Modeling and Multiple Modeling in the Chesapeake Bay Program

- Models in the Chesapeake TMDL
- Future Multiple Model Activities
- CBP view of M3

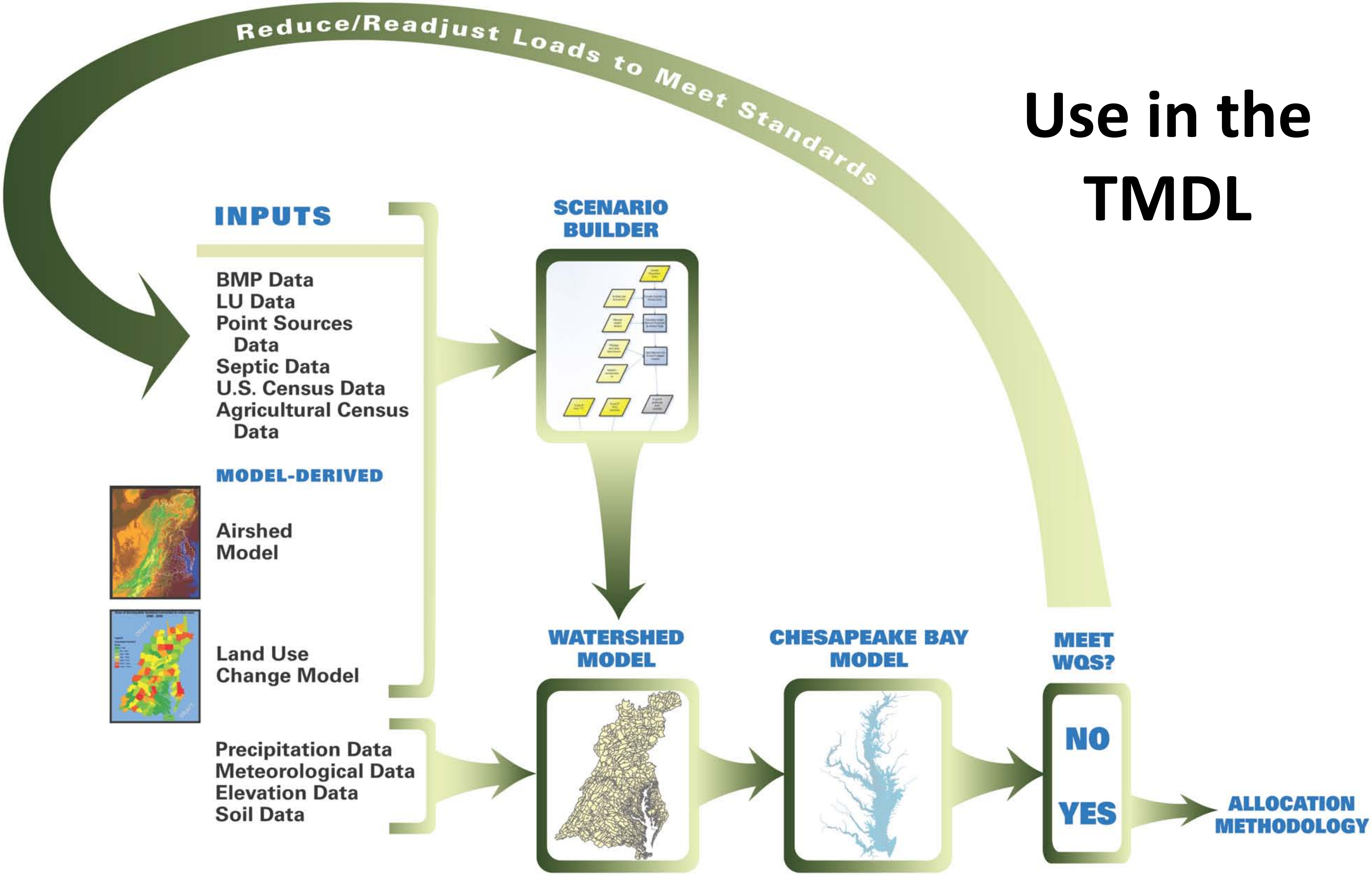
Gary Shenk EPA – CBPO

2/25/13

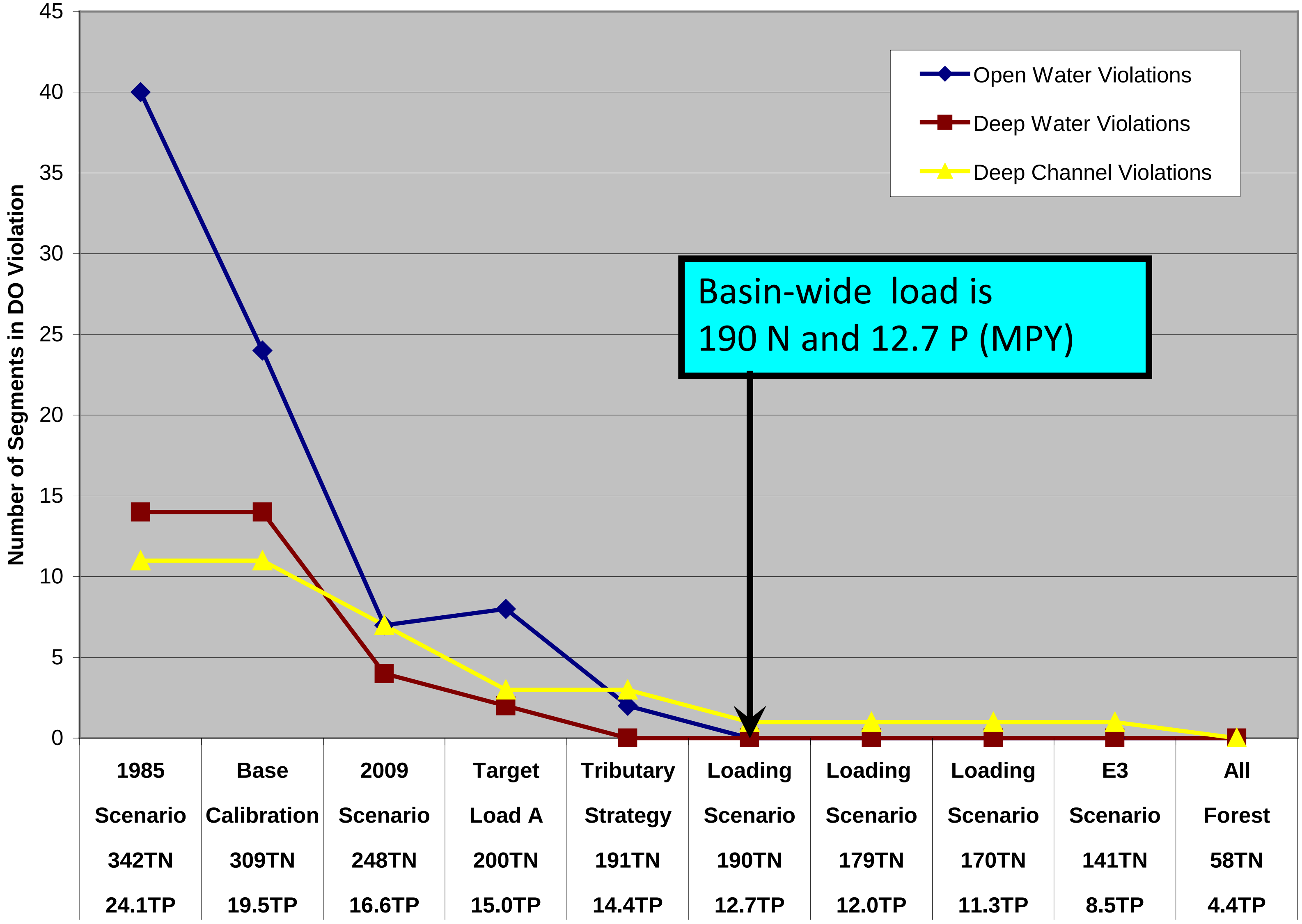
STAC Multiple Models for Management Workshop

Chesapeake Bay Partnership Models

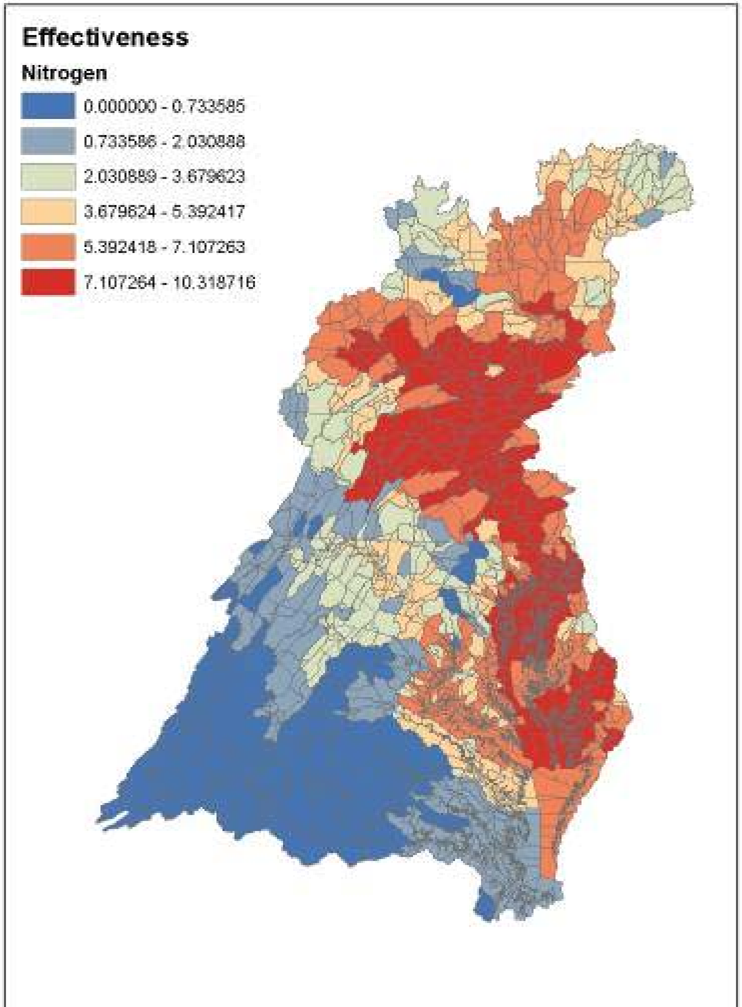
Use in the TMDL

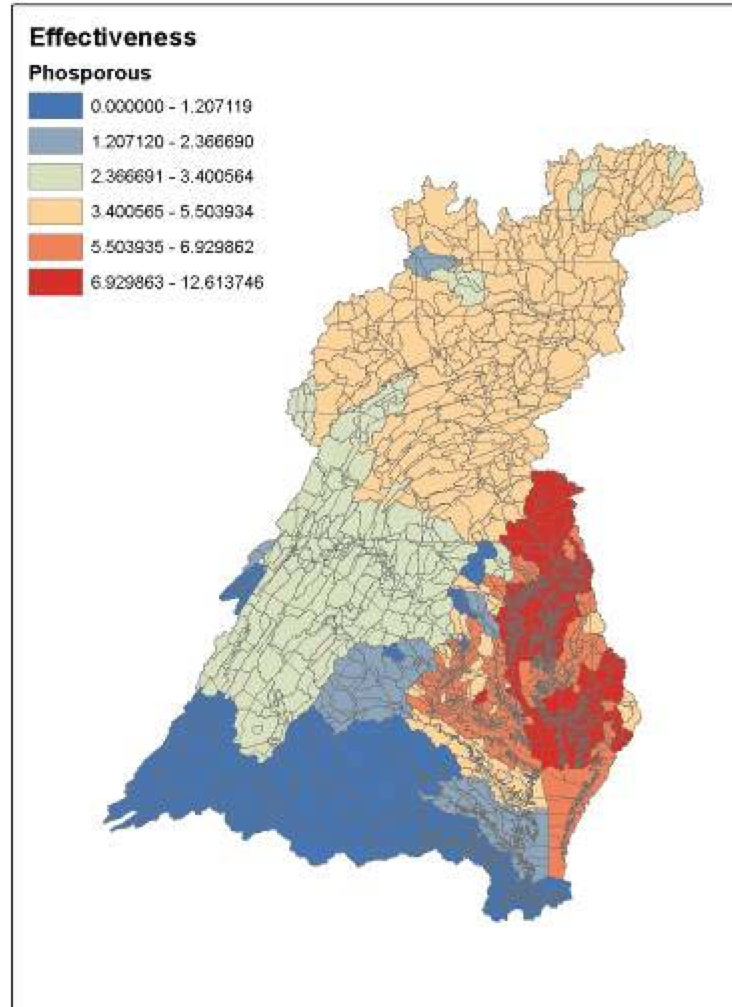


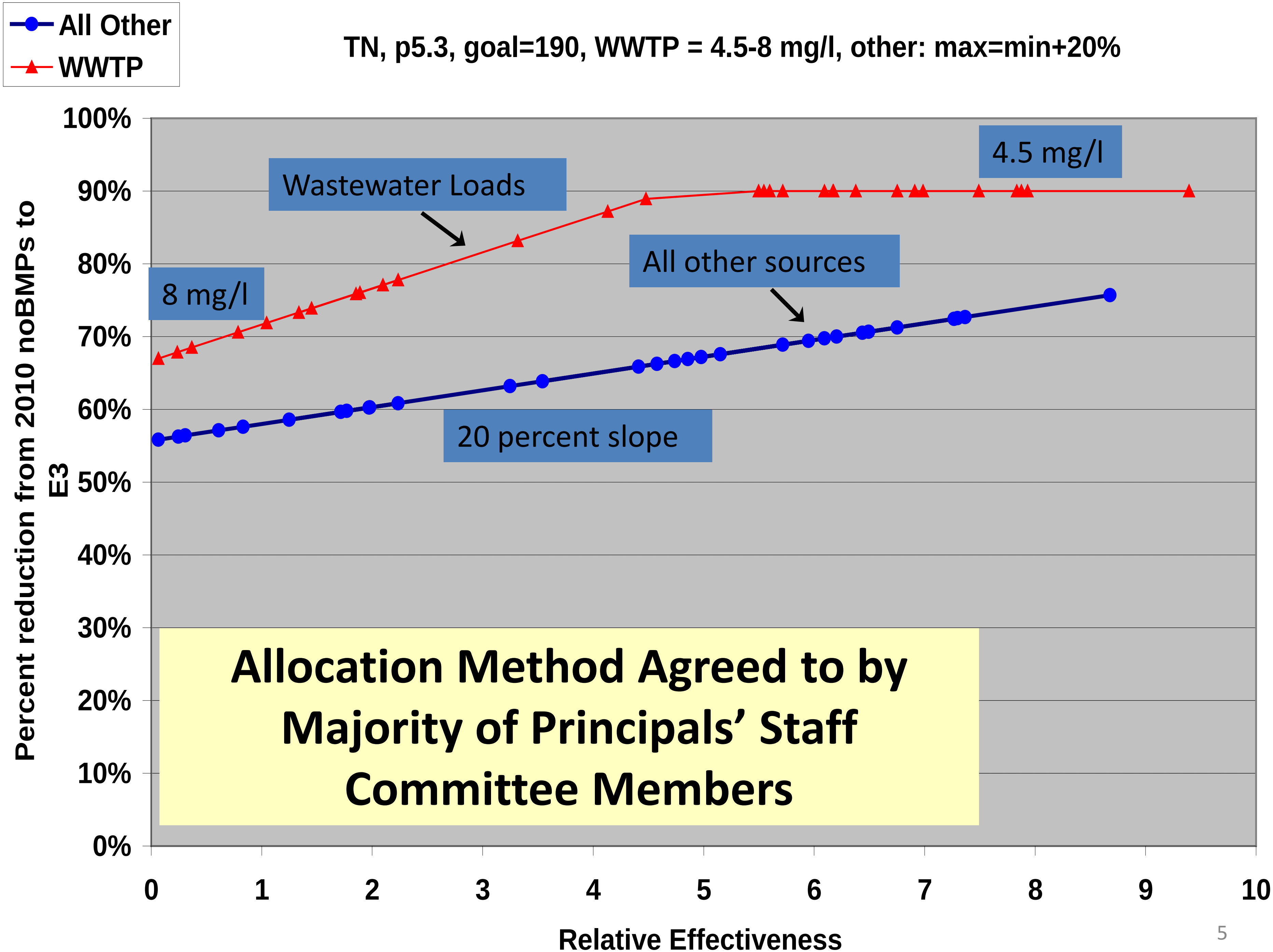
Use of modeling suite in the Chesapeake TMDL

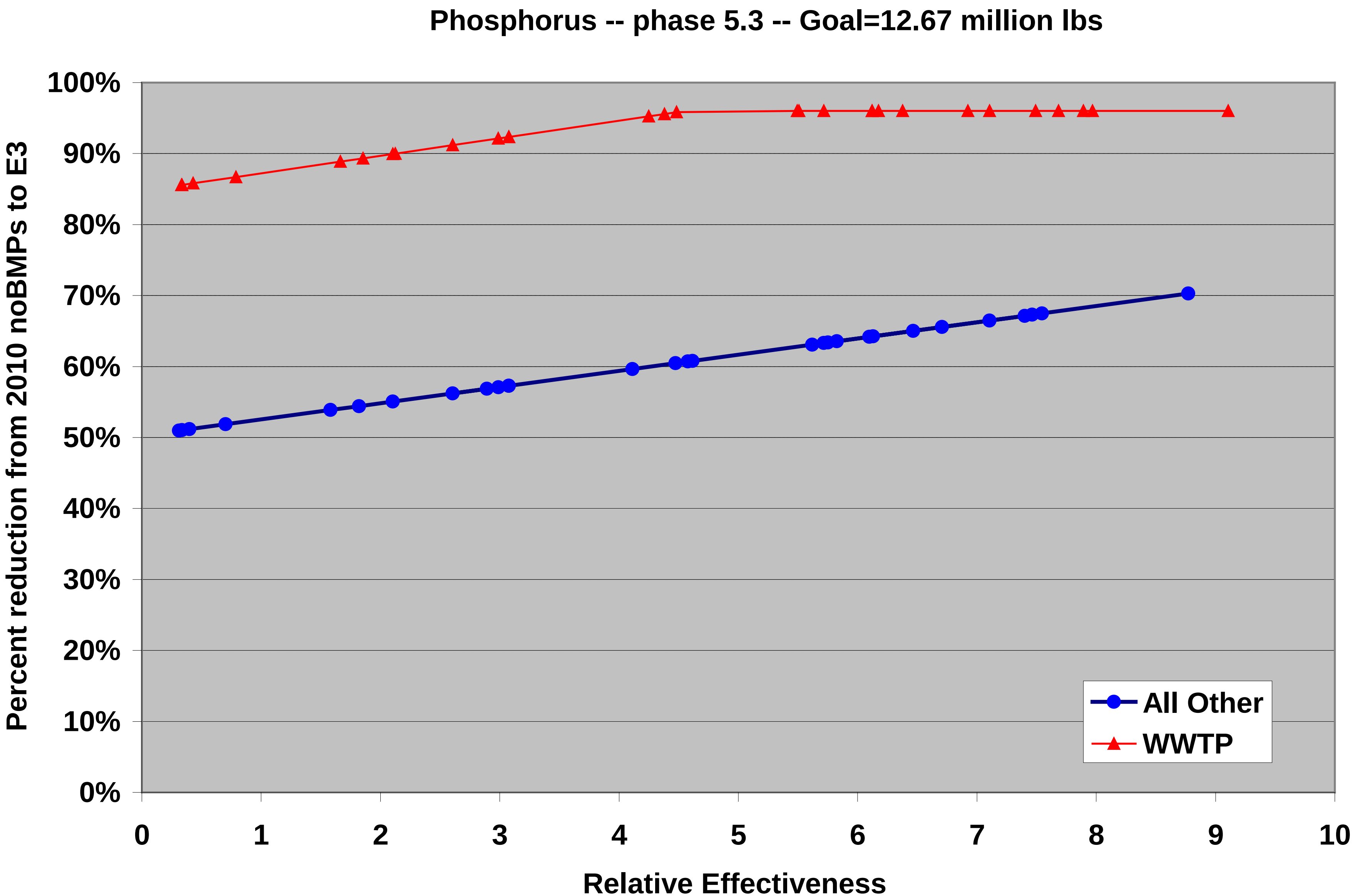


Nutrient Impacts on Bay WQ



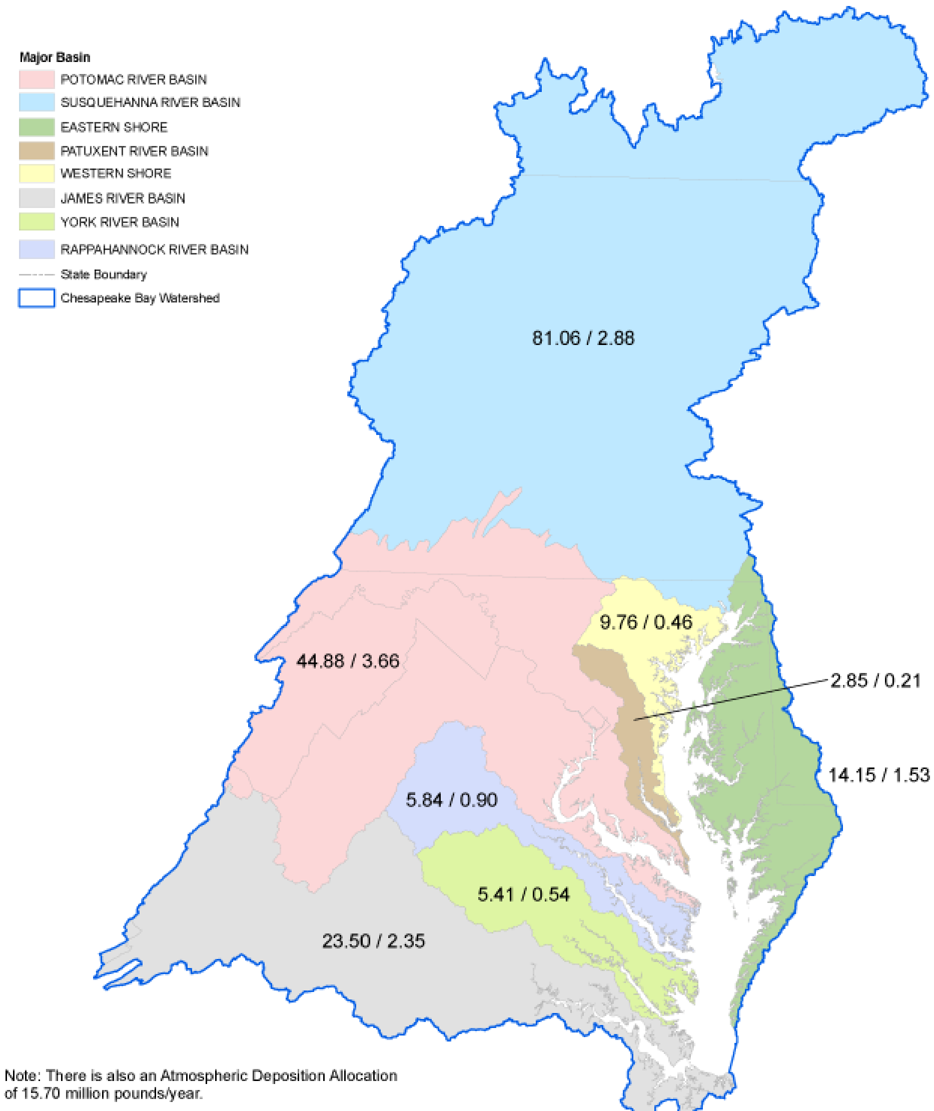



All Other
WWTP
TN, p5.3, goal=190, WWTP = 4.5-8 mg/l, other: max=min+20%
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent reduction from 2010 noBMPs to E3
Wastewater Loads
4.5 mg/l
8 mg/l
All other sources
20 percent slope
Allocation Method Agreed to by Majority of Principals' Staff Committee Members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



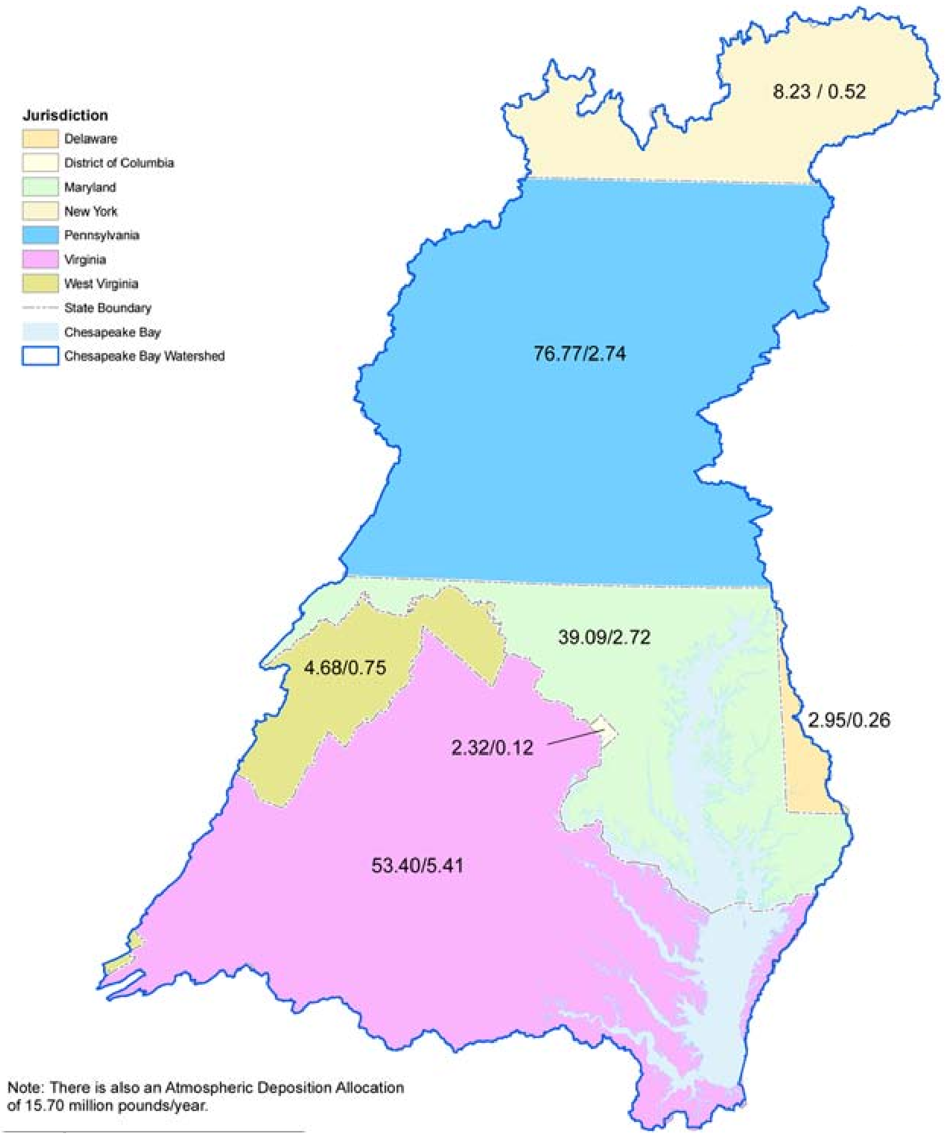
Phosphorus -- phase 5.3 -- Goal=12.67 million lbs
Percent reduction from 2010 noBMPs to E3
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6
7
8
9
10
Relative Effectiveness
All Other
WWTP

Pollution Diet by River



Note: There is also an Atmospheric Deposition Allocation of 15.70 million pounds/year.

Pollution Diet by State



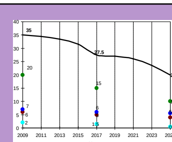
Note: There is also an Atmospheric Deposition Allocation of 15.70 million pounds/year.

Accountability Framework

Components of Bay TMDL Accountability Framework

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

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

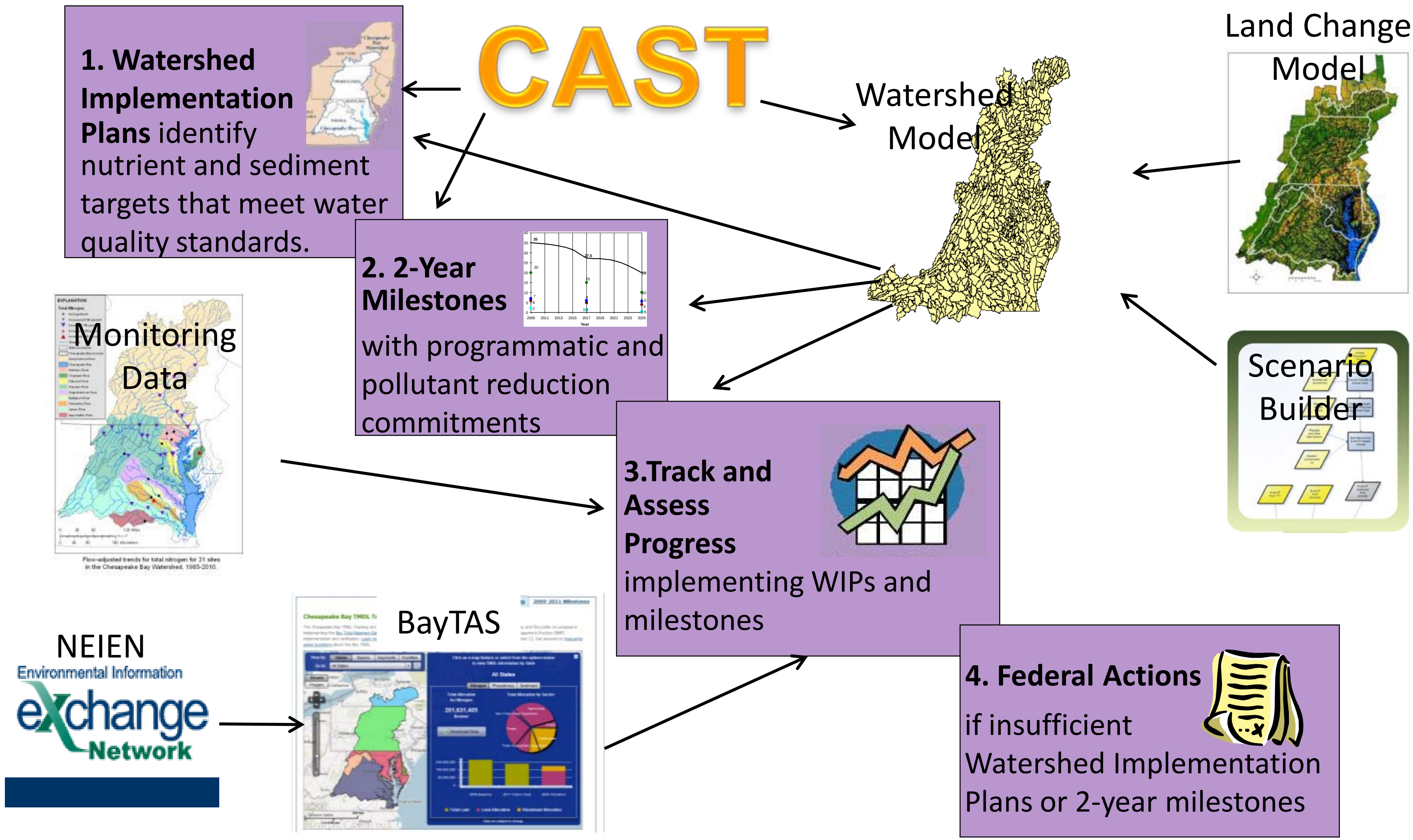


3.Track and Assess Progress implementing WIPs and milestones

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

Source: Chesapeake Bay TMDL Section 7

Accountability Framework

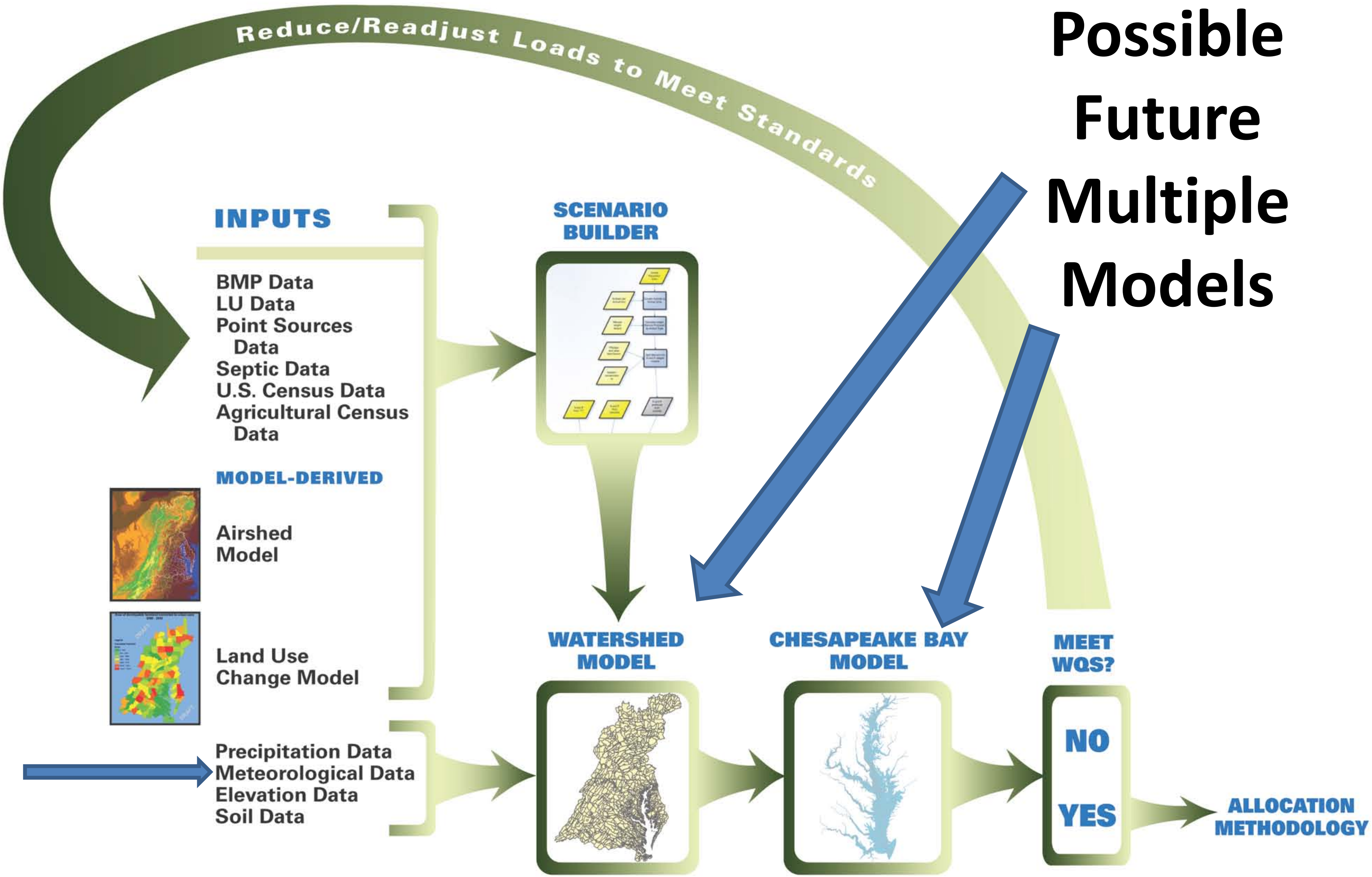


TMDL Margin of Safety

- TMDL = WLA + LA + MOS

- Chesapeake TMDL
- TMDL = WLA + LA
  - Models has sufficient conservative assumptions to consider the margin of safety as implicit.

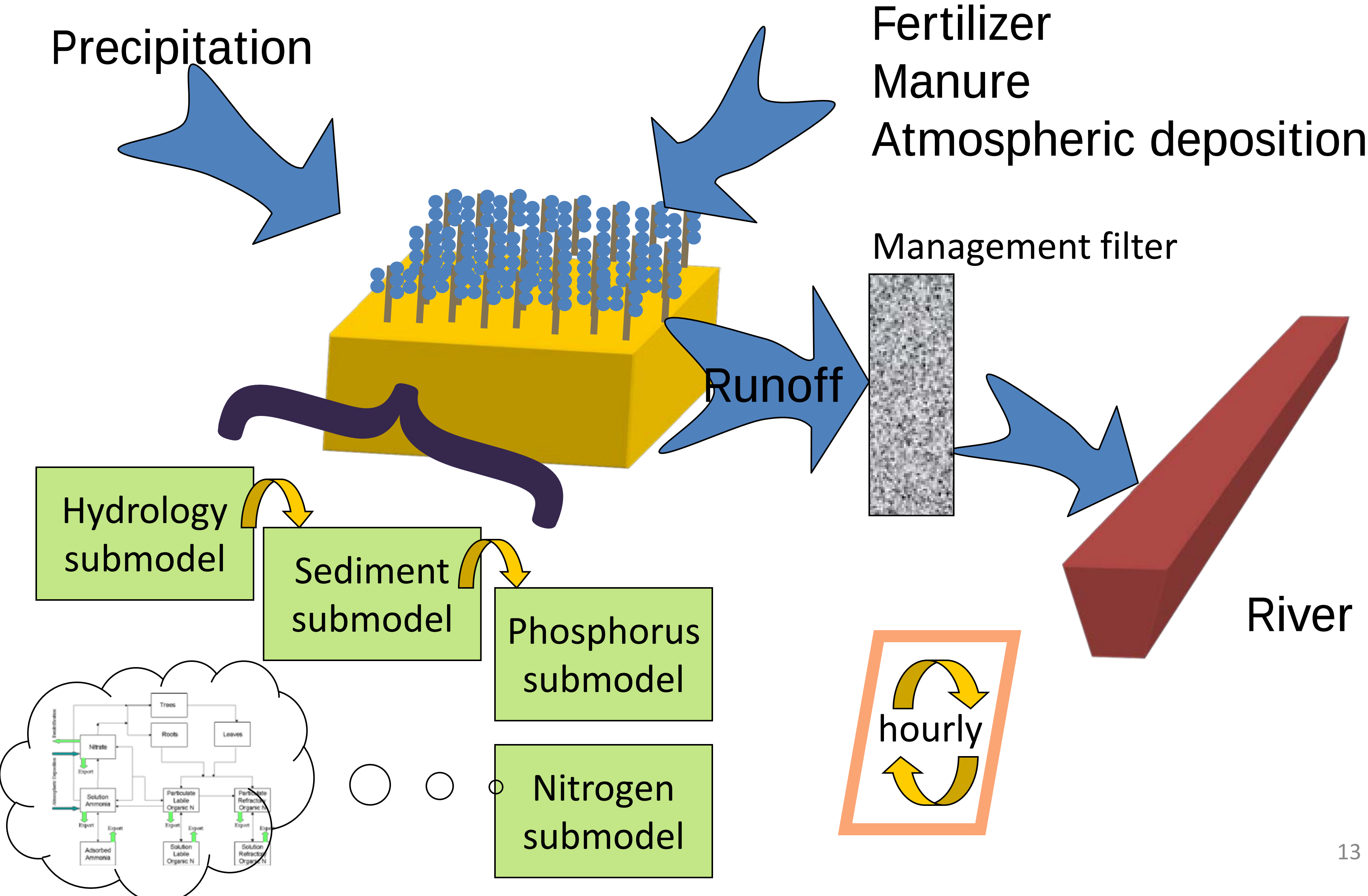
Chesapeake Bay Partnership Models



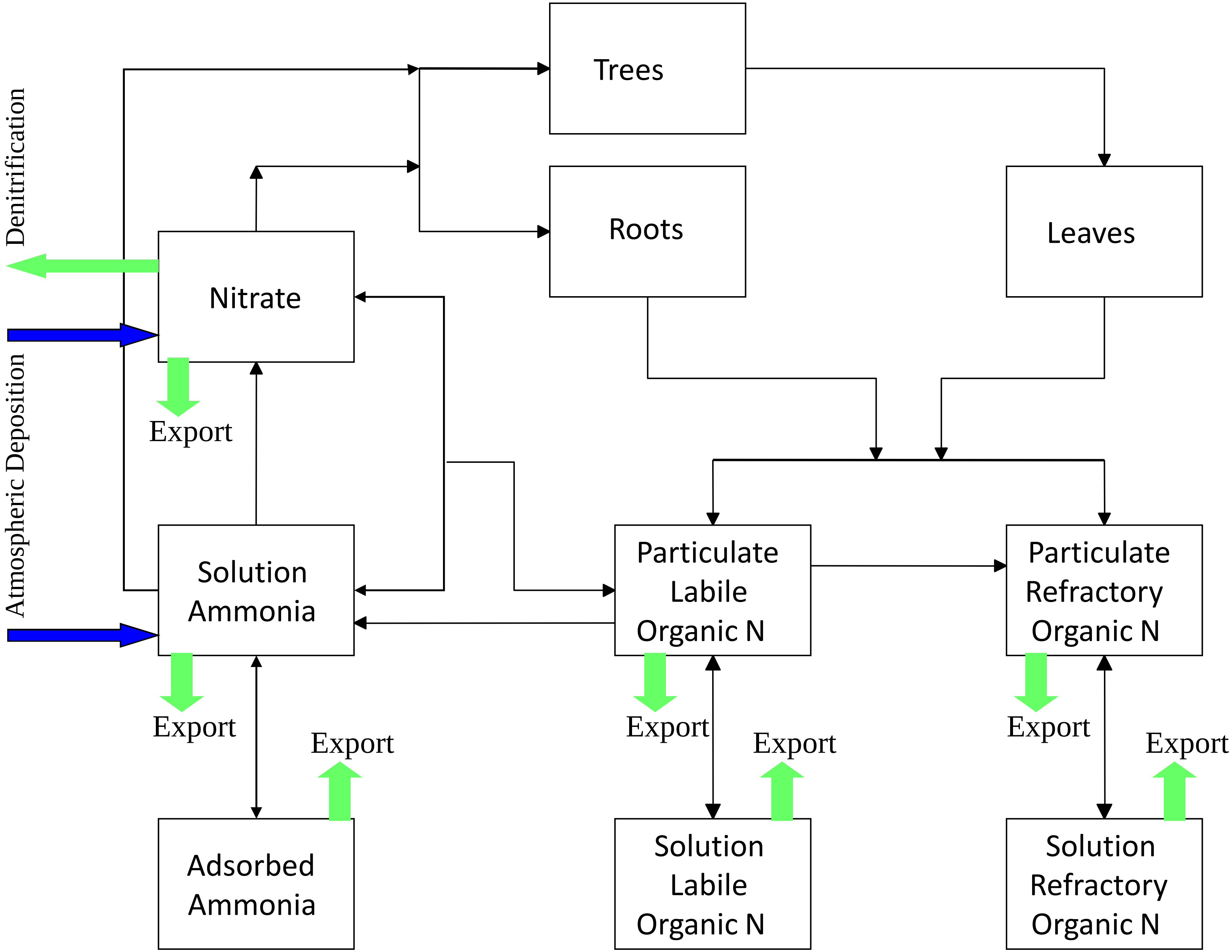
Insert memory of Marjy's presentation here

Big caveat: Can we make the money available?

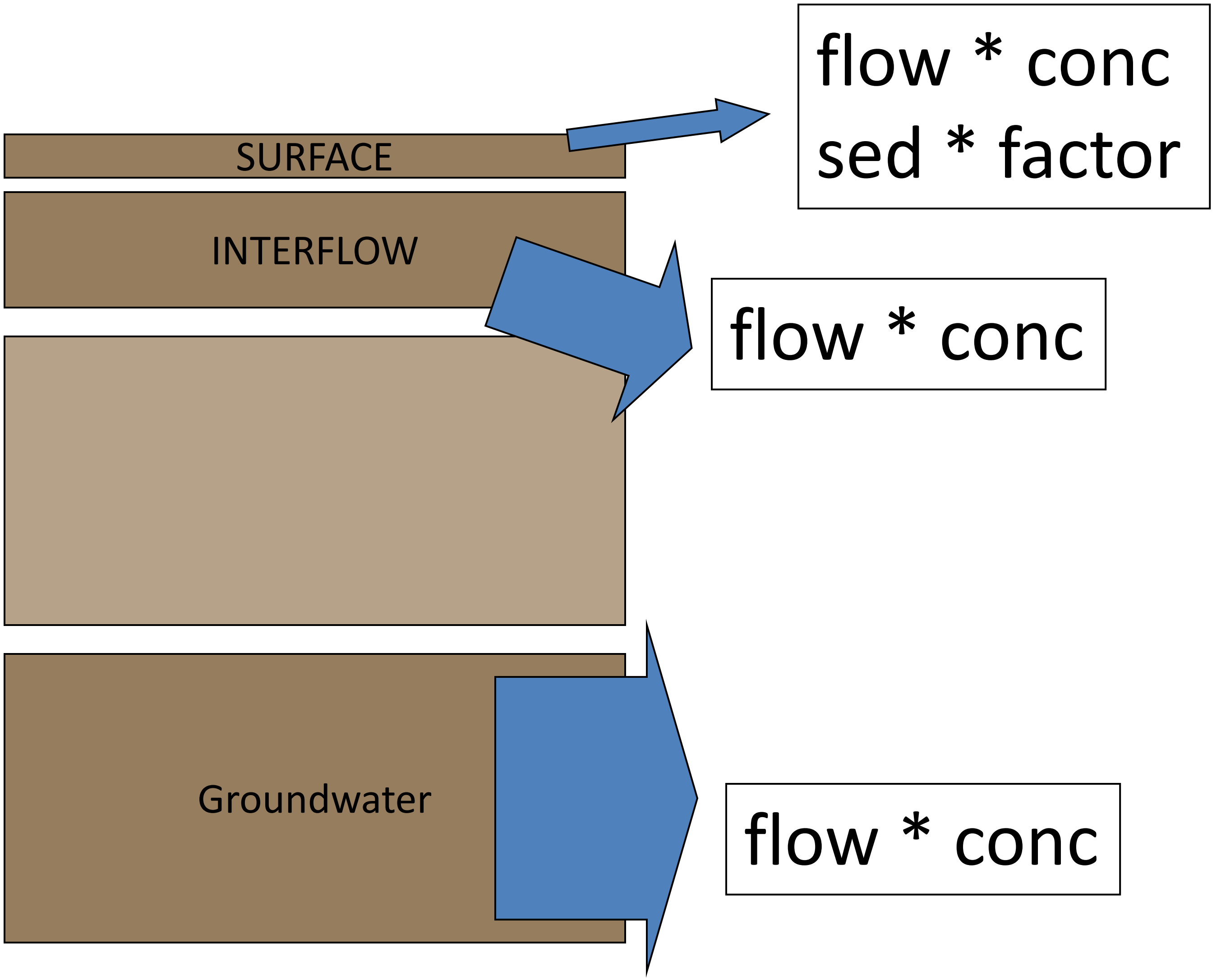
Multiple Models in the Watershed Model



AGCHEM Loading Model - simulated separately in each soil layer



PQUAL loading model

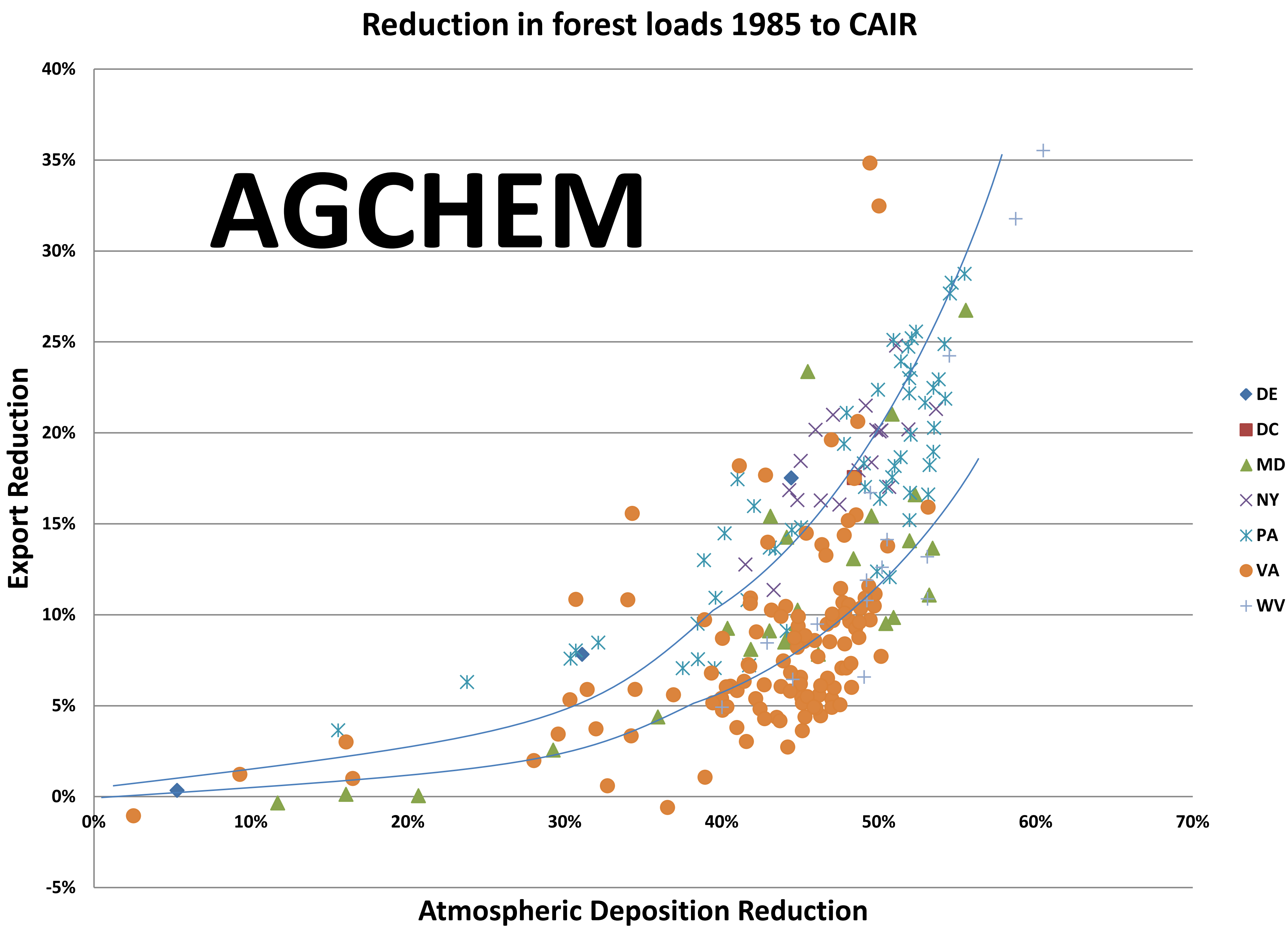


AGCHEM *vs* PQUAL

- Calibration is complex and time consuming
- Calibration is imprecise
- Longer run time
- Simulated sensitivity to inputs

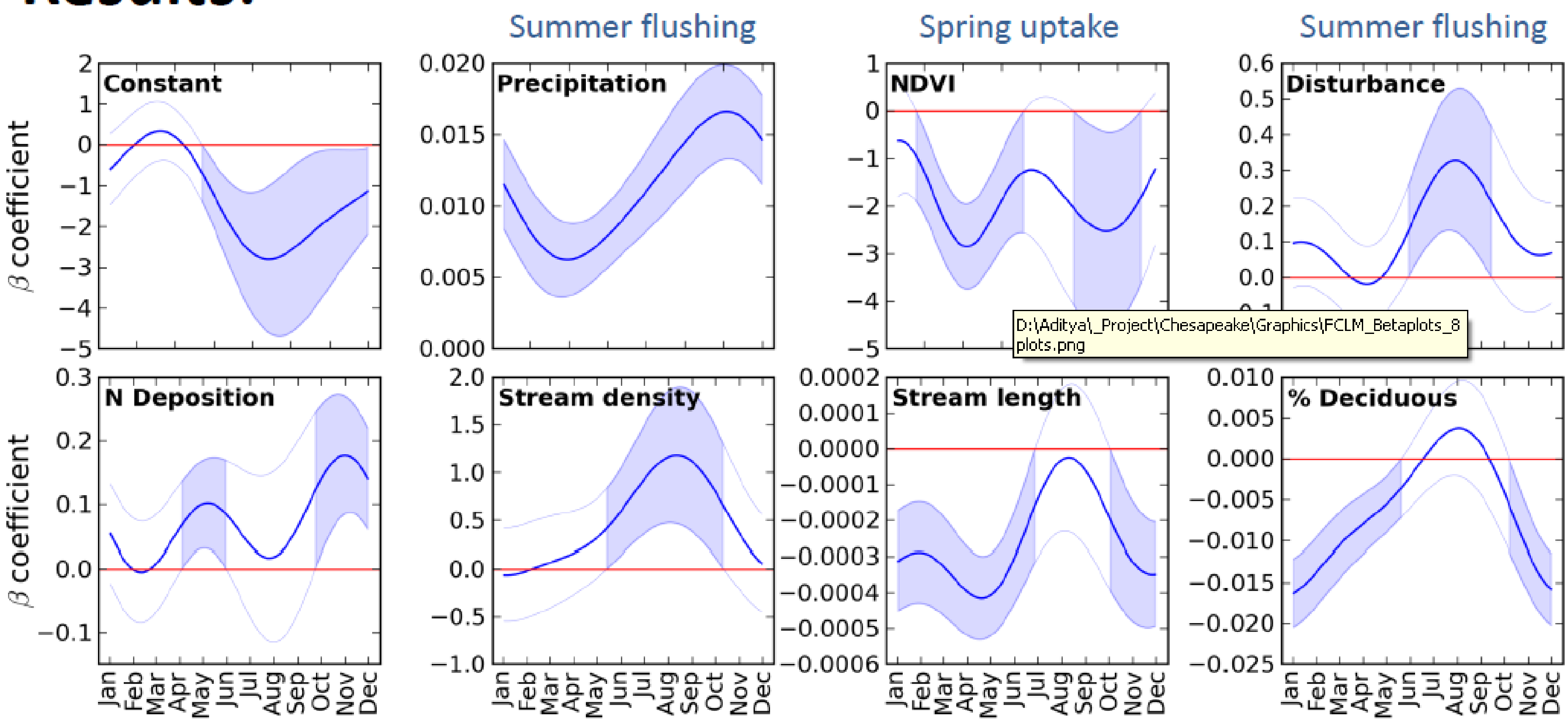
- Calibration is relatively simple and fast
- Calibration is precise
- Shorter run time
- Sensitivity to inputs must be specified

Multiple Models


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

Results:

Regression of monthly nitrate yield



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

Aditya Singh and Phil Townsend

Angélica Gutiérrez-Magness

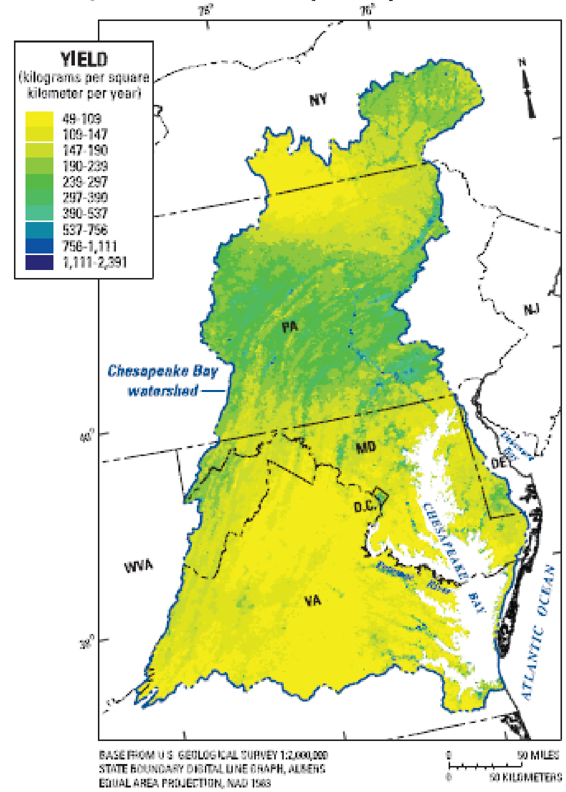
Keith Eshleman

Brenden McNeil

USGS
science for a changing world

SPARROW Surface Water-Quality Modeling

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

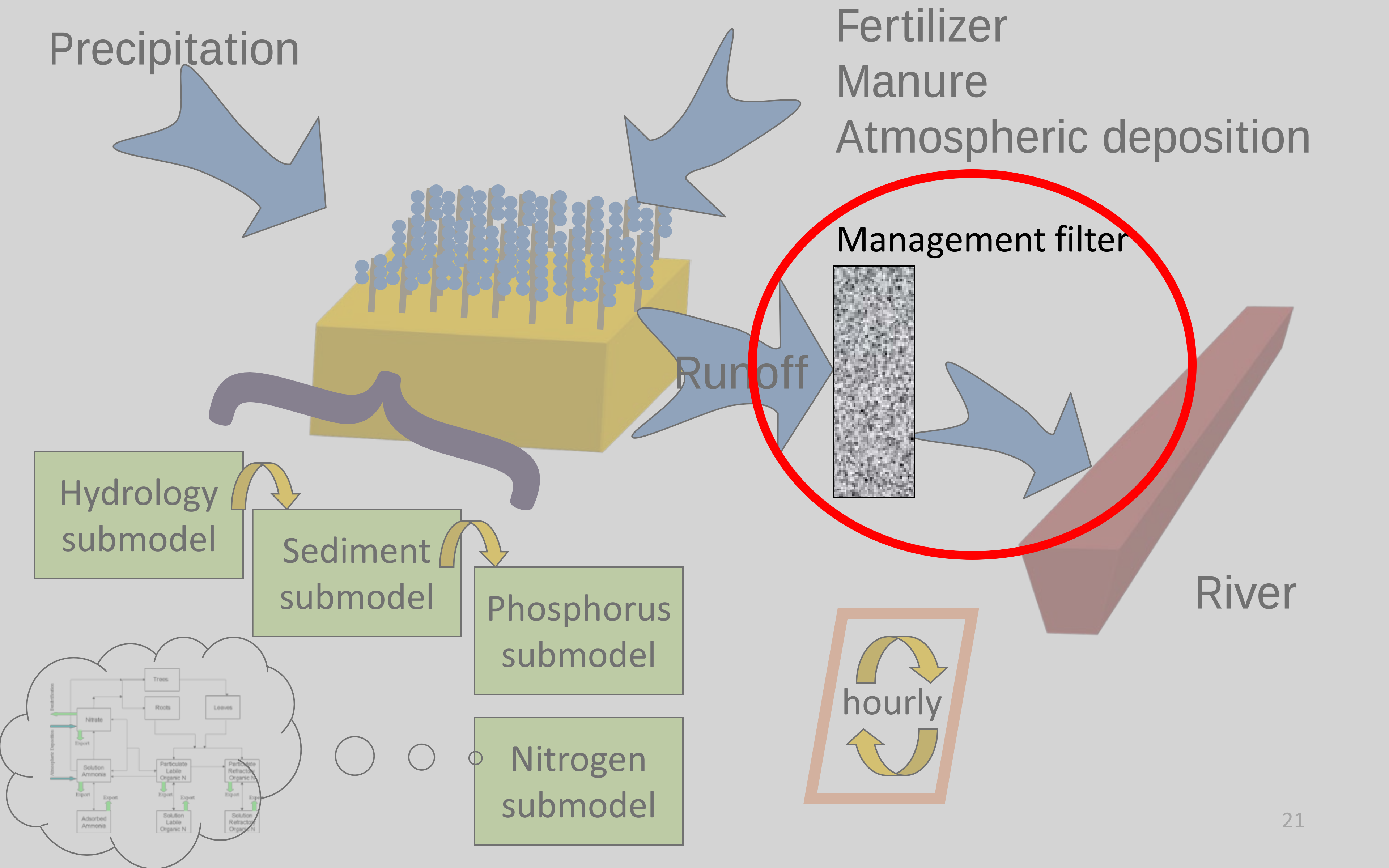


Explanatory variables	Estimate	Units	90-percent confidence interval	Standard error	p^1
Total Nitrogen, 2002 (n = 181, MSE = 0.0836, RMSE = 0.289, flux R^2 = 0.978, yield R^2 = 0.858					
Sources					
Point sources (kg yr^{-1})	0.774		0.375 – 1.17	0.242	0.0008
Crop fertilizer and fixation (kg yr^{-1})	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
Aquatic decay					

Benefits

- The CBP Partnership wants transparency:
  - Simplicity
  - Scalability
  - Ease of Use
  - Understandability
- Ease of calibration and operations
- Clear role for multiple models

Multiple Models in the Watershed Model



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

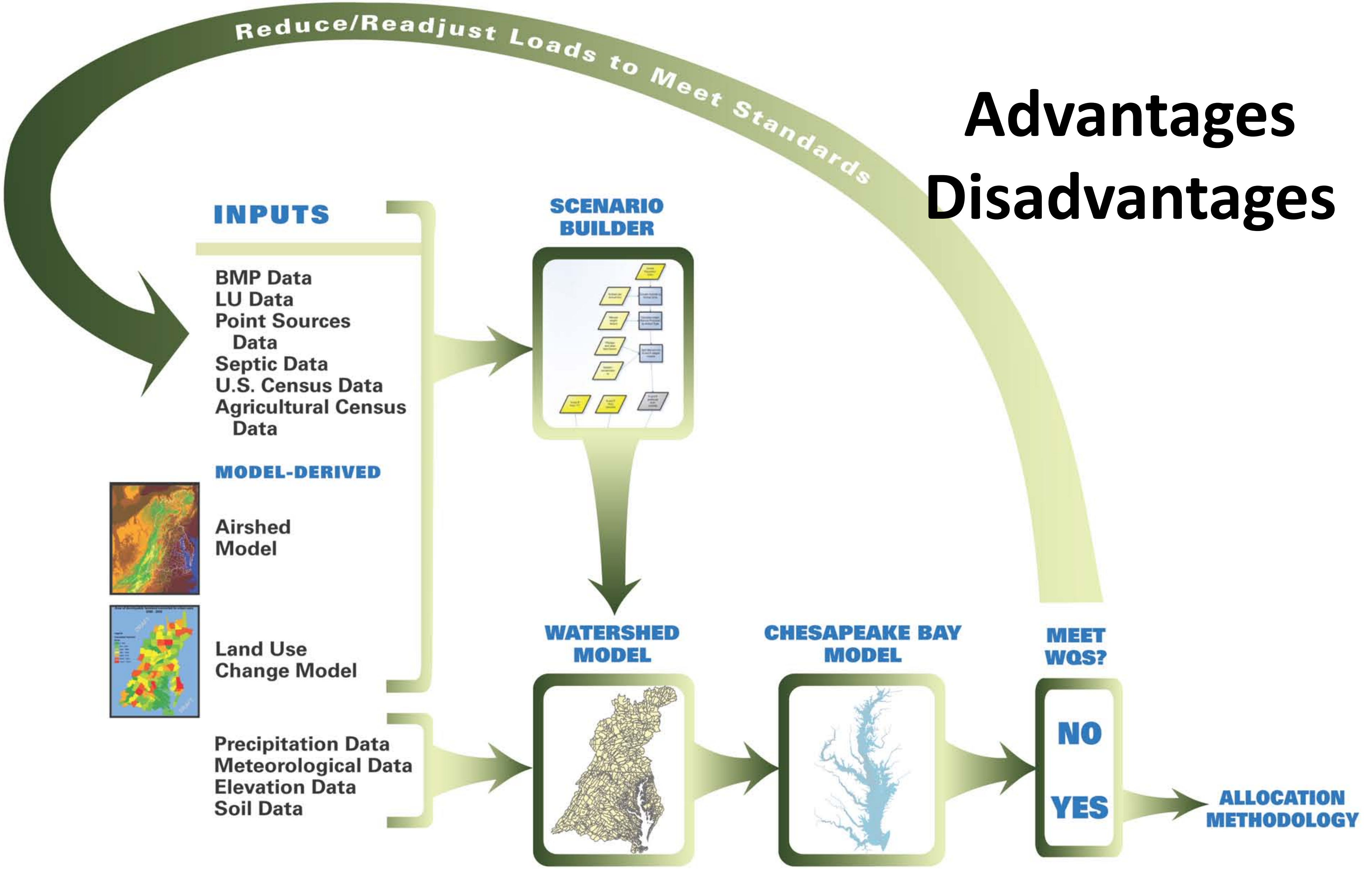
- Urban Retrofits
- Performance Based Management
- Stream Restoration
- LID and Runoff Reduction
- Urban Fertilizer Management
- Erosion and Sediment Control
- Illicit Discharge Elimination
- Impervious Disconnect
- Floating Wetlands
- MS4 Minimum Management Measures

Forestry

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

Multiple Models

Advantages
Disadvantages



Scientific advantages of MM

- Compares hypotheses about system function
- Identifies agreements (high confidence)
- Identifies disagreements (low confidence)
- Guides research and data collection
- Helps quantify uncertainties
  - Prediction uncertainty
  - Model selection uncertainty

Possible management benefits

- Demonstrate skill of decision model (as good or better than others)
- Bolster confidence (scientists, managers, & public) in model and decisions based upon it

CBP

Possible objections to MM

- More work, costs more
- Highlights uncertainties
- May confuse public and decision makers
- May provoke legal challenges
- May be incompatible with CWA and TMDL rules

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CBP

Difference between Hurricane and TMDL: Managers decide where the TMDL lands