ESTIMATES OF COUNTY-LEVEL NITROGEN AND PHOSPHORUS DATA FOR USE IN MODELING POLLUTANT REDUCTION

DOCUMENTATION FOR SCENARIO BUILDER VERSION 2.4

COMPLETED FOR THE U.S. EPA

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1 OVERVIEW OF THE NUTRIENT AND SEDIMENT SCENARIO BUILDER

1.1 Purpose of the Scenario Builder

The Chesapeake Bay Program facilitates increased nutrient and sediment control strategies by creating a framework and toolkit for increased implementation. The Chesapeake Bay Program recognizes that integrating regional water quality needs into local land use decisions is critical to restoring the Bay. The Chesapeake Bay Program has worked for 30 years to track progress toward abating nitrogen, phosphorus, and sediment pollution in the Bay. With the 2010 basin-wide TMDL and amidst criticism of overestimating progress in achieving nutrient and sediment load reductions, the Chesapeake Bay Program developed the Nutrient and Sediment Scenario Builder. This tool creates inputs to the Chesapeake Bay Program's Watershed Model.

Scenario Builder allows local governments and watershed organizations to translate land use decisions such as zoning, permit approvals and BMP implementation into changes in pounds of nitrogen, phosphorus and sediment originating from a particular county or watershed. The underlying model to the Nutrient and Sediment Scenario Builder is process-based. The sources of nutrients include farm animals, chemical fertilizer, biosolids, septic and sewer systems (although sewer is not currently in this model). By comparing scenarios, estimates can be made of the impact of land use changes on nutrient and sediment loads. The implication of where and which best management practices are applied may also be determined. This information can help target limited resources to the locations where they will have the most impact. Exploring these scenarios, coupled with monitoring and explanatory information, provides a powerful adaptive management tool to decrease nutrient and sediment loads to the Chesapeake Bay.

The Scenario Builder is also used to provide the inputs to the Chesapeake Bay Program's Watershed Model – Hydrological Simulation Program in Fortran (HSPF), which was updated to Phase 5.3.2. In order to take advantage of the improvements in the Phase 5.3.2 Watershed Model, the intent is to have the model inputs fully developed in Scenario Builder. The data used to calculate the inputs to the Watershed Model – HSPF Phase 5.3.2 are finer scale and take additional factors into consideration, such as mineralization from organic fertilizer, crop types, and double-cropping.

1.2 User-Controlled Variables using CAST, MAST or VAST

Users may provide inputs to Scenario Builder using the web-based nutrient and sediment load estimator tool – Chesapeake Assessment Scenario Tool (CAST, www.casttool.org), Maryland Assessment Scenario Tool (MAST, www.mastonline.org), or the Virginia Assessment Scenario Tool (VAST, www.vasttool.org). The purpose of these tools is to simplify the process for building scenarios and to provide initial estimates of nitrogen, phosphorus, and sediment load reductions using a variety of implementation practices. Each of these tools is designed so that users control many of the parameters including best management practice (BMP) selection, location, and amount. Users make selections to apply BMPs to: an area of one or more geographical areas, the livestock types and the number of animals, number of septic systems, and the land use using the 25 Watershed Model-HSPF land use categories.

CAST/MAST/VAST creates data files for direct input to the Chesapeake Bay Program's Scenario Builder, avoiding the need to transform or transpose such data. CAST/MAST/VAST also provides initial estimates of point and nonpoint source nitrogen, phosphorus, and sediment loads to the Chesapeake Bay (delivered) and loading to the land (edge-of-stream) prior to making CBP Watershed Model runs. CAST/MAST/VAST allows users to rapidly create scenarios. Scenarios may be compared to each other, TMDL allocations, or the amount of nitrogen, phosphorus, and sediment with no BMPs implemented.

1.3 Process-Based Model

Scenario Builder was designed to follow the nutrient generation process from the animal through storage and application. Loss of nitrogen and phosphorus to groundwater is not considered in Scenario Builder, it is instead simulated in the Watershed Model - HSPF.

In Scenario Builder, crop types and livestock types and numbers may be altered for specific scenarios.

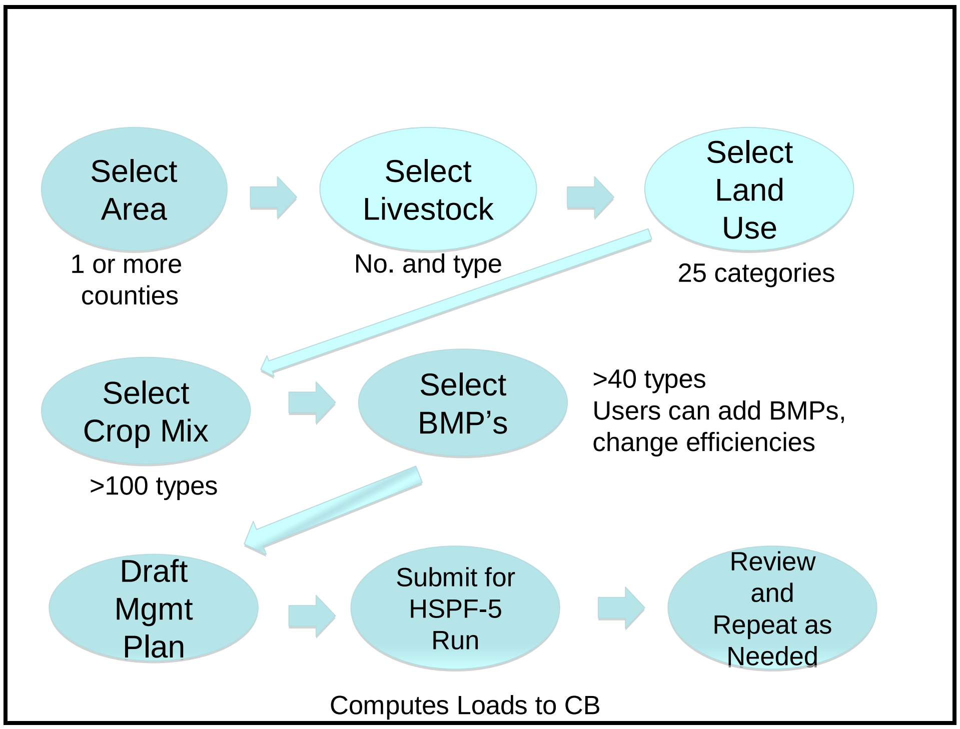

Figure 1-1: User-controlled model parameters for Scenario Builder

While the calculations are performed at the county scale, the processes follow what happens at a farm scale. For example, manure from various animal types is kept separate throughout the production, volatilization, storage, and application to crops' sequence. This was deliberate and allows for considerations about changes in animal types, along with species' manure that is applied to crops.

Even though the model is at a county scale or greater, specific questions may be asked if we assume a county as a single farm. This is not an optimal solution to the lack of a farm scale model, but it does provide an interim tool until such a model is available. More importantly, the consideration of farm-scale decisions in the design allows for a true process based model.

Crop growth parameters are also considered in nutrient applications. We calculate nitrogen fixation by legumes, amount of bare soil based on residue and leaf cover, and nutrient uptake by plants. Scenario Builder is designed to estimate these parameters independently of each other. The types of data and parameters used in this process-based model are listed in Figure 1-2.

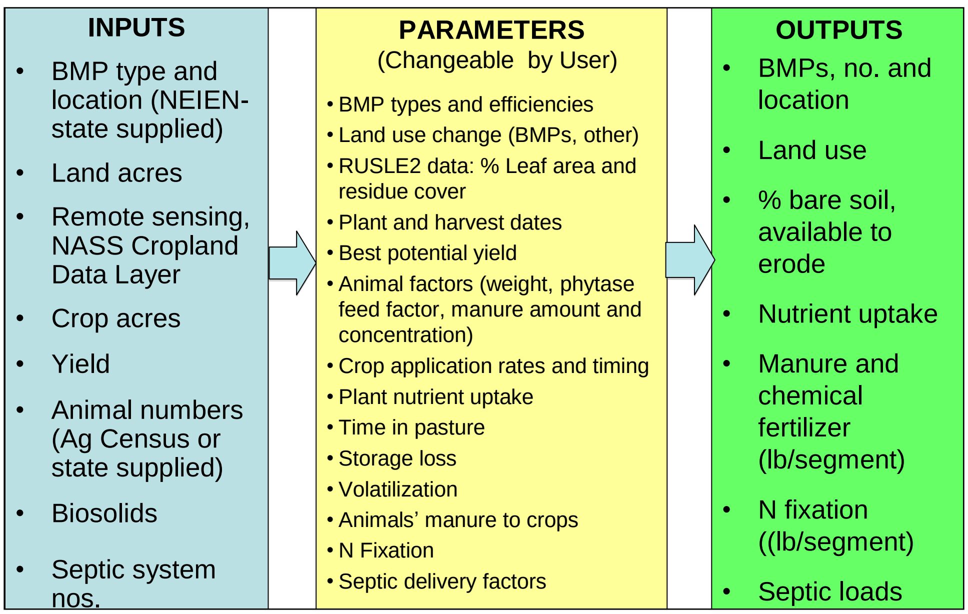

Figure 1-2: Model data relationships

1.4 Scenario Builder Output

Scenario Builder produces tabular reports of loading to land by land use and segment for the following data.

- Manure and Chemical Fertilizer (lbs/acre)
- Land Use (acres per land-river segment)
- BMP reduction (fraction of the load reduced)
- Plant Uptake (lbs/acre)
- N Fixation (lbs/acre)
- Bare soil % (erodible portion)
- Detached sediment (rate of increase in monthly sediment erosion in tons/acre)
- Septic N delivery (fraction of septic N delivered)
- Scenario parameters specified by user (table of specified parameters)

The manure and chemical fertilizer application are stored in two separate files of the applications by each nutrient type. Biosolids are included in the manure file. The land use output is simply the acres in each land use. An interim data product provides acres in each crop type. The BMP reduction file is the area of land that is affected by each BMP. Plant uptake gives the amount of total nitrogen and total phosphorus taken into the entire plant (roots, and all above-ground parts) each month. The nitrogen fixation is the amount of N fixed by leguminous plants each month. The bare soil fraction is the area of soil that is not covered by residue or leaves and is available to be eroded. The detached sediment is the monthly rate of increase in eroded sediment. The amount of nitrogen from septic system drainage fields is calculated and reported as well.

The last output is the parameters, which documents the scenario parameters as specified by the user. This documentation ensures fair comparison among various scenarios.

Interim data products also are available. The most commonly used interim data products are the Submitted vs. Credited report and the locations that had excess manure, also referred to as disposal manure load.

2 AVAILABLE DATA SOURCES FOR AGRICULTURAL NONPOINT SOURCE LOADING TO THE LAND

Agricultural nutrient sources in the Nutrient and Sediment Scenario Builder are from animal manure and fertilizer. Atmospheric deposition and point sources are applied to the land outside of Scenario Builder. Loss of nitrogen and phosphorus to groundwater is accounted for in the Phase 5 Watershed Model and not in Scenario Builder.

A useful model requires reliable and credible data. Table 2-1 lists the sources of data used to estimate nutrients applied to crops, crop area, and land area. Each source is discussed in the following sections.

Table 2-1: Data sources used

Source	Data	Time Period	Scale
USDA National Agricultural Statistics Service—Census of Agriculture	Animal population, Land Area, Crop Area, Yield	1982, 1987, 1992, 1997, 2002, 2007	State and county
State reported (2002 Pennsylvania Equine Survey - Department of Dairy and Animal Science - Penn State, 2002 Maryland Equine Census - Maryland Agricultural Statistics Service, 2000 New York Equine Survey - New York Agricultural Statistics Service, 2001 Virginia Equine Report - Virginia Agricultural Statistics Service, 2004 Tennessee Department of Agriculture - NASS - Equine Survey, and 2004 Delaware State Equine Survey)	Horse population	2002, 2000, 2001, 2004	County
State reported	Biosolids	1982 - 2009	County, Virginia only state to report

2.1 USDA National Agricultural Statistics Service

2.1.1 Introduction

Farm animals are a major source of non-point source nutrients. To model nutrient concentrations in the Chesapeake Bay Watershed Model, the Chesapeake Bay Program (CBP) must know the population and location of animals. The United States Department of Agriculture National Agricultural Statistics Service (NASS) produces an agricultural census twice each decade in years ending with a two or seven. The NASS Agricultural Census is conducted on a county scale and includes data on animal populations, farms, agricultural land areas, and crop yields.

Annual data is available from NASS. These annual data are not comprehensive and do not include all crop or animal types each year. If annual data were used, then situations could arise where data from multiple years were applied to a single year in Scenario Builder. For example, the corn acreage could come from 2011, but the vegetable acres could come from the last Census of 2007. Both of these would be used for a 2011 scenario. This mix of data over multiple years misrepresents what is actually on the ground. Therefore, annual data could not be used since it is not comprehensive.

The Census' land area, crop area, crop yields, and animal population inventory data are used. The data are available for the period covered in the Watershed Model, which is 1982 to present with projections into the future. Data for years in between the Censuses are interpolated. Years beyond the Censuses are projected.

Data for all years must be processed retroactively with each new Census to align the Census categories with CBP model categories and to make data among the Census years comparable despite Census changes to sampling methodology or categorization. The Census' land area is only one of several sources contributing to land use data. Land use is processed as part of the Chesapeake Bay Land Change Model for which separate documentation is available (P. Claggett, 2009).

2.1.2 Sampling Methodology Change

With each subsequent Ag census, the prior census data with revisions are reported. Data are obtained from the latest Ag census that reports any year's data. Where a category was not reported in revised data, the data from the original publication of that year's Census was obtained. There were major revisions in 2002 and only a portion of 1997 data was revised. The unrevised categories were culled from the original publication of the 1997 Census.

NASS first employed a sampling methodology in the 1982 Ag Census. Previously, the Ag Census was compiled from direct enumeration. In 2002, NASS changed its sampling methodology for the Ag census to address under reporting. NASS used statistical methods to determine where under reporting was likely, and targeted efforts to improve the response rate in those areas. NASS revised the 1997 Ag census using statistical methods to make the 1997 data comparable to the 2002 data. The categories in the revised 1997 Ag Census published in 2002 that were not adjusted and annotated as NA were those that were new categories in 2002. In these cases, the original 1997 data were used. Adjustments for the 1982, 1987, and 1992 Ag censuses are unavailable. For those years NASS recommended against making adjustments (Barbara Rater, MD NASS, personal communication, 4/14/2008 and Jim Burt, NASS National Office).

2.1.3 USDA data confidentiality

NASS withholds data that could identify any particular farm operation. Withheld data are reported as “D”. When withholding one county’s data could identify a farm in a neighboring county, then the neighboring county is reported as “D” also. This situation is likely to occur where there is a single large farm operation of a specific type in one county and zero farm operations of that type in the neighboring county. The NASS Census reports data on a county scale and as a state total. Data for omitted counties are combined in the Census and presented as “all other counties”. Counties may report a “D” in one year, yet report in other years. Procedures for estimating a “D” value are listed.

A linear interpolation is made for the non-reported value between prior and subsequent Ag census years for which values were reported. This interpolation is for county and state scale. If this interpolation causes the sum of counties to be greater than the reported state values for that item in that year, then method two is used. If 30% or more of all counties in a state cannot be done with this method, then proceed to method two.

Where there is no reported value for prior and subsequent years, then the difference between the state total and the sum of the counties is parsed between all the counties that were listed as “D”. The data listed for *All Other Counties* represent the sum of the data for all counties in which data were omitted (denoted by an *N* in the electronic version of the Ag Census). Parsing of the omitted data is done in proportion to the average of the datum in that county to the state total for each year where there are reported data. This average is calculated as the ratio of the average of the item in that county for any reported years to the state total for that same year.

Where there is no reported state value for any Ag census year, and the state value is listed as “D”, a linear regression is performed over all Ag census years.

Where there is no reported value for any Ag census year, then the difference between the state total and the sum of the counties is parsed in proportion to agricultural land area in the county to the state for the year in question. Agricultural land areas are from the Ag census table Farms, Land in Farms, Value of Land and Buildings, and Land Use. Items from this table include: “Total Cropland”, “Pastureland and Rangeland other than cropland and woodland pastured”. (When converted to Chesapeake Bay Program land uses these include pasture, degraded riparian pasture, hay with nutrients, hay without nutrients, high till without manure, high till with manure, low till with manure, nutrient management pasture, nutrient management hay, nutrient management alfalfa, nutrient management high till without manure, nutrient management high till with manure, nutrient management low till, and animal feeding operations). This is done for each year. The total of all of the counties, reported and estimated, should be no greater than the state total for the given year. If the total of all the counties is greater than the state total, and there is a county that reported zero agricultural land uses, then that county’s animal population is set to zero. For land or crop areas, the counties' cropland areas are reduced proportionally.

Crop area and crop yield are related data and cannot be estimated independently. Where *yield is reported and acres are withheld* for a crop in a county, then the acres are estimated from the yield. The NASS Census reports yields as total yield, and not yield/acre so it is possible to estimate these acres directly from the yield. The procedures below address situations where the yields are reported and acres are withheld.

1. Determine the average yield/acre for the state from reported data for that year where pairs (acres yield) are available. Where there are less than three values and an average may not be determined, use the average from that state among any years.
2. For areas without reported pairs, use the theoretical maximum yield for the average yield/acre.
3. Calculate state totals where not reported
4. For all pairs where acres were not reported, divide the reported yield for that county and crop type by the average yield of that crop type.
5. Check that the sum of these calculated acres equals the total reported for the acres of that crop type in the state. In each of the cases below, follow the same procedure to adjust the yields to match the state yield value.
6. If the sum of the calculated county acres are 10% > state total and the state acre was reported, not calculated, then decrease the yield so that the calculated acres have the average yield. (Note: this assumes that the yield was incorrectly reported.) Where the state acres are exceeded, set the remaining yields and acres pairs to zero where neither acres nor yields were reported.
7. If the calculated county acres are 10% < or > the state total and the state acre was calculated, then adjust the calculated state acres total to accommodate the calculated county acres. (Note: this assumes that the state acres were incorrectly calculated.)
8. If the calculated county acres are 10% < state total and the state acre was reported, not calculated, then increase the county acres proportional to that area. (Note: this will result in lower than average yields.)
9. If the acres are within 10% of the state total, then adjust the county acres to match the state acres proportional to the calculated county area.
10. For all pairs where yield were not reported, multiply the acres by the average yield to get yield
11. Should there be a yield adjustment like the acres adjustment where the calculated yields would be reduced to match the state reported yield where all counties in state have either reported yields or yields calculated in the method in step 6 immediately above, calculate the yield by multiplying the calculated acres by the

average yield for all pairs missing yield. Note that this step, if necessary, would have to be done prior to acres having the withheld data estimated.

12. Where *both acres and yields are withheld*, then estimate acres first using the Ag Census classification for withheld data and proceed as with the scenario of acres reported and yield withheld.
13. Where *acres are reported but yields are withheld*, and then use the average yield/acre for the state from the same year. If the average yield cannot be calculated due to less than two values being reported, then use the state value. If the state value is withheld, then use the theoretical maximum yield as defined in Section 5 below.

2.1.4 Interpolation

Interpolation is necessary in years the NASS Agricultural Census was not taken. These are the four years in between the Census being taken every five years. Annual data between the Agricultural Censuses is produced by interpolation using the following methodology:

Interpolated year = 1993
Agricultural Census year=1992 and 1997
1993population = 1992 population + 1 * (1997 population – 1992population) / 5

Interpolations are calculated at the county level by each item type.

2.1.5 Projection

To project data beyond the most recent NASS Agricultural Census year, a linear regression is performed. This is done at the county level by each animal type and crop. At least three reported values are used where available. If less than three values are available, then calculated data points are used.

Equation 1: Regression equation used for projections

$y=\alpha + \beta x$
Calculate β first.
N=number of observations

$$\beta = \frac{N\sum xy - \sum x \sum y}{N(\sum x^2) - (\sum x)^2}$$

$$\alpha = \frac{\sum y - \beta \sum x}{N}$$

2.1.6 Animal Data

Two types of animal-related information were obtained from the Agricultural Census—the number of animals and the number of farms for each county and year.

2.1.6.1.1 Animal numbers

The Agricultural Census animal inventory data is used in lieu of animal sales data. The inventory information from the Agricultural Census is the number of animals on the farm at the end of the year. Using the animal inventory data assumes no seasonal fluctuations in herd size and continuous replacement. This steady state assumption tends to underestimate animal numbers.

The alternative to using animal inventory values is to use animal sales data, which overcomes the error inherent in assuming steady state. The sales data are more complete because some farms only report sales data. If animal sales data are used, then the calculation requires the number of sales per cycle. These data would be converted to an annual average animal number and used the same way inventory data are used. The inventory may be used as follows:

AU= (inventory of pullets * 1/2.25)/666 + (pullet sales/2.25 * (1.25./2.25)) / 666

This assumes there are 2.25 cycles per year for pullets and the au conversion is 666 for pullets. For pullet sales, the animals are assumed to be 17 weeks old with an animal unit conversion of 666, but this would need to be adapted to reflect that all animals are heavier at time of sale. The 1.25 is the number of cycles minus 1, since that first cycle is accounted for in the first term.

A comparison of pullets in PA for 2002 using both inventory and sales follows:

Using inventory, there are 5,334,483 pullets simply based on inventory. This gives us au=8010.

Using sales, there are 14,387,070 sold, which gives us au=8894.

Sales data deliver a greater number of pullets in PA in 2002 than inventory. To be conservative, the Chesapeake Bay Program is using the inventory data.

2.1.7 Categorization Changes among Censuses

Data types reported by the Agricultural Census have changed from one Census year to the next. Specific changes are described by specie.

2.1.7.1 Bovine Category Changes

Agricultural Census categories of “beef cattle” and “cows and heifers that have calved” directly relate to Chesapeake Bay Program (CBP) categories of beef and heifers. The 2002 Census category of other cattle encompasses what were two separate categories in previous years—“heifers and heifer calves” and “steers, steer calves, bulls, and bull calves”. Years prior to 2002 add those categories together to make them comparable to the 2002 Census and CBP category of other cattle.

2.1.7.2 Poultry Category Changes

The classification of poultry changed significantly with the 2002 Census. The “pullet chicks < 13 weeks” and “pullets 13 – 20 weeks” categories were eliminated and replaced by “pullets for laying flock replacement”. The “pullet 13 – 20 weeks” category had been a subcategory of layers, so this clearly conveys to the new pullet for laying replacement category. The pullet chicks < 13 weeks could have been comprised of either future layers or broilers. The CBP has assumed that all of the birds in this category grow up to be layers. NASS confirmed that this is a valid assumption (Barbara Rater, MD NASS, personal communication on 4/14/2008).

The “layers 20+ weeks” category was a subcategory prior to the revised 1997 and subsequent years. This equated directly to the new categorization. Broilers and turkeys are not split out by age group, so equate directly as well.

2.1.7.3 Swine Category Changes

The Agricultural Census categories of “Hogs and pigs for breeding” and “Other hogs and pigs” relate directly to the CBP category of “Sows” and “Hogs”, respectively.

Table 2-2: Agricultural Census animal categorization changes

Species	Watershed model phase 5 animal categories	Agricultural Census – County Inventory Categories
Bovine	Beef	Beef cows – 1982, 1987, 1992, 1997, and 2002.
Bovine	Dairy	Milk cows – 1982, 1987, 1992, 1997, and 2002.
Bovine	Other cattle	Heifers and heifer calves + steers, steer calves, bulls, and bull calves – 1982, 1987, 1992, and 1997. ‘Other cattle’ including steers, steer calves, bulls, and bull calves category + heifers and heifer calves - 2002.
Horses	Horses	Handled separately through state supplied equine census data. 2002 Pennsylvania Equine Survey - Department of Dairy and Animal Science - Penn State Results of the 2002 Maryland Equine Census - Maryland Agricultural Statistics Service 2000 New York Equine Survey - New York Agricultural Statistics Service - Covers 1988 and 2000 data 2001 Virginia Equine Report - Virginia Agricultural Statistics Service 2004 Tennessee Department of Agriculture - NASS - Equine Survey

		2004 Delaware State Equine Survey
Poultry	Layers	Hens and pullets of laying age – 1982, 1987, and 1992. Layers > 20 weeks – 1997 and 2002.
Poultry	Pullets	Pullet chicks and pullets < 13 weeks old + Pullets 13+ weeks, not laying – 1982, 1987, and 1992. Pullet chicks and pullets < 13 weeks old + Pullets between 13 and 20 weeks – 1997. Pullets for laying flock replacement – 2002.
Poultry	Broilers	Broilers – 1982, 1987, 1992, 1997, and 2002.
Poultry	Turkeys	Turkeys – 1982, 1987, 1992, 1997, and 2002.
Swine	Sows	Hogs and pigs for breeding – 1982, 1987, 1992, 1997, and 2002.
Swine	Hogs	Other hogs and pigs – 1982, 1987, 1992, 1997, and 2002.
Ovine	Sheep and Lambs--Inventory, Wool Production, and Number Sold	Sheep and Lambs—Inventory – 1982, 1987, 1992, 1997, and 2002.
Caprine	Milk Goats	Milk goats inventory – 1982, 1987, 1992, 1997, and 2002.
Caprine	Angora Goats	Angora goats inventory – 1982, 1987, 1992, 1997, and 2002.

Agricultural Census categories that are not included in the CBP Watershed model are shown in Table 2-3.

Table 2-3: Agricultural Census categories not included in the Watershed Model

Species	Reason for not including	Agricultural Census – County Inventory Categories
Poultry	Data pulled from a more specific Agricultural Census subcategory	Chickens 13+ weeks – 1982, 1987, and 1992.
Poultry	Data pulled from a more specific	Layers and pullets 13+ weeks – 1997.

	Agricultural Census subcategory	
Swine	No immature swine categories are included. Specific animal numbers not listed, just number of litters.	Pig litters farrowed – 1982, 1987, 1992, and 1997.

2.1.7.4 Horses

Horse data are not directly pulled from the Agricultural Census. The horse information is culled from state-supplied data including: 2002 Pennsylvania Equine Survey - Department of Dairy and Animal Science - Penn State, Results of the 2002 Maryland Equine Census - Maryland Agricultural Statistics Service, 2000 New York Equine Survey - New York Agricultural Statistics Service - Covers 1988 and 2000 data, 2001 Virginia Equine Report - Virginia Agricultural Statistics Service, 2004 Tennessee Department of Agriculture - NASS - Equine Survey, and the 2004 Delaware State Equine Survey. These data are used for every year because no states have provided annual updates.

2.1.8 Number of Farms

The number of farms for each animal type is also taken from the Censuses (Table 2-4). The number of farms informs the acres assigned for the *Animal Feeding Operation* land use category. As with the other data from the NASS Agricultural Census, these data are selected for each county, state, and year. The *Concentrated Animal Feeding Operation* land area was taken from the total *Animal Feeding Operation* land use.

Table 2-4: Agricultural Census Number of Farms

Table Name	Item Name	Unit
Cattle and calves – Inventory and Sales	Cattle and calves	no. of farms
Hogs and Pigs – Inventory and Sales	Total hogs and Pigs	no. of farms
Poultry – Inventory and Sales	Any Poultry	no. of farms
Sheep and Lambs – Inventory, Wool Production, and Number Sold	Sheep and Lambs – Inventory	no. of farms
Milk Goats	Milk goats inventory	no. of farms
Angora Goats	Angora goats inventory	no. of farms

2.1.9 Crop Data

To model nutrient applications in the Chesapeake Bay Watershed Model, the Chesapeake Bay Program must know the land area in agriculture and the types and acreage of crops. The Census' data on crop types, harvested acres and yields, farms, and agricultural land uses are obtained from the Censuses between 1982 and 2007 for the crops listed in Table 2-5. Some of the items listed are referred to as “protected area”. This denotes crops grown under glass or other protection, such as in a greenhouse. Otherwise, the crop types are grown in the open.

Table 2-5: Crops modeled in Scenario Builder

Crop name
Wheat for Grain Harvested Area
Triticale Harvested Area
Sorghum for Grain Harvested Area
Sorghum for silage or greenchop Area
Soybeans for beans Harvested Area
Sunflower seed, non-oil varieties Harvested Area
Sunflower seed, oil varieties Harvested Area
Rye for grain Harvested Area
Peanuts for nuts Harvested Area
Popcorn Harvested Area
Oats for grain Harvested Area
Mushrooms Area
Mushrooms Protected Area
Barley for grain Harvested Area
Canola Harvested Area
Corn for Grain Harvested Area
Corn for silage or greenchop Harvested Area
Buckwheat Harvested Area
Dry edible beans, excluding limas Harvested Area
Emmer and spelt Harvested Area
Escarole and Endive Harvested Area
Dry Onions Harvested Area
Eggplant Harvested Area
Cucumbers and Pickles Harvested Area
Cut Christmas Trees Production Area
Cut flowers and cut florist greens Area
Bulbs, corms, rhizomes, and tubers – dry Harvested Area
Cotton Harvested Area
Cantaloupe Harvested Area
Carrots Harvested Area
Cauliflower Harvested Area
Celery Harvested Area
Chinese Cabbage Harvested Area
Collards Harvested Area
Beets Harvested Area
Berries- all Harvested Area
Broccoli Harvested Area
Bedding/garden plants Area
Asparagus Harvested Area
Aquatic plants Area
Other nursery and greenhouse crops Area
Brussels Sprouts Harvested Area
Parsley Harvested Area
Mustard Greens Harvested Area

Nursery stock Area
Okra Area
Land in Orchards Area
Lettuce, All Harvested Area
Head Cabbage Harvested Area
Herbs, Fresh Cut Harvested Area
Honeydew Melons Harvested Area
Kale Harvested Area
Foliage plants Area
Garlic Harvested Area
Green Lima Beans Harvested Area
Green Onions Harvested Area
Potatoes Harvested Area
Potted flowering plants Area
Peas, Chinese (sugar and Snow) Harvested Area
Peas, Green (excluding southern) Harvested Area
Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area
Peppers, Bell Harvested Area
Peppers, Chile (all peppers – excluding bell) Harvested Area
short-rotation woody crops Harvest Area
short-rotation woody crops Production Area
Pumpkins Harvested Area
Radishes Harvested Area
Sweet Corn Harvested Area

Sweet potatoes Harvested Area
Spinach Harvested Area
Squash Harvested Area
Turnip Greens Harvested Area
Turnips Harvested Area
Vegetable & flower seeds Area
Snap Beans Harvested Area
Sod harvested Area
tobacco Harvested Area
Tomatoes Harvested Area
Vegetables, Mixed Area
Vegetables, Other Harvested Area
Rhubarb Harvested Area
Watermelons Harvested Area
Vetch seed Harvested Area
Timothy seed Harvested Area
Red clover seed Harvested Area
Small grain hay Harvested Area
Ryegrass seed Harvested Area
Orchard grass seed Harvested Area
Other field and grass seed crops Harvested Area
Other haylage, grass silage, and greenchop Harvested Area
Other managed hay Harvested Area
Bromegrass seed Harvested Area
Birdsfoot trefoil seed Harvested Area
Cropland on which all crops failed or were abandoned Area

Fescue Seed Harvested Area	Protected Area
Cropland idle or used for cover crops or soil improvement but not harvested and not pastured or grazed Area	Nursery stock Protected Area
Cropland in cultivated summer fallow Area	Greenhouse vegetables Area
Wild hay Harvested Area	Greenhouse vegetables Protected Area
Pastureland and rangeland other than cropland and woodland pastured Area	Foliage plants Protected Area
Cropland used only for pasture or grazing Area	Potted flowering plants Protected Area
Bulbs, corms, rhizomes, and tubers – dry Protected Area	Sod harvested Protected Area
Cut flowers and cut florist greens Protected Area	Vegetable & flower seeds Protected Area
Aquatic plants Protected Area	Haylage or greenchop from alfalfa or alfalfa mixtures Harvested Area
Bedding/garden plants Protected Area	Alfalfa Hay Harvested Area
Other nursery and greenhouse crops	Alfalfa seed Harvested Area
	Turf grass

2.1.9.1 Obtaining Data from the NASS Agricultural Census

Land area data are obtained to give the total area classified as agricultural. Crop data are obtained to determine crop yields and crop areas. There may be more crop acres than land acres because each acre of land may have more than one crop planted and harvested during a year; this is termed double cropping. Chapter 1 of the Census is state-scale data and Chapter 2 is county-scale data. The states that are modeled include: New York, Pennsylvania, Delaware, Maryland, District of Columbia, West Virginia, Tennessee, and North Carolina. Tennessee and North Carolina are included even though they do not drain to the Bay because the Bay Program models the southern rivers of Virginia.

2.1.9.2 Categorization changes over time

Item names change among census years. Specific actions to address these changes are described in Table 2-6. Some data items selected from different tables are identical. Selecting both items allows for validation. In other cases, state aggregated data are selected as well as county level data. This is to inform the calculation of withheld data values. Some crops are listed in one state's census but not in another because certain crops are not present in all states.

Table 2-6: Agricultural Census crop categorization changes

Agricultural Census	Chesapeake Bay Program item	Categorization Action

Item Name	name	
Cropland idle, cover crops or soil improvement but not harvested and not pastured or grazed	Cropland idle, cover crops or soil improvement but not harvested and not pastured or grazed	Combined the two categories from the Census of “cropland idle” with “cover crops or soil improvement but not harvested and not pastured or grazed”
Cut Christmas Trees	Cut Christmas Trees	Data only available from 2002
Flower seeds, vegetable seeds	Flower and vegetable seeds	Combined with vegetable seeds in 1997 and 1992 and 1987 and 1982 for some states. Summed 2002 flower and vegetable seed categories
Sunflower seed-oil, sunflower seed-non-oil	Sunflower seed (all)	In years where there was no oil vs. non-oil varieties all was used as non-oil
Wild hay	Managed hay	Renamed

2.1.9.3 Turf grass

The crop type “Turf grass” is the only portion of urban land that has nutrients applied directly. Other nutrients on urban lands come from point sources and atmospheric deposition. Turf grass is comprised of those areas that include lawns for private homes and businesses. Sod farms are not considered part of this category. On average, turf grass equals 79% of the urban area in each county and 93% of the land uses that are pervious urban. Cappiella and Brown (2001) measured the percentage of open space on residential lots to range from 68% to 90%. Robbins et al., (2003) calculated the maximum potential lawn area in 205 residential census tracts in Ohio as averaging 82%. These estimates are liberal in that they do not subtract non-lawn areas (forests, flower beds, etc.) from their open space percentages. However, the numbers do lend some support to the calculated county average of 79% (44% min and 97% max).

Turf grass acreage was determined on a county scale as follows: Total acres of pervious urban land - acres of forested urban land. Many older subdivisions appear forested from a land cover perspective. The land cover used for the Watershed Model-HSPF Phase 5.3.2 uses housing unit and residential road density to identify such areas. To differentiate urban forests from lawns under canopy, the larger interior forest patches were classified as urban forests while the edge and speckled forest areas were identified as lawns under canopy (P. Claggett, 2009).

The methods for determining turf grass areas were performed using GIS analysis of land cover data (Section 7.2.2).

3 CALCULATION OF AVAILABLE NITROGEN AND PHOSPHORUS FOR APPLICATION TO THE LAND

The nutrient sources that are considered in the Scenario Builder include animals, inorganic fertilizer, septic, and land-applied biosolids. Each is discussed in the following sections. Other contributions of nutrients modeled in the Chesapeake Bay Program's Watershed Model-HSPF include atmospheric deposition and point sources. These data are produced by data analysis systems separate from the Scenario Builder.

3.1 Animals

The animal units are determined by the average number of animals making up 1,000 lbs of that animal type. To calculate this, the average live weight of each animal type is required. The methodology for determining the live animal weight uses the amount of manure produced, and then back calculates to the average live animal weight (Kellogg 2000; Agricultural Waste Management Field Handbook, Moffitt and Lander 1997, Moffitt and Alt 1998). The average live weight is the average of the animals at any age in that category. For example, pullets are defined by NASS as less than 20 weeks of age, so the live animal weight is the average of a pullets' weight during those 20 weeks. Animal units are calculated for each animal type as:

Equation 2: Animal unit

Animal Unit = 1,000 lbs / avg. weight of animal

Turkey weights are the average weight at slaughter split equally among hens and toms rather than the average over the growing period (Kellogg, 2000). Source information on horse weights and manure are from the USDA-NRCS National Engineering Handbook Part 651, Agricultural Waste Management Field Handbook. Animal weights were set for sheep and lambs as 100 lb, angora goats as 65 lbs, and milk goats including kids as 65 lbs (S. Schoenian, Sheep 201, Sheep & Goat Specialist, Maryland Cooperative Extension). The Agricultural Census does not categorize meat goats, which are prominent in the Mid-Atlantic region (S. Schoenian, personal communication, 2008). Thus, the primary goat type is not considered by the NASS Agricultural Census data, which may lead to an underrepresentation of this animal type.

The 2002 Census defines "other cattle" as: heifers, steers, bulls 500 lbs+, and all calves less than 500 lbs. Using Kellogg (2000), the average for other cattle is 2.08 animals/animal unit. This weight and the amount of manure produced were derived by averaging the following:

- Beef calves from calving to about 500 lbs, 4 animals/au
- Beef heifers for replacement herds, 1.14 animals/au
- Beef breeding herds (cows and bulls), 1 animal/au
- Beef stockers and grass fed beef, 1.73 animals/au
- Dairy calves from calving to about 500 lbs, 4 animals/au
- Dairy heifers for replacement herds, 0.94 animals/au

- Dairy stockers and grass fed animals marketed as beef, 1.73 animals/au

This average was used because each state has a different mix of the animals that are in the “other” category. Weighting toward any one type creates an unfair bias toward a particular state or region. Weighting also creates a static variable eliminating the possibility of fluctuation over time.

The pullets’ category includes those less than 13 weeks of age and also those between 13 and 20 weeks. These categories were separated in censuses prior to 2002. Average animals per animal unit for these categories are 250 pullets for those between 13 and 20 weeks and 455 pullets for those less than 13 weeks. The average of these two is 352.5 and is used for the combined pullets category.

These data were found to be comparable with the Virginia Nutrient Management Standards and Criteria, Revised October 2005, Virginia Department of Conservation and Recreation.

Table 3-1: Animal types, animal units, and pounds of manure/day/animal unit

Animal type	Live animal weight (lbs)	No. of animals per animal unit (animal unit=1000 lbs)	Manure (lbs) per day per animal unit	Animal weight and manure (lbs) data source
beef	877.19	1.14	58	Kellogg et. al. (2000)
dairy	1351.35	0.74	86	Kellogg et. al. (2000)
other cattle	480.77	2.08	64.39	Kellogg et. al. (2000)
broilers	2.20	455	85	Kellogg et. al. (2000)
layers	4.00	250	64	Kellogg et. al. (2000)
pullets	2.84	352.5	45.56	Kellogg et. al. (2000)
turkeys	14.93	67	47	Kellogg et. al. (2000)
hogs and pigs for breeding	374.53	2.67	33.46	Kellogg et. al. (2000)
hogs for slaughter	110.01	9.09	84	Kellogg et. al. (2000)
horses	1000.00	1	51	USDA-NRCS National Engineering Handbook Part 651, Agricultural Waste Management Field Handbook
angora goats	65.02	15.38	41	Schoenian (2008)
milk goats	65.02	15.38	41	Schoenian (2008)

sheep and lambs	100.00	10	40	Schoenian (2008)

The number of animals in each category except horses comes directly from the 5-year NASS Agricultural Censuses. The horse data came from state-sponsored censuses ranging from 2000-2004. The NASS Agricultural Census data does collect data on horses and ponies, but this information is typically completed only by farmers who use horses and ponies as work animals. This leaves out all pleasure horse farms and racehorse training and breeding operations. It is the pleasure horses and racehorses that comprise the majority of horses in many parts of the watershed, so these numbers must be gathered from other sources.

There are a certain number of animals that are raised that do not make it to slaughter. These dead animals are also a source of nutrients in reality. However, in the model they are not counted as a source of nutrients. Nevertheless, there are practices that may be put in place to ameliorate the nutrient loss from these animals. The fraction of animals that do not make it to slaughter in the model are in Table 3-2**Error! Reference source not found.**.

Table 3-2: Mortality fraction of animals.

SourceName	MortalityFraction
Pullets	0.1
Turkeys	0.07
Hogs and pigs for breeding	0.06
Beef	0.06
Broilers	0.05
Dairy	0.06
Hogs for slaughter	0.06
Horses	0.06
Layers	0.1
Other cattle	0.06
Sheep and lambs	0.06
Angora and milk goats	0.06

3.2 Inorganic Fertilizer

In the Scenario Builder, fertilizer sales data were consulted for comparison purposes only. The fertilizer sales data are prepared by the Association of American Plant Food Control Officials based on fertilizer consumption information submitted by state fertilizer control offices. The consumption data include total fertilizer sales or shipments for farm and non-farm use. Liming materials, peat, potting soils, soil amendments, soil additives, and soil conditioners are excluded. Materials used for the manufacture or blending of reported fertilizer grades or for use in other fertilizers are excluded to avoid duplicate reporting.

The fertilizer sales data were not used directly due to complications with consistency of reported data throughout the modeled time period and region. In addition, there are several major ports in the Chesapeake Bay Watershed. Fertilizer may be sold at the port and transferred to another region for resale, which could result in double counting these sales.

3.3 Biosolids

Land-applied biosolids (sewage sludge) can be a significant source of nutrients on farm land. The Chesapeake Bay Program requested that each state submit data on the use of sewage sludge used as a fertilizer. Virginia submitted such data for the modeled period of 1982-2005. These data were in units of dry tons/year. The data were further broken out so that each month received an equal amount, but the distribution was to the most likely land use type between hay/pasture and crops. This likelihood was informed by a regulatory change influencing management practices in 1997 (K. Berger and W. Keeling, personal communication, 2008). Between 1982 and 1996, there are more months with cropland applications. Crops receive 80% of monthly production hay and pasture receives the other 20% during certain months. The remaining monthly production numbers are 100% applied to hay and pasture. After 1996, there are more months where sewage sludge only goes on hay and pasture.

Some data were received from Maryland, but these data were in wet tons. Maryland was unable to provide information on how to convert from wet to dry tons for each sewage sludge provider. A general assumption of moisture content was unacceptable to Maryland.

3.4 Septic Systems

Septic systems are commonly designed so that the waste goes into a tank, where solids sink to the bottom, and liquids flow through to a septic field. While some phosphorus can become soluble, in this model, we assume that only nitrogen is distributed to the septic field.

To calculate the amount of nitrogen generated from septic systems, we used the number of people on septic systems in the Chesapeake Bay Watershed. This question was asked on the 1990 U.S. Census, but was removed in subsequent censuses. To estimate this number, we calculate the ratio of the number of people in a county on septic to the total number of people in the county from 1990. That ratio is multiplied by the total population in the county, from the U.S. Census (Equation 17).

4 ACCOUNTING FOR NITROGEN AND PHOSPHORUS LOSSES AND TRANSFORMATIONS

Methods for calculating the nutrient speciation, volatilization, and storage and handling loss for organic and inorganic fertilizer, and manure directly excreted are discussed in the following sections.

4.1 Nutrient Speciation

The forms of nitrogen and phosphorus that are modeled in the Scenario Builder were established to mirror those in the Chesapeake Bay Program's Watershed Model-HSPF with the addition of mineralized forms of nitrogen and phosphorus. Since the amount of manure applied to crops is generally calculated by farmers to include only the plant-available portion, we included the mineralized forms. These mineralized forms are the conversion of organic N to NH_4. The mineralization process liberates plant-available N. While the nutrient NH_3 is written and referred to as such, it is generally used to represent both NH_3 and NH_4 in the Scenario Builder and Watershed Model-HSPF lexicon. Nutrients modeled in the Scenario Builder include:

- NH_3
- Organic N
- Mineralized N
- NO_3
- PO_4
- Organic P
- Mineralized P

4.1.1 Inorganic Fertilizer

The amount of nitrogen and phosphorus are independent of each other for inorganic fertilizer. The speciation was set at the most commonly used mixture since fertilizer sales data could not be analyzed for this purpose (Chesapeake Bay Program, Agricultural Nutrient and Sediment Workgroup, 2008). The nitrogen component of inorganic fertilizer is comprised of NH_3 and $NO_{3.}$ NH_3 is 75% and NO_3 is the other 25% of total N. All of the phosphorus is found in the form of $PO_{4.}$

4.1.2 Organic Fertilizer

Organic fertilizer sources include animal manure and biosolids. In organic fertilizer, N and P are linked, since a farmer does not chemically separate the various forms. The total mass of manure per day per animal unit is split into total N and total P for each animal species (Table 4-1). Goat waste is assumed to have the same proportion of nutrients as sheep waste. The category 'other cattle' is an average of the species described in Section 3.1.

Table 4-1: Nutrient content of animal manure and biosolids (ASAE, 2003)

Source types	Nutrient	lb-Nutrient/lb manure
Angora goats	TN	0.0110
Beef	TN	0.0059
Biosolids	TN	0.0390
Broilers	TN	0.0129
Dairy	TN	0.0052
Hogs and pigs for breeding	TN	0.0066
Hogs for slaughter	TN	0.0062
Horses	TN	0.0059
Layers	TN	0.0131
Milk goats	TN	0.0110
Other cattle	TN	0.0037
Pullets	TN	0.0136
Sheep and lambs	TN	0.0105
Turkeys	TN	0.0132
Angora goats	TP	0.0027
Beef	TP	0.0016
Biosolids	TP	0.0250
Broilers	TP	0.0035
Dairy	TP	0.0011
Hogs and pigs for breeding	TP	0.0021
Hogs for slaughter	TP	0.0021
Horses	TP	0.0014
Layers	TP	0.0047
Milk goats	TP	0.0027
Other cattle	TP	0.0010

Pullets	TP	0.0053
Sheep and lambs	TP	0.0022
Turkeys	TP	0.0049

Total N is further broken into NH_3, organic N, and mineralized N. NO_3 is not present in animal wastes in measurable amounts (Kellogg et al. 2000). TN, NH_3, TP, and PO_4 values were taken from ASAE standards (2003).

Equation 3: Organic N and P speciation

$TN-NH_3=ORG\ N$
$TP-PO_4=ORG\ P$
Where values are not specified data from the most similar animal species are used (Table 4-2).

Table 4-2: Animal type used for specific nutrients if specified animal type data unavailable

Animal type missing nutrient fraction	Animal type used	Nutrient type(s)
Goats	beef	Org N
Other cattle	beef	Org N
Sheep	beef	Org N
Broilers	layers	NH_3
Pullets	layers	NH_3
Turkeys	layers	NH_3
Goats	sheep	Org P and PO_4
Horses	swine	Org N

The calculation of mineralized N uses typical values for spring or early fall land-applied manure; (Table 4-3). N mineralization factors for bovine, swine and poultry were taken from the Mid-Atlantic Nutrient Management Handbook, February 2006, originally cited from VADCR, 2005. Though temperature, water content, drainage features, and organic carbon all have an impact on mineralization; these factors are not considered in this estimation.

Equation 4: Mineralized N

Mineralized N = Mineralization factor * Original Organic N
Organic N is then retroactively adjusted as:
Organic N = Original Organic N – Mineralized N

Plant available phosphorus is conserved in the soil, so mineralized P is zero and all organic P is assumed to be biologically available.

Table 4-3: Nutrient mineralization factors

Animal type	Phosphorus Mineralization factor	Nitrogen Mineralization factor
Bovine	1	0.35
Swine	1	0.50
Poultry	1	0.60
Horses	1	0.50
Sheep, lambs, and goats	1	0.35

Equation 5: Quantity of species of each nutrient

Mass of nutrient= (mass of waste / animal unit / unit of time) * (lb nutrient/lb manure)

4.1.2.1.1 Phytase Feed Additive

Phytase is an enzyme added to poultry-feed that helps poultry absorb phosphorus. The addition of phytase to poultry feed allows more efficient nutrient uptake by poultry, which in turn allows decreased phosphorus levels in feed and less overall phosphorus in poultry waste. The use of phytase is a best management practice (BMP). In Scenario Builder, no poultry have the phytase feed additive prior to 2002, 50% are classified as phytase for 2002, and 100% for 2003 and later. Phosphate nutrient forms are approximately 80% of the non-phytase animals' values for the forms of phosphorus depending on animal type and jurisdiction (Agricultural Nutrient and Sediment Reduction Workgroup).

4.2 Volatilization

Volatilization rates are calculated as the amount of NH_3 that moves into the atmosphere from stored manure. Ammonia volatilization is highly variable and literature suggests values that range from 0 to 40%. Numerous factors affect the volatilization rate including, but not limited to, temperature, moisture, and pH.

In Scenario Builder, volatilization is not calculated for directly excreted manure or for manure once it is applied to the land. Volatilization for direct excretion and land-applied manure is handled by the Watershed Model, which uses rates based on temperature and hydrology.

Ammonia volatilization in inorganic fertilizer varies by factors other than just the type or composition of inorganic fertilizer. Therefore, there is also no volatilization for inorganic fertilizer calculated in Scenario Builder.

Volatilization data will be reconciled with the atmospheric deposition model in the next version of Scenario Builder.

The volatilization rates have been used in the previous versions of the Watershed Model-HSPF and were not changed when incorporated into the Scenario Builder (Table 4-4).

Sheep, lambs and goats are new animal types; they are given the same volatilization rates as cattle since all of those animal species are ruminants (S. Schoenian, personal communication 2008).

Table 4-4: Volatilization rates of ammonia from nutrient sources

Source	Fraction not volatilized
Pullets	0.43
Turkeys	0.43
Hogs and pigs for breeding	0.19
Beef	0.35
Broilers	0.43
Heifers (cows and heifers that have calved)	0.35
Hogs for slaughter	0.5
Horses	0.68
Layers	0.43
Other cattle	0.35
Sheep and lambs	0.35
Angora goats	0.35
Milk goats	0.35
Biosolids	0.4875

4.3 Animal confinement (% time in pasture)

The amount of time an animal is in pasture determines the amount of manure directly excreted on pasture. In the Scenario Builder model, animals are always in one of two locations while alive, in a pasture or an animal production area. Chesapeake Bay Program Watershed Model-HSPF pasture land uses include: pasture, nutrient management pasture, or trampled riparian buffer. The animal production area land use is named the ‘animal feeding operation” or AFO. For areas where it was deemed that there were greater than 145 animal units per acre, then the land use is considered the “concentrated animal feeding operation” or CAFO.

The amount of time animals are in pasture varies by the animal type and the region of the watershed. Table 4-5 lists the fraction of time each animal is in pasture based on the region of the watershed. Region descriptions are in Section 5.

While animals may be turned out to fields to forage after a crop is harvested, the length of time is typically only a few days (Doug Goodlander, PA State Conservation Commission, personal communication, 2008). While the animal is foraging, they may excrete manure. This excreted manure is not captured in this model. In Virginia, this practice occurred primarily in the Shenandoah Valley (specifically in Augusta and Rockingham Counties). According to staff in the valley, that practice is fading out and need not be addressed by Scenario Builder (William Keeling, VA DCR, personal communication, 2008).

Should there be no pasture land in a county, then Table 4-5 is not relevant; rather the Scenario Builder classifies the animals as 100% confined and all manure is considered to be produced on the AFO or CAFO acres.

Equation 6: The amount of nutrients applied directly to pasture for each animal type by county

Number of animals * fraction of time in pasture
Convert to animal unit (process previously described in Section 3.1)
Determine mass of manure in terms of N and P forms (process previously described in Section 4.1.2)

The land use of trampled riparian pasture receives nine times the amount of nutrients the pasture and nutrient management pasture components receive in each county.

Table 4-5: Fraction of time animals are in pasture by animal type and growth region.

Animal	Growth Region	% Time in Pasture											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Angora Goat, Milk Goat	DE_1, MD_2	0	0.5	1	1	1	1	1	1	1	1	1	0.5
	MD_1, MD_3, NY_1, PA_1, PA_2, PA_3	0	0	0	0	1	1	1	1	1	1	0	0
	VA_1, VA_2, VA_3	0.8	0.8	1	1	1	1	1	1	1	1	1	0.8
	WV_1	0	0	0.5	1	1	1	1	1	1	1	0	0
Sheep and lambs	DE_1, MD_2	0	0.5	1	1	1	1	1	1	1	1	1	0.5
	MD_1,PA_3	0	0	1	1	1	1	1	1	1	1	1	0
	VA_3	0.8	0.8	1	1	1	1	1	1	1	1	1	1
	MD_3, PA_1, PA_2	0	0	0	1	1	1	1	1	1	1	1	0
	NY_1	0	0	0	1	1	1	1	1	1	1	0	0
	VA_1, VA_2	1	1	1	1	1	1	1	1	1	1	1	1
	WV_1	0	0	0.5	1	1	1	1	1	1	1	0	0
Other Cattle	DE_1, MD_2, WV1	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	MD_1, PA_3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	MD_3, PA_1, PA_2	0.75	0.75	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.75
	NY_1	0	0	0	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0	0

	VA_1, VA_2	1	1	1	1	1	1	1	1	1	1	1	1
	VA_3	0.8	0.8	1	1	1	1	1	1	1	1	1	0.8
Beef	DE_1, MD_1, MD_2, PA_3, VA_1, VA_2	1	1	1	1	1	1	1	1	1	1	1	1
	MD_3, PA_1, PA_2, WV_1	0	0	1	1	1	1	1	1	1	1	1	0.6
	VA_3	0.8	0.8	1	1	1	1	1	1	1	1	1	1
	NY_1	0	0	0.25	1	1	1	1	1	1	1	0.5	0
Dairy	DE_1, MD_2, VA_1, VA_2, VA_3, WV_1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	MD_1, PA_1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	MD_3, PA_1, PA_2	0	0	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	NY_1	0	0	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0
Broilers, Layers	DE_1, MD_1, MD_2, MD_3, PA_1, PA_2, PA_3, VA_1, VA_2, VA_3, WV_1	0	0	0	0	0	0	0	0	0	0	0	0
	NY_1	0	0	0	0	0.45	0.45	0.45	0.45	0.45	0.45	0	0
Pullets, Hogs and pigs for breeding, hogs for	DE_1, MD_1, MD_2, MD_3, NY_1, PA_1, PA_2, PA_3, VA_1, VA_2, VA_3, WV_1	0	0	0	0	0	0	0	0	0	0	0	0

slaughter													
Turkeys	DE_1, MD_1, MD_2, MD_3, PA_1, PA_2, PA_3, VA_1, VA_2, VA_3, WV_1	0	0	0	0	0	0	0	0	0	0	0	0
	NY_1	0	0	0	0	0.65	0.65	0.65	0.65	0.65	0.65	0	0
Horses	DE_1, MD_2, PA_1, PA_2, PA_3, WV_1	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	MD_1, PA_3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	MD_3, PA_1	0.6	0.6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.6
	NY_1	0.3	0.3	0.3	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.3	0.3

4.4 Manure Storage and Handling Residual

Loss of manure and other nutrient sources occurs during storage due to physical processes. The physical loss occurs when some manure falls out of the bucket of a front-end loader, leaks out of a spreader in unintended locations, or inadvertently slips off a concrete pad where it is stored. However, storage loss is most common when manure is absorbed or incorporated into the soil in animal concentration areas (Doug Goodlander, PA State Conservation Commission, personal communication, 2008).

Storage loss will vary by animal type, since management practices associated with animal concentration areas and storage facilities vary by animal type. *Storage loss does not account for the type of storage system used on any particular farm or the angle of repose for dry heaps of manure.* Rather, storage loss applies the average annual loss across the dominant storage systems in use throughout the simulation period.

For all poultry and swine, 15% of manure is lost during storage. For beef, dairy, sheep and lambs, goats, and horses, 20% is lost (CBP Watershed Technical Workgroup and CBP Agricultural and Nutrient Sediment Reduction Workgroup approval, 2008).

The mass of nutrients lost during storage and handling is applied to the land use that includes the animal production area (animal feeding operation (AFO) or concentrated animal feeding operation (CAFO)).

5 ACCOUNTING FOR SPATIAL AND TEMPORAL VARIATION IN AGRICULTURAL PRACTICES

Nutrient application amount and timing is governed by the following principles:

- Temperature zone variations
- Agricultural practice data (as found in state nutrient management and land grant university cooperative extension recommendations)
- Actual yield history, from the NASS Agricultural Census

To introduce spatial variability, the construct of growing regions was created. Each state is established as its own region to accommodate variations in state-recommended nutrient application rates and timing. The three largest states—Virginia, Maryland, and Pennsylvania—are each classified further into three smaller regions. This further classification into growing regions allows for variation among planting and harvest dates based on typical last frost and first killing frost.

Modeled agricultural variables include plant and harvest dates, nitrogen fixation, bare soil cover, plant nutrient uptake, nutrient application rate, and nutrient application timing. These agricultural practices are modeled where each year is independent of the previous or subsequent year. While this seems counter-intuitive based on how a farmer operates, it holds true to the scale of the source data and avoids making assumptions which would introduce error.

The classifications of the growing regions, temporal scale, and agricultural practice data are discussed separately in the following sections.

5.1 Growing Regions

There are twelve growth regions in the Chesapeake Bay Watershed. Each state is necessarily its own region, since there are separate crop management and nutrient guidelines for each state. Where the agronomy guide from each state divided the state into different growing regions, then those regions were used. Where the guides did not make a distinction, the 1990 USDA Hardiness Zone delineations were used to see if the state should be divided. The more recent 2003 hardiness zones were not used since it is considered unlikely that farmers changed planting dates and 1990 is closer to the mid-point of the modeled period (1982 – 2005). The USDA Hardiness Zone boundaries are set where there is a 10° Fahrenheit difference in the average annual temperature. The lines were established by comparing multiple maps and determining which counties fell into which regions. Boundary lines were shifted to match county lines. Specifically:

- In New York, the portion of the state that lies in the watershed is primarily the central part, which the Cornell Ag Guide considers one region.
- In Pennsylvania, the Agronomy Guide divides the state into separate growing regions for each crop; however, the lines of the regions are very similar to each other and to the lines of USDA Hardiness Zones. Therefore, it was determined that Pennsylvania would be divided into three regions that follow the boundaries given in the Agronomy Guide: Zone 1, Zone 2 and Zone 3.

- In West Virginia, the portion of the state that lies in the watershed was in a single USDA Zone, so WV has one region.
- Maryland's Nutrient Management Manual does not divide the state; however, there are two USDA Zones. Therefore, MD was divided into USDA Zone 6 and USDA Zone 7. Concern arose that this left an eastern shore county in the same zone as a Western Maryland county and were thus subject to the same conditions. To address this concern, a third zone, "Western MD" was added that includes Garrett, Allegheny and Washington counties.
- Delaware also falls into one USDA Zone, and was therefore left undivided.
- Virginia's Agricultural Guide divides the state into three sections that roughly follow geologic provinces: Eastern, Piedmont and West of Blue Ridge.
- North Carolina and Tennessee counties follow physiographic provinces (note that these two areas were not actually added to Scenario Builder since the VA southern rivers were not modeled in the Watershed Model-HSPF).

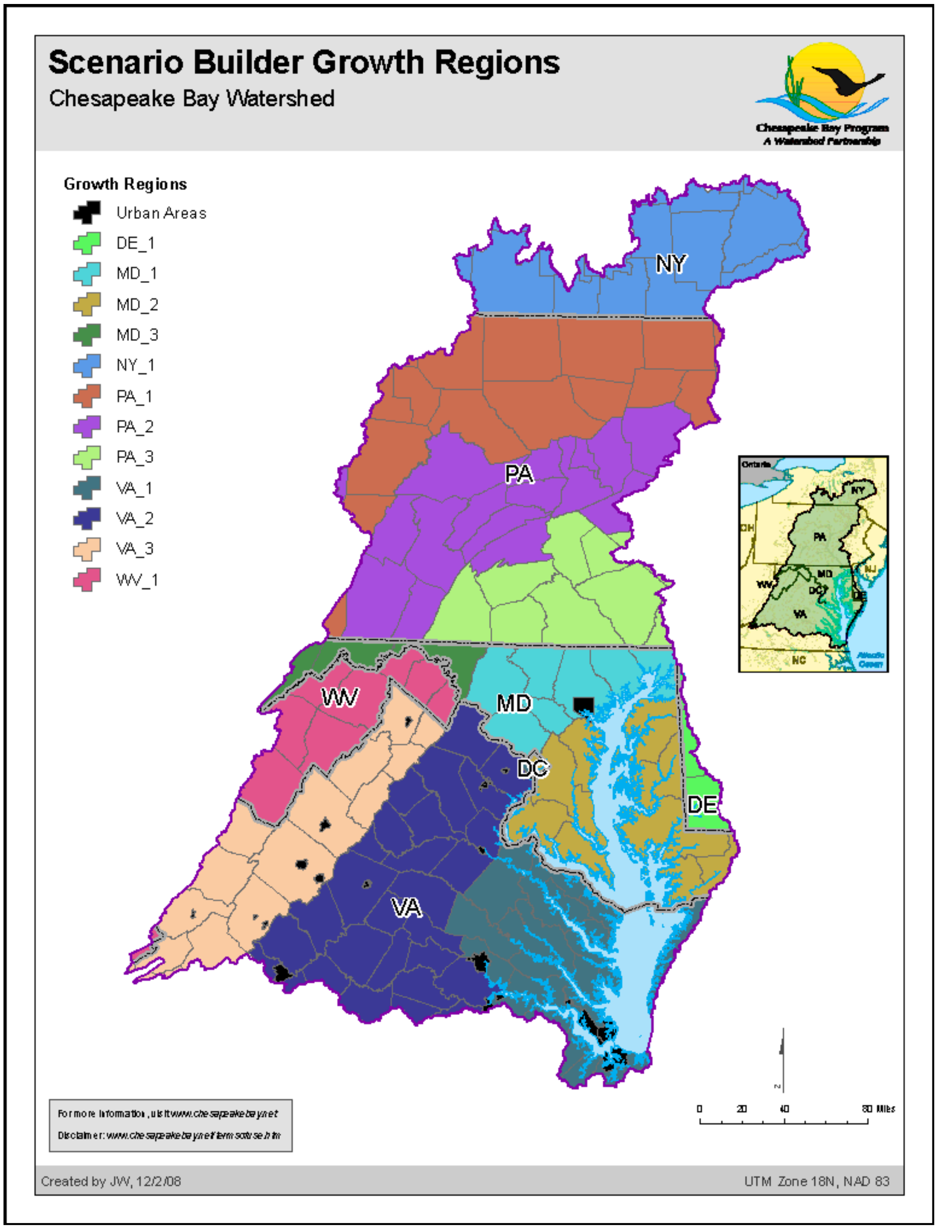

Figure 5-1: Growing Regions

USDA Hardiness Zones were incorporated into the identification of the regions to make it possible to relate data on planting and harvesting dates in one state to another state. The guides in Maryland, Delaware and West Virginia only report recommended nutrient application rates, not dates. If a region in one of these states corresponds to a region in another state that lies in the same USDA Hardiness Zone, it was assumed that the planting and harvesting dates would be similar for both of those regions. For example, the dates for Eastern VA were also used for MD Zone 2 and Delaware because all three lie in USDA Zone 7.

While source data was initially prepared using growing regions, it is stored at the county scale. This has allowed more precision as source data is fine-tuned to the county level.

5.2 Temporal Scale

Data is calculated on a monthly time scale. Much of the source data is taken from the National Agricultural Statistics Service's (NASS) Agricultural Census and is from the years 1982, 1987, 1992, 1997, 2002, and 2007. Years between Agricultural Census years and those in the future are interpolated or projected using a linear regression per Section 2.1.4.

5.3 Agricultural Practices

Scenario Builder uses agricultural practice information only to determine the timing of nutrient application and the amount of nutrients required. Scenario Builder does not have temperature or rainfall data and is not designed to be a full crop growth model. For this reason, few of the crop parameters are linked. (For example, uptake and nutrient application are calculated independently.)

Crop-related data include plant and harvest dates, nutrient application timing, plant uptake, crop yields, nutrient application rates, nitrogen fixation, and erodible area. Each of these parameters is discussed separately in the sections below.

5.3.1 Plant and harvest dates

Plant and harvest dates are used to inform the timing of plant uptake, nitrogen fixation, and nutrient application. Uptake and nitrogen fixation can only occur when the plant is growing. The days between the plant and harvest date define this growing time. A single plant and harvest date is used for each crop or plant type in each growth region.

Having only a single date for planting and harvesting is problematic for double cropping and crops such as vegetables, which are planted and harvested multiple times in a single season, or hay and alfalfa, which are harvested multiple times in a single season. The need to incorporate multiple plant and harvest dates is a known issue and will be incorporated in a future phase of the model development. Currently, the first plant and last harvest date is used for hay and alfalfa and the last plant and harvest dates are used for vegetables.

Scenario Builder's calculations are performed on a county scale and use the most typical plant and harvest dates at that scale. While it is commonly understood that there is variation among plant and harvest dates among farmers, the spatial scale of this model is at the county and cannot accommodate farm-scale variation.

First and last frost dates were used as a guiding parameter for the plant and harvest dates. Agronomy guides for each state frequently base planting and harvesting dates on the last frost in the spring and the first frost in the fall. In order to determine those dates for each growing region, the "Freeze/Frost Data" from the National Climatic Data Center (CLIM20) was used. This publication lists the frost dates for numerous sites within each state in the United States at various probability levels. Using five monitoring sites within the watershed in each of the 12 growing regions, the 50% probability level was used. Then the midpoint of the range among the five sites in each growing region was used (Table 5-1).

Table 5-1: First and last frost dates for each growing region

Growing Region	Last Frost	First Killing Frost
DE 1	April	October
MD 1	April	October
MD 2	April	October
MD 3	April	October
NY 1	May	October
PA 1	May	October
PA 2	May	September
PA 3	April	October
VA 3	May	October
VA 2	April	October
VA 1	April	November
WV 1	May	October

Most planting and harvest dates are given as a range for each crop in each state's agronomy guide. Sometimes a season alone was given as a planting or harvest range. Sometimes harvest dates were not given at all. Rules that applied where the planting and harvest dates are not expressly stated in the agronomy guide are as follows:

- Spring and fall dates were assumed the true range of spring and fall. If a guide referred to early spring, the range of dates for the first half of spring was used in lieu of the midpoint. Likewise, late spring referred to the second half of spring. Early fall referred to the first half of fall and late fall referred to the second half of fall. Since Scenario Builder is at a monthly scale, these typically fell in the same month as the midpoint.
- Where the guides gave a choice of plant dates, the first was used.
- If the crop or plant type is a perennial, the plant date corresponds to emergence and the harvest date corresponds to the killing frost.
- If the guide did not provide planting and harvest dates at all, then the dates are used for an adjacent region. For example, Maryland's eastern shore (MD 2) could be used for Delaware (DE 1).
- Frequently harvest times were specified in terms of stages of maturity. In those cases, a variety of sources was consulted to estimate the time taken to reach the indicated maturity stage. Sources include Cooperative Extension factsheets, and variety trials. Zadok's growth stages were used where possible.

- Where data were unavailable from state agronomy or nutrient management guides, then the crop cover canopy estimates generated from RUSLE 2 were consulted.
- For green lima beans in Delaware, the plant and harvest dates were taken from the RUSLE 2 data for snap beans
- Vegetable planting dates were taken from http//www.hgic.umd.edu/_media/documents/hg16_000.pdf.

5.3.2 Yield data

The yield is taken from the Agricultural Census from the years 1982 through 2007. Two yield numbers are used: best potential yield and a yield range with upper and lower limits. The best potential yield is calculated according to the nutrient management recommendations, which differ by state.

> *Delaware*: average of the highest four of seven yields from the agricultural census. If less than seven agricultural censuses are available, use as manure are available as long as there are greater than four.
>
> *Maryland*: average the highest 60% of the available agricultural censuses.
>
> *New York, Pennsylvania, District of Columbia, West Virginia, Tennessee, and North Carolina*: average the highest three of five yields from the agricultural censuses.

For the yield range with an upper and lower limit, the limits were defined as the 0.95 to 0.05 of the Agricultural Censuses reported yields for the period on record.

County crop yields could have been under or over-estimated. Upper and lower limits were identified to overcome this issue. Upper and lower limits were defined as the quantile (p=0.95) and the quantile (p=0.05) respectively to remove outliers (Table 5-2).

Table 5-2: Agricultural census upper and lower limits on yield

CropName	Units	Upper limit	Lower limit
Alfalfa Hay Harvested Area	dry tons	3.6	1.6
Alfalfa seed Harvested Area	pounds	88.8	41.0
Barley for grain Harvested Area	bushels	81.1	37.1
Birdsfoot trefoil seed Harvested Area	pounds	98.9	67.7
Buckwheat Harvested Area	bushels	37.6	12.6
Canola Harvested Area	pounds	1686.0	1073.7
Corn for Grain Harvested Area	bushels	120.0	47.7
Corn for silage or greenchop Harvested Area	tons	17.9	7.6
Cotton Harvested Area	bales	1.4	0.5

Dry edible beans, excluding limas Harvested Area	cwt	17.8	9.3
Emmer and spelt Harvested Area	bushels	84.3	49.5
Fescue Seed Harvested Area	pounds	272.5	148.5
Haylage or greenchop from alfalfa or alfalfa mixtures Harvested Area	green tons	7.6	3.5
Oats for grain Harvested Area	bushels	74.7	39.3
Orchardgrass seed Harvested Area	pounds	306.5	66.1
Other field and grass seed crops Harvested Area	pounds	248.3	112.2
Other haylage, grass silage, and greenchop Harvested Area	green tons	6.6	3.2
Other managed hay Harvested Area	dry tons	2.3	1.3
Peanuts for nuts Harvested Area	pounds	2492.0	957.0
Popcorn Harvested Area	pounds	2591.7	970.4
Potatoes Harvested Area	cwt	272.7	68.7
Red clover seed Harvested Area	pounds	136.6	50.1
Rye for grain Harvested Area	bushels	42.2	20.4
Ryegrass seed Harvested Area	pounds	783.9	201.9
Small grain hay Harvested Area	dry tons	3.0	1.0
Sorghum for Grain Harvested Area	bushels	77.3	23.3
Sorghum for silage or greenchop Area	tons	14.1	5.3
Soybeans for beans Harvested Area	bushels	39.6	17.8
Sunflower seed, non-oil varieties Harvested Area	pounds	1652.1	100.3
Sunflower seed, oil varieties Harvested Area	pounds	824.3	176.6
Sweet potatoes Harvested Area	cwt	190.3	52.9
Timothy seed Harvested Area	pounds	297.5	60.1
tobacco Harvested Area	pounds	2302.2	941.8
Triticale Harvested Area	bushels	45.1	13.1
Vetch seed Harvested Area	pounds	318.6	116.6
Wheat for Grain Harvested Area	bushels	66.3	28.3
Wild hay Harvested Area	dry tons	1.8	0.7

The best potential crop yield ratio is calculated using:

Equation 7: Best potential crop yield ratio

$$agcensus\_yield\_ratio \equiv \frac{agcensus\_yield}{yield\_upper\lim it}$$

If the agricultural census yield is lower than the lower limit, the lower limit is used. The average crop yield ratio is 0.7 (Figure 5-2: Agricultural Census yield ratio distributionFigure 5-2).

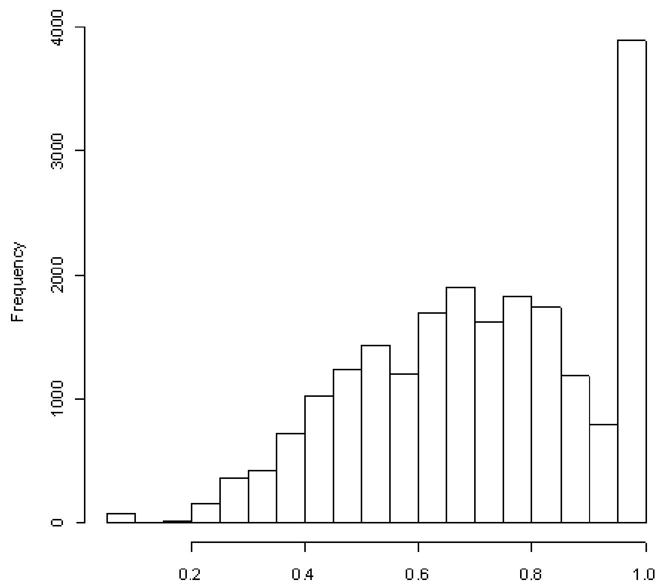

Figure 5-2: Agricultural Census yield ratio distribution

5.3.2.1 Maximum yield

Doerge et al. (1991) presented yields and nitrogen removal and uptake for several crops in Arizona. Zandstra and Price (1988) reported maximum yields of a large list of crops under optimum growing conditions in Michigan. These yields are a result of favorable weather, sufficient moisture and adequate fertilizer and good pet control. FAO (2009) reported maximum harvested yields obtained under actual farming conditions and a high level of crop and water management. Crop yields and maximum yields data are at the harvest and they are in wet units. National Agriculture Statistics Service (NASS) was also used as a source of information.

Maximum yields were compared to crop yield and maximum yield data found in the literature. For the most part the maximum yields were found reasonable and in many cases were updated. Maximum yield units (yield unit per acre) were converted to units that were compatible to the theoretical uptakes (pound per yield unit) when it was required.

Table 5-3. Maximum yields.

CropName	Max yield	unit/acre	Source
Alfalfa Hay Harvested Area	9	dry tons	FAO
Alfalfa seed Harvested Area	440	pounds	NASS
Asparagus Harvested Area	4	tons	University of Arizona
Berries- all Harvested Area	8	tons	Michigan State University
Broccoli Harvested Area	8	tons	NASS
Brussels Sprouts Harvested Area	9	tons	NASS
Cantaloupe Harvested Area	20	tons	University of Arizona
Carrots Harvested Area	40	tons	Michigan State University
Collards Harvested Area	9	tons	Michigan State University
Corn for Grain Harvested Area	200	bushels	University of Arizona
Cotton Harvested Area	8	bales	FAO
Cucumbers and Pickles Harvested Area	14	tons	Michigan State University
Dry edible beans, excluding limas Harvested Area	20	cwt	FAO
Dry Onions Harvested Area	25	tons	Michigan State University
Eggplant Harvested Area	12	tons	Michigan State University
Escarole and Endive Harvested Area	20	tons	Michigan State University
Fescue Seed Harvested Area	590	pounds	NASS
Green Lima Beans Harvested Area	5	tons	Michigan State University
Green Onions Harvested Area	9	tons	NASS
Head Cabbage Harvested Area	24	tons	FAO
Herbs, Fresh Cut Harvested Area	20	tons	Michigan State University
Lettuce, All Harvested Area	25	tons	Michigan State University

Mustard Greens Harvested Area	180	cwt	Michigan State University
Okra Area	5	tons	Michigan State University
Parsley Harvested Area	200	cwt	Michigan State University
Peanuts for nuts Harvested Area	4250	pounds	NASS
Peas, Green (excluding southern) Harvested Area	4	tons	Michigan State University
Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	4	tons	Michigan State University
Peppers, Bell Harvested Area	13	tons	Michigan State University
Peppers, Chile (all peppers – excluding bell) Harvested Area	202	cwt	FAO
Popcorn Harvested Area	4550	pounds	NASS
Potatoes Harvested Area	440	cwt	Michigan State University
Pumpkins Harvested Area	500	cwt	Michigan State University
Radishes Harvested Area	20	tons	NASS
Rhubarb Harvested Area	10	tons	Michigan State University
Rye for grain Harvested Area	100	bushels	NASS
Snap Beans Harvested Area	5	tons	Michigan State University
Sorghum for Grain Harvested Area	135	bushels	University of Arizona
Squash Harvested Area	20	tons	Michigan State University
Sunflower seed, non-oil varieties Harvested Area	2833	pounds	FAO
Sunflower seed, oil varieties Harvested Area	2833	pounds	FAO
Sweet Corn Harvested Area	20000	pounds	Michigan State University
Sweet potatoes Harvested Area	320	cwt	NASS
Turfgrass	5	tons	University of Arizona

Turnip Greens Harvested Area	15	tons	Michigan State University
Vetch seed Harvested Area	800	pounds	NASS
Watermelons Harvested Area	40	tons	University of Arizona
Wheat for Grain Harvested Area	133	bushels	University of Arizona

5.3.3 Nutrient uptake

Uptake is the amount of N and P taken from the soil into the plant. It includes the amount that would be removed with a harvest as well as the amount in the roots and shoots, which is in contrast with many other models that only examine crop removal. Scenario Builder calculates three sets of data for uptake:

1. Total uptake / county / year / crop or plant type
2. Fraction taken up each month / county / year / crop or plant type
3. Watershed Model – HSPF calibration input file: Average nutrient uptake over entire modeling period on average crop and land areas

The data are produced on a monthly basis. Uptake only occurs in months where the plants are growing. Uptake only occurs between the plant and harvest dates. For those crops that over winter, the data are reflected in the appropriate month of the same year. This is because there is no interaction among years and each year stands on its own in Scenario Builder.

Meisinger and Randall (1991) and Lander (2009) reported nutrient uptake values for many crops. Uptake values were estimated only for the harvested part and do not consider crop residue and roots as a part of the harvest material. Nutrient uptake is reported in pounds per yield unit (bushel, tons, etc.) per acre (Table 5-4. Theoretical nutrient uptake.Table 5-4).

Sullivan et al. (1999) reported that 75 to 95% of nitrogen uptake is in the portion of the crop above the ground. Sullivan et al. (1999) report that 25 to 33% of the amount of nitrogen found in the portion of the crop above the ground usually is present in the roots. For annual crops, most of that nitrogen present in roots moves to plant tops at maturity. According to Alley and Vanlauwe (2009), the total nitrogen uptake is a function of the total crop biomass (top growth and roots). Alley and Vanlauwe calculate uptake using:

Equation 8: Total nutrient uptake

$$Total\_NutrienUptake(lb/acre) = \left(\frac{yield\_drymatter}{acre}\right) \times \left(\frac{nutrient\_content(lb)}{yield\_drymatter}\right)$$

Using the maximum yields and theoretical uptake found in the literature and eliminating the yield ratio, crop uptake is calculated using:

Equation 9: Crop uptake

$$Uptake\_per\_month(lb) \equiv \frac{\max imum\_yield}{acre} \times \frac{theoretical\_uptake(lb)}{yield\_unit} \times acres$$

$$Uptake\_per\_month\_per\_acre(lb/acre) \equiv \frac{\max imum\_yield}{acre} \times \frac{theoretical\_uptake(lb)}{yield\_unit}$$

Uptake per month is proportional to the heat units received by the crop. Nitrogen and phosphorus uptakes per land use are calculated using an area weighted average of all the crops contained in the land use is used (Figure 3 and 4).

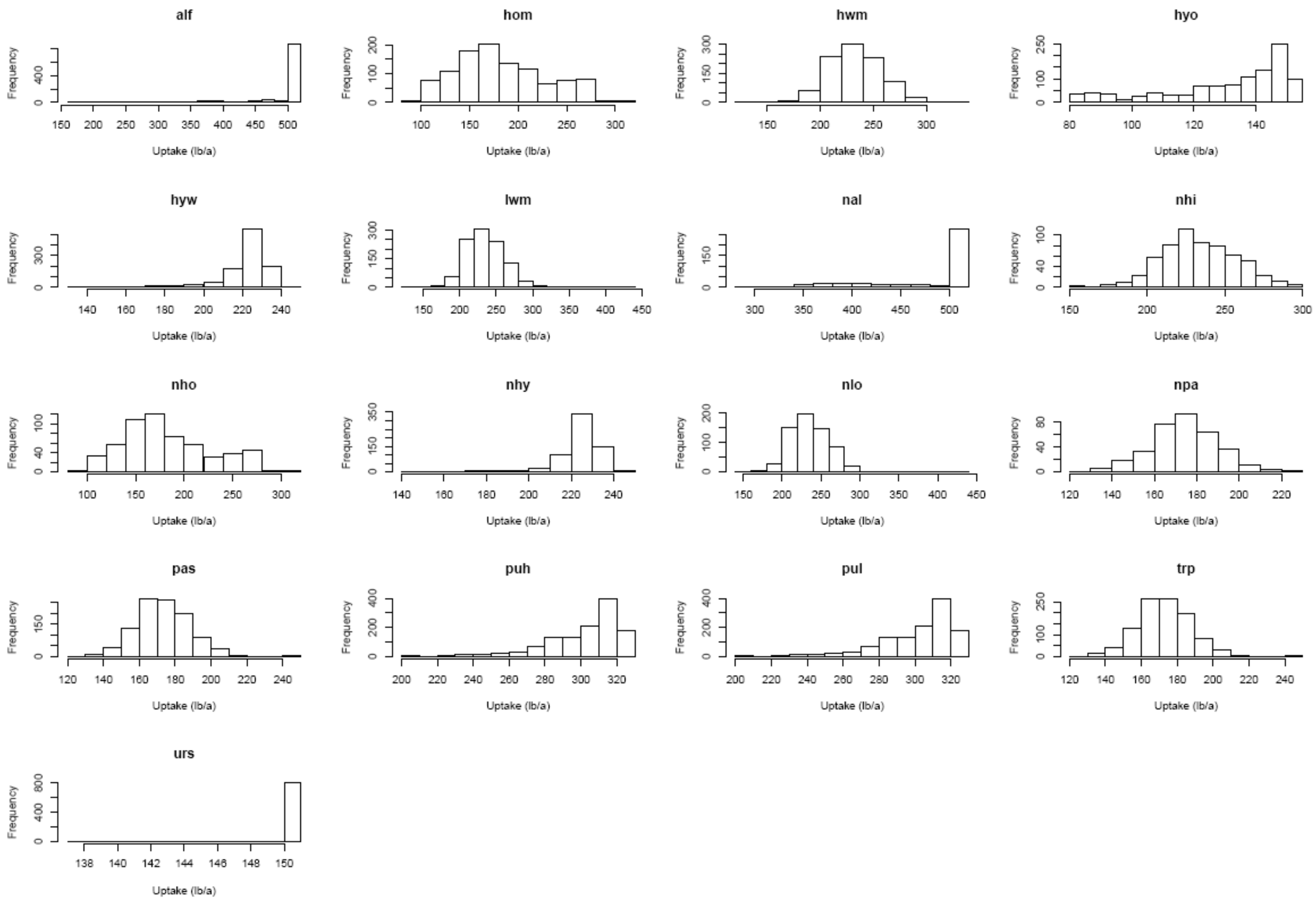

Figure 5-3: Maximum nitrogen uptake per land use

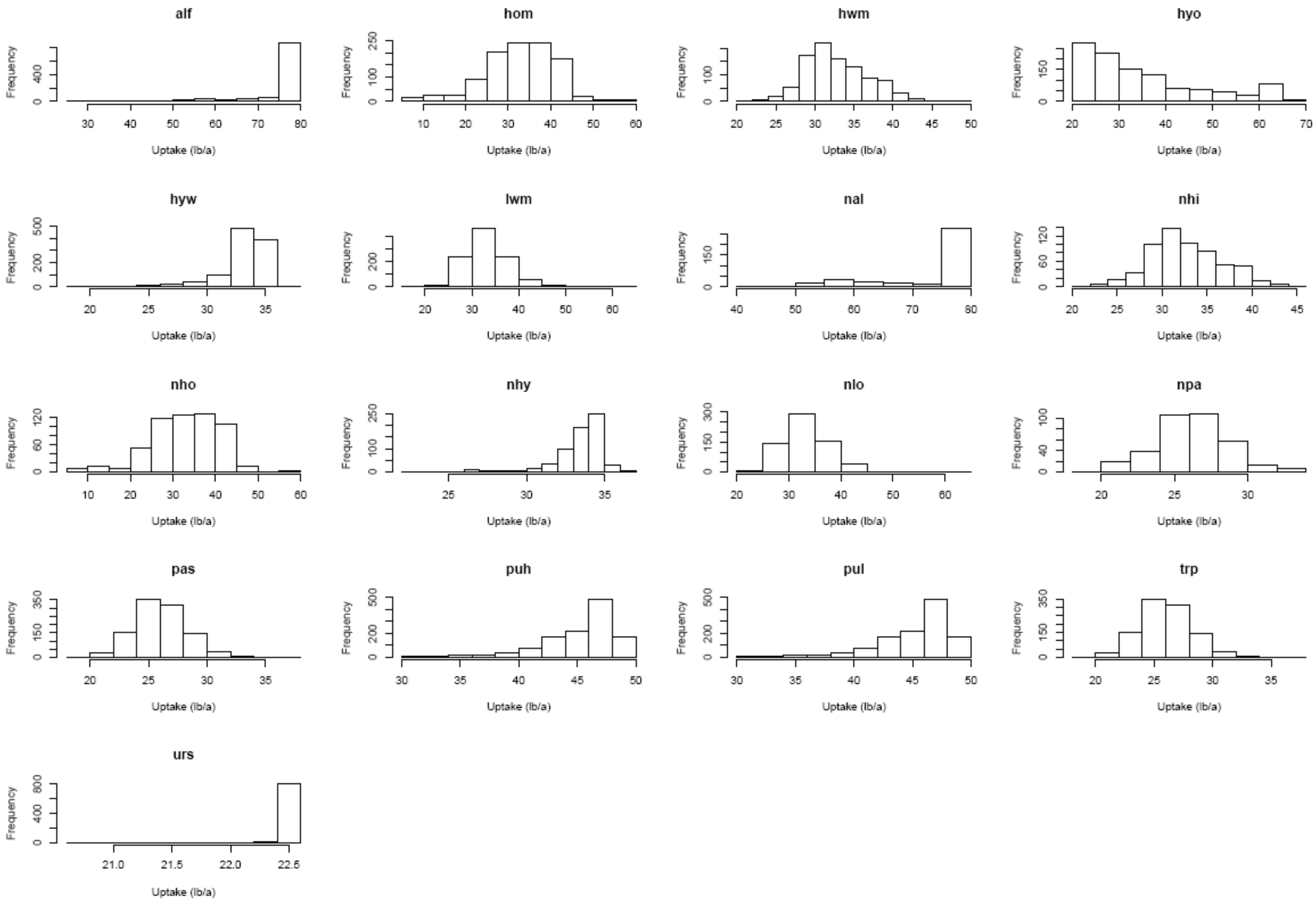

Figure 5-4: Maximum phosphorus uptake per land use

For calibration uptake, yields from the agricultural census are used instead of the maximum yields.

Equation 10: Calibration uptake

$$Uptake\_permonth(lb) \equiv \frac{agcensus\_yield}{acre} \times \frac{theoretical\_uptake(lb)}{yield\_unit} \times acres$$

$$Uptake\_permonth\_peracre(lb/acre) \equiv \frac{agcensus\_yield}{acre} \times \frac{theoretical\_uptake(lb)}{yield\_unit}$$

When there is not crop yield data from the censuses, maximum yields are used and they are multiplied by the agricultural census average yield ratio to obtain a more realistic uptake for calibration.

Equation 11: Uptake where there are no yield data from the Agricultural Census

$$Uptake\_permonth(lb) \equiv 0.7 \times \frac{\max\_yield}{acre} \times \frac{theoretical\_uptake(lb)}{yield\_unit} \times acres$$

$$Uptake\_permonth\_peracre(lb/acre) \equiv 0.7 \times \frac{\max\_yield}{acre} \times \frac{theoretical\_uptake(lb)}{yield\_unit}$$

Table 5-4. Theoretical nutrient uptake.

Crop Name	Nitrogen pounds per yield unit	Phosphorus pounds per yield unit	Yield unit	Source
Alfalfa Hay Harvested Area	59.516	8.927	dry tons	Meisinger, 1991
Alfalfa seed Harvested Area	0.511	0.058	pounds	NRCS
Asparagus Harvested Area	11.647	1.747	tons	Meisinger, 1991
Barley for grain Harvested Area	1.059	0.212	bushels	NRCS
Beets Harvested Area	7.059	1.059	tons	Meisinger, 1991
Birdsfoot trefoil seed Harvested Area	0.251	0.038	pounds	Meisinger, 1991
Broccoli Harvested Area	16.471	2.471	tons	Meisinger, 1991
Bromegrass seed Harvested Area	0.387	0.066	pounds	NRCS
Buckwheat Harvested Area	1.012	0.188	bushels	NRCS

Canola Harvested Area	0.041	0.007	pounds	NRCS
Cantaloupe Harvested Area	4.000	0.600	tons	Meisinger, 1991
Carrots Harvested Area	4.824	0.724	tons	Meisinger, 1991
Cauliflower Harvested Area	10.588	1.588	tons	Meisinger, 1991
Corn for Grain Harvested Area	0.976	0.146	bushels	Meisinger, 1991
Corn for silage or greenchop Harvested Area	10.235	1.535	tons	Meisinger, 1991
Cotton Harvested Area	20.329	3.049	bales	Meisinger, 1991
Cucumbers and Pickles Harvested Area	3.412	0.512	tons	Meisinger, 1991
Dry edible beans, excluding limas Harvested Area	4.824	0.724	cwt	Meisinger, 1991
Dry Onions Harvested Area	5.882	0.882	tons	Meisinger, 1991
Emmer and spelt Harvested Area	1.129	0.224	bushels	NRCS
Fescue Seed Harvested Area	0.404	0.082	pounds	NRCS
Haylage or greenchop from alfalfa or alfalfa mixtures Harvested Area	23.529	3.529	green tons	Meisinger, 1991
Head Cabbage Harvested Area	6.941	1.041	tons	Meisinger, 1991
Land in Orchards Area	28.235	4.235	tons	Meisinger, 1991
Lettuce, All Harvested Area	5.765	0.865	tons	Meisinger, 1991
Oats for grain Harvested Area	0.812	0.122	bushels	Meisinger, 1991
Orchard grass seed Harvested Area	0.412	0.041	pounds	NRCS

Other field and grass seed crops Harvested Area	0.387	0.066	pounds	NRCS
Peanuts for nuts Harvested Area	0.047	0.004	pounds	NRCS
Peas, Chinese (sugar and Snow) Harvested Area	37.647	5.647	tons	Meisinger, 1991
Peas, Green (excluding southern) Harvested Area	37.647	5.647	tons	Meisinger, 1991
Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	37.647	5.647	tons	Meisinger, 1991
Peppers, Bell Harvested Area	5.059	0.759	tons	Meisinger, 1991
Peppers, Chile (all peppers – excluding bell) Harvested Area	0.253	0.038	cwt	Meisinger, 1991
Potatoes Harvested Area	0.588	0.088	cwt	Meisinger, 1991
Red clover seed Harvested Area	0.494	0.058	pounds	NRCS
Rye for grain Harvested Area	1.412	0.212	bushels	Meisinger, 1991
Ryegrass seed Harvested Area	0.329	0.066	pounds	NRCS
Small grain hay Harvested Area	37.647	5.271	dry tons	NRCS
Snap Beans Harvested Area	10.588	1.588	tons	Meisinger, 1991
Sorghum for Grain Harvested Area	1.153	0.212	bushels	NRCS
Sorghum for silage or greenchop Area	17.365	2.871	tons	NRCS
Soybeans for beans Harvested Area	4.176	0.424	bushels	NRCS
Spinach Harvested Area	11.647	1.747	tons	Meisinger, 1991
Squash Harvested Area	6.588	0.988	tons	Meisinger, 1991
Sunflower seed, non-oil varieties Harvested Area	0.076	0.011	pounds	Meisinger, 1991

Sunflower seed, oil varieties Harvested Area	0.068	0.010	pounds	Meisinger, 1991
Sweet Corn Harvested Area	0.006	0.004	pounds	NRCS
Timothy seed Harvested Area	0.346	0.066	pounds	NRCS
Tobacco Harvested Area	0.039	0.002	pounds	NRCS
Tomatoes Harvested Area	4.353	0.653	tons	Meisinger, 1991
Triticale Harvested Area	1.765	0.200	bushels	NRCS
Vetch seed Harvested Area	0.346	0.041	pounds	NRCS
Watermelons Harvested Area	3.176	0.476	tons	Meisinger, 1991
Wheat for Grain Harvested Area	1.529	0.229	bushels	Meisinger, 1991
Wild hay Harvested Area	25.882	20.000	dry tons	NRCS

5.3.3.1 Fraction of uptake per month

The fraction of the annual uptake mass is calculated on a monthly basis for each of the 12 growing regions using the recommended plant date. This does not account for the range of varieties used throughout the watershed. The curve information was informed by normalizing empirical data from peer-reviewed research to a fraction of the total uptake / month. For each crop type where measurements were available, the normalized data were averaged. Uptake fraction per month was generalized to all the crop types modeled in Scenario Builder from the peer-reviewed research data on corn, soybeans, and winter wheat.

The timing of uptake should be based on the average temperature. Thus, heat units and the number of growing degree days establish plant growth stages.

Equation 12: Growing degree days

(Temperature Minimum + Temperature Maximum) / 2 – crop basal unit

The basal unit for corn is generally accepted as 50 degrees Fahrenheit. There are established basal units for most crops that are modeled in Scenario Builder. Since development is faster when temperatures are warmer, and slower when temperatures are cooler, then the use of growing degree days more closely informs the timing of nutrient uptake. Moreover, maturity dates for crops change by variety. In the Scenario Builder, we do not have various varieties of crops. The heat units serve to approximate the uptake for crops even without varietal differences being specified.

This provides every crop acres with efficient timing of nutrients, which is a significant goal of nutrient management. However, there still is a nutrient management and non-nutrient management rate.

Calibration input data

Average data are produced for calibrating the Watershed Model. This set of data averages the actual yields for each crop over the entire period on record. Since this set of data must be applied to a land and crop area, the average area of each crop over the same period of record is also calculated. Thus, the data is produced as uptake (lbs) / acre.

5.3.4 Nutrient application timing and fraction

Each state issues recommendations for nutrient application rates and timing. These recommendations were used for the fraction of nutrients applied on each crop at a particular time. For example, split application to corn may be 50% of the total nutrients applied 20 days prior to planting and 50% applied 60 days after planting. This section discusses how the data are used and the data generalizations.

The state recommendations for application timing were used for all crops; including those under a nutrient management plan as well as those without a plan (Penn State Agronomy Guide 2009-2010, University of Delaware Soil Testing Program Nutrient Guidelines, consulted on-line 2008-2009, Virginia Cooperative Extension Agronomy Guide 2000, Maryland Cooperative Extension Soil Fertility Management-1 2002, Nitrogen Guidelines for Field Crops in New York 2003). The data supplied by states have been updated through many versions of Scenario Builder. The most recent update was incorporated for Version 2.4 after a data request from the Agriculture Workgroup (1/14/11).

Nutrient application timing (as well as rates, form, and methods) may vary between farmers using a nutrient management plan as opposed to those farmers without a plan. However, specific dates can only be defined if there is a consistent behavior among a specific set of farmers. That is, if farmers not under a nutrient management plan always applied nutrients all at once, or always at inopportune times, such as in the winter when crops may not be actively growing, then those dates could be specified for crops not under nutrient management. We were unable to define a consistent behavior among farmers without a nutrient management plan. Thus, the nutrient application timing does not vary according to nutrient management planning. In contrast, the nutrient application rate *does* vary between nutrient management and non-nutrient management.

In Scenario Builder 2.4 and the Watershed Model 5.3.2, a change was used to the nutrient crediting procedure. The time step for nutrient application remains monthly. However, if an excess of one nutrient is applied in one month, the later requirement is credited with this excess. For example, manure is applied to a crop in May. The May application is primarily a nitrogen requirement, and the manure is applied on a nitrogen-based plan. This means that phosphorus is over applied. However, this example crop requires additional phosphorus nutrients in October. The excess phosphorus applied in May is credited toward that phosphorus need in October. This example holds true where nitrogen is over applied and needed later in the year. Thus, the timing does not change for application, but the amount applied at each specified time varies.

A number of strategies were necessarily employed to convert the recommendations to normalized data (Table 5-5). The recommendations for the fraction of nutrients applied at each time were originally in multiple formats. A list of the strategies to normalize the various recommendations in which the formats were made follows. Final adjustments were made to the nutrient application timing by multiple parties including the Chesapeake Bay Program jurisdictions. The strategies to normalize the recommendations occurred prior to the final review by the jurisdictions, where additional changes may have been made.

- Commonly, nutrient application timing is dictated by the growth stage of the plant. Zadok's growth stage scale was used to inform the number of days after planting that a particular stage would be reached.
- Whenever the guides recommend nutrients applied as pre-plant, 20 days prior to the plant date was used.
- When no timing information was offered at all, it was assumed the recommended nutrients were applied at planting.
- Where not other specified for small grains, hay and pasture, all nutrients were applied 60 days after planting
- For all crops where the nutrient application timing was "when vines start to run", it was assumed to be 60 days after planting.
- If the application method was "Banded with planter" then the application timing was set to apply with planting.
- If the application method was broadcast and disk in, then the application timing was set as pre-plant (20 days prior to planting).

Table 5-5: Generalization of fraction applied and application timing

Growing Region	Crop	Generalization, source of data
All	Dry edible beans	Used the same recommendations as for peas, black eyed
All	garlic	Used the same recommendations as for dry onions
All	Peanuts and popcorn	Used the same recommendations from Virginia throughout the watershed
All	rhubarb	Used the same plant dates and nutrient recommendations as buckwheat since rhubarb is in the buckwheat family
All	Turf grass	Nutrient application timing information was taken from the Maryland Home and Garden Information Center (http//www.hgic.umd.edu/_media/documents/hg103_002.pdf)
All regions	Aquatic plants	Assumed to be planted bimonthly with split application
DC	All crops	Used the same recommendations as Maryland for all crops in the District
DE	Alfalfa Hay Harvested Area	Used the same recommendations as "alfalfa," which did not specify "hay"

DE	Asparagus Harvested Area	Used the recommendation for “Cutting Beds”
DE	Broccoli	Four P-Index values for soil are given; used the 26-50 which was consistent with the optimum value of 30 that was used in PA
DE	Chinese cabbage	Used the same recommendations as for "cabbage", did not specify Chinese
DE	Cut Christmas Trees Production Area	Used the recommendation for "field-grown Christmas trees"
DE	Eggplant Harvested Area	Used the recommendation for "traditional culture"
DE	orchard grass seed	Used the same recommendation as Maryland
DE	Potatoes Harvested Area	Used the recommendation for "russet potatoes". Second application of TN specified for second cultivation of crop and assumed to be five months after planting.
DE	Sorghum Hogged or Grazed, Sorghum for Syrup, Corn for dry fodder Harvested Area	Used the recommendation for Sorghum for silage
DE	Squash Harvested Area	Used the recommendation for "summer squash"
DE	Sunflower seed, oil varieties and non-oil varieties Harvested Area	Used the recommendation for "sunflowers", did not specify oil or non-oil
DE	Sweet Corn Harvested Area	Used the recommendation for "fresh market" corn
DE	Tobacco	Used the same recommendation for as for Maryland
DE	Tomatoes Harvested Area	Used the recommendation for "traditional production" under "loams and silt loams"
DE	Turf grass	Used the recommendation for "turf- athletic fields and industrial lawns- blue grass-fescue mixes, maintenance"
DE, MD	Dry Onions Harvested Area	Used the recommendation for Bulb Onions
DE, MD	Head Cabbage Harvested Area	Used the recommendation for "cabbage"- did not specify "head cabbage"
DE, MD	Oats for grain	Used the recommendation for spring oats

	Harvested Area – not double-cropped	
DE, MD	Oats for grain Harvested Area – double-cropped	Used the recommendation for winter oats
DE, MD, VA, NY	Peppers, Bell Harvested Area ; Peppers, Chile all peppers – excluding bell Harvested Area;	Used the recommendation for "peppers", did not specify type
DE, VA	Fescue	Used the same recommendation for as for Maryland
MD	Alfalfa Hay Harvested Area and Alfalfa Seed Harvested Area	Used the recommendation for "Alfalfa & Alfalfa-Grass Mix"
MD	Asparagus Harvested Area	Used the recommendation for "cutting beds".
MD	Berries- all Harvested Area	Used the recommendation for strawberries- matted row older plantings
MD	Corn for Grain Harvested Area	Used the recommendation for full season corn
MD	Cut Christmas Trees Production Area	Averaged all varieties for the second year of growth
MD	Green Lima Beans Harvested Area	Used the recommendation for a single crop, not after peas
MD	Potatoes Harvested Area	Used the recommendation for “White Potatoes”, did not specify type
MD	Red clover seed Harvested Area	Used the recommendation for "clover and clover-grass mix", didn't specify red clover
MD	Ryegrass seed Harvested Area	Used the recommendation for perennial ryegrass, not annual ryegrass
MD	Snap Beans Harvested Area	Used the recommendation for Snap Beans single crop, not after peas
MD	Soybeans for	Used the recommendation for small grain double cropped with soybean

	beans Harvested Area – double cropped	
MD	Soybeans for beans Harvested Area – not double-cropped	Used the recommendation for Soybean-full season, NOT forage-type soybeans (http//www.hgic.umd.edu/_media/documents/hg16_000.pdf)
MD	Spinach Harvested Area	Used the recommendation for Spring/Fall, NOT Overwinter
MD	Squash Harvested Area	Used the recommendation for Summer Squash, not Pumpkins/Winter Squash
MD	Timothy seed	Used the recommendation for hay
MD	Turf grass	Used the recommendation for warm season grasses, like tall fescue
MD	Watermelons Harvested Area	Used the recommendation for non-irrigated
MD	Wheat for Grain Harvested Area – double-cropped	Used the recommendation for small grain double cropped with soybeans
MD, PA	Sorghum Hogged or Grazed, Sorghum for Syrup, Corn for dry fodder Harvested Area	Used the recommendation for forage sorghum
MD, VA, NY	Peas, Chinese sugar and Snow Harvested Area; Peas, Green excluding southern Harvested Area; Peas, Green Southern cowpeas – Black-eyed, Crowder, etc. Harvested Area	Used the recommendation for "Peas"- did not specify which variety
NY	All crops, except for barley, soybeans, and winter wheat	Used the same recommendations as PA_1
NY	Barley for grain Harvested Area	Used the recommendation for spring barley (http://ipmguidelines.org/FieldCrops/content/CH05/CH05-5.asp)
PA	Alfalfa	Used the recommendation for early spring alfalfa.

PA	Barley for grain Harvested Area – double-cropped	Used the recommendation for spring barley
PA	Barley for grain Harvested Area – not double-cropped	Used the recommendation for winter barley
PA	Buckwheat	Used RUSLE2 plant and harvest dates.
PA	canola	uses MD nut application timing recommendations
PA	Corn grain and silage or greenchop	Apply when plant is 10-20 inches tall was interpreted as 45 days after planting.
PA	Hay or silage	Used the recommendations from RUSLE 2 cover data, which were specific to growing regions.
PA	Oats for grain Harvested Area	Used recommendations for spring oats
PA	Red clover seed	Used recommendations for spring red clover
PA	Rye for grain Harvested Area	Used recommendations for winter rye
PA	Soybeans for beans Harvested Area – double-cropped	Used soybeans double cropped with barley. The planting date for non-double cropped soybeans was selected. The harvest date was the planting month for winter barley, since in this situation the soybeans were being double cropped with barley.
PA	spring wheat	No varieties recommended-Maryland recommendation for nutrient application timing was used.
PA	Tobacco and sunflowers	Used the recommendation for Maryland nutrient application timing
PA	Triticale Harvested Area	Used winter triticale for forage- winter or spring. Triticale for grain was not recommended so no information was available.
PA , DE	cotton	Used the recommendations for Maryland
VA	canola	Used the recommendations for Delaware
VA	Lettuce	Used the recommendation for “leaf”
VA	sod and turf	Used the recommendation for Maryland
VA, DE	Timothy seed	Used the recommendation for Maryland
VA, NY	Cabbage, Chinese and head	Used the recommendation from RUSLE 2 cover data
WV	All crops	Used the same recommendations as Pennsylvania growing region 1
WV, NY,	Hay crops	Application timing was changed to match alfalfa which had a split

PA, VA		application, per G. Shenk. This accommodates a spikiness exhibited by the loading data.

5.3.5 Nutrient Application Rate

The application rate sets the amount of nutrients to be applied. This rate does not inform the source of those nutrients. Thus, nutrients may be sewage sludge, manure, or inorganic fertilizer. Note that if there is manure in excess of the application rate, the manure will be disposed of on a plant or crop type in the Scenario Builder model. So, the nutrient application rate is idealized and is not based on the actual amount of nutrients available. However, the actual application rate is based on the actual amount of nutrients available. This means that in a scenario where there is more manure than crop need, the actual application rate exceeds the idealized application rate. Following the same logic, if only inorganic fertilizer is available (or a modest amount of manure), then the idealized application rate is equivalent to the actual application rate.

Each year is modeled independently. This means that Scenario Builder does not model situations where a farmer put less nutrients on a crop because the previous season's crop failed. In addition, Scenario Builder only accounts for the likelihood that higher value crops may receive more nutrients than lower value crops in the sequence in which the available nutrients are used—sewage sludge (which is regulated), regulated manure (CAFO), unregulated manure (AFO), and lastly inorganic nutrients.

The application rate is calculated using a yield. The calculation of the yield varies depending on whether the crop is under a nutrient management plan or not.

5.3.5.1 Application Rate

A maximum application rate is adjusted by the yield and a factor. The maximum application rate is used to calculate the best potential nutrient application rate using Equation 13. The implication of the logic in the rate equation is that the best potential yield is adjusted to fall between 95% and 78% of the yield range. When the best potential yield varies by more than 30%, then the rate is adjusted by the ratio of the lower to upper limit of the yield. This takes into account local soil conditions. When the best potential yield varies by less than 30%, then the rate is reduced by 30%.

Equation 13: Best potential nutrient application rate

WHEN Best Potential Yield = yield upper limit AND Best Potential Yield = yield lower limit THEN Max Application Rate * 0.78

WHEN Best Potential Yield >= yield upper limit THEN Max Application Rate * 0.95

WHEN Best Potential Yield <= yield lower limit AND (yield lower limit / yield upper limit) > 0.7 THEN Max Application Rate * (yield lower limit / yield upper limit)

WHEN Best Potential Yield <= yield lower limit AND (yield lower limit / yield upper limit) <=0 .7 THEN Max Application Rate * 0.7

WHEN Best Potential Yield > yield lower limit AND Best Potential Yield < yield upper limit AND (Best Potential Yield / yield upper limit) <=0.7 THEN Max Application Rate * 0.7

ELSE (Max Application Rate * (Best Potential Yield / yield upper limit)

Methods of application are not modeled differently. Methods of application include side-dress, pelletized, coated or other slow-release fertilizers, injected, or disked-in. Equipment availability, custom, and emerging technology all introduce a degree of variability that is difficult to generalize to the county scale.

These nutrient application rates are taken from each states agronomy guide or nutrient management recommendations for optimum soil conditions. These state recommendations include an estimate of nitrogen from atmospheric nitrogen deposition. The recommendations from each state's agronomy guide or nutrient management handbook were not complete for all of the crops modeled in Scenario Builder. Some generalizations were made among crops and geographic regions (Table 5-6).

Table 5-6: Nutrient application rate data generalizations

Growing Region	Crop	Generalization, source of data
DC 1	All crops	uses same values as MD
WV 1	All crops	uses same values as PA
NY 1	all hay with nutrients	Chenango County was used for calculations for nitrogen in grasses. Average yield was 75 T/A.
All regions	All seed crops	Used the theoretical maximum yield calculated from the census-reported yields and acres. For the years with missing data, used the average of the years with data. Delaware was missing all years so used MD data.
All regions	Aquatic plants	Used Maryland's published data
All regions	Bedding/garden plants	Used Maryland's published data
All regions	Bulbs, corms, rhizomes, and tubers,	Used Maryland's published data
All regions except DE	Canola	Used MD published information which correlated to http://www.ag.ndsu.edu/pubs/plantsci/crops/a1280.pdf
All regions	Cropland on which all crops failed or were abandoned	Set application rate to 50 lbs of N and P

All regions	Cut flowers and cut florist greens	Used Maryland's published data
DE	fescue, orchard grass, and other field and forage	Used millet-sudangrass.
All regions	Foliage plants	Used Maryland's published data
All regions	Greenhouse vegetables	Used Maryland's published data
All regions	mushrooms	Spent mushroom substrate nutrient content from Penn state: http://spentmushroomsubstrate.turfgrass.psu.edu/links.cfm. Amount/acre assumes maximum amount is 10,000 lbs of spent mushroom substrate per acre, 2% N and 1% P per lb. Peter Shenderschoot, Penn State, personal communication, 1/9/2009
All regions	Nursery stock	Used Maryland's published data
All regions	Other nursery and greenhouse crops	Used Maryland's published data
All regions	Peanuts	Used Virginia's recommendations
All regions	Potted flowering plants	Used Maryland's published data
All regions	sod	Used Maryland's published data
NY 1, PA 1, PA 2, PA 3	Sunflower seed	used MD yields and NY app rates
MD 1, MD 2, MD 3, DC, NY, PA 1, PA 2, PA 3, WV	Tobacco	Advised by Dave Conrad, MD Tobacco Extension Specialist. Use Type 32, light air cured. Verified application rate in extension publications.
VA 1, DE	Tobacco	Used burley tobacco recommendations from Virginia
All regions but VA 1, VA 2, VA 3	Turf grass (urban lawns)	100 lbs N/A, 50 lbs P/A based on ratio of difference from HGIC Master Gardeners and the Phase 4.3 rate for N. (For Virginia, used actual recommendation.)

All regions	Vegetable and flower seeds	Used Maryland's published data
All regions	vegetables	MD vegetable values used where not available for other states.

There are several special cases for application rates. Pasture land uses used by the Watershed Model-HSPF include the following classifications: Nutrient Management Pasture, Pasture, and Trampled Riparian Pasture.

Equation 14: Trampled Riparian Pasture application rate of manure

> 9 * amount of direct deposit manure on pasture, where manure is in excess of need

The purpose of this is to reflect the proclivity of cattle to spend more time in riparian areas near their water source. The implication is that more manure is directly deposited in these areas. The nine times pasture amount is only for the trampled riparioan pasture and only when there is manure in excess of crop and pasture need in a county.

5.3.5.1.1 Nutrient Management Application Rate

Nutrient management planners typically use soil test data for determining application rates. However, soil test data is not available on a county scale throughout the watershed. Where soil test data are not available to nutrient management planners, on-farm yield records are used. Should an on-farm yield record be unavailable, then regional databases or the Agricultural Census is used. In Scenario Builder only the Agricultural Census is used, because it is the only available data currently. Therefore, the nutrient management application rate is the best potential nutrient application rate that was calculated from the Agricultural Census.

5.3.5.1.2 Non-Nutrient Management Application Rate

The non-nutrient management rate is different from the nutrient management rate because of the way the yield is used. The non-nutrient management yield cannot be greater than the upper limit (1.05) of best potential application rate. This means that the non-nutrient management application rate is always higher than the nutrient management application rate. Where sewage sludge and manure are available, then the application rate for non-nutrient management will be even higher. In these cases, the rate is calculated as the maximum nutrient application rate – ((1- (Stored Nutrients / Maximum Application Rate)) * (1.05 of the best potential application rate. Thus, for non-nutrient management in counties where enough manure is generated or transported in to satisfy a rate above nutrient management, then manure is applied up to 5% greater than the best potential application rate. If manure remains, then manure is applied in a sequence on various crop types until the manure is depleted. This excess manure application is termed "disposal load".

Where starter fertilizer is specified as inorganic fertilizer and not manure, then there is likely to be excess manure that is applied using the "disposal load" logic. For instance, on the Eastern Shore, corn has approximately 75% of its need met by starter nutrients.

5.3.6 Nitrogen fixation

The Scenario Builder calculates the amount of nitrogen that is fixed by the plant on a monthly time-scale. Nitrogen fixation includes the portion fixed in the roots and taken up into the plant.

Legumes are a class of plants that generally grow pods. Legumes develop nodules on the roots that are a bacterial infection. These bacteria transform N_2 to NH_3, a process called nitrogen fixation. Thus, N is added to the plant-soil system from the air. The Scenario Builder reports the pounds/acre of ammonia (NH_3) that is fixed by crop, county, month, and year.

Leguminous plant types that are modeled are listed in Table 5-7. The Agricultural Census categories that include legumes but are not exclusively legumes are not considered for legume fixation. We do not calculate N fixation from these broader categories because the fraction of legumes is not known and can significantly vary at a plot scale (Table 5-8).

Each year is considered independent of all other years. Therefore, nutrients cannot accumulate in the soil in data produced by the Scenario Builder. It follows that N in the soil after one year may repress N fixation. This situation is not considered in the calculation of these data.

No N is fixed in the month of planting. It was assumed that the nodules take 2-4 weeks to establish. For subsequent months of growth, the total amount of NH_3 is parsed evenly. That means that the same amount of N is fixed in the second month of growing as in the final month before the plant senesces. A perennial, like alfalfa, will fix the same amount every month between emergence (plant date for annuals) and first hard frost (harvest date for annuals).

It was assumed that fixation occurs on all leguminous plants, which would require that legumes are inoculated or sufficient rhizobia are present. It also assumes that carbon is at optimum levels for fixation to occur.

Nitrogen fixation amounts are generally not adjusted for temperature or rainfall in Scenario Builder or in the Chesapeake Bay Program's Watershed Model. The exception is alfalfa. The Watershed Model users can choose whether to calculate alfalfa fixation or use the alfalfa fixation provided from Scenario Builder. As of October 14, 2008, nitrogen fixation for alfalfa will be calculated by the Watershed Model so that rainfall and temperature data can parameterize fixation amounts.

The Chesapeake Bay Program's Watershed Model accounts for processes that occur after N fixation, such as where crops are killed and left on the soil or incorporated into the soil, thereby returning N to the soil. These data are not included in Scenario Builder.

Many researchers have indicated that fertilizer applications in the form of NO_3 do not decrease N fixation by legumes (Johnson et al., 1975; Blumenthal et al., 1996). These data refute the dogma that NO_3 substitutes for fixed N where NO_3 is increased. Literature searches did not produce data that quantifies the reciprocality of the NO_3 sorption and N_2 fixation. Without identifying values of N fixation and the interaction with NO_3 for each leguminous plant, we are unable to consider these data in the Scenario Builder model. Therefore, Scenario Builder calculates N fixation so that if there is adequate N available to the plant from nutrient applications, then N fixation is suppressed. The implication is that if a farmer applies fertilizer to legumes, then N is not fixed.

Additionally, this parameter is based on the assumption that 50% of what is fixed is taken up into the plant. The remaining 50% is returned to the soil in crop residue or is in the roots and is released into the soil over the coming seasons. This does not mean it i available; it may become immobilized in the organic fraction. The portion returned at senescence is the nitrogen credit considered in nutrient management plans (PA Agronomy Guide 2007-2008, Table 1.2-7 and the Mid-Atlantic NM Handbook, 2006 Table 4.4).

The data in the Mid-Atlantic Nutrient Management Handbook summarized the 2005 PA Agronomy Guide, 2005 Maryland Nutrient Management Manual, Sims and Gartley 1996, and VaDCR 2005).

Equation 15: Adjusting nitrogen fixation downward when nitrogen is applied in the form of manure or fertilizer

$$\text{Nitrogen fixation rate} - \text{Actual applied rate} * 0.2021 = \text{new nitrogen fixation rate}$$

The ideal minus the actual is only considered when the amount < 0.

Where the amount fixed is < 0, the lower bound is set to zero. It is not possible for a plant to “unfix” nitrogen.

The only circumstance in which N is applied to leguminous plants is if there is manure in excess of crop need and it is applied to these leguminous crops as disposal load.

In New York, alfalfa is not persistent in years subsequent to planting. Within one to two years after planting, an alfalfa field typically only has 50% alfalfa. Yet, it is reported by the farmer to the Agricultural Census as an alfalfa crop. For this reason, New York N fixation by alfalfa was reduced by 50% in Scenario Builder.

The source of data for the soybean N fixation was based on a yield in Scenario Builder. For soybeans in Delaware, a yield of 30 lbs/acre was used. This was based on the average yield from Agricultural Census years between 1992 and 2002. For those states where fixation values were not reported for a crop, data was used from the nearest state that did report a value.

Table 5-7: Legumes for which N fixation is calculated.

NASS Crop Type	CBP Land use	CBP Land use abbreviation
Alfalfa hay	Alfalfa	Alf
Alfalfa seed	Alfalfa	Alf
Birdsfoot trefoil seed	hay-fertilized	HYW
Dry edible beans, excluding limas	Conventional or Conservation Tillage with Manure	HWM or LWM
Green Lima Beans	Conventional Tillage without Manure	HOM

Peanuts for nuts	Conventional or Conservation Tillage with Manure	HOM
Peas, Chinese (sugar and Snow)	Conventional Tillage without Manure	HOM
Peas, Green (excluding southern)	Conventional Tillage without Manure	HOM
Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc.	Conventional Tillage without Manure	HOM
Red clover seed	hay-fertilized	HYW
Snap Beans	Conventional Tillage without Manure	HOM
Soybeans for beans	Conventional or Conservation Tillage with Manure	HWM or LWM
Vetch seed	hay-fertilized	HYW

Table 5-8: NASS categories that include legumes, but are not exclusively legumes

NASS Crop Type	CBP Land use	CBP Land use abbreviation
Other tame hay	hay-fertilized	HYW
Pastureland and rangeland other than cropland and woodland pastured	Pasture	PAS
Wild hay	hay-unfertilized	HYO

Table 5-9: Nitrogen fixation rates by growth region, land use and crop.

Growth Region	Crop Name	Nitrogen Fixation (Lbs Per Acre)
DE_1	Alfalfa Hay Harvested Area	180
MD_1	Alfalfa Hay Harvested Area	300
MD_2	Alfalfa Hay Harvested Area	300
MD_3	Alfalfa Hay Harvested Area	300
NY_1	Alfalfa Hay Harvested Area	120
PA_1	Alfalfa Hay Harvested Area	240
PA_2	Alfalfa Hay Harvested Area	240

PA_3	Alfalfa Hay Harvested Area	240
VA_1	Alfalfa Hay Harvested Area	180
VA_2	Alfalfa Hay Harvested Area	180
VA_3	Alfalfa Hay Harvested Area	180
WV_1	Alfalfa Hay Harvested Area	180
DE_1	Alfalfa seed Harvested Area	180
MD_1	Alfalfa seed Harvested Area	300
MD_2	Alfalfa seed Harvested Area	300
MD_3	Alfalfa seed Harvested Area	300
NY_1	Alfalfa seed Harvested Area	120
PA_1	Alfalfa seed Harvested Area	240
PA_2	Alfalfa seed Harvested Area	240
PA_3	Alfalfa seed Harvested Area	240
VA_1	Alfalfa seed Harvested Area	180
VA_2	Alfalfa seed Harvested Area	180
VA_3	Alfalfa seed Harvested Area	180
WV_1	Alfalfa seed Harvested Area	180
DE_1	Birdsfoot trefoil seed Harvested Area	120
MD_1	Birdsfoot trefoil seed Harvested Area	80
MD_2	Birdsfoot trefoil seed Harvested Area	80
MD_3	Birdsfoot trefoil seed Harvested Area	80
NY_1	Birdsfoot trefoil seed Harvested Area	180
PA_1	Birdsfoot trefoil seed Harvested Area	180
PA_2	Birdsfoot trefoil seed Harvested Area	180
PA_3	Birdsfoot trefoil seed Harvested Area	180
VA_1	Birdsfoot trefoil seed Harvested Area	160
VA_2	Birdsfoot trefoil seed Harvested Area	160
VA_3	Birdsfoot trefoil seed Harvested Area	160
WV_1	Birdsfoot trefoil seed Harvested Area	160
DE_1	Dry edible beans, excluding limas Harvested Area	300
MD_1	Dry edible beans, excluding limas Harvested Area	300

MD_2	Dry edible beans, excluding limas Harvested Area	300
MD_3	Dry edible beans, excluding limas Harvested Area	300
NY_1	Dry edible beans, excluding limas Harvested Area	300
PA_1	Dry edible beans, excluding limas Harvested Area	300
PA_2	Dry edible beans, excluding limas Harvested Area	300
PA_3	Dry edible beans, excluding limas Harvested Area	300
VA_1	Dry edible beans, excluding limas Harvested Area	300
VA_2	Dry edible beans, excluding limas Harvested Area	300
VA_3	Dry edible beans, excluding limas Harvested Area	300
WV_1	Dry edible beans, excluding limas Harvested Area	300
DE_1	Green Lima Beans Harvested Area	300
MD_1	Green Lima Beans Harvested Area	300
MD_2	Green Lima Beans Harvested Area	300
MD_3	Green Lima Beans Harvested Area	300
NY_1	Green Lima Beans Harvested Area	300
PA_1	Green Lima Beans Harvested Area	300
PA_2	Green Lima Beans Harvested Area	300
PA_3	Green Lima Beans Harvested Area	300
VA_1	Green Lima Beans Harvested Area	300
VA_2	Green Lima Beans Harvested Area	300
VA_3	Green Lima Beans Harvested Area	300
WV_1	Green Lima Beans Harvested Area	300
DE_1	Peanuts for nuts Harvested Area	90
MD_1	Peanuts for nuts Harvested Area	90
MD_2	Peanuts for nuts Harvested Area	90

MD_3	Peanuts for nuts Harvested Area	90
NY_1	Peanuts for nuts Harvested Area	90
PA_1	Peanuts for nuts Harvested Area	90
PA_2	Peanuts for nuts Harvested Area	90
PA_3	Peanuts for nuts Harvested Area	90
VA_1	Peanuts for nuts Harvested Area	90
VA_2	Peanuts for nuts Harvested Area	90
VA_3	Peanuts for nuts Harvested Area	90
WV_1	Peanuts for nuts Harvested Area	90
DE_1	Peas, Chinese (sugar and Snow) Harvested Area	300
MD_1	Peas, Chinese (sugar and Snow) Harvested Area	300
MD_2	Peas, Chinese (sugar and Snow) Harvested Area	300
MD_3	Peas, Chinese (sugar and Snow) Harvested Area	300
NY_1	Peas, Chinese (sugar and Snow) Harvested Area	300
PA_1	Peas, Chinese (sugar and Snow) Harvested Area	300
PA_2	Peas, Chinese (sugar and Snow) Harvested Area	300
PA_3	Peas, Chinese (sugar and Snow) Harvested Area	300
VA_1	Peas, Chinese (sugar and Snow) Harvested Area	300
VA_2	Peas, Chinese (sugar and Snow) Harvested Area	300
VA_3	Peas, Chinese (sugar and Snow) Harvested Area	300
WV_1	Peas, Chinese (sugar and Snow) Harvested Area	300
DE_1	Peas, Green (excluding southern) Harvested Area	300
MD_1	Peas, Green (excluding southern) Harvested Area	300
MD_2	Peas, Green (excluding southern) Harvested Area	300
MD_3	Peas, Green (excluding southern) Harvested Area	300
NY_1	Peas, Green (excluding southern) Harvested Area	300
PA_1	Peas, Green (excluding southern) Harvested Area	300
PA_2	Peas, Green (excluding southern) Harvested	300

	Area	
PA_3	Peas, Green (excluding southern) Harvested Area	300
VA_1	Peas, Green (excluding southern) Harvested Area	300
VA_2	Peas, Green (excluding southern) Harvested Area	300
VA_3	Peas, Green (excluding southern) Harvested Area	300
WV_1	Peas, Green (excluding southern) Harvested Area	300
DE_1	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
MD_1	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
MD_2	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
MD_3	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
NY_1	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
PA_1	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
PA_2	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
PA_3	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
VA_1	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
VA_2	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
VA_3	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
WV_1	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300
DE_1	Red clover seed Harvested Area	120
MD_1	Red clover seed Harvested Area	80

MD_2	Red clover seed Harvested Area	80
MD_3	Red clover seed Harvested Area	80
NY_1	Red clover seed Harvested Area	180
PA_1	Red clover seed Harvested Area	360
PA_2	Red clover seed Harvested Area	360
PA_3	Red clover seed Harvested Area	360
VA_1	Red clover seed Harvested Area	160
VA_2	Red clover seed Harvested Area	160
VA_3	Red clover seed Harvested Area	160
WV_1	Red clover seed Harvested Area	160
DE_1	Snap Beans Harvested Area	300
MD_1	Snap Beans Harvested Area	300
MD_2	Snap Beans Harvested Area	300
MD_3	Snap Beans Harvested Area	300
NY_1	Snap Beans Harvested Area	300
PA_1	Snap Beans Harvested Area	300
PA_2	Snap Beans Harvested Area	300
PA_3	Snap Beans Harvested Area	300
VA_1	Snap Beans Harvested Area	300
VA_2	Snap Beans Harvested Area	300
VA_3	Snap Beans Harvested Area	300
WV_1	Snap Beans Harvested Area	300
DE_1	Soybeans for beans Harvested Area	30
MD_1	Soybeans for beans Harvested Area	40
MD_2	Soybeans for beans Harvested Area	40
MD_3	Soybeans for beans Harvested Area	40
NY_1	Soybeans for beans Harvested Area	130
PA_1	Soybeans for beans Harvested Area	130
PA_2	Soybeans for beans Harvested Area	130
PA_3	Soybeans for beans Harvested Area	130
VA_1	Soybeans for beans Harvested Area	40
VA_2	Soybeans for beans Harvested Area	40

VA_3	Soybeans for beans Harvested Area	40
WV_1	Soybeans for beans Harvested Area	40
DE_1	Vetch seed Harvested Area	300
MD_1	Vetch seed Harvested Area	300
MD_2	Vetch seed Harvested Area	300
MD_3	Vetch seed Harvested Area	300
NY_1	Vetch seed Harvested Area	300
PA_1	Vetch seed Harvested Area	300
PA_2	Vetch seed Harvested Area	300
PA_3	Vetch seed Harvested Area	300
VA_1	Vetch seed Harvested Area	200
VA_2	Vetch seed Harvested Area	200
VA_3	Vetch seed Harvested Area	200
WV_1	Vetch seed Harvested Area	200

5.3.7 Erodible Area (Area where sediment may be detached)

Scenario Builder calculates the area of land available to be eroded. There are two files that are inputs to the Watershed Model-HSPF – "detached sediment" and "crop cover". These data are used to determine the change in the monthly amount of erodible sediment. Data are provided at the land segment scale and by month as tons per acre. The area of bare soil is considered the amount available to be eroded. Therefore, we estimate the fraction of residue cover and canopy cover and assume the remainder is available for erosion.

Residue and canopy cover are calculated using the Revised Universal Soil Loss Equation modeling tool (RUSLE 2 Version 1.26.6.4). It should be noted that residue and canopy cover do not directly correlate to the percentage of bare ground and that neither of these values used alone or the values used in combination are the same as the percentage of the ground covered. However, we were able to achieve realistic results in a consistent manner across the entire Chesapeake Bay Watershed.

The greater of the two variables, residue cover and canopy cover, were used on a monthly time scale. An underestimation may result in early plant growth period for conservation till crops because residue may still be on the ground and leaf cover may not overlap. In conventional till crops most of the residue is plowed under at planting. This calculation is bound where the monthly value is greater than zero and less than 0.95. An alternative method of summing the residue and canopy cover was tested. This method provided less accurate results because canopy shades residue.

Crop residue cover is influenced by soil disturbance. Soil disturbance is determined by plant and harvest dates. Because more than one plant and harvest date may be provided for a crop, the crop residue cover calculations incorporate all planting and harvesting dates. Thus, subsequent plantings contribute to the amount of crop residue cover.

In general, the data are not representative of any individual site or situation. In addition, the data are not reflective of typical crop rotations used in the watershed. RUSLE 2 values should not be averaged. The planting dates used influence when the canopy cover numbers change. RUSLE 2 can show growth at any time of year, even if a crop will not grow at that time of year or in a given area. All data was generated without applying any other conservation practices or methods.

Variations in residue and canopy cover exist due to climatic variation, yields, tillage, and double cropping. How each of these variables was handled will be discussed in the following sections.

5.3.7.1 Spatial differentiation

The NRCS Crop Management Zones (CMZs) were used for generating spatial zones within the Bay region (Figure 5-5). The data in the CMZs are representative of typical planting dates and yields that are possible for a crop in the area. If more than one yield was available for a crop, a moderate yield was used. The information included in the CMZs is periodically updated and may vary from the information used in a different version. The templates used were those available in RUSLE 2 as of January 2009.

More than one Scenario Builder Growth Region may be represented by the same data set. Scenario Builder Growth Region MD 2 was divided into two areas—one east of the Bay and one west of the Bay. In the initial preparation of the dataset, the MD 2 East values were used for the entire MD 2 growing region. Quality control and assurance were performed in summer 2009 as the data were being more carefully prepared for use. These generalizations will be removed as part of that process. Kent and Queen Anne’s County in Maryland use the same data as MD 1. CMZ 4.1 was used to generate the data for NY 1 and PA 1; CMZ 65.0 for PA 2 and MD 3; CMZ 66.0 for MD 2 West and VA 2; CMZ 65.0 for MD 1 and PA 3; CMZ 62.0 for WV 1; CMZ 59.0 for MD 2 east and DE 1; CMZ 67.0 for VA 1; and CMZ 64.0 for VA 3.

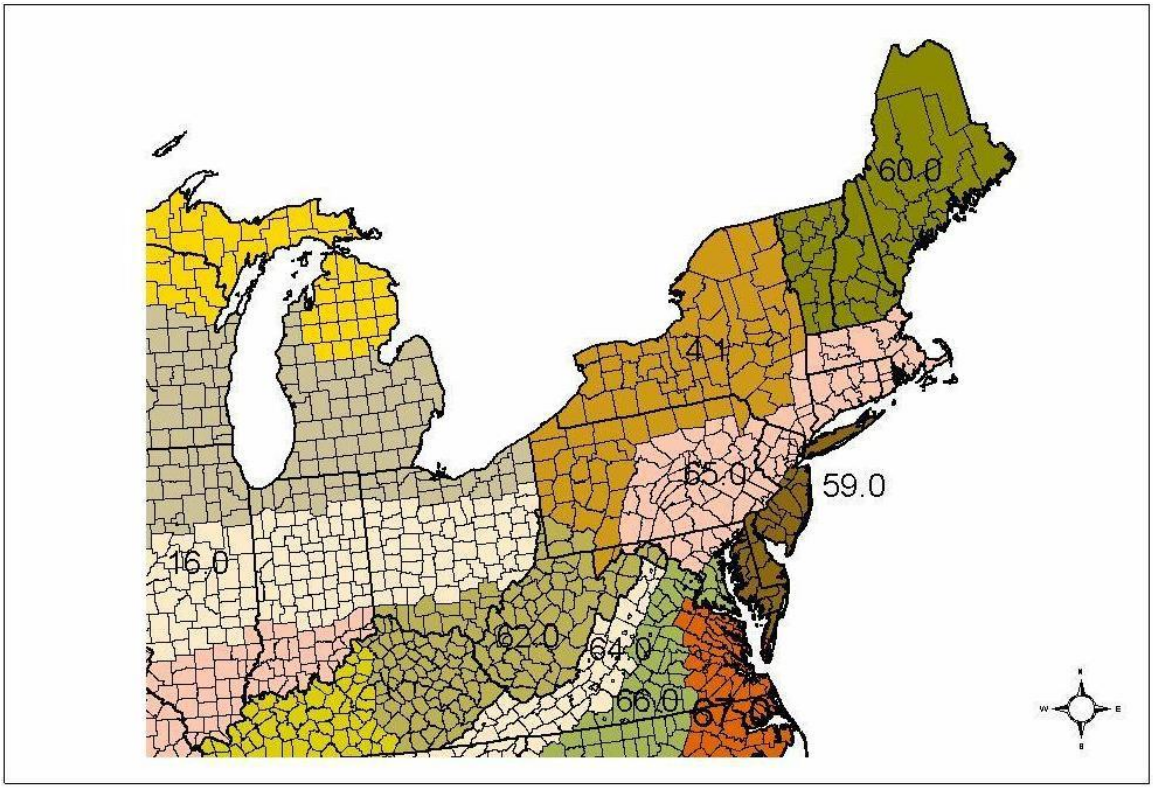

Figure 5-5: RUSLE 2 Crop Management Zones

5.3.7.2 Tillage

One of the most important variations in erodible land data is in the tillage practice. The Chesapeake Bay Program currently recognizes two different tillage practices: low till and high till. Low till is generally equated as conservation till and high till is generally equated with conventional till. NRCS Practice Standard 345 for Residue Management Mulch Till states, "The annual Soil Tillage Intensity Rating (STIR) value for all soil-disturbing activities shall be no more than 70 for high residue crops (e.g., grain corn) and no more than 10 for low residue crops (e.g., grain, soybeans). These STIR values will result in approximately 30% or more surface residue for the entire crop rotation." By using the RUSLE 2 tillage management practices, the data necessarily meets the conservation tillage STIR values. Conventional establishment was usually represented by moldboard plowing and conservation tillage was usually represented by no-till planting methods as appropriate to the crop. The tillage method has minimal impact on the crop canopy but a major impact on the residue.

5.3.7.3 Continuous monoculture

The RUSLE 2 single year crop templates were used for annual crops and a non-establishment year was used for perennial crops. When using continuous monoculture, RUSLE 2 assumes a one-year rotation, where the same crop is grown with the same method year after year. This will potentially underestimate residue for fragile residue crops and overestimate residue for coarse residue crops. This is especially true in low till systems. In most places in the Chesapeake Bay Watershed, crops are not typically grown in a continuous fashion. Usually crops are grown as part of a rotation. This process of single crops is particularly limited for fruit and vegetables, which may have several crops in the same year. There are also differences in the timing and staggering of planting of fruit and vegetable production for direct sale versus processing purposes.

5.3.7.4 Data generalizations among crops

Where there were missing data for a particular crop in a particular growing region, values from the nearest growing region were used. The fruit and vegetable cover data was generalized among similar plants according to viney or bushy plant character. Turf grass (urban lawns) did not have a value generated from RUSLE 2 and 0.95 was used for the entire year. For cultivated summer fallow cropland and idle cropland, a consistent value of 0.05 was used. Failed crops were assigned a consistent value of 0.2. Many nursery crops that are grown out in the open used a consistent value of 0.5.

RUSLE 2 crop cover data does not contain data for all the crops in SB. Missing crop cover values were replicated from the same crop type from surrogate regions. The surrogate regions were defined base on physiographic region and proximity (Table 5-10). Surrogate crops data was used to replicate crops with no cover data. Surrogate crops are listed in Table 5-11.

Table 5-10: The surrogate regions based on physiographic region and proximity

Growth region	Surrogate region 1	Surrogate region 2	Surrogate region 3	Surrogate region 4	Surrogate region 5	Surrogate region 6	Surrogate region 7	Surrogate region 8	Surrogate region 9	Surrogate region 10	Surrogate region 11	Surrogate region 12	Surrogate region 13
DE_1	MD_2 east	MD_2 west	VA_1	MD_1	all regions	VA_2	VA_3	MD_3	PA_1	PA_2	PA_3	WV_1	NY_1
MD_1	PA_3	VA_2	MD_2 west	all regions	DE_1	MD_2 east	MD_3	PA_1	PA_2	VA_1	VA_3	WV_1	NY_1
MD_2 east	DE_1	MD_2 west	VA_1	MD_1	all regions	VA_2	VA_3	PA_2	PA_3	MD_3	PA_1	WV_1	NY_1
MD_2 west	MD_2 east	DE_1	VA_1	MD_1	all regions	VA_2	VA_3	MD_3	PA_1	PA_2	PA_3	WV_1	NY_1
MD_3	WV_1	PA_2	VA_3	PA_1	all regions	MD_1	PA_3	MD_2 east	MD_2 west	VA_2	DE_1	VA_1	NY_1
NY_1	PA_1	PA_2	MD_3	WV_1	all regions	PA_3	MD_1	MD_2 west	MD_2 east	VA_2	VA_3	DE_1	VA_1
PA_1	NY_1	PA_2	MD_3	WV_1	all regions	PA_3	VA_3	MD_1	MD_2 east	MD_2 west	VA_2	DE_1	VA_1
PA_2	MD_3	WV_1	PA_3	VA_3	all regions	PA_1	NY_1	MD_1	MD_2 east	MD_2 west	VA_2	DE_1	VA_1
PA_3	MD_1	PA_2	VA_2	all regions	DE_1	MD_3	MD_2 east	MD_2 west	VA_3	WV_1	PA_1	VA_1	NY_1
VA_1	MD_2 east	MD_2 west	DE_1	all regions	VA_2	MD_1	MD_3	PA_1	PA_2	PA_3	VA_3	WV_1	NY_1
VA_2	MD_1	PA_3	MD_2 west	all regions	MD_3	MD_2 east	PA_1	PA_2	VA_1	DE_1	VA_3	WV_1	NY_1
VA_3	WV_1	MD_3	PA_2	PA_1	all regions	VA_2	MD_1	PA_3	MD_2 east	MD_2 west	VA_1	DE_1	NY_1
WV_1	MD-3	VA_3	PA_2	PA_1	all regions	VA_2	MD_1	PA_3	MD_2 east	MD_2 west	VA_1	DE_1	NY_1

Table 5-11. Surrogate crops.

Missing Crop	Surrogate Crop
Turfgrass	Other managed hay Harvested Area
Aquatic plants Area	no actions
Aquatic plants Protected Area	no actions
Asparagus Harvested Area	Cotton Harvested Area
Bedding/garden plants Area	no actions
Bedding/garden plants Protected Area	no actions
Birdsfoot trefoil seed Harvested Area	Alfalfa Hay Harvested Area
Bromegrass seed Harvested Area	Other managed hay Harvested Area
Brussels Sprouts Harvested Area	Peanuts for nuts Harvested Area
Bulbs, corms, rhizomes, and tubers – dry Harvested Area	Peanuts for nuts Harvested Area
Bulbs, corms, rhizomes, and tubers – dry Protected Area	no actions
Cauliflower Harvested Area	Cotton Harvested Area
Celery Harvested Area	Cotton Harvested Area
Cropland idle or used for cover crops or soil improvement but not harvested and not pastured or grazed Area	Other managed hay Harvested Area
Cropland in cultivated summer fallow Area	Cotton Harvested Area
Cropland on which all crops failed or were abandoned Area	Cotton Harvested Area
Cropland used only for pasture or grazing Area	Other managed hay Harvested Area
Cut flowers and cut florist greens Area	Cotton Harvested Area
Cut flowers and cut florist greens Protected Area	no actions
Dry edible beans, excluding limas Harvested Area	Soybeans for beans Harvested Area
Escarole and Endive Harvested Area	Peanuts for nuts Harvested Area
Fescue Seed Harvested Area	Other managed hay Harvested Area
Foliage plants Area	no actions
Foliage plants Protected Area	no actions
Garlic Harvested Area	Peanuts for nuts Harvested Area
Green Lima Beans Harvested Area	Soybeans for beans Harvested Area
Greenhouse vegetables Area	no actions
Greenhouse vegetables Protected Area	no actions
Herbs, Fresh Cut Harvested Area	Cotton Harvested Area
Mushrooms Area	Peanuts for nuts Harvested Area

Mushrooms Protected Area	no actions
Nursery stock Area	Peanuts for nuts Harvested Area
Nursery stock Protected Area	no actions
Orchardgrass seed Harvested Area	Other managed hay Harvested Area
Other field and grass seed crops Harvested Area	Other managed hay Harvested Area
Other haylage, grass silage, and greenchop Harvested Area	Other managed hay Harvested Area
Other nursery and greenhouse crops Area	no actions
Other nursery and greenhouse crops Protected Area	no actions
Parsley Harvested Area	Peanuts for nuts Harvested Area
Popcorn Harvested Area	Corn for Grain Harvested Area
Potted flowering plants Area	no actions
Potted flowering plants Protected Area	no actions
Radishes Harvested Area	Peanuts for nuts Harvested Area
Rhubarb Harvested Area	Cotton Harvested Area
Ryegrass seed Harvested Area	Other managed hay Harvested Area
short-rotation woody crops Harvest Area	Cotton Harvested Area
short-rotation woody crops Production Area	Cotton Harvested Area
Small grain hay Harvested Area	Barley for grain Harvested Area
Sod harvested Protected Area	Other managed hay Harvested Area
Squash Harvested Area	Peanuts for nuts Harvested Area
Timothy seed Harvested Area	Other managed hay Harvested Area
Turnips Harvested Area	Peanuts for nuts Harvested Area
Vegetable & flower seeds Area	Cotton Harvested Area
Vegetable & flower seeds Protected Area	no actions
Vegetables, Mixed Area	Peanuts for nuts Harvested Area
Vegetables, Other Harvested Area	Peanuts for nuts Harvested Area
Vetch seed Harvested Area	Alfalfa Hay Harvested Area
Wild hay Harvested Area	Other managed hay Harvested Area

5.3.7.5 Pasture

Pasture cover data should be regarded with special care and considered as general guidance. Pastures vary greatly in management and grazing frequency and this variability is much greater than the management options in agronomic fields. The grazing variability particularly impacts canopy cover. Because of this management and impact variability, there are many limitations to using pasture cover values from RUSLE 2. RUSLE 2 is scheduled to be updated in late 2009 to better represent pastures. Other options for addressing pasture cover may involve summing the residue and canopy cover rather than selecting the greater of the two for any given date. This option may be explored for a later release of Scenario Builder.

5.3.7.6 Double cropping

Double cropping cover is addressed by classifying a double-cropped crop as its own crop type with different plant and harvest dates than the same crop that is not double-cropped. Since the first crop planted is not considered as the double-crop, then those dates are not shortened to reflect what may be an earlier harvest. Therefore, there may be some overestimate of cover from leaf area coverage and an underestimate of residue cover during the harvest time of the first crop and the planting time of the double crop. Cover values for double cropping are the same as single crops. Variation is addressed by differences in plant and harvest dates.

5.3.7.7 Detached sediment calculation

The purpose of the detached sediment logic is to determine the rate of increase in the monthly amount of erodible sediment for each land area in a given year in units of tons per acre. This rate of increase is calculated as sediment in tons per month. Key factors needed are the growing area, crop name, crop acreage, planting and harvesting dates, and a reference table containing crop-specific rates of sedimentation (months after planting).

The amount of erodible sediment must be determined for a crop. The erodible sediment rate is influenced by soil disturbance (determined from planting and harvest dates). For each combination of crop and till class (hi/low) a monthly increase in the amount of erodible sediment will be calculated in tons/acre. Each crop type has a specified plant and harvest date. There are more than one type of soybeans, for example—a long-season soybean crop type that is not double-cropped, and a short-season soybean crop that is double-cropped. With more plantings in a year, the liklihood of increased detached sediment increases.

The erodible sediment for each crop should be weighted by the crop-specific acreage and summarized by land segment, land use, and month. The weighting for the crop –specific acreage is simply the acreage multiplied by the monthly rate and then divided by the total acreage.

6 NUTRIENT MASS APPORTIONING WITH TEMPORAL AND SPATIAL CHARACTER

Nitrogen and phosphorus are applied to crops and turf in urban areas according to plant growth requirements. The plant growth requirements were established as application rates, discussed in Section 5.

Scenario Builder applies nutrients in a sequence, intended to mirror the applications in order of unavoidable, regulatory, highest priority, and then least damaging from an economic point of view. The unavoidable nutrient application is the amount of manure that goes on pasture that is directly excreted from the animals. The regulatory applications are a result of CAFO manures being applied to meet nutrient management crop needs before AFO manure is applied. The highest priority applications are those that are high-value crops and would be a priority for a farmer. Lastly, manure may be applied simply as a way to dispose of excess. We assume that a farmer will do this application in such a way as to avoid harming crops. Nutrient over application could cause lodging in grains or other harmful effects on plants. This is least likely to occur on hay and pasture crops so application greater than plant need may occur where excess manure is produced.

The sequence of nutrient application is described in order in the following sections.

6.1 Manure Applied through Direct Excretion

Manure is applied to pasture according to the amount of animals in a county and the amount of time that animal type spends in the pasture. These data are calculated on a monthly time scale for each county, keeping animal type distinct.

Even where there are animals in a county that typically would be pastured, if there are no pasture acres in that county, then there is no manure applied as direct excretion. Therefore, all of that animal type's manure will be stored and applied to cropland.

BMPs may impact the amount of nutrients from direct excretion by reducing the concentration of nitrogen or phosphorus in the manure, as with phytase feed additive.

Manure applied via direct excretion is not considered as a component meeting the application rate. For example, if the application rate for a pasture were 25 lbs-N/acre and there were a herd of beef cattle pastured all the time on that land, then the amount of direct excretion on that land would not contribute toward meeting that 25 lb-N/acre rate. If a large herd were pastured much of the time a significant amount of manure would be directly excreted. On top of the direct excretion, the 25 lb-N/acre would also be applied.

Stored manure may augment the manure directly excreted on pasture, but direct excretion can only be applied to pasture and not other land uses. Livestock are sometimes foraged on harvested crop land. The Scenario Builder does not account for direct excretion of livestock on harvested crop land. The amount of time livestock are on this land is considered insignificant (Doug Goodlander, PA State Conservation Commission, personal communication, 2008). Moreover, NASS data does not track this item and no source of data on the number of livestock or days livestock spend on these lands was available.

6.2 Manure Applied to Animal Production Areas (Storage loss manure)

The sum of manure that was removed due to storage loss is applied to land classified as Animal Feeding Operation (AFO) or Concentrated Animal Feeding Operation (CAFO). These areas are considered the animal production areas. The lost manure is applied evenly across months and the data on the amount of manure from each animal type is kept distinct. Manure is applied to C/AFO in the county in which it was produced. All of the nutrients in storage loss manure are applied to the C/AFO edge of stream load after BMPs have been applied. The ammonia reduction BMP reduces the amount of nitrogen available to be applied to C/AFO land.

6.3 Inorganic-only Fertilizer Application

Where nutrient application is specified as inorganic only, no manure, it is referred to as "starter". This is a misnomer for those who work in agriculture, where starter is typically defined as fertilizer put down prior to or at the time of planting. In the context of Scenario Builder, starter is a nutrient application that is only fertilizer. So, starter includes side-dress, for example.

The starter fertilizer application amount is specified by crop type, county, and timing. Many crop types have split applications and some of the nutrient applications may be manure and some inorganic fertilizer. Starter fertilizer is considered a portion of the total amount applied toward meeting the application rate. These nutrient applications are applied prior to the manure distribution. This means that in counties even where there is excess manure, there will also be some inorganic fertilizer applied.

6.4 Biosolids Application

Biosolids, or sewage sludge, is applied next in the sequence of nutrient applications. Since biosolids are applied in the sequence prior to manure nutrients AND the priority of lands begins with regulated (like nutrient management) then the crop need will be met earlier where biosolids are available and on nutrient management land. Note that the source of biosolids data is from each state in the watershed. The only jurisdiction that provided biosolids data was Virginia. Therefore, in Virginia, there is likely to be more excess nutrients from manure in counties with biosolids and a high acreage of regulated land.

Biosolids data is provided with the amount in an annual total. This annual amount is proportioned across the months based on the unmet amount in the application rate. A crop is eligible to receive biosolids if it is on a land use that is eligible to receive manure.

The crop type, nutrient type, and month are all kept distinct throughout this calculation. If there is remaining biosolids remaining after the application rate is met, then an error is logged with the amount of biosolids that could not be applied and reported to the user.

A modification to apportion the biosolids to various crops with a preference toward certain months that changes prior to 1997 was not implemented as of June 2009.

6.5 Manure Application

Manure follows next in the sequence of application. A crop may receive manure if it is a crop specified as a type that is eligible to have a manure application. Fruits and vegetables are among those that are not eligible to receive manure, for example. A crop is also eligible to receive manure if the application rate was not already met by starter or biosolids. Direct excretion manure does not count toward meeting the crop application need.

Equation 16: Amount of manure available to be applied

> Manure produced – direct excretion – feed additive BMPs – ammonia reduction BMPs – volatilization – storage loss – plus/minus manure transport = available manure

This manure is assumed to have been stored. Data are unavailable on the type and capacity of manure storage facilities throughout the Chesapeake Bay Watershed. Therefore, manure is available by an annual total. It is assumed that manure is applied only when the crop could utilize the nutrients. It follows that manure storage is available to handle the volume produced until applied. Therefore, there is an assumption of no winter application of manure (since crops are not growing in winter and cannot utilize the manure). Manure is applied based on nutrient application rates and optimal crop use based on regional planting dates.

In the models, the manure from animals designated as CAFO is applied prior to the manure from animals designated as AFO. The CAFO and AFO split of animals was informed by data supplied by the states.

The annual amount of stored manure is proportioned across the months based on the unmet application rate amount. Manure is a limited nutrient, so it is applied in a priority order. The priority order is determined by crop sets.

Crops are grouped into sets; each set may have a member of one crop, or may be grouped so that many crops comprise one set. Sets can be configured so they are comparable to Watershed Model-HSPF land uses. Application of the nutrients within each nutrient type category (starter, biosolids, manure, and/or fertilizer) is proportional among the crops in each set where the nutrient is limited. Limited nutrients are biosolids and manure.

All crops in the first set receive manure nutrients prior to the subsequent set of crops. Where there is not enough manure to meet the application rate in any one set, then the manure is proportioned evenly among all the crops in that crop set, simultaneously.

In the models, biosolids and manure are applied to crops in sets, so each crop within the set each receives nutrient applications in the same ratio of manure to fertilizer rather than one crop receiving primarily manure and the others receiving primarily fertilizer. The next set in the sequence would not have any manure available.

The crop sets are ordered differently for AFO manure than for CAFO manure and the biosolid nutrient source. For CAFO and biosolids, nutrient management crops comprise the first sets and non-nutrient management crops comprise the subsequent sets. Biosolids and then CAFO manure are spread to nutrient management crops before being applied to non-nutrient management crops. AFO manure is applied to nutrient management and non-nutrient management crop sets at the simultaneously.

Likewise, manure is proportioned over months where there is inadequate amount to meet the full application rate. For example, if 80% of the annual need can be met by manure, then for each month that receives a nutrient application, 80% of the need will be met by manure. The remaining 20% of every month that receives application will receive nutrients from inorganic fertilizer.

Crop, animal type, nutrient, and month are all kept distinct when tracking this data.

6.5.1 Mineralization

A portion of manure N and P is mineralized. The portion of organic N and organic P mineralized during the first year is included in the calculation of plant available nutrients. The other portion of the manure, which includes organic N that is not mineralized, is applied to the land as well.

This means that an acre of corn with an application rate of 100 lb-N/acre will receive different masses of N depending on the nutrient source. If there are no animals in that county, then the corn acre will receive 100 lb of TN in the form of inorganic fertilizer. If there are all broilers in that county, then the corn acre will receive 148 lb of TN because there are 100 lbs of available nitrogen in broiler manure. The inorganic fertilizer composition is 75 lb NH_3 and 25 lb NO_3. The broiler manure is 0.26 lb NH_3/lb manure, 0.43 lb organic N/lb manure, 0.65 lb mineralized N/lb manure, and 0.0 lb NO_3/lb manure (Table 6-1). The nitrogen application rate is met through the nutrient forms of NH_3, mineralized N, and NO_3. The organic N is also applied, but not counted toward the application rate.

Table 6-1: Nutrient comparison of fertilizer and broiler manure

Nutrient	Fertilizer	Broiler manure (lb-nutrient/lb-manure)
NH_3	0.75	0.0026
Organic N	0	0.0043
Mineralized N	0	0.0065
NO_3	0.25	0

6.5.2 Inflation of Nutrient Management Land Applications under Certain Circumstances

The Watershed Model-HSPF Phase 5.2 was calibrated with crops grouped into sets that matched the Watershed Model-HSPF land uses. Since land uses are distinguished by nutrient management, and the crop sets were grouped so that nutrient management land uses were first in the sequence for biosolids and CAFO manure, then the nutrient management land was more likely to have manure applied than inorganic fertilizer. This, combined with the starter fertilizer and mineralization factor, means that the total nutrients applied on nutrient management land appear higher than those on non-nutrient management land even though the application rate is higher for non-nutrient management land.

6.5.3 Disposal of Manure beyond Meeting Crop Application Rate

Manure that exceeded the application rate in the county in which it was produced is spread in additional applications according to state submissions for each growth region. Generally, this sequence is: alfalfa, conventional tillage land, hay, conservation tillage lands, and pasture followed by the nutrient management versions of those land uses. This disoposal load of manure is applied after the inorganic fertilizer application.

If there is still excess after applying to all of these crops on these land uses, then an error is logged with the amount of disposal load that could not be applied.

The amount applied is proportioned across the months equally. The monthly allocation for each crop in the land use(s) is applied based on the proportion of acres in the crop to the total acres of the crops in the land use(s).

6.6 Inorganic Fertilizer Application

Inorganic fertilizer is applied last in the sequence of nutrient application. Where the application rate has not already been met with manure, then inorganic fertilizer is applied to meet the nutrient management application rate. It is not a limited nutrient and is never under or over-applied.

Chemical fertilizer is assumed to be mixed to specification. If N was met through manure, then chemical fertilizer containing only P may be applied. This is a more precise use of chemical fertilizers than may be typical in the Chesapeake Bay Watershed.

For urban lawns, or turf grass, the nutrients are only applied to all areas in the regulated, non-regulated, and CSS pervious developed urban land uses.

6.1 Nitrogen or Phosphorus-Based Nutrient Plan

Manure nutrients may be applied on either an N or P-based nutrient management plan acres. Depending on whether an N or P-based plan is selected, then the opposite nutrient (P for an N-based plan) may be over or under applied depending on manure content of an animal type and crop application rate requirements. Remaining secondary nutrient need is only considered when applying fertilizer.

6.2 Septic System load

Septic systems are commonly designed so that the waste goes into a tank, where solids sink to the bottom, and liquids flow through to a septic field. While some phosphorus can become soluble, in this model, we assume that only nitrogen is distributed to the septic field.

To calculate the amount of nitrogen generated from septic systems, we used the number of people on septic systems in the Chesapeake Bay Watershed. This question was asked on the 1990 U.S. Census, but was removed in subsequent censuses. To estimate this number, we calculate the ratio of the number of people in a county on septic to the total number of people in the county from 1990. That ratio is multiplied by the total population in the county, projected from the U.S. Census. The number of people in a county on septic is determined from the average of the household size.

Equation 17: Number of people in a county on septic for each year

(No. of people on septic in 1990 / no. of people in 1990) * total population of year being calculated

Using the average household size and the number of septic systems on a land-river segmentation scale, we apply a value of 8.92 lbs-N / person / year and assume a 60% attenuation rate.

Equation 18: Septic load

Total population on septic * 8.92 lbs-N / person * 0.40

7 APPORTIONING DATA TO THE WATERSHED MODEL - HSPF SEGMENTATION AND LAND USE CLASSIFICATIONS

The Scenario Builder model performs calculations at a county scale. Output may also be delivered at the Watershed Model-HSPF scale (Figure 7-1). Each model segment has up to 31 land uses. Data is narrowed to the Watershed Model-HSPF scale using an area weighted average. Methods for creating the land use data and apportioning it to the Watershed Model-HSPF scale are described in detail in the following sections.

Figure 7-1: Scale of Watershed Model-HSPF Phase 5 Output.

7.1 Using Land Cover Data to Create the Land Use Data

Land cover data are integrated and used to inform the area in each land use for each of the Watershed Model-HSPF's segments. These calculations are performed in the Chesapeake Bay Land Change Model (CBLCM) developed by Peter Claggett in 2008. The CBLCM forecasts the proportional future growth in urban land and resulting proportional loss of forests and agricultural for each Watershed Model segment. These segments are named land river segments, or lrsegs.

For each Watershed Model segment, the proportional increase in total urban area is distributed proportionally to the five urban land uses reported for the base year of the forecast. For example, a forecasted growth of 100 urban acres from 2002 to 2010 in LRseg *x* should be distributed to the five urban land use classes in LRseg *x* reported in the 2002 land use dataset used as part of the Phase 5.3 calibration. The resulting increase in total urban area is then subtracted proportionally from the total of all forest land uses (e.g., forests + harvested forests) and from the total of all agricultural land uses reported in the 2002 land use dataset for LRseg *x*.

All of the proportions of urban, forest, and agricultural land uses relative to the total urban, total forest, and total agricultural land uses are kept constant through time.

However, an iterative mass balance routine must be implemented to maintain total land acres in each LRseg while preventing any one land use (e.g., hay with manure) from falling into negative acres. Negative land use acres must be redistributed to other related land uses. For example, if “hay with manure” is forecasted to fall below zero acres in year 2010 then “hay with manure” must be set to zero and the deficit acres subtracted proportionally from all remaining agricultural land uses. This correction must be run iteratively until all land uses contain zero or more acres. Note that Animal Feeding Operations, Extractive, Nursery, and Open Water were kept constant throughout the forecast period.

7.2 Assembling Land Use Data from Multiple Data Sets

The total segment area and water areas are never changed. Other land use areas may be changed to accommodate the segment area and water areas. This is done in a recursive procedure in a set order. Agricultural land use area is derived from the Agricultural Censuses. Urban area is determined with the CBLCM. Forest is found by subtraction from all other calculated areas. When forest is found to be negative, the land use is set to zero and the urban land uses are proportionally reduced to make up the balance and finally Ag land uses are proportionally reduced. Harvested forest is assumed to be 1% of the total forest acres in each county. This factor is set on a county basis, so more specific county data can be incorporated.

7.2.1 Determining Agricultural and Crop Areas on Each Land use

The agricultural land use area is derived from the sum of all agricultural land uses in Scenario Builder. The acres of crops from Table 7-1 in Ag Census are summed into the respective Scenario Builder land use and the total represents the Agricultural area. In Scenario Builder there are 11 land uses attributed to aggregate crop types, three land uses are pasture, and two are animal production areas.

The pasture type, degraded riparian pasture (TRP), is equal to the amount acreage reported by the Bay jurisdictions in the Tributary Strategies. The regular pasture acres are then reduced according to the TRP acreage.

All calculations in the Scenario Builder are at the crop level. The Scenario Builder may accommodate infinite crop types. For the Watershed Model-HSPF Phase 5.2 calibration, most of the crops reported in the NASS Agricultural Census are used (exceptions include ginseng and dried herbs).

For data reported to the Watershed Model - HSPF, the crops are summed into Watershed Model land uses. The matrix of the crop or groups of crops in the Scenario Builder which make up each Watershed Model land category is in Table 7-1. The Watershed Model land uses have nutrient management and conservation versus conventional tillage analogues for most of the land categories in the matrix. The nutrient management and tillage analogues do not affect which crop is in each land use and are not reported separately in Table 7-1. The land uses that have nutrient management analogues include: alfalfa, row with manure, row without manure, hay with nutrients, and pasture. The land uses that have low-till (conservation) tillage analogues include: row with manure and nutrient management row with manure.

Table 7-1: Crops and the land use to which they are applied

Crop ID	Crop Name	Land use ID	Land use
1	Alfalfa Hay Harvested Area	7	Alfalfa
3	Alfalfa seed Harvested Area	7	Alfalfa
7	Aquatic plants Area	6	Nursery
8	Aquatic plants Protected Area	6	Nursery
9	Asparagus Harvested Area	2	Row without manure
10	Barley for grain Harvested Area	1	Row with manure
12	Bedding/garden plants Area	6	Nursery
13	Bedding/garden plants Protected Area	6	Nursery
14	Beets Harvested Area	2	Row without manure
15	Berries- all Harvested Area	2	Row without manure
17	Birdsfoot trefoil seed Harvested Area	3	Hay with nutrients
19	Broccoli Harvested Area	2	Row without manure
20	Bromegrass seed Harvested Area	3	Hay with nutrients
22	Brussels Sprouts Harvested Area	2	Row without manure
23	Buckwheat Harvested Area	1	Row with manure
25	Bulbs, corms, rhizomes, and tubers – dry Harvested Area	6	Nursery
26	Bulbs, corms, rhizomes, and tubers – dry Protected Area	6	Nursery
27	Canola Harvested Area	1	Row with manure
29	Cantaloupe Harvested Area	2	Row without manure
30	Carrots Harvested Area	2	Row without manure
31	Cauliflower Harvested Area	2	Row without manure
32	Celery Harvested Area	2	Row without manure
33	Chinese Cabbage Harvested Area	2	Row without manure

34	Collards Harvested Area	2	Row without manure
35	Corn for Grain Harvested Area	1	Row with manure
37	Corn for silage or greenchop Harvested Area	1	Row with manure
39	Cotton Harvested Area	2	Row without manure
41	Cropland idle or used for cover crops or soil improvement but not harvested and not pastured or grazed Area	4	Hay without nutrients
42	Cropland in cultivated summer fallow Area	4	Hay without nutrients
44	Cropland on which all crops failed or were abandoned Area	3	Hay with nutrients
45	Cropland used only for pasture or grazing Area	5	Pasture
46	Cucumbers and Pickles Harvested Area	2	Row without manure
47	Cut Christmas Trees Production Area	2	Row without manure
48	Cut flowers and cut florist greens Area	6	Nursery
49	Cut flowers and cut florist greens Protected Area	6	Nursery
50	Dry edible beans, excluding limas Harvested Area	1	Row with manure
52	Dry Onions Harvested Area	2	Row without manure
53	Eggplant Harvested Area	2	Row without manure
54	Emmer and spelt Harvested Area	1	Row with manure
56	Escarole and Endive Harvested Area	2	Row without manure
58	Fescue Seed Harvested Area	3	Hay with nutrients
64	Foliage plants Area	6	Nursery
65	Foliage plants Protected Area	6	Nursery
68	Garlic Harvested Area	2	Row without manure
69	Green Lima Beans Harvested Area	2	Row without manure
70	Green Onions Harvested Area	2	Row without manure

71	Greenhouse vegetables Area	6	Nursery
72	Greenhouse vegetables Protected Area	6	Nursery
76	Haylage or greenchop from alfalfa or alfalfa mixtures Harvested Area	7	Alfalfa
78	Head Cabbage Harvested Area	2	Row without manure
79	Herbs, Fresh Cut Harvested Area	2	Row without manure
80	Honeydew Melons Harvested Area	2	Row without manure
81	Kale Harvested Area	2	Row without manure
84	Land in Orchards Area	2	Row without manure
86	Lettuce, All Harvested Area	2	Row without manure
87	Mushrooms Area	1	Row with manure
88	Mushrooms Protected Area	1	Row with manure
89	Mustard Greens Harvested Area	2	Row without manure
90	Nursery stock Area	6	Nursery
249	Nursery stock Area on hom	2	Row without manure
91	Nursery stock Protected Area	6	Nursery
94	Oats for grain Harvested Area	1	Row with manure
96	Okra Area	2	Row without manure
97	Orchard grass seed Harvested Area	3	Hay with nutrients
101	Other field and grass seed crops Harvested Area	3	Hay with nutrients
103	Other haylage, grass silage, and greenchop Harvested Area	3	Hay with nutrients
105	Other managed hay Harvested Area	3	Hay with nutrients
107	Other nursery and greenhouse crops Area	6	Nursery
108	Other nursery and greenhouse crops Protected Area	6	Nursery
109	Parsley Harvested Area	2	Row without manure
111	Pastureland and rangeland other than	5	Pasture

	cropland and woodland pastured Area		
112	Peanuts for nuts Harvested Area	2	Row without manure
114	Peas, Chinese (sugar and Snow) Harvested Area	2	Row without manure
115	Peas, Green (excluding southern) Harvested Area	2	Row without manure
116	Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	2	Row without manure
117	Peppers, Bell Harvested Area	2	Row without manure
118	Peppers, Chile (all peppers – excluding bell) Harvested Area	2	Row without manure
119	Popcorn Harvested Area	1	Row with manure
121	Potatoes Harvested Area	2	Row without manure
123	Potted flowering plants Area	6	Nursery
124	Potted flowering plants Protected Area	6	Nursery
125	Pumpkins Harvested Area	2	Row without manure
126	Radishes Harvested Area	2	Row without manure
127	Red clover seed Harvested Area	3	Hay with nutrients
129	Rhubarb Harvested Area	2	Row without manure
130	Rye for grain Harvested Area	1	Row with manure
132	Ryegrass seed Harvested Area	3	Hay with nutrients
134	short-rotation woody crops Harvest Area	2	Row without manure
135	short-rotation woody crops Production Area	2	Row without manure
136	Small grain hay Harvested Area	3	Hay with nutrients
138	Snap Beans Harvested Area	2	Row without manure
139	Sod harvested Area	1	Row with manure
140	Sod harvested Protected Area	6	Nursery
141	Sorghum for Grain Harvested Area	1	Row with manure

143	Sorghum for silage or greenchop Area	1	Row with manure
145	Soybeans for beans Harvested Area	1	Row with manure
147	Spinach Harvested Area	2	Row without manure
148	Squash Harvested Area	2	Row without manure
153	Sunflower seed, non-oil varieties Harvested Area	1	Row with manure
155	Sunflower seed, oil varieties Harvested Area	1	Row with manure
157	Sweet Corn Harvested Area	2	Row without manure
158	Sweet potatoes Harvested Area	2	Row without manure
160	Timothy seed Harvested Area	3	Hay with nutrients
162	tobacco Harvested Area	2	Row without manure
164	Tomatoes Harvested Area	2	Row without manure
166	Triticale Harvested Area	1	Row with manure
0	Turfgrass	9	Urban
168	Turnip Greens Harvested Area	2	Row without manure
169	Turnips Harvested Area	2	Row without manure
170	Vegetable & flower seeds Area	6	Nursery
171	Vegetable & flower seeds Protected Area	6	Nursery
173	Vegetables, Mixed Area	2	Row without manure
174	Vegetables, Other Harvested Area	2	Row without manure
175	Vetch seed Harvested Area	3	Hay with nutrients
177	Watermelons Harvested Area	2	Row without manure
178	Wheat for Grain Harvested Area	1	Row with manure
180	Wild hay Harvested Area	4	Hay without nutrients

Some over-arching guidelines governed the calculations. Where inconsistencies or error introduced in the estimation of withheld (“D”) data led to inconsistencies between crop areas and land areas, then the land areas were adjusted to be commiserate with the crop areas.

Maryland currently has a commodity cover crop program that allows a partial payment for crops planted but not harvested when no nutrients are applied in the fall. If the farmer applies spring nutrients and harvests the crop for sale, then there is a smaller subsidy payment (R. Wieland, personal communication, 2008). This may provide some overlap in NASS data for small grains and cover crops reported as a best management practice.

Vegetables that are grown in plasticulture are not treated differently in this model. Plasticulture managed vegetables are grown so that approximately one third of a field is covered (Ed Joiner, Nutrient Management Planner, VA, personal communication 2008). This increases infiltration since the irrigation system is under the plastic and decreases erosion. It also decreases volatilization. If plasticulture is about 7,000 acres in Virginia, and there are 195,000 acres in high-till row crop without manure (HOM), then these acres comprise 3.6% of the total and the plastic-covered portion of the field is 1.1% of that land use. Therefore, this is assumed to be insignificant portion for the outcome of loads.

Sunflower can be for seed oil or for wildlife. Where sunflower is grown for wildlife stands then it is not double cropped but left fallow other times of the year. NASS reports sunflowers in two categories: Sunflower seed, non-oil varieties and Sunflower seed, oil varieties. Only sunflower seed, oil variety is available to be double cropped. Years prior to 2002 do not have sunflower seed split into the two categories, so double cropping is not calculated for sunflowers prior to the categorization split. Rather, sunflower-all are categorized as sunflower non-oil varieties for the years prior to 2002.

Barley can be grown for grain or silage, yet the agricultural census does not differentiate. Barley for silage is lumped with the category haylage, grass silage, or greenchop whereas Corn and Sorghum silage and greenchop are distinct. Where grown for silage it is harvested 1.5 months earlier and is double-cropped with either sorghum or corn. This is common in the dairy industry (Bobby Long, Nutrient Management Planner, VA, personal communication 2008). Since the source data do not allow barley for silage as a distinct category, barley effectively will only be double cropped as a grain with sorghum.

While potatoes grown in the southern portion of the Chesapeake Bay Watershed are harvested early enough that they may be double cropped with beans and wheat, they are not included as a crop that may be double cropped with anything other than vegetables (Ed Joiner, Nutrient Management Planner, VA, personal communication 2008). Vegetables are double cropped. This is to be handled by a not-yet-implemented feature to Scenario Builder for multiple plant and harvest dates within each crop type or land use.

7.2.1.1 Determining when two crops are planted on the same acre in the same 12-month period

When a farmer plants a summer crop followed by a winter crop, then two different crops may exist on the same acre of land. This situation is termed double-cropping. Double cropping is accounted for in Scenario Builder by determining the amount of land available to be double-cropped and subtracting the actual acres of crop types that are eligible to be double-cropped. This requires identifying pairs of crop types that are typically cropped one after the other.

Table 7-2 List of crops eligible for double cropping.

Crop Id	Crop Name	Group	Plant Month	Plant Date Day	Harvest Month	Harvest Date Day
35	Corn for Grain Harvested Area	1	5	1	9	30
37	Corn for silage or greenchop Harvested Area	1	5	1	9	30
50	Dry edible beans, excluding limas Harvested Area	1	5	1	9	30
119	Popcorn Harvested Area	1	5	1	9	30
141	Sorghum for Grain Harvested Area	1	5	1	9	30
143	Sorghum for silage or greenchop Area	1	5	1	9	30
145	Soybeans for beans Harvested Area	1	5	1	9	30
155	Sunflower seed, oil varieties Harvested Area	1	5	1	9	30
27	Canola Harvested Area	2	10	1	4	30
10	Barley for grain Harvested Area	2	10	1	4	30
23	Buckwheat Harvested Area	2	10	1	4	30
54	Emmer and spelt Harvested Area	2	10	1	4	30
94	Oats for grain Harvested Area	2	10	1	4	30
130	Rye for grain Harvested Area	2	10	1	4	30
166	Triticale Harvested Area	2	10	1	4	30
178	Wheat for Grain Harvested Area	2	10	1	4	30

To determine the area for double cropping, the total harvested area (single line item in Ag census) is reduced by the area of ineligible crops. If the result is negative, there are no double crops. Positive acreage is compared to the sum of area for all crops above (double croppable). If double crop acreage is less than total harvested minus double crop ineligible, then no double crops exist. If the double crop area exceeds the harvested area, the difference is the acreage of double crops. Proportions of this acreage from each first crop set and each second crop set are based on acreage from each crop to the total.

> For example, if corn is 50%, sunflower seed-oil is 2%, and sorghum is 48% of land acreage as reported in the agricultural census, then the number of acres double-cropped will be covered by 50% corn, 2% sunflower seed-oil, and

> 48% sorghum (This example assumes there are enough acres of the first crop to accommodate all acres of the second double-croppable crop).

Finally, the acres are marked as double cropped to have independent plant and harvest dates. If the acres of the second crops or first crops are imbalanced, the remainder is single cropped and the harvested area is adjusted.

> For example, if first crops are 300 acres and second crops are 50 acres and total harvested area is 100 acres, the total harvest acreage is increased to 300 acres where 50 are double cropped. This can be done to accommodate second crops too.

At this point, we have the acres of crops on model land uses including double cropped acres.

7.2.2 Determining urban lawn areas

The area of the crop type “turf grass” is found by multiplying the fraction of urban lawn by each of the urban categories: low intensity pervious urban and high intensity pervious urban for each county and year. The fraction of urban lawn was determined by subtracting the acres of forested urban land from the total acres of pervious urban land within each county. The remaining pervious urban land is assumed to be turf grass. Many older subdivisions appear forested from a land cover perspective. The Watershed Model-HSPF Phase 5.3.2 land cover, however, uses housing unit and residential road density to identify such areas. To differentiate urban forests from lawns under canopy, the larger interior forest patches were used - eliminating edge and speckled forest areas. The GIS methods were as follows:

1. Create an urban mask using the Phase 5.3 land cover dataset
2. Within the urban mask, separate and group all forests and wetlands
3. Map interior forests by shrinking the forest/wetland extent around the edges by 1 cell (98.4 ft.).
4. Eliminate all patches of interior forest less than one-acre.
5. Expand remaining interior forest patches back to their original extent.
6. Summarize the acres of interior urban forest for each county.
7. Summarize the total urban extent (land cover, not land use).
8. Using a 2001 P5.3 land use file (corresponding to the date of the imagery), estimate the total urban and pervious urban land use acres by county. Pervious urban acres include “construction”.
9. Calculate a land cover to land use adjustment factor based on the ratio of total urban land cover to total urban land use per county.
10. Multiply the adjustment factor by the total acres of interior urban forest per county and subtract that from the total pervious urban land use acres to derive acres of turf grass.

On average, turf grass equals 79% of the urban area in each county and 93% of what we call either high or low intensity pervious urban. Cappiella and Brown (2001) measured the percentage of open space on residential lots to range from 68% to 90%. Robbins et al., (2003) calculated the maximum potential lawn area in 205 residential census tracts in Ohio as averaging 82%. These estimates are liberal in that they do not subtract non-lawn areas (forests, flower beds, etc.) from their open space percentages. However, the numbers due lend some support to our county average of 79% (44% min and 97% max) (P. Claggett, personal communication, 2009).

The nutrients are only applied to the urban lawn areas that are in low intensity pervious urban and high intensity pervious urban land uses, although the turf grass area available was calculated using construction.

7.2.3 Deriving the Area for Animal Production

Animal production areas are generally those areas located around barns and where manure storage is most likely to occur. The Chesapeake Bay Program names these areas AFOs or CAFOs. These areas are where manure lost during storage and handling loss is applied. C/AFO land areas are added to existing agricultural land use areas using the following criteria.

1. For each county and year, multiply the number of farms for each animal type times the appropriate value found in Table 7-3.
2. AFO acres are added to the agricultural acres.
3. AFOs are broken down into land segments, and later into land-river segments, using an area weighted average based on the amount of agriculture in the county. The acres of AFOs in the county are multiplied by the agricultural acres in each land-river segment and divided by the total agricultural acres in the county. Agricultural acres are defined as those in the land uses:

    - animal feeding operations
    - alfalfa
    - row without manure
    - row with manure
    - hay without nutrients
    - hay with nutrients
    - pasture
    - degraded riparian pasture
    - nursery

Table 7-3: Animal Feeding Operation Acres/Farm by Animal Type

Item Name	Acreage/farm
Cattle and calves	0.5
Total hogs and Pigs	0.2

Any Poultry	0.25
Sheep and Lambs	0.1
Milk goats	0.05
Angora goats	0.05

The Agricultural Census only lists farms by animal type, yet many farms have more than one animal type. Certain acreages are designated for each farm with an animal type; therefore areas that are shared by more than one species of animal are overestimated.

The land area of the farm is not related to the AFO or CAFO size, but rather the size of an animal type and the number of animals.

On AFO or CAFO land, the following animal types are not captured: Other poultry (such as ducks, geese, emus, ostriches and squab) or miscellaneous livestock and animal specialties (such as bison, llamas, and rabbits). We assume that there are few farms with significant acreage specializing in solely these animals, so that land area is captured under other animal types.

7.3 Disaggregating Data from County to Land-River Segments

County data is parsed to the Watershed Model-HSPF land-river segments by the CBLCM. The CBLCM estimates the percent of agricultural acres in each land-river segment of a county. Checks are put in place to make sure the sum of land area in the land-river segments that make up a county match the total for the county. The same procedure is used for animal numbers.

8 BEST MANAGEMENT PRACTICE IMPLEMENTATION

8.1 Introduction to Phase 5 BMPs

The effectiveness estimates for best management practices (BMPs) that are implemented and reported by the Chesapeake Bay partners, as well as those planned for future implementation, were reviewed and refined for the Phase 5 Model (Simpson and Weammert, 2008). The objective was to develop BMP definitions and effectiveness estimates that represent the average operational condition of the entire watershed. In the previous versions of the Watershed Model, relatively optimistic effectiveness estimates were assigned that were often based on controlled research studies that were highly managed and maintained by BMP experts. This approach failed to take into account the variability of effectiveness estimates in real-world conditions where farmers, county stormwater officials, and others who are not BMP scientists are implementing and maintaining BMPs across wide spatial and temporal scales with various hydrologic flow regimes, soil conditions, climates, management intensities, vegetation, and BMP designs. By assigning effectiveness estimates that are more closely aligned with operational and average conditions, the Phase 5 Model and any derivative watershed plans will better represent watershed monitoring observations.

BMP design objectives typically aim to meet three criteria: 1) minimizing offsite nutrient and sediment impacts, 2) maintaining healthy productive soil, and 3) meeting landowner/producer objectives. An array of nonpoint source conservation practices is available to address nutrient and sediment pollution problems. Soil, weather, slope, cropping system, tillage method, and management objectives influence the set of practices used to reduce nutrient and sediment export and protect soil quality. The practices installed are the result of an on-site evaluation by a technical specialist. Site conditions, production system, crop rotation, owner/producer objectives, and other factors need to be taken into account when developing a conservation plan which is usually the first step in BMP installation.

Conservation practices, or BMPs, may take many forms, but essentially can be placed into one of four categories: prevention, land conversion, in-field protection, and reduced rate of load increase (Table 8-1).

The CBP applies an adaptive management approach to BMP development that allows for forward progress in BMP implementation, management, and policy, while acknowledging uncertainty and knowledge limitations. The adaptive management approach to BMP development incorporates the best applicable science along with best current professional judgment into current effectiveness estimates while acknowledging that the best available knowledge will improve and change in the future.

Table 8-1: Types of conservation practices/BMPs.

Category	Definition	Result/Example

Load or source nutrient reduction	Creating or using less nutrients for land application.	Reduces nutrient production (E.g.: precision feeding, feed additives) - or - Erosion control structures prevent movement of sediment and nutrients to surface water. Often reductions are calculated per BMP foot.
Land use change	Land is converted from one type of use to another with a different intensity.	Land restoration or enhancement (E.g.: wetlands) - or - Land taken out of intensive agricultural use (E.g.: CRP, CREP)
Efficiency change	Agronomic changes affecting the amount of nutrient lost from land	Conservation plans decrease loss -or- Bypassed filter structures result in increased loss
Systems change	Existing infrastructure that has been converted to a different system	Septic connections result in fewer septic systems and become point sources.

There are other types of BMP that are applied within or adjacent to the estuary. These estuarine BMPs include, SAV plantings, offshore structures to reduce wave action, and oyster bar protection or creation among others. These tidal Bay BMPs are outside the Phase 5 model domain, which stops at the tidal water's edge.

8.2 Methods Used to Determine BMP Effectiveness

8.2.1 Factors Considered in the Effectiveness Estimation

The estimation of BMP efficiencies under operational conditions was guided by one key question: Is BMP efficiency recommended by the experts and/or from literature representative of what would be expected at the watershed scale? If the efficiency does not represent watershed-wide effectiveness, an adjustment was made to reflect the operational conditions of the watershed. When no quantified data on how much to adjust research values to reflect operational values exists, best professional judgment was exercised based on known scientific processes to make an adjustment on the efficiency.

The BMP efficiencies were estimated primarily through literature review and professional judgment. Literature on individual BMPs was reviewed and their definitions were recommended by selected experts (Simpson and Weammert 2008). Specifically, these experts were asked to review literature that is applicable to the Chesapeake Bay watershed, with the applicable location defined as humid, temperate climates east of the Rockies. Experts were also asked to provide efficiency recommendations that should be used in the Chesapeake Bay Program's Watershed Model and associated Tributary Strategies from literature values. The expert recommendations were augmented by the application of the following criteria:

- Efficiency recommendations should reflect operational conditions, defined as the average watershed-wide condition. Research scale efficiencies were adjusted to account for differences upon scaling up to the watershed scale.
- Studies with negative efficiencies, i.e., the BMP acted as a source, not a sink for nutrient and/or sediment were included in the efficiency development process as they reflected real world operational conditions.
- The evaluation criteria and process should be consistent among all experts involved.
- Peer reviewed literature has been subject to stringent evaluation, and results from that literature were given more weight than literature without the same review process.
- Data from individual BMP project sites were utilized over median or average values calculated from multi-site analysis.
- The expected spatial and temporal variability for a practice was estimated based on available science and knowledge of the expected geographic extent for implementation of the practice. Different reduction efficiencies were established for practice implementation across different physiographic, geomorphic, and hydrologic settings. Where possible, efficiencies were adjusted for surface water and groundwater interactions (permeability), along with geology and soil types (slope, seeps, floodplain, etc.). BMPs such as cover cropping are affected by age, size, time to maturity, species composition and site specific conditions, creating spatial and temporal variability in efficiencies.
- Management conditions, including BMP operation and maintenance, design and construction supervision, and/or land use change will also impact efficiencies, usually making them lower than at research scales. While there is little quantitative information on how BMP efficiencies should be adjusted to account for the impacts of improper maintenance on receiving waters, general adverse impacts of poor construction or maintenance are understood to occur. If maintenance is neglected, a BMP may become impaired, and will no longer provide its designed functions. Proper maintenance of outlet structures, flow splitters, and clean out gates is critical to achieving a stormwater BMP's designed efficiency (Koon, 1995). "Average" management was assumed but it was assumed the practices were implemented and being operated and maintained. Reviews and audits of BMP implementation and performance are needed to better estimate the actual impacts of reported practices.

8.2.2 Translating Research Studies to Operational Scale Efficiencies

Using research-site and demonstration-site derived efficiencies for watershed scale implementation efforts fail to reflect the spatial variability of the entire watershed. Both the scale and management differences between a research plot and a BMP site will alter efficiencies. The research-based estimates of best management practices need to be adjusted to provide more realistic estimates of efficiencies for widespread adoption of the practice.

Virtually all research data is generated under controlled management conditions; meaning that studies are done on typical or representative soils (marginal land is usually excluded), agronomic management is optimal (timely planting, precise farm management, high seed emergence, etc.), and other hazards (goose grazing, deer grazing, etc) are minimized or excluded. Hence, the research estimates are more representative of a best-case scenario. This optimistic scenario needs to be adjusted to lower effectiveness when the efficiencies are being applied to widespread field implementation under "average conditions" across the Chesapeake Bay watershed.

Given the multitude of factors that influence water quality at the watershed scale of analysis, detecting a change does not lead to the conclusion that the BMPs were responsible for the change unless the other factors can be ruled out. This problem becomes more severe as watershed size increases. For these reasons, the scale of the study was taken into account and reflected in efficiency adjustment as research and demonstration site derived efficiencies for watershed scale implementation fail to reflect the spatial viability of the entire watershed. Data extrapolation to any scale is difficult, but research, field, and watershed scale estimated efficiencies will differ for the same BMP which justifies adjusting efficiencies when comparing BMP efficiencies between scales.

8.2.3 Using Best Professional Judgment

While literature was reviewed and experts were recruited to suggest BMP efficiencies for annual practices in the BMP project, there were several cases where it was necessary to use best professional judgment to adjust for spatial, temporal, and management variability and the estimated resulting change in practice effectiveness at widespread "average" implementation across the Chesapeake Bay watershed (Simpson and Weammert 2008). On some occasions it was necessary to adjust for differences in approach among the experts.

We chose to consider the need for efficiency modification based on best professional judgment on a practice-by-practice basis based on availability of literature, field scale implementation data, recent revisions to BMP efficiencies, and other factors. This resulted in a variable application of best professional judgment to different practices which was warranted based the factors above (Simpson and Weammert 2008).

It must also be recognized that these BMP efficiencies were developed using an adaptive management approach that recognizes that our knowledge is incomplete. Adaptive management proposes a science based and conservative approach to efficiencies. This allows BMP efficiency review and updating at recurring intervals based on new research, monitoring, and experience. The conservative approach is always advisable in adaptive management and is particularly warranted here since there is little if any data that suggests actual watershed-wide implementation efficiencies as high as those in the research literature.

8.2.4 Accounting for Variability in Management

When scaling-up BMPs from the research plot or small scales to watershed-wide implementation it is important to account for the impact that expanded variability will have on practice performance. Several studies have shown that when BMPs are applied across even a small watershed the resulting improvement in water quality is far less than would have been projected based on research scale data. While some part of this may be due to "legacy" nutrients or sediments, this does not explain all of the difference. USGS research has suggested an average nitrogen lag time of about ten years in the Bay watershed to see the full impact of BMP changes.

Spatial and temporal variability due to soils, hydrology, geology, climate, etc. are often recognized as sources of variability. However, management and operation can also be highly variable between research watershed scales, operational watershed scales and even between different managers within an operational watershed scale. When practices are implemented across a large area on parcels managed by many different individuals, it is important to assume an "average" level of expertise, control and management in planning design, implementation and operation of any given BMP. While there may be limited data quantifying the difference between research and "average" planning, design, implementation and management, it is recognized that widespread implementation rarely has the same level of oversight and control that is essential to get statistically meaningful results observed at research scale. As a result, there is a need to lower effectiveness from the research scale when widespread implementation occurs.

While the effect of "average" management has been considered in proposed BMP efficiencies, whether or not a practice is fully or partially implemented and whether it is properly maintained and revised, replaced, or upgraded as needed was not considered in these BMP Effectiveness estimates. These tend to be program management and compliance issues and should be addressed in considering the actual likely impact of implementation of a suite of BMPs as part of a watershed management plan, however, they were not considered in development of efficiencies for individual BMPs. We assumed the BMPs were implemented and revised, upgraded, or replaced as recommended for the practice.

8.2.5 Incorporating Negative Efficiencies

Negative BMP efficiencies are reported in literature, usually due to natural processes, or issues associated with constructing and operating a BMP. Those negative efficiencies were included in the analysis, because in some situations BMPs act as a source rather than a sink (Simpson and Weammert 2008). Errors in the design, construction, and maintenance of a BMP can also create a system that is unable to provide its expected pollutant removal. In some cases, these errors can lead to flow bypassing the whole BMP, possibly resulting in negative efficiencies. Additionally, BMPs with permanent water pools often release phosphorous from saturated sediment, which can leach phosphorous into the water column, causing negative efficiencies.

8.2.6 Literature Used to Determine BMP Effectiveness Estimates

The literature cited in efficiency estimation was screened based on pre-established criteria. For existing BMP efficiencies that were developed with limited data or best professional judgment, newly available literature was consulted before refinement. Applicability and credibility of new studies were vigorously reviewed. Alternatively, BMP efficiencies that were developed from sufficient/adequate data, a large body of consistent data was required to justify a refinement to the BMP efficiency. Among consulted literature, peer reviewed literature was given more weight than design standards and manuals. Peer reviewed literature has undergone a robust, critical screening before it is published; while non-peer reviewed literature is not submitted to the same screening process. Design manuals are written to result in aspirational BMP effectiveness, and often include additional components that increase the BMPs estimated median effectiveness. As such, more confidence lies in the peer reviewed literature.

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

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

Peer reviewed literature was also categorized based on scope of research. Studies taking place on a single site with a single BMP more accurately represented the BMP efficiency compared to single site studies with multiple BMPs and the two previous study types were preferable to multi-site studies. Multi-site review and analysis studies generally lost the specificity of individual site characteristics. Characteristics of a site like soils, climate and hydrology are important in evaluating the effectiveness of a BMP. Also, multi-site review and analysis studies generate a median or average of one BMP or multiple BMPs which can enhance or diminish the value of the effectiveness estimate. Furthermore, multi-site studies tend to underreport or not publish negative efficiencies.

It is important to note that none of the above criteria takes into account the variability and uncertainty associated with rate of implementation, operation and maintenance, replacement, spatial variability or tracking and reporting of a BMP. These factors that adjust efficiencies need to be investigated and applied to future efficiency refinement procedures.

Developing efficiencies that reflect operational, real-world conditions requires a holistic view point. There are certain qualities of research studies that do not incorporate all the factors that will influence operational efficiencies. To account for this, research based effectiveness estimates must be adjusted using the aforementioned guidelines.

Model output and monitoring data must be consistent and used appropriately. Better research on demonstration and monitoring of BMP, system and small watershed conservation effects will increase confidence in BMP effectiveness. Finally, managers, policymakers, and involved citizens must be made aware of potential implications of the iterative-adaptive BMP effectiveness approach so they understand the recurring need to change effectiveness estimates as knowledge advances (Simpson and Weammert, 2007).

8.2.7 Oversight and Review

As BMP efficiencies were reviewed and recommended by multiple experts, naturally there were differences in their approaches to efficiency development and adjustment. Additional overview and adjustment were exercised to ensure consistency of BMP evaluations among all parties involved (Simpson and Weammert 2008).

CBP workgroups with expertise on specific BMPs reviewed the BMP reports. They first determined if tracking and reporting data on BMP implementation was available in each jurisdiction to receive credit in the Watershed Model for the BMPs associated nutrient and sediment reductions. Some BMPs are subcategorized based on certain design elements. If a jurisdiction did not have existing infrastructure in place to report at sub-categorical level, either the jurisdictional program managers refined reporting procedures to reflect this new detail or a default definition and effectiveness estimate were substituted.

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

8.3 BMP Types

The four types of BMPs: Land use change, load or source nutrient reduction, efficiency, and systems change are discussed in detail.

8.3.1 Land Use Changes Due to BMP Implementation

The land uses are modified according to the information on BMP implementation supplied by individual State agencies. Nutrient and/or sediment load reductions resulting from land use changes due to BMPs implementation are simulated in the Watershed Model, such as the case when higher-yielding land uses such as *conventional tillage with manure* are converted to the ones exporting lower levels of pollutants such as *conservation tillage with manure*.

8.3.2 BMP Efficiency Estimates

In the Phase 5 Model the BMP reduction efficiencies are applied across the entire Bay watershed. In the model, the simulation of a particular land use within a land-segment is not a representation of all the different types of that particular land use in the segment. The land use is modeled as a single representative average land use, therefore, the assumption of a representative nutrient and sediment reduction capacity is reasonable.Section: 8.5 BMP definitions and reduction values lists the BMPs in the model associated with reduction efficiencies and efficiencies for total nitrogen, total phosphorus, and sediment. The appendix to the table in this section shows reductions specific to certain geographies that have inherently different efficiencies because of physical properties.

The BMP effectiveness inputs to the Phase 5 model are calculated with the source information of the land use data after integrating BMPs that involve land use changes; the BMP implementation levels from Bay Program jurisdictions after compilation, computations for formatting, and QA; and the BMP reduction efficiency file. These three sources are used to compute, by land-segment and by land use, the model input inputs according to the following equation.

Equation 19: BMP effectiveness value general equation

$$\text{Fraction Reduction} = \frac{\text{acres treated by BMP}}{\text{total segment acres}} \times \text{BMP efficiency}$$

Built into the program are assignments for each BMP as to whether the practice is considered additive or multiplicative. BMPs that cannot be applied to the same land use are mutually exclusive and are considered additive in nutrient reduction capabilities. An example of additive BMPs would be stream-bank protection with fencing and without fencing where the pasture land has either type of protection, but never both.

The other type of BMP, which applies to most controls, is considered to be multiplicative and several BMPs are applied on the same land use. These practices are considered to behave as consecutive BMPs since one BMP reduces the nutrients available for subsequent BMPs to reduce. Multiplicative functions are applied to this class of BMP and an example of multiplicative BMPs would be cropland where cover crops, a conservation plan and riparian forest buffers down-gradient from cropland where are applied.

The product of the BMP relational database is, again, a spreadsheet file of pass-through factors for each land use and for TN, TP, and sediment by model land-segment. The Phase 5 Model "passes through" the fraction of the nutrient and sediment load resulting from the combined impact of BMPs. Pollutant reductions due to BMP land use changes are accounted for through the simulation of a lower-yielding land use. For details on how many of the BMP effectiveness estimates were assigned see: www.mawaterquality.org/bmp_reports.htm. Additional information with example BMP calculations may also be found in the CAST documentation at www.casttool.org under the documentation page.

8.3.2.1 Calculation sequence for land use change and efficiency BMPs

BMPs are calculated in a specified sequence. To understand the calculation sequence of BMPs, it is simplest to consider that each BMP is a member of a group. Within each group, there may be more than one BMP. There is a specified sequence for each group and for each BMP within a group. This grouping allows there to be some BMPs that are mutually exclusive with other BMPs.

Land use change BMPs are always calculated before any other BMP type and follow this specific order:

1. Urban Growth Reduction
2. Impervious Urban Surface Reduction
3. Forest Conservation
4. Stream Access Control with Fencing
5. Streamside Forest Buffers
6. Wetland Restoration trp
7. Land Retirement of TRP to HYO (HEL)
8. Streamside Grass Buffers
9. Tree Planting; Vegetative Environmental Buffers - Poultry
10. Forest Buffers
11. Wetland Restoration
12. Land Retirement to pas (HEL)
13. Land Retirement to HYO (HEL)
14. Grass Buffers; Vegetated Open Channel - Agriculture
15. Tree Planting; Vegetative Environmental Buffers - Poultry
16. Alternative Crops
17. Urban Forest Buffers
18. Urban Grass Buffers
19. Urban Tree Planting; Urban Tree Canopy
20. Abandoned Mine Reclamation
21. Conservation Tillage
22. Nutrient Management
23. Enhanced Nutrient Management
24. Decision Agriculture

Each of these BMPs converts a land use or group of land uses to a different land use. A few also have an effectiveness value that is implemented as a percent reduction of nutrients. The BMPs with effectiveness values are: grass buffers, forest buffers, enhanced nutrient management, decision agriculture, and wetland restoration. An effectiveness value is applied to a proportion of the original land use group that was used in the land use change. Agricultural grass and forest buffers have a nitrogen benefit on four times the amount of land that was converted and phosphorus and sediment benefit on two times the amount of land that was converted. All of the other land use change BMPs have the effectiveness values applied to the original land use group as a one to one ratio.

In these land use change BMPs there is one group with more than one member—Nutrient Management. The Nutrient Management group includes Nutrient Management, Enhanced Nutrient Management, and Decision Agriculture, which are sequenced in that order. While it may seem simpler to have an overall sequence without groups, it is necessary to maintain the group level to accommodate those BMPs that are mutually exclusive with other BMPs. the following section discusses overlapping and mutually exclusive BMPs.

After land use change BMPs are calculated, effectiveness value BMPs are calculated. They also are grouped and follow a specific sequence. For example, Wetland Restoration and Forest Buffers are land use change and effectiveness value BMPs. Forest Buffers have a higher effectiveness value than Wetland Restoration. Wetland Restoration is earlier than Forest Buffers in the calculation sequence. Therefore, where a user can decide to steer resources toward implementing either Wetland Restoration or Forest Buffers, it would produce a greater load reduction to implement Forest Buffers.

8.3.3 Load or source reduction BMPs

Load reduction BMPs are those that result in an amount of nutrient or sediment reduced per unit length or area. BMPs like Dirt and Gravel Road erosion and sediment controls receive an amount of sediment and phosphorus reduced per foot of implementation. Pounds of reduction per foot is a common unit of load reduction for this type of BMP.

Source reduction BMPs are generally applied to animal units to accommodate BMPs like *phytase* where the BMP results in smaller amounts of nutrients. Application reduction BMPs are simple to quantify because the amount of phosphorus in excrement is easily measured before and after phytase feed additive. The application reductions should be evaluated often to represent the current level of technology.

8.3.4 System change BMPs

System change BMPs are utilized for septics that are converted to sewer. This is analogous to a land use change where loads change based on the simulated loading of the land use, but septics and sewer are simulated on the same land use. The method of waste management is modeled within the urban land uses. See Section 6.2 for septic modeling.

8.4 BMP Calculation steps

There are five steps used to calculate the loads given various BMP inputs. The following sections describe each step.

Step 1: Determine BMP 2007 percent of land (Equation 1)

Step 2: Verify acres available

Step 3: BMP pass-through value (Equation 2)

Step 4: Overall pass-through value (Equation 3)

Step 5: Overall BMP reduction (Equation 4)

8.4.1 Determine BMP 2007 percent of land (Back out procedure)

The first step in calculating the load reduction is to verify that certain BMPs submitted are greater than those submitted in 2007. This rule applies to the following BMPs:

1. Urban Growth Reduction
2. Abandoned Mine Reclamation
3. Forest Conservation
4. Impervious Surface Reduction
5. Forest Buffers
6. Urban Forest Buffers
7. Wetland Restoration
8. Land Retirement on hyo
9. Land Retirement on pas
10. Grass Buffers
11. Urban Grass Buffers
12. Tree Planting
13. Carbon Sequestration/Alternative Crops
14. Urban Tree Planting

Since the base land use (2010) includes land use change BMPs from prior years, then 2007 is used as a baseline for minimum BMP implementation. The purpose of this rule is to verify that only increases in BMPs beyond 2007 levels are counted, not decreasing levels of BMPs. While it is logical to consider that 2010 is a projection and should include land use change, and therefore no credit should be given for any land use change made prior to 2010, this is not the way the Chesapeake Bay Program handles the calculation.

Equation 20: Addressing land use change since 2007.

your scenario BMP % land > 2007 Progress scenario % land.

Example 1:
Abandoned Mine Reclamation

2007 40 acres

2010 10 acres

- ❖ No credit given because acres in 2010 are not > 2007

Example 2:

Abandoned Mine Reclamation

2007 35 acres

2010 45 acres

Credit given for 10 acres because 2007 - 2010 = 10

- ❖ Credit only given for difference.

8.4.2 Verify acres available

The second step in calculating the load reduction is to verify that there are adequate acres for each BMP. If there are not enough acres to accommodate the BMPs, then those BMPs later in the sequence will only be applied to the available acres. It is possible for the user to specify a BMP for more acres than are available.

For example, there are three members of the Nutrient Management group: nutrient management enhanced nutrient management and decision agriculture. Whenever there is more than one member of a group, the BMPs are necessarily mutually exclusive. Since Nutrient Management is mutually exclusive with Enhanced Nutrient Management, the acres available for Enhanced Nutrient Management are only those that remain after Nutrient Management is calculated. If there are a total of 100 acres, and the user specifies 95% of the acres are in Nutrient Management and 45% of the acres are in Enhanced Nutrient Management, then Scenario Builder will return 95 acres in Nutrient Management and 5 acres in Enhanced Nutrient Management. The full 45% of enhanced nutrient management was not credited because there were not enough available acres after the nutrient management was calculated. Thus, the user must consider the BMP groups and the order within groups to optimize reductions.

User input:

Total acres = 100

Nutrient Management = 95%

Enhanced Nutrient Management = 45%

Model Calculates:

Nutrient Management acres: 95% * 100 = 95

Minimum of the user input or amount remaining after the previous BMP: Min (45% * 100), (100-95)

The minimum in this case is what remains after the previous BMP: 100-95=5

Result:

Nutrient Management acres = 95

Enhanced Nutrient Management acres = 5

8.4.3 BMP pass-through value

BMPs are calculated by land use for each segment for each pollutant. Scenario Builder calculates a single pass-through factor for BMPs in each group. A pass-through factor is simply the amount of pollutant that is not removed by the effectiveness value.

A single pass-through factor is calculated for all BMPs in a group using the following formula. This same formula also is used even where there is only one BMP in a group.

Equation 21: BMP group pass-through value

$$For\ each\ BMP group, g = 1 \ldots G, \qquad F_g = 1 - \sum_{BMP=1}^{n} \left(\frac{i}{t} * E_{BMP}\right)$$

Where:
BMP=a specific BMP
g=BMP group
G=total number of BMP groups
F=pass-through factor
n=total number of BMPs in the group
i=implementation acres
t=total acres available
E= effectiveness value

8.4.4 Overall pass-through value

An overall pass-through factor is calculated by multiplying the pass-through for each group. The result will necessarily be less than or equal to one. If the result is one, then all pollutants pass through and there are no BMP reductions.

Equation 22: All groups pass-through value

$$F_O = \prod_{g=1}^{G} F_g \ \leq 1$$

Where:
F=pass-through factor
O=overall
g=BMP group
G=total number of BMP groups

8.4.5 Overall BMP reduction

If it is more intuitive to consider this in terms of the overall reduction then convert the overall pass-through factor by:

Equation 23: Overall BMP reduction fraction

$$E_O = 1 - F_O$$

Where:
E=effectiveness value
O=overall
F=pass-through factor
Remember, there should be an overall reduction effectiveness value calculated for each land use and segment and pollutant.

8.5 *BMP definitions and reduction values*

The list of all BMPs and their definitions are in .The source of information is from the MAWP and the CBP workgroups.

Table 8-2: BMP definitions

Sector	BMP	BMP Description
Agriculture	Alternative Crops	Alternative crops is a BMP that accounts for those crops that are planted and managed as permanent, such as warm season grasses, to sequester carbon in the soil. Carbon sequestration refers to the conversion of the Watershed Model land uses that are cropland to the hay land use.
Agriculture	Animal Waste Management System	Practices designed for proper handling, storage, and utilization of wastes generated from confined animal operations. Reduced storage and handling loss is conserved in the manure and available for land application.
Agriculture	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. Different efficiencies exist if controls are installed on an operation with manure storage or if the controls are installed on a loafing lot without a manure storage.
Agriculture	Biofilters	Ammonia emission reduction includes housing ventilation systems that pass air through a biofilter media with a layer of organic material, typically a mixture of compost and wood chips or shreds, that supports a microbial population. The ammonia emissions are reduced by oxidizing volatile organic compounds into carbon dioxide, water and inorganic salts. The ammonia conserved in the BMP is no longer considered in the model.
Agriculture	Commodity Cover Crop Early Arial Rye	A winter rye crop planted at least 2 weeks prior to the average frost date with an aerial seeding method. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Early Arial Wheat	A winter wheat crop planted at least 2 weeks prior to the average frost date with an aerial seeding method. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Early Drilled Barley	A winter barley crop planted at least 2 weeks prior to the average frost date with a drilled seeding method. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Early Drilled Rye	A winter rye crop planted at least 2 weeks prior to the average frost date with a drilled seeding method. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.

Agriculture	Commodity Cover Crop Early Drilled Wheat	A winter wheat crop planted at least 2 weeks prior to the average frost date with a drilled seeding method. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Early Other Rye	A winter rye crop planted at least 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Early Other Wheat	A winter wheat crop planted at least 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Early-Planting Aerial Corn Barley	A winter barley crop planted at least 2 weeks prior to the average frost date with an aerial seeding method. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Early-Planting Aerial Soy Barley	A winter barley crop planted at least 2 weeks prior to the average frost date with an aerial seeding method . The cover crop follows soybeans.The crop may be neither fertilized nor harvested.
Agriculture	Commodity Cover Crop Early-Planting Aerial Soy Rye	A winter rye crop planted at least 2 weeks prior to the average frost date with an aerial seeding method. This cover crop follows soybeans. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Early-Planting Aerial Soy Wheat	A winter wheat crop planted at least 2 weeks prior to the average frost date with an aerial seeding method. This crop follows soybeans. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.

Agriculture	Commodity Cover Crop Early-Planting Other Barley	A winter barley crop planted at least 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Late Other Wheat	A winter rye crop planted after the average first frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Late-Planting Drilled Rye	A winter rye crop planted after the average first frost date with a drilled seeding method. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Late-Planting Drilled Wheat	A winter wheat crop planted after the average first frost date with a drilled seeding method. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Late-Planting Other Rye	A winter rye crop planted after the average first frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Standard Drilled Rye	A winter rye crop planted no more than 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Standard Other Rye	A winter rye crop planted no more than 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.

Agriculture	Commodity Cover Crop Standard Other Wheat	A winter wheat crop planted no more than 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Standard-Planting Drilled Barley	A winter barley crop planted no more than 2 weeks prior to the average frost date with a drilled seeding method. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Standard-Planting Drilled Wheat	A winter wheat crop planted no more than 2 weeks prior to the average frost date with a drilled seeding method. A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Commodity Cover Crop Standard-Planting Other Barley	A winter barley crop planted no more than 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). A commodity cover crop may receive nutrient applications after March 1 of the following year after establishment.
Agriculture	Conservation Till Without Nutrients	This conservation till BMP reflects conservation tillage on land areas that receive only inorganic fertilizer. This BMP is a reduction applied to high till without nutrients and requires: (a) a minimum 30% residue coverage at the time of planting, and (b) a non-inversion tillage method.
Agriculture	Conservation Tillage - Additional Acres	Conservation tillage requires: (a) a minimum 30% residue coverage at the time of planting, and (b) a non-inversion tillage method. Each segment is assigned a default amount of conservation tillage based on historical data from the Conservation Technology Information Center (Documentation Appendix 6). Specifying acres under this BMP adds the specified acres to the historical amount. Only one submission unit may be used per scenario.

Agriculture	Conservation Tillage - Percent of Acres	Conservation tillage requires: (a) a minimum 30% residue coverage at the time of planting, and (b) a non-inversion tillage method. Each segment is assigned a default amount of conservation tillage based on historical data from the Conservation Technology Information Center (Documentation Appendix 6). Applying a percent implementation overwrites the default amount of this BMP. Only one submission unit may be used per scenario.
Agriculture	Conservation Tillage - Total Acres	Conservation tillage requires: (a) a minimum 30% residue coverage at the time of planting, and (b) a non-inversion tillage method. Each segment is assigned a default amount of conservation tillage based on historical data from the Conservation Technology Information Center (Documentation Appendix 6). Specifying acres under this BMP overwrites the default amount of this BMP. Only one submission unit may be used per scenario.
Agriculture	Continuous No Till	The Continuous No-Till (CNT) BMP is a crop planting and management practice in which soil disturbance by plows, disk or other tillage equipment is eliminated. CNT involves no-till methods on all crops in a multi-crop, multi-year rotation. When an acre is reported under CNT, it will not be eligible for additional reductions from the implementation of other practices such as cover crops or nutrient management planning. Multi-crop, multi-year rotations on cropland are eligible. Crop residue should remain on the field. Planting of a cover crop might be needed to maintain residue levels. The system must be maintained for a minimum of five years. All crops must be planted using no-till methods.
Agriculture	Cover Crop Early Arial Barley	A winter barley crop planted at least 2 weeks prior to the average frost date with an aerial seeding method . The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Early Arial Rye	A winter rye crop planted at least 2 weeks prior to the average frost date with an aerial seeding method . The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Early Arial Wheat	A winter wheat crop planted at least 2 weeks prior to the average frost date with an aerial seeding method . The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Early Drilled Rye	A winter rye crop planted at least 2 weeks prior to the average frost date with a drilled seeding method. The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Early Drilled Wheat	A winter wheat crop planted at least 2 weeks prior to the average frost date with a drilled seeding method. The crop may be neither fertilized nor harvested.

Agriculture	Cover Crop Early Other Rye	A winter rye crop planted at least 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Early Other Wheat	A winter wheat crop planted at least 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Early-Planting Aerial Soy Barley	A winter barley crop planted at least 2 weeks prior to the average frost date with an aerial seeding method . The cover crop follows soybeans.The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Early-Planting Aerial Soy Rye	A winter rye crop planted at least 2 weeks prior to the average frost date with an aerial seeding method . The cover crop follows soybeans.The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Early-Planting Aerial Soy Wheat	A winter wheat crop planted at least 2 weeks prior to the average frost date with an aerial seeding method . The cover crop follows soybeans.The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Early-Planting Drilled Barley	A winter barley crop planted at least 2 weeks prior to the average frost date with a drilled seeding method. The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Early-Planting Other Barley	A winter barley crop planted at least 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Late Drilled Rye	A winter rye crop planted after the average first frost date with a drilled seeding method. The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Late Other Wheat	A winter wheat crop planted after the average first frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Late-Planting Drilled Wheat	A winter wheat crop planted after the average first frost date with a drilled seeding method. The crop may be neither fertilized nor harvested.

Agriculture	Cover Crop Late-Planting Other Rye	A winter rye crop planted after the average first frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Standard Drilled Barley	A winter barley crop planted no more than 2 weeks prior to the average frost date with a drilled seeding method. The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Standard Drilled Rye	A winter rye crop planted no more than 2 weeks prior to the average frost date with a drilled seeding method. The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Standard Drilled Wheat	A winter wheat crop planted no more than 2 weeks prior to the average frost date with a drilled seeding method. The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Standard Other Barley	A winter barley crop planted no more than 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Standard Other Rye	A winter rye crop planted no more than 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). The crop may be neither fertilized nor harvested.
Agriculture	Cover Crop Standard Other Wheat	A winter wheat crop planted no more than 2 weeks prior to the average frost date with a seeding method that is neither drilled nor aerial (e.g. surface broadcast or with stalk chopping or light disking). The crop may be neither fertilized nor harvested.
Agriculture	Cropland Irrigation Management	Cropland under irrigation management is used to decrease climatic variability and maximize crop yields. The potential nutrient reduction benefit stems not from the increased average yield (20-25%) of irrigated versus non-irrigated cropland, but from the greater consistency of crop yields over time matched to nutrient applications. This increased consistency in crop yields provides a subsequent increased consistency in plant nutrient uptakes over time matched to applications, resulting in a decrease in potential environmental nutrient losses. The current placeholder effectiveness value for this practice has been proposed at 4% TN, 0%TP and 0%TSS, utilizing the range in average yields from the 2002 and 2007 NASS data for irrigated and non-irrigated grain corn as a reference. The proposed practice is applied on a per acre basis, and can be implemented and reported for cropland on both lo-till and hi-till land uses that receive or do not receive manure.

Agriculture	Dairy Manure Injection	The subsurface application of liquid manure from cattle and swine has been demonstrated in research studies to significantly reduce nutrient losses for both surface runoff and ammonia emissions. Recent studies by Pennsylvania State University (PSU) and USDA-ARS indicate that the effectiveness of the practice is dependent on the technology used for injection, and that some systems are not consistent with the USDA-NRCS management requirements for high residue management systems; e.g. Continuous No-Till. This proposed practice is indicative of low disturbance soil injection systems and is not appropriate for tillage incorporation or other post surface application incorporation methods. The current placeholder effectiveness value for this practice has been proposed at 25% TN, 0%TP and 0%TSS, utilizing a conservative estimate in combined nutrient and sediment loss reductions by current university and ARS research as a reference. The proposed practice is applied on a per acre basis, and can be implemented and reported for cropland on both lo-till and hi-till land uses that receive manure, pasture and hay with manure.
Agriculture	Dairy Precision Feeding and/or Forage Management	Dairy Precision Feeding 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.
Agriculture	Decision Agriculture	A management system that is information and technology based, is site specific and uses one or more of the following sources of data: soils, crops, nutrients, pests, moisture, or yield for optimum profitability, sustainability, and protection of the environment. This BMP is modeled as a land use change to a nutrient management land use with an effectiveness value applied to create an additional reduction.
Agriculture	Dirt & Gravel Road Erosion & Sediment Control - Driving Surface Aggregate + Raising the Roadbed	Reduce the amount of sediment runoff from dirt and gravel roads through the use of driving surface aggregates (DSA) such as durable and erosion resistant road surface and raising road elevation to restore natural drainage patterns.
Agriculture	Dirt & Gravel Road Erosion & Sediment Control - Outlets only	Reduce the amount of sediment runoff from dirt and gravel roads through the use of additional Drainage Outlets (creating new outlets in ditchline to reduce channelized flow).
Agriculture	Dirt & Gravel Road Erosion & Sediment Control - with Outlets	Reduce the amount of sediment runoff from dirt and gravel roads through the use of driving surface aggregates (DSA) such as durable and erosion resistant road surface and through the use of additional Drainage Outlets (creating new outlets in ditchline to reduce channelized flow).

Agriculture	Enhanced Nutrient Management	Based on research, the nutrient management rates of nitrogen application are set approximately 35% higher than what a crop needs to ensure nitrogen availability under optimal growing conditions. In a yield reserve program using enhanced nutrient management, the farmer would reduce the nitrogen application rate by 15%. An incentive or crop insurance is used to cover the risk of yield loss. This BMP effectiveness estimate is based on a reduction in nitrogen loss resulting from nutrient application to cropland 15% lower than the nutrient management recommendation. The effectiveness estimate is based on conservativeness and data from a program run by American Farmland Trust. This BMP is modeled as a land use change to a nutrient management land use with an effectiveness value applied to create an additional reduction.
Agriculture	Forest Buffers	Agricultural riparian forest buffers are linear wooded areas along rivers, stream and shorelines. Forest buffers help filter nutrients, sediments and other pollutants from runoff as well as remove nutrients from groundwater. The recommended buffer width for riparian forest buffers (agriculture) is 100 feet, with a 35 feet minimum width required.
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Agricultural riparian grass buffers are linear strips of grass or other non-woody vegetation maintained between the edge of fields and streams, rivers or tidal waters that help filter nutrients, sediment and other pollutants from runoff. The recommended buffer width for riparian forests buffers (agriculture) is 100 feet, with a 35 feet minimum width required. Vegetated open channels are modeled identically to grass buffers.
Agriculture	Heavy Use Poultry Area Concrete Pads	The stabilization of areas frequently and intensively used by people, animals or vehicles by surfacing with suitable materials.
Agriculture	Horse Pasture Management	Horse Pasture Management is defined as maintaining a 50% pasture cover with managed species (desirable, inherent) and managing high traffic areas.
Agriculture	Irrigation Water Capture Reuse	This practice involves the collection of runoff water from container nursery operations where runoff of irrigation water and leachate from plant containers grown on plastic or in greenhouses is routed to lined return ditches or piped to lined holding ponds. Ponds would be designed to retaining all excess irrigation water runoff or leachate and capturing the first one-half to one-inch of stormwater runoff. Water would be recirculated for irrigation in nursery and greenhouse operations or irrigated at the proper times of year on other vegetation capable of trapping nutrients at agronomic rates, such as cool season grasses.
Agriculture	Lagoon Covers	Permeable and impermeable covers of lagoons to prevent volatilization of ammonia. A cover can be, and is applied, to various species including swine and dairy.

Agriculture	Land Retirement to hay without nutrients (HEL)	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. Agricultural agencies have a program to assist farmers in land retirement procedures.
Agriculture	Land Retirement to pasture (HEL)	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.
Agriculture	Loafing Lot Management	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.
Agriculture	Mortality Composters	A physical structure and process for disposing of any type of dead animals. Composted material land applied using nutrient management plan recommendations.
Agriculture	No Till allowing combinations with other practices	The No till BMP is a crop planting and management practice in which soil disturbance by plows, disk or other tillage equipment is eliminated for all crops for a minimum of five years. Planting of a cover crop might be needed to maintain residue levels. When an acre is reported under No till, it is eligible for additional reductions from the implementation of other practices such as cover crops or nutrient management planning, unlike continuous no-till. Submission of No Till precludes submission of continuous no-till in the same scenario, and vice-a-versa.
Agriculture	Non Urban Stream Restoration (interim)	This is an interim BMP and the units may change depending on the outcome of the expert panel, anticipated in Fall 2012. This BMP maintains the integrity of shorelines by preventing or controlling erosion. The reduction is 0.2 lb nitrogen per foot, 0.068 phosphorus per foot, and 310 lbs sediment per foot.
Agriculture	Non Urban Stream Restoration; Shoreline Erosion Control	Stream restoration in urban areas is used to restore the urban stream ecosystem by restoring the natural hydrology and landscape of a stream, help improve habitat and water quality conditions in degraded streams. The reduction is 0.02 lb nitrogen per foot, 0.0025 phosphorus per foot, and 2 lbs sediment per foot .
Agriculture	Nutrient Management	Nutrient management plan (NMP) implementation (crop) is a comprehensive plan that describes the optimum use of nutrients to minimize nutrient loss while maintaining yield. A NMP details the type, rate, timing, and placement of nutrients for each crop. Soil, plant tissue, manure and/or sludge tests are used to assure optimal application rates. Plans should be revised every 2 to 3 years.

Agriculture	Off Stream Watering Without Fencing	This BMP requires the use of alternative drinking water sources away from streams. The BMP may also include options to provide off-stream shade for livestock, and implementing a shade component is encouraged where applicable. The hypothesis on which this practice is based is that, given a choice between a clean and convenient off-stream water source and a stream, cattle will preferentially drink from off-stream water source and reduce the time they spend near and in streams and streambanks. Alternative watering facilities typically involves the use of permanent or portable livestock water troughs placed away from the stream corridor. The source of 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 or without improved pasture management systems such as prescribed grazing or PIRG.
Agriculture	Poultry Litter Injection	The subsurface injection of poultry manure has been demonstrated in university and USDA-ARS research studies to significantly reduce nutrient losses for both surface runoff and ammonia emissions. Recent studies by universities and USDA-ARS indicate that dry manure injection is feasible and effective by utilizing current research technology. These systems are also consistent with the USDA-NRCS management requirements for high residue management systems; e.g. Continuous No-Till. This proposed practice is indicative of low disturbance soil injection systems and is not appropriate for tillage incorporation or other post surface application incorporation methods. The current placeholder effectiveness value for this practice has been proposed at 25% TN, 0%TP and 0%TSS, utilizing a conservative estimate in combined nutrient and sediment loss reductions by current university and ARS research as a reference. The proposed practice is applied on a per acre basis, and can be implemented and reported for cropland on both lo-till and hi-till land uses that receive manure, pasture and hay with manure.
Agriculture	Poultry Litter Treatment (alum, for example)	Surface application of alum, an acidifier, to poultry litter to acidify poultry litter and maintain ammonia in the non-volatile ionized form (ammonium).
Agriculture	Poultry Phytase	Phytase is an enzyme added to poultry-feed that helps poultry absorb phosphorus. The addition of phytase to poultry feed allows more efficient nutrient uptake by poultry, which in turn allows decreased phosphorus levels in feed and less overall phosphorus in poultry waste. The use of phytase is a best management practice (BMP). No poultry automatically have the phytase feed additive.

Agriculture	Precision Intensive Rotational Grazing	This practice utilizes more intensive forms 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 of the upland pastures. PIRG can be applied to pastures intersected by streams or upland pastures outside of the degraded stream corridor (35 feet width from top of bank). The modeled benefits of the PIRG practice can be applied to pasture acres in association with or without alternative watering facilities. They can also be applied in conjunction with or without stream access control. This practice requires intensive management of livestock rotation, also known as Managed Intensive Grazing systems (MIG), that have very short rotation schedules. Pastures are defined as having a vegetative cover of 60% or greater.
Agriculture	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). The modeled benefits of prescribed grazing practices can be applied to pasture acres in association with or without alternative watering facilities. They can also be applied in conjunction with or without stream access control. Pastures under the PG systems are defined as having a vegetative cover of 60% or greater.
Agriculture	Soil Conservation and Water Quality Plans	Farm conservation plans are a combination of agronomic, management and engineered practices that protect and improve soil productivity and water quality, and to prevent deterioration of natural resources on all or part of a farm. Plans may be prepared by staff working in conservation districts, natural resource conservation field offices or a certified private consultant. In all cases the plan must meet technical standards.
Agriculture	Sorbing Materials in Ag Ditches	The University of Maryland and the USDA Agricultural Research Service (ARS) have demonstrated through an existing research project at the University of Maryland-Eastern Shore the application of “Phosphorus-sorbing” materials to absorb available dissolved phosphorus in cropland drainage systems for removal and reuse as an agricultural fertilizer. These in-channel engineered systems can capture significant amounts of dissolved phosphorus in agricultural drainage water by passing them through phosphorus-sorbing materials, such as gypsum, drinking water treatment residuals, or acid mine drainage residuals. The proposed practice is applied on a per acre basis, and can be implemented and reported for cropland on both lo-till and hi-till land uses that receive or do not receive manure.

Agriculture	Stream Access Control with Fencing	Stream access control with fencing involves excluding a strip of land with fencing along the stream corridor to provide protection from livestock. The fenced areas may be planted with trees or grass, or left to natural plant succession, and can be of various widths. To provide the modeled benefits of a functional riparian buffer, the width must be a minimum of 35 feet from top-of-bank to fence line. The implementation of stream fencing provides stream access control for livestock but does not necessarily exclude animals from entering the stream by incorporating limited and stabilized in-stream crossing or watering facilities. The modeled benefits of stream access control can be applied to degraded stream corridors in association with or without alternative watering facilities. They can also be applied in conjunction with or without pasture management systems such as prescribed grazing or PIRG. Alternative watering facilities typically involves the use of permanent or portable livestock water troughs placed away from the stream corridor. The source of 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.
Agriculture	Streamside Forest Buffers	Converts streamside areas to forest. In the model, converts degraded riparian pasture to hay without nutrients. Should be used with Stream Access Control with Fencing to convert from hay without nutrients to forest.
Agriculture	Streamside Grass Buffers	Converts degraded riparian pasture to hay without nutrients
Agriculture	Streamside Wetland Restoration	Converts degraded riparian pasture to forest.
Agriculture	Swine Phytase	This BMP reduces the concentration of phosphorus in manure. Less phosphorus is necessary in the feed because an enzyme feed supplement increases the amount of phosphorus absorbed by the hog.
Agriculture	Tree Planting; Vegetative Environmental Buffers - Poultry	Tree planting includes any tree planting, except those used to establish riparian forest buffers, targeting lands that are highly erodible or identified as critical resource areas.
Agriculture	Water Control Structures	Installing and managing boarded gate systems in agricultural land that contains surface drainage ditches.

Agriculture	Wetland Restoration	Agricultural wetland restoration activities re-establish the natural hydraulic condition in a field that existed prior to the installation of subsurface or surface drainage. Projects may include restoration, creation and enhancement acreage. Restored wetlands may be any wetland classification including forested, scrub-shrub or emergent marsh.
Urban	Abandoned Mine Reclamation	Abandoned mine reclamation stabilizes the soil on lands mined for coal or affected by mining, such as wastebanks, coal processing, or other coal mining processes.
Urban	Bioretention/rain gardens	An excavated pit backfilled with engineered media, topsoil, mulch, and vegetation. These are planting areas installed in shallow basins in which the storm water runoff is temporarily ponded and then treated by filtering through the bed components, and through biological and biochemical reactions within the soil matrix and around the root zones of the plants.
Urban	Bioswale	With a bioswale, the load is reduced because, unlike other open channel designs, there is now treatment through the soil. A bioswale is designed to function as a bioretention area.
Urban	Dirt & Gravel Road Erosion & Sediment Control - Driving Surface Aggregate + Raising the Roadbed	Reduce the amount of sediment runoff from dirt and gravel roads through the use of driving surface aggregates (DSA) such as durable and erosion resistant road surface and raising road elevation to restore natural drainage patterns.
Urban	Dirt & Gravel Road Erosion & Sediment Control - Outlets only	Reduce the amount of sediment runoff from dirt and gravel roads through the use of additional Drainage Outlets (creating new outlets in ditchline to reduce channelized flow).
Urban	Dirt & Gravel Road Erosion & Sediment Control - with Outlets	Reduce the amount of sediment runoff from dirt and gravel roads through the use of driving surface aggregates (DSA) such as durable and erosion resistant road surface and through the use of additional Drainage Outlets (creating new outlets in ditchline to reduce channelized flow).

Urban	Dry Detention Ponds and Hydrodynamic Structures	Dry Detention Ponds are depressions or basins created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. Hydrodynamic Structures are devices designed to improve quality of stormwater using features such as swirl concentrators, grit chambers, oil barriers, baffles, micropools, and absorbent pads that are designed to remove sediments, nutrients, metals, organic chemicals, or oil and grease from urban runoff.
Urban	Dry Extended Detention Ponds	Dry extended detention (ED) basins are depressions created by excavation or berm construction that temporarily store runoff and release it slowly via surface flow or groundwater infiltration following storms. Dry ED basins are designed to dry out between storm events, in contrast with wet ponds, which contain standing water permanently. As such, they are similar in construction and function to dry detention basins, except that the duration of detention of stormwater is designed to be longer, theoretically improving treatment effectiveness.
Urban	Erosion and Sediment Control	Erosion and sediment control practices applied to construction land. Acres in excess of available construction land rolls to other urban land uses. Protects water resources from sediment pollution and increases in runoff associated with land development activities. By retaining soil on-site, sediment and attached nutrients are prevented from leaving disturbed areas and polluting streams.
Urban	Erosion and Sediment Control on Extractive, excess applied to all other pervious urban	Erosion and sediment control applied to extractive land uses, such as mining. Protects water resources from sediment pollution and increases in runoff associated with land development activities. By retaining soil on-site, sediment and attached nutrients are prevented from leaving disturbed areas and polluting streams.
Urban	Forest Conservation	This BMP in Maryland is the implementation of the Maryland Forest Conservation Act that requires developers to maintain at least 20% of a development site in trees (forest condition). This Act serves to alter the rate of urban conversion. Report those acres that were maintained as forest. The model treats this as a land use conversion from urban to forest land.
Urban	Impervious Urban Surface Reduction	Reducing impervious surfaces to promote infiltration and percolation of runoff storm water.
Urban	MS4 Permit-Required Stormwater Retrofit	MS4 Retrofit is a generalized BMP that has an average reduction efficiency of 25% for total nitrogen.

Urban	Permeable Pavement - with sandveg no under drain with A/B soils	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has no underdrain, has sand and/or vegetation and is in A or B soil.
Urban	Permeable Pavement – with sandveg with under drain with A/B soils	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has an underdrain, has sand and/or vegetation and is in A or B soil.
Urban	Permeable Pavement - with sandveg with under drain with C/D soils	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has an underdrain, has sand and/or vegetation and is in C or D soil.
Urban	Permeable Pavement - no sandveg no under drain with A/B soils	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has no underdrain, no sand or vegetation and is in A or B soil.
Urban	Permeable Pavement - no sandveg with under drain with A/B soils	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has an underdrain, no sand or vegetation and is in A or B soil.

Urban	Permeable Pavement - no sandveg with under drain with C/D soils	Pavement or pavers that reduce runoff volume and treat water quality through both infiltration and filtration mechanisms. Water filters through open voids in the pavement surface to a washed gravel subsurface storage reservoir, where it is then slowly infiltrated into the underlying soils or exits via an underdrain. This BMP has an underdrain, no sand or vegetation and is in C or D soil.
Urban	Regenerative Stormwater Conveyance	Improving stormwater drainage infrastructure by installing open-channel, sand seepage filtering systems that utilize a series of shallow aquatic pools, riffle weir grade controls, native vegetation, and underlying carbon-rich sand channel to treat and safely detain and convey storm flow, and convert stormwater to groundwater through infiltration.
Urban	Shoreline Erosion Control	Protection of shoreline from excessive wave action by creating a marsh or an offshore structure such as a sill, breakwater or sand containment structure.
Urban	Stormwater Management by Era 1985 to 2002 MD	Stormwater management implemented on land during the time period of 1985 to 2002
Urban	Stormwater Management by Era 2002 to 2010 MD	Stormwater management implemented on land during the time period of 2001 to 2010
Urban	Stormwater to the Maximum Extent Practicable (SW to the MEP)	Stormwater implemented to the Maximum Extent Practicable, according to MDE's Stormwater Regulations.
Urban	Street Sweeping 25 times a year-acres (formerly called Street Sweeping Mechanical Monthly)	Street sweeping conducted on a twice monthly basis. The regularity of the street sweeping and reduces nitrogen, phosphorus, and sediment whereas less regular street sweeping reduces only sediment. The same street must be swept 25 times a year. The acres submitted are for the area of streets that are swept.
Urban	Street Sweeping 25 times a year-lbs	Street sweeping conducted on a twice monthly basis. The regularity of the street sweeping and reduces nitrogen, phosphorus, and sediment whereas less regular street sweeping reduces only sediment. The same street must be swept 25 times a year. The lbs submitted are for the lbs of material picked up by the sweeper. These lbs of material are the lbs of TSS removed. The TN reduction is 0.00175 of the TSS. The TP reduction is 0.0007 of the TSS.

Urban	Street Sweeping Pounds	Street sweeping measured by the weight of street residue collected. Street sweeping and storm drain cleanout practices rank among the oldest practices used by communities for a variety of purposes to provide a clean and healthy environment, and more recently to comply with their National Pollutant Discharge Elimination System stormwater permits. The ability for these practices to achieve pollutant reductions is uncertain given current research findings. Only a few street sweeping studies provide sufficient data to statistically determine the impact of street sweeping and storm drain cleanouts on water quality and to quantify their improvements. The ability to quantify pollutant loading reductions from street sweeping is challenging given the range and variability of factors that impact its performance, such as the street sweeping technology, frequency and conditions of operation in addition to catchment characteristics. Fewer studies are available to evaluate the pollutant reduction capabilities due to storm drain inlet or catch basin cleanouts.
Urban	Urban Filtering Practices	Practices that capture and temporarily store runoff and pass it through a filter bed of either sand or an organic media. There are various sand filter designs, such as above ground, below ground, perimeter, etc. An organic media filter uses another medium besides sand to enhance pollutant removal for many compounds due to the increased cation exchange capacity achieved by increasing the organic matter. These systems require yearly inspection and maintenance to receive pollutant reduction credit.
Urban	Urban Forest Buffers	An area of trees at least 35 feet wide on one side of a stream, usually accompanied by trees, shrubs and other vegetation that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals.
Urban	Urban Grass Buffers	This BMP changes the land use from pervious urban to pervious urban. Therefore, there is no change and no reduction from using this BMP.
Urban	Urban Growth Reduction	Change from urban to non-urban landuse in forecasted conditions.
Urban	Urban Infiltration Practices - no sand\veg no under drain – A/B soils	A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration.

Urban	Urban Infiltration Practices - with sandveg no under drain – A/B soils	A depression to form an infiltration basin where sediment is trapped and water infiltrates the soil. No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Design specifications require infiltration basins and trenches to be build in good soil, they are not constructed on poor soils, such as C and D soil types. Engineers are required to test the soil before approved to build is issued. To receive credit over the longer term, jurisdictions must conduct yearly inspections to determine if the basin or trench is still infiltrating runoff.
Urban	Urban Nutrient Management	Urban nutrient management involves the reduction of fertilizer to grass lawns and other urban areas. The implementation of urban nutrient management is based on public education and awareness, targeting suburban residences and businesses, with emphasis on reducing excessive fertilizer use. This does not account for the recent laws passed to remove P from fertilizer.
Urban	Urban Stream Restoration (interim)	This is an interim BMP and the units may change depending on the outcome of the expert panel, anticipated in Fall 2012. This BMP maintains the integrity of shorelines by preventing or controlling erosion. The reduction is 0.2 lb nitrogen per foot, 0.068 phosphorus per foot, and 310 lbs sediment per foot.
Urban	Urban Stream Restoration; Shoreline Erosion Control; Regenerative Stormwater Conveyance	Stream restoration in urban areas is used to restore the urban stream ecosystem by restoring the natural hydrology and landscape of a stream, help improve habitat and water quality conditions in degraded streams. The reduction is 0.02 lb nitrogen per foot, 0.0025 phosphorus per foot, and 2 lbs sediment per foot .
Urban	Urban Tree Planting; Urban Tree Canopy	Urban tree planting is planting trees on urban pervious areas at a rate that would produce a forest-like condition over time. The intent of the planting is to eventually convert the urban area to forest. If the trees are planted as part of the urban landscape, with no intention to covert the area to forest, then this would not count as urban tree planting
Urban	Vegetated Open Channel –Urban – A/B soils, no underdrain	Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils. This BMP has no underdrain and is in A or B soil.

Urban	Vegetated Open Channel –Urban – C/D soils, no underdrain	Open channels are practices that convey stormwater runoff and provide treatment as the water is conveyed, includes bioswales. Runoff passes through either vegetation in the channel, subsoil matrix, and/or is infiltrated into the underlying soils. This BMP has no underdrain and is in C or D soil.
Urban	Wet Ponds and Wetlands	A water impoundment structure that intercepts stormwater runoff then releases it to an open water system at a specified flow rate. These structures retain a permanent pool and usually have retention times sufficient to allow settlement of some portion of the intercepted sediments and attached nutrients/toxics. Until recently, these practices were designed specifically to meet water quantity, not water quality objectives. There is little or no vegetation living within the pooled area nor are outfalls directed through vegetated areas prior to open water release. Nitrogen reduction is minimal.
Forest	Dirt & Gravel Road Erosion & Sediment Control - Driving Surface Aggregate + Raising the Roadbed	Reduce the amount of sediment runoff from dirt and gravel roads through the use of driving surface aggregates (DSA) such as durable and erosion resistant road surface and raising road elevation to restore natural drainage patterns.
Forest	Dirt & Gravel Road Erosion & Sediment Control - Outlets only	Reduce the amount of sediment runoff from dirt and gravel roads through the use of additional Drainage Outlets (creating new outlets in ditchline to reduce channelized flow).
Forest	Dirt & Gravel Road Erosion & Sediment Control - with Outlets	Reduce the amount of sediment runoff from dirt and gravel roads through the use of driving surface aggregates (DSA) such as durable and erosion resistant road surface and through the use of additional Drainage Outlets (creating new outlets in ditchline to reduce channelized flow).
Forest	Forest Harvesting Practices	Forest harvesting practices are a suite of BMPs that minimize the environmental impacts of road building, log removal, site preparation and forest management. These practices help reduce suspended sediments and associated nutrients that can result from forest operations.
Forest	Non Urban Stream Restoration (interim)	This is an interim BMP and the units may change depending on the outcome of the expert panel, anticipated in Fall 2012. This BMP maintains the integrity of shorelines by preventing or controlling erosion. The reduction is 0.2 lb nitrogen per foot, 0.068 phosphorus per foot, and 310 lbs sediment per foot.

Forest	Non Urban Stream Restoration; Shoreline Erosion Control	Stream restoration in urban areas is used to restore the urban stream ecosystem by restoring the natural hydrology and landscape of a stream, help improve habitat and water quality conditions in degraded streams. The reduction is 0.02 lb nitrogen per foot, 0.0025 phosphorus per foot, and 2 lbs sediment per foot .
Septic	Septic Connection	This is when septic systems get converted to public sewer. This reduces the number of systems because the waste is sent into the sewer and treated at a wastewater treatment plant.
Septic	Septic Denitrification	Septic denitrification represents the replacement of traditional septic systems with more advanced systems that have additional nitrogen removal capabilities. Traditional septic systems usually consist of a large tank designed to hold the wastewater allowing grits and solids time for settling and decomposition. Wastewater then flows to the second component, the drainfield. An enhanced septic system like that shown can provide further treatment of nitrogen through processes that encourage denitrification of the wastewater.
Septic	Septic Pumping	Septic systems achieve nutrient reductions through several types of management practices, including frequent maintenance and pumping. On average, septic tanks need to be pumped once every three to five years to maintain effectiveness. The pumping of septic tanks is one of several measures that can be implemented to protect soil absorption systems from failure. When septic tanks are pumped and sewage removed, the septic system's capacity to remove settable and floatable solids from wastewater is increased.
Waste Water	% Reduction	This BMP calculates a percent reduction in the volume of waste water.
Waste Water	Set Nutrient Concentrations	Users may specify the actual concentrations for a waste water facility.
Waste Water	Set Permitted Load	Users may specify the actual load for a waste water facility as mg/L.

The land use change and efficiency BMPs in Table 8-3 include interim BMPs that have not had final approval by the CBP workgroups as of July 2012. These interim BMPs are allowed for planning purposes, but not for reporting progress. The sector for each of these BMPs is shown. Some of these BMPs vary by hydrogeomorphic region. These BMPs show the minimum and the maximum effectiveness value. The actual value for each hydrogeomorphic region is in Table 8-4. The cover crop BMPs are listed in Table 8-5.

Table 8-3: Land use change and efficiency BMPs

Sector	BMP	Notes	Variables	Nitrogen Percent Effectiveness-Minimum	Nitrogen Percent Effectiveness-Maximum	Phosphorus Percent Effectiveness-Minimum	Phosphorus Percent Effectiveness-Maximum	Sediment Percent Effectiveness-Minimum	Sediment Percent Effectiveness-Maximum
Agriculture	Runoff Control Systems			20	20	20	20	40	40
Agriculture	Irrigation Water Capture Reuse	Interim-for use in planning only		75	75	75	75	0	0
Agriculture	Alternative Crops	Land use change BMP, no efficiency							
Agriculture	Soil Conservation and Water Quality Plans		hydrogeomorphic region	3	8	5	15	8	25
Agriculture	Conservation Tillage - Additional Acres	Land use change BMP, no efficiency. Mutually exclusive with the other Conservation tillage BMPs of percent of acres or total acres. Works by using the default % of conservation till and adds specified acres to the							

		default.								
Agriculture	Conservation Till Without Nutrients	Interim-for use in planning only			7	7	18	18	31	31
Agriculture	Conservation Tillage - Percent of Acres	Land use change BMP, no efficiency. Mutually exclusive with the other Conservation tillage BMPs of additional acres or total acres. Works by applying the specified % and overwrites the default.								
Agriculture	Conservation Tillage - Total Acres	Land use change BMP, no efficiency. Mutually exclusive with the other Conservation tillage BMPs								

		of additional acres or percent of acres. Works by applying the specified acres and overwrites the default.							
Agriculture	Continuous No Till	Mutually exclusive with No Till BMP	hydrogeomorphic region	10	15	20	40	70	70
Agriculture	Cropland Irrigation Management	Interim-for use in planning only		4	4	0	0	0	0
Agriculture	Decision Agriculture	Also a land use change		3.5	3.5	0	0	0	0
Agriculture	Sorbing Materials in Ag Ditches	Interim-for use in planning only		0	0	40	40	0	0
Agriculture	Decision Agriculture-Efficiency BMP	Interim-for use in planning only. Created for VA.		9.4	9.4	9.2	9.2	0	0
Agriculture	Enhanced Nutrient Management Application Reduction Efficiency BMP	Interim-for use in planning only. Created for VA.		12.9	12.9	9.2	9.2	0	0
Agriculture	Nutrient Management Application Reduction Efficiency BMP	Interim-for use in planning only. Created for VA.		5.9	5.9	9.2	9.2	0	0

Agriculture	Enhanced Nutrient Management Application Reduction	Also a land use change		7	7	0	0	0	0
Agriculture	Forest Buffers	Also a land use change	hydrogeomorphic region	19	65	30	45	40	60
Agriculture	Streamside Forest Buffers	Also a land use change. Frequently used in combination with Stream Access Control Without Fencing (PastFence). PastFence converts degraded riparian pasture (trp) to hay without nutrients (hyo). ForestBuffersTRP converts hyo to forest (for)	hydrogeomorphic region	19	65	30	45	40	60
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Also a land use change. However, the change is from pervious	hydrogeomorphic region	13	46	30	45	40	60

		developed to pervious developed so this BMP has no effect.							
Agriculture	Streamside Grass Buffers	Also a land use change	hydrogeomorphic region	13	46	30	45	40	60
Agriculture	Horse Pasture Management			0	0	20	20	40	40
Agriculture	Land Retirement to hay without nutrients (HEL)	Land use change BMP, no efficiency							
Agriculture	Land Retirement to pasture (HEL)	Land use change BMP, no efficiency							
Agriculture	Dairy Manure Incorporation	Interim-for use in planning only		25	25	0	0	0	0
Agriculture	Loafing Lot Management			20	20	20	20	40	40
Agriculture	No Till	Interim-for use in planning only. Mutually exclusive with Continuous No Till BMP		5	5	10	10	20	20
Agriculture	Nutrient Management Application Reduction	Land use change BMP, no efficiency							
Agriculture	Off Stream Watering Without Fencing			5	5	8	8	10	10

Agriculture	Stream Access Control with Fencing	Land use change BMP, no efficiency							
Agriculture	Poultry Litter Incorporation	Interim-for use in planning only		25	25	0	0	0	0
Agriculture	Prescribed Grazing		hydrogeomorphic region	9	11	24	24	30	30
Agriculture	Tree Planting; Vegetative Environmental Buffers - Poultry	Land use change BMP, no efficiency							
Agriculture	Precision Intensive Rotational Grazing		hydrogeomorphic region	9	11	24	24	30	30
Agriculture	Water Control Structures			33	33	0	0	0	0
Agriculture	Wetland Restoration	Also a land use change	hydrogeomorphic region	7	25	12	50	4	15
Agriculture	Streamside Wetland Restoration	Land use change BMP, no efficiency							
Agriculture	Cover Crops all types including commodity and regular	See Appendix 1 for detailed cover crop types.	hydrogeomorphic region and land use	5	45	0	15	0	20
Forest	Forest Harvesting Practices			50	50	60	60	60	60
Urban	Abandoned Mine Reclamation	Land use change BMP, no efficiency							
Urban	Bioretention/raingardens			75	75	70	70	80	80
Urban	Bioswale			75	75	70	70	80	80

Urban	Dry Detention Ponds and Hydrodynamic Structures		5	5	10	10	10	10
Urban	Stormwater to the Maximum Extent Practicable (SW to the MEP)		50	50	60	60	90	90
Urban	Erosion and Sediment Control		25	25	40	40	40	40
Urban	Erosion and Sediment Control on non-regulated pervious urban	Interim-for use in planning only	25	25	40	40	40	40
Urban	Erosion and Sediment Control on extraction land use	Interim-for use in planning only	25	25	40	40	40	40
Urban	Dry Extended Detention Ponds		20	20	20	20	60	60
Urban	Urban Filtering Practices		40	40	60	60	80	80
Urban	Urban Forest Buffers	Also a land use change	25	25	50	50	50	50
Urban	Forest Conservation	Land use change BMP, no efficiency						
Urban	Impervious Urban Surface Reduction	Land use change BMP, no efficiency						
Urban	Urban Infiltration Practices - with sandveg A/B soils no underdrain		85	85	85	85	95	95
Urban	Urban Infiltration Practices – no sandveg, A/B soils		80	80	85	85	90	90

	no underdrain						
Urban	Permeable Pavement - with sandveg no underdrain with AB soils	80	80	80	80	85	85
Urban	Permeable Pavement – with sandveg with underdrain with AB soils	50	50	50	50	70	70
Urban	Permeable Pavement – with sandveg with underdrain with CD soils	20	20	55	55	55	55
Urban	Permeable Pavement – no sandveg no underdrain with AB soils	75	75	80	80	85	85
Urban	Permeable Pavement – no sandveg with underdrain with AB soils	45	45	50	50	70	70
Urban	Permeable Pavement – no sandveg with underdrain with CD soils	10	10	20	20	55	55
Urban	MS4 Permit-Required Stormwater Retrofit	25	25	35	35	65	65

Urban	Street sweeping 25 times a year		3	3	3	3	9	9
Urban	Stormwater Management by Era 2002 to 2010 MD		30	30	40	40	80	80
Urban	Stormwater Management by Era 1985 to 2002 MD		17	17	30	30	40	40
Urban	Urban Nutrient Management		17	17	22	22	0	0
Urban	Urban Tree Planting; Urban Tree Canopy	Land use change BMP, no efficiency						
Urban	Urban Grass Buffers	Land use change BMP, no efficiency						
Urban	Urban Growth Reduction	Land use change BMP, no efficiency						
Urban	Vegetated Open Channel – A/B soils, no underdrain Urban		45	45	45	45	70	70
Urban	Vegetated Open Channel – C/D soils, no underdrain Urban		10	10	10	10	50	50
Urban	Wet Ponds and Wetlands		20	20	45	45	60	60

Table 8-4: BMPs that vary by hydrogeomorphic region.

Sector	BMP	Hydro Geomorphic Region	N Efficiency	P Efficiency	S Efficiency
Agriculture	Continuous No Till	Appalachian Plateau Carbonate	15	40	70

		Non Tidal			
Agriculture	Continuous No Till	Appalachian Plateau Siliciclastic Non Tidal	15	40	70
Agriculture	Continuous No Till	Blue Ridge Non Tidal	15	40	70
Agriculture	Continuous No Till	Mesozoic Lowlands Non Tidal	15	40	70
Agriculture	Continuous No Till	Piedmont Carbonate Non Tidal	15	40	70
Agriculture	Continuous No Till	Piedmont Crystalline Non Tidal	15	40	70
Agriculture	Continuous No Till	Valley and Ridge Carbonate Non Tidal	15	40	70
Agriculture	Continuous No Till	Valley and Ridge Siliciclastic Non Tidal	15	40	70
Agriculture	Continuous No Till	Coastal Plain Dissected Uplands Non Tidal	10	20	70
Agriculture	Continuous No Till	Coastal Plain Dissected Uplands Tidal	10	20	70
Agriculture	Continuous No Till	Coastal Plain Lowlands Non Tidal	10	20	70
Agriculture	Continuous No Till	Coastal Plain Lowlands Tidal	10	20	70
Agriculture	Continuous No Till	Coastal Plain Uplands Non Tidal	10	20	70
Agriculture	Continuous No Till	Coastal Plain Uplands Tidal	10	20	70
Agriculture	Forest Buffers	Coastal Plain Dissected Uplands Non Tidal	65	42	56
Agriculture	Forest Buffers	Coastal Plain Lowlands Non Tidal	56	39	52
Agriculture	Forest Buffers	Piedmont Crystalline Non Tidal	56	42	56
Agriculture	Forest Buffers	Appalachian Plateau Carbonate Non Tidal	54	42	56
Agriculture	Forest Buffers	Appalachian Plateau Siliciclastic Non Tidal	54	42	56
Agriculture	Forest Buffers	Piedmont Carbonate Non Tidal	46	36	48

Agriculture	Forest Buffers	Valley and Ridge Siliciclastic Non Tidal	46	39	52
Agriculture	Forest Buffers	Blue Ridge Non Tidal	34	30	40
Agriculture	Forest Buffers	Mesozoic Lowlands Non Tidal	34	30	40
Agriculture	Forest Buffers	Valley and Ridge Carbonate Non Tidal	34	30	40
Agriculture	Forest Buffers	Coastal Plain Uplands Non Tidal	31	45	60
Agriculture	Forest Buffers	Coastal Plain Dissected Uplands Tidal	19	45	60
Agriculture	Forest Buffers	Coastal Plain Lowlands Tidal	19	45	60
Agriculture	Forest Buffers	Coastal Plain Uplands Tidal	19	45	60
Agriculture	Streamside Forest Buffers	Coastal Plain Dissected Uplands Non Tidal	65	42	56
Agriculture	Streamside Forest Buffers	Coastal Plain Lowlands Non Tidal	56	39	52
Agriculture	Streamside Forest Buffers	Piedmont Crystalline Non Tidal	56	42	56
Agriculture	Streamside Forest Buffers	Appalachian Plateau Carbonate Non Tidal	54	42	56
Agriculture	Streamside Forest Buffers	Appalachian Plateau Siliciclastic Non Tidal	54	42	56
Agriculture	Streamside Forest Buffers	Piedmont Carbonate Non Tidal	46	36	48
Agriculture	Streamside Forest Buffers	Valley and Ridge Siliciclastic Non Tidal	46	39	52
Agriculture	Streamside Forest Buffers	Blue Ridge Non Tidal	34	30	40
Agriculture	Streamside Forest Buffers	Mesozoic Lowlands Non Tidal	34	30	40
Agriculture	Streamside Forest Buffers	Valley and Ridge Carbonate Non Tidal	34	30	40
Agriculture	Streamside Forest Buffers	Coastal Plain Uplands Non Tidal	31	45	60
Agriculture	Streamside Forest Buffers	Coastal Plain Dissected Uplands Tidal	19	45	60

Agriculture	Streamside Forest Buffers	Coastal Plain Lowlands Tidal	19	45	60
Agriculture	Streamside Forest Buffers	Coastal Plain Uplands Tidal	19	45	60
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Coastal Plain Dissected Uplands Non Tidal	46	42	56
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Coastal Plain Lowlands Non Tidal	39	39	52
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Piedmont Crystalline Non Tidal	39	42	56
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Appalachian Plateau Carbonate Non Tidal	38	42	56
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Appalachian Plateau Siliciclastic Non Tidal	38	42	56
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Piedmont Carbonate Non Tidal	32	36	48
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Valley and Ridge Siliciclastic Non Tidal	32	39	52
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Blue Ridge Non Tidal	24	30	40
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Mesozoic Lowlands Non Tidal	24	30	40
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Valley and Ridge Carbonate Non Tidal	24	30	40
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Coastal Plain Uplands Non Tidal	21	45	60
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Coastal Plain Dissected Uplands Tidal	13	45	60
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Coastal Plain Lowlands Tidal	13	45	60
Agriculture	Grass Buffers; Vegetated Open Channel - Agriculture	Coastal Plain Uplands Tidal	13	45	60
Agriculture	Streamside Grass Buffers	Coastal Plain Dissected Uplands	46	42	56

		Non Tidal			
Agriculture	Streamside Grass Buffers	Coastal Plain Lowlands Non Tidal	39	39	52
Agriculture	Streamside Grass Buffers	Piedmont Crystalline Non Tidal	39	42	56
Agriculture	Streamside Grass Buffers	Appalachian Plateau Carbonate Non Tidal	38	42	56
Agriculture	Streamside Grass Buffers	Appalachian Plateau Siliciclastic Non Tidal	38	42	56
Agriculture	Streamside Grass Buffers	Piedmont Carbonate Non Tidal	32	36	48
Agriculture	Streamside Grass Buffers	Valley and Ridge Siliciclastic Non Tidal	32	39	52
Agriculture	Streamside Grass Buffers	Blue Ridge Non Tidal	24	30	40
Agriculture	Streamside Grass Buffers	Mesozoic Lowlands Non Tidal	24	30	40
Agriculture	Streamside Grass Buffers	Valley and Ridge Carbonate Non Tidal	24	30	40
Agriculture	Streamside Grass Buffers	Coastal Plain Uplands Non Tidal	21	45	60
Agriculture	Streamside Grass Buffers	Coastal Plain Dissected Uplands Tidal	13	45	60
Agriculture	Streamside Grass Buffers	Coastal Plain Lowlands Tidal	13	45	60
Agriculture	Streamside Grass Buffers	Coastal Plain Uplands Tidal	13	45	60
Agriculture	Prescribed Grazing	Appalachian Plateau Siliciclastic Non Tidal	11	24	30
Agriculture	Prescribed Grazing	Blue Ridge Non Tidal	11	24	30
Agriculture	Prescribed Grazing	Mesozoic Lowlands Non Tidal	11	24	30
Agriculture	Prescribed Grazing	Piedmont Crystalline Non Tidal	11	24	30
Agriculture	Prescribed Grazing	Valley and Ridge Siliciclastic Non Tidal	11	24	30
Agriculture	Prescribed Grazing	Appalachian Plateau Carbonate Non Tidal	9	24	30
Agriculture	Prescribed Grazing	Coastal Plain Dissected Uplands	9	24	30

		Non Tidal			
Agriculture	Prescribed Grazing	Coastal Plain Dissected Uplands Tidal	9	24	30
Agriculture	Prescribed Grazing	Coastal Plain Lowlands Non Tidal	9	24	30
Agriculture	Prescribed Grazing	Coastal Plain Lowlands Tidal	9	24	30
Agriculture	Prescribed Grazing	Coastal Plain Uplands Non Tidal	9	24	30
Agriculture	Prescribed Grazing	Coastal Plain Uplands Tidal	9	24	30
Agriculture	Prescribed Grazing	Piedmont Carbonate Non Tidal	9	24	30
Agriculture	Prescribed Grazing	Valley and Ridge Carbonate Non Tidal	9	24	30
Agriculture	Precision Intensive Rotational Grazing	Appalachian Plateau Siliciclastic Non Tidal	11	24	30
Agriculture	Precision Intensive Rotational Grazing	Blue Ridge Non Tidal	11	24	30
Agriculture	Precision Intensive Rotational Grazing	Mesozoic Lowlands Non Tidal	11	24	30
Agriculture	Precision Intensive Rotational Grazing	Piedmont Crystalline Non Tidal	11	24	30
Agriculture	Precision Intensive Rotational Grazing	Valley and Ridge Siliciclastic Non Tidal	11	24	30
Agriculture	Precision Intensive Rotational Grazing	Appalachian Plateau Carbonate Non Tidal	9	24	30
Agriculture	Precision Intensive Rotational Grazing	Coastal Plain Dissected Uplands Non Tidal	9	24	30
Agriculture	Precision Intensive Rotational Grazing	Coastal Plain Dissected Uplands Tidal	9	24	30
Agriculture	Precision Intensive Rotational Grazing	Coastal Plain Lowlands Non Tidal	9	24	30
Agriculture	Precision Intensive Rotational Grazing	Coastal Plain Lowlands Tidal	9	24	30
Agriculture	Precision Intensive Rotational Grazing	Coastal Plain Uplands Non Tidal	9	24	30
Agriculture	Precision Intensive Rotational Grazing	Coastal Plain Uplands Tidal	9	24	30
Agriculture	Precision Intensive Rotational Grazing	Piedmont Carbonate Non Tidal	9	24	30

Agriculture	Precision Intensive Rotational Grazing	Valley and Ridge Carbonate Non Tidal	9	24	30
Agriculture	Wetland Restoration	Coastal Plain Dissected Uplands Non Tidal	25	50	15
Agriculture	Wetland Restoration	Coastal Plain Dissected Uplands Tidal	25	50	15
Agriculture	Wetland Restoration	Coastal Plain Lowlands Non Tidal	25	50	15
Agriculture	Wetland Restoration	Coastal Plain Lowlands Tidal	25	50	15
Agriculture	Wetland Restoration	Coastal Plain Uplands Non Tidal	25	50	15
Agriculture	Wetland Restoration	Coastal Plain Uplands Tidal	25	50	15
Agriculture	Wetland Restoration	Blue Ridge Non Tidal	14	26	8
Agriculture	Wetland Restoration	Mesozoic Lowlands Non Tidal	14	26	8
Agriculture	Wetland Restoration	Piedmont Carbonate Non Tidal	14	26	8
Agriculture	Wetland Restoration	Piedmont Crystalline Non Tidal	14	26	8
Agriculture	Wetland Restoration	Valley and Ridge Carbonate Non Tidal	14	26	8
Agriculture	Wetland Restoration	Valley and Ridge Siliciclastic Non Tidal	14	26	8
Agriculture	Wetland Restoration	Appalachian Plateau Carbonate Non Tidal	7	12	4
Agriculture	Wetland Restoration	Appalachian Plateau Siliciclastic Non Tidal	7	12	4

There are an enormous variety of cover crop types. These vary by planting date, variety, plant method, and hydrogeomorphic region. These are listed in Table 8-5.

Table 8-5: Cover crop effectiveness values

BMP	BMP Short Name	Hydro Geomorphic Region	N Efficiency	P Efficiency	S Efficiency	Land use
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Appalachian Plateau Siliciclastic Non Tidal	6	0	0	All

Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Blue Ridge Non Tidal	6	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Mesozoic Lowlands Non Tidal	6	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Valley and Ridge Siliciclastic Non Tidal	6	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Appalachian Plateau Carbonate Non Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Coastal Plain Dissected Uplands Non Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Coastal Plain Dissected Uplands Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Coastal Plain Lowlands Non Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Coastal Plain Lowlands Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Coastal Plain Uplands Non Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Coastal Plain Uplands Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Piedmont Carbonate Non Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Piedmont Crystalline Non Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Barley	ComCovCropEAB	Valley and Ridge Carbonate Non Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Appalachian Plateau Siliciclastic Non Tidal	8	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Blue Ridge Non Tidal	8	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Mesozoic Lowlands Non Tidal	8	0	0	All

Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Valley and Ridge Siliciclastic Non Tidal	8	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Appalachian Plateau Carbonate Non Tidal	10	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Coastal Plain Dissected Uplands Non Tidal	10	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Coastal Plain Dissected Uplands Tidal	10	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Coastal Plain Lowlands Non Tidal	10	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Coastal Plain Lowlands Tidal	10	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Coastal Plain Uplands Non Tidal	10	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Coastal Plain Uplands Tidal	10	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Piedmont Carbonate Non Tidal	10	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Piedmont Crystalline Non Tidal	10	0	0	All
Commodity Cover Crop Early Aerial Rye	ComCovCropEAR	Valley and Ridge Carbonate Non Tidal	10	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Appalachian Plateau Siliciclastic Non Tidal	9	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Blue Ridge Non Tidal	9	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Mesozoic Lowlands Non Tidal	9	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Valley and Ridge Siliciclastic Non Tidal	9	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Appalachian Plateau Carbonate Non Tidal	12	0	0	All

Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Coastal Plain Dissected Uplands Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Coastal Plain Dissected Uplands Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Coastal Plain Lowlands Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Coastal Plain Lowlands Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Coastal Plain Uplands Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Coastal Plain Uplands Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Piedmont Carbonate Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Piedmont Crystalline Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Barley	ComCovCropEASB	Valley and Ridge Carbonate Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Appalachian Plateau Siliciclastic Non Tidal	13	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Blue Ridge Non Tidal	13	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Mesozoic Lowlands Non Tidal	13	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Valley and Ridge Siliciclastic Non Tidal	13	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Appalachian Plateau Carbonate Non Tidal	17	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Coastal Plain Dissected Uplands Non Tidal	17	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Coastal Plain Dissected Uplands Tidal	17	0	0	All

Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Coastal Plain Lowlands Non Tidal	17	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Coastal Plain Lowlands Tidal	17	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Coastal Plain Uplands Non Tidal	17	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Coastal Plain Uplands Tidal	17	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Piedmont Carbonate Non Tidal	17	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Piedmont Crystalline Non Tidal	17	0	0	All
Commodity Cover Crop Early Aerial Soy Rye	ComCovCropEASR	Valley and Ridge Carbonate Non Tidal	17	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Appalachian Plateau Siliciclastic Non Tidal	9	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Blue Ridge Non Tidal	9	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Mesozoic Lowlands Non Tidal	9	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Valley and Ridge Siliciclastic Non Tidal	9	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Appalachian Plateau Carbonate Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Coastal Plain Dissected Uplands Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Coastal Plain Dissected Uplands Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Coastal Plain Lowlands Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Coastal Plain Lowlands Tidal	12	0	0	All

Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Coastal Plain Uplands Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Coastal Plain Uplands Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Piedmont Carbonate Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Piedmont Crystalline Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Soy Wheat	ComCovCropEASW	Valley and Ridge Carbonate Non Tidal	12	0	0	All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Appalachian Plateau Siliciclastic Non Tidal	6	0	0	All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Blue Ridge Non Tidal	6	0	0	All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Mesozoic Lowlands Non Tidal	6	0	0	All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Valley and Ridge Siliciclastic Non Tidal	6	0	0	All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Appalachian Plateau Carbonate Non Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Coastal Plain Dissected Uplands Non Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Coastal Plain Dissected Uplands Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Coastal Plain Lowlands Non Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Coastal Plain Lowlands Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Coastal Plain Uplands Non Tidal	7	0	0	All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Coastal Plain Uplands Tidal	7	0	0	All

Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Piedmont Carbonate Non Tidal	7	0	0 All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Piedmont Crystalline Non Tidal	7	0	0 All
Commodity Cover Crop Early Aerial Wheat	ComCovCropEAW	Valley and Ridge Carbonate Non Tidal	7	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Appalachian Plateau Siliciclastic Non Tidal	13	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Blue Ridge Non Tidal	13	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Mesozoic Lowlands Non Tidal	13	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Valley and Ridge Siliciclastic Non Tidal	13	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Appalachian Plateau Carbonate Non Tidal	17	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Coastal Plain Dissected Uplands Non Tidal	17	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Coastal Plain Dissected Uplands Tidal	17	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Coastal Plain Lowlands Non Tidal	17	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Coastal Plain Lowlands Tidal	17	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Coastal Plain Uplands Non Tidal	17	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Coastal Plain Uplands Tidal	17	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Piedmont Carbonate Non Tidal	17	0	0 All
Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Piedmont Crystalline Non Tidal	17	0	0 All

Commodity Cover Crop Early Drilled Barley	ComCovCropEDB	Valley and Ridge Carbonate Non Tidal	17	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Appalachian Plateau Siliciclastic Non Tidal	19	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Blue Ridge Non Tidal	19	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Mesozoic Lowlands Non Tidal	19	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Valley and Ridge Siliciclastic Non Tidal	19	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Appalachian Plateau Carbonate Non Tidal	25	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Coastal Plain Dissected Uplands Non Tidal	25	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Coastal Plain Dissected Uplands Tidal	25	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Coastal Plain Lowlands Non Tidal	25	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Coastal Plain Lowlands Tidal	25	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Coastal Plain Uplands Non Tidal	25	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Coastal Plain Uplands Tidal	25	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Piedmont Carbonate Non Tidal	25	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Piedmont Crystalline Non Tidal	25	0	0	All
Commodity Cover Crop Early Drilled Rye	ComCovCropEDR	Valley and Ridge Carbonate Non Tidal	25	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Appalachian Plateau Siliciclastic Non Tidal	13	0	0	All

Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Blue Ridge Non Tidal	13	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Mesozoic Lowlands Non Tidal	13	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Valley and Ridge Siliciclastic Non Tidal	13	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Appalachian Plateau Carbonate Non Tidal	17	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Coastal Plain Dissected Uplands Non Tidal	17	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Coastal Plain Dissected Uplands Tidal	17	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Coastal Plain Lowlands Non Tidal	17	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Coastal Plain Lowlands Tidal	17	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Coastal Plain Uplands Non Tidal	17	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Coastal Plain Uplands Tidal	17	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Piedmont Carbonate Non Tidal	17	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Piedmont Crystalline Non Tidal	17	0	0	All
Commodity Cover Crop Early Drilled Wheat	ComCovCropEDW	Valley and Ridge Carbonate Non Tidal	17	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Appalachian Plateau Siliciclastic Non Tidal	11	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Blue Ridge Non Tidal	11	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Mesozoic Lowlands Non Tidal	11	0	0	All

Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Valley and Ridge Siliciclastic Non Tidal	11	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Appalachian Plateau Carbonate Non Tidal	15	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Coastal Plain Dissected Uplands Non Tidal	15	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Coastal Plain Dissected Uplands Tidal	15	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Coastal Plain Lowlands Non Tidal	15	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Coastal Plain Lowlands Tidal	15	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Coastal Plain Uplands Non Tidal	15	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Coastal Plain Uplands Tidal	15	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Piedmont Carbonate Non Tidal	15	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Piedmont Crystalline Non Tidal	15	0	0	All
Commodity Cover Crop Early-Planting Other Barley	ComCovCropEOB	Valley and Ridge Carbonate Non Tidal	15	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Appalachian Plateau Siliciclastic Non Tidal	16	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Blue Ridge Non Tidal	16	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Mesozoic Lowlands Non Tidal	16	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Valley and Ridge Siliciclastic Non Tidal	16	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Appalachian Plateau Carbonate Non Tidal	21	0	0	All

Commodity Cover Crop Early Other Rye	ComCovCropEOR	Coastal Plain Dissected Uplands Non Tidal	21	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Coastal Plain Dissected Uplands Tidal	21	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Coastal Plain Lowlands Non Tidal	21	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Coastal Plain Lowlands Tidal	21	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Coastal Plain Uplands Non Tidal	21	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Coastal Plain Uplands Tidal	21	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Piedmont Carbonate Non Tidal	21	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Piedmont Crystalline Non Tidal	21	0	0	All
Commodity Cover Crop Early Other Rye	ComCovCropEOR	Valley and Ridge Carbonate Non Tidal	21	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Appalachian Plateau Siliciclastic Non Tidal	11	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Blue Ridge Non Tidal	11	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Mesozoic Lowlands Non Tidal	11	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Valley and Ridge Siliciclastic Non Tidal	11	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Appalachian Plateau Carbonate Non Tidal	15	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Coastal Plain Dissected Uplands Non Tidal	15	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Coastal Plain Dissected Uplands Tidal	15	0	0	All

Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Coastal Plain Lowlands Non Tidal	15	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Coastal Plain Lowlands Tidal	15	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Coastal Plain Uplands Non Tidal	15	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Coastal Plain Uplands Tidal	15	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Piedmont Carbonate Non Tidal	15	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Piedmont Crystalline Non Tidal	15	0	0	All
Commodity Cover Crop Early Other Wheat	ComCovCropEOW	Valley and Ridge Carbonate Non Tidal	15	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Appalachian Plateau Siliciclastic Non Tidal	9	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Blue Ridge Non Tidal	9	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Mesozoic Lowlands Non Tidal	9	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Valley and Ridge Siliciclastic Non Tidal	9	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Appalachian Plateau Carbonate Non Tidal	11	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Coastal Plain Dissected Uplands Non Tidal	11	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Coastal Plain Dissected Uplands Tidal	11	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Coastal Plain Lowlands Non Tidal	11	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Coastal Plain Lowlands Tidal	11	0	0	All

Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Coastal Plain Uplands Non Tidal	11	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Coastal Plain Uplands Tidal	11	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Piedmont Carbonate Non Tidal	11	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Piedmont Crystalline Non Tidal	11	0	0	All
Commodity Cover Crop Late Drilled Rye	ComCovCropLDR	Valley and Ridge Carbonate Non Tidal	11	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Appalachian Plateau Siliciclastic Non Tidal	6	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Blue Ridge Non Tidal	6	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Mesozoic Lowlands Non Tidal	6	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Valley and Ridge Siliciclastic Non Tidal	6	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Appalachian Plateau Carbonate Non Tidal	7	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Coastal Plain Dissected Uplands Non Tidal	7	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Coastal Plain Dissected Uplands Tidal	7	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Coastal Plain Lowlands Non Tidal	7	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Coastal Plain Lowlands Tidal	7	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Coastal Plain Uplands Non Tidal	7	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Coastal Plain Uplands Tidal	7	0	0	All

Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Piedmont Carbonate Non Tidal	7	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Piedmont Crystalline Non Tidal	7	0	0	All
Commodity Cover Crop Late-Planting Drilled Wheat	ComCovCropLDW	Valley and Ridge Carbonate Non Tidal	7	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Appalachian Plateau Siliciclastic Non Tidal	7	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Blue Ridge Non Tidal	7	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Mesozoic Lowlands Non Tidal	7	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Valley and Ridge Siliciclastic Non Tidal	7	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Appalachian Plateau Carbonate Non Tidal	9	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Coastal Plain Dissected Uplands Non Tidal	9	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Coastal Plain Dissected Uplands Tidal	9	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Coastal Plain Lowlands Non Tidal	9	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Coastal Plain Lowlands Tidal	9	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Coastal Plain Uplands Non Tidal	9	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Coastal Plain Uplands Tidal	9	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Piedmont Carbonate Non Tidal	9	0	0	All
Commodity Cover Crop Late Other Rye	ComCovCropLOR	Piedmont Crystalline Non Tidal	9	0	0	All

Commodity Cover Crop Late Other Rye	ComCovCropLOR	Valley and Ridge Carbonate Non Tidal	9	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Appalachian Plateau Siliciclastic Non Tidal	5	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Blue Ridge Non Tidal	5	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Mesozoic Lowlands Non Tidal	5	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Valley and Ridge Siliciclastic Non Tidal	5	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Appalachian Plateau Carbonate Non Tidal	6	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Coastal Plain Dissected Uplands Non Tidal	6	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Coastal Plain Dissected Uplands Tidal	6	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Coastal Plain Lowlands Non Tidal	6	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Coastal Plain Lowlands Tidal	6	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Coastal Plain Uplands Non Tidal	6	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Coastal Plain Uplands Tidal	6	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Piedmont Carbonate Non Tidal	6	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Piedmont Crystalline Non Tidal	6	0	0	All
Commodity Cover Crop Late Other Wheat	ComCovCropLOW	Valley and Ridge Carbonate Non Tidal	6	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Appalachian Plateau Siliciclastic Non Tidal	11	0	0	All

Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Blue Ridge Non Tidal	11	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Mesozoic Lowlands Non Tidal	11	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Valley and Ridge Siliciclastic Non Tidal	11	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Appalachian Plateau Carbonate Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Coastal Plain Dissected Uplands Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Coastal Plain Dissected Uplands Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Coastal Plain Lowlands Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Coastal Plain Lowlands Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Coastal Plain Uplands Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Coastal Plain Uplands Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Piedmont Carbonate Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Piedmont Crystalline Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Barley	ComCovCropSDB	Valley and Ridge Carbonate Non Tidal	15	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Appalachian Plateau Siliciclastic Non Tidal	16	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Blue Ridge Non Tidal	16	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Mesozoic Lowlands Non Tidal	16	0	0	All

Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Valley and Ridge Siliciclastic Non Tidal	16	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Appalachian Plateau Carbonate Non Tidal	21	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Coastal Plain Dissected Uplands Non Tidal	21	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Coastal Plain Dissected Uplands Tidal	21	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Coastal Plain Lowlands Non Tidal	21	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Coastal Plain Lowlands Tidal	21	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Coastal Plain Uplands Non Tidal	21	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Coastal Plain Uplands Tidal	21	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Piedmont Carbonate Non Tidal	21	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Piedmont Crystalline Non Tidal	21	0	0	All
Commodity Cover Crop Standard Drilled Rye	ComCovCropSDR	Valley and Ridge Carbonate Non Tidal	21	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Appalachian Plateau Siliciclastic Non Tidal	11	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Blue Ridge Non Tidal	11	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Mesozoic Lowlands Non Tidal	11	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Valley and Ridge Siliciclastic Non Tidal	11	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Appalachian Plateau Carbonate Non Tidal	15	0	0	All

Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Coastal Plain Dissected Uplands Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Coastal Plain Dissected Uplands Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Coastal Plain Lowlands Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Coastal Plain Lowlands Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Coastal Plain Uplands Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Coastal Plain Uplands Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Piedmont Carbonate Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Piedmont Crystalline Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Drilled Wheat	ComCovCropSDW	Valley and Ridge Carbonate Non Tidal	15	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Appalachian Plateau Siliciclastic Non Tidal	10	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Blue Ridge Non Tidal	10	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Mesozoic Lowlands Non Tidal	10	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Valley and Ridge Siliciclastic Non Tidal	10	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Appalachian Plateau Carbonate Non Tidal	12	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Coastal Plain Dissected Uplands Non Tidal	12	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Coastal Plain Dissected Uplands Tidal	12	0	0	All

Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Coastal Plain Lowlands Non Tidal	12	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Coastal Plain Lowlands Tidal	12	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Coastal Plain Uplands Non Tidal	12	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Coastal Plain Uplands Tidal	12	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Piedmont Carbonate Non Tidal	12	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Piedmont Crystalline Non Tidal	12	0	0	All
Commodity Cover Crop Standard-Planting Other Barley	ComCovCropSOB	Valley and Ridge Carbonate Non Tidal	12	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Appalachian Plateau Siliciclastic Non Tidal	14	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Blue Ridge Non Tidal	14	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Mesozoic Lowlands Non Tidal	14	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Valley and Ridge Siliciclastic Non Tidal	14	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Appalachian Plateau Carbonate Non Tidal	18	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Coastal Plain Dissected Uplands Non Tidal	18	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Coastal Plain Dissected Uplands Tidal	18	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Coastal Plain Lowlands Non Tidal	18	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Coastal Plain Lowlands Tidal	18	0	0	All

Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Coastal Plain Uplands Non Tidal	18	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Coastal Plain Uplands Tidal	18	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Piedmont Carbonate Non Tidal	18	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Piedmont Crystalline Non Tidal	18	0	0	All
Commodity Cover Crop Standard Other Rye	ComCovCropSOR	Valley and Ridge Carbonate Non Tidal	18	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Appalachian Plateau Siliciclastic Non Tidal	9	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Blue Ridge Non Tidal	9	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Mesozoic Lowlands Non Tidal	9	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Valley and Ridge Siliciclastic Non Tidal	9	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Appalachian Plateau Carbonate Non Tidal	12	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Coastal Plain Dissected Uplands Non Tidal	12	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Coastal Plain Dissected Uplands Tidal	12	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Coastal Plain Lowlands Non Tidal	12	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Coastal Plain Lowlands Tidal	12	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Coastal Plain Uplands Non Tidal	12	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Coastal Plain Uplands Tidal	12	0	0	All

Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Piedmont Carbonate Non Tidal	12	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Piedmont Crystalline Non Tidal	12	0	0	All
Commodity Cover Crop Standard Other Wheat	ComCovCropSOW	Valley and Ridge Carbonate Non Tidal	12	0	0	All
Cover Crop Early Aerial Barley	CoverCropEAB	Appalachian Plateau Siliciclastic Non Tidal	12	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Blue Ridge Non Tidal	12	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Mesozoic Lowlands Non Tidal	12	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Valley and Ridge Siliciclastic Non Tidal	12	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Appalachian Plateau Carbonate Non Tidal	15	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Dissected Uplands Non Tidal	15	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Dissected Uplands Tidal	15	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Lowlands Non Tidal	15	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Lowlands Tidal	15	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Uplands Non Tidal	15	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Uplands Tidal	15	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Piedmont Carbonate Non Tidal	15	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Piedmont Crystalline Non Tidal	15	15	20	High till
Cover Crop Early Aerial Barley	CoverCropEAB	Valley and Ridge	15	15	20	High till

		Carbonate Non Tidal				
Cover Crop Early Aerial Barley	CoverCropEAB	Appalachian Plateau Siliciclastic Non Tidal	12	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Blue Ridge Non Tidal	12	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Mesozoic Lowlands Non Tidal	12	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Valley and Ridge Siliciclastic Non Tidal	12	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Appalachian Plateau Carbonate Non Tidal	15	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Dissected Uplands Non Tidal	15	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Dissected Uplands Tidal	15	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Lowlands Non Tidal	15	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Lowlands Tidal	15	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Uplands Non Tidal	15	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Coastal Plain Uplands Tidal	15	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Piedmont Carbonate Non Tidal	15	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Piedmont Crystalline Non Tidal	15	0	0	Low till
Cover Crop Early Aerial Barley	CoverCropEAB	Valley and Ridge Carbonate Non Tidal	15	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Appalachian Plateau Siliciclastic Non Tidal	14	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Blue Ridge Non Tidal	14	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Mesozoic Lowlands Non	14	15	20	High till

		Tidal				
Cover Crop Early Aerial Rye	CoverCropEAR	Valley and Ridge Siliciclastic Non Tidal	14	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Appalachian Plateau Carbonate Non Tidal	18	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Dissected Uplands Non Tidal	18	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Dissected Uplands Tidal	18	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Lowlands Non Tidal	18	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Lowlands Tidal	18	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Uplands Non Tidal	18	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Uplands Tidal	18	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Piedmont Carbonate Non Tidal	18	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Piedmont Crystalline Non Tidal	18	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Valley and Ridge Carbonate Non Tidal	18	15	20	High till
Cover Crop Early Aerial Rye	CoverCropEAR	Appalachian Plateau Siliciclastic Non Tidal	14	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Blue Ridge Non Tidal	14	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Mesozoic Lowlands Non Tidal	14	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Valley and Ridge Siliciclastic Non Tidal	14	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Appalachian Plateau Carbonate Non Tidal	18	0	0	Low till

Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Dissected Uplands Non Tidal	18	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Dissected Uplands Tidal	18	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Lowlands Non Tidal	18	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Lowlands Tidal	18	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Uplands Non Tidal	18	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Coastal Plain Uplands Tidal	18	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Piedmont Carbonate Non Tidal	18	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Piedmont Crystalline Non Tidal	18	0	0	Low till
Cover Crop Early Aerial Rye	CoverCropEAR	Valley and Ridge Carbonate Non Tidal	18	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Appalachian Plateau Siliciclastic Non Tidal	20	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Blue Ridge Non Tidal	20	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Mesozoic Lowlands Non Tidal	20	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Valley and Ridge Siliciclastic Non Tidal	20	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Appalachian Plateau Carbonate Non Tidal	27	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Dissected Uplands Non Tidal	27	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Dissected Uplands Tidal	27	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Lowlands	27	15	20	High till

		Non Tidal				
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Lowlands Tidal	27	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Uplands Non Tidal	27	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Uplands Tidal	27	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Piedmont Carbonate Non Tidal	27	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Piedmont Crystalline Non Tidal	27	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Valley and Ridge Carbonate Non Tidal	27	15	20	High till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Appalachian Plateau Siliciclastic Non Tidal	20	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Blue Ridge Non Tidal	20	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Mesozoic Lowlands Non Tidal	20	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Valley and Ridge Siliciclastic Non Tidal	20	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Appalachian Plateau Carbonate Non Tidal	27	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Dissected Uplands Non Tidal	27	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Dissected Uplands Tidal	27	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Lowlands Non Tidal	27	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Lowlands Tidal	27	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Uplands Non Tidal	27	0	0	Low till

Cover Crop Early Aerial Soy Barley	CoverCropEASB	Coastal Plain Uplands Tidal	27	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Piedmont Carbonate Non Tidal	27	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Piedmont Crystalline Non Tidal	27	0	0	Low till
Cover Crop Early Aerial Soy Barley	CoverCropEASB	Valley and Ridge Carbonate Non Tidal	27	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Appalachian Plateau Siliciclastic Non Tidal	24	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Blue Ridge Non Tidal	24	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Mesozoic Lowlands Non Tidal	24	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Valley and Ridge Siliciclastic Non Tidal	24	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Appalachian Plateau Carbonate Non Tidal	31	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Dissected Uplands Non Tidal	31	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Dissected Uplands Tidal	31	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Lowlands Non Tidal	31	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Lowlands Tidal	31	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Uplands Non Tidal	31	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Uplands Tidal	31	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Piedmont Carbonate Non Tidal	31	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Piedmont Crystalline Non Tidal	31	15	20	High till

Cover Crop Early Aerial Soy Rye	CoverCropEASR	Valley and Ridge Carbonate Non Tidal	31	15	20	High till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Appalachian Plateau Siliciclastic Non Tidal	24	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Blue Ridge Non Tidal	24	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Mesozoic Lowlands Non Tidal	24	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Valley and Ridge Siliciclastic Non Tidal	24	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Appalachian Plateau Carbonate Non Tidal	31	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Dissected Uplands Non Tidal	31	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Dissected Uplands Tidal	31	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Lowlands Non Tidal	31	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Lowlands Tidal	31	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Uplands Non Tidal	31	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Coastal Plain Uplands Tidal	31	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Piedmont Carbonate Non Tidal	31	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Piedmont Crystalline Non Tidal	31	0	0	Low till
Cover Crop Early Aerial Soy Rye	CoverCropEASR	Valley and Ridge Carbonate Non Tidal	31	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Appalachian Plateau Siliciclastic Non Tidal	17	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Blue Ridge Non Tidal	17	15	20	High till

Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Mesozoic Lowlands Non Tidal	17	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Valley and Ridge Siliciclastic Non Tidal	17	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Appalachian Plateau Carbonate Non Tidal	22	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Dissected Uplands Non Tidal	22	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Dissected Uplands Tidal	22	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Lowlands Non Tidal	22	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Lowlands Tidal	22	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Uplands Non Tidal	22	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Uplands Tidal	22	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Piedmont Carbonate Non Tidal	22	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Piedmont Crystalline Non Tidal	22	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Valley and Ridge Carbonate Non Tidal	22	15	20	High till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Appalachian Plateau Siliciclastic Non Tidal	17	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Blue Ridge Non Tidal	17	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Mesozoic Lowlands Non Tidal	17	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Valley and Ridge Siliciclastic Non Tidal	17	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Appalachian Plateau	22	0	0	Low till

		Carbonate Non Tidal				
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Dissected Uplands Non Tidal	22	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Dissected Uplands Tidal	22	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Lowlands Non Tidal	22	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Lowlands Tidal	22	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Uplands Non Tidal	22	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Coastal Plain Uplands Tidal	22	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Piedmont Carbonate Non Tidal	22	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Piedmont Crystalline Non Tidal	22	0	0	Low till
Cover Crop Early Aerial Soy Wheat	CoverCropEASW	Valley and Ridge Carbonate Non Tidal	22	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Appalachian Plateau Siliciclastic Non Tidal	10	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Blue Ridge Non Tidal	10	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Mesozoic Lowlands Non Tidal	10	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Valley and Ridge Siliciclastic Non Tidal	10	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Appalachian Plateau Carbonate Non Tidal	12	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Dissected Uplands Non Tidal	12	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Dissected Uplands Tidal	12	15	20	High till

Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Lowlands Non Tidal	12	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Lowlands Tidal	12	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Uplands Non Tidal	12	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Uplands Tidal	12	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Piedmont Carbonate Non Tidal	12	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Piedmont Crystalline Non Tidal	12	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Valley and Ridge Carbonate Non Tidal	12	15	20	High till
Cover Crop Early Aerial Wheat	CoverCropEAW	Appalachian Plateau Siliciclastic Non Tidal	10	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Blue Ridge Non Tidal	10	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Mesozoic Lowlands Non Tidal	10	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Valley and Ridge Siliciclastic Non Tidal	10	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Appalachian Plateau Carbonate Non Tidal	12	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Dissected Uplands Non Tidal	12	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Dissected Uplands Tidal	12	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Lowlands Non Tidal	12	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Lowlands Tidal	12	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Uplands Non	12	0	0	Low till

		Tidal				
Cover Crop Early Aerial Wheat	CoverCropEAW	Coastal Plain Uplands Tidal	12	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Piedmont Carbonate Non Tidal	12	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Piedmont Crystalline Non Tidal	12	0	0	Low till
Cover Crop Early Aerial Wheat	CoverCropEAW	Valley and Ridge Carbonate Non Tidal	12	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Appalachian Plateau Siliciclastic Non Tidal	29	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Blue Ridge Non Tidal	29	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Mesozoic Lowlands Non Tidal	29	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Valley and Ridge Siliciclastic Non Tidal	29	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Appalachian Plateau Carbonate Non Tidal	38	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Dissected Uplands Non Tidal	38	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Dissected Uplands Tidal	38	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Lowlands Non Tidal	38	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Lowlands Tidal	38	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Uplands Non Tidal	38	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Uplands Tidal	38	15	20	High till
Cover Crop Early-Planting Drilled	CoverCropEDB	Piedmont Carbonate Non	38	15	20	High till

Barley		Tidal				
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Piedmont Crystalline Non Tidal	38	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Valley and Ridge Carbonate Non Tidal	38	15	20	High till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Appalachian Plateau Siliciclastic Non Tidal	29	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Blue Ridge Non Tidal	29	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Mesozoic Lowlands Non Tidal	29	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Valley and Ridge Siliciclastic Non Tidal	29	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Appalachian Plateau Carbonate Non Tidal	38	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Dissected Uplands Non Tidal	38	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Dissected Uplands Tidal	38	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Lowlands Non Tidal	38	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Lowlands Tidal	38	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Uplands Non Tidal	38	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Coastal Plain Uplands Tidal	38	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Piedmont Carbonate Non Tidal	38	0	0	Low till
Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Piedmont Crystalline Non Tidal	38	0	0	Low till

Cover Crop Early-Planting Drilled Barley	CoverCropEDB	Valley and Ridge Carbonate Non Tidal	38	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Appalachian Plateau Siliciclastic Non Tidal	34	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Blue Ridge Non Tidal	34	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Mesozoic Lowlands Non Tidal	34	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Valley and Ridge Siliciclastic Non Tidal	34	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Appalachian Plateau Carbonate Non Tidal	45	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Dissected Uplands Non Tidal	45	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Dissected Uplands Tidal	45	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Lowlands Non Tidal	45	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Lowlands Tidal	45	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Uplands Non Tidal	45	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Uplands Tidal	45	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Piedmont Carbonate Non Tidal	45	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Piedmont Crystalline Non Tidal	45	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Valley and Ridge Carbonate Non Tidal	45	15	20	High till
Cover Crop Early Drilled Rye	CoverCropEDR	Appalachian Plateau Siliciclastic Non Tidal	34	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Blue Ridge Non Tidal	34	0	0	Low till

Cover Crop Early Drilled Rye	CoverCropEDR	Mesozoic Lowlands Non Tidal	34	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Valley and Ridge Siliciclastic Non Tidal	34	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Appalachian Plateau Carbonate Non Tidal	45	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Dissected Uplands Non Tidal	45	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Dissected Uplands Tidal	45	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Lowlands Non Tidal	45	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Lowlands Tidal	45	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Uplands Non Tidal	45	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Coastal Plain Uplands Tidal	45	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Piedmont Carbonate Non Tidal	45	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Piedmont Crystalline Non Tidal	45	0	0	Low till
Cover Crop Early Drilled Rye	CoverCropEDR	Valley and Ridge Carbonate Non Tidal	45	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Appalachian Plateau Siliciclastic Non Tidal	24	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Blue Ridge Non Tidal	24	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Mesozoic Lowlands Non Tidal	24	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Valley and Ridge Siliciclastic Non Tidal	24	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Appalachian Plateau	31	15	20	High till

		Carbonate Non Tidal				
Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Dissected Uplands Non Tidal	31	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Dissected Uplands Tidal	31	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Lowlands Non Tidal	31	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Lowlands Tidal	31	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Uplands Non Tidal	31	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Uplands Tidal	31	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Piedmont Carbonate Non Tidal	31	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Piedmont Crystalline Non Tidal	31	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Valley and Ridge Carbonate Non Tidal	31	15	20	High till
Cover Crop Early Drilled Wheat	CoverCropEDW	Appalachian Plateau Siliciclastic Non Tidal	24	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Blue Ridge Non Tidal	24	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Mesozoic Lowlands Non Tidal	24	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Valley and Ridge Siliciclastic Non Tidal	24	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Appalachian Plateau Carbonate Non Tidal	31	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Dissected Uplands Non Tidal	31	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Dissected Uplands Tidal	31	0	0	Low till

Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Lowlands Non Tidal	31	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Lowlands Tidal	31	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Uplands Non Tidal	31	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Coastal Plain Uplands Tidal	31	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Piedmont Carbonate Non Tidal	31	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Piedmont Crystalline Non Tidal	31	0	0	Low till
Cover Crop Early Drilled Wheat	CoverCropEDW	Valley and Ridge Carbonate Non Tidal	31	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Appalachian Plateau Siliciclastic Non Tidal	25	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Blue Ridge Non Tidal	25	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Mesozoic Lowlands Non Tidal	25	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Valley and Ridge Siliciclastic Non Tidal	25	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Appalachian Plateau Carbonate Non Tidal	32	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Dissected Uplands Non Tidal	32	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Dissected Uplands Tidal	32	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Lowlands Non Tidal	32	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Lowlands Tidal	32	15	20	High till

Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Uplands Non Tidal	32	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Uplands Tidal	32	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Piedmont Carbonate Non Tidal	32	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Piedmont Crystalline Non Tidal	32	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Valley and Ridge Carbonate Non Tidal	32	15	20	High till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Appalachian Plateau Siliciclastic Non Tidal	25	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Blue Ridge Non Tidal	25	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Mesozoic Lowlands Non Tidal	25	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Valley and Ridge Siliciclastic Non Tidal	25	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Appalachian Plateau Carbonate Non Tidal	32	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Dissected Uplands Non Tidal	32	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Dissected Uplands Tidal	32	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Lowlands Non Tidal	32	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Lowlands Tidal	32	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Uplands Non Tidal	32	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Coastal Plain Uplands Tidal	32	0	0	Low till

Cover Crop Early-Planting Other Barley	CoverCropEOB	Piedmont Carbonate Non Tidal	32	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Piedmont Crystalline Non Tidal	32	0	0	Low till
Cover Crop Early-Planting Other Barley	CoverCropEOB	Valley and Ridge Carbonate Non Tidal	32	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Appalachian Plateau Siliciclastic Non Tidal	29	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Blue Ridge Non Tidal	29	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Mesozoic Lowlands Non Tidal	29	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Valley and Ridge Siliciclastic Non Tidal	29	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Appalachian Plateau Carbonate Non Tidal	38	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Dissected Uplands Non Tidal	38	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Dissected Uplands Tidal	38	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Lowlands Non Tidal	38	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Lowlands Tidal	38	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Uplands Non Tidal	38	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Uplands Tidal	38	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Piedmont Carbonate Non Tidal	38	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Piedmont Crystalline Non Tidal	38	15	20	High till
Cover Crop Early Other Rye	CoverCropEOR	Valley and Ridge	38	15	20	High till

		Carbonate Non Tidal				
Cover Crop Early Other Rye	CoverCropEOR	Appalachian Plateau Siliciclastic Non Tidal	29	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Blue Ridge Non Tidal	29	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Mesozoic Lowlands Non Tidal	29	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Valley and Ridge Siliciclastic Non Tidal	29	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Appalachian Plateau Carbonate Non Tidal	38	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Dissected Uplands Non Tidal	38	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Dissected Uplands Tidal	38	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Lowlands Non Tidal	38	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Lowlands Tidal	38	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Uplands Non Tidal	38	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Coastal Plain Uplands Tidal	38	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Piedmont Carbonate Non Tidal	38	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Piedmont Crystalline Non Tidal	38	0	0	Low till
Cover Crop Early Other Rye	CoverCropEOR	Valley and Ridge Carbonate Non Tidal	38	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Appalachian Plateau Siliciclastic Non Tidal	20	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Blue Ridge Non Tidal	20	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Mesozoic Lowlands Non	20	15	20	High till

		Tidal				
Cover Crop Early Other Wheat	CoverCropEOW	Valley and Ridge Siliciclastic Non Tidal	20	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Appalachian Plateau Carbonate Non Tidal	27	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Dissected Uplands Non Tidal	27	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Dissected Uplands Tidal	27	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Lowlands Non Tidal	27	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Lowlands Tidal	27	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Uplands Non Tidal	27	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Uplands Tidal	27	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Piedmont Carbonate Non Tidal	27	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Piedmont Crystalline Non Tidal	27	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Valley and Ridge Carbonate Non Tidal	27	15	20	High till
Cover Crop Early Other Wheat	CoverCropEOW	Appalachian Plateau Siliciclastic Non Tidal	20	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Blue Ridge Non Tidal	20	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Mesozoic Lowlands Non Tidal	20	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Valley and Ridge Siliciclastic Non Tidal	20	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Appalachian Plateau Carbonate Non Tidal	27	0	0	Low till

Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Dissected Uplands Non Tidal	27	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Dissected Uplands Tidal	27	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Lowlands Non Tidal	27	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Lowlands Tidal	27	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Uplands Non Tidal	27	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Coastal Plain Uplands Tidal	27	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Piedmont Carbonate Non Tidal	27	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Piedmont Crystalline Non Tidal	27	0	0	Low till
Cover Crop Early Other Wheat	CoverCropEOW	Valley and Ridge Carbonate Non Tidal	27	0	0	Low till
Cover Crop Late Drilled Rye	CoverCropLDR	Appalachian Plateau Siliciclastic Non Tidal	15	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Blue Ridge Non Tidal	15	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Mesozoic Lowlands Non Tidal	15	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Valley and Ridge Siliciclastic Non Tidal	15	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Appalachian Plateau Carbonate Non Tidal	19	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Coastal Plain Dissected Uplands Non Tidal	19	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Coastal Plain Dissected Uplands Tidal	19	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Coastal Plain Lowlands	19	0	0	All

		Non Tidal				
Cover Crop Late Drilled Rye	CoverCropLDR	Coastal Plain Lowlands Tidal	19	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Coastal Plain Uplands Non Tidal	19	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Coastal Plain Uplands Tidal	19	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Piedmont Carbonate Non Tidal	19	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Piedmont Crystalline Non Tidal	19	0	0	All
Cover Crop Late Drilled Rye	CoverCropLDR	Valley and Ridge Carbonate Non Tidal	19	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Appalachian Plateau Siliciclastic Non Tidal	10	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Blue Ridge Non Tidal	10	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Mesozoic Lowlands Non Tidal	10	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Valley and Ridge Siliciclastic Non Tidal	10	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Appalachian Plateau Carbonate Non Tidal	13	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Coastal Plain Dissected Uplands Non Tidal	13	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Coastal Plain Dissected Uplands Tidal	13	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Coastal Plain Lowlands Non Tidal	13	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Coastal Plain Lowlands Tidal	13	0	0	All
Cover Crop Late-Planting Drilled	CoverCropLDW	Coastal Plain Uplands Non	13	0	0	All

Wheat		Tidal				
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Coastal Plain Uplands Tidal	13	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Piedmont Carbonate Non Tidal	13	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Piedmont Crystalline Non Tidal	13	0	0	All
Cover Crop Late-Planting Drilled Wheat	CoverCropLDW	Valley and Ridge Carbonate Non Tidal	13	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Appalachian Plateau Siliciclastic Non Tidal	12	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Blue Ridge Non Tidal	12	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Mesozoic Lowlands Non Tidal	12	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Valley and Ridge Siliciclastic Non Tidal	12	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Appalachian Plateau Carbonate Non Tidal	16	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Coastal Plain Dissected Uplands Non Tidal	16	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Coastal Plain Dissected Uplands Tidal	16	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Coastal Plain Lowlands Non Tidal	16	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Coastal Plain Lowlands Tidal	16	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Coastal Plain Uplands Non Tidal	16	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Coastal Plain Uplands Tidal	16	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Piedmont Carbonate Non Tidal	16	0	0	All

Cover Crop Late-Planting Other Rye	CoverCropLOR	Piedmont Crystalline Non Tidal	16	0	0	All
Cover Crop Late-Planting Other Rye	CoverCropLOR	Valley and Ridge Carbonate Non Tidal	16	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Appalachian Plateau Siliciclastic Non Tidal	9	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Blue Ridge Non Tidal	9	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Mesozoic Lowlands Non Tidal	9	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Valley and Ridge Siliciclastic Non Tidal	9	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Appalachian Plateau Carbonate Non Tidal	11	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Coastal Plain Dissected Uplands Non Tidal	11	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Coastal Plain Dissected Uplands Tidal	11	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Coastal Plain Lowlands Non Tidal	11	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Coastal Plain Lowlands Tidal	11	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Coastal Plain Uplands Non Tidal	11	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Coastal Plain Uplands Tidal	11	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Piedmont Carbonate Non Tidal	11	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Piedmont Crystalline Non Tidal	11	0	0	All
Cover Crop Late Other Wheat	CoverCropLOW	Valley and Ridge Carbonate Non Tidal	11	0	0	All
Cover Crop Standard Drilled Barley	CoverCropSDB	Appalachian Plateau	22	7	10	High till

		Siliciclastic Non Tidal				
Cover Crop Standard Drilled Barley	CoverCropSDB	Blue Ridge Non Tidal	22	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Mesozoic Lowlands Non Tidal	22	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Valley and Ridge Siliciclastic Non Tidal	22	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Appalachian Plateau Carbonate Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Dissected Uplands Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Dissected Uplands Tidal	29	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Lowlands Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Lowlands Tidal	29	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Uplands Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Uplands Tidal	29	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Piedmont Carbonate Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Piedmont Crystalline Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Valley and Ridge Carbonate Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Barley	CoverCropSDB	Appalachian Plateau Siliciclastic Non Tidal	22	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Blue Ridge Non Tidal	22	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Mesozoic Lowlands Non Tidal	22	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Valley and Ridge	22	0	0	Low till

		Siliciclastic Non Tidal				
Cover Crop Standard Drilled Barley	CoverCropSDB	Appalachian Plateau Carbonate Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Dissected Uplands Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Dissected Uplands Tidal	29	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Lowlands Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Lowlands Tidal	29	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Uplands Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Coastal Plain Uplands Tidal	29	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Piedmont Carbonate Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Piedmont Crystalline Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Barley	CoverCropSDB	Valley and Ridge Carbonate Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Appalachian Plateau Siliciclastic Non Tidal	31	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Blue Ridge Non Tidal	31	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Mesozoic Lowlands Non Tidal	31	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Valley and Ridge Siliciclastic Non Tidal	31	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Appalachian Plateau Carbonate Non Tidal	41	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Dissected Uplands Non Tidal	41	7	10	High till

Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Dissected Uplands Tidal	41	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Lowlands Non Tidal	41	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Lowlands Tidal	41	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Uplands Non Tidal	41	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Uplands Tidal	41	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Piedmont Carbonate Non Tidal	41	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Piedmont Crystalline Non Tidal	41	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Valley and Ridge Carbonate Non Tidal	41	7	10	High till
Cover Crop Standard Drilled Rye	CoverCropSDR	Appalachian Plateau Siliciclastic Non Tidal	31	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Blue Ridge Non Tidal	31	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Mesozoic Lowlands Non Tidal	31	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Valley and Ridge Siliciclastic Non Tidal	31	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Appalachian Plateau Carbonate Non Tidal	41	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Dissected Uplands Non Tidal	41	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Dissected Uplands Tidal	41	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Lowlands Non Tidal	41	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Lowlands	41	0	0	Low till

		Tidal				
Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Uplands Non Tidal	41	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Coastal Plain Uplands Tidal	41	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Piedmont Carbonate Non Tidal	41	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Piedmont Crystalline Non Tidal	41	0	0	Low till
Cover Crop Standard Drilled Rye	CoverCropSDR	Valley and Ridge Carbonate Non Tidal	41	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Appalachian Plateau Siliciclastic Non Tidal	22	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Blue Ridge Non Tidal	22	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Mesozoic Lowlands Non Tidal	22	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Valley and Ridge Siliciclastic Non Tidal	22	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Appalachian Plateau Carbonate Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Dissected Uplands Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Dissected Uplands Tidal	29	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Lowlands Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Lowlands Tidal	29	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Uplands Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Uplands Tidal	29	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Piedmont Carbonate Non	29	7	10	High till

		Tidal				
Cover Crop Standard Drilled Wheat	CoverCropSDW	Piedmont Crystalline Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Valley and Ridge Carbonate Non Tidal	29	7	10	High till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Appalachian Plateau Siliciclastic Non Tidal	22	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Blue Ridge Non Tidal	22	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Mesozoic Lowlands Non Tidal	22	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Valley and Ridge Siliciclastic Non Tidal	22	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Appalachian Plateau Carbonate Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Dissected Uplands Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Dissected Uplands Tidal	29	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Lowlands Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Lowlands Tidal	29	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Uplands Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Coastal Plain Uplands Tidal	29	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Piedmont Carbonate Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Piedmont Crystalline Non Tidal	29	0	0	Low till
Cover Crop Standard Drilled Wheat	CoverCropSDW	Valley and Ridge Carbonate Non Tidal	29	0	0	Low till

Cover Crop Standard Other Barley	CoverCropSOB	Appalachian Plateau Siliciclastic Non Tidal	19	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Blue Ridge Non Tidal	19	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Mesozoic Lowlands Non Tidal	19	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Valley and Ridge Siliciclastic Non Tidal	19	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Appalachian Plateau Carbonate Non Tidal	24	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Dissected Uplands Non Tidal	24	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Dissected Uplands Tidal	24	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Lowlands Non Tidal	24	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Lowlands Tidal	24	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Uplands Non Tidal	24	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Uplands Tidal	24	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Piedmont Carbonate Non Tidal	24	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Piedmont Crystalline Non Tidal	24	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Valley and Ridge Carbonate Non Tidal	24	7	10	High till
Cover Crop Standard Other Barley	CoverCropSOB	Appalachian Plateau Siliciclastic Non Tidal	19	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Blue Ridge Non Tidal	19	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Mesozoic Lowlands Non Tidal	19	0	0	Low till

Cover Crop Standard Other Barley	CoverCropSOB	Valley and Ridge Siliciclastic Non Tidal	19	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Appalachian Plateau Carbonate Non Tidal	24	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Dissected Uplands Non Tidal	24	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Dissected Uplands Tidal	24	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Lowlands Non Tidal	24	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Lowlands Tidal	24	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Uplands Non Tidal	24	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Coastal Plain Uplands Tidal	24	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Piedmont Carbonate Non Tidal	24	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Piedmont Crystalline Non Tidal	24	0	0	Low till
Cover Crop Standard Other Barley	CoverCropSOB	Valley and Ridge Carbonate Non Tidal	24	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Appalachian Plateau Siliciclastic Non Tidal	27	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Blue Ridge Non Tidal	27	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Mesozoic Lowlands Non Tidal	27	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Valley and Ridge Siliciclastic Non Tidal	27	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Appalachian Plateau Carbonate Non Tidal	35	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Dissected	35	7	10	High till

		Uplands Non Tidal				
Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Dissected Uplands Tidal	35	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Lowlands Non Tidal	35	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Lowlands Tidal	35	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Uplands Non Tidal	35	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Uplands Tidal	35	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Piedmont Carbonate Non Tidal	35	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Piedmont Crystalline Non Tidal	35	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Valley and Ridge Carbonate Non Tidal	35	7	10	High till
Cover Crop Standard Other Rye	CoverCropSOR	Appalachian Plateau Siliciclastic Non Tidal	27	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Blue Ridge Non Tidal	27	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Mesozoic Lowlands Non Tidal	27	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Valley and Ridge Siliciclastic Non Tidal	27	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Appalachian Plateau Carbonate Non Tidal	35	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Dissected Uplands Non Tidal	35	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Dissected Uplands Tidal	35	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Lowlands Non Tidal	35	0	0	Low till

Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Lowlands Tidal	35	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Uplands Non Tidal	35	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Coastal Plain Uplands Tidal	35	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Piedmont Carbonate Non Tidal	35	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Piedmont Crystalline Non Tidal	35	0	0	Low till
Cover Crop Standard Other Rye	CoverCropSOR	Valley and Ridge Carbonate Non Tidal	35	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Appalachian Plateau Siliciclastic Non Tidal	19	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Blue Ridge Non Tidal	19	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Mesozoic Lowlands Non Tidal	19	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Valley and Ridge Siliciclastic Non Tidal	19	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Appalachian Plateau Carbonate Non Tidal	24	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Dissected Uplands Non Tidal	24	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Dissected Uplands Tidal	24	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Lowlands Non Tidal	24	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Lowlands Tidal	24	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Uplands Non Tidal	24	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Uplands Tidal	24	7	10	High till

Cover Crop Standard Other Wheat	CoverCropSOW	Piedmont Carbonate Non Tidal	24	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Piedmont Crystalline Non Tidal	24	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Valley and Ridge Carbonate Non Tidal	24	7	10	High till
Cover Crop Standard Other Wheat	CoverCropSOW	Appalachian Plateau Siliciclastic Non Tidal	19	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Blue Ridge Non Tidal	19	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Mesozoic Lowlands Non Tidal	19	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Valley and Ridge Siliciclastic Non Tidal	19	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Appalachian Plateau Carbonate Non Tidal	24	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Dissected Uplands Non Tidal	24	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Dissected Uplands Tidal	24	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Lowlands Non Tidal	24	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Lowlands Tidal	24	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Uplands Non Tidal	24	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Coastal Plain Uplands Tidal	24	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Piedmont Carbonate Non Tidal	24	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Piedmont Crystalline Non Tidal	24	0	0	Low till
Cover Crop Standard Other Wheat	CoverCropSOW	Valley and Ridge	24	0	0	Low till

In addition to the load reduction BMPs in Table 8-6, there are also a number of source reduction BMPs. These include air and ammonia emissions (biofilters, lagoon covers, poultry litter treatment such as alum), animal waste management systems (including runoff control systems, loafing lot, mortality composters), application rate change BMPs (including new crop BMPs or an application reduction), feed additives (dairy precision feeding and or forage management, poultry and swine phytase), and manure transport. These BMPs serve to reduce either the mass of manure produced or the concentration of nutrients in the mass of manure produced.

Table 8-6: Load reduction BMPs

Sector	BMP	Unit	Nitrogen Reduction Factor	Phosphorus Reduction Factor	Sediment Reduction Factor
Agriculture	Dirt & Gravel Road Erosion & Sediment Control - Driving Surface Aggregate + Raising the Roadbed	feet	0	0	2.96
Agriculture	Dirt & Gravel Road Erosion & Sediment Control - Outlets only	feet	0	0	1.76
Agriculture	Dirt & Gravel Road Erosion & Sediment Control - with Outlets	feet	0	0	3.6
Agriculture	Non Urban Stream Restoration (interim)	feet	0.2	0.068	310
Agriculture	Non Urban Stream Restoration; Shoreline Erosion Control	feet	0.02	0.0025	2
Forest	Dirt & Gravel Road Erosion & Sediment Control - Driving Surface Aggregate + Raising the Roadbed	feet	0	0	2.96
Forest	Dirt & Gravel Road Erosion & Sediment Control - Outlets only	feet	0	0	1.76
Forest	Dirt & Gravel Road Erosion & Sediment Control - with Outlets	feet	0	0	3.6

Urban	Dirt & Gravel Road Erosion & Sediment Control - Driving Surface Aggregate + Raising the Roadbed	feet	0	0	2.96
Urban	Dirt & Gravel Road Erosion & Sediment Control - Outlets only	feet	0	0	1.76
Urban	Dirt & Gravel Road Erosion & Sediment Control - with Outlets	feet	0	0	3.6
Urban	Street Sweeping pould 25 times a year	lbs	0.00175	0.0007	1
Urban	Street Sweeping Pounds	lbs	0	0	1
Urban	Urban Stream Restoration (interim)	feet	0.2	0.068	310
Urban	Urban Stream Restoration; Shoreline Erosion Control; Regenerative Stormwater Conveyance	feet	0.02	0.0025	2

8.6 Interim Agricultural BMPs

8.6.1 Cropland Irrigation Management

Cropland under irrigation management is used to decrease climatic variability and maximize crop yields. The potential nutrient reduction benefit stems not from the increased average yield (20-25%) of irrigated versus non-irrigated cropland, but from the greater consistency of crop yields over time matched to nutrient applications. This increased consistency in crop yields provides a subsequent increased consistency in plant nutrient uptakes over time matched to applications, resulting in a decrease in potential environmental nutrient losses.

The current placeholder effectiveness value for this practice has been proposed at 4% TN, 0%TP and 0%TSS, utilizing the range in average yields from the 2002 and 2007 NASS data for irrigated and non-irrigated grain corn as a reference. The proposed practice is applied on a per acre basis, and can be implemented and reported for cropland on both lo-till and hi-till land uses that receive or do not receive manure.

8.6.2 Cropland Drainage Phosphorus-sorbing Materials (PSMs)

The University of Maryland and the USDA Agricultural Research Service (ARS) have demonstrated through an existing research project at the University of Maryland-Eastern Shore the application of “Phosphorus-sorbing” materials to absorb available dissolved phosphorus in cropland drainage systems for removal and reuse as an agricultural fertilizer. These in-channel engineered systems can capture significant amounts of dissolved phosphorus in agricultural drainage water by passing them through phosphorus-sorbing materials, such as gypsum, drinking water treatment residuals, or acid mine drainage residuals.

The current placeholder effectiveness value for this practice has been proposed at 0% TN, 40%TP and 0%TSS, utilizing a conservative estimate in phosphorus removal measured by the UMD/ARS research project as a reference. The proposed practice is applied on a per acre basis, and can be implemented and reported for cropland on both lo-till and hi-till land uses that receive or do not receive manure. Based upon the documentation, the proposed practice is currently limited to Coastal Plain soils with shallow groundwater levels requiring drainage ditches for agricultural production.

8.6.3 Liquid Manure Injection

The subsurface application of liquid manure from cattle and swine has been demonstrated in research studies to significantly reduce nutrient losses for both surface runoff and ammonia emissions. Recent studies by Pennsylvania State University (PSU) and USDA-ARS indicate that the effectiveness of the practice is dependent on the technology used for injection, and that some systems are not consistent with the USDA-NRCS management requirements for high residue management systems; e.g. Continuous No-Till. This proposed practice is indicative of low disturbance soil injection systems and is not appropriate for tillage incorporation or other post surface application incorporation methods.

The current placeholder effectiveness value for this practice has been proposed at 25% TN, 0%TP and 0%TSS, utilizing a conservative estimate in combined nutrient and sediment loss reductions by current university and ARS research as a reference. The proposed practice is applied on a per acre basis, and can be implemented and reported for cropland on both lo-till and hi-till land uses that receive manure, pasture and hay with manure.

8.6.4 Poultry Manure Injection

The subsurface injection of poultry manure has been demonstrated in university and USDA-ARS research studies to significantly reduce nutrient losses for both surface runoff and ammonia emissions. Recent studies by universities and USDA-ARS indicate that dry manure injection is feasible and effective by utilizing current research technology. These systems are also consistent with the USDA-NRCS management requirements for high residue management systems; e.g. Continuous No-Till. This proposed practice is indicative of low disturbance soil injection systems and is not appropriate for tillage incorporation or other post surface application incorporation methods.

The current placeholder effectiveness value for this practice has been proposed at 25% TN, 0%TP and 0%TSS, utilizing a conservative estimate in combined nutrient and sediment loss reductions by current university and ARS research as a reference. The proposed practice is applied on a per acre basis, and can be implemented and reported for cropland on both lo-till and hi-till land uses that receive manure, pasture and hay with manure.

8.6.5 Mortality Incineration

The definition of the approved BMP entitled Mortality Composting does not include the alternative process of incineration practiced by some livestock operations. The proposed interim practice of Mortality Incineration is defined as a physical structure and process for disposing of dead livestock and poultry through incineration versus composting. The resulting ash material is land applied using nutrient management plan recommendations. The current placeholder effectiveness value for this practice has been proposed at 40% TN, 10%TP and 0%TSS, utilizing the existing Mortality Composting effectiveness estimate as a reference. The proposed practice is applied on a livestock type and operation basis, and can be implemented and reported for the CAFO or AFO land use.

8.6.6 Vegetative Environmental Buffers (VEB)

A vegetative environmental buffer, or VEB, is the strategic dense planting of combinations of trees and shrubs around poultry houses to address environmental, production, and public relations issues. Research conducted by the University of Delaware have indicated that mature tree plantings can offer filtration benefits for poultry operations by entrapping dust, odor, feathers, and noise emitted by air exhaust from ventilation systems. Documentation on the effectiveness of VEB's in reducing nitrogen losses to the environment through ammonia emission reductions is currently non-conclusive. The current placeholder effectiveness value for this practice will be described as a land use change for the area directly planted to trees and shrubs. The proposed practice is applied on a per acre basis, and results in a conversion to forest land from cropland, on both lo-till and hi-till land uses that receive manure or do not receive manure, pasture or hay land with or without nutrients.

It's important to note that a recent scientific analysis report from the University of Maryland/Mid-Atlantic Water Program, funded by EPA, indicated that the practice has not undergone a science-based evaluation by the Chesapeake Bay Program Partnership to be included on the official list of agricultural BMPs in the models. Available scientific data on the potential nutrient reductions associated with VEB's is unfortunately very limited at this time. A recent study conducted by Dr. Bud Malone with the University of Delaware on VEB's demonstrated the ability of vegetative buffers to remove (filter) dust and associated ammonia emissions vented from poultry houses. Unfortunately, the study was not able to determine the fate of those emissions once they were filtered by the vegetation. The Chesapeake Bay Program Partnership's Agriculture Workgroup, which is responsible for recommending new agricultural BMPs to the Partnership for inclusion in the models, has identified this issue as one needing further research and study to determine the potential nutrient reduction effectiveness values.

8.6.7 Manure Processing Technology

As part of the innovative advanced technology element for the Watershed Implementation Plan (WIP), PA DEP is working with the Pennsylvania Department of Agriculture and a number of companies looking to install various technologies such as methane digesters and electrical co-generation on dairy, poultry and hog operations. Many of these technologies can produce electricity and marketable soil amendments; reduce methane emissions; and generate renewable energy, nutrient reduction and carbon credits that can then be sold. Some forms of technology, such as digesters, alone will not substantially change the nutrient content of manure. Pennsylvania is looking more closely at technologies that include a process element that helps ensure overall nutrient reductions. Examples of nutrient processing technology include: denitrification; solids separation; flocculation, combustion, etc.

DEP has formally approved several technologies for nutrient credit generation. As part of this approval, a process for quantifying credits is approved as well as a plan to verify the reductions. Each technology or process has been different, but the approvals contain several common requirements critical to quantification such as 1) Throughput of manure is monitored for the quantity being processed; 2) Sampling for nutrient content is performed at various key stages of the process, such as the inlet and the outlets to the process; and 3) The number of credits are

reduced if the overall process indicates a need to account for either the process' product potentially introducing reduced nutrients back to the watershed (e.g. stack emissions), or if nutrients are applied to replace manure that was previously land applied.
To allow for recognition in the Watershed Implementation Plan of the nutrient reductions associated with manure processing technology efforts, EPA has worked with PA to develop a placeholder Best Management Practice (BMP) and a process for crediting the resulting nutrient reductions.

8.6.8 Passive Hay Production

The Chesapeake Bay Program Bay Watershed Model currently has the land use category "hay with nutrients" set at 80 lbs N/acre and 40 lbs P/acre for NY. After discussion with USC Agricultural committee, an interim BMP was developed that reflected additional savings farmers have been implementing to reduce N and P on their hay fields. Farmers have reported using fewer nutrients on rented hay fields due to the uncertainty of long-term use, cost of fuel and fertilizer, and ability to use naturally fertilized hayfields.

Farmers developed a BMP where they eliminated nutrient spreading on some of their hayland. The USC analyzed 15,402 acres of hay land from nutrient management plans. The analysis prorated each field's nutrient load according to size. Information was garnered throughout the watershed to reflect regional differences.

For N and P, the BMP is to spread the CBP nutrient load per acre 80 pounds of N on 61% the each farm's hayland (model and analysis virtually same at 80 and 79 pounds). For P the CBP rate of 40 pounds is spread on 48 % of all hayland (to account for 40 pounds P in model versus 32 pounds applied). On the remainder of the hayland (39% and 52 %, respectively,) no N or P of any sort is spread, leaving this hay to be fertilized solely by atmospheric deposition. These figures are supported by the references below.

8.6.9 Container Nursery and Greenhouse Runoff and Leachate Collection and Reuse

This practice involves the collection of runoff water from container nursery operations where runoff of irrigation water and leachate from plant containers grown on plastic or in greenhouses is routed to lined return ditches or piped to lined holding ponds. Ponds would be designed to retaining all excess irrigation water runoff or leachate and capturing the first one-half to one-inch of stormwater runoff. Water would be recirculated for irrigation in nursery and greenhouse operations or irrigated at the proper times of year on other vegetation capable of trapping nutrients at agronomic rates, such as cool season grasses. Proposed BMP efficiency would be the same as for an animal waste storage system: 75% N reduction, 75% P reduction. This BMP is requested by Virginia DCR.

8.7 Interim Stormwater BMP

8.7.1 Volume Reduction and/or Retention Standard

This BMP credits efforts to increase the retention of stormwater on site or reduce the volume of stormwater entering the edge of stream. DC used a 1.2 inch retention standard and NY's WIP included a 50% volume reduction of stormwater on some urban acres. This is modeled as a conversion of impervious urban acres to urban acres that achieve a known volume reduction. Each jurisdiction has its own average and this was used to achieve a specified benefit. A similar practice with an implicit model reduction is known as impervious surface reduction.

8.8 BMP Annual Time Series

The structure of Scenario Builder and Phase 5 Model allows annual changes in land use and in BMPs as explained in more detail in Phase 5 Model documentation Section 12. The complete time series of information on BMPs as applied in the Phase 5 land-segments from 1985 to 2005 can be found at the Chesapeake Community Modeling Program's (CCMP) Phase 5 data library located on the web at: http://ches.communitymodeling.org/models/CBPhase5/datalibrary.php.

8.9 BMP effectiveness adjustment

High rainfall events can also influence BMP function and efficiency particularly for events above a BMP's designed maximum storm (Maule et al., 2005 and Glozier et al., 2006). Conservation practices are designed to function up to a specific storm event, for example a 10-year storm. Many continue to perform in more intense storm events. However, there is a level of storm intensity that impedes performance, and in extreme circumstances, may prevent nutrient or sediment reduction altogether. Research that estimates performance boundaries related to weather events is sparse. In addition, conservation practices may perform above literature values during low intensity storm events.

The weather adjustment links an expected loss in BMP efficiency due to storm intensity (Table 6.1.2). Only post-processed conservation practices receive this form of adjustment as land use change and explicit simulation of BMP would already have the effect of large events directly simulated. This adjustment is additive.

Table 8-2: Table of expected loss in efficiency due to storm intensity.

Storm Recurrence Frequency	Efficiency Level
0-15 year storm	conservation practice efficiency
5-50 year storm	70% of conservation practice efficiency
51+ year storm	30% of conservation practice efficiency

9 REVIEWS

9.1 Internal and external review

The objective in conducting reviews was to: 1) mirror in Scenario Builder the actual practices used by the agricultural community, and 2) correctly reflect the urban loadings. An extensive team of people both internal and external to the Chesapeake Bay Program were consulted throughout the development process. Working through a team brought diverse perspectives and made Scenario Builder more accurately reflect on-the-ground practices.

Internal reviews were conducted with the Chesapeake Bay Program modeling and nutrient staff (Jing Wu, Gary Shenk, Lewis Linker, Jeffrey Sweeney, and Mark Dubin), and the software development team leader (Jessica Rigelman). Each set of requirements were presented, discussed, and edited as recommended.

External guidance was provided primarily by:

1. Karl Berger-MWCOG
2. William Keeling-VA-DCR
3. Larry Fender-VA-DCR
4. Kenn Pattison-PA-DEP
5. Norm Goulet-Northern Virginia Regional Commission
6. David Kindig-VA-DCR
7. William Angstadt-MD and VA Fertilizer Sales Consultant
8. Bobby Long-VA-DCR Nutrient Management Planner
9. Edward Joyner-VA-DCR-Nutrient Management Planner
10. Robert Shoemaker-VA-DCR Nutrient Managed Planner
11. Doug Goodlander-PA State Conservation Commission
12. Don Fiesta-PA-DEP
13. Bill Rohr-Delaware Department of Agriculture

A series of conference calls were conducted from August through October, 2008. Each call addressed a different set of calculation procedures. In addition, Patricia Steinhilber-Program Coordinator, Agricultural Nutrient Management Program of the University of Maryland and David Hansen-University of Delaware Extension Program Leader for Agriculture and Natural Resources, were consulted throughout.

A joint meeting of the Agricultural and Nutrient and Sediment Reduction Workgroup and the Watershed Technical Workgroup was held 12/11/2008. Minutes from this meeting may be found on the Chesapeake Bay Program's website (http://www.chesapeakebay.net/committee_agworkgroup_meetings.aspx?menuitem=16733). The primary purpose was to approve source data and also review all the calculation processes for determining uptake and application rates. The group provided valuable input on volatilization changes to beef and hogs where beef TN would be 42.5% and hogs and pigs for breeding and growing TN would be 30%. However, since volatilization occurs after the nutrients are split into the various species of N and P, then these values were unable to be incorporated. Members of these workgroups also advised on the amount of time horses and heifers spend in pasture. As a result, changes were made to these variables. In addition, the workgroup members identified a more comprehensive source of data for animal manure speciation (ASAE, 2003). The workgroup members were in consensus that the ratio of NH_3 to NO_3 for inorganic fertilizer was incorrect, but no method was agreed upon for how to make a more representative split.

9.2 Validation

Test cases were developed and conducted parallel to the actual Watershed Model-HSPF calibration. The data from the Agricultural Census was spot checked by John Clune of USGS. His analysis was presented at the aforementioned joint workgroup meeting on 12/11/2008.

Further quality control and quality assurance procedures were implemented by the Chesapeake Bay Program's information technology contractor. These checks compared output to expected results with extensive input deck test cases.

10 APPENDICES

10.1 Manure and Fertilizer Application Process (J. Rigelman 01/30/09)

1. Calculate Best Potential and Max Application Mass and Rate
    a. The best potential and max should be the total mass needed by the crop inclusive of starter mass
    b. This is calculated for crops on land uses keeping double cropped crops separate by major nutrient by month

2. Calculate Starter Application Mass and Rate
    a. This is calculated for crop on land uses keeping double cropped crops separate by nutrient by month
    b. Starter is calculated from best potential application mass, not max.
    c. There is no starter max.

3. Calculate Direct Deposit Manure
    a. This is calculated on a monthly basis and nutrients and sources are kept separate

4. Calculate Manure and Biosolid Storage Loss
    a. This is calculated on a monthly basis and sources and nutrients are kept separate

5. Calculate Stored Manure and Biosolids
    a. This is calculated on an annual basis and sources and nutrients are kept separate

6. Apply Starter
    a. Apply fertilizer equal to the N and P starter mass.
    b. Take amount applied and subtract from best potential and max application masses.
    c. Take amount applied and add to applied source total.

7. Apply Storage Loss Manure to AFO
    a. Take all manure lost in storage and put on AFO land use.
    b. Keep months, animals, nutrients separate.
    c. AFO has no crops. Therefore, AFO has no N and P application mass.

8. Apply Direct Deposit Manure
    a. This manure is applied to pasture land uses – PAS, NPA, TRP
    b. TRP has an acres effective area of 9* the actual acres.
    c. This data is available monthly and will need to be applied monthly and animals and nutrients are should be kept separate
    d. Take the mass of the plant available N and plant available P pooped in pasture and subtract from best potential and max application mass. Take the total mass of N and total mass of P pooped in pasture and add to applied source total.
    e. If more nutrients pooped in pasture than is needed by the crops, apply it all anyway.
9. Apply Biosolids
    a. Biosolids are available by yearly total.
    b. Whether a crop is eligible to receive biosolids is determined by

i. If the crop is on a land use that can receive manure
ii. If the crop-land use can receive biosolids.
iii. If the crop-land use has a remaining best potential or max application mass

c. The annual amount of biosolids should be proportioned across the months based on remaining best potential and max application mass for crop-land use combinations that are eligible to receive biosolids.
d. Once the biosolids are proportioned monthly, the monthly allocation is applied in crop set order.
e. If the amount of biosolids available is between best potential and max then best potential must be met for all crops in all months before proportioning out the remainder to the remaining max application mass.
f. Take the mass of the plant available N and plant available P in biosolids that were applied and subtract from best potential and max application mass. Take the total mass of N and total mass of P in biosolids that were applied and add to applied source total.
g. Crop, land use, source, nutrient, month should all be kept separate.
h. If there are biosolids remaining after meeting max, an error is logged with the amount of biosolids that could not be applied.

10. Apply Stored Manure
    a. Stored manure is available by yearly total.
    b. Whether a crop is eligible to receive manure is determined by
        i. If the crop is on a land use that can receive manure
        ii. If the crop-land use has a remaining best potential or max application mass
        iii. It is assumed that if a crop is on a land use that can receive manure that it can receive all animal sources of manure.
    c. The annual amount of stored manure should be proportioned across the months based on remaining best potential and max application mass for crop-land use combinations that are eligible to receive manure.
    d. Once the stored manure is proportioned monthly, the monthly allocation is applied in crop set order.
    e. If the amount of manure available is between best potential and max then best potential must be met for all crops in all months before proportioning out the remainder to the remaining max application mass.
    f. If there is manure remaining after spreading the max for all crop-land use combinations, the remainder is eligible for transport.
    g. Take the mass of the plant available N and plant available P in manure that was applied and subtract from best potential and max application mass. Take the total mass of N and total mass of P in manure that was applied and add to applied source total.
    h. Crop, land use, source, nutrient, month should all be kept separate.

11. Manure Transport
    a. Manure can only be transported to another county if it shares a border.
    b. Manure transport cannot cross state lines.
    c. Only counties that have excess manure after meeting max application mass for all crop-land use combinations that can receive manure are eligible for transport.
    d. The order in which counties transport within a state is based on the greatest amount of excess manure.
    e. Manure is transported to adjacent counties proportionally based on the remaining best potential application mass. If an adjacent county does not have enough manure to meet best potential than you will transport to it.

f. Manure is transported to all adjacent counties proportionally based on adjacent counties remaining application mass.
g. Never transport manure to an adjacent county to meet a crops max application mass.
h. Transported manure is spread the same way stored manure is spread.
i. If a county cannot transport all of its excess manure to adjacent counties, the remainder goes to disposal load.

12. Disposal Load
    a. Apply disposal load manure to crops on the land use non nutrient management pasture (PAS) first.
    b. Apply disposal load manure to crops on the land use trampled riparian pasture (TRP) second if not eliminated on PAS.
    c. Apply disposal load manure to crops on the land use hay with nutrients (HYW) third if not eliminated on TRP.
    d. Apply disposal load manure to crops on the land use non nutrient management row w/manure (HWM, LWM) forth if not eliminated on HYW.
    e. If there is still excess after applying to HWM and LWM crops, an error is logged with the amount of disposal load that could not be applied.
    f. Sum max application mass for all crops on the land use(s) you are applying to annually.
    g. Multiply the annual sum for all crop times 10 to get the annual disposal load application mass for all crop on the land use(s).
    h. Proportion the annual mass across the months equally. 1/12 for each month.
    i. Apply the monthly allocation the crops in the land use(s) proportionally based on the proportion of acres in the crop to the total acres of the crops in the land use(s).
    j. If you have more manure than disposal load need in that land use(s) move to next land use(s)
    k. Take the total mass of N and total mass of P in the disposal manure that was applied and add to applied source total. There is no reason to subtract from application mass.

13. Apply Fertilizer
    a. Apply fertilizer to crops to meet remaining N and P best potential application mass
    b. Do not apply fertilizer to meet max
    c. Do not apply fertilizer to crops that do not take fertilizer as a source.
    d. Some crops only take fertilizer as a source and do not take biosolids or manure.
    e. Fertilizer is mixed to the exact remaining N and P application mass. If there is no remaining N application mass after manure spreading but P application mass remains then the fertilizer applied would only contain P.

Assumptions:

We are applying manure and biosolids on an N based plan. For these 2 application types we are comparing N application mass to plant available N applied. P can be over or under applied. We only look at possible remaining P need when applying fertilizer.

10.2 Manure and Fertilizer Input File (O. Devereux, 1/10/09)

Format

The input files to the Watershed Model are to match the sample below. All landsegs, land uses, and constituents are represented. NULL values are to be reported in the Watershed Model input files as “-9”. Do not code any NULL values as anything for any other output. Values of zero will be assumed to equal zero. Data is reported to two decimal places with a unique column for each month.

A separate table is constructed for nutrient types manure, which includes biosolids, and fertilizer. Each year is a separate table. Table name is to include: whether it is manure or fertilizer, year, and version. Data that needs to be associated with the table are the parameters used to create the data. This includes whether an N or P-based plan was in effect, year, nutrient type, units (lbs/acre), date created, and user.

Sample input table

lseg	lu	constituent	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
A10001	alf	nh3n	0	0	0	0	0	0	0	0	0	0	0	0
A10001	alf	no3n	0	0	0	0	0	0	0	0	0	0	0	0
A10001	alf	po4p	0	18.85	18.85	0	0	0	0	0	0	0	0	0
A10003	alf	nh3n	0	0	0	0	0	0	0	0	0	0	0	0
A10003	alf	no3n	0	0	0	0	0	0	0	0	0	0	0	0
A10003	alf	po4p	0	21.42	21.42	0	0	0	0	0	0	0	0	0

Procedure for grouping all nutrient application by land use and rescaling data from county to land segment

1. Sum the lbs of manure and biosolids by each form of n and p, county, month, year, and land use.
2. Add Mineralized N to Organic N and Mineralized P to Organic P. Do not report Mineralized portions since they are now in the organic portions.
3. Insert storage loss manure on AFO land use. (The Nutrient Application Procedures calculated the mass of nutrients applied to all land uses for which nutrients are eligible to be applied except for animal feeding operation (AFO). AFO receives manure from storage loss.)
4. Sum the lbs of fertilizer by each form of n and p, county, month, year, and land use.
5. For both the manure+biosolids mass (steps 1 and 2) and the fertilizer mass (step 3) lbs, multiply by the landseg acres divided by the area of all the landsegs in that county for each month and year. An example for a single month of a year, given 300 lbs in land use hwm in county 10001, where that county has 50 acres in segment A10001 and 75 in segment B10001, then 300 lbs * 50/125 acres = 120 lbs in land segment A10001. This yields the lbs/landseg.
6. For chemical fertilizer, 0.75 of TN is NH_3 and 0.25 of TN is NO_3. These percentages should remain flexible to the user. In addition, the ability to classify these percentages by county should remain a possibility as the user-interface interface and accompanying flexibility is introduced.

lbs	lu	County
300	hwm	10001
lu	**lseg**	**acres**
hwm	a10001	50
hwm	b10001	75
300 lbs * 50/125 acres = 120 lbs		
300 lbs * 75/125 acres = 180 lbs		

7. To report the lbs/acre in each landseg, divide by the number of acres in that landseg. Following the example above, landseg A10001 with land use hwm would have 2.40 lbs/acre. There are simpler ways to calculate the number. As long as the results are the same, the simplest method will suffice. However, interim data products for the broader range of users and data products for quality assurance may require calculating this differently.

Data checks

1. Land uses that receive no nutrients are: bar, ext, for, hvf, hyo, imh, and iml. Check that these land uses have zero nutrients applied.
2. No manure is applied to nursery (urs), high till without manure (hom), nutrient management high till without manure (nhi), or pervious urban (puh and pul). Check the manure input file to ensure that these land uses have zero manure and biosolids applied.
3. Check that the correct number of landsegs is in each nutrient file (236 at last check).
4. Manual checks by the user should include:
    a. No applications outside of crop plant to harvest months.
    b. The rate by aggregated categories of land uses is reasonable given knowledge of crops, application rates, and like knowledge.
    c. Total rate by crop is reasonable given knowledge of crop nutrient application rates.

To afford the capacity to rapidly perform the data checks that require agronomy and related discipline knowledge, data needs to be summarized by crops and also by land uses.

Summarize land use categories for an N or P rate (lb/acre) and annual application rate for each crop

Produce a table with the columns: crop, land use, land use category, lbs/acre, nutrient type (manure, biosolids, and fertilizer), nutrient form (total nitrogen or total phosphorus), months, and year. The spatial scale is land segment. Thus, there is not a separate column for each month, but rather one column with data ranging from 1 to 12. Similar land uses are grouped together. While it would be most helpful to have flexibility in grouping land use categories, we can define a priori the categories as:

Nutrient management row: nhi, nho, nlo

Row: lwm, hwm, hom

Alfalfa: nal, alf

Pasture: npa, pas, trp

Urban: puh, pul

Hay: hyw, nhy

Nursery: urs

Animal feeding operation: AFO

1. Convert N and P from lbs/acre to total mass by multiplying the segment by the number of acres for each land use.
2. Sum the acres for the land use types that support the desired type, e.g.: agriculture row crop, all agriculture, agriculture hay and forage, or etc. on the desired segment scale (e.g.: county, lrseg, etc.).
3. Sum the N and P mass by the same categorization of land uses in #2.
4. Convert N and P to lbs/acre for the new aggregated land use by multiplying the total mass by the acres in the aggregated land use categories.

Summarize animal types and other nutrient sources for mass of nutrients contributed to each crop or land use

Produce a table with the columns: crop, land use, lbs, nutrient form (total nitrogen or total phosphorus), animal type, animal unit, and year. The spatial scale is land segment. Thus, we can assess which species and other nutrient sources contribute what amount of manure to which crop or land use.

10.3 Manure Mineralization (O. Devereux, 1/10/2009)

Calculate amount of manure mineralized

Uses mineralization factor and amount of organic N and P by county, year and animal type.

1. Calculate the amount of organic N available in first year as Organic N * Mineralization factor. The mineralization factor is in a look up table.

2. Subtract the amount of mineralized N in first year from step 1 from organic N. This gives the mineralized N fraction.
3. Perform the same process for phosphorus. Since no phosphorus is immobilized, all organic P becomes mineralized P.

animal type	Phosphorus Mineralization factor	Nitrogen Mineralization factor
bovine	1	0.35
swine	1	0.5
poultry	1	0.6

Assumptions:

Mineralization factors taken from Mid-Atlantic Nutrient Management Handbook, 2002.

Mineralization factor: used values for spring or early fall applied, less winter topdress. Mineralization originally from VaDCR, 2005.

While temperature, water content, drainage features, and organic C all have an impact on mineralization, these factors are not considered in this Bay-wide estimation.

Plant Available Phosphorus behaves conservatively in the soil and not considered in model.

10.4 Septic Loads (J. Sweeney, 12/09/2008)

Following is a sequenced listing of parameters and functions used to calculate septic input decks for the Phase 5 Watershed Model. The calculations occur for each land-river segment (CATCODE2FIPSAB) in the domain.

Base data tables and an example of all calculations can be found in the Excel workbook "Septic_BaseTables-Calculations" under S:\VortexDevelopment\Requirements. The base data tables are identified as "PopSeptic (lrseg)" and "AHHS (county)". Worksheet "scenario_BMPs" is an example a scenario's BMPs for the septic work-up. Worksheet "septic_calculations" are the step-by-step calculations. Worksheet "septic_input-deck" is an example Watershed Model input deck for septic.

PopSepticyr (Pre-SC) – the number of septic systems, pre-septic connections for the relevant year of the scenario is taken from the base table "PopSeptic (lrseg)" and the respective column

- For example, column "PopSeptic00" is the population on septic for the year 2000

- The number of septic systems is the systems prior to changes due to “septic connections” practice
- If a land-river segment is not identified on the table “PopSeptic (lrseg)”, the default for *PopSepticyr (Pre-SC)* = 0
- Years not specifically identified in the base data table “PopSeptic (lrseg) can be populated through interpolation between known years.

AHHSyr – average household size by county for the relevant year of the scenario is also taken from the base data table “AHHS (county)” and the respective column

- For example, column “AHHS2000” is the average household size for the year 2000
- The average household size for a county, by FIPS designation, is applied to the respective FIPS for the land-river segment
- If a county (FIPS) is not identified on the table “AHHS (county)”, the default for *AHHSyr* = 0
- Years not specifically identified in the base data table “AHHS (county)” can be populated through interpolation between known years.

Systems (Pre-SC) – pre-septic connection systems for the scenario year

- Divide *PopSepticyr* by *AHHSyr*
- If *AHHSyr* = 0, then the number of pre-septic connection systems = 0

Septic Connections (SC)

- The number of septic connections is a BMP that varies by scenario, read from the BMP table “scenario_BMPs”
- The number of septic connections is summed by county in the BMP table and redistributed to land-river segments according to relative number of *Systems (Pre-SC)*
- If there is division by 0, the default *Septic Connections (SC)* = 0
- The number of *Septic Connections (SC)* cannot exceed the number of *Systems (Pre-SC)*

Systems (Post-SC) – post-septic connection systems for the scenario year:

- Subtract *Septic Connections (SC)* from *Systems (Pre-SC)*

PopSepticyr (Post-SC)

- Subtract (*AHHSyr* * *SC*) from *PopSeptic10 (Pre-SC)*

Load w/o SD-SP – TN (total nitrogen) load without septic denitrification and septic pumping in units of lbs. TN/year

- *PopSepticyr (Post-SC)* * *Lbs/Person-Year (edge of septic field)* * *Pass-through Factor* where

- *Lbs/Person-Year (edge of septic field)* = 8.91586080319759
- *Pass-through Factor* = 0.4

Septic Denitrification systems (SD)

- The number of septic denitrification systems is a BMP that varies by scenario, read from the BMP table "scenario_BMPs"
- The number of denitrifying systems is summed by county in the BMP table and redistributed to land-river segments according to relative number of *Systems (Post-SC)*
- If there is division by 0, the default *Septic Denitrification systems (SD)* = 0
- The number of *Septic Denitrification systems (SD)* cannot exceed the number of *Systems (Post-SC)*

Septic Pumping systems (SP)

- The number of septic pumping systems is a BMP that varies by scenario, read from the BMP table "scenario_BMPs"
- The number of pumped systems is summed by county in the BMP table and redistributed to land-river segments according to relative number of *Systems (Post-SC)*
- If there is division by 0, the default *Septic Pumping systems (SP)* = 0
- The number of *Septic Pumping systems (SP)* cannot exceed the number of *Systems (Post-SC)*

SD Reduction – the load reduction due to septic denitrification

- *SD Reduction = SD (systems)* divided by *Systems (Post-SC)* * 0.5
- Where *SD (systems)* is the number of septic systems with denitrification is a BMP that varies by scenario, read from the BMP table by land-river segment
- 0.5 is the TN reduction efficiency associated with the practice
- If *Systems (Post-SC)* = 0, then *SD Reduction* = 0

SP Reduction – the load reduction due to septic pumping

- *SP Reduction = SP (systems)* divided by *Systems (Post-SC)* * 0.05
- Where *SP (systems)* is the number of septic systems with pumping as maintenance is a BMP that varies by scenario, read from the BMP table by land-river segment
- 0.05 is the TN reduction efficiency associated with the practice
- If *Systems (Post-SC)* = 0, then *SD Reduction* = 0

BMP Reduction – the combined reduction of septic denitrification and septic pumping

- Add *SD Reduction* and *SP Reduction*

BMP Pass-through

- 1 minus *BMP Reduction*

Load (lbs TN/year) – annual TN load after all BMPs are applied in units of lbs. TN/year

- *Load w/o SD-SP * BMP Pass-through*

Load (lbs TN/day) – annual TN load after all BMPs are applied in units of lbs. TN/day

- *Load (lbs TN/year)* divided by 365.25
- *Load (lbs TN/day)* is the input deck for the Phase 5 Watershed Model with the example as follows:

landseg	riverseg	thisyear	constit	septicload
A10001	DE0_3380_0000	2010	totn	46.20288874
A10001	DE0_3410_0000	2010	totn	96.66787702
A10001	DE0_3790_0000	2010	totn	119.7432514
A10001	DE0_3791_0001	2010	totn	72.11308665
A10001	DE0_3840_0000	2010	totn	24.82286021
A10001	DE0_4140_0000	2010	totn	189.4786688
A10001	DE0_4141_0001	2010	totn	19.3595919

10.5 Nitrogen Fixation by Legumes (O. Devereux, 1/27/2009)

Legumes are a class of plants that generally grow pods. Legumes develop nodules on the roots that are an infection from bacteria. These bacteria transform N_2 to NH_3, a process called nitrogen fixation. The Scenario Builder reports the pounds/acre of ammonia (NH_3) that is fixed by crop, county, month, and year. These data may also be reported as Watershed Model land uses and land segments.

Nitrogen fixation

When in an aerobic system, not a wetland, then N fixation occurs. For a refresher, the nitrogen cycle may be summarized as:

$2 N_2 + 6 H_2O \rightarrow 4 NH_3$ (organism-mediated) $+ 3 O_2$

When the organism dies, then

$4 NH_3 + 4 H_2O \rightarrow 4 NH_4^+ + 4 OH^-$

This progresses very quickly to

$4 NH_4^+ + 6 O_2 \rightarrow 4 NO_2^- + 8 H^+ + 4 H_2O$ and $4 NO_2^- + 2 O_2 \rightarrow 4 NO_3^-$

Plant roots take up the NO_2^- and NO_3^- and convert to an amino acid.

Thus, N is added to the plant-soil system from the air. Leguminous plant types that we model are listed in Table 1. There are also broader categories in the NASS Agricultural Census that include legumes, but are not predominantly legumes. We do not calculate N fixation from these broader categories because the amount of legumes is not known (Table 2).

If there is adequate N available in the soil, then N fixation is suppressed. The implication is that if a farmer applies fertilizer to legumes, then N is not fixed.

Procedure

1. For legume crops on a county and annual scale, subtract the actual amount of N applied from the application rate for N (best potential rate). The actual amount of N applied and the application rate were calculated as part of the nutrient application procedures. Legume crops are listed in Table 1.
    a. If the result is ≥ 0, then record the full amount of N fixed from the look up table with the name of the crop, growth region, and amount in lbs/acre fixed.
    b. If the result is < 0, then the amount of N fixed is zero or a partial amount from the look up table with the name of the crop, growth region, and amount in lbs/acre fixed.
        i. In this case, add the difference between the application rate and actual amount of N applied (from step #1) to the amount of N fixed from the look up table.
        ii. Where the amount fixed is equal to the difference between the application rate and the actual amount applied, then the amount fixed will be zero.
        iii. Where the amount fixed is less than the difference between the application rate and the actual amount applied, then the amount fixed will be less than zero. When this situation occurs, set the lower bound to zero. It is not possible for a plant to "unfix" nitrogen.
        iv. Where the amount fixed is greater than the difference between the application rate and the actual amount applied, then the amount fixed will be a portion of the amount fixed.
            1. For example: if the amount of N fixed is 200 lbs-N/acre and N applied is 150 lbs-N/acre and the N application rate is 10 lbs-N/acre, then the result of step #1 is -140. Add -140 and 200 to get 60 lbs-N/acre.
2. Take the calculated lbs-N/acre that is fixed and multiply by the number of acres of that crop in the county. This yields the mass of N that is fixed by crop and year.

3. Distribute this mass of N fixed over the months that the plant is growing.
    a. N is fixed in the month after planting until harvest (For perennials, planting date corresponds to emergence and harvest date corresponds to hard frost. This is set in the source data table).
    b. Distribute the mass of N fixed evenly over these months by dividing the total N fixed in a year by the number of months the plant is growing minus the month of planting.
4. Convert N fixation monthly mass to land use. Sum the crops' monthly values that correspond to the same land use for each land use. Use the crops to land use table.
5. Convert to lbs-NH_3/acre by dividing by the number of acres in that land use.
6. Check to make sure that fixation < uptake. If fixation is ≥ uptake, then report an error.

Table 1: Legumes for which N fixation is calculated.

NASS Crop Type	**CBP Land use**	**CBP Land use abbreviation**
Alfalfa hay	alfalfa	Alf
Alfalfa seed	alfalfa	Alf
Birdsfoot trefoil seed	hay-fertilized	HYW
Dry edible beans, excluding limas	Conventional or Conservation Tillage with Manure	HWM or LWM
Green Lima Beans	Conventional Tillage without Manure	HOM
Peanuts for nuts	Conventional or Conservation Tillage with Manure	HWM or LWM
Peas, Chinese (sugar and Snow)	Conventional Tillage without Manure	HOM
Peas, Green (excluding southern)	Conventional Tillage without Manure	HOM
Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc.	Conventional Tillage without Manure	HOM
Red clover seed	hay-fertilized	HYW
Snap Beans	Conventional Tillage without Manure	HOM

Soybeans for beans	Conventional or Conservation Tillage with Manure	HWM or LWM
Vetch seed	hay-fertilized	HYW

Table 2: NASS categories that include legumes, but are not exclusively legumes.

NASS Crop Type	**CBP Land use**	**CBP Land use abbreviation**
Other tame hay	hay-fertilized	HYW
Pastureland and rangeland other than cropland and woodland pastured	pasture	PAS
Wild hay	hay-unfertilized	HYO

Assumptions

The Agricultural Census categories that include legumes but are not exclusively legumes are not considered for legume fixation. We assume the area comprising legumes is insignificant.

Each year is considered independent of any other year. Therefore, nutrients can not "build up" in the soil in data produced by the Scenario Builder. It follows that N in the soil after one year may repress N fixation. This situation is not considered in the calculation of these data.

No N is fixed in the month of planting. We assume that the nodules take 2-4 weeks to establish. For subsequent months of growth, the total amount of NH_3 is parsed evenly. That means that the same amount of N is fixed in month 2 as in the final month before the plant is killed or dies. A perennial, like alfalfa, will fix the same amount every month between emergence (plant date for annuals) and first hard frost (harvest date for perennials).

We assume that fixation occurs on all leguminous plants. This assumes that legumes are inoculated or sufficient rhizobia are present. It also assumes that carbon is at optimum levels.

Nitrogen fixation amounts are not adjusted for temperature or rainfall in the Chesapeake Bay Program's Watershed Model. The exception is alfalfa. As of October 14, 2008, nitrogen fixation for alfalfa will likely be calculated by the Watershed Model so that rainfall and temperature data can parameterize fixation amounts.

The Chesapeake Bay Program's Watershed Model accounts for processes that occur after N fixation, such as where crops are killed and left on the soil or incorporated into the soil, thereby returning N to the soil.

Many researchers have indicated that fertilizer application in the form of NO_3 does not decrease N fixation by legumes (Johnson et al., 1975; Blumenthal et al., 1996). These data refute the dogma that NO_3 substitutes for fixed N where NO_3 is increased. Literature searches did not produce data that quantifies the reciprocally of the NO_3 sorption and N2 fixation. Without identifying values of N fixation and the interaction with NO_3 for each leguminous plant, we are unable to consider these data in our model.

References

Bourion, 2007; Brady and Weil, 2002; Xu-Ri and Prentice, 2008; Johnson et al., 1975; Blumenthal et.al., 1996.

10.6 Land Use (O. Devereux, P. Claggett, J. Sweeney, G. Shenk, 1/27/2009)

Note on precision:

Land use acreage is an intermediate calculation between source data sets and loads, rather than a reported value, so values should not be rounded. On the output step, there should be at least 7 significant digits as the values are read in as single precision FORTRAN variables

Note on Time Scale:

Each run of the scenario builder land use calculation creates a data set that represents a single point in time or a year if the outputs are monthly. The direct inputs to the scenario builder land use calculation are files that represent a single set of assumptions. These files are

1. urban (5 uses), extractive, water, total acres by LRseg
2. crop types and animals by county from the Ag census
3. BMPs by LRseg

These files are identified by a scenario identifier that may or may not pertain to any given year. The calibration is a particular set of cases of the scenario builder land use generator where the inputs and outputs represent each year from 1982-2005.

Spatial reference:

"County" means County or independent city, referenced by the 5-digit FIPS code

"Lseg" = Land segment, which are divisions of counties. Referenced by the 5-digit FIPS code, with a preceding "A", "B", or "C"

"Rseg" = River segment or watershed, independent of county or lseg, referenced by a 13-character name, with the form XYn_1234_5678 where:

X = major basin

Y = minor basin

n = logarithmic reference to stream size

1234 = unique numerical ID, semi-randomly assigned

5678 = downstream ID. The unique ID of the downstream segment

Rsegs can be referenced by their full 13-character name or just their unique ID

LRseg = spatial intersection of the Lsegs and Rsegs. Referenced by the concatenation of thier names

Apply crops to land use: calculated on a county scale by year.

Use source data table: Ag Census crop type, county, year, and associated CBP land use

The land uses that have nutrient management analogues include: alfalfa, row with manure, row without manure, hay with nutrients, and pasture. The land uses that have low-till (conservation) tillage analogues include: row with manure and nutrient management row with manure.

1. Sum acres of crop type for the types of crops that relate to a CBP land use type, using the table of agricultural census crops. (Crop type area comes from a table derived from the agricultural census. There can be one land use with many crops but a crop can not be put on more than one land use, except where a portion is grown in a protected area or out in the open.)

This gives acres of crop where the total acres match the Watershed Model land use acres for each year and county.

Crops modeled include the following, which comes from the agricultural census. Where there are duplicates, it is because a portion of the crop area falls into two separate land uses, depending on whether it is grown in the open or in protected areas.

Alfalfa Hay Harvested Area

Alfalfa seed Harvested Area

Aquatic plants Area

Aquatic plants Protected Area

Asparagus Harvested Area

Barley for grain Harvested Area

Bedding/garden plants Area

Bedding/garden plants Protected Area

Beets Harvested Area

Berries- all Harvested Area

Birdsfoot trefoil seed Harvested Area

Broccoli Harvested Area

Bromegrass seed Harvested Area

Brussels Sprouts Harvested Area

Buckwheat Harvested Area

Bulbs, corms, rhizomes, and tubers – dry Harvested Area

Bulbs, corms, rhizomes, and tubers – dry Protected Area

Canola Harvested Area

Cantaloupe Harvested Area

Carrots Harvested Area

Cauliflower Harvested Area

Celery Harvested Area

Chinese Cabbage Harvested Area

Collards Harvested Area

Corn for Grain Harvested Area

Corn for silage or greenchop Harvested Area

Cotton Harvested Area

Cropland idle or used for cover crops or soil improvement but not harvested and not pastured or grazed Area

Cropland in cultivated summer fallow Area

Cropland on which all crops failed or were abandoned Area

Cropland used only for pasture or grazing Area

Cucumbers and Pickles Harvested Area

Cut Christmas Trees Production Area

Cut flowers and cut florist greens Area

Cut flowers and cut florist greens Protected Area

Dry edible beans, excluding limas Harvested Area

Dry Onions Harvested Area

Eggplant Harvested Area

Emmer and spelt Harvested Area

Escarole and Endive Harvested Area

Fescue Seed Harvested Area

Foliage plants Area

Foliage plants Protected Area

Garlic Harvested Area

Green Lima Beans Harvested Area

Green Onions Harvested Area

Greenhouse vegetables Area

Greenhouse vegetables Protected Area

Haylage or greenchop from alfalfa or alfalfa mixtures Harvested Area

Head Cabbage Harvested Area

Herbs, Fresh Cut Harvested Area

Honeydew Melons Harvested Area

Kale Harvested Area

Land in Orchards Area

Lettuce, All Harvested Area

Mushrooms Area

Mushrooms Protected Area

Mustard Greens Harvested Area

Nursery stock Area

Nursery stock Protected Area

Oats for grain Harvested Area

Okra Area

Orchardgrass seed Harvested Area

Other field and grass seed crops Harvested Area

Other haylage, grass silage, and greenchop Harvested Area

Other managed hay Harvested Area

Other nursery and greenhouse crops Area

Other nursery and greenhouse crops Protected Area

Parsley Harvested Area

Pastureland and rangeland other than cropland and woodland pastured Area

Peanuts for nuts Harvested Area

Peas, Chinese (sugar and Snow) Harvested Area

Peas, Green (excluding southern) Harvested Area

Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area

Peppers, Bell Harvested Area

Peppers, Chile (all peppers – excluding bell) Harvested Area

Popcorn Harvested Area

Potatoes Harvested Area

Potted flowering plants Area

Potted flowering plants Protected Area

Pumpkins Harvested Area

Radishes Harvested Area

Red clover seed Harvested Area

Rhubarb Harvested Area

Rye for grain Harvested Area

Ryegrass seed Harvested Area

short-rotation woody crops Harvest Area

short-rotation woody crops Production Area

Small grain hay Harvested Area

Snap Beans Harvested Area

Sod harvested Area

Sod harvested Protected Area

Sorghum for Grain Harvested Area

Sorghum for silage or greenchop Area

Sorghum Hogged or Grazed, Sorghum for Syrup, Corn for dry fodder Harvested Area

Soybeans for beans Harvested Area

Spinach Harvested Area

Squash Harvested Area

Sunflower seed, non-oil varieties Harvested Area

Sunflower seed, oil varieties Harvested Area

Sweet Corn Harvested Area

Sweet potatoes Harvested Area

Timothy seed Harvested Area

tobacco Harvested Area

Tomatoes Harvested Area

Triticale Harvested Area

Turfgrass

Turnip Greens Harvested Area

Turnips Harvested Area

Vegetable & flower seeds Area

Vegetable & flower seeds Protected Area

Vegetables, Mixed Area

Vegetables, Other Harvested Area

Vetch seed Harvested Area

Watermelons Harvested Area

Wheat for Grain Harvested Area

Wild hay Harvested Area

Winter wheat for grain Harvested Area

Double cropping: calculated on a county scale by year.

1. Subtract the following categories from the Item - Harvested croplands that is found in the Agricultural Census Table - *Farms, Land in Farms, Value of Land and Buildings, and Land Use*. Note that the item Harvested croplands is a land category so is not listed in the crop list above.
    a. Hay that was cut (found in table Field Seeds, Grass Seeds, Hay, Forage, and Silage under item Hay – all hay including alfalfa, other tame, small grain and wild). This item is the sum of the crops:
        1. Alfalfa hay
        2. Small grain hay
        3. Other managed hay
        4. Wild hay
    b. Land used to grow short-rotation woody crops. This is not a crop type, but does encompass the correct area for this calculation.
    c. land in orchards,
    d. Christmas trees, data only available for 2002 forward.

e. Land in Nursery, Greenhouse, Floriculture, Mushrooms, Sod, and Vegetable Seeds Grown for Sale under the item Floriculture crops – bedding/garden plants, cut flowers and cut florist greens, foliage plants, and potted flowering plants, total for both the Square feet under glass or other protection and acres in the open. Note this is not a crop type, but a land area.

f. If a negative value results, then set the land use to equal the crop area. The negative values for land area are likely due to scenarios with internal logic flaws or from error associated with estimating withheld (“D”) data from the NASS Agricultural Census.

2. Sum the double cropped eligible crop types from the agricultural census or user-input crops and acres data. Double cropped eligible crop types include:

Barley for grain
Corn for Grain Harvested
Corn for silage or greenchop
Emmer and spelt
Sorghum Hogged or Grazed, Sorghum for Syrup, Corn for dry fodder Harvested Area
Popcorn
Rye for grain
Sorghum for Grain
Sorghum for silage or greenchop
Soybeans for beans
Sunflower seed, oil varieties
Triticale
Wheat for Grain
Winter wheat for grain

3. Subtract the area in item #1 from the area in item #2. This yields the acres double cropped by crop type which are in the CBP land use categories of conventional or conservation tillage with manure.
    a. Where crops minus land (#2 - #1) yields a positive number, then this is the area double cropped.
    b. Where the subtraction is ≤ 0, then decrease the land area to match the crops. In this case, no land is double cropped.
4. Apportion the acres that are double cropped proportional to the amount of total land each comprises among:
    a. Corn for grain
    b. Corn for silage or greenchop
    c. Sorghum Hogged or Grazed, Sorghum for Syrup, Corn for dry fodder Harvested Area
    d. Popcorn
    e. Sorghum for grain
    f. Sorghum for silage or greenchop
    g. sunflower seed-oil varieties

    For example, if corn is 50%, sunflower seed-oil is 2%, and sorghum is 48% of land acreage as reported in the agricultural census, then the number of acres double-cropped will be covered by 50% corn, 2% sunflower seed-oil, and 48% sorghum.

    h. Where the acres of double cropped crops in the group calculated in step #4 is less than the difference between the crop and land areas from step #3, use the acreage calculated in step#4 for doublecropping. Increase the land area from step #1 by the difference between the double cropped crops and the doublecroppable land acres.
5. The crops paired with the corn varieties, sunflower seed-oil, and sorghum varieties are soybeans, barley, and total winter grains.
    a. Total winter grains are the sum of the following items: rye, triticale, emmer spelt, barley, and wheat (both types). The percent of total winter grains of each component is maintained. Total winter grains is by definition 100%, which may be composed of, for example, rye 30%, triticale 25%, barley 20%, wheat-both types 20%, and emmer spelt 5%.
6. For the total winter grains group and soybeans, each crop is paired proportionally with corn varieties, sunflower seed-oil, and sorghum varieties. The pairing is split so that the total proportion of corn varieties, sunflower seed-oil, and sorghum varieties is maintained. For example, if corn is 50%, sunflower seed is 2%, and sorghum is 48% (from step #4 above), then apply 50% of total winter grains group or soybeans to corn, 2% to sunflower seed, and 48% of soybeans or the total winter grains group to sorghum.
    a. Within the total winter grains group applied to corn varieties, sunflower seed, or sorghum varieties, use the specific crop type percentages calculated in step #5 above. This gives the grain group proportioned as a second step to determining the corn varieties, sunflower, and sorghum varieties amount double cropped.

These acres will be stored by the county and year marked as double-cropped crop. It is a separate category of crop type because it has its own plant and harvest dates as well as fertilizer application amount and time.

7. Acres of the soybeans, total winter grains group, or barley that exceed the corn varieties, sunflower oil-seed, or sorghum variety acres available for double-cropping remain as a single crop.

8. Verify that the timing of plant and harvest dates by growth region do not result in two crops growing at the same time. That is, if corn is planted in April and harvested in August, then soybeans can not be planted in July. In this case, apply the double cropping to a different available crop (among corn, sorghum, and sunflowers) where there is no overlap of crop plant and harvest time periods. *NOTE: THIS REQUIREMENT WAS NOT IMPLEMENTED.*

At this point, we have the acres of crops on model land uses including double cropped acres.

Turf grass

Determine the crop type turf grass area by multiplying the fraction of urban lawn by each of the urban categories: barren-construction, low intensity pervious urban, and high intensity pervious urban for each county and year.

Assumptions for crops to land uses and double cropping

Where inconsistencies or error introduced in the estimation of withheld ("D") data led to inconsistencies between crop areas and land areas, then the land areas were adjusted to be commiserate with the crop areas.

All failed cropland is included in the Watershed Model land use hay-fertilized. The agricultural census does not report which crops failed. Therefore, whatever failed is not double cropped.

Corn and sorghum are equally likely to be double cropped in this model.

Maryland currently has a commodity cover crop program that allows a partial payment for crops planted but not harvested when no nutrients are applied in the fall. If the farmer applies spring nutrients and harvests the crop for sale, then there is a smaller subsidy payment (R. Wieland, personal communication, 2008). This may provide some overlap in NASS data for small grains and cover crops reported as a best management practice

Vegetables that are grown in plasticulture are not treated differently in this model. Plasticulture–managed vegetables are grown so that approximately one third of a field is covered(Ed Joiner, Nutrient Management Planner, VA). This increases infiltration since the irrigation system is under the plastic and decreases erosion. It also decreases volatilization. If plasticulture is about 7,000 acres in Virginia, and there are 195,000 acres in high-till row crop without manure (HOM), then these acres comprise 3.6% of the total and the plastic-covered portion of the field is 1.1% of that land use. Therefore, this is assumed to be insignificant portion for the outcome of loads.

Sunflower can be for seed oil or for wildlife. Where sunflower is grown for wildlife stands then it is not double cropped but left fallow. NASS reports sunflowers in two categories: Sunflower seed, non-oil varieties and Sunflower seed, oil varieties. Only sunflower seed, oil variety is available to be double cropped. Years prior to 2002 do not have sunflower seed split into the two categories, so double cropping is not calculated for sunflowers prior to the categorization split. Rather, sunflower-all are categorized as sunflower non-oil varieties for the years prior to 2002.

Barley can be grown for grain or silage, yet the agricultural census does not differentiate. Barley for silage is lumped into the category haylage, grass silage, or greenchop whereas corn and sorghum silage or greenchop are distinct. Where grown for silage it is harvested 1.5 months earlier and is double-cropped with either sorghum or corn. This is common in the dairy industry (Bobby Long, Nutrient Management Planner, VA). Since the source data do not allow barley for silage as a distinct category, barley effectively will only be double cropped as a grain with sorghum.

While potatoes grown in the southern portion of the Chesapeake Bay Watershed are harvested early enough that they may be double cropped with beans and wheat, they are not included as a crop that may be double cropped with anything other than vegetables (Ed Joiner, Nutrient Management Planner, VA). Vegetables are double cropped. This is handled by multiple plant and harvest dates within each crop type or the land use.

Derived Agricultural Land Uses—Animal Feeding Operation

Animal Feeding Operations (AFO) are those areas where manure lost during storage and handling loss is applied. AFO land areas are added using the following criteria.

1. For each county and year, multiply the number of farms by animal type times the value in the look-up table. A sample look up table is below; it should be populated from the Agricultural Census.
2. AFO acres are added to the agricultural acres.
3. AFOs are broken down into land segments, and later into land-river segments, using an area weighted average based on the amount of agriculture in the county. Multiply the acres of AFOs in the county by the agricultural acres in each land-river segment divided by the total agricultural acres in the county. Agricultural acres are defined as those in the land uses:
    - animal feeding operations
    - alfalfa
    - row without manure
    - row with manure
    - hay without nutrients
    - hay with nutrients
    - pasture
    - degraded riparian pasture
    - nursery

Table CountySourceFarmAcres: Sample data

Agricultural Census Table Name	Item Name	No. of Farms	Acreage/farm	Year	County
Cattle and calves – Inventory and Sales	Cattle and calves		5		
Hogs and Pigs – Inventory and Sales	Total hogs and Pigs		2		
Poultry--Inventory and Sales	Any Poultry		2.5		
Sheep and Lambs--Inventory, Wool Production, and Number Sold	Sheep and Lambs--Inventory		1		
Milk Goats	Milk goats		0.5		

	inventory				
Angora Goats	angora goats inventory		0.5		

Where the area of BMPs reported by the states exceeds the land area in AFO, then the AFO land area is increased. Further specificity will be included in the BMP requirements.

Assumptions for derived land use: AFOs

The Agricultural Census only lists farms by animal type, yet many farms have more than one animal type. Certain acreages are designated for each farm with an animal type; therefore areas that are shared by more than one species of animal are overestimated.

The land area of the farm is not related to the AFO size, but rather the size of an animal type and the number of animals.

On AFO land, we are not capturing the following animal types: Other poultry (such as ducks, geese, emus, ostriches and squab) or Misc. livestock and animal specialties (such as bison, llamas, and rabbits). We assume that there are few farms with significant enough acreage specializing in solely these animals, so that land area is captured under other animal types.

The acreage/farm was 0.5 as specified by Robert W. Burgholzer. Jeff Sweeney indicated this was not enough area to apply the state-reported BMPs. Values were increased relative to animal size and typical operation management principles, and approved by CBP workgroups.

Integrating Ag Census with other data sources and scaling from County to Land-River Segmentation

Procedure 1: Creating ”CBP Ag LU by LRseg”

INPUTS

1. P5lc

Tabular summary of raster land cover acres with unique classes for undefined agriculture (AG), cropland (CROP), and pasture/hay (PH) by Lrseg

Note: this will be static for the calibration and most scenarios.

Nursery, row crops with and without manure are considered CROP. Hay with and without nutrients, alfalfa and pasture are considered PH.

2. Agricultural Land Uses by County

These data are in a source table derived from the Agricultural Census above. Where the steps below refer to a land use, perform the same procedure on all of the crops in that land use.

3. AG Land Cover Index = AG / (CROP + PH)

Distribute undefined agriculture land cover into cropland and pasturehay land cover classes at the LRseg scale.

1. For LRsegs with a non-zero Ag Land Cover Index that is also less than 1, inflate the PH and CROP acres by distributing the undefined agriculture (AG) class to PH and CROP based on the proportions of PH and CROP in each LRseg.

1a. Create a multiplier = (PH + CROP +AG)/(PH + CROP)

This must always be >= 1

1b. Multiply PH and CROP by this multiplier

2. For LRsegs with no undefined agriculture (AG) and for LRsegs where the Ag Land Cover Index >=1 (e.g., the amount of undefined agriculture equals or exceeds the combined amount of PH and CROP), distribute the undefined agriculture (AG) class to LRsegs based on the proportions of pasturehay land use (CountyPastureHay) and cropland land use (CountyCropland) to total amount of agricultural land uses reported in the 2002 County Agricultural Census:

2a. PH = PH + (AG * CountyPastureHay/TotalCountyAgriculture)

2a. CROP = CROP + (AG * CountyCropland/TotalCountyAgriculture)

3. You now have PH and CROP acres for all LRsegs and zero 'AG' acres for all LRsegs, The acres do not add up to the ag census, however.

Distribute the ag land use classes based on the proportion of each ag land cover class within each LRseg

For all 'crop' classes:

Acres of crop land uses = acres of CROP in lrseg / acres of CROP in county

Do the same for PH

For a zero Ag Land Cover Index and crops available to go on that land, apply proportional to the lrseg acres / county acres.

AFOs are disaggregated to land river segments proportional to the area of all agricultural acres in each LRseg to the total agricultural acres in the county.

Procedure 2: Creating"CBP Land Use by LRseg"

INPUT

1. "CBP Ag LU by LRseg", from procedure 1
2. "CBP Urban LU by LRseg" – external table
3. Total Acres by LRseg – external table
4. water acres by LRseg – external table

5. extractive acres by LRseg – external table

The purpose of this procedure is to assemble the data set from different sources. Since these are based on different data sets, they do not add up to 100% of the area. Some guidelines have been developed in order of importance:

1. Total LRseg size and water must be preserved

2. Forest is found by subtraction

Procedure: follow for each Lrseg

Forest = total acres minus water, ext, urban, and ag.

If forest is non-negative STOP

Set AcresNeeded = -forest

Set forest to zero

Low intensity pervious urban = Low intensity pervious urban - AcresNeeded

If low intensity pervious urban is non-negative STOP

Set AcresNeeded = -(low Intensity pervious urban)

Set Low intensity pervious urban to zero

If ag > 0

  Set ag multiplier = 1 - (AcresNeeded)/(total ag) (multiplier < 1)

  Multiply all ag categories by the ag multiplier

  If ag multiplier is positive STOP

  Set AcresNeeded = - (total ag)

  Set all ag to zero

End if ag > 0

If total urban > 0

  Set urban multiplier = 1 - (AcresNeeded) / (total urban)

  Multiply all urban categories by the urban multiplier

  If urban multiplier is positive STOP

  Set AcresNeeded = - (total urban)

  Set all urban to zero

End If total urban > 0

Set ext = LRseg total minus water

If ext positive STOP

Set ext = 0

Set water = LRseg total

End Procedure

Projecting Land Use

THIS IS NOT PART OF THE REQUIREMENTS FOR CALCULATING LAND USE

For the purposes of integration and consistency with the Phase 5.2 Watershed Model, the Chesapeake Bay Land Change Model (CBLCM) forecasts the proportional future growth in urban land and resulting proportional loss of forests and farmlands for each LRseg. .

1. For each LRSEG, the proportional increase in total urban area should be distributed proportionally to the five urban land uses reported for the base year of the forecast. For example, a forecasted growth of 100 urban acres from 2002 to 2010 in LRseg X should be distributed to the five urban land use classes in LRseg X reported in the 2002 land use dataset used as part of the Phase 5.2 calibration. The resulting increase in total urban area is then subtracted from the total of all forest land uses (e.g., forests + harvested forests) and from the total of all agricultural land uses reported in the 2002 land use dataset for LRseg X.

a. 2. All of the proportions of urban, forest, and agricultural land uses relative to the total urban, total forest, and total agricultural land uses are kept constant through time. However, an iterative mass balance routine must be implemented to maintain total land acres in each LRseg while preventing any one land use (e.g., hay with manure) from falling into negative acres. Negative land use acres must be redistributed to other related land uses. For example, if “hay with manure” is forecasted to falls below zero acres in year 2010 then “hay with manure” must be set to zero and the deficit acres subtracted proportionally from all remaining agricultural land uses. This correction must be run iteratively until all land uses contain zero or more acres.

10.7 Manure Transformations (O. Devereux, 10/28/2008)

Calculate amount of manure available for direct excretion method on a county scale by year

Uses fraction of time in pasture by animal by month and growth region

Yields stored manure

Yields manure produced in pasture/month

Check to see if the county has pasture (pas, npa, trp) acres. If a county has no pasture acres, no manure is available for direct excretion. All manure will move into storage.

Take the lbs of nutrients that are produced by animals daily from "manure production" and aggregate to months.

Multiply sources by time in pasture to filter lbs of nutrients directly excreted in pasture.

Take lbs of nutrients excreted in pasture and disaggregate to pasture land use types (pas, npa, and trp). Trp gets 9 times the rate of pas and npa.

10.8 Crop Uptake (Guido Yactayo, 2/19/2010 and O. Devereux, 4/17/2009)

Yactayo:

Previously, uptake was calculated using:

1. 5% was added to the highest actual yield from the ag census to calculate the best yield
2. The yield ratio = (best yield/ max yield)
3. Best potential uptake (lb/yield unit)= yield ratio* theoretical maximum uptake (lb/yield unit)
4. Finally the final uptake per month (lb) = best potential uptake (lb/unit)* area (acres)* actual yield (unit/acre)
5. Final uptake per month per acre (lb/acre) = best potential uptake (lb/unit)* actual yield (unit/acre)

According to Alley and Vanlauwe (2009), the total nitrogen uptake is a function of the total crop biomass (top growth and roots) and it is calculated using:

$$Total\_NutrienUptake(lb/acre) = \left(\frac{yield\_drymatter}{acre}\right) \times \left(\frac{nutrient\_content\,(lb)}{yield\_drymatter}\right)$$

Using the maximum yields and theoretical uptake found in the literature and eliminating the yield ratio, crop uptake is calculated using:

$$Uptake\_permonth(lb) \equiv \frac{\max imum\_yield}{acre} \times \frac{theoretica\,l\_uptake(lb)}{yield\_unit} \times acres$$

$$Uptake\_permonth\_peracre(lb/acre) \equiv \frac{\max imum\_yield}{acre} \times \frac{theoretica\,l\_uptake(lb)}{yield\_unit}$$

Uptake per month is proportional to the heat units received by the crop. Nitrogen and phosphorus uptakes per landuse are calculated using an area weighted average of all the crops contained in the landuse is used.

Devereux:

N and P Uptake Mass calculated at a land segment scale for all forms of N and P

Uptake is the amount of N and P taken from the soil into the plant. It includes the amount that would be removed with a harvest. It is calculated as a mass by month for each crop type. Maximum potential uptake is that which is calculated from a longer term average regional yield.

HARVEST Yield	**Uptake or nutrient use**	**Nutrient Application Rate**
Actual	Average of actual yields (calculated) #	Actual (unknown)
Best potential (two different calculation methods, one for uptake and another for nutrient application rates)	Maximum potential (calculated)$	Nutrient management (calculated)#$
Theoretical maximum ***	Theoretical maximum***	Theoretical maximum***#$

Notes:

Watershed model calibration input file

$ Watershed model scenario input file

*** Source data table. Table includes the N and P application rates and uptake mass by month in a look-up table.

1. Nutrient application rate is included for comprehensiveness, but not relative to uptake or land cover calculations.
2. The <u>theoretical maximum</u> is the yield, rate, or uptake from the maximum possible given best soil and best weather conditions.

Calculation of Best Potential Yield

<u>Best potential</u> for uptake is calculated as the best yield from any year plus 5%. Best potential for the nutrient application rate is described in detail in nutrient application requirements.

Transform the NASS Ag Census yield data from bushels to bushels per acre. Use NASS data for each county, crop type, and year.

1. There should be no occurrences of yields without acres or acres without yields. The source data from the ag census has been cleaned up to remove these situations. Where a user imports their data and this error occurs, the user should be notified of the error.
2. Using the bushels per acre, determine which year had the highest yield. (TblCropHarvest)
3. Add 5% to the year with the highest yield, which gives the best potential yield for that crop type.

Calculation of Nutrient Uptake Mass

The look-up table data looks like:

CID	Crop	nutrient	max uptake/mo/yield unit	month after planting
0	Turf grass	N	0.0024061	1
0	Turf grass	N	0.0101054	2
0	Turf grass	N	0.0015124	4
0	Turf grass	N	0.0023526	5
0	Turf grass	N	0.0117629	6
0	Turf grass	N	0.0117629	7
0	Turf grass	N	0.0084021	8
0	Turf grass	P	0.0003711	1
0	Turf grass	P	0.0015585	2
0	Turf grass	P	0.0002333	4
0	Turf grass	P	0.0003628	5
0	Turf grass	P	0.0018142	6
0	Turf grass	P	0.0018142	7
0	Turf grass	P	0.0012958	8
1	Alfalfa Hay Harvested Area	N	3.0068182	1
1	Alfalfa Hay Harvested Area	N	12.628636	2
1	Alfalfa Hay Harvested Area	N	1.89	4
1	Alfalfa Hay Harvested Area	N	2.94	5
1	Alfalfa Hay Harvested Area	N	14.7	6
1	Alfalfa Hay Harvested Area	N	14.7	7
1	Alfalfa Hay Harvested Area	N	10.5	8

1. Determine plant date and harvest date for each crop and county. Using the month after planting, assign a month for the crop and county. (TblCropCounty)
    a. All other months will equal zero.

   b. Where a crop's harvest date is after January 1, and the plant date is prior to December 31, then the crop growth period will loop back to the beginning of that year. This means that where a winter wheat crop may have a plant date of October 1 and a harvest date of April 1, it will have growing dates of Jan, Feb, Mar, Apr, Oct, Nov, and December. This preserves the internal logic of each year being independent.
   c. If there is a month between plant and harvest dates that does not have a "month after planting" number assigned, the max uptake/mo/yield unit equals zero.
2. Calculate the best potential yield for *uptake* rather than the calculated best potential yield table for the *nutrient application rate*.
   a. Determine the **yield ratio** of the calculated best potential yield to the theoretical maximum yield for each year. (TblCropMaxYield)
   b. If theoretical maximum yield= null, then set yield ratio to 1
   c. If theoretical maximum yield=0, then set yield ratio to 0
3. Multiply this yield ratio for each county, crop type, month and nutrient by the theoretical maximum uptake in the source data table to get **best potential uptake**. The maximum uptake is by TN or TP in units of uptake/month/yield unit.
4. Convert units from uptake/month/yield unit as follows.
   a. Multiply the maximum uptake adjusted for annual yield variation (best potential uptake from step 3) by the *actual annual yield* (for example (bushels).
   b. Multiply the uptake/month by the acres for each crop type so the data is now in units of uptake/month.
5. Convert the uptake monthly mass to land use by summing the crops' monthly values that correspond to the same land use for each land use. Use the crops to land use table.
6. This gives a monthly mass by land use that may be summed across months for an annual mass.

Calibration nutrient uptake file—average over all years.

The one-time file for the Watershed Model calibration is calculated in a similar way. Since there is only a single file that is the average of the period, all related data used in the uptake calculation is averaged. This includes the yields, crop acres, and land acres. In addition, the source data file for yield is the actual harvest yield rather than the calculated best potential yield.

N and P Uptake Curve calculated at a county scale for all forms of N and P

Data used are N and P uptake percentages in a look-up table. The monthly curve number is the percent N or P applied per month. These percents are in a look-up table by crop type. Any variation is from crop variation or land use change from year to year.

1. To compute the curve by land use, use the monthly mass by land use (from #5 in crop uptake mass procedure) and sum these by land use for each month and for the annual sum.
2. Divide the monthly mass of N and P by the annual sum for each month. Report this fraction.

Assumptions:

The Watershed Model will calculate actual uptake based on temperature, rainfall, and other parameters not including yields. The Scenario Builder introduces variability due to geographical yield differences such as those from soil. Actual uptake is not calculated as part of the Watershed Model scenario inputs. Rather, best potential uptake is reported. Therefore, any variation in uptake is the result of variation in crops planted, not growth conditions.

There are no differences in uptake for nutrient management or tillage practices. Uptake is based on best potential yields calculated from actual yield data.

Maximum potential uptake is taken from crop removal data and doubled to represent the whole plant, unless other data indicated differently (as with corn at 2/3 in removal).

The crop uptake curve information is calculated for each of the 12 growth regions using the recommended plant date. This does not account for the variation in varieties used throughout the watershed. A better way and one that should be investigated in the future is using heat units to inform the curves.

The theoretical maximum is the yield, rate, or uptake from the maximum possible given best soil and best weather conditions. These data are from states' nutrient management handbooks and the state extension programs' agronomy recommendations.

10.9 Unexposed Soil Surface (O. Devereux, 4/17/2009)

Uses data:

County

Plant and harvest dates

Tillage practice: low till or high till as associated with land use

Soil surface cover by month

Acres of crops

Double cropped

1. Calculate crop residue cover

a. For each crop and double cropped crop and tillage practice in each county, multiply the monthly soil surface cover fraction (given in a source data table) by the acres of cropland to get acres/month.

b. Sum the crop residue cover by land use for each month to get land use acres/month.

2. Divide the monthly acres of unexposed soil surface cover from #1 by the total acres of land in that land use. This gives the percent cover by land use.

3. This calculation is bound where:

   a. monthly value is < 0.95

   b. monthly value is >zero

Assumptions

Double cropping cover is addressed by classifying a double-cropped crop as its own crop type with different plant and harvest dates than the same crop that is not double-cropped. Since the first crop planted is not considered as the double-crop, then those dates are not shortened to reflect what may be an earlier harvest. Therefore, there may be some overestimate of cover from leaf area coverage and an underestimate of residue cover during the harvest time of the first crop and the planting time of the double crop.

This process selects the residue cover or the canopy cover fraction, whichever is higher. An underestimation may result in early plant growth period for low till crops because residue may still be on the ground and leaf cover may not overlap. This is not an issue for high till crops where most of the residue is plowed under at planting.

NRCS Practice Standard 345 for Residue Management Mulch Till states, "The annual Soil Tillage Intensity Rating (STIR) value for all soil-disturbing activities shall be no more than 70 for high residue crops (e.g., grain corn) and no more than 10 for low residue crops (e.g., grain soybeans). These STIR values will result in approximately 30% or more surface residue for the entire crop rotation." By using the RUSLE2 tillage management practices, the data necessarily meets the conservation tillage STIR values.

10.10 Classifying Nutrient Applications in Terms of Land Use

Nutrients are eligible to be applied to land based on the land use in which they are classified. Table 10-1**Error! Reference source not found.** indicates which broader categorization of agricultural land each land use falls into: row, hay, or pasture. These classifications are used to establish the eligibility of manure and/or fertilizer applications to crops within each of these land uses.

Table 10-1: Nutrient type classifications

Name	Short Name	Tillage	Row	Hay	Pasture	Nutrient Management	Manure	Fertilizer
animal feeding operations	afo	NA	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
alfalfa	alf	NA	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE
hightill without manure	hom	High	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE
hightill with manure	hwm	High	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE
hay without nutrients	hyo	NA	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
hay with nutrients	hyw	NA	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE
lowtill with manure	lwm	Low	TRUE	FALSE	FALSE	FALSE	TRUE	TRUE
nutrient management alfalfa	nal	NA	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
nutrient management hitil with manure	nhi	High	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE
nutrient management hitil without manure	nho	High	TRUE	FALSE	FALSE	TRUE	FALSE	TRUE
nutrient management hay	nhy	NA	FALSE	TRUE	FALSE	TRUE	TRUE	TRUE
nutrient management lotil	nlo	Low	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE
nutrient management pasture	npa	NA	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
pasture	pas	NA	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE
degraded riparian pasture	trp	NA	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
nursery	urs	NA	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
low intensity pervious urban	Pul	NA	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
high intensity pervious urban	Puh	NA	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE

10.11 Double cropping Requirements

The actual procedure is below.

1. Acquire "Harvested Cropland Area" for a county from Ag census
2. Summarize the acreage of double crop ineligible crops from the following types in Ag census

Alfalfa Hay Harvested Area

Cut Christmas Trees Production Area

Cut Christmas Trees Production Area

Floriculture crops – bedding/garden plants, cut flowers and cut florist greens, foliage plants, and potted flowering plants, total Area

Floriculture crops – bedding/garden plants, cut flowers and cut florist greens, foliage plants, and potted flowering plants, total Protected Area

Land in Orchards Area

Other managed hay Harvested Area

short-rotation woody crops Harvest Area

short-rotation woody crops Production Area

Small grain hay Harvested Area

Wild hay Harvested Area

3. Subtract ineligible crops from cropland area
4. If the resultant area is negative, then reset or redefine the cropland area equal to the summarized crop acreage calculated in step 2 above.
5. Summarize the acreage of "double cropped eligible" crop types

Identify the *double cropped eligible* crop types by county.

Summarize (add) the acreage of these crop types.

6. Subtract the area determined from step 3 from the area determined in step 5. This difference yields the acres double cropped.
   a. When this number is a positive number (more crop acreage than land area), it represents the *area double cropped*. Proceed to Step 4.
   b. When this number is negative (less double-crop acreage than land area), re-set the *Initial land area* to be equal to the *Initial double-crop area*. In this case, no land is double cropped.
7. Determine the first (spring/summer) *crop-specific acres double-cropped*. Summarize acreage of crop types listed as a *first crop* in Table 7-2, and determine

crop-specific proportions of the total. Multiply the crop-specific proportions with the *area double cropped* (from step 0) to get the *crop-specific acres double cropped*.

> For example, if corn is 50%, sunflower seed-oil is 2%, and sorghum is 48% of land acreage as reported in the agricultural census, then the number of acres double-cropped will be covered by 50% corn, 2% sunflower seed-oil, and 48% sorghum (This example assumes there are enough acres of the first crop to accommodate all acres of the second double-croppable crop).

8. The second set of crops that should be paired with the early season crops (corn varieties, sunflower seed-oil, and sorghum) are soybeans, barley, and total winter grains based on crop-specific proportional acreage. The full list is presented in table Table 7-2 (as first and second crop columns).

> For example, if corn is 50%, sunflower seed-oil is 2%, and sorghum is 48% of land acreage as reported in the agricultural census, then the number of acres double-cropped will be covered by 50% corn, 2% sunflower seed-oil, and 48% sorghum (This example assumes there are enough acres of the first crop to accommodate all acres of the second double-croppable crop).

9. These acres will be stored by the county and year marked as double-cropped crop. It is a separate category of crop type because it will eventually have its own plant and harvest dates as well as fertilizer application amount and time.

10. Acres of the soybeans, total winter grains group, or barley that exceed the corn varieties, sunflower oil-seed, or sorghum variety acres available for double-cropping remain as a single crop. These excess acres are not considered to be double-cropped. The initial land area should be increased to reflect that these crops have not been double-cropped.

    Example: Initial land area = 100

    First Crop area = 300
    Second Crop area = 50

    If the second crop is double-croppable, the initial land area should be increased from 100 to 250. If the second crop is not double-croppable the land area would be increased from 100 to 350.

Note:

Double cropping cover is addressed by classifying a double-cropped crop as its own crop type with different plant and harvest dates than the same crop that is not double-cropped. Since the first crop planted is not considered as the double-crop, then those dates are not shortened to reflect what may be an earlier harvest. Therefore, there may be some overestimate of cover from leaf area coverage and an underestimate of residue cover during the harvest time of the first crop and the planting time of the double crop.

This process selects the residue cover or the canopy cover fraction, whichever is higher. An underestimation may result in early plant growth period for low till crops because residue may still be on the ground and leaf cover may not overlap. This is not an issue for high till crops where most of the residue is plowed under at planting.

NRCS Practice Standard 345 for Residue Management Mulch Till states, "The annual Soil Tillage Intensity Rating (STIR) value for all soil-disturbing activities shall be no more than 70 for high residue crops (e.g., grain corn) and no more than 10 for low residue crops (e.g., grain soybeans). These STIR values will result in approximately 30% or more surface residue for the entire crop rotation." By using the RUSLE2 tillage management practices, the data necessarily meets the conservation tillage STIR values.

Where inconsistencies or error introduced in the estimation of withheld ("D") data led to inconsistencies between crop areas and land areas, then the land areas were adjusted to be commiserate with the crop areas.

All failed cropland is included in the Watershed Model land use hay-fertilized. The agricultural census does not report which crops failed. Therefore, whatever failed is not double cropped.

Corn and sorghum are equally likely to be double cropped in this model.

Maryland currently has a cover crop program that allows a partial payment for crops planted but not harvested when no nutrients are applied in the fall and a smaller payment if the farmer applies spring nutrients and harvests the crop for sale (R. Wieland, personal communication, 2008). This may provide some overlap in NASS data for small grains and cover crops reported as a best management practice

Vegetables that are grown in plasticulture are not treated differently in this model. Plasticulture–managed vegetables are grown so that approximately one third of a field is covered(Ed Joiner, Nutrient Management Planner, VA). This increases infiltration since the irrigation system is under the plastic and decreases erosion. It also decreases volatilization. If plasticulture is about 7,000 acres in Virginia, and there are 195,000 acres in high-till row crop without manure (HOM), then these acres comprise 3.6% of the total and the plastic-covered portion of the field is 1.1% of that land use. Therefore, this is assumed to be insignificant portion for the outcome of loads.

Sunflower can be for seed oil or for wildlife. Where sunflower is grown for wildlife stands then it is not double cropped but left fallow. NASS reports sunflowers in two categories: Sunflower seed, non-oil varieties and Sunflower seed, oil varieties. Only sunflower seed, oil variety is available to be double cropped. Years prior to 2002 do not have sunflower seed split into the two categories, so double cropping is not calculated for sunflowers prior to the categorization split. Rather, sunflower-all are categorized as sunflower non-oil varieties for the years prior to 2002.

Barley can be grown for grain or silage, yet the agricultural census does not differentiate. Barley for silage is lumped into the category haylage, grass silage, or greenchop whereas corn and sorghum silage or greenchop are distinct. Where grown for silage it is harvested

1.5 months earlier and is double-cropped with either sorghum or corn. This is common in the dairy industry (Bobby Long, Nutrient Management Planner, VA). Since the source data do not allow barley for silage as a distinct category, barley effectively will only be double cropped as a grain with sorghum.

While potatoes grown in the southern portion of the Chesapeake Bay Watershed are harvested early enough that they may be double cropped with beans and wheat, they are not included as a crop that may be double cropped with anything other than vegetables (Ed Joiner, Nutrient Management Planner, VA). Vegetables are double cropped. This is handled by multiple plant and harvest dates within each crop type or the land use.

An additional step that is not yet implemented in Scenario Builder development is to verify that the timing of plant and harvest dates by growth region do not result in two crops growing at the same time. That is, if corn is planted in April and harvested in August, then soybeans can not be planted in July. In this case, apply the double cropping to a different available crop (among corn, sorghum, and sunflowers) where there is no overlap of crop plant and harvest time periods.

10.12 Legumes

The Agricultural Census categories that include legumes but are not exclusively legumes are not considered for legume fixation. We assume the area comprising legumes is insignificant.

Each year is considered independent of any other year. Therefore, nutrients can not "build up" in the soil in data produced by the Scenario Builder. It follows that N in the soil after one year may repress N fixation. This situation is not considered in the calculation of these data.

No N is fixed in the month of planting. We assume that the nodules take 2-4 weeks to establish. For subsequent months of growth, the total amount of NH_3 is parsed evenly. That means that the same amount of N is fixed in month 2 as in the final month before the plant is killed or dies. A perennial, like alfalfa, will fix the same amount every month between emergence (plant date for annuals) and first hard frost (harvest date for perennials).

We assume that fixation occurs on all leguminous plants. This assumes that legumes are inoculated or sufficient rhizobia are present. It also assumes that carbon is at optimum levels.

Nitrogen fixation amounts are not adjusted for temperature or rainfall in the Chesapeake Bay Program's Watershed Model. The exception is alfalfa. As of October 14, 2008, nitrogen fixation for alfalfa will likely be calculated by the Watershed Model so that rainfall and temperature data can parameterize fixation amounts.

The Chesapeake Bay Program's Watershed Model accounts for processes that occur after N fixation, such as where crops are killed and left on the soil or incorporated into the soil, thereby returning N to the soil.

Many researchers have indicated that fertilizer application in the form of NO_3 does not decrease N fixation by legumes (Johnson et al., 1975; Blumenthal et al., 1996). These data refute the dogma that NO_3 substitutes for fixed N where NO_3 is increased. Literature searches did not produce data that quantifies the reciprocally of the NO_3 sorption and N2 fixation. Without identifying values of N fixation and the interaction with NO_3 for each leguminous plant, we are unable to consider these data in our model.

References

Bourion, 2007; Xu-Ri and Prentice, 2008; Johnson et al., 1975; Blumenthal et.al., 1996.

10.13 Integrating Ag census with other data sources and scaling from County to Land-River Segmentation

Procedure 1: Creating ”CBP Ag LU by LRseg”

INPUTS

1. P5lc

Tabular summary of raster land cover acres with unique classes for undefined agriculture (AG), cropland (CROP), and pasture/hay (PH) by Lrseg

Note: this will be static for the calibration and most scenarios.

Nursery, row crops with and without manure are considered CROP. Hay with and without nutrients, alfalfa and pasture are considered PH.

2. Agricultural Land Uses by County

These data are in a source table derived from the Agricultural Census above. Where the steps below refer to a land use, perform the same procedure on all of the crops in that land use.

3. AG Land Cover Index = AG / (CROP + PH)

Distribute undefined agriculture land cover into cropland and pasturehay land cover classes at the LRseg scale.

1. For LRsegs with a non-zero Ag Land Cover Index that is also less than 1, inflate the PH and CROP acres by distributing the undefined agriculture (AG) class to PH and CROP based on the proportions of PH and CROP in each LRseg.

1a. Create a multiplier = (PH + CROP +AG)/(PH + CROP)

This must always be >= 1

1b. Multiply PH and CROP by this multiplier

2. For LRsegs with no undefined agriculture (AG) and for LRsegs where the Ag Land Cover Index >=1 (e.g., the amount of undefined agriculture equals or exceeds the combined amount of PH and CROP), distribute the undefined agriculture (AG) class to LRsegs based on the proportions of pasturehay land use (CountyPastureHay) and cropland land use (CountyCropland) to total amount of agricultural land uses reported in the 2002 County Agricultural Census:

2a. PH = PH + (AG * CountyPastureHay/TotalCountyAgriculture)

2a. CROP = CROP + (AG * CountyCropland/TotalCountyAgriculture)

3. You now have PH and CROP acres for all LRsegs and zero 'AG' acres for all LRsegs, The acres do not add up to the Ag census, however.

Distribute the ag land use classes based on the proportion of each ag land cover class within each LRseg

For all 'crop' classes:

Acres of crop land uses = acres of CROP in lrseg / acres of CROP in county

Do the same for PH

For a zero Ag Land Cover Index and crops available to go on that land, apply proportional to the lrseg acres / county acres.

AFOs are disaggregated to land river segments proportional to the area of all agricultural acres in each LRseg to the total agricultural acres in the county.

Procedure 2: Creating "CBP Land Use by LRseg"

INPUT

1. "CBP Ag LU by LRseg", from procedure 1

2. "CBP Urban LU by LRseg" – external table

3. Total Acres by LRseg – external table

4. water acres by LRseg – external table

5. extractive acres by LRseg – external table

The purpose of this procedure is to assemble the data set from different sources. Since these are based on different data sets, they do not add up to 100% of the area. Some guidelines have been developed in order of importance:

1. Total LRseg size and water must be preserved
2. Forest is found by subtraction

Procedure: follow for each Lrseg

Forest = total acres minus water, ext, urban, and ag.
If forest is non-negative STOP

Set AcresNeeded = -forest
Set forest to zero

Low intensity pervious urban = Low intensity pervious urban - AcresNeeded
If low intensity pervious urban is non-negative STOP

Set AcresNeeded = -(low Intensity pervious urban)
Set Low intensity pervious urban to zero

If ag > 0
    Set ag multiplier = 1 - (AcresNeeded)/(total ag) (multiplier < 1)
    Multiply all ag categories by the ag multiplier
    If ag multiplier is positive STOP

    Set AcresNeeded = - (total ag)
    Set all ag to zero
End if ag > 0

If total urban > 0
    Set urban multiplier = 1 - (AcresNeeded) / (total urban)
    Multiply all urban categories by the urban multiplier
    If urban multiplier is positive STOP

    Set AcresNeeded = - (total urban)
    Set all urban to zero

End If total urban > 0

Set ext = LRseg total minus water

If ext positive STOP

Set ext = 0

Set water = LRseg total

End Procedure

10.14 Detached Sediment (M. Hurd)

The purpose of the Detached Sediment logic is to determine the increase in the monthly amount of erodible sediment by Phase 5 land use (post-bmp) for a Land Segment in a given year. Key factors needed are the growing area, Crop Name, Crop Acreage, Planting & Harvesting dates, a reference table containing crop-specific rates of sedimentation (months after planting).

The amt. of erodible sediment must be determined for a crop. The erodible sediment rate is influenced by soil disturbance (determined from planting and harvest dates). Because more than one planting/harvest dates may be provided for a crop, the detached sediment calculations should incorporate all planting and harvesting dates; a second, third, or fourth planting would contribute to the amt. of erodible sediment.

For each combination of Crop and Till Class (Hi/Low) a monthly increase in the amount of erodible sediment will be calculated in tons/acre.

The rate of increase in the monthly amt. erod. sed. and the months relative to planting/harvesting will be stored in the database (by growing region, crop name, tillage type). Note that months may be zero or negative (negative indicating months prior to the plant/harvest date).

The months relative to planting/harvesting should be added/joined to the actual plant and harvest dates to determine which month the rate is associated with. (Join by growing region, crop name, tillage type.)

The rates should be summarized by cropname and month.

The erodible sediment for each crop should be weighted by the crop-specific acreage and summarized by Land Segment, P5 land use & month.

Each crop-specific monthly rate should be weighted by the crop acreage (multiply acreage and monthly rate).

The crop-specific acreage should be summarized by P5 land use categories.

The monthly, weighted rates for all crops should be summarized by the P5 land use (acreage total that has already accounted for doublecropping) and Land Segment and then divided by the total acreage.

The output format should be a comma delimited file with the following name: "dets_{descriptor}.csv" where {descriptor} is the name of the Scenario Builder scenario. Column headings are specified in the use case file.

10.15 Application rate calculation (Guido Yactayo and Jessica Rigelman, 2/19/2010)

Nutrient Best Potential Application Rate:

Using the agricultural census, the best potential yield for each state is calculated differently:

> *Delaware*: average of the highest four of seven yields from the agricultural census. If less than seven agricultural censuses are available, use as manure are available as long as there are greater than four.
>
> *Maryland*: average the highest 60% of the available agricultural censuses.
>
> *New York, Pennsylvania, District of Columbia, West Virginia, Tennessee, and North Carolina*: average the highest three of five yields from the agricultural censuses.

The nutrient application yield ratio is calculated using:

$$app\_yield\_ratio \equiv \frac{bestpotential\_yield}{yield\_upper\lim it}$$

The best potential yield cannot be greater than the upper limit (quantile p=0.95) and lower than the lower limit (quantile p=0.05). The average application yield ratio is 0.78 (Figure 5).

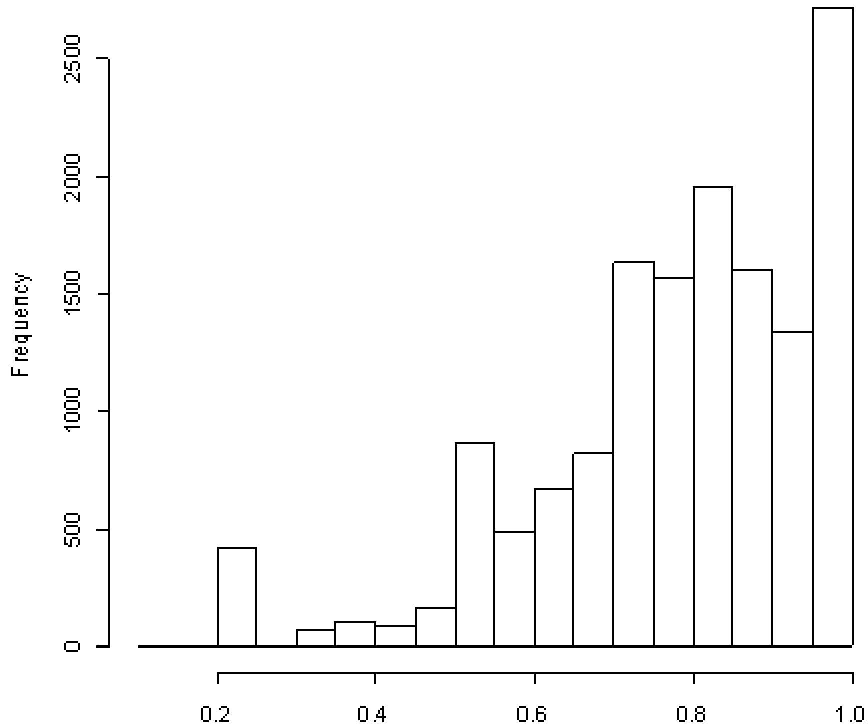

Figure 10-1. Application yield ratio distribution.

The Adjusted application rate is calculated using:

$$Adjusted\_app\_rate(lb/a) \equiv annual\_multiplier \times \max imum\_app\_rate$$

An annual factor was developed by R. Burgholzer using analysis of the fertilizer sales data from 1980 to 2002 (Table 10-2)

Table 10-2: Annual fertilizer application adjustment factor

Sample Year	Annual Nitrogen Multiplier	Annual Phosphorus Multiplier
1980	1.01	1.25
1982	1.1	1.37
1983	1.092	1.358
1984	1.084	1.346
1985	1.076	1.334
1986	1.068	1.322
1987	1.06	1.31
1988	1.05	1.298
1989	1.04	1.286
1990	1.03	1.274
1991	1.02	1.262
1992	1.01	1.25

1993	1.005	1.26
1994	1	1.27
1995	1	1.24
1996	1	1.21
1997	1	1.18
1998	1	1.14
1999	1	1.1
2000	1	1.07
2001	1	1.03
2002 +	1	1

The annual factor was set to one for all the years, which nullifies it. The annual factor is still in the system if it is needed in the future. The maximum application rate is the nutrient application recommended by the states. The nutrient best potential application rate is calculated using:

$$Bestpotential\_app\_rate(lb/a) \equiv app\_yield\_ratio \times adjusted\_app\_rate$$

To avoid under estimating the application rates, the application yield ratio cannot be under 0.7. If there is not censuses yield data, the average application ratio is used.

$$Bestpotential\_app\_rate(lb/a) \equiv 0.78 \times adjusted\_app\_rate$$

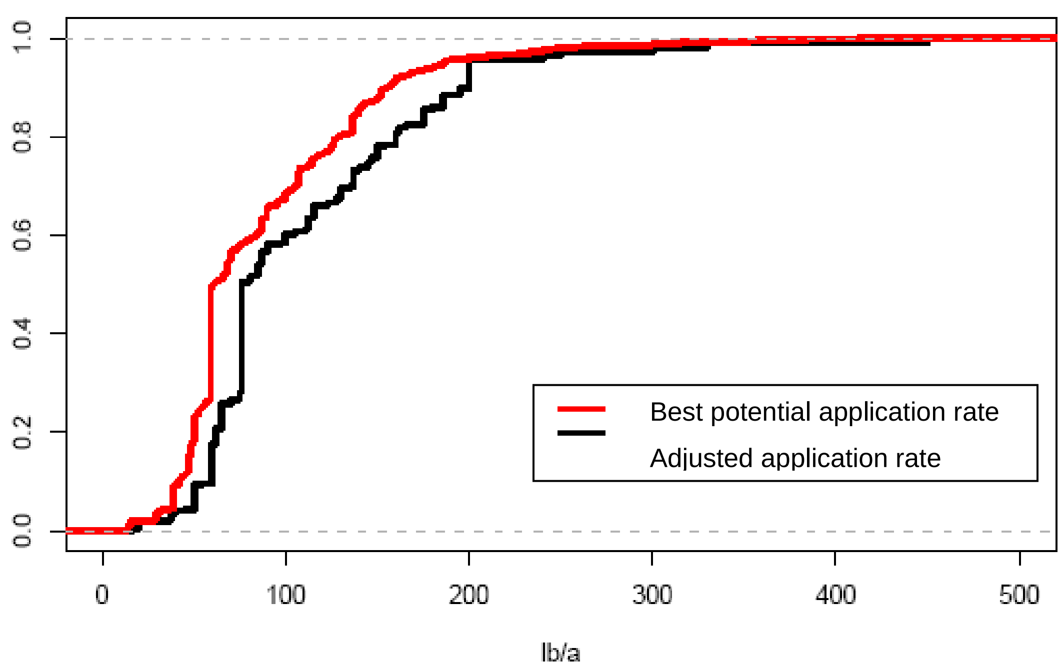

Figure 10-2. Nitrogen application rates cumulative probability.

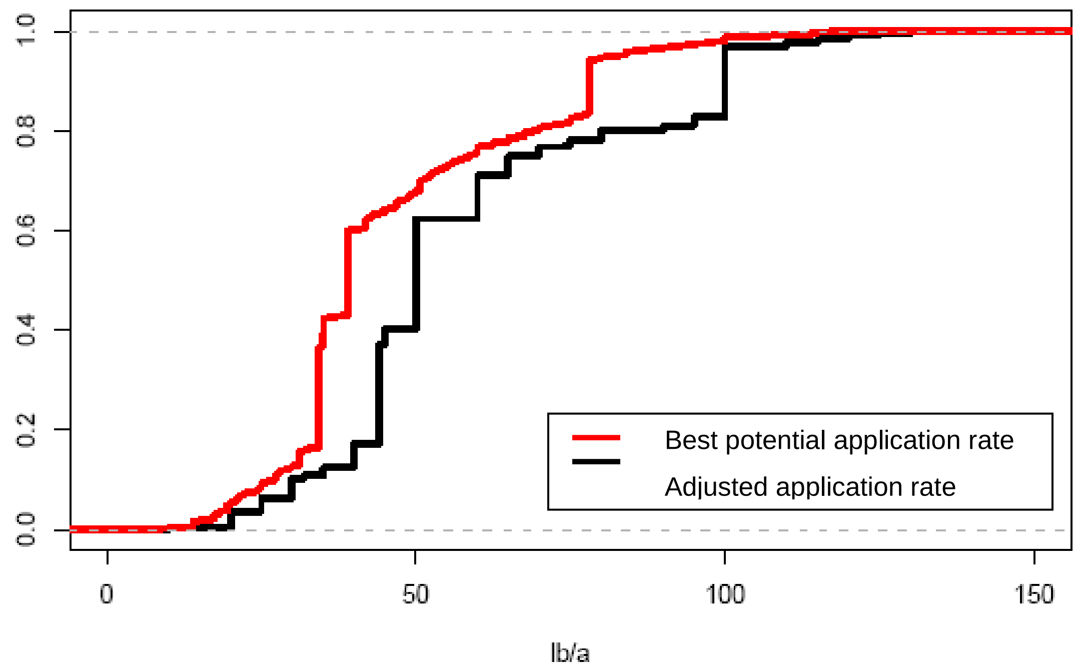

Figure 10-3. Phosphorus application rates cumulative probability.

Max Yield* = From TblCrop, data was researched and supplied by Guido Yactayo. Where Ag census supplied acres then Max yield = yield

Yield Upper and Lower Limits* = From TblCrop, data was researched and supplied by Guido.

*For many crops the max, upper limit, and lower limit yields are all the same.

Best Potential Yield = This is the one that calculated differently for each state - best 3 of of 5 for some states, 4 of 7 for another.

Rate Reduction = This is the SB input data if a state submits. It is basically a % reduction to the Max App Rate submitted by County and Crop. Usually used only for Turfgrass.

Starting Max App Rate = Max App Rate from TblCropMaxApplicationRate - literature, state input, Mark, Chris, Guido, Jeff, and Gary adjustments.

Max App Rate = Max App Rate * (1- Rate Reduction) e.g. 100 lbs/acres * (1 - 25% reduction/100) = 75 lbs/acres

Best Potential Nutrient App Rate =

WHEN BestPotYield = yieldupperlimit AND BestPotYield = yieldlowerlimit THEN MaxApplicationRate * (1-RateReduction) * .78
WHEN BestPotYield >= yieldupperlimit THEN MaxApplicationRate * (1-RateReduction) *.95
WHEN BestPotYield <= yieldlowerlimit AND (yieldlowerlimit / yieldupperlimit) > .7 THEN MaxApplicationRate * (1-RateReduction) * (yieldlowerlimit / yieldupperlimit)
WHEN BestPotYield <= yieldlowerlimit AND (yieldlowerlimit / yieldupperlimit) <= .7 THEN MaxApplicationRate * (1-RateReduction) * 0.7
WHEN BestPotYield > yieldlowerlimit AND BestPotYield < yieldupperlimit AND (BestPotYield / yieldupperlimit) <= .7 THEN MaxApplicationRate * (1-RateReduction) * 0.7
ELSE (MaxApplicationRate * (1-RateReduction) * (BestPotYield / yieldupperlimit)

ManureAvailableToCropNeedRatio = NutrientLbsStored / MaxNutrientAppMass

NutrientLbsStored = manure and biosolid nutrients that count to towards crop need that are stored

MaxNutrientAppMass = Max App Rate * acres

Crop Application Rates

- For NM landuses the App Rate = Best Potential Nutrient App Rate
- For Non NM landuses that do not receive manure the App Rate = MaxNutrientAppRate - (MaxNutrientAppRate - BestPotNutrientAppRate) * 0.95
- For Non NM landuses that receive manure the App Rate = MaxNutrientAppRate - ((1 - ManureAvailableToCropNeedRatio) * (MaxNutrientAppRate - BestPotNutrientAppRate) * 0.95)

The rates are turned into mass by multiplying by acres and the total mass is distributed to months on Plant Date (TblcropCounty) and Days After Planting (TblCropCountyNutrientApplicationFraction). Both of these tables are like the app rate source data. Tweaked by everyone and the states "approved" at the start of v24.

For landuses that don't receive manure, this need is met by fertilizer. For those that do receive manure the TblCropCountyNutrientApplicationFraction table has a column (confusingly) labeled Starter that dictates which application are met only with fertilizer. For example, in MD corn has about 75% of its N need allocated to fertilizer only so it is no wonder disposal load happens so much on the eastern shore. This was pointed out to MD before v24 calibration but they chose not to change.

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