CBP Watershed Model
STAC Panel on P simulation

Gary Shenk
2/6/2012
The Chesapeake Bay and Watershed

Legend
- Phase 5 Study Area
- State Boundary

Phase 5 Land Use
- Water
- Urban
- Extractive
- Bare
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Agriculture
- Grass

Forest: 64%
Agricultural: 24%
Urban: 8%
Other: 4%

Ratio of Areas
Watershed : Estuary ~ 15:1
Reduce Nutrient Pollution Loads

As we reduce loads...

...we increase achievement of water quality conditions.

Chesapeake 2000 Goal
Reduce Sediment Pollution Loads

As we reduce loads...

...we increase achievement of bay grass restoration goals.

![Sediment Load Graph](#)

**Sediment Load (million tons/yr)**

- **1985**
- **2000**
- **Chesapeake 2000 Goal**

![Bay Grasses Graph](#)

**Bay Grasses (x 1,000 acres)**

- **1985**
- **2000**
- **Chesapeake 2000 Goal**

Reduce Sediment Pollution Loads... As we reduce loads... we increase achievement of bay grass restoration goals.
Chesapeake Bay Partnership Models

INPUTS
- BMP Data
- LU Data
- Point Sources Data
- Septic Data
- U.S. Census Data
- Agricultural Census Data

MODEL-DERIVED
- Airshed Model
- Land Use Change Model
- Precipitation Data
- Meteorological Data
- Elevation Data
- Soil Data

SCENARIO BUILDER

WATERSHED MODEL

CHESAPEAKE BAY MODEL

MEET WQS?
- NO
- YES

ALLOCATION METHODOLOGY

Reduce/Readjust Loads to Meet Standards
Bay Airshed Model

Inputs: Hourly

- Meteorology from a Weather Model
- Emissions from the EPA National Inventory

Outputs: Hourly

Air Concentrations: $O_3$, $PM_{2.5}$

Air Quality Model: CMAQ

- Transport
- Transformation: Gas Chemistry
- Aqueous Chemistry
- Loss Processes

Wet and Dry Deposition

- $SO_2$ gas
- $SO_4$ aerosol
- $SO_4$ wet
- $Hg^0$
- RGM
- Hg(part.)
- Hg wet
- NO
- $NO_2$
- $N_2O_5$
- $HNO_3$ gas
- NO$_3$ aerosol
- Organic NO$_3$
- NO$_3$ wet
- PAN’s
- NH$_3$ gas
- NH$_4$ aerosol
- NH$_4$ wet

CMAQ: Community Multi-scale Air Quality Model
Forecasted Urban Growth (2000 to 2030)

Source: Chesapeake Bay Land Change Model Version 3
Forecasted Population Growth on Sewer vs. Septic (2000 to 2030)

Source: Chesapeake Bay Land Change Model Version 3
Farmland and Forest Land Loss (2000 to 2030)

Source: Chesapeake Bay Land Change Model Version 3
A Quarter Century of Watershed Model Development

Phase 1
- Completed in 1982
- 63 model segments
- 5 land uses
- 2 year calibration period (Mar.- Oct.)

Phase 4
- Completed in 1998
- 94 model segments
- 9 land uses
- 14 year calibration period (1984-97)

Phase 5
- Completed in 2009
- 1,000+ model segments
- 25 land uses using time-varying land use & BMPs
- 21 year calibration period (1985-2005)
Bay Water Quality Model

- 57,000 cells
- Predicts changes in water quality due to changes in nitrogen, phosphorus, and sediment loads
  - Dissolved Oxygen
  - Water clarity
  - Chlorophyll $a$
- Also simulates algae, underwater Bay grasses, bottom dwelling worms and clams, oysters, and menhaden

Developed by scientists at the US Army Corps of Engineers, University of Maryland, Virginia Institute of Marine Science, HydroQual, Versar, and Rutgers University
Use of modeling suite in the Chesapeake TMDL

Basin-wide load is 190 N and 12.7 P (MPY)
Nutrient Impacts on Bay WQ

Effectiveness

**Nitrogen**
- 0.000000 - 0.733585
- 0.733586 - 2.030888
- 2.030889 - 3.679623
- 3.679624 - 5.392417
- 5.392418 - 7.107263
- 7.107264 - 10.318716

**Phosphorous**
- 0.000000 - 1.207119
- 1.207120 - 2.366690
- 2.366691 - 3.400564
- 3.400565 - 5.503934
- 5.503935 - 6.929862
- 6.929863 - 12.613746
Major River Basin by Jurisdiction Relative Impact on Bay Water Quality
TN, p5.3, goal=190, WWTP = 4.5-8 mg/l, other: max=min+20%

Allocation Method Agreed to by Majority of Principals’ Staff Committee Members
Phosphorus -- phase 5.3 -- Goal=12.67 million lbs

Percent reduction from 2010 noBMPs to E3

All Other

WWTP
Chesapeake Bay Partnership Models

Reduce/Readjust Loads to Meet Standards

Inputs:
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Model-Derived:
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- Land Use Change Model
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Scenario Builder

Watershed Model

Chesapeake Bay Model

Meet WQS?
- No
- Yes

Allocation Methodology
Chesapeake Bay Watershed Model

• **Open model development process:**
  
  – Open participation in modeling workgroup, the water quality goal implementation team and its workgroups
  
  – Anyone can work with the CBPO to provide credible data or to get new restoration practices incorporated
  
  – Complete watershed model available for download

• **Peer Review Status:**
  
  – CBP STAC independent scientific peer reviews of Phase 5 model conducted in 2005 and 2008 (200th presentation)

• **More Information:**
  
  
  – [http://www.chesapeakebay.net/phase5.htm](http://www.chesapeakebay.net/phase5.htm)
Integrated model built by integrated community of decision makers and modelers

Chesapeake Bay Program

Developers
- EPA
- U of Maryland
- USGS
- NRCS
- Chesapeake Research Consortium
- Virginia Tech

Advisors and data suppliers
- State Governments of NY, PA, MD, DE, VA, WV, DC
- Scientific and Technical Advisory Committee

Maryland Department of the Environment
Virginia Department of Conservation and Recreation

Interstate Commission on the Potomac River Basin

USGS
How the Watershed Model Works

Calibration Mode

Hourly or daily values of Meteorological factors:
- Precipitation
- Temperature
- Evapotranspiration
- Wind
- Solar Radiation
- Dew point
- Cloud Cover

Annual, monthly, or daily values of anthropogenic factors:
- Land Use Acreage
- BMPs
- Fertilizer
- Manure
- Tillage
- Crop types
- Atmospheric deposition
- Waste water treatment
- Septic loads

Daily flow, nitrogen, phosphorus, and sediment compared to observations over 21 years
How the Watershed Model Works

Each segment consists of 30 separately-modeled land uses:

- Regulated Pervious Urban
- Regulated Impervious Urban
- Unregulated Pervious Urban
- Unregulated Impervious Urban
- Construction
- Extractive
- Combined Sewer System
- Wooded / Open
- Disturbed Forest

- Corn/Soy/Wheat rotation (high till)
- Corn/Soy/Wheat rotation (low till)
- Other Row Crops
- Alfalfa
- Nursery
- Pasture
- Degraded Riparian Pasture
- Afo / Cafo
- Fertilized Hay
- Unfertilized Hay
  - Nutrient management versions of the above

Each calibrated to nutrient and Sediment targets
How the Watershed Model Works

Precipitation

Fertilizer
Manure
Atmospheric deposition

Runoff

Management filter

River

Hydrology submodel

Sediment submodel

Phosphorus submodel

Nitrogen submodel

hourly
Each submodel has a complex hydrologic or nutrient cycling structure.
Max uptake specified as input, parsed into hourly max uptake by soil layer, controlled by nutrient and water availability.

Not Robust Simulation. Set as a ratio to Organic N.

Organic P

Solution PO4

Plant P

Freundlich Isotherm

Adsorbed PO4

Export – concentration on sediment

Application – input
Export - concentration in outflow

Export / Application
Interesting Point

• In late 90s, the WSM simulated phosphorus saturation and breakthrough on the Eastern Shore
• Nutrient Subcommittee did not think that that was an accurate simulation so it was removed by calibration
Organic Simulation

- Labile ORGN
- Labile ORGP
- Refract ORGN
- Refract ORGP

BOD
P:N = 0.1384

Algae
P:N = 0.1384

Refractory ORGN

Refractory ORGP

DIN
DIP

Benthic Algae
P:N = 0.1384

Median Observed ORGP:ORGP ratio is 0.056
P and N simulation in AGCHEM

- DIN
- OrgN
- Labile OrgN
- Labile OrgP
- OrgP
- DIP
- TN
- TP

Flow diagram:

- DIN → OrgN
- OrgN → Labile OrgN
- Labile OrgN → Labile OrgP
- Labile OrgP → OrgP
- OrgP → DIP
- TN
- TP

Numbers:

- 0.1384
- 0.01384
Phase 5 land segmentation is primarily county-based

- Some counties were divided to accommodate different rainfall patterns.

Reasons why counties are a practical choice for segmentation:
- Most counties are completely within a hydrogeomorphic region
- BMP and Crop data are not known on a finer scale in most cases
- Near the limit of computing capacity
Phase 5 river segmentation

• Consistent criteria over entire model domain
  – Greater than 100 cfs
  or
  – Has a flow gage

• Near the limit of meaningful data
With different and non-nesting land and river segmentation schemes, how do you run the model?

The river segment (shown in black outline) must take inputs from four different land segments (shown in red outline).

The intersection of land segment and river segment should have a particular land use acreage based on satellite imagery, not just proportional to the land segment as a whole.
Scale in Phase 5 - Sediment

Edge of Field
Expected loads from one acre

BMP Factor

Land Acre Factor

Delivery Factor

Edge of Stream
60-100 sq miles

Scour/Deposition

In Stream Concentrations
Scale in Phase 5 - Nutrients

Edge of Stream
Expected loads from one acre that reach 100 cfs stream or tidal waters

BMP Factor

Land Acre Factor

Regional Factor

Edge of Stream
60-100 sq miles

In Stream Concentrations

Gains/Losses
How do we calibrate?

Reasonable values of sediment, nitrogen, and phosphorus

Observations of flow, sediment, nitrogen, and phosphorus
Calibration Strategy

• Match observations in rivers
• Match properties and trends
  – Groundwater recession curve
  – Crop uptake
• Match literature and other models
  – Reasonable rates of nutrient export
  – USGS estimator and sparrow models
Nutrient EOF Targets

• Purpose: Develop targets that:
  – Appropriately order the influence of different land uses in the same area
  – Appropriately account for differences in loading between the same land uses in different areas.

• Regional differences due to physiographic effects are resolved through load balancing in the river calibration.
Sources of Data

• Literature Reviews
  – Beaulac & Reckhow (1982)
  – Sweeney (2001)
  – Lin (2004)
  – Primary Sources (about 30)

• Previous Modeling Studies
  – Phase 4.3
  – Sparrow
Targets

- Chose average export load based on literature
- Created method of differentiating between the same land use in different segments based on the balance of inputs and uptake
## Average Targets

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<th>Land Use</th>
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</table>
Differentiating between regions

• Forest – Assume constant loss efficiency
• Crop –
  – median balance = median export
  – Zero balance = ½ median export
• Urban – Assume constant concentration
• No method of differentiation for
  – Alfalfa, construction, extractive, harvested forest, hay without nutrients, nurseries
How do we calibrate?

Reasonable values of sediment, nitrogen, and phosphorus

Observations of flow, sediment, nitrogen, and phosphorus
Water Quality Calibration Stations

- Phosphorus
- Nitrogen and Phosphorus
- WSM Phase 5 River Segments
'Unbiased' USGS samples vs WSM Population TN p5.3

TN concentration (mg/l)

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<th>Sample Code</th>
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How the Watershed Model Works

Scenario Mode

Constant values of anthropogenic factors:
- Land Use Acreage
- BMPs
- Fertilizer
- Manure
- Tillage
- Crop types
- Atmospheric deposition
- Waste water treatment
- Septic loads

Hourly or daily values of Meteorological factors:
- Precipitation
- Temperature
- Evapotranspiration
- Wind
- Solar Radiation
- Dew point
- Cloud Cover

Run for 1984-2000
Average 1991-2000
For ‘flow-normalized average annual loads’
WSM Uses: Divide Load into contributing areas and sources

Land Use Source

Ultimate Source

- Agriculture - manure 19%
- Agriculture - chemical fertilizer 16%
- Agriculture - Atmospheric Deposition - livestock & fertilized soil emissions 6%
- Natural - lightning + forest soils 1%
- Urban & Suburban Runoff - chemical fertilizer 11%
- Atmospheric Deposition - mobile (on-road + non-road) + utilities + industries 21%
- Municipal & Industrial Wastewater 21%
- Septic 5%
- Agriculture 40%
- Forest 15%
- Urban & Suburban Runoff 18%
- Atmospheric Deposition to Non-Tidal Water 1%
- Municipal & Industrial Wastewater 21%
- Septic 5%
Nitrogen Loads Delivered to the Chesapeake Bay By Jurisdiction

Point source loads reflect measured discharges while nonpoint source loads are based on an average-hydrology year.

<table>
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<th>Year</th>
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million lbs./year

Strategy State Cap Goal

million lbs./year

NY PA DC MD WV VA DE
Nitrogen Loads by Source Sector and Scenario - Watershed Model Phase 5.3

- **1985**
  - Reserve: 161.8
  - Forest: 55.9
  - Septic: 8.2
  - WWTP: 21.0
  - Urban Runoff: 20.6
  - Agriculture: 111.1

- **2009**
  - Reserve: 190.9
  - Forest: 50.5
  - Septic: 11.0
  - WWTP: 53.3
  - Urban Runoff: 44.3
  - Agriculture: 70.8

- **Tributary Strategy**
  - Reserve: 185.9
  - Forest: 181.6
  - Septic: 11.0
  - WWTP: 50.9
  - Urban Runoff: 8.4
  - Agriculture: 68.8

Note: The data is presented in Million Pounds per Year.
Chesapeake Bay Partnership Models

INPUTS
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- Agricultural Census Data

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SCENARIO BUILDER

WATERSHED MODEL

CHESAPEAKE BAY MODEL

MEET WQS?
- NO
- YES

ALLOCATION METHODOLOGY

Redistribute/Readjust Loads to Meet Standards
Scenario Builder

- Input processor for the Watershed Model
- Generates past, present or future state of watershed conditions
- Specific WSM Inputs from Scenario Builder:
  - Management practices
  - Land use acres
  - Manure and chemical fertilizer application rates
  - Crop growth
  - Septic loads
Scenario Builder

Inputs
- BMP Type and location (NEIEN/State supplied)
- Land acres
- Remote Sensing, NASS Crop land Data layer
- Crop acres
- Yield
- Animal Numbers (Ag Census or state supplied)
- Land applied biosolids
- Septic system (#s)

Parameters
(Changeable by user)
- BMP types and efficiencies
- Land use change (BMPs, others)
- RUSLE2 Data: % Leaf area and residue cover
- Plant and Harvest dates
- Best potential yield
- Animal factors (weight, phytase feed, manure amount and composition)
- Crop application rates and timing
- Plant nutrient uptake
- Time in pasture
- Storage loss
- Volatilization
- Animal manure to crops
- N fixation
- Septic delivery factors

Outputs
- BMPs, # and location
- Land use
- % Bare soil, available to erode
- Nutrient uptake
- Manure and chemical fertilizer (lb/segment)
- N fixation (lb/segment)
- Septic loads
Scenario Builder Direction

- Water Quality Goal Implementation Team
  - Watershed Technical Workgroup
  - Agriculture Workgroup
  - Urban Stormwater Workgroup
  - Forestry Workgroup
  - Sediment Workgroup
- Modeling Workgroup
- Scientific and Technical Advisory Committee
- Principals’ Staff Committee (state secretary)
Agricultural Workgroup

- **Federal**
  - USDA, EPA

- **State**
  - Chesapeake Bay Commission, Delaware Department of Agriculture, Maryland Department of Agriculture, NY DEC, PA Department of Environmental Protection, Pennsylvania Department of Environmental Protection, Pennsylvania State Conservation Commission, VA DCR, VA DEQ, West Virginia Department of Agriculture, WV DEP

- **University**
  - Chesapeake Research Consortium, Cornell University, Penn State University, University of Delaware, University of Maryland, West Virginia University

- **Industry Groups**
  - Delaware Maryland Agribusiness Association, Delaware Pork Producers Association, Delmarva Poultry Industry, Inc., MD Farm Bureau, VA Farm Bureau, VA Grain Producers Producers Association, Virginia Agribusiness Council, Virginia Poultry Association, U.S. Poultry & Egg Association,

- **Local organizations**
  - Cortland County Soil and Water Conservation District, Lancaster County Conservation District, Madison Co. SWCD, Upper Susquehanna Coalition

- **NGOs**
  - American Farmland Trust, Environmental Defense Fund, Keith Campbell Foundation for the Environment, MidAtlantic Farm Credit, PA NoTill Alliance
The Collaborators are Many...

These are the federal, state, and regional agency, academic institution, non-governmental organization and agricultural industry contributors to just the two-year effort to evaluate and revised the best management practice efficiencies:

Agricultural Processes in Scenario Builder

Christopher F. Brosch
University of Maryland, College Park
Chesapeake Bay Program
Scenario Builder Ag Data Output

- BMPs
  - Acres
  - Pounds nitrogen, phosphorus and sediment reduced
- Manure application (nutrient species/month)
- Fertilizer application (month)
- Legumes (pounds ammonium)
- Crop uptake (monthly nutrients)
- Bare soil
- Detached Sediment
- Landuses
Crop and Plant Types

Most of those in the Agricultural Census are used

120 total

– 54 are fruits and vegetables
– 21 are greenhouse crops
Manure generation: calculated monthly

Produced on AFO/CAFO

Produced on Pasture
Manure produced in confinement

CAFO

ALL NH3 losses

Storage to be land applied

S & H Loss

Soil losses

export to streams
Animal Counts ➔ Animal Units (AUs)

- 1 Animal Unit = 1000 lbs avg. weight of animal
- Sources available in documentation

<table>
<thead>
<tr>
<th>Animal type</th>
<th>Live animal weight (lbs)</th>
<th>No. of animals per animal unit (animal unit=1000 lbs)</th>
<th>Manure (lbs) per day per animal unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>beef</td>
<td>877.19</td>
<td>1.14</td>
<td>58</td>
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<td>250</td>
<td>64</td>
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<td>374.53</td>
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<td>horses</td>
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<td>65.02</td>
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<tr>
<td>milk goats</td>
<td>65.02</td>
<td>15.38</td>
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<tr>
<td>sheep and lambs</td>
<td>100.00</td>
<td>10</td>
<td>40</td>
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## Manure Nutrient Concentration

<table>
<thead>
<tr>
<th>Source types</th>
<th>TN lb/lb manure</th>
<th>TP lb/lb manure</th>
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<tbody>
<tr>
<td>angora goats</td>
<td>0.011</td>
<td>0.0027</td>
</tr>
<tr>
<td>Beef</td>
<td>0.0059</td>
<td>0.0016</td>
</tr>
<tr>
<td>Biosolids</td>
<td>0.039</td>
<td>0.025</td>
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<tr>
<td>Broilers</td>
<td>0.0129</td>
<td>0.0035</td>
</tr>
<tr>
<td>Dairy</td>
<td>0.0052</td>
<td>0.0011</td>
</tr>
<tr>
<td>hogs and pigs for breeding</td>
<td>0.0066</td>
<td>0.0021</td>
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<tr>
<td>hogs for slaughter</td>
<td>0.0062</td>
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<td>Horses</td>
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<td>0.0014</td>
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<tr>
<td>Layers</td>
<td>0.0131</td>
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<tr>
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<td>0.011</td>
<td>0.0027</td>
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<td>0.0132</td>
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<table>
<thead>
<tr>
<th>Nutrient</th>
<th>N fertilizer</th>
<th>P Fertilizer</th>
<th>Broiler manure (lb-nutrient/lb-manure)</th>
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</thead>
<tbody>
<tr>
<td>Phosphate</td>
<td>0</td>
<td>1</td>
<td>0.001082</td>
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<tr>
<td>Min P</td>
<td>0</td>
<td>0</td>
<td>0.002447</td>
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<tr>
<td>NH₃</td>
<td>0.25</td>
<td>0</td>
<td>0.003235</td>
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<tr>
<td>NO₃</td>
<td>0.75</td>
<td>0</td>
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<tr>
<td>Min N</td>
<td>0</td>
<td>0</td>
<td>0.005824</td>
</tr>
<tr>
<td>Org N – not Plant Available</td>
<td>0</td>
<td>0</td>
<td>0.003882</td>
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</table>
## Mineralization by manure type

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<thead>
<tr>
<th>Manure type</th>
<th>Phosphorus Mineralization factor</th>
<th>Organic Nitrogen Mineralization factor</th>
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</thead>
<tbody>
<tr>
<td>All bovine</td>
<td>1</td>
<td>0.35</td>
</tr>
<tr>
<td>All swine</td>
<td>1</td>
<td>0.50</td>
</tr>
<tr>
<td>All poultry</td>
<td>1</td>
<td>0.60</td>
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<tr>
<td>horses</td>
<td>1</td>
<td>0.50</td>
</tr>
<tr>
<td>Biosolids</td>
<td>1</td>
<td>0.30</td>
</tr>
<tr>
<td>sheep, lambs, and goats</td>
<td>1</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Example: Broilers - 60% = MinN/(MinN+OrgN)
Animal Un-confinement

- Time spent on pasture is based on estimates from states
  - Is growth-region specific, Full version available in documentation
- Defines portion of manure produced in month to be direct deposited on pasture land

<table>
<thead>
<tr>
<th>Growing Area ID</th>
<th>Animal Type</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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<tbody>
<tr>
<td>PA_1</td>
<td>angora goats</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>1</td>
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<td>1</td>
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<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
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<td>0</td>
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<td>1</td>
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<tr>
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<td>0.9</td>
<td>0.9</td>
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<td>0.9</td>
<td>0.9</td>
<td>0.65</td>
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<tr>
<td>PA_1</td>
<td>hogs and pigs for breeding</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>PA_1</td>
<td>hogs for slaughter</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>PA_1</td>
<td>horses</td>
<td>0.6</td>
<td>0.6</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
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<td>0.9</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>PA_1</td>
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<td>0</td>
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<td>1</td>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
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<td>0.75</td>
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<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
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<td>0.9</td>
<td>0.9</td>
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<td>0.75</td>
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<td>pullets</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
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<tr>
<td>PA_1</td>
<td>sheep and lambs</td>
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<td>0</td>
<td>0</td>
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<td>1</td>
<td>1</td>
<td>1</td>
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<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>PA_1</td>
<td>turkeys</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Storage and Handling loss

• Assuming Pre-BMP condition:
  – All poultry and swine, 15% of manure is lost during storage.
  – Beef, dairy, sheep and lambs, goats, and horses, 20% is lost

• Amount lost is AFO or CFO load

• Amounts flagged as issue and scheduled for thorough review in Agriculture and Sediment Reduction Workgroup
Stored Manure Apportionment

• Manure stored from AFO/CAFO is retained until monthly crop need calls on nutrients to be supplied from manure

• Manure applied to crops is removed from the amount stored

• N:P Ratio of the original manure is preserved through process after volatilization
  – Generally results in over-application of P when applied for N
BMPs
CBP Agricultural BMPs

**Nutrient Management**
- Nutrient Management
- Precision Agriculture
- Enhanced Nutrient Management

**Conservation Tillage**
- Continuous No-Till
- Other Conservation Tillage

**Cover Crops**
- Cover Crops – Late Planting
- Cover Crops – Early Planting
- Small Grain Enhancement – Late Planting
- Small Grain Enhancement – Early Planting

**Pasture Grazing BMPs**
- Pasture Fencing
- Precision or Intensive Rotational Grazing
- Horse Pasture Management
- Water Control Structures

**Other Agricultural BMPS**
- Forest Buffers
- Wetland Restoration
- Land Retirement
- Grass Buffers
- Tree Planting
- Carbon Sequestration/Alternative Crops
- Conservation Plans/SCWQP
- Non-Urban Stream Restoration
- Manure transport
- Animal Waste Management Systems
- Mortality Composters
- Poultry Phytase
- Dairy Precision Feed and/or Forage Management
- Swine Phytase
- Ammonia Emissions Reductions
Feed Mgmt: Load Reduction BMP

- Dairy Precision Feeding: PA: 24% TN; 25% TP
- Phytase Default: Broilers 16%; Layers 21%; Pullets 21%; Turkeys 16%; Sows and hogs 0%

To AFO/CAFO

To Pasture
Loafing Lot Mgmt/Barnyard Runoff Control

- Efficiency reduction with nutrients being removed from system

| Effectiveness estimate: | TN: 20%, TP:20%, TSS:40% |
Manure BMP Processes

Generated Manure

Pasture: direct deposit

 Stored on AFO/CAFO

Volatilization

Land applied

Storage and Handling loss

Dairy Prec. Feeding; Phytase

Biofilters

Animal Waste Mgmt Sys; Mortality composting

Loafing Lot Mgmt; Barnyard Runoff Control
Land Application of Nutrients
Nutrients Applied To Land

• Calculated by
  – County
  – Year
  – Crops, post-BMP landuse changes

• Elements include
  – Manure
  – Fertilizer
  – Biosolids
  – Nitrogen Fixation (total fixed includes uptake)
  – Uptake (includes whole plant uptake, not just removal)
  – BMPs (reductions)
Rates and Timing

- Rates are important for applying the proper amount of nutrient
- Timing of nutrients is parsed out and fulfilled monthly – based on HSPF time step
- Starter fertilizer is applied based on state supplied data

<table>
<thead>
<tr>
<th>Growing area code</th>
<th>Crop id</th>
<th>Crop name</th>
<th>Major nutrient</th>
<th>Double crop (1=true)</th>
<th>Days after planting</th>
<th>Fraction applied</th>
<th>Starter fertilizer (1=true)</th>
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</thead>
<tbody>
<tr>
<td>PA_1</td>
<td>35</td>
<td>Corn for Grain</td>
<td>Nitrogen</td>
<td>0</td>
<td>-15</td>
<td>0.3</td>
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<td>Phosphorus</td>
<td>0</td>
<td>-15</td>
<td>1</td>
<td>0</td>
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<td>Nitrogen</td>
<td>0</td>
<td>45</td>
<td>0.7</td>
<td>1</td>
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</tbody>
</table>
Nutrient Application

• Nutrient Type
  – Biosolids
    • Treated same rules as manure for crop types and rates
    • applied according to plant-available N: 30% Organic N
  – Manure (applied according to plant-available N 35-65% Org N)
  – Fertilizer (inorganic; N assumed 100% Plant available)

• Order by Nutrient Source
  1. Starter fertilizer
  2. Direct Deposition
  3. Biosolids (to NM land first if available)
  4. CAFO Manure (to NM land first if available)
  5. AFO manure
  6. Fertilizer (to supplement remaining need)
  7. Disposal sequence
Very High P Applications on nutrient management land

• All Biosolid and CAFO manure goes to satisfy nitrogen need on nutrient management land first

• Crop need is satisfied in application by inorganic + mineralizable organic.

• ‘Unmineralizable’ N is still available for runoff

• Biosolids and manure have a high P:N ratio relative to crop need
Disposal Sequence

- Excess manure after all crop need is satisfied and manure transport has been credited is applied at disposal rate
• Estimates of County-Level Nitrogen and Phosphorus Data for Use in Modeling Pollutant Reduction

• Chesapeake Bay TMDL – Section 5. Chesapeake Bay Monitoring and Modeling Frameworks

• Chesapeake Community Modeling Program – Models & Data, HSPF Phase 5 (Chesapeake Bay Program), Chesapeake Bay Watershed Phase 5.3 Model
Some direction going forward

• The Golden Rule of Modeling
  – Always improve
  – Never Change

• The Absolute Axiom of Modeling
  – Include everything
  – Keep it simple

• Increase transparency - Stakeholders
• Use multiple models – Scientific Community
• Be done on time – CBP management
Watershed Model Results

• Calibration run – entire watershed and ESMD
  – Annual storage increase
  – Increasing export load trend
• Load change across 100 scenarios – ESMD counties
  – Export follows application
• Removing poultry manure creates significant load reduction on ESMD
• Load change across ‘progress’ scenarios ESMD
  – Base load increasing – controlled by BMPs
Frequency of Annual Phosphorus Storage Change

p532cal_062211, hwm, 1985-2005 - ESMD

Number of segments X years

Pounds of phosphorus change

-20 -10 0 10 20 30 40 50

incremental sorbed

incremental plant

-20 -10 0 10 20 30 40 50
Frequency of Annual Phosphate Load Change
p532cal_062211, hwm, 1985-2005

Average Load = 2.45 lbs/acre
Average Annual increase = 0.034 lbs/ac
or 1.4% per year increase
Frequency of Annual Phosphate Load Change
p532cal_062211, hwm, 1985-2005 - ESMD

Average Load = 3.76 lbs/acre
Average Annual increase = 0.4 lbs/ac
or 10% per year increase
Caroline County non-Nutrient Management Corn, Soy, Wheat P application, uptake, and direct HSPF export across scenarios
Caroline County Nutrient Management Corn, Soy, Wheat P application, uptake, and direct HSPF export across scenarios

HSPF export before regional factor or BMP factors

Pounds P per Acre per Year

- PO4 manure
- Org P manure
- PO4 Fertilizer
- Total App
- Uptake
Dorchester County non-Nutrient Management Corn, Soy, Wheat
P application, uptake, and direct HSPF export across scenarios
Dorchester County Nutrient Management Corn, Soy, Wheat
P application, uptake, and direct HSPF export across scenarios

Pounds P per Acre per Year

HSPF export before regional factor or BMP factors

- PO4 manure
- Org P manure
- PO4 Fertilizer
- Total App
- Uptake
Kent County non-Nutrient Management Corn, Soy, Wheat P application, uptake, and direct HSPF export across scenarios
Kent County Nutrient Management Corn, Soy, Wheat
P application, uptake, and direct HSPF export across scenarios
QA County non-Nutrient Management Corn, Soy, Wheat
P application, uptake, and direct HSPF export across scenarios

HSPF export before regional factor or BMP factors
QA County Nutrient Management Corn, Soy, Wheat
P application, uptake, and direct HSPF export across scenarios

- PO4 manure
- Org P manure
- PO4 Fertilizer
- Total App
- Uptake

Pounds P per Acre per Year

HSPF export before regional factor or BMP factors
Talbot County non-Nutrient Management Corn, Soy, Wheat P application, uptake, and direct HSPF export across scenarios

- PO4 manure
- Org P manure
- PO4 Fertilizer
- Total App
- Uptake
Talbot County Nutrient Management Corn, Soy, Wheat
P application, uptake, and direct HSPF export across scenarios
Wicomico County non-Nutrient Management Corn, Soy, Wheat P application, uptake, and direct HSPF export across scenarios
Wicomico County Nutrient Management Corn, Soy, Wheat
P application, uptake, and direct HSPF export across scenarios
Worchester County non-Nutrient Management Corn, Soy, Wheat P application, uptake, and direct HSPF export across scenarios

Pounds P per Acre per Year

HSPF export before regional factor or BMP factors

PO4 manure
Org P manure
PO4 Fertilizer
Total App
Uptake
Worchester County Nutrient Management Corn, Soy, Wheat
P application, uptake, and direct HSPF export across scenarios

HSPF export before regional factor or BMP factors

Pounds P per Acre per Year

PO4 manure
Org P manure
PO4 Fertilizer
Total App
Uptake
Modeled N Reduction in Load from removal of Poultry Manure

[Graph showing the percent reduction in load for different counties (Caroline, Dorchester, Kent, Queen Annes, Talbot, Wicomico, Worcester) as a function of the percent removal of poultry manure. The graph includes a line for the total reduction.]
Modeled N Reduction in Load from removal of Poultry Manure

Percent Reduction in Load

Percent Removal of Poultry Manure

- Caroline
- Kent
- Queen Annes
- Talbot
- Wicomico
- Worcester
- Total
Modeled P Reduction in Load from removal of Poultry Manure
Big part of the drop 1985-2002 is due to better animal waste storage.
ADDITIONAL SB MATERIAL
Landuse and Crops

• Vegetable and fruit row crops (54 crops) map to high till without manure (hom & nho)
  – Not eligible for manure
  – Not eligible for conservation till (yet)
• Alfalfa (alf & nal) landuse includes 3 crops
  – Alfalfa Hay
  – Alfalfa Seed
  – Haylage or greenchop from alfalfa or alfalfa mixture
• Pasture land (pas & npa)
  – 2 crops: pasture and rangeland, pasture for grazing
Landuse and Crops

• Hay crops that are designated as harvested by Ag census (hyw, nhy)
  – i.e. fescue, orchard grass, red clover, etc.
  – Includes category “failed crops”

• Hay without nutrients (hyo)
  – Receives no nutrients except atmo. dep.
  – Maps to a few unharvested ag census “crops” & harvested wild hay

• Nursery (urs) covers 21 high input crops
  – grown under glass or
  – in-ground nursery stock

• Row crops with manure covering grain and silage crops (hwm, nhi)
  – Eligible for conservation tillage (lwm, nlo) and manure application
  – ~40 crops
Degraded Riparian Pasture (TRP)

- Acreage taken from pasture to simulate higher loading portion of pasture adjacent to streams
- Acreage based on state data from trib strategies
- Direct deposition rate 9 times regular pasture
- Receives no other nutrients

<table>
<thead>
<tr>
<th>Geographic unit</th>
<th>Unit</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>NY_Chemung River</td>
<td>acres</td>
<td>4106.61</td>
</tr>
<tr>
<td>NY_North Sus</td>
<td>acres</td>
<td>8517.597</td>
</tr>
<tr>
<td>PA_Potomac River Basin</td>
<td>acres</td>
<td>1591.11536</td>
</tr>
<tr>
<td>PA_Sus River Basin</td>
<td>acres</td>
<td>15025.4766</td>
</tr>
<tr>
<td>MD_Choptank River</td>
<td>acres</td>
<td>14.7937641</td>
</tr>
<tr>
<td>MD_Lower Eastern Shore</td>
<td>acres</td>
<td>7.21745348</td>
</tr>
<tr>
<td>MD_Lower Potomac</td>
<td>acres</td>
<td>20.8967</td>
</tr>
<tr>
<td>MD_Lower Western Shore</td>
<td>acres</td>
<td>2.40716815</td>
</tr>
<tr>
<td>MD_Middle Potomac</td>
<td>acres</td>
<td>20.6656055</td>
</tr>
<tr>
<td>MD_Patapsco/Back</td>
<td>acres</td>
<td>54.63695</td>
</tr>
<tr>
<td>MD_Patuxent River</td>
<td>acres</td>
<td>40.6168861</td>
</tr>
<tr>
<td>MD_Upper Eastern Shore</td>
<td>acres</td>
<td>146.719666</td>
</tr>
<tr>
<td>MD_Upper Potomac</td>
<td>acres</td>
<td>405.9285</td>
</tr>
<tr>
<td>MD_Upper Western Shore</td>
<td>acres</td>
<td>91.59927</td>
</tr>
<tr>
<td>VA</td>
<td>fraction</td>
<td>0.05</td>
</tr>
<tr>
<td>WV_Eastern Panhandle Conservation District</td>
<td>acres</td>
<td>3425.6543</td>
</tr>
<tr>
<td>WV_Potomac Valley Conservation District</td>
<td>acres</td>
<td>20697.9336</td>
</tr>
</tbody>
</table>
Double Cropping

- Double cropping added to account for summed crop acres exceeding Ag census acres of crop land.
- Dates of doubled crops were adjusted to provide sequential coverage of crops.
  - Most common sequence for crops chosen:
    - Corn, soybeans and sunflowers planted before oats, rye or wheat in a calendar year.
  - Universal dates for each crop chosen by AgWG to avoid >100% leaf cover, not specific to region like other crops.
Covered Soil % (1 – Bare Soil %)

- Output to P5.3.2 WSM for leaf and residue coverage by month
- Crop specific from nearly 100 crop types in RUSLE runs
- TRP = pasture*0.88
- Upper limit set to 95%
Sample of cover fractions from PA

<table>
<thead>
<tr>
<th>month</th>
<th>HiTill Corn grain Cover</th>
<th>LoTill Corn grain Cover</th>
<th>HiTill Corn Silage Cover</th>
<th>LoTill Corn Silage Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.78</td>
<td>0.85</td>
<td>0.19</td>
<td>0.23</td>
</tr>
<tr>
<td>2</td>
<td>0.78</td>
<td>0.85</td>
<td>0.19</td>
<td>0.23</td>
</tr>
<tr>
<td>3</td>
<td>0.7767742</td>
<td>0.8487097</td>
<td>0.19</td>
<td>0.23</td>
</tr>
<tr>
<td>4</td>
<td>0.6168666</td>
<td>0.8326667</td>
<td>0.1529667</td>
<td>0.2296667</td>
</tr>
<tr>
<td>5</td>
<td>0.03341936</td>
<td>0.7990323</td>
<td>0.01052258</td>
<td>0.216129</td>
</tr>
<tr>
<td>6</td>
<td>0.1396667</td>
<td>0.7363333</td>
<td>0.1396667</td>
<td>0.1876667</td>
</tr>
<tr>
<td>7</td>
<td>0.6896774</td>
<td>0.6777419</td>
<td>0.6896774</td>
<td>0.5041935</td>
</tr>
<tr>
<td>8</td>
<td>0.9487097</td>
<td>0.9164516</td>
<td>0.9487097</td>
<td>0.9164516</td>
</tr>
<tr>
<td>9</td>
<td>0.95</td>
<td>0.95</td>
<td>0.5416667</td>
<td>0.578</td>
</tr>
<tr>
<td>10</td>
<td>0.857742</td>
<td>0.9170968</td>
<td>0.18</td>
<td>0.2406452</td>
</tr>
<tr>
<td>11</td>
<td>0.7936667</td>
<td>0.8646666</td>
<td>0.1886667</td>
<td>0.24</td>
</tr>
<tr>
<td>12</td>
<td>0.7822581</td>
<td>0.8596774</td>
<td>0.19</td>
<td>0.2319355</td>
</tr>
</tbody>
</table>
Detached Sediment

• Estimates sediment loss from soil disturbance (i.e. plowing)
• Quantifies load from planting date in T/ac
• Supplies difference between high and low till landuses
Legumes: N Fixation

- Available for source data to be county specific, most are only state specific
- PA lbs NH3/Ac/yr:

<table>
<thead>
<tr>
<th>Product</th>
<th>NH3/Ac/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa Hay</td>
<td>240</td>
</tr>
<tr>
<td>Alfalfa seed</td>
<td>240</td>
</tr>
<tr>
<td>Birdsfoot trefoil seed</td>
<td>180</td>
</tr>
<tr>
<td>Dry edible beans, excluding limas</td>
<td>300</td>
</tr>
<tr>
<td>Green Lima Beans</td>
<td>300</td>
</tr>
<tr>
<td>Peanuts for nuts</td>
<td>90</td>
</tr>
<tr>
<td>Peas, Chinese (sugar and Snow)</td>
<td>300</td>
</tr>
<tr>
<td>Peas, Green (excluding southern)</td>
<td>300</td>
</tr>
<tr>
<td>Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc.</td>
<td>300</td>
</tr>
<tr>
<td>Red clover seed</td>
<td>360</td>
</tr>
<tr>
<td>Snap Beans</td>
<td>300</td>
</tr>
<tr>
<td>Soybeans for beans</td>
<td>130</td>
</tr>
<tr>
<td>Vetch seed</td>
<td>300</td>
</tr>
</tbody>
</table>
Fixed N

• Only produced between plant and harvest dates
• Not produced in month of planting
• Divided out equally by month
• Crops summed into landuses
• Reduced if manure applied for disposal

=fix-(disposal*0.2021)
<table>
<thead>
<tr>
<th>Crop</th>
<th>hom</th>
<th>hwm</th>
<th>lwm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley for grain Harvested Area</td>
<td>1.7</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Broccoli Harvested Area</td>
<td>8.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buckwheat Harvested Area</td>
<td>3.2</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>Canola Harvested Area</td>
<td>1.8</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>Cantaloupe Harvested Area</td>
<td>12.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn for Grain Harvested Area</td>
<td>7.34</td>
<td>1.39</td>
<td></td>
</tr>
<tr>
<td>Corn for silage or greenchop Harvested Area</td>
<td>12.4</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>Cotton Harvested Area</td>
<td>8.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cucumbers and Pickles Harvested Area</td>
<td>12.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cut Christmas Trees Production Area</td>
<td>8.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emmer and spelt Harvested Area</td>
<td>8.6</td>
<td>1.8</td>
<td>0.69</td>
</tr>
<tr>
<td>Escarole and Endive Harvested Area</td>
<td>12.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garlic Harvested Area</td>
<td>12.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Lima Beans Harvested Area</td>
<td>6.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Onions Harvested Area</td>
<td>12.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head Cabbage Harvested Area</td>
<td>8.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Herbs, Fresh Cut Harvested Area</td>
<td>8.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honeydew Melons Harvested Area</td>
<td>12.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kale Harvested Area</td>
<td>12.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land in Orchards Area</td>
<td>8.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lettuce, All Harvested Area</td>
<td>12.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mushrooms Area</td>
<td>12.6</td>
<td>0.9</td>
<td></td>
</tr>
</tbody>
</table>

NM versions of the landuses will have same data.
AFO/CAFO acreage

- USDA Ag Census farm counts per animal type are multiplied by these fractions to produce an acreage to support BMP implementation that is tracked by systems.

<table>
<thead>
<tr>
<th>Farm’s Animal Type</th>
<th>Acreage/farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>All bovine categories</td>
<td>0.5</td>
</tr>
<tr>
<td>Both hog and pig categories</td>
<td>0.2</td>
</tr>
<tr>
<td>All poultry categories</td>
<td>0.25</td>
</tr>
<tr>
<td>Sheep and Lambs</td>
<td>0.1</td>
</tr>
<tr>
<td>Both goat categories</td>
<td>0.05</td>
</tr>
</tbody>
</table>
# Ammonia Volatilization

<table>
<thead>
<tr>
<th>Source</th>
<th>Fraction not volatilized</th>
</tr>
</thead>
<tbody>
<tr>
<td>pullets</td>
<td>0.43</td>
</tr>
<tr>
<td>turkeys</td>
<td>0.43</td>
</tr>
<tr>
<td>hogs and pigs for breeding</td>
<td>0.19</td>
</tr>
<tr>
<td>beef</td>
<td>0.35</td>
</tr>
<tr>
<td>broilers</td>
<td>0.43</td>
</tr>
<tr>
<td>Heifers (cows and heifers that have calved)</td>
<td>0.35</td>
</tr>
<tr>
<td>hogs for slaughter</td>
<td>0.5</td>
</tr>
<tr>
<td>horses</td>
<td>0.68</td>
</tr>
<tr>
<td>layers</td>
<td>0.43</td>
</tr>
<tr>
<td>other cattle</td>
<td>0.35</td>
</tr>
<tr>
<td>sheep and lambs</td>
<td>0.35</td>
</tr>
<tr>
<td>angora goats</td>
<td>0.35</td>
</tr>
<tr>
<td>milk goats</td>
<td>0.35</td>
</tr>
<tr>
<td>biosolids</td>
<td>0.4875</td>
</tr>
</tbody>
</table>
## Volatilization effect on N Concentration

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>N fertilizer</th>
<th>P Fertilizer</th>
<th>Broiler manure (lb-nutrient/lb-manure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate</td>
<td>0</td>
<td>1</td>
<td>0.001082</td>
</tr>
<tr>
<td>Min P</td>
<td>0</td>
<td>0</td>
<td>0.002447</td>
</tr>
<tr>
<td>NH3</td>
<td>0.25</td>
<td>0</td>
<td>0.003235*0.43=0.001391</td>
</tr>
<tr>
<td>NO3</td>
<td>0.75</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Min N</td>
<td>0</td>
<td>0</td>
<td>0.005824</td>
</tr>
<tr>
<td>Org N – not Plant Available</td>
<td>0</td>
<td>0</td>
<td>0.003882</td>
</tr>
</tbody>
</table>
### Nutrient Application Rates

- **Max rate - Theoretical Rate**
  - max yield from any Ag census * max uptake from literature values for all crops

<table>
<thead>
<tr>
<th>Crop Name</th>
<th>Nitrogen pounds per yield unit</th>
<th>Phosphorus pounds per yield unit</th>
<th>Yield unit</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa Hay Harvested Area</td>
<td>59.516</td>
<td>8.927</td>
<td>dry tons</td>
<td>Meisinger, 1991</td>
</tr>
<tr>
<td>Alfalfa seed Harvested Area</td>
<td>0.511</td>
<td>0.058</td>
<td>pounds</td>
<td>NRCS</td>
</tr>
<tr>
<td>Asparagus Harvested Area</td>
<td>11.647</td>
<td>1.747</td>
<td>tons</td>
<td>Meisinger, 1991</td>
</tr>
<tr>
<td>Barley for grain Harvested Area</td>
<td>1.059</td>
<td>0.212</td>
<td>bushels</td>
<td>NRCS</td>
</tr>
<tr>
<td>Beets Harvested Area</td>
<td>7.059</td>
<td>1.059</td>
<td>tons</td>
<td>Meisinger, 1991</td>
</tr>
<tr>
<td>Birdsfoot trefoil seed Harvested Area</td>
<td>0.251</td>
<td>0.038</td>
<td>pounds</td>
<td>Meisinger, 1991</td>
</tr>
<tr>
<td>Broccoli Harvested Area</td>
<td>16.471</td>
<td>2.471</td>
<td>tons</td>
<td>Meisinger, 1991</td>
</tr>
<tr>
<td>Bromegrass seed Harvested Area</td>
<td>0.387</td>
<td>0.066</td>
<td>pounds</td>
<td>NRCS</td>
</tr>
<tr>
<td>Buckwheat Harvested Area</td>
<td>1.012</td>
<td>0.188</td>
<td>bushels</td>
<td>NRCS</td>
</tr>
<tr>
<td>Canola Harvested Area</td>
<td>0.041</td>
<td>0.007</td>
<td>pounds</td>
<td>NRCS</td>
</tr>
<tr>
<td>Cantaloupe Harvested Area</td>
<td>4.000</td>
<td>0.600</td>
<td>tons</td>
<td>Meisinger, 1991</td>
</tr>
<tr>
<td>Corn for Grain Harvested Area</td>
<td>0.976</td>
<td>0.146</td>
<td>bushels</td>
<td>Meisinger, 1991</td>
</tr>
</tbody>
</table>
Nutrient Application Rates

• Nutrient Management
  – Max rate discounted for yield history
    • Average yield history is substituted for Max yield based on state specific NM guide.
      – 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.
    • Calculated for each crop by county
Nutrient Application Rates, cont.

• Non-Nutrient Management
  – Calculated as incremental increase from NM rate
    • NM rate + [(max rate * max yield) – (NM rate)] * % contribution to limiting nutrient of Manure
    • Counties or crops receiving no manure contribution are given a lower limit of 5%
    • Calculated for each crop by county

• NM and Non-NM rates act as “Crop need,” so the rate of the limiting nutrient must be satisfied and the secondary nutrient will be met or exceeded
Watershed Model Ag Data Sources

Livestock Production and Manure:


– Federal and State Equine Survey Data: (USDA-NASS, Delaware, Maryland, New York, Pennsylvania, Virginia)

– USDA and State Nutrient Management Standards and Handbooks (USDA-NRCS, Maryland, Virginia)

– University Extension Agronomy Handbooks and Fact Sheets (Delaware, Maryland, New York, Pennsylvania, Virginia)

– Mid-Atlantic Nutrient Management Handbook: USDA-NIFA Mid-Atlantic Water Program (MAWP)

– Nutrient Budgets for the Mid-Atlantic States: USDA-NIFA Mid-Atlantic Water Program (MAWP)

– Professional Agronomy, Engineering, Environmental and Soil Science Peer-Reviewed Journal Articles and Publications

– Chesapeake Bay Program’s Agricultural Nutrient and Sediment Reduction Workgroup (AgNSRWG)
Watershed Model Ag Data Sources

Cropland Production and Nutrient Management:


- Revised Universal Soil Loss Equation (RUSLE2): USDA Natural Resource Conservation Service (NRCS)

- USDA and State Nutrient Management Standards (USDA-NRCS, Maryland, Virginia)

- University Extension Agronomy Handbooks and Fact Sheets (Delaware, Maryland, New York, Pennsylvania, Virginia)

- Mid-Atlantic Nutrient Management Handbook: USDA-NIFA Mid-Atlantic Water Program (MAWP)

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- Chesapeake Bay Program’s Agricultural Nutrient and Sediment Reduction Workgroup (AgNSRWG)
Watershed Model Ag Data Sources

Implementation of Best Management Practices (BMPs):

– Agricultural implementation data is provided to the Chesapeake Bay Program through the following representative state agencies or organizations:

  • Delaware: Department of Natural Resources and Environmental Control (DNREC)
  • Maryland: Department of the Environment (MDE)
  • New York: Upper Susquehanna Coalition (USC)
  • Pennsylvania: Department of Environmental Protection (PADEP)
  • Virginia: Department of Conservation and Recreation (VADCR)
  • West Virginia: Department of Environmental Protection (WVDEP)

– Implementation data is provided to the representative state agency or organization by a diverse partnership of federal, state and county agencies and Non-Governmental Organizations.

– Chesapeake Bay Program’s Agricultural Nutrient and Sediment Reduction Workgroup (AgNSRWG)
• Estimates of County-Level Nitrogen and Phosphorus Data for Use in Modeling Pollutant Reduction

• Chesapeake Bay TMDL – Section 5. Chesapeake Bay Monitoring and Modeling Frameworks
  o http://www.epa.gov/reg3wapd/pdf/pdf_chesbay/FinalBayTMDL/CBayFinalTMDLTMDLSection5_final.pdf

• Chesapeake Community Modeling Program – Models & Data, HSPF Phase 5 (Chesapeake Bay Program), Chesapeake Bay Watershed Phase 5.3 Model
  o http://ches.communitymodeling.org/models/CBPhase5/documentation.php#scenario