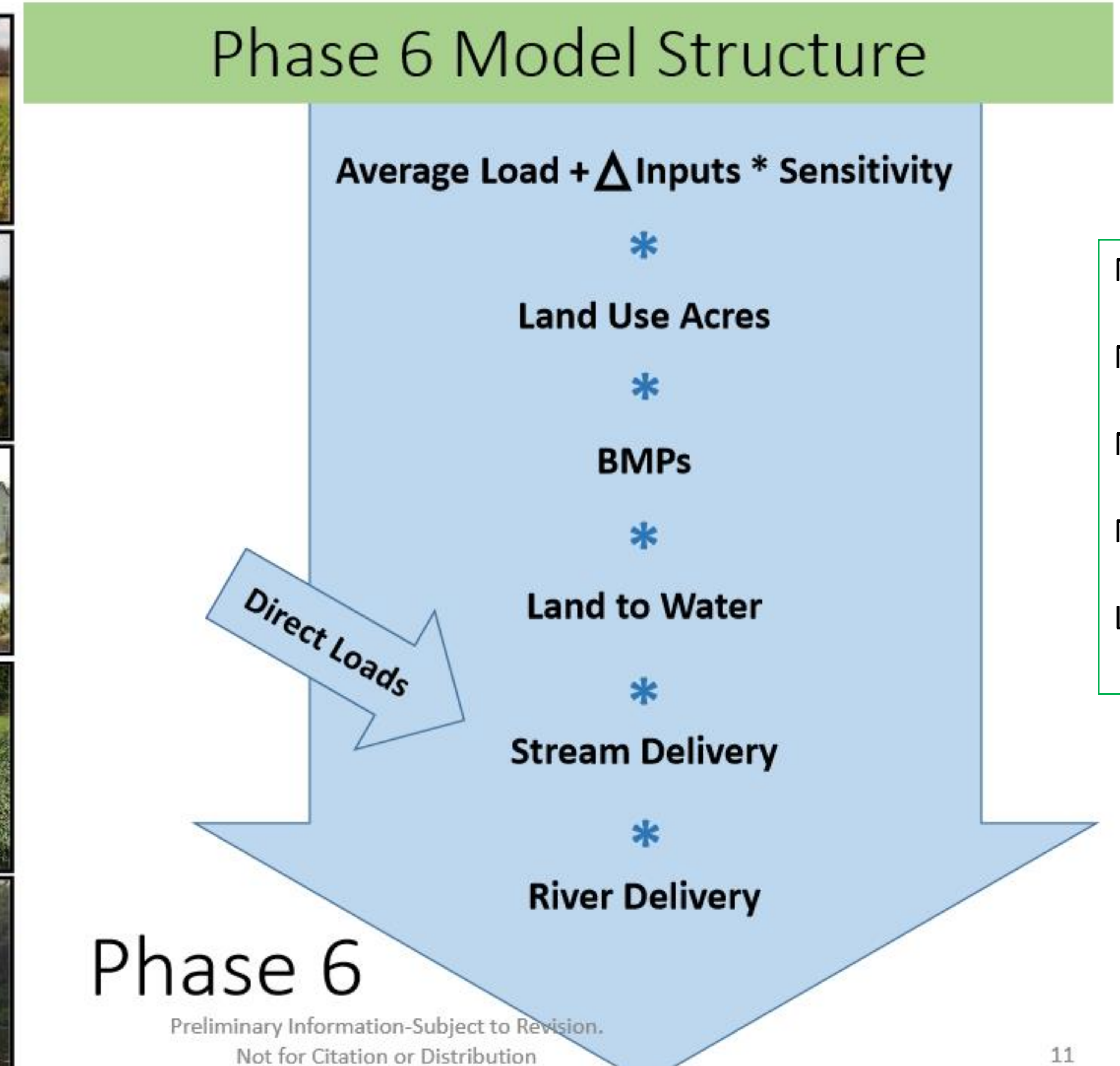
Partnership Review 6.0

Ag WG June 29, 2017

Bill Angstadt, WQGIT member



N Target Load

N Average Load

N spread

NM BMP

Land to Water coefficient

P Average Loads

P Loading Ratio

P Export Rate

P soil mass balance *crop removal

P runoff

P Sensitivity

P Target Loads

Sector Equity

Measuring Progress

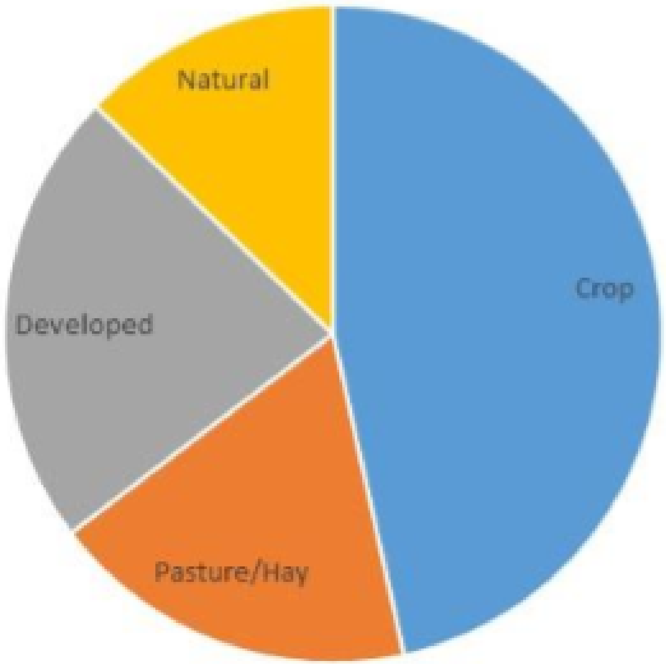
Partnership Review

A fatal flaw may be the basis for the implementation of changes to the draft Phase 6 models.

A fatal flaw is defined as a significant impediment, based on a weight of evidence approach, of the ability of the partnership to establish reasonable planning targets or evaluate progress toward achieving the planning targets or meet the conditions of EPA's "Interim Expectations for the Phase III Watershed Implementations Plans," dated January 19, 2017 (Expectations Document) due to:

- A calculation or method that does not follow the documented final decisions of the CBP partnership
- A calculation or method, or combinations thereof, that produce illogical results that result in significant impediment
- The omission of data submitted by the CBP partnership subject to established deadlines
- The overall failure of the model calibration to match observed flows and loads when compared to the level of performance in previous models

Average Loads



The Agricultural Land Use Loading Rate Subgroup determined that the phosphorus export rate for cropland and pasture land uses is a function of the soil P storage and landscape properties rather than land use.

January 21, 2016 AgWG Decision: DECISION: The AgWG approved the final Phase 6.0 Ag Land Use Loading Ratios Report.

Phase 6.0 Ag Land Use Loading Ratios Report

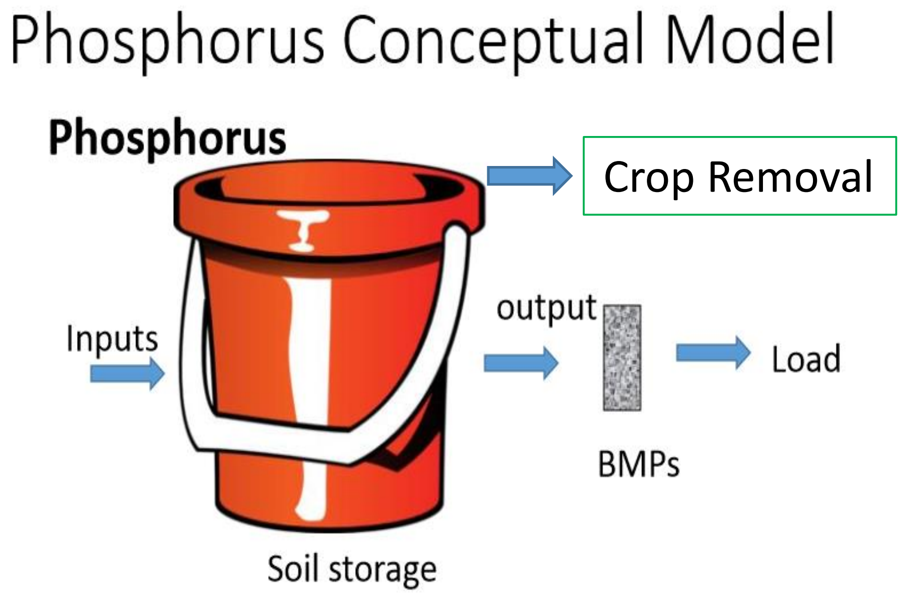
- Recommendation: Since the APLE2.4 simulated phosphorus loads also encompass sub-factors that incorporate land use and geographically-distributed characteristics, our Sub-group also endorsed using APLE 2.4 as a reasonable basis for P6 land use derived phosphorus loads. Since land use and geographical variability is already incorporated into the phosphorus calculation, the Sub-group recommends no additional adjustment for land use be made to the APLE2.4 predictions of EOF phosphorus loads. Any fractional adjustment to these loads during calibration should also be applied equally to all land uses.
- For future review: Although our Sub-group endorsed the use of APLE2.4 for generating phosphorus loads and relative loading ratios, current results from APLE2.4 simulated phosphorus loads are based on RUSLE and soil P concentrations from Phase 5.3.2, and simulated results using the RUSLE2 erosion loads and the updated soil P test results should be reviewed for consistency.

Use of Multiple Models
for Phosphorus Export Rate

Land class	Crop	Pasture/Hay	Developed	Natural
Acres above RIM stations	2,620,895	4,535,321	2,690,480	21,458,991
P532 Loading Rate (pounds per acre per year)	2.23	1.48	1.22	0.12
CEAP Loading Rate (pounds per acre per year)	3.12	1.29	Not used	0.10
SPARROW Loading Rate with BMP effects removed (pounds per acre per year)	0.94	0.22	0.34	0.06
Average Ratio to Crop Rate	1.00	0.44	0.46	0.05
Average Land class Loading Rate (phosphorus pounds per acre per year)	1.87	0.81	0.85	0.09
Total Land class Load (million pounds per year)	4.89	3.69	2.38	1.98

Phosphorous

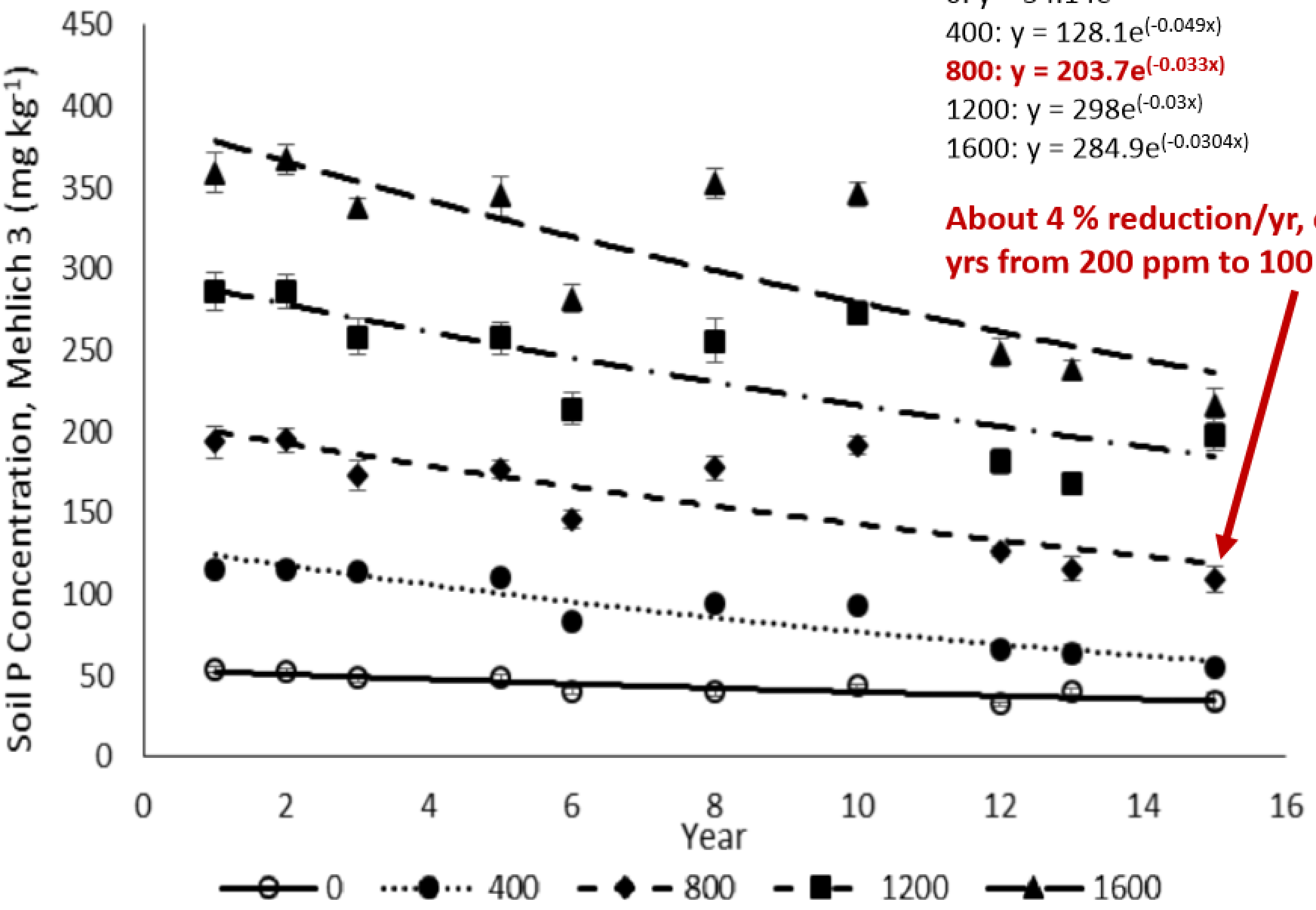
- (March 16, 2017) DECISION: The AgWG approved the AMS recommendation to simulate soil P history by using a mass balance modeling approach combining APLE and soil test data. This decision was made with Pennsylvania abstaining.



Basis for 25 Years?

0: $y = 54.14e^{(-0.0306x)}$
400: $y = 128.1e^{(-0.049x)}$
800: $y = 203.7e^{(-0.033x)}$
1200: $y = 298e^{(-0.03x)}$
1600: $y = 284.9e^{(-0.0304x)}$

About 4 % reduction/yr, or 25 yrs from 200 ppm to 100 ppm



Fiorellino, et al., 2017 https://dl.sciencesocieties.org/publications/aj/abstracts/109/2/455?access=0&view=pdf

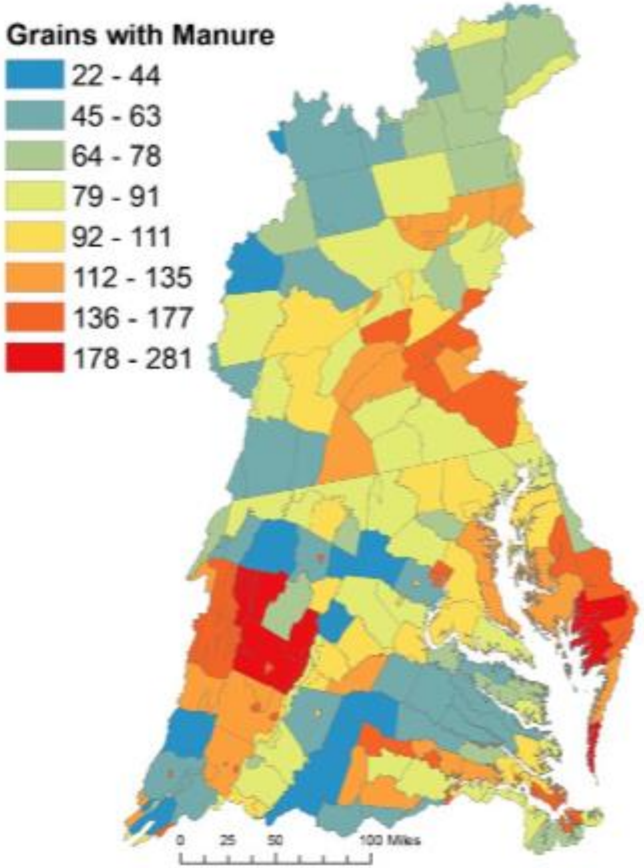
How P Runoff Responds to Time

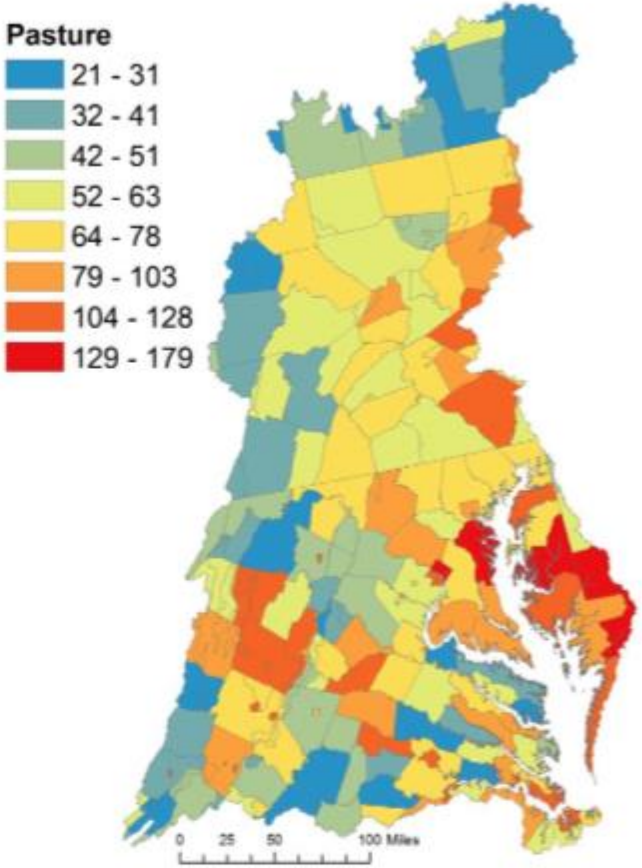
- Assume an annual 4 ppm decrease in soil P in a scenario. Everything else remains constant.
- Remember that average, annual P runoff for crop land uses is 1.87 lbs P/acre.

Input	Input Unit	Change in EOSS P loss (lbs)	Runoff (1 Yr)	Runoff (10 Yrs)	Runoff (25 Yrs)
Soil P	**ppm**	**0.015**	**-0.06**	**-0.6**	**-1.5**
Sediment Washoff	ton/ac	0.168	0	0	0
Runoff	Inches	0.057	0	0	0
Water Extractable P (WEP)	lbs/acre	0.018	0	0	0

Soil Mehlich 3 reanalysis using APLE

- APLE model was calibrated against observed soil Mehlich 3 data using Beta 3 nutrient inputs.





See appendix for variability in Soil Mehlich 3 for P6 agricultural land uses, and across P6 land segments

Average Load + Δ Inputs * Sensitivity

P Load from grain without manure =
1.87 + 0.013 * (Mehlich – 98.2) ppm
+ 0.144 * (storm runoff - 6.73) inches
+ 0.049 * (sediment loss - 4.75) tons
+ 0.015 * (WEP – 14.3) lbs

Question: How does a farm manage for load reduction?

Grain without Manure	TP	TP	Fert	0
Grain without Manure	TP	TP	Runoff	0.0492
Grain without Manure	TP	TP	Sediment	0.1449
Grain without Manure	TP	TP	SoilP	0.0129
Grain without Manure	TP	TP	WEP	0.0179
Grain with Manure	TP	TP	Fert	0
Grain with Manure	TP	TP	Runoff	0.0492
Grain with Manure	TP	TP	Sediment	0.1449
Grain with Manure	TP	TP	SoilP	0.0129
Grain with Manure	TP	TP	WEP	0.0179

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

High Till Landuse
APLE Model Sensitivity Analysis

Parameter	Slope (Sensitivity)	R^2	Median *Sr*	Max *Sr*	Min *Sr*
Mehlich (ppm)	0.016	0.745	0.685	0.914	0.230
Sediment (Ton/a)	0.179	0.805	0.598	0.938	0.036
Manure (lbs/a)	0.026	0.924	0.404	1.554	0.044
Runoff (inches)	0.070	0.784	0.396	3.055	0.027
Fertilizer (lbs/a)	0.015	0.853	0.229	0.740	0.034
Uptake (lbs/a)	-0.012	0.848	0.165	0.502	0.042

APLE is more sensitive to mehlich, sediment, manure, and runoff than to fertilizer and uptake

Documentation 4A - Sensitivity analysis of the HSPF AGCHEM Model

Richard Tian, Guido Yactayo, Gary Shenk, Lewis Linker

September 2013

- Therefore, for the 2017 mid-point assessment, it is planned to shift from a combined PQUAL and AGCHEM simulation, which was systematically used in the previous phases of the Chesapeake Bay Program, to a full version of PQUAL. However, the Chesapeake Bay Program must develop a new version of PQUAL as robust as the ACHEM prior to application. To this end, the Chesapeake Bay Program Modeling Team has conducted a series of comprehensive sensitivity analyses of the AGCEHM simulation between all nutrient inputs and outputs over all land segments and all land uses in the Bay watershed. The functions resulted from these sensitivity analyses will be used to specify functional links between nutrient inputs and outputs in the PQUAL version of the Watershed Model.
- These scenarios were simulated over ten years from 1991 to 2000 and average annual data of both inputs and outputs were used for the analyses.

10C Targets Draft Final

Average Load + ΔInputs * Sensitivity

LoadSource	LandSegment		TN/Acre	beta 6/17	TP/Acre	beta 6/17
Grain without Manure	N24029	Kent MD	38.0	39.07	1.42	1.87
Grain with Manure	N24029		59.3	54.7	1.49	
Silage without Manure	N24029		43.1	45.33	1.67	
Silage with Manure	N24029		59.0	63.3	1.74	
Grain with Manure	N42055	Franklin	57.0	54.7	1.29	
Silage without Manure	N42055		46.5	45.33	1.59	
Grain without Manure	N42055		39.9	39.07	1.15	
Silage with Manure	N42055		67.4	63.3	1.75	
Grain without Manure	N42075	Lebanon	40.7	39.07	1.42	
Grain with Manure	N42075		58.0	54.7	1.56	
Silage without Manure	N42075		47.3	45.33	1.85	
Silage with Manure	N42075		68.6	63.3	2.02	

Chesapeake Bay Program Phase 6 Watershed Model – Section 2 – Average Loads Draft Phase 6 – for partnership review – 6/1/2017

Section 2.5

An area of considerable uncertainty is the phosphorus losses in stream reaches that are not reservoirs.

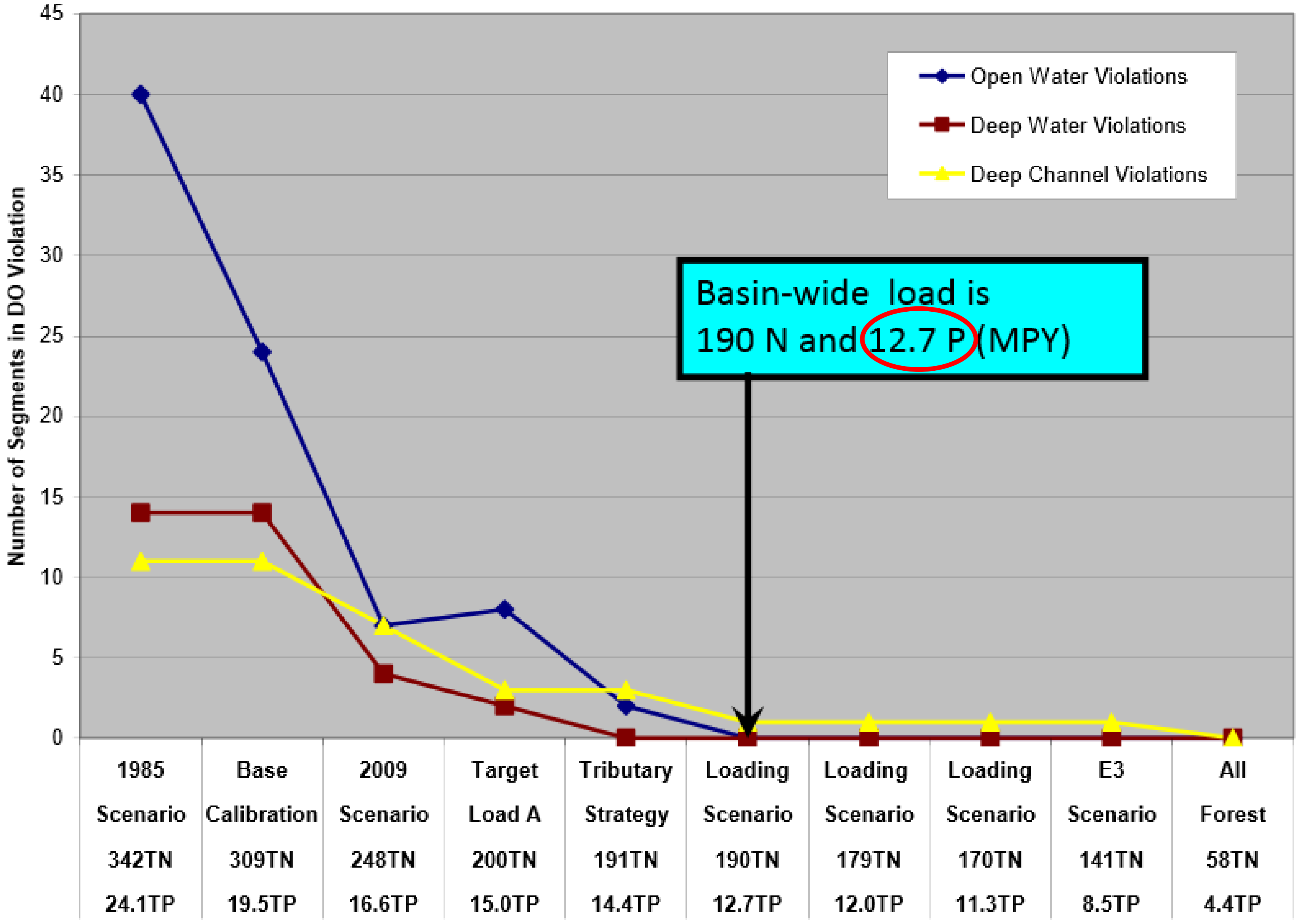
Ator and others, 2011, Noe and others 2015a and 2016b indicate that the losses in free-flowing streams and rivers are relatively small.

The Phase 5.3.2 watershed model had a significant loss of 12.8 million pounds of P in these systems.

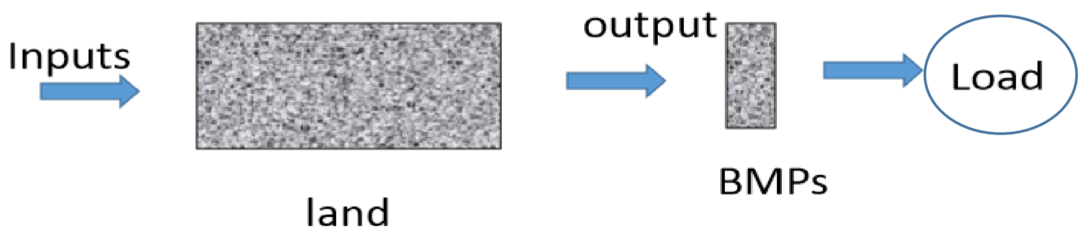
Attempts to calibrate the Phase 6 model in beta versions using the assumption of no let loss were not successful. Several major river systems had more phosphorus measured at the output than was generated by all upstream sources.

For this reason, the Phase 5.3.2 losses of 12.8 million pounds were used in the final version.

Dissolved Oxygen Criteria Attainment



Nitrogen Conceptual Model



Land to Water coefficient

SPARROW

1 lb reduction in fertilizer is about a quarter lb reduction in output

Table 7-2: Estimated Coefficients and Statistics from SPARROW Nitrogen Model of the Chesapeake Bay Watershed, Version 4

Variable	Estimate	90% Confidence Interval	Standard Error	P-value
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
Urban2 (km^2)	1090	707 – 1480	234	< 0.0001
Land-to-Water Delivery				
ln(Mean EVI for WY02 (dimensionless))	-1.7	-2.65 – -0.737	0.58	0.0039

- less than 6 percent of TN from manure and TP from both fertilizers and manure is transported to watershed streams
- Approximately 24 percent of estimated nitrogen applications in fertilizers and direct fixation by crops reaches watershed streams

Use of Multiple Models
for Nitrogen Export Rate

Land class	Crop	Pasture/Hay	Developed	Natural
Acres	2,620,895	4,535,321	2,690,480	21,458,991
P532 No BMP Loading Rate (pounds per acre per year)	47.51	14.95	16.80	4.21
CEAP Loading Rate (pounds per acre per year)	42.52	10.19	Not used	1.61
SPARROW Loading Rate with BMP effects removed (pounds per acre per year)	22.35	7.30	8.35	0.40
Average Ratio to Cropland Rate	1.00	0.29	0.36	0.05
Average Land class Loading Rate (pounds per acre per year)	38.22	11.22	13.90	1.84
Total Land class Load (million pounds per year)	100.16	50.88	37.39	39.45

Phase 5 Average Targets

Land Use	TN Lbs/Acre	TP Lbs/Acre
Nursery	240	85
Crop	23	2-2.5
Harvested Forest	20	0.8
Extractive	12.5	3.5
Urban	9.3	1.5
Hay	6	0.4-0.8
Pasture	4.5	0.7
Forest	2	0.15

Table 3.7. Estimates of long-term average annual field-level effects of conservation practices on nitrogen sources and loss pathways on cropped acres in the Chesapeake Bay region: the no-practice scenario, 2003-06 baseline condition, and 2011 conservation condition.

Model simulated outcome	Average annual values in pounds per acre			---Percent Change ---	
	No-practice Scenario	2003-06	2011	No-practice to 2003-06	2003-06 to 2011
All cropped acres					
Nitrogen sources					
Atmospheric deposition	8.8	8.8	8.9	0	0.1
Bio-fixation by legumes	31.9	31.8	36.4	-0.1	4.6
Commercial fertilizer	94.9	73.0	79.7	-21.9	6.7
Manure	24.6	22.0	24.8	-2.6	2.8
All nitrogen sources	160.1	135.6	149.9	-24.5	14.3
Nitrogen in crop yield removed at harvest	99.7	89.0	98.4	-10.7	9.4
Nitrogen loss pathways					
Volatilization	18.4	14.2	17.4	-4.2	3.2
Denitrification processes	1.8	3.0	4.9	1.2	1.9
Windborne sediment	0.11	0.09	0.05	-0.02	-0.04
Surface runoff, including waterborne sediment	27.9	15.7	9.7	-12.2	-6.0
Surface water (soluble)	4.9	2.4	2.1	-2.5	-0.3
Waterborne sediment	23.0	13.3	7.6	-9.7	-5.7
Subsurface flow pathways	30.4	25.9	22.9	-4.5	-3.0
Total nitrogen loss for all loss pathways	78.4	58.8	54.9	-19.6	-3.9
Change in soil nitrogen	-23.3	-17.2	-10.8	6.1	6.4
Highly erodible land (HEL)					
Nitrogen applied as commercial fertilizer and manure	128.8	105.2	103.7	-23.6	-1.5
Total nitrogen loss for surface and subsurface loss pathways	80.5	54.3	36.1	-26.2	-18.2
Non-highly erodible land (NHEL)					
Nitrogen applied as commercial fertilizer and manure	114.9	89.9	105.1	-25.0	15.2
Total nitrogen loss for surface and subsurface loss pathways	47.3	35.5	30.3	-11.8	-5.2
Acres with manure applied					
Nitrogen applied as commercial fertilizer and manure	161.7	133.3	130.8	-28.4	-2.5
Total nitrogen loss for surface and subsurface loss pathways	78.8	58.9	40.5	-19.9	-18.4
Acres without manure applied					
Nitrogen applied as commercial fertilizer	95.0	72.8	80.8	-22.2	8.0
Total nitrogen loss for surface and subsurface loss pathways	46.4	31.7	25.5	-14.7	-6.2

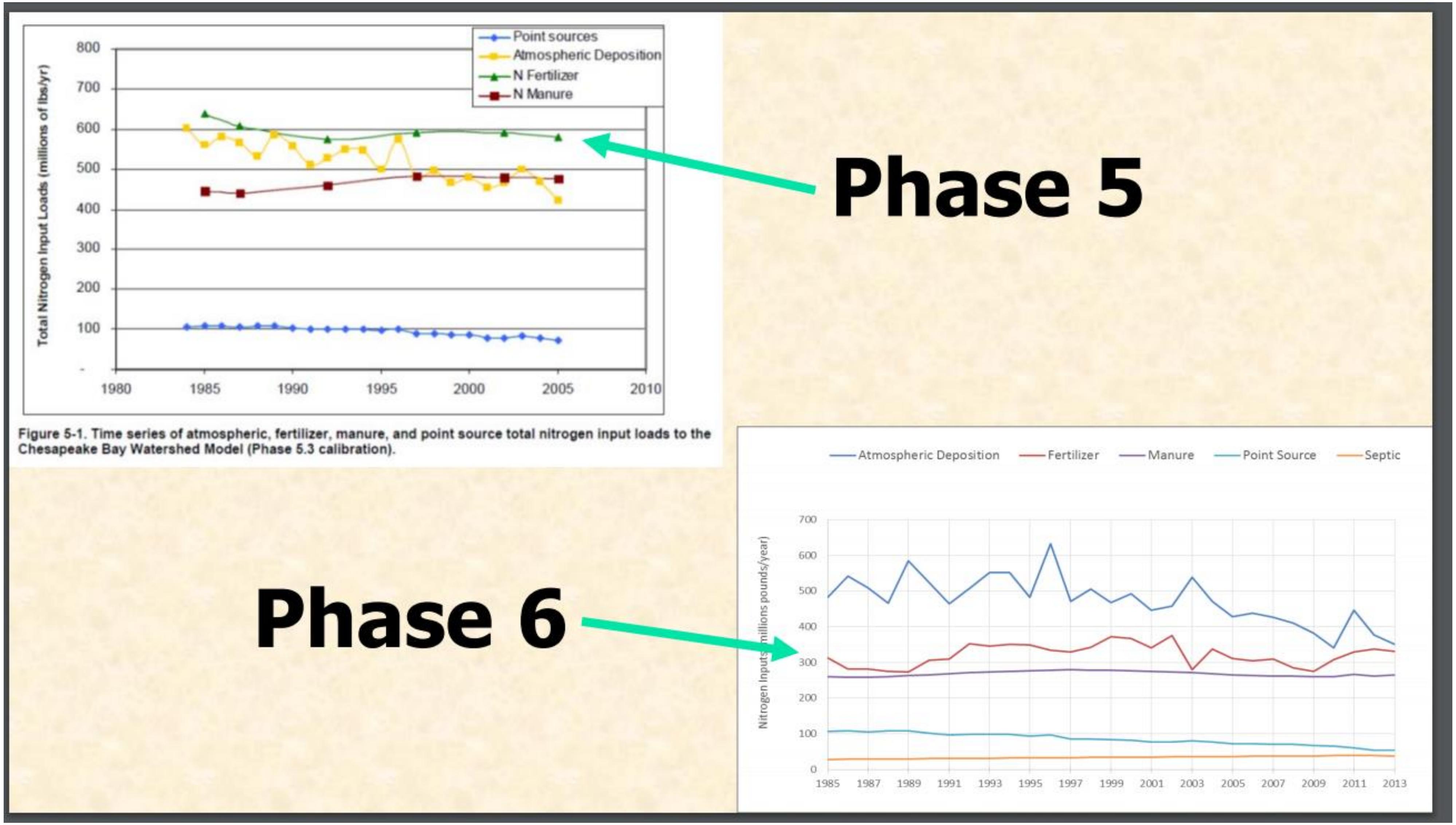
** On about half of the cropped acres, more nitrogen volatilization and denitrification occurs with practices than without practices, resulting in only a small change in nitrogen volatilization and denitrification on average for the region due to conservation practices. In preventing nitrogen loss to other loss pathways, conservation practices keep more of the nitrogen compounds on the field longer, where they are exposed to wind and weather conditions that promote volatilization and denitrification.

Note: Percent reductions were calculated prior to rounding the values for reporting in the table and the associated text. Model simulation results for the baseline conservation condition are presented in Appendix E for the 4 subregions.

Split classes into individual land uses – Crop Nitrogen

Land class	Land Use	Acres	Loading Rate Ratio	Loading Rate (lb/ac/yr)
Cropland	Double Cropped Land	165,396	0.79	30.87
	Full Season Soybeans	282,456	0.71	27.74
	Grain with Manure	389,811	1.4	54.7
	Grain without Manure	451,318	1	39.07
	Other Agronomic Crops	417,838	0.45	17.58
	Silage with Manure	392,156	1.62	63.3
	Silage without Manure	69,204	1.16	45.33
	Small Grains and Grains	291,677	0.84	32.82
	Specialty Crop High	35,525	1.34	52.36
	Specialty Crop Low	125,509	0.31	12.11

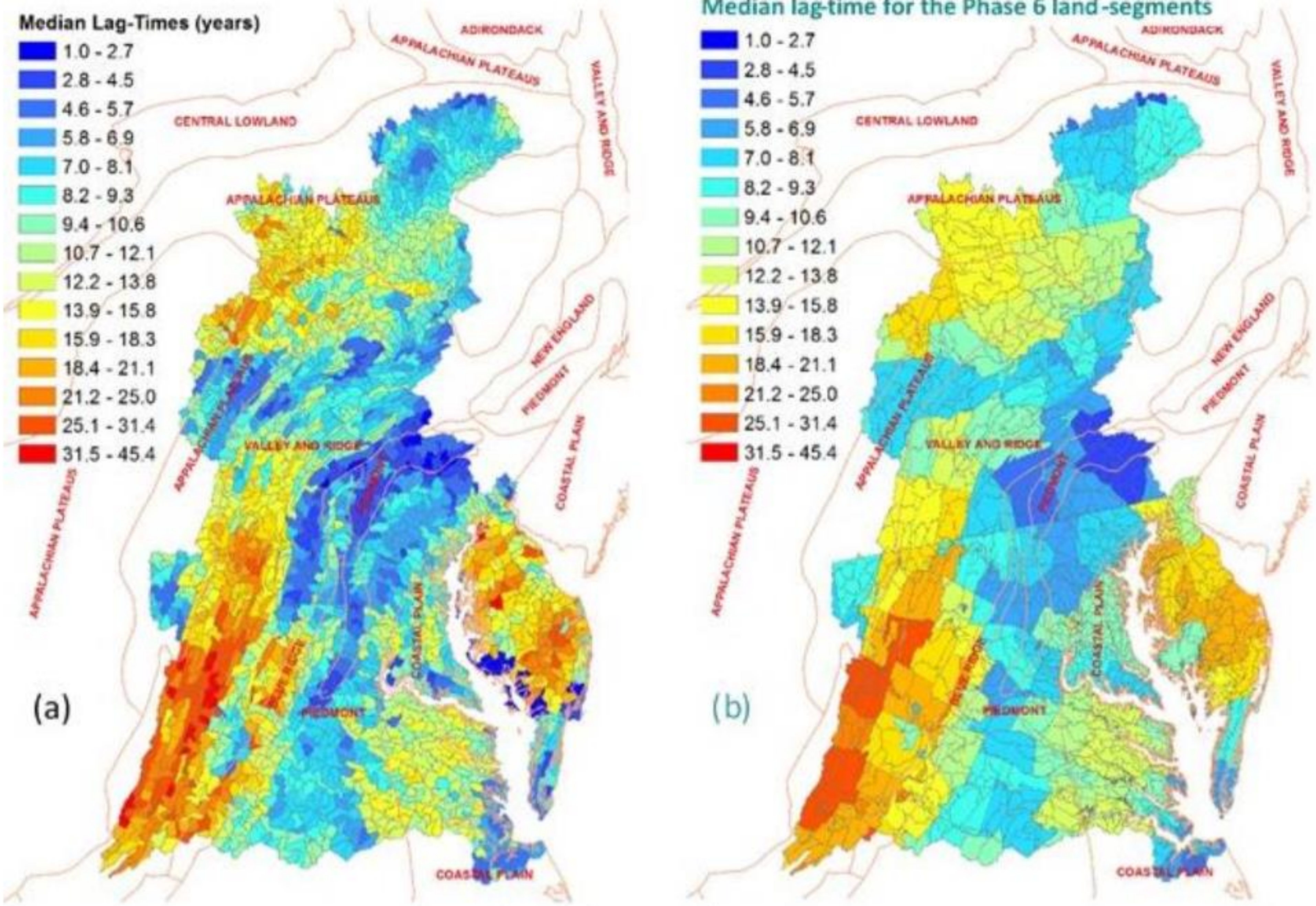
Total nitrogen

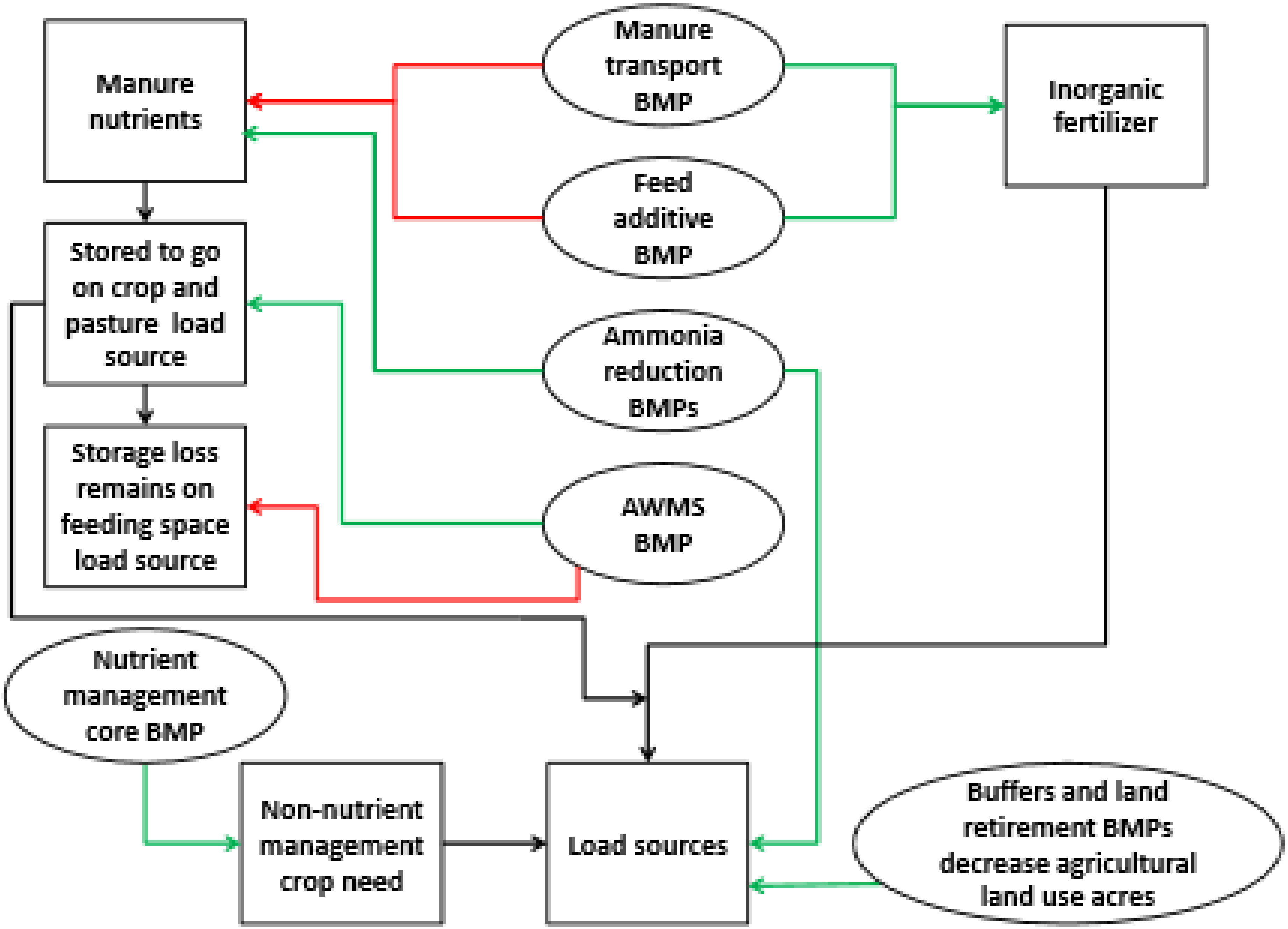


Provided by J. Sweeney, WQGIT 26 June

Draft Phase 6 Values

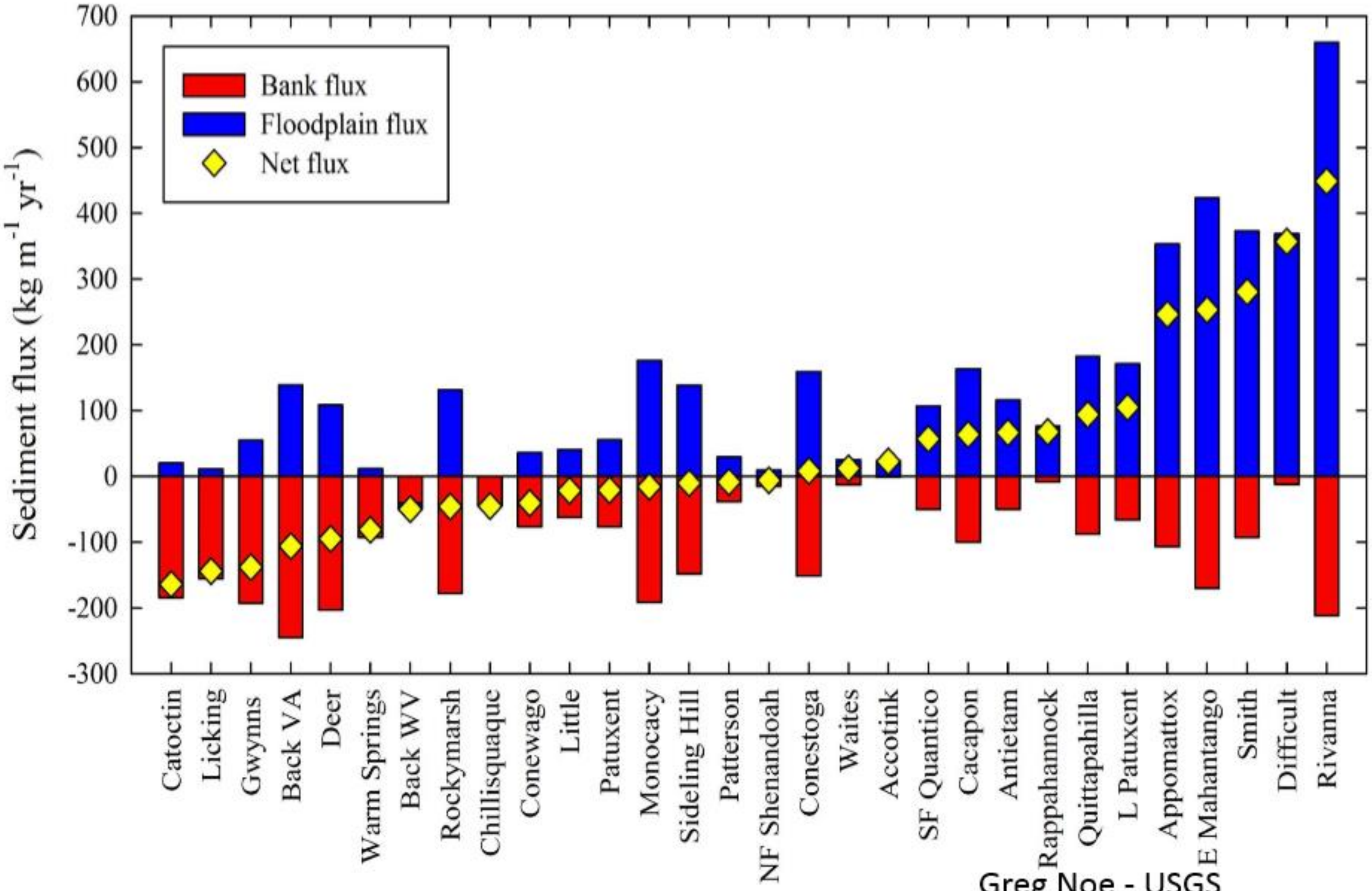
Component	Total Nitrogen		Total Phosphorus	
	Factor (%) or Amount (million pounds per year)	Load (million pounds per year)	Factor (%) or Amount (million pounds per year)	Load (million pounds per year)
Monitored Load at Rim Stations	NA	210.3	NA	13.8
BMP Effects Removed	15.6	226.5	1.5	15.3
River Attenuation Removed	74.7%	270.6	86.9%	19.3
Wastewater Removed	30.8	239.8	5.2	14.1
Animal Feeding Space Removed	18.2	221.7	0.7	13.3
Riparian Pasture Deposition Removed	5.8	215.9	1.8	11.6
Atm. Deposition on Water Removed	6.5	209.4	0.2	11.3
Septic Systems Removed	5.9	203.5	NA	11.3
Rapid Infiltration Basin	0.1	203.5	0.002	11.3
Small Stream Attenuation Removed	89.3%	219.7	88.2%	10.0
Global Edge of Small Stream Load	NA	227.9	NA	12.8


Median Lag-Times (years)
1.0 - 2.7
2.8 - 4.5
4.6 - 5.7
5.8 - 6.9
7.0 - 8.1
8.2 - 9.3
9.4 - 10.6
10.7 - 12.1
12.2 - 13.8
13.9 - 15.8
15.9 - 18.3
18.4 - 21.1
21.2 - 25.0
25.1 - 31.4
31.5 - 45.4
ADIRONDACK
APPALACHIAN PLATEAUS
CENTRAL LOWLAND
VALLEY AND RIDGE
NEW ENGLAND
PIEDMONT
COASTAL PLAIN
(a)
Median lag-time for the Phase 6 land-segments
1.0 - 2.7
2.8 - 4.5
4.6 - 5.7
5.8 - 6.9
7.0 - 8.1
8.2 - 9.3
9.4 - 10.6
10.7 - 12.1
12.2 - 13.8
13.9 - 15.8
15.9 - 18.3
18.4 - 21.1
21.2 - 25.0
25.1 - 31.4
31.5 - 45.4
(b)



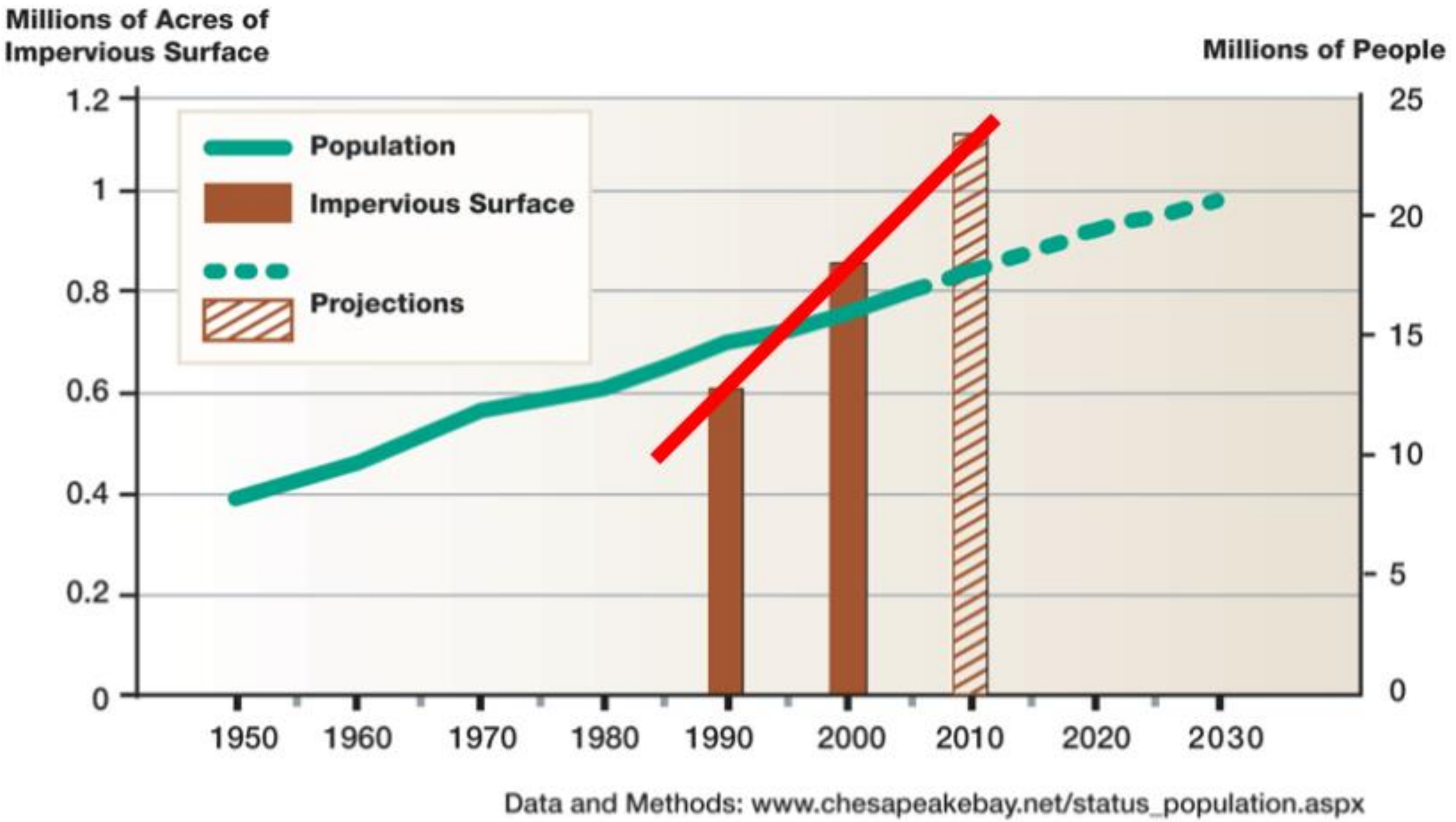
Manure nutrients
Manure transport BMP
Inorganic fertilizer
Feed additive BMP
Stored to go on crop and pasture load source
Ammonia reduction BMPs
Storage loss remains on feeding space load source
AWMS BMP
Nutrient management core BMP
Non-nutrient management crop need
Load sources
Buffers and land retirement BMPs decrease agricultural land use acres

Chesapeake Floodplain Network



Greg Noe - USGS

Bay Watershed Population, Impervious Surfaces and Stormwater Pollution Loads



Conversion of land for DEVELOPMENT since 1970 has grown at double the rate of housing and triple the rate of population