in USEPA (2007)
Treatment wetlands	71	53	55	26	31	41	L	Includes applications other than stormwater; from North American Wetland Average performance data for surface and subsurface-flow wetlands from the North American Wetland Treatment System Database (Knight et al. 1994); Reductions based on concentration are 72% (TSS), 53% (TN), 62%(NO3), 52% (NH4), 56% (TP), and 37% (PO4)	Kadlec and Knight (1996) in DeBusk (1999)
Wet ponds	65	28	43		46		L	Median removal; review study--values may be based on some previously reported studies	Wossink and Hunt (2003)
Stormwater wetlands	61	22	55		33		L	Median removal; review study--values may be based on some previously reported studies	Wossink and Hunt (2003)
Wet detention ponds	70				60		NS	Midpoint of range	Schueler (1992b) in USEPA (1999)
Wet detention ponds	85						NS	Midpoint of range	Hartigan (1988) in USEPA (1999)
Wet ponds	91	40			40		NS	Midpoint of range	USEPA (1983) in Olsson Environmental Sciences and Wright Water Engineers (2004)
Wet ponds		35			50		NS	Midpoint of range	Hartigan (1989) in Olsson Environmental Sciences and Wright Water Engineers (2004)

Constructed wetlands	71						NS	Mean of 8 projects	Wright Water Engineers (1991) in Olsson Environmental Sciences and Wright Water Engineers (2004)
Stormwater wet ponds	80	33	43		51	66	L, C	Review of 145 stormwater management projects	Winer (2000)
System description	**TSS**	**TN**	**NO3**	**NH4**	**TP**	**PO4**	**Calc. Method**	**Comments**	**Reference**
Stormwater wetlands	76	30	67		49	36	L, C	Review of 145 stormwater management projects	Winer (2000)
Shallow Marsh	83	26	73		43	29	NS	Review; mean of 23 sites	Winer (2000)
Extended Detention Wetland	69	56	35		39	32	NS	Review; mean of 4 sites	Winer (2000)
Pond/Wetland System	71	19	40		56	43	NS	Review; mean of 10 sites	Winer (2000)
Submerged Gravel Wetland	83	19	81		64	-10	NS	Review; mean of 2 sites	Winer (2000)
Stormwater ponds	80	30			50		NS	Design rating based on data, modeling, and professional judgement	Haubner et al. (2001)
Stormwater wetlands	80	30			40		NS	Design rating based on data, modeling, and professional judgement	Haubner et al. (2001)
Submerged gravel wetlands	80	20			50		NS	Design rating based on data, modeling, and professional judgement	Haubner et al. (2001)
Stormwater wetlands	75	25			45		NS	Projected rates for Mid-Atlantic Wetlands	Schueler (1992a)
Wet Ponds		32			46		NS	Calculated from Schueler et al. (1992c)	Camacho (1992)
Wet Ponds/Extended Detention		54			69		NS	Calculated from Schueler et al. (1992c)	Camacho (1992)
Stormwater wetlands		24			47		NS	Calculated from Schueler et al. (1992c)	Camacho (1992)
Wetlands/Extended Detention		21			16		NS	Calculated from Schueler et al. (1992c)	Camacho (1992)

Pond/Wetland systems	29	64	NS	Calculated from Schueler et al. (1992c)	Camacho (1992)

APPENDIX C: STAC REVIEWER COMMENTS
Urban Wet Ponds and Wetlands Best Management Practice
Definition and Nutrient and Sediment Reduction Efficiencies

Review by W.C. Hession, May 6, 2007

1. Evaluation of appropriateness of the proposed definitions and efficiencies
    a. Definitions
        i. I think the CBP should really work on these definitions more fully to ensure clarity. Many of the defined practices are subsets of others and many have overlaps. Some sort of tiered flow chart would be great.
        ii. Wet pond versus Wet extended detention pond – is there a difference? Please clarify and if they are not different, pick one.
        iii. Pocket pond versus pocket wetland: The definitions are essentially the same. I suggest having "Pocket wetlands" and, within that definition, have 2 subsets: Pocket w/pond and Pocket w/no pond. This is typically what you see in practice. Most "pocket" wetlands I have seen do NOT have permanent ponds, the have low "pockets" that retain water, until infiltrated or evapotranspired.
        iv. 6^{th} definition? No "practice" listed. Could be any of these that are used in Appendix A and B, but not defined: "In-line wet detention pond"; "Shallow marsh"; "Stormwater wetland"; "Detention pond".
        v. Related to this, there should be NO systems listed in the appendices that are NOT defined.
        vi. Constructed wetlands – this should certainly have TWO subcategories: Free water surface (FWS) and Subsurface flow (SF). They are VERY different in design, intent, and reduction efficiencies. I am traveling and don't have access to literature to provide definitions of the two subsets, however I would suggest looking in: *Campbell, C.S., and Ogden, M. 1999. Constructed Wetlands in the Sustainable Landscape. John Wiley & Sons, Inc., New York. pg 20.*
        vii. Constructed wetlands – "plant uptake accounts for removal of dissolved constituents" – this is very over-rated, the main benefits of plants/roots is the delivery of oxygen to the subsurface and the creation of addition "sites" for microbial activity.
        viii. Retention pond (wet) versus Retention basin: I don't think there is any difference and that the CBP definition list should pick a single term, then in the definition you could add at the end… (also called "retention basin", "wet retention pond", etc.)
    b. Efficiencies
        i. The resulting efficiencies seem reasonable given the available literature and research.
        ii. I COMPLETELY AGREE with the approach of using "values closer to the mean and median efficiencies of the single-site studies" than those of the "multi-site studies."
        iii. Also, the statement that "the removal efficiencies currently used in the Chesapeake Bay model are optimistic" and that their proposed efficiencies

will help remedy this. It is VERY important that the Bay modeling activities be conservative, rather than "optimistic."

2. Applicability of all referenced data to the Chesapeake Bay watershed
    a. It would help to have the literature cited to see where the references came from. Especially since many the efficiencies listed in Appendix A don't have "location" listed in the "Comments" column. This should be a requirement – in fact, I suggest adding a column specifically listing where the reported study took place.
    b. Many of the listed efficiency are from Florida. I suspect these are very different condition than in the Chesapeake Bay watershed. Perhaps they should have had less weight in the averaging?
    c. However, given the limited amount of good studies of removal efficiencies, I do believe it was appropriate to use whatever they could get their hands on.
3. Specific concerns not addressed (future research needs)
    a. My main concern is the lumping of this incredible array of practices into a single removal efficiency number. Perhaps subdivision into 3-4 for "categories" of urban wet ponds and wetlands would be an option. Then different efficiencies could be applied to the different practices.
    b. Uncertainty – we should NOT be reducing these efficiencies to single numbers. If nothing else we should retain some information about the inherent variability (SD, Var, 75^{th} percentile, anything). The model should then be run to reflect the possibility of less or more reduction.
    c. We need more research to find out what impact "mitigation wetlands" might be having on reducing nutrients to the Chesapeake Bay. To my knowledge, we are not currently taking (or giving) credit for this. However, I do understand that the reason wetland mitigation takes place is because another wetland was lost somewhere. Regardless, we need to know more about how this impacts the Bay.
    d. We need research to better know how to take an existing "detention" practice and retrofit it to provide a more ecological, wetland-like system that would reduce nutrients
    e. There are thousands of "ponds" (some stormwater, some recreational/scenic) in the Chesapeake Bay that are highly eutrophic and, during events, the nutrients are flushed out to the receiving stream. We need to develop "practices" to remove these nutrients while we have them "trapped" and before they are flushed. See the following for information about how many of these ponds there are: *Smith, S.V., Renwick, W.H., Bartley, J.D., and Buddemeier, R.W. (2002). "Distribution and significance of small, artificial water bodies across the United States Landscape." Science of the Total Environment, 299, 21-36.* And see the following about how these nutrients are typically flushed to the local stream system: *Hogan, D.M., and Walbridge, M.R. (2007). "Best management practices for nutrient and sediment retention in urban stormwater runoff." Journal of Environmental Quality, 36, 386–395.*
4. Additional concerns
    a. None to report at this time.

<u>Miscellaneous Editorial Comments</u>

1. Appendix A – no explanation for footnote (*)

Appendix D. References used to develop BMP effectiveness estimates and in jurisdictional design manuals

Statements have been made that the Mid-Atlantic Water Quality Program -University of Maryland wetland and wet pond report by Dr. Andrew Baldwin does not include studies used in state design manuals, National Urban Runoff Program data, and Center for Watershed Protection (CWP) literature (Winer, 2000- the database). Upon reviewing the report it is apparent Dr. Baldwin included the aforementioned studies. In PA's manual other studies are cited but the vast majority are from the CWP database; VA's draft regulations reference the database; MD's manual used the database to determine its design requirements. Both PA and MD stormwater design manuals reference the Center for Watershed Protection (CWP) National Pollutant Removal Performance Database for Stormwater Treatment Practices when citing the source of its BMP efficiencies. The MAWQ-UMD report on urban stormwater wetlands conducted by Dr. Andy Baldwin uses this database, the 1997 and 2000 editions, when calculating efficiencies. The database is referenced as Brown and Schueler, 1997 for the earlier edition and Winer, 2000 for the later edition. These manuals do not utilize all studies from the CWP database while Dr. Baldwin's report uses the 145 studies from the 2000 manual, along with other studies.

Not only did Dr. Baldwin include the CWP BMP database information from 1997 (used to develop MD's design manual), he also used the updated 2000 report (used in PA manual). CWP is publishing updates to the 2000 database in the summer of 2007 and VA used this updated database for its design manual. Tom Schueler sent the appendix that includes the additional 20 studies added to the database, most additions relate to bioretention and do not change the pollutant removal estimates for wetlands and wet ponds, but later requested this information not be used as there was an error in the pollutant removal tables.

In PA's manual for wet pond/ retention basin 37 studies are listed of which 7 are not from Winer 2000. Nine referenced reports in the manual are included in the MAWQ report under the single study category. However, the remaining references not listed in the single study analysis are captured in the multi study analysis. Including both the individual/single study analysis and multi study analysis 32 of 37 referenced literature from PA's manual is included in the wetland and wet pond report by Dr. Baldwin. In PA's manual under constructed wetlands Winer 2000 is the reference for all but one study listed. Again Winer 2000 is the CWP database and it is also referenced in the wetland and wet pond report under the multi study category.

Under the multi-study category in Dr. Baldwin's report 145 stormwater management projects were used to calculate the mean for stormwater wet ponds. PA's manual lists 36 projects under this category. In Dr. Baldwin's report 145 stormwater management projects were used to calculate the mean for stormwater wetlands. 8 are used in PA's manual. The mean of 23 sites was used to calculate an efficiency for shallow marshes in Dr. Baldwin's report; 13 in PA manual. The mean of 4 extended detention wetland sites was used in Dr. Baldwin's report to calculate an efficiency; 5 in PA's manual.

In addition to the CWP BMP database used in the jurisdictional design manuals and in the analysis to refine wetland and wet pond BMP effectiveness estimates for the CBP, NURP studies are included in Dr. Baldwin's report.

Appendix E. Meeting Minutes

URBAN STORMWATER WORKGROUP CONFERENCE CALL
May 29, 2007

- The current efficiencies in the model are 80% for TSS, 30% for TN, and 50% for TP. Andy recommended that these efficiencies be reduced to 60%, 20%, and 45%. UMD recommended that these efficiencies be reduced even further to 50%, 15%, and 40%.
- The efficiencies in PA's BMP manual are similar to the current efficiencies for this practice, with the exception of TP reductions which are higher in the PA manual.
- One concern is that the proposed efficiencies for wet ponds are not very different from the proposed efficiencies for dry ponds. Workgroup members had expected the wet pond efficiencies to be higher than the dry pond efficiencies. Right now, many areas are trying to retrofit from dry to wet to get higher efficiencies. The efficiencies proposed by UMD and Andy would discourage this.
- This analysis looked at a large number of studies. The number of single-site studies for TSS, TN, and TP ranged from 40-62 and the number of multi-site studies ranged from 18-22.
- The median efficiencies for the single site studies are lower than the median efficiencies for the multi-site studies. Did the multi-site studies ignore studies with negative efficiencies? If so, this may be causing their median efficiencies to be higher.
- Q: Should studies with negative numbers be included in this analysis?
  - A: Some members thought that negative numbers should be thrown out because they may indicate a failing or malfunctioning system. UMD decided to include the negative numbers in their analysis because using all data, including negative numbers, is a realistic representation of what is there. If we are looking at operational conditions, these factors need to be taken into consideration.
- The efficiencies for this practice should be conservative due to maintenance issues. This was the approach that was taken when the efficiencies that are currently being used in the model were developed.
- The USWG recommended that UMD evaluate PA data used to develop the efficiencies for their handbook, comment on negative efficiency studies and the appropriateness of

- using them, and determine whether their studies are weighted towards regions that are not similar to the Chesapeake Bay watershed (for example, FL).
- DECISION: The USWG rejected both Andy Baldwin's and UMD's recommendations, citing that efficiencies were too low. The USWG will make their own recommendation to the TSWG on June 4th. They are pushing for efficiencies that are more in line with the multi-study references instead of the individual studies, some of which report negative efficiencies.

Minutes: Tributary Strategy Workgroup Meeting
June 4, 2007
10:00 AM to 3:00 PM
NRCS MD State Office, Annapolis

- The MARWP recommended reduction efficiencies less than what the expert reviewer recommended. The USWG recommended using the current efficiencies.
- ACTION: The USWG will write up a formal recommendation for their proposed reduction efficiencies of urban wetlands and wet ponds with documented reasoning. The USWG and the MARWP will present their different recommendations to the TSWG and/or the NSC when it is time to make the final decision.
- ACTION: Andy Baldwin, the expert efficiency developer for urban wetlands and wet ponds, will provide a short piece to the workgroups that clearly explains why his recommendation for wet pond efficiencies is very close to the dry pond efficiency recommendations.
- ACTION: The MARWP will ensure that their analysis included studies and data used by the states in their stormwater manuals and handbooks.
- DECISION: The TSWG will wait to make a decision until the USWG formally presents their proposed recommendations and Andy Baldwin provides the logic behind his suggested efficiencies.

URBAN STORMWATER WORKGROUP CONFERENCE CALL
June 26, 2007

IV. MAWP/UMD BMP Definitions and Efficiencies Simpson and Weammert

- At their May 29th conference call, the USWG reviewed the year-one urban BMP definitions and efficiencies that MAWP/UMD is proposing as part of an EPA-CBP funded project.
- Following are the decisions made by the workgroup during the May conference call:
  - Wetlands and Wet ponds: The USWG rejected both Andy Baldwin's and MAWP's recommendations, citing that efficiencies were too low.
- Based on their review during the May conference call, workgroup members felt that the proposed efficiencies for these practices did not take into account all relevant studies. In order to address these concerns, members were given until June 8th to submit additional references to MAWP.
- After reviewing the additional information provided by workgroup members, MAWP has decided that their recommendations for the year-one urban BMPs will remain unchanged. At

today's conference call, Tom Simpson, UMD, and Sarah Weammert, UMD, explained their reasoning for this decision. The handout that was distributed to the group explains their approach for BMP efficiency development. It can be accessed at http://www.chesapeakebay.net/calendar.cfm?EventDetails=8034&DefaultView=2.

- The main pieces of literature that USWG members asked MAWP to look at were the design manuals for the different jurisdictions, NERP data, and the Center for Watershed Protection (CWP) database. MAWP found that all of these sources were included in Andy Baldwin's BMP reports (Andy Baldwin developed the proposal documents for each of these practices).
- BMP projects from the CWP database were used to develop VA draft regulations and MD and PA stormwater design manuals. Upon further evaluation of all sources considered in the development of the urban wetland and wet pond practices, it was found that the developer had included the sources from the design manuals in his multi-site analyses. The analysis by the database developer includes the median values for all 145 studies used in the 2000 version of the Center for Watershed Protection database. In addition, some single site studies from the database are also included in the developers single site analyses. The 2007 CWP database will not be published until later this summer.
- ISSUES: Two concerns that the USWG had at the May conference call were: (1) MAWP's proposed efficiencies are based on single-site studies rather than multi-site studies and (2) the analysis includes studies with negative efficiencies. The USWG would instead like to base the efficiencies on multi-site studies and omit studies with negative efficiencies.
- MAWP decided that they would not change their recommended efficiencies based on the above two concerns. The developer and the STAC reviewer stated that the values closer to the mean and median efficiencies of the single-site studies should be used to determine effectiveness rather than those of the multi-site studies. In regards to negative efficiency studies, MAWP thinks that they should be included because these situations do occur operationally in real world situations. Also, negative efficiencies that have been published have undergone a rigorous scientific review.
- At the WQSC meeting it was suggested that statistics be provided for the studies in the analyses. These statistics are already listed in the reports for the year-one urban BMPs.
- ACTION: Workgroup members should submit ideas for future Bay Program needs (such as additional practices, changes in the overall approach to practices, ect.) to MAWP. It is beyond the scope of their project to address these needs, but they will include a list of issues that need to be addressed in their report.
- This project is not trying to define an efficiency for the perfect example of this practice. It is instead trying to identify an efficiency that characterizes this practice as it functions on broad application in the landscape and reflects real-world operational conditions.
- The workgroup needs to look at the definitions for wetlands & wet ponds and urban erosion & sediment control because there seems to be conflicting opinions between the developer, the reviewer, and the workgroup.

V. Workgroup Recommendations **All**

- The workgroup discussed what their next steps should be and whether or not they would like to approve the MAWP recommendations or submit their own separate recommendations to the Tributary Strategy Workgroup on July 9th.
- Q: What does the rest of the review process look like for these BMPs?

- A: MAWP's recommendations and the source workgroup recommendations will be presented to the TSWG on July 9th, to the NSC on August 15th, and to the WQSC in mid to late August. STAC is also concurrently reviewing MAWP's work. They will provide two reports for the TSWG to review at their August 6th meeting. One report will look at the process MAWP is using to come up with these efficiencies and whether or not it is sound and the second report will look at whether or not the BMP efficiencies make sense when you look at them across the board. Essentially, STAC is evaluating whether or not this combination of science and judgment is appropriate for what we are doing and if it is consistent, logical, and valid. They are not evaluating the efficiency number.

- The proposed efficiencies are based on both science and best professional judgment. We need to know where the science ends and where the best professional judgment begins. This is addressed in the individual BMP reports.
- ISSUE: Concern was voiced over the difference between the MAWP efficiencies and the efficiencies used in state regulations and programs.
    - DE is not including efficiencies in their regulations, however other states, such as VA, need to include efficiencies.
    - CWP is developing efficiencies for the VA regulations. It would be helpful if VA could provide the workgroup with their proposed state regulation efficiencies before the July TSWG meeting.
    - MD's efficiencies were also developed by CWP and they differ from MAWP's recommendations.
    - Some of the states feel that they can not support the MAWP proposed efficiencies if they are different from their state efficiencies.
    - The efficiencies used in the CBP model and the efficiencies in the state regulations are different because the efficiencies were developed with different assumptions and are intended for different purposes. The state efficiencies describe what a BMP is capable of achieving if operation, design, and maintenance are optimal (best case scenario), whereas the efficiencies used in the Bay Program model describe what is happening operationally across the watershed from a realistic standpoint, taking into account maintenance issues, errors in design, etc.
    - There is currently no information that shows that the Bay region is operating at a much more effective rate than the rest of the country. Inspection reports and monitoring data are not available. If this type of data did exist, then MAWP could have factored it into their analysis.
    - It was pointed out that the state efficiencies and the MAWP proposals were developed using essentially the same data, however they are both looking at it differently from a statistical analysis standpoint.
    - It was suggested that the USWG write an issue paper that discusses this need for consistency with state stormwater programs and how it may play out. This paper could explain what the workgroup would ideally like to see and how it is backed up by the data.
    - It was also suggested that the different objectives and assumptions for state efficiencies and Bay Program efficiencies be documented.

- Q: Who is going to make the final decision regarding what efficiencies are used in the Bay Program model?
    - A: Ideally, the TSWG and the NSC will make the final decision. However, if a decision cannot be reached by these groups, then the decision will have to be made by the WQSC.
- ISSUES: As mentioned earlier, the USWG thinks that multi-site studies rather than single-site studies should be used and that studies with negative efficiencies should be omitted.
- STAC has been made aware of the USWG's concerns and they are looking closely at the above two issues.
- Q: Why do we still track individual BMP practices in the watershed model? Instead, could we look at the number of acres meeting performance standards?
    - A: Individual BMP practices are tracked in the model due to a previous decision made by the workgroup. The model could be based more on performance standards if monitoring information and data were available. We need to have a way to monitor the performance standard. You can't make a blanket assumption that you have 100% performance standard compliance.
- It was suggested that the USWG's argument may be stronger if it was more technical. For example, the workgroup could explain why the states didn't use all of the studies that MAWP used, why they omitted negative efficiencies, why their numbers are better, etc. It would be useful if the argument was linked to MAWP's recommendations.
- ACTION: Representatives from the USWG need to attend the July 9th TSWG meeting in order to present the workgroup's argument and recommendations. Norm Goulet, workgroup chair, will be unable to attend. Sally Bradley will send workgroup members the agenda for the July 9th TSWG meeting when it is available.
- ACTION: It would also be helpful if someone would write down the workgroup's concerns and the justification for their proposed approach. This draft document could then be emailed to the workgroup for comments.

VI. Meeting Adjourned

- The meeting was adjourned at 12:20 pm.

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MINUTES: TRIBUTARY STRATEGY WORKGROUP MEETING
July 9, 2007
10:00 AM – 1:30 PM
NRCS MD State Office

Urban BMPs

- Reggie Parrish updated the TSWG on the status of the urban BMPs review process.
- The USWG has been addressing three areas of discrepancy:
  - Wetlands and Wet Ponds: The USWG believed the proposed efficiencies were too low.
  - Dry Detention Ponds and Hydrodynamic Structures: The USWG accepted the proposed Dry Detention Ponds efficiencies but wanted to separate out Hydrodynamic Structures into its own BMP. The workgroup believed the existing efficiencies should remain unchanged for Hydrodynamic Structures.
  - Urban Erosion and Sediment Control: The USWG rejected the proposed efficiencies and requested more work in this area before it is revisited.
- The USWG has been preparing their own recommendations for urban BMPs and providing Tom and Sarah with additional information that they believe should be considered.
- The USWG made various suggestions for the literature review process. First, the USWG suggested that the literature that finds negative efficiencies from the BMPs be eliminated in the review. The USWG also suggested that only multiple-site studies be used in the literature review, not single-site studies. Finally, the USWG did not believe enough attention was given to the state stormwater manual efficiencies.
  - Tom and WQSC members believed studies with negative efficiencies should be factored into the literature review.
  - Tom explained that all of the data behind the state stormwater manuals was used, and more, in the literature review process. The suggested efficiencies given in the manuals were not directly used, however, because they represent a target efficiency to shoot for, not an actual average widespread implementation efficiency.
  - ACTION: Tom and Sarah will clarify in their report that although the state stormwater manuals "target" efficiency was not directly used in the literature review, the data behind the state stormwater manuals, and more, were used in developing the recommended efficiencies.
- Reggie proposed 3 options on behalf of the USWG (who had not yet reviewed the document) for moving forward with the urban BMPs:

- Option 1: Proceed with a different set of efficiencies for state/local and CBP.
  - Kelly Shenk thought it would be useful to understand the different purposes that the partnership uses the BMP efficiencies for. For example, CBP is interested in showing the average reduction of loads across the watershed, by using the model as a projection tool for necessary management actions.
    - Reggie explained that local governments have a scale issue with the BMP information, as some states are looking at a series of BMPs and how they function rather than just looking at a single BMP.
  - Virginia is in the process of developing regulations based on their BMP efficiencies. VA was in favor of Option 1 for defensibility reasons as they more forward with their regulations.
  - Helen did not wish for Option 1 to move forward because she believed consistency is necessary. MD's local governments demand consistency.
- Option 2: Work with modelers to determine feasibility and possibility of not changing the urban BMP efficiencies until year 2 BMPs are revised in the model.
  - Helen confirmed that the BMP efficiencies won't make a dent in the model but are important for planning options, TMDLs, trading, etc.
  - Kelly thought this option may be worth exploring but that more time may not provide more data to inform our decision, it would just prolong the deadline for making a decision. Likewise, we're given the opportunity make these changes in the model simultaneously right now. Waiting until year 2 may be impossible politically.
- Option 3: Shift from a single BMP efficiency approach to a systems approach.
  - Most states are looking at this issue holistically, so the USWG is asking if this review process is our opportunity to change course and start to look at BMP efficiencies holistically.
  - Ken Pensyl informed the workgroup that some BMPs do not get accounted for because they have no drainage area associated with them, however the broad spectrum of runoff from development could be addressed using a systems approach.
  - DECISION: The workgroup agreed that moving to a systems approach as outlined in Option 3 is the best way to move forward.
    - Tom confirmed that they could support a systems approach but that data to document the hydrology of the landscape are necessary.
    - The systems approach would factor in landscape conditions such as slope and soil type.
    - Kelly agreed by saying that a lot of states are heading in this direction of performance-based approaches. We will still need to determine what the realistic reduction is that we can expect to achieve with the performance-based approach.
    - The USWG wants to collect performance data on different types of land uses across the region.
- Although the workgroup agreed to pursue Option 3, this shift to a systems approach could take years, so a more immediate solution is still needed for proceeding with the BMP efficiencies for the model.

- Kelly suggested that the efficiencies be developed by first starting with the state stormwater manuals as the design standards for the BMPs and then applying a margin of safety based on the data collected by the MARWP.
- Referring back to our adaptive management approach, Kelly suggested we use the MARWP's recommended efficiencies as the conservative estimate to be fed into the model until we have monitoring data and can make adjustments.
- DECISION: The USWG will discuss the options for moving forward in the short-term with the urban BMP efficiencies, considering the TSWG's input.
- Helen suggested that looking at each BMP's margin of safety could help us to decide the appropriate margin of safety to use for the urban BMPS.
- ACTION: Per Tom's suggestion, the USWG will figure out a way to include the negative efficiency studies in their efficiency recommendations because their dismissal cannot be justified.

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Urban Stormwater Workgroup Conference Call
July 25, 2007
Minutes

- Reggie Parrish, workgroup coordinator, began the meeting at 10:10 am. Introductions were made and the meeting's agenda was reviewed.

- At the July 9th Tributary Strategy Workgroup meeting, Reggie presented the USWG's concerns regarding the UMD/MAWP proposed efficiencies to the TSWG. Three potential options were suggested that were based on previous USWG conference calls.
- Based on the discussion at the TSWG meeting, two additional options have also been proposed. All five of the options are listed in the handout for today's call, which can be accessed at: http://www.chesapeakebay.net/calendar.cfm?EventDetails=9014&DefaultView=2. The TSWG strongly supported option C, but recognized that the workgroup would need to propose a short-term solution if this option were chosen.
- At the July 9th TSWG meeting, the TSWG asked the USWG to develop a specific position that they can formally submit to the TSWG, the Nutrient Subcommittee and ultimately the Water Quality Steering Committee.
- During today's conference call, we had hoped to come up with a specific position supported by the USWG; however, since many key players were unable to participate in today's call, conference call participants decided that the call should be rescheduled for sometime next week and that we should postpone making a decision on the workgroup's position until that time.
- The USWG needs to decide on a position before the next TSWG meeting, which is being held on August 6th.
- Q: How do our no net increase efforts relate to the BMP efficiency efforts?
    - A: We are not sure exactly how these efforts are related yet. The performance based systems approach, which is one of the proposed BMP efficiency options, seems like it would be relevant to no net increase efforts.
- Q: What is the definition of no net increase?
    - A: In PA, they are trying to move forward with the concept of no net change rather than no net increase. The Stormwater and New Development Taskgroup did not define no net increase at their last meeting. It is important to point out, however, that we do not want the efficiencies to get bogged down with the no net increase issue. We still need the efficiencies in the more short term timeframe.
- Q: Right now, the states are only providing the Bay Program with data on implementation. What data would need to be provided for option E (see handout) to show that the BMP is properly designed, inspected, maintained and operating? It seems like a lot of data would be needed. Do we have this information?
    - A: We are not exactly sure yet what data would be needed for this option. One suggestion was that if a state could ensure that a good O and M plan was in place, then maybe this could ensure a higher efficiency. Before choosing this option, the workgroup would really need to explore it further.
- Workgroup members were interested in how the other sectors chose their efficiencies in the Bay model and what data they used to do this.
- In other sectors, it is not assumed that the BMPs reported meet design standards and are properly maintained. Essentially, they apply a safety factor for long-term maintenance. This is also why UMD/MAWP adjusted their efficiencies down.
- It was pointed out that there is not long-term data available for most BMPs. It is just a matter of ensuring implementation. In PA, there is an inspection program to ensure that BMPs are properly installed.

- Compared to focusing on individual BMPs, a systems approach would be more in line with state design manuals.
- Q: Is there any documentation of the discussion that took place to develop PA's BMP manual?
    - A: There is some documentation, however it is not very detailed.
- Some participants thought that implementation information and water quality monitoring (to show that you are getting the expected results) should be all of the data that is needed.
- Option D (see handout) says that state manuals use efficiencies that describe optimal performance, but that Bay Program and UMD/MAWP efficiencies acknowledge that BMPs do not work optimally all of the time in the real world.
- PA pointed out, however, that the Bay Program and UMD/MAWP efficiencies are based on single BMPs and in PA they use a combination of BMPs that this approach does not capture. In reality, these are being looked at as systems and multiple BMPs are being relied on to achieve results. Using a systems approach is option C in the handout.
- Could the urban sector use an approach similar to the ag sector's conservation plans, which is essentially a suite of BMPs?
- A systems approach could develop different efficiencies for various tiers of a system.
- It was suggested that we default to state standards and then add some sort of qualifier on that shows that they are not achieving their goals 100%.
- Some participants felt that option E (see handout) is sort of the "do nothing option" and that it pushes the decision to a later point in time.
- The model calibration period is from 1985 to 2004. For stormwater management in PA, the Bay Program has one number for each year that covers the entire watershed portion of the state. Jeff Sweeney needs to know what efficiency should be applied to these stormwater management acres. PA agreed to follow up on this issue for Jeff.
- Essentially there appear to be two issues: 1) what we need immediately for calibration, and 2) what we will use in the future.
- Q: If we come up with some numbers for calibration and then we come up with different efficiencies to be used for future planning, we would have to revise those efficiencies in the model, correct?
    - A: Yes. Jeff said that this could be done though.
- One concern that was voiced was that members do not want to see efficiencies lowered based on historic expectations, compared to future expectations. It was suggested that we have two separate efficiencies for 1985-2000 and 2000 and beyond.
- For whatever position they choose, the USWG needs to provide supporting documentation equivalent to what UMD/MAWP provided for all of the other BMPs.
- Q: Did UMD/MAWP separate out dry detention ponds and hydrodynamic structures, as was proposed at the May 29th conference call?
    - A: These practices were combined based on the categories created previously by the USWG. As far as Reggie and Sally know, UMD/MAWP did not make any revisions to their proposals to separate out these practices. Reggie will contact Sarah Weammert, UMD/MAWP, to find out whether or not they made this change.
- During today's conference call, there seemed to be general agreement that we need to look at a systems approach on a more long-term basis. However, in the short-term we really need to decide on some way to assess BMP efficiency for model calibration.

- Reggie Parrish will set up a call for sometime this week between Ken Murin and Norm Goulet so that they can further discuss a potential USWG position on BMP efficiencies.
- The meeting was adjourned at 11:30 am. A date for next week's conference call will be sent out to workgroup members as soon as it is selected.

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Urban Stormwater Workgroup Conference Call
August 1, 2007

- Norm Goulet, USWG chair, began the conference call at 9:30 am. Introductions were made and the meeting's agenda was reviewed.
- All of the handouts for today's conference call can be accessed at: http://www.chesapeakebay.net/calendar.cfm?EventDetails=9016&DefaultView=2
- The purpose of this conference call was to come up with a workgroup position on urban BMP efficiencies. This position needs to be presented by the workgroup at the next Tributary Strategy Workgroup Meeting, which is being held on August 6th.
- Highlights from the STAC review of the UMD/MAWP BMP efficiency process include:
    - STAC agreed with UMD/MAWP on the use of negative efficiencies. They said that the Chesapeake Bay model must be calibrated to function with operational rather than research BMP efficiencies. Hence, if reported negative efficiencies reflect operational conditions, STAC felt that they should be considered in an assessment of the BMP efficiency literature.
    - STAC stated that peer-reviewed literature should be given more weight than state BMP manuals. They do not consider state manuals to be peer-reviewed since they were not subjected to independent examination.
    - STAC commented on the fact that some experts used the lack of research data to justify deep discounts of the few reported efficiencies, while other experts refused to change current efficiencies because of the lack of research data. STAC said that they hope that such a situation was anticipated, and that the charge to the expert specifically stated how such situations were to be handled.

- In the workgroup's draft position paper, the following three specific concerns are listed: 1) negative studies should be eliminated, 2) single site studies should not be used, and 3) state manual BMP efficiencies not appropriately considered.
- It was thought by some members that the biggest workgroup concern, which is not listed, is that the efficiencies are based on historic data. More recently, the states have increased volumes, changed their strategies, added pre-treatment, and changed BMP design criteria. These changes are not reflected in the studies that UMD/MAWP used to come up with their efficiencies. Members thought that the efficiencies that UMD/MAWP proposed may be good for BMPs that were put on the ground between 1984 and 2000, but not for more recent BMPs.
- The calibration period for the CBP model is from 1985-2002. Thus, based on the above comments, it seems that the efficiencies from UMD/MAWP would be appropriate to use for model calibration. This is our immediate need.
- Post-construction BMPs are a bigger issue than construction BMPs. They should be the focus of the information that states report to the CBP office.
- Norm proposed that the following modifications be made to the USWG's position paper:
    - Acknowledge that the UMD/MAWP numbers are incorrect for a variety of reasons.
    - State that the workgroup will, however, accept the efficiencies from UMD/MAWP with the stipulation that they have the option to increase the efficiencies later if sufficient data is available to show that they are achieving higher efficiencies.
    - The UMD/MAWP numbers will be used in the upcoming model calibration.
    - The UMD/MAWP efficiencies will only be used for one year. During that time, we will work towards switching to a systems approach.
    - If a systems approach is not developed within one year, then the default is still the UMD/MAWP numbers.
- It was suggested that we have an on-going evaluation of the BMPs to determine how they actually function in the long-term.
- Ideas for how we could develop a systems approach include:
    - Two systems could be developed: ultra-urban and a more suburban approach. Each of these would have different values.
    - Gather information from each state since different states have different soils, slopes, etc. Maybe a research group could look at this and come up with calculated values for the land use. This would be similar to what UMD did for the BMP efficiencies.
    - Unfortunately, there is not much monitoring data out there.
    - Right now, CBP efforts should focus on just sediments and nutrients. Maybe later they could expand this effort to include other pollutants.
    - The systems must be something that we know we can track in the future.
- The workgroup will develop a funding proposal for a project that will research and potentially develop a systems approach. In addition, the workgroup may need to develop its own report that they will pass up to the Tributary Strategy Workgroup and the Nutrient Subcommittee.
- There is a protocol for peer review on the Bay Program website.

- Q: Will we be able to get CBP funding for this project?
    - A: After a proposal is developed, it can be taken to the Budget Steering Committee. However, there is unlikely to be money available from the CBPO at this time due to a budget shortfall. Therefore, we may need to be creative and look for other funding sources. It was pointed out that there was no CBPO money available for the UMD BMP efficiency project either, but we were able to gain the Budget Steering Committee's support for this project and another source of funding was found.
- Q: Can UMD's scope of work be modified so that they look at the systems approach in year 2 of their BMP project?
    - A: It is unlikely, but Kelly Shenk will look into this just in case. It will depend on how much of a departure this is from the project's original scope. Even if we can get them to look at the systems approach in year 2, their review will not be as extensive as what the workgroup was discussing earlier. If we are going to switch to a systems approach, maybe we no longer need UMD to look at infiltration practice efficiencies in year 2. Perhaps we could replace this with gathering data on the systems approach.
- Q: Could we use the UMD efficiencies for the model calibration period, and then use the state BMP manual numbers when we do implementation runs later?
    - A: No. The state BMP manual numbers cannot be used.
- Q: What do we do in the mean time while we are developing this systems approach?
    - A: It was suggested that we use the UMD efficiencies unless the states have data that shows that they are achieving a higher efficiency.
- Workgroup members decided to accept the position laid out in today's handout once Norm's proposals (see above) are included. Reggie will revise the handout so that it includes Norm's proposals and text on model calibration and historic vs. future values.
- Norm and Reggie will present the workgroup's position at the August 6th Tributary Strategy Workgroup meeting. Information on this meeting can be found at http://www.chesapeakebay.net/calendar.cfm?EventDetails=8816&DefaultView=2.

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Minutes: Tributary Strategy Workgroup
August 6, 2007
Chesapeake Bay Program Office—Fish Shack

Urban BMPs

- DECISION: The TSWG agreed with the USWG's recommendations to use the developer's recommendations for the Urban Wetlands and Wet Ponds efficiencies.

- The USWG does not concur with the report's findings. Sarah and Tom tried to address the workgroup's concerns.
- The USWG's main concerns are that the literature do not reflect current design requirements, the literature is dated, negative studies and single site studies are included, and that state manual BMP efficiencies are not appropriately considered.
    - Some of the urban BMPs use single site studies while others use multi and single site studies.

Urban Wetlands and Wet Ponds:

- Across the board, states do not find the MARWP recommendations acceptable.
- The median efficiency of 64 for TSS was similar to the developer recommendation of 60; however, MARWP recommended an efficiency of 50.
- The USWG would like to see the efficiencies be consistent with the developer's recommendations of 60 for TSS, 20 for TN, and 45 for TP.
- The developer was reluctant to lower the literature values because he was not considering operational results. MARWP lowered the efficiencies to reflect real-world implementation.
- Norm believed that by including negative efficiencies, operational variability is accounted for.
    - Tom added that there are other circumstances where the efficiencies would be lower than expected beyond just design problems.
- DECISION: The TSWG agreed with the USWG's recommendations to use the developer's recommendations for the Urban Wetlands and Wet Ponds efficiencies.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
August 15, 2007

- Norm Goulet, Urban Stormwater Workgroup Chair, presented the recommended BMP efficiencies for urban wetlands and wet ponds, urban erosion and sediment control, dry extended detention basins, and dry detention ponds/basins and hydrodynamic structures.
- The USWG is recommending these efficiencies with some caveats. The way urban BMPs are modeled needs to change from stand alone BMPs to a systems approach. Until that can be accomplished, these BMP recommendations should be used to calibrate the model along with additional data from the jurisdictions.
- There is also concern that the CBP recommended efficiencies are not always consistent with the efficiencies provided in state handbooks. If facilities can provide documentation regarding implementation, maintenance, and inspection processes, are the handbook efficiencies acceptable? Will this cause confusion?
- It was noted that there is also a difference in efficiency if a jurisdiction has a strong enforcement program. Stronger enforcement leads to more maintenance at facilities and higher efficiencies.
- Was consideration given to splitting dry ponds and hydrodynamic structures since they behave differently? Consideration was given; however, there is not a lot of recent information available regarding hydrodynamic structures and each state handles these structures differently which makes it difficult to develop a stand alone BMP efficiency rating.
- A concern was raised regarding super-load areas in the Phase 5 model. They seem reasonable in applied to highly disturbed areas only; however, they would not be accurate if applied to whole acreages. The Tributary Strategies Workgroup will take a look at this issue and report back to the NSC.
- It will be necessary to update the CBP website to clearly link urban BMPs with their efficiencies and to explain the transition from Phase 4.3 to Phase 5 of the CBP model to make it more understandable to users.
- Infiltration and filtering processes were omitted from the MAWP year 1 project scope but will be included in year 2. It is valuable to examine these BMPs even if the model eventually moves to a systems-based approach as it will take time to make the needed changes to the model and the jurisdictions are currently implementing these BMPs.

- What about N and P speciation? How effective are BMPs at treating various forms of N and P? There is not enough information available to develop general rules about the various N and P species; however, this issue will be highlighted in the MAWP report as a research need.
- The recommended urban BMPs were approved.

Efficiency Recommendation	TN	TP	TSS
Urban Wetlands and Wet Ponds	20	45	60
Urban Erosion and Sediment Control	25	40	40
Dry Extended Detention Basins	20	20	60
Dry Detention Ponds/Basins and Hydrodynamic Structures	5	10	10

Participants

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Chesapeake Bay Program
Water Quality Steering Committee
Conference Call
August 27, 2007

SUMMARY OF DECISIONS, ACTIONS AND ISSUES

Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

DECISION: The Water Quality Steering Committee approved the 12 BMP definitions and efficiencies, described in the advance briefing papers, as recommended by the Nutrient Subcommittee and its workgroups for use in Phase 5 Chesapeake Bay Watershed Model.

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WETLAND RESTORATION AND WETLAND CREATION BEST MANAGEMENT PRACTICES (AGRICULTURAL)

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in the Phase 5.0 of the Chesapeake Bay Program Watershed Model

Consulting Scientist

Tom Jordan, Ph.D.
Smithsonian Environmental Research Center
Chemical Ecologist

Synthesis Agreement by

Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary

Wetland Restoration and Creation:
Wetland Restoration: Returning natural/historic functions to a *former* wetland. Results in a gain in wetland acres. Nutrients and suspended particles are removed via settling. Nitrogen is further removed primarily via plant and microbial uptake and nitrification-denitrification reactions, while phosphorus is further removed by soil sorption.

Wetland Creation: Developing a wetland that did not previously exists on an upland or deepwater site. Results in a gain in wetland acres. Nutrients and suspended particles are removed via settling. Nitrogen is further removed primarily via plant and microbial uptake and nitrification-denitrification reactions, while phosphorus is further removed by soil sorption.

- TN and TP removal depends on wetland size, see page 10 for effectiveness estimates; TSS is 15% regardless of wetland size

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University Of Maryland (UMD) led a project during 2006-2007 to review and refine definition and effectiveness estimates for BMPs implemented and reported by the Chesapeake Bay watershed jurisdictions prior to 2003. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

Attached to this report is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix C.

Definition/Description

The Chesapeake Bay Program will utilize the following definitions to classify wetland restoration on agricultural land and wetland creation:

Re-establishment (restore) – Manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a *former* wetland. Results in a gain in wetland acres.

Establishment (create) – Manipulation of the physical, chemical, or biological characteristics present to develop a wetland that did not previously exists on an upland or deepwater site. Results in a gain in wetland acres.

This BMP report discusses the water quality benefits of wetland restoration and wetland creation. The literature search for this report captures the water quality benefits that wetlands provide and literature on the wildlife, mitigation wetlands, and natural wetlands is not discussed. In addition these systems are not designed to treat wastewater, as they are not designed like a stormwater facility, nor intended to have the same maintenance as a stormwater facility.

These wetland treatment system designs have an even flow distribution and adequate retention time. The temporal variability of water flow through wetlands also results in variability of water detention times, which in turn affects the removal efficiencies. The longer water is detained within a wetland the more material may be removed from the water within the wetland. As flow variability increases the effective water detention time decreases and therefore the removal efficiency decreases (Jordan et al. 2003). It is intuitively clear that a wetland with steady water flow is likely to have higher removal rate than a wetland with the same amount of annual flow concentrated during a few days of high flow. Understanding these temporal flow conditions is absolutely necessary to provide estimated effectiveness.

Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Components included in the Wetland Restoration Practices on Agricultural Land, and Wetland Creation, include, but are not limited to the following USDA-NRCS conservation practices:

- Constructed Wetland (656)
- Wetland Creation (658)
- Wetland Restoration (657)

Restored versus created wetlands

It is important to distinguish wetland restoration from wetland creation. Agricultural wetland restoration activities re-establish the natural hydraulic condition in a field that existed prior to the installation of subsurface or surface drainage. In contrast, “wetland creation” establishes a wetland in a place where none previously existed. Created wetlands may use artificial or highly engineered hydrology. Often created wetlands have regulated water inputs, with water being pumped or fed in at steady controlled rates. In contrast, restored wetlands generally have natural or unregulated water inputs, with water entering through surface or subsurface flows at variable uncontrolled rates.

Efficiency

Using guidelines for efficiency development (see Appendix B) and the report below, effectiveness estimates for wetland creation and wetland restoration will be determined utilizing the contributing drainage area and wetland area equation supplied by Dr. Tom Jordan, SERC.

Total Nitrogen and Phosphorous

The efficiency of removal of waterborne materials by wetlands is often expressed as the percentage of the inflowing material that was removed in the wetland. Absolute removal rates may also be given in units of mass per wetland area. For example, Mitsch et al. (2000) suggest that sustainable removal rates range from about 5 to 50 kg ha^{-1} yr^{-1} for P and 100 to 400 kg ha^{-1} yr^{-1} for N. Removal rates are generally thought to follow first order kinetics, where the rate of removal is proportional to the concentration of the substance in the water. Many studies have found evidence supporting first order kinetics, but it does not always apply. For example, Braskerud (2002) found that the rate of removal of suspended sediment increased with sediment concentration faster than would be predicted by first order kinetics. Also, there are upper limits to absolute rates of removal, which prevent removal rates from rising indefinitely with increases in concentration. However, the general tendency of removal to follow first order kinetics makes it very useful to express efficiency as the percentage of inflowing material removed because this percentage will be relatively constant with variation in concentration.

Effects of wetland size and water detention time on efficiency

Changes in factors relating to soil, vegetation, or hydrologic conditions may alter the effectiveness of wetlands for removal of suspended solids or nutrients. For example, longer detention times will in general tend to improve efficiency due to increased contact between water and soil or microbial surfaces and vegetation, as well as longer times for settling of particulates. Longer detention times can be created by increasing the area or volume of wetlands relative to drainage area entering the system, or conversely by reducing the volume of runoff entering the wetland. Efficiency can also be affected by the geomorphology of the unit; designs that maximize the area of contact between water and soil, vegetation, or microbial surfaces should in general increase efficiency (e.g., long, linear wetlands with shallow water depth are likely to be more effective than deep, concave basins of the same volume).

The efficiency of removal will vary as a function of the size of the wetland. For example, if a 1 ha wetland removes 50% of the total N it receives from agricultural runoff and if another similar 1 ha wetland is restored downstream to remove 50% of the total N it receives in discharge from the first wetland, then the combined 2 ha wetland system will remove 75% of the total N received from agricultural runoff. Also, a 1 ha wetland would likely remove a greater percentage of material from discharge of a 10 ha watershed than from discharge from a 100 ha watershed. The effect of size is related to the ratio of wetland area to watershed area and probably reflects the detention time of water within the wetland. The longer water is detained within a wetland the more material may be removed from the water within the wetland due to increased contact between water and soil or microbial surfaces and vegetation, as well as longer times for settling of particulates. The detention time is the water volume of the wetland divided by the rate of water inflow. This varies with the area of the watershed and the area of the wetland. Thus, we would expect to find relationships between the removal efficiency and the ratio of the wetland to watershed areas. Simple models have been developed to account for these size effects.

The processes that remove materials

Waterborne materials removed by wetlands are either stored within the wetland or converted to gaseous forms and released to the atmosphere. Since P has no important gaseous phase it can only be accumulated within the wetland. Usually, most of the P discharged from watersheds is bound to particulate matter. Therefore, sedimentation of particulate matter is an important process for P removal. Particulate N and organic C may also be trapped by sedimentation. N and P may be taken up by plants, algae, bacteria, and fungi, and, thus be converted to particulate organic forms, which may accrete in the wetland. However, dissolved inorganic N and P may be released from organic matter as it decomposes. Wetland vegetation can enhance sedimentation by slowing water velocity, reducing turbulence, and providing surfaces for particle adhesion (Braskerud 2001). N, organic C, and especially P can be held in wetland sediment by adsorption. However, sites of surface adsorption have a finite capacity and can eventually become saturated.

It is important to note that the capacity of a wetland to accumulate particulate material is limited because the trapped material will eventually fill the wetland to the extent that incoming waterborne particles will pass through without being trapped. Reservoirs similarly fill up with sediment eventually. As wetlands fill with sediment or accumulated organic matter, their holding capacity and detention time for water decreases gradually diminishing their capacity to remove particles from incoming water.

The microbial process of denitrification can convert nitrate N to nitrous oxide, nitric oxide, or nitrogen gases, which may be released to the atmosphere. Unlike accretion processes, denitrification can continue indefinitely. Denitrification requires organic matter and a lack of oxygen, conditions often found in the waterlogged soils of wetlands. Like N, organic C can be converted to gaseous forms (carbon dioxide and methane), which are released to the atmosphere rather than accumulating in the wetland. Rates of these biotically mediated processes generally increase with temperature.

<u>Variability of removal efficiencies</u>

Although restored wetlands have significant potential to remove waterborne materials such as nutrients and sediments from watershed discharges, the efficiency of removals is highly variable. For 29 annual measurements the average total N removal efficiency was 20%, with a standard error of 3.7, and a range of -12% to 52%. For 36 annual measurements, the average total P removal efficiency was 30%, with a standard error of 5 and a range of -54% to 88%.

Some of the variance in efficiencies is due to size differences. These effects would be best evaluated by comparing the water detention times among wetlands. However, data needed to calculate water detention times are seldom reported. The ratio of the area of the wetland to the area of the watershed is a possible surrogate for water detention time and is more often available. Tonderski et al. (2005) developed a simple model to account for variability in the ratio of areas. Their model predicts a nearly linear increase in removal efficiencies as the percentage of the watershed area occupied by wetlands increases (Fig. 1). This modeled relationship looks useful for predicting the effect of wetland restoration but actual measurements show much less predictability (Fig. 2).

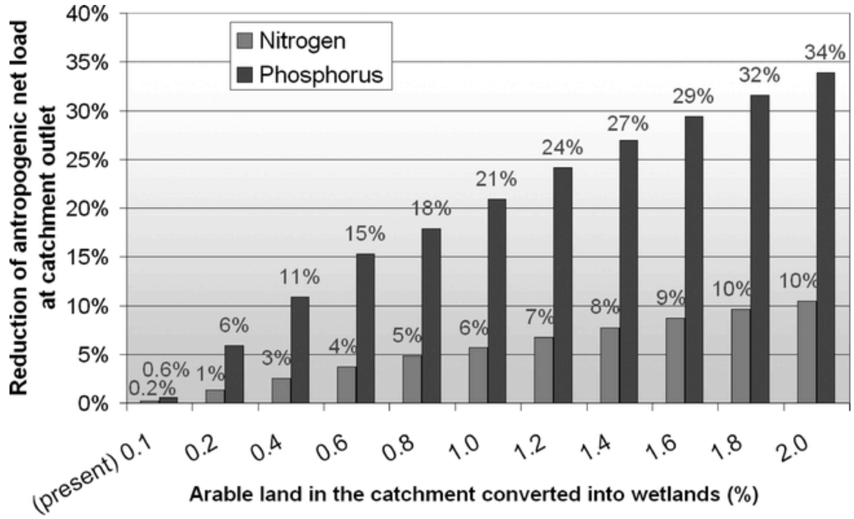


Fig. 1. Modeled effect of wetlands on anthropogenic net load at the catchment scale. Different proportions of catchment wetland areas were considered in the HBV-NP model (figure and caption from Tonderski et al. 2005).

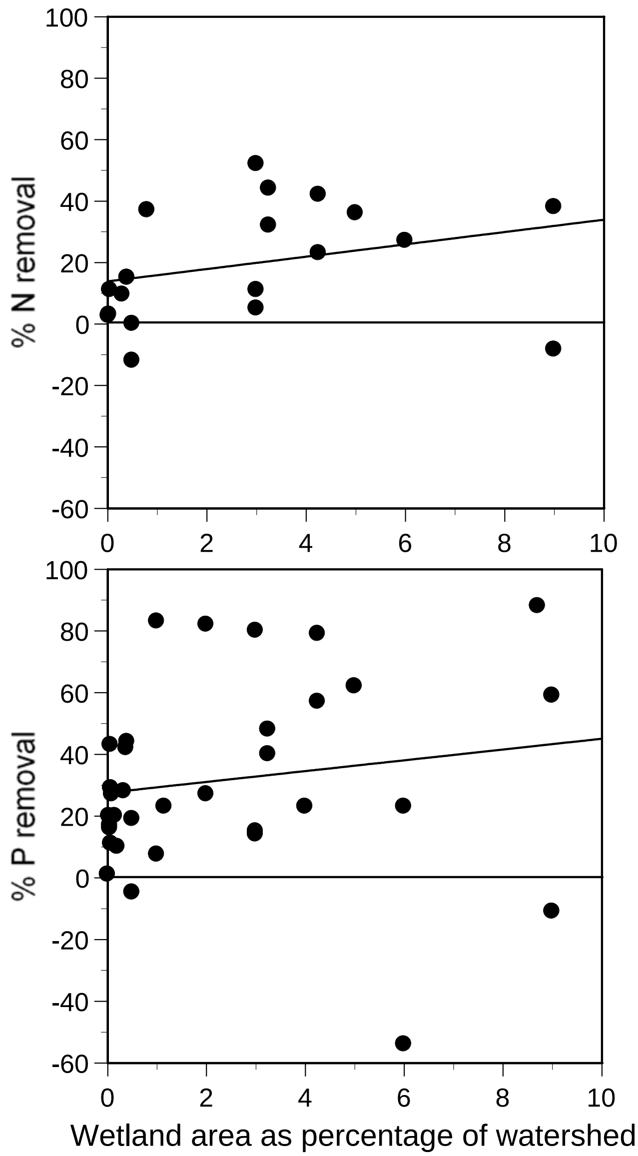


Fig. 2. Percentages of N or P removed annually versus the wetland area expressed as a percentage of the watershed area. Sloped lines are fit by linear regression. Most of the data points represent different wetlands but some are for different years for a given wetland. Data are from references marked with asterisks in the bibliography.

The temporal variability of water flow through wetlands also results in variability of water detention times, which in turn affects the removal efficiencies. As flow variability increases the effective water detention time decreases and therefore the removal efficiency decreases (Jordan et al. 2003). It is intuitively clear that a wetland with steady water flow is likely to have higher removal efficiencies than a wetland with the same amount annual flow concentrated during only a few days of high flow. The effect of flow variability is vividly illustrated by data from

Reinhardt et al. (2005) (Fig. 3.) They found that efficiencies of dissolved reactive phosphorus removal (or retention) over two-day periods varied with water detention (or residence) time as well as with the concentration, and followed patterns consistent with a model they developed. Flow variability is influenced by rainfall patterns and increases with the proportion of impervious surface in a watershed. Restored or created wetlands receiving unregulated inflows may be equipped with flow control structures that decrease flow variability. For example, wetland drains may be designed to allow continued slow outflow after high flow events, thus creating capacity to hold water inputs from subsequent events.

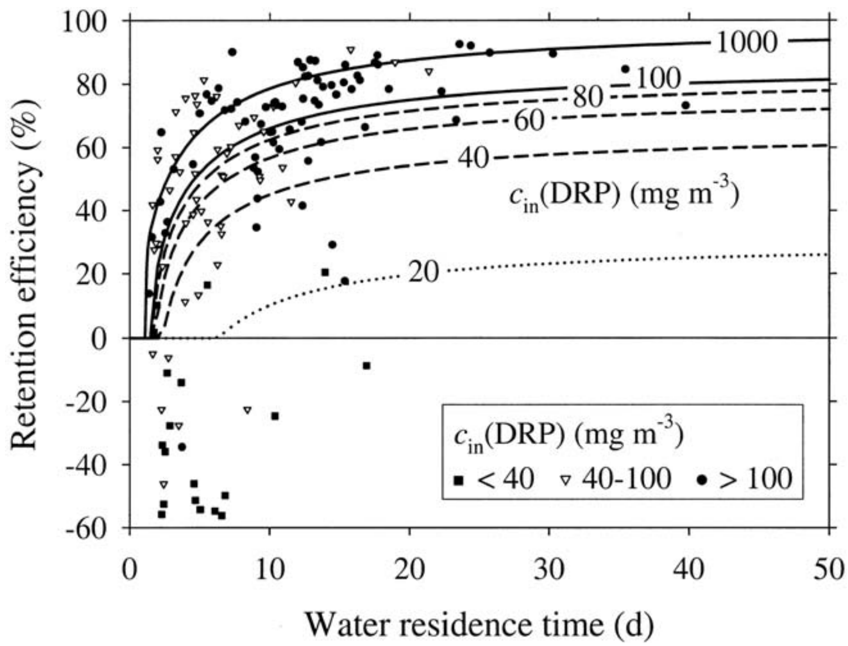


Fig. 3. Retention efficiency of dissolved reactive (bioavailable) phosphorus (DRP) predicted by the model (lines) and observed in Wetland Sonnhof in 2001 (symbols) as a function of water residence time and concentration of dissolved reactive phosphorus at the inlet c_{in}(DRP). Line styles and symbol types indicate DRP inlet concentration. Two-day retention efficiency was calculated according to Eq. [15]. Twenty-two data points ranging between –60 and –500% (τ: 1–6 d) are not shown (figure and caption from Reinhardt et al. 2005).

Effects of wetland age

Removal efficiencies are likely to vary with the age of the wetland although there are few data available to quantify this. When a wetland is first restored or created, it may lack vegetation. This would likely reduce removal efficiencies because vegetation can assimilate nutrients, enhance sediment trapping, and provide organic matter to support denitrification. Initial rapid increases in vegetation biomass may enhance accumulation of nutrients and organic matter.

Later when the wetland vegetation is fully established, the rate of biomass increase will slow, thus reducing the accumulation of removed materials in biomass. As wetlands fill with sediment and biomass over time, their water holding capacity and water detention time decline, diminishing their ability to trap and accumulate new material. Although denitrification does not depend on accumulation of material in the wetland, the reduction of water detention time would also limit N removal by denitrification.

The likely effects of wetland age lead to two important conclusions. First, the effectiveness of a newly restored wetland may improve as vegetation becomes established and organic matter becomes available to support denitrification. It probably takes at least one year, possibly several, for a restored wetland to reach its full potential removal efficiency. Second, a wetland will eventually fill in and loose its capacity to remove waterborne materials. To restore this capacity the wetland would need to be excavated and the accumulated material removed. Periodic excavation would require a long-term commitment of effort and might also require special legal provisions.

Effects of improper maintenance

While no studies have specifically evaluated how BMP efficiencies should be adjusted to account for the impacts of improper maintenance on receiving waters, some general adverse effects to water quality are understood. If maintenance is neglected a BMP will become impaired, no longer providing its designed functions.

In addition sediment accumulation is one concern that if not addressed will adversely affect the BMPs effectiveness. As sediment accumulates it decreases storage volume and detention time, bypassing the intended functions of the BMP and increasing discharge of nutrient and sediment rich water (Livingston et al. 1997). Increased discharge will lead to decreased downstream channel stability, resulting in an increase of sediment loads and a reduction in available aquatic habitat. The consequences of increased discharges from sediment filled BMPs, are a reduction in the BMPs pollution removal efficiencies, and ultimately, increased ecological impairments. The uncertainty in how improper maintenance will adjust BMP efficiencies supports the recommendation to use a more conservative percent removal estimate.

Properly designed wetlands should require little or no maintenance for long-term treatment. However, periodic inspections should be performed to identify changes in hydrology, vegetation, or soils like those described above so that remedial measures can be taken in necessary. Particularly when systems are new, it is important to make sure water levels are suitable for the growth and persistence of wetland vegetation. Development of channels or other evidence of erosion should be dealt with expeditiously, for example by diverting some portion of the runoff, installing rock berms, or otherwise decreasing flow velocities in the BMP.

Effects of flow paths

Removal efficiencies may also be affected by the pathways of flow through the wetlands. For example, even dispersal of water flow over the entire wetland area maximizes removal efficiency by maximizing the area of the wetland's microbes, soil, or vegetation that is interacting with the through-flowing water. If surface water flow follows a short cut from the wetland inlet to outlet while bypassing the main area of the wetland, the effective water detention time is reduced. Persson et al. (1999) discuss design features that improve the dispersal of water (hydrologic efficiency). Both surface- and groundwater flow can follow by passes. Velledis et al. (2003) noted that nitrate removal efficiency of a riparian wetland was reduced by groundwater flowing through limited preferential flow paths. Groundwater flow may be more effective than surface water flow in delivering nitrate for denitrification because groundwater can inject nitrate, which is formed in oxygenated environments, directly into anoxic water logged sediments where as nitrate entering a wetland in surface flow must diffuse slowly downward into anoxic sediments.

Effects of climate change

Climatic variables may also affect BMP performance over time, either positively or negatively. Periods of greater precipitation will likely result in shorter residence times, or even bypassing of the BMP due to high flow volumes, both of which will reduce performance. On the other hand, higher temperatures should increase metabolic rates, increasing growth of microbes and plants and facilitating greater transformation and uptake of nutrients. Global climate change may therefore affect performance by changing precipitation patterns and temperature in unpredictable ways. An additional factor is higher CO2 concentrations, which may result in shifts toward species competitively favored under high atmospheric CO2 levels. Changes in species composition may have some effect on performance, although effects are likely to be small unless there are large changes in stem density or biomass.

Predicting Removal Efficiency

Removal of total N and P by restored wetlands can be predicted from the relationship between the percentage of N or P removed and the percentage of the watershed occupied by wetland receiving discharge from the entire watershed. We assume that removal proceeds exponentially with detention time, as expected with first order kinetics. We also assume that detention time (wetland volume divided by water flow rate) is proportional to the percentage of watershed occupied by wetland. This follows if water discharge is proportional to watershed area and if different wetlands have similar average depths. Finally, we assume that there is no removal if there is no wetland area (i.e., the curve must go through the origin). Based on these assumptions:

$$\text{Removal} = 1 - e^{-k\,(\text{area})}$$

Where "removal" is the proportion (not percentage) of the input removed by the wetland, "area" is the proportion of the watershed area occupied by the wetland, and "k" is a fitted parameter.

We used non-linear regression (SAS 2004) to fit this equation to data from studies reported in the literature.

Some studies reported negative removal values (i.e. a net export from the wetland) but negative values could not be used for our simple model. When negative removal occurred in particular years but not on the average (e.g. Kovacic et al. 2000, Jordan et al. 2003), we used the average removal percentage in fitting our model. In rare cases where only negative removal was observed, we omitted the observation from our analysis. Omission was only needed for total P removal by one of the wetlands studied by Kovacic et al. (2000) and total N removal by one of the wetlands studied by Koskiako et al. (2003).

While microbial removal processes that affect nitrogen removal are sustainable indefinitely under relative constant environmental conditions, soil surfaces may become phosphorus-saturated, and further phosphorus sorption is therefore not possible. Depending on the soil type and phosphorus loading rates, saturation may take many years, if it occurs at all. Phosphorus can also be sequestered in undecomposed plant material (i.e., peat) under certain waterlogged conditions in wetlands; however, if hydrology is altered, oxidation and decomposition of plant parts may release the phosphorus (and nitrogen) they contain. Capacity for sediment removal may also be impeded if high loading rates result in clogging or burial of vegetation. Additionally, high flow rates may lead to the formation of preferential flow pathways that reduce contact between water and microbes, soil, or vegetation. These and other variables may lead to changes in the efficiency of wetlands or wet ponds for stormwater quality improvement over time. Some processes may increase efficiency (e.g. peat formation) while other processes may simultaneously decrease efficiency (e.g. channel formation).

The non-linear regressions produced values of the k that can be used in the equation above to predict the proportion of total N or P removed based on the proportion of wetland area in the watershed. For total N, k=7.90 with lower and upper 95% confidence limits of 4.56 and 11.2. For total P, k=16.4 with lower and upper 95% confidence limits of 8.74 and 24.0. The proportion removed increases with the proportion of wetland area but the rate of increase declines as the proportion of wetland area increases (Fig. 4). Thus, the additional benefit of adding more wetland area gradually diminishes. The curves fit to the literature data are very similar to predictions of the more complex watershed scale models of Tonderski et al. (2005) (shown in Fig. 1 of the report for which this addendum applies).

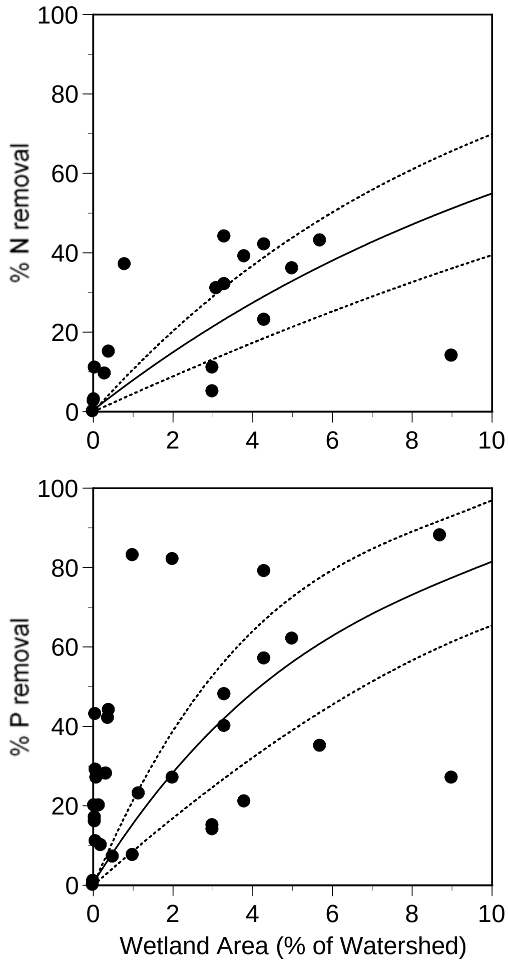


Fig. 4. The percentage of total N (top) or P (bottom) removed in wetlands versus the percentage of wetland area in the watershed. The curves are fit by non-linear regression to literature data on annual removal efficiencies after eliminating negative values of removal (see text). The dotted lines indicate the upper and lower 95% confidence interval. The data point at the origin is assumed by the model.

Reporting

In the event a jurisdiction does not report the area of the wetland or drainage area a one percent, two percent and four percent ratio of area of wetland to area of watershed will be used for the Appalachian, Piedmont and Valley, and Coastal Plain, respectively. Using the equation supplied by Jordan the effectiveness estimates for each geomorphic region are determined (Table 1).

Table 1. TN, TP and TSS removal efficiencies for wetlands broken down by geomorphic region.

Geomorphic Province	TN Removal Efficiency	TP Removal Efficiency
Appalachian (1% wetland area)	7%	12%
Piedmont and Valley (2% wetland area)	14%	26%
Coastal Plain (4% wetland area)	25%	50%

We assume wetland area increases moving from upland to lowland regions. The assigned wetland areas for each geomorphic area are based on natural hydrology and topography found in each region and is best professional judgment based on those natural conditions. As topography decreases, becomes flatter, wetland size increases. Surface and subsurface flow paths are clearly defined in upland regions, while these flow pathways interact to a greater degree with flatter terrain, providing more available area for larger wetland areas in coastal regions.

Total Suspended Solid

There are less data on removal of total suspended solids (TSS) then on removal of total N or P. The percentage of TSS removed averaged 21.6 (standard error 9.9) for five annual removal rates from Koskiaho et al. (2003) and two annual rates from Jordan et al. (2003). More data would be needed to determine the relationship between TSS removal and percentage of wetland area in the watershed.

The CBP approved effectiveness estimate for total suspended solid removal is 15%. This is calculating using the average from seven annual removal rates of 20%. Per our guidelines the average efficiency was adjusted because the research projects used to calculate the average do not always represent operational conditions (see Appendix B).

Other factors that adjust efficiencies not captured by the equation

While the use of wetland area as a percentage of the watershed is a step in the right direction it does not address all factors that adjust efficiencies. Wetland age, seasonal variation, spatial and temporal variability of flow, landscape (position or type of wetland) will change residence time and loadings, consequences of land use conversions, and sediment accumulation is not addressed by the graph. Some studies have data that shows how efficiencies will be altered around these factors but no current method for calculating efficiencies for all these factors exists. To assist the CBP in future reviews that determine how to refine wetland creation efficiencies, the following studies are summarized.

Craft and Schubauer-Berigan (2007) surveyed the literature to evaluate the role of landscape position, hydrologic connectivity, loading rate and wetland age on nitrogen (N) and phosphorus (P) removal by freshwater wetlands. N and P removal is three times greater in connected (floodplain, fringe) wetlands than depressional wetlands. In floodplain wetlands, 8-15 MT N/km^2 and 1-3 MT P/km^2 are sequestered annually in soil as compared to 3 MT $N/km^2/yr$ and 0.5 MT $P/km^2/yr$ for depressional wetlands. Denitrification removes an additional 3 to 15 MT of $N/km^2/yr$ under low nitrate loadings. N removal is sustainable over the long-term (Fig. 5). Nitrogen removal is stimulated by increased nutrient loading, mostly through greater Denitrification, and, in highly loaded wetlands, N removal may exceed 10-50 $MT/km^2/wetland/yr$.

Nichols and Higgins (2000) determined that over an 18 year period nitrogen removal was consistent. However, phosphorous removal is variable. Increased nutrient loading also boosts P removal though P removal (1-5 $MT/km^2/yr$) is an order of magnitude less than N. Nichols and Higgins (2000) observed increasingly high phosphorous removal up to year 6, then removal drastically decreases around year 11 and finally remains consistently lower (Fig. 6). And P removal declines with time as sedimentation reduces water storage capacity and sorption sites become saturated. Floodplain wetlands can remove around 200 kg N ha annually and up to 600 kg ha yr under high nitrate loading rates. Creation, restoration and enhancement of wetlands for nutrient and sediment removal must recognize that (i) nutrient removal not consistent throughout the year (ii) P retention high at first but decreases with time as sorption sites become saturated and over a longer time scale sedimentation reduces wetland water storage capacity (iii) legacy effects (long term fertilization, drainage, soil oxidation) of re-flooding agricultural land may initially release P and possibly N, iv) not all wetlands are equal when it comes to nutrient removal, (v) N removal is greater than N removal, and (vi) effective N removal is sustainable over time but P removal declines as wetland age (Fig. 7).

Figure 5.

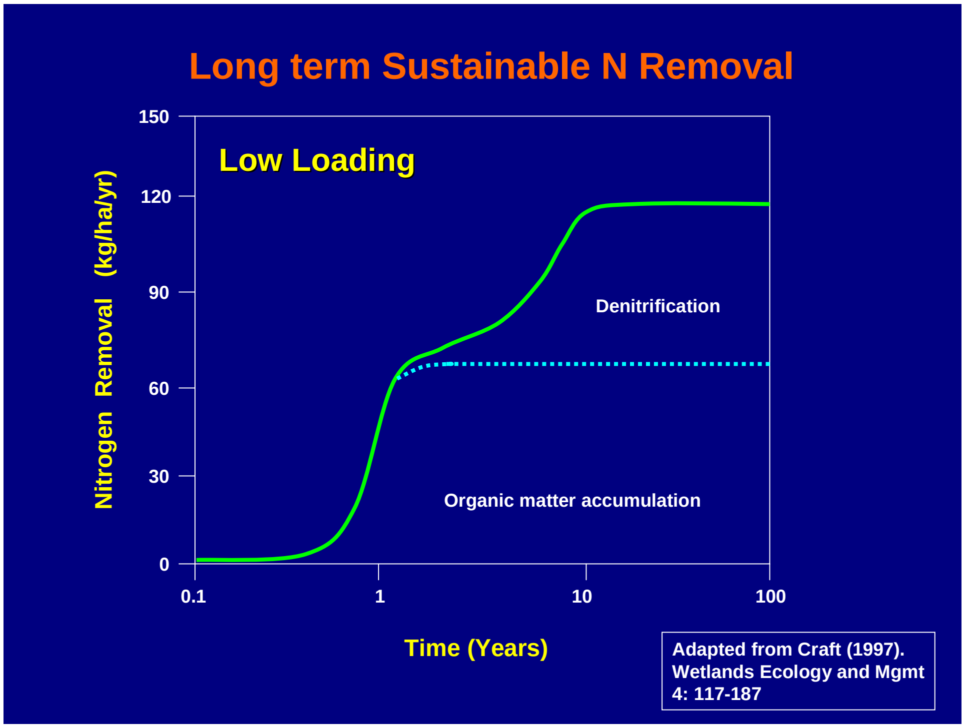


Figure 6.

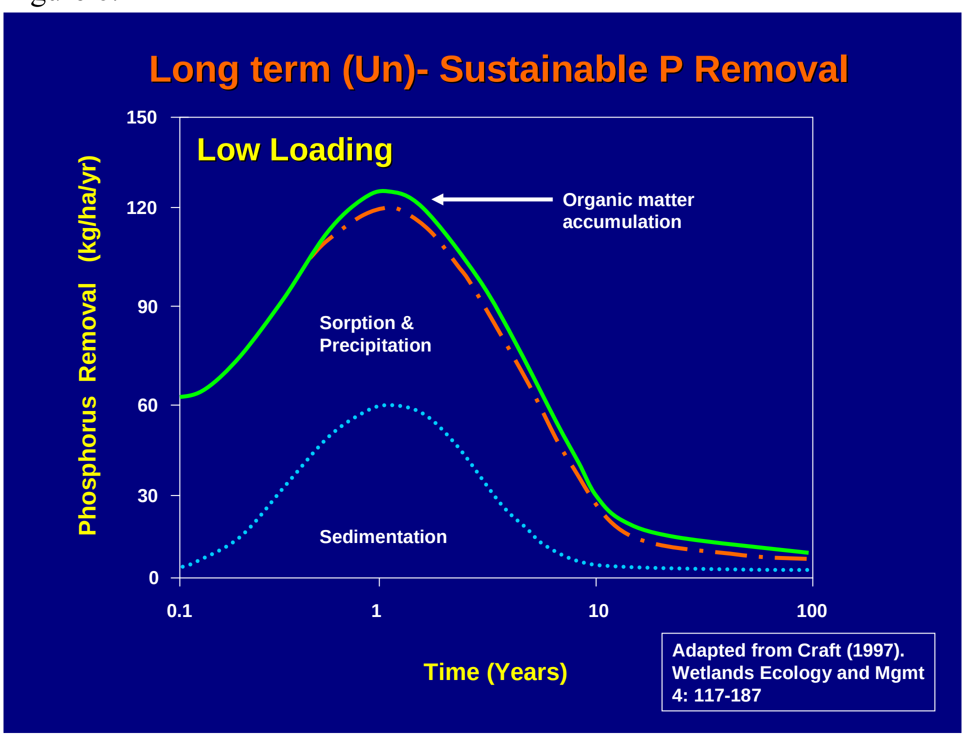
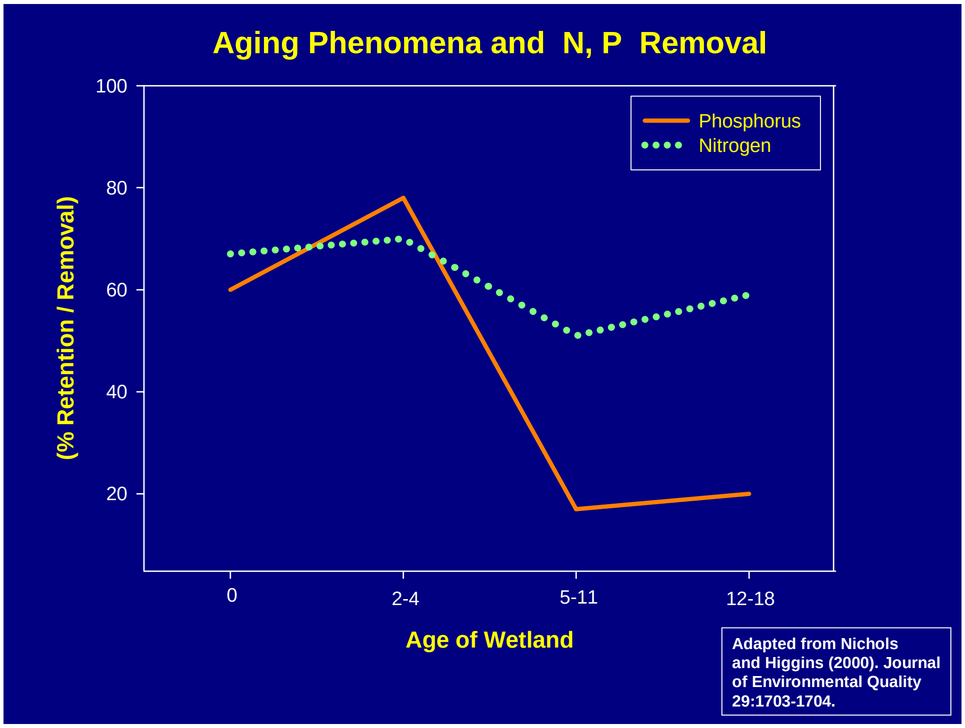


Figure 7.



Potential areas for wetland restoration

By definition wetland restoration areas are those where wetlands previously existed. Thus, the potential area for wetland restoration is most extensive in landscapes with extensive drainage ditches or drain tiles. The coastal plain is likely to have more area for wetland restoration than other physiographic provinces. However, the benefits of wetland restoration may also be extended to landscapes where wetlands may be created where none previously existed (e.g., Braskerud et al. 2005). In general, areas with flat topography and limited soil permeability are best for wetland restoration. Obviously, the wetlands must be positioned to receive drainage from areas that are the sources of materials that the wetlands are intended to remove. This positioning is assumed by the relationship between percent removal efficiency and the proportion of the watershed covered by wetland shown in Fig. 1. Natural wetlands are sometimes located at drainage divides (interfluves), high spots in the landscape. Restoring such wetlands may have other important benefits but will not contribute to intercepting materials released from uplands.

Because wetlands at the bottom of watersheds remove materials from emerging drainage water, the surface water quality benefits are immediate. In contrast, BMPs such as cover crops or special fertilizer application methods aimed at reducing loss of nutrients to groundwater may not affect surface water quality for several years because of the slow rate of groundwater flow to streams. Despite this time lag, it is still important to reduce nutrient losses at the source.

Future Research Needs

Variances in efficiencies due to size differences can be evaluated by comparing the water detention times among wetlands. However, data needed to calculate water detention times are seldom reported. The ratio of the area of the wetland to the area of the watershed is a possible surrogate for water detention time and is more often available, but incorporating water detention time into required procedures and methods would provide a more accurate picture of efficiencies.

As the effects of improper maintenance are not well known, it makes sense that we could try to account for improperly maintained wetlands by using conservative estimates of efficiencies. However, more research is needed to improve our understanding of how to properly maintain wetlands that are managed to remove nutrients and sediments. Also, we need to establish some protocol for evaluating wetland condition to determine if maintenance is needed. For example, there should be some way to assess whether a wetland is losing efficiency due to acretion.

Analyzing the potential negative benefits of using natural wetlands for sediment retention should be examined. This would include determining the potential negative effects of sedimentation on biotic quality that results when sediment deposition alters wetland soil texture and organic matter thus possibly promoting the growth of undesirable plan species. Carol Johnson, Department of Biology and Microbiology, South Dakota State University, Brookings, SD is investigating this issue.

In addition, net global warming potential due to greenhouse gas emissions from microbial process in restored wetlands should be examined. Marcelo Ardon, Department of Biology, Duke University, PO Box 90338, Durham, NC 27709, mla5@duke.edu should be contacted for more information on this topic.

And finally, as previously discussed, research is needed to determine how to calculate TSS removal efficiencies based on percent wetland area.

Recommendations for Future Refinements

1. Seasonal correction factor – while the proposal does note that there is seasonal variability in rates of retention/uptake/transformation, it only addresses it by using average rates. Further work on seasonal variability and periods of nutrient discharge is needed to refine the model.
2. Hydraulic loading rate - during high flow periods, retention time in wetlands is reduced, leading to decreased removal of nutrients and sediment
3. Wetland aging - as wetlands collect sediment over time, they begin to fill and reach a point where they are no longer able to serve as a sediment sink. The Living Resources Subcommittee (LRSC) of the Chesapeake Bay Program notes the distinction between created “wet ponds” and wetlands that are voluntarily restored on agricultural land. While

"maintenance" of stormwater facilities is well understood and necessary, excavation of voluntarily established forested wetlands to restore capacity is not desirable.

4. Reporting on wetland drainage area - The percentage of wetlands in a watershed, by physiographic region, should be further investigated. LRSC will request that States begin to provide this information on a project-by-project basis, beginning with the 2007 reporting year. LRSC will work with IMS to streamline collection of this information, and investigate use of USGS' "EDNA" tool for estimating drainage area in places where drainage is not reported.
5. Potential for dissolved P discharge from wetlands with high P content, due to past removal, under anaerobic conditions needs to be investigated.

How modeled

The equation outlined here replaces the modeling approach used by version 4.3 of the Chesapeake Bay Program's Watershed Model that assumes each acre of restored or created wetland removes a proportion of the nutrients discharged from four watershed acres. This 1:4 ratio of wetland :watershed area will no longer be applied to wetland modeling. Also, effectiveness estimates in version 4.3 are assumed to be synonymous with riparian forest buffer estimates. As this report shows, extensive literature regarding nutrients/sediment processes is available to evaluate the effectiveness of wetlands and develop estimates of pollutant removal unique to wetland restoration and creation.

Conclusions

Efficiency of removal of N and P by restored wetlands can be approximately predicted from the ratio of wetland area to watershed area (Fig. 1) but actual efficiencies may be very variable. Implementation of wetland restoration BMPs should be linked with assessment of their effectiveness. Management of wetland BMPs should be adaptive, with provision for adjustment of expectations as more information on effectiveness becomes available.

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Appendix A: Efficiency of Wetland Restoration BMP, Thomas E. Jordan, Smithsonian Environmental Research Center, March 2007

Restored versus constructed wetlands—

It is important to distinguish wetland restoration from wetland construction. The current definition of "wetland restoration" used by the Chesapeake Bay Program states that "Agricultural wetland restoration activities re-establish the natural hydraulic condition in a field that existed prior to the installation of subsurface or surface drainage." In contrast, "wetland construction" establishes a wetland in a place where none previously existed. Constructed wetlands may use artificial or highly engineered hydrology. Often constructed wetlands have regulated water inputs, with water being pumped or fed in at steady controlled rates. In contrast, restored wetlands generally have natural or unregulated water inputs, with water entering through surface or subsurface flows at variable uncontrolled rates.

Many of the literature examples provided by UMD to evaluate wetland restoration actually refer to constructed wetlands. These include wetlands constructed to treat dairy wastewater (e.g., Schaafsma et al. 2000, Newman et al. 2000), swine wastewater (Hunt et al. 2002, Stone et al. 2002) and aquaculture effluents (Schwartz and Boyd 1995). Similar constructed wetland systems are used for sewage treatment. The efficiencies of such systems for improving water quality have been extensively studied and their capabilities and design criteria are well known (e.g., Hammer 1989, Kadlec and Knight 1996). When properly designed, constructed wetlands are potentially very effective in treating wastewater that can be fed through at controlled rates. The performance of constructed wetlands can be estimated from design characteristics.

This report will focus on the efficiency of restored wetlands. However, I will also consider constructed wetlands that receive water from natural unregulated sources because these may act like restored wetlands. Six of the publications provided by the UMD literature review were especially relevant (Kadlec and Hey 1994, Kovacic et al. 2000, Hoagland et al. 2001, Jordan et al. 1999, 2003, Velledis et al. 2003). However, these represent a small sampling of recent related studies. Therefore, I supplemented these with additional studies published in the last five years. My literature review is not exhaustive. A more complete literature review would improve the assessment of the efficiency of restored wetlands.

Efficiency—

The efficiency of removal of waterborne materials by wetlands is often expressed as the percentage of the inflowing material that was removed in the wetland. Absolute removal rates may also be given in units of mass per wetland area. For example, Mitsch et al. (2000) suggest that sustainable removal rates range from about 5 to 50 kg ha^{-1} yr^{-1} for P and 100 to 400 kg ha^{-1} yr^{-1} for N. Removal rates are generally thought to follow first order kinetics, where the rate of removal is proportional to the concentration of the substance in the water. Many studies have found evidence supporting first order kinetics, but it does not always apply. For example, Braskerud (2002a) found that the rate of removal of suspended sediment increased with sediment concentration faster than would be predicted by first order kinetics. Also, there are upper limits to absolute rates of removal, which prevent removal rates from rising indefinitely with increases in concentration. However, the general tendency of removal to follow first order kinetics makes it very useful to express efficiency as the percentage of inflowing material removed because this percentage will be relatively constant with variation in concentration.

Effects of wetland size and water detention time on efficiency—

Clearly, the efficiency of removal will vary as a function of the size of the wetland. For example, if a 1 ha wetland removes 50% of the total N it receives from agricultural runoff and if another similar 1 ha wetland is restored downstream to remove 50% of the total N it receives in discharge from the first wetland, then the combined 2 ha wetland system will remove 75% of the total N received from agricultural runoff. Also, a 1 ha wetland would likely remove a greater percentage of material from discharge of a 10 ha watershed than from discharge from a 100 ha watershed. Actually, the effect of size is related to the ratio of wetland area to watershed area and probably reflects the detention time of water within the wetland. The longer water is detained within a wetland the more material may be removed from the water within the wetland. The detention time is the water volume of the wetland divided by the rate of water inflow. This clearly varies with the area of the watershed and the area of the wetland. Thus, we would expect to find relationships between the removal efficiency and the areas of the wetland and watershed and the ratios of those areas. Simple models have been developed to account for these size effects.

The processes that remove materials—

Waterborne materials removed by wetlands are either stored within the wetland or converted to gaseous forms and released to the atmosphere. Since P has no important gaseous phase it can only be accumulated within the wetland. Usually, most of the P discharged from watersheds is bound to particulate matter. Therefore, sedimentation of particulate matter is an important process for P removal. Particulate N and organic C may also be trapped by sedimentation. N and P may be taken up by plants, algae, bacteria, and fungi, and, thus be converted to particulate organic forms, which may accrete in the wetland. However, dissolved inorganic N and P may be released from organic matter as it decomposes. Wetland vegetation can enhance sedimentation by slowing water velocity, reducing turbulence, and providing surfaces for particle adhesion (Braskerud 2001). N, organic C, and especially P can be held in wetland sediment by adsorption. However, sites of surface adsorption have a finite capacity and can eventually become saturated.

It is important to note that the capacity of a wetland to accumulate particulate material is limited because the trapped material will eventually fill the wetland to the extent that incoming waterborne particles will pass through without being trapped. Reservoirs similarly fill up with sediment eventually. As wetlands fill with sediment or accumulated organic matter, their holding capacity and detention time for water decreases gradually diminishing their capacity to remove particles from incoming water.

The microbial process of denitrification can convert nitrate N to nitrous oxide, nitric oxide, or nitrogen gases, which may be released to the atmosphere. Unlike accretion processes, denitrification can continue indefinitely. Denitrification requires organic matter and a lack of oxygen, conditions often found in the waterlogged soils of wetlands. Like N, organic C can be converted to gaseous forms (carbon dioxide and methane), which are released to the atmosphere rather than accumulating in the wetland. Rates of these biotically mediated processes generally increase with temperature.

Variability of removal efficiencies—

Although restored wetlands have significant potential to remove waterborne materials such as nutrients and sediments from watershed discharges, the efficiency of removals is highly variable. I reviewed recent measurements of total N and P removal efficiencies (references in bibliography marked with asterisks). For 29 annual measurements the average total N removal efficiency was 20%, with a standard error of 3.7, and a range of -12% to 52%. For 36 annual measurements, the average total P removal efficiency was 30%, with a standard error of 5 and a range of -54% to 88%.

Some of the variance in efficiencies is due to size differences. These effects would be best evaluated by comparing the water detention times among wetlands. However, data needed to calculate water detention times are seldom reported. The ratio of the area of the wetland to the area of the watershed is a possible surrogate for water detention time and is more often available. Tonderski et al. (2005) developed a simple model to account for variability in the ratio of areas. Their model predicts a nearly linear increase in removal efficiencies as the percentage of the watershed area occupied by wetlands increases (Fig. 1). This modeled relationship looks useful for predicting the effect of wetland restoration but actual measurements show much less predictability (Fig. 2).

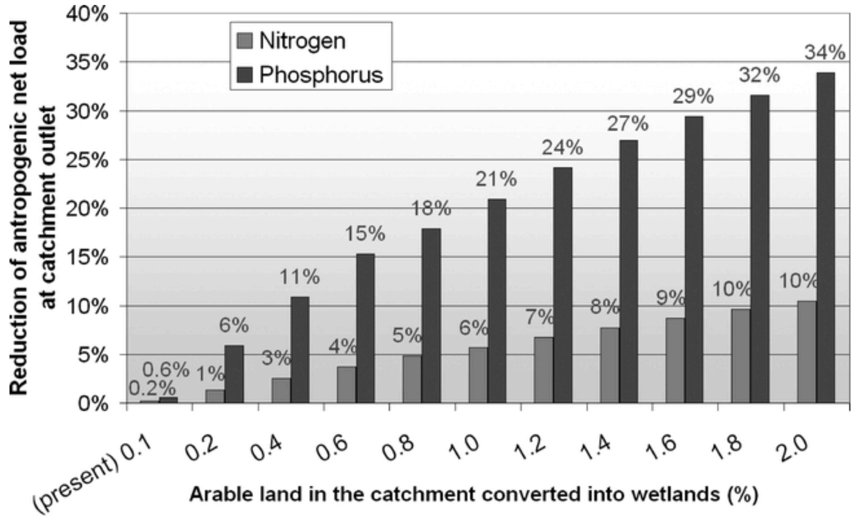

Fig. 1. Modeled effect of wetlands on anthropogenic net load at the catchment scale. Different proportions of catchment wetland areas were considered in the HBV-NP model (figure and caption from Tonderski et al. 2005).

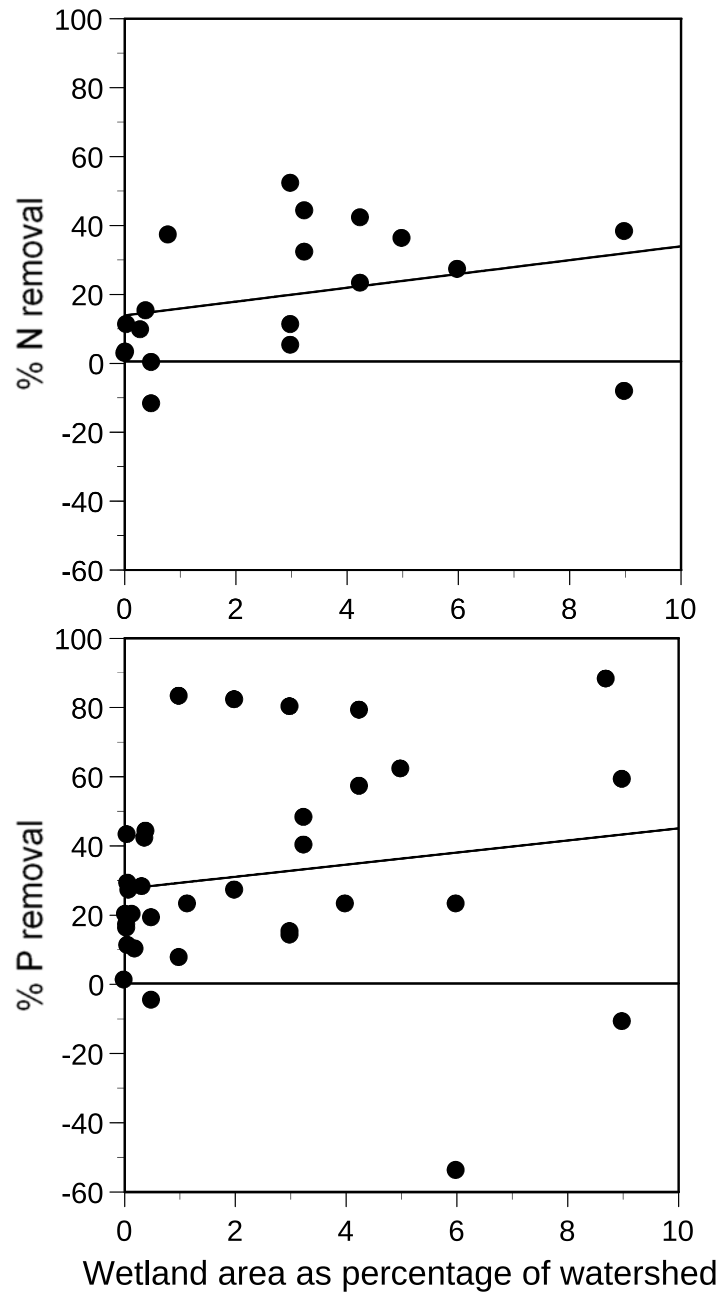

Fig. 2. Percentages of N or P removed annually versus the wetland area expressed as a percentage of the watershed area. Sloped lines are fit by linear regression. Most of the data points represent different wetlands but some are for different years for a given wetland. Data are from references marked with asterisks in the bibliography.

The temporal variability of water flow through wetlands also results in variability of water detention times, which in turn affects the removal efficiencies. As flow variability increases the effective water detention time decreases and therefore the removal efficiency decreases (Jordan et al. 2003). It is intuitively clear that a wetland with steady water flow is likely to have higher removal efficiencies than a wetland with the same amount annual flow concentrated during only a few days of high flow. The effect of flow variability is vividly illustrated by data from Reinhardt et al. (2005) (Fig. 3.) They found that efficiencies of dissolved reactive phosphorus removal (or retention) over two-day periods varied with water detention (or residence) time as well as with the concentration, and followed patterns consistent with a model they developed. Flow variability is influenced by rainfall patterns and increases with the proportion of impervious surface in a watershed. Restored or constructed wetlands receiving unregulated inflows may be equipped with flow control structures that decrease flow variability. For example, wetland drains may be designed to allow continued slow outflow after high flow events, thus creating capacity to hold water inputs from subsequent events.

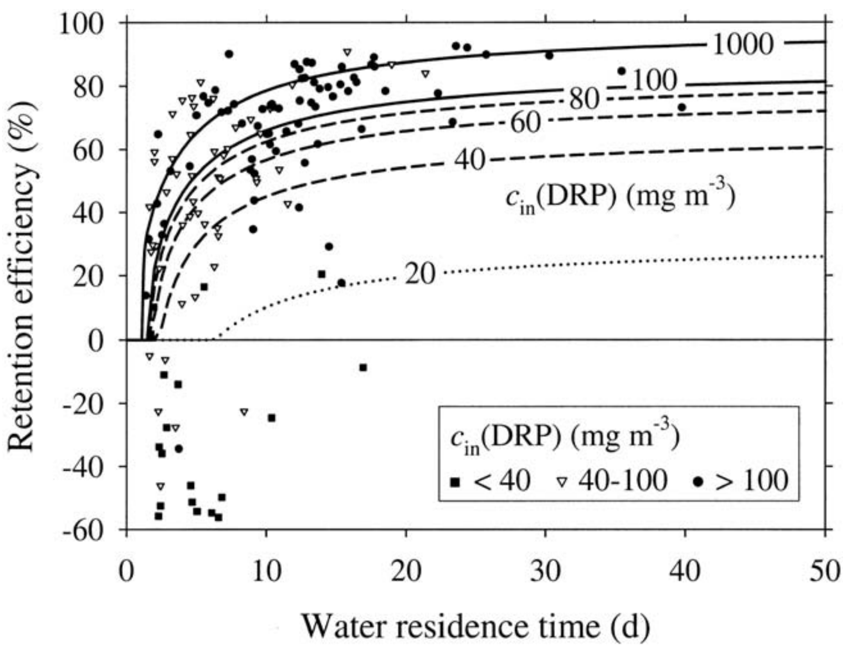

Fig. 3. Retention efficiency of dissolved reactive (bioavailable) phosphorus (DRP) predicted by the model (lines) and observed in Wetland Sonnhof in 2001 (symbols) as a function of water residence time and concentration of dissolved reactive phosphorus at the inlet c_{in}(DRP). Line styles and symbol types indicate DRP inlet concentration. Two-day retention efficiency was calculated according to Eq. [15]. Twenty-two data points ranging between –60 and –500% (τ: 1–6 d) are not shown (figure and caption from Reinhardt et al. 2005).

Effects of wetland age—

Removal efficiencies are likely to vary with the age of the wetland although there are few data available to quantify this. When a wetland is first restored or constructed, it may lack vegetation. This would likely reduce removal efficiencies because vegetation can assimilate nutrients, enhance sediment trapping, and provide organic matter to support denitrification. Initial rapid increases in vegetation biomass may enhance accumulation of nutrients and organic matter. Later when the wetland vegetation is fully established, the rate of biomass increase will slow, thus reducing the accumulation of removed materials in biomass. As wetlands fill with sediment and biomass over time, their water holding capacity and water detention time decline, diminishing their ability to trap and accumulate new material. Although denitrification does not depend on accumulation of material in the wetland, the reduction of water detention time would also limit N removal by denitrification.

The likely effects of wetland age lead to two important conclusions. First, the effectiveness of a newly restored wetland may improve as vegetation becomes established and organic matter becomes available to support denitrification. It probably takes at least one year, possibly several, for a restored wetland to reach its full potential removal efficiency. Second, a wetland will eventually fill in and loose its capacity to remove waterborne materials. To restore this capacity the wetland would need to be excavated and the accumulated material removed. Periodic excavation would require a long-term commitment of effort and might also require special legal provisions.

Effects of flow paths—

Removal efficiencies may also be affected by the pathways of flow through the wetlands. For example, even dispersal of water flow over the entire wetland area maximizes removal efficiency by maximizing the area of wetland that is interacting with the through-flowing water. If surface water flow follows a short cut from the wetland inlet to outlet while bypassing the main area of the wetland, the effective water detention time is reduced. Persson et al. (1999) discuss design features that improve the dispersal of water (hydrologic efficiency). Both surface- and groundwater flow can follow by passes. Velledis et al. (2003) noted that nitrate removal efficiency of a riparian wetland was reduced by groundwater flowing through limited preferential flow paths. Groundwater flow may be more effective than surface water flow in delivering nitrate for denitrification because groundwater can inject nitrate, which is formed in oxygenated environments, directly into anoxic water logged sediments where as nitrate entering a wetland in surface flow must diffuse slowly downward into anoxic sediments.

Potential areas for wetland restoration—

By definition wetland restoration areas are those where wetlands previously existed. Thus, the potential area for wetland restoration is most extensive in landscapes with extensive drainage ditches or drain tiles. The coastal plain is likely to have more area for wetland restoration than other physiographic provinces. However, the benefits of wetland restoration may also be extended to landscapes where wetlands may be constructed where none previously existed (e.g., Braskerud et al. 2005). In general, areas with flat topography and limited soil permeability are best for wetland restoration. Obviously, the wetlands must be positioned to receive drainage from areas that are the sources of materials that the wetlands are intended to remove. This positioning is assumed by the relationship between percent removal efficiency and the proportion of the watershed covered by wetland shown in Fig. 1. Natural wetlands are sometimes located at drainage divides (interfluves), high spots in the landscape. Restoring such wetlands may have other important benefits but will not contribute to intercepting materials released from uplands.

Because wetlands at the bottom of watersheds remove materials from emerging drainage water, the surface water quality benefits are immediate. In contrast, BMPs such as cover crops or special fertilizer application methods aimed at reducing loss of nutrients to groundwater may not affect surface water quality for several years because of the slow rate of groundwater flow to streams. Despite this time lag, it is still important to reduce nutrient losses at the source.

Predicting removal efficiency—

Removal of total N and P by restored wetlands can be predicted from the relationship between the percentage of N or P removed and the percentage of the watershed occupied by wetland receiving discharge from the entire watershed. We assume that removal proceeds exponentially with detention time, as expected with first order kinetics. We also assume that detention time (wetland volume divided by water flow rate) is proportional to the percentage of watershed occupied by wetland. This follows if water discharge is proportional to watershed area and if different wetlands have similar average depths. Finally, we assume that there is no removal if there is no wetland area (i.e., the curve must go through the origin). Based on these assumptions:

$$\text{Removal} = 1 - e^{-k\ (\text{area})}$$

Where "removal" is the proportion (not percentage) of the input removed by the wetland, "area" is the proportion watershed area occupied by wetland, and "k" is a fitted parameter. We used non-linear regression (SAS 2004) to fit this equation to data from studies reported in the literature.

Some studies reported negative removal values (i.e. a net export from the wetland) but negative values could not be used for our simple model. When negative removal occurred in particular years but not on the average (e.g. Kovacic et al. 2000, Jordan et al. 2003), we used the average removal percentage in fitting our model. In rare cases where only negative removal was observed, we omitted the observation from our analysis. Omission was only needed for total P removal by one of the wetlands studied by Kovacic et al. (2000) and total N removal by one of the wetlands studied by Koskiako et al. (2003).

The non-linear regressions produced values of the k that can be used in the equation above to predict the proportion of total N or P removed based on the proportion of wetland area in the watershed. For total N, k=7.90 with lower and upper 95% confidence limits of 4.56 and 11.2. For total P, k=16.4 with lower and upper 95% confidence limits of 8.74 and 24.0. The proportion removed increases with the proportion of wetland area but the rate of increase declines as the proportion of wetland area increases (Fig. 3). Thus, the additional benefit of adding more wetland area gradually diminishes. The curves fit to the literature data are very similar to predictions of the more complex watershed scale models of Tonderski et al. (2005) (shown in Fig. 1).

Removal efficiency of total suspended solids—

There are less data on removal of total suspended solids (TSS) then on removal of total N or P. The percentage of TSS removed averaged 21.6 (standard error 9.9) for five annual removal rates from Koskiaho et al. (2003) and two annual rates from Jordan et al. (2003). More data would be needed to determine the relationship between TSS removal and percentage of wetland area in the watershed.

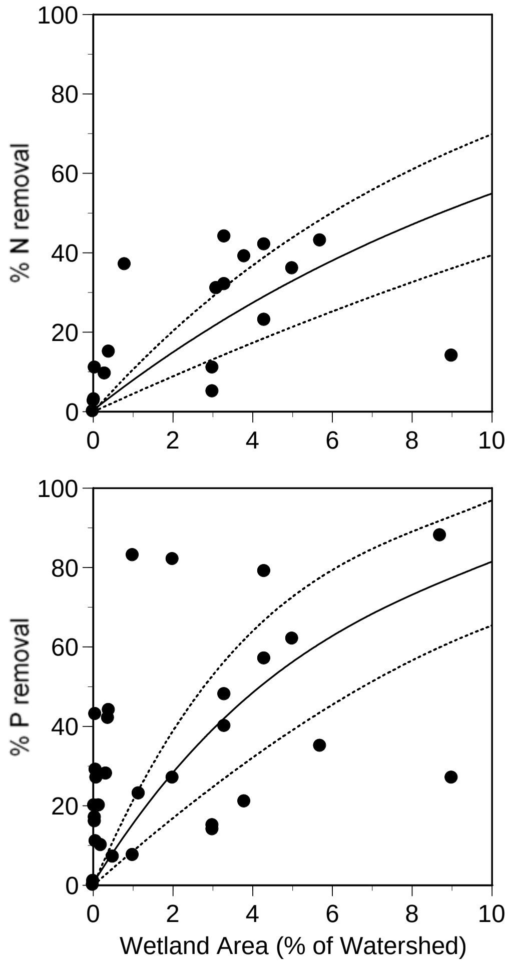

Fig. 3. The percentage of total N (top) or P (bottom) removed in wetlands versus the percentage of wetland area in the watershed. The curves are fit by non-linear regression to literature data on annual removal efficiencies after eliminating negative values of removal (see text). The dotted lines indicate the upper and lower 95% confidence interval. The data point at the origin is assumed by the model.

Conclusions—

Efficiency of removal of N and P by restored wetlands can be approximately predicted from the ratio of wetland area to watershed area (Fig. 1) but actual efficiencies may be very variable. Implementation of wetland restoration BMPs should be linked with assessment of their effectiveness. Management of wetland BMPs should be adaptive, with provision for adjustment of expectations as more information on effectiveness becomes available.

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*Denotes group

Appendix B. Memo from Living Resources Subcommittee

Chesapeake Bay Program
A Watershed Partnership

TO: Tom Simpson, Chair, Nutrient Subcommittee
Sarah Weammert, UMD / MAWQP

VIA: Kelly Shenk, Tributary Strategy Workgroup

FROM: Matt Fleming, Chair, Living Resources Subcommittee

DATE: August 1, 2007

RE: LRSC Recommendations on Wetland BMP Proposal

In response to the request from the Nutrient Subcommittee for input into the re-evaluation of various BMPs, I submit the recommendations and comments on behalf of the Living Resources Subcommittee regarding the University of Maryland Mid-Atlantic Water Quality Program's proposal for wetlands on agricultural lands.

Overall, LRSC agrees with the approach of weighting wetland efficiency based on percent drainage area of the watershed. However, members continue to express concern over the validity of the drainage area percentages in the proposal, including documentation in the scientific literature, how these percentages will be applied, and the inability of this approach to capture other important factors that impact wetland efficiency in N/P/S uptake and retention, such as seasonal variation, hydraulic load rate, and wetland aging. These concerns are detailed below.

We recommend that the final report on this particular BMP to the Water Quality Steering Committee provide a strengthened background/introductory section on how the model currently treats wetlands in agricultural areas, the rationale for change, and clear articulation of how the wetland drainage area percentages in the proposal will be applied in the model. Toward that end, LRSC offers the following specific comments on the definitions and efficiencies, with suggestions for future refinements and scientific references to strengthen validity of the model.

Recommendation on Definitions Section

Based on findings of the Chesapeake Bay Program's 2005 Wetland Evaluation, the Implementation Committee in September 2005 agreed to adopt standard tracking definitions* for purposes of tracking progress of the partnership toward wetland-related commitments. These official definitions were then referenced in subsequent guidance from the Principals' Steering Committee to the partnership, along with corresponding "common" terms. For consistency, LRSC strongly recommends that the NSC use the following wetland project definitions:

Re-establishment ("restore") – Manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a *former* wetland. Results in a gain in wetland acres.

Establishment ("create") – Manipulation of the physical, chemical, or biological characteristics present to develop a wetland that did not previously exist on an upland or deepwater site. Results in a gain in wetland acres.

Rehabilitation ("improve") - Manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a *degraded* wetland. Results in gain in wetland function, not acres.

Enhancement ("enhance") - Manipulation of the physical, chemical, or biological characteristics of an existing wetland (undisturbed or degraded) site to heighten, intensify, or improve specific function(s) or for a purpose such as water quality improvement, flood water retention, or wildlife habitat. Results in gain in function, not acres.

Protection ("protect") – Removal of a threat to, or preventing the decline of, wetland conditions by an action in or near a wetland. Includes purchase of land or easements of 30 years minimum duration. Does not result in a gain of wetland acres or function.
**As identified in 2000 by the White House Wetlands Working Group, Federal Geographic Data Committee, and reiterated by the President's Council on Environmental Quality in 2004.*

Recommendations on Efficiency Section

- Currently, the watershed model assumes that each acre of restored wetland removes a proportion of the nutrients discharged from four acres watershed. Thus, if the efficiency is 25%, it is assumed that each acre of wetland removes 25% of the nutrients released from four acres of watershed. Clearly, the functional efficiency of the wetlands currently depends on the assumed ratio of wetland: watershed area. The rationale for the 1:4 ratio is unclear. LRSC urges the TSWG and NSC to clarify this rationale.

- If the new efficiency estimates will be used with the assumption that each acre of wetland treats four acres of upland, then the seemingly arbitrary selection of the 1:4 ratio essentially sets the functional efficiency of the wetlands. With the 1:4 area ratio assumption, the new efficiencies will predict the same amount of nutrient removal by wetlands in the Coastal Plain as predicted in the current model, but half as much nutrient removal in the Piedmont and one forth as much in the Appalachian Province.

- Different predictions of nutrient removal will be obtained if the new efficiency estimates will be applied according to the assumed (or known) percentages of wetland area in the watersheds. For example, to estimate efficiency it is assumed that Coastal Plain wetlands make up 4% of the watershed area. Thus, it follows that each acre of wetland would treat the discharge from 24 acres of watershed. Therefore, the predicted amount of nutrient removal would be six times higher than is predicted by the current model using the same removal efficiency but assuming a 1:4 ratio of wetland area: watershed area. By similar reasoning the predicted amount of nutrient removed in the Piedmont and Appalachian Provinces would be 6-7 times that predicted by the current model. The percentage of wetlands in a watershed, by physiographic region, should be further investigated. Maryland Department of the Environment estimates are higher, particularly for the Coastal Plain.

- If nutrient removal is calculated using the assumed percentages of wetland in each province, then the calculation is not sensitive to the selection of the percentage of wetland area. This is because the efficiency roughly doubles as the area of watershed draining to the wetland is halved, so the amount of nutrient uptake would stay the same regardless of the estimated area percentage, assuming that the calculation of the amount of nutrient uptake uses the same area percentages as those used to estimate efficiency.

Recommendations for Future Refinements

LRSC members feel strongly that the model should be further refined at the earliest opportunity to reflect the following:

1. Seasonal correction factor – while the proposal does note that there is seasonal variability in rates of retention/uptake/transformation, it only addresses it by using average rates. Further work on seasonal variability and periods of nutrient discharge is needed to refine the model.
2. Hydraulic loading rate – during high flow periods, retention time in wetlands is reduced, leading to decreased removal of nutrients and sediment
3. Wetland aging – as wetlands collect sediment over time, they begin to fill and reach a point where they are no longer able to serve as a sediment sink. LRSC notes the distinction between created “wet ponds” and wetlands that are voluntarily restored on agricultural land. While “maintenance” of stormwater facilities is well understood and necessary, excavation of voluntarily established forested wetlands to restore capacity is not desirable.

4. Reporting of wetland drainage area – LRSC will request that States begin to provide this information on a project-by-project basis, beginning with the 2007 reporting year. We will work with IMS to streamline collection of this information, and investigate use of USGS' "EDNA" tool for estimating drainage area in places where drainage is not reported.

It is LRSC's understanding that such refinements to the model, if not considered "significant", do not need to wait until the next calibration. LRSC will work with STAC to advocate for necessary funding, data collection, and reporting to the Chesapeake Bay Program to pursue these refinements using actual, long-term studies in a variety of wetland types, including restored, rehabilitated, and created wetlands, as well as the wide range of existing natural wetlands, should be conducted for future model refinements.

It should also be considered that many voluntarily restored/created wetlands are intended to resemble natural wetlands. The extensive literature regarding nutrients/sediment processes in natural wetlands should have been considered, both in the model for newly established areas, and for existing wetlands. There are far more existing natural wetlands than restored sites, and refinement of the model to more accurately account for natural wetlands should be pursued.

Recommendations for Scientific References

- We recognize that the wetland BMP was evaluated in two ways by two different PIs (wetlands restored on agricultural land and those created in urban areas). LRSC notes that most voluntarily restored wetlands are not designed primarily as treatment wetlands. As such, the literature search for the agricultural portion appears to have been too narrow, with too much emphasis placed on wetlands that are treatment stuctures. Studies on wetlands established for wildlife, mitigation wetlands, and natural wetlands should have been evaluated. The wetlands being voluntarily built are for wildlife, aesthetics, with some water quality benefits, but they are, for the most part, not designed like a stormwater facility nor intended to have the same maintenance as a stormwater facility. Specifically, it is disconcerting that none of the references is from the journal *Wetlands.*

- Dr. William Crumpton's study "Predicting Water Quality Performance of Wetlands Receiving Nonpoint Source Loads: Nitrate Removal Efficiency and Mass load Reduction by Emergent Marshes," was presented at the STAC/LRSC Wetland BMP workshop in April 2007. While from a different part of the country, these results may be most applicable for the Bay Program model in that the wetlands studied are most similar to the wetlands most commonly restored/created in Maryland (emergent wetlands located in agricultural watersheds.) An abstract for this work follows for reference by the NSC:

Predicting Water Quality Performance of Wetlands Receiving Nonpoint Source Loads: Nitrate Removal Efficiency and Mass Load Reduction by Emergent Marshes. William G.

Crumpton**,** Department of Ecology, Evolution, and Organismal Biology, Iowa State University, Ames, IA, USA, Phone: 515-294-4752, email: crumpton@iastate.edu

The effectiveness of wetlands in nitrate reduction is largely a function of hydraulic loading rate, hydraulic efficiency, nitrate concentration, temperature, and wetland condition. Hydraulic loading rate and nitrate concentration are especially important for wetlands intercepting nonpoint source loads. Hydrologic and nitrate loading patterns vary considerably for different landscape positions and different geographic regions. In addition to spatial variation in land use and precipitation, there is considerable temporal variation in precipitation. As a result, loading rates to wetlands receiving nonpoint source loads can be expected to vary by more than an order of magnitude, and will to a large extent determine nitrate loss rates for individual wetlands. Much of the variability in mass nitrate removal among wetlands can be accounted for by explicitly considering the effect of hydraulic loading rate and nitrate concentration. Analysis of 34 "wetland years" of mass balance data (12 wetlands with 1-9 years of data each) for sites in Ohio, Illinois, and Iowa demonstrates that the **performance of wetlands representing a broad range of loading and loss rates can be reconciled by a model explicitly incorporating hydraulic loading rate and nitrate concentration. The model explains 94 % of the variability in mass removal rates for these wetlands.**

- The Conservation Effects Assessment Project (CEAP) sponsored by USDA will be collecting actual measurements from natural and established wetlands in the Coastal Plain. The information will be very useful for model refinements. An extensive bibliography for the project "Wetlands in Agricultural Landscapes: A Conservation Effects Assessment Project (CEAP) Bibliography" (National Agricultural Library Special Reference Briefs 2006-01) is available.

Appendix C. Meeting Summaries

Quantifying the Role of Wetlands in Achieving Nutrient and Sediment Reductions in Chesapeake Bay

Summary of the LRSC/STAC Wetlands Workshop

April 4, 2007

WELCOME AND EXPECTATIONS:

Matt Fleming (LRSc Chair) and Jennifer Greiner (Wetlands Chair) welcomed presenters and participants to this timely and most important workshop addressing the role that wetlands play in achieving nutrient and sediment reductions in Chesapeake Bay. The purposes of the workshop were reiterated: to assemble most current scientific information on the role of wetlands in reducing loads of nitrogen, phosphorus, and sediment in overland flow, and, if possible, to recommend modifications for future versions of the Bay Program's watershed model in terms of how it calculates credit for States in implementing wetland restoration/creation as a BMP.

<u>OVERVIEW OF WATERSHED MODEL</u>:

Jeff Sweeney (UMD-CBPO) gave an overview of the Bay Program's Watershed Model and how it is currently used, particularly as it relates to wetlands. The *Chesapeake 2000* agreement forms the mandate for the model; its main role is to forecast and help correct the nutrient- and sediment-related problems in the Chesapeake Bay and its tidal tributaries sufficiently to remove the Bay and the tidal portions of its tributaries from the list of impaired waters under section 303(d) of the Clean Water Act. Regarding wetlands as a BMP for water quality, the model is used in two ways:

- Nutrient/sediment load reduction in both agricultural and mixed open (i.e. urban) areas (removal efficiency by wetlands is currently assumed to be equal to that of forest cover, which in Phase 4.3 of the model is credited as 57% for N and 70% for P and S; the difference is that 2 acres area assumed to be treated by each acre of forest buffer, whereas 4 acres are assumed to be treated by each acre of wetland);
- Land use conversion (changing from another land use to wetland, or vice versa).

<u>MORNING SESSION</u>: Nutrient and Sediment Retention by Wetlands

Nutrient Removal by Restored Wetlands in Agricultural Watersheds
Tom Jordan ~ Smithsonian Environmental Research Center:

Wetlands that receive unregulated, non-point source inflows differ greatly in their capacity to remove nutrients, partly due to differences in water detention time. According to first order kinetics, concentrations of removed materials should decline exponentially with time while they are held in the wetland. Water detention time is roughly proportional to the ratio of wetland area to watershed area because watershed discharge and wetland volume increase with their respective areas. Simulation models predict that removal percentages increase as the proportion of wetland areas increases, with the rate of increase in removal declining as the wetland proportion increases. However, published measurements show that much of the variance in removal percentages remains unexplained by the simple area relationships. Nevertheless, a non-linear regression model fit to measured P removal percentages suggests that the average proportion of inflowing P removed is 1-e-16.4a where *a* is the proportion of wetland in the watershed. By the same anlaysis, the average proportion of inflowing N removed is 1-e-7.9a.

Removal efficiencies decrease with increased variability of water flow. Thus, a wetland with steady inflow rate would have higher removal efficiencies than a similarly-sized wetland with the same annual water flow concentrated during a few high flow events. Removal efficiencies may improve the first few years after wetland restoration due to establishment of vegetation, which helps trap particulate matter, and due to the production of organic matter, which supports denitrification. Removal efficiencies should later decline with age as the wetland fills in with trapped sediment and accumulated organic matter. Eventually, it may be necessary to excavate wetlands to renew their nutrient removal capacity.

Dr. Jordan presented research that he conducted on Kent Island, Maryland. The research consisted of a wetland restoration project in an agricultural watershed. Water entering the wetland was slowed by a berm and then slowly drained by a standpipe. A v-notch weir was placed on the standpipe to accurately measure the velocity of water through the pipe. This project was monitored for 2 years with the 1st year being very dry with no surface flow out of the wetland and the 2nd year being very wet. It was observed and measured that during the 2nd year of monitoring, water moved through the system so fast that there was little time for nutrient removal. During the 1st year (dry), the wetland experienced a percentage of inflow removed by the wetland of 59 for TP, 38 for TN and -4.1 for total suspended solids. During the 2nd year (wet) the results were not so compelling with -11 for TP, -8.4 for TN and 27 for total suspended solids. Combining the two years lead to a percentage of inflow removed by the wetland of 27 for TP, 14 for TN and 13 for total suspended solids.

Dr. Jordan's team then conducted a literature review comparing N and P removal among wetland receiving unregulated inflows. This literature was comparable to what Dr. Jordan was observing in the wetland project on Kent Island. When predicting efficiency, assumptions must be made. The assumption can be made that the removal of N or P is exponential with time; water detention time equals wetland volume/flow which equals wetland area/watershed area; wetland receives watershed discharge; wetland area is less than the watershed area; and removal is equal to 0 if wetland area is equal to 0. When looking at the effects of detention time and are the following rules apply: efficiency increases with increasing detention time and increasing wetland area; efficiency decreases with increasing flow variability…..which therefore concludes that wetlands receiving unregulated inflow are less efficient and wetlands become less efficient as impervious surface increase in the watershed. Also, as wetlands age the efficiency increases with age in the first few years as vegetation and organic matter accumulate and the efficiency decreases with age after the wetland begins to fill in. Dr. Jordan concluded in saying that efficiency cannot be assigned a single value because it is a function of wetland size relative to inflow. He made the following recommendations:

- Design wetlands to reduce flow variability
- Plan to cope with the problem of filling in
- Link assessment with implementation
- Incorporate size effects in models
- Adapt management with new information

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The Wet Season Nitrogen Budget of an Everglades Tree Island: Potential Role in Wetland Landscape Biogeochemical Fluxes

Tiffany Troxler-Gann ~ Florida International University

In the Florida Everglades, tree islands are conspicuous as heterogeneous elements of the wetland landscape. We characterized bigeochemical interactions among tree islands and the marsh landscape matrix, specifically examining hydrologic flows of nitrogent (N) and N retention capacity. We combined estimates of tree island ecosystem N standing stocks and fluxes, soil and litter N transformation rates, and hydrologic inputs of N to quantify the net sequestration of N by a seasonally flooded tree island. Results showed that hydrologic sources of N were dominated by surface water loads of NO_3^- and NH_4^+. Nitrate immobilization associated with soils and surficial leaf litter was on important soil N transformation promoting the net loss of surface water DIN. This study showed net inorganic N retention up to 37 g m^{-2} wet season $^{-1}$. This value exceeds that for wetland systems, but is a typical value for hyporethic zones of riparian systems. A second tree island study was developed to examine both P sources and N transformation processes in a tree island of the Water Conservation Area 3A. In this paper, we will also compare results of both tree island studies.

Dr. Troxler-Gann presented research that she and her team conducted on tree islands in the everglades at the Florida Coastal Everglades (LTER). Tree islands occur in tropical and sub-tropical landscapes. Their structure and root system is developed on a substrate of limestone and do experience nutrient transfers. Tree islands that occur in the southern everglades have soils that are carbonate derived, have low ammonia concentrations and low P and dissolved organic Carbon. There are many problems with tree islands and the everglades. Tree islands were once important to nutrient storage of the everglade system. They have been lost throughout the years by the degradation of the Florida everglades. Once they are restored, they may have the same importance as they once did at reducing outputs. The everglades themselves have problems as well. The extent has been reduced by half from drainage and conversion for agricultural and urban expansion; sugarcane farming produces effluent enriched phosphorus; and current water management activities direct water out to sea instead of through wetlands to recharge aquifers, which are the primary sources of drinking water for south Florida. Mechanisms of nitrogen sequestration and potential nitrogen sources in tree islands of southern Everglades include: tree islands as important sites of nitrogen biogeochemical flux; important structural component of the pre-drainage Everglades landscape and contain large quantities of nutrients in standing biomass and soil; significant tree island loss over the last 50 years; and a comprehensive metric for assessment of hydrologic change

Specifically, Dr. Troxler-Gann's research hypothesis focused on tree islands as contributors to N sequestration in the southern Everglades landscape. Her approach was to combine estimates of tree island ecosystem N standing stocks and fluxes, N soil and litter transformation rates, and hydrologic inputs of N to quantify net N sequestration. The littler and soil N standing stocks were found in plants, surficial littler, island surface water, soil pool and in soil water. N fluxes occurred in litterfall, readily labile N, recalcitrant N, N accumulated in soil and N recycled by plants. A nitrogen budget was produced to see what pools and uptakes were active in the tree islands. She presented her **conclusions as follows:**

- Results show that hydrologic sources of N were dominated by surface water loads of NO3- and NH4+. Nitrate immobilization associated with soils and surficial leaf litter was an important soil N transformation promoting the net loss of surface water DIN.
- When upstream loads (62.7 g m-2 wet season-1) are compared with downstream loads (24.3 g m-2 wet season-1), this DIN immobilization value (based on Input-Storage=Output) appears realistic, assuming no other fixation in the marsh system. However, this is highly unlikely since we know that periphyton fixes N despite availability of N in marsh surface water.
- This value of net inorganic N retention exceeds that for other wetland systems, but is a typical value for highly biogeochemically-active hyporheic zones of riparian systems.
- N pool dilution experiments probably provide a better indication of *potential* immobilization depending on the enrichment level. More work is needed to insure no artifact of N enrichment on microbial consumption of NO3-.

Application to Chesapeake Bay Watershed Model Goals:

- Given the variability inherent to intact and enhanced wetlands - a function of hydrology, soil, parent material, and vegetation structure - site specific assessment of nutrient efficiencies are important
- While a range for wetlands could be provided, it would be subject to error given the areal extent of and variability among wetlands in the Chesapeake Bay Watershed
- For example, values for N removal in floodplain and riparian forests range from less than 1 to 35 g m-2 yr-1 (Walbridge and Lockaby 1994); removal mechanisms cited sediment/particulate deposition, denitrification, NH4+ adsorption, microbial immobilization and plant uptake
- These mechanisms and their removal efficiencies will vary by wetland type
- To ensure accurate efficiency assessments, rates could be verified with additional mass balance parameters.

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Sedimentation Sequestration Potential in Wetlands
John Galbraith ~ Virginia Tech.

One of the most important functions wetlands offer is the storage of sediment and reduction of suspended solids. Natural and constructed wetlands have variable and temporal states of disturbance that affect sedimentation rates and services. The questions are: 1) can we quantify the sediment retention functions of wetlands by wetland type, wetland hydrology, wetland vegetation, drainage area characteristics, land use in the watershed, water velocity, or physiographic region? 2) how do rates of sediment retention compare between constructed, enhanced, reference, and degraded wetlands? And 3) is there enough information applicable to the Chesapeake Bay watershed to develop effective best management practices (BMPs) for sustainable sediment retention? Published studies indicate that ranges of sediment entrapment are available for only a few types of natural wetlands and that insufficient sediment entrapment studies have been conducted. However, by compiling information from studies across the country we can produce ranges of sediment sequestration potential based on simple classes of wetland ecosystems, such as condition, sediment loading potential, vegetation, hydrology and geomorphology. Existing BMPs may be used for preventing sediment from entering wetlands, and new BMPs may be produced for sustainably sequestering sediment and prevent re-suspension.

Dr. Galbraith reaffirmed that some of the most important functions wetlands offer are the storage of sediment and reduction of suspended solids. He began by asking the questions of what are the relationships between wetland enhancement, geomorphology, sediment flux, and nutrient removal? Wetlands offer many methods to retain sediment: settling due to decrease in velocity or turbulence; settling due to flocculation; and adsorption onto plants and soil particles. Factors that affect the variability of these sedimentation rates are 1) intrinsic factors which include wetland geomorphology and hydrology; exposure/anchoring of sediment; and vegetation types and ground cover (i.e. fine leaf grasses, broad-leaf forbs, tree trunks, bursh stems, bare ground with annual vegetation, and litter). 2) Extrinsic factors include dynamic changes in watershed over time (i.e changes in stream or water body character; varying water velocity and quantity, and varying type and supply of sediment to wetland); direct human disturbance; and catastrophic events. The differences in wetland geomorphology and hydrology also play a role in the sediment retention. Wetland characteristics of closed depressions, lacustrine and pond, and flats play an important role. For example, lacustrine and pond areas that are several feet deep, isolated and have inflow will have high retention of inputs – steady retention from flowthrough waters if the wetland is vegetated. Riverine systems (overbank) will have sandy soil retention at the natural levee as well as at the backswamp. As for tidal (estuarine and freshwater) wetlands, the entrapment is dependent on wave energy and vegetation type. These are very dynamic systems and storms can have catastrophic effects. Factors that affect tidal marsh entrapment and erosion are vegetation type and density, sediment supply, fetch, exposure to currents and boat wakes, difference in high and low tide, exposure to storm tides, hurricanes and tsunamis.

Dr. Galbraith went on to describe natural vs. constructed. He stated that the same principles and factors that affect sedimentation in natural systems apply; loading rates may be high and storm events more frequent or turbulent; design and construction are critical; large differences in stormwater ponds in cropland, surface flow wetlands, and subsurface flow wetlands; few studies can compare rates because it is similar to comparing apples to oranges – they need to be studied and monitored on a case by case basis but seldom matched with a reference wetland. He concluded by describing the two most important watershed parameters as being:

- **Incoming sediment load** (land use, soil type, vegetation type, litter cover that affect runoff and erosion, and amount of impervious surfaces)
- **Water velocity and turbulence** (wetland type and amount and type of vegetation cover; precipitation events and antecedent conditions; morphology of water body; streamflow, currents or tidal influences; and construction and human activity.

Also, published studies indicate that ranges of sediment entrapment are available for only a few types of natural wetlands and that insufficient sediment entrapment studies have been conducted. Many studies do not include sufficient information about the watershed characteristics of the normality of rainfall events, or the amount of human alteration of the watershed hydrology.

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Retention of Riverine Nutrient and Sediment Loads by Floodplains in the Chesapeake Bay Watershed

Greg Noe ~ U.S. Geological Survey

Few quantitative estimates exist for the percent retention of annual river loads of nitrogen, phosphorus, and suspended sediment by wetlands. We measured depositional fluxes of nutrients and suspended sediment onto floodplain soil surfaces (g m^{-2} yr^{-1} ; 1-6 yrs of accumulation) over a sampling network that included the Coastal Plain portion of five rivers in the Chesapeake Bay watershed. For each river, the average nitrogen, phosphorus, and sediment depositional flux rates were multiplied by an estimate of floodplain area to calculate floodplain trapping rates (kg yr^{-1}), and then compared to average river loads. Average material retention among the rivers was 27% of nitrogen (range 6-70%), 38% of phosphorus (15-82%), and 69% of suspended sediment (5-95%). Uncertainty in these estimates of retention derive from several assumptions related to adequacy of sampling network, permanency of the sink of deposited nutrients and sediment, and relative importance of the rivers as the source of deposited material. Coastal plain floodplains in the Chesapeake Bay watershed likely function as an important long-term sink for material transported by rivers, greatly reducing loading rates to the Bay. Restoration activities that increase floodplain area or the hydraulic connectivity between floodplains and river channels most likely would enhance nutrient and sediment retention.

Noe reaffirmed the importance of floodplains in retaining nutrient and suspended sediment in the Chesapeake Bay watershed. Floodplains represent the last location to retain materials in which case it is ideal to restore the system and let the water return to the floodplain. The floodplain acts as a speed bump for water, slowing it down and giving it time to spread across the plain and filter out its nutrients and sediments. Noe expressed that the role of coastal plain floodplains in the Chesapeake Bay watershed is three-fold:

- **Sediment, phosphorus and nitrogen load retention rates are potentially very high (Sediment>P>N)**
- **Load retention is a function of floodplain area [sink] and upstream land use [source]**
- **More information is needed on permanence and sources of deposited material**

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Where Does Sediment Go in Wetlands (and What Does it Do to Them)?

Carol A. Johnston ~ South Dakota State University

Sedimentation is an important mechanism by which wetlands improve stream water quality, but sediment is not uniformly deposited throughout wetlands. Streams migration, abandoned channels, and the formation of streamside levees in natural wetlands alter the spatial patterns of new sediment deposition. Measured sedimentation and associated phosphorus deposition within several Midwestern wetlands was greatest within short distances (<20m) of tributary streams. Within-wetland geomorphic structure (riverbed, levee, backwater) exhibited different sedimentation rates: sedimentation was greater in marshy strips adjacent to the mainstem of the river than it was in backwater areas behind the natural river levee. Sediment deposition raises the level of the wetland surface, altering its inundation frequency and aeration, which in turn alters redox-associated processes. Sediment deposition also alters the texture and organic matter content of wetland soils, which can promote the growth of often undesirable plant species. In Great Lakes coastal wetlands, 90 of 169 plant species studied had a significant affinity for a particular soil type (sand, silt, clay, organic). The water quality benefits of using natural wetlands for sediment retention should be weighed against potential negative effects of sedimentation on biotic quality.

Dr. Johnston expressed that sediment is high in P, which is a pollutant in many aquatic ecosystems and also that sediment, in and of itself, can be a pollutant. Pros and cons of sediment retention were stated to be:

- PRO: Sediment retention in wetlands keeps P out of aquatic ecosystems.
- CON: Sediment retention in wetlands can promote the growth of undesirable plant species
- CON: Wetlands have finite capacity for sediment retention.

Johnston examined material retention at 2 study sites: 1) White Clay Lake and 2) Lake Superior tributaries. White Clay Lake showed greatest material retention in alluvial soils of natural levees. Material was also retained by enrichment of soil surface. She concluded that at White Clay Lake that there was an average soil alluvial soil accretion of 1.3 cm/yr; average sediment accumulation was 2.0 kg m^{-2} yr^{-1}; average P accumulation was 2.6 g m^{-2} yr^{-1}; and the average N accumulation was 12.8 g m^{-2} yr^{-1}. A site 2, Lake Superior tributaries, depending on flow, soil texture and water depth, varied in their sedimentation rates along the tributaries. Material flux, measured at the riverbed, backwater and back marsh at several sub-sites, was mostly found to be higher in the riverbed and lower in the back marsh, with the backwater flux being in the middle.

Sedimentation efficiencies are as follows:

- Sedimentation is an important material retention mechanism in wetlands along streams of all sizes
- Sediment (and associated P) retention is localized in certain geomorphic structures:
  - Natural levees
  - Marsh strips on the river side of levees
  - Sparsely vegetated backwater sloughs

Dr. Johnston made the following conclusions:

- Wetlands are effective material traps
- Spatial “hot spots” of material retention within wetlands
- Sediment retention in wetlands can promote undesirable plant species
- Wetlands are not a panacea for poor water quality
- BMPs must be implemented to keep sediment on the land

CONTACT INFORMATION: Carol A. Johnston, Department of Biology and Microbiology, South Dakota State University, Brookings, SD, USA.

<u>AFTERNOON SESSION</u>: Transport and Process of Nutrients and Sediments

Predicting Water Quality Performance of Wetlands Receiving Nonpoint Source Loads: Nitrate Removal Efficiency and Mass Load Reduction by Emergent Marshes
William G. Crumpton ~ Iowa State University

The effectiveness of wetlands in nitrate reduction is largely a function of hydraulic loading rate, hydraulic efficiency, nitrate concentrations, temperature, and wetland condition. Hydraulic loading rate and nitrate concentration are especially important for wetlands intercepting non-point source loads. Hydrologic and nitrate loading patterns vary considerably for different landscape positions and different geographic regions. In addition to spatial variation in land use and precipitation, there is considerable temporal variation in precipitation. As a result, loading rates to wetlands receiving non-point source loads can be expected to vary by more than an order of magnitude, and will to a large extent determine nitrate loss rates for individual wetlands. Much of the variability in mass nitrate removal among wetlands can be accounted for by explicitly considering the effect of hydraulic loading rate and nitrate concentration. Analysis of 34 "wetland years" of mass balance data (12 wetlands with 1-9 years of data each) for sites in Ohio, Illinois, and Iowa demonstrates that the performance of wetlands representing a broad range of loading and loss rates can be reconciled by a model explicitly incorporating hydraulic loading rate and nitrate concentration. The model explains 94% of the variability in mass removal rates for these wetlands.

Dr. Crumpton's focus was on water quality benefits of wetland restoration by specifically looking at nitrate removal efficiency and mass nitrate load reduction by emergent marshes in agricultural watersheds. When restoring wetlands as N sinks in agricultural watersheds, the following must be taken into account:

- N sources and loads in agricultural watersheds
- N transformation in wetlands
- Mass balance analysis and modeling of wetland performance
- Predicting watershed scale nitrogen loading and load reductions by restored wetlands.

The following are primary factors controlling non-point source (NPS) nitrate loss in wetlands:

- Bioactive surface area
- Organic carbon supply
- Nitrate transport rate
- Temperature
- Dissolved oxygen
- Nitrate concentration and residence time

Dr. Crumpton's conclusions:

1. Mass nitrate removal by wetlands is inversely related to the hydraulic load rate as measured in meters/year (primary determinant in ability of wetland to act as N sink).

2. Only if nitrate concentrations are low enough then wetlands could potentially act as source of N (otherwise, they act as a net sink for N).
3. To optimize N removal by wetlands, first determine where nitrate concentrations are highest, then target restoration/protection of those wetlands that drain the size watershed(s) that produce the hydraulic load rate (m/yr) you want to receive.

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Hydrogeomorphic Control of Nutrient and Sediment Removal by Freshwater Wetlands
Chris Craft ~ Indiana State University

Dr. Craft, et al. surveyed literature to evaluate the role of landscape position, hydrologic connectivity, loading rate and wetland age on nitrogen (N) and phosphorus (P) removal by freshwater wetlands. Nitrogen and P removal is three times greater in connected (floodplain, fringe) wetlands than in depressional wetlands. In floodplain wetlands, 8-15 MT N/km^2 and 1-3 MT P/km^2 are sequestered annually in soil as compared to 3 MT N/km^2/yr under low nitrate loadings. Nitrogen removal is stimulated by increased nutrient loading, mostly through greater denitrification, and, in highly loaded wetlands, N removal may exceed 10-50 MT/km^2 wetland/yr. Increased nutrient loading also boosts P removal through P removal (1-5 MT/km^2/yr) is an order of magnitude less than N. And P removal declines with time as sedimentation reduces water storage capacity and sorption sites become saturated. Creation, restoration and enhancement of wetlands for nutrient and sediment removal must recognize that (1) not all wetlands are equal when it comes to nutrient removal, (2) N removal is greater than P removal and (3) effective N removal is sustainable over time but P removal declines as wetlands age.

Phosphorus in wetlands is retained by, 1) accumulation with soil organic matter, 2) sedimentation of particulate P (PP), and 3) sorption and precipitation. Nitrogen retention and removal occurs by 1) accumulation with soil organic matter (SOM), and 2) denitrification. Denitrification is then controlled by, 1) soil moisture/wetness, 2) nitrate concentration, 3) soil organic carbon, and 4) retention time. Dr. Craft concluded that:

- Restored floodplain wetlands offer the best opportunities for nutrient removal and TMDL compliance.
- Floodplain wetlands can remove around 200 kg N ha^{-1} annually, and up to 600 kg ha^{-1} yr under high nitrate loading rates.

There are three caveats to Dr. Craft's findings: 1) legacy effects (long-term fertilization, drainage, soil oxidation) of re-flooding agricultural lands may initially release P and possibly N; 2) nutrient removal is not consistent throughout the year; and 3) phosphorus retention is high at first but decreases with time as sorption sites become saturated and sedimentation reduces wetland water storage capacity.

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Wetlands and Riparian Buffers: How are They Different?
Judy Okay ~ U.S. Forest Service / Chesapeake Bay Program

Dr. Okay, who is a riparian specialist with the Forest Service, summarized the differences between riparian buffer and wetland systems. She explained that the position of the wetland or buffer system on the landscape usually defines its function. The following show how landscape influences function:

- Wetlands usually located in depressional areas and prominent along shorelines in coastal areas will tolerate the hydrologic inundation better than forest buffers.
- Forest buffers found from headwater areas to confluences of streams and along shorelines are not as tolerant of constant hydrologic inundation.
- Many time forest buffers line wetland borders when in a coastal situation.
- Wetlands in piedmont areas drain toward streams that have a riparian forest buffer.

Wetland and buffer systems have similar and subtle differences in how they function. Some of the **similarities** are as follows:

- Hydrologic inundation: both experience tidal and non-tidal hydrology and surface flow (runoff)
- Pollutant reduction: both intercept and reduce non-point source pollution from multiple land uses, alone and in sequence of each other.
- Vegetation: serves as the nutrient processing units structural sediment traps
- Accumulate detritus: as nitrogen and carbon sinks
- Atmospheric deposition: interception and processing of air borne nutrients.

Wetland and buffer systems show subtle **differences** in the following way:

- Seasonal performance of nutrient reduction: forest buffers show winter processing activity (slower).
- Wetland soils are in consistently reduced condition with continual moisture content for nitrogen processing.
- Wetlands have continual water inundation.
- Forests buffers provide large woody debris.

Dr. Okay concluded by showing how we can relate these similarities and differences to the Bay Program Model: **1)** consider crediting each by their efficiency performance; and **2)** consider each in a landscape combination giving higher credit to the combination.

CONTACT INFORMATION: Dr. Judy Okay, U.S. Forest Service at the Chesapeake Bay Program, 410 Severn Avenue, Suite 109, Annapolis, MD 21403. Phone: 410-295-1311.

How Do We Quantify Trade-offs Between Various Wetland Ecosystem Costs and Benefits?
Marcelo Ardon (Duke University)

Wetlands can transform reactive nitrogen into inert gaseous forms (N_2) through microbial activity. Sedimentation, soil adsorption and plant uptake are important mechanisms for phosphorus uptake in wetlands. While water quality improvements of wetland mitigation have been well documented, trade-offs due to trace gas emissions from restored wetlands have not received as much attention. Denitrification in wetland soils can improve surface water quality, yet this and other microbial processes are also major sources of trace gases. Emissions of nitrous oxide and methane have been well documented in wetland environments, such as rice paddies and constructed wetlands. In this talk we use examples from our own research and the literature to quantify multiple ecosystems costs and benefits of wetlands. We are investigating effects of NC's largest (400 ha) wetland mitigation project to date in: a) altering nutrient export; b) sequestering carbon in plant biomass; and c) altering the forms and quantity of trace gas emissions. Hydrologic reconnection of the site in winter 2007 inundated ~ 80 ha of site, mobilized soil P and altered denitrification potential and emission of N_20. Better understanding of the role of wetlands in achieving nutrient reductions and their net global warming potential will aid future management practices.

Dr. Ardon and his team researched North Carolina's largest mitigation bank, the Great Dismal Swamp. Great Dismal Swamp is located on the coastal plains of North Carolina. These plains were once forested with pond pine and white cedar. But wildfires and ditching and draining of these plains for agriculture purposes has led to the degradation of the coastal plains ability to adequately filter nutrients. The mitigation itself included the movement of land, the planting of 750,000 trees and channels to reconnect its hydrology. There were stop pumps and flap gates installed throughout the area to reconnect the area with water and to form a wetland forest. The site performed quite well and it was found that P was mobilized, there was an increased retention and mobilization of N and emissions of trace gases decreased. The potential long-term retention of nutrients can be linked to 1) biomass; 2) soil and sediments; and 3) atmosphere. Dr. Ardon concluded with the following findings:

- Flooding leads to P mobilization
- There is spatial heterogeneity in nutrient transformations

- It is hard to maximize both N and P "retention" in wetland ecosystems

CONTACT INFORMATION: Marcel Ardon, Department of Biology, Duke University, PO Box 90338, Durham, NC 27708, USA, Phone (919) 660-7262, Fax (919) 660-7425, Email: mla5@duke.edu

Sediment and Nutrient Retention in Riverine Wetlands and Riparian Zones: Natural Ecosystem Services and Their Role in Agricultural Landscapes
Mark R. Walbridge (USDA Agricultural Research Service)

Please note: Dr. Walbridge was not present at the workshop to present his findings but did submit the following abstract:

Riverine wetlands and riparian zones are well known for their sediment and nutrient retention functions. This paper will review and synthesize available data for the sediment and nutrient (N, P) retention functions of these areas, focusing on relatively natural ecosystems and their role as important components of complex agricultural landscapes. Specific products will include: 1) estimates of sediment and nutrient retention for riverine wetlands and riparian zones, and how they vary with stream order; and 2) examples of how ecosystem functions can be used to ameliorate sediment and nutrient exports arising from agriculture. Results will be analyzed in light of the potential of using wetland ecosystem services to manage complex watershed-scale eutrophication problems, such as those in the Chesapeake Bay watershed, through management of existing wetlands, wetland creation and restoration, wetland mitigation banking and environmental credit trading.

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WORKSHOP CONCLUSIONS & RECOMMENDATIONS

Nine presenters summarized recent research, findings and offered their conclusions and recommendations for 1) nutrient and sediment retention by wetlands; and 2) transport and process of nutrient and sediments. Currently, removal efficiencies for created or restored wetlands used in the Chesapeake Bay Watershed Model are assumed to be the same as riparian buffers and no efficiencies are available for enhanced wetlands and therefore not accounted for in the Model. With this in mind, the presenters were able to shed light on recent findings of efficiencies through their research of wetlands restoration. Generally, presenters concluded that each wetland system is unique and depending on its hydrology, flow rate, loadings, etc. will vary in its efficiency in retaining nutrients and sediments.

A moderated discussion, led by Dr. Carl Hershner, Virginia Institute of Marine Science, between the audience and presenters led to the following conclusions and recommendations:

1. Things we know:

- area in acres and geo-referenced location where wetland restoration and creation projects are being implemented in Bay watershed States.
- Published work by Drs. John Day and Bill Mitsch provides gross aerial estimates of phosphorus and sediment removal (per unit area wetland).
- Project managers at the field level working on wetland restoration/creation projects tend to know the drainage area for a given project, but this information is not reported to the Chesapeake Bay Program or the State regulatory agency. This drainage area works for riverine and estuarine wetlands, but not for riparian systems.
- Ratio of agricultural land in the Chesapeake Bay watershed by hydrologic unit.

2. Things we need to know more about (i.e. addition research required) in order to calculate exact efficiencies for restored, created and enhanced wetland systems:

- Bay Program lacks high resolution, up-to-date data on acreage of wetlands as current land use
- Bay Program lacks data on wetland age (which relates to phosphorus retention)
- Bay Program lacks pre and post BMP wetland condition and monitoring data

Recommendations:

- Examine most recently released National Land Cover Data for existing wetland acreage.
- Investigate use of Digital Elevation Model (DEM) to determine drainage area of wetlands (works well in non-tidal areas, but not as well in tidal areas).
- Examine EDNA (a USGS product) for wetland age information.
- Target wetland BMPs for areas of known high Nitrate loading, and prioritize wetlands based on drainage area.
- For targeted watersheds, collect pre- BMP wetland condition data, and work with State and Federal funding partner agencies to require 3 years post- BMP monitoring data.
- Ask States to improve reporting of wetland project location to the HUC 11 level; also ask that they begin to report drainage area associated with each project.
- For Phase 5 of the model and beyond, consider “extra credit” for wetlands associated with riparian forest buffers (places where both exist on landscape in combination).
- Modify wetland efficiency based on drainage area as reported by States or using surrogate values as outlined in the following UMD proposal, subject to review.

(The following summary was drafted by the University of Maryland BMP Project Team based on review of scientific and technical literature and scientific review is being sought by experts involved in this STAC workshop via separate email communication from Jennifer Greiner)

Predicting removal efficiency—

Removal of total N and P by created and restored wetlands can be predicted from the relationship between the percentage of N or P removed and the percentage of the watershed occupied by wetland receiving discharge from the entire watershed. We assume that removal proceeds exponentially with detention time, as expected with first order kinetics. We also assume that detention time (wetland volume divided by water flow rate) is proportional to the percentage of watershed occupied by wetland. This follows if water discharge is proportional to watershed area and if different wetlands have similar average depths. Finally, we assume that there is no removal if there is no wetland area (i.e., the curve must go through the origin). Based on these assumptions:

$$\text{Removal} = 1 - e^{-k\ (\text{area})}$$

Where "removal" is the proportion (not percentage) of the input removed by the wetland, "area" is the proportion watershed area occupied by wetland, and "k" is a fitted parameter. We used non-linear regression (SAS 2004) to fit this equation to data from studies reported in the literature.

Some studies reported negative removal values (i.e. a net export from the wetland) but negative values could not be used for our simple model. When negative removal occurred in particular years but not on the average (e.g. Kovacic et al. 2000, Jordan et al. 2003), we used the average removal percentage in fitting our model. In rare cases where only negative removal was observed, we omitted the observation from our analysis. Omission was only needed for total P removal by one of the wetlands studied by Kovacic et al. (2000) and total N removal by one of the wetlands studied by Koskiako et al. (2003).

The non-linear regressions produced values of the k that can be used in the equation above to predict the proportion of total N or P removed based on the proportion of wetland area in the watershed. For total N, k=7.90 with lower and upper 95% confidence limits of 4.56 and 11.2. For total P, k=16.4 with lower and upper 95% confidence limits of 8.74 and 24.0. The proportion removed increases with the proportion of wetland area but the rate of increase declines as the proportion of wetland area increases (Fig. 1A). Thus, the additional benefit of adding more wetland area gradually diminishes. The curves fit to the literature data are very similar to predictions of the more complex watershed scale models of Tonderski et al. (2005) (shown in Fig. 1 of the report for which this addendum applies).

Removal efficiency of total suspended solids—

There are less data on removal of total suspended solids (TSS) then on removal of total N or P. The percentage of TSS removed averaged 21.6 (standard error 9.9) for five annual removal rates from Koskiaho et al. (2003) and two annual rates from Jordan et al. (2003). More data would be needed to determine the relationship between TSS removal and percentage of wetland area in the watershed.

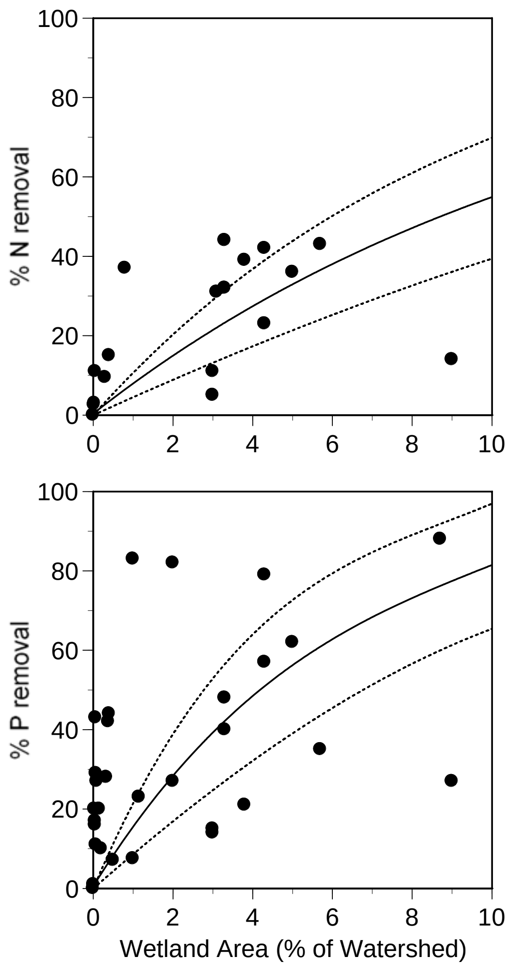

Figure 1. The percentage of total N (top) or P (bottom) removed in wetlands versus the percentage of wetland area in the watershed. The curves are fit by non-linear regression to literature data on annual removal efficiencies after eliminating negative values of removal (see text). The dotted lines indicate the upper and lower 95% confidence interval. The data point at the origin is assumed by the model.

Recommended procedure for calculating efficiencies when wetland area or drainage area is not provided

In the event a jurisdiction does not report the area of the wetland or drainage area the following wetland areas will be applied:

Figure 2. TN and TP removal efficiencies for wetlands broken down by geomorphic region.

Geomorphic Province	Area of wetland as % of watershed area	TN	TP
Appalachian	1%	7%	12%
Piedmont and Valley	2%	14%	26%
Coastal Plain	4%	25%	50%

Agricultural Nutrient and Sediment Reduction Workgroup

Maryland Department of Agriculture
Annapolis, Maryland
May 10, 2007

Wetland Restoration

- In addition to this workgroup, the wetland restoration BMP will also be reviewed by the Living Resources Subcommittee and the Wetlands Workgroup.
- The Bay Program previously adopted the federal definitions for wetlands, which scientists are now saying may not be the best definitions to use. The definitions may therefore need to be revised. The AgNSRWG agreed that the Wetlands Workgroup should be the group to review the definitions for this BMP. If any AgNSRWG members wish to attend the meeting at which this issue will be discussed, please let Sally Bradley know and she will provide you with more information.
- Workgroup recommendations:

When tracking this practice, perhaps we should be using information from the wetland database instead of information from the cost-share database. This issue should be brought up at the Wetlands Workgroup meeting. Perhaps some of the state ag representatives who report this data could come to the Wetlands Workgroup meeting in order to discuss these data issues.

Participants

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Minutes: Nutrient Subcommittee Meeting
June 6, 2007
10:00 AM to 3:00 PM
Fish Shack—Chesapeake Bay Program Office

Wetland Restoration and Creation

The MAWP and the AgNSRWG agreed to have the Wetlands Workgroup and the Living Resources Subcommittee review this BMP. The MAWP should be receiving comments from the LRSC very soon.

Participants

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Meeting Minutes
Agricultural Nutrient and Sediment Reduction Workgroup
Adams County Agricultural and Natural Resource Center
Gettysburg, Pennsylvania
July 12th, 2007

Wetlands:

No comment. Ag WG will defer to Wetlands Workgroup.

Participants

Greg Albretcht	NYS SWCC CNMP

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Mark Dubin	UMD-MARWP
Suzie Friedman	Environmental Defense
Beth Horsey	MDA
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Russ Perkinson	VA DCR
Tim Pilkowski	NRCS
Bill Rohrer	DNMC
Kevin Schabow	CRC-CBPO
Jennifer Shaafsma	MDA
Kelly Shenk	EPA-CBPO
Becky Thur	CRC

Calling In

Tom Simpson	UMD

WET Conference Call Minutes
Wetlands BMP Proposal Discussion
Friday, July 20, 2007 10:00am – 12:00pm
Third Floor Conference Room

Attendance: Mark Mendlesohn, Sarah Weammert, Jeff Sweeney, Denise Clearwater, Ellen Gilinski, Jennifer Greiner, Krystal Freeman

Jennifer gave an overview of who would review the Wetland BMP proposal. LRSC forms a position on the proposal, the proposal and the LRSC position goes to the Nutrient Subcommittee. After review it is then sent to the Water quality subcommittee and is finally sent to the modelers to incorporate the new BMP efficiencies.

A few concerns were raised about the proposal which lead to recommendations. The seasonal component of wetlands is not accounted for in the proposal. Wetlands are not as efficient in the winter and not accounting for this will cause an over estimate of wetland efficiency. The proposal provides a general percent drainage area based on geomorphic regions. We would like to ask those collecting data to report the percent drainage area for each project if possible. CBP has taken heat for overstating accomplishments so we want to be sure the BMP efficiencies contain all the variables we know of. Some want to hold off on using the efficiencies until they are completely accurate but that is not the best approach given that the current efficiencies in the model for wetlands is based on forest buffers. There is room for improvement in the proposal however it is better than what we currently use.

Recommendations

- LRSC recommends the IC definitions adopted by CBP in 2005
- LRSC approves efficiencies with a strong advisement to further adjust the numbers accounting for seasonality, flow, robust, age, and fill. We recommend revisions to the efficiencies every 3-5 years as more accurate information becomes available.

Action Items

- Sarah will send references of sediment and BMP standards to those on the conference call.
- Krystal will send the proposal with the WET aggregated comments to those on the conference call.

Minutes: Tributary Strategy Workgroup
August 6, 2007
Chesapeake Bay Program Office—Fish Shack

- DECISION: MARWP will accept the definitions proposed by the IC and LRSC with the caveat that efficiencies are only applicable to created and restored wetlands.
- ACTION: MARWP will incorporate the LRSC's recommendations into the Wetlands BMP report.
    - ACTION: MARWP will clarify the difference between the treatment system and natural wetlands.
- DECISION: The TSWG agreed with the LRSC's recommendations for the Wetland BMP efficiencies.
- Krystal Freeman, the Living Resources Subcommittee fellow, presented the LRSC recommendation.
- The LRSC agrees with basing the Wetland efficiency on the percent drainage area.
- The LRSC will being asking states to report the percent drainage areas.
- The LRSC would like to move forward with some caveats to be addressed in the future.
- The LRSC recommends that the definitions adopted by the Implementation Committee be used.
    - Tom mentioned that we will have to think about how to further subdivide BMPs but we are not prepared to provide separate efficiencies.
- A wetlands workshop was held to bring in scientific research on wetlands creation and restoration. Not a lot of work was done on enhanced wetlands to be able to come up with an efficiency. MARWP accepted the workshop's recommendation to use the percent drainage area.
- LRSC asked for more clarification on the 1 to 4 ratio for acres of restored wetlands and nutrient removal.

    - Tom clarified that this approach is being replaced by the interim percentages based on hydrogeography.
- MDE believed the coastal plains numbers were not as efficient as they should be, so LRSC would like the hydrogeography percentages to be further addressed.
- LRSC would like to see some further refinements in the model, including more work on developing a seasonal correction factor, hydraulic loading rate, wetland aging, using the EDNA tool to estimate and report drainage areas, and efficiencies of naturally existing wetlands.
- LRSC recommended that natural wetlands be further addressed in addition to treatment ponds and suggested literature to review.
    - MARWP was contracted to look at treatment ponds, not the functionality of a natural wetland.
- DECISION: MARWP will accept the definitions proposed by the IC and LRSC with the caveat that efficiencies are only applicable to created and restored wetlands.
    - The workshop did not believe there was enough knowledge about the efficiency of enhanced wetlands. Existing wetlands, like existing buffers, are not credited with additional nutrient reduction benefits.
- ACTION: MARWP will incorporate the LRSC's recommendations will be into the Wetlands BMP report. MARWP wants to be sure the LRSC understands the approach.
    - MARWP will clarify the difference between the treatment system and natural wetlands.

- DECISION: The TSWG agreed with the LRSC's recommendations.

Participants

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
August 15, 2007

Wetland BMPs **Kelly Shenk**

- The Wetlands Evaluation Taskgroup has changed their reporting requirements so that states must include wetland drainage area in their reports to the task group. If you have the drainage area, the efficiency of the wetland can be calculated using the following formula.

$$\text{Removal} = 1 - e^{-k\,(\text{area})}$$

  When the drainage area is not known, the recommended efficiencies can be used to assess the wetland.
- Jeff Sweeny noted that the wetlands data used in the model is reported directly to him by the states, and is different than what is reported to the Wetlands Evaluation Taskgroup. This will need to be remedied if the above recommendation of using drainage acres is implemented.
- Clarification is needed on the definition of "wetland treatment systems." The workgroup states that this terminology does not mean waste water treatment, but systems designed so that water is distributed through the wetland with enough retention time to allow for reductions. NSC will need to be sure the BMP definition and information on the website uses the workgroups definition of "wetland treatment systems."

Efficiency Recommendation	TN	TP	TSS
Wetland Restoration and Wetland Creation			
Appalachian	7	12	--
Piedmont and Valley	14	26	--
Coastal Plain	25	50	--

Efficiency recommendations for urban, forestry, wetland, and agricultural BMPs were reviewed and approved by the Nutrient Subcommittee with the exception of the off-stream watering practices and cover crop BMPs. These two BMPs will be reviewed on a joint NSC, TSWG, AgNSRWG, MAWP conference call scheduled for August 24, 2007.

Participants

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Kari Cohen, NRCS
Melissa Fagan, CRC
Norm Goulet, NOVRC

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Fred Samadani, MDA
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Don VanHassent, FWG Chair
Jennifer Volk, DNREC
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Chesapeake Bay Program

WATER QUALITY STEERING COMMITTEE
Conference Call

August 27, 2007

SUMMARY OF DECISIONS, ACTIONS AND ISSUES

Water Quality Steering Committee Approval of Year 1 MAWP BMP Efficiencies

Issue: At the Water Quality Steering Committee's June 20-21, 2007 meeting, the Steering Committee agreed that they would conduct the final review all of the Nutrient Subcommittee's recommended BMP definitions and efficiencies and take action on any BMPs that the Nutrient Subcommittee (NSC) could not agree on an efficiency for. Definitions and efficiencies for twelve of the thirteen Year 1 BMPs were approved by the Nutrient Subcommittee and determined to be consistent with the available data by the MAWP. The Cover Crop BMP was not resolved. The Steering Committee was asked by the Nutrient Subcommittee to approve the package of the 12 consensus-supported BMP efficiencies and make the final decision on the cover crop BMP efficiencies based on three options.

DECISION: The Water Quality Steering Committee approved the 12 BMP definitions and efficiencies, described in the advance briefing papers, as recommended by the Nutrient Subcommittee and its workgroups for use in Phase 5 Chesapeake Bay Watershed Model.

Conference Call Participants

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COMPREHENSIVE FUTURE RESEARCH NEEDS

BMP Development, Refinement and Implementation

Throughout the BMP project many data gaps where identified across all sectors (agricultural, forestry, and urban stormwater). These research needs are listed below to help guide future BMP projects. Specific research needs for each individual BMP are included in the individual BMP reports. BMP development and implementation needs were also identified, these are included to help create a process that develops and refines BMP effectiveness estimates. The process UMD/MAWP used in the BMP Project should not be abandoned, but the lessons learned during the last two and a half years should be used to refine estimates and should provide valuable lessons for others trying to create nutrient and sediment reduction strategies.

Future Research Needs: BMP Science

This project identified an improved method for representing dissolved reactive phosphorus (DRP), but the UMD/MAWQ recommends the CBP refine the relationship between total suspended sediment (TSS) and total phosphorus (TP) that assumed 75% percent of TP is bound to sediment and the remainder is DRP. While this relationship is based on research conducted in the Chesapeake Bay watershed it is a watershed wide generalization, additional research is warranted to further develop the accuracy of phosphorous transport. In addition, most studies only examine total nitrogen (TN), TP and TSS, and do not investigate specific species of nutrients. Future research projects should quantify the pollution reduction benefits of all species such as dissolved reactive phosphorous and nitrate.

Future research projects should categorize effectiveness estimates based on their hydrogeomorphic region. This can be accomplished by allocating efficiencies based on surface and subsurface flow proportions. Cover crops and riparian buffers use this approach. Specifically, a better understanding of the surface and subsurface flow proportions in each geographic setting will refine pollutant removal for nitrate.

All practices have a lifespan that needs to be taken into account when modeling BMP implementation. Future projects should evaluate BMPs to determine their lifespan.
The updated model can also simulate a range in effectiveness and performance estimates should use a reasonable range of pollution removal instead of one value. Simultaneously, the new version of the model can simulate ranges in BMP performance based on flow events. The influence of runoff on BMPs, and the maximum flow rate a BMP can treat before bypass occurs, should be determined.

The influence of concentrated flow on effectiveness is not documented. These flow patterns may bypass BMPs reducing the pollution runoff reductions of practices. The prevalence and influence of concentrated flow paths for all practices, specifically riparian buffers, should be determined.

Better research, demonstrations and monitoring data of small watershed area conservation effects will increase confidence in BMP effectiveness. Research- and demonstration-site derived efficiencies for catchment-scale implementation efforts do not reflect the spatial variability of an entire watershed area. A system that accounts for scale differences when moving from research to watershed scale should be developed.

Future Research Needs: BMP Policy

The CBP must adopt a consistent, rigorous process for developing new BMPs and refining established practices. The Nutrient Subcommittee is designing this process in early 2009. UMD/MAWP recommends modeling the CBP review process off the process used in year two of the BMP Project. Specifically, require new BMPs and refinements be evaluated using the BMP Project guidelines, data applicability review, best professional judgment protocols, and adjustments are made for factors that introduce variability in pollutant removal.

When estimating performance we assume proper implementation, operation and maintenance, function, and replacement, however, is this accurate? Specifically, what is the impact of maintenance, or lack thereof, on performance? Efforts should be made to assure that reported implementation is close to actual and to determine if implementation and operation is as rigorous as specified in the practice. What is the actual level and degree of implementation? How does this effect performance? How do design errors affect performance? In addition, steps must be taken to ensure accurate tracking and reporting.

There is a need for a standard in monitoring protocol, parameters, methods, and data analysis in all BMP effectiveness studies to assist in development of BMP performance averages. Comparing studies that were not necessarily developed using the same guidelines will introduce error and thus compromise the accuracy of any calculated data range.

BMP FORUM SUMMARY

The BMP Forum was held on December 4, 2008 in Frederick, Maryland. Revised and newly developed BMP definitions and effectiveness estimates were presented and a consistent process for BMP development was discussed. Topics presented, and their presenters are listed below:

Introduction by Kelly Shenk

a. Background
b. Project Objectives and Guidelines
c. How Effectiveness Values will be Used

Process by Sarah Weammert

a. Year one
b. Lessons Learned
c. Year two

Dairy Feed Management by Ginny Ishler

Cover Crops by Dean Hively

Pasture Systems by Les Vough

a. Offstream Watering With Fencing
b. Offstream Watering Without Fencing
c. Horse Pasture Management
d. Livestock Pasture Management

Ammonia Emissions Reductions by Tom Simpson

a. Alum
b. Covers
c. Biofilters

Urban Stormwater Treatment by Andy Baldwin

a. Dry Detentions Ponds and Hydrodynamic Structures
b. Urban Wetlands and Wetponds
c. Extended Detention Ponds
d. Urban Erosion and Sediment Controls

Field Management by Mark Dubin

a. Conservation Planning
b. Conservation Tillage

Riparian Grass and Forest Buffers by Judy Okay

Infiltration and Filtration by Kelly Collins

a. Bioretention
b. Infiltration Basins and Trenches
c. Permeable Pavement and Pavers
d. Filters
e. Vegetated Open Channels

Other BMPs by Sarah Weammert

a. Mortality Composting
b. Forest Harvesting
c. Dirt and Gravel Road Erosion and Sediment Control
d. Wetland Restoration and Creation

Closing Panel, Moderator: Tom Simpson

a. Urban Stormwater, Norm Goulet
b. Agriculture, Russ Perkinson
c. Policy and Market Based Programs, Ron Korcak

Lessons Learned and Conclusions by Tom Simpson

Visit www.chesapeakebay.net/marylandbmp.aspx for copies of the presentations.

APPENDIX A: YEAR ONE BMP TEMPLATE

The following is a template all experts were asked to fill in and use when reporting on their BMP.

<u>BMP Name</u>
Definition and Nutrient and Sediment Reduction Efficiencies

For use in calibration of the Phase 5 of the Chesapeake Bay Program Watershed Model

Recommendations for Formal Approval by the Nutrient Subcommittee's Tributary Strategy and <u>Source Area</u> Workgroups

This document summarizes the recommended definition and nutrient and sediment reduction efficiencies for <u>BMP name</u> for review and final approval by the Tributary Strategy Workgroup and <u>source area</u> Workgroup on <u>date</u>. Attached to these recommendations is a full accounting of the discussions on this BMP and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed.

<u>Insert Photograph of BMP here</u>

<u>Description/Definition of BMP</u>

Include problem addressed and nutrient/sediment reduction benefits. Include narrative description of other benefits (i.e., besides nutrient and/or sediment reductions achieved through BMP; for example habitat, economic, or social benefits).Identify the loss pathways and estimate the hydrologic lag time associated with the practice. If there are multiple definitions for this BMP please list all definitions.

<u>Efficiency</u>

Efficiency expressed as a percentage reduction for nitrogen, phosphorus and/or sediment (all that are applicable). When reporting your efficiency, provide the range of efficiencies you encountered while researching this BMP and explain why you selected the proposed efficiency.

BMP Efficiency Development. Please use the following set of questions to adjust the efficiency. Please also provide information on the following adjustments that alter efficiencies. If you cannot provide quantified adjusted reduction efficiency based on the following factors please identify the issues. For example, mention that the BMP takes high operation and maintenance to work properly but you cannot provide the resulting adjusted reduction efficiency percent.

Identify the loss pathways and estimate the hydrologic lag time associated with the practice.

The expected spatial variability for a practice should be estimated based on available science and knowledge of the expected geographic extent of implementation of the practice. Different reduction efficiencies should be established for practice implementation across different physiographic, geomorphic or hydrologic settings. Where possible, discuss how surface water and groundwater interactions (permeability), along with geology and soil types (slope, seeps, floodplain, etc.) alter efficiencies.

Implementation lag times - BMP efficiencies should match the practice implementation schedule. Many practices are reported as implemented once the plan or design has been completed. In reality, the plan may call for phased implementation over as much as five to ten years. In addition, the farmer may not implement the practice as scheduled due to climatic, management or economic constraints. The time it takes for an implemented practice to reach its full potential may also delay pollution reduction percentages. Identify possible lag times in reaching BMP pollution reductions due to phased-in implementation or time to maturity of BMP.

Discuss how the efficiency will change from the research/demonstration scale to the watershed/basin scale.

Define the impact of extreme climatic events on the BMP and discuss the BMPs efficiency function in events above its designed maximum. Where data is available, please discuss how the practice efficiency should be adjusted for events approaching, but within, the design maximum. Explain how different lengths or widths of the BMP (where applicable, for example Riparian Forest Buffers) will alter efficiencies.

Discuss how watershed management conditions, including operation and maintenance of BMP, construction supervision, and/or upland land use changes alter effectiveness.

Discuss your thoughts on how to adjust the efficiency for watershed scale application. This does not have to be a quantified answer, but please identify the issue with adjusting the various scales. For example if the BMP requires high operation and maintenance to work properly please explain that here.

Please provide the efficiency you recommend the Chesapeake Bay Program uses for its Watershed Model and Tributary Strategies.

Qualitative or Quantitative Statement: statement about the soundness of the BMP efficiency and amount of data.

Include a narrative on how you dealt with any uncertainty or incompleteness in the data.

If applicable, explain how you adjusted the efficiencies down to be more conservative. Mention what level of reductions you had initially calculated and explain level of conservatism you are recommending. Indicate how confident you are in your proposed efficiencies, high, somewhat limited, limited, or best professional judgment. You are providing your recommended level of conservatism for the efficiency you are proposing, not on the efficiencies from studies you referenced.

Results of all data analysis conducted. Make sure it is well documented in terms of the purpose of the analysis and findings and who conducted them.

Outstanding issues to resolve in the future

How BMP is tracked and reported

Future research needs

References: list of all literature and studies evaluated.

On-going research: Also please include a other literature or on-going studies that you did not use to report your proposed efficiency but that may be important in future reviews of this BMP.

APPENDIX C: ADDITIONAL BMP REPORTS PENDING CBP REVIEW AND APPROVAL

The UMD/MAWP was tasked with developing definitions and effectiveness estimates for seven BMPs in year two and four reports were not approved by the CBP. They are dirt and gravel road erosion and sediment control, horse pasture management, livestock pasture management, and enhanced nutrient management. The UMD/MAWP reports for these four BMPs are below but do not reflect a final Chesapeake Bay Program-approved consensus on definition or effectiveness estimate for these practices. Task forces, lead by CBP, are currently working to develop these remaining BMP into approved CBP practices.

Dirt and Gravel Road Erosion and Sediment Control – PENDING CBP APPROVAL

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in Phase 5 of the Chesapeake Bay Program Watershed Model

Recommendations for Endorsement by the Chesapeake Bay Program Nutrient Subcommittee and its Workgroups

Consulting Scientists

Mike Klimkos
Program Coordinator
PA Dirt and Gravel Road Maintenance Program

And

Barry Scheetz
Interim Director
Center for Dirt and Gravel Road Studies

Synthesis and Recommendation by

Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary

Dirt and Gravel Roads: Reduce the amount of sediment runoff from dirt and gravel roads through the use of driving surface aggregates (DSA), berm removal, additional drainage outlets, raising the road profile, and grade breaks.

Technique		TSS Effectiveness Estimate
Driving Surface Aggregate	Limestone*	50%
	Sandstone	55%
Raising the Road Profile		45%
Grade Breaks		30%
Additional Drainage Outlets		15%
Berm Removal		35%

* If a jurisdiction is unable to report the driving surface aggregate material used the CBP assumes limestone.

The CBP has not approved the dirt and gravel road erosion and sediment control effectiveness estimates because the UMD/MAWP discounted research values because the study method that determine the research values did not capture the first flush of sediment, thus overcrediting performance by basing their reductions on a smaller load. CBP partners stated the 'first flush', the first minute of flow, is less than one percent of the total flow and is not a concern on dirt and gravel roads as it is on urban land. They believe nothing in the data supports a first flush effect, except for a slight increase in concentrations in the first five to six minutes. The Nutrient Subcommittee will follow up with the Center for Dirt and Gravel Roads and then return with recommendations for effectiveness estimates.

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project during 2007-2008 to develop the components or subcategories of this BMP, a corresponding definition(s) and effectiveness estimates. The BMPs developed have not been previously reported to the Chesapeake Bay Program. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

UMD/MAWP recommends the following effectiveness estimates. Attached to these definitions and effectiveness estimates is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix A.

UMD/MAWP consulted a panel of experts from the academic, industrial, state agency and non-profit sectors to advise in the development of BMP definitions and effectiveness estimates. Discussions during panel meetings, data and best professional judgment was used to craft the recommendations presented here. While their input strongly influenced the recommendations, inclusion of panel members name does not constitute endorsement.

Guidelines. The following guidelines were used when selecting data to include in the data set:

- Effectiveness estimates should reflect operational conditions, defined as the average Chesapeake Bay watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.

- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.

- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process. As such, peer reviewed literature should be given more weight than design standards and manuals.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

Data applicability. As with any literature review, data should be evaluated for its applicability. Before selecting a study for use in developing a BMP effectiveness estimate and definition, UMD/MAWP and panel members considered the questions below. The data used to develop effectiveness estimates was selected based on its applicability to the natural conditions of the Chesapeake Bay watershed, such as, soil type, hydrologic flow paths, and species composition. The studies were evaluated for their BMP design and implementation compatibility to those in the Chesapeake Bay watershed. Rates and timing of fertilizer applications, and the relationship between cultivation and planting dates, were evaluated to determine if the study was applicable to farming methods in the watershed.Studies were also reviewed to determine if the study duration accurately represents average effectiveness results. The time when removal rates are monitored may influence performance by under or overestimating effectiveness.

- Are natural characteristics (soil type, climate, flow paths, geology, vegetation, etc.) of the research site similar to conditions in the Chesapeake Bay watershed?
- Is the practice consistent with NRCS codes, jurisdictional stormwater design manuals? If not, how would effectiveness estimates be different?
- How critical is the duration of the experiment to the reported effectiveness results?
- Do results reflect changes in pollution reduction benefits over the lifetime of the BMP?
- Briefly explain the study method used?
- What parameters were sampled and monitored?
- Who conducted the research?
- How was the effectiveness estimate calculated?
- What was the scale of the study?
- What assumptions, outside of experimental results, were made in reaching the conclusions?

Only one data set that evaluates the sediment reduction of erosion and sediment controls on dirt and gravel roads is available. The Center for Dirt and Gravel Road Studies (Center) conducted the research and after considering the aforementioned questions an issue arose with the Center’s report. The Center monitored performance of various techniques that reduce erosion from dirt and gravel roads. Timing of pre-BMP and post-BMP sampling occurred one minute after the wetting front initially reached the sampling point. This reduced the infiltration rate on the initial run, but also eliminated the first flush of dried road sediment. During the first flush, the majority of sediment is transported. By missing the first flush the load associated with the first flush is missing from reduction calculations. By missing the load off the road during the first flush the Center is over crediting dirt and gravel road erosion and sediment control techniques by basing reductions on a smaller load. Thus, if the Center's procedure did not capture the sediment in the first flush then sediment reduction calculations are erroneous.

Solid-phase pollutants typically exhibit a first flush effect. Barbosa and Hvitved-Jacobsen (1999) observed a first flush effect for TSS. Extensive work in Florida has defined the first flush as the first 25 mm of runoff and determined it carries 90% of the pollution load from a storm. Yousef et al (1985) and Miller (1985) observed first flush for many pollutants, especially particulates. Sansalone and Cristina (2004) shows most of the pollutants in the first flush are associated with large particles.

To account for sediment movement during the first flush, UMD/MAWP recommends discounting the Center's sediment reduction estimates by a relative 60%. Data is unavailable to determine the exact portion of sediment carried off dirt and gravel roads during the beginning of a precipitation event, but research from other land uses suggests first flush volumes carry the majority of sediment load in the runoff. First flush is related to factors such as the distribution of intensities during a storm, percent impervious cover, the number of dry days, and watershed area. 60% is selected as it is above 50% to represent the majority, but not too high as first flush sediment transport is highly variable and not well understood on the dirt and gravel road land use. The selection of 60% versus any other value above 50% is based on best professional judgment.

A summary table with the UMD/MAWP recommended effectiveness estimates is below, followed by an explanation of its calculations and methodology.

Technique		TSS Effectiveness Estimate
Driving Surface Aggregate	Limestone*	50%
	Sandstone	55%
Raising the Road Profile		45%
Grade Breaks		30%
Additional Drainage Outlets		15%
Berm Removal		35%

* If a jurisdiction is unable to report the driving surface aggregate material used the CBP's assumes limestone.

If the first flush effect is not used to adjust the Center's performance values there are other factors that call for a more conservation effectiveness estimate. All Dirt and Gravel Road Erosion and Sediment Control technique effectiveness estimates have limitations based on the amount and type of data available. These limitations warrant assigning a more conservative effectiveness estimate to the Center's report on five ESMPs. The most significant limitation is the amount of data available. The Center's study is the only one evaluating performance of dirt and gravel road erosion and sediment control techniques. The monitoring timeline of the study is also a concern. As monitoring only occurs directly after implementation the existence of sheet flow over time is unknown. The question becomes, with time is sheet flow maintained? In addition, without inspection and maintenance to ensure functionality and proper design, implementation performance values should be discounted. To be consistent with the other BMPs evaluated under the UMD/MAWP project, a discount for proper implementation and design is not applied as it was not investigated. There are many other limitations in the data, however, to warrant a more conservative estimate of effectiveness than the Center's report indicates.

Some limitations only apply to individual techniques. With berm removal and raising the road profile time after implementation is important. With time a berm may be reformed and a profile lowered creating the condition the BMP was meant to address. Time after implementation should be considered for both of these techniques and reflected in effectiveness estimates. UMD/MAWP recommends 'turning off' a berm removal of raising the road profile's performance after 5 years; unless maintenance of those sites is verified to ensure a berm has not been reformed or a profile lowered again. Additional limitations for each technique is discussed below.

UMD/MAWP recommends a discount baseline, to be applied to the Center's effectiveness estimates, of a relative 25%, consistent with other discounting methods recommended for agricultural and urban BMPs, and to account for factors applicable to individual ESMPs. An explanation of these individual factors and why they warrant a relative reduction from the Center's can be found in Appendix B.

BMP Structure/Subcategories

The Center has developed practices to help reduce the amount of sediment runoff from dirt and gravel roads. The Center terms these techniques environmentally sensitive road maintenance practices (ESMPs) and is currently studying five of these ESMPs, quantifying their effectiveness to reduce sediment discharge. These five ESMPs studied are:

Driving Surface Aggregate(DSA): durable and erosion resistant road surface;
Raising the Profile: raising road elevation to restore natural drainage patterns;
Grade Breaks: elongated humps in the road surface designed to shed water;
Additional Drainage Outlets: creating new outlets in ditchline to reduce channelized flow; and

Berm Removal: Removing unnecessary berm and ditch on downhill side of road to encourage sheet flow.

These five techniques will be the 'subcategories' under the Dirt and Gravel Road Erosion and Sediment Control BMP. Definitions and performance estimates will be broken out using these five ESMPs. These five ESMP were selected because they are easily quantifiable, commonly implemented, relatively cost effective, and effective at reducing sediment discharge.

Description/Definition of BMP and Effectiveness Estimate:

Driving Surface Aggregate (DSA)

Definition: DSA is a specific gradation of crushed stone developed by the Center for Dirt and Gravel Road Studies specifically for use as a surface wearing course for unpaved roads. DSA achieves sediment reductions by decreasing erosion and transport of fine material from the road surface.

Effectiveness:
The research level sediment reductions obtained by covering a native surface road with DSA were approximately 75% after one month, and 90% after one year. A breakdown between limestone and sandstone derived aggregates shows limestone removes 86% of sediment and sandstone removes 93%. If a jurisdiction cannot report DSA type, assign the most conservative type, in this case limestone.

To account for the first flush of sediment runoff during a precipitation event, UMD/MAWP recommends the following. For limestone, 60% of 86% is equal to 51.6%, round down to the nearest factor of five for a sediment effectiveness estimate of 50%. With sandstone 60% of 93% is 55.8%, round down to the nearest factor of five for a sediment effectiveness estimate of 55%.

Raising the Road Profile:

Definition: Raising the road profile involves importing material to raise the elevation of an unpaved road. It is typically practiced on roads that have become entrenched (lower than surrounding terrain). Raising the elevation of the road is designed to restore natural drainage patterns by eliminating the down-slope ditch and providing cover for pipes to drain the up-slope ditch. Removing the down-slope ditch will eliminate concentrated flow conveyed in the ditch and will create sheet flow. Raising the Road Profile achieves sediment reduction by controlling and reducing the volume of road runoff.

Raising the road profile involves importing fill material to raise the elevation of the roadway up to the elevation of the surrounding terrain. The road is filled to a sufficient depth as to eliminate the ditch on the down-slope side of the road and encourage sheet flow. Shale and gravel are the most common fill materials for roads. Other potential recycled fill materials include ground glass, waste sand, automobile tires, clean concrete rubble, etc.

Effectiveness:
The Center's research showed one month after raising the road profile sediment was reduced by 78%, and after one year 81%. To account for the first flush of sediment runoff during a precipitation event, UMD/MAWP recommends the following. 60% of 81% is 48.6%, round down to the nearest factor of five for a sediment reduction of 45%.

Grade Breaks

Definition: Grade breaks are an intentional increase in road elevation on a downhill grade which causes water to flow off of the road surface. It is designed to reduce erosion on the road surface by forcing water into the ditches or surrounding terrain. Erosion of the road surface is reduced by forcing runoff laterally off the road. In some cases, grade breaks are used to force water off the road entirely, serving as an additional drainage outlet. Sites where water is not forced off the road entirely convey the water into a roadside ditch.

The Center's report forced water into the roadside ditch.

Effectiveness:
Two sites were used to test grade breaks. One site resulted in a 43% reduction in sediment, the other 57%. The average sediment reduction from these two sites is 50%. 60% of 50% is equal to 30%. Thus 30% is assigned as the effectiveness estimate. As the ditch is considered part of the road, any erosion from the ditch itself should be accounted for in the effectiveness estimate of dirt and gravel road erosion and sediment control via a grade break.

Additional Drainage Outlets

Definition: Drainage outlets are designed to capture water flowing in the roadside ditch and force it to leave the road area. There are two major types of drainage outlets. Turnouts (also called bleeders or cutouts) outlet water from the down-slope road ditch. They usually consist of relatively simple cuts in the down-slope road bank to funnel road drainage away from the road. Drainage that is carried by the up-slope road ditch is usually outletted under the roadway by the use of a crosspipe (also called culvert, sluice pipe, or tile drain). Installing additional drainage outlets reduces concentrated flow, peak flow discharges and sediment transport and delivery from unpaved roads and ditches into streams, and can increase infiltration. It does not affect sediment generation from the road surface or deliver in the up-slope ditch, thus all data on sediment reductions in the report is only for down-slope ditch unless otherwise noted. Drainage outlets are to be placed in locations that have the least likelihood of reaching streams. If a newly added outlet conveys sediment to the stream, little, if any, sediment reductions will be obtained.

Effectiveness:
When analyzing the down-slope ditch only sediment is reduced by 48%. Considering both ditches yields a sediment reduction of 31%. UMD/MAWP recommends considering both ditches as this reflects the entire dirt and gravel road. To account for the first flush of sediment runoff during a precipitation event, UMD/MAWP recommends the following. 60% of 31% is 18.6%, round down to the nearest factor of five for a sediment effectiveness estimate of 15%.

Berm Removal

Definition: A berm is a mound of earthern material that runs parallel to the road on the down-slope side. Berms can be formed by maintenance practices and road erosion that lowers the road elevation over time. In many cases, the berm is unnecessary and creates a ditch on the down-slope side of the road. This berm can be removed to encourage sheet flow into surrounding land instead of concentrated flow in an unnecessary ditch. Restoring sheet flow results in decreased runoff and sediment transport along the roadway, increase infiltration, and reduced maintenance associated with the road drainage system.

Effectiveness:
When analyzing the down-slope ditch only sediment is reduced by 94%. Considering both ditches yields a sediment reduction of 59%. UMD/MAWP recommends considering both ditches as this reflects the entire dirt and gravel road. To account for the first flush of sediment runoff during a precipitation event, UMD/MAWP recommends the following. 60% of 59% is 35.4%, rounding down to the nearest factor of five yields a sediment reduction of 35% for berm removal.

Combination Practices
In practice ESMPs are combined at one site. In these situations credit will be given by calculating the pollution reduction consecutively, not additively, because the ESMPs are treating the same load. The effectiveness for that site is calculated by reducing the load by the effectiveness estimate assigned to the first ESMP, and then reducing that load by the effectiveness estimate associated with the second ESMP. For example, if a project combines DSA (50%) and berm removal (35%), first the pollution reduction associated with DSA, 50%, is applied to the loading resulting in 50% of the sediment load remaining. Next, take the remaining sediment load percent after it has been treated by DSA, 50%, and multiply it by the effectiveness

value for the other ESMP, in this case berm removal,35%. Thus 50% of 35 is 17.5%. Add the DSA credit, 50%, and the percent removed by berm removal, 17.5%, to get a total sediment reduction of 67.5% for that site. Performance values cannot be added together as the percent reduction is lower with multiple BMPs as the load will be reduced exiting the first BMP.

Nutrient Removal

Total Nitrogen (TN) and Total Phosphorous (TP) removal is minimal with dirt and gravel road erosion and sediment control. One reason is that dirt and gravel roads are not fertilized. The other is that the environmental benefit association with dirt roads is such that nitrogen (N) and phosphorus (P) reductions are not anticipated, nutrient reductions are not a component of the average function of dirt and gravel roads. If N and P reductions are associated with dirt and gravel roads they should track sediment reductions.

One situation where nutrient reductions could be associated with dirt and gravel roads is on farm lanes where the road was used as a conduit to the stream. If projects remove that mechanism so water is dispersed out onto the field, then the nutrient removal is proportional to the amount of water reduced from discharging directly to the stream.

UMD/MAWP suggests any nutrient reduction is eliminated due to increases in nutrient runoff during construction. With bank cutting, seeding and mulching nutrients are released, possibly counterbalancing any nutrient reductions.

Threshold

Research has not been done to determine a threshold storm even when ESMPs no longer function due to a volume of water beyond the capability of the practice to perform sediment removal. During Hurricane Ivan ESMP designs consistent with the Centers specifications held up very well. However, municipalities that cut corners (poor installation, fewer cross pipes, etc.) had problems. Refinements to dirt and gravel road erosion and sediment control should evaluate the influence various precipitation events have on performance.

Flow Patterns

Groundwater impacts from dirt and gravel roads is negligible because the subsurface is too compact to allow high percolation. Projects such as turnouts and outflow pipes that incorporate sheet flow into areas that allow infiltration (wetland, forest, etc.) will provide groundwater recharge. The number of projects that actual implement one of these techniques is unknown. UMD/MAWP suggests refining erosion and sediment control definitions to encourage designs that provide groundwater recharge by requiring runoff discharge to wetlands, forests or other lands that provide infiltration.

Practice Duration and Maintenance
Inspection and maintenance is required to ensure proper design implementation and performance values. Without inspection and maintenance effectiveness estimates should be discounted as the site is not constructed to match the BMP definition and associated pollution reduction estimates.

The Center's report only monitors projects that are one year old or younger. There is antidotal evidence from QAQC efforts conducted by the Center on their project sites that practices are functional for 3-5 years conservatively, 10 years at the best sites. Ultimately, the long-term performance depends on average daily traffic load.

For crediting dirt and gravel road erosion and sediment control ESMPs it is agreed to use a 3-5 year life cycle with guaranteed inspection and reported maintenance of the practice. Without inspection and necessary maintenance, percent effectiveness should be discounted from its original performance value. There is no data on average degradation, however effectiveness should never go to zero.

Project sites with DSA will see degradation over a five year period. To account for this the panel supports providing full performance for year one of installation, and at year five performance will be relatively 80% of total performance. Between age one and five a linear function can be applied.

The other ESMP techniques are a permanent practice and as long as water is still directed as the ESMP is designed to carry water, the practice will still function at 100% of its performance estimate. This is maintained as long as maintenance practices do not reform the berm or other structure that necessitated the ESMP in the beginning.

Modeling the Effectiveness Estimate

Treated Area
The current placeholder of assigning a length and width (lbs/ft of removal) is not appropriate for dirt and gravel roads. Roads have width and ESMP treat the whole surface. In addition, a load (lb/sq area) is not comparable because native soil results in various erosion rates.

Some ESMPs treat both the road and the ditch, while some only treat the road. This will influence the size of area the ESMP treats. Summarizing the Center's study the following can be concluded:

DSA – only the road is treated. Average width of projects in the Centers study is 14ft
Raising the Road Profile – both the ditch and road are treated. Average length in the study is .5 mile and width is 16 ft

Grade Breaks – only the road is treated. The study listed 12ft average widths with lengths over 50 ft
Additional Drainage Outlets – only the ditch is treated.
Berm Removal – both the ditch and road are treatment. In the study, average width is 12ft and length is 200-1000 feet

Baseline Sediment Loads by Native Soil

The Center's study lists the total sediment loss by lbs per 30 minute events for the native surface (pre ESMP). These values are included below to provide guidance in developing a baseline.

Average Total 30 Minute Sediment Loss (lbs)	Road Location	Native Surface	Road Use Characteristics	Road Slope
0.7	Mifflin County	Hard packed limestone	Narrow farm road, grass in median, surrounding area grasses and pasture	3%
1.0	Huntingdon County	Hard packed limestone	Narrow forest road, low-medium use	1-2%
5.7	Potter County (Lebo)	Native soil with limestone remnants	Narrow forest road, low use	1-2%
8.7	Potter County (Lebo)	Native soil with limestone remnants	Narrow forest road, low use	1-2%
12.2	Columbia County	Limestone with fine silt component	Wide township road, low use, forst and meadow	5-6%

All data is averaged from three rainfall simulations and represents one thirty-minute event with a 6 month return frequency.

Default Effectiveness

When a jurisdiction cannot report which erosion and sediment control technique was implemented the technique with the lowest effectiveness is used (per Watershed Technical Workgroup policy).

Future Research Needs

The CBP's WSM now has the ability to model additional storm events (6-month, 5-year, 10-year storm, etc.), slopes and daily traffic rates. The Center devised a model (3rd scale truck) with a 100 psi truck tire that can do 7,200 runs an hour. It costs $7.20/hour to run the machine, for one ESMP technique under one set of conditions at one time, and two hours of runs represents one year of data at 40 cars a day. For each ESMP technique various storm events, slopes, soils, and daily traffic rates can be evaluated and performance calculated to address the factors of uncertainty. The CBP would need to determine which factors heavily influence ESMP performance and then set up runs to evaluate these conditions. UMD/MAWP recommends funding and employing this research when refining this BMP, focusing on slope and native soil type.

In addition, UMD/MAWP recommends refining these techniques in the future to include a type one and type two subcategory. Type one would encompass the techniques as described in this report, while type two include additional design elements such as sheet flow and native vegetation. This is similar to some urban stormwater BMPs categories. Additional pollution reduction credit is assigned to type two techniques, encouraging their implementation. The definitions for type two techniques would include the following (except DSA):

"Locate discharge outflow where there is high infiltration capacity or into vegetated areas or sediment traps before the discharge reaches surface waterways. Also, native vegetation should be used at the discharge site whenever possible."

Type two definitions could also state, "discharge should not be concentrated, but achieve sheet flow."

Reference:

Barbosa, A.E., and T. Hvitved-Jacobsen. 1999. Highway Runoff and Potential for Removal of Heavy Metals in an Infiltration Pond in Portugal. *Science of Total Environment*, vol. 235, no. 1-3, pp. 151-159.

Miller, R.A. 1985. Percentage Entrainment of Constituent Loads in Urban Runoff, South Florida. USGS WRI 84-4329.

Sansalone, J.J. and C.M. Cristina. 2004. First flush concepts for suspended and dissolved solids in small impervious watersheds. Journal of environmental engineering, vol 130, no 11, pp. 1301-1314.

Yousef, Y.A., M.P. Wanielista, H.H. Harper, D.B. Pearce and R.D. Tolbert. 1985. Best Management Practices – Removal of Highway Contaminants by Roadside Swales. Final Report, Submitted to the Florida Dept. of Transportation, Tallahassee, FL.

APPENDIX A. MEETING MINUTES

Dirt and Gravel Road Agenda and Questions to Discuss
Harrisburg, PA
April 15, 2008

Attendance:
Barry Scheetz
Mike Klimkos
Sarah Weammert

Action Items:
ACTION: Sarah to provide a list of Phase V land uses to Mike and Barry to help ID proper category.

ACTION: Sarah to contact Matt Beaver, PA Bureau of Forestry, to discuss private development (gated community) roads (miles, ESMP used, performance, maintenance, etc.).

ACTION: Sarah to discuss the proper NRCS code designation with Mark Dubin (Access Road?). Yes, when access roads are farm lanes, the standard includes specifications for construction.

ACTION: Mike and Barry will help Sarah develop a list of co-benefits (besides water quality) from employing ESMP techniques on dirt and gravel roads.

ACTION: Have ability to model additional storm events (6-month, 5-year, 10-year storm, etc.), slopes and daily traffic rates. The Center devised a model (3rd scale truck) with a 100 psi truck tire that can do 7,200 runs an hour. It costs $7.20/hour to run the machine and two hours of runs represents one year of data at 40 cars a day. ADD TO FUTURE RESEARCH NEED SECTION

ACTION: Sarah will discuss WV Tributary Strategy definition of dirt and gravel road erosion and sediment control with a WV representative. How is silt fence, slope drain and vegetation defined?

ACTION: Mike and Barry will send Sarah a couple pictures of damage due to Ivan from sites that did not follow Center design specifications, and project sites that were designed and installed properly (according to Center design standards) and maintained their level of performance during Hurricane Ivan.

ACTION: Mike will attempt to determine the number of miles of public dirt and gravel road in the Chesapeake Bay watershed, the number of projects, and the average length of the project (section of road treated).

ACTION: Projects such as turnouts and outflow pipes that incorporate sheet flow into areas that allow infiltration (wetland, forest, etc.) will provide groundwater recharge. The number of projects that actual implement one of these techniques is unknown. Barry will check on the number of projects that incorporate infiltration areas. Is sheet flow achieved and maintained? Should this be a requirement in the definition?

1. Overview of BMP Project

Estimates of BMP performance will be used in TMDL and trading permits and WSM modeling, and for continued use in Tributary Strategies. While our scope dictates that we quantify the nutrient and sediment reductions, UMD/MAWP recognizes there are additional co-benefits (social, economic, etc.). UMD/MAWP is asking panel members to help create a list of all co-benefits.

Our most important task is to estimate BMP performance at the operational, average watershed wide scale. UMD/MAWP's job is to ensure panel decisions, scientific justification, and best professional judgment are within the framework of our guidelines designed to estimate operational, average watershed wide conditions:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.

- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.

- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process. As such, peer reviewed literature should be given more weight than design standards and manual.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

UMD/MAWP will ask detailed questions about the BMP, not to discredit the performance of the BMP, but to get to operational conditions.

Panel members' primary task is to develop a report for the BMP using the guidelines, decision matrix, and factors of variability found in the template. A final report from the panel is due to the Chesapeake Bay Program by July 15, 2008 so partners can begin their technical review process. Bay Program partners are made up of jurisdictional agencies, the EPA and the Chesapeake Bay Commission. During technical review (mid-July to September) workgroups may bring specific question to panel/scientists for discussion.

Questions posed to panel:

Are the techniques mostly to reduce the cost of maintenance and protect the road? Do they address WQ?
The techniques reduce the frequent need to maintain roads. Traditional dirt and gravel roads, without ESMP, require grading and other types of maintenance two to three times a year. Dirt and gravel roads with ESMP require maintenance every three to four years, with some roads requiring more, some less, frequent maintenance. The maintenance cycles depends on the amount of traffic using the roads. The first DSA project (Hell Hallow) did not need maintenance.

What is the particle size being reduced? Is it gravel? Must keep in mind the WSModel uses average particle size when modeling. Would erosion of non-coarse sediment (sand, silt, clay) be reduced with the practices that keep ditches from eroding and collect/pond water to wetlands/ponds and infiltration areas?
Mostly fines, silts and clays, are captured

Framework based on treatment goals/targets (no more than 3 or 4)?:

a) Controlling road erosion – maintenance (is there a WQ benefit? Besides gravel reductions to trout streams – within 100ft of the downstream direction)
b) Ditch bank and water management/ managing water while not eroding the ditch
c) Treatment mechanisms for water treatment – wetlands and infiltration areas

Center ESMPs are designed to control road and bank erosion. While some have design elements that create sheet flow into infiltration areas, this is not an explicit ESMP.

Should effectiveness be broken down by E&S technique used? How is maintenance different for each technique (is one require higher maintenance than another)?
Yes, use the draft report performance values.

Should effectiveness be broken down into material used and placement method? How will the life of the material influence effectiveness with time?
That level of data is not available yet. The two most important research needs to better refine effectiveness is the influence of slope and daily traffic rates on performance.

How important is sheet flow to guarantee performance? Does the effectiveness change when concentrated flow is present? Is concentrated outlet drainage a concern with some techniques? If so, which ones, and how can it be avoided? Should higher effectiveness be given to techniques without concentrated outlet drainage?
Barry is checking on the language that encourages sheet flow from ESMP design elements. The ESMP techniques, however, do not explicitly list sheet flow drainage into an infiltration area as a BMP.

Will effectiveness change based on the land use the road is constructed on (forest, mixed open, agricultural)?
No, erosion and runoff control is from the road, the surrounding land area is not contributing sediment onto the road. Runoff is influenced by the off-road category.

For practices that trap sediment, what is the ultimate fate of that deposit?

Are there surveys on what counties have done with design, construction, and maintenance? How close to Center designs and O&M are county projects? How do we assure O&M over the long-term? Who assures BMPs are design and constructed correctly?
The PA State Conservation Program gives money to county conservation district and has to record the ESMP used (ex – stabilized x amount of bank). The Program has a QAQC element that has surveyed 51 to 52 county projects in PA to ensure proper implementation and found program required designs elements are reflected in Program implemented projects. This is largely due to the training the Program gives to grant recipients. But there is no reporting on what townships do on their own.

Do losses increase or decrease with paved roads? Is paved roads worse than dirt and gravel roads?

Paved roads are better with greater topography (slope) to reduce erosion. Dirt roads are more effective on low traffic areas because the substrate is not heating up like asphalt, which increases water temperature and impacts trout streams. Asphalt is usually installed to avoid maintenance costs associated with dirt and gravel roads. Some Pennsylvania townships are turning asphalt roads back into dirt and gravel. In order to obtain Center money for these projects the township must show an environmental benefit from turning asphalt roads back into dirt and gravel.

Discussion

Barry submitted a draft report (to be published by the end of 2008) of the Environmentally Sensitive Maintenance Practices for Unpaved Roads: Sediment Reduction Study. The objective of the study was to take five of these established environmentally sensitive road maintenance practices (ESMPs) and to quantify the effectiveness of each. The experimental approach taken in this study was to use a rainfall simulation device to collect sediment loads on a section of road long enough to be representative of the roadway. These data would be used as a baseline for comparison with similar sediment load data from after each ESMP was implemented. The five ESMPs selected for this study were:

Driving Surface Aggregate(DSA): durable and erosion resistant road surface;
Raising the Profile: raising road elevation to restore natural drainage patterns;
Grade Breaks: elongated humps in the road surface designed to shed water;
Additional Drainage Outlets: creating new outlets in ditchline to reduce channelized flow; and
Berm Removal: Removing unnecessary berm and ditch on downhill side of road to encourage sheet flow.

These five techniques will be the 'subcategories' under Dirt and Gravel Road Erosion and Sediment Control BMP. Definitions and performance estimates will be broken out using these five ESMPs. These five ESMP were selected because they are easily quantifiable, common, cheap to implement and effective.

The sediment reductions obtained by covering a native surface road with DSA were approximately 75% after one month, and 90% after one year. The sediment reductions obtained by raising the road elevation to restore natural drainage were approximately 78% after one month, and 81% after one year. The sediment reductions obtained by installing a grade break are pending final data. The sediment reductions obtained by adding a drainage outlet were approximately 48% when considering the down-slope ditch only and 31% when considering the entire road area. The sediment reductions obtained by removing an unnecessary berm were approximately 94% when considering the down-slop ditch only and 59% when considering the entire road area.

These figures represent the reductions achieved for a single 30 minute storm event with a six-month return frequency on specific sections of road. Because of the variability in erosion resistance, slope, and composition of existing unpaved roads, more iterations of this research are needed before average sediment reductions for entire practices can be obtained.

Expand on methodology:
3 rainmaker runs at 30-minute sample periods for both the before ESMP and after ESMP condition. The flow rates and sediment concentrations for these three runs are then combined to obtain the average sediment and flow rates for each section of road. During the test section the rainfall simulator was turned on and run until flow reached sample points. This was done to reduce infiltration on the initial run, and to *eliminate the "first flush" of dried road sediment.*
Will this result in lower estimates of sediment loss pre-BMP (baseline)?

Definition:
<u>**DSA: Driving Surface Aggregate (DSA)**</u> is a specific gradation of crushed stone developed by the Center for Dirt and Gravel Road Studies specifically for use as a surface wearing course for unpaved roads. DSA achieves sediment reductions by decreasing erosion and transport of fine material from the road surface.

<u>Add to definition????,</u> "DSA should be placed using a motor-paver and compacted. The paver is used to place aggregate in one 8" lift (compacted to 6") and avoid aggregate segregation that can occur with typical "dump and spread" methods of aggregate placement."

Limestone 86%
Sandstone 93%
If cannot report DSA type assign the most conservative type, in this case limestone.

<u>Add to effectiveness section:</u> It should be noted that sediment reduction calculations are highly dependant on the stability of the native surface. – language from the report
In the study there was a very high degree of variability in sediment production (.7 to 12 lbs) from the 5 native surface roads used as "befores".
<u>This supports a conservative estimate of DSA.</u>

<u>Conservatism Effectiveness:</u>
Study of a young practice – how maintenance (grading, etc.) influence performance
One study
High variability due to native surface
Utilize motor-paver over dump and spread cannot be ensured. Be conservative to account for placement method.

If can't report DSA type (sandstone or limestone) go with more the material with the more conservative performance (limestone).

<u>Raising the Road Profile</u>: Raising the road profile involves importing material to raise the elevation of an unpaved road. It is typically practiced on roads that have become entrenched (lower than surrounding terrain). Raising the elevation of the road is designed to restore natural drainage patterns by eliminating the down-slope ditch and providing cover for pipes to drain the up-slope ditch. Removing the down-slope ditch will eliminate concentrated flow conveyed in the ditch and will create sheet flow. Raising the Road Profile achieves sediment reduction by controlling and reducing the volume of road runoff.

Raising the road profile involves importing fill material to raise the elevation of the roadway up to the elevation of the surrounding terrain. The road is filled to a sufficient depth as to eliminate the ditch on the down-slope side of the road and encourage sheet flow. Shale and gravel are the most common fill materials for roads. Other potential recycled fill materials include ground glass, waste sand, automobile tires, clean concrete rubble, etc.

81% sediment reduction and water volume reductions in road runoff reaching the stream

<u>Add to Effectiveness:</u>
"The nature of the rainfall simulator will cause an underestimation of sediment reductions due to raising the road profile because the rainmaker only creates precipitation on the road and ditches. Factors that bring water to the road during natural rain events such as springs, seeps, and overland flow are not accounted for by the rainmaker. However, some of the runoff generated by the rainmaker infiltrated into the fill material. Although the fill material was compacted to the maximum extent possible, some infiltration was noticed on the roadsides and in the ditchlines. The ultimate destination of water that infiltrates into the road fill material is unknown. The amount of infiltration can be expected to <u>decrease over time</u> as the fill settles and compacts, leading to slightly higher runoff rates in the future for this study site."

The sheet flow created by removing the downslope ditch, is sheet flow maintained?

Variability: Sediment reduction calculations are highly dependent on the stability of the native surface. The native surface consisted mostly of limestone and silt fines.

The sediment concentrations were kept constant, thus the 81% reduction also represent water volume reductions in road runoff reaching the stream.

<u>Grade Breaks</u>: are an intentional increase in road elevation on a downhill grade which causes water to flow off of the road surface. It is designed to reduce erosion on the road surface by forcing water into the ditches or surrounding terrain. Erosion of the road surface is reduced by forcing runoff laterally off the road. In some cases, grade breaks are used to force water off the road entirely, serving as an additional drainage outlet. Sites where water is not forced off the road entirely convey the water into a roadside ditch.

<u>Effectiveness:</u>
Not done to scale, so research site not operational

"Any sediment reductions seen would be due to water flowing in the ditch instead of down the road surface. In some cases, grade breaks are used to force water off the road entirely. In these cases, the grade break also serves as an additional drainage outlet."
If directing water in the ditch wouldn't there be erosion from the ditch????

The Draft report forced water into the roadside ditch.

<u>Additional Drainage Outlets:</u> Drainage outlets are designed to capture water flowing in the roadside ditch and force it to leave the road area. There are two major types of drainage outlets. Turnouts (also called bleeders or cutouts) outlet water from the down-slope road ditch. They usually consist of relatively simple cuts in the down-slope road bank to funnel road drainage away from the road. Drainage that is carried by the up-slope road ditch is usually outletted under the roadway by the use of a crosspipe (also called culvert, sluice pipe, or tile drain). Installing additional drainage outlets reduces concentrated flow, peak flow discharges and sediment transport and delivery from unpaved roads and ditches into streams, and can increase infiltration. It does not affect sediment generation from the road surface or deliver in the up-slope ditch, thus all data on sediment reductions in the report is only for down-slope ditch unless otherwise noted. Drainage outlets are to be placed in locations that have the least likelihood of reaching streams. If a newly added outlet conveys sediment to the stream, little if any sediment reductions will be obtained.

31% whole road
48% down-slope ditch only

<u>Effectiveness:</u>
Sediment reduction calculations are highly dependent on the stability (surface material, slope, etc.) of the native road surface.
The study site was very flat and stable and produced the lowest sediment runoff rates of any native surface road tested with the rainmaker.

Rainfall simulator will cause an underestimation of sediment savings due to adding additional drainage outlets. This is because factors that bring water to the road during natural rain fall events such as springs, seeps, overland flow are not accounted for by the rainmaker.

Considering both ditches % sediment reduction is 31%
Down-slope ditch only % sediment reduction is 48%

The limited 100 foot scope of the rainmaker will most likely cause an under-prediction of sediment reductions because ditch erosion is fairly minimal due to low flows.

Berm Removal: A berm is a mound of earthern material that runs parallel to the road on the down-slope side. Berms can be formed by maintenance practices and road erosion that lowers the road elevation over time. In many cases, the berm is unnecessary and creates a ditch on the down-slope side of the road. This berm can be removed to encourage sheet flow into surrounding land instead of concentrated flow in an unnecessary ditch. Restoring sheet flow results in decreased runoff and sediment transport along the roadway, increase infiltration, and reduced maintenance associated with the road drainage system.

59% whole road, both ditches
94% down-slope ditch only

Effectiveness:
It should be noted that sediment reduction calculations are highly dependent on achieving and maintaining sheet flow off the roadway. Is sheet flow maintained? Reduce performance with age?

Is there nutrient loading from berm removal?

In calculating sediment and flow reductions, it is necessary to make the assumptions that water was transported directly to the stream before berm removal, while the sheet flow achieved after berm removal will not empty directly into the stream.

The rainfall simulator will cause an underestimation of sediment savings due to berm removal. This is because the rainmaker only creates precipitation on the road and ditches. Factors that bring water to the road during natural rain events such as springs, seeps, and overland flow are not accounted for by the rainmaker. Berm removal will alter the flow characteristics of water from these sources as it did for water from the rainfall simulation.

Consider that the sheet flow in this study was considered not to be entering or affecting the stream. In certain situations when the stream and road are in very close proximity for long distances, the assumption that sheet flow does not affect the stream is not valid. – **Reason to be conservative**

The limited 100 foot scope of the rainmaker will most likely cause an under-prediction of sediment reductions because ditch erosion is fairly minimal due to low flows.

Berm removal on the down-slope side of the road will not affect the sediment or flow characteristics of the up-hill ditch.
Consider both ditches to account for the entire road. Because berm removal on the down-slope side of the road does not affect sediment generation or delivery in the up-slope ditch, all data presented here is only for the down-slope ditch unless otherwise needed.

Combination Practices

In practice ESMPs are combined at one site. In these situations credit will be given to the ESMP technique with the highest effectiveness. For example, if a project combines DSA (86 or 93%) and berm removal (59%) the effectiveness of DSA will be used. Performance values cannot be combined to equal anything higher than the value assigned to the practice that performs the best. Essentially effectiveness estimates cannot be added together or combined in anyway to achieve a higher level of removal than what one individual ESMP is capable of.

The panel feels this is a conservative approach because credit is applied to a lesser amount of sediment than if a combination of performance was used.

Nutrient Removal

Total Nitrogen (TN) and Total Phosphorous (TP) removal is minimal with dirt and gravel road erosion and sediment control. One reason is that dirt and gravel roads are not fertilized. The other is that the environmental benefit association with dirt roads is such that nitrogen (N) and phosphorus (P) reductions are not anticipated, nutrient reductions are not a component of the average function of dirt and gravel roads. If N and P reductions are associated with dirt and gravel roads they should track sediment reductions.

One situation where nutrient reductions could be associated with dirt and gravel roads is on farm lanes where the road was used as a conduit to the stream. The Center removed that mechanism so water dispersed out onto the field, and the nutrient removal is proportional to the amount of water reduced from discharging directly to the stream.

Threshold

Research has not been done to determine a threshold storm even when ESMPs no longer function due to a volume of water beyond the capability of the practice to perform sediment removal. During Hurricane Ivan ESMP designs consistent with the Centers specifications held up very well. However, municipalities that cut corners (poor installation, fewer cross pipes, etc.) had problems.

<u>Flow Patterns</u>

Groundwater impacts from dirt and gravel roads is negligible because the subsurface is too compact to allow flow. Projects such as turnouts and outflow pipes that incorporate sheet flow into areas that allow infiltration (wetland, forest, etc.) will provide groundwater recharge. The number of projects that actual implement one of these techniques is unknown.

<u>Practice Duration and Maintenance</u>

The draft report only monitors projects that are one year old or younger. There is antidotal evidence from QAQC efforts that practices are functional for 3-5 years conservatively, 10 years at the best sites. The long-term performance depends on average daily traffic load.

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<u>Effectiveness Estimation</u>

The current placeholder of assigning a length and width (lbs/ft of removal) is not appropriate for dirt and gravel roads. Roads have width and ESMP treat the whole surface. In addition, a load (lb/sq area) is not comparable because native soil results in various erosion rates.

<u>Confidence</u>

Mike and Barry have very high confidence in the effectiveness estimations (values from draft report). While they measured one location, this is the only research on this particular BMP. Results are easily duplicated and represent average conditions. The rainmaker was placed in the same location every run. Sediment loads pre-BMP represent a good range of values (.7 to 12 lbs). Some areas in Montana show higher sediment loading rates (about 36lbs) but the climate of the area is not applicable to the Chesapeake Bay Watershed.

Confidence

Mike Klimkos and Barry Scheetz have very high confidence in the effectiveness estimations (research values from draft report, not the values recommended by UMD/MAWP that consider first flush). While they measured one location, this is the only research on this particular BMP. Results are easily duplicated and represent average conditions. The rainmaker was placed in the same location every run. Sediment loads pre-BMP represent a good range of values (.7 to 12 lbs). While some areas in Montana show higher sediment loading rates (about 36lbs), the climate of the area is not applicable to the Chesapeake Bay Watershed.

UMD/MAWP is confident in the effectiveness estimates if a discount for first flush is included in the final values. In addition, there are many reasons to be conservative when assigning effectiveness estimates based on the Center's report. One reason is that the study only evaluated 'young' practices. Studying young practices will not capture how maintenance (grading, plowing, etc.) influence performance. Thus sheet flow may not be established or maintained over time. Concentrated flow paths will not provide treatment, instead conveying runoff directly off roads and ditches into nearby streams. Also, these effectiveness values are estimated from one study and collaborating data is not available to compare results.

Further Questions and Action Items:

Should we add to all the definitions (except DSA): "locate discharge outflow where there is high infiltration capacity or into vegetated areas or sediment traps before the discharge reaches surface waterways"? And should we add, "native vegetation should be used at the discharge site whenever possible" to the grade breaks (locate grade breaks adjacent to native vegetation), additional drainage outlets (water outletted by the crosspipe and turnout), and berm removal definitions. And/or should, "discharge should not be concentrated, must achieve sheet flow", be added to the raising the road profile and berm removal definitions (similar to last sentence in additional drainage outlet definition)?

ACTION: Sarah to provide a list of Phase V land uses to Mike and Barry to help ID proper category.

ACTION: Sarah to contact Matt Beaver, PA Bureau of Forestry, to discuss private development (gated community) roads (miles, ESMP used, performance, maintenance, etc.).

ACTION: Sarah to discuss the proper NRCS code designation with Mark Dubin (Access Road?). Yes, when access roads are farm lanes, the standard includes specifications for construction.

ACTION: Mike and Barry will help Sarah develop a list of co-benefits (besides water quality) from employing ESMP techniques on dirt and gravel roads.

ACTION: Have ability to model additional storm events (6-month, 5-year, 10-year storm, etc.), slopes and daily traffic rates. The Center devised a model (3^{rd} scale truck) with a 100 psi truck tire that can do 7,200 runs an hour. It costs $7.20/hour to run the machine and two hours of runs represents one year of data at 40 cars a day. ADD TO FUTURE RESEARCH NEED SECTION

ACTION: Sarah will discuss WV Tributary Strategy definition of dirt and gravel road erosion and sediment control with a WV representative. How is silt fence, slope drain and vegetation defined?

ACTION: Mike and Barry will send Sarah a couple pictures of damage due to Ivan from sites that did not follow Center design specifications, and project sites that were designed and installed properly (according to Center design standards) and maintained their level of performance during Hurricane Ivan.

ACTION: Mike will attempt to determine the number of miles of public dirt and gravel road in the Chesapeake Bay watershed, the number of projects, and the average length of the project (section of road treated).

ACTION: Projects such as turnouts and outflow pipes that incorporate sheet flow into areas that allow infiltration (wetland, forest, etc.) will provide groundwater recharge. The number of projects that actual implement one of these techniques is unknown. Barry will check on the number of projects that incorporate infiltration areas. Is sheet flow achieved and maintained? Should this be a requirement in the definition?

Sediment Workgroup Conference Call
August 26, 2008

Highlights and Action Items

- Workgroup members reviewed the UMD/MAWP definition and effectiveness estimate recommendation report for dirt and gravel road erosion and sediment control.
- **ACTION:** Sarah Weammert, UMD/MAWP, agreed to revise the report based on the comments that were received from workgroup members during today's call. The revised report will be distributed to the workgroup next week.

- **ACTION:** After workgroup members receive the revised report, they will have several days to provide any additional comments or voice any objections. If no comments or objections are received, then the report will be considered approved.

Handouts

Meeting Website: http://archive.chesapeakebay.net/calendar.cfm?eventdetails=9726

- Year-2 UMD/MAWP BMP Project Review Questions
- Dirt and Gravel Road Erosion and Sediment Control Recommendations from Year 2 of the UMD/MAWP BMP Project

Minutes

- Jeff Halka, SedWG Chair, began the conference call at 1:30 pm. Introductions were made and the conference call's agenda was reviewed.
- The purpose of today's conference call was to review the UMD/MAWP definition and effectiveness estimate recommendation for dirt and gravel road erosion and sediment control. The recommendations are described in detail in the report that was distributed to the workgroup prior to today's call. Sarah Weammert, UMD/MAWP, presented an overview of this report.
- The Sediment Workgroup has been charged with reviewing this document and providing a recommendation to the Watershed Technical Workgroup (formerly the Tributary Strategy Workgroup) by September 10th.
- The effectiveness estimate that is recommended in the report is intended to represent average operational conditions.
- When selecting data to include in the data set, UMD/MAWP used a set of guidelines. These guidelines are listed on page 2-3 of the report.
- They found that there is a lot of gray literature on how to install and construct this BMP, but there is only one study that actually evaluates the sediment reduction capabilities of this practice. This study was conducted by the Center for Dirt and Gravel Road Studies (Center). Sarah received a draft version of this report from the Center.
- The expert panel that was consulted during the development of this BMP report included Barry Scheetz of the Center and Mike Klimkos with the PA Dirt and Gravel Maintenance Program.
- First flush issue:
    - The Center's study did not account for sediment movement during the first flush. Timing of pre-BMP and post-BMP sampling occurred one minute after the wetting front initially reached the sampling point.
    - The Center said that they did this to reduce the infiltration rate on the initial run.
    - UMD/MAWP feels that the first flush is important since a majority of the sediment is transported at this time.
    - Another reason why analyzing the first flush is important is because the concentration of sediment is not the same for the entire rainfall event.
    - If this BMP is tied more to transport, would this be more of a peak event issue, rather than a first flush issue?

    - Lewis pointed out that the definition of first flush seems to be inconsistent with the first one minute of rainfall. Sarah said that in the literature there did not seem to be any consistency on this definition, including in the urban sector.
    - Since the majority of sediment is transported during the first flush and the first flush was not accounted for, UMD/MAWP feels that this justifies a more conservative effectiveness estimate than the value determined in the Center's study. They recommend discounting the Center's sediment reduction estimates by a relative 60%.
    - The decision to use 60% was best professional judgment. Research from other land uses suggested that the first flush volumes carry the majority of the sediment load in the runoff. Therefore, since this first flush load was described as carrying a "majority" of the load, this percentage had to be above 50%. 60% was chosen.
    - The expert panel did not agree to the 60% discount. This discount is UMD/MAWP's recommendation.
- There were also other factors that UMD/MAWP felt warranted their decision to be conservative and reduce the Center's values. For example, one factor was that the tests that the Center performed for their study were done on very young practices that had been installed within one month of the tests.
- Q: How are gravel roads currently handled in the model?
    - A: Lewis said that right now there are zero miles of gravel roads in the model and the model does not include a base number for gravel road delivery.
- Dirt and gravel roads are included in the Tributary Strategies.
- Q: How do the UMD/MAWP recommended effectiveness estimates compare to what was used before in the Tributary Strategies?
    - A: Sarah said that she did not look at the original effectiveness estimates that were used because she did not want these numbers to influence the numbers in her report. Kenn said that according to PA's spreadsheet, the dirt and gravel road efficiency was applied against the forest and mixed open load and 0.2 lbs/ft was the efficiency listed for nitrogen.
- Before this practice was listed as a nutrient reduction practice, but this report recommends that it only be listed as a sediment reduction practice based on the information that is available at this time.
- Q: Are these roads going to be reported by area or by linear foot?
    - A: The expert panel recommended that area be used. Kenn said that the states will likely be reporting only linear feet, but this could be multiplied by a default width number in order to estimate area.
- Soil type and slope are also factors that would affect effectiveness.
- Under the "Combination Practices" heading in the report, it says that if two practices are combined at one site, then credit will be given to the technique with the highest effectiveness. The workgroup suggested that there instead be a multiplicative effect.
    - Sarah said that she was not aware that this version of the watershed model could use a multiplicative effect at the time that she wrote this report.
    - An additive effect would be if the effectiveness values for the two practices were added together, whereas a multiplicative effect would be if you credited the effectiveness value for the first practice and then took what is left and applied the effectiveness value for the second practice to that.

- Sarah said that UMD/MAWP would recommend using a multiplicative effect over an additive effect.
- Kenn suggested that either the term sequential or consecutive be used instead of multiplicative.

- The workgroup suggested that Sarah also touch base with West Virginia because they have a dirt and gravel roads program. Sarah said that she has already talked to them, and it appears that their program is really just construction erosion and sediment control.
- Suggested Revisions:
  - The statement explaining the need for the 60% discount is confusing. The wording should be changed to make this statement more clear. (By missing the first flush, they were in fact missing part of the sediment load that was coming off of the road and by missing this they were over-crediting themselves since they were basing their reduction on a smaller load.)
  - The report should include an explanation for why 60% was chosen. It should say that this was best professional judgment and explain the reasoning behind it.
  - A base number for gravel road delivery should be included in this report. Lewis suggested that the base number be the midpoint of the range reported in the "Confidence" section (0.7 to 12 lbs).
  - The "Combination Practices" heading, and the rest of the headings that follow, should be bolded.
  - The report should include UMD/MAWP's new recommendation that a multiplicative (or consecutive/sequential) effect be used. This should be described in the "Combination Practices" section.
  - In the first paragraph of the "Future Research Needs" section, it was suggested that it be made clear that many runs would be required. (Saying that it only costs $7.20/hour to run the machine is misleading.)
- The workgroup said that the review questions that were listed in the handout were well answered in the report. The workgroup found no fatal flaws with the report, just several editorial recommendations.

ACTION: Sarah Weammert will revise the UMD/MAWP Dirt and Gravel Road Erosion and Sediment Control report based on the comments that were received during today's conference call. The revised report will be distributed to the workgroup next week.

ACTION: After workgroup members receive the revised report, they will be given several days to provide any additional comments or voice any objections. If no comments or objections are received, then the report will be considered approved.

- The conference call was adjourned at 3:10 pm.

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Minutes: Watershed Technical Workgroup
October 6, 2008

Dirt and Gravel Road Erosion and Sediment Control

- Pennsylvania and West Virginia include dirt and gravel road erosion and sediment control in their Tributary Strategies.
- Kenn Pattison would like to talk to researchers at Penn State who study this practice before recommending moving forward with the dirt and gravel road BMP.
    - Kenn suggested that Jeff Sweeney use a 30% effectiveness estimate in the interim to be used in the model runs until a final decision is made.
- Jeff Sweeney informed the states that report this practice that they need to clarify which of the five dirt and gravel road erosion and sediment control techniques were implemented.

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Chesapeake Bay Program Nutrient Subcommittee
October 22, 2008 Meeting

SUMMARY OF DECISION, ACTIONS AND ISSUES

Dirt and Gravel Road Erosion and Sediment Control

- Kenn Pattison said that Pennsylvania cannot support the dirt and gravel road BMP as written. Data does not support the first flush effect (what comes off of urban land after the first ½ inch of rainfall). The first minute of flow is less than 1% of the total flow. Nothing in the data supports a first flush effect, except for a slight increase in concentrations in the first 5-6 minutes. First flush is a concern in urban land, but dirt and gravel roads are not urban land. Also, the flows coming off of the BMPs differed in the before and after in the Penn State Dirt and Gravel Road Center report.
    - Kenn Pattison would like more time to discuss this BMP with the Chesapeake Bay Commission who funded the Penn State Dirt and Gravel Road Center report.
- Jeff Sweeney needs jurisdictions to report dirt and gravel road erosion and sediment control practices by area, not miles.
- Collin Burrell offered that the Nutrient Subcommittee needs to decide whether or not the science behind the recommendation is credible.
- The Sediment Workgroup approved UMD/MAWP's recommendations, but only a handful of members participated in the discussion. Bill Keeling said that the Watershed Technical Workgroup approved the recommendations with the intent of using only an interim efficiency.
- Beth Horsey pointed out that the STAC Task Force did not believe there was enough science to develop a reduction efficiency for dirt and gravel road erosion and sediment control.
- Kenn Pattison agreed to tentatively move forward with the recommendation as is, and he will still speak to the Chesapeake Bay Commission.

DECISION: The Nutrient Subcommittee agreed with the dirt and gravel road erosion and sediment control BMP as written. Pennsylvania agreed to move forward with the BMP as is but expressed concern which Kenn Pattison will discuss with the Chesapeake Bay Commission.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
January 21, 2009

III. Review of Year 2 BMP Definitions and Effectiveness Estimates Hansen

Attachment C: Year Two BMP Approval Status

- The remaining four BMPs are still being revised and have not yet been approved by the Nutrient Subcommittee and its workgroups. A status update was provided for each of these BMPs:
  - **Dirt and Gravel Road Erosion and Sediment Control:** At the October NSC meeting, Kenn Pattison said that Pennsylvania could not support the proposed recommendations. Since then, Kenn has been working with the Dirt and Gravel Road Center to revise the recommended effectiveness estimate. He would like to recommend that UMD/MAWP's efficiency recommendation be adjusted. Kenn is planning on submitting a revised recommendation to Jeff Sweeney on Friday. This recommendation will then have to be reviewed by the Sediment Workgroup, the Watershed Technical Workgroup, and the Nutrient Subcommittee.

ACTION: The remaining Year 2 BMP definitions and effectiveness estimate will be revised and presented to the source Workgroups, the Watershed Technical Workgroup, and the Nutrient Subcommittee at a later date for review and approval. These BMPs were dirt and gravel road erosion and sediment control; horse pasture management; dairy, beef, and livestock pasture management; and nutrient use efficiency.

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CHESAPEAKE BAY PROGRAM
WATER QUALITY STEERING COMMITTEE
January 26, 2009 Conference Call

SUMMARY OF DECISIONS, ACTIONS, AND ISSUES

Review and Approval of the Recommended Year 2 BMPs and Efficiencies

Dave Hansen, Nutrient Subcommittee Chair, reviewed Attachment A and updated the Steering Committee on the status of the review process for Year 2 University of Maryland Mid-Atlantic Regional Water Program (UMD/MAWP) BMPs.

Review of Year 2 UMD/MAWP BMP Effectiveness Estimates

- Dirt and gravel roads, nutrient use efficiency, horse pasture, and other pasture BMPs are still under development and review.
  - These final BMPs will likely be reviewed b the Nutrient Subcommittee in March and Water Quality Steering Committee in April.
  - In the meantime, placeholder values will be used for the model calibration.

ACTION: The Nutrient Subcommittee will bring the remaining set of Year 2 BMPs—dirt and gravel roads, nutrient use efficiency, horse pasture, and other pasture—back to the Water Quality Steering Committee in April for final review and approval by the Steering Committee.

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Appendix B: Discount Factors
Summary:
All Dirt and Gravel Road Erosion and Sediment Control technique effectiveness estimates have limitations based on the amount and type of data available. These limitations warrant assigning a more conservative effectiveness estimate to the Center for Dirt and Gravel Roads (Center) report on five environmentally sensitive maintenance practices (ESMPs). The most significant limitation is the amount of data available. The Center's study is the only one evaluating performance of dirt and gravel road erosion and sediment control techniques. The monitoring timeline of the study is also a concern. As monitoring only occurs directly after implementation the existence of sheet flow over time is unknown. The question becomes, with time is sheet flow maintained? In addition, without inspection and maintenance to ensure functionality and proper design, implementation performance values should be discounted. To be consistent with the other BMPs evaluated under the UMD/MAWP project, a discount for proper implementation and design is not applied as it was not investigated. There are many other limitations in the data, however, to warrant a more conservative estimate of effectiveness than the Center's report indicates.

Some limitations only apply to individual techniques. With berm removal and raising the road profile time after implementation is important. With time a berm may be reformed and a profile lowered creating the condition the BMP was meant to address. Time after implementation should be considered for both of these techniques and reflected in effectiveness estimates. UMD/MAWP recommends 'turning off' a berm removal of raising the road profile's performance after 5 years; unless maintenance of those sites is verified to ensure a berm has not been reformed or a profile lowered again. Additional limitations for each technique is discussed below.

UMD/MAWP recommends a discount baseline, to be applied to the Center's effectiveness estimates, of a relative 25%, consistent with other discounting methods recommended for agricultural and urban BMPs, and to account for factors applicable to individual ESMPs. An explanation of these individual factors and why they warrant a relative reduction from the Center's report follow.

Driving Surface Aggregate (DSA):

There are multiple reasons UMD/MAWP supports a conservative estimate to DSA. One reason is that the Center's studied DSA while it was a 'young practice'. Studying young practices will not capture how maintenance (i.e. grading) influences performance. Effectiveness is not verified over time, credits are continuously assigned based on previous implementation regardless of actual performance. In addition the effectiveness is derived from one study, however, this is the only study available so UMD/MAWP is not recommending an effectiveness estimate 30% or below as outlined in the BMP decision matrix. Also, as the Center's report states, the performance of DSA is highly dependent on the native surface. This variability should be reflected in future refinements of the effectiveness estimates. Finally, the report states that when DSA is applied a motor-paver should be utilized over 'dump and spread' methods to avoid aggregate segregation. The even distribution of different sized particles gives DSA its characteristics that make it a stronger, more consistent and longer lasting driving surface for unpaved roads. The placement method cannot be assured so effectiveness should be reduced from study values to account for this. If the placement method is trackable a higher effectiveness estimate could be assigned.

A relative 25% reduction from the Center's study is warranted based on the aforementioned factors.

Raising the Road Profile:

The Center's studied raising the road profile while it was a 'young practice'. Studying young practices will not capture how maintenance (grading, etc.) influences performance. A conservative estimate of performance is needed as maintenance of these roads is what really degrades the performance with time. Effectiveness is not verified over time, credits are continuously assigned based on previous implementation regardless of actual performance.

In addition to the limited study sample and age of the practice, there are other factors influencing the performance of raising the road profile. The Center's reports states,

> "The nature of the rainfall simulator will cause an *underestimation of sediment reductions* due to raising the road profile because the rainmaker only creates precipitation in the road and ditches. Factors that bring water to the road during natural rain events such as springs, seeps, and overland flow are not accounted for by the rainmaker. However, some of the runoff generated by the rainmaker infiltrated into the fill material. Although the fill material was compacted to the maximum extent possible, some infiltration was noticed on the roadsides and in the ditchlines. The ultimate destination of water that infiltrates into the road fill material is unknown. The amount of infiltration can be expected to *decrease over time* as the fill settles and compacts, leading to *slightly higher runoff rates* in the future for this study site."

The increased volume of road runoff resulting from compaction will also increase sediment runoff. The higher runoff rates expected to occur in the future due to compaction should be accounted for and a reduction in the research value addresses this need. Based on scientific BPJ the underestimation of sediment reductions due to the rainfall simulator design, research values should not be discounted. However, it is unknown how many sites throughout the watershed will have springs, seeps, and overland flow directed to the road and ditch. These statements, however, are based on the assumption that ESMPs do not have an effluent quality limit, that with increases in water volume one will observe a continued decrease in sediment runoff.

Sites with non-uniform flow are a recognized problem on the landscape, and thus need to be considered in effectiveness estimations. Where concentrated flow paths are established water flow is funneled into the concentrated flow paths, even if they only occupy a small portion of the landscape, and account for the majority of water transport. Concentrated flow is characterized as a fast flow path, when compared to sheet flow, and will cause additional erosion. The sheet flow created by removing the downslope ditch is not guaranteed to be maintained into the future. As concentrated flow will influence performance, but the extent of its pervasiveness across the watershed, and the degree of its influence on performance is unknown, a conservative reduction to the research value is recommended.

To be consistent with the reduction assigned for the native surface factor a reduction from the research value is recommended. Sediment reduction calculations are highly dependent on the stability of the native surface and in the Center's study the native surface consisted mostly of limestone and silt fines.

A relative 25% reduction from the Center's study is warranted based on the aforementioned factors.

Grade Breaks:

The Center's studied grade breaks while it was a 'young practice'. Studying young practices will not capture how maintenance (grading, etc.) influences performance. As the research value was calculated from a 'young practice', UMD/MAWP recommends reducing the research value to be consistent with the reduction assigned for this factor to other ESMP, because maintenance of these roads is what really degrades the performance with time. Effectiveness is not verified over time, credits are continuously assigned based on previous implementation regardless of actual performance. In addition, the effectiveness is derived from one study, however, this is the only study available so UMD/MAWP is not recommending an effectiveness estimate 30% or below as outlined in the BMP decision matrix. UMD/MAWP recommends reducing the research value to be consistent with the value used throughout the report.

In addition, the Center's report states,

> "Any sediment reductions seen would be due to water flowing in the ditch instead of down the road surface. In some cases, grade breaks are used to force water off the road entirely. In these cases, the grade break also serves as an additional drainage outlet."

If a grade break directs water to the ditch there would be erosion of the ditch material. UMD/MAWP recommends reducing the research value to account for increased erosion. Ditches serve as concentrated flow paths, thus the research value should be decreased to be consistent with the value assigned to concentrated flow paths already used in this report. Increased water volume from flow being diverted from the road to the ditch will increase sediment runoff, age of the practice, and the limited number of studies all support a reduction from the research based value.

A relative 25% reduction from the Center's study is warranted based on the aforementioned factors.

Additional Drainage Outlets:

The Center's studied additional drainage outlets while it was a 'young practice'. Studying young practices will not capture how maintenance (grading, etc.) influences performance. As the research value was calculated from a 'young practice', UMD/MAWP recommends reducing the research value to be consistent with the reduction assigned for this factor to other ESMP, because maintenance of these roads is what really degrades the performance with time. Effectiveness is not verified over time, credits are continuously assigned based on previous implementation regardless of actual performance. In addition the effectiveness is derived from one study, however, this is the only study available so UMD/MAWP is not recommending an effectiveness estimate 30% or below as outlined in the BMP decision matrix. UMD/MAWP recommends reducing the research value for the limited data set, to be consistent with the value used throughout the report.

Sediment reduction calculations are highly dependent on the stability (surface material, slope, etc.) of the native road surface. The study site was very flat and stable and produced the lowest sediment runoff rates of any native surface road tested with the rainmaker. To be consistent with the reduction value assigned to native surfaces used throughout this report, the research value should be reduced.

As the Center's report states for raising the road profile the rainfall simulator will also cause an underestimation of sediment savings due to adding additional drainage outlets. This is because factors that bring water to the road during natural rain fall events such as springs, seeps, overland flow are not accounted for by the rainmaker. However, based on scientific BPJ the underestimation of sediment reductions due to the rainfall simulator design, research values should be not increased as the increased volume of road runoff resulting from compaction will also increase sediment runoff. Also it is unknown how many sites throughout the watershed will have springs, seeps, and overland flow directed to the road and ditch.

In addition, the Center's report states that a limited 100 foot scope of the rainmaker will most likely cause an under-prediction of sediment reductions because ditch erosion is fairly minimal due to low flows. Again these statements are based on the assumption that ESMPs do not have an effluent quality limit, that with increases in water volume one will observe a continued decrease in sediment runoff.

Newly added outlets must be located so sediment is not directed to a stream or little if any sediment reductions will be obtained. Guaranteeing outlets are not conveying sediment to a waterway is hard to determine and report, thus a reduction in performance should be assigned.

A relative 25% reduction from the Center's study is warranted based on the aforementioned factors.

Berm Removal

The Center's studied berm removal while it was a 'young practice'. Studying young practices will not capture how maintenance (grading, etc.) influences performance. As the research value was calculated from a 'young practice', UMD/MAWP recommends reducing the research value to be consistent with the reduction assigned for this factor to other ESMP, because maintenance of these roads is what really degrades the performance with time. Effectiveness is not verified over time, credits are continuously assigned based on previous implementation regardless of actual performance. In addition the effectiveness is derived from one study, however, this is the only study available so UMD/MAWP is not recommending an effectiveness estimate 30% or below as outlined in the BMP decision matrix. UMD/MAWP recommends reducing the research value for being one study (but not higher because only study is available one), to be consistent with the value used throughout the report.

The reports notes sediment reduction calculations are highly dependent on achieving and maintaining sheet flow off the roadway. How can we determine if sheet flow if ever established or maintained? As discussed earlier in this report, concentrated flow paths will negatively influence a practices performance. In calculating sediment and flow reductions, it is necessary to make the assumptions that water was transported directly to the stream before berm removal, while the sheet flow achieved after berm removal will not empty directly into the stream. To be consistent with other reductions in performance assigned for concerns with establishment and maintenance of concentrated flow, a reduction in the research value is recommended.

Furthermore, the sheet flow in this study was considered not to be entering or affecting the stream. The report states, "In certain situations when the stream and road are in very close proximity for long distances, the assumption that sheet flow does not affect the stream is not valid." As such, UMD/MAWP sediment reductions should be decreased, being consistent with other reductions assigned for sheet flow. The report further notes the sediment reductions are highly influenced by the stability and slope of the native surface. Throughout this report UMD/MAWP recommended assigning a reduction to the research value to account for this.

The rainfall simulator will cause an underestimation of sediment savings due to berm removal. This is because the rainmaker only creates precipitation on the road and ditches. Factors that bring water to the road during natural rain events such as springs, seeps, and overland flow are not accounted for by the rainmaker. Berm removal will alter the flow characteristics of water from these sources as it did for water from the rainfall simulation. Based on scientific BPJ the underestimation of sediment reductions due to the rainfall simulator design, research values should not be increased. It is unknown how many sites throughout the watershed will have springs, seeps, and overland flow directed to the road and ditch, thus a low value is assigned. In addition, the limited 100 foot scope of the rainmaker will most likely cause an under-prediction of sediment reductions because ditch erosion is fairly minimal due to low flows. These statements, however, are based on the assumption that ESMPs do not have an effluent quality limit, that with increases in water volume one will observe a continued decrease in sediment runoff.

During berm removal implementation there is the potential for nutrient and sediment discharge when removing an existing berm. UMD suggests an additional reduction in performance for year one of the practices existence to account for this. Thus, the first year of berm removal implementation, the Center's performance value should be reduced by a relative 30% and following years will use an effectiveness estimate at a relative 25% value from the Center's data.

Horse Pasture Management
PENDING CBP APPROVAL
Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For Phase 5 of the Chesapeake Bay Program Watershed Model

Recommendations for Endorsement by the Chesapeake Bay Program Nutrient Subcommittee and its Workgroups

Consulting Scientists

Amy Burk
Extension Horse Specialist
University of Maryland

Shelly Dehoff
Agriculture/Public Liaison
The PA Agricultural Ombudsman Program

Elmer Dengler
Maryland State Grazing Specialist
MD NRCS

Mark Dubin
Agricultural Technical Coordinator
Chesapeake Bay Program/Mid-Atlantic Water Quality Program

Mike Harper
Penn State University

Kathy Soder
Animal Scientist
USDA-ARS-Pasture Systems and Watershed Management Research Unit

Ann Swinker
Extension Specialist Equine
Penn State University

Donna Vaulk
Northhampton Co Extension

Penn State University

And

Les Vough
Forage Crops Specialist Emeritus
University of Maryland

Synthesis and Recommendation by

Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary

Horse Pasture Management: Horse pasture management includes maintaining a 50% pasture cover with managed species (desirable inherent) and managing high traffic areas.

- Effectiveness Estimates: 40% TSS, 20% TP, no TN reduction

The proposed horse pasture management effectiveness estimates and definitions were not approved by the CBP. There was considerable confusion on how the recommended effectiveness estimates would work in Phase 5 of the watershed model as the final methodology was not yet complete during the development of the proposed values. When scenarios were simulated using the recommended effectiveness estimates the reductions were not in line with other pasture practices. For these two reasons the Chesapeake Bay Program decided to convene another panel of pasture experts to review the literature when the modeling components of pasture management were final.

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project during 2007-2008 to develop the components or subcategories of the BMP, a corresponding definition(s) and effectiveness estimates. The BMPs developed have not been previously reported to the Chesapeake Bay Program. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

UMD/MAWP recommend the following interim estimates, and while the pasture panel feels the pasture improvement credit is low (20%), no other alternative estimate is suggested. Attached to these definitions and effectiveness estimates is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix A. Sarah Weammert will add CBP review minutes after WQSC review.

UMD/MAWP consulted a panel of experts from the academic, industrial, state agency and non-profit sectors to advise in the development of BMP definitions and effectiveness estimates. Discussions during panel meetings, data and best professional judgment was used to craft the recommendations presented here.

Guidelines. The following guidelines were used when selecting data to include in the data set:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.
- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.
- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process by independent scientists. As such, peer reviewed literature should be given more weight than design standards and manuals. For this BMP, however, no peer reviewed literature was available and gray literature, or limited research scale type publications, and best professional judgment was used.
- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

Data applicability. As with any literature review, data should be evaluated for its applicability. Before selecting a study for use in developing a BMP effectiveness estimate and definition, UMD/MAWP and panel members considered the questions below. The data used to develop effectiveness estimates was selected based on its applicability to the natural conditions of the Chesapeake Bay watershed, such as, soil type, hydrologic flow paths, and species composition. The studies were evaluated for their BMP design and implementation compatibility to those in the Chesapeake Bay watershed. Rates and timing of fertilizer applications, and the relationship between cultivation and planting dates, were evaluated to determine if the study was applicable to farming methods in the watershed.Studies were also reviewed to determine if the study duration accurately represents average effectiveness results. The time when removal rates are monitored may influence performance by under or overestimating effectiveness.

- Are natural characteristics (soil type, climate, flow paths, geology, vegetation, etc.) of the research site similar to conditions in the Chesapeake Bay watershed?
- Is the practice consistent with NRCS codes, jurisdictional stormwater design manuals? If not, how would effectiveness estimates be different?
- How critical is the duration of the experiment to the reported effectiveness results?
- Do results reflect changes in pollution reduction benefits over the lifetime of the BMP?
- Briefly explain the study method used?
- What parameters were sampled and monitored?
- Who conducted the research?

- How was the effectiveness estimate calculated?
- What was the scale of the study?
- What assumptions, outside of experimental results, were made in reaching the conclusions?

After considering these questions the panel decided most of the horse pasture management data available should not be included in our data set. Please see Appendix A, meeting minutes from April 16, 2008 for a list of the literature reviewed and reasons why it was not selected. Many of the values found in the literature were repeated, however, after tracking the numbers to their original source it was discovered they were based on best professional judgment, not scientific research. The panel also felt the values extrapolated from dairy or beef pasturelands does not accurately reflect horse pastures. Unfortunately, the literature deemed applicable addressed very specific aspects of horse management (i.e., composting, bedding use, stocking densities) that were not helpful in determining the pollution reduction associated with pasture management. However, some had general information that was useful in determining our definition of horse pasture management.

Description/Definition of BMP:

Horse pasture management includes maintaining a 50% pasture cover with managed species (desirable inherent) and managing high traffic areas. High traffic area management is utilized to reduce the highest load contributing areas associated with pasture lands, and maintaining a 50% cover will improve the pasture so erosion and nutrient loss is further reduced. High traffic areas are concentration areas within the pasture where the grass is sparse or nonexistent. These often are feeding areas, such as hay deposits around fencelines. These areas are treated as sacrifice areas.

Horse pasture management does not include offstream watering with and without fencing, instead these stream protection BMPs are credited as separate practices. See CBP's off-stream watering with fencing and without fencing BMP report for details. Pasture management applies to all pasture lands, as not every pasture has a stream linked to it the offstream watering BMPs may be implemented on pastures adjacent to waterways. Where pastures are in contact with a stream managing animal contact to the stream is critical. The dominant source of nutrient and sediment loss from pasture lands is associated with animal contact with the stream. Overstocking is also frequently the cause of many nutrient and sediment problems, when preparing horse pasture management plans they should include pasture management, heavy use area improvement, and management of stocking densities.

Applicable NRCS codes:

Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Cultural components consisting of shorter term conservation measures included in the Pasture Management for Horse Pasture Management definition include, but may not be limited to the USDA-NRCS conservation practices listed below. When reporting pasture management a combination of NRCS practices must be implemented to achieve the definition of pasture management as defined here as including both pasture and heavy use area management. Thus, for example, in order to report pasture management, Animal Trails and Walkways (575) must be implemented with Prescribed Grazing (528) or Pasture and Hay Planting (512). Also Heavy Use Area (561) also must include either a Prescribed Grazing (528) or Pasture and Hay Planting (512). Addressing only one aspect, grass cover or untreated heavy use area, does not meet the definition and does not constitute credit.

Prescribed Grazing (528) - Managing the harvest of vegetation with grazing and/or browsing animals.

PURPOSE
This practice may be applied as a part of conservation management system to achieve one or more of the following:
- Improve or maintain desired species composition and vigor of plant communities.
- Improve or maintain quantity and quality of forage for grazing and browsing animals' health and productivity.
- Improve or maintain surface and/or subsurface water quality and quantity.
- Improve or maintain riparian and watershed function.
- Reduce accelerated soil erosion, and maintain or improve soil condition.
- Improve or maintain the quantity and quality of food and/or cover available for wildlife.
- Manage fine fuel loads to achieve desired conditions.

CONDITIONS WHERE PRACTICE APPLIES
This practice applies to all lands where grazing and/or browsing animals are managed.

Pasture and Hay Planting (512) - Establishing native or introduced forage species.

PURPOSE
- Establish adapted and compatible species, varieties, or cultivars for forage production.
- Improve or maintain livestock nutrition and/or health.
- Balance forage supply and demand during periods of low forage production.

- Reduce soil erosion and improve water quality.
- Increase carbon sequestration

CONDITIONS WHERE PRACTICES APPLIES
This practice may be applied on lands where forage production and/or conservation is needed and feasible.

Heavy Use Area (561) - The stabilization of areas frequently and intensively used by people, animals or vehicles by establishing vegetative cover, by surfacing with suitable materials, and/or by installing needed structures.

PURPOSE
- Reduce soil erosion
- Improve water quantity and quality
- Improve air quality
- Improve aesthetics
- Improve livestock health

CONDITIONS WHERE PRACTICE APPLIES
This practice applies to urban, agricultural, recreational or other frequently and intensively used areas requiring treatment to address one or more resource concerns.
Animal Trails and Walkways (575) - Established lanes or travel ways that facilitate animal movement.

PURPOSES
- Provide or improve access to forage, water, working/handling facilities, and/or shelter,
- Improve grazing efficiency and distribution, and/or
- Protect ecologically sensitive, erosive and/or potentially erosive sites.

CONDITIONS WHERE THIS PRACTICE APPLIES
On lands where control of animal movement is needed to facilitate access, improve grazing, prevent erosion, and/or protect ecologically sensitive areas.

Factors that Create Variability.

There are multiple factors that influence pastures ability to stabilize soil and improve nutrient uptake. Drought, soil nutrient content, species of grass (legumes), species mix and diversity, and weed control will all affect a pastures effectiveness at reducing sediment and phosphorous loads. These factors collectively result in temporal and spatial differences in pollutant reduction across horse pastures.

Management and operation can also be highly variable both between the research and operational scale and between different managers within the operational scale. When practices are implemented across a large area on parcels managed by many different individuals, it is important to assume an "average" level of expertise, control and management in planning design, implementation and operation of any given BMP. While there may be limited data quantifying the difference between research and "average" management, it is recognized that widespread implementation rarely has the same level of oversight and control that is essential to get statistically meaningful results observed at research scale. As a result, there is a need to lower effectiveness from the research scale when widespread implementation occurs.

Proposed Methodology to Determine an Effectiveness Estimate

Effectiveness Estimates:
40% TSS
20% TP

If we can answer these questions using best professional judgment or data an effectiveness estimate can be determined. If these data gaps cannot be answered, UMD/MAWP proposes the following effectiveness reduction estimates for horse pasture management.

Assumptions:
As high traffic areas located around gates, feeding and watering areas, and pathways, contribute the majority of sediment and nutrient runoff from pastures, we assume 75% of the pasture load is from these areas.

We assume high traffic management results in a 50% reduction in sediment loads.

Improvement in pastures leads to a 20% reduction in sediment runoff.

Under pre pasture management conditions (no grass nor high traffic area management) soils are not rich in phosphorous. After pasture management occurs (with grass and high traffic area management), manure is deposited across the pasture contributing more phosphorous to the pasture than under the pre BMP condition. A life cycle analysis is needed to evaluate the benefits of pasture management. Either an increase in animal numbers, or reducing pasture acres with same number of animals, will influence reductions associated with pasture management. Pasture management is compared to continuous grazed areas because pasture management offsets the need for feed supplement, and reduces grain and forage.

Calculation:
If 75% of pasture load is from high traffic areas, and management of those areas results in a 50% in loads, then 75 multiplied by 50% is 37.5%. We round down to the nearest value of five and assign a 35% sediment reduction in pasture load for high traffic management.

If pasture improvement (grass height and density) results in a 20% reduction in loadings, and pasture grasses contribute 25% of the pasture load, then 25 multipllied by 20% is 5%. Adding the benefit from high traffic management (35%) and pasture improvement (5%) equals a **total sediment effectiveness estimate of 40%**.

With pasture management manure is intentionally managed and more phosphorous is deposited across the pasture, resulting in higher phosphorous levels compared to the pre BMP condition. As sediment is reduced sediment-bound phosphorous runoff will also be reduced to some degree. We assume phosphorus reductions are half as much as the sediment reduction, thus pasture management **reduces 20% of all phosphorous** from the average pasture load in the WSM (40% sediment reduction divided in half equals 20%).

Horse behavior will result in a heavier impact to pasture lands when compared to the degradation caused by dairy or beef operations. Horses tend to spot (graze pasture to inconsistent heights). Some areas will have grass heights of 1-3 ft, others ½-1 inch. Horse grazing behavior is not uniform. There are areas in pastures that are grazed, others where horses lay down, and others where they defecate. With cattle all of these activities are mutually exclusive. With unmanaged grazing, horses also tend to selectively graze certain species of grass. Furthermore, movement behavior is highly variable and depends on the number of horses, housing facility, the presence of neighboring horses, and other factors. To account for these behavior differences horse pasture management effectiveness estimates will be applied against 1.5 times the average pasture load in the CBP's Watershed Model. While dairy and beef effectiveness estimates are applied against 1.0 times the average pasture load in the Watershed Model.

Effectiveness estimates, **40% TSS and 20% TP,** are **interim** and must be refined as more data becomes available in 2009. Many CIG projects will have data to address our data gaps and that information will be used to refine pasture management effectiveness.

These effectiveness estimates are interim and should be refined as more scientific information becomes available. In the near term we recommend using RUSLE2 to determine the water quality benefits of pasture management as defined here. However, once model results are available an independent group of RUSLE experts, outside the Chesapeake Bay Program, must convene to review the applicability of RUSLE to pasture lands. RUSLE was not developed for pasture lands and as such the inputs do not necessarily match those for pasture lands.

Level of Confidence

The effectiveness estimate is based primarily on best professional judgment and an understanding of the mechanisms of pasture management and horse behavior that reduce pollutant loadings.

Identify outstanding issues to be resolved in the future

Additional data is needed to refine the interim effectiveness estimate:

- What is the actual improvement in pasture loading rates associated with maintaining a 50% cover on horse pastures?
- What phosphorous levels are found in horse pasture soils?
- What is the actual load reduction from high traffic area management?

Future Research Need

Manure as excreted variations between horse and dairy, and between dairy and beef, due to variations in diet (i.e., grain in dairy diets versus no grain feed to horses). The P content of horse manure as it falls on pasture is not comparable to dairy manure content. The manure P content, as it falls on pasture lands, must be determined for horses and used in the model.

Cost-share programs allow for either mobile or stationary watering troughs, but the AgNSRWG and UMD/MAWP recommend installing mobile water sources to promote pasture improvements.

Contact Ann Swinker, Penn State, for her data available in early 2009 on horse pastures.

Appendix A: Meeting Minutes

Horse Pasture Management Meeting April 16, 2008

http://www.mawaterquality.org/bmp_project/year2/horse_pasture_management.htm

Attendees:
Ann Swinker
Shelly Dehoff
Sarah Weammert

On phone:
Amy Burk

Action Items:
How would the components of pasture management work together, a system approach (pasture management; runoff management from stall, SA, arena; manure management)? One concern is that a horse owner will do one aspect (i.e. pasture) and claim credit for whole system. This leads to double and triple counting (report one aspect in year one, another in year two, and a final in year 3). This needs to be discussed further.

Ann will send Sarah Eileen Wheeler's more recent fencing information. – Complete

All: "Bedding Use" (Rutgers fact sheet) by Mike Westendorf - look into his numbers (already on website)

Sarah will find who AEM is; review applicability after identifying AEM - Complete (see Appendix A)

Ann will send Sarah Eileen Wheeler's compost work for inclusion in data set - Complete

All: read and evaluate "Equine stocking density effect" by Singer et al 2001.; 40 pastures on various farms; ran statistics, have P value

Ann has article in PA on manure utilization of horse owners in PA. Published in 2004 with 2003 data that would be more applicable. ACTION: Ann will send Sarah the publication. - Complete

Sarah will ask Donna Faulk to join the panel; also ask Les and Elmer to join as well

Nutrient levels in pasture soils: ACTION: Ann is sampling pasture soils, can we review the lab results?

All (for next meeting discussion) the pasture management benefits were determined to be captured through grazing controls such as, eliminating *grazing on slopes or tree outcrops*, and controlling *forage height and density* (percent cover). The height and density values need to be determined (minimum of 2-3 inches; maximum?).

All: figure out loading rates for horses, is it the same as other livestock?

<u>Overview of Project</u>
Estimates of BMP performance will be used in TMDL and trading permits and WSM modeling, and for continued use in Tributary Strategies. While our scope dictates that we quantify the nutrient and sediment reductions, UMD/MAWP recognizes there are additional co-benefits (social, economic, etc.). UMD/MAWP is asking panel members to help create a list of all co-benefits.

Our most important task is to estimate BMP performance at the operational, average watershed wide scale. UMD/MAWP's job is to ensure panel decisions, scientific justification, and best professional judgment are within the framework of our guidelines designed to estimate operational, average watershed wide conditions:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.
- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.
- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process. As such, peer reviewed literature should be given more weight than design standards and manual.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

UMD/MAWP will ask detailed questions about the BMP, not to discredit the performance of the BMP, but to get to operational conditions.

Panel members' primary task is to develop a report for the BMP using the guidelines, decision matrix, and factors of variability found in the template. A final report from the panel is due to the Chesapeake Bay Program by July 15, 2008 so partners can begin their technical review process. Bay Program partners are made up of jurisdictional agencies, the EPA and the Chesapeake Bay Commission. During technical review (mid-July to September) workgroups may bring specific question to panel/scientists for discussion.

Proposed Framework:
Facility Management – Stall, SA, paddock
Manure/Bedding Mgt – not managed due to parasite concerns?
Pasture Mgt – is this mainly an erosion reduction practice?

ACTION: How would these components work together, a system approach? One concern is that a horse owner will do one aspect (i.e. pasture) and claim credit for whole system. This leads to double and triple counting (report one aspect in year one, another in year two, and a final in year 3). THIS NEEDS TO BE ADDRESSED

Data Set Review
The panel reviewed the data set collected and evaluated its applicability and credibility. Many extension publications are available on horse pasture management, but scientific sources of information, peer reviewed research, is limited. Panel members comments and justification for inclusion or exclusion from our data set follow. After reviewing the data set additional scientific sources were identified and will be reviewed for inclusion in our data set.

Reference (Reliable Science?):
Many Extension publications do not provide scientific data, but are okay for popular press.

Bartlett, 2005. ABC's of Pasture Grazing: conservative (watered down); good study; number of references is low but the group that authored the document is knowledgeable; nice summary; peer reviewed; but not specific to horses; redundant and not as important to our efforts. DELETE

Bedding Use (Rutgers fact sheet) by Mike Westendorf - look into his numbers (ACTION); KEEP

Composting Horse Manure - covers breath of compost; KEEP because it covers details on how composting is done

Water Quality BMPs for Horses. CA study – panel is not familiar with this particular document. roof runoff and facility runoff (page 9 with BMPs), address slope stabilization. Authors have done their homework, but no data is provided. BMPs captured in MD's pasture system fact sheet. DELETE

Equine Pasture Management A Year Round Approach – Rutgers; general publication for horse owner, too general for our needs. DELETE

High Traffic Area Pads for Horses (Kentucky) – good study; author knowledgeable; KEEP

Horse Farm AEM Tier 2 - Assessment of old information, no new info ACTION: find who AEM is; assessment tool that defines higher risk (i.e. high vegetative cover); Review applicability after identifying AEM

Improving equine waste management (Kentucky) - not too useful; DELETE

Composting Horse Manure (MD) - Carbon and nitrogen ratios are useful; KEEP

BMPs for Horses in NY NRCS – uses LRCES info; compost work good, however there are other documents that cover the specifics and major issues with compost. DELETE

Runoff from Alum Treated Aanure (Edwards et al 1999) - not a good study; only took manure from a couple horses and mixing horse manure with sludge; was horse manure with bedding to make a solid rather than liquid. DELETE

Agricultural Management Practices for Commercial Equine Operations - Rutgers; Donna Foulk author is very knowledgeable, she is not an extension agent, she works for Rutgers University; good authors; pretty good information but popular press; 70% vegetative cover recommendation was not based on science, picked using best professional judement, does this include desirable and undesirable species (are we looking at anything that grows here and reduces sediment and uptakes nutrients), from non-animal health issue having high density and grass height is desirable for nutrient and sediment reductions; 2 or more acres per horse with limited management number picked out of air also (under stocking rate section). Less 40% desirable species – what are desirable species, (depends on animal use)? PA work using P-index showed needed 3 acres, but when addressing nitrogen not enough. KEEP for general information but recognize based on best professional judgment, not science

Singer, et al. Effectiveness of Extension Equine - survey in NJ; addresses how good extension services are at reaching farmers; DELETE

A Guide to Composting – repeat of information, done better elsewhere, not useful; DELETE

Composting Horse Manure from NC Cooperative Extension - photos and plans are good, elaborate plans; repeated in other places, but other publications by Eileen Wheeler has the original information source. ACTION: collect Eileen’s work for inclusion in data set

Assessing your risks to water resources livestock on small acreages - nothing unique, repeated information; PA has assessment program (home assist); DELETE

BMPs for Horse Pasture, Paddocks and Stables - adopted from MDA's publication horse owners guide to protecting the Chesapeake Bay, 10 pager handed out at horse fairs; repeat of information from Rutgers; nothing unique, good basic information for horse owner; Many articles stuck together in one bigger document; not bad. KEEP

Horse Paddocks Designed and Managed to Protect Water Quality – from CA: considerations for paddock dimensions; paddocks have berms help with water quality but semi arid climate approach; DELETE

Equine Barnyard Management (Rutgers) - basic, covered elsewhere in Donna Faulks's larger publication; DELETE

Establishing and Managing Horse Pastures (Kentucky) - authors knowledgeable; information is good; however seeding rates area specific (not necessarily for the Chesapeake Bay but general information is good) KEEP

Horse Pasture Management Species Selection (Rutgers) - species selection one good aspect of pasture management but distant from our objective; need more general stuff for this; maybe follow up

Healthy Horses, Clean Water - 72 pages; general horse owner info, common sense; well-written and organized; maybe follow up

Managing small acreage horse farms (Oregon) - species similar to mid-atlantic (cool season grasses) even though more mountain; good info, not what need directly;

Management of Established horse pastures (MD) - redundant of Rutgers and Healthy Horses, Clean Water

Pervious concrete as flooring material - do this to replace septic systems and drain fields; channels away from barn – will work with small operation but clog up with a lot of horse hair, nice suggestion for small operation; needs high maintenance to remain pervious; DELETE

Establishing and Managing Horse Pastures (Rutgers) - same as Donna Faulks's big publication; DELETE

ACTION: read and evaluate "Equine stocking density effect" (Singer et al 2001): 40 pastures on various farms; ran statistics, have P value; may be too detailed for our purpose

Fencing Options for Horse Farm Management in VA - old, ACTION: Ann will send Sarah Eileen Wheeler's fencing information, more recent

MD HOW factsheets – data reflective of Rutgers extension publications
Environmental Impact handout – new handout, hasn't been used; extension professional numbers (70% ground cover used); good whole farm approach to horses; KEEP but recognize it is simplistic and repeats the Rutgers numbers.

Singer et al 2002 - good study but conducted in NJ which has more high dollar horses. DELETE. Ann has article in PA on manure utilization of horse owners in PA. Published in 2004 with 2003 data that would be more applicable. ACTION: Ann will send Sarah the publication.

ACTION: ask Donna Faulk to join, in PA; ask Les and Elmer to join as well

Compost references are ok. PA has good composting publications, KEEP PA's compost references

<u>Data Needed</u>:
Data broken down by type of pasture and its ability to take up nutrients

Nutrient levels in pasture soils: ACTION: Ann is sampling pasture soils, can we review the lab results?

Information on how to dispose manure and utilize it

Use:
Pasture Condition Scoring Index: NRCS Grazing Lands Institute. (Ann Swinker is testing its applicability to horses by measuring it on 23 farms this growing season.)
P-index
RUSLE2

<u>Baseline:</u> Continuous (unimproved), no vegetation, no rotation, no management
Biggest credit when owner can get horses off the pasture, eliminating continuous grazing.

<u>Framework:</u>
The panel developed a tiered system that captures the general (majority) horse owner community, and will also work for higher end breeders.

Pasture Management through grazing controls such as, eliminating *grazing on slopes or tree outcrops*, and controlling *forage height and density* (percent cover)– (minimum? (2-3 inches); maximum? Needs to be determined).
The framework will not be broken down by function of farm (breeding, race, therapeutic, etc.), instead focus on *stocking density and grazing schedule* (continuous or rotational). The grazing schedule is defined by horse behavior. Limited hours in rotation is required on horse farms, or rotationally grazed systems are not intensively grazed.
Runoff control is achieved by directing offslope water away from the paddock, sacrifice area, and riding area. The technique to accomplish this is to keep grass buffers between barn/arenas and streams to capture water runoff.
No manure management because all horse operations only spread manure on walkways and arenas, not on fields, due to concerns about parasites.
Practice will not include buffers and nutrition factors.
Future refinement: determine effectiveness based on slope and soil type.

The rotational grazing pasture practices developed for other livestock will not work for horses because of their different behavioral characteristics:
Rotational grazing limitations for horses – horses will excrete in one area and then they will not graze in that location, whereas cattle will forage up to their manure deposit site. The dominate horse will kill other horses, because they are very territorial. Whereas cattle can co-mingle, horses can't intensively graze. Temporary fences cannot be used with babies horses because they will become tangled. Horses need permanent fencing on breeding operations. Older horse facilities or an average riding horse could only intensively graze with horses who know each other well. With herd changes a horse owner is better off not using intensive grazing.

<u>Target to Estimate Performance:</u>
Ultimate: Use pasture condition score sheet and MD environment impact worksheet (HOW handout).
Year one: Use multiple pastures, runoff control for the stall, sacrifice area and paddock areas. Utilize a point system like MD's environment impact worksheet.
Next year improve sacrifice area surface to reduce erosion.
Next year highlight pasture management, focusing on techniques that reduce erosion and nutrient losses (terraces, etc.).

ACTION: figure out loading rates for horses, is it the same as other livestock?

<u>Discussion</u>
Are pasture fertilized? Some operations base fertilization on soil test, some on spread manure recommendations (Ann has figure - percent hauled, spread in PA; published, economic impact study. ACTION: Sarah will obtain a copy of this report), while some go off feed

recommendations. Frequency of fertilization is typically once a year, but depends on company doing fertilization and what they recommend.

Manure has a high carbon content, and can be land applied (made into compost mushrooms grown in).

Is manure 3 parts bedding/1 part manure? Depends on operation. Some operations add pellets to reduce the volume of manure after excretion (product that condenses the compost pile). There is also a synthetic product takes nitrogen out of the soil when spread on field. Not sure how many people using these techniques.

Are there ways to reduce the volume of manure excreted? The highest quality feed will reduce volume. Traditionally owners don't feed enough forage.
There is horse manure characteristics (N and P) in Ann's CIG project. (FOLLOW UP STUDY)
Manure is a solid with a high carbon content due to bedding. Horses erode soil due to compaction and overgrazing, and if soil high in P then there are increases in P loss. Manure management is not a nutrient reducing practice.

Paranoid by parasites – don't apply composted manure to pasture. May change now that fertilizer costs inc, may start looking. Do spread on outdoor arenas, walkways, hayfield, vacant lot.

ACTION: Sarah will contact Donna Faulk at Penn State – North Hampton County – soils research.

Next meeting in mid-May, combine pasture and horse pasture panel meetings together (after 16^{th})

Appendix A: Information Collected After April 16, 2008 Meeting

http://www.agmkt.state.ny.us/SoilWater/aem/techtools.html

AEM is a voluntary, incentive-based program that helps farmers make common-sense, cost-effective and science-based decisions to help meet business objectives while protecting and conserving the State's natural resources. Farmers work with local AEM resource professionals to develop comprehensive farm plans using a tiered process:
- **Tier 1** – Inventory current activities, future plans and potential environmental concerns.
- **Tier 2** – Document current land stewardship; assess and prioritize areas of concern.

- **Tier 3** – Develop conservation plans addressing concerns and opportunities tailored to farm goals.
- **Tier 4** – Implement plans utilizing available financial, educational and technical assistance.
- **Tier 5** – Evaluate to ensure the protection of the environment and farm viability.

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Combo pasture management meeting:
May 19, 2008

On Phone:
Ann Swinker
Donna Vaulk
Mike Harper
Kathy Soder

In attendance:
Sarah Weammert
Tom Simpson
Shelly Dehoff
Les Vough
Elmer Dingler
Amy Burk
Mark Dubin

Action Items:
ACTION: Mark will contact Dave Lightle for his pasture data
ACTION: Ann has pasture soil test numbers in her project, she will send us her results.

ACTION: use RUSLE2 with unmanaged baseline vs one that meets our criteria (50% cover, high traffic use) with someone evaluating our process; panel determines if response is applicable.

ACTION: Sarah will find out how equine manure is tracked in the model. Estimate amount of horse manure.

ACTION: Mark talk with Tim to set up chat with Dave to run RUSLE2; then group will discuss via conference call

ACTION: Elmer will send MD manure management data to group

Discussion:

Can we approve this using density, (cover or height), and need or feasibility of rotation? How will differ between animals? Will height be the same?
Ann: not the same for horses and livestock. Horses want Kentucky bluegrass along with different species of grasses. With beef as they move around the pasture they forage.

For our subcategories can pasture species be sorted into bluegrass vs fescue?
Elmer: percentage of cover is more important. Instead rank management levels with percent cover managed in a way that keeps a healthy grass stand.
Amy: make height recommendation by species; horses have compaction issue greater than bovine

Also grazing behavioral differences:
Horse: inconsistent grazing over an area. Some areas grass is 1ft, others 2 inches
Horses have non-uniform grazing (pick places to graze, others to lay down, others defecate; with cattle all activities mutually exclusive); selection also depends on age of horse

Do horses spend more time on edges of pasture? Movement behavior?
Variable, depends on number of horses, housing facility, presence of neighboring horses.
Boarding facilities have more opportunity for movement.

Does RUSLE2 have factors in there that gives us the variability we need?
Tracking sediment and nutrient movement, what components affect that?
Percentage of cover
Roughness coefficient
Stem density

In terms of how we deal with pasture management as a BMP, should it be more focused on limited to select ownership types?
Yes, treat large operation as farm unit under conservation plan. Thus constrained to casual boarder, not 50 horse operation.

Through improved forage management, pasture management – what are the stocking rates?
Ann: In PA it is typical for horses to not even be on pasture, providing nutrition by feed in stall. Pasture is used for turn out exercise, attitude adjustment, etc. Some owners do turn horses on pasture for nourishment.
Amy: in MD see a lot of co-ops with just a run-in shed and are feeding horses on the field
Ann: In those situations where horses are on pasture owners rotate horses, not pastures (pasture always has horse on it).

What would a pasture management BMP look like?
Not an easy task, PA meet monthly for 4 years to discuss this with no finalized report.

Could measure time in confinement?
Manure management now concern, horse owners will not apply due to concerns with parasites. Also dealing with more carbon content than solid product (3 parts bedding, one part manure). 45-48% of operations have manure hauled away.

Before and after manure management situation no difference.
Just focusing on paddock or pasture management.

Assuming excluded from stream, what opportunity for reducing loss?
Good percent cover, density, roughness (height)
Amy: So much variability with horses (compaction, grazing behavior, etc.) need to be conservative
Ann: with actual testing of percent cover on places that looked great and with good management see 60% cover. Found same score using both methods of measurement. Looking at desirable species, but scored for organic matter vs bare ground vs weeds (receive higher point value for desirable species)

70% ground cover is found in all extension publications. But again this number was not based on science. A team of scientists from Rutgers 'picked the number out of the air'. When looking at actual measurements rarely are they that high. Don't want to encourage the myth that it is easy to get 70% if good pasture has 50-60% cover (with random sampling).

To calculate cover the MD NRCS pasture worksheet throws out the bad area and an extremely good area. Do straight transect through average management conditions. What is immediately below each foot over a one hundred foot distance, is used to get percentage. Score card measures get into a lot of additional parameters.

Practice is, what are the actions you take to get to desired result? What does it take to get above 50% cover?
Data is lacking, using a best professional judgment.
Shelly: couldn't find good scientific credible for horse pasture. That's why went to pasture condition score index using percent cover.
Elmer: concern with score card, don't use it in MD. Because the time spent doing score card *CORRECTLY* is very time consuming and it is hard to do correctly due to the terminology and approach.

At what level is vegetative cover needed to slow water?
Elmer: Residue cover: 30% is conservative, Above 60%. But residue cover doesn't address soil quality so moving towards using STIR values too.
Les: 98% of pasture lands has excellent cover, less than 1% high contributor of soil and nutrient. This 1% area is a high traffic area - runoff from barn roof straight to stream. If rate pasture alone get great cover score, but nutrients from one percent is high. Can't just rate the pasture.

Is the practice having decent pasture cover AND high traffic area management?
Shelly, Amy: yes, go hand in hand.
Elmer: look at entire system, keep dirty water separate from clean water, but there is no tool to measure entire system.

Elmer: it should not be considered grazing, b/c with horse pasture management will not fit within rotational grazing system.
Ann: horse owner not managing pasture for reduced feed costs
Amy: horse pasture avoids weed

Amy: some horse operations do not want pasture b/c makes horses too fat and basically have mud lot

Elmer questioned Beth Horsey on her definition of horse paddock and she did not include grass as part of the definition.

Multiple pastures is loafing lot system, all horse owners have them. In MD under heavy use area standard have vegetative loafing lot alternative, comes closest to horse pastures. Grass not primary component in forage, it is there to capture nutrients and provide pleasant environment for horse to occupy.

What soil quality and plant performance needed for water quality?
With 50-60% cover, using random transect method across pasture and address high traffic areas, addresses other management issues it takes to get that cover (soil pH and fertility management). from horse perspective: hours on pasture

For environmental impact, can we convert into horse hours per day per acre? How many horses for how long on a unit of land?
Need to know plant height, soil compaction, soil moisture (winter/summer) – when put out there very important
Price of hay rising so may see increase in pasture used for forage

Elmer: prescribed grazing, beef one acre per animal unit, horses using 1.5 acres used based on observations with good management. Still have issue of, with poor management and those rates what will happen?

50-60% cover, what about annual versus perennial?
Temporal cover throughout the year.
Ask to overseed in winter for winter cover.

Ann's data will be available later this year to help address these questions.
ACTION: Mark: Dave Lightle pasture data

To achieve a 50% cover will have different management plan based on horse operation.
Not looking for forage, looking for something that won't harm the animal.

If just use 50% cover how know the vegetative species take up nutrients?
Concern not nutrient loading rate, instead addressing erosion. Not trying to take up excess nutrients in bio-mass, prevent erosion and water flow so don't flush sediment and manure into the stream.

FOLLOW UP STUDY: Beth Horsey has a project to compare mud lot to good management.

No definitive answers.

On an operation what percentage total manure deposited out there, is it proportional to hours?
Factor to determine accuracy
Largely deposit manure and urine in stable or pasture?
FUTURE REFINEMENT NEED

What should we do? <u>Cover with high traffic area management</u>

50% Cover: will not consider weeds part of 50% cover, manage for species
This is best professional judgment, it is not based on science.
Should be interim number, not final practice. Data is being developed in next couple years that will help refine number.
Ann: percent cover with meeting management then doesn't matter stocking rate

Manage high traffic areas?
With heavy use pads, or turf; with vegetation around it?
NRCS heavy use area standard: managed in way meets NRCS heavy use standards

Not just high traffic management or percent cover, *need both to receive credit for horse pasture management.*

Implementable components using cost share, with bermuda grass in summer, assistance to plant rye for winter protection?
Horse people don't have equipment to do this
Adapt to what use pasture for

<u>Interim practice definition</u>: maintain a 50% pasture cover with managed species (desirable inherent), and manage for high traffic areas,

50% should be re-evaluated in near term based on outcome of research

What value/effectiveness for before and after?
ACTION: Ann has pasture soil test numbers in her project, obtain results.

Even if operation does recommendation, will see change? What is the baseline?
What's typical before and typical after?
No data on this, but professional guess is continuous grazing (unimproved pasture) with no vegetation, no rotation and no management.

Sediment:
If get 50% cover and treat high traffic area what percent sediment is reduced?
Mark: with nothing to work with use RUSLE2
Tom: using RUSLE2 for use not evaluated for, allow an advanced RUSLE expert evaluate after we use it. When misusing a tool with science behind it, acting like have science to evaluate BMP.
Mark: send to Dave Wigel, outside BMP, he developed RUSLE2

ACTION: use RUSLE2 with unmanaged baseline vs one that meets our criteria (50% cover, high traffic use) with someone evaluating our process; panel determines if response is applicable.

RUSLE is the best alternative with no science

What percent of horses in our target type of operation (eliminate breeders) already meet our definition? Will we see a change in operational conditions? Give practice effectiveness estimate based on change from bad case when in actuality the baseline was better; or plan shows no change because operations already doing these things.
Mark: use breakouts from Ann's data to determine typical management
Elmer: beef, cattle, dairy 30-50% have these management properties. 25-30% do not have cover. 1/3 out there that are not significant nutrient and sediment contributor
Tom: high percent have adequate cover but is it reducing erosion?
Ann: large operations focused on aesthetics (flowerly pasture, grass, no mud), don't want mud lot. Small operations that are not profiting from horses have mud areas because don't care about aesthetics.
Ann: unwanted horses population will boom soon adding another management group with bad management. Non-professional horse owners are not able to afford these practices.
Shelly: are driving extension offices to providing professional help? Do want these offices with no horse experience assisting horse operations?
Elmer: MD is heading in this direction. HOW uses education components. If doing things that allow for increased cover and adding high use areas management better than typical operation in our target operation (small horse owner, not for profit horse owners).
Mark: equine council pushing helps. Standard helps educate and changes behavior

Elmer: manure management has positive effect (compost, improved storage, proper land applied, transport)
Horse panel in April 2008 decided to exclude manure management from BMP
Elmer: Beth and Elmer has numbers on manure, and model should address manure management because making significant improvement.
Tom: may not be included in model ACTION: find out if equine is tracked in the model. Estimate amount of horse manure.
Elmer: within MDA over last 7-8 years has documented storage and management
Ann: Not dealing with land application on pasture, but how manure is managed has improved. But there is still a need to educate on manure management.
ACTION: Elmer has numbers on MD manure management
HIGHLIGHT: Manure Management: if handled properly will see benefit because it changes the amount of manure available for loss. However, manure is not land applied to horse pastures.

BMP components: manure management, 50% cover of desirable species and heavy use area management

Heavy use definition: NRCS criteria

LUNCH

Pasture Management Discussion (livestock)

MIG vs rotation: amount of time on pasture
MIG – every 3 days to as little half day for dairy operations, meeting peak performance for grass
Rotational – move once a week for managers convenience. Some things for grass needs but not for high forage quality or peak performance

Is there water quality difference between the two?

Beef and others vs dairy: different because of nutritional requirements

RUSLE Dave Lightle: **dave.lightle@lin.usda.gov**
Scenario for six runs

Piedmont, coastal plain, etc.?

Scenario Set up:
Average Slope
Cover
Forage residue estimates; cool season vs warm
Soil types
Residue height

Baseline (typical pasture management): continuously grazed for both dairy and beef and other

Cool season grasses
Predominantly grazed, to half inch
Fescue same, and crab grass
Predominant in hilly areas, use 8% for slope
Soil types: no karst, somewhat shale to capture MD and PA ridge and valley. Berks, Whiekert for shale.
Deeper well drained soil: Calvin Ernst series (silty soil),
Cover: ? use Dave's data

Height: vary height by species

ACTION look up soil association series, think about percent cover

Separate blue grass from orchard grass with fescues in between

Grass management will not effect yield for some grasses. Blue grass 2-2.5 tons; orchardgrass isn't there with continuous grazing (ACTION look up old agronomic handbooks for reference)

On rotational or MIG orchardgrass is 3.5 tons average yield. Fescue 4 tons of yield (better tolerance on varied soils and drought tolerance; also longer growing period)

Average grass hay yield across MD is 2.5 tons, aphala 3.5.

Cover: Dave already has direct pasture measurements. Plug in his data.

ACTION: send group draft scenarios; Mark talk with Tim to set up chat with Dave to run RUSLE2

Agricultural Nutrient and Sediment Reduction Workgroup Meeting Minutes
Chesapeake Bay Program Office; Annapolis, MD
August 5, 2008

Pasture Management & Horse Pasture Management
Pasture Management: http://archive.chesapeakebay.net/pubs/calendar/ANRWG_08-05-08_Handout_2_9618.pdf
Horse Pasture Management: http://archive.chesapeakebay.net/pubs/calendar/ANRWG_08-05-08_Handout_3_9618.pdf

- For both pasture management and horse pasture management, UMD/MAWP recommended interim effectiveness estimates of 40% for TSS and 20% for TP. Although the effectiveness values for these practices are the same, they would be applied differently in the model.
- Originally, they had planned to use RUSLE2 for this project. However, RUSLE2 was delayed and it was not available in time. Sarah said that they are still working with NRCS to see if they can use RUSLE2 in the future.
- Two experts who are not involved in this Bay-effort have said that they would be willing to review RUSLE2 to make sure that it applies to pasture.
- UMD/MAWP recommends that the effectiveness estimates that are being proposed today for these practices be considered interim estimates. These practices are relatively new and there is still research in the works. If these are interim estimates, then the Nutrient Subcommittee and the AgNSRWG could revisit these estimates as new information becomes available.

- The applicable NRCS codes that are listed in the reports are the ones that were initially suggested. What is the crosswalk between the NRCS practice codes and the Bay Program? What combination of practice codes, or which code, do you need to fulfill the definition? They will work with NRCS to figure this out.
- Comments/Suggestions:
  - Currently both reports are titled "Pasture Management". The titles should instead differentiate between the two practices- "Horse Pasture Management" and "Beef/Dairy Pasture Management".
  - The reductions should be clearly defined up front in the report in either a table or in a specific section.
  - The report does not contain any discussion regarding animal units.
  - "Feed supplement" should be added to the MIG definition section in the beef/dairy BMP report.
  - Need to differentiate between dairy and beef in the rotational grazing definition (UMD/MAWP did not assume rotational grazing with horses).
  - In the calculations section for both reports, change 25 divided by 20% to 25 multiplied by 20% (the answer is correct though).
  - Is the Heavy Use Area (NRCS code 561) an applicable code for pasture?
    - The panel said that the heavy use areas are responsible for a large majority of the loss.
    - We should ask NRCS if they routinely report that standard as having been applied when they do pasture management and management intensive grazing.
  - Under NRCS code 528 (prescribed grazing), there appears to be a typo where it says "manage fine fuel loads". Sarah copied this phrase directly out of the NRCS practice standard. She will check with NRCS to see if it is a typo.
  - The last sentence in the third paragraph of the calculations section ("We assume…") should be rephrased. They are assuming that the TP reduction will be half of the TSS reduction.
  - Are these practices separate from the stream fencing practice?
    - Yes, they are not linked to stream protection.
    - These practices are in a majority of the state's tributary strategies, thus they need an effectiveness estimate.
    - One potential idea would be to use this practice when the field doesn't have contact with the stream, but when it does have contact with a stream you could require that they do both this practice and the stream fencing practice in order to get credit.
    - A statement should be added at the beginning of the report that says that this practice does not include riparian corridor management and that the dominant source of loss from pastures is where there is contact with the stream.
  - In the Horse Pasture Management report, a statement should be added to the narrative that says that overstocking is frequently the cause of many of these problems. Therefore, when planning a pasture management system for horses, it is essential that stocking issues also be addressed.
  - If you have a mobile water source, would that count?

  - The definition that is used in the report is a combination of what they were given and what the panel recommended.
  - They are working on a rather broad scale and separate practices were not proposed for mobile and stationary water sources. In the report, however, they could recommend that the water source be mobile.
  - MD only cost-shares stationary water troughs.
- Comments sent by Tom Juengst via email:
  - Both reports seem okay. Finding, determining, and documenting good information and analysis is much easier said than done.

ACTION: Tom Simpson and Sarah Weammert will revise the two pasture management reports based on today's discussion. A revised version will be sent out by Friday.

ACTION: AgNSRWG members can provide UMD/MAWP with any additional comments over the next few weeks.

ACTION: At the workgroup's September 3rd meeting, members will review the revised pasture management reports and they will finalize their recommendation to the Watershed Technical Workgroup and the Nutrient Subcommittee.

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Minutes: Agricultural Nutrient and Sediment Reduction Workgroup
September 3, 2008

Horse Pasture Management

- The horse pasture management practice reflects most of the criteria of the pasture management practice except that it would be applied to a load 1.5 times.

DECISION: The AgNSRWG recommended moving forward with the horse pasture management practice definition and effectiveness estimates with the following changes:

  - RUSLE 2 breakdowns will be added to the report.
  - The report will be revised to reflect that some combination of NRCS codes can achieve the pasture management practice. Either of NRCS codes 561 or 575 must be implemented alongside of 512 and 528.

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Minutes: Watershed Technical Workgroup
October 6, 2008

Pasture Management for Dairy, Beef, and Livestock and *Horse Pasture Management*

- Efficiencies for livestock and horse pasture management are the same but are applied to a different load.
- Livestock pasture receives 1.0x the average pasture load. Horse pasture receives 1.5x the average pasture load to account for variations in animal behavior.
- The Agricultural Nutrient and Sediment Reduction Workgroup would like to use the 40% TSS and 20% TP as placeholder values but would ultimately like to do is use RUSLE2.
- The pasture management differs from the other two pasture BMPs because pasture management for livestock addresses upland rotational grazing. The two Year 1 pasture BMPs were for offstream watering with and without fencing.
- The Workgroup approved the pasture management BMP, acknowledging that the 20% TP and 40% TSS numbers are interim.

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Chesapeake Bay Program Nutrient Subcommittee
October 22, 2008 Meeting

SUMMARY OF DECISION, ACTIONS AND ISSUES

Pasture Management

- Pasture management reductions are 40% for TSS and 20% for TP.

- There are no nitrogen reductions associated with pasture management. This was a panel decision.
- When reporting pasture management, a combination of NRCS practices must be implemented to achieve benefits under the pasture management BMP.
- For horse pasture management, the effectiveness estimates are the same as livestock pasture but will be applied to loads 1.5 times that of livestock pasture.
- Bill Keeling expressed concern about the fact that no one from Virginia was represented on the panel.
- Bill Keeling pointed out that the Watershed Technical Workgroup approved the pasture management BMPs because the recommendations are only for interim efficiencies until better numbers can be developed.
    - Tom Simpson clarified that there are several studies in development that will provide a lot more information on some practices when they are completed. When these studies are completed, the Bay Program can reexamine these BMPs with new information and revise them accordingly.
- Russ Perkinson pointed out that we may see a land use change with implementation of pasture management BMPs because as animals start eating more grass on pastureland, there will be less demand for corn and, therefore, less cropland and associated nutrient runoff.
- Ron Entringer believed that the BMP recommendations had a lot of needed work, but he was okay with moving forward with it.

DECISION: The Nutrient Subcommittee approved recommended BMP efficiencies for horse pasture management and pasture management for dairy, beef, and livestock for final decision by the Water Quality Steering Committee. Concerns expressed by specific Subcommittee jurisdictional representatives were noted for the record.

ACTION: The Watershed Technical Workgroup will review all of the BMPs from Year 1 and Year 2 that deal with pasture, and solidify how the various pasture BMPs function together for tracking and reporting reasons.

Participants

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Joint Watershed Technical Workgroup and Agricultural Nutrient and Sediment Reduction Workgroup Meeting
Chesapeake Bay Program Office; Annapolis, MD
December 11, 2008

III. Discuss Pasture Management BMPs **Keeling**

Presentation: http://archive.chesapeakebay.net/pubs/calendar/ANRWG_12-11-08_Presentation_1_9226.pdf

- Bill Keeling initiated a discussion on pasture management BMPs. Issues for discussion include how the practices and land uses fit together, how many upland acres can be treated by a buffer, and what will happen to Year 1 BMPs in Phase 5 of the Watershed Model. This discussion will be continued at the joint WTWG / AgNSRWG meeting in January.
- The definitions and efficiencies of the pasture BMPs were revised in the UMD/MAWP BMP Project. These definitions and efficiencies will be used by the Chesapeake Bay Program in Phase 5 of the Watershed Model.
- Bill Keeling said that one concern that he has is that the definition of pasture management that UMD/MAWP proposed for Phase 5 is different from the definition that was used in Phase 4.3. (See the PowerPoint presentation for definitions)
- The Phase 5 definition describes a more intensive form of pasture management than the Phase 4.3 definition.
- Bill Keeling said that only about 5-10% of the pasture management practices that VA has reported would fit under the new definition. If CBP goes strictly with this new definition, then approximately 90% of the pasture management BMPs that VA has previously reported would need to be disregarded.
- Q: What components of the new definition cause many of the VA pasture management practices to be ineligible?
    - A: Maintain 2-3 inches, 3-7 day rotation.
- In particular, Bill Keeling said that he was told that this new definition does not apply to dairy because many of the dairy farmers were trying to increase their forage time.
- In VA, you are not eligible for cost share if you have greater than 60% cover.
- Bill Keeling is concerned that we may be defining rotational grazing or upland pasture management too narrowly to fit what is going on in VA pasture management.

- Tom Simpson explained that the UMD/MAWP definition is based on what they were told by the experts, including NRCS pasture experts. These experts said that maintaining a decent height of grass, a good cover, and frequent rotation is what they were calling rotational grazing.
    - Bill Keeling agreed that frequent rotation is a component of intensive grazing, but he said that many farmers in VA are not implementing this practice this intensively. He said that the NRCS code 528, which is prescribed grazing, doesn't call for this practice to always be done this intensively. There are also lesser variations.
- Darrell Emmick said that the time factor is also an important consideration. If you allow grazing when the forage is approximately 6-8 inches tall (about 100% cover) and you move the cows after every milking (twice a day), then at the end of the day the forage is going to be down to 3 inches. The cattle will then be moved and the pasture can start to grow back over night. From that perspective, even if the cover has dropped from 100% to 50% in one day, it can recover very quickly. It could reach 100% again in 5-6 days. Some things that he had not heard yet in today's discussion include: When are we looking at the cover? How long is the pasture left with that cover?
    - Tom Simpson said that this sounds consistent with what he heard from the expert panel for the UMD/MAWP BMP Project.
- Q: In NY, do farmers use a moveable fence? And do they back fence as the herd moves?
    - A: Yes. Darrell Emmick explained that this was often the case in NY. Farmers could have moveable water or a laneway to a water source. If the water is moveable, then there is not a heavy use area around the water source. This would be an ideal situation.
- As written, the definition can leave the impression that the area was left at 50% cover. However, it would be a mistake to think this. Tom Simpson explained that 50% is the bottom, not the top. At no time would you let the cover go below 50%. This may need to be stated more clearly.
- Although UMD/MAWP developed an efficiency for stream protection and water with fencing, this efficiency will not be used in Phase 5. Instead, a land use conversion from degraded stream corridor will be used. Jeff Sweeney will use this efficiency to help determine what the loading rate should be on that trampled area.
- Bill Keeling presented several Phase 5 scenarios for workgroup members to consider. See the PowerPoint presentation for details.
- In Scenario 2, the area between the fence and the stream is the buffer and the area beyond the fence is the area treated by the buffer.
- Sarah Weammert said that in the UMD/MAWP report, they did not recommend a change to how buffers are currently modeled. This would mean that there would be 4 acres of upland to 1 acre of buffer for N, and 2 acres of upland for 1 acre of buffer for P.
- When you convert cropland to pasture, does a degraded stream corridor automatically get created? The degraded corridor is a very high loader.
    - Tom Simpson and Bill Keeling agreed that they did not think that it would be best to create more degraded corridor.
    - In the future, the conversion of cropland to pasture will not be as extensive.
    - Olivia Devereux explained that if cropland was converted to pasture in the model, then a trampled corridor would also be created.

- Do we have any way of knowing if row crop land that is converted to pasture is adjacent to a stream?
    - Bill Keeling said no. Hardly any of this is really tracked. How this should be reported needs to be determined. Jeff Sweeney will also need some ground rules on how to handle this information when it gets reported to him.
    - Kenn Pattison said that NRCS reports fencing under one category, no matter what kind it is. NRCS will also report a watering system, but you won't know if it is for fencing or without fencing.
- Since a majority of the practices that have been reported in VA do not fit the new Phase 5 pasture management definition that is more intensive, Jeff Sweeney suggested that another BMP category be created for less intensive pasture management.
- Kenn Pattison said that it would be useful if we determined which CBP BMPs go with which NRCS codes. There is no common understanding on how to report between the states.
    - The UMD/MAWP BMP reports state which NRCS codes go with each of the Year 2 BMPs.
    - Beth Horsey said that she can provide Kenn with what MD has been using for NRCS codes for with and without fencing.
- In VA, no one is tracking the intensity of grazing or rotational grazing.
- Bill Keeling said that another concern that he has is that the percent cover for pasture in Phase 5.1 does not represent the percent cover in VA. He suggested that a percent cover be used that mirrors the seasonal growth curves. (See slides 28-29)
- Olivia Devereux explained that none of the percent covers are going to be the same in Phase 5.2 as they were in Phase 5.1.
- Bill Keeling suggested that the UMD/MAWP BMP could be called management intensive grazing, and that another BMP be proposed that is not as intensive. One possible alternative would be to do the following:
    - Use NRCS cover definitions for pastures to define pre and post BMP conditions related to pasture management.
        - Poor <50% cover
        - Fair 50% to 75% cover (62.5%)
        - Good >75% cover (87.5%)
    - Use the model to determine loading differences assuming pasture management improves cover from fair to good.
- Tom Simpson said that what Bill is proposing sounds like a pasture management BMP, and not a rotational grazing BMP.
- Bill Keeling said that based on what the experts in VA say, less than a week is "intensive" rotation.
- Tom Simpson and Bill Keeling agree that the UMD/MAWP BMP sounds like intensive or rotational grazing, while what Bill is proposing sounds more like prescribed grazing. The BMP that Bill is proposing could refer back to the 528 standard.
- Intensive grazing produces a greater amount of forage.
- Tom Simpson explained that one of the assumptions in their discussion with the expert panel was that this practice was not being used to increase animal number.
- Bill Keeling was concerned that there is no nitrogen benefit. Sarah Weammert said that this was the panel's decision.

ACTION: The discussion on the pasture BMP issues and the new prescribed grazing BMP that was proposed by Bill Keeling will be continued at the next joint workgroup meeting on January 15th.

IV. Adjourn

- The meeting was adjourned at 3:00 pm.
- Another joint Watershed Technical Workgroup and Ag Nutrient and Sediment Reduction Workgroup meeting will be held on January 15th in the Fish Shack at the Chesapeake Bay Program Office in Annapolis, MD.

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Pasture Management for Dairy, Beef, and Livestock – PENDING CBP APPROVAL

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For use in Tributary Strategy runs of Phase 5 of the Chesapeake Bay Program Watershed Model

Recommendations for Endorsement by the Chesapeake Bay Program Nutrient Subcommittee and its Workgroups

Consulting Scientists

Amy Burk
Extension Horse Specialist
University of Maryland

Larry Chase
Professor & Extension Specialist in Dairy Nutrition
Cornell University

Shelly Dehoff
Agriculture/Public Liaison
The PA Agricultural Ombudsman Program

Elmer Dengler
Maryland State Grazing Specialist
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Mark Dubin
Agricultural Technical Coordinator
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Mike Harper
Penn State University

Kathy Soder
Animal Scientist
USDA-ARS-Pasture Systems and Watershed Management Research Unit

Ann Swinker
Extension Specialist Equine

Penn State University

Donna Vaulk
Northhampton Co Extension
Penn State University

And

Les Vough
Forage Crops Specialist Emeritus
University of Maryland

Synthesis and Recommendation by

Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary
Dairy, Beef and Other Livestock Management Intensive Grazing requires maintenance of 2-3inches of grass at 50% cover, with high traffic area management, while incorporating uniform grazing and a rotation of at least every 3 days to as little half day for dairy operations to meet peak performance requirements for grass.

- Effectiveness Estimates: 40% TSS, 20% TP, no TN reduction

<u>Rotational Grazing</u> – Maintains 2 to 3 inches of grass height and a 50% pasture cover consisting of managed species (desirable inherent) and includes a rotation of once a week for uniform distribution.

- Effectiveness Estimates: 40% TSS, 20% TP, no TN reduction

The proposed horse pasture management effectiveness estimates and definitions were not approved by the CBP. There was considerable confusion on how the recommended effectiveness estimates would work in Phase 5 of the watershed model as the final methodology

was not yet complete during the development of the proposed values. When scenarios were simulated using the recommended effectiveness estimates the reductions were not in line with other pasture practices. For these two reasons the Chesapeake Bay Program decided to convene another panel of pasture experts to review the literature when the modeling components of pasture management were final.

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project during 2007-2008 to develop the components or subcategories of the BMP, a corresponding definition(s) and effectiveness estimates. The BMPs developed have not been previously reported to the Chesapeake Bay Program. The objective is to develop definitions and effectiveness estimates that reflect the average operational condition representative of the entire watershed. The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers and county stormwater officials, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions modeling scenarios and watershed plans will better reflect monitored data.

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances knowledge and experience becomes available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

UMD/MAWP recommend the following interim estimates, and while the pasture panel feels the pasture improvement credit is low (20%), no other alternative estimate is suggested. Attached to these definitions and effectiveness estimates is a full accounting of the Chesapeake Bay Program's discussions on this BMP, who was involved, and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix A. Sarah Weammert will add the CBP minutes after the CBP review.

UMD/MAWP consulted a panel of experts from the academic, industrial, state agency and non-profit sectors to advise in the development of BMP definitions and effectiveness estimates. Discussions during panel meetings, data and best professional judgment was used to craft the recommendations presented here.

Guidelines. The following guidelines were used when selecting data to include in the data set:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.

- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.

- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process by independent scientists. As such, peer reviewed literature should be given more weight than design standards and manuals. For this BMP, however, no peer reviewed literature was available and gray literature, or limited research scale type publications, and best professional judgment was used.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

Description/Definition of BMP:

Pasture management does not include offstream watering with and without fencing, instead stream protection is a separate practice. See CBP’s off-stream watering with fencing and without fencing BMP for details. Pasture management applies to all pasture lands, as not every pasture has a stream linked to it. Where pastures are in contact with a stream managing animal contact to the stream is critical. The dominant source of nutrient and sediment loss from pasture lands is associated with animal contact with the stream. Overstocking is also frequently the cause of many nutrient and sediment problems, when preparing pasture management plans they should include pasture management, heave use area improvement, and management of stocking densities.

Pasture management is divided into three categories that capture differences in pasture and animal management:

Dairy Management Intensive Grazing (MIG) requires maintenance of 2-3inches of grass at 50% cover, with high traffic area management, while incorporating uniform grazing and a rotation of at least every 3 days to as little half day for dairy operations to meet peak performance requirements for grass. By improving pasture, erosion and nutrient loss is further reduced. An improvement in pasture results in less pasture required per animal, creating the opportunity to increase stocking densities. In addition, less hay and silage is produced when pasture forages are supplemented into the animals diet, also reducing time in confinement. High traffic management reduces the loads from pasture as these areas are contributing the vast majority of sediment and nutrients from pasturelands. One aspect that may increase the load from pasture, however, occurs when some portion of feed supplement is applied directly to the pasture. Loafing area management is a separate BMP and is not included under pasture management.

High traffic areas are concentration areas within the pasture where the grass is sparse or nonexistent. These often are feeding areas, such as water troughs. These areas are treated as sacrifice areas.

Beef and other livestock MIG- MIG components are the same as above. With beef operations the difference in before and after implementation of pasture management is based on improvements in pasture and high traffic area management. Time in confinement, hay and silage production, and pasture area does not change by incorporating pasture management on beef operations. Loafing area management and stream fencing are separate BMPs and are not included under pasture management.

The comparison is to non intensive management, unimproved pasture, not feedlot operations. Beef and other livestock MIG allows for more animals on fewer acres with comparable environmental impacts to unimproved pasture (excluding stream impacts, which are captured in another BMP).

Rotational grazing – Maintain 2-3 inches in grass height and a 50% pasture cover consisting of managed species (desirable inherent) and includes a rotation of once a week for uniform distribution. High traffic area management is utilized to reduce the highest load contributing areas associated with pasture lands. Loafing area management is a separate BMP and is not included under pasture management.

Applicable NRCS codes:
Practice components meet criteria standards under the USDA-NRCS National Handbook of Conservation Practices (NHCP) (http://www.nrcs.usda.gov/technical/standards/nhcp.html) and associated Field Office Technical Guides (http://www.nrcs.usda.gov/technical/efotg/) for each state. Cultural components consisting of shorter term conservation measures included in the Pasture Management for Dairy, Beef and Livestock definition include, but may not be limited to the USDA-NRCS conservation practices listed below. When reporting pasture management a combination of NRCS practices must be implemented to achieve the definition of pasture management as defined here as including both pasture and heavy use area management. Thus, for example, in order to report pasture management, Animal Trails and Walkways (575) must be implemented with Prescribed Grazing (528) or Pasture and Hay Planting (512). Also Heavy Use Area (561) also must include either a Prescribed Grazing (528) or Pasture and Hay Planting (512). Addressing only one aspect, grass cover or untreated heavy use area, does not meet the definition and does not constitute credit.

Prescribed Grazing (528) - Managing the harvest of vegetation with grazing and/or browsing animals.

PURPOSE:
This practice may be applied as a part of conservation management system to achieve one or more of the following:

- Improve or maintain desired species composition and vigor of plant communities.
- Improve or maintain quantity and quality of forage for grazing and browsing animals' health and productivity.
- Improve or maintain surface and/or subsurface water quality and quantity.
- Improve or maintain riparian and watershed function.
- Reduce accelerated soil erosion, and maintain or improve soil condition.
- Improve or maintain the quantity and quality of food and/or cover available for wildlife.
- Manage fine fuel loads to achieve desired conditions.

Conditions where practice applies:
This practice applies to all lands where grazing and/or browsing animals are managed.

Pasture and Hay Planting (512) - Establishing native or introduced forage species.

PURPOSE

- Establish adapted and compatible species, varieties, or cultivars for forage production.
- Improve or maintain livestock nutrition and/or health.
- Balance forage supply and demand during periods of low forage production.

- Reduce soil erosion and improve water quality.
- Increase carbon sequestration

CONDITIONS WHERE PRACTICE APPLIES
This practice may be applied on lands where forage production and/or conservation is needed and feasible.

Heavy Use Area (561) - The stabilization of areas frequently and intensively used by people, animals or vehicles by establishing vegetative cover, by surfacing with suitable materials, and/or by installing needed structures.

PURPOSE
- Reduce soil erosion
- Improve water quantity and quality
- Improve air quality
- Improve aesthetics
- Improve livestock health

CONDITIONS WHERE PRACTICE APPLIES
This practice applies to urban, agricultural, recreational or other frequently and intensively used areas requiring treatment to address one or more resource concerns.

Animal Trails and Walkways (575) - Established lanes or travel ways that facilitate animal movement.

PURPOSE
- Provide or improve access to forage, water, working/handling facilities, and/or shelter,
- Improve grazing efficiency and distribution, and/or
- Protect ecologically sensitive, erosive and/or potentially erosive sites.

CONDITIONS WHERE THIS PRACTICE APPLIES
On lands where control of animal movement is needed to facilitate access, improve grazing, prevent erosion, and/or protect ecologically sensitive areas.

Factors that Create Variability.

There are multiple factors that influence pastures ability to stabilize soil and improve nutrient uptake. Drought, soil nutrient content, species of grass (legumes), species mix and diversity, and weed control will all affect a pastures effectiveness at reducing sediment and phosphorous loads. These factors collectively result in temporal and spatial differences in pollutant reduction across pastures

Management and operation can also be highly variable both between the research and operational scale and between different managers within the operational scale. When practices are implemented across a large area on parcels managed by many different individuals, it is important to assume an "average" level of expertise, control and management in planning design, implementation and operation of any given BMP. While there may be limited data quantifying the difference between research and "average" management, it is recognized that widespread implementation rarely has the same level of oversight and control that is essential to get statistically meaningful results observed at research scale. As a result, there is a need to lower effectiveness from the research scale when widespread implementation occurs.

Proposed Methodology to Determine an Effectiveness Estimate

Interim Effectiveness Estimates:
40% TSS
20% TP

To quantify the benefits of pasture management, we need help answering the following:

- What is the actual improvement in pasture loading rates associated with maintaining 2-3 inches of grass at a 50% cover?
- What phosphorous levels are found in MIG pasture soils?
- How much less pasture area per animal is needed with pasture improvement? How much does this reduce sediment and nutrient loss?
- How much less hay and silage is produced when pasture management is implemented? How much does this reduce sediment and nutrient loss?
- What is the reduction in time in confinement associated with pasture management? What is the nutrient reduction associated with reduced time in confinement?
- What is the actual load reduction from high traffic area management?
- What percent of supplement is applied directly to the pasture?

If we can answer these questions using best professional judgment or data an effectiveness estimate can be determined. If these data gaps cannot be answered, UMD/MAWP proposes the following effectiveness reduction estimates for pasture management.

Assumptions:
As high traffic areas located around gates, feeding and watering areas, and pathways contribute the majority of sediment and nutrient runoff from pastures, we assume 75% of the pasture load is from these areas.

We assume high traffic management results in a 50% reduction in sediment loads.

Improvement in pastures leads to a 20% reduction in sediment runoff.

Under pre pasture management conditions, no rotation, soils are not rich in phosphorous. After pasture management occurs, rotation is implemented, manure is distributed across the pasture contributing more phosphorous to the pasture than under the pre BMP condition. A life cycle analysis is needed to evaluate the benefits of pasture management. Either an increase in animal numbers, or reducing pasture acres with same number of animals, will influence reductions associated with pasture management. Pasture management not only compares MIG acres to continuous grazed areas because pasture management offsets the need for feed supplement, and reduces grain and forage.

Calculation:
If 75% of pasture load is from high traffic areas, and management of those areas results in a 50% in loads, then 75 multiplied by 50% is 37.5%. We round down to the nearest value of five and assign a 35% sediment reduction in pasture load for high traffic management.

If pasture improvement (grass height and density) results in a 20% reduction in loadings, and pasture grasses contribute 25% of the pasture load, then 25 multiplied by 20% is 5%. Adding the benefit from high traffic management (35%) and pasture improvement (5%) equals a **total sediment effectiveness estimate of 40%**.

With pasture management manure is intentionally managed and phosphorous is distributed across the pasture, resulting in higher phosphorous levels compared to the pre BMP condition. As sediment is reduced sediment-bound phosphorous runoff will also be reduced to some degree. We assume phosphorus reductions are half as much as the sediment reduction, thus pasture management **reduces 20% of all phosphorous** from the average pasture load in the WSM (40% sediment reduction divided in half equals 20%).

Unless we can quantify the additional benefits dairy pasture management provides, dairy and beef MIG pasture management will be assigned the same effectiveness estimate.

Effectiveness estimates **40% TSS and 20% TP**, are **interim** and must be refined as more data becomes available in 2009. Many CIG projects will have data to address our data gaps and that information will be used to refine pasture management effectiveness.

Level of Confidence

The effectiveness estimate is based primarily on best professional judgment and an understanding of the mechanisms of pasture management that reduce pollutant loadings.

Identify outstanding issues to be resolved in the future

- How BMP is tracked and reported?
- Additional data to collect to refine effectiveness estimate?
    - What is the actual improvement in pasture loading rates associated with maintaining 2-3 inches of grass at a 50% cover?
    - What phosphorous levels are found in MIG pasture soils?
    - How much less pasture area per animal is needed with pasture improvement?
    - How much less hay and silage is produced when pasture management is implemented?
    - What is the reduction in time in confinement associated with pasture management?
    - What is the actual load reduction from high traffic area management?
    - What percent of supplement is applied directly to the pasture?
- Others?

APPENDIX A: MEETING MINUTES

Pasture Management Meeting Minutes April 11, 2008

Attendance:
Les Vough
Elmer Dingler
Mark Dubin
Tom Simpson
Sarah Weammert

On Phone:
Larry Chase

Action Items:

All: UMD/MAWP is asking panel members to help create a list of all co-benefits associated with pasture management, including and beyond nutrient and sediment reductions, to be listed in the pasture management report.

Mark and Elmer: Change within NRCS code components is ongoing and Mark Dubin has pulled a regional workgroup together to help integrate the NRCS system with practice implementation. Elmer is also discussing regional coordination of techniques with Greensboro representatives to provide additional insight.

Sarah: From White et al 2001 look up Peterson and Gerrish 1996 – conference proceedings references.

Sarah: Use Mid-Atlantic network to ask extension offices the following:
Population (# animals) by breakouts
Ideas for confinement between the groups

Mark: Need data on nutrient and sediment benefits associated with MIG. Mark has PA AFT data on management intensive systems. Monitored streamside and tile drains (surface and subsurface). Not published. Cove Mountain Farm

- After meeting Sarah talked with Matt Saunderson about this study and Matt stated it was not a good study. Errors with the study design.

Sarah: Contact Matt Saunderson, Kathy Soder – PA data on differences with MIG. Deanna Osmond may have info too

Elmer and Mark: Use RUSLE2 runs to refine breakouts. Elmer and Mark will talk to Tim Pilcowski from MD NRCS

Sarah: contact Virginia Tech and find their forage specialist. She will also contact Owens - author on our papers from data set.

Larry, Elmer and Sarah: What are the application rates of N and P? Where is manure being land applied? Larry is talking with NRCS grazing specialists to answer some of these questions
Elmer – asking MD grazers network.
Matt Saunderson – application (state college) may also be able to help answer some of these questions (Sarah will contact). Cove Mountain Farm

Sarah: To determine zones/breakouts for winter confinement we will use map of temperate zones (USDA climatic zones). Mark using them with Olivia for other practices, applicable to VORTEX.

Sarah: Will also consult map of buffer zones, will get a copy of the map.

All: Is there data between excreted TMR versus pasture based rations?
No data panel knows of. Will (with dairy and beef separate) panel please consider other ways pasture is enhancing feed efficiency, or difference in manure nutrient content, or form (how soluble are the nutrients)? These things effect reductions in feed supplements and changes to manure composition.
Elmer: will ask around for data (pasture lab)

Sarah: how many lbs of hay horse needs day or week? ACTION: Sarah will ask Ann Swinker

All: If you have not done so already, send Sarah your availability for May 19-22.

I. Lunch Orders and Introduction

II. Overview of BMP Project

Estimates of BMP performance will be used in TMDL and trading permits and WSM modeling, and for continued use in Tributary Strategies. While our scope dictates that we quantify the nutrient and sediment reductions, UMD/MAWP recognizes there are additional co-benefits (social, economic, etc.). UMD/MAWP is asking panel members to help create a list of all co-benefits.

Our most important task is to estimate BMP performance at the operational, average watershed wide scale. UMD/MAWP's job is to ensure panel decisions, scientific justification, and best professional judgment are within the framework of our guidelines designed to estimate operational, average watershed wide conditions:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.

- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.

- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process. As such, peer reviewed literature should be given more weight than design standards and manual.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

UMD/MAWP will ask detailed questions about the BMP, not to discredit the performance of the BMP, but to get to operational conditions.

Panel members' primary task is to develop a report for the BMP using the guidelines, decision matrix, and factors of variability found in the template. A final report from the panel is due to the Chesapeake Bay Program by July 15, 2008 so partners can begin their technical review process. Bay Program partners are made up of jurisdictional agencies, the EPA and the Chesapeake Bay Commission. During technical review (mid-July to September) workgroups may bring specific question to panel/scientists for discussion.

III. Develop Framework/Breaks

Ex – cover crops did by geophysiographic region, planting date, crop species, planting technique

What are the current levels of management by jurisdiction?
MD NRCS: Prescribed grazing has 4 categories of intensive/improved grazing management – do not indicate performance variation just a different level of management:

1. continuous grazing w/ decent cover
2. rotational grazing for cover -maintain enough stocking to do rotational grazing but stocking rates so high primary food source is not from grazing
3. rotational grazing where principle food source is from pasture
4. management intensive grazing - strip grazing for stockpiling, strip grazing for warm season

NY approach to grazing/types of intensive grazing systems:
Continuous use – for dairy, no rotational grazing
Intensive rotation – movable fence, in pasture most time except to milk, new paddock twice a day (morning paddock, milk, then on new paddock in afternoon). Some move once a day some twice; pushing for this approach.

VA uses controlled grazing as its term. We can lead the way to a regional understanding and definition b/c the reporting aspect of this will drive credit. Need a universal system; which may mean a change within the NRCS practice codes.

Setting up the Baseline: unimproved/native pasture with improvements beyond that (improved pasture managed for decent cover)

Techniques to include in breakout/definition/description of pasture management:

1. Rotational grazing with principle forage from grass = moving animals every 3 to 7 days; results in good rotation, distributes nutrients (manure).

Management Intensive Grazing – rotating once, sometimes twice a day
Intensive Rotational grazing – 3 to 7 days of rotation

MIG and rotational grazing breakouts provide a tiered system that encourages increased payments for increased management.

2. Can we define MIG vs rotational grazing for cow/calf (separate from dairy)?
This is ideal because grazing is guided by demand of animal. Need two pronged approach based on level of demand by animal.

Cow/calf – rotational grazing just rotate at least once week. MIG maintain at least 2-3in forage height, rotate at least once a week, maintain high quality forage over entire pasture so achieve even distribution of grazing. This considers nutritional needs of animal and water quality.

Beef – MIG doesn't require as much rotation, and a 7 day rotation that maintains a 2-3in cover with uniform grazing is a good definition.

Rotational grazing with dominate forage source from grass (mostly cow/calf systems) – may need to sort out beef vs dairy. During warm weather if livestock are only in confinement for milking you have now reduced the volume of confined manure to deal with, resulting in an additional benefit. Traditionally, cow/calf operations are not confined a majority of the time. Diary may see higher benefit to reduced time in confinement. Dairy heifer fits within cow/calf category because rotate dairy less frequently like cow/calf systems.

Dairy efforts lumped in with beef – is this reportable?
CBP modelers working with NAS census data – separate dairy from beef and calves/heifers/bulls. From reporting base – separating animals within grazing system is not plausible.

Beef – ground cover for density and height. Length of time between rotation not as critical. The bigger the pasture the harder to get uniform grazing. As subdivide pasture moving water source and likely to have better distribution. One large pasture with one watering source and one shade area will create a localized ‘hotspot’ for manure deposits. Real short rotation is unnecessary for beef, due to economics. What is the length? Is it more than 2 weeks setting up a continuous like system?

Dairy - Start looking at dairy pasture for its impacts individually on time in confinement, volume of confinement waste, acres of hay grown, and combined, to estimate performance. Is there data on reduction in confinement time due to rotational grazing that will assist in estimating reductions in manure to be handled? YES – NC State spatial distribution of dairy excreta (in our data set; White et al 2001). Moved cows once or twice a day (intensive system).

Data out of Missouri – Jim Gerrish – deals with beef and the number of paddocks, time in confinement.

Other data to collect:

Gerrish, J.R., J.R. Brown, and P.R. Peterson. 1993. Impact of grazing cattle on distribution of soil minerals. p.66-70. In American Forage and Grassland Council Proc. Des Moines, IA, 29-31 March, 1993.

Gerrish, J.R., P.R. Peterson, and R.E. Morrow. 1995. Distance cattle travel to water affects pasture utilization rate. American Forage and Grassland Council Proc. Lexington KY, 12-16 March, 1995.

Mathews, B.W., L.E. Sollenberger, P Nkedi-Kizza, L.A. Gaston, and H.D. Hornsby. 1994. Soil sampling procedures for monitoring potassium distribution in grazed pastures. Agron. J. 86:121-126.

Peterson, P.R. and J.R. Gerrish. 1995. Grazing management affects manure distribution by beef cattle. In American Forage and Grassland Council Proc. Lexington, KY, 12-16 March, 1995.

ACTION From White et al 2001 look up Peterson and Gerrish 1996 – conference proceedings references

3. Maintaining vegetative cover is the goal, not the frequency/length of the rotation. Can we distinguish performance by forage height?

Emphasis on forage height and density!!! Number of days secondary to that when looking at water quality.

Percent cover doesn't work well as in indicator of vegetative cover, looking at way to break that measurement out by looking at heights, stem counts. That may be used here.

On some sites height could be good but there is poor density. Need both to provide a water quality benefit.

Grass species will dictate height – grazing heights by species recommendations by NRCS

Are feed supplements applied to pasture?
Lactating cow – how is supplement provided? In the barn, not in the pasture.
How wide spread is the practice of adding supplement to pasture land? Few people use this, not widespread. Systems with pasture are managing it well and not doing this.
Should we reduce the performance it for that impact?

Buffers:
Buffers are a stand alone practice in the CBP WSM and will not be included in this report.

Reporting
Change within NRCS code components is ongoing and Mark Dubin has pulled a regional workgroup together to help integrate system. Elmer is also discussing regional coordination of techniques with Greensboro representatives to provide additional insight.
ACTION ITEM

Policy Limitations
MD's cost share program only allows one water trough which eliminates ability to do rotational grazing.

Breakouts
1. Dairy – Management Intensive Grazing (MIG) -maintaining 2-3inches of cover with uniform grazing
2. Beef and other – MIG, different value in load applied against dairy but MIG components the same as above
3. Rotational grazing - height, density, and some length of rotation for uniform distribution. Ex: cow/calf

Use continuous grazing (unimproved pasture) as the baseline

Acknowledge, some systems are not captured with these breakouts. Techniques to reduce impacts from sacrifice lots are captured elsewhere.

What need to determine performance (effectiveness estimate):
1. Percent reduction in confinement time – White, Gerrish, others?
2. Improved quality of pasture
3. Lower demand for other feed so whether grain or hay don't have to produce as much
4. Number of months in winter confinement between dairy and beef

Do cows excrete more during pasture or milking? If handle calmly most in pasture (can't get them up quickly from pasture and move them without time to stand around). Excretion is a function of movement.

Converting cropland into pasture? If dairy assumed 85% confinement, which is average for all dairies. So if have farmer using grass

How much less corn and less hay are you growing b/c using grass to feed?

LUNCH

ACTION
Use Mid-Atlantic network to send to extension offices to understand:
Population (# animals) by breakouts
Ideas for confinement between the groups

2. Improved quality of pasture
What is difference in nutrient and sediment loss between continuous grazing (unimproved pasture) and MIG?

Les - Continuously grazed pasture usually has majority ground cover, with the exception of the pathways. From a water quality standpoint continuously grazing may be better than a rotational system.

Bulk pasture loads are low (3lbs to 2lbs, not 40lbs to 10lbs typically associated with other practices such as row crop management). Reduced time in confinement and manure management combined with pasture management (grass height and density) is the meat of pollution reductions associated with pasture management. We are not considering the stream impact (covered in offstream watering). If use MIG, do we have data on differences in nutrient and sediment loss from surface runoff?

Collect data on benefits of MIG.

Mark – PA AFT on management intensive systems. Monitored streamside and tile drains (surface and subsurface). USGS data. Not published.
However, concerns with study – site concerns.

Why would there be less pollution reduction with MIG compared to continuous grazing? To determine this, list the pros and cons of MIG. Benefits of MIG are: better ground cover, with time soil improvement, better distribution of manure. Is there any literature showing we are not achieving a benefit? IS there evidence of concentrated disturbance around certain areas?
Use Bill's data.

ACTION for Sarah Contact Matt Saunderson, Kathy Soder – PA data

Cover study in existing dataset – (document from Elmer) – addresses the direct movement of nitrogen. If use percent cover how measure? Contact Deanna Osmond -

Is there any indirect information that shows improvements with MIG?

Using best professional judgment, what difference in average soil loss between umimproved pasture and MIG?
Elmer – traditional systems, depending on soil, could have a soil loss tolerance of 5. A bare bones rotational system could lose up to 3lbs/acre. But with good cover this would drop below 1 lb/acre. Looking at whole range: within beef operations see systems that exceed soil loss t.
Les – need to use RUSLE2 to determine

RUSLE2 – forage data sets has errors. Jim Cropper has reviewed draft of new RUSLE factors and feels comfortable with using it for pasture. Elmer will follow up with Tim Pilcowski to see how RUSLE2 is working with forage.
ACTION

Need to consult Penn State (Kathy Soder, Matt Saunderson) and Virginia Tech (need to identify their forage specialist). Owens - author on papers from our data set would be a good scientist to consult– ACTION for Sarah

Is there capability breaking surface and subsurface? YES
What is the reduction with MIG?
Subsurface is not the dominant flow path.

With MIG what are the fertilizer rates? Depend on species. Les and Elmer - Orchardgrass, fescue recommendation is 250lbs (one set of recommendations for hay and for pasture). How many people actually apply fertilizer at that lbs? No most apply lower quantities. What are the

application rates of N and P? Where is manure being land applied? ACTION: Larry is talking with NRCS grazing specialists to answer some of these questions
Elmer – asking MD grazers network.
Matt Saunderson – application (state college) may also be able to help answer some of these questions.

Les – with MIG have a good mix of legumes.
MD nutrient management plan law states once a farmer is above 25% legume cover they can not apply nitrogen.

Should we segregate pastures receiving manure from confinement vs those receiving manure from rotational grazing? Can we even track that?
WSM now assumes excess manure generated within the system is applied to pasture acres.
Elmer – concerned pastures are being used as a dumping ground for manure. Whether excess manure is land applied is a function of the area and if they need to get rid of manure.

4. Number of months in confinement.
What is the amount of time beef spends in confinement during the winter? As move north through the watershed should we consider additional winter confinement time? To capture should we split watershed into 3 or 4 sections, essentially no time in confinement in the lower (southern- warmer) areas up to 3-5 months for the upper (northern – colder) watershed areas?

In NY winter confinement lasts 5-7 months, same amount of time for dairy and beef.

Stockpile grazing will add 2-3 more months of grazing time in the lower watershed.

0-5 months of winter confinement is average, depending on where you are.

To determine zones/breakouts for winter confinement we will use map of temperate zones (USDA climatic zones). Mark using them with Olivia for other practices, applicable to VORTEX.

Will also consult map of buffer zones ACTION – Sarah will get a copy of the map.

3. Reduced cropland acres
If doing MIG (with differences for beef and dairy), how much less food is needed to be produce for x amount of cows? Does that reduce the number of hay acres? If so, how much? How much hay is imported?

Horse – how many lbs of hay horse needs day or week? ACTION: Sarah will ask Ann Swinker

Les – MD hay producers supplying very small percent of hay feed to horses.

Larry stated this is a straight forward calculation for dairy.

Do you have reduction in protein needs with more grazing?
Larry stated a pasture has high protein content so grazing will reduce protein needs from supplements.
Total yearly protein, whether bought or grown, is reduced if use fescue.

Is there data between excreted TMR versus pasture based rations?
No data panel knows of. Will (with dairy and beef separate) panel please consider other ways pasture is enhancing feed efficiency, or difference in manure nutrient content, or form (how soluble are the nutrients)? These things effect reductions in feed supplements and changes to manure composition.
ACTION: ask around for data (pasture lab) **-** Elmer will ask this question along with the others already highlighted here.

WSM model issues: What is imported into the watershed (TMR mixes) versus what is recycled on the farm? WSM uses mass balance approach at the county scale and suballocates based on census data. Imported hay, is it tracked and accounted for?
Les – may not be capable of getting handle on all nutrient movement? Hole in mass balance? Makes harder to capture all value of MIG b/c don't know what we're replacing.

If we know how much cow needs under an old pasture/confinement system, now getting so much from MIG system so determine that amount. Know eliminated need of x amount of feed from MIG. Can calculate what replaced under MIG versus continuous grazing.

Feed offset due to MIG – ACTION/FUTURE RESEARCH NEED. Are we really accounting for how feed is moving around the watershed? No

Les – importing a lot of hay and it is not tracked and reported and incorporated into the nutrient balance. Nutrient management is offset by hay imports.
Tom – our purpose is to move it to the next step, knowing it is incomplete. Are we reasonably simulating the actual implementation of the practice?

Improvement to ignoring it, begin trying to account for it = To feed this amount of cows, calf, and horses would require x amount of hay, but we only have the ability to produce -x amount, thus importing the difference. Must consider how productive those hay acres are, we report tonnage but how accurate is our reporting?

Next panel meeting:
Mid-May send tentative dates of availability to Sarah
Continue to meet monthly until July 15th due date

Combo pasture management meeting:
May 19, 2008

On Phone:
Ann Swinker
Donna Vaulk
Mike Harper
Kathy Soder

In attendance:
Sarah Weammert
Tom Simpson
Shelly Dehoff
Les Vough
Elmer Dingler
Amy Burk
Mark Dubin

Action Items:

ACTION: Mark will contact Dave Lightle for his pasture data

ACTION: Ann has pasture soil test numbers in her project, she will send us her results.

ACTION: use RUSLE2 with unmanaged baseline vs one that meets our criteria (50% cover, high traffic use) with someone evaluating our process; panel determines if response is applicable.

ACTION: Sarah will find out how equine manure is tracked in the model. Estimate amount of horse manure.

ACTION: Mark talk with Tim to set up chat with Dave to run RUSLE2; then group will discuss via conference call

ACTION: Elmer will send MD manure management data to group

Discussion:

Can we approve this using density, (cover or height), and need or feasibility of rotation? How will differ between animals? Will height be the same?
Ann: not the same for horses and livestock. Horses want Kentucky bluegrass along with different species of grasses. With beef as they move around the pasture they forage.

For our subcategories can pasture species be sorted into bluegrass vs fescue?
Elmer: percentage of cover is more important. Instead rank management levels with percent cover managed in a way that keeps a healthy grass stand.
Amy: make height recommendation by species; horses have compaction issue greater than bovine

Also grazing behavioral differences:
Horse: inconsistent grazing over an area. Some areas grass is 1ft, others 2 inches
Horses have non-uniform grazing (pick places to graze, others to lay down, others defecate; with cattle all activities mutually exclusive); selection also depends on age of horse

Do horses spend more time on edges of pasture? Movement behavior?
Variable, depends on number of horses, housing facility, presence of neighboring horses. Boarding facilities have more opportunity for movement.

Does RUSLE2 have factors in there that gives us the variability we need?
Tracking sediment and nutrient movement, what components affect that?
Percentage of cover
Roughness coefficient
Stem density

In terms of how we deal with pasture management as a BMP, should it be more focused on limited to select ownership types?
Yes, treat large operation as farm unit under conservation plan. Thus constrained to casual boarder, not 50 horse operation.

Through improved forage management, pasture management – what are the stocking rates?
Ann: In PA it is typical for horses to not even be on pasture, providing nutrition by feed in stall. Pasture is used for turn out exercise, attitude adjustment, etc. Some owners do turn horses on pasture for nourishment.
Amy: in MD see a lot of co-ops with just a run-in shed and are feeding horses on the field
Ann: In those situations where horses are on pasture owners rotate horses, not pastures (pasture always has horse on it).

What would a pasture management BMP look like?
Not an easy task, PA meet monthly for 4 years to discuss this with no finalized report.

Could measure time in confinement?
Manure management now concern, horse owners will not apply due to concerns with parasites. Also dealing with more carbon content than solid product (3 parts bedding, one part manure). 45-48% of operations have manure hauled away.

Before and after manure management situation no difference.
Just focusing on paddock or pasture management.

Assuming excluded from stream, what opportunity for reducing loss?
Good percent cover, density, roughness (height)
Amy: So much variability with horses (compaction, grazing behavior, etc.) need to be conservative
Ann: with actual testing of percent cover on places that looked great and with good management see 60% cover. Found same score using both methods of measurement. Looking at desirable species, but scored for organic matter vs bare ground vs weeds (receive higher point value for desirable species)

70% ground cover is found in all extension publications. But again this number was not based on science. A team of scientists from Rutgers 'picked the number out of the air'. When looking at actual measurements rarely are they that high. Don't want to encourage the myth that it is easy to get 70% if good pasture has 50-60% cover (with random sampling).

To calculate cover the MD NRCS pasture worksheet throws out the bad area and an extremely good area. Do straight transect through average management conditions. What is immediately below each foot over a one hundred foot distance, is used to get percentage. Score card measures get into a lot of additional parameters.

Practice is, what are the actions you take to get to desired result? What does it take to get above 50% cover?
Data is lacking, using a best professional judgment.
Shelly: couldn't find good scientific credible for horse pasture. That's why went to pasture condition score index using percent cover.
Elmer: concern with score card, don't use it in MD. Because the time spent doing score card *CORRECTLY* is very time consuming and it is hard to do correctly due to the terminology and approach.

At what level is vegetative cover needed to slow water?
Elmer: Residue cover: 30% is conservative, Above 60%. But residue cover doesn't address soil quality so moving towards using STIR values too.
Les: 98% of pasture lands has excellent cover, less than 1% high contributor of soil and nutrient. This 1% area is a high traffic area - runoff from barn roof straight to stream. If rate pasture alone get great cover score, but nutrients from one percent is high. Can't just rate the pasture.

Is the practice having decent pasture cover AND high traffic area management?
Shelly, Amy: yes, go hand in hand.
Elmer: look at entire system, keep dirty water separate from clean water, but there is no tool to measure entire system.

Elmer: it should not be considered grazing, b/c with horse pasture management will not fit within rotational grazing system.
Ann: horse owner not managing pasture for reduced feed costs
Amy: horse pasture avoids weed

Amy: some horse operations do not want pasture b/c makes horses too fat and basically have mud lot

Elmer questioned Beth Horsey on her definition of horse paddock and she did not include grass as part of the definition.

Multiple pastures is loafing lot system, all horse owners have them. In MD under heavy use area standard have vegetative loafing lot alternative, comes closest to horse pastures. Grass not primary component in forage, it is there to capture nutrients and provide pleasant environment for horse to occupy.

What soil quality and plant performance needed for water quality?
With 50-60% cover, using random transect method across pasture and address high traffic areas, addresses other management issues it takes to get that cover (soil pH and fertility management).
from horse perspective: hours on pasture

For environmental impact, can we convert into horse hours per day per acre? How many horses for how long on a unit of land?
Need to know plant height, soil compaction, soil moisture (winter/summer) – when put out there very important
Price of hay rising so may see increase in pasture used for forage

Elmer: prescribed grazing, beef one acre per animal unit, horses using 1.5 acres used based on observations with good management. Still have issue of, with poor management and those rates what will happen?

50-60% cover, what about annual versus perennial?
Temporal cover throughout the year.
Ask to overseed in winter for winter cover.

Ann's data will be available later this year to help address these questions.
ACTION: Mark: Dave Lightle pasture data

To achieve a 50% cover will have different management plan based on horse operation.
Not looking for forage, looking for something that won't harm the animal.

If just use 50% cover how know the vegetative species take up nutrients?
Concern not nutrient loading rate, instead addressing erosion. Not trying to take up excess nutrients in bio-mass, prevent erosion and water flow so don't flush sediment and manure into the stream.

FOLLOW UP STUDY: Beth Horsey has a project to compare mud lot to good management.

No definitive answers.

On an operation what percentage total manure deposited out there, is it proportional to hours?
Factor to determine accuracy
Largely deposit manure and urine in stable or pasture?
FUTURE REFINEMENT NEED

What should we do? <u>Cover with high traffic area management</u>
50% Cover: will not consider weeds part of 50% cover, manage for species
This is best professional judgment, it is not based on science.
Should be interim number, not final practice. Data is being developed in next couple years that will help refine number.
Ann: percent cover with meeting management then doesn't matter stocking rate

Manage high traffic areas?
With heavy use pads, or turf; with vegetation around it?
NRCS heavy use area standard: managed in way meets NRCS heavy use standards

Not just high traffic management or percent cover, *need both to receive credit for horse pasture management.*

Implementable components using cost share, with bermuda grass in summer, assistance to plant rye for winter protection?
Horse people don't have equipment to do this
Adapt to what use pasture for

Interim practice definition: maintain a 50% pasture cover with managed species (desirable inherent), and manage for high traffic areas,

50% should be re-evaluated in near term based on outcome of research

What value/effectiveness for before and after?
ACTION: Ann has pasture soil test numbers in her project, obtain results.

Even if operation does recommendation, will see change? What is the baseline?
What's typical before and typical after?
No data on this, but professional guess is continuous grazing (unimproved pasture) with no vegetation, no rotation and no management.

Sediment:
If get 50% cover and treat high traffic area what percent sediment is reduced?
Mark: with nothing to work with use RUSLE2
Tom: using RUSLE2 for use not evaluated for, allow an advanced RUSLE expert evaluate after we use it. When misusing a tool with science behind it, acting like have science to evaluate BMP.
Mark: send to Dave Wigel, outside BMP, he developed RUSLE2

ACTION: use RUSLE2 with unmanaged baseline vs one that meets our criteria (50% cover, high traffic use) with someone evaluating our process; panel determines if response is applicable.

RUSLE is the best alternative with no science

What percent of horses in our target type of operation (eliminate breeders) already meet our definition? Will we see a change in operational conditions? Give practice effectiveness estimate based on change from bad case when in actuality the baseline was better; or plan shows no change because operations already doing these things.
Mark: use breakouts from Ann's data to determine typical management

Elmer: beef, cattle, dairy 30-50% have these management properties. 25-30% do not have cover. 1/3 out there that are not significant nutrient and sediment contributor
Tom: high percent have adequate cover but is it reducing erosion?
Ann: large operations focused on aesthetics (flowerly pasture, grass, no mud), don't want mud lot. Small operations that are not profiting from horses have mud areas because don't care about aesthetics.
Ann: unwanted horses population will boom soon adding another management group with bad management. Non-professional horse owners are not able to afford these practices.
Shelly: are driving extension offices to providing professional help? Do want these offices with no horse experience assisting horse operations?
Elmer: MD is heading in this direction. HOW uses education components. If doing things that allow for increased cover and adding high use areas management better than typical operation in our target operation (small horse owner, not for profit horse owners).
Mark: equine council pushing helps. Standard helps educate and changes behavior

Elmer: manure management has positive effect (compost, improved storage, proper land applied, transport)
Horse panel in April 2008 decided to exclude manure management from BMP
Elmer: Beth and Elmer has numbers on manure, and model should address manure management because making significant improvement.
Tom: may not be included in model ACTION: find out if equine is tracked in the model. Estimate amount of horse manure.
Elmer: within MDA over last 7-8 years has documented storage and management
Ann: Not dealing with land application on pasture, but how manure is managed has improved. But there is still a need to educate on manure management.
ACTION: Elmer has numbers on MD manure management
HIGHLIGHT: Manure Management: if handled properly will see benefit because it changes the amount of manure available for loss. However, manure is not land applied to horse pastures.

<u>BMP components</u>: manure management, 50% cover of desirable species and heavy use area management

Heavy use definition: NRCS criteria

LUNCH

Pasture Management Discussion (livestock)

MIG vs rotation: amount of time on pasture
MIG – every 3 days to as little half day for dairy operations, meeting peak performance for grass

Rotational – move once a week for managers convenience. Some things for grass needs but not for high forage quality or peak performance

Is there water quality difference between the two?

Beef and others vs dairy: different because of nutritional requirements

RUSLE Dave Lightle: **dave.lightle@lin.usda.gov**
Scenario for six runs

Piedmont, coastal plain, etc.?

Scenario Set up:
Average Slope
Cover
Forage residue estimates; cool season vs warm
Soil types
Residue height

Baseline (typical pasture management): continuously grazed for both dairy and beef and other

Cool season grasses
Predominantly grazed, to half inch
Fescue same, and crab grass
Predominant in hilly areas, use 8% for slope
Soil types: no karst, somewhat shale to capture MD and PA ridge and valley. Berks, Whiekert for shale.
Deeper well drained soil: Calvin Ernst series (silty soil),
Cover: ? use Dave's data
Height: vary height by species

ACTION look up soil association series, think about percent cover

Separate blue grass from orchard grass with fescues in between

Grass management will not effect yield for some grasses. Blue grass 2-2.5 tons; orchardgrass isn't there with continuous grazing (ACTION look up old agronomic handbooks for reference)

On rotational or MIG orchardgrass is 3.5 tons average yield. Fescue 4 tons of yield (better tolerance on varied soils and drought tolerance; also longer growing period)

Average grass hay yield across MD is 2.5 tons, aphala 3.5.

Cover: Dave already has direct pasture measurements. Plug in his data.

ACTION: send group draft scenarios; Mark talk with Tim to set up chat with Dave to run RUSLE2

Agricultural Nutrient and Sediment Reduction Workgroup Meeting Minutes
Chesapeake Bay Program Office; Annapolis, MD
August 5, 2008

Pasture Management & Horse Pasture Management

Pasture Management: http://archive.chesapeakebay.net/pubs/calendar/ANRWG_08-05-08_Handout_2_9618.pdf

Horse Pasture Management: http://archive.chesapeakebay.net/pubs/calendar/ANRWG_08-05-08_Handout_3_9618.pdf

- For both pasture management and horse pasture management, UMD/MAWP recommended interim effectiveness estimates of 40% for TSS and 20% for TP. Although the effectiveness values for these practices are the same, they would be applied differently in the model.
- Originally, they had planned to use RUSLE2 for this project. However, RUSLE2 was delayed and it was not available in time. Sarah said that they are still working with NRCS to see if they can use RUSLE2 in the future.
- Two experts who are not involved in this Bay-effort have said that they would be willing to review RUSLE2 to make sure that it applies to pasture.
- UMD/MAWP recommends that the effectiveness estimates that are being proposed today for these practices be considered interim estimates. These practices are relatively new and there is still research in the works. If these are interim estimates, then the Nutrient Subcommittee and the AgNSRWG could revisit these estimates as new information becomes available.
- The applicable NRCS codes that are listed in the reports are the ones that were initially suggested. What is the crosswalk between the NRCS practice codes and the Bay Program? What combination of practice codes, or which code, do you need to fulfill the definition? They will work with NRCS to figure this out.
- Comments/Suggestions:
    - Currently both reports are titled “Pasture Management”. The titles should instead differentiate between the two practices- “Horse Pasture Management” and “Beef/Dairy Pasture Management”.
    - The reductions should be clearly defined up front in the report in either a table or in a specific section.
    - The report does not contain any discussion regarding animal units.
    - “Feed supplement” should be added to the MIG definition section in the beef/dairy BMP report.

- o Need to differentiate between dairy and beef in the rotational grazing definition (UMD/MAWP did not assume rotational grazing with horses).
- o In the calculations section for both reports, change 25 divided by 20% to 25 multiplied by 20% (the answer is correct though).
- o Is the Heavy Use Area (NRCS code 561) an applicable code for pasture?
  - The panel said that the heavy use areas are responsible for a large majority of the loss.
  - We should ask NRCS if they routinely report that standard as having been applied when they do pasture management and management intensive grazing.
- o Under NRCS code 528 (prescribed grazing), there appears to be a typo where it says "manage fine fuel loads". Sarah copied this phrase directly out of the NRCS practice standard. She will check with NRCS to see if it is a typo.
- o The last sentence in the third paragraph of the calculations section ("We assume…") should be rephrased. They are assuming that the TP reduction will be half of the TSS reduction.
- o Are these practices separate from the stream fencing practice?
  - Yes, they are not linked to stream protection.
  - These practices are in a majority of the state's tributary strategies, thus they need an effectiveness estimate.
  - One potential idea would be to use this practice when the field doesn't have contact with the stream, but when it does have contact with a stream you could require that they do both this practice and the stream fencing practice in order to get credit.
  - A statement should be added at the beginning of the report that says that this practice does not include riparian corridor management and that the dominant source of loss from pastures is where there is contact with the stream.
- o In the Horse Pasture Management report, a statement should be added to the narrative that says that overstocking is frequently the cause of many of these problems. Therefore, when planning a pasture management system for horses, it is essential that stocking issues also be addressed.
- o If you have a mobile water source, would that count?
  - The definition that is used in the report is a combination of what they were given and what the panel recommended.
  - They are working on a rather broad scale and separate practices were not proposed for mobile and stationary water sources. In the report, however, they could recommend that the water source be mobile.
  - MD only cost-shares stationary water troughs.
- o Comments sent by Tom Juengst via email:
  - Both reports seem okay. Finding, determining, and documenting good information and analysis is much easier said than done.

ACTION: Tom Simpson and Sarah Weammert will revise the two pasture management reports based on today's discussion. A revised version will be sent out by Friday.

ACTION: AgNSRWG members can provide UMD/MAWP with any additional comments over the next few weeks.

ACTION: At the workgroup's September 3rd meeting, members will review the revised pasture management reports and they will finalize their recommendation to the Watershed Technical Workgroup and the Nutrient Subcommittee.

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Minutes: Agricultural Nutrient and Sediment Reduction Workgroup
September 3, 2008

Pasture Management for Dairy, Beef, and Livestock

- Eileen McLellan noticed that the RUSLE2 refined breakdowns were not present in the description.
    - UMD/MAWP will add this section back into the report.

- Beth Horsey believes that it needs to be clearly laid out in the report how NRCS will determine at what point enough codes have been implemented to suffice as the pasture management BMP.
    - Tom Simpson suggested that the report say that one or any combination of practices that fulfils the BMP description will be labeled as a pasture management BMP.
- Eileen McLellan was concerned about whether the NRCS 528 rotational grazing standard called for maintaining 2-3" of grass height.
- Mark Dubin said that he will be talk to the regional NRCS offices about these reports, and he will ask them about how to coordinate the reporting definitions.
- Jeff Sweeney has 20 years of data on state implemented rotational grazing practices that he will need to recharacterize under pasture management or another practice.
- NRCS will evaluate the practices to ensure they meet the pasture management BMP.
- Renato Cuizon suggested that the Workgroup propose creating an interim practice code with NRCS for the pasture management BMP.
- Bill Rohrer suggested that the AgNSRWG be involved with the inputs of load calculations for pasture loads.

DECISION: The AgNSRWG recommended the pasture management for dairy, beef, and livestock definition and effectiveness estimates move forward with the addition of the following suggested changes:

- RUSLE 2 breakdowns will be added to the report.
- The report will be revised to reflect that some combination of NRCS codes can achieve the pasture management practice. Either of NRCS codes 561 or 575 must be implemented alongside of 512 and 528.

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Minutes: Watershed Technical Workgroup
October 6, 2008

Pasture Management for Dairy, Beef, and Livestock and *Horse Pasture Management*

- Efficiencies for livestock and horse pasture management are the same but are applied to a different load.
- Livestock pasture receives 1.0x the average pasture load. Horse pasture receives 1.5x the average pasture load to account for variations in animal behavior.
- The Agricultural Nutrient and Sediment Reduction Workgroup would like to use the 40% TSS and 20% TP as placeholder values but would ultimately like to do is use RUSLE2.
- The pasture management differs from the other two pasture BMPs because pasture management for livestock addresses upland rotational grazing. The two Year 1 pasture BMPs were for offstream watering with and without fencing.
- The Workgroup approved the pasture management BMP, acknowledging that the 20% TP and 40% TSS numbers are interim.

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Chesapeake Bay Program Nutrient Subcommittee
October 22, 2008 Meeting

SUMMARY OF DECISION, ACTIONS AND ISSUES

Pasture Management

- Pasture management reductions are 40% for TSS and 20% for TP.
- There are no nitrogen reductions associated with pasture management. This was a panel decision.
- When reporting pasture management, a combination of NRCS practices must be implemented to achieve benefits under the pasture management BMP.
- For horse pasture management, the effectiveness estimates are the same as livestock pasture but will be applied to loads 1.5 times that of livestock pasture.
- Bill Keeling expressed concern about the fact that no one from Virginia was represented on the panel.
- Bill Keeling pointed out that the Watershed Technical Workgroup approved the pasture management BMPs because the recommendations are only for interim efficiencies until better numbers can be developed.
  - Tom Simpson clarified that there are several studies in development that will provide a lot more information on some practices when they are completed. When these studies are completed, the Bay Program can reexamine these BMPs with new information and revise them accordingly.
- Russ Perkinson pointed out that we may see a land use change with implementation of pasture management BMPs because as animals start eating more grass on pastureland, there will be less demand for corn and, therefore, less cropland and associated nutrient runoff.
- Ron Entringer believed that the BMP recommendations had a lot of needed work, but he was okay with moving forward with it.

DECISION: The Nutrient Subcommittee approved recommended BMP efficiencies for horse pasture management and pasture management for dairy, beef, and livestock for final decision by the Water Quality Steering Committee. Concerns expressed by specific Subcommittee jurisdictional representatives were noted for the record.

ACTION: The Watershed Technical Workgroup will review all of the BMPs from Year 1 and Year 2 that deal with pasture, and solidify how the various pasture BMPs function together for tracking and reporting reasons.

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Nutrient Use Efficiency

PENDING CBP APPROVAL

Definition and Nutrient and Sediment Reduction Effectiveness Estimates

For Phase 5 of the Chesapeake Bay Program Watershed Model

Recommendations for Endorsement by the Chesapeake Bay Program Nutrient Subcommittee and its Workgroups

Consulting Scientists

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Mid-Atlantic States Director
American Farmland Trust

Tracy Blackmer
Director
Iowa Soybean Association On Farm Network

Greg Binford
Associate Professor and
Extension Specialist, Plant and Soil Science
University of Delaware

Brian Brandt
Director of Risk Management Programs
American Farmland Trust's Agricultural Conservation Innovation Center

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Stan Schlosnagle
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Wade Thomason
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Susan White
Associate Scientist, GIS Specialist
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And

Craig Yohn
Certified Crop Advisor
Extension Agent - Jefferson County

Synthesis and Recommendation by

Tom W. Simpson, Ph.D.
University of Maryland/Mid-Atlantic Water Program
Project Manager

And

Sarah E. Weammert
University of Maryland/Mid-Atlantic Water Program
Project Leader

Summary
Straight application reduction: 10% or higher reduction of total nitrogen (TN) applications from the University recommended rate.

Decision Agriculture: In this approach a farmer implements successful techniques to improve NUE by employing a suite of practices that increased NUE (not just amount of fertilizer applied).

The Chesapeake Bay Program stated clearer definitions, effectiveness estimates and methodologies for tracking and reporting nutrient use efficiency practices are needed. To accomplish this the Chesapeake Bay Program asked Frank Coale to lead a new panel. The panel's recommendations will then be reviewed by the Agricultural Nutrient and Sediment Workgroup, Watershed Technical Workgroup, and Nutrient Subcommittee prior to forwarding a recommendation to the Water Quality Steering Committee for final approval.

Introduction

The Mid-Atlantic Water Program (MAWP) housed at the University of Maryland (UMD) led a project during 2007-2008 to develop standard procedures and methods that farm operators could follow to investigate alternatives to conventional nutrient management plans that would enhance nutrient use efficiency (NUE) and maintain profits in a framework supported by the cooperation of the Chesapeake Bay program, ii) provide a listing of NUE practices and their effectiveness estimates, and iii) develop models to predict the impact of NUE plans on nutrient and sediment loss (effectiveness estimates) according to operational conditions representative of the Chesapeake Bay Watershed. The objective is to define the average operational condition that is representative of the Chesapeake Bay watershed and categorize and quantify soil and topographical characteristics that interact with these operational conditions to influence the effectiveness estimates and their spatial and temporal variability.

The Chesapeake Bay Program (CBP) historically assigned effectiveness estimates based on controlled research studies that are highly managed and maintained by a BMP expert. This approach is not reflective of the variability of effectiveness estimates in real-world conditions where farmers, not BMP scientists, are implementing and maintaining a BMP across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that more closely align with operational, average conditions, modeling scenarios and watershed plans will better reflect actual conditions..

One important outcome of the project is the wealth of documentation compiled on the BMPs. To provide precise documentation the UMD/MAWP designed a robust practice development and review process utilizing literature, data, and best current professional judgment. The initial step was a literature and knowledge synthesis. Available scientific data were compiled and analyzed for quality and applicability and included in a report that summarizes all decisions on how effectiveness estimates were developed. The process for incorporating both science and best professional judgment to estimate average operational effectiveness is also well documented.

Another objective of the project was to initiate an adaptive management approach for BMP effectiveness for the CBP. An adaptive management approach allows forward progress in implementation, management and policy, while acknowledging uncertainty and limits in knowledge. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment in the definition and effectiveness estimate recommendations. With adaptive management it is necessary to include a schedule that allows for revisions as advances in knowledge and experience become available. UMD/MAWP recommends continued monitoring of BMPs, with revision of definitions and effectiveness estimates scheduled for every three to five years to incorporate new data and knowledge.

Attached to these definitions of BMP's and their corresponding effectiveness estimates is a full accounting of the Chesapeake Bay Program's discussions on NUE, who was involved, and how these recommendations were developed, including data, literature, data analysis results, and discussions of how various issues were addressed. All meeting minutes are included in Appendix A (CBP meeting minutes will be added after the CBP review).

UMD/MAWP consulted a panel of experts from the academic, industrial, state agency and non-profit sectors to advise in the development of BMP definitions and effectiveness estimates. Discussions during panel meetings, data and best professional judgment was used to craft the recommendations presented here.

Guidelines. The following guidelines were used when selecting data to include in the data set and recommending effectiveness estimates:

- Effectiveness estimates should reflect operational conditions, defined as the average condition throughout the Chesapeake Bay watershed. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.

- Where studies with negative pollution reduction data (BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.

- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process by independent scientists. As such, peer reviewed literature should be given more weight than design standards and manuals. For this BMP, however, no peer reviewed literature was available and gray literature, or limited research scale type publications, and best professional judgment was used.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

BMP Name Change

We recommend changing the name of the precision agriculture BMPs to Nutrient Use Efficiency. This name better reflects in intent of the practice and how it refines nitrogen use calibrated with yield potential, with the ultimate goal of reducing N loss. It also captures all subcategories of the BMP. NUE strives to optimize efficiency in plant use of applied N and reduce N loss through reductions in leaching, erosion, surface runoff, ammonia volatilization and mineralization (nitrification and dentrification).

BMP Structure/Subcategories

Description/Definition of BMP:

The ultimate goal of nutrient use efficiency is to reduce loss and increase nutrient availability to optimize nutrient use efficiency. NUE includes two components, Crop Removal Efficiency, and increases in residual nutrients available from the soil for subsequent crops due to the immobilization of nitrogen (Ladha et al, 2005). Residual nutrients available from the soil for that growing season should be consistent with state regulatory requirements, such as PA Technical Manual (2003) Section II: Required Nutrient Management Plan Elements; and Net Crop Nutrient Needs Calculation Factors for residual manure nitrogen and residual legume nitrogen. Crop Removal Efficiency is equal to the removal of nutrient in harvested crop as a percent of nutrient applied (Mosier et al, 2004).

This BMP is divided into two subdivisions: 1. reduced application rate 2. decision agriculture. The first subdivision is simply a reduction in the nutrients applied, while the second subdivision incorporates testing to adjust field inputs to ensure optimum yield is achieved in an efficient manner.

1) Straight application reduction: 10% or higher reduction of total nitrogen (TN) applications from the University recommended rate. The baseline, the original application rate, is based on the complete nutrient management plan for that crop, farmer and field to capture manure applications and the previous crop. This BMP is not applicable in situations where the University recommended rates are zero. Little application of this BMP is needed in areas where lower rates are already recommended. The organization or agency that runs the reduced application rate program is responsible for reporting the number of acres and the percent reduction in applied nutrients under reduced application. For nutrient credit generation reduced application can be no lower than 10%, but can exceed 10% by any factor of five.

2) Decision Agriculture: In this approach a farmer implements successful techniques to improve NUE by employing a suite of practices that increased NUE (not just amount of fertilizer applied).

Definition:
CBP will accept a jurisdictions definition of decision agriculture by state by state basis.
Maryland's definition states:
"Utilize a GPS and yield monitoring system to collect field-specific crop data, and a software/record keeping system that analyzes that data. Utilize this analysis to adjust field inputs, which may include variable rate fertilizer, lime, and/or variable rate planting. This system involves the development and use of an extensive record keeping system of crop management and yield data inputs using GPS technology to ensure the most efficient production is achieved. GPS/record keeping is done with commercial software. There are numerous software programs on the market that a program participant may use."

Delaware's definition states:
"The producer must utilize a light bar, or a yield monitor, or a variable rate planter. The producer must utilize a GPS/record keeping software and yield monitor to collect field specific data. With the data, the producer must analyze the field-specific crop data and adjust within field inputs, including lime and variable rate planting.[2,3] In addition software (recordkeeping system) must be used to maintain a historical record of each field(s) input(s).

[1]Smart sampling and precision soil sampling use the knowledge of field conditions, such as soils and topography. As the knowledge of within-field variability is gained from yield maps and other layers of information that have been collected using precision agricultural technologies, soil sampling sites can be refined. Smart sampling is usually not grid sampling because it takes fewer soil samples. Before "smart sampling", a consultant can use aerial maps and photographs, topographical maps, and yield monitor information, to divide the field into natural areas that have similar soil characteristics and yields.

[2]If a program participant or consultant utilizes GPS and recording keeping for “smart sampling”, this falls under Tier II, not Tiers III and IV.

[3]GPS/record keeping is done with commercial software. There are numerous software programs on the market that a program participant can use.”

To credit decision agriculture state NRCS must first approve the minimum software, database or programs that fall under decision agriculture. NRCS will then determine a comparable set of standards that can be used to evaluate other programs of comparable management intensities expected to give comparable improvements in efficiencies. To do this NRCS, will collect a list of elements that the system (whether it is commercial or not) uses to define decision agriculture and determine if the process constitutes decision agriculture. Commercial software packages will be evaluated but are not the only source of information a farmer can use to qualify for credit. For example, in PA a commercial software package is not used in its decision agricultural program. Instead they collect data to develop their own database, utilize it to analyze data and ultimately implement decision agriculture tools.

Mark Dubin and Tim Pilkowski will work with the nutrient management planners from the other jurisdictions to develop comparable decision agriculture programs and verification. UMD/MAWP will continue working with proprietary databases to develop an efficiency estimate that can be used to generalize crop uptake improvement associated with decision agriculture.

Description:
The farmer or his advisor will use test strips to determine additional ways to reduce N loss or better utilize available N, thus improving NUE over time. Strip trials must be replicated, with at least three repetitions, or they lose their value. It is recommended that a 5-year incentive payment contract be provided to the farmer with the obligation to use test strips to improve NUE and to incorporate successful tests results into their crop management system within the contract period. Nutrient reduction impacts will be estimated by determining the improvement in NUE (total application vs. total yield for a field or operation). Over time, increased NUE will reduce the loss of nutrients to ground and surface water because N is not available for loss since it was utilized by the crop. Tracking and reporting mechanisms will need to be developed to allow estimation of NUE improvement during contract terms either on a case by case basis or based on a statistically valid sample of participating farmers. Assessment and reporting of improvement in NUE could be a requirement of the contract or an added payment that allowed third party independent verification of change over time.

In practice decision agriculture includes a broad suite of BMPs and many are tracked and reported separately for the CBP and are credited there. These BMPs reduce N loss, but are not credited under NUE, and include conservation tillage, crop rotation, cover crops, conservation plans, and nutrient management with incorporation or injection (NRCS, 2007). This report concentrated on improved nutrient use efficiency and captures only the elements that relate to it. Examples of Decision Agriculture components include, but are not limited to (Fixen, 2005a,b):

Crop Testing: detect N excess through use of a leaf color chart, corn stalk nitrate test or real time chlorophyll measurement for variable rate application. The test provides a report card on that season's NUE, taken in the fall, and provides very helpful feedback for determining rates, timing, and form for the next year.
Crop Nutrient Removal: Evaluate the gap between application and removal to maintain existing soil fertility levels through the use of charts to software.
Soil Testing: Measure soil nutrient supplying capacity to understand within field variability in soil test levels and select appropriate nutrient rate. These results should be turned into fertilizer rate maps.
Plant and Grain Analysis: Real time sensing of plant and grain characteristics to evaluate past nutrient management practices and produce protein maps to manage fertilizer application on a site-specific basis
Nutrient Response Measurement: Measure response to each nutrient in question with controlled experiments to refine nutrient management decisions
Economic Analysis: Analyze relationship between nutrient use decisions, yield potential and production costs
Nutrient Source Integration: Assists in developing manure management plans to reduce the probability of water quality impairments, automates manure application records, and estimates supplemental fertilizer needs.
Environmental Risk Assessment: While UMD/MAWP did not observe intentional environmental risk assessment during its discussion with researchers and industry, we recommend it become an expectation of decision agriculture in the future. Environmental risk assessment reviews a specific site for its potential to impair water quality based on location and transport factors
Aerial Imagery and Strip Trials (On-Farm Network, 2008): When taken near the end of the growing season, aerial photos highlight the spatial variability across the field so farmers can avoid sampling in areas where planter or applicator skips, diseased or pest damaged areas, weedy patches and other non-uniform areas are responsible for spatial variability. Replicated N fertilizer strip trials are several side-by-side strips the length of a field, where farmers estimate yield differences between treatments and confirm whether the variability observed in the imagery can be attributed to N by coupling yield monitors with GPS. To provide value, strip trials need to be replicated with at least three repetitions per trial. If replicated strip trials are not feasible or growers do not have yield monitors with GPS results of stalk nitrate testing can help interpret

and independently verify yield responses observed from aerial imagery, or based on observed areas that appear to be under stress.

Stalk nitrate tests (On-Farm Network, 2008): Stalk nitrate tests, by testing previous management activities and intensities, are the best way to guess optimal N rate. End-of-the-season stalk nitrate test shows if too low or deficient, marginal, optimal, or excess nitrogen was available to produce optimal grain yields. Use test results to improve NUE by sharing results with other local farmers with stalk results to compare their individual results to those of the group and work with specialists (extension, NRCS, consultants, researchers) familiar with the test.

Guidelines:

- Multiple years of data should be used to account for the effects of weather on N availability.
- Collect at least 10 corn stalks from a relatively uniform area in soil properties, corn plant stand, and corn appearance.
- Each stalk segment should be 8 in. long and it is cut between 6 and 14 in. above the ground.

These aids will help determine if the following management and conservation practices are warranted:

- Timing of fertilizer applications with side dress and/or split application to match crop uptake patterns
- Fertilizer application placement with injection, incorporation or band application.
- Slow or controlled release fertilizer or inhibitors
- Crop selection of varieties that improve NUE

Applicable NRCS code:

Nutrient Management (590) will be expanded to include techniques unique to nutrient use efficiency.

Factors that Create Variability.

Nutrient use efficiency may vary across different soil types. Excessively drained sandy soils may leach N, while poorly drained soils may lose N in surface runoff. This is not a major barrier as variability in soils is captured in the model.

Nitrate stalk tests are a great tool and are valid when testing is on healthy plants, stalks with no damage, under controlled conditions. However, there is concern that nitrate stalk tests are less useful when plants were significantly stressed by factors other than nitrogen. To account for this, combine stalk tests with yield data to determine effectiveness. In the future real reporting must be done, not just a model estimate.

Management and operation can also be highly variable both between the research and operational scale and between different managers within the operational scale. When practices are implemented across a large area on parcels managed by many different individuals, it is important to assume an "average" level of expertise, control and management in planning design, implementation and operation of any given BMP. While there may be limited data quantifying the difference between research and "average" management, it is recognized that widespread implementation rarely has the same level of oversight and control that is essential to get statistically meaningful results observed at research scale. As a result, there is a need to lower effectiveness from the research scale when widespread implementation occurs.

Interim Effectiveness Estimate

A percent reduction is not proposed, alternatively UMD/MAWP proposes using the Chesapeake Bay Program's Watershed Model to determine effectiveness. For decision agriculture and the hybrid, it may be necessary to commission surveys to determine the impacts of the BMPs if changes in use and yield cannot be tracked. Reduced application is simulated by a reduction of input rates, which may translate into higher output reductions. The benefits of this BMP would be modeled just as the benefits of regular nutrient management plans are simulated. The model will simulate NUE as a land use change, with lower loads assigned to land under enhanced nutrient management compared to loads assigned to traditional nutrient management land. This mirrors the current system where regular nutrient management load is less than the runoff generated from lands without regular nutrient management.

For the reduced application rate subdivision, a jurisdiction will report the acreage receiving a 10%, 15%, 20%, etc. reduction in applied fertilizer and the model input data will reflect the reduction in nutrient load applied in the segment (cannot do field? For TSWG to answer). If a jurisdiction offers a program that allows farmers to choose a reduction percent, they must be able to track and report the acreage separately or it will be assumed that all acreage had a 10% reduction. A range of application rates is not reported, the number of acres under a 10%, or higher factor of five, reduction in applications is reported.

For subdivision two, decision agriculture, the Watershed Model (WSM) estimates the change in efficiency given the expected change in NUE from decision agriculture. To simulate the effectiveness of decision agriculture BMP, alter the input of nitrogen into the WSM based on increased efficiency. A jurisdiction will report the number of acres in a segment where efficiency changed by a certain amount. To estimate nitrogen loss reductions from decision agriculture, a jurisdiction reports the number of acres grown with decision agriculture and the ratio of production to input (potential for higher yield per pounds applied) is simulated.

A back up approach is use an aggregated database to determine average change in efficiency by geographic region. An adaptive management approach is warranted to improve the database as more data becomes available that refines the benefits of NUE. Tracking and reporting will have to be developed for the adaptive management/decision agriculture program but can be based on improvement in NUE, if that can be tracked and reported.

American Farmland Trust's BMP Challenge reports an average 27 lbs/acre reduction in nitrogen application. Nutrient BMP test results on over 100 fields across the Midwest showed a reduction in nitrogen fertilizer use by 23 percent (approximately 41 pounds) while fully protecting farm income. A model is used to determine the reduction in nitrogen loads. The BMP challenge, by partnering with Team Ag is sampling highly managed sites with excellent NUE. Upon scaling up to an average managed farm, we can expect to see less of a yield impact.
Also please note we are still meeting with various companies and evaluating their data to hopefully further refine the long-term adaptive management subcategory. When this information is available it must be used to refine nutrient use effectiveness estimates.

NEED FOR TECHNICAL ASSISTANCE FOR DECISION AGRICULTURE

While an individual grower can learn about their own nitrogen management by conducting stalk sampling, an understanding of corn N status variability within a region is extremely valuable to growers. Participatory learning through farmer meetings in small groups would allow growers to view results from a number of fields that use the same rotations, fertilizer forms, application methods, or timing of applications, to guide future N management activities. By making decision that improve efficiency and advance both environmental and farmer economic goals significant changes to water quality can be achieved.

DA is a process of learning that is information intensive and requires active participation from those most likely to be affected by the policies being implemented. To conduct this labor intensive multi-year data collecting, analysis, and distribution, technical assistance is needed. If decision agriculture is to be utilized to its best ability additional staff is needed to train farmers to use and calibrate GPS technology and conduct field sampling, understand results and set up avenues for data sharing.

Future Research Need

Beyond the need for technical assistance previously discussed, another future need to successfully implement reduced application rates, decision agriculture, or a hybrid of the two, is to replace these interim effectiveness estimates with actual field data. Accuracy of equipment, equipment availability, and user error are the major barriers to reporting field data for use as determining pollution reduction credits.

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Appendix A: Meeting Minutes

Precision Agriculture: Reduced Application Rate

April 29, 2008
On phone: Jim Pease
In attendance: Mark Dubin, Tom Simpson, Suzy Friedman; Jim Baird; Tracy Blackmer; Stan Schlosnagle, Brian Brandt

ACTION ITEMS:

ACTION: Tom and Sarah will develop initial numbers based on data. Then get input from panel. Schedule conference call to get agreement, for now, recognizing evolving, do these steps.

Overview of Project

Estimates of BMP performance will be used in TMDL implementation plans, trading permits and WSM modeling, and for continued use in Tributary Strategies. While our scope dictates that we quantify the nutrient and sediment reductions, UMD/MAWP recognizes there are additional co-benefits (social, economic, etc.). UMD/MAWP is asking panel members to help create a list of all co-benefits.

Our most important task is to estimate BMP performance at the operational, average watershed wide scale. UMD/MAWP's job is to ensure panel decisions, scientific justification, and best professional judgment are within the framework of our guidelines designed to estimate operational, average watershed wide conditions:

- Effectiveness estimates should reflect operational conditions, defined as the average watershed wide condition. Research scale effectiveness estimates should be adjusted to account for differences upon scaling up to operational conditions.

- Where studies with negative pollution reduction data (the BMP acted as a source, not a sink for pollution) are found, they should be included in the effectiveness development process as they reflect operational conditions.

- Peer reviewed literature has been subject to stringent evaluation and results from that literature are given more weight than literature that has not undergone the same review process. As such, peer reviewed literature should be given more weight than design standards and manual.

- Data from individual BMP project sites are to be utilized over median or average values calculated from multi-site analysis (meta-analysis). Single site studies evaluate individual BMP projects, while multi-site analyses are a collection of BMP projects.

UMD/MAWP will ask detailed questions about the BMP, not to discredit the performance of the BMP, but to get to operational conditions.

Panel members' primary task is to develop a report for the BMP using the guidelines, decision matrix, and factors of variability found in the template. A final report from the panel is due to the Chesapeake Bay Program by July 15, 2008 so partners can begin their technical review process. Bay Program partners are made up of jurisdictional agencies, the EPA and the Chesapeake Bay Commission. During technical review (mid-July to September) workgroups may bring specific question to panel/scientists for discussion.

Pre-meeting Discussion:
Tracy Blackmer meet with a larger group of individuals at the Chesapeake Bay Trust to discuss the Iowa Soybean Association's On-Farm Network.

The On-Farm Network is producer-led and producer-focused. Its primary goal is to increase grower profitability by using precision agricultural technologies to identify ways to increase productivity. Most of the group's effort is focused on conducting replicated strip trials comparing two practices or products within a field. Usually, the grower's normal management is compared with a new product or practice.

The On-Farm Network strip trials uses simple testing to find if N rates could be reduced without sacrificing yields and profits. Farmers reduce normal N application rates by a specific amount and use the data to evaluate timing, application method, and the fertilizer material being used.

Questions Posed to Panel:

There is a concern that overlap between precision agricultural techniques will occur, because nutrient use efficiency and slow release sources may generate the outcome of reduced application rates. Variable rate application (both spatial or temporal) will drive nutrient use efficiency, and temporal will reduce application rates. How do we avoid an overlap? Should we develop a "super" precision agricultural category/component that incorporates the benefits of all precision agriculture techniques and practices?

Could a benchmark ratio be established that identifies an individual farmer's success at achieving environmental stewardship based on fertilizer effectiveness? How would organic sources of nutrients (manures and biosolids) alter the ratio?

How do we determine the precise application rate? Is it based on improved crop N requirement predictions, using yield monitors, PSNT, late-season stalk test, spectral evaluation (chlorophyll meter, NDVI), and then incorporating more complicated algorithms for predicting yield potential that include in season climatic conditions and direct measurement of N mineralization or crop N uptake?

Discussion:
Afterwards we adjourned to discuss reduced application rate as a BMP for the Chesapeake Bay.

MD nutrient management highlights:
No fall application
Biggest advantage with reduced application may be improving nutrient use efficiency
N and P rate based on historic yield

PA reduced application highlights:
Some fields needed more nitrogen, however, overall farmers over applied nitrogen
Manure focus nutrient management (unlike MD)
Making a "Farmer Board" to determine how to display data and avoid confidentiality and confidence issues
Program is paying cost of strip trails (extra labor); no yield payments like Iowa's program (and unlike AFT BMP Challenge); PA no problem with enrollment even with no payments for potential decreases in yield; average size of PA field enrolled is 12 acres (Iowa is about 80 acres)

BMP name change: Nutrient Use Efficiency

Definition: Reduce loss and increase variability to optimize nutrient use efficiency

Subcategories (first attempt): 1) knowledge based reduction, like On-Farm Network approach; go to right application rate providing environment and economic optimum benefits 2) flat reduction in application (straight buy-down), for market systems but not behavior change

The BMP challenge initially used a reduced application approach, but with knowledge used better timing, rate, etc. Reduction rates are based off nutrient management plans but 590 based on historic use, book values of manure; not a lot of accuracy in developing nutrient management plan.

VA tech (Jim Pease) looked at the cost of employing reduced application rates for the farmer. Concluded participation (15% reduction in N) reduces expected net revenue $10 to $13/ha

UMD (Stan and Frank Coale's work) didn't have full response curve from a few research sites. Do have data showing 80% of N recommendation up to 120% at point where N fertilizer costs as high, farmers can reduce N rates and be economically ahead with a 36-40lb N reduction. N cost having huge impact on optimum N. Linear between 80% and 120% recommendation, not quadratic.
If use more updated corn and fertilizer prices: $5 corn and $.60 lb with $49/acre at new prices; $3.50 corn and $.60lb N showed $15 acre.

Need better term than buy-down for communicating to farmers.

What have greatest opportunity for loss? Variability in soils (poorly drained) is preferred over blanket application of any BMP. N application rates, get a lot more back on return, if target sandy soils (poorly drained).

What would a nutrient use efficiency program look like?
Iowa model is good, but don't want to restrict to Iowa's approach
Continuous process with farmer constantly collecting data; keep records and revise as go along; measuring participation in the program

If by making payment can get someone to improve nutrient use efficiency – point of BMP

Constrained by how many aspects we can represent and what can be tracked and reported.
Subcategories (attempt two):

1) flat reduction
2) knowledge based continuous improvement that includes behavior change – participation in program used as measure; phased in performance for when farmer enters program after 5 years of participation (document continued participation). Make reduced application rate a learning based practice so focus less on following NRCS practice standard, and more on are you doing continuous learning and improvement with milestones along the way.
3) Pick specific things that would increase efficiency (using corn stalk, going to sidedressing, etc.) OR make part of knowledge base approach?

Should we assign effectiveness to one and not the other b/c one year get benefit, one year may not?

- Already know all factors to report (stalk test, yield data).
- Need to remember this approach will be used in trading system. Under trading permit an NPS won't use average value, they will need real end of year data.
    - But right now can't report this finely of a scale. Average person after 5 years in program will have achieved this type of change in behavior. Buy down is more straight forward (% cut). Subcategory 2 is focused on behavior change. Future Research Need – redo effectiveness based on real data, not average estimations of behavior change.
    - Need find happy medium between operational behavior change and model need
    - To estimate performance with rate cut all you need is a straight data calculation, but other subcategory does not have data. Not just number of acres under precision ag, it's how a change in timing, application, etc. increases NUE and lowers pollution runoff.
    - Our approach captures areas that will increase N use and areas that will decrease
    - One factor of variability - drought year vs wet year will vary performance
    - Can the program pay based on stalk test? Data confidentially is another barrier to using this. High precipitation year will run N off field but stalk test would be optimal, not capturing N not captured by plant; need N input parameter. Iowa now trying to get benchmark to test fields year to year. This tangible data allows anonymous farmer participation.
    - Williard looks at yield results across county every year and determines where ranked in overall group with similar climate variables.

- If combine N input, stalk test, and how relate to carefully controlled calibrated plots. How know N input? Need farmer tell you. N input, yield response and stalk test, and rainfall needed. Develop model to determine performance
- Will Iowa's benchmark fit in our model? Can track and report because AFT paying guarantee so must know inputs.
- In PA reporting is done by organizations not seen as government. We can create tracking system
- Was implementation really achieved? How answer this to public?
- In Iowa the data is shown as an aerial image and points, so as to not run into issues with credibility of data. From grower perspective, need way be paid to collect data (create benchmark). Combine stalk nitrate with N input and compare to localized benchmark.
- Use dedicated response trails from low application to very high application, then do stalk nitrate test. Biggest concern is history of manure application and soil variability too high.
- High variability is not always bad because then won't come in and prescribe one number. Benefit of system is not that every field hit optimal, but farms started to show x amount of the field hit a high yield and then 5 years later x number hit a high yield.
- Concern with real calibrations is that trend over time is meaningful, but if calibration sites not operational, how account for this? Need worst case calibration site to accurately capture operational, average behavior. Manage calibration site to determine how performance changes and how much time it takes to see a change. Need a way properly categorize all behavior. To do this we must determine how many sites are needed? For our July report back to CBP where effectiveness will be used for management scenarios over the next year, we need to have a system defined and in place. We can recommend it and push it forward. Can we develop interium effectiveness, average behavior change, and long-term effectiveness built around concept of change in community over time with adoption?
- Need to be assured interim effectiveness estimates leads to re-evaluation for long-term use.
- One way to determine effectiveness is to base the guaranteed payments off of calibration sites; way account for variability. Other side: what happens, regardless of location, get incentives for improving effiency. Give application and yield info and can provide incentives

Framework/Subcategories (third attempt):
1. Flat buydown
2. Flat buydown but with incentives things get to knowledge base – incentive for moving towards improving efficiency
3. Knowledge base approach – use information from subcategory two

Reporting: crop management systems doing self reporting

- Two sources of info: Data submitted by state and other groups is compared. CBP did this in 2008 for a whole jurisdiction. CBP recommended other data set to jurisdiction and CBP used other data set in model. Need manage to avoid overlap. Opportunity for CBPO to push higher data confidence.
- Self reporting has lacked accountability, because career is to sell fertilizer. How have quality assurance and credibility?
    - Groups there to represent producers are not selling a product.
    - But there on behalf producer, if make angry may not get dues and continued support
    - Need GPA, fertilizer receipts, enforcement
    - Get away stalk nitrate test, instead have the fertilizer company apply the recommended rate and slightly less (80% N rate), then county agent comes out to supplement strip to match correct rate. One method is needed to check if the rates applied are correct.
    - State jurisdiction also have vested interest
- Does anyone over apply nitrogen in bay model? Yes. How establish? By segment nitrogen balance, flawed in sense don't actual know where purchased n goes. But take purchased N and allocate among county. Manure generation also allocated by county to either pasture, cropland, etc.
    - Over application is profit maximizing. Don't confuse profit max rate with recommended rate. Recommended rate judgment rate set up a long time ago, don't necessarily reflect profit maximizing today. Higher prices pushing out on flater part of curve in profit maximizing. Do get change in N application rate when price of corn or N fertilizer changes. Only one small area when N cost goes up high where don't get 100% recommended rate application. May be applying higher rates for good economic values.
    - Model over application from manures not fertilizer. Not enough ag land to apply manure – farmers want ways be efficient b/c sticker shock of fertilizer. Economics still favor adding more N b/c price corn is high.

- The approach should be - zoom in one site with most environmental impact. High manure generation higher impact b/c not economic impact. Commercial N has economic impact.

Framework/Subcategory (fourth and final version):

1) Straight buy down: 20% reduction (the number is a first stab, not final)
2) Interim (25% reduction, again number is a first stab and is not final, because it is better than buydown; because buy down is an absolute thing, it sets the base. This interim category recognizes that with buydown plus improved efficiency, higher effectiveness is achieved than just using buydown). Here a farmer goes 15-20% below the recommended rate, but over time receives incentives to try things to improve efficiency at an even lower rate (such as splits, etc.) on one test strip. Farmer picks and chooses the additional activities to experiment with. Environmental measurement occurs by applying the same rate of N but changing how it is apply and achieving a higher yield, thus reducing the potential transfer of nutrients to surface water because N is not available for runoff because it was utilized by the crop.

3) Long-term, adaptive management approach, continuous improvement (30% reduction, again number is not final, because this subcategory takes NUE further than the interim approach)– This approach addresses how average behavior change relates to a suite of practices that increased NUE (not just amount of fertilizer applied) over a 5 year period, with some means documenting participation. A 5 year contract is needed (MD precision ag program is 5 year agreement) that states a farmer will use test strips to modify timing and rate based on test strip results. This continuous use of test strips results in improvements in NUE over time. This approach also helps farmers determine if there are more efficient materials (i.e., switch from UAN to injecting hydrous) to improve NUE. One expectation for farmer is to test current N levels, look for ways to use split applications to improve efficiency. Several test strips will be needed.

    - Concern with small sample size - Intermediate step includes one test site but level three includes a series of test strips

HIGHLIGHT: Having adequate test strips to reduce number of times get erroneous results is really important.
The BMP Challenge program has two versions. One has little subsidy for yield checks, and not a lot of money for extra strip checks. Another version provides more money to producer and farmer, not unreasonable to add in extra test strips.

- Can't replicate enough to have statistical validation. Assume symmetric distribution and may pay
- Extra strips reduces variability, so don't have big hits
- Not having a pay out option creates more money for more test sites

Base nutrient management – follow recommended rates, if use manure analyze it, little timing restraints with certain crops. We are recommending enhancing nutrient management.

There is concern that the nitrate stalk test results are valid under conditions where corn wasn't taking up water and nitrate because there was no moisture in the ground. Articles can determine if over applied but nothing that says can use test to determine if didn't apply enough fertilizer. Great tool if good stalks (no damage) under controlled conditions that make test valid.

- Ultimately combine stalk tests with yield data. Under buy-down can test enough to capture 20lb difference in N applications. Needs to be done on farms with big long strips and yield monitors.
- Would this limit implementation of the BMP to farmers with yield monitors? With public money how exclude farmers who don't have equipment?
- Correlates to farm size, and those farmers doing more careful job of applying N. This approach indirectly segregates the group this BMP does not need to study. Farmers with the equipment are doing a better job of applying N and are not the target of this practice.

Continuous improvement and buydown hybrid teaches behavior change. With funding removed still have environmental and economical benefit. Can make up yield decrease with techniques that increase nutrient use efficiency.

Reduction in loss is greater than buydown. Buy-down baseline: can't be 3 or 5%?
Tom: 15% starting point; based on Josh's research, below 10% not comfortable.
Jim/Brian – first year looking at 10%, been 15% before (27 lbs/acre reduction).
Mark – existing programs based on 15-25%
Jim – use 15%
Tom – BMP challenge is sampling the best through partnering with Team Ag. If scale up to average see less yield impact, lower payment cost for lower yields.
Comparing mid-west to PA, in general PA farmers much closer to need than in cornbelt?
Brian – rate above BMP to BMP level in mid-west. PA first year, one farmer above BMP to at BMP. Following years and rest participants moved from at recommended levels to below.

ACTION: Tom and Sarah develop initial numbers based on data. Then get input from panel. Schedule conference call to get agreement, for now, recognizing evolving, do these steps.

With precision agriculture (slow release/variable rate group), use the adaptive management approach described here.

- Knowledge (field data) is a valuable part of the variable rate and it was not available. Two issues: with variable rate testing had real hard time with equipment dispensing accurate rates. Second, there is a philosophy among producers that with more fertilizer on high yielding fields and adjust fertilizer application on fields with low yields. Also don't have data providing guidance on the right thing do from an efficiency standpoint in those situations.
- Need to plug in On-Farm Network data
- Our subcategory 3 may fit with the slow release/variable rate groups approach (bring Tim Pilkowski into this review)

Future: move towards real reporting

<u>Precision Agriculture: Slow Release/Variable Rate</u>

April 24, 2008

Attendees:
Sarah Weammert
Tim Pilkowski

Tom Simpson
Mark Dubin
Susan White
Jack Meisinger
Greg Binford
Craig Yohn
Dean Hively

On phone:
Wade Thomason

Action Items:

ACTION: Precision agriculture is currently credited as nutrient management (NRCS code 590) and is not considered its own practice. There needs to be a new code or subcode based on intensity of management that captures precision agriculture. Mark Dubin is working on this.

ACTION: panel members will compile a list of tracking and reporting obstacles to be included in BMP report sent to CBP

ACTION Sarah: Ask Mark Alley and Wade for Virginia implementation

Is there research available to quantify pollution reduction of slow release and variable rate?
ACTION: There is field test data from PA on precision ag work. Mark has contacts at Penn State who he will contact for information. Sarah will contact Lynn Hoffman (retired?) – Doug Beegle – David Wagner (try first; dgw4@psu.edu; (814)865-3722). Penn State contacts precision ag; comparison data on research plots?
Williards in PA may have data but they are not using variable rates. Tim and Tom - Mark Twining from Williards– Tim has contact information; but may have issues with system matching up locations. Williards doing yield monitoring.
ACTION: Ask Southern States for data on precision ag. They have grid sampling on variable rate. Mark Fuchs (try 1st), Brian Schilling (Susan knows). Southern states has variable rate, lime, P and K.
ACTION: Tim Fullen, consulting in Charlotte NC (who Craig knows) has data on precision ag sampling, may have yield data; Craig will contact Tim and try to tease the data. Zone sampling w/ variable rate application of P and K and lime.
ACTION: Sarah will contact Farm Works for data– independent and run by farmer may have data. Like MD NRCS decision system.

There was some work done in forages evaluating the economic benefits. 600 acres and collecting more. Here levels by which variable rate is justifiable. Dr. Rayburn: knows critical levels and response by forage. ACTION ITEM – Craig will contact the scientist who did this experiment

NSC two years ago, show economic benefit of precision ag at field level in the Mid-west. Developed a simple computer model related to corn. Sarah - ACTION find NSC agenda/minutes

ACTION Mid-Atlantic Water Program (land grant universities) help organize groups to begin putting a package together that uses chlorophyll meters, green seekers, split application, and corn stalk N to analyze variable rate using Innovative grants from EPA administered by NFWF. Money coming out in July.

ACTION – for slow release product ESN, Mark knows the product personally and can discuss product with them.
ACTION – Greg has database on slow release products and will share it with the group.

NRCS has product list they provide to field technicians of 'approved' products. ACTION Tim will distribute list to group.

ACTION Sarah will find information on the PA law stating the effectiveness of a product must be proved before application of the product can occur.

Questions Posed to Panel:

There is a concern that overlap between precision agricultural techniques will occur, because nutrient use efficiency and slow release sources may generate the outcome of reduced application rates. Variable rate application (both spatial or temporal) will drive nutrient use efficiency, and temporal will reduce application rates. How do we avoid an overlap? Should we develop a "super" precision agricultural category/component that incorporates the benefits of all precision agriculture techniques and practices?

How does Decision Agriculture Technology differ or parallel our components of slow release and variable rate?

Could a benchmark ratio be established that identifies an individual farmer's success at achieving environmental stewardship based on fertilizer effectiveness? How would organic sources of nutrients (manures and biosolids) alter the ratio?

How do we account for climate issues with slow release?

How much variable rate is occurring? Will implementation increase in the near future?

What is the management philosophy (operationally) with variable rate? Ex – top yield 250 bushels with 150lbs of N. other area has 60 bushels with 150 lbs of N, how implement variable rate? Want test highest and lowest yield spots to determine how much N is needed. Ex – test strip on highest yield with increased N and no N, or low lbs of N, on lowest yield strip

Can we determine the percent reduction by asking the CBP to simulate percent reduction from the norm?

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Discussion

Tim Pilkowski, MD NRCS, reviewed MD's 'Precision Agriculture' Program.

Tier One:
$3/acre for a 3 year commitment; started in 2005 and took off in 2006;
Setbacks are based on CAFO regulations
This is the tier consultants really sell to producers

Tier Two, for 2008 called Enhanced Nutrient Management (nutrient application efficiency):
One time flat rate payment (paying to implement technology not the equipment, and not paying for testing). Typically pay for calibration of the equipment (ex -manure spreader) and also include an incentive.
Verify and document with signed statement stating calibrated with extension agent on this date.
PSNT and tissue sampling are encouraged and NRCS asks to see the test results

Tier Two B and C, Decision Support System:
Not one time payment
Complete operating system for the farm that evaluates type of crop, pesticide application, type of equipment used for tillage, etc. The robust record keeping system provides farmers with a decision making tool for the future.
Farmers are not required to utilize database, but when they do the data is anonymous. For example a farmer can view the data on hybrid crops, see how it was managed, and determine if it will work on their soil. This develops a benchmark.
The disadvantage is the cost. There is a lack of technical expertise for smaller fields. Tim is working with Suzy Friedman to bring in outreach and support. There are companies (Southern States, Williards, John Deere) that do provide this service, but most counties do not offer technical support.
Required to work through a third party. In PA Williards is collecting data and removing farmer identifiers. This data is on a server and one can log on and look at other producer data by county or watershed, but individual farm data is not available.

ACTION: Precision agriculture is currently credited as nutrient management (NRCS code 590) and is not considered its own practice. There needs to be a new code or subcode based on intensity of management that captures precision agriculture. Mark Dubin is working on this with a group made up of NRCS staff.

Can NRCS make reporting change and yield as requirement of program participation? Currently don't even document the practice – reported as code 590 (nutrient management). Document doing practice, but don't report on what changed, actions taken. Captured by Mark Dubin's work w/ Bay jurisdictions.

ACTION: Panel members will compile a list of tracking and reporting obstacles to be included in BMP report sent to CBP.

Group discussion:

What opportunities are there for nutrient reduction? What benefits and data do we have on slow release and variable rate? Do we have data providing increased nutrient use efficiency (NUE) in crop production? Is there actual data on reduced losses below the root zone and to surface water?

Is there research available to quantify pollution reduction of slow release and variable rate?

- ACTION: There is field test data from PA on precision ag work. Mark has contacts at Penn State who he will contact for information. Sarah will contact Lynn Hoffman (retired?) – Doug Beegle – David Wagner (try first). Penn State contacts precision ag; comparison data on research plots?
- Williards in PA may have data but they are not using variable rates. Tim and Tom - Mark Twining from Williards– Tim has contact information; but may have issues with system matching up locations. Williards doing yield monitoring.
- ACTION: Ask Southern States for data on precision ag. They have grid sampling on variable rate. Mark Fuchs (try 1st), Brian Schilling (Susan knows). Southern states has variable rate, lime, P and K.
- ACTION: Tim Fullen, consulting in Charlotte NC (who Craig knows) has data on precision ag sampling, may have yield data; Craig will contact Tim and try to tease the data. Zone sampling w/ variable rate application of P and K and lime.

ACTION Sarah: Ask Mark Alley and Wade for Virginia implementation

ACTION: Sarah will contact Farm Works for data– independent and run by farmer may have data. Like MD NRCS decision system.

When asking for data look for the average benefit by region served, not field level data. Coastal plain vs piedmont, etc.
In documentable fashion, what is the change in nutrient inputs?

Use to estimate impact:
DE may have little data
WV study – 12 farms, did conventional and precision sampling.

MD NRCS Environmental Quality Incentive Payments (EQIP) is cost shared for 3 years in hope farmer continues. May not be enough time to see benefit. After 3 years contract is over but MD NRCS may modify the EQUP program to extend the contract to 5 years to meet data needs. This will help the farmer target implementation and help us gather operational data FUTURE RESEARCH NEED.

Questions arose about how accurate variable rate equipment is. Susan White and Josh McGrath had trouble getting equipment calibrated when looking at N on corn. Problem was with the technology, the Apex system claimed it could import ESRI shape files but when Susan and Josh did this, the maps didn't match up. The other problem with the technology is will the user understand the technology enough to get files calibrated to the field?

Is variable rate population part of this? Simplify to something that can get reported in a useable form. Define a system as our approach. To qualify as precision ag requires some level of grid sampling or detailed sampling, good knowledge of variability of pH and nutrients in field, the ability apply nutrients at rate to meet soil needs and yield response data. Could also say this includes varying population density to meet plant available water, but this may not be a required aspect of the BMP framework. Tiered credit system by defining a system that includes a lower end of management intensity and recognize people who go above it. When go way above low end and credit new practice.

For the eastern US do we have enough science to determine an additional benefit in N and P use efficiency from precision ag/variable rate beyond what is achieved with nutrient management? Can we defensibly explain an increase in NUE because of precision ag? Or do we have reasonable evidence?

- Susan and Craig stated we don't have science to support variable rate as a nutrient reducing strategy that goes beyond nutrient management.
- There was some work done in forages evaluating the economic benefits. 600 acres and collecting more. Here levels by which variable rate is justifiable. Dr. Rayburn: knows critical levels and response by forage. ACTION ITEM – Craig will contact the scientist who did this experiment

- NSC two years ago, show economic benefit of precision ag at field level in the Mid-west. Developed a simple computer model related to corn. Sarah - ACTION find NSC agenda/minutes

Do have this kind of information beyond eastern US that shows changes in NUE?

- The principles are similar, but documentation insufficient (i.e., fuzzy and thin). P precision ag research has been going on for 10-15 years
- Data is very variable; lime in OH study show highly variable pH. Reality not like hypothetical soil. Look at tissue instead of yields.
- The wheat studies that Sarah posted are good, but they are not applicable to the Chesapeake Bay; don't have enough info for variable rate to give any improvement more than 5% over nutrient management.
- DECISION: Taking into account variability and uncertainty the benefit of slow release/variable rate is too low of an impact over nutrient management; with decision ag may be able to quantify behavior change.

Not enough data to segregate the precision agriculture management intensities.
PA range system – decision ag highest end range; precision ag includes basic elements of responsive system. Any given year value different based on crop response.
MD requires tier one to move into tier two.

Baseline - is 590 traditional nutrient management

Precision (not decision): encourage it and continue working to develop it.
FUTURE RESEARCH NEED: increase expectation of nutrient management – get into chlorophyll, stalk tests, split application of corn requirement.
Tom Morris (Connecticut) working with Environmental Defense, did cornstalk N tests and results will be available later. The panel recommends using this data as a FOLLOW UP STUDY for further refinements.

Recommendation from panel: look into ways to incorporate new practices in old nutrient management. Continue working on data on variable rate. New practices are; corn stalk nitrate, chlorophyll tests
Encourage group scientists to get together a package that documents our knowledge about different management levels and tools of nutrient management – chlorophyll meters, green seekers, split application, corn stalk N, variable rate – using Innovative grants from EPA administered by NFWF. Money coming out in July. ACTION Mid-Atlantic Water Program (land grant universities) help organize groups to begin putting a package together.

Slow release materials

Is it economically viable for agronomic crop use?
Jack – believes it is not economically viable agronomically; is this only for agronomic crops?
Tom – do need consider nursery?
Mark – not new use, been around for long time

Use NC journal article

There are many products coming out, but sticker price is high for some products. But one product called ESN is selling faster than production, developed and sold for corn belt. claim $.10 unit great than urea. Crop Production Services are selling ESN. ACTION – Mark knows personally and can discuss product with them.
ACTION – Greg has database and will share it with the group. Greg is determining if product can be as efficient as side dressing? On sandy soils no. some merit in other applications. If use as sidedress hadn't released in August and field showed nitrogen deficit - broke down too slowly. Applying on soil surface without residue not recommended because product floats in water and moved around. If apply pre-plant may be beneficial, release rate of product follows growth rate of corn. Greg lost a lot applying urea pre plant on sandy soils (80 bushels), ESN pre plant (150 bushels), urea side dress (170).
Alan Blaylock, contact for info – Greg has contact info

Enhance definition of nutrient management by adding language that requires sidedressing. In areas where you cannot sidedress, farmers should be using a proven product that slows down the release of N. However, who proves the effectiveness of the product needs to be discussed and approved.

Of different slow releases available are the prices the same?
Not sure

How much N put down pre plant to get same yield as if side-dressing with ESN? Total N application to corn crop if putting all down pre-plant, vs little starter and bulk as side-dress?
Can't answer.
Mass balance?
Don't have enough data to understand the mass balance.

Not creating new practice, setting up for future use – general recommendation is that you side dress. If not doing that need to do something to limit available of nitrate early in the season.
HIGHLIGHT
Side dress clearly preferred. If can't side-dress must do something to delay nitrification.

What is the effectiveness differences between knifing vs dribble? Best place to apply is a couple inches in soil substrate. Jack stated dribbling is not as efficient. Percent that knife it in is small – HIGHLIGHT add to the report that additional benefit to knifing over dribbling is observed.

NRCS has product list they provide to field technicians of 'approved' products. ACTION Tim will distribute list to group. Two years old, may be new products not included.
PA has law must prove efficiency of product before application. ACTION find that law, consult PA (Sarah)

Agricultural Nutrient and Sediment Reduction Workgroup Meeting Minutes
Chesapeake Bay Program Office; Annapolis, MD
August 5, 2008

Nutrient Use Efficiency
Nutrient Use Efficiency Report: http://archive.chesapeakebay.net/pubs/calendar/ANRWG_08-05-08_Handout_4_9618.pdf
Comments: http://archive.chesapeakebay.net/pubs/calendar/ANRWG_08-05-08_Handout_10_9618.pdf

- The panel recommended that the nutrient use efficiency practice have three subpractices:
    - Reduced application rate or buy down
    - Decision ag as a stand alone
    - Hybrid of reduced application rate and decision ag
- UMD/MAWP could not identify an easy way to have a simple efficiency.
- They recommended that an aggregate of data be used to determine what a typical improvement in efficiency is when the practice is implemented in a particular region. It would be preferable, however, if there were a mechanism that could actually show by area what the changes were in efficiency.
- They proposed that these practices be credited by providing an estimate of the change in efficiency. Under this approach, the input of nutrients into the watershed model would be changed based on either buy down or increased efficiency.
- This approach would be similar to the way nutrient management is applied in the model.
- Tracking may be an issue with this method.
- Comments/Suggestions:
    - Delete "stormwater officials" from the 2nd paragraph in the introduction.
    - Instead of saying that this practice reduces nitrogen pollution in the BMP Name Change section, this section should say "refines nitrogen use calibrated with yield potential with the ultimate goal of reducing nitrogen loss".
    - The three subpractices that they are recommending should be made clearer in the report. The hybrid subpractice should also be listed last.
    - What peer-reviewed science is being used to substantiate these three efficiencies?
        - UMD/MAWP does not have peer-reviewed literature for this practice.

    - If peer-reviewed literature is unavailable, the project's decision matrix says that other information can be used.
    - Many of their sources for this practice fall into the third category of best professional judgment (not peer-reviewed, not published).
    - The land grant universities did not offer UMD/MAWP any peer reviewed literature during this process.
- For the straight application reduction, what is the reduction being compared to?
    - The percentages indicate a reduction below field-level nutrient management plans.
- Concern was voiced over the reduced application rate/buy down subpractice:
    - If farmers decide to put less nitrogen on than is recommended for an economic incentive, then this is a farmer's economic decision. Why should it be a Bay BMP?
    - With the buy down concept, there is a problem with land use efficiency. If a farmer is going to grow less yield, then they will have to plant some other ground for economic return. Thus, this practice does not make any sense if a whole farm approach is not taken.
    - By endorsing this practice and giving it an efficiency, it seems like we are encouraging it when it may not be the best option.
    - UMD/MAWP is standing by their recommendation for the three different subpractices. It is up to the workgroup whether or not they decide to recognize a reduced application rate subpractice.
- Bill Angstadt suggested that Sarah and Tom look at Ron Mulford's work from UMD.
- What yields are being used in the model? If we are going to use these practices, we should be comparing them against current efficiencies and yields.
    - Mark Dubin said that the model uses an average of the yields over the calibration period (1985-2005).
- The guidelines infer that the design standards and manuals are not peer reviewed, but Beth Horsey said that this is incorrect and that they are peer reviewed.
    - Sarah Weammert said that these are the guidelines that they have been using since Year 1 of the project.
    - Tom Simpson said that this was a point that UMD/MAWP was scolded for by STAC last year.
- In the last sentence of the BMP Structure/Subcategories Interim section, the last sentence talks about split applications. Sarah agreed to caveat this with "where not already being applied with the nutrient management plan".
- Comments from Tom Juengst sent via email:
    - This could potentially be broken into separate BMPs or processes: 1) reduced N fertilizer; 2) expected yield assignment; 3) split application / side-dressing / alternative fertilizers (slow or hydrous); and 4) plant testing. Having a lot of ideas lumped together may not work as well.
    - This practice might work well if were developed into a program or process, and not just a BMP.
    - Equipment, yield monitoring, measurement, field, pest, and weather variability make a big difference.
    - Too much or too little water affects yields about half the time.

- There has been talk of just starting the reduced N fertilizer at 5% to get things started, which is an okay chunk of fertilizer not listed.
- Variable rate would go under Precision Ag.

ACTION: Tom Simpson and Sarah Weammert will make the minor editorial changes suggested by the workgroup. They will also consider the workgroup's other comments, although they said that they are standing by their decision to recommend the three subpractices.

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Agricultural Nutrient and Sediment Reduction Workgroup Meeting Minutes
MD NRCS Office; Annapolis, MD
August 19, 2008

Nutrient Use Efficiency

Report: http://archive.chesapeakebay.net/pubs/calendar/ANRWG_08-19-08_Handout_9_9619.pdf

- This BMP improves the efficiency of production by reducing the amount of nutrients needed per bushel.
- How would this BMP efficiency be incorporated into the model? What types of records/data will be needed?

- Tracking and reporting is an issue.
- Q: If we have a yield increase with the same nutrients applied, can this be added into the model?
    - A: Gary Shenk said that this would probably be possible. Incorporating changing uptakes into the model should be pretty straight forward if they have the information. After this is incorporated, however, they will need to check and make sure that the model is handling it correctly.
- It would be useful to have some estimate of how yields are changing overtime.
- Tom Simpson said that there are databases that show how people have changed their fertilization patterns and the yield changes that have occurred. We could possibly work with those companies to determine what the average change in efficiency was over the last x years.
- Overtime, maybe we could even get to the point where we are using the yield in a specific year, rather than average yield over the calibration period.
- Gary Shenk said that the model is expecting a time series of yields. Olivia Devereux can add this trend into Vortex.
- The maximum uptake allowed in the model could be increased for decision agriculture.
- A crop uptake efficiency is needed. It was also pointed out that it may be necessary to look at the ratio of nutrient input to uptake.
- This BMP seems like it would be a subcategory of nutrient management.
- UMD/MAWP assumed that the starting point for decision agriculture is nutrient management.
- One tracking and reporting issue is that MDA and NRCS are not reporting levels of nutrient management. MD NRCS said that they will not attempt to change this until these efficiency recommendations are final. In order to change this, they will need to propose a regional or national change.
- If this method were used, decision agriculture would only be applied to nutrient management acres and there would be a multiplicative effect.
- One option that UMD/MAWP recommends is that we work with existing databases to determine the average change in efficiency over the last x years, perhaps by region.
- General information could be used to get an average reduction. Some of the database companies, such as Willards, said that they would share their general information with UMD/MAWP.
- NRCS can get the data for the farms that they work with, but there are other farms that don’t work with NRCS that do this practice and should also be credited.
- The information from Willards would just be used to give us an idea for a number. This number could also be applied to others that are implementing similar practices but are not working with Willards.
- How would we track the acres for farms that are not working with Willards? Could MDA do this?
    - Renato Cuizon said that MDA’s reporting system could be customized to get this type of information.
- The definition in the report should clearly say what needs to be done for an acre to qualify as decision agriculture.

- MD NRCS defines decision agriculture in their EQIP program. In addition, they also determine which software programs qualify for this practice
- Could we use Willards database to figure out the average reduction that farmers get when they follow a list of practices?
- Some members felt that this BMP should not be narrowed down to a few specific practices. Decision agriculture is based on the decision making process, and not a specific list of practices that need to be used.
- One option may be to say that the people participating in a specific program saw this improvement efficiency, and than make some sort of comparison that says that other programs of comparable intensity would be expected to result in comparable improvements in efficiency until such time when better information is available.

- Suggested revisions:
  - Add the MD NRCS definition into the report.
  - State in the report that we accept the NRCS definition for decision agriculture on a state-by-state basis.
    - Mark Dubin and Tom Simpson will talk with the NRCS offices in the other Chesapeake Bay watershed states to see if they are comfortable with this.
  - Include a statement that says that the software review process is an important component of this practice, thus each state would need to have a software approval process.
  - UMD/MAWP should work with Willards to come up with a number.

ACTION: Tom Simpson and Sarah Weammert will revise the Nutrient Use Efficiency BMP report based on today's discussion. The revised report will be sent to workgroup members in advance of the September 3rd workgroup meeting.

ACTION: The workgroup should make a recommendation to national NRCS asking them to develop a way for subcomponents of the 590 standard to be reported.

ACTION: At the workgroup's September 3rd meeting, members will review the revised nutrient use efficiency report and they will finalize their recommendation to the Watershed Technical Workgroup and the Nutrient Subcommittee.

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Minutes: Agricultural Nutrient and Sediment Reduction Workgroup
September 3, 2008

Nutrient Use Efficiency

- Suzy Friedman sent recommendations to Tom and Sarah before the meeting saying that she was not comfortable with the hybrid approach. She recommended starting with a flat rate reduction but use adaptive management techniques to reach that.
- Tim Pilkowski does not think decision agriculture can be included in the report as is because each state defines it differently. He suggests keeping the straight application reduction with different levels of management.
- Decision agriculture would replace enhanced nutrient management.
- The NRCS 590 standard for nutrient management includes application rates, timing, and placement but only rate is considered in the UMD/MAWP nutrient use efficiency report.
- Bill Rohrer wants greater clarity about the practices involved in nutrient use efficiency.
- Tom Juengst was not pleased with a two tier approach.
- Beth Horsey agreed that more discussion is needed on nutrient use efficiency.

DECISION: The AgNSRWG wants clearer definitions, efficiencies, and methodologies for tracking and reporting nutrient use efficiency practices. They need more discussion on this BMP before making a decision.

ACTION: Dave Hansen will work with Jeff Sweeney to find out what his model needs are in the way of nutrient use efficiency practices. Then, the Workgroup will reconvene to make a decision.

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Chesapeake Bay Program Nutrient Subcommittee
October 22, 2008 Meeting

SUMMARY OF DECISION, ACTIONS AND ISSUES

Nutrient Use Efficiency

- The Nutrient Use Efficiency (NUE) BMP had two reports. The Agricultural Nutrient and Sediment Workgroup proposed an interim efficiency for model runs to come up with a number based on various scenarios. Their proposal can be found on Year 2 BMP Draft Effectiveness Estimates.
    - The final sentence of this document should be deleted.
- UMD/MAWP's NUE report recognizes that it is still a work in progress. The development of an effectiveness estimate is delayed because a new panel is being convened. The new panel has been organized and will be led by Frank Coale, University of Maryland-College Park.
- Russ Perkinson stated that most of the concern was about the nutrient use efficiency portion of the report. The write-up about the rate reduction part was not much different from the way nutrient management is currently handled.
- Jeff Sweeney said that we need to run the Tributary Strategies through the Phase 5.1 model. Jeff does not know what to do with nutrient management, one of the biggest hitters in the

watershed. The Strategies have traditional nutrient management, enhanced nutrient management, and one level in between. Jeff would like to know if the NUE recommends three levels of efficiencies.

- Sarah Weammert clarified that the NUE BMP is the same thing as enhanced nutrient management.
- States will report to Jeff Sweeney what percent reduction they have for nutrient management. It is up to the states to track acres under various percentages, otherwise all nutrient management acres reported will receive the state's default reduction.

- Dave Hansen suggested deferring the nutrient use efficiency BMP to the new panel, which will be provided with the Nutrient Subcommittee members' comments based on today's discussion.
  - The panel's recommendation will then be reviewed by the Agricultural Nutrient and Sediment Reduction Workgroup, then the Watershed Technical Workgroup, and, finally, the Nutrient Subcommittee.
- Jeff Sweeney reminded the group that he needs to know draft numbers for the nutrient use efficiency in order to complete the Tributary Strategy model runs.
  - Rich Batiuk responded that we will have to rely on the old nutrient management numbers, and caveat the model run results with that information.

DECISION: The Nutrient Subcommittee decided to defer the nutrient use efficiency BMP for further review to a new expert panel. The panel's recommendation will then be reviewed by the Agricultural Nutrient and Sediment Reduction Workgroup, Watershed Technical Workgroup, and Nutrient Subcommittee prior to forwarding a recommendation to the Water Quality Steering Committee for final approval.

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Minutes: Watershed Technical Workgroup
October 6, 2008

I. Year 2 Practice and Program Definitions and Effectiveness Estimates

Sarah Weammert, UMD MAWP, presented their recommendations as approved by the source area workgroups for a select list of new, Year 2 BMPs. Year 2 BMPs include ammonia emission reduction, dairy precision feeding, pasture management for dairy, beef, and livestock, horse pasture management, mortality composting, and infiltration and filtration practices.

Nutrient Use Efficiency

- The nutrient use efficiency practice will not be ready for review for another couple of weeks.

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Nutrient Subcommittee Meeting
Chesapeake Bay Program Office; Annapolis, MD
January 21, 2009

IV. Review of Year 2 BMP Definitions and Effectiveness Estimates Hansen

Attachment C: Year Two BMP Approval Status

- The Nutrient Subcommittee reviewed the proposed definitions and effectiveness estimates for the Year 2 BMPs.
- The remaining four BMPs are still being revised and have not yet been approved by the Nutrient Subcommittee and its workgroups. A status update was provided for each of these BMPs:
    - **Nutrient Use Efficiency:** Members of the AgNSRWG and NSC had concerns with the NUE recommendation. A panel is currently being reconvened to revise these recommendations to address these concerns. The new panel will be chaired by Frank Coale, who is with the University of Maryland. This panel will consist of many of the original panel members, plus several new members who will fill in some of the gaps that were identified in the original panel. Bill Keeling, Watershed Technical Workgroup Chair, and Dave Kindig, AgNSRWG Chair, will also participate in the panel in order to represent their respective workgroup's interests. This panel will have their first meeting during the first week of February. Panel members will be given the original report, all of the comments that have been collected, and some new information that Mark Dubin has pulled together. They will then draft a new recommendation. Once this new recommendation has been developed, it will be presented to the AgNSRWG, the Watershed Technical Workgroup, and the Nutrient Subcommittee.

ACTION: The remaining Year 2 BMP definitions and effectiveness estimate will be revised and presented to the source Workgroups, the Watershed Technical Workgroup, and the Nutrient Subcommittee at a later date for review and approval. These BMPs were dirt and gravel road erosion and sediment control; horse pasture management; dairy, beef, and livestock pasture management; and nutrient use efficiency.

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CHESAPEAKE BAY PROGRAM
WATER QUALITY STEERING COMMITTEE
January 26, 2009 Conference Call

SUMMARY OF DECISIONS, ACTIONS, AND ISSUES

Review and Approval of the Recommended Year 2 BMPs and Efficiencies

Dave Hansen, Nutrient Subcommittee Chair, reviewed Attachment A and updated the Steering Committee on the status of the review process for Year 2 University of Maryland Mid-Atlantic Regional Water Program (UMD/MAWP) BMPs.

Review of Year 2 UMD/MAWP BMP Effectiveness Estimates

- Dirt and gravel roads, nutrient use efficiency, horse pasture, and other pasture BMPs are still under development and review.

- These final BMPs will likely be reviewed b the Nutrient Subcommittee in March and Water Quality Steering Committee in April.
- In the meantime, placeholder values will be used for the model calibration.

ACTION: The Nutrient Subcommittee will bring the remaining set of Year 2 BMPs—dirt and gravel roads, nutrient use efficiency, horse pasture, and other pasture—back to the Water Quality Steering Committee in April for final review and approval by the Steering Committee.

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