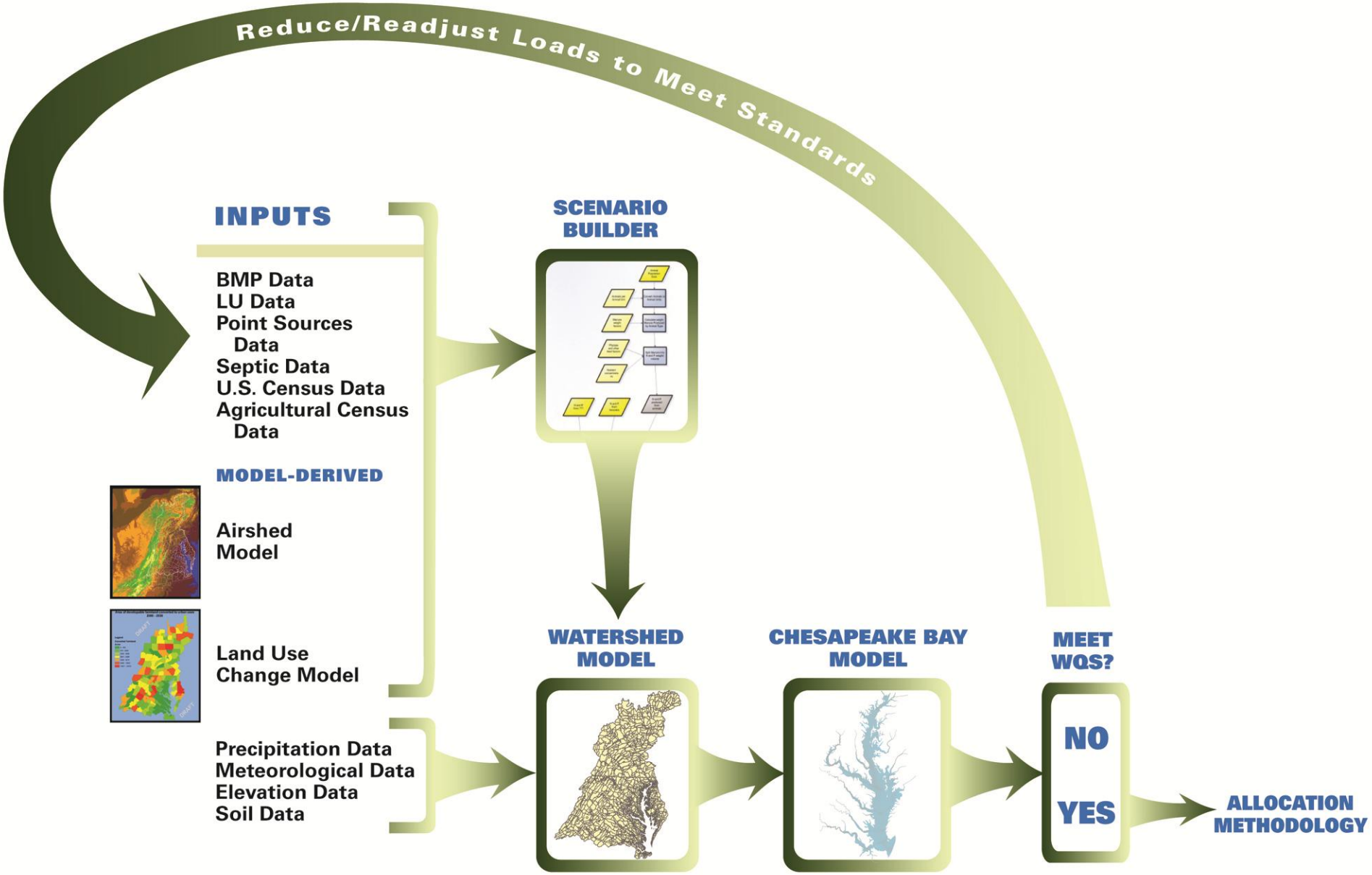
The Chesapeake Bay Program's Decision Support Tools and Research Opportunities

Gary Shenk

5/2/2013

Chesapeake Bay Partnership Models



CBP Modeling Tools

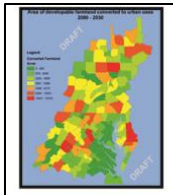
Interaction Tools

NEIEN
Environmental Information eXchange Network

CAST

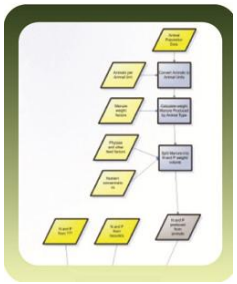
ChesapeakeStat
BayTAS
Chesapeake Bay TMDL Tracking and Accounting System

Decision Models/ Databases


Land Use Change Model

CMAQ
NOAA
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SCENARIO BUILDER

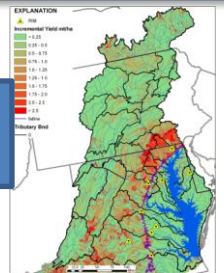


WATERSHED MODEL

Bay WQSTM

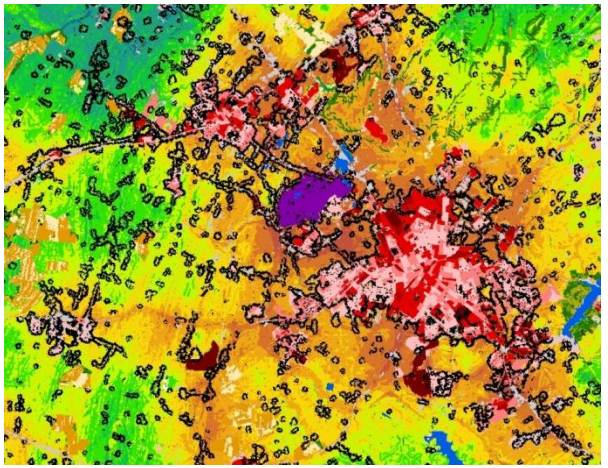
Related Tools

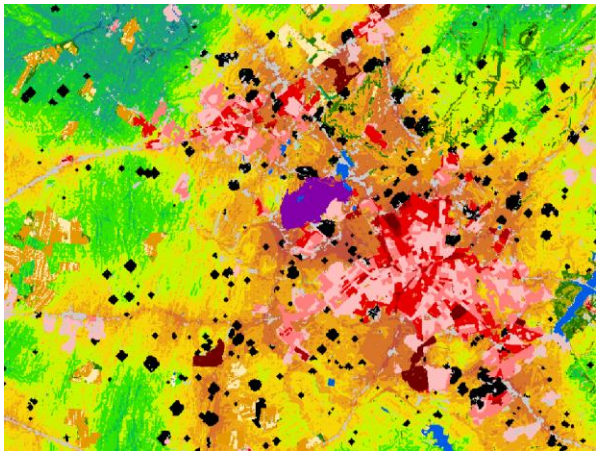
sparrow



Land Change Modeling at the CBP

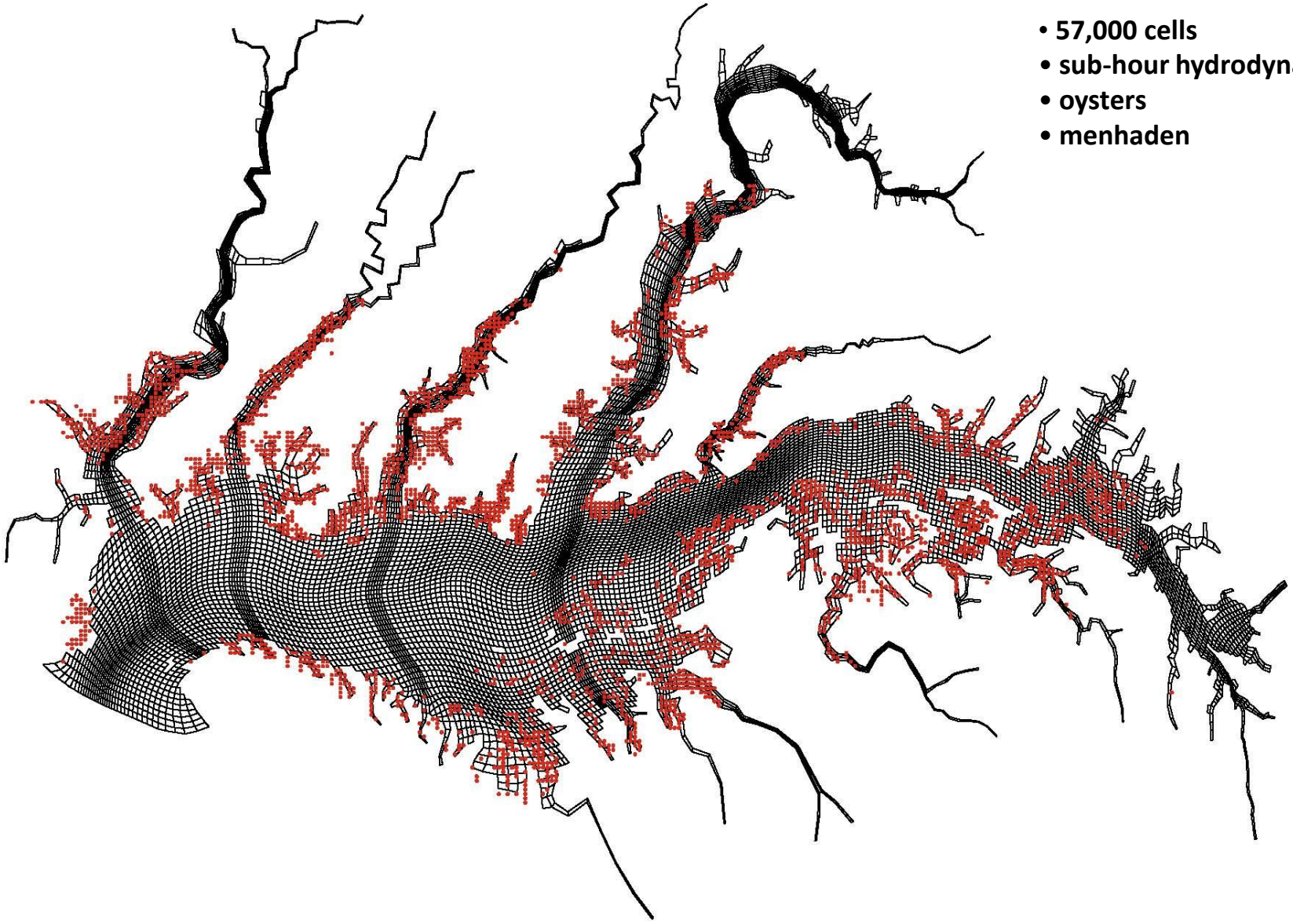
- 1980s – 1990s – simple empirical relationships
- CBLCM
  - v1 – Sleuth
  - V2 –empirical relationships
  - V3 – Patch-based growth
    - Existing Lu/Lc
    - Topographic/Geologic data
    - Population Projections





Probability surface

Estuarine Model



- 57,000 cells
- sub-hour hydrodynamics
- oysters
- menhaden

- 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 biolsolids
- Septic system (#s)

Inputs

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

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

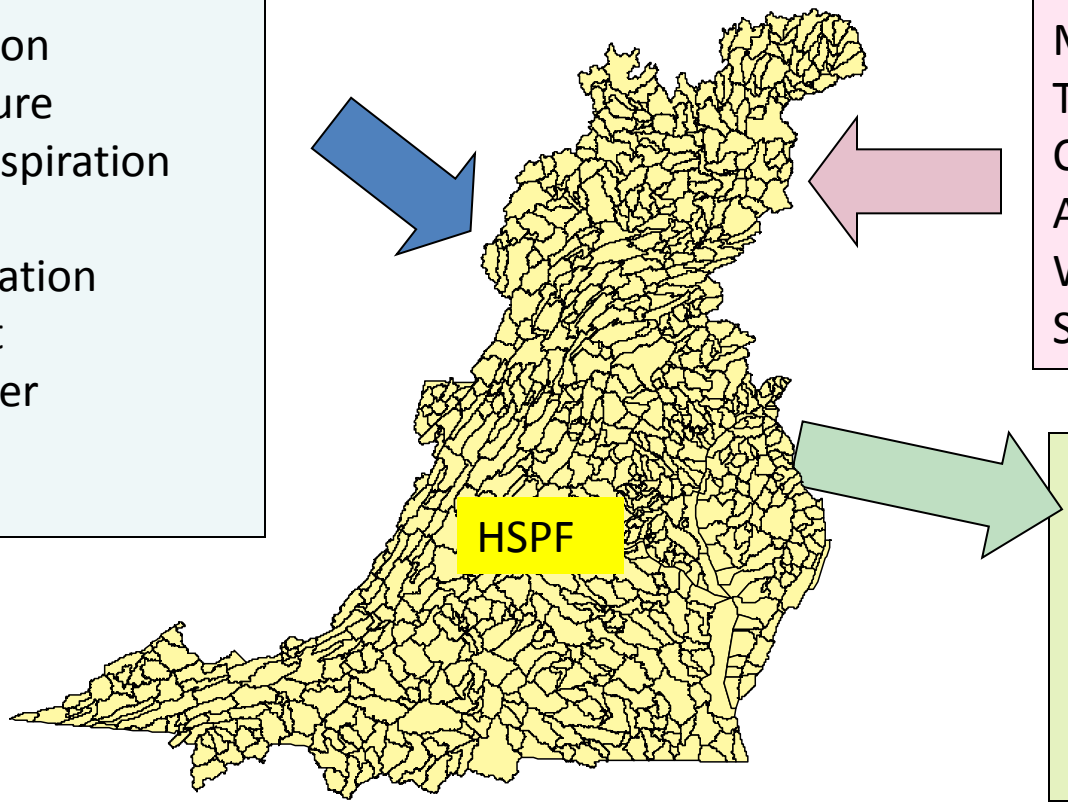
Outputs

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:

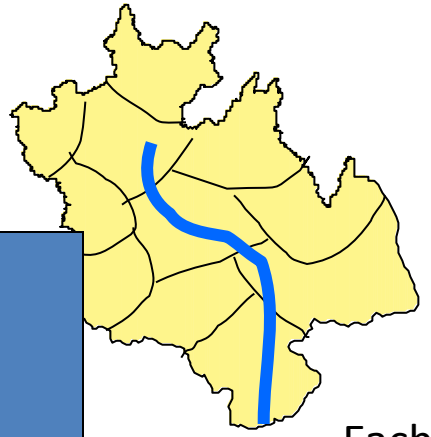
Land Use Acreage
BMPs
Fertilizer
Manure
Tillage
Crop types
Atmospheric deposition
Waste water treatment
Septic loads

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

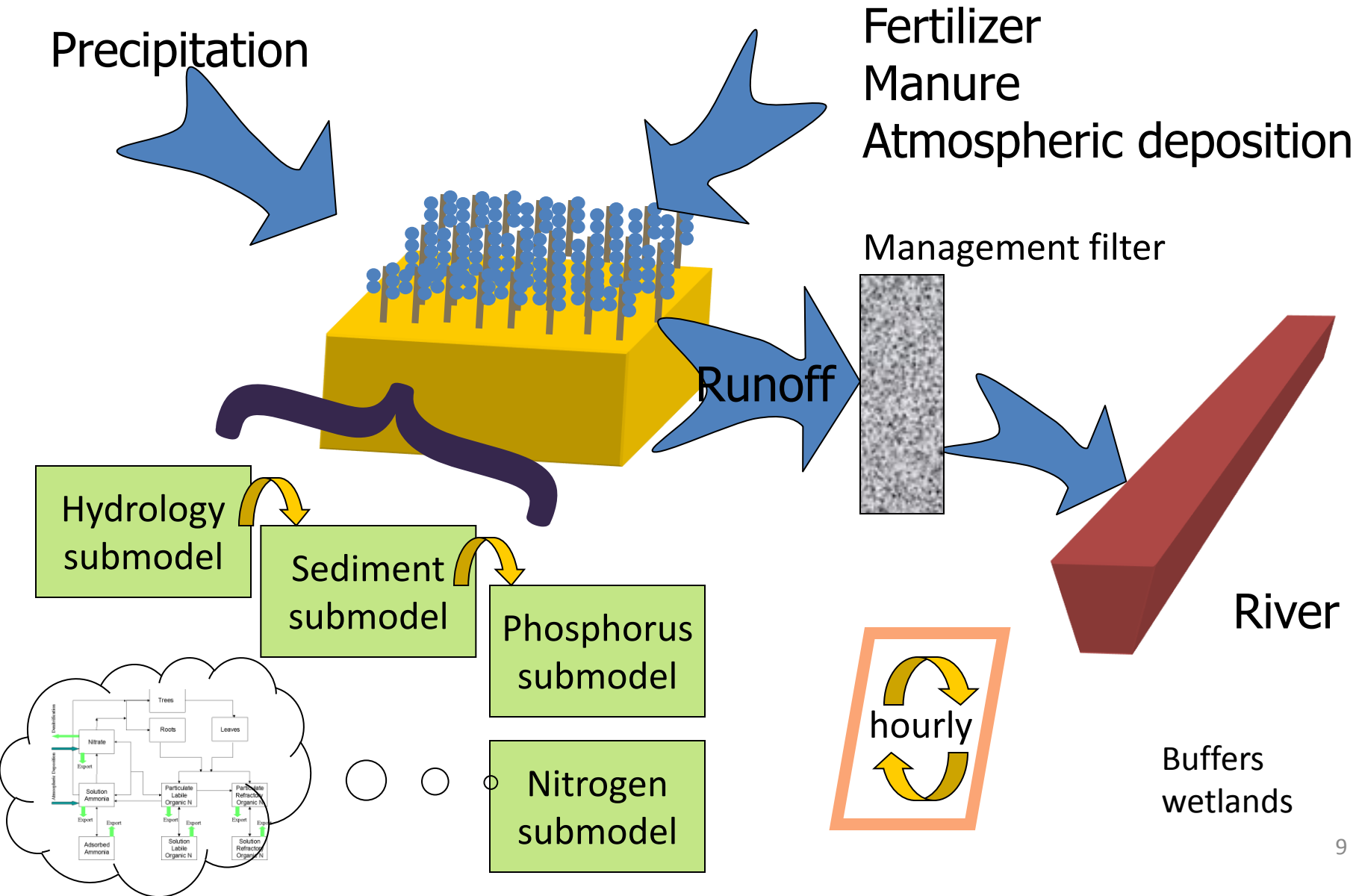


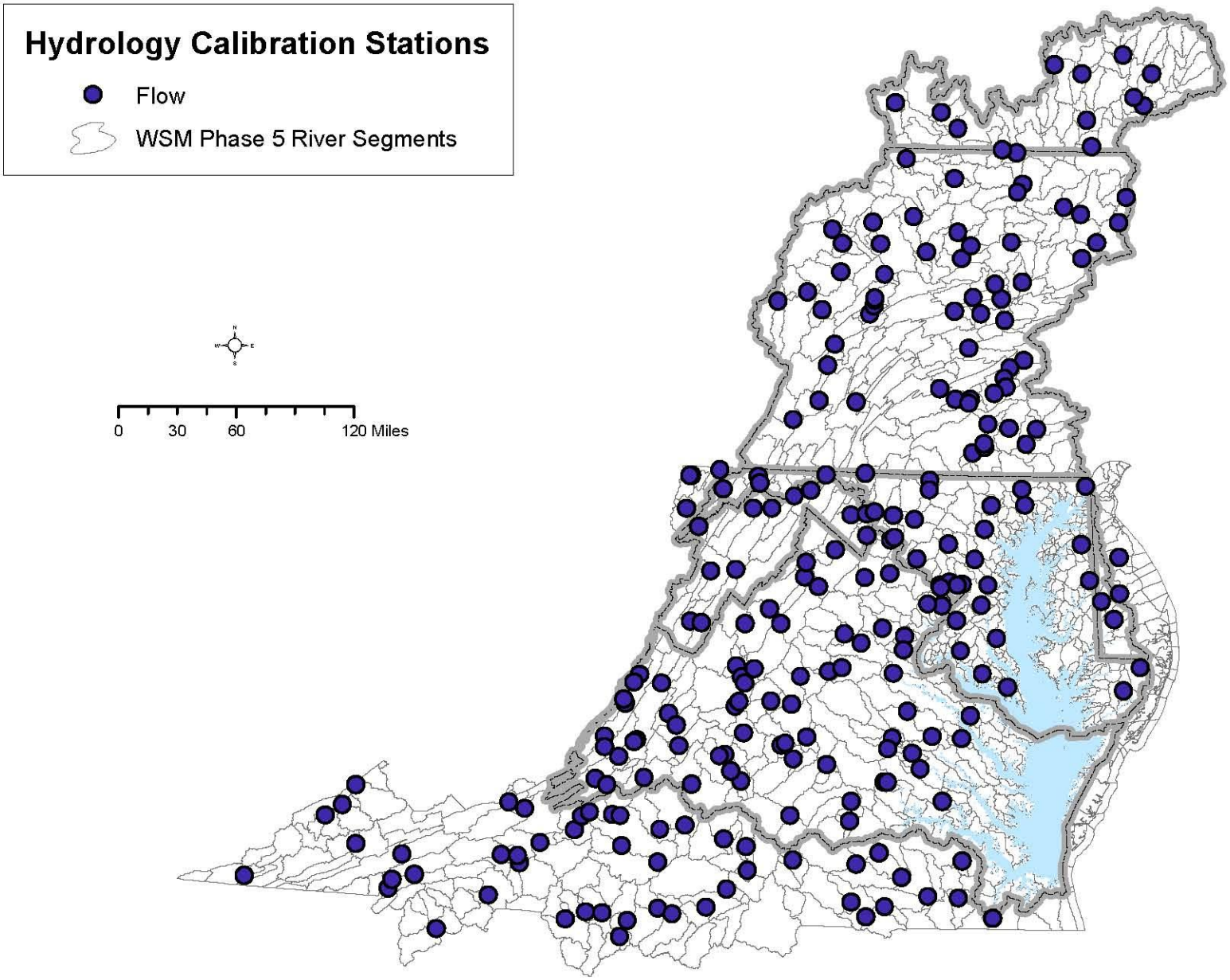
Plus: Point Source and Septic Loads, and Atmospheric Deposition Loads

- 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

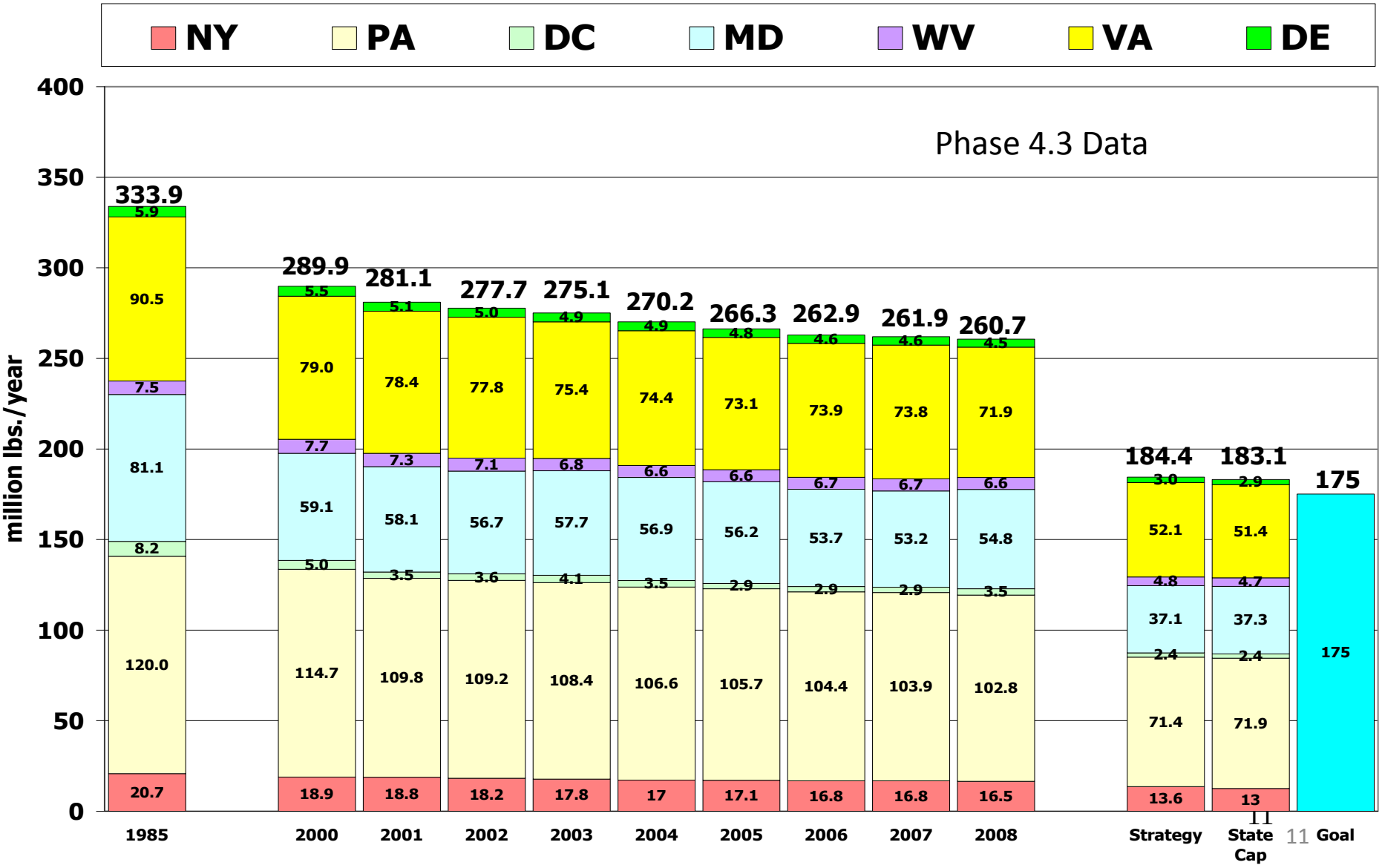
How the Watershed Model Works



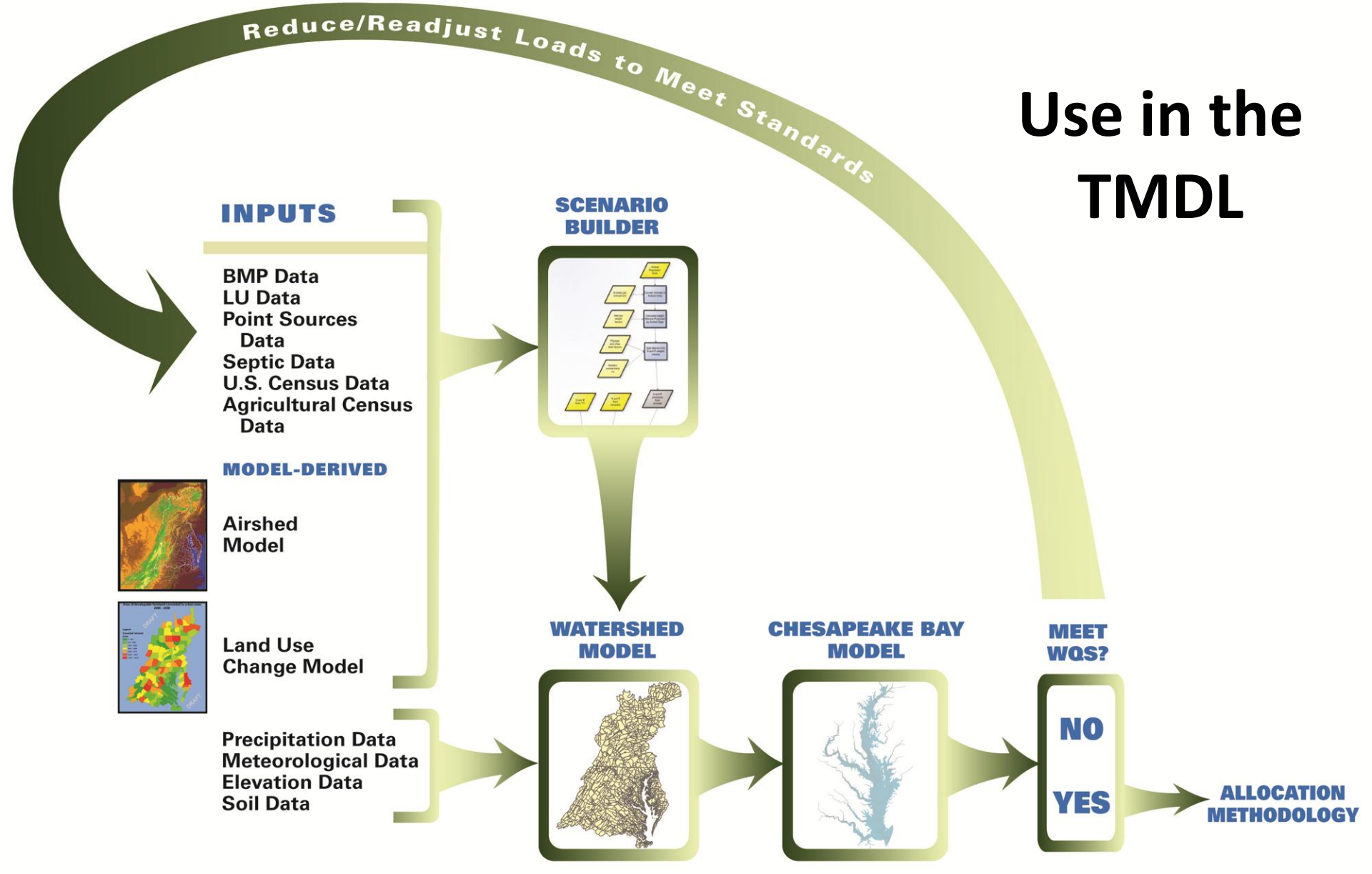

Hydrology Calibration Stations
Flow
WSM Phase 5 River Segments
0
30
60
120 Miles

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

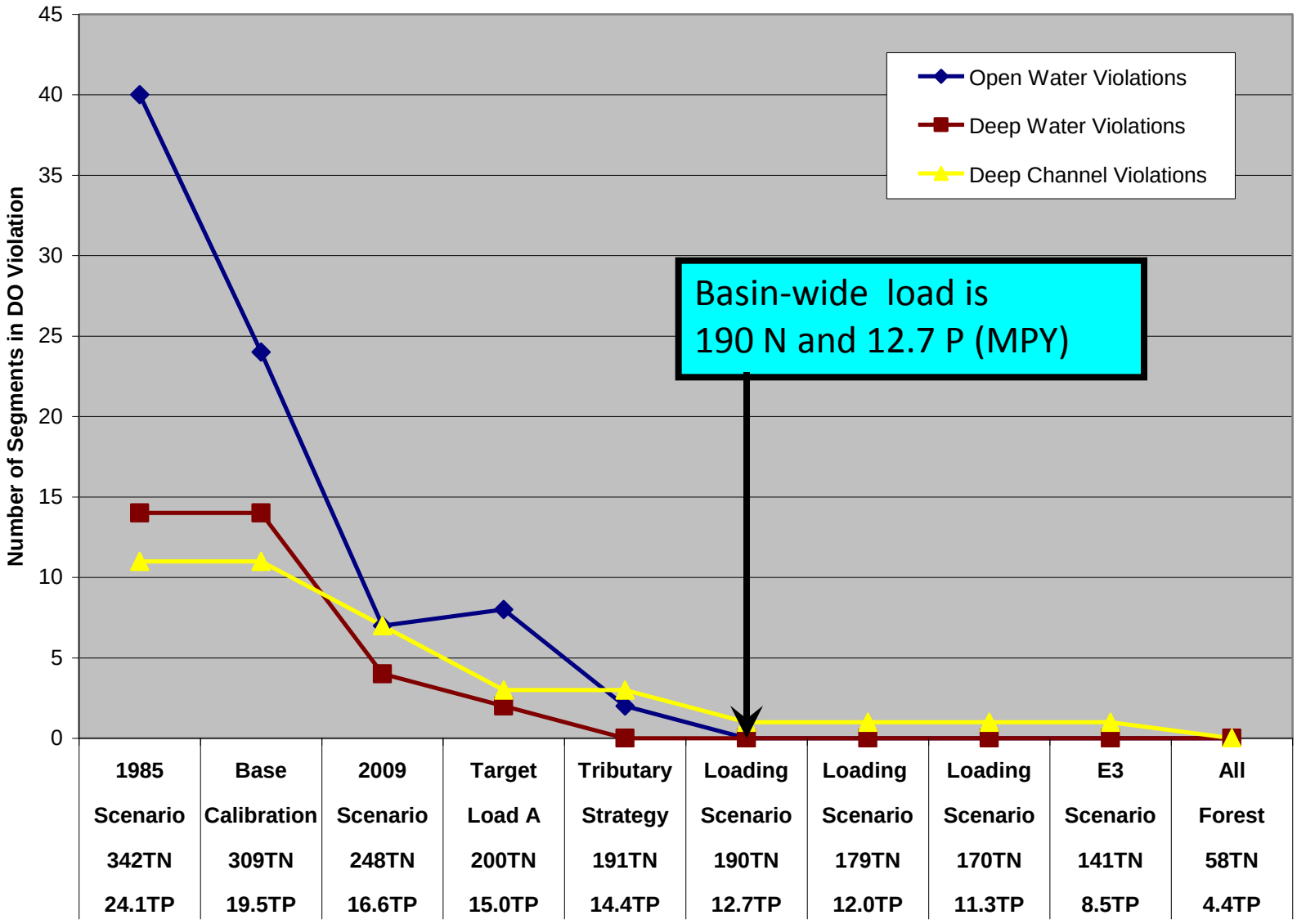


Chesapeake Bay Partnership Models

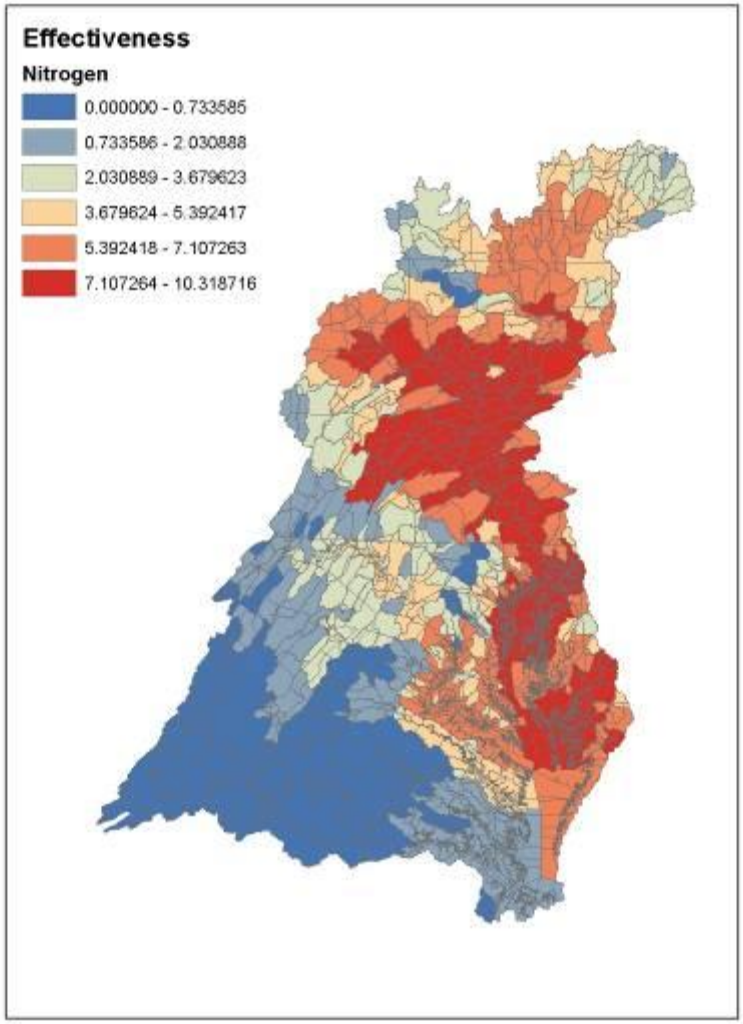


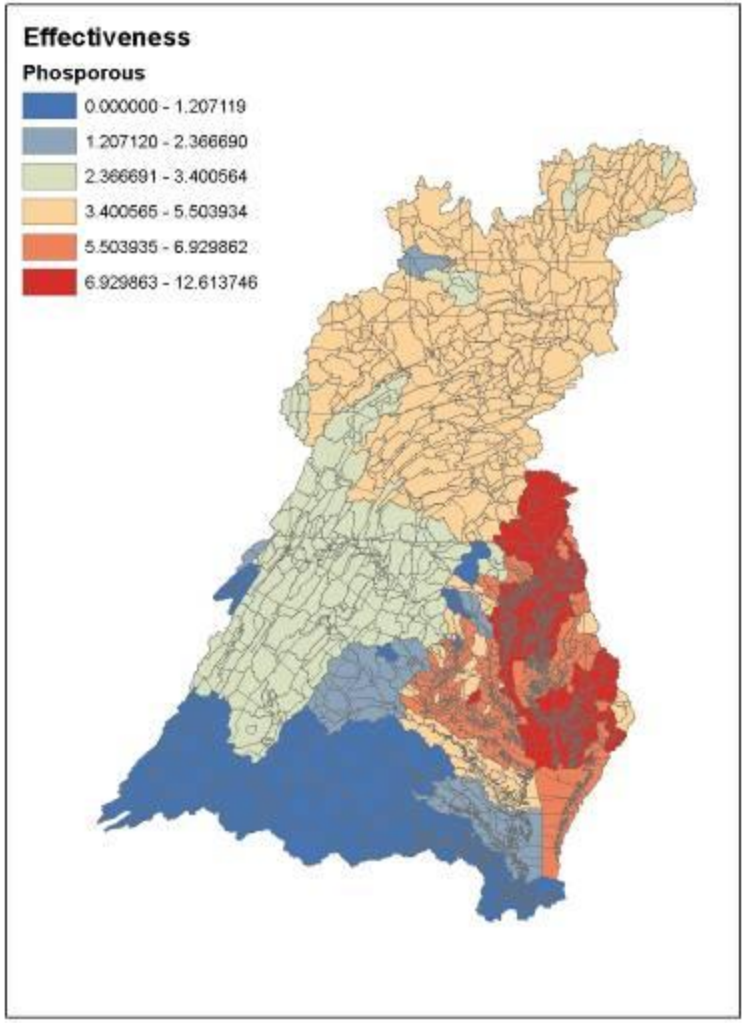
Use in the TMDL

Use of modeling suite in the Chesapeake TMDL

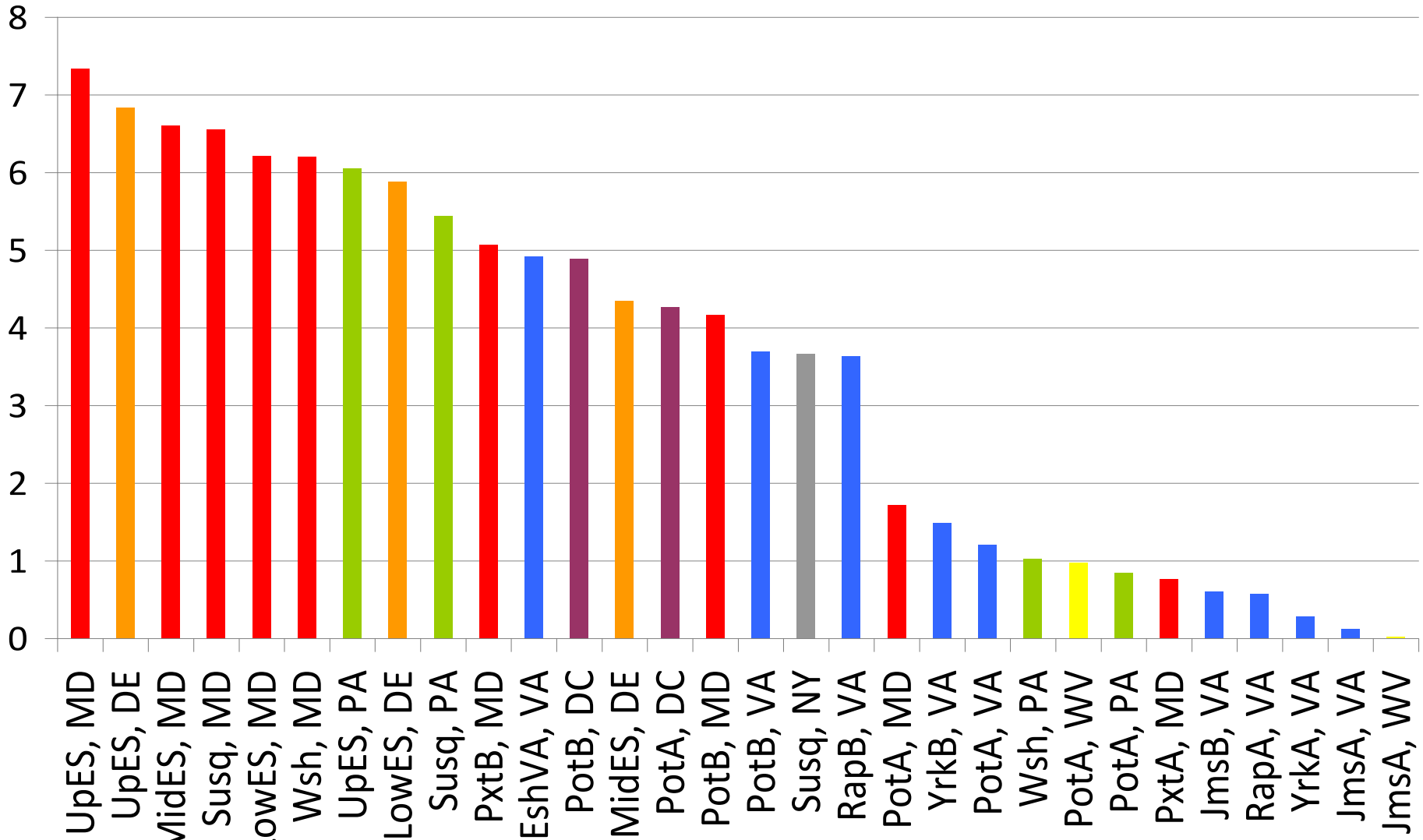


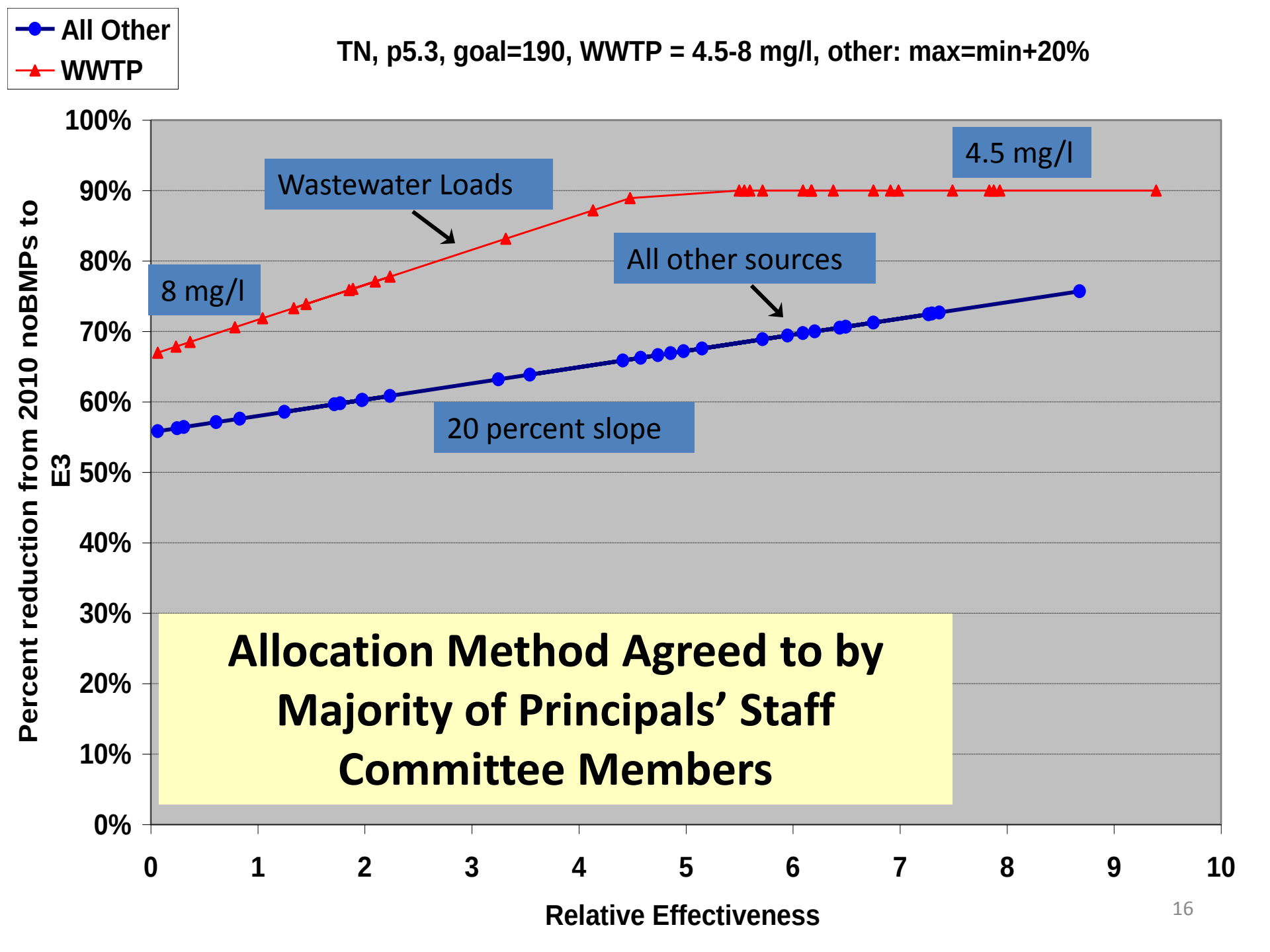
Nutrient Impacts on Bay WQ

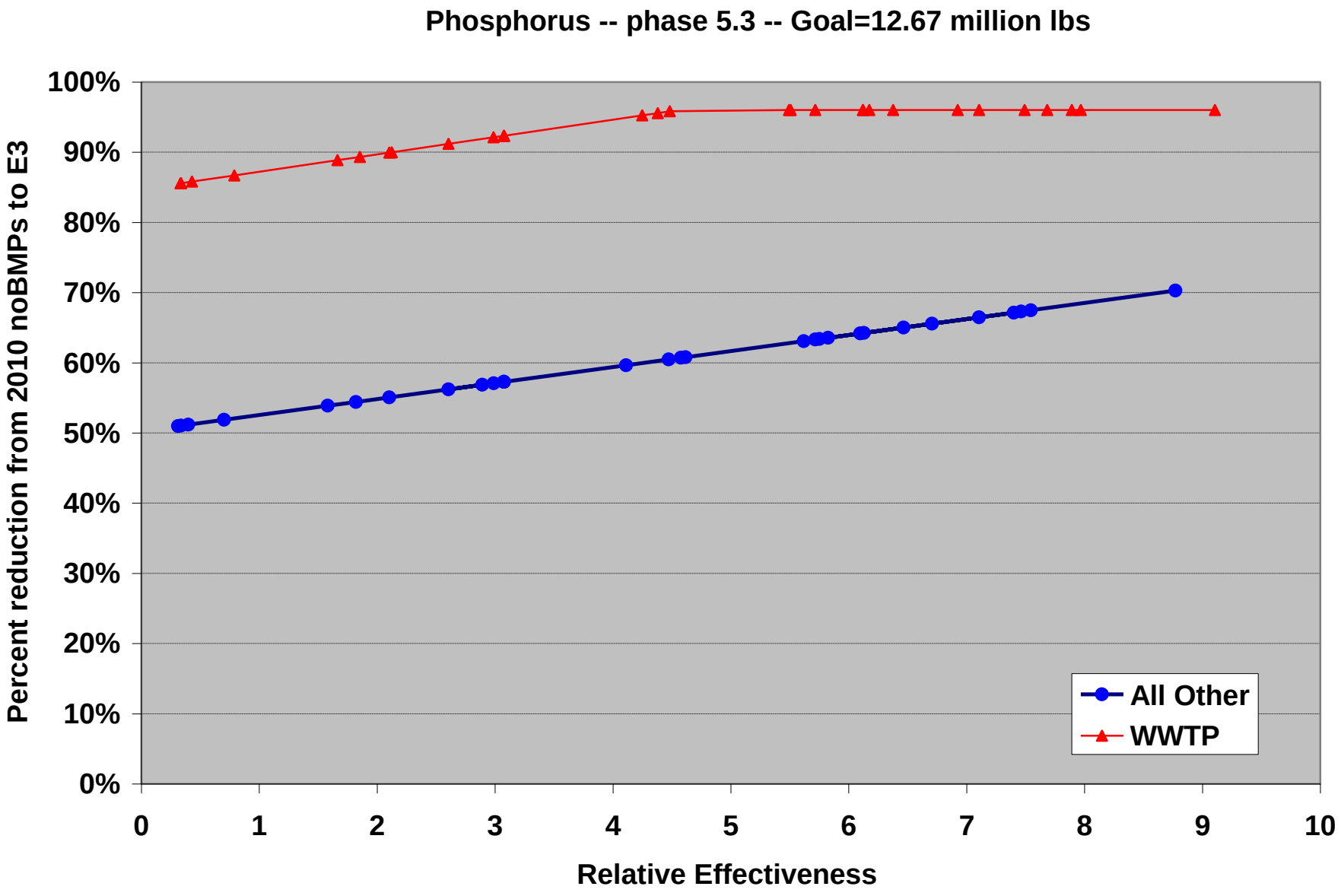




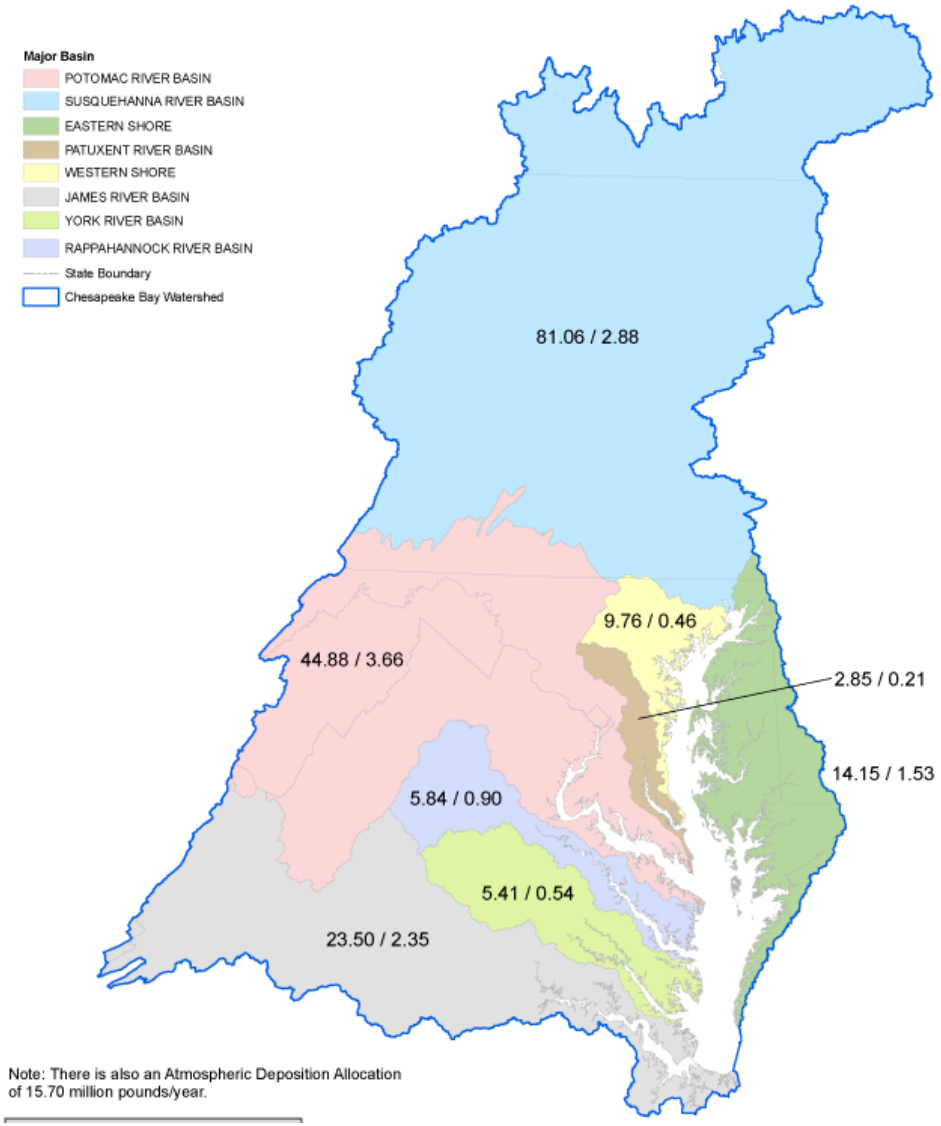
Major River Basin by Jurisdiction Relative Impact on Bay Water Quality



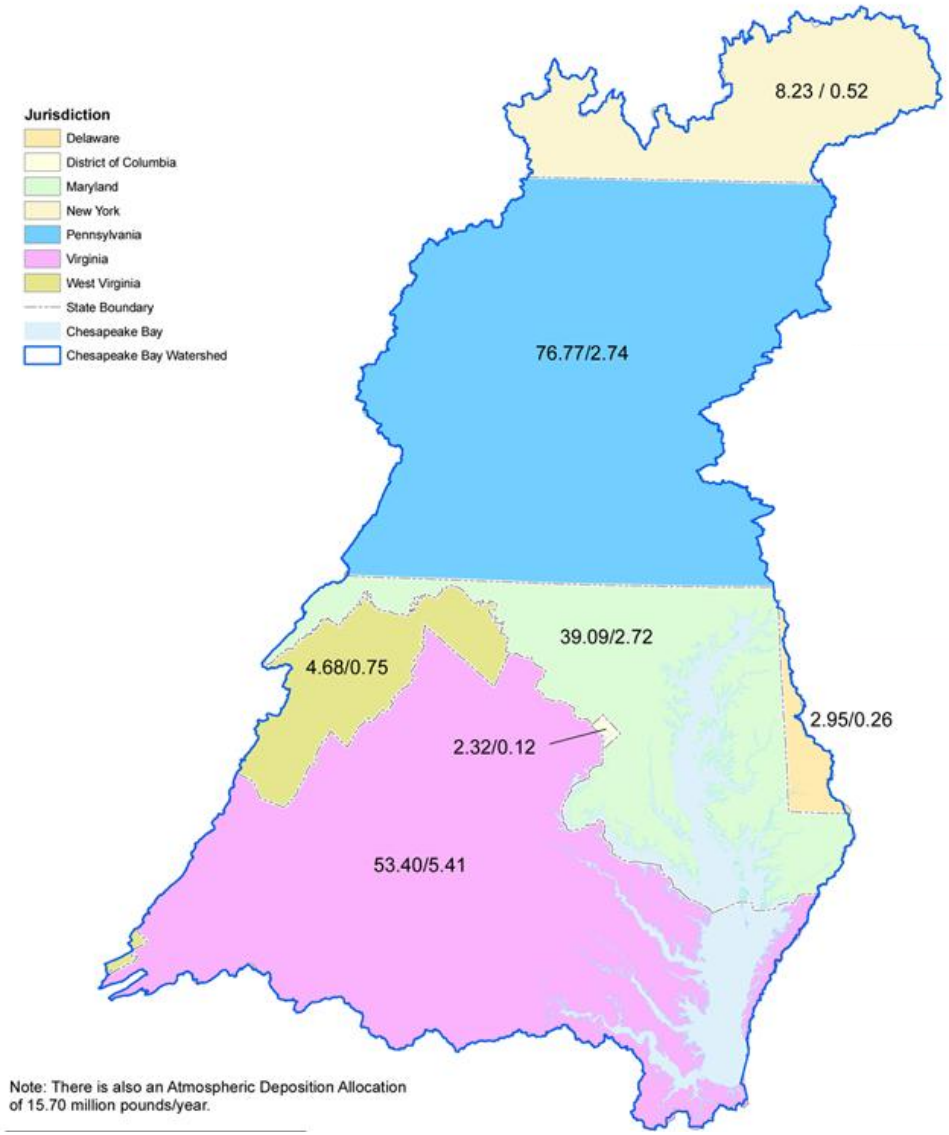

All Other
WWTP
TN, p5.3, goal=190, WWTP = 4.5-8 mg/l, other: max=min+20%
Percent reduction from 2010 noBMPs to E3
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6
7
8
9
10
Relative Effectiveness
Wastewater Loads
4.5 mg/l
8 mg/l
All other sources
20 percent slope
Allocation Method Agreed to by Majority of Principals' Staff Committee Members


Phosphorus -- phase 5.3 -- Goal=12.67 million lbs
Percent reduction from 2010 noBMPs to E3
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6
7
8
9
10
Relative Effectiveness
All Other
WWTP

Pollution Diet by River



Pollution Diet by State

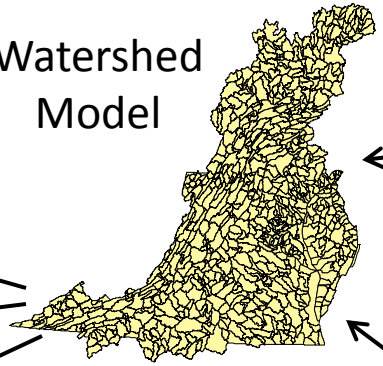


Accountability Framework

1. Watershed Implementation Plans identify nutrient and sediment targets that meet water quality standards.

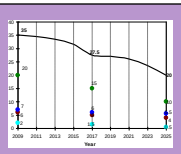
CAST

Watershed Model

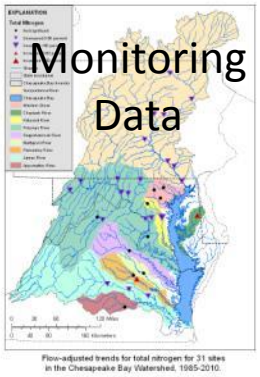


Land Change Model

2. 2-Year Milestones with programmatic and pollutant reduction commitments

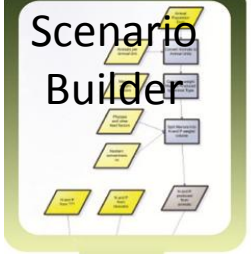


Monitoring Data



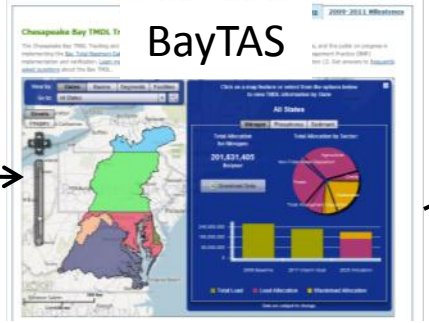
Flow-adjusted trends for total nitrogen for 31 sites in the Chesapeake Bay Watershed, 1985-2010.

Scenario Builder



3.Track and Assess Progress implementing WIPs and milestones

BayTAS



NEIEN

Environmental Information eXchange Network

4. Federal Actions if insufficient Watershed Implementation Plans or 2-year milestones

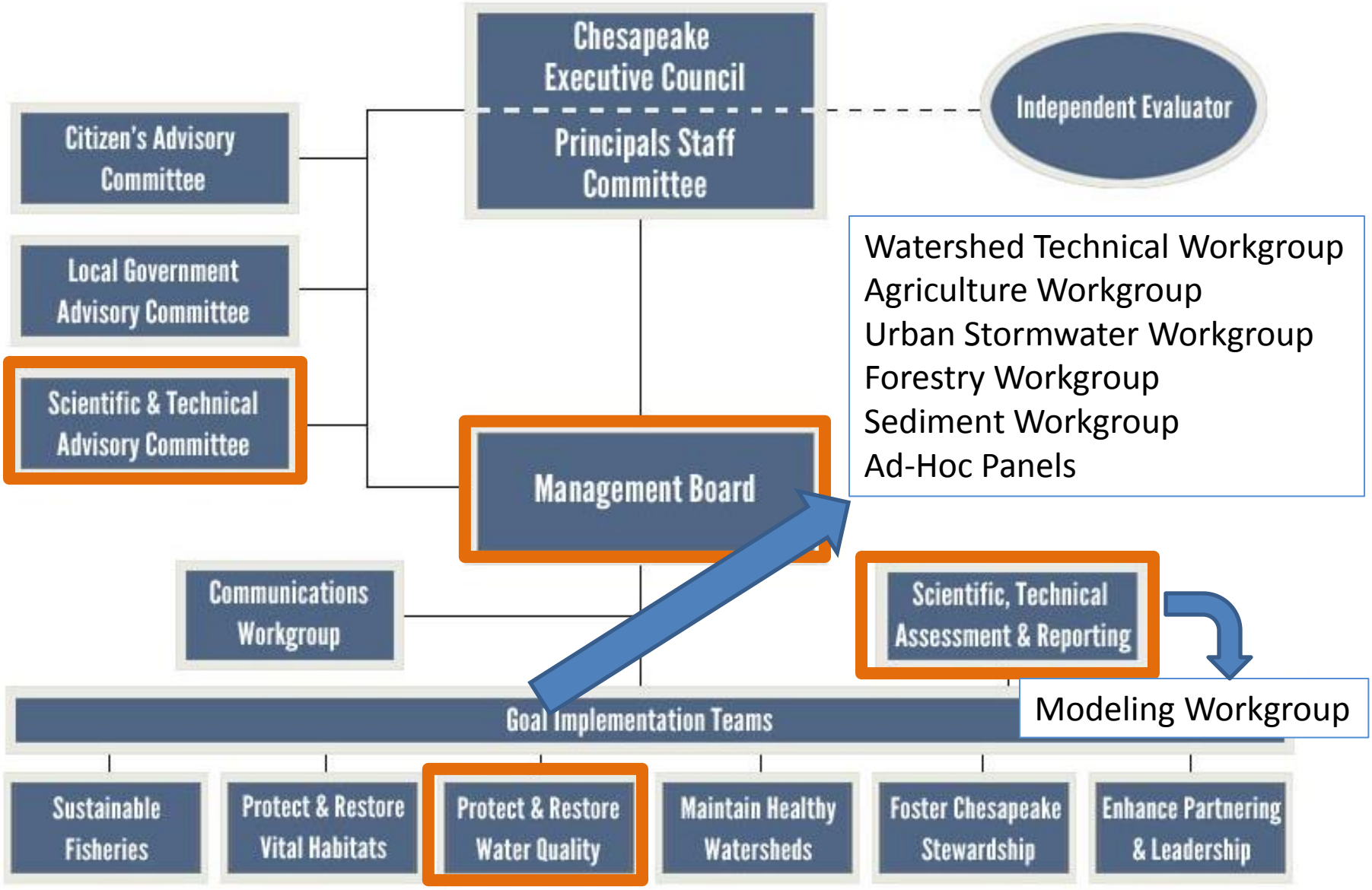
Chesapeake Bay Program Partners

- Signatories to the Chesapeake Bay Agreement
  - PA, MD, VA, DC
  - CBC
  - EPA
- Headwater States
  - DE, NY, WV
- Federal Agencies
  - NOAA
  - USDA
  - USGS
  - NPS
  - USFW
  - DOD
  - NASA
  - NCPC
  - D.Ed.
  - USPS
  - GSA

How many meetings did it take to create the Chesapeake TMDL?

- TMDL on the agenda: about 375 since 2005
- TMDL a principal topic: about 450 since 2008
- Model development started in 1999

Chesapeake Bay Program Partnership



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

One Ad-Hoc Subgroup of the Agricultural Workgroup

Mid-Atlantic Water Program, U.S. Department of Agriculture-Natural Resources Conservation Service, Virginia Department of Conservation and Recreation, Virginia Department of Forestry, Pennsylvania State Conservation Commission, Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Department of Environmental Protection, Maryland Department of Agriculture, Maryland Department of Natural Resources, Maryland Department of the Environment, University of Maryland Cooperative Extension, University of Maryland-College Park, Delaware Department of Agriculture, Delaware Department of Natural Resources and Environmental Control, Delaware Maryland Agribusiness Association, West Virginia Department of Agriculture, West Virginia Department of Environmental Protection, Cacapon Institute - West Virginia, New York Department of Environmental Conservation, Upper Susquehanna Coalition, American Farmland Trust, Chesapeake Bay Commission, U.S. Forest Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Environmental Protection Agency, Keith Campbell Foundation for the Environment, Pinchot Institute, Piedmont Environmental Council

Expert Review Panels; Planned and Active

Agriculture

- Nutrient Management
- Poultry Litter
- Conservation Tillage
- Cover Crop Panel
- Manure Treatment Technologies
- Animal Waste Storage Systems
- Manure Injection/Incorporation
- Cropland Irrigation Management

Urban

- Urban Retrofits
- Performance Based Management
- Stream Restoration
- LID and Runoff Reduction
- Urban Fertilizer Management
- Erosion and Sediment Control
- Illicit Discharge Elimination
- Impervious Disconnect
- Floating Wetlands
- MS4 Minimum Management Measures

Forestry

- Riparian Buffers
- Urban Tree Planting
- Forest Management
- Urban Filter Strips and Upgraded Stream Buffers

CBP Model Input

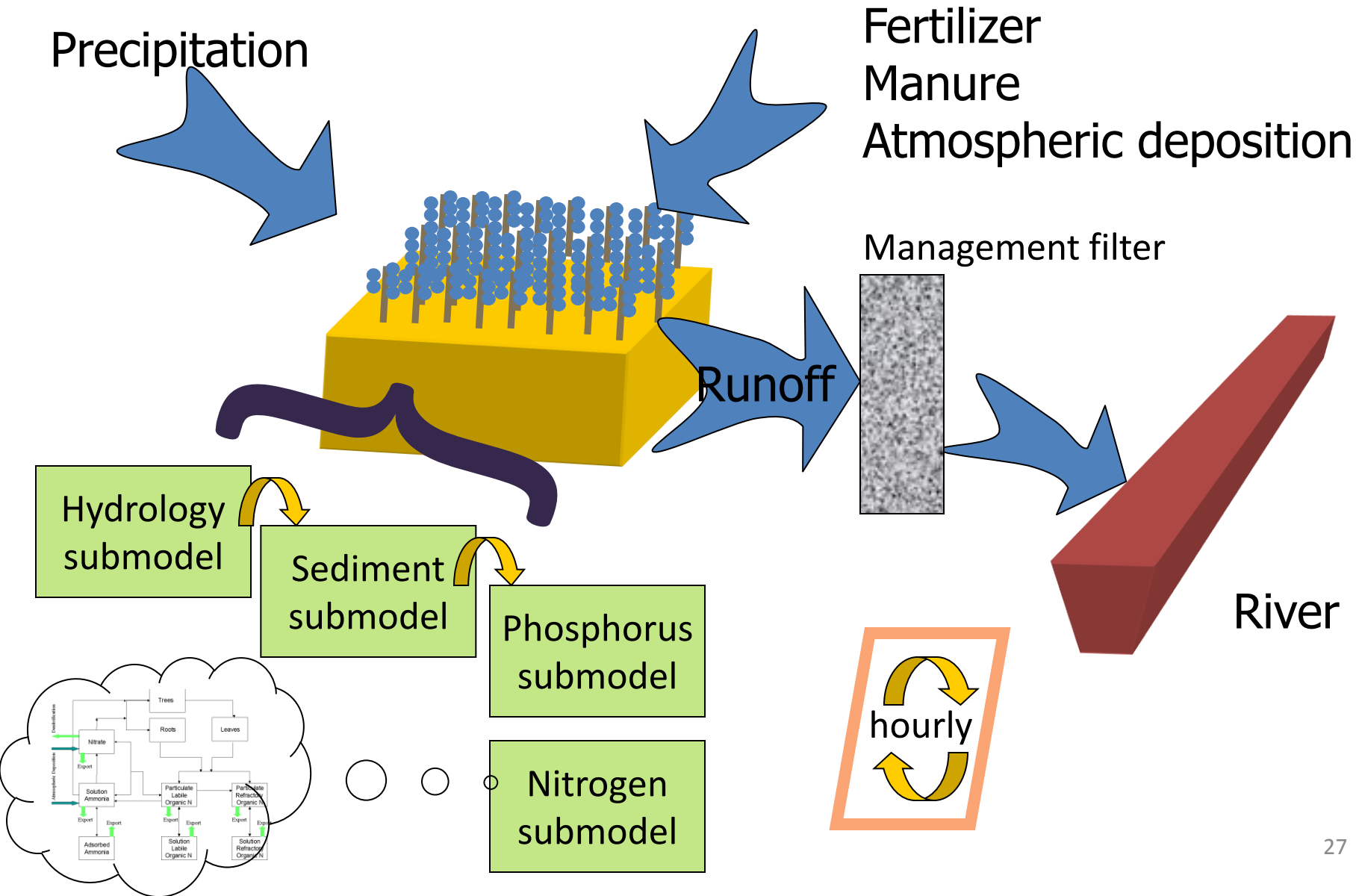
Lots of input on

- Individual BMP efficiencies
- Input data
  - Land use
  - Nutrient applications
- Calibration methods
- Scenario Analysis

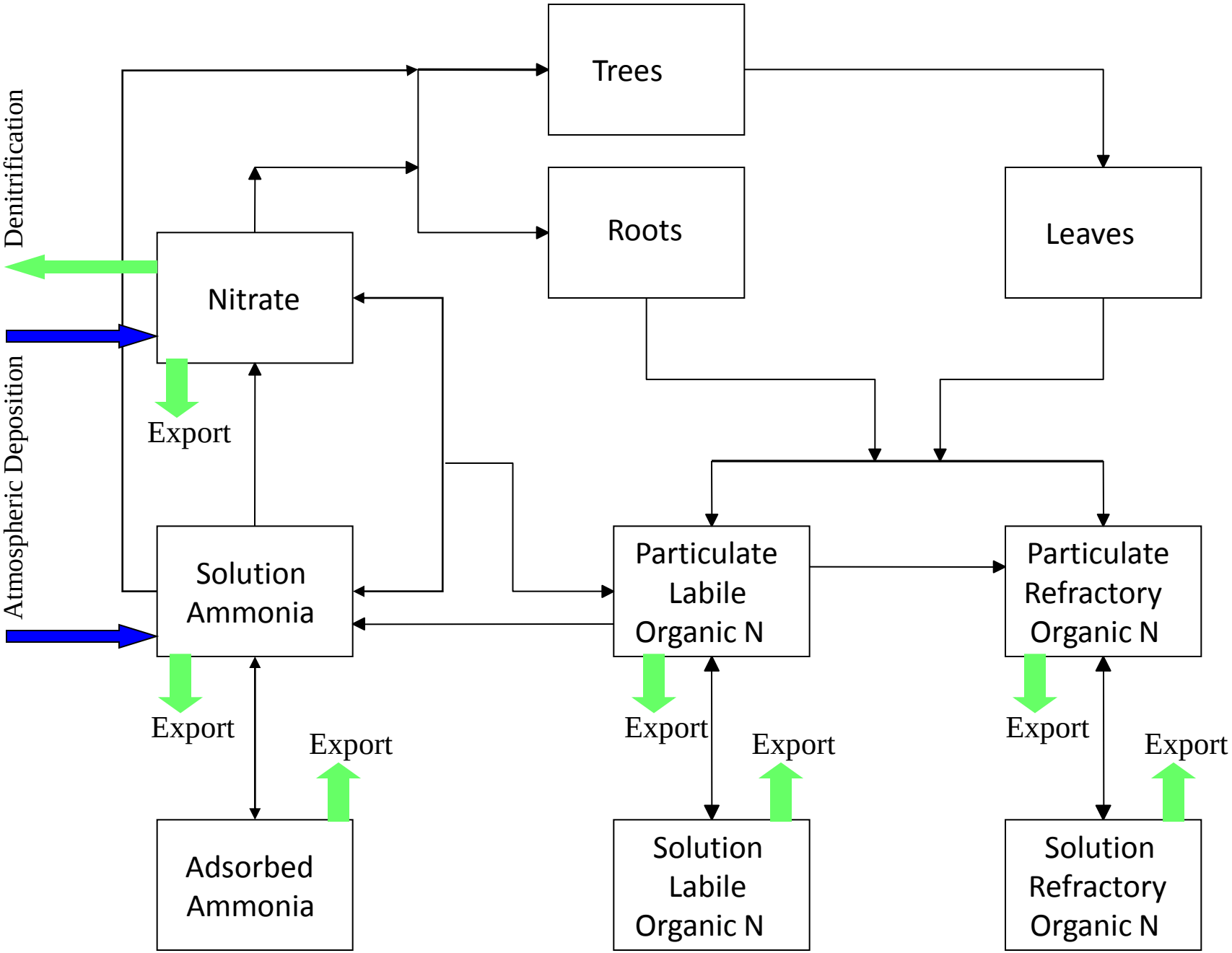
Not so much

- Physical factors
- Nutrient processing
- Overall check of whether the system is working well

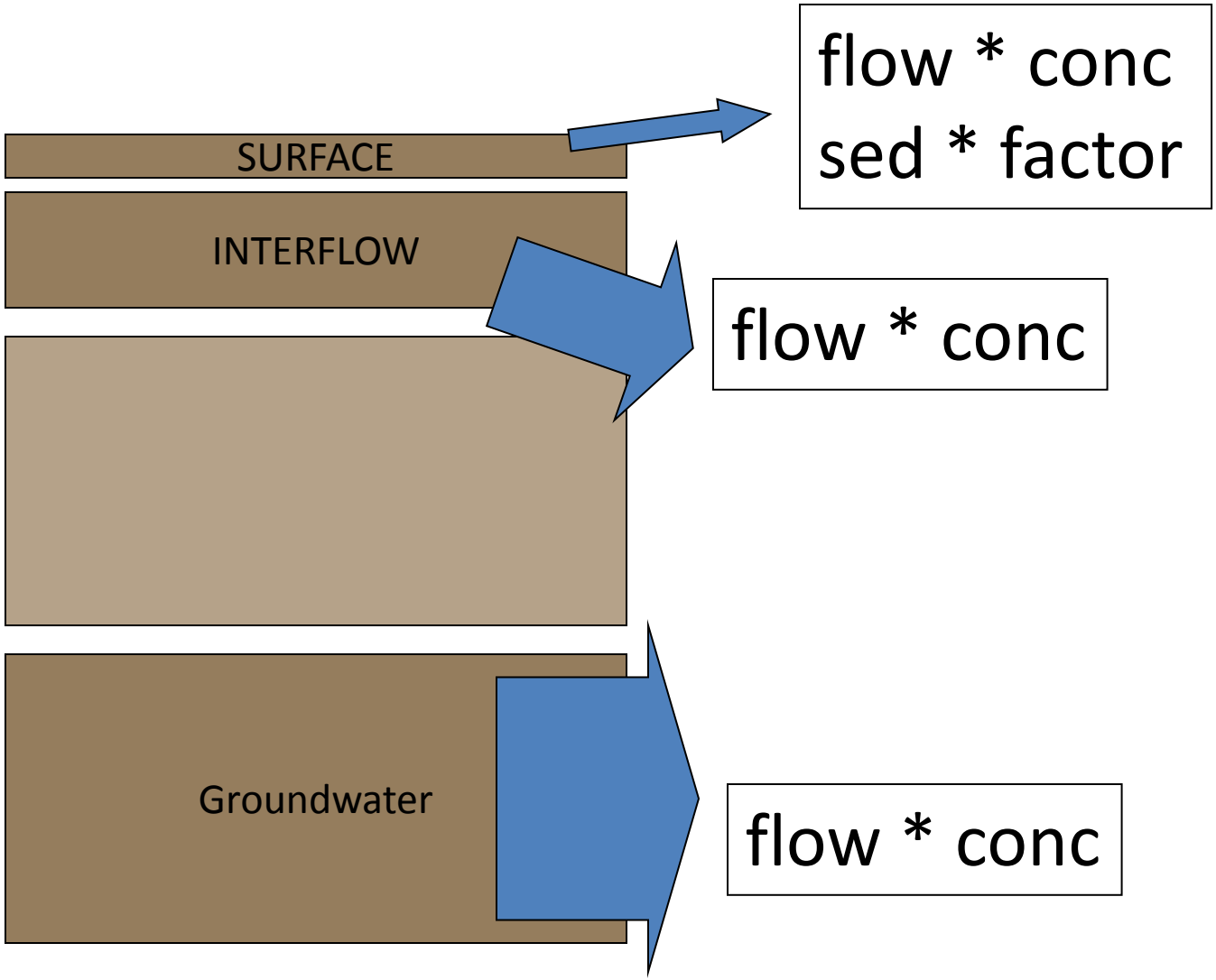
Near-Term Development Plan



AGCHEM Nitrogen Cycle



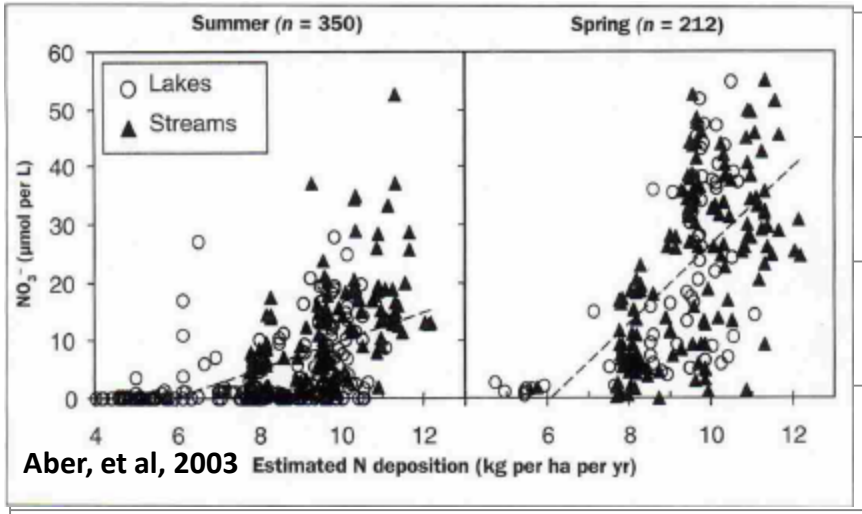
PQUAL loading model



Complex *vs* Simple

Complex	Simple
• Calibration is complex and time consuming	• Calibration is relatively simple and fast
• Calibration is imprecise	• Calibration is precise
• Longer run time	• Shorter run time
• Simulated sensitivity to inputs	• Sensitivity to inputs must be specified (by multiple research models and methods)

Reduction in forest loads from 1985 to CAIR

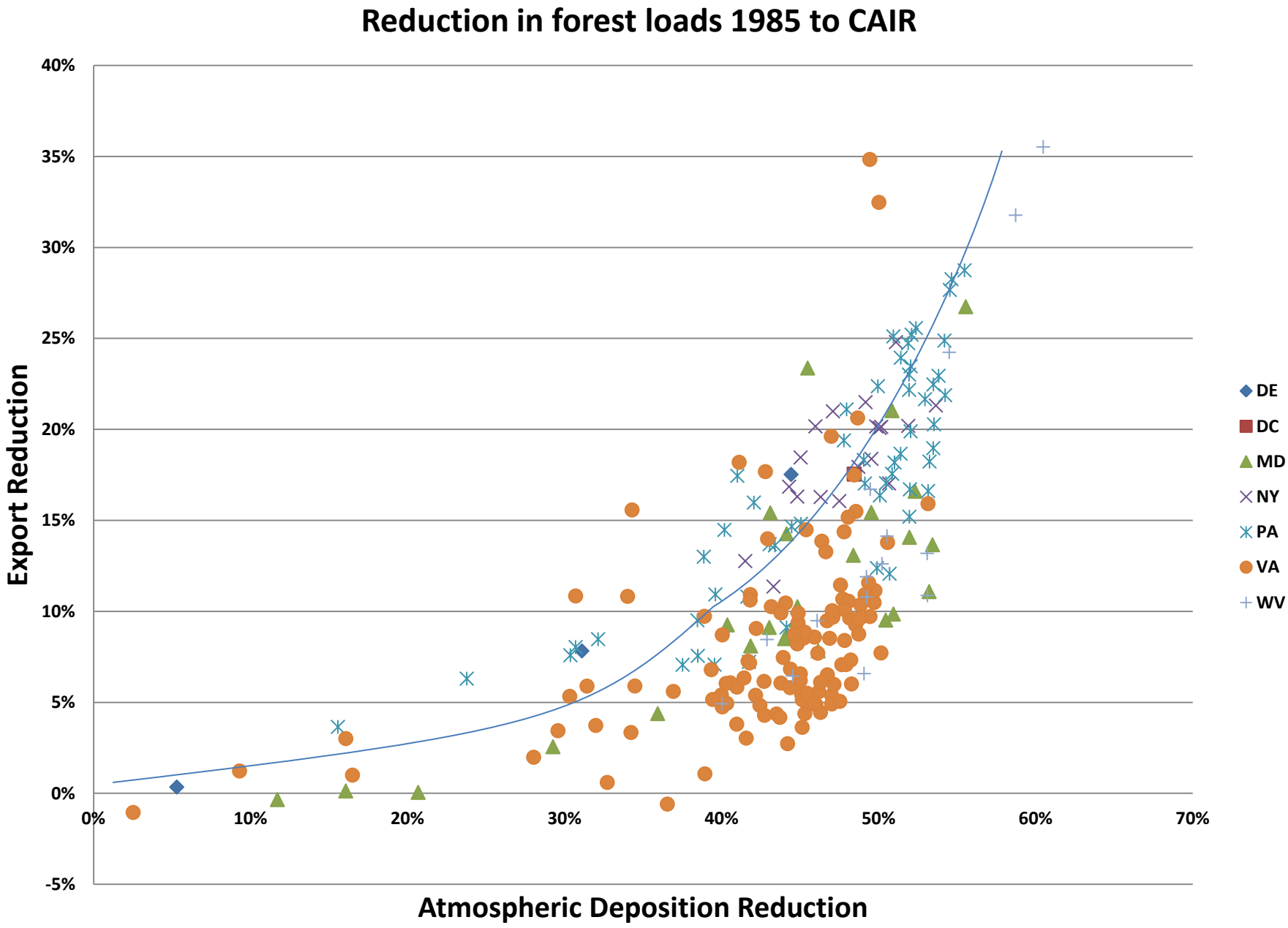


Export Reduction

40%
35%
30%
25%
20%
15%
10%
5%
0%
-5%

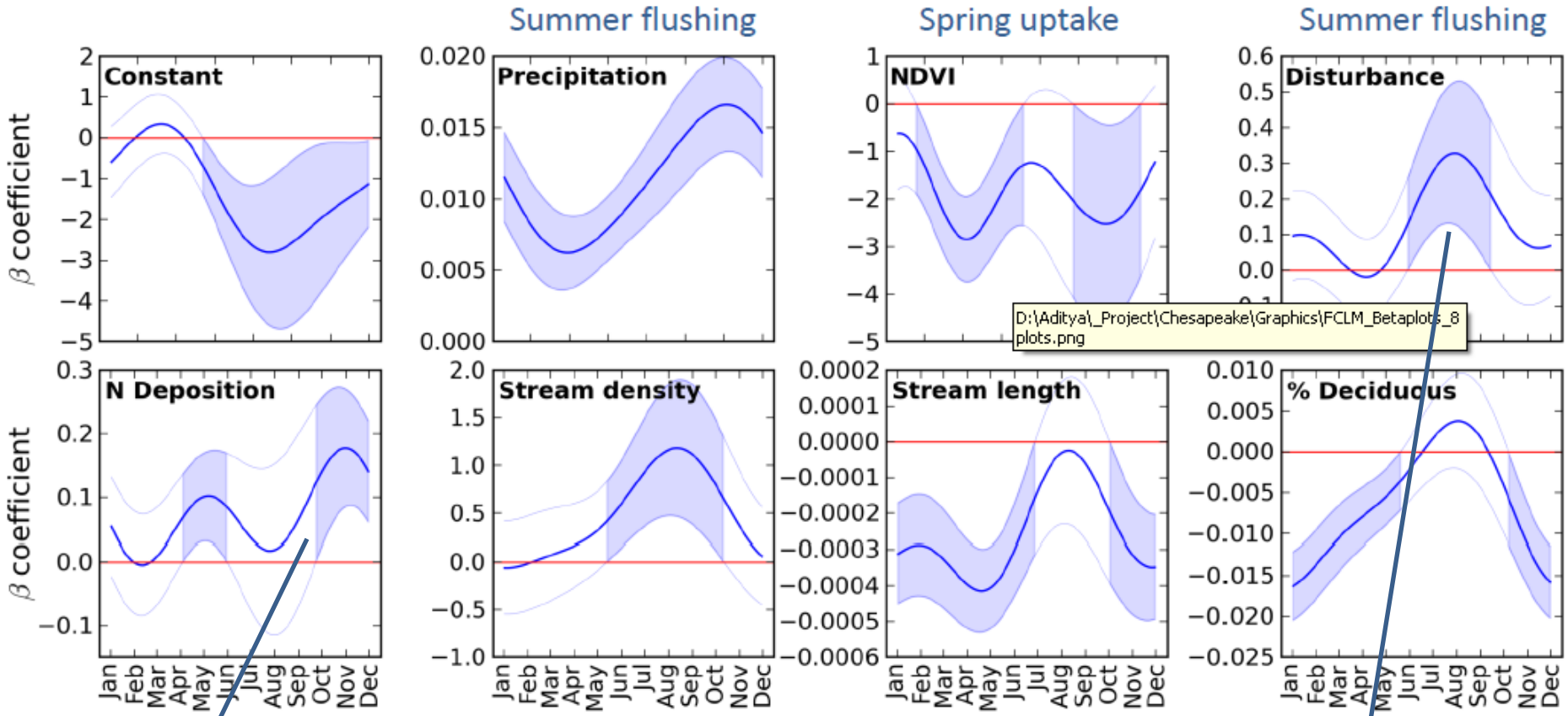
0%
10%
20%
30%
40%
50%
60%
70%

Atmospheric Deposition Reduction


Reduction in forest loads 1985 to CAIR
Export Reduction
Atmospheric Deposition Reduction
40%
35%
30%
25%
20%
15%
10%
5%
0%
-5%
0%
10%
20%
30%
40%
50%
60%
70%
DE
DC
MD
NY
PA
VA
WV

Results:

Regression of monthly nitrate yield – Preliminary Results



Estimating nitrate export from Chesapeake Bay watersheds using MODIS and climate data

Aditya Singh and Phil Townsend

Angélica Gutiérrez-Magness

Keith Eshleman

Brenden McNeil

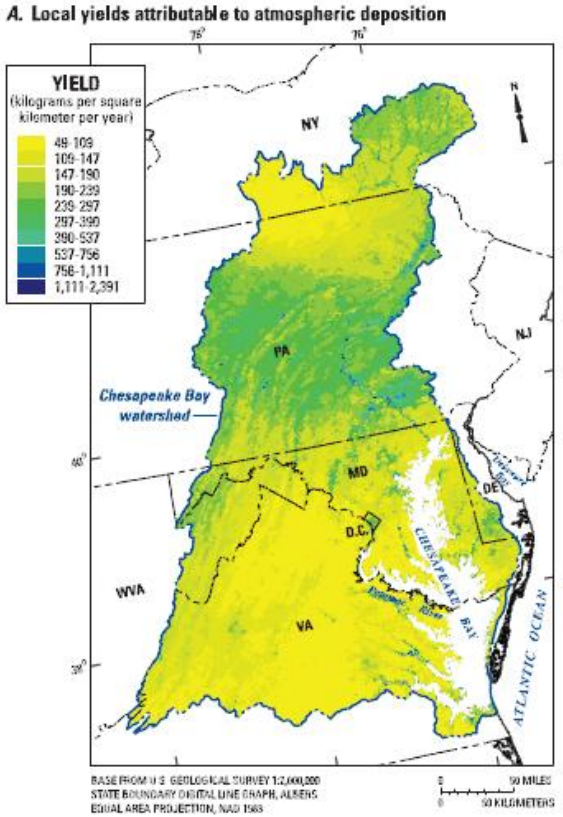
Deposition is Important in the spring and fall

Disturbance is Important in the summer

USGS
science for a changing world

SPARROW Surface Water-Quality Modeling

NAWQA Home | Model Description | Fact Sheet | Decision Support System | FAQs



Total Nitrogen, 2002
(n = 181, MSE = 0.0836, RMSE = 0.289, flux R^2 = 0.978, yield R^2 = 0.858

Explanatory variables	Estimate	Units	90-percent confidence interval	Standard error	p[1]
Sources					
Point sources (kg yr^{-1})	0.774		0.375 – 1.17	0.242	0.0008
Crop fertilizer and fixation (kg yr^{-1})	0.237		0.177 – 0.297	0.0363	< 0.0001
Manure (kg yr^{-1})	0.0582		0.0138 – 0.103	0.0269	0.0157
Atmospheric deposition (kg yr^{-1})	0.267		0.179 – 0.355	0.0533	< 0.0001
Urban[2] (km^2)	1,090	kg km^{-2} yr^{-1}	707 – 1,480	234	< 0.0001
Land-to-water delivery					
ln[Mean EVI for WY02 (dimensionless)]	-1.70		-2.65 – -0.737	0.580	0.0039
ln[Mean soil AWC (fraction)]	-0.829		-1.26 – -0.401	0.260	0.0016
ln[Groundwater recharge (mm)]	0.707	mm^{-1}	0.499 – 0.916	0.126	< 0.0001
ln[Piedmont carbonate (percent of area)]	0.158		0.0755 – 0.241	0.0500	0.0018

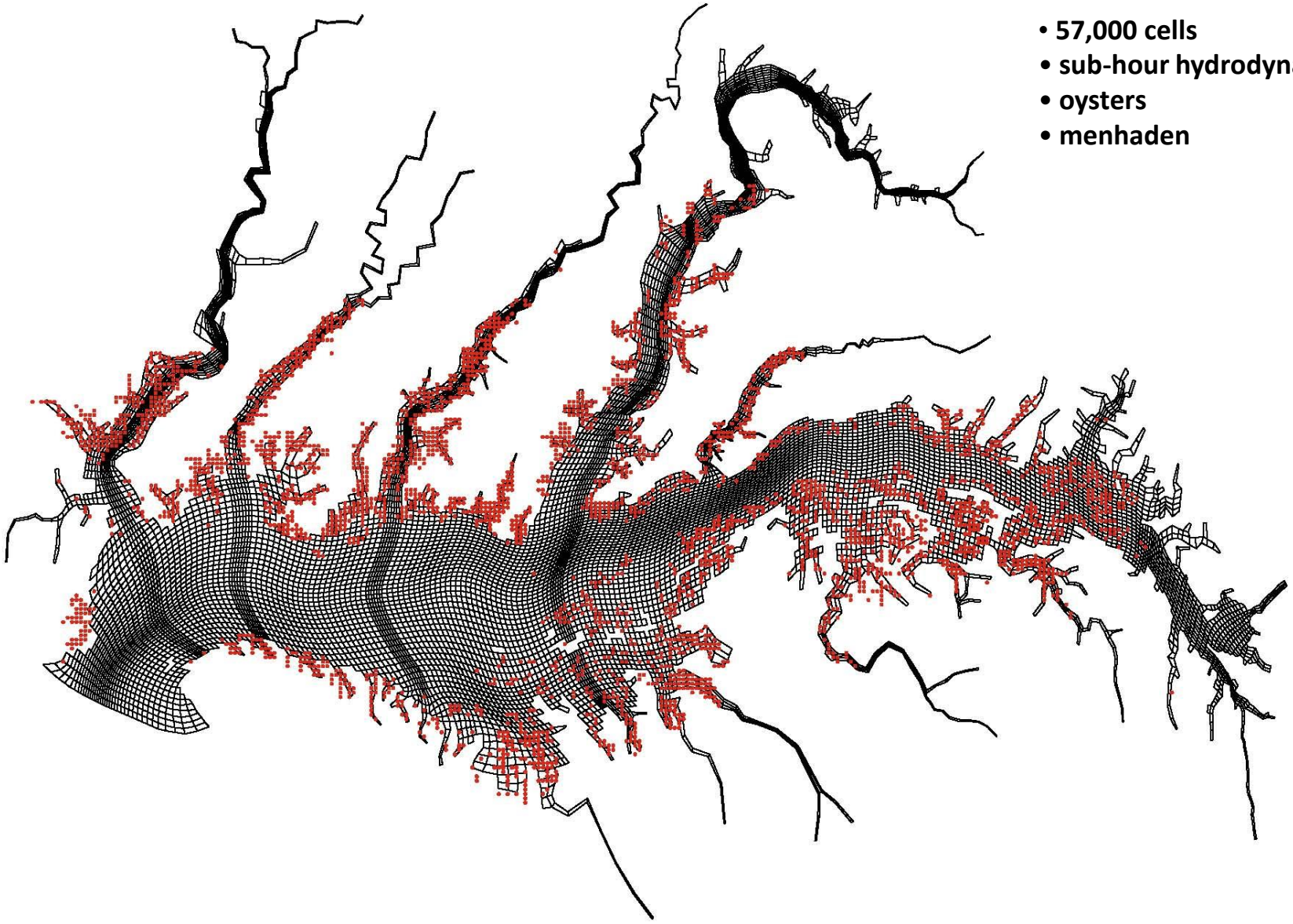
Watershed Research Opportunities

- Synthesize existing information on watershed response and loading (how to put together the 3+ answers we have for forest)
- Develop new information on watershed response and loading (what about the 30 other land uses)

Watershed Research Opportunities

- Reservoir simulation
- Soil P data and how to use it
- Incorporation of sediment grain size
- Fine scale river model
- Effect of spatial arrangement of land uses
- Uncertainty Analysis
- Calibration methods
- Lag times
- Seasonal Effects
- …

Estuarine Model: Near-Term Plan



- 57,000 cells
- sub-hour hydrodynamics
- oysters
- menhaden

Estuarine Model Plans

- Extend Simulation through 2011
- Oysters and Menhaden
- Climate Change
- Living Resource Ribbon
- Wetlands

Estuarine Gap