Quick Reference Guide for Best Management Practices

Nonpoint Source BMPs to Reduce Nitrogen, Phosphorus and Sediment Loads to the Chesapeake Bay and its Local Waters

Chesapeake Bay Program
Science. Restoration. Partnership.

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For individual BMP reference sheets:

Chesapeake Bay Program. Title of specific BMP reference sheet. *Chesapeake Bay Program Quick Reference Guide for Best Management Practices (BMPs): Nonpoint Source BMPs to Reduce Nitrogen, Phosphorus and Sediment Loads to the Chesapeake Bay and its Local Waters,* version date of the specific BMP reference sheet.

Example:

Chesapeake Bay Program. A-3: Conservation Tillage. *Chesapeake Bay Program Quick Reference Guide for Best Management Practices (BMPs): Nonpoint Source BMPs to Reduce Nitrogen, Phosphorus and Sediment Loads to the Chesapeake Bay and its Local Waters,* MONTH DD, YYYY.

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A note on the reference sheets: Sheets marked TBA have not yet been written but will be available in future editions of this guide.

Introduction

About the Chesapeake Bay Program

The Chesapeake Bay Program (CBP) is a regional partnership that leads and directs Chesapeake Bay restoration and protection. CBP partners include federal and state agencies, local governments, non-profit organizations and academic institutions.

The CBP has a number of goal teams, advisory committees and workgroups to facilitate its partners' coordinated efforts (Figure 1). The Water Quality Goal Implementation Team (WQGIT) works to evaluate, focus and accelerate the implementation of practices, policies and programs that will restore water quality in the Chesapeake Bay and its tributaries. Those involved in the WQGIT and its numerous workgroups are among the individuals most deeply involved with implementation, tracking and reporting of best management practices (BMPs) to reduce nitrogen, phosphorus and sediment loads to the Chesapeake Bay.

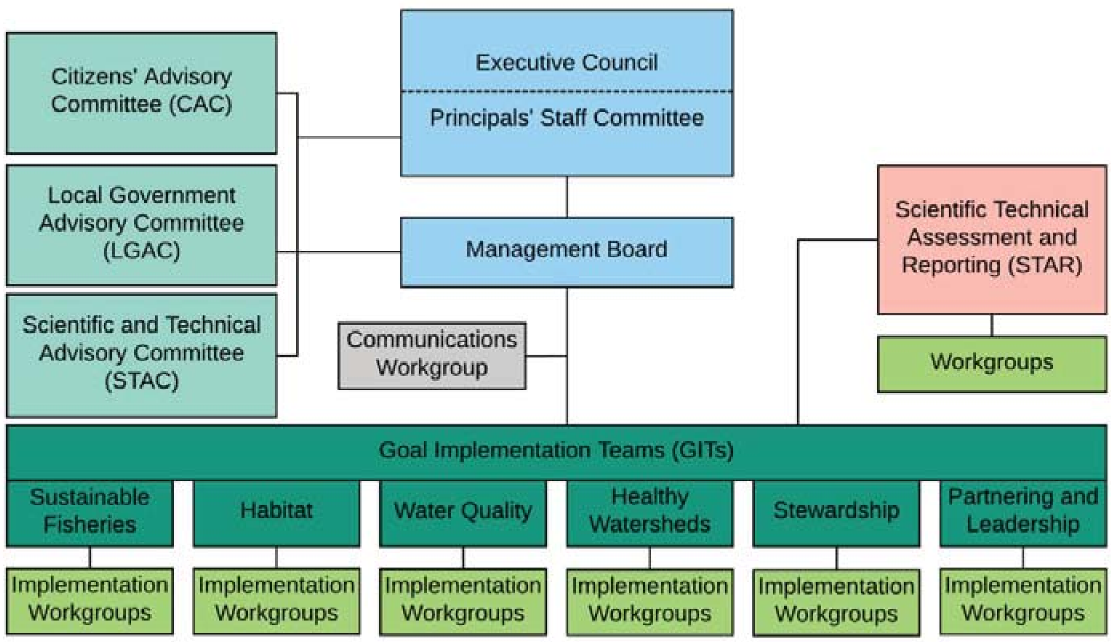


Figure 1 - Chesapeake Bay Program organizational structure

About this Guide

There are countless individuals involved at some stage of the BMP implementation, tracking and reporting process who are responsible for a wide range of tasks, of which Bay-related activities and BMPs may only be a small piece. These individuals rarely or never interact directly with the CBP groups depicted in Figure 1 and this exacerbates the challenge of understanding the modeling tools and practices available to reduce nutrient and sediment loads to the Bay.

As of fall 2017, the CBP partnership has over 200 best management practices (BMPs) for accreditation in the Phase 6 Chesapeake Bay Watershed Model (Watershed Model). Some BMPs, such as cover crops, have numerous individual variants, but even when those individual BMPs are grouped for simplicity, there are dozens of BMPs for partners to consider in the development of their Phase III Watershed Implementation Plans (WIPs) and beyond.

Coordination, planning and implementation by state, regional and local partners is strengthened when all parties have a consistent understanding of CBP-approved BMPs that are eligible for nitrogen, phosphorus and sediment reductions toward their Phase III WIP planning targets. However, basic key information about these BMPs and how they fit within the Watershed Model – while publicly available online – is scattered among lengthy reports, appendices and dense spreadsheets. This adds further confusion to already complex processes for Phase III WIP development, two-year milestone development and annual BMP reporting.

There are examples of explanatory materials that are more accessible to those who want a clearer sense of the basic elements of specific CBP-approved BMPs, e.g., Chesapeake Stormwater Network fact sheets. Unfortunately, this kind of accessible information does not exist for all sectors and all BMPs, particularly BMPs reviewed and approved prior to 2012. Therefore, CBP partners expressed interest in the development of a guide with basic information for each CBP-approved BMP summarized in a brief and consistent format.

The main purpose of this guide is to provide summarized profiles for each CBP-approved BMP in the Watershed Model. Each profile—or reference sheet—includes:

- General information about a BMP;
- How a BMP functions within the Watershed Model;
- What's needed for the BMP to be reported for annual progress submissions; and
- Links to additional information for readers who want more detailed information about the practice.

Implementation aspects of a practice such as cost, potential ecosystem co-benefits or impacts, maintenance or funding sources are not discussed in the reference sheets because they vary by region, state or local area.

The reference sheets are grouped according to their affiliated source sector in the Watershed Model (agriculture, stormwater and septic). Some BMPs, such as stream restoration, may appear in multiple sections. The overall document is organized to allow for the addition of new BMPs, as well as for revisions to existing BMPs in the Watershed Model. BMP sheets are available for download both individually and in more aggregated formats (e.g., whole guide and by sector).

Understanding Best Management Practices and the Phase 6 Chesapeake Bay Watershed Model

The focus of this guide is how BMPs fit within the overall model framework. This overview offers context needed to understand technical elements in each BMP reference sheet. The description of how BMPs are simulated intends to be almost comprehensive when it comes to important concepts, but does not explain certain details covered in the Watershed Model documentation. Readers interested in detailed technical documentation should consult the online resources in Table 1, particularly the Phase 6 Model Documentation and Chesapeake Assessment Scenario Tool (CAST).

Table 1 - List of online tools and resources for additional information or detailed documentation

Resource	Brief description of what the resource includes	URL
Phase 6 Watershed Model documentation	Complete documentation and appendices about the Phase 6 Chesapeake Bay Watershed Model.	http://cast.chesapeakebay.net/Documentation/ModelDocumentation
Chesapeake Assessment Scenario Assessment Tool (CAST)	This online tool can be used for planning purposes. Users can create and evaluate scenarios of various BMPs to estimate loads and load reductions for a geographic area of interest. The CAST website also provides extensive documentation for users and is updated periodically.	http://cast.chesapeakebay.net/
BMP expert panel reports	BMP expert panel reports approved since 2012 are posted as "publications" on the Chesapeake Bay Program website. A "BMP Expert Panels" group page compiles these together under "Publications." Links to individual reports are provided in the corresponding BMP reference sheet.	http://www.chesapeakebay.net/groups/group/bmp_expert_panels
Simpson and (Weammert) Lane (2009)	This report was developed by Tom Simpson and Sarah (Weammert) Lane of the Mid-Atlantic Water Program. The report and process served as a model for the current BMP Protocol and expert panel process. Many current BMP definitions and effectiveness values are included in this report.	http://archive.chesapeakebay.net/pubs/BMP_ASSESSMENT_REPORT.pdf

What is the Watershed Model?

The CBP and its partners have worked together since the 1980s to improve computer modeling tools that simulate the Chesapeake Bay and its 64,000 square mile watershed. The watershed has a land-to-water ratio of 17 to 1, higher than any estuary in North America, which illustrates that water quality in the Bay itself is greatly influenced by actions on the land and the condition of its watershed. The CBP uses the Watershed Model to understand and simulate changes in loads of nitrogen, phosphorus and sediment to the tidal portion of the Chesapeake Bay due to management actions implemented in the watershed.

The Watershed Model represents the latest iteration in the partnership's efforts to improve the modeling tools used to track progress toward water quality goals. Since the release of the Chesapeake Bay Total Maximum Daily Load (Bay TMDL)—which established nutrient and sediment targets for each Bay jurisdiction—since 2010 the Watershed Model has been instrumental in evaluating progress toward pollution reduction targets.[1]

[1] For more information on the Watershed Model's use in the TMDL, refer to the TMDL documentation, particularly Section 4 for the modeling of the inputs, Section 5 for the modeling of the physical setting, and Section 6 for the specifics on how they were used to set the TMDL. Available online at: https://www.epa.gov/chesapeake-bay-tmdl/chesapeake-bay-tmdl-document

Watershed Implementation Plans (WIPs) are plans for how the Bay jurisdictions, in partnership with federal and local governments, will achieve the Bay TMDL allocations and planning targets. Phase I WIPs were developed in 2010 to inform the Bay TMDL allocations. Phase II WIPs were developed in 2012 to meet nitrogen, phosphorus and sediment planning targets based on updated information in the Phase 5.3.2 Watershed Model. Phase III WIPs will be developed in 2018-2019 using the Phase 6 Watershed Model.

What does the Phase 6 Watershed Model do?

The Watershed Model has been designed through extensive, long-term collaboration by the CBP partnership. The history of the partnership's efforts, modeling philosophy and purposes of the Watershed Model are described in Section 1 of the Watershed Model documentation.

A primary use of the Watershed Model is to predict changes in loads entering the Chesapeake Bay due to management actions in the watershed. The model simulates loads from a range of source sectors, including agriculture, wastewater, developed and natural areas. To do this, the model uses a large amount of data to simulate the application, fate and transport of nitrogen, phosphorus and sediment in their journey from the field, lawn or forest to the stream, river and ultimately to the tidal Chesapeake Bay (Figure 2).

The Phase 6 Watershed Model at a glance

A simplified conceptual understanding of the overall model structure makes it is easier to understand how BMPs function within the model. Figure 2 shows the basic structure of the model. The processes represented correspond to separate domains that exist across the landscape of the watershed as pollutants move from a field to stream, stream to river, and from river to the Bay's tidal waters.

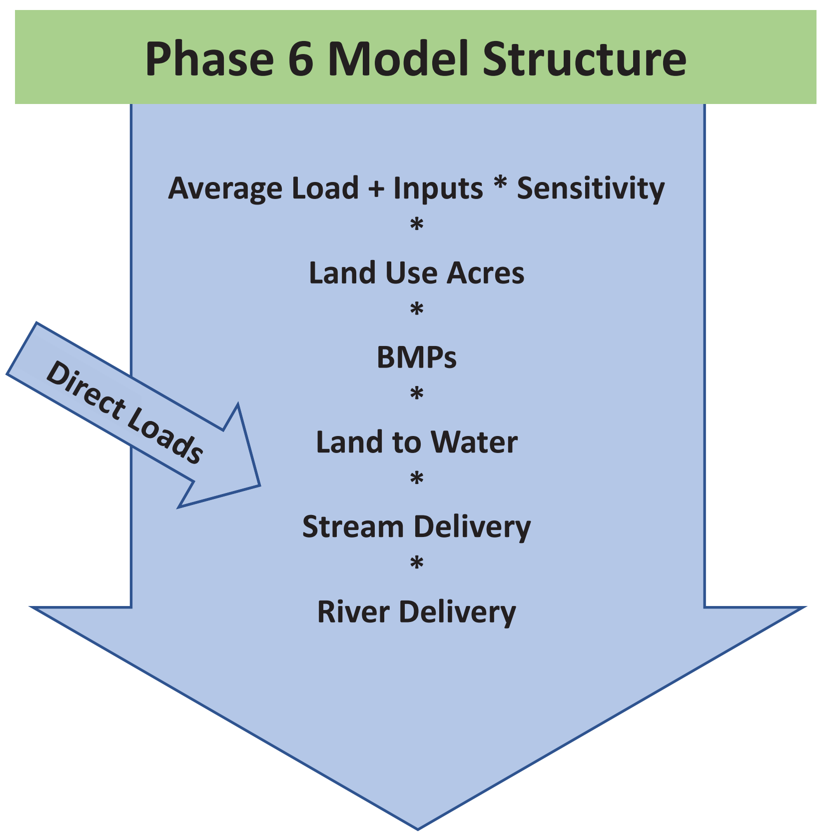


Figure 2 - Phase 6 Watershed Model Structure: If the model is considered as a single equation, each step above is a coefficient determined using the available information.

Average Loads are loads per acre for each land use averaged across the entire Chesapeake Bay watershed. Average loads are not true edge-of-field loads, but average for what would reach a small stream.

Inputs are the applications to the landscape of nutrients from atmospheric deposition, fertilizer, manure and biosolids. *Delta inputs* are the difference between the inputs to the land use in the local area and the Chesapeake Bay-wide average input.

Sensitivities are the Chesapeake Bay-wide average change in export load to a stream for each unit change for an input load.

Export loads are the net loads of nitrogen, phosphorus and sediment for a land use once the average loads, inputs and sensitivities are factored in.

The top line in Figure 2 therefore represents the loads exported from a land use to a stream in a land segment taking into account local applications, but not local watershed conditions. Those loads are then multiplied by the area of the land use in the segment (**Land Use Acres**); the effect of local **BMPs,** which act to decrease the loads; and local **Land to Water** factors.

Land to Water factors account for spatial differences in loads due to physical watershed characteristics, such as the available water capacity of soil and groundwater recharge. Land to Water factors do not add or subtract to the loads over the Chesapeake Bay watershed, but instead add spatial variance for nutrient transmission.

The application of the above factors results in an estimate of loads delivered to a stream or waterbody in a land-river segment.

Next, **Stream to River** factors are applied to account for nutrient and sediment processes in streams with average flow less than 100 cubic feet per second. These are attenuation factors that act to reduce nutrient delivery in the small, non-modeled streams as the loads move to the boundary of the larger modeled river reaches.

River Delivery factors account for nutrient attenuation processes in the larger, modeled rivers as loads move to the estuary.

Direct Loads are loads that do not come from the land surface or subsurface. Point sources (e.g., waste water treatment plants) and livestock deposition directly into the stream fall under this category. Depending upon their location, direct loads may enter the conceptual model either before or after application of Stream or River Delivery Factors, though Figure 2 is simplified by only showing the direct loads preceding Stream Delivery.

Interested readers may, for an increased understanding of the individual modeling factors, see the Phase 6 Watershed Model documentation.

How to use the BMP Quick Reference Sheets

Each BMP reference sheet is comprised of elements intended to provide key "bottom-line" information about the practice as currently defined and understood by the CBP partnership. This section outlines each element listed in the BMP reference sheets and provides a brief statement of what information is provided by that element.

Practice Description

This is a brief narrative description of the practice(s). It is not the CBP-approved definition for modeling and reporting purposes.

CBP Definition(s)

These are the most recent BMP definitions adopted by the CBP partnership for purposes of tracking progress toward nutrient and sediment goals under the TMDL. Some reference sheets have more than one BMP definition in cases where there is more than one category. Sometimes within a specific BMP or BMP category (e.g., see A-4: Cover Crops – Traditional) there are numerous variations of specific practices that fall within the definitions. The reference sheets may provide the definitions of other terms that are not BMPs to help further understanding. For example, A-3: Conservation Tillage provides a definition of "conventional tillage" to help gain knowledge of conservation tillage BMPs.

> *Watershed Model BMP Name:* Current CBP definition of the practice (or related term) as determined by the most recent BMP expert panel or partnership decision.

The general format is better understood with an example (from A-3: Conservation Tillage):

> *Conventional Tillage:* Any tillage routine that does not achieve 15 percent crop residue coverage immediately after planting is considered conventional tillage and does not qualify as a BMP.
>
> *Low Residue Tillage:* A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain 15 to 29 percent crop residue coverage immediately after planting each crop.
>
> *Conservation Tillage*: A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain 30 to 59 percent crop residue coverage immediately after planting each crop.
>
> *High Residue, Minimum Soil Disturbance Tillage*: A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain at least 60 percent crop residue coverage immediately after planting each crop.

Specifications or Key Qualifying Conditions

Qualifying conditions are parameters necessary to meet the definition or intent of the BMP. When a BMP expert panel defines a practice and its ability to reduce nutrients and sediment, those expected reductions assume that the practice functions or performs as intended. This means the practice must meet criteria or qualifying conditions recommended by the panel as a part of the practice definition, if any. For example, a 15 to 29 percent residue coverage is a qualifying condition for the Low Residue Tillage BMP described in A-3: Conservation Tillage.

For each reference sheet, this brief paragraph notes key qualifying conditions described by BMP panels but is not a comprehensive list of what may be described in the full BMP panel report, existing state practice standards or other sources of reference. Ultimately, the jurisdictions determine their own expectations, standards and specifications for BMPs that are implemented to meet their TMDL goals. For example, each state has its own Stormwater BMP Manual that explains specific engineering standards and specifications for stormwater practices.

Nitrogen, Phosphorus and Sediment Reductions

A summary of the nutrient and sediment reductions attributed to the BMP in the Watershed Model is provided here, in narrative or tabular format, or both.

Applicable Land Use Types (or other load sources) Treated by the BMP

Every BMP is applied to specific land uses or attributed to another load source in the Watershed Model. This element notes which land uses or other sources the practice can treat.

Brief Description of BMP Simulation in the Model

This provides a brief narrative description of what BMP type the given practice is simulated as in the Watershed Model (e.g., effectiveness value, land use change, etc.). More information about BMPs and the various types of BMPs simulated in the Watershed Model is available in Appendix A.

- *Annual or Cumulative?* Annual BMPs (e.g., cover crops, street sweeping) have a one-year credit duration in the Watershed Model and the amount of implementation must be reported every year. Cumulative BMPs are often structural or associated with longer term management, such as A-6: Animal Waste Management Systems, A-23: Tree Planting (Agricultural). Each answer will include the credit duration of the BMP in parentheses, which is the amount of time that a practice will remain in model simulations until it is verified and re-reported through NEIEN. Credit duration is different than the lifespan of a practice. The lifespan of some practices can be ten to thirty years, or more, depending on the engineered design or contractual agreements.
- *Can this practice be combined with other BMPs?* The answer to this question specifies whether or not the BMP is considered "stackable." A stackable BMP can reduce loads from the same land use or load source as other BMPs in the Watershed Model, which means it is not mutually exclusive of other practices and can therefore overlap with other practices or that other practices can subsequently apply (see Appendix A for more information).

Key Elements for State BMP Reporting through NEIEN

Each reference sheet summarizes the specific information needed to report the practice through NEIEN. This is intended to help jurisdictional partners that manage data for eventual submission to NEIEN. This same information about NEIEN reporting elements is found in the Technical Appendix of recent BMP panel reports.

- *BMP Name:* The specific BMPs available in NEIEN are listed here. Many BMPs are split in NEIEN according to the various animal types, land sources or hydrogeomorphic regions to which they can be applied. This sometimes makes it impossible to list every variation of the BMP available in NEIEN, but the most common or default practices will be listed as those are the most useful to the average reader.
- *Measurement name:* Each BMP is associated with certain units of measurement that should be reported (i.e., acres, feet, pounds, tons, number of animals, number of animal units, etc.). The units needed for the given BMP are listed here.
- *Load Source:* Load sources on which the BMP can be reported, if applicable. Not applicable for animal BMPs.

- *Geographic location:* Scales at which the BMP can be reported, e.g., hydrologic unit code (HUC), county, etc.
- *Date of implementation:* Date associated with installation or observation of the BMP.

Synonymous BMP names for Watershed Model, NEIEN and other sources

Each reference sheet includes a table that compares synonymous BMP names used by the CBP for the Watershed Model, in NEIEN and from other common sources such as NRCS Conservation Practice Standards. It is important to remember that definitions of nonpoint source BMPs in the reference sheets are used by the CBP to track progress toward water quality goals under the TMDL. The terminology and definitions used for this purpose are described by expert panels and agreed to by the CBP so that the partnership's definitions are consistent across the jurisdictions for BMP tracking and reporting. However, there are often programs at a national, regional, state or local level that use similar terminology in slightly different contexts or with subtle differences in definitions. It is not possible to clarify every possible term or name used for practices in various contexts, but the table should provide at least some clarity for readers attempting to understand how the CBP's name for a BMP might relate to terminology or an NRCS Conservation Practice Code they are more familiar with.

Table 2 – Example Table of Synonymous BMP names for Watershed Model, NEIEN and other sources. Modified from Reference Sheet A-3: Conservation Tillage for this example.

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Low Residue Tillage	Reduced Tillage	Residue and Tillage Management, No-Till (NRCS 329)*
Conservation Tillage	Conservation Tillage Mulch Tillage No Tillage Ridge Tillage	Residue and Tillage Management, No-Till (NRCS 329)* Residue and Tillage Management, Reduced Till (NRCS 345)*
High Residue, Minimum Soil Disturbance Tillage	High Residue Tillage Management	Residue and Tillage Management, No-Till (NRCS 329)*

**Sometimes a practice that is cost-shared and implemented using a NRCS Conservation Practice Standard meets the BMP definition and conditions of the CBP. However, there are cases when a NRCS Conservation Practice Code can potentially meet the CBP definition but does not automatically fulfill the definition. In this example, NRCS 329 (Residue and Tillage Management, No Till) can potentially meet any of the three BMP definitions used by the CBP, but the jurisdiction needs to verify how many acres meet which definition, if any. Similarly, NRCS 345 (Residue and Tillage Management, Reduced Till) does not automatically fulfill the CBP's definition of Conservation Tillage, but the jurisdiction can verify how many acres meet the definition.*

Additional Information

This section provides links to more detailed information relevant to the practice, such as the latest BMP expert panel report, fact sheets, webpages or other resources. The number of links provided on a given reference sheet may vary based on suggestions from workgroups, space limitations and the long-term usefulness of the information.

Version and History Statement

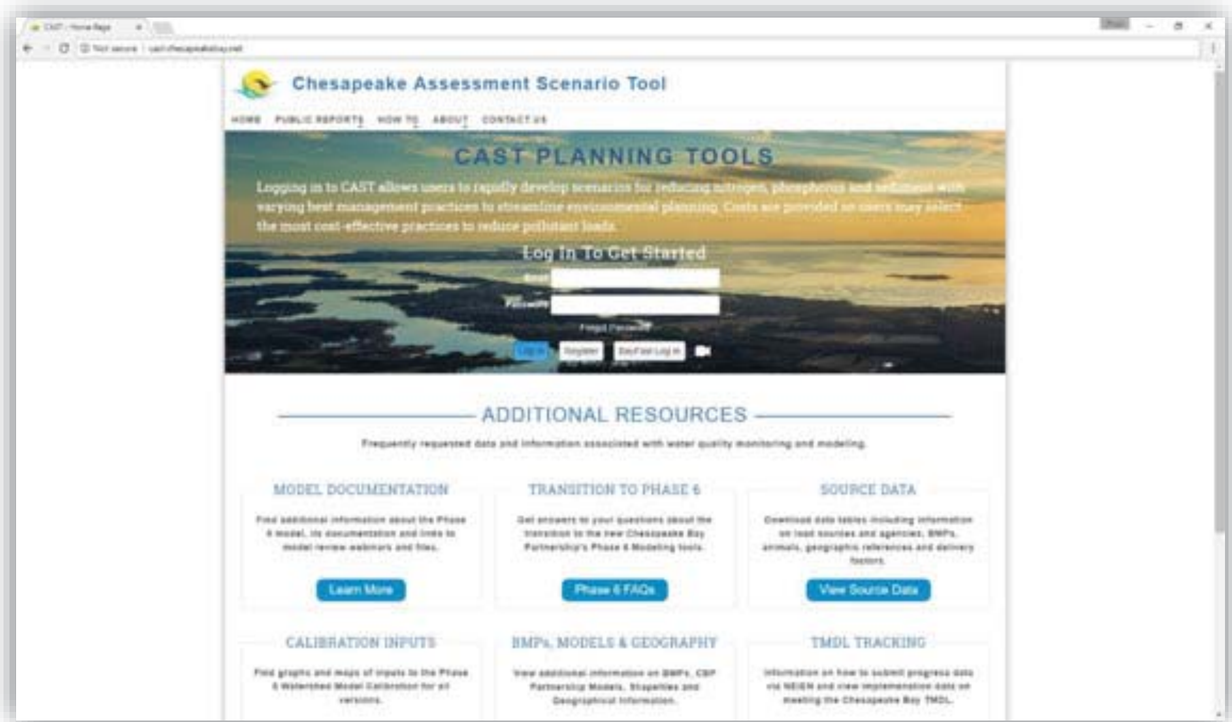
The CBP has a long history of evaluating the effectiveness of BMPs to reduce nitrogen, phosphorus and sediment loads. The partnership often revisits existing BMPs and also evaluates new, innovative BMPs when new science and research is available to determine what reductions are scientifically reasonable and defensible. A statement at the end of each reference sheet will inform the reader when the BMP was most recently evaluated and approved by the partnership, followed by a short statement that all

BMP definitions and effectiveness estimates are subject to potential future reviews in accordance with the BMP Protocol (see Appendix A).

> This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in MONTH YEAR.
>
> All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

Chesapeake Assessment Scenario Tool (CAST)

http://cast.chesapeakebay.net/



What is CAST?

The Chesapeake Assessment Scenario Tool (CAST) is a web-based nitrogen, phosphorus and sediment load estimator tool that streamlines environmental planning. It is identical to the Watershed Model.

Users specify a geographical area and then select BMPs to apply on that area. CAST builds the user's scenarios—or sets of planned or implemented BMPs—and provides estimates of nitrogen, phosphorus and sediment load reductions. The estimated cost of a scenario is also provided so that users may select the most cost-effective practices to reduce pollutant loads.

Would CAST help me?

Local jurisdictions and states use CAST for their WIPs, two-year milestones and even local TMDLs. Any user may see the source of the data that was used in developing the TMDL and the state's most recent annual progress scenario, milestone and WIP. This allows involvement of the counties and other local planners in the Bay TMDL.

How do I sign up and learn to use it?

CAST is easily accessible online at http://cast.chesapeakebay.net/. It is free to register and create an account to create and run scenarios, and users can view model documentation, download public loads or BMP reports or source data without an account. Archived training webinars and other instructive materials are available on the website to teach new users how to use the tool. Learn more about CAST here: http://cast.chesapeakebay.net/about

The National Environmental Information Exchange Network

The National Environmental Information Exchange Network (NEIEN) is a state-federal data-sharing partnership by which environmental information can be shared, integrated, analyzed and reported without having to take possession of the data. Within the CBP, NEIEN is an internet- and standards-based tool for securely exchanging non-point source BMP information between jurisdictional partners and EPA through a system of "nodes" that communicate and handle requests.

A designated agency within each jurisdiction handles BMP submissions into NEIEN, including annual submissions to track progress toward TMDL targets. Any implementation within a jurisdiction should be submitted to the state NEIEN lead. This includes federal or other partners whose implementation may not be directly tracked through state funding or other tracking programs. So while only a small number of individuals directly interact with NEIEN, it helps to understand its role in receiving and validating BMP data to then translate the data for use and processing in the Watershed Model (**Error! Reference source not found.**).

BMP data from the jurisdictions is submitted to NEIEN in the form of an XML file which allows multiple data elements to be associated with each BMP record. Those elements depend on the BMP, but can include: implementation date, maintenance date, inspection date, reporting agency, funding source, geographic coordinates, etc. This detailed BMP information is then processed into the Watershed Model based on rules developed in consultation with the state and documented in the appropriate jurisdiction's Quality Assurance Project Plan (QAPP).

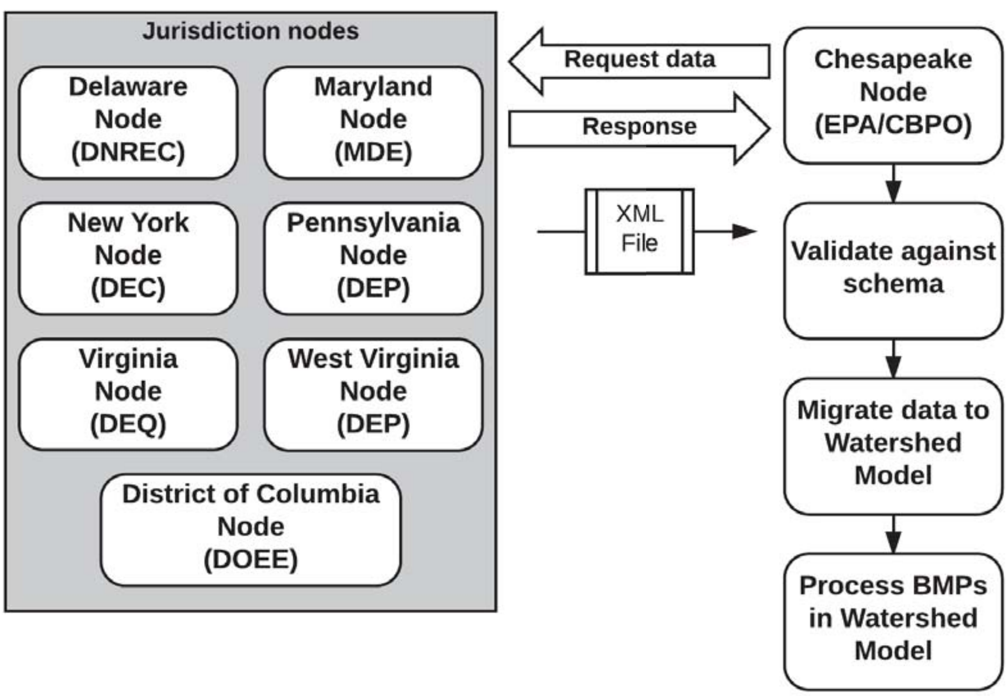


Figure 3 - Illustration of National Environmental Information Exchange Network (NEIEN) process

Appendix A – Understanding Best Management Practices in the Phase 6 Watershed Model

This section is primarily adapted from Section 6 of the Phase 6 Watershed Model Documentation. Less technical detail is provided here than the Watershed Model documentation, so what follows should be considered an abridged version for the reader and should not be cited in lieu of the Watershed Model Documentation for any purpose.

What is the process for adding new BMPs or modifying existing BMPs in the modeling tools?

The BMPs available for credit in annual progress runs are approved by the partnership according to the CBP's Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model (more commonly called BMP Protocol). Since the definitions and values used for both loading and effectiveness estimates have important implications for the CBP and various partners, it is critical that such estimates be developed in a process that is consistent, transparent and scientifically defensible. To this end, the Water Quality Goal Implementation Team (WQGIT) established the BMP Protocol and has amended it over time.

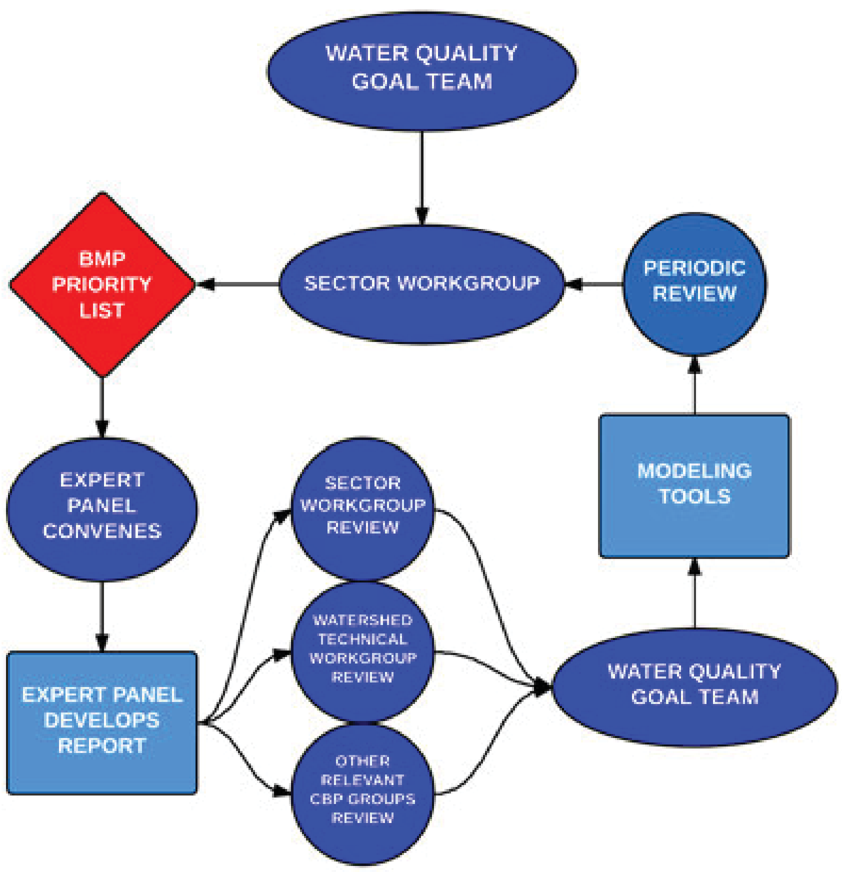


Figure 1 - Diagram of the CBP process for BMP expert panels and WQGIT to add/modify BMPs

Figure 1 illustrates the process for BMP expert panels and the WQGIT to add/modify BMPs. Each expert panel consists of six or more scientific and technical experts whose relevant research or field experience allow them to deliberate available science and deliver a report detailing their recommendations. Most BMPs approved prior to when the BMP Protocol was first adopted in 2010 were reviewed as a part of the Mid-Atlantic Water Program's BMP Assessment report (Simpson and Weammert 2009), which followed a similar process for convening experts and reaching science-based recommendations based on consensus.

What types of BMPs does the Watershed Model simulate?

The Watershed Model simulates BMPs in a number of ways. The categories below describe how the effectiveness of the six common types of BMPs is calculated. However, exceptions to these categories exist. The full Model Documentation and CAST user documentation explain those exceptions.

Efficiency values

This is the most common type of BMP. An efficiency value is the percentage of a pollutant that is removed when the BMP is applied. For example, dry extended detention ponds remove 20 percent of the nitrogen that would have been delivered without the detention ponds. The pass-through value for the BMP is 100 percent minus the efficiency value. In this case, the pass-through value for dry extended detention ponds is 80 percent. For some BMPs, efficiency values can vary across different hydrogeomorphic regions and load sources (for example, cover crops would have varying effects depending on the type of land where they are planted).

Load source change

Load source change practices alter a previously-projected load source to a new load source. For example, tree planting can alter an acre of pasture to an acre of forest. By changing from a higher-loading load source to a lower-loading one (from pasture to forest), nutrients are automatically reduced on that acre of land. Each additional unit of load source change typically results in a lower load for a given geographic area. However, too much land conversion could potentially result in higher loads if the conversion results in other inputs, such as manure and fertilizer, being piled onto an increasingly small number of acres.

Load source change with efficiency values

Some BMPs work as both a load source change and an efficiency BMP, since the land conversion also reduces the amount of nutrients delivered from upland acres. In these cases, the load source change is calculated first. An efficiency is then applied to a certain number of upland acres to account for the full benefits of the practice. Load source change BMPs that also have an efficiency value include grass buffers, grass buffer-streamside with exclusion fencing, forest buffers, forest buffer-streamside with exclusion fencing, wetland creation and wetland restoration.

Figure 2 illustrates an example of a forest buffer applied to agricultural land. If an agricultural forest buffer is applied to 10 acres of land, those 10 acres are converted to forest land (a load source change). However, forest buffers also help trap pollutants running off of surrounding land, so efficiency values apply to some of those upland acres. For forest buffers, four times the number of acres converted (4 x 10 = 40 acres) qualify for an efficiency nitrogen pollution reduction from the forest buffer BMP. There would also be an efficiency reduction applied to two times the number of acres converted (2 x 10 = 20 acres) for both phosphorous and sediment. If this forest buffer was instead located on urban land, the upland acres receiving the efficiency are a one to one ratio with the acres converted (instead of 4:1 for nitrogen and 2:1 for phosphorus and sediment).

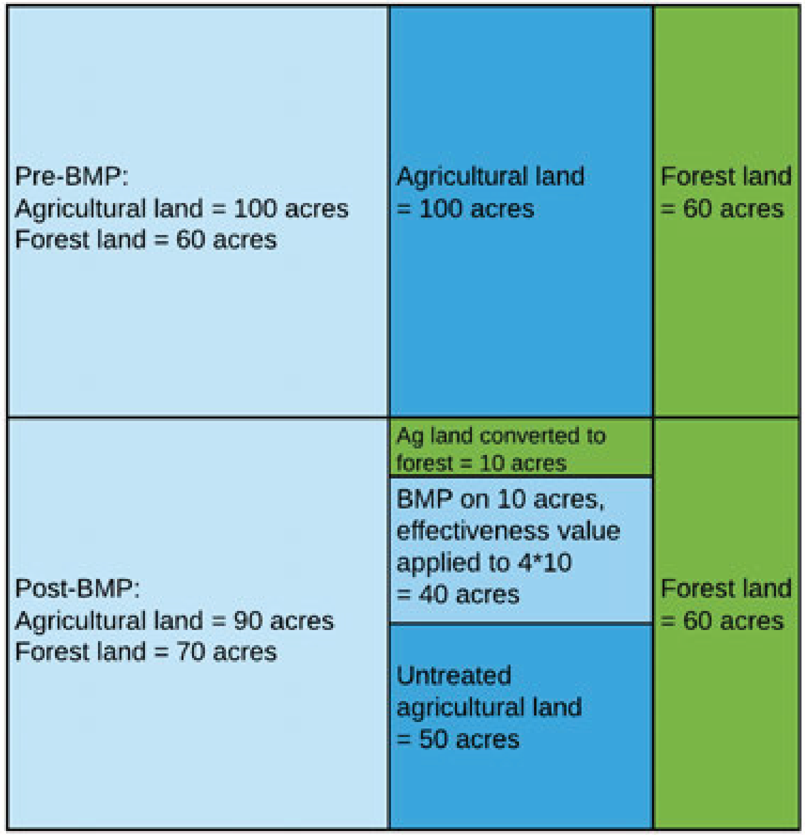


Figure 2 - Load source change with effectiveness example

Load source input reduction practices

Some BMPs directly reduce the amount of nutrients applied to each acre of land. For example, if a jurisdiction indicated that manure was transported out of the county, the total application of manure to a load source within the county/jurisdiction could be reduced. The reduced input application rate is taken into account before applying efficiency BMPs or load reduction practices.

Load reduction BMPs

Load reduction BMPs are modeled as a simple removal of pounds of nitrogen, phosphorus and/or sediment from the edge of a stream, river or tide load. For every unit (e.g., feet) of BMP submitted, a certain amount of nitrogen, phosphorus or sediment is removed. In some cases, the submitted unit is the pounds of nitrogen, phosphorus and/or sediment removed. Load reduction BMPs include algal flow-way, oyster aquaculture, stream restoration, shoreline management, dirt and gravel roads and storm drain cleaning.

Animal BMPs

These BMPs are applied to animal manure for specific animal types. Some animal BMPs, like dairy precision feeding, directly reduce the concentration of nitrogen or phosphorus per ton of manure. Other animal BMPs relocate the manure from one load source to another; for example, animal waste management systems reduce the amount of nitrogen deposited on the feeding space load source and increase the amount of nitrogen available for field application or transport.

Figure 3 shows the impact of animal BMPs on the loads in the model. Nutrients are applied to meet a crop's nitrogen needs. When manure is the nutrient source, it typically results in an over application of phosphorus. Load input-reducing BMPs decrease the manure load, but the crop's nutrient needs have not changed and other sources of nutrients (e.g., fertilizer) will make up the difference where they are available. Crops require a certain ratio of N:P. Since manure contains a greater portion of P relative to N than fertilizers do, switching from manure applications to fertilizer can in many cases result in an overall phosphorus reduction for that crop. In some cases, there is no change in loads. In cases where there is a great deal of manure in a county and not much cropland, there is a decrease in both nitrogen and phosphorus.

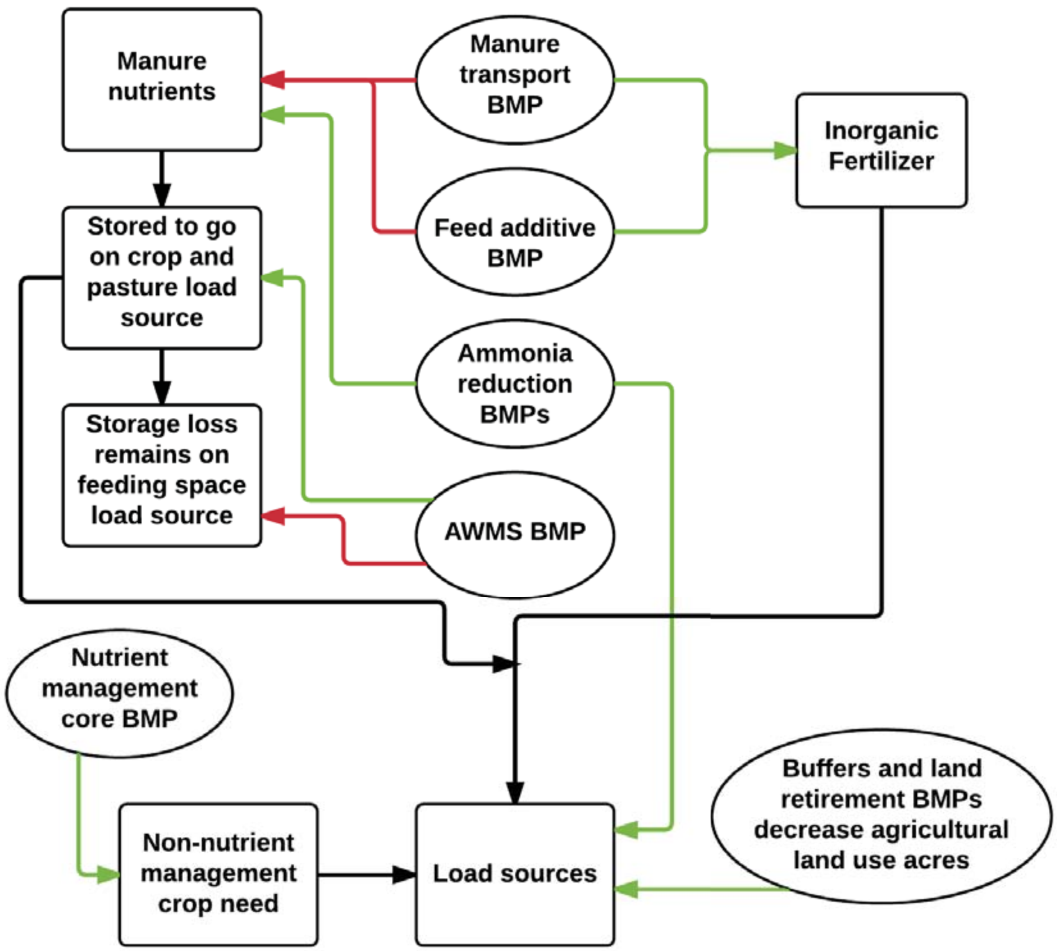


Figure 3 - Impact of Animal BMPs on Loads. Red arrows indicate decreasing amounts; green arrows indicate increasing amounts; black arrows indicate calculation procedures. All manure storage loss stays on feeding space load sources. For any scenario that is post 2012, fertilizer is projected and the green arrow showing an increase is correct. For 2012 and earlier, we have actual fertilizer data and the fertilizer amount does not change. Nutrient management core BMP only impacts the non-nutrient crop needs.

Animal waste management BMPs reduce the amount of manure that is lost during manure storage. That manure becomes available to spread on crops. Thus, the load from the animal/concentrated animal feeding operation load source decreases, but the load from manure on the crop land increases. In these cases, the fertilizer load may decrease, resulting in no change in nutrients on crop land. In situations where the entire crop need was already met by manure, the model assumes the additional manure is spread on crop and pasture land even in excess of crop nutrient requirements. Thus, animal waste management BMPs can result in higher loads from some load sources even as loads from animal feeding operations decrease.

Concurrent to the BMP impacts, reduction of agricultural land can decrease the acres available for manure application. Development of rural areas and some BMPs, such as grass and forest buffers or retirement of highly erodible land, reduce the acres of land available to receive manure. Even where the amount of manure remains the same, the application rate may increase because of the reduction of acres where the manure can be applied.

Exceptions

There are some BMPs that do not fit among the previous six categories. Principal among these exceptions are the two Stormwater Performance Standard BMPs (runoff reduction and stormwater treatment). The efficiency of each project or group of projects is determined by the number of impervious acres and the total volume of water treated. Graphs describing these relationships were developed by the Stormwater Performance Standards Expert Panel. All the BMP type exceptions are discussed in Section 6.6 of the Watershed Model Documentation.

How is the effectiveness of BMPs calculated in the Watershed Model?

Just as each acre of land on the landscape may be impacted by multiple practices which reduce nutrient runoff, each acre in the BMP calculations can have multiple practices applied to it, contributing to what is referred to as a “pass-through factor” in the Watershed Model documentation.

BMPs that cannot physically occupy the same acre of land – two separate types of cover crop, for example – are known as mutually exclusive BMPs. All other BMPs in the Watershed Model are assumed to be randomly distributed in an area so that the probability of overlapping BMPs increases as the implementation level of each BMP increases.

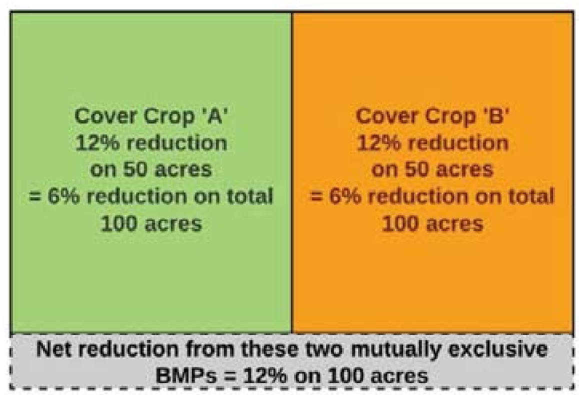


Figure 4 – Hypothetical example of two mutually exclusive BMPs with the same efficiency on 100 acres

Mutually exclusive BMPs can be thought of as **additive** since their efficiencies are added together. For example, if 50 acres of a 100-acre load source have cover crop A and 50 acres have cover crop B and both BMPs result in a 12 percent reduction on covered acres, then cover crop A effects a six percent reduction over the entire 100 acres as does cover crop B. The individual percentages can be added to arrive at a 12 percent total reduction for the load source. This is illustrated in Figure 4.

Alternatively, consider overlapping BMPs on a 100-acre load source with 100 acres of cover crop A at 12 percent reduction and 100 acres of a nutrient input reduction BMP with an eight percent reduction, as shown in Figure 5. The reductions are not additive since they apply to the same areas. The first BMP is applied, reducing the load to 88 percent of the original load. The second BMP causes an 8 percent reduction from that reduced load (i.e., an eight percent reduction to 88 percent of original load). Thus, the overall reduction is 19.04 percent (1.00 – ([1.00 – 0.08] × [1.00 – 0.12])). BMPs that can be applied to the same acre are called overlapping or **multiplicative**.

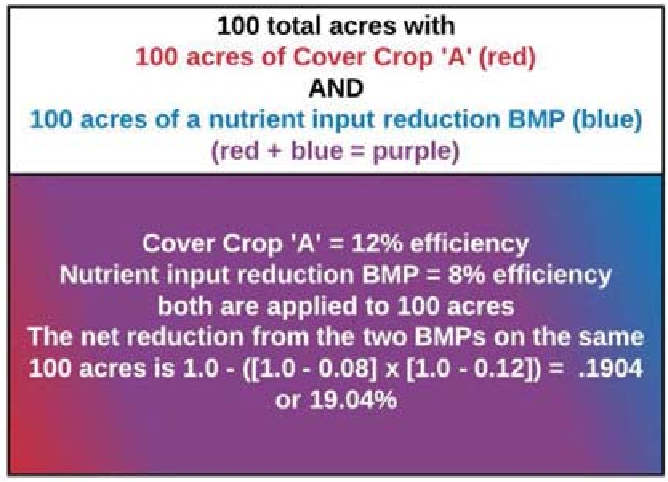


Figure 5 – Hypothetical example of two overlapping BMPs with different individual efficiencies on same 100 acres

When the Watershed Model generates the total efficiency of all BMPs, it first accounts for any load source change BMPs and then calculates the total efficiency of all BMPs for a single load source. The aggregate efficiency of sets of mutually-exclusive BMPs are calculated, and then overlapping BMPs are combined with the previously-calculated efficiencies. A pass-through factor for the cumulative sets of BMPs is calculated within the load source, land-river segment and agency for nitrogen, phosphorus and sediment (see section 4.1 for a description of load sources, land-river segments and agencies). Section 6 of the Watershed Model Documentation describes the equations and steps to calculate pass-through factors in more detail. For the purposes of this guide it helps to understand that every BMP applied to a specific area contributes to the total pass-through factor for that area. Mutually-exclusive sets of BMPs and overlapping BMPs contribute to that net pass-through factor in different ways. The Watershed Model and tools like CAST do all the math, but it is easier to understand the results after learning the underlying concepts.

How are BMPs applied and distributed?

The application and distribution of BMPs can become complicated at a technical level, but is simpler to understand at a conceptual level. For those involved in annual BMP reporting and WIP development, it helps to understand these concepts, summarized below and described in more detail in Section 6.5 of the Watershed Model documentation:

- BMP distribution
- Load source groups
- Maximum implementation values

BMP distribution

BMPs are always applied in the Watershed Model at the smallest spatial scale: a single load source in a single land-river segment for an agency.

Load sources include different types of land use acres (e.g., pasture), as well as direct loads that are not associated with an area of land (e.g., direct manure deposition by cattle in a stream).

Land segments are portions of counties. River segments are uninterrupted lengths of a waterway and its adjacent area. The intersection of a land segment and river segment is a *land-river segment* (often referred to as “LRSeg” in Watershed Model source data and documentation). The spatial distribution also includes *agencies*, which are designations of federal and non-federal areas within a land river segment. There are nine federal agencies and three non-federal agencies in the Watershed Model, listed in *Table 1*.

Table 1 – List of federal and non-federal agency categories in the Phase 6 Watershed Model. Agency designations help stakeholders to better understand the attribution of load sources and BMPs within their geographic area.

Federal agencies in Watershed Model	Non-federal agencies in Watershed Model
Agricultural Research Service	Maryland State
Department of Defense	Maryland State Highway Administration
Other federal land	Non-federal
U.S. Forest Service	
U.S. Fish and Wildlife Service	
General Services Administration	
National Aeronautics and Space Administration	
National Park Service	
Smithsonian Institution	

How do HUCs work?

Hydrologic Unit Codes (HUCs) are a common classification system for watersheds. The greater number of digits in a HUC, the smaller the area and more specific the designation. A four-digit HUC represents a subregion (e.g., 0205 is the Susquehanna River), six digits is a basin (e.g., 020501 is the Upper Susquehanna), eight digits is a sub-basin (e.g., 02050105 is the Chemung), ten digits is a watershed and twelve is a sub-watershed. Twelve-digit HUCs, on average, represent areas of only 10,000 to 40,000 acres according to the U.S. Geological Survey and USDA Natural Resources Conservation Service. HUC scales are available on even numbers from four to 12.

Source: U.S. Geological Survey and U.S. Department of Agriculture, Natural Resources Conservation Service, 2013, Federal Standards and Procedures for the National Watershed Boundary Dataset (WBD) (4 ed.): U.S. Geological Survey Techniques and Methods 11–A3, 63 p. Available at http://pubs.usgs.gov/tm/tm11a3/

The National Environmental Information Exchange Network (NEIEN) is used for tracking annual progress of BMP implementation. States can submit implementation of BMPs through NEIEN at a variety of scales—by latitude and longitude, county, state or hydrologic unit code (HUC). For geographic areas that cross the Chesapeake Bay watershed boundary, data can be submitted either for the entire county or for just the portion that is inside the watershed. For example, Chester County in Pennsylvania is mostly outside of the Chesapeake Bay watershed. BMPs can be submitted for only the watershed portion of Chester County or the entire county. If submitted for the entire county, they are assumed to be evenly spread throughout the county and any land-river segments within it.

When BMPs are submitted at a larger scale than land-river segment (for example, at a major-basin scale), they are distributed proportionately based on the number of receiving load source acres in each land-river segment within the larger-scale area (i.e., the land-river segments within a larger major basin). Figure 6 illustrates a hypothetical example of how this works for a single BMP reported for a whole county.

For planning scenarios, such as milestones and WIPs, more general data are needed; however, the same geographic designations can be used. In addition, BMPs can be submitted on the geographies listed in the CAST Source Data.

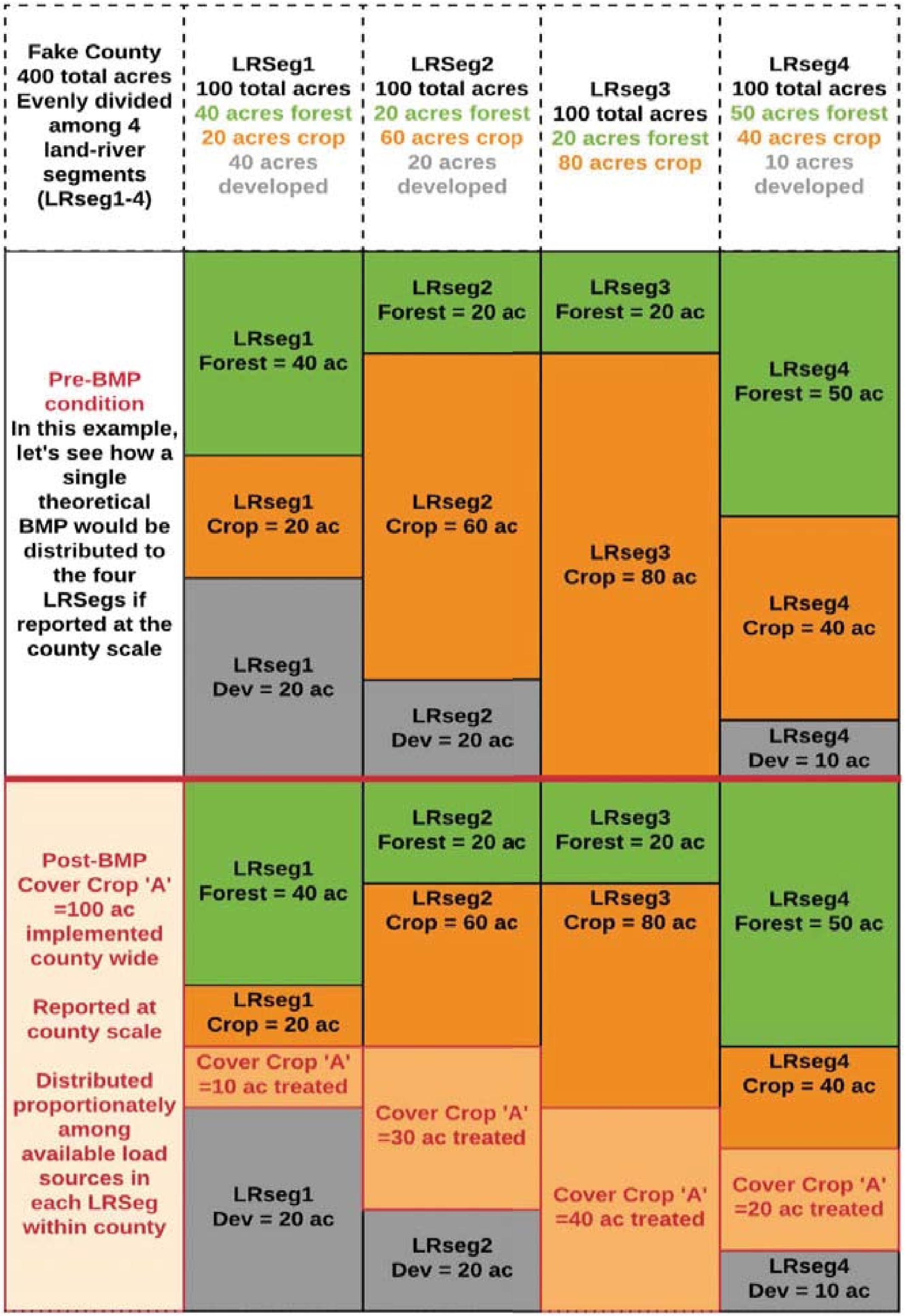


Figure 6 – Hypothetical example of how a single BMP is distributed among land-river segments within a county. This example is greatly simplified for illustrative purposes. Though it becomes more complex as more BMPs are added or as you move to larger scale (e.g., to major-basin or statewide scale) or finer specificity (e.g., to specific load sources and agencies within an LRseg), the same underlying logic applies.

Load source groups and order of load source change BMPs

BMPs can be submitted on a defined load source or animal groups, e.g., “crop” or “poultry.” When submitted as a group, BMPs are divided according to the fraction of each area or load that comprises the group. The load source groups and animal groups are provided in the “source data” spreadsheet available through CAST (see “Load Source Group Components” or “Animal Group Components” tabs). Load source and animal groups can help to simplify BMP planning or reporting in cases where specific information is unknown.

Load source change BMPs that are applied to the same load source may be limited by the amount of load source available in that land-river segment for that agency. They are applied in an order such that BMPs higher on the list will be preferentially credited. Appendix 6B of the Watershed Model documentation shows the order and the load source that the BMP modifies. This information is also available in the Source Data on the CAST website.

Since Animal and Load Source BMPs can alter load sources available for other BMPs, they are credited prior to efficiency BMPs. Load reduction BMPs are credited last.

Enforcing maximum implementation values

BMP implementation values are capped at the available load source, which means that a load source cannot go below zero. Also, the sum of BMPs for a load source and land-river segment and agency cannot exceed the available area. If the BMP area exceeds the load source area, each BMP is reduced proportionally so that the sum of all the area equals the available area. An example:

- Submitted BMP amount:
  - Total acres available for the load source = 100
  - Cover Crop: Traditional Barley Early Drilled = 90%
  - Cover Crop: Traditional Forage Radish Plus Early Aerial = 60%
- Model Calculates:
  - Barley acres: 90/(90+60)% × 100 = 60
  - Forage radish acres: 60/(90+60)% × 100 = 40
- Result:
  - Barley acres = 60
  - Forage radish acres = 40

In the above example, the two BMPs are mutually exclusive and when added together cannot exceed the available area (100 acres). Therefore, they are reduced proportionately so that 60 acres of the barley cover crop and 40 acres of the forage radish cover crop are applied to the available load source area.

Tip: If using CAST, download the “BMPs Submitted vs. Credited” report from the reports page to verify that acres were available.

There are additional assumptions for maximum implementation specifically for the stream restoration BMP; if interested in that information, see section 6.5.4.1 of the Watershed Model documentation.

BMPs for future scenarios or planning scenarios

Some BMPs are available for simulation in the Watershed Model, but are not approved for reporting in annual progress scenarios. If using CAST, you can choose which BMPs are available for the scenario you wish to create, either "official BMPs" or "planning BMPs."

Interim BMPs

Under the BMP Protocol, jurisdictions and workgroups can request review of new BMPs or technologies so they can be added to Model as "approved" or "official" BMPs following expert panel review. However, a panel may not form or provide recommendations for one to two years, posing a challenge for jurisdictions that may want to include the new practice in their planning scenarios for WIPs or 2-year milestones. To meet that need, jurisdictions can use an interim BMP, which is a type of "planning BMP" with an assigned effectiveness value, but only for planning scenarios. If planning scenarios in CAST use interim practices extensively, it is important to remember that the practice effectiveness value will likely change based on the in-depth review and recommendations by the BMP expert panel. Once a practice is approved through the BMP Protocol's expert panel review process, the BMP is added to the list of "official BMPs" available for progress scenarios.

Land policy BMPs

There are multiple Land Policy BMPs available. These BMPs change the acres of land use to meet certain planning goals. Since these practices are for future scenarios, they are only available in CAST as "planning BMPs." The definitions below are also available in the CAST user documentation. The definitions summarize the assumptions made for each Land Policy BMP to affect future changes to land use.

Forest conservation

Organizations and governments proactively pursuing a variety of actions to conserve forests and wetlands, which provide the greatest benefits to wildlife, human safety, and water quality. Example priority areas include riparian zones, shorelines, large contiguous forest tracts, and other high-priority forest conservation areas.

- Conserve riparian zones (default width = 30m)
- Conserve wetlands (NWI, State Designated Wetlands, and Potential Conservable Wetlands (PA only))
- Conserve all lands subject to inundation due to sea level rise (default = 1m rise by the year 2100)
- Conserve all lands surrounding National Wildlife Refuges (default = 1 mile buffer)
- Conserve all large forest tracts (default >= 250 acres)
- Conserve Bay shorelines (default = 305m buffer (~1000-ft) of the tidal Bay and Atlantic shorelines)
- Conserve all high-value forest and forested wetlands identified by the Chesapeake Conservation Partnership

Growth management

Organizations and governments proactively pursuing a variety of actions to encourage growth in areas with supporting infrastructure. Example priority areas include undeveloped or under-developed areas with adequate existing roads, wastewater and water supply infrastructure.

- Increase proportion of growth occurring as infill/redevelopment (default = 10% per decade)
- Increase urban densities (default = 10% per decade)
- Increase proportion of urban vs rural growth (default = 10% per decade)
- Expand sewer service areas (default = ~1 mile))
- Avoid growth on all soils unsuitable for septic systems (based on depth to bedrock, drainage class, saturated hydraulic conductivity, and flood frequency)

Agriculture and soil conservation

Organizations and governments proactively pursuing a variety of actions to conserve farmland and productive soils. Example priority areas include agricultural districts, prime farmland, farmland of state importance and floodplains, and other high-priority farmland conservation areas.

- Conserve all farmland within designated Agricultural Districts
- Conserve all lands within the floodplain (default = 100-year recurrence interval)
- Conserve all lands with flooded soils (default = frequently flooded)
- Conserve all prime farmlands and farmland of state importance
- Conserve potential restorable wetlands (applies only to PA farmland)
- Conserve all high-value farmland identified by the Chesapeake Conservation Partnership

A-1. Land Retirement and Alternative Crops

General Information

Farmers sometimes retire or convert cropland into less intensively managed vegetation such as hay or grasses. This is often done through voluntary state or federal conservation programs and typically focuses on marginal or highly erodible cropland. This land conversion is done for extended periods of time to reduce soil erosion, improve water quality, provide habitat or improve soil health.

Figure A-1-1. Land retired or converted to permanent vegetation requires less fertilizer and is not tilled or intensively managed once vegetation is established. Photo: USDA NRCS

CBP Definition(s)

Alternative crops: Accounts for those crops that are planted and managed as permanent, such as warm season grasses, to sequester carbon in the soil.

Land retirement to Ag open space: Converts land area to hay without nutrients. Agricultural land retirement takes marginal and highly erosive cropland out of production by planting permanent vegetative cover such as shrubs, grasses and/or trees.

Land retirement to pasture: Converts land area to pasture. Agricultural land retirement takes marginal and highly erosive cropland out of production by planting permanent vegetative cover such as shrubs, grasses, and/or trees. Agricultural agencies have a program to assist farmers in land retirement procedures.

Specifications or Key Qualifying Conditions

There are no specific conditions for CBP purposes beyond the definitions above, with the expectation that reported cost-share practices conform to state or federal practice standards, and any non-cost-shared practices conform to the criteria described in the *Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report* (linked under Additional Information below).

Nitrogen, Phosphorus and Sediment Reductions

The reductions are equal to the difference between the prior higher-load crop land use and the new lower-load land use of either Ag Open Space or Pasture; average estimates of these BMP reductions for the Chesapeake Bay watershed-portion of the states are provided in Table A-1-1 below.

Table A-1-1. Average per-unit reductions for land retirement and alternative crop BMPs, by state, for nitrogen and sediment. These average load reductions are subject to change with the model. As statewide averages they may not reflect simulated reductions for practices in some areas. For current data or detailed methods for these estimated averages see "BMP Pounds Reduced and Costs by State." Available under "Develop Plans," http://cast.chesapeakebay.net/Documentation/DevelopPlans

Data from April 30, 2018 version of "BMP Pounds Reduced and Costs by State"	**Alternative crops** *(avg lbs reduced per acre)*		**Land retirement to Ag Open Space** *(avg lbs reduced per acre)*		**Land retirement to Pasture** *(avg lbs reduced per acre)*	
State	***TN***	***TSS***	***TN***	***TSS***	**TN**	**TSS**
Delaware	57	237	50	235	49	235
Maryland	24	875	20	708	17	799
New York	12	632	6	278	4	344
Pennsylvania	28	909	17	535	15	630
Virginia	31	919	11	318	15	555
West Virginia	19	1,712	5	190	4	371

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

The following load sources are applicable for the Alternative Crops BMP; if no load source or load source group is specified the default will be ROW.

- Double Cropped Land
- Full Season Soybeans
- Grain with Manure
- Grain without Manure
- Other Agronomic Crops
- Silage with Manure
- Silage without Manure
- Small Grains and Grains

Load sources below marked with an asterisk (*) are only applicable for Land Retirement to Ag Open Space and are not eligible for Land Retirement to Pasture. Otherwise, they are applicable for both BMPs. If no load source or load source group is specified the default will be ROW.

- Crop
- Crop Hay
- Crop Hay With Manure
- Crop With Manure
- Grains
- Hay
- Legume Hay
- Other Hay
- Pasture*
- Pasture Hay*
- Row
- Row With Manure
- Specialty
- Ag No Open*

Brief Description of BMP Simulation in the Model

The Land Retirement practices are *Load Source Change BMPs*. Each acre planted and reported under the Land Retirement BMP converts one acre from the previous load source to either Ag Open Space or Pasture. Each acre planted and reported under the Alternative Crops BMP converts one acre into Ag Open Space.

Annual or Cumulative? Cumulative (10-year credit duration; 5-years for Resource Improvement practices)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Alternative crops
    - Alternative crops/switchgrass RI (RI-3)
    - Land Retirement to Ag Open Space
    - Land Retirement to Pasture
    - Conversion to hayland RI (RI-14)
    - Conversion to pasture RI (RI-13)
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be ROW

- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year the land area was retired.

Table A-1-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common BMP names
Alternative crops	Alternative crops; Alternative crop/Switchgrass RI (RI-3)	Carbon sequester alternative crop
Land retirement to Ag Open Space	Conservation cover; Conversion to hayland RI (RI-14); CREP Wildlife habitat; Critical area planting; Grass nutrient exclusion area on watercourse narrow; Land retirement; Permanent wildlife habitat, non-easement; Retirement of highly erodible land	Critical area planting (NRCS 342); Conservation cover (NRCS 327); permanent vegetative cover, retirement of highly erodible land
Land retirement to Pasture	Same NEIEN BMP names listed above for "Land Retirement to Ag Open Space" except "Conversion to Hayland (RI-14)" is not applicable; Conversion to pasture RI (RI-13); Pasture and hay planting	

Additional Information

Chesapeake Bay Program Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report: Ensor, R., Absher, D., Moore, G., Garber, L., McGee, B., Albrecht, G., Weibley, E., Wootton, C., & J. Hill. 2014. Chesapeake Bay Program Resource Improvement Practice Definitions and Verification Visual Indicators Report. Approved by CBP Water Quality Goal Implementation Team, August 2014.
https://www.chesapeakebay.net/documents/RI_Report_5_8-8-14.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definition and benefits that have remained in use since review and approval by the CBP partnership's source sector workgroups for tributary strategy development.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-2. Nutrient Management

General Information

Nutrient management planning has been a common practice for decades, as it helps the farmer maximize profits by balancing crop yields and nutrient inputs. Nutrient management has four basic components: nutrient source, rate, placement and timing. Under a Nutrient Management Plan, each of these four components is managed at the field or sub-field scale in a manner that supports crop productivity, achieves high nutrient use efficiency by the crop and minimizes nutrient loss.

Figure A-2-1. A tractor spreads liquid manure on a field. All crops need nutrients such as nitrogen and phosphorus to grow, and farmers can get those nutrients from animal manure, commercial inorganic fertilizers or both. Source: Chesapeake Bay Program

CBP Definition(s)

Nutrient Management (NM): The implementation of a site-specific combination of nutrient source, rate, timing, and placement into a strategy that seeks to optimize agronomic and environmentally efficient utilization of nitrogen (N) and phosphorus (P). Improvement in nutrient-use efficiency necessitates documentation of nutrient management implementation strategies that are suitable for independent verification.

The BMPs for Nutrient Management are categorized into *Core Nutrient Management* and *Supplemental Nutrient Management* for both N and P. *Supplemental NM* is further divided by *Rate*, *Placement*, and *Timing*.

Nitrogen Core Nutrient Management: Applications of nitrogen are made in accordance to all of the following elements as applicable:

- Land-grant university recommendations for nitrogen applications at field level.
- Manure analysis and volume, using either test or book values to determine nitrogen content.
- Calibration of spreader/applicator.
- Yield estimates and cropping plan at the field level.
- Cropping and manure application history at the field level.

Figure A-2-2. A crop consultant collects a soil sample to test nitrogen availability in the soil. A test like this helps decide how much nitrogen the growing crop needs for optimum production. Source: NRCS Photo Gallery

Phosphorus Core Nutrient Management: Applications of phosphorus are made in accordance to all of the following elements as applicable:

- Land-grant university recommendations for phosphorus at the field level. This may include recommendations resulting from advanced assessment (i.e. P Index, etc.) that recommend higher P application rates where the risk of P loss is low.
- Soil test for phosphorus levels at the field level. This requirement may be waived if restrictions on manure applications (rate, timing, and placement) are imposed that limit P application rates and management to the same degree as if the soil test result for phosphorus was in the “high” category.
- Manure analysis and volume using either test or book values to determine phosphorus content.
- Calibration of spreader/applicator.

- Yield estimates and cropping plan at the field level.
- Cropping and manure history at the field level.

Nitrogen Rate Supplemental NM: Applications of nitrogen are made in accordance to all elements of the Nitrogen Core practice, and one or more of the following practices are implemented resulting in a reduction in application rate of nitrogen:

- Nitrogen application rate made at less than land-grant university recommendations.
- Nitrogen applications split across the growing season, resulting in lower-than-planned applications.
- Nitrogen applications are made using variable rate goals, resulting in lower-than-planned applications.

Nitrogen Placement Supplemental NM: Applications of nitrogen are made in accordance to all elements of the Nitrogen Core practice, and one or more of the following practices are implemented resulting in better placement and utilization of nitrogen:

- Applications of inorganic nitrogen are injected into the subsurface or incorporated into the soil.
- Applications of nitrogen are made with setbacks from surface water features.

Nitrogen Timing Supplemental NM: Applications of nitrogen are made in accordance to all elements of the Nitrogen Core practice, and are split across the growing season into multiple applications to increase utilization of nitrogen.

Phosphorus Rate Supplemental NM: Applications of phosphorus are made in accordance to all elements of the Phosphorus Core practice, and one or more of the following practices are implemented resulting in a reduction in application rate of phosphorus:

- Applications of manure are based upon annual crop removal of phosphorus rather than nitrogen.
- Applications of phosphorus are made at less than land-grant university recommendations.
- Phosphorus applications are made using variable rate goals resulting in lower than planned applications.

Phosphorus Placement Supplemental NM: Applications of phosphorus are made in accordance to all elements of the Phosphorus Core practice, and one or more of the following practices are implemented resulting in better placement and utilization of nitrogen:

- Applications of inorganic phosphorus are injected into the subsurface or incorporated into the soil.
- Applications of phosphorus are made with setbacks from surface water features.

Phosphorus Timing Supplemental NM: Applications of phosphorus are made in accordance to all elements of the Phosphorus Core practice, and are made in seasons with a lower risk of phosphorus loss.

- Applications of phosphorus are split across the growing season resulting in lower than planned applications.

Specifications or Key Qualifying Conditions

All elements of the Core Nutrient Management BMP must be met to be eligible for one or more of the Supplemental BMPs for nitrogen and/or phosphorus.

Nitrogen, Phosphorus and Sediment Reductions

There are no sediment reductions for NM BMPs. Nutrient reductions vary for the Core and the three Supplemental NM practices for N and P. The acres of Core NM in a county impact the overall application goal for each crop within a county, using the values in Table A-2-1.

Table A-2-1. Core Nitrogen and Phosphorus NM Application Goal Multipliers

Land Use	Nitrogen *Non-NM*	Nitrogen Core *With NM*	Phosphorus *Non-NM*	Phosphorus Core *With NM*
Full Season Soybeans	1.2	1.0	1.5	1.0
Grain w/ Manure	1.3	1.0	3.0	1.0
Grain w/o Manure	1.2	1.0	1.5	1.0
Legume Hay	1.2	1.0	1.0	1.0
Silage w/ Manure	1.4	1.0	3.0	1.0
Silage w/o Manure	1.2	1.0	1.5	1.0
Small Grains and Grains	1.2	1.0	1.5	1.0
Double Cropped (Small Grains and Soybeans)	1.2	1.0	1.5	1.0
Specialty Crop High	1.3	1.0	2.0	1.0
Specialty Crop Low	1.2	1.0	2.0	1.0
Other Agronomic Crops	1.1	1.0	1.5	1.0
Other Hay	1.0	1.0	1.0	1.0
Pasture	1.0	1.0	1.0	1.0

Each supplemental practice is simulated as a percent reduction to estimated runoff from the appropriate land use, using the percent reductions listed in Table A-2-2.

Table A-2-2. Supplemental Nitrogen and Phosphorus Percent Reductions to Land Use Runoff

Land Use	N Rate Supplemental	N Placement Supp.	N Timing Supp.	P Rate Supplemental	P Placement Supp.	P Timing Supp.
Full Season Soybeans	0%	0%	0%	5%	10%	1%
Grain w/ Manure	15%	5%	10%	10%	20%	20%
Grain w/o Manure	5%	3%	5%	5%	10%	1%
Legume Hay	0%	0%	0%	1%	10%	1%
Silage w/ Manure	15%	5%	10%	10%	20%	20%
Silage w/o Manure	5%	3%	5%	5%	10%	1%
Small Grains and Grains	5%	3%	10%	5%	10%	1%
Double Cropped (Small Grains and Soybeans)	5%	3%	10%	5%	10%	1%
Specialty Crop High	15%	5%	5%	5%	10%	1%
Specialty Crop Low	5%	3%	5%	5%	10%	1%
Other Agronomic Crops	5%	3%	5%	5%	10%	1%
Other Hay	0%	3%	5%	0%	10%	1%
Pasture	0%	0%	0%	0%	0%	0%

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Full season Soybeans
- Grain with Manure
- Grain without Manure
- Silage with Manure
- Silage without Manure
- Small Grains and Grains
- Specialty Crop High
- Specialty Crop Low

- Other Agronomic Crops
- Other Hay
- Pasture

Because many of the land uses listed above represent rotational crops, it is not recommended that states track and report this level of detail. Instead, it is recommended that states report these acres on the land use group, "Crop," which contains all of the above individual land uses.

Brief Description of BMP Simulation in the Model

The Core nutrient management practices are *Load Source Input Reduction BMPs*, while the Supplemental Nutrient Management practices are *Efficiency Value BMPs*. Each acre reported under the Core practices will adjust the nutrient application goal slightly from land-grant university recommendations using the values in Table A-2-1. For example, an acre of corn not receiving manure (a crop in the Grain without Manure land use) under the Nitrogen NM Core practice will have an application goal of 0.92 lbs. of nitrogen/bushel/acre. The modified land-grant university application goals will be increased by the multipliers provided in the tables above for each acre **not** under Core NM. All Supplemental NM practices are simulated as a percent reduction of the estimated runoff using the values in Table A-2-2.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes. Additionally, a single acre of land may qualify for all four types of NM BMPs (Core and three Supplemental) for both N and P if appropriate.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Nitrogen Core NM; Phosphorus Core NM; Nitrogen Rate Supplemental NM; Nitrogen Timing Supplemental NM; Nitrogen Placement Supplemental NM; Phosphorus Rate Supplemental NM; Phosphorus Timing Supplemental NM; Phosphorus Placement Supplemental NM
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be CROP
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year plan was active.

Table A-2-3. Synonymous BMP names for Watershed Model, NEIEN and other sources

<table>
<tr><th>CBP or Expert Panel term</th><th>NEIEN BMP name</th><th>Other common practice names</th></tr>
<tr><td>Nitrogen Core NM</td><td>Nutrient Management Core N</td><td rowspan="8">NRCS 590,* E590118Z,* E590119Z,* E590118X*

*Acres of nutrient management cost-shared under the NRCS 590 or enhanced 590 standards do not automatically fulfill the Core or Supplemental NM definitions. However, partners can verify how many of the acres meet which Core and/or Supplemental NM definitions.</td></tr>
<tr><td>Phosphorus Core NM</td><td>Nutrient Management Core P</td></tr>
<tr><td>Nitrogen Placement Supplemental NM</td><td>Nutrient Management N Placement</td></tr>
<tr><td>Nitrogen Rate Supplemental NM</td><td>Nutrient Management N Rate</td></tr>
<tr><td>Nitrogen Timing Supplemental NM</td><td>Nutrient Management N Timing</td></tr>
<tr><td>Phosphorus Placement Supplemental NM</td><td>Nutrient Management P Placement</td></tr>
<tr><td>Phosphorus Rate Supplemental NM</td><td>Nutrient Management P Rate</td></tr>
<tr><td>Phosphorus Timing Supplemental NM</td><td>Nutrient Management P Timing</td></tr>
</table>

Additional Information

Expert panel report:
Coale, F., Osmond, D., Beegle, D., Meisinger, J., Fisher, T., & Q. Ketterings. 2016. Nutrient Management Practices for use in the Phase 6.0 Chesapeake Bay Program Watershed Model. CBP/TRS-307-16. http://www.chesapeakebay.net/documents/Phase_6_NM_Panel_Report_11-28-2016_New_Template_FINAL.pdf

Example USDA NRCS National Conservation Practice Standards:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/

USDA NRCS Nutrient Management:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/landuse/crops/npm/

International Plant Nutrition Institute. Video. The Role of 4R Nutrient Stewardship in Reducing Greenhouse Gas Emissions:
https://youtu.be/eD2SeH8IZZw

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in December 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-3. Conservation Tillage

General Information

Conservation tillage involves the planting, growing and harvesting of crops with minimal disturbance to the soil. The amount of crop residue coverage is higher when compared to conventional or high tillage methods. This practice uses seeders and techniques that are more precise and requires fewer passes, which reduces soil disturbance. Greater crop residue coverage and lower soil disturbance protect against erosion from wind and rain.

Figure A-3-1. Corn growth with crop residue. Crop residue is a mix of stalks, leaves, roots or other plant materials left on the field following harvest. The residue helps prevent erosion from wind and rain while allowing the next crop to grow through. Source: CTIC

CBP Definition(s)

Conventional Tillage: Any tillage routine that does not achieve 15 percent crop residue coverage immediately after planting is considered conventional tillage and does not qualify as a BMP.

Low Residue Tillage: A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain 15 to 29 percent crop residue coverage immediately after planting each crop.

Conservation Tillage: A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain 30 to 59 percent crop residue coverage immediately after planting each crop.

High Residue, Minimum Soil Disturbance Tillage: A conservation tillage routine that involves the planting, growing and harvesting of crops with minimal disturbance to the soil in an effort to maintain at least 60 percent crop residue coverage immediately after planting each crop.

Figure A-3-2. Rows grown in the ridge till method. Source: CTIC

Specifications or Key Qualifying Conditions

The tillage routine must maintain 15 percent or greater crop residue coverage immediately after planting to be considered a BMP. There are no additional specifications or qualifying conditions beyond those described in the definitions above.

Nitrogen, Phosphorus and Sediment Reductions

Nutrient reductions vary based on hydrogeomorphic region (HGMR), while sediment reductions are consistent across all regions. It is not expected that the specific HGMR of a farm field is known, instead the reported acres are distributed by the model. For example, if 50 percent of cropland in a county is in Piedmont Carbonate and 50 percent Piedmont Crystalline, then the conservation tillage acres submitted for that county are split 50/50.

Table A-3-1. Nitrogen, Phosphorus and Sediment Efficiency Value Reductions for Tillage Practices

				Phosphorus Reductions (%)					
HGMR	**Low Residue**	**Conser-vation Tillage**	**High Residue**	**Low Residue**	**Conser-vation Tillage**	**High Residue**	**Low Residue**	**Conser-vation Tillage**	**High Residue**
Appalachian Plateau, Siliciclastic	5	10	14	7	17	27	18	41	79
Appalachian Plateau, Carbonate	5	10	14	7	27	38	18	41	79
Blue Ridge	5	10	14	8	50	63	18	41	79
Coastal Plain Dissected Upland	2	4	12	8	35	47	18	41	79
Coastal Plain Lowland	2	4	15	6	2	11	18	41	79
Coastal Plain Upland	2	4	12	7	16	26	18	41	79
Mesozoic Lowland	5	10	14	7	21	32	18	41	79
Piedmont Carbonate	5	10	14	9	60	74	18	41	79
Piedmont Crystalline	5	10	14	9	58	71	18	41	79
Valley and Ridge Carbonate	5	10	14	9	57	71	18	41	79
Valley and Ridge Siliciclastic	5	10	14	8	49	62	18	41	79

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Full season Soybeans
- Grain with Manure
- Grain without Manure
- Silage with Manure
- Silage without Manure
- Small Grains and Grains
- Double Cropped Land
- Specialty Crop High
- Specialty Crop Low
- Other Agronomic Crops

Figure A-3-3. Corn (left) and soybean (right) residue cover percentages (25, 50, 75, 90). The percentage of residue coverage increases from top to bottom for each crop in a column. Source: University of Nebraska Extension

Because many of the land uses listed above represent rotational crops, it is not recommended that states track and report this level of detail. Instead, it is recommended that states report these acres on the land use group, "Crop," which contains all of the above individual land uses.

Brief Description of BMP Simulation in the Model

All conservation tillage practices are *Efficiency Value BMPs*. Runoff from applicable load sources are reduced by the efficiency values listed below in Table A-3-1. For example, if a state submits that 100 percent of acres within a county in the Appalachian Plateau Siliciclastic region are covered by High Residue Tillage Management, then nitrogen from all acres will be reduced by 14 percent, phosphorus by 27 percent and sediment by 79 percent as compared to the same land under conventional tillage. If however, only 50 percent of acres are reported for the same practice, then half the cropland in that county would be simulated as conventional tillage and half would have the respective nitrogen, phosphorus and sediment reductions for the High Residue Tillage Management BMP applied.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Low Residue Tillage may be reported under the names: Reduced Tillage
  - Conservation Tillage may be reported under the names: Conservation Tillage; Mulch Tillage; No Tillage, and; Ridge Tillage
  - High Residue, Minimum Soil Disturbance may be reported under the name: High Residue Tillage Management
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be CROP
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year residue was observed.

Table A-3-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Low Residue Tillage	Reduced Tillage	Residue and Tillage Management, No-Till (NRCS 329)*
Conservation Tillage	Conservation Tillage Mulch Tillage No Tillage Ridge Tillage	Residue and Tillage Management, No-Till (NRCS 329)* Residue and Tillage Management, Reduced Till (NRCS 345)*
High Residue, Minimum Soil Disturbance Tillage	High Residue Tillage Management	Residue and Tillage Management, No-Till (NRCS 329)*

*Acres cost-shared and implemented under the NRCS 329 standard do not automatically fulfill the CBP's definitions for Low Residue Tillage, Conservation Tillage, or High Residue, Minimum Soil Disturbance Tillage, but with proper verification can demonstrate how many acres meet which of the definitions. Likewise, acres cost-shared and implemented under the NRCS 345 standard do not automatically fulfill the CBP's definition for Conservation Tillage, but proper verification can demonstrate how many acres meet the definition.

Additional Information

Expert panel report:
Thomason, W., Duiker, S., Ganoe, K., Gates, D., McCollum, B., & M. Reiter. 2016. Conservation Tillage Practices for use in Phase 6 of the Chesapeake Bay Watershed Model. CBP/TRS-308-16.
http://www.chesapeakebay.net/documents/CT_6.0_Conservation_Tillage_EP_Revised_Full_Report_12-14-16.2_FINAL_NEW_TEMPLATE.pdf

Example USDA NRCS National Conservation Practice Standards:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/

USDA NRCS. Video. The Science of Soil Health: Using Cover Crops to Soak up Nutrients for the Next Crop:
https://youtu.be/CVf2yF19tx8

Conservation Technology Information Center: https://www.ctic.org/

Version and History Statement

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All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-4. Cover Crops – Traditional

General Information

Cover crops are short-term crops grown after the main cropping season to reduce nutrient and sediment losses from the farm field. The selected crop species and management of cover crops vary based on the farmer's needs and preferences.

Figure A-4-1. Farm field with visible cover crops. Source: CBP

CBP Definition(s)

Traditional Cover Crop: A short-term crop grown after the main cropping season to reduce nutrient losses to ground and surface water by sequestering nutrients. This type of cover crop may not receive nutrients in the fall, and may not be harvested in the spring.

Traditional Cover Crop with Fall Nutrient Applications: A short-term crop grown after the main cropping season to reduce nutrient losses to ground and surface water by sequestering nutrients. This type of cover crop is planted upon cropland where manure is applied following the harvest of a summer crop and prior to cover crop planting. The crop may not be harvested in the spring.

Specifications or Key Qualifying Conditions

As noted in the definitions, the application of nutrients in the fall determines which Traditional Cover Crop practice is applicable. Traditional Cover Crops are not harvested in the spring. If a cover crop is harvested (e.g., a winter cereal) then it would count as a Commodity Cover Crop (see A-5. Cover Crops – Commodity).

The planting date (early, standard, or late) is based on the average frost date for the area. *Early* means the cover crop is planted more than two weeks before the average frost date. *Standard* or *normal* is when the cover crops is planted between the average frost date and two weeks before that date. *Late* is when the cover crop is planted within three weeks after the average frost date.

Figure A-4-2. As pictured here, cover crops such as ryegrass can be combined with other practices such as no-till management (see Sheet A-3: Conservation Tillage). These practices can help build organic matter, improving the soil health in addition to reducing erosion and nutrient pollution. Source: NRCS Soil Health Campaign, Flickr

Cover crop BMPs can also be distinguished by the planting or seeding method (aerial, drilled, other). *Aerial* includes seeding by airplane and other broadcast methods where the seed is not incorporated into the soil (including broadcast only and broadcast/stalk-chopped). *Drilled* involves planting with a seed drill, whether no-till or conventional till conditions apply. *Other* includes any non-drilled seeding method where the seed is incorporated into the soil, e.g., broadcast and disked.

Nitrogen, Phosphorus and Sediment Reductions

Nutrient reductions vary based on hydrogeomorphic region (HGMR), cover crop species, planting date and planting method.

The nitrogen efficiency values for Traditional Cover Crops range from 3 to 45 percent; the nitrogen values for Traditional Cover Crops with Fall Nutrients range from 6 to 32 percent. For Traditional Cover Crops both with and without fall nutrients, phosphorus effectiveness values range from 0 to 15 percent, and sediment effectiveness values range from 0 to 20 percent. Table A-4-1 lists the nitrogen, phosphorus and sediment efficiency values for two common cover crops – Rye and Wheat – without fall nutrients. A complete list of the values for all cover crop variants is available in Appendix A of the expert panel report, as well as in the source data posted on the CAST website (http://cast.chesapeakebay.net/).

Table A-4-1. Traditional Cover Crop effectiveness values for total nitrogen (TN), total phosphorus (TP) and sediment (TSS). Only Rye and Wheat cover crops listed; full table of values available in panel report and CAST documentation.

	Coastal Plain/ Piedmont Crystalline/ Karst						Mesozoic Lowlands/ Valley and Ridge Siliciclastic					
	Low-till land uses			High-till land uses			Low-till land uses			High-till land uses		
BMP long name	TN (%)	TP (%)	TSS (%)	TN (%)	TP (%)	TSS (%)	TN (%)	TP (%)	TSS (%)	TN (%)	TP (%)	TSS (%)
Cover Crop Traditional Rye Early Drilled	45	0	0	45	15	20	34	0	0	34	15	20
Cover Crop Traditional Rye Early Other	38	0	0	38	15	20	29	0	0	29	15	20
Cover Crop Traditional Rye Early Aerial	25	0	0	25	15	20	19	0	0	19	15	20
Cover Crop Traditional Rye Normal Drilled	41	0	0	41	7	10	31	0	0	31	7	10
Cover Crop Traditional Rye Normal Other	35	0	0	35	7	10	27	0	0	27	7	10
Cover Crop Traditional Rye Late Drilled	19	0	0	19	0	0	15	0	0	15	0	0
Cover Crop Traditional Rye Late Other	16	0	0	16	0	0	12	0	0	12	0	0
Cover Crop Traditional Wheat Early Drilled	31	0	0	31	15	20	24	0	0	24	15	20
Cover Crop Traditional Wheat Early Other	27	0	0	27	15	20	20	0	0	20	15	20
Cover Crop Traditional Wheat Early Aerial	17	0	0	17	15	20	13.5	0	0	13.5	15	20
Cover Crop Traditional Wheat Normal Drilled	29	0	0	29	7	10	22	0	0	22	7	10
Cover Crop Traditional Wheat Normal Other	24	0	0	24	07	10	19	0	0	19	7	10
Cover Crop Traditional Wheat Late Drilled	13	0	0	13	0	0	10	0	0	10	0	0
Cover Crop Traditional Wheat Late Other	11	0	0	11	0	0	9	0	0	9	0	0

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

Because many of the applicable land uses represent rotational crops, it is not recommended that states track and report this level of detail. Instead, it is recommended that states report these acres on the land use group "Crop," which contains all of the following individual land uses:

- Full season Soybeans
- Grain with Manure
- Grain without Manure
- Silage with Manure
- Silage without Manure
- Small Grains
- Specialty Crop High
- Specialty Crop Low
- Other Agronomic Crops
- Double-Cropped

Brief Description of BMP Simulation in the Model

All cover crop practices are *Efficiency Value BMPs*. Runoff from applicable load sources is reduced by the efficiency values listed in Table A-4-1 and Figure 1 in Appendix A of the expert panel report.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - There are many variants of Traditional Cover Crops available in the NEIEN appendix, which are not listed here. BMP names vary by the species of the cover crop, planting date (early, normal, late), and planting method (aerial, drilled, other). A smaller number of variants are also available for Traditional Cover Crops with Fall Nutrients.
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses (Full season Soybeans; Grain with Manure; Grain without Manure; Silage with Manure; Silage without Manure; Small Grains; Specialty Crop High; Specialty Crop Low; Other Agronomic Crops; Double-Cropped); if none are reported the default will be CROP
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year cover crop was observed.

Table A-4-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Traditional Cover Crop	There are 220 variants of traditional cover crops available in NEIEN. Not listed here due to space. The available species of cover crops for this BMP are listed in the right-hand column of this table.	Cover Crop (NRCS 340)* Wheat, Rye, Barley, Forage Radish, Annual Legume, Triticale, Legume plus Grass 25-50%, Legume plus Grass 50%, Annual Ryegrass, Oats, Brassica
Traditional Cover Crop with Fall Nutrients	There are 36 variants of traditional cover crops with fall nutrients available in NEIEN. Not listed here due to space. The available species of cover crops for this BMP are listed in the right-hand column of this table.	Wheat, Rye, Barley, Forage Radish, Annual Legume, Triticale, Legume plus Grass 25-50%, Legume plus Grass 50%, Annual Ryegrass, Oats, Brassica

*Acres implemented and reported as NRCS 340 will default to "Cover Crop Traditional Wheat Late Other," unless the state has other information to specify those acres as other cover crop variants.

Additional Information

Expert panel report:
Staver, K., White, C., Meisinger, J., Salon, P., & W. Thomason. 2016. Cover Crops Practices for use in Phase 6 of the Chesapeake Bay Watershed Model. CBP/TRS-310-16. http://www.chesapeakebay.net/documents/Phase_6_CC_EP_Final_Report_12-16-2016-NEW_TEMPLATE_FINAL.pdf

Example USDA NRCS National Conservation Practice Standards:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/

Version and History Statement

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A-5. Cover Crops – Commodity

General Information

Cover crops are short term crops grown after the main cropping season to reduce nutrient and sediment losses from the farm field. The selected crop species and management of cover crops vary based on the farmer's needs and preferences. Winter cereals such as barley, rye and wheat are often harvested in the spring, unlike many traditional species of cover crops (see Sheet A-4. Cover Crops – Traditional).

Figure A-5-1. Winter wheat planted in the fall and harvested in the spring is an example of a Commodity Cover Crop. Source: Danny Navarro, Flickr

CBP Definition(s)

Commodity Cover Crop: A winter cereal crop planted for harvest in the spring which does not receive nutrient applications in the fall. Any winter cereal crop which did receive applications in the fall is not eligible for nutrient reductions.

Specifications or Key Qualifying Conditions

Commodity cover crops may be harvested, but if it received nutrient applications then it is not eligible as a BMP.

The planting date (early, standard, or late) is based on the average frost date for the area. *Early* means the cover crop is planted more than two weeks before the average frost date. *Standard* or *normal* is when the cover crop is planted between the average frost date and two weeks before that date. *Late* is when the cover crop is planted within three weeks after the average frost date.

Cover crop BMPs can also be distinguished by the planting or seeding method (aerial, drilled, other). *Aerial* includes seeding by airplane and other broadcast methods where the seed is not incorporated into the soil (including broadcast only and broadcast/stalk-chopped). *Drilled* involves planting with a seed drill, whether no-till or conventional till conditions apply. *Other* includes any non-drilled seeding method where the seed is incorporated into the soil, e.g., broadcast and disked.

Nitrogen, Phosphorus and Sediment Reductions

Nitrogen reductions range from 4 to 15 percent and vary based on hydrogeomorphic region (HGMR), planting date (early, standard or late) and whether they are applied to low- or high-till land uses. The effectiveness values for nitrogen are summarized in Table A-5-1. There are no phosphorus or sediment reductions associated with this BMP.

Table A-5-1. Commodity cover crop TN reductions. There are no TP or Sediment reductions associated with this BMP.

	Coastal Plain, Piedmont Crystalline and Karst HGMRs		Mesozoic Lowlands, Valley and Ridge Silliciclastic HGMRs	
	Low-Till land uses	High-Till land uses	Low-Till land uses	High-Till land uses
BMP	**TN (%)**	**TN (%)**	**TN (%)**	**TN (%)**
Commodity Cover Crop, Early	5	5	4	4
Commodity Cover Crop, Standard	10	10	8	8
Commodity Cover Crop, Late	15	15	12	12

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

Because the applicable land uses represent rotational crops, it is not recommended that states track and report this level of detail. Instead, it is recommended that states report these acres on the land use group, "Small Grains and Double-Crops," which contains all of the following individual land uses:

- Small Grains and Grains
- Double Cropped Land

Brief Description of BMP Simulation in the Model

All cover crop practices are *Efficiency Value BMPs*. Runoff from applicable load sources are reduced by the efficiency values listed in Table A-5-1.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Commodity Cover Crop, Early
    - Commodity Cover Crop, Standard
    - Commodity Cover Crop, Late
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be Small Grains and Double-Crop
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year cover crop was observed.

Table A-5-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Commodity Cover Crop	Commodity Cover Crop, Early Commodity Cover Crop, Standard Commodity Cover Crop, Late There are ~142 other variants of commodity cover crops available in NEIEN, not listed here due to space, which are based on the crop species, planting date and planting method. The eligible species are listed in the right-hand column.	Cover Crop – Harvestable, Commodity Cover Crop. Harvestable commodity cover crops include: Barley, Rye, Ryegrass, Wheat, Clover/Wheat, Spring Oats, Oats, Canola/Rapeseed, Triticale

Additional Information

Expert panel report:
Staver, K., White, C., Meisinger, J., Salon, P., & W. Thomason. 2016. Cover Crops Practices for use in Phase 6 of the Chesapeake Bay Watershed Model. CBP/TRS-310-16.
http://www.chesapeakebay.net/documents/Phase_6_CC_EP_Final_Report_12-16-2016-NEW_TEMPLATE_FINAL.pdf

Example USDA NRCS National Conservation Practice Standards:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/

Conservation Technology Information Center: https://www.ctic.org/

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A-6. Animal Waste Management System

General Information

Manure is a resource that can be used in a variety of ways, but before it can be applied to a field or transported elsewhere, farms must first collect and store the manure. Farmers and other practitioners understand Animal Waste Management System (AWMS) as a general system that includes all aspects of managing manure (Figure A-6-2). However, the AWMS BMP, as defined by the CBP for purposes of annual BMP progress reporting and the Phase 6 Watershed Model, reflects manure storage and the expected improvements in manure recoverability. Manure storage improves the farmer's ability to manage manure through additional practices, such as Manure Treatment (A-15. Manure Treatment Thermochemical) or improved timing of field application (A-2. Nutrient Management).

Figure A-6-1. This dry manure stacking facility (at left in photo) is used to store manure until the farmer is ready to treat, transport or apply it. The pictured facility has a roof and concrete walls to prevent manure loss or runoff. Source: NRCS Photo Gallery

CBP Definition(s)

Animal Waste Management System (AWMS): Any structure designed for collection, transfer and storage of manures and associated wastes generated from the confined portion of animal operations and complies with NRCS 313 (Waste Storage Facility) or NRCS 359 (Waste Treatment Lagoon) practice standards. Manure conserved through reduced storage and handling losses associated with AWMS implementation are available for land application or export from the farm.

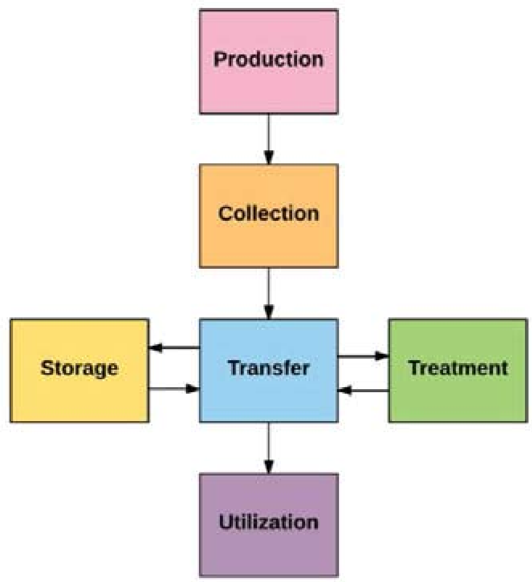

Figure A-6-2. Animal waste management is a general system that encompasses a range of management activities on the farm, including collection, storage, transfer and utilization of the manure. Adapted from NRCS 1992 Agricultural Waste Management Field Handbook, Chapter 9.

Specifications or Key Qualifying Conditions

There are no additional specifications or qualifying conditions beyond those described in the definitions above.

Nitrogen, Phosphorus and Sediment Reductions

AWMS practices alter the amount of manure that is recovered for subsequent field application or transport. There is no sediment load, and thus no sediment reduction, associated with animal manure and this practice. The amount of manure recovered by the BMP varies by the animal type, as shown in Table A-6-1. The values for manure recoverability in Table A-6-1 apply only to the confined portion of each type of animal operation. In other words, manure deposited on pasture or directly in a stream is not recoverable and not affected by the AWMS practice.

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

AWMS practices are applicable to all animal types in the Watershed Model (see Table A-6-1). When the specific animal type is not known, the practice can also be reported on "Poultry" or "Livestock."

Brief Description of BMP Simulation in the Model

AWMS practices are simulated as *Animal BMPs*. Specifically, the amount of manure that is lost from storage or handling is reduced according to the values listed in Table A-6-1, thus making the recovered manure available for transport or application to crops.

Annual or Cumulative? Cumulative (15-year credit duration)

Can this practice be combined with other BMPs? Yes. This practice is the only BMP that affects manure recoverability and any subsequent BMPs can also be applied.

Table A-6-1. Manure recoverability before and after AWMS

Animal Type	% Recoverable without AWMS	% Recoverable with AWMS
Beef	60	99
Dairy	75	95
Other Cattle	60	99
Hogs for Slaughter	90	99
Hogs for Breeding	90	99
Broilers	90	99
Layers	90	99
Turkeys	90	99
Pullets	90	99
Sheep	95	98
Horses	95	98
Goats	95	98

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Choose from available BMP names in the NEIEN Phase 6 Appendix
- *Measurement unit:* Choose from: Systems; (Animal)_AU; or Animals
- *Land Use:* N/A
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year system was constructed.

Figure A-6-3. Storage practices come in different shapes and sizes. Storage pits or lagoons are used for liquid manure such as dairy cow or swine manure. Pictured is a lagoon in Virginia. Source: NRCS Photo Gallery

Table A-6-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Animal Waste Management System	Animal Waste Management System (AWMS)	Waste Storage Facility (NRCS 313) Waste Treatment Lagoon (NRCS 359) Waste Storage Structure, Dry Waste Storage Structure, Waste Storage Pond

Additional Information

Expert panel report:
Hawkins, S., Hamilton, D., McIntosh, B., Moyle, J., Risse, M., & P. Vanderstappen. 2016. Animal Waste Management Systems: Recommendations from the BMP Expert Panel for Animal Waste Management Systems in the Phase 6 Watershed Model. CBP/TRS-315-16.
http://www.chesapeakebay.net/documents/AWMS_EP_Report_WQGIT_approved_December_2016_final.pdf

eXtension.org – What does manure collection and storage look like? http://articles.extension.org/pages/74482/what-does-manure-collection-and-storage-look-like

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in December 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-7. Barnyard Runoff Control and Loafing Lot Management

General Information

Many farmers utilize roof gutters and other practices to help protect water quality and improve management of livestock production areas, including barnyards and loafing areas.

Figure A-7-1. Gutters, or roof runoff structures, can divert precipitation away from areas where animals and manure are present, which keeps the runoff water clean. Photo: USDA NRCS

CBP Definition(s)

Barnyard runoff control includes the installation of practices to control runoff from barnyard areas. This includes practices such as roof runoff control, diversion of clean water from entering the barnyard and control of runoff from barnyard areas.

Loafing lot management is the stabilization of areas frequently and intensively used by people, animals or vehicles by establishing vegetative cover, surfacing with suitable materials, and/or installing needed structures. This does not include poultry pad installation.

Specifications or Key Qualifying Conditions

Cost-shared runoff control or stabilization must meet the standards of the federal or state program in which they are enrolled. Non-cost-shared gutters or runoff control structures must be documented and meet the CBP's criteria as defined for the relevant Resource Improvement (RI) practice (CBP RI-16, barnyard clean water diversion).

Nitrogen, Phosphorus and Sediment Reductions

The nitrogen, phosphorus and sediment reductions for barnyard runoff control and loafing lot management are summarized in Table A-7-1. The efficiency values are applied to permitted and non-permitted feeding space in the Watershed Model.

Table A-7-1. Nitrogen, phosphorus and sediment efficiency values for barnyard runoff control and loafing lot management in the Phase 6 Watershed Model

	Nitrogen *Efficiency* (%)	Phosphorus Efficiency (%)	Sediment Efficiency (%)
Barnyard Runoff Control	20	20	40
Loafing Lot Management	20	20	40

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

This BMP can be reported on feeding space load sources:

- Non-permitted Feeding Space
- Permitted Feeding Space

If the specific load source is not known the load source group "FEED" can be used, which includes both Non-permitted and Permitted Feeding Space load sources.

Brief Description of BMP Simulation in the Model

Both the barnyard runoff control and loafing lot management practices *Efficiency Value BMPs*. Each acre reported under the practices will reduce the nitrogen, phosphorus and sediment loads from feed space according to the efficiencies in Table A-7-1.

Annual or Cumulative? Cumulative (10-year credit duration for both barnyard runoff control and loafing lot management; 5-year credit duration for CBP RI-16, barnyard clean water diversion)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Barnyard Runoff Control
  - Loafing Lot Management
- *Measurement unit:* Acres or Percent
- *Load Source:* Approved NEIEN agricultural feeding space load sources; if none are reported the default will be FEED
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year system was installed or inspected.

Table A-7-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Barnyard Runoff Control	Barnyard Runoff Control	Roof runoff structure (NRCS 558); Diversion (NRCS 362); Stormwater Runoff Control (NRCS 570); Trails and Walkways (NRCS 575)
Barnyard clean water diversion	Barnyard clean water diversion RI	Barnyard clean water diversion (CBP RI-16)
Loafing Lot Management	Loafing Lot Management	Loafing Lot Management System

Additional Information

Locate and consult your state and county USDA Field Office Technical Guide (FOTG) for details on conservation practices: https://efotg.sc.egov.usda.gov/

Chesapeake Bay Program Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report: Ensor, R., Absher, D., Moore, G., Garber, L., McGee, B., Albrecht, G., Weibley, E., Wootton, C., & J. Hill. 2014. Chesapeake Bay Program Resource Improvement Practice Definitions and Verification Visual Indicators Report. Approved by CBP Water Quality Goal Implementation Team, August 2014. https://www.chesapeakebay.net/documents/RI_Report_5_8-8-14.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the Chesapeake Bay Program's Nutrient Subcommittee in 2003.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-8. Pasture and Grazing management practices

General Information

Figure A-8-1. Animals' diets may be supplemented in other ways by the farmer, but grazing time in a pasture allows animals to eat, drink, socialize, exercise or relax at their own pace. Photos: USDA NRCS (top); Chesapeake Bay Program (bottom)

Many farmers allow horses, dairy cows and beef cattle to eat grass or other forage vegetation – i.e., graze – in pastures during non-winter months. Grazing, movement and manure deposition by the animals encourages growth of pasture vegetation. However, animals can overgraze a pasture if there is not enough area to graze for the number of animals, or if they are not moved to a fresh area frequently enough. Overgrazing can lead to a loss of vegetative cover, soil erosion and nutrient runoff. By rotating animals to other areas or pastures, the recently grazed vegetation has an opportunity to regrow. Farmers consider a number of factors specific to their operational needs and capacity, such as animal type, pasture soils and vegetation, when determining the most effective way to manage their herd. Related BMPs, such as buffers with exclusion fencing (see A-13) or off-stream watering (see A-19), are not discussed here.

CBP Definition(s)

Horse Pasture Management: maintaining a 50% pasture cover with managed species and managing high traffic areas.

Precision Intensive Rotational/Prescribed Grazing: This practice utilizes a range of pasture management and grazing techniques to improve the quality and quantity of the forages grown on pastures and reduce the impact of animal travel lanes, animal concentration areas or other degraded areas. PG can be applied to pastures intersected by streams or upland pastures outside of the degraded stream corridor (35 feet width from top of bank). Pastures under the PG systems need to have a vegetative cover of 60% or greater.

Specifications or Key Qualifying Conditions

Jurisdictions may have additional requirements for management of grazing and pasture areas, such as stocking rates (animals per acre). For CBP purposes the only requirement is the minimum vegetative cover. These BMPs can be applied with or without related BMPs such as stream exclusion fencing or off-stream watering systems.

Nitrogen, Phosphorus and Sediment Reductions

The horse pasture management BMP receives no nitrogen reduction. Its phosphorus and sediment efficiency values are the same for all hydrogeomorphic regions (HGMRs) in the watershed. The BMP for precision intensive rotational/prescribed grazing has two different nitrogen efficiency values based on the HGMR as seen in Table A-8-1; the phosphorus and sediment efficiency values are 24 percent and 30 percent, respectively, regardless of HGMR.

Table A-8-1. Nitrogen, phosphorus and sediment efficiency values for horse pasture management and rotational grazing BMPs

BMP	Hydrogeomorphic region (HGMR)	Nitrogen	Phosphorus	Sediment
Horse Pasture Management	All	0%	20%	40%
Precision Intensive Rotational/Prescribed Grazing	Appalachian Plateau Carbonate; Coastal Plain Dissected Uplands; Piedmont Carbonate; Valley and Ridge Carbonate; all Coastal Plain HGMRs	9%	24%	30%
Precision Intensive Rotational/Prescribed Grazing	Valley and Ridge Siliciclastic; Appalachian Plateau Siliciclastic; Mesozoic Lowlands; Blue Ridge; Piedmont Crystalline	11%	24%	30%

Specific Reporting and Modeling Information

Figure A-8-2. Grazing systems that maintain healthy, dense vegetative cover in a pasture throughout the year are beneficial to water quality. Photos: USDA NRCS

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Pasture

Brief Description of BMP Simulation in the Model

The grazing and pasture management BMPs described here are *Efficiency Value BMPs*. One acre of pasture is treated for each acre reported under the BMPs, using the efficiency values in Table A-8-1.

Annual or Cumulative? Cumulative (10-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Horse Pasture Management
  - Precision Intensive Rotational/Prescribed Grazing
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be Pasture
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year grazing plan/system was implemented.

Table A-8-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common BMP names
Horse Pasture Management	Horse Pasture Management	Prescribed grazing (NRCS 528 or 528A)
Precision Intensive Rotational/Prescribed Grazing	Grazing land protection; Prescribed grazing; Rotational grazing RI (RI-15)	Managed intensive grazing; Prescribed grazing (NRCS 528 or 528A)

Additional Information

Chesapeake Bay Program. 2015. [Video]. Restoration Spotlight: The *Grass Whisperer gets to the root of grazing.* *https://vimeo.com/144890052*

USDA NRCS. Pasture resources. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/landuse/rangepasture/pasture/

University of Maryland Extension. Publications: [Horse] Pasture Management: https://extension.umd.edu/horses/resources/publications

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definition and benefits that were reviewed and approved by the Agriculture Workgroup and WQGIT in 2010.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-9. Stream Restoration (Ag)

General Information

New stream restoration techniques have been pioneered in the Chesapeake Bay watershed to restore streams. Approaches to stream restoration include natural channel design, regenerative stream channel and legacy sediment removal. Stream restoration projects require state and federal permits and thus extensive regulatory review. Projects often take multiple years from concept to construction, involving high costs and extensive effort from multiple stakeholders at the community, state and federal level. Note: This BMP reference sheet is targeted for the agricultural sector. See Sheets N-1: Stream Restoration (Urban and Non-Urban) and D-5: Urban Stream Restoration if interested in developed or general sectors, though the information is the same.

Figure A-9-1. Stream restoration projects can improve the health of aquatic resources and can be one of the more cost-effective practices to reduce nutrient and sediment loads in urban watersheds. A stream prior to restoration (top) that has an eroded stream bank and channel can be restored so that natural processes reduce the erosive energy of the stream flow during storm events. The bottom picture is the same stream shortly after completion of the project. Photos: US Fish and Wildlife Service

CBP Definition(s)

Natural Channel Design (NCD) applies the principles of stream geomorphology to maintain a state of dynamic equilibrium among water, sediment, and vegetation that creates a stable channel.

Legacy Sediment Removal (LSR) seeks to remove legacy sediments from the stream and its floodplain and thereby restore the natural potential of aquatic resources including a combination of streams, floodplains, and wetlands.

Regenerative Stream Channel (RSC, aka Regenerative Stormwater Conveyance) uses in-stream weirs in perennial streams to increase the interaction with the floodplain during smaller storm events. These projects may also include sand seepage wetlands and other habitats to increase the stream's connection with its floodplain. Only wet channel RSC practices are eligible as stream restoration projects. Dry channel RSC projects are considered a runoff reduction retrofit practice, which is not applicable to agricultural load sources (see Sheet D-2: Stormwater Retrofits).

Stream Restoration refers to any NCD, RSC, LSR or other restoration project that meets the qualifying conditions for credits, including environmental limitations and stream functional improvements.

Specifications or Key Qualifying Conditions

There are further protocol-specific qualifying criteria detailed in other resources listed under Additional Information below. All projects must meet the following criteria to be eligible for credit:

- Reach restored must be greater than 100ft in length.
- Reach restored must be actively enlarging or degrading.
- Reach restored MAY NOT be tidally influenced.
- The project MAY NOT be primarily designed to protect public infrastructure. Bank armoring and rip rap are not eligible for stream restoration credit.

- Restoration plan must utilize a comprehensive approach to stream restoration design, addressing long-term stability of the channel, banks, and floodplain.
- Must comply with all state and federal permitting requirements, including 404 and 401 permits.

Stream restoration is a carefully designed intervention to improve the hydrologic, hydraulic, geomorphic, water quality, and biological condition of degraded urban streams, and must not be implemented for the sole purpose of nutrient or sediment reduction. Restoration projects should be developed through a functional assessment process, such as the stream functions pyramid (Harman et al., 2012) or functional equivalent.

Nitrogen, Phosphorus and Sediment Reductions

There are three general protocols to define the pollutant load reductions from stream restoration practices. There is also a default rate for historic projects and new projects that cannot conform to the recommended reporting requirements.

- Protocol 1. Credit for prevented sediment during storm flow
- Protocol 2. Credit for in-stream nitrogen processing during base flow
- Protocol 3. Credit for reconnection to the floodplain

For details on how to use the protocols consult the resources listed under Additional Information.

Table A-9-1. Summary of stream restoration protocols for nitrogen, phosphorus and sediment reductions

Protocol	TN (lbs/ linear ft/ year)	TP (lbs/ linear ft/ year)	TSS (lbs/ linear ft/ year)
Protocol 1. Prevented sediment	Site-specific	Site-specific	Site-specific
Protocol 2. In-stream nitrogen processing	Site-specific	N/A	N/A
Protocol 3. Floodplain reconnection	Site-specific	Site-specific	Site-specific
Default for existing/non-conforming projects*	0.075	0.068	248**

*The existing/non-conforming rates were adjusted following a test drive period. These adjustments are explained in Appendix G of the expert panel report.
**Because small stream loads are explicitly modeled in the Phase 6 tools, no sediment delivery factors are needed to reduce the default edge-of-field rate of 248 lbs of TSS/linear ft/year published by the panel.

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Stream Bed and Bank

The practice can only be applied to the "Stream Bed and Bank" load source, but it is recommended to distinguish the BMP based on its sector using the appropriate secondary BMP designation of either "Urban Stream Restoration" or "Non-Urban Stream Restoration."

Brief Description of BMP Simulation in the Model

All stream restoration practices are *Load Reduction BMPs,* which means they are modeled as a simple removal of pounds of nitrogen, phosphorus and/or sediment from the edge-of-stream load. To calculate the pounds reduced for each protocol, follow the methods and examples described in the panel report and other resources listed under Additional Information. The protocols are additive. So, a project that reduces 100 lbs TN under Protocol 1, 25 lbs TN under Protocol 2, and 30 lbs TN under Protocol 3 has a net reduction of 155 lbs TN. As another example, pretend the project design is unknown for a project planned to restore 1,000 linear feet of a degraded stream. Using the default rate for that project yields reductions of 7.5 lbs TN, 6.8 lbs TP and 24,800 lbs TSS, which would be removed from the edge-of-stream load in the Watershed Model. Load reduction BMPs such as stream restoration cannot remove more pounds of nitrogen, phosphorus or sediment than are available in a watershed, however. So, the Watershed Model does enforce maximum reductions that are described in Section 6.5.4.1 of the Watershed Model documentation.

Annual or Cumulative? Cumulative (10-year credit duration for non-urban stream restoration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Non-Urban Stream Restoration Protocol
  - Non-Urban Stream Restoration
- *Measurement unit(s): Length restored (feet); Protocol 1 TN (lbs); Protocol 1 TP (lbs); Protocol 1 TSS (lbs); Protocol 2 TN (lbs); Protocol 3 TN (lbs); Protocol 3 TP (Lbs); Protocol 3 TSS (lbs)*
- *Load Source:* Stream Bed and Bank
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year the project was completed.

Table A-9-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

<table>
<tr><th>CBP or Expert Panel term</th><th>NEIEN BMP name</th><th>Other common practice names</th></tr>
<tr><td>Stream Restoration (Ag)</td><td>Non-Urban Stream Restoration Protocol*</td><td rowspan="2">natural channel design, legacy sediment removal, regenerative stream channel or regenerative stormwater conveyance (wet channel only)</td></tr>
<tr><td>Stream Restoration (Ag)</td><td>Non-Urban Stream Restoration**</td></tr>
<tr><td colspan="3">* Uses protocols 1-3 summarized in Table A-9-1. Requires unit of feet in addition to the pounds reduced for each respective protocol.
** For use when specific project design is not known. Requires unit of feet.</td></tr>
</table>

Additional Information

Expert panel report:
Berg, J., Burch, J., Cappuccitti, D., Filoso, S., Fraley-McNeal, L., Goerman, D., Hardman, N., Kaushal, S., Medina, D., Meyers, M., Kerr, B., Stewart, S., Sullivan, B., R. Walter & J. Winters. 2013. Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects. Prepared by T. Schueler, Chesapeake Stormwater Network, and B. Stack, Center for Watershed Protection. Test-drive revisions approved by the WQGIT September 8, 2014.
https://www.chesapeakebay.net/documents/Stream_Panel_Report_Final_08282014_Appendices_A_G.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-4: Urban Stream Restoration. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network. BMP Resources, Urban Stream Restoration: http://chesapeakestormwater.net/bmp-resources/urban-stream-restoration/

Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs & C. Miller. 2012. A function-based framework for developing stream assessments, restoration goals, performance standards and standard operating procedures. U.S. Environmental Protection Agency. Office of Wetlands, Oceans and Watersheds. Washington, D.C. EPA 843-K-12-006. https://www.epa.gov/sites/production/files/2015-08/documents/a_function_based_framework_for_stream_assessment_3.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in May 2013, with test-drive revisions approved in September 2014.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-10. Dairy precision feeding and forage management

General Information

Dairy cows are given a regular diet of feed, typically composed of grains and forage. Feed can often be the most expensive component of an operation. Feeding dairy cows more efficient amounts of nutrients reduces nitrogen and phosphorus excreted in their manure, which benefits both water quality and the farmer's bottom line.

Figure A-10-1. It is important to farmers to balance the cows' nutritional needs with the amount, type and cost of feed. Photo: Chesapeake Bay Program

CBP Definition(s)

Dairy precision feeding and/or forage management reduces the quantity of phosphorus 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.

Specifications or Key Qualifying Conditions

This BMP is only applicable to dairy operations.

Nitrogen, Phosphorus and Sediment Reductions

There are no sediment reductions for this BMP; nitrogen and phosphorus reductions are in Table A-10-1 below.

Table A-10-1. Nitrogen and phosphorus effectiveness values for dairy precision feeding BMP

	Nitrogen (%)	Phosphorus (%)
Dairy precision feeding and forage management	24	25

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Feeding Space, Permitted Feeding Space or Non-Permitted Feeding Space

Brief Description of BMP Simulation in the Model

The dairy precision feeding and forage management practice is an *Animal BMP* that reduces the concentration of nitrogen and phosphorus in dairy manure by 24 and 25 percent, respectively, which reduces the nutrient load applied to eligible cropland from manure.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Feed management
- *Measurement unit:* Animal count, animal units or percent
- *Animal type:* Dairy
- *Land Use:* Feeding Space, Permitted Feeding Space or Non-Permitted Feeding Space
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year

Figure A-10-2. Feed management allows for more efficient nutrient utilization while providing dairy cows with the energy and proteins they need to be healthy and productive. Photo: USDA

Table A-10-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common BMP names
Dairy precision feeding and/or forage management	Feed management	Feed Management (NRCS 592) for dairy

Additional Information

Harrison, J.H., et al. 2013. An introduction to NRCS Feed Management Practice Standard 592: http://articles.extension.org/pages/11312/an-introduction-to-natural-resources-conservation-service-nrcs-feed-management-practice-standard-592

eXtension.org, Dairy video archive: http://articles.extension.org/pages/15830/dairy-video-archive

Penn State Extension. Precision feeding dairy heifers: strategies and recommendations. https://extension.psu.edu/precision-feeding-dairy-heifers-strategies-and-recommendations

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in 2009.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-12. Forest Buffers and Grass Buffers

General Information

Forest buffers and grass buffers are widely implemented conservation practices in the region. This reference sheet is applicable to forest buffers and grass buffers planted in agricultural cropland settings. For buffers in agricultural pasture settings, see A-13: Forest and Grass Buffers with Stream Exclusion Fencing. For forest buffers in developed areas, see D-7: Urban Tree Planting BMPs.

Figure A-12-1. Aerial view of a riparian forest buffer. Buffers reduce the impact of pollutants from upland sources while providing additional habitat and environmental benefits. Photo: USDA NRCS

CBP Definition(s)

Forest Buffer: Linear wooded areas that help filter nutrients, sediments and other pollutants from runoff as well as remove nutrients from groundwater. The recommended buffer width is 100 feet, with a 35 feet minimum width required.

Forest Buffer – Narrow: Linear strips of wooded areas maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow forest buffer strips are between 10 and 35 feet in width.

Grass Buffer: Linear strips of grass or other non-woody vegetation maintained to help filter nutrients, sediment and other pollutants from runoff. The recommended buffer width for buffers is 100 feet, with a 35 feet minimum width required.

Grass Buffer – Narrow: Linear strips of grass or other non-woody vegetation maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow grass buffers are between 10 and 35 feet in width.

Figure A-12-2. Aerial view of a forest buffer recently planted to expand an existing riparian forested area. Buffers reduce the impact of pollutants from upland sources while providing additional habitat and environmental benefits. Photo: Chesapeake Bay Program

Specifications or Key Qualifying Conditions

These practices are only applicable on converted cropland; see Reference Sheet A-13 for applicable buffer practices on pasture. Any buffer less than 35 feet in (average) width is only eligible for the *narrow* buffer practices. Cost-shared buffers must meet the standards of the federal or state program in which they are enrolled. Non-cost-shared buffers must be documented and meet the CBP's criteria as defined for the relevant Resource Improvement (RI) practices (CBP RI-7,8 for grass buffers; CBP RI-9,10 for forest buffers).

Nitrogen, Phosphorus and Sediment Reductions

The net reductions in nitrogen, phosphorus and sediment for forest buffers are significant, but not simple to quantify without the use of CAST (http://cast.chesapeakebay.net/). There is a load source change of the buffered area from the previous land use (e.g., cropland) into forest, which reduces the simulated load. Then there is also an efficiency applied to upland acres that further reduces pollutant loads. The efficiency values applied to upland acres vary based on the hydrogeomorphic region where the buffer is installed; the values are summarized in Table A-12-1. Narrow buffers are only simulated as a load source change to forest and do not receive the additional upland treatment summarized in the tables below.

Table A-12-1. Nitrogen, phosphorus and sediment efficiency values applied to upland acres for agricultural forest buffers and grass buffers in the Phase 6 Watershed Model, by hydrogeomorphic region (HGMR). Note: These efficiency values are not applicable to narrow buffers (between 10 and 35 feet in width).

HGMR	Nitrogen Efficiency (%) applied on 4 upland acres per 1 acre of buffer Forest Buffer	Nitrogen Efficiency (%) applied on 4 upland acres per 1 acre of buffer Grass Buffer	Phosphorus Efficiency (%) applied on 2 upland acres per 1 acre of buffer Forest Buffer and Grass Buffer	Sediment Efficiency (%) applied on 2 upland acres per 1 acre of buffer Forest Buffer and Grass Buffer
Coastal Plain Dissected Uplands	65	46	42	56
Piedmont Carbonate	46	32	36	48
Appalachian Plateau Siliciclastic	54	38	42	56
Coastal Plain Uplands	31	21	45	60
Appalachian Plateau Carbonate	54	38	42	56
Piedmont Crystalline	56	39	42	56
Valley and Ridge Carbonate	34	24	30	40
Valley and Ridge Siliciclastic	46	32	39	52
Blue Ridge	34	24	30	40
Coastal Plain Lowlands	19	13	45	60
Mesozoic Lowlands	34	24	30	40

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Cropland
- Cropland and Hay
- Cropland and Hay Eligible for Manure
- Cropland Eligible for Manure
- Grains not Double Cropped
- Hay
- Leguminous Hay
- Other Hay
- Row Crops
- Row Crops Eligible for Manure
- Specialty Cropland

Forest and grass buffers can be reported on any of the above load source groups. The default load source group is Cropland and Hay, or "CropHay.

Brief Description of BMP Simulation in the Model

The forest buffer and grass buffer practices are both simulated as a *Load Source Change with an Efficiency Value* in the Watershed Model. Each acre reported under the practices will be converted to the forest or agricultural open space load sources, respectively, and then there is an additional reduction in upland loads using the efficiency values in Table A-12-1. For example, one acre of cropland that is converted into a riparian forest buffer will increase the overall acres of forest by one and reduce the amount of cropland by that same amount. Additionally, the nitrogen load from four other acres will be reduced by 31 percent (assuming the buffer is installed in a Coastal Plain Upland setting for this example); the phosphorus and sediment loads from two acres will be reduced by 45 and 60 percent, respectively. If the one acre in this example was instead used for a grass buffer then it would be simulated in the same way, except the acre of cropland would be converted to agricultural open space and the upland acres would be treated using the efficiency value of 21 percent for nitrogen. The efficiency values for phosphorus and sediment, and the ratio of acres treated are the same for both forest and grass buffers. While it is difficult to estimate the net reductions of this practice without the use of CAST, the net load reduction can be significant.

Figure A-12-3. Aerial view of a grass buffer. Photo: USDA NRCS

Annual or Cumulative? Cumulative (10-year credit duration; 5-year credit duration for RI practices)

Can this practice be combined with other BMPs? Yes, acres of upland load sources treated by regular forest or grass buffers can also receive other eligible agriculture BMPs. The area of land converted to either forest or agricultural open space by the buffer, however, cannot receive additional BMPs. Narrow buffers cannot be combined with other BMPs since they do not treat upland acres and only change the load source of the buffered area.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Forest Buffer-Upland
        - Forest Buffer
        - Forest Buffer-Narrow
        - Grass Buffer
        - Grass Buffer-Narrow
- *Measurement unit:* Area of buffer (acres)
- *Land Use:* Approved NEIEN agricultural load source groups; if none are reported the default will be CropHay.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year buffer was installed.

Table A-12-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Forest Buffer	Forest Buffer	Riparian Forest Buffer (NRCS 391); Riparian Buffer (FSA CP22);
	Forest Buffer on Watercourse RI	Forest Buffer on Watercourse (CBP RI-10)
Forest Buffer-Narrow	Forest Buffer-Narrow	
	Forest Nutrient Exclusion Area on Watercourse RI	Forest Nutrient Exclusion Area on Watercourse (CBP RI-9)

Grass Buffer	Grass Buffer	Riparian Herbaceous Cover (NRCS 390); Filter Strip (NRCS 393); Filter Strip (FSA CP21); Field Border (NRCS 386); Grass Waterway (NRCS 412); Grass Waterway, Noneasement (FSA CP8A);
	Grass Buffer on Watercourse RI	Grass Buffer on Watercourse (CBP RI-8)
Grass Buffer-Narrow	Grass Buffer-Narrow	
	Grass Nutrient Exclusion Area on Watercourse RI	Grass Nutrient Exclusion Area on Watercourse (CBP RI-7)

Additional Information

Expert panel report:
Belt, K., Groffman, P., Newbold, D., Hession, C., Noe, G., Okay, J., Southerland, M., Speiran, G., Staver, K., Hairston-Strang, A., Weller, D., & D. Wise. 2014. Recommendations of the Expert Panel to Reassess Removal Rates for Riparian Forest and Grass Buffers Best Management Practices. Prepared by S. Claggett, US Forest Service and Tetra Tech, Inc. Approved by CBP Water Quality Goal Implementation Team, October 2014.
https://www.chesapeakebay.net/documents/Riparian_BMP_Panel_Report_FINAL_October_2014.pdf

T. Simpson and S. Weammert (Lane). 2009. Riparian Forest Buffer Practice (Agriculture) and Riparian Grass Buffer Practice Definition and Nutrient and Sediment Reduction Effectiveness Estimates. In Mid-Atlantic Water Program, *Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus and Sediment in the Chesapeake Bay Watershed*. T. Simpson and S. Weammert (Lane), eds. Final Report, December 2009. Pages 469-506.
http://archive.chesapeakebay.net/pubs/BMP_ASSESSMENT_REPORT.pdf

Locate and consult your state and county USDA Field Office Technical Guide (FOTG) for details on conservation practices:
https://efotg.sc.egov.usda.gov/

Chesapeake Bay Program Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report:
Ensor, R., Absher, D., Moore, G., Garber, L., McGee, B., Albrecht, G., Weibley, E., Wootton, C., & J. Hill. 2014. Chesapeake Bay Program Resource Improvement Practice Definitions and Verification Visual Indicators Report. Approved by CBP Water Quality Goal Implementation Team, August 2014.
https://www.chesapeakebay.net/documents/RI_Report_5_8-8-14.pdf

Chesapeake Riparian Forest Buffer Network: *http://chesapeakeforestbuffers.net/*

Chesapeake Bay Program. Video and webpage. Forest Buffers. https://www.chesapeakebay.net/issues/forest_buffers

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in 2009 and 2014.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-13. Forest Buffers and Grass Buffers with Stream Exclusion Fencing

General Information

Forest buffers and grass buffers are widely implemented conservation practices in the region. This reference sheet is only applicable to buffers planted in agricultural pasture settings, which includes fencing. See D-7: Urban Tree Planting BMPs for information about forest buffers in developed settings. For buffers in cropland agricultural settings, see A-12: Forest Buffers and Grass Buffers.

Figure A-13-1. A recently planted forest buffer, with exclusion fencing to prevent livestock from entering the buffered area or stream. When installing a riparian forest buffer in a pasture it is standard to include exclusion fencing. Many such conservation practices in the Chesapeake Bay Watershed are cost-shared through programs such as the US Department of Agriculture's Conservation Reserve Enhancement Program (CREP) and Environmental Quality Incentives Program (EQIP). Photo: Chesapeake Bay Program

CBP Definition(s)

Forest Buffer: Linear wooded areas that help filter nutrients, sediments and other pollutants from runoff as well as remove nutrients from groundwater. The recommended buffer width is 100 feet, with a 35 feet minimum width required.

Forest Buffer – Narrow: Linear strips of wooded areas maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow forest buffer strips are between 10 and 35 feet in width.

Figure A-13-2. Fencing combined with grass or forest buffers protect streams from animal waste and streambank erosion. Photo: USDA

Grass Buffer: Linear strips of grass or other non-woody vegetation maintained to help filter nutrients, sediment and other pollutants from runoff. The recommended buffer width for buffers is 100 feet, with a 35 feet minimum width required.

Grass Buffer – Narrow: Linear strips of grass or other non-woody vegetation maintained on agricultural land between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. Narrow grass buffers are between 10 and 35 feet in width.

When buffers are implemented along a pasture *exclusion fencing* is installed to prevent livestock from grazing and trampling the buffer or entering the stream.

Specifications or Key Qualifying Conditions

These buffer practices with exclusion fencing are only applicable on converted pasture; see Reference Sheet A-12 for applicable buffer practices on converted cropland. Any buffer less than 35 feet in (average) width is only eligible for the *narrow* buffer practices. Cost-shared buffers must meet the standards of the federal or state program in which they are enrolled. Non-cost-shared buffers must be documented and meet the CBP's criteria as defined for the relevant Resource Improvement (RI) practices (CBP RI-4a,4b for narrow grass and forest buffers, respectively; CBP RI-5 for grass buffers and CBP RI-6 for forest buffers).

Nitrogen, Phosphorus and Sediment Reductions

The net reductions in nitrogen, phosphorus and sediment for forest and grass buffers in the Watershed Model are significant, but not simple to estimate without the use of CAST (http://cast.chesapeakebay.net/). There is a load source change from the previous land use (cropland) into either forest (forest buffer) or agricultural open space (grass buffer), which reduces the simulated load. Then there is also an efficiency applied to upland acres that further reduces pollutant loads. The efficiency values applied to upland acres vary based on the hydrogeomorphic region where the buffer is installed; the efficiency values are summarized in Table A-13-1. Narrow buffers are only simulated as a load source change to forest or agricultural open space and do not receive the additional upland treatment summarized in Table A-13-1.

Table A-13-1. Nitrogen, phosphorus and sediment efficiency values applied to upland acres for agricultural forest buffers and grass buffers in the Phase 6 Watershed Model, by hydrogeomorphic region (HGMR). Note: These efficiency values are not applicable to narrow buffers (between 10 and 35 feet in width).

HGMR	Nitrogen Efficiency (%) applied on 4 upland acres per 1 acre of buffer Forest Buffer	Nitrogen Efficiency (%) applied on 4 upland acres per 1 acre of buffer Grass Buffer	Phosphorus Efficiency (%) applied on 2 upland acres per 1 acre of buffer Forest Buffer and Grass Buffer	Sediment Efficiency (%) applied on 2 upland acres per 1 acre of buffer Forest Buffer and Grass Buffer
Coastal Plain Dissected Uplands	65	46	42	56
Piedmont Carbonate	46	32	36	48
Appalachian Plateau Siliciclastic	54	38	42	56
Coastal Plain Uplands	31	21	45	60
Appalachian Plateau Carbonate	54	38	42	56
Piedmont Crystalline	56	39	42	56
Valley and Ridge Carbonate	34	24	30	40
Valley and Ridge Siliciclastic	46	32	39	52
Blue Ridge	34	24	30	40
Coastal Plain Lowlands	19	13	45	60
Mesozoic Lowlands	34	24	30	40

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Pasture

Forest and grass buffers with exclusion fencing can only be applied on Pasture in the Watershed Model.

Brief Description of BMP Simulation in the Model

The forest buffer and grass buffer practices are both simulated as a *Load Source Change with an Efficiency Value* in the Watershed Model. Each acre reported under the practices will be converted to the forest or agricultural open space load sources, respectively, and then there is an additional reduction in upland loads using the efficiency values in Table A-13-1. For example, one acre of cropland that is converted into a riparian forest buffer will increase the overall acres of forest by one and reduce the amount of cropland by that same amount. Additionally, the nitrogen load from four other acres will be reduced by 31 percent (assuming the buffer is installed in a Coastal Plain Upland setting for this example); the phosphorus and sediment loads from two acres will be reduced by 45 and 60 percent, respectively. If the one acre in this example was instead used for a grass buffer then it would be simulated in the same way, except the acre of cropland would be converted to agricultural open space and the upland acres would be treated using the efficiency value of 21 percent for nitrogen. The efficiency values for phosphorus and sediment, and the ratio of acres treated are the same for both forest and grass buffers. Forest and grass buffer practices with exclusion fences have a unique additional benefit because they also reduce the amount of manure applied to the riparian pasture load source and shift the manure to the pasture load source. While it is difficult to estimate the net reductions of this practice without the use of CAST, the net load reduction can be significant.

Annual or Cumulative? Cumulative (10-year credit duration; 5-year credit duration for RI practices)

Can this practice be combined with other BMPs? Yes, acres of upland load sources treated by forest or grass buffers can also receive other eligible agriculture BMPs. The area of land converted to either forest or agricultural open space by the buffer, however, cannot receive additional BMPs. Narrow buffers cannot be combined with other BMPs since they do not treat upland acres and only change the load source of the buffered area.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Buffer-Streamside
    - Forest Buffer-Streamside with Exclusion Fencing
    - Forest Buffer-Narrow with Exclusion Fencing
    - Grass Buffer-Streamside with Exclusion Fencing
    - Grass Buffer-Narrow with Exclusion Fencing
- *Measurement unit:* Area of buffer (acres)* or Length (feet). Optional: Width (feet), Number of Animal Units (AU) excluded by fence. *If reported in units of acres only, a default of 22.9 animal units per acre is calculated and the manure is then applied to pasture instead of riparian pasture deposition.
- *Land Use:* Pasture
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year buffer was installed.

Table A-13-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Forest Buffer (with exclusion fence)	Forest Buffer-Streamside with Exclusion Fencing	Riparian Forest Buffer (NRCS 391); Riparian Buffer (FSA CP22);
	Exclusion Fence with Forest Buffer RI	Watercourse Access Control-Trees aka Exclusion Fence with Forest Buffer RI (CBP RI-6)
Forest Buffer-Narrow (with exclusion fence)	Forest Buffer-Narrow with Exclusion Fencing	
	Exclusion Fence with Narrow Forest Buffer RI	Watercourse Access Control-Narrow Trees, aka Exclusion Fence with Narrow Forest Buffer RI (CBP RI-4b)
Grass Buffer (with exclusion fence)	Grass Buffer-Streamside with Exclusion Fencing	Riparian Herbaceous Cover (NRCS 390); Filter Strip (NRCS 393); Filter Strip (FSA CP21); Field Border (NRCS 386); Grass Waterway (NRCS 412); Grass Waterway, Noneasement (FSA CP8A);
	Exclusion Fence with Grass Buffer RI	Watercourse Access Control-Grass aka Exclusion Fence with Grass Buffer RI (CBP RI-5)

Grass Buffer-Narrow (with exclusion fence)	Grass Buffer-Narrow with Exclusion Fencing Exclusion Fence with Narrow Grass Buffer RI	 Watercourse Access Control-Narrow Grass, aka Exclusion Fence with Narrow Grass Buffer RI (CBP RI-4a)

Additional Information

Expert panel report:
Belt, K., Groffman, P., Newbold, D., Hession, C., Noe, G., Okay, J., Southerland, M., Speiran, G., Staver, K., Hairston-Strang, A., Weller, D., & D. Wise. 2014. Recommendations of the Expert Panel to Reassess Removal Rates for Riparian Forest and Grass Buffers Best Management Practices. Prepared by S. Claggett, US Forest Service and Tetra Tech, Inc. Approved by CBP Water Quality Goal Implementation Team, October 2014.
https://www.chesapeakebay.net/documents/Riparian_BMP_Panel_Report_FINAL_October_2014.pdf

T. Simpson and S. Weammert (Lane). 2009. Riparian Forest Buffer Practice (Agriculture) and Riparian Grass Buffer Practice Definition and Nutrient and Sediment Reduction Effectiveness Estimates. In Mid-Atlantic Water Program, *Developing Best Management Practice Definitions and Effectiveness Estimates for Nitrogen, Phosphorus and Sediment in the Chesapeake Bay Watershed*. T. Simpson and S. Weammert (Lane), eds. Final Report, December 2009. Pages 469-506.
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https://www.chesapeakebay.net/documents/RI_Report_5_8-8-14.pdf

Chesapeake Riparian Forest Buffer Network:
http://chesapeakeforestbuffers.net/

Chesapeake Bay Program. Video and webpage. Forest Buffers.
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Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in 2009 and 2014.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-14. Manure Treatment (Composting)

General Information

Composting is a type of manure treatment that involves decomposition of solid organic materials in the presence of oxygen, leading to a stable end product called *compost.* Compost is a valuable product once it meets maturity requirements, including a Carbon-to-Nitrogen (C:N) ratio less than or equal to 25. Other measures of compost maturity require additional metrics as delineated by industry accepted indices. Mature compost can be applied to nearby fields or transported off the farm to be sold or applied elsewhere.

Figure A-14-1. A handful of finished compost. Photo: Chesapeake Bay Program

CBP Definition(s)

There are four categories of composting systems and twelve total BMPs defined by the CBP. The four composting systems are listed below.

1. *In-Vessel and Rotating Bin*
2. *Forced Aeration*
3. *Turned Pile and Windrows*
4. *Static (passive) Pile and Windrows*

The BMPs are further distinguished based on the bulking agent and its C:N ratio. A bulking agent is the material or media added to the composting system that increases the porosity and aeration capacity of the manure. Carbonaceous bulking agents – such as wood chips, sawdust or straw – also add degradable carbon to the composting mixture. Each of the four composting systems are divided into three BMPs: (1) when the bulking agent or its C:N ratio are unknown; (2) when the bulking agent or its C:N ratio are known and C:N > 100, and (3) when the bulking agent or its C:N are known and the C:N < 100.

Specifications or Key Qualifying Conditions

By definition, finished compost has a C:N at or below 25. Manure composting BMPs are only applicable to agricultural operations and excludes composting systems used for animal mortality management. In-house windrowing of poultry litter between flocks is not considered a composting BMP, but is considered a storage process.

Table A-14-1. Nitrogen efficiency values for manure composting BMPs

Composting system	CAST BMP Short Name	TN Removal (%)
In-Vessel and Rotating Bin- Standard	MTT7†	10
In-Vessel and Rotating Bin- C:N>100**	MTT8	11
In-Vessel and Rotating Bin- C:N<100**	MTT9	13
Forced Aeration- Standard	MTT10	25
Forced Aeration- C:N>100**	MTT11	28
Forced Aeration- C:N<100**	MTT12	32
Turned Pile and Windrow- Standard	MTT13	25
Turned Pile and Windrow- C:N>100**	MTT14	28
Turned Pile and Windrow- C:N<100**	MTT15	32
Static Pile and Windrow- Standard	MTT16	26
Static Pile and Windrow- C:N>100**	MTT17	29
Static Pile and Windrow- C:N<100**	MTT18	33

† Default BMP if the type of composting system is unknown
***Carbon-to-Nitrogen factor of bulking agent*

Nitrogen, Phosphorus and Sediment Reductions

As seen in Table A-14-1, composting BMPs only provide nitrogen reductions. This accounts for the portion of N transformed and removed to the atmosphere. All phosphorus is retained in the final solid product. Transport of the final product may or may not provide additional reductions in N or P not accounted for in Table A-14-1 (see A-16: Manure Transport).

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Load Source
  - Permitted Feeding Space; Nonpermitted Feeding Space
- Animal Groups, which may include some overlap among categories
  - All animals; livestock; poultry; beef; broilers; cattle; chickens; dairy; goats; hogs and pigs for breeding; hogs for slaughter; horses; layers; other cattle; pullets; sheep and lambs; swine; turkeys

Brief Description of BMP Simulation in the Model

Manure composting practices are categorized as *Manure Transport BMPs*. Manure transport BMPs directly influence the amount of nutrients available from animal manure for field application and subsequent BMPs. The total application of manure could be reduced in a county if a jurisdiction indicated that manure was treated and/or transported out of that county. However, the crop nutrient need is not changed; other sources of nutrients will make up the difference in the crop need where they are available. Nutrients are applied to meet the nitrogen crop need. This can result in an over application of phosphorus where manure is the nutrient source. In cases where manure becomes less available and is replaced with inorganic fertilizer, there is a decrease in phosphorus. There may be an increase in nitrogen loads, since nitrogen from inorganic fertilizer is more likely to run off to streams than nitrogen from manure. In some cases, there is no change in nutrient loads. In cases where there is a great deal of manure in a county and not much cropland, there is a decrease in both nitrogen and phosphorus. A portion of the reduced nitrogen amount is applied to the feeding space load source in the source county at the edge-of-tide. Analysis of edge-of-stream loads will not show this BMP's full effect since some of the nitrogen is applied to back to the source county's edge-of-tide load.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Figure A-14-2. In-Vessel composting is performed in an insulated silo, channel, or bin using a high-rate, controlled aeration system designed to provide optimal conditions. Rotating Drum Composters are a subset of in-vessel composters that aerate compost by turning the compost inside a rotating drum. Photo: Jason Governo, U. of Georgia

Figure A-14-3. Forced aeration systems, or aerated static piles, use blowers to provide oxygen into the compost pile instead of turning or moving the pile. Photo: Jason Governo, U. of Georgia

Figure A-14-4. Turned Piles and Windrows rely on frequent turning, usually with specialized machinery, to aerate the compost. Photo: Robb Meinen, Penn State

Key Elements for State BMP Reporting through NEIEN

Figure A-14-5. Static (passive) piles and windrows rely on natural aeration. Heat generated during composting rises and pulls air into the pile. Piles are turned or mixed occasionally. This is usually accomplished by moving the pile from one bin to another or moving the windrow to a new area. Photo: Clatsop County (OR) SWCD

- *BMP Name:*
    - Manure Treatment Rotating Bin (MTT7-9);
    - Manure Treatment Forced Aeration (MTT10-12);
    - Manure Compost Turned Pile Windrow (MTT13-15);
    - Manure Compost Static Pile Windrow (MTT16-18);
- *Measurement unit:* Dry tons.
- *Animal Group:* Eligible on any animal type or animal group; if none are reported the default will be "all animals."
- *Load Source:* Approved NEIEN agricultural load sources; if none are reported the default will be FEED
- *County From:* County or Outside Watershed (where manure or litter originated)*
- *County To:* County or Outside Watershed (destination of composted product)*
- *Date of implementation:* Year manure was treated.

Note that the location of the composting facility is not needed, only the "County From" and "County To" for the manure and the end product.

Table A-14-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
In-Vessel and Rotating Bin- Standard	Manure Treatment Rotating Bin (MTT7) †	In-vessel; rotating bin; rotating drum;
In-Vessel and Rotating Bin- C:N>100	Manure Treatment Rotating Bin High CN (MTT8)	In-vessel; rotating bin; rotating drum;
In-Vessel and Rotating Bin- C:N<100	Manure Treatment Rotating Bin, Low CN (MTT9)	In-vessel; rotating bin; rotating drum;
Forced Aeration- Standard	Manure Treatment Forced Aeration (MTT10)	Aerated static pile;
Forced Aeration- C:N>100	Manure Compost Forced Aeration High CN (MTT11)	Aerated static pile;
Forced Aeration- C:N<100	Manure Compost Forced Aeration Low CN (MTT12)	Aerated static pile;
Turned Pile and Windrow- Standard	Manure Compost Turned Pile Windrow (MTT13)	Turned pile; turned windrow;
Turned Pile and Windrow- C:N>100	Manure Compost Turned Pile Windrow High CN (MTT14)	Turned pile; turned windrow;
Turned Pile and Windrow- C:N<100	Manure Compost Turned Pile Windrow Low CN (MTT15)	Turned pile; turned windrow;
Static Pile and Windrow- Standard	Manure Compost Static Pile Windrow (MTT16)	Static pile; static windrow;
Static Pile and Windrow- C:N>100	Manure Compost Static Pile Windrow High CN (MTT17)	Static pile; static windrow;
Static Pile and Windrow- C:N<100	Manure Compost Static Pile Windrow Low CN (MTT18)	Static pile; static windrow;
† Default BMP if the type of composting system is unknown		

Additional Information

Hamilton, D., Cantrell, K., Chastain, J., Ludwig, A., Meinen, R., Ogejo, J. & J. Porter. 2016. Manure Treatment Technologies: Recommendations from the Manure Treatment Technologies Expert Panel to the CBP's WQGIT to define Manure Treatment Technologies as a Best Management Practice. Hamilton, D., and J. Hanson, Editors. CBP/TRS-311-16.
https://www.chesapeakebay.net/documents/MTT_Expert_Panel_Report_WQGIT_approved_Sept2016.pdf

Farm Manure-to-Energy Initiative. 2016. Final Report: Using Excess Manure to Generate Farm Income in the Chesapeake Bay Region's Phosphorus Hotspots. Full report and accompanying materials available at http://articles.extension.org/pages/73602/farm-manure-to-energy-initiative-in-the-chesapeake-region-report-january-2016

Chesapeake Bay Commission, Chesapeake Bay Foundation, Maryland Technology Development Corporation and Farm Pilot Project Coordination, Inc. 2012. Manure to Energy: Sustainable Solutions for the Chesapeake Bay Region. http://www.chesbay.us/Publications/manure-to-energy%20report.pdf

Science of Composting. Video. Webinar #1 of Mid-Atlantic Composting and Compost Use Webinar Series. https://youtu.be/ZgnilGcBcL0

Version and History Statement

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All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-15. Manure Treatment (Thermochemical)

General Information

Manure treatment practices stabilize and reduce organic matter, thereby reducing nuisance conditions and making plant nutrients more marketable for off-farm use. Treatment practices can also enable more cost-effective manure transport (see A-16: Manure Transport). There are many technologies available to treat livestock and poultry manure, including anaerobic digestion, settling practices, mechanical separation of manure liquids and solids, and composting (see A-14: Manure Composting). All of these practices provide numerous benefits to the farmer and the environment. However, not all manure treatment technologies remove nitrogen or phosphorus from the manure that ends up applied or transported. Composting and thermochemical practices are the only ones with CBP-approved nitrogen removal benefits.

Figure A-15-1. Combustion system at poultry operation. Photo: Livestock and Poultry Environmental Learning Center (LPELC)

CBP Definition(s)

The Chesapeake Bay Program has defined BMPs for three types of thermochemical conversion (TCC) processes used for manure treatment: combustion, gasification and pyrolysis. Any directly monitored or measured treatment system can also earn credit for Total Nitrogen (TN) removal as a BMP, regardless of what technology the system is comprised of.

Pyrolysis is the conversion of organic matter in the absence of oxygen. Pyrolysis temperatures range between 575 and 1,475˚F (300 to 800°C). Organic matter is broken down to produce some combination of liquids, gases and solids, depending on the type of pyrolysis process. *Fast Pyrolysis* has a short residence time (seconds) and moderate temperatures, and is primarily used to produce bio-oil (up to 75% by weight of feedstock). *Slow Pyrolysis* has longer residence times (hours to days) and lower temperatures and is used to produce char.

Gasification is the thermochemical reformation of biomass in a low oxygen or starved oxygen environment, using air or steam as reaction medium. Gasification temperatures range between 1,870 and 2,730˚F (1,000 to1,500°C). The main purpose of gasification is to produce syngas–primarily CO, H_2, Methane (CH_4) and other light weight hydrocarbons.

Combustion is the direct consumption of dry manure to produce heat without generating intermediate fuel gases or liquids. Combustion temperatures range between 1,500 and 3,000˚F (820 to 1,650°C). Usually, excess air is supplied to ensure maximum fuel conversion. Combustion produces CO_2, H_2O, ash and heat, with the heat typically used for steam production.

Figure A-15-2. Thermochemical conversions (TCC) processes are high-temperature chemical-reforming processes that convert organic matter into a combination of syngas, bio-oil and char/ash. Photo: LPELC

A *data-driven or directly monitored manure treatment system* utilizes one or more of manure treatment technologies. The technologies may be proprietary or non-proprietary and may be used in any sequence to produce one or more end products for transport or land application. On-farm or multi-farm centralized manure treatment systems reported under this category will have unique transfer efficiencies that must be determined using monitoring data collected on site.

Specifications or Key Qualifying Conditions

These BMPs are applicable to systems designed for treatment of animal manure and do not apply to systems used for animal mortality management.

Nitrogen, Phosphorus and Sediment Reductions

As seen in Table A-15-1, thermochemical BMPs only provide nitrogen reductions. This accounts for the portion of N transformed and removed to the atmosphere. All phosphorus is retained in the final solid product. Transport of the final product may or may not provide additional reductions in N or P not accounted for in Table A-15-1 (see below and A-16: Manure Transport).

Table A-15-1. Nitrogen reductions for thermochemical manure treatment practices

Practice name	BMP short name in CAST and NEIEN	TN removal
Slow pyrolysis	MTT1	25%
Fast pyrolysis	MTT2	75%
Gasification-Low Heat	MTT3	25%
Gasification-High Heat	MTT4	85%
Combustion	MTT5	85%
Combustion-High Heat	MTT6	95%
Directly Monitored	MTT19	Monitored

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Load Source
  - Permitted Feeding Space; Nonpermitted Feeding Space
- Animal Groups, which may include some overlap among categories
  - All animals; livestock; poultry; beef; broilers; cattle; chickens; dairy; goats; hogs and pigs for breeding; hogs for slaughter; horses; layers; other cattle; pullets; sheep and lambs; swine; turkeys

Brief Description of BMP Simulation in the Model

Manure treatment practices are categorized as *Manure Transport BMPs*. Manure transport BMPs directly influence the amount of nutrients available from animal manure for field application and subsequent BMPs. The total application of manure could be reduced in a county if a jurisdiction indicated that manure was treated and/or transported out of that county. However, the crop nutrient need is not changed; other sources of nutrients will make up the difference in the crop need where they are available. Nutrients are applied to meet the nitrogen crop need. This can result in an over application of phosphorus where manure is the nutrient source. In cases where manure becomes less available and is replaced with inorganic fertilizer, there is a decrease in phosphorus. There may be an increase in nitrogen loads, since nitrogen from inorganic fertilizer is more likely to run off to streams than nitrogen from manure. In some cases, there is no change in nutrient loads. In cases where there is a great deal of manure in a county and not much cropland, there is a decrease in both nitrogen and phosphorus. A portion of the reduced nitrogen amount is applied to the feeding space load source in the source county at the edge-of-tide. Analysis of edge-of-stream loads will not show this BMP's full effect since some of the nitrogen is applied to back to the source county's edge-of-tide load.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Manure Treatment Slow Pyrolysis (MTT1);
    - Manure Treatment Fast Pyrolysis (MTT2);
    - Manure Treatment Low Heat Gasification (MTT3);
    - Manure Treatment High Heat Gasification (MTT4);
    - Manure Treatment Combustion (MTT5);
    - Manure Treatment High Heat Combustion (MTT6);
    - Manure Treatment Direct Monitor (MTT19)*
- *Measurement unit:* Dry tons. *For the directly monitored BMP, the amount of nitrogen reduced also is reported (lbs TN). This amount reduced is used instead of a factor.
- *Animal Group:* Eligible on any animal type or animal group; if none are reported the default will be "all animals."
- *Load Source:* Approved NEIEN agricultural load sources; if none are reported the default will be FEED
- *County From:* County or Outside Watershed (where manure or litter originated)**
- *County To:* County or Outside Watershed (destination of end product)**
- *Date of implementation:* Year manure was treated.

***Note that the location of the treatment system is not needed, only the "County From" and "County To" for the manure and the end product.*

Table A-15-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Slow Pyrolysis	Manure Treatment Slow Pyrolysis (MTT1)	
Fast Pyrolysis	Manure Treatment Fast Pyrolysis (MTT2)	
Gasification-Low Heat	Manure Treatment Low Heat Gasification (MTT3)	
Gasification-High Heat	Manure Treatment High Heat Gasification (MTT4)	
Combustion	Manure Treatment Combustion (MTT5)	
Combustion-High Heat	Manure Treatment High Heat Combustion (MTT6)	
Directly monitored manure treatment systems; data-driven manure treatment systems	Manure Treatment Direct Monitor (MTT19)	Can be any combination of proprietary or non-proprietary system with appropriate monitoring data

Additional Information

Expert panel report:

Hamilton, D., Cantrell, K., Chastain, J., Ludwig, A., Meinen, R., Ogejo, J. & J. Porter. 2016. Manure Treatment Technologies: Recommendations from the Manure Treatment Technologies Expert Panel to the CBP's WQGIT to define Manure Treatment Technologies as a Best Management Practice. Hamilton, D., and J. Hanson, Editors. CBP/TRS-311-16.
https://www.chesapeakebay.net/documents/MTT_Expert_Panel_Report_WQGIT_approved_Sept2016.pdf

Farm Manure-to-Energy Initiative. 2016. Final Report: Using Excess Manure to Generate Farm Income in the Chesapeake Bay Region's Phosphorus Hotspots. Full report and accompanying materials available at http://articles.extension.org/pages/73602/farm-manure-to-energy-initiative-in-the-chesapeake-region-report-january-2016

Chesapeake Bay Commission, Chesapeake Bay Foundation, Maryland Technology Development Corporation and Farm Pilot Project Coordination, Inc. 2012. Manure to Energy: Sustainable Solutions for the Chesapeake Bay Region. http://www.chesbay.us/Publications/manure-to-energy%20report.pdf

Thermal Manure-to-Energy Systems for Farms. Videos, case studies and other informational resources. http://articles.extension.org/pages/68455/thermal-manure-to-energy-systems-for-farms

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in September 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-16. Manure Transport

General Information

Animal manure is a valuable source of carbon and nutrients for farmers. Animal operations sometimes transport their collected manure to other farms or facilities to utilize its nutrients, which includes nitrogen and phosphorus.

Figure A-16-1. A truck is loaded with chicken litter, which is a mixture of manure, bedding and other materials collected from the floor of a chicken house. Animal manure and poultry litter is sometimes transported to other farms for field application or sent to facilities where it is converted into organic fertilizer products. Photo: USDA

CBP Definition(s)

Manure Transport: Transport of excess manure in or out of a county. Manure may be of any type—poultry, dairy, or any of the animal categories. Transport should only be reported for county to county transport. Movement within the same county should not be included.

Specifications or Key Qualifying Conditions

None for CBP purposes beyond what is included in the definition. States may have requirements for haulers or producers that are not summarized here.

Nitrogen, Phosphorus and Sediment Reductions

There are no sediment reductions for the manure transport practice. Nitrogen and phosphorus reductions depend on the animal type, destination and amount (tons) of manure transported. Specific information about the nitrogen and phosphorus content of (dry) manure and litter can be found in Chapter 3 (Table 3-2) of the Watershed Model documentation and the Poultry Litter Subcommittee Report.

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Load Source
  - Permitted Feeding Space; Nonpermitted Feeding Space
- Animal Groups, which may include some overlap among categories
  - All animals; livestock; poultry; beef; broilers; cattle; chickens; dairy; goats; hogs and pigs for breeding; hogs for slaughter; horses; layers; other cattle; pullets; sheep and lambs; swine; turkeys

Brief Description of BMP Simulation in the Model

The manure transport practice is a *Manure Transport BMP*. Manure transport BMPs directly influence the amount of nutrients available from animal manure for field application and subsequent BMPs. The total application of manure could be reduced in a county if a jurisdiction indicated that manure was transported out of that county. However, the crop nutrient need is not changed; other sources of nutrients will make up the difference in the crop need where they are available. Nutrients are applied to meet the nitrogen crop need. This can lead to application of phosphorus in excess of crop need where manure is the nutrient source. In cases where manure becomes less available and is replaced with inorganic fertilizer, there is a decrease in phosphorus. There may be an increase in nitrogen loads, since nitrogen from inorganic fertilizer is more likely to run off to streams than nitrogen from manure. In some cases, there is no change in nutrient loads. In cases where there is a great deal of manure in a county and not much cropland, there is a decrease in both nitrogen and phosphorus.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Manure Transport
- *Measurement unit:* Dry tons or Wet tons. Note: Calculations are done using dry tons, so if wet tons are reported they are converted to dry tons for you.
- *Animal Group:* Eligible on any animal type or animal group; if none are reported the default will be "all animals."
- *Load Source:* Approved NEIEN agricultural load sources; if none are reported the default will be FEED
- *County From:* County or Outside Watershed (where manure or litter originated)
- *County To:* County or Outside Watershed (destination of manure or litter)
- *Date of implementation:* Year manure was transported.

Figure A-16-2. Some Bay states help farmers identify certified manure haulers that will transport excess manure to areas that need it. Photo: Maryland Department of Agriculture

Table A-16-1. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Manure Transport	Manure Transport	Manure/litter hauling; manure/litter transport

Additional Information

Poultry Litter Subcommittee. 2015. Recommendations to estimate poultry nutrient production in the Phase 6 Watershed Model. https://www.chesapeakebay.net/documents/recommendations_to_estimate_poultry_nutrients_for_phase_6_model_03062015.pdf

Manure Value and Economics. Webpage and additional resources: http://articles.extension.org/pages/8652/manure-value-and-economics

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definition and benefits that have remained in use since review and approval by the CBP partnership's source sector workgroups for tributary strategy development.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-17. Manure Incorporation or Injection

General Information

Manure is a byproduct of animal agriculture and is a valuable fertilizer for crop production. Applying manure to the soil surface is a common method for distributing manure and its nutrients on crop fields. However, this results in the loss of ammonia nitrogen, can cause odor issues and increases the risk of phosphorus runoff. When manure is incorporated or injected into the soil the potential odors or loss of nutrients are reduced. There are many different specialized pieces of equipment that enable farmers to incorporate or inject manure into the soil based on their needs or manure used.

Figure A-17-1. Specialized equipment is used for manure incorporation and injection. Manure incorporation requires machinery that mixes dry, semi-dry or liquid organic nutrient sources – such as manure, bio-solids, and compost – into the soil profile. Photo: Chesapeake Bay Program

CBP Definition(s)

Manure Incorporation is defined as the mixing of dry, semi-dry, or liquid organic nutrient sources (including manures, biosolids, and compost) into the soil profile within a specified time period from application by a range of field operations (≤24hr for full ammonia loss reduction credit and 3 days for P reduction credit(s)). These methods can provide nutrient loss reductions that may differ for P and N by method used. Nutrient loss reductions are primarily due to lower ammonia-N volatilization and in many cases lower dissolved P and N losses in surface runoff. Nutrient loss reductions may vary with timing between application and soil mixing, degree of soil mixing, and percent soil surface disturbance. The CBP has established two categories of incorporation:

Figure A-17-2. Manure injection mechanically applies the organic nutrients – manure, bio-solids, or compost – into the root zone with surface soil closure at the time of application. This offers the greatest nutrient reduction and odor reduction due to limited soil disruption, amount of material left on the soil and immediate soil closure. Photo: Livestock and Poultry Environmental Learning Center (LPELC)

High disturbance incorporation provides the highest degree of mixing of organic nutrient sources into the root zone, but effectively eliminates the erosion control benefits of conservation tillage. Incorporation plus additional field operations retain <30% of residue cover at planting.

Low disturbance incorporation: leaves greater quantities of organic nutrient sources on the soil surface, but maintains most of the benefits of conservation tillage. Incorporation plus additional field operations retains at least 30 % of residue cover at planting to meet criteria for the Phase 6 Conservation Tillage practice.

Manure Injection is a specialized category of placement in which organic nutrient sources (including manures, biosolids, and composted materials) are mechanically applied into the root zone with surface soil closure at the time of application. Injection is expected to provide the greatest level of nutrient loss reduction to both atmospheric and surface runoff pathways (including both dissolved and sediment bound nutrients), as well as odor reduction, due to limited quantities of material left on the soil surface, limited soil disruption, and immediate soil closure. Total soil surface disturbance for injection plus planting and any other field operations should be less than 40% so that the practice is compatible with the Low Residue, Strip Till/No-Till practice.

Specifications or Key Qualifying Conditions

Manure must be incorporated into the soil within 1-3 days to be eligible for the manure incorporation (late) BMPs and must be incorporated within 24 hours to be eligible for the incorporation (early) BMPs. The expert panel report (see Additional Information below) provides other qualifying conditions, such as appropriate application technologies for injection and incorporation (low-disturbance). Any tillage system is appropriate for high-disturbance incorporation, but not all tillage systems may be consistent with disturbance or crop residue requirements for separate BMPs such as conservation tillage.

Nitrogen, Phosphorus and Sediment Reductions

Only nitrogen and phosphorus efficiencies have been established for these practices. Any sediment loss reductions associated with injection or low disturbance incorporation are addressed through corresponding conservation tillage BMPs (see A-3: Conservation Tillage). Phosphorus efficiency values differ based on whether the practice is implemented in an area of the Coastal Plain or in any other hydrogeomorphic region (HGMR), as shown in Table A-17-1.

Table A-17-1. Nitrogen and Phosphorus Efficiency Values for Manure Incorporation and Injection BMPs

BMP	Nitrogen *All HGMRs* (%)	Phosphorus *Coastal Plain HGMRs* (%)	Phosphorus *All other HGMRs* (%)
Incorporation Low Disturbance Early*	8	14	24
Incorporation Low Disturbance Late**	8	14	24
Incorporation High Disturbance Early*	8	14	12
Incorporation High Disturbance Late**	8	14	12
Injection	12	22	36

*Early = manure is incorporated into soil within 24 hours application
**Late = manure is incorporated into soil between 1 and 3 days of application

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Cropland Eligible for Manure*
- Row Crops Eligible for Manure*
- Specialty Cropland*
- Cropland and Hay Eligible for Manure
- Hay
- Leguminous Hay
- Other Hay
- Pasture
- Pasture and Hay

Manure Injection and Manure Incorporation Low Disturbance (Early or Late) can be applied to any of the above land use groups. Manure Incorporation High Disturbance (Early or Late) is only applicable to the load source groups above with an asterisk (*).

Brief Description of BMP Simulation in the Model

The manure incorporation and injection practices are *Efficiency Value BMPs*. All nitrogen and phosphorus loads from acres treated by manure injection or incorporation are simulated as a percent reduction of the estimated runoff using the values in Table A-17-1.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Manure Incorporation Low Disturbance Early
    - Manure Incorporation Low Disturbance Late
    - Manure Incorporation High Disturbance Early
    - Manure Incorporation High Disturbance Late
    - Manure Injection
- *Measurement unit:* Acres or percent
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be Row Crops Eligible for Manure
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year practice was implemented.

Table A-17-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Immediate Low Disturbance Manure Incorporation	Manure Incorporation Low Disturbance Early	
Low Disturbance Manure Incorporation	Manure Incorporation Low Disturbance Late	
Immediate High Disturbance Manure Incorporation	Manure Incorporation High Disturbance Early	
High Disturbance Manure Incorporation	Manure Incorporation High Disturbance Late	
Manure Injection	Manure Injection	

Additional Information

Expert panel report:
Dell, C., Allen, A., Dostie, D., Meinen, R., & R. Maguire. 2016. Manure Incorporation and Injection Practices for use in Phase 6.0 of the Chesapeake Bay Program Watershed Model. D. Meals (ed.) with M. Dubin, L. Gordon, J. Sweeney & C. Brosch. CBP/TRS-309-16.
https://www.chesapeakebay.net/documents/Phase_6_FINAL_MII_Final_Report_FINAL.pdf

Maguire, R., Beegle, D., McGrath, J., & Q. Ketterings. 2018. Manure Injection in No-Till and Pasture Systems. Virginia Cooperative Extension, Publication CSES-22P.
https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/CSES/CSES-22/CSES-231.pdf

Version and History Statement

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All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-19. Off-stream watering without fencing

General Information

When livestock have access to the stream as a water source, they degrade the areas along the streambank, increasing erosion while also depositing manure directly into the stream. Alternatively, when livestock have water sources away from the stream, there is less erosion and their manure is less likely to wash into the stream.

Figure A-19-1. Alternative water sources away from the stream keep livestock in pasture or heavy use areas, reducing erosion and manure deposition to the stream. Photos: USDA NRCS

CBP Definition(s)

Off-stream watering without fencing: This BMP requires the use of alternative drinking water sources, such as permanent or portable livestock water troughs placed away from the stream corridor. Implementing off-stream shade for livestock is encouraged where applicable. The water supplied to the facilities can be from any source, including pipelines, spring developments, water wells and ponds. In-stream watering facilities, such as stream crossings or access points, are not considered in this definition. The modeled benefits of alternative watering facilities can be applied to pasture acres in association with improved pasture management systems such as rotational grazing.

Watering trough (CBP Resource Improvement Practice, RI-18): A permanent or portable device to provide an adequate amount and quality of drinking water for livestock.

Specifications or Key Qualifying Conditions

This BMP is only applicable for livestock pastures that do not have stream exclusion practices, as pastures that exclude livestock from streams already provide alternative water sources as part of those practices. See buffers with exclusion fencing (A-13) as an example. Otherwise, there are no specific conditions for CBP purposes. It is expected that reported cost-share practices conform to state or federal practice standards, and that any non-cost-shared practices conform to the criteria described in the *Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report* (linked under Additional Information below).

Nitrogen, Phosphorus and Sediment Reductions

Table A-19-1. Supplemental Nitrogen and Phosphorus Percent Reductions to Land Use Runoff

	Nitrogen (%)	Phosphorus (%)	Sediment (%)
Off-stream watering without fencing	5	8	10

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Pasture

Brief Description of BMP Simulation in the Model

The off-stream watering without fencing BMP is an *Efficiency Value BMP*. Each acre of pasture reported under the BMP will have its nitrogen, phosphorus and sediment loads reduced using the values in Table A-19-1.

Annual or Cumulative? Cumulative (10-year credit duration; 5-year credit duration for RI-18)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Off-stream watering without fencing
  - Watering trough RI
- *Measurement unit:* Acres; if only the number of systems is known, this can be reported and NEIEN will convert to acres
- *Land Use:* Pasture
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year watering system was implemented.

Table A-19-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common BMP names
Off stream watering without fencing; Alternative water source;	Alternative water system; extension of CREP watering system; watering facility; watering trough RI (RI-18)	Watering facility (NRCS 614);

Additional Information

Chesapeake Bay Program Resource Improvement (RI) Practice Definitions and Verification Visual Indicators Report: Ensor, R., Absher, D., Moore, G., Garber, L., McGee, B., Albrecht, G., Weibley, E., Wootton, C., & J. Hill. 2014. Chesapeake Bay Program Resource Improvement Practice Definitions and Verification Visual Indicators Report. Approved by CBP Water Quality Goal Implementation Team, August 2014.
https://www.chesapeakebay.net/documents/RI_Report_5_8-8-14.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in May 2010.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-23. Tree Planting (Agricultural)

General Information

Forests provide a host of environmental benefits. They reduce the quantity and velocity of surface runoff, improve local water quality and offer wildlife habitat, to name just a few. To protect these benefits, it is important to conserve and maintain existing forested areas, but there are also opportunities to expand forest coverage through tree planting in agricultural areas. This reference sheet pertains to tree planting in agricultural settings (for Forest Buffers see A-12 and A-13; for tree planting practices in developed areas see D-7).

Figure A-23-1. Tree planting on agricultural lands provides numerous environmental benefits, including improved water quality, especially when the trees create forested areas. Photo: USDA NRCS

CBP Definition(s)

Tree planting includes any trees planted on agricultural land, except those used to establish riparian forest buffers, targeting lands that are highly erodible or identified as critical resource areas.

Specifications or Key Qualifying Conditions

This BMP does not apply to trees planted as riparian buffers or for trees planted in developed settings, which are separate BMPs.

Nitrogen, Phosphorus and Sediment Reductions

Nitrogen, phosphorus and sediment reductions are determined based on the prior land use that is converted to forest. Actual simulated reductions will vary based on your specific area and can be calculated in CAST, but an average per-acre reduction is provided in Table A-23-1 for reference.

Table A-23-1. Average nitrogen, phosphorus and sediment reductions per acre of agricultural tree planting. Actual reductions will vary and can be calculated in CAST. All values in the table are pounds removed at the edge-of-tide. Source: BMP Pounds Reduced and Costs by State (April 30, 2018 version) available online at http://cast.chesapeakebay.net/Documentation/DevelopPlans

State	Nitrogen *Average reduction (lbs/ac, Edge of Tide)*	Phosphorus *Average reduction (lbs/ac, Edge of Tide)*	Sediment *Average reduction (lbs/ac, Edge of Tide)*
Delaware	52.6	0.3	241
Maryland	21.2	0.7	703
New York	5.8	0.2	229
Pennsylvania	18.1	0.4	505
Virginia	11.5	0.5	309
West Virginia	6.7	0.2	165

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

Agricultural tree planting can be reported on any of the load source groups below; the default is the combined group "AG."

- Ag Open Space
- Double Cropped Land

- Full season Soybeans
- Grain with Manure
- Grain without Manure
- Legume Hay
- Other Agronomic Crops
- Other Hay
- Silage with Manure
- Silage without Manure
- Small Grains and Grains
- Specialty Crop High
- Specialty Crop Low
- Pasture

Brief Description of BMP Simulation in the Model

The agricultural Tree Planting practice is a *Load Source Change BMP*. Each acre planted and reported under the BMP converts one acre from an AG load source into Forest.

Annual or Cumulative? Cumulative (10-year credit duration)

Can this practice be combined with other BMPs? No. An area converted to the Forest load source by this BMP is no longer eligible for application of other agricultural BMPs.

Figure A-23-2. Newly planted young trees benefit from cylindrical tubes –or "shelters" – and wooden stakes that protect them from harsh conditions and predation by deer as they establish their roots and grow. Photo: Chesapeake Bay Program

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:* Tree Planting
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be AG
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year trees were planted.

Table A-23-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Tree planting (agriculture)	Tree planting	Reforestation; forest planting; tree planting; Windbreak/shelter establishment (NRCS 380); Tree/Shrub Establishment (NRCS 612); Tree Planting (FSA CP3); Hardwood Tree Planting (FSA CP3A)

Additional Information

A Guide for Forestry Practices in the Chesapeake Bay TMDL Phase III Watershed Implementation Plans. Prepared by the Forestry Workgroup. https://www.chesapeakebay.net/what/publications/25951

Version and History Statement

This info sheet was first published on August 10, 2108 and reflects the BMP definition and benefits that have remained in use since review and approval by the CBP partnership's source sector workgroups for tributary strategy development.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-24. Soil Conservation and Water Quality Plans

General Information

A Soil Conservation and Water Quality Plan (SCWQP) is a comprehensive plan that considers management of natural resources on agricultural lands and utilizes BMPs that control soil erosion and manage runoff. These plans include a range of management practices such as crop rotations and structural practices such as sediment basins or grade stabilization structures. The CBP accounts for several major practices under their own unique BMPs, such as conservation tillage (A-3) or pasture and grazing management (A-8). The benefits from a number of other common practices without their own standalone BMPs as defined by the CBP are simulated under this Soil Conservation and Water Quality Plan BMP.

Figure A-24-1. At a farmer's request professional conservation agents – from university extension offices, state/local conservation districts, NRCS or FSA offices, or private consulting firms – assist them to develop conservation plans that consider an appropriate suite of practices for their operation's specific erosion and runoff concerns. Photo: USDA NRCS

CBP Definition(s)

Soil Conservation and Water Quality Plan: For CBP purposes, these are farm conservation plans that involve a combination of agronomic, management and engineered practices that protect and improve soil productivity and water quality and prevent deterioration of natural resources on all or part of a farm. Plans must meet applicable NRCS technical standards.

Specifications or Key Qualifying Conditions

As noted above, for CBP purposes plans and any associated conservation practices implemented must meet applicable NRCS technical standards. Plans are subject to other state-specific programmatic requirements, where they exist; the term used for a "Soil Conservation and Water Quality Plan" may vary based on state programs but the purpose of the qualifying conservation plans remains the same.

Nitrogen, Phosphorus and Sediment Reductions

Nutrient and sediment reductions vary for this BMP based on the load source they apply to, as summarized in Table A-24-1 below.

Table A-24-1. Nitrogen, Phosphorus and Sediment Efficiency Values for Soil Conservation and Water Quality Plan BMP, by load source

Load source	Nitrogen	Phosphorus	Sediment
Ag Open Space	3%	5%	8%
Double Cropped Land	8%	15%	25%
Full Season Soybeans	8%	15%	25%
Grain w/ Manure	8%	15%	25%
Grain w/o Manure	8%	15%	25%
Legume Hay	3%	5%	8%
Other Agronomic Crops	8%	15%	25%
Other Hay	3%	5%	8%
Pasture	5%	10%	14%
Silage w/ Manure	8%	15%	25%
Silage w/o Manure	8%	15%	25%
Small Grains and Grains	8%	15%	25%
Specialty Crop High	8%	15%	25%
Specialty Crop Low	8%	15%	25%

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Ag
- Ag No Open
- Ag Open Space
- Crop
- Crop Hay
- Crop Hay with Manure
- Crop with Manure
- Grains
- Hay
- Legume Hay
- Other Hay
- Pasture
- Pasture Hay
- Row
- Row with Manure
- Specialty

The BMP is applicable to any load source groups listed above; if none is selected, the default is "AG."

Brief Description of BMP Simulation in the Model

The Soil Conservation and Water Quality Plan is an *Efficiency Value BMP*. Each acre reported under the BMP has its load reduced by the percent reductions listed in Table A-24-1.

Annual or Cumulative? Cumulative (10-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Conservation Plans
  - Conservation Plans/SCWQP
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be CROP
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year plan was developed.

Table A-24-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Soil Conservation and Water Quality Plan; Conservation Planning: Field and Pasture Erosion Control Practices	Conservation Plans; Conservation Plans/SCWQP	Name used for these conservation plans may vary based on state programs; may involve multiple practices, not listed here due to space.

Additional Information

Maryland Department of Agriculture. 2017. [Brochure] What is a Soil Conservation and Water Quality Plan? http://mda.maryland.gov/resource_conservation/Documents/scwqplan.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions developed through Simpson and Weammert (Lane) and approved by the WQGIT in 2009.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

A-25. Nontidal Wetland Restoration

General Information

Wetlands provide numerous crucial environmental functions such as wildlife habitat, flood protection and water quality improvements. Many organizations throughout the Chesapeake Bay Watershed work to restore sites that were previously converted from wetlands for other use back to their natural wetland condition; this is known as wetland restoration or re-establishment. Wetland restoration can be done in both tidally-influenced and nontidal freshwater systems, but this BMP is only applicable to nontidal areas. See Sheet N-2: Urban and Non-Urban Shoreline Erosion Control and Management for protocols that are applicable to wetland restoration in tidal areas.

Figure A-25-1. An earthen ditch plug returns marginal cropland to functional wetland condition in Maryland. Source: USDA NRCS.

CBP Definition(s)

Definitions for wetland practices used by the Chesapeake Bay Program do not affect regulatory or other legal definitions that exist for federal, state or local programs. To account for the range of nontidal wetland practices that occur in the Chesapeake Bay Watershed, yet distinguish practices based on key differences, four BMP categories have been established: restoration, rehabilitation, enhancement and creation. All four are defined here for reference, but the nutrient and sediment reductions associated with rehabilitation, enhancement and creation are currently under review by a BMP expert panel and therefore not summarized here.

Wetland Restoration (re-establishment): The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former wetland.

Wetland Rehabilitation: The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions to a degraded wetland.

Wetland Enhancement: The manipulation of the physical, chemical, or biological characteristics of a wetland to heighten, intensify, or improve a specific function(s).

Wetland Creation (establishment): The manipulation of the physical, chemical, or biological characteristics present to develop a wetland that did not previously exist at a site

Of these four categories, restoration and creation are considered *acreage gains*, which means there is an increase in the total area of wetlands. The other two – rehabilitation and enhancement – are considered *functional gains* because they do not change the overall acres of wetlands, but they do improve the wetland's function from its current state.

Specifications or Key Qualifying Conditions

Wetland restoration practices are critical to meeting the Chesapeake Bay's water quality 2025 goals under both the Chesapeake Bay TMDL and the 2014 Watershed Agreement. However, the conversion or alteration of high quality wetlands strictly for the purposes of nitrogen, phosphorus or sediment load reductions should be avoided. Changing the functions and/or values of existing high quality wetland systems and high quality non-wetland ecosystems that already provide denitrification and phosphorous or sediment trapping should not be pursued. Also, important ecosystems such as rare and endangered species habitat, older growth forests, unique ecotones (i.e. Delmarva Bays, Magnolia bogs, critical fish spawning areas, among others) should not be priorities for wetland practices solely for the nutrient and sediment reductions under the Bay TMDL. Each project should be assessed based on federal, state, and local regulatory requirements, according to best professional judgments in the field, and supported by benchmarks presented in state and federal guidance documents.

Nitrogen, Phosphorus and Sediment Reductions

The net reductions in nitrogen, phosphorus and sediment for wetland restoration buffers are significant, but not simple to quantify without the use of CAST (http://cast.chesapeakebay.net/). There is a load source change of the restored area from the previous land use (e.g., cropland) into wetland, which reduces the simulated load. Then there is also an efficiency applied to upland acres that further reduces pollutant loads. The efficiency values applied for nitrogen, phosphorus and sediment are 42, 40 and 31 percent, respectively. The number of upland acres that are treated by the efficiency values varies based on the hydrogeomorphic region where the wetland restoration project was implemented, as summarized in Table A-25-1.

Table A-25-1. Upland acres treated, nutrient and sediment efficiency values for wetland restoration in the Phase 6 Watershed Model, by hydrogeomorphic region

Phase 6 Watershed Model HGMR	Other (Headwater)	Floodplain	Nitrogen efficiency (%)	Phosphorus efficiency (%)	Sediment efficiency (%)
Appalachian Plateau Siliciclastic	1	2	42	40	31
Valley and Ridge Siliciclastic	1	2	42	40	31
Blue Ridge	2	3	42	40	31
Piedmont Crystalline Mesozoic Lowlands	2	3	42	40	31
Western Shore: Coastal Plain Uplands Coastal Plain Dissected Uplands	4	6	42	40	31
Eastern Shore: Coastal Plain Uplands	1	2	42	40	31
Eastern Shore: Coastal Plain Dissected Uplands	2	3	42	40	31
Coastal Plain Lowlands	2	3	42	40	31
Piedmont Carbonate Valley and Ridge Carbonate Appalachian Plateau Carbonate	2	3	42	40	31

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Agriculture
- Agriculture without Open Space
- Cropland
- Cropland and Hay
- Cropland and Hay Eligible for Manure
- Cropland Eligible for Manure
- Grains not Double Cropped
- Hay
- Leguminous Hay
- Other Hay
- Pasture
- Pasture and Hay
- Row Crops
- Row Crops Eligible for Manure
- Specialty Cropland

Wetland restoration can be reported on any of the above load source groups. The default load source group is Agriculture, or “AG.”

Brief Description of BMP Simulation in the Model

The wetland restoration practice is simulated as a *Load Source Change with an Efficiency Value* in the Watershed Model. Each acre reported under the practice is converted to either the Nontidal Floodplain Wetland or Headwater/Isolated Wetland load sources, and then there is an additional reduction to upland loads using the efficiency values in Table A-25-1. For example, one acre of marginal cropland that is restored back to its historical wetland condition will increase the overall acres of wetland by one and reduce the amount of cropland by that same amount. Additionally, the nitrogen load from four other acres will be reduced by 42 percent (assuming the restored wetland is not in the floodplain and is in a Western Shore Coastal Plain Upland setting for this example); the phosphorus and sediment loads from four acres will be reduced by 40 and 31 percent, respectively. While it is difficult to estimate the net reductions of this practice without the use of CAST, the net load reduction can be significant.

Annual or Cumulative? Cumulative (15-year credit duration)

Can this practice be combined with other BMPs? Yes, acres of upland load sources treated by wetland restoration can also receive other eligible agriculture BMPs. The area of land converted to either Nontidal Floodplain Wetland or Headwater or Isolated Wetland, however, cannot receive additional BMPs since wetland enhancement and wetland rehabilitations are the only two BMPs applied to wetland load sources.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Wetland Restoration – Floodplain
  - Wetland Restoration – Headwater
- *Measurement unit:* Acres
- *Land Use:* Approved NEIEN agricultural land uses; if none are reported the default will be AG
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year wetland restoration was completed.

Table A-25-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Wetland Restoration	Wetland Restoration – Floodplain Wetland Restoration – Headwater	Wetland restoration (NRCS 657); CRP or CREP wetland restoration (CP23) and wetland restoration, non-floodplain (CP23A); restore hydrology to prior-converted agricultural land (cropland or pasture); elevate subsided marsh and re-vegetate; ditch plugging on cropland; legacy sediment removal

Additional Information

Expert panel report:

Mason, P., Spagnolo, R., Boomer, K., Clearwater, D., Davis, D., Denver, J., Hartranft, J., Henicheck, M., McLaughlin, E., Miller, J., Staver, K., Strano, S., Stubbs, Q., Thompson, J. & T. Uybarreta. 2016. Wetlands and wetland restoration: Recommendations of the Wetland Expert Panel for the incorporation of non-tidal wetland best management practices (BMPs) and land uses in the Phase 6 Chesapeake Bay Watershed Model. CBP/TRS-314-16. https://www.chesapeakebay.net/documents/Wetland_Expert_Panel_Report_WQGIT_approved_December_2016.pdf

Nontidal Wetland BMPs fact sheet: https://www.chesapeakebay.net/what/publications/28332

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in December 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-1. Stormwater Performance Standards

General Information

In the past several years, all of the Bay jurisdictions have adopted more stringent stormwater regulations, written new stormwater design criteria and shifted to low impact development practices. This means that new development and redevelopment will have less post-construction impact on water quality in local streams and the Bay, because nutrient and sediment loads will be closer to pre-development levels under these stormwater performance standards.

Figure D-1-1. Bioretention is one type of practice that can be used to reduce stormwater pollution that runs off from impervious areas such as roads, buildings and parking lots. Photo: Diane Cordell, Flickr

CBP Definition(s)

Stormwater Performance Standards (aka Stormwater Practices for New and Redevelopment Projects): This refers to the range of structural and non-structural measures installed over the entire development (or redevelopment) site to reduce runoff, flooding and downstream bank erosion, as well as improve stream water quality. These practices capture stormwater runoff generated over a wide range of storm events and then treat it through some combination of settling, filtering, adsorption or biological uptake to remove nutrients and sediment.

Runoff Reduction is the total post-development runoff volume that is reduced through canopy interception, soil amendments, evaporation, rainfall harvesting, engineered infiltration, extended filtration or evapo-transpiration. Stormwater practices that achieve at least a 25 percent reduction of the annual runoff volume are classified as *Runoff Reduction (RR) practices* and therefore earn a higher net removal rate. Stormwater practices that employ a permanent pool, constructed wetlands or sand filters are classified as *Stormwater Treatment (ST) practices* that have less runoff reduction capability and therefore lower removal rates than RR practices.

Common types of ST and RR practices are listed in Table D-1-1.

Table D-1-1. Classification of BMPs based on runoff reduction capability. Source: New State Performance Standards BMP Expert Panel, 2012.

Stormwater Treatment (ST) Practices	Runoff Reduction (RR) Practices
Constructed wetland ilte ring practices (e.g., sand filter) Wet swale Wet pond	*Non-structural Practices*
	Landscape restoration/reforestation Riparian buffer restoration Impervious disconnection Sheet flow to vegetated filter strip or open space Non-Structural BMPs, Pennsylvania 2006 BMP Manual, Chapter 5
	Structural Practices
	Environmental site design practices in 2007 Maryland Stormwater BMP Manual Bioretention and rain garden Dry channel regenerative stormwater conveyance (Dry Channel RSC) Dry swale Expanded tree pits rass channels and bioswales r een roofs r een streets Infiltration practices (aka infiltration basin, infiltration bed, infiltration trench, dry well/seepage pit, landscape infiltration) Permeable pavement (aka porous pavement) Rainwater harvesting (aka capture and re-use)

Specifications or Key Qualifying Conditions

These are practices installed on a newly developed or a redeveloped site. Practices installed to treat an existing development that is untreated, or inadequately treated, are considered retrofits (see D-2: Stormwater Retrofits). Consult the expert panel report for additional suggested qualifying conditions and your corresponding state stormwater BMP manual for specific design specifications or requirements.

Figure D-1-2. Permeable pavement is a type of runoff reduction (RR) practice because it allows processes such as filtration and evapo-transpiration to occur. This approach reduces runoff and removes a greater portion of pollutants than stormwater treatment (ST) practices that employ a permanent pool – such as wet ponds, wet swales, and constructed wetlands – because such practices simply provide storage and treatment before discharge. Photo: Chesapeake Bay Program

Nitrogen, Phosphorus and Sediment Reductions

Each pollutant (nitrogen, phosphorus and sediment) has its own equation and "adjustor curve" for RR and ST practices, as shown in Figure D-1-3 for nitrogen. The y-axis shows the percent of pollutant removal (%) based on the runoff depth captured by the practice per impervious acres in its drainage area (shown on the x-axis as inches per impervious acre).

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- All Developed Land Uses (Non-Regulated, MS4 and CSS) except construction

It is recommended that states report these practices on the appropriate land use group, i.e., either "Nonregulated," "MS4" or "CSS." Alternatively, the combined group "MS4CSSNonRegulated" can be used; this combined group is the default if one of the three is not specified.

Brief Description of BMP Simulation in the Model

All stormwater practices that comply with new performance standards are *Efficiency Value BMPs*, whose efficiency is determined by curves and underlying equations, such as those in Figure D-1-3 for total nitrogen. Pollutant loads from the site are reduced by the corresponding efficiency values.

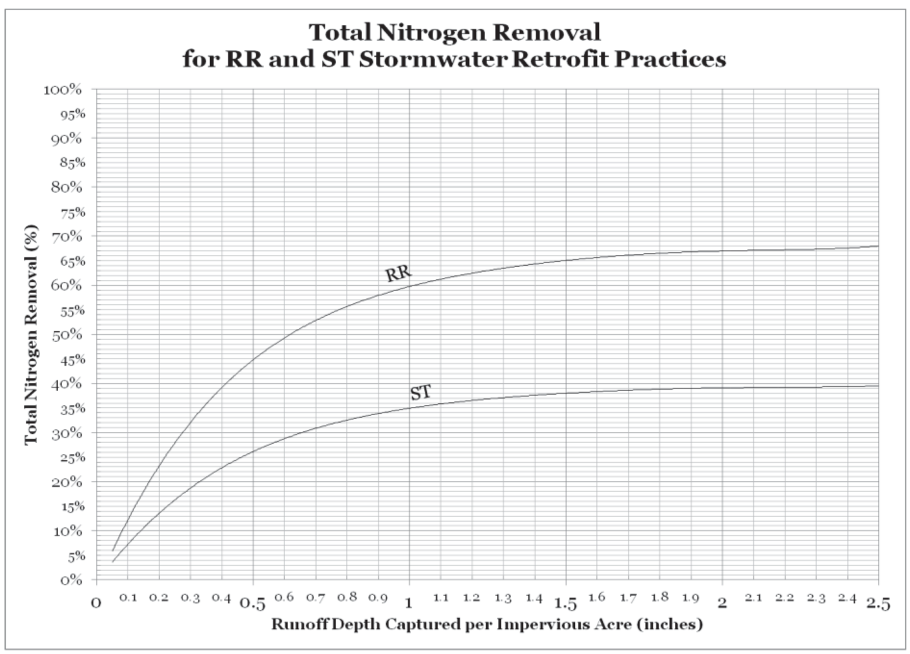

Figure D-1-3. "Adjustor" curves of estimated nitrogen removal for runoff reduction (RR) and stormwater treatment (ST) retrofit practices. Separate curves for phosphorus and sediment are not pictured here but are available in the expert panel report and other resources listed below. Source: Chesapeake Stormwater Network. Use the standard equation for "Runoff Depth Captured per Impervious Acre" (in inches) to find the appropriate location on the X-axis:

$$\text{Runoff depth captured per Impervious Acre} = \frac{12 \times RS}{IA}$$

RS = Runoff Storage Volume (acre-feet) is the amount of volume treated by the stormwater practice
IA = Impervious Area in acres

For example, Figure D-1-3 indicates that an ST practice that captures one inch of runoff per one impervious acre reduces nitrogen from the total treatment area by about 35 percent, whereas an RR practice that also treats one inch of runoff per one impervious acre reduces nitrogen from the total treatment area by about 60 percent. Multiple practices on a single site can be combined to calculate the removal for the whole site. In cases where both RR and ST practices are implemented on a site the dominant type of practice can be used to determine which curve applies for the site as a whole, unless your state stormwater contact indicates otherwise (see the resources listed under Additional Information).

Annual or Cumulative? Cumulative (10-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Retrofit Runoff Reduction
  - Retrofit Stormwater Treatment
- *Measurement unit(s):* Runoff storage volume; impervious acres; acres treated
- *Land Use:* Approved NEIEN Developed load source groups (Non-Regulated, MS4, CSS); if none are reported the default load source group will be combination of all three (MS4CSSNonRegulated).
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year practice was installed.

Table D-1-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
New State Stormwater Performance Standards (aka Stormwater Practices for New Development and Redevelopment), Runoff Reduction (RR) practices	New Runoff Reduction (RR)*	Bioretention, Dry swale, Infiltration, Permeable pavement, Green roof, Dry channel regenerative stormwater conveyance
New State Stormwater Performance Standards (aka Stormwater Practices for New Development and Redevelopment), Stormwater Treatment (ST) practices	New Stormwater Treatment (ST)*	Constructed wetland, Filtering practices (e.g., sand filter), Wet swale, Wet pond
* Stormwater Performance Standards (Sheet D-1) and Retrofits (Sheet D-2) BMPs are not distinguished within CAST. All BMPs in these two categories are listed only as "RR" or "ST". While there is no distinction in CAST, jurisdictions have separate goals and milestones based on whether the practices are for new or existing development and should thus report them differently in NEIEN. For planning purposes, please select "Stormwater Performance Standards" in CAST if you wish to simulate Retrofit BMPs.		

Additional Information

Expert panel report:
Comstock, S., Crafton, S., Greer, R., Hill, P., Hirschman, D., Karimpour, S., Murin, K., Orr, J., Rose, F., & S. Wilkins. 2012. Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards. Prepared by T. Schueler and C. Lane, Chesapeake Stormwater Network. Revised with

updated curves January 2015. http://www.chesapeakebay.net/documents/Final-CBP-Approved-Expert-Panel-Report-on-Stormwater-Performance-Standards-LONG_012015.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-2: Stormwater Practices for New and Redevelopment Projects. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network, Archived (2014) webcast: Crediting BMPs used for New and Redevelopment Webcast: http://chesapeakestormwater.net/events/webcast-ms4-implementers-and-the-bay-tmdl-crediting-bmps-used-for-new-and-redevelopment/

Version and History Statement

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D-2. Stormwater Retrofits

General Information

Stormwater retrofits are a diverse group of projects that reduce nutrient and sediment loads from existing development. Though there are many retrofit designs and practices, they all basically function the same way: retrofit practices capture polluted stormwater runoff in temporary storage areas, where physical and biological mechanisms help prevent nutrients, sediment or other pollutants from reaching local waterways.

Figure D-2-1. Retrofit projects often combine multiple practices, such as bioretention and rain gardens, bioswales and pervious pavement to improve stormwater management in a developed area. Photos: Center for Neighborhood Technology, Flickr

CBP Definition(s)

Stormwater retrofits can be classified into two broad project categories: *New retrofits* or *existing BMP retrofits.*

New retrofits: New retrofit projects create storage to reduce nutrients on land that is not currently receiving stormwater treatment. Common examples of new retrofit facilities include creating new storage:

a) Near existing stormwater outfalls
b) Within the existing stormwater conveyance system
c) Adjacent to large parking lots
d) Green street retrofits
e) On-site Low Impact Development (LID) retrofits

With the exception of (e), many new retrofit facilities are typically located on public land and utilize a range of stormwater treatment and runoff reduction mechanisms. Due to site constraints, new retrofits may not always meet past or future performance standards for BMP sizing that applies to new development.

Existing BMP retrofits: An existing stormwater practice is either converted into a different type of practice that is more effective at removing pollutants, enhanced by increasing the amount of runoff it can treat and/or increasing its hydraulic retention time, or restored to renew its performance.

Runoff Reduction is the total post-development runoff volume that is reduced through canopy interception, soil amendments, evaporation, rainfall harvesting, engineered infiltration, extended filtration or evapo-transpiration. Retrofit projects that achieve at least a 25 percent reduction of the annual runoff volume are classified as *Runoff Reduction (RR) practices* and therefore earn a higher net removal rate. Retrofit practices that employ a permanent pool, constructed wetlands or sand filters are classified as *Stormwater Treatment (ST) practices* that have less runoff reduction capability and therefore lower removal rates than RR practices.

Common types of ST and RR practices are listed in Table D-2-1.

Specifications or Key Qualifying Conditions

Retrofit projects apply to existing development that is currently untreated or inadequately treated by one or more stormwater practices. Practices installed on a newly developed or redeveloped site are categorized under Stormwater Performance Standards (see Sheet D-1). Consult the expert panel report for additional suggested qualifying conditions and your corresponding state stormwater BMP manual for specific design specifications or requirements.

Nitrogen, Phosphorus and Sediment Reductions

Each pollutant (nitrogen, phosphorus and sediment) has its own equation and "adjustor curve" for RR and ST practices, as shown in Figure D-2-3 for nitrogen. The y-axis shows the percent of pollutant removal (%) based on the runoff depth captured by the practice per impervious acres in its drainage area (shown on the x-axis as inches per impervious acre).

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- All Developed Land Uses (Non-Regulated, MS4 and CSS) except construction

It is recommended that states report these practices on the appropriate land use group, i.e., either "Nonregulated," "MS4" or "CSS." Alternatively, the combined group "MS4CSSNonRegulated" can be used; this combined group is the default if one of the three is not specified.

Table D-2-1. Classification of BMPs based on runoff reduction capability. Source: New State Performance Standards BMP Expert Panel, 2012.

Stormwater Treatment (ST) Practices	Runoff Reduction (RR) Practices
Constructed wetland	*Non-structural Practices*
Filtering practices (e.g., sand filter)	Landscape restoration/reforestation
Wet swale	Riparian buffer restoration
Wet pond	Impervious disconnection
	Sheet flow to vegetated filter strip or open space
	Non-Structural BMPs, Pennsylvania 2006 BMP Manual, Chapter 5
	Structural Practices
	Environmental site design practices in 2007 Maryland Stormwater BMP Manual
	Bioretention and rain garden
	Dry channel regenerative stormwater conveyance (Dry Channel RSC)
	Dry swale
	Expanded tree pits
	Grass channels and bioswales
	Green roofs
	Green streets
	Infiltration practices (aka infiltration basin, infiltration bed, infiltration trench, dry well/seepage pit, landscape infiltration)
	Permeable pavement (aka porous pavement)
	Rainwater harvesting (aka capture and re-use)

Urban Filter Strips: Another expert panel developed specific methods to compute removal for urban filter strips used in a retrofit context, please consult their report to see how credit is provided for this practice located here: http://chesapeakestormwater.net/bay-stormwater/baywide-stormwaterpolicy/urban-stormwater-workgroup/urban-filter-strips/

Dry Ponds: Retrofits of existing dry ponds or dry extended detention ponds do NOT use the adjustor curves to define their pre-retrofit performance. They use lower pollutant removal rates shown in Table A-5 of the Expert Panel Report (see Additional Information section)

Brief Description of BMP Simulation in the Model

All stormwater retrofit practices are *Efficiency Value BMPs,* with an added exception that their efficiency value is determined by curves and underlying equations such as those in Figure D-2-2 for total nitrogen. Runoff from the applicable impervious area is reduced by the corresponding efficiency values. For example, an ST practice that captures one inch of runoff per one impervious acre reduces nitrogen from that area by about 35 percent, whereas an RR practice that also treats one inch of runoff per one impervious acre reduces nitrogen from that area by about 60 percent. Multiple practices on a single site can be combined to calculate the removal for the whole site. In cases where both RR and ST practices are implemented on a site the dominant type of practice can be used to determine which curve applies for the site as a whole, unless your state stormwater contact indicates otherwise (see the resources listed under Additional Information).

Annual or Cumulative? Cumulative (10-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Retrofit Runoff Reduction
  - Retrofit Stormwater Treatment
- *Measurement unit(s):* Runoff storage volume; impervious acres; acres treated
- *Land Use:* Approved NEIEN Developed load source groups (Non-Regulated, MS4, CSS); if none are reported the default load source group will be combination of all three (MS4CSSNonRegulated).
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year practice was installed.

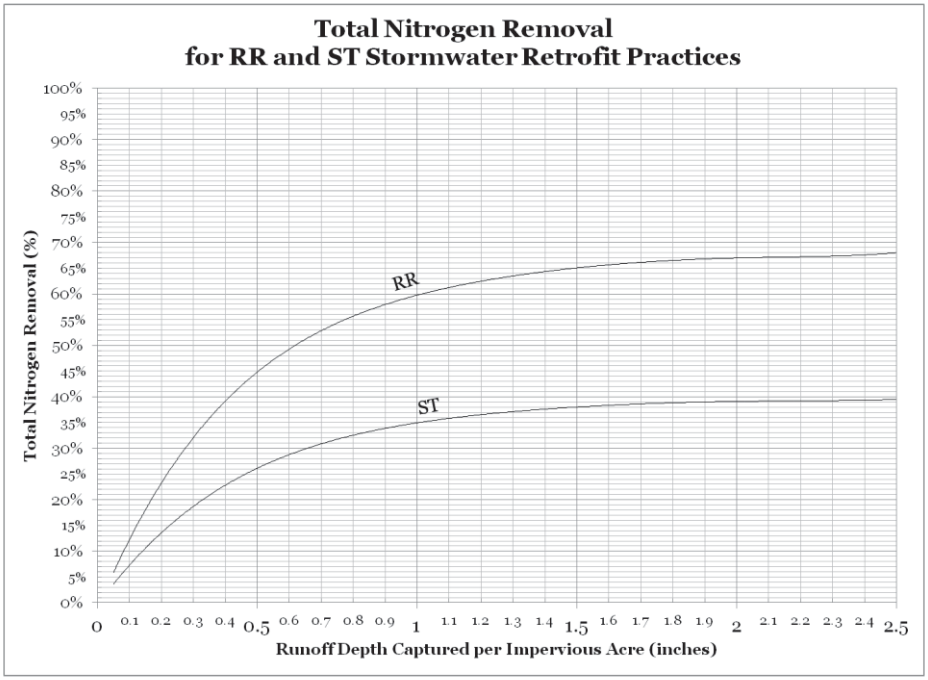

Figure D-2-2. "Adjustor" curves of estimated nitrogen removal for runoff reduction (RR) and stormwater treatment (ST) retrofit practices. Separate curves for phosphorus and sediment are not pictured here but are available in the expert panel report and other resources listed below. Source: Chesapeake Stormwater Network. Use the standard equation for "Runoff Depth Captured per Impervious Acre" (in inches) to find the appropriate location on the X-axis:

$$\textit{Runoff depth captured per Impervious Acre} = \frac{12 \times RS}{IA}$$

RS = Runoff Storage Volume (acre-feet) is the amount of volume treated by the stormwater practice
IA = Impervious Area in acres

Table D-2-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Stormwater Retrofit, Runoff Reduction (RR) practices	Retrofit Runoff Reduction (RR)*	Bioretention, Dry swale, Infiltration, Permeable pavement, Green roof, Dry channel regenerative stormwater conveyance
Stormwater Retrofit, Stormwater Treatment (ST) practices	Retrofit Stormwater Treatment (ST)*	Constructed wetland, Filtering practices (e.g., sand filter), Wet swale, Wet pond
* Stormwater Performance Standards (Sheet D-1) and Retrofits (Sheet D-2) BMPs are not distinguished within CAST. All BMPs in these two categories are listed only as "RR" or "ST". While there is no distinction in CAST, jurisdictions have separate goals and milestones based on whether the practices are for new or existing development and should thus report them differently in NEIEN. For planning purposes, please select "Stormwater Performance Standards" in CAST if you wish to simulate Retrofit BMPs.		

Additional Information

Expert panel report:
Bahr, R., Brown, T., Hansen, L.J., Kelly, J., Papacosma, J., Snead, V., Stack, B., Stack, R., & S. Stewart. 2012. Recommendations of the Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects. Prepared by T. Schueler and C. Lane, Chesapeake Stormwater Network. Revised with updated curves January 2015. http://www.chesapeakebay.net/documents/Final-CBP-Approved-Expert-Panel-Report-on-Stormwater-Retrofits-long_012015.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-1: Urban Stormwater Retrofits. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network, Archived (2014) webcast: Accounting for Urban Stormwater Retrofits: http://chesapeakestormwater.net/events/webcast-ms4-implementers-and-the-bay-tmdl-retrofits/

Version and History Statement

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D-5. Urban Stream Restoration

General Information

New stream restoration techniques have been pioneered in the Chesapeake Bay watershed to restore urban streams. Approaches to stream restoration include natural channel design, regenerative stream channel and legacy sediment removal. Stream restoration projects require state and federal permits and thus extensive regulatory review. Projects often take multiple years from concept to construction, involving high costs and extensive effort from multiple stakeholders at the community, state and federal level. Note: This BMP reference sheet is targeted for the Developed sector. See Sheets A-9: Stream Restoration (Ag) and N-1: Urban and Non-Urban Stream Restoration if interested in agricultural or general sectors, though the information is almost entirely the same.

Figure D-5-1. Stream restoration projects can improve the health of aquatic resources and can be one of the more cost-effective practices to reduce nutrient and sediment loads in urban watersheds. A stream in a residential area prior to restoration (top) that has an eroded stream bank and channel can be restored so that natural processes reduce the erosive energy of the stream flow during storm events. Small step pools and reconnecting the stream channel to the floodplain are two methods for restoring natural processes to a stream. The bottom picture is of the same stream three years after restoration. Photos: Arlington County (VA), Department of Environmental Services (https://projects.arlingtonva.us/projects/donaldson-run-stream-restoration-tributary-b/)

CBP Definition(s)

Natural Channel Design (NCD) applies the principles of stream geomorphology to maintain a state of dynamic equilibrium among water, sediment, and vegetation that creates a stable channel.

Legacy Sediment Removal (LSR) seeks to remove legacy sediments from the stream and its floodplain and thereby restore the natural potential of aquatic resources including a combination of streams, floodplains, and wetlands.

Regenerative Stream Channel (RSC, aka Regenerative Stormwater Conveyance) uses in-stream weirs in perennial streams to increase the interaction with the floodplain during smaller storm events. These projects may also include sand seepage wetlands and other habitats to increase the stream's connection with its floodplain. Only wet channel RSC practices are eligible as stream restoration projects. Dry channel RSC projects are considered a runoff reduction retrofit practice (see Sheet D-2: Stormwater Retrofits).

Stream Restoration refers to any NCD, RSC, LSR or other restoration project that meets the qualifying conditions for credits, including environmental limitations and stream functional improvements.

Specifications or Key Qualifying Conditions

There are further protocol-specific qualifying criteria detailed in other resources listed under Additional Information below. All projects must meet the following criteria to be eligible for credit:

- Reach restored must be greater than 100ft in length.

- Reach restored must be actively enlarging or degrading.
- Reach restored MAY NOT be tidally influenced.
- The project MAY NOT be primarily designed to protect public infrastructure. Bank armoring and rip rap are not eligible for stream restoration credit.
- Restoration plan must utilize a comprehensive approach to stream restoration design, addressing long-term stability of the channel, banks, and floodplain.
- Must comply with all state and federal permitting requirements, including 404 and 401 permits.

Stream restoration is a carefully designed intervention to improve the hydrologic, hydraulic, geomorphic, water quality, and biological condition of degraded urban streams, and must not be implemented for the sole purpose of nutrient or sediment reduction. Restoration projects should be developed through a functional assessment process, such as the stream functions pyramid (Harman et al., 2012) or functional equivalent.

Nitrogen, Phosphorus and Sediment Reductions

There are three general protocols to define the pollutant load reductions from stream restoration practices. There is also a default rate for historic projects and new projects that cannot conform to the recommended reporting requirements.

- Protocol 1. Credit for prevented sediment during storm flow
- Protocol 2. Credit for in-stream nitrogen processing during base flow
- Protocol 3. Credit for reconnection to the floodplain

For details on how to use the protocols consult the resources listed under Additional Information.

Table D-5-1. Summary of stream restoration protocols for nitrogen, phosphorus and sediment reductions

Protocol	TN (lbs/ linear ft/ year)	TP (lbs/ linear ft/ year)	TSS (lbs/ linear ft/ year)
Protocol 1. Prevented sediment	Site-specific	Site-specific	Site-specific
Protocol 2. In-stream nitrogen processing	Site-specific	N/A	N/A
Protocol 3. Floodplain reconnection	Site-specific	Site-specific	Site-specific
Default for existing/non-conforming projects*	0.075	0.068	248**
*The existing/non-conforming rates were adjusted following a test drive period. These adjustments are explained in Appendix G of the expert panel report. **Because small stream loads are explicitly modeled in the Phase 6 tools, no sediment delivery factors are needed to reduce the default edge-of-field rate of 248 lbs of TSS/linear ft/year published by the panel.			

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Stream Bed and Bank

The practice can only be applied to the "Stream Bed and Bank" load source, but it is recommended to distinguish the BMP based on its sector using the appropriate secondary BMP designation of either "Urban Stream Restoration" or "Non-Urban Stream Restoration."

Brief Description of BMP Simulation in the Model

All stream restoration practices are *Load Reduction BMPs,* which means they are modeled as a simple removal of pounds of nitrogen, phosphorus and/or sediment from the edge-of-stream load. To calculate the pounds reduced for each protocol, follow the methods and examples described in the panel report and other resources listed under Additional Information. The protocols are additive. So, a project that reduces 100 lbs TN under Protocol 1, 25 lbs TN under Protocol 2, and 30 lbs TN under Protocol 3 has a net reduction of 155 lbs TN. As another example, pretend the project design is unknown for a project planned to restore 1,000 linear feet of a degraded stream. Using the default rate for that project yields reductions of 7.5 lbs TN, 6.8 lbs TP and 24,800 lbs TSS, which would be removed from the edge-of-stream load in the Watershed Model. Load reduction BMPs such as stream restoration cannot remove more pounds of nitrogen, phosphorus or sediment than are available in a watershed, however. So, the Watershed Model does enforce maximum reductions that are described in Section 6.5.4.1 of the Watershed Model documentation.

Annual or Cumulative? Cumulative (5-year credit duration for urban stream restoration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Urban Stream Restoration Protocol
    - Urban Stream Restoration
- *Measurement unit(s): Length restored (feet); Protocol 1 TN (lbs); Protocol 1 TP (lbs); Protocol 1 TSS (lbs); Protocol 2 TN (lbs); Protocol 3 TN (lbs); Protocol 3 TP (Lbs); Protocol 3 TSS (lbs)*
- *Load Source:* Stream Bed and Bank.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year the project was completed.

Table D-5-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

<table>
<tr><th>CBP or Expert Panel term</th><th>NEIEN BMP name</th><th>Other common practice names</th></tr>
<tr><td>Stream Restoration (Urban)</td><td>Urban Stream Restoration Protocol*</td><td rowspan="2">natural channel design, legacy sediment removal, regenerative stream channel or regenerative stormwater conveyance (wet channel only)</td></tr>
<tr><td>Stream Restoration (Urban)</td><td>Urban Stream Restoration**</td></tr>
<tr><td colspan="3">* Uses protocols 1-3 summarized in Table D-5-1. Requires unit of feet in addition to the pounds reduced for each respective protocol.
** For use when specific project design is not known. Requires unit of feet.</td></tr>
</table>

Additional Information

Expert panel report:
Berg, J., Burch, J., Cappuccitti, D., Filoso, S., Fraley-McNeal, L., Goerman, D., Hardman, N., Kaushal, S., Medina, D., Meyers, M., Kerr, B., Stewart, S., Sullivan, B., R. Walter & J. Winters. 2013. Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects. Prepared by T. Schueler, Chesapeake Stormwater Network, and B. Stack, Center for Watershed Protection. Test-drive revisions approved by the WQGIT September 8, 2014.
https://www.chesapeakebay.net/documents/Stream_Panel_Report_Final_08282014_Appendices_A_G.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-4: Urban Stream Restoration. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network. BMP Resources, Urban Stream Restoration: http://chesapeakestormwater.net/bmp-resources/urban-stream-restoration/

Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs & C. Miller. 2012. A function-based framework for developing stream assessments, restoration goals, performance standards and standard operating procedures. U.S. Environmental Protection Agency. Office of Wetlands, Oceans and Watersheds. Washington, D.C. EPA 843-K-12-006. https://www.epa.gov/sites/production/files/2015-08/documents/a_function_based_framework_for_stream_assessment_3.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in May 2013, with test-drive revisions approved in September 2014.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-6. Urban Nutrient Management

General Information

Turfgrass is everywhere in suburban and developed areas of the Chesapeake Bay Watershed, comprising roughly ten percent of the region's total land area. Therefore, the management of turfgrass – whether it is a private lawn, public park or golf course – affects local water quality. Three Bay States (Maryland, New York and Virginia) have passed laws that ban residential fertilizers from containing phosphorus, among other requirements.

Figure D-6-1. Fertilizers contain nutrients such as nitrogen, phosphorus and potassium that help grass and other plants grow. Excessive nitrogen and phosphorus can create water quality problems, however. Jurisdictions in the Chesapeake Bay Watershed have programs to educate homeowners and certify commercial applicators in best practices for nutrient management. Photo: Centers for Disease Control.

CBP Definition(s)

Urban Nutrient Management (UNM) is defined as the proper management of major nutrients for turf and landscape plants on a property to best protect water quality.

An *urban nutrient management plan (UNM plan)* is a written, site-specific plan which addresses how the major plant nutrients (nitrogen, phosphorus and potassium) are to be annually managed for expected turf and landscape plants and for the protection of water quality. The goal of an urban turf and landscape nutrient management plan is to minimize adverse environmental effects, primarily upon water quality, and avoid unnecessary nutrient applications. It should be recognized that some level of nutrient loss to surface and groundwater will occur even by following the recommendations in a nutrient management plan. The impacts of urban nutrient management plans will differ from lawn-to-lawn depending on nutrient export risk factors.

High risk areas: Pervious areas that are subject to one or more risk factors listed in Table D-6-2 (left-hand column).

Specifications or Key Qualifying Conditions

The technical support and qualifications needed to write a UNM plan varies in each Bay State. Localities should consult with State agencies to determine information requirements for UNM plans or if state regulations prevent reporting UNM plans as unique BMPs (see resources listed under Additional Information).

Nitrogen, Phosphorus and Sediment Reductions

There are no sediment reductions for UNM practices. The nutrient reductions are summarized in Table D-6-1.

Table D-6-1. Nitrogen and Phosphorus reductions for Urban Nutrient Management in the Phase 6 Watershed Model

	TN reduction	TP reduction
Nutrient Management Maryland Commercial Applicators	9%	0%
Nutrient Management Maryland Do It Yourself	4.5%	0%
Nutrient Management Plan*	9%	4.5%
Nutrient Management Plan High Risk Lawn	20%	10%
Nutrient Management Plan Low Risk Lawn	6%	3%
* Default practice for lawns with unknown risk type.		

Table D-6-2. Lists of risk factors and core nutrient management practices for turf and lawns. Source: Nutrient Management Expert Panel (Aveni et al, 2013).

High Risk Export Factors for nutrients	Core Urban Nutrient Management Practices
1. Currently over-fertilized beyond state or extension recommendations	1. Consult with the local extension service, master gardener or certified applicator to get technical assistance to develop an effective urban nutrient management plan for the property
2. P-saturated soils as determined by a soil P test	2. Maintain a dense vegetative cover of turf grass to reduce runoff, prevent erosion, and retain nutrients
3. Newly established turf (i.e., less than three years old)	3. Choose not to fertilize, OR adopt a reduce rate/monitor approach OR the small fertilizer dose approach
4. Steep slopes	4. Retain clippings and mulched leaves on the yard and keep them out of streets and storm drains
5. Exposed soil	5. Do not apply fertilizers before spring green up or after grass becomes dormant
6. High water table	6. Maximize use of slow release N fertilizer during the active growing season
7. Over-irrigated lawns	7. Set mower height at 3 inches or taller
8. Soils that are sandy, shallow, compacted or have low water holding capacity	8. Do not apply fertilizer within 15 to 20 feet of a water feature (depending on applicable state regulations) and manage this zone as a perennial planting, meadow, grass buffer or a forested buffer
9. High use areas (e.g., athletic fields, golf courses)	9. Immediately sweep off any fertilizer that lands on a paved surface
10. Adjacent to stream, river or Bay	10. Employ lawn practices to increase soil porosity and infiltration capability, especially along portions of the lawn that convey or treat stormwater runoff.
11. Karst terrain	

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- All Developed pervious land uses (Non-Regulated, MS4 and CSS), which includes Turfgrass and Tree Canopy over Turfgrass
- Construction (Non-Regulated, MS4 and CSS)

The load source group "Pervious" can be used as a default, which includes all Turfgrass and Tree Canopy over Turfgrass (Non-Regulated, MS4 and CSS).

Brief Description of BMP Simulation in the Model

All UNM practices are *Efficiency Value BMPs*. Nutrient loads from pervious areas are reduced by the corresponding efficiency values listed in Table D-6-1. In the Phase 6 Watershed Model there is no more "state-wide" phosphorus credit because all P application rates are now adjusted to reflect non-agriculture fertilizer sales data.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Figure D-6-2. Soil tests by university extension or commercial professionals help determine optimal fertilizer application rates for UNM plans. Photo: USDA NRCS.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Nutrient Management Maryland Commercial Applicators
  - Nutrient Management Maryland Do It Yourself
  - Nutrient Management Plan
  - Nutrient Management Plan High Risk Lawn
  - Nutrient Management Plan Low Risk Lawn
- *Measurement unit(s):* Acres or percent
- *Land Use:* Approved NEIEN Developed load source groups (Non-Regulated, MS4, CSS) including Pervious and Construction; if none are reported the default load source group will be Pervious
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year UNM plan was active.

Table D-6-3. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
UNM, Maryland Commercial Applicator Lawn	Nutrient Management Maryland Commercial Applicators	
UNM, Maryland Do It Yourself (DIY) Fertilized Lawn	Nutrient Management Maryland Do It Yourself	
UNM [Blended]*	Nutrient Management Plan*	
UNM High Risk	Nutrient Management Plan High Risk Lawn	
UNM Low Risk	Nutrient Management Plan Low Risk Lawn	
* Default practice for lawns with unknown risk type.		

Additional Information

Expert panel report:
Aveni, M., Berger, K., Champion, J., Felton, G., Goatley, M., Keeling, W., Law, N., & S. Schwartz. 2013. Recommendations of the Expert Panel to Define Removal Rates for Urban Nutrient Management. Prepared by T. Schueler and C. Lane, Chesapeake Stormwater Network. Approved by the WQGIT March 2013. https://www.chesapeakebay.net/documents/Final_CBP_Approved_Expert_Panel_Report_on_Urban_Nutrient_Management--short.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-5: Urban Nutrient Management. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network, Archived (2014) webcast: Crediting BMPs used for New and Redevelopment Webcast: http://chesapeakestormwater.net/events/webcast-urban-nutrient-management/

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in March 2013.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-7. Urban Tree Planting BMPs

General Information

Trees in urban and suburban areas provide a host of environmental benefits. They reduce stormwater runoff and improve local water quality, mitigate the urban heat island effect in highly developed settings, provide habitat for wildlife and trap air pollution, among other benefits. Planting new trees is one way to increase those benefits in developed areas, but it is vital to conserve and maintain existing trees to protect the services they offer. The BMPs described here relate to planting new trees in developed areas (for Forest Buffers in agricultural settings see A-12 and A-13; for tree planting in agricultural areas, see A-23).

CBP Definition(s)

To understand tree planting BMPs for developed areas, it helps to understand the three different land uses that represent tree cover in the Watershed Model:

- *Tree Canopy over Impervious* includes trees over roads and non-road impervious surfaces such as buildings and parking lots.
- *Tree Canopy over Turfgrass* includes trees within 30'-80' of non-road impervious surfaces where the understory is assumed to be turf grass or otherwise altered through compaction, removal of surface organic material and/or fertilization.
- *Forest* includes trees farther than 30'-80' from non-road impervious surfaces and forming contiguous patches greater than one-acre in extent.

Urban Tree Canopy Expansion: The planting of trees in an urban area that are not part of a riparian forest buffer, structural BMP (e.g., bioretention, tree planter) or do not conform to the definition of the Urban Forest Planting BMP. The land use area conversion factor is based on the panel's recommendation of 144 square foot average of canopy per tree planted. Thus, 300 newly planted trees are equivalent to one acre of tree canopy land use; however, this is not a planting density requirement and each tree converts 1/300 of an acre of either pervious or impervious developed area to tree canopy land uses. This BMP does not require trees to be planted in a contiguous area.

Urban Forest Planting: Tree planting projects in urban or suburban areas that are not part of a riparian buffer, structural BMP or Urban Tree Canopy Expansion BMP, with the intent of establishing forest ecosystem processes and function. This requires urban forest

Figure D-7-1. Trees in developed areas yield many benefits, but they provide the greatest environmental uplift when they form areas of forest as seen (top) in Rock Creek Park, Washington, D.C. Trees over managed turfgrass or near road corridors provide important environmental benefits, but are considered "tree canopy over turfgrass" (middle) or "tree canopy over impervious" (bottom) to distinguish these trees from higher-functioning areas of forest. Photos: Chesapeake Bay Program plantings to be documented in a planting and maintenance plan that meets state planting density and associated standards for establishing forest conditions, including no fertilization and minimal mowing as needed to aid tree and understory establishment. Under this BMP, trees are planted in a contiguous area as documented in the planting plan and the acreage of this BMP is converted from the developed turfgrass land use into forest in the modeling tools.

Urban Forest Buffer: Forest buffers are linear wooded areas that help filter nutrients, sediment and other pollutants from runoff as well as remove nutrients from groundwater. The recommended buffer width is 100 feet, with a 35 feet minimum width required.

Specifications or Key Qualifying Conditions

Trees planted for mitigation or as part of other BMPs or not eligible under these practices; an area of planted trees can only be counted towards one BMP. For example, if an acre of trees is planted along a stream as a forest buffer in a developed area it can be reported as an Urban Forest Buffer, but that same acre of trees cannot also be reported as Urban Forest Planting or Urban Tree Canopy Expansion.

Nitrogen, Phosphorus and Sediment Reductions

Each pollutant (nitrogen, phosphorus and sediment) is reduced according to the area of trees planted, with buffers reducing the load from upland developed acres. Average per-acre reduction estimates are provided in Table D-7-1 to illustrate the significant expected benefits for these practices, but actual estimates can be calculated using CAST.

Table D-7-1. Baywide average nitrogen, phosphorus and sediment reductions per acre of implementation. Pounds reduced edge-of-tide (EOT). TN and TP rounded to nearest hundredth of a pound; TSS rounded to nearest whole pound. Values derived in Phase 6 version of CAST and available by county or state. These values provided as useful estimates but the actual reductions for specific BMPs will be different from these average estimates. Source: BMP Pounds Reduced and Cost by State, July 13, 2018 version, available under "Cost Effectiveness" section at http://cast.chesapeakebay.net/Documentation/DevelopPlans

Jurisdiction	BMP	Nitrogen Average reduction per acre, Edge of tide (lbs/ac)	Phosphorus Average reduction per acre, Edge of tide (lbs/ac)	Sediment Average reduction per acre, Edge of tide (lbs/ac)
Delaware	Forest buffer	35.25	0.95	113
	Forest planting	32.47	0.67	63
	Tree planting - canopy	15.91	0.10	15
District of Columbia	Forest buffer	5.86	1.07	915
	Forest planting	4.08	0.80	414
	Tree planting - canopy	-	0.03	18
Maryland	Forest buffer	8.06	1.10	729
	Forest planting	6.15	0.77	381
	Tree planting - canopy	0.62	0.10	64
New York	Forest buffer	5.85	0.37	730
	Forest planting	4.40	0.24	363
	Tree planting - canopy	0.60	0.04	267
Pennsylvania	Forest buffer	9.69	0.48	661
	Forest planting	7.33	0.32	341
	Tree planting - canopy	0.83	0.05	92
Virginia	Forest buffer	8.77	1.61	854
	Forest planting	7.33	1.16	451
	Tree planting - canopy	1.82	0.15	223
West Virginia	Forest buffer	7.52	0.56	1491
	Forest planting	5.77	0.36	847
	Tree planting - canopy	0.77	0.06	236

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

All Developed Turfgrass Land Uses (Non-Regulated, MS4 and CSS); Tree Canopy is also applicable to all Developed impervious land uses (Roads; Buildings and Other)

It is recommended that states report these practices on the appropriate version of Turfgrass, i.e., either “Nonregulated,” “MS4” or “CSS.” Alternatively, the combined group “Turfgrass” can be used; this combined group is the default if one of the three is not specified.

Brief Description of BMP Simulation in the Model

Urban Tree Canopy Expansion and Urban Forest Planting are *Load Source Change BMPs*, whose reductions are determined by the difference in nitrogen, phosphorus and sediment loading rates between the previous and the new land use (e.g., the difference in loads between Roads and Tree Canopy over Impervious). Urban Forest Buffers are a *Load Source Change with Efficiency Value BMP*. Each acre reported under the Urban Forest Buffer BMP is converted to the Forest load source, and then there is an additional treatment of upland load sources (25% TN, 50% TP and 50% sediment). For example, if one acre of trees is planted as a buffer along a stream, it converts one acre of Turfgrass into Forest, and reduces the load from an additional acre of Developed land by 25% for TN and 50% for TP and Sediment.

Annual or Cumulative? Cumulative (10-year credit duration for urban tree canopy expansion or urban forest buffer; 15-year credit duration for urban forest planting)

Can this practice be combined with other BMPs? Yes. However, land converted to Forest by the Urban Forest Planting or Urban Forest Buffer BMPs cannot receive other developed BMPs in the model.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Tree Planting – Canopy
    - Urban Forest Planting
    - Urban Forest Buffer
- *Measurement unit(s):* Acres (of the forested buffer or planted with trees)
- *Land Use:* Approved NEIEN Developed load source groups (Non-Regulated, MS4, CSS);
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year trees were planted, or year forest buffer was established.

Table D-7-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Urban Tree Canopy Expansion	Tree Planting – Canopy	Street trees; landscape or individual tree planting
Urban Forest Planting	Urban Forest Planting	
Urban Forest Buffer	Urban Forest Buffer	

Additional Information

Expert panel report for urban tree canopy and forest planting BMPs:
Law, N., Cappiella, K., Claggett, S., Cline, K., Day, S., Galvin, M., MacDonagh, P., Sanders, J., Whitlow, T. & Q. Xiao. 2016. Recommendations of the Expert Panel to Define BMP Effectiveness for Urban Tree Canopy Expansion. Prepared by N. Law, Center for Watershed Protection and J. Hanson, Virginia Tech. https://www.chesapeakebay.net/documents/Urban_Tree_Canopy_EP_Report_WQGIT_approved_final.pdf

Center for Watershed Protection. 2017. *Making Urban Trees Count.* Report and other supporting materials available at: https://www.cwp.org/making-urban-trees-count/

Chesapeake Stormwater Network, Archived (2016) webcast: Urban Tree Canopy and Forest Planting: http://chesapeakestormwater.net/2016/09/webcast-urban-tree-canopy/

Chesapeake Tree Canopy Network: http://chesapeaketrees.net/

Trees and Stormwater: http://treesandstormwater.org/

Chesapeake Bay Program Forestry Workgroup Phase 3 WIP packet: https://www.chesapeakebay.net/what/publications/25951

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in September 2016 for the urban tree canopy and urban forest planting BMPs. The urban forest buffer BMP definition and benefits have remained in use since review and approval by the CBP partnership's source sector workgroups for tributary strategy development.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

D-9. Street Cleaning (Street Sweeping)

General Information

Streets comprise a significant portion of impervious cover in the Chesapeake Bay watershed. Most communities operate some kind of street sweeping program, using vehicles to clean their roads along curbside gutters where debris and dirt accumulate. Street sweeping provides a number of benefits to the community by removing trash, debris, sand, road salt and other solids. This prevents pollution from entering local waterways while creating a more attractive streetscape. The accumulated materials may also contain toxic pollutants or pose other risks to the local environment. The effectiveness of street sweeping is greatest when cleaning high-use roadways free of parked cars which block access to curbs and gutters where materials accumulate.

Figure D-9-1. There are different types of street sweeping vehicles, but the most common technology are mechanical broom sweepers, like the one pictured here. More advanced and effective, but expensive, options include vacuum-assisted and regenerative air sweepers (not pictured). Photo: Mississippi Watershed Management Organization

CBP Definition(s)

The CBP has two categories of street cleaning practices (SCPs) based on the type of sweeper technology.

Mechanical broom technology sweepers: Researchers have found that while mechanical sweepers are effective in picking up coarse-grained particles, they leave behind fine-grained particles, which are then subject to future wash-off. Therefore, mechanical broom sweepers are useful in removing gross solids, trash and litter from streets but have very limited capabilities to reduce nutrients and fine sediment.

Advanced sweeping technology: Technologies with greater demonstrated ability to remove solids and even finer particles from street surfaces.

Regenerative air sweepers are equipped with a sweeping head which creates suction and uses forced air to transfer street debris into the hopper.

Vacuum-assisted sweepers are sweepers equipped with a high power vacuum to suction debris from street surface.

The practices are further divided into eleven BMPs based on the frequency of sweeping (see Table D-9-1), since more frequent sweeping increases the likelihood that sweepers will remove accumulated material before precipitation washes it into storm drains or waterways.

Specifications or Key Qualifying Conditions

Mechanical broom sweepers are only eligible for SCP-9, SCP-10 or SCP-11 based on the frequency of sweeping a given route. The other eight SCPs require an advanced sweeper, either vacuum-assisted or regenerative air. Localities should check with their state stormwater agency for specific data reporting or tracking requirements.

Nitrogen, Phosphorus and Sediment Reductions

Advanced sweeper technologies (SCP-1 through SCP-8) have efficiency values for nitrogen, phosphorus and sediment, summarized in Table D-9-1. Mechanical broom sweepers (SCP-1 through SCP-3) only have efficiency values for sediment. The efficiency values are applied to an area of roads or impervious surfaces; generally, one curb-lane mile equals one acre in terms of area swept.

Table D-9-1. Street cleaning practices' sediment, nitrogen and phosphorus efficiency values in the Phase 6 Watershed Model

Type	Practice	Description of passes by sweeper; approx. # of passes per year	Sediment (%)	Nitrogen (%)	Phosphorus (%)
Advanced	SCP-1	2 passes per week; ~100 per year	21	4	10
Advanced	SCP-2	1 pass per week; ~50 per year	16	3	8
Advanced	SCP-3	1 pass every 2 weeks; ~25 per year	11	2	5
Advanced	SCP-4	1 pass every 4 weeks; ~10 per year	6	1	3
Advanced	SCP-5	1 pass every 8 weeks; ~6 per year	4	0.7	2
Advanced	SCP-6	1 pass every 12 weeks; ~4 per year	2	0	1
Advanced	SCP-7*	Seasonal scenario 1 or 2; ~15 per year	7	1	4
Advanced	SCP-8*	Seasonal scenario 3 or 4; ~20 per year	10	2	5
Mech. Broom	SCP-9	2 passes per week; ~100 per year	1	N/A	N/A
Mech. Broom	SCP-10	1 pass per week; ~50 per year	0.5	N/A	N/A
Mech. Broom	SCP-11	1 pass every 4 weeks; ~10 per year	0.1	N/A	N/A

*Seasonal scenarios for SCP-7 and SCP-8 are defined as follows:

- Seasonal scenario 1: Spring – One pass every week from March to April. Monthly otherwise
- Seasonal scenario 2: Spring – One pass every other week from March to April. Monthly otherwise
- Seasonal scenario 3: Spring and fall – One pass every week (March to April, October to November). Monthly otherwise
- Seasonal scenario 4: Spring and fall – One pass every other week during the season. Monthly otherwise

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- All Developed Roads and Impervious Land Uses (Non-Regulated, MS4 and CSS)

If a land use is not specified the default is "Roads."

Brief Description of BMP Simulation in the Model

All street sweeping practices are *Efficiency Value BMPs*. Pollutant loads from roads or other treated impervious surfaces are reduced by the percentage values in Table D-9-1. For example, a community that sweeps 10 curb lane miles twice a week for a whole year with an advanced street sweeper (SCP-1) will have loads from that area of road reduced by 21 percent for sediment, four percent for nitrogen and 10 percent for phosphorus; if they used a mechanical broom sweeper (SCP-11) they will reduce sediment loads from that area of roads by one percent.

Annual or Cumulative? Annual (1-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
  - Street Sweeping
  - Street Cleaning Practice (SCP-1 through SCP-11)
- *Measurement unit(s):* Runoff storage volume; impervious acres; acres treated
- *Land Use:* Approved NEIEN Developed load source groups for Roads and Impervious cover (Non-Regulated, MS4, CSS); if none are reported the default load source group will be Roads.
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year sweeping was performed.

Table D-9-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Advanced sweeping technology sweepers	Street Cleaning Practice 1 (SCP1); Street Cleaning Practice 2 (SCP2); Street Cleaning Practice 3 (SCP3); Street Cleaning Practice 4 (SCP4); Street Cleaning Practice 5 (SCP5); Street Cleaning Practice 6 (SCP6); Street Cleaning Practice 7 (SCP7); Street Cleaning Practice 8 (SCP8)	Vacuum-assisted sweepers and/or regenerative air sweepers, with variable sweeping frequency for respective routes
Mechanical broom technology sweepers	Street Cleaning Practice 9 (SCP9); Street Cleaning Practice 10 (SCP10); Street Cleaning Practice 11 (SCP11); Street Sweeping (equal to SCP11)	Mechanical broom sweepers with variable sweeping frequency for respective routes

Additional Information

Expert panel report:

Donner, S., Frost, B., Goulet, N., Hurd, M., Law, N., Maguire, T., Selbig, B., Shafer, J., Stewart, S., and J. Tribo. 2016. Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices. Prepared by T. Schueler, E. Giese, J. Hanson and D. Wood. https://www.chesapeakebay.net/documents/FINAL_APPROVED_Street_and_Storm_Drain_Cleaning_Expert_Panel_Report_--_Complete2.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-8: Street Cleaning Practices Fact Sheet. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network, Archived (2016) webcast: Crediting Street Sweeping and Storm Drain Cleaning in the Bay Watershed. Webcast: http://chesapeakestormwater.net/events/webcast-street-sweeping/

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the Management Board in May 2016.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

N-1. Urban and Non-Urban Stream Restoration

General Information

New stream restoration techniques have been pioneered in the Chesapeake Bay watershed to restore streams in urban and non-urban settings. Approaches to stream restoration include natural channel design, regenerative stream channel and legacy sediment removal. Stream restoration projects require state and federal permits and thus extensive regulatory review. Projects often take multiple years from concept to construction, involving high costs and extensive effort from multiple stakeholders at the community, state and federal level. Note: This BMP reference sheet is not targeted to a particular sector. See Sheets A-9: Stream Restoration (Ag) and D-5: Urban Stream Restoration if interested in agricultural or developed sectors, respectively, though the information is the same.

Figure N-1-1. Stream restoration projects can improve the health of aquatic resources and can be one of the more cost-effective practices to reduce nutrient and sediment loads in urban watersheds. A stream in a residential area prior to restoration (top) that has an eroded stream bank and channel can be restored so that natural processes reduce the erosive energy of the stream flow during storm events. Small step pools and reconnecting the stream channel to the floodplain are two methods for restoring natural processes to a stream. The bottom picture is of the same stream three years after restoration. Photos: Arlington County (VA), Department of Environmental Services (https://projects.arlingtonva.us/projects/donaldson-run-stream-restoration-tributary-b/)

CBP Definition(s)

Natural Channel Design (NCD) applies the principles of stream geomorphology to maintain a state of dynamic equilibrium among water, sediment, and vegetation that creates a stable channel.

Legacy Sediment Removal (LSR) seeks to remove legacy sediments from the stream and its floodplain and thereby restore the natural potential of aquatic resources including a combination of streams, floodplains, and wetlands.

Regenerative Stream Channel (RSC, aka Regenerative Stormwater Conveyance) uses in-stream weirs in perennial streams to increase the interaction with the floodplain during smaller storm events. These projects may also include sand seepage wetlands and other habitats to increase the stream's connection with its floodplain. Only wet channel RSC practices are eligible as stream restoration projects. Dry channel RSC projects are considered a runoff reduction retrofit practice, which is not applicable to agricultural load sources (see Sheet D-2: Stormwater Retrofits).

Stream Restoration refers to any NCD, RSC, LSR or other restoration project that meets the qualifying conditions for credits, including environmental limitations and stream functional improvements.

Specifications or Key Qualifying Conditions

There are further protocol-specific qualifying criteria detailed in other resources listed under Additional Information below. All projects must meet the following criteria to be eligible for credit:

- Reach restored must be greater than 100ft in length.

- Reach restored must be actively enlarging or degrading.
- Reach restored MAY NOT be tidally influenced.
- The project MAY NOT be primarily designed to protect public infrastructure. Bank armoring and rip rap are not eligible for stream restoration credit.
- Restoration plan must utilize a comprehensive approach to stream restoration design, addressing long-term stability of the channel, banks, and floodplain.
- Must comply with all state and federal permitting requirements, including 404 and 401 permits.

Figure N-1-2. A stream prior to restoration (top). The bottom picture is the same stream shortly after completion of the project. Photos: US Fish and Wildlife Service

Stream restoration is a carefully designed intervention to improve the hydrologic, hydraulic, geomorphic, water quality, and biological condition of degraded urban streams, and must not be implemented for the sole purpose of nutrient or sediment reduction. Restoration projects should be developed through a functional assessment process, such as the stream functions pyramid (Harman et al., 2012) or functional equivalent.

Nitrogen, Phosphorus and Sediment Reductions

There are three general protocols to define the pollutant load reductions from stream restoration practices. There is also a default rate for historic projects and new projects that cannot conform to the recommended reporting requirements.

- Protocol 1. Credit for prevented sediment during storm flow
- Protocol 2. Credit for in-stream nitrogen processing during base flow
- Protocol 3. Credit for reconnection to the floodplain

For details on how to use the protocols consult the resources listed under Additional Information.

Table N-1-1. Summary of stream restoration protocols for nitrogen, phosphorus and sediment reductions

Protocol	TN (lbs/ linear ft/ year)	TP (lbs/ linear ft/ year)	TSS (lbs/ linear ft/ year)
Protocol 1. Prevented sediment	Site-specific	Site-specific	Site-specific
Protocol 2. In-stream nitrogen processing	Site-specific	N/A	N/A
Protocol 3. Floodplain reconnection	Site-specific	Site-specific	Site-specific
Default for existing/non-conforming projects*	0.075	0.068	248**

*The existing/non-conforming rates were adjusted following a test drive period. These adjustments are explained in Appendix G of the expert panel report.
**Because small stream loads are explicitly modeled in the Phase 6 tools, no sediment delivery factors are needed to reduce the default edge-of-field rate of 248 lbs of TSS/linear ft/year published by the panel.

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Stream Bed and Bank

The practice can only be applied to the "Stream Bed and Bank" load source, but it is recommended to distinguish the BMP based on its sector using the appropriate secondary BMP designation of either "Urban Stream Restoration" or "Non-Urban Stream Restoration."

Brief Description of BMP Simulation in the Model

All stream restoration practices are *Load Reduction BMPs,* which means they are modeled as a simple removal of pounds of nitrogen, phosphorus and/or sediment from the edge-of-stream load. To calculate the pounds reduced for each protocol, follow the methods and examples described in the panel report and other resources listed under Additional Information. The protocols are additive. So, a project that reduces 100 lbs TN under Protocol 1, 25 lbs TN under Protocol 2, and 30 lbs TN under Protocol 3 has a net reduction of 155 lbs TN. As another example, pretend the project design is unknown for a project planned to restore 1,000 linear feet of a degraded stream. Using the default rate for that project yields reductions of 7.5 lbs TN, 6.8 lbs TP and 24,800 lbs TSS, which would be removed from the edge-of-stream load in the Watershed Model. Load reduction BMPs such as stream restoration cannot remove more pounds of nitrogen, phosphorus or sediment than are available in a watershed, however. So, the Watershed Model does enforce maximum reductions that are described in Section 6.5.4.1 of the Watershed Model documentation.

Annual or Cumulative? Cumulative (5-year credit duration for urban stream restoration; 10-year credit duration for non-urban stream restoration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:*
    - Urban Stream Restoration Protocol
    - Urban Stream Restoration
    - Non-Urban Stream Restoration Protocol
    - Non-Urban Stream Restoration
- *Measurement unit(s): Length restored (feet); Protocol 1 TN (lbs); Protocol 1 TP (lbs); Protocol 1 TSS (lbs); Protocol 2 TN (lbs); Protocol 3 TN (lbs); Protocol 3 TP (Lbs); Protocol 3 TSS (lbs)*
- *Load Source:* Stream Bed and Bank
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year the project was completed.

Table N-1-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Stream Restoration (Urban)	Urban Stream Restoration Protocol*	natural channel design, legacy sediment removal, regenerative stream channel or regenerative stormwater conveyance (wet channel only)
Stream Restoration (Urban)	Urban Stream Restoration**	
Stream Restoration (Ag)	Non-Urban Stream Restoration Protocol*	
Stream Restoration (Ag)	Non-Urban Stream Restoration**	
* Uses protocols 1-3 summarized in Table N-1-1. Requires unit of feet in addition to the pounds reduced for each respective protocol. ** For use when specific project design is not known. Requires unit of feet.		

Additional Information

Expert panel report:

Berg, J., Burch, J., Cappuccitti, D., Filoso, S., Fraley-McNeal, L., Goerman, D., Hardman, N., Kaushal, S., Medina, D., Meyers, M., Kerr, B., Stewart, S., Sullivan, B., R. Walter & J. Winters. 2013. Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects. Prepared by T. Schueler, Chesapeake Stormwater Network, and B. Stack, Center for Watershed Protection. Test-drive revisions approved by the WQGIT September 8, 2014. https://www.chesapeakebay.net/documents/Stream_Panel_Report_Final_08282014_Appendices_A_G.pdf

Chesapeake Stormwater Network, Good Recipes for the Bay Pollution Diet: U-4: Urban Stream Restoration. Available at: http://chesapeakestormwater.net/bay-stormwater/fact-sheets/

Chesapeake Stormwater Network. BMP Resources, Urban Stream Restoration: http://chesapeakestormwater.net/bmp-resources/urban-stream-restoration/

Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs & C. Miller. 2012. A function-based framework for developing stream assessments, restoration goals, performance standards and standard operating procedures. U.S. Environmental Protection Agency. Office of Wetlands, Oceans and Watersheds. Washington, D.C. EPA 843-K-12-006. https://www.epa.gov/sites/production/files/2015-08/documents/a_function_based_framework_for_stream_assessment_3.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in May 2013, with test-drive revisions approved in September 2014.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.

N-2. Shoreline Management (Urban and Non-Urban)

General Information

There are a range of practices that can limit tidal shoreline erosion and protect property. Many states encourage practices that use natural habitats such as vegetation, sometimes with the addition of hard structures, to create living shorelines.

CBP Definition(s)

Shoreline management is any tidal shoreline practice that prevents and/or reduces tidal sediments to the Bay. Shoreline management practices can include living shorelines, revetments and/or breakwater systems, bulkheads and seawalls.

The particular definition varies by state, but for CBP purposes a *living shoreline* refers to a shoreline management practice or suite of stabilization and erosion control measures that preserve natural shoreline, minimize shoreline eorsion, maintains coastal processes and provides aquatic habitat. Living shoreline can be non-structural with only vegetated and natural elements, or hybrid with vegetation plus some hard structures such as stone sills or breakwaters.

(Urban or Non-Urban) Shoreline Erosion Control Non-Vegetated are shoreline management practices without a vegetated area along an urban- or agriculturally-dominated tidal shoreline that prevent and/or reduces tidal sediments to the Bay.

(Urban or Non-Urban) Shoreline Erosion Control Vegetated are shoreline management practices with a vegetated area along an urban- or agriculturally-dominated tidal shoreline that prevent and/or reduces tidal sediments to the Bay.

Figure N-2-1. Erosion is a natural process, but sometimes it is necessary to protect property from excessive erosion, like occurred (top) with Hurricane Isabel in 2003. Often the shoreline in or near developed areas is hardened – or "armored" – against erosion using bulkheads, revetments or riprap (middle). The use of softer approaches – such as the living shoreline (bottom) seen from the air – are becoming more common. Living shorelines protect against excessive erosion while providing ecological functions like habitat. Photos: Chesapeake Bay Program

Specifications or Key Qualifying Conditions

These BMPs are only applicable along tidal shorelines. They should be implemented in areas with a demonstrated need to control erosion based on the jurisdiction's respective thresholds and qualifying conditions for shoreline management projects. Only projects with vegetated areas can receive credit for Protocols 2-4 of this BMP. Any shoreline practices implemented prior to 2008 are automatically credited in the model and should not be reported.

Nitrogen, Phosphorus and Sediment Reductions

There are four general protocols to define the pollutant load reductions from shoreline management practices. There is also a default rate for historic projects and new projects that cannot conform to the recommended reporting requirements.

- Protocol 1. Credit for prevented sediment
- Protocol 2. Dentrification in vegetated areas
- Protocol 3. Sedimentation in vegetated areas
- Protocol 4. Marsh redfield ratio for vegetated areas

Table N-2-1. Summary of protocols for nitrogen, phosphorus and sediment reductions of shoreline management BMPs

Protocol		TN (lbs. per unit)	TP (lbs. per unit)	TSS (lbs. per unit)
Protocol 1. Prevented sediment	Linear feet	Project-specific	Project-specific	Project-specific
Protocol 2. Denitrification	Acres of re-vegetation	85	N/A	N/A
Protocol 3. Sedimentation	Acres of re-vegetation	N/A	5.289	6,959
Protocol 4. Marsh Redfield Ratio	Acres of re-vegetation	6.83	0.3	N/A
Non-conforming/existing practices	Linear feet	0.04756 / 0.01218*	0.03362 / 0.00861*	164 / 42 **

* Analysis by Modeling Workgroup indicated that an average of 0.00029 lbs. TN per lb. of TSS and 0.000205 lbs. TP per lb. of TSS. These values can be used directly by jurisdictions for their calculations in Protocol 1, and were adapted for non-conforming/existing practices by multiplying by the default TSS reduction for non-conforming projects by the average nutrient concentrations in sediment. The first number applies to MD, DE and DC (i.e., 0.04756 for TN and 0.03362 for TP) and the second number applies to VA.
** The default rate is based on fine sediment erosion estimates from the expert panel report (Table 3) and a 50% reduction factor applied. The first number applies to Maryland, Delaware and Washington, D.C., and the second number applies to Virginia.

Specific Reporting and Modeling Information

Applicable Land Use Types (or other load sources) Treated by the BMP:

- Shoreline

The practice can only be applied to the "Shoreline" load source, but the BMP can be distinguished based on sector using the appropriate secondary BMP designation of either "Urban Shoreline Management" or "Non-Urban Shoreline Management."

Brief Description of BMP Simulation in the Model

All shoreline management practices are *Load Reduction BMPs,* which means they are modeled as a simple removal of pounds of nitrogen, phosphorus and/or sediment. However, the shoreline load source is only at the edge-of-tide in the model. Therefore, the load reduction from shoreline management practices are removed at the edge-of-tide and not the edge-of-stream as is done for stream restoration.

Annual or Cumulative? Cumulative (10-year credit duration)

Can this practice be combined with other BMPs? Yes.

Key Elements for State BMP Reporting through NEIEN

- *BMP Name:* Shoreline Management
  - Urban Shoreline Management*
  - Urban Shoreline Erosion Control Vegetated**
  - Urban Shoreline Erosion Control Non-Vegetated
  - Non-Urban Shoreline Management*
  - Non-Urban Shoreline Erosion Control Vegetated**
  - Non-Urban Shoreline Erosion Control Non-Vegetated
- *Measurement unit(s): Length restored (feet); Acres planted**; Protocol 1 TN (lbs); Protocol 1 TP (lbs); Protocol 1 TSS (lbs)*
- *Load Source:* Shoreline
- *Geographic location:* Approved NEIEN geographies: County; County (CBW only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBW only)
- *Date of implementation:* Year the project was completed.

* These BMPs provide default load reductions based on length restored (feet) of shoreline, which can be used for non-conforming projects or planning purposes.
** These BMPs are for practices with some vegetated area, i.e. non-structural or hybrid living shoreline. Acres planted or the vegetated area is needed for load reductions based on Protocols 2-4. Eligible hybrid practices can also report reductions for Protocol 1.

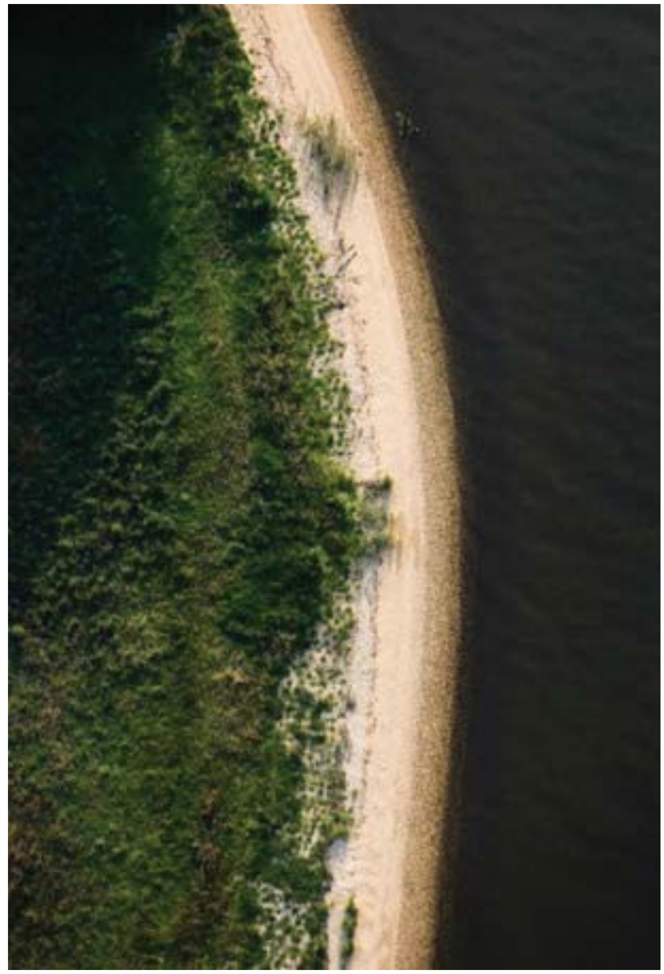

Figure N-2-2. Living shorelines can use a variety of natural design elements to create or restore vegetated areas to reduce shoreline erosion while protecting near-shore aquatic habitat important for young blue crabs and fish. Photo: Chesapeake Bay Program

Table N-2-2. Synonymous BMP names for Watershed Model, NEIEN and other sources

CBP or Expert Panel term	NEIEN BMP name	Other common practice names
Urban Shoreline Management*	Urban Shoreline Management	
Urban Shoreline Erosion Control Non-Vegetated	Urban Shoreline Non-Vegetated	
Urban Shoreline Erosion Control Vegetated	Urban Shoreline Vegetated	Living shoreline
Non-Urban Shoreline Management*	Ag Shoreline Management	
Non-Urban Shoreline Erosion Control Non-Vegetated	Ag Shoreline Non-Vegetated	
Non-Urban Shoreline Erosion Control Vegetated	Ag Shoreline Vegetated	Living shoreline
* Default BMPs for planning purposes or for non-conforming existing practices.		

Additional Information

Expert panel report:
Forand, F., DuBois, K., Halka, J., Hardaway, S., Janek, G., Karrh, L., Koch, E., Linker, L., Mason, P., Morgereth, E., Proctor, D., Smith, K., Stack, B., Stewart, S. & B. Wolinski. 2015. Recommendations of the Expert Panel to Define Removal Rates for Shoreline Management Projects. Prepared by S. Drescher and B. Stack, Center for Watershed Protection. Approved by the WQGIT July 13, 2015, with revised credits approved June 26, 2017. https://www.chesapeakebay.net/documents/Shoreline-Management-Protocols_Final_Approved_07132015-WQGIT-approved_Revised_06012017_formatted.pdf

Version and History Statement

This info sheet was first published on August 10, 2018 and reflects the BMP definitions and reductions approved by the WQGIT in July 2015 with crediting revisions approved June 2017.

All BMP effectiveness estimates are subject to potential future reviews according to the availability of new scientific information and CBP partnership needs, as defined in the BMP Review Protocol.