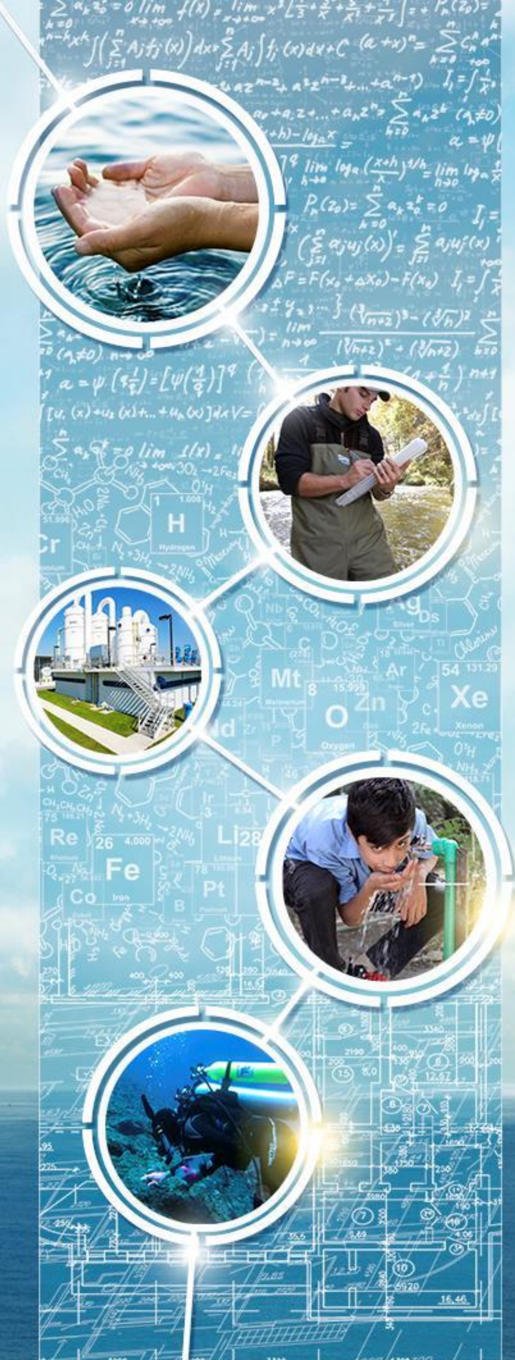


TETRA TECH

Nutrient Attenuation in Chesapeake Bay Watershed Onsite Wastewater Treatment Systems

September 13, 2016

Victor D’Amato

Panel History

- On-Site Wastewater Treatment Systems Nitrogen Reduction Technologies Panel
  - Initial BMP report approved in February 2014
  - Currently considering two additional BMPs
- Attenuation Panel formed in June 2014
  - Approximately 20 conference calls/meeting
  - Approx. 13 engineers, 10 soil scientists, 4 modelers, 3 geologists, 2 hydrologists, others
  - Draft report released yesterday!

Attenuation Panel Charge

Review available science on how to factor nutrient attenuation into Chesapeake Bay TMDL onsite wastewater treatment system load estimates and BMP efficiency factors

- Determine whether the Bay TMDL model can be improved by using variable total nitrogen (TN) attenuation rates
- Determine whether the currently used 100% removal of total phosphorus (TP) is warranted
- Recommend methodologies to be used and specific attenuation rates to be used in different contexts

Attenuation Panelists

Bay States

- **Tom Boekeloo**, New York State DEC
- **Jay Conta**, Virginia Tech/Virginia DOH
- **Marcia Degen**, Virginia Dept. of Health
- **Joshua Flatley**, Maryland Dept. of Environment
- **Jack Hayes**, Delaware DNREC
- **Nick Hong** - PA DEP
- **Dave Montali**, West Virginia DEP

Other Panelists

- **Steven Berkowitz**, North Carolina DHHS
- **Judy Denver**, USGS
- **John Galbraith**, Virginia Tech
- **Barry Glotfelty**, Frederick County (MD) HD
- **Robert Goo**, US EPA - OWOW
- **George Heufelder**, Barnstable County (MA) DHE
- **Michael O'Driscoll**, East Carolina/Duke University
- **David Radcliffe**, University of Georgia
- **Eberhard Roeder**, Florida Department of Health
- **Robert Siegrist**, Colorado School of Mines

Other Contributors and Former Panelists

Chesapeake Bay Program Office

- Lewis Linker
- David Wood
- Ning Zhou

United States Geological Survey (USGS)

- Scott Ator
- John Brakebill
- Andrew Sekellick

Advisors/Contributors

- Rob Adler, US EPA - Region 1 (retired)
- Jim Anderson, University of Minnesota
- Jason Baumgartner, Delaware DNREC
- John Diehl, Pennsylvania DEP (retired)
- Paul Finnell, US Department of Agriculture
- Mengistu Geza, Colorado School of Mines
- Kristina Heinemann, US EPA - Region 2
- Charles Humphrey, East Carolina University
- Joyce Hudson, US EPA - OWM (retired)
- Ruth Izraeli, US EPA - Region 2

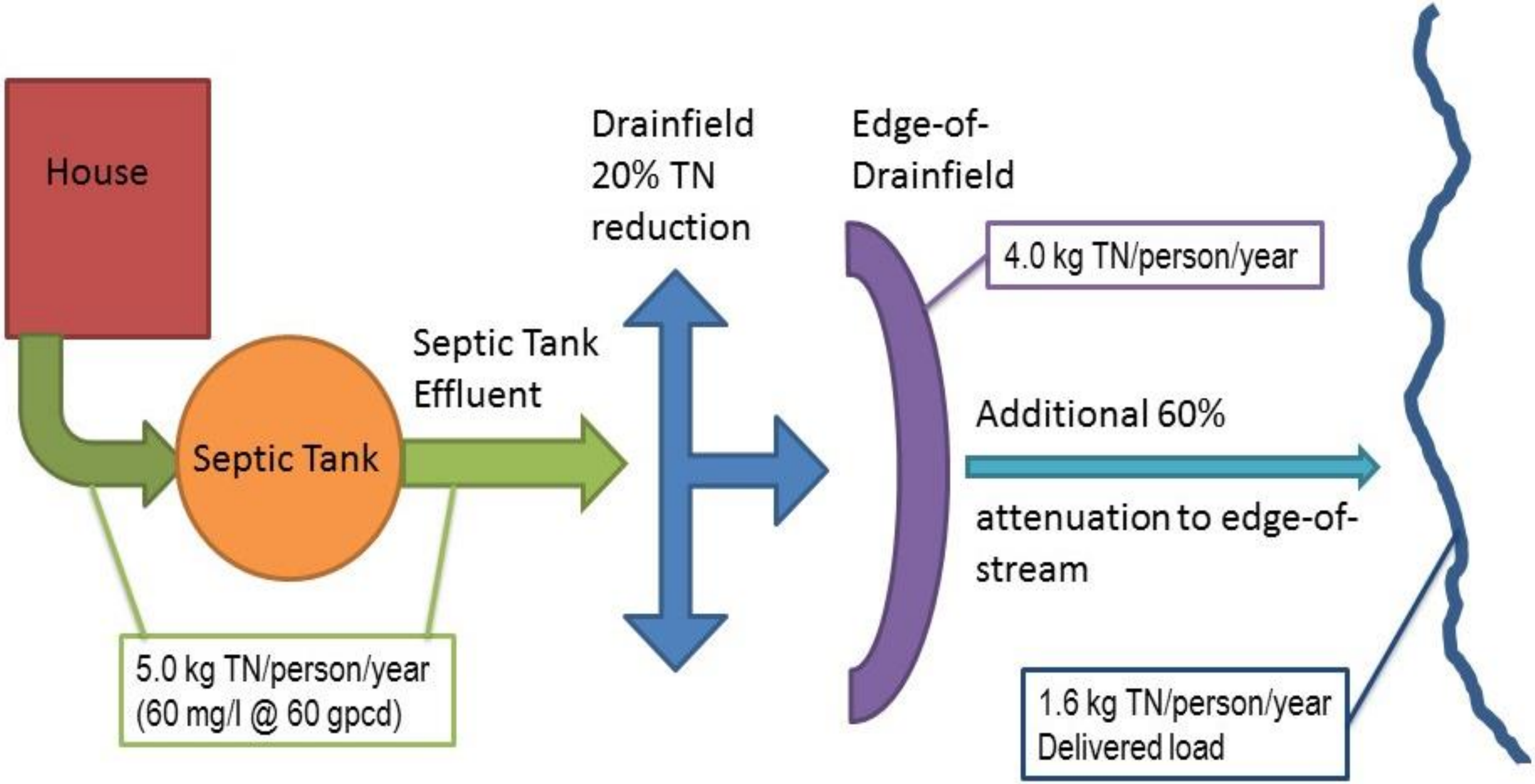
Advisors/Contributors (continued)

- Jim Kreissl, Tetra Tech
- David Lindbo, US Department of Agriculture
- Andrew J. Maupin, Idaho DEQ
- Kevin McLeary, Pennsylvania DEP
- Randy Miles, University of Missouri
- Ross Mandel, ICPRB
- Jeff Moeller, Water Environment Research Foundation
- Rich Piluk, Anne Arundel County (MD) Health Department
- Sushama Pradhan, North Carolina DHHS
- Jay Prager, Maryland Department of Environment (retired)
- Carol Ptacek, University of Waterloo
- Eric Regensburger, Montana DEQ
- David Sample, Virginia Tech
- Durrelle Scott, Virginia Tech
- Ivan Valiela, Cornell University
- Janice Vollero, Pennsylvania DEP
- Kang Xia, Virginia Tech

Methods

- Develop conceptual framework for evaluating and reporting nutrient removal in OWTS
- Literature review
- Modeling, which was used to corroborate findings from the literature
  - STUMOD (Soil Treatment Unit Model) by CSM
  - SPARROW (Spatially Referenced Regression on Watershed Attributes) by USGS

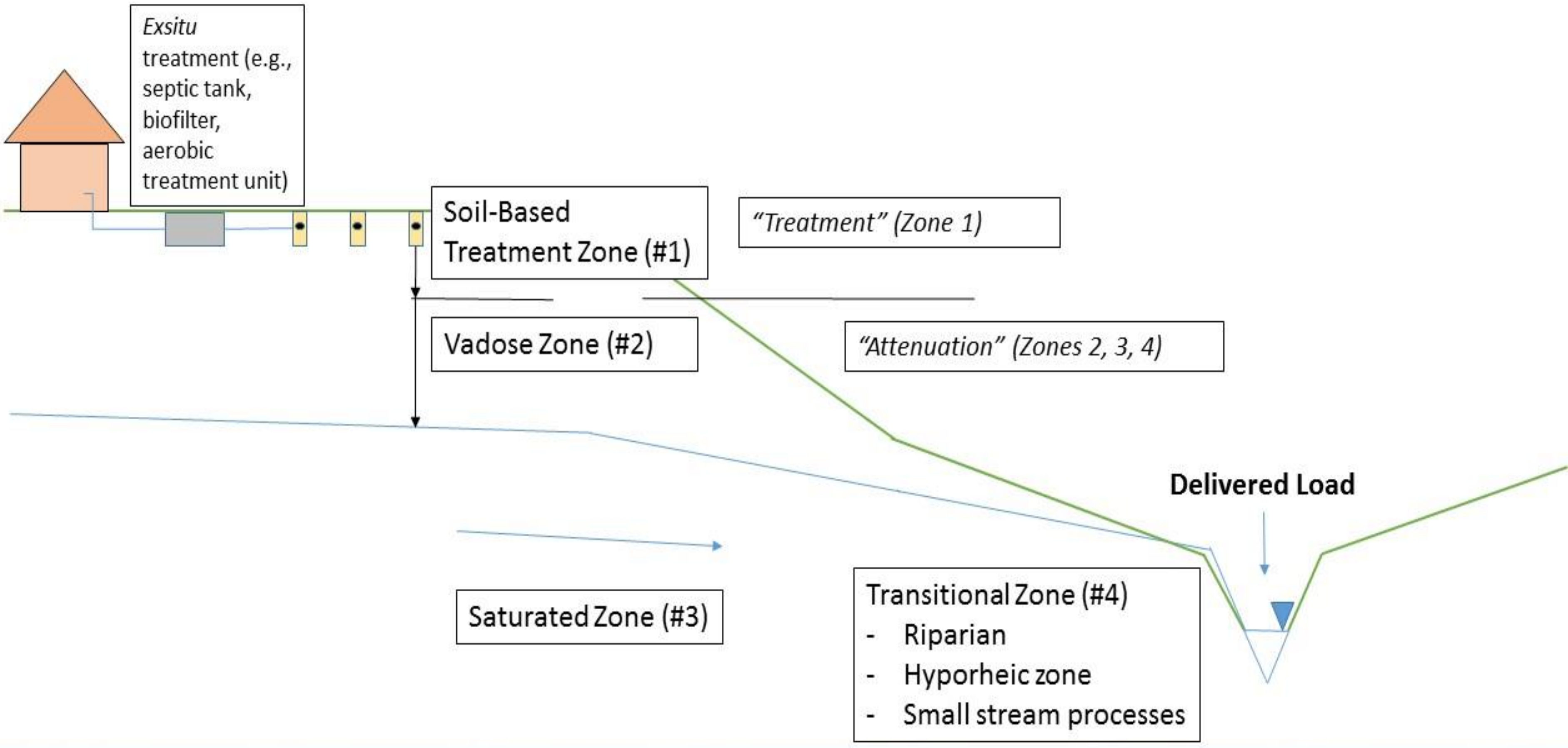
Current CBP OWTS Assumptions



Panel Task: can we improve upon 20% and 60% TN reduction assumptions throughout watershed?

Attenuation Panel Conceptual Framework

Assume: residential wastewater, 5 kg TN/cap/year



Zone Descriptions

- **Zone 1 – Soil-Based Treatment Zone**
  - Extends 30-60 cm below infiltrative surface; outer edge similar to current "edge-of-drainfield"
  - Defined by biogeochemistry induced by wastewater infiltration
  - CBP currently assumes 20% TN reduction watershed-wide
- **Zone 2 – Vadose Zone**
  - TN reduction magnitude and rates similar to background conditions
  - Typically insignificant TN reduction in comparison to other zones
- **Zone 3 – Groundwater Zone**
  - Mostly horizontal flow toward outlet/stream
  - TN reduction function of decay rate and travel time
  - TN reduction varies with hydrogeomorphology
- **Zone 4 – Transitional Zones**
  - Includes floodplain and riparian areas, hyporheic zone, small streams
  - TN reductions can be significant (e.g., >50%)
  - Being partially addressed by other CBP efforts
- **CBP currently assumes 60% for Zones 2-4 watershed-wide**

TN Reductions in OWTS Components

Component	Comment
Exsitu unit 1 (e.g., septic tank)	No TN reduction assumed in septic tank (e.g., TN = 5 kg/cap /day)
Exsitu unit 2 (e.g., intermittent sand filter)	TN reductions based on CBP approved BMP credits
Insitu Zone 1 (Soil-Based Treatment)	Varies by soil texture, based on STUMOD and field observations
Insitu Zone 2 (Vadose Zone)	Assumed low in comparison to Zones 1 and 3; not explicitly addressed by Panel
Insitu Zone 3 (Groundwater Zone)	Varies by physiography and geology, informed by SPARROW modeling and field observations
Insitu Zone 4 (Transitional Zones)	Small stream and riparian processing being partially addressed by other CBP efforts

Zone 1 Results and Recommendation

Soil textural class	Loading rate (cm/day)	TN reduction for a specified depth to groundwater and actual hydraulic loading rate applied			
		30 cm/100%	30 cm/50%	60 cm/100%	60 cm/50%
Sand	4	7%	16%	16%	31%
Loamy sand	4				
Sandy loam	3				
Loam	3				
Silt loam	1.8	11%	30%	34%	59%
Clay loam	1.8				
Sandy clay loam	1.8				
Silty clay loam	1.8				
Silt	1.8				
Sandy clay	1	29%	54%	54%	80%
Silty clay	1				
Clay	1				

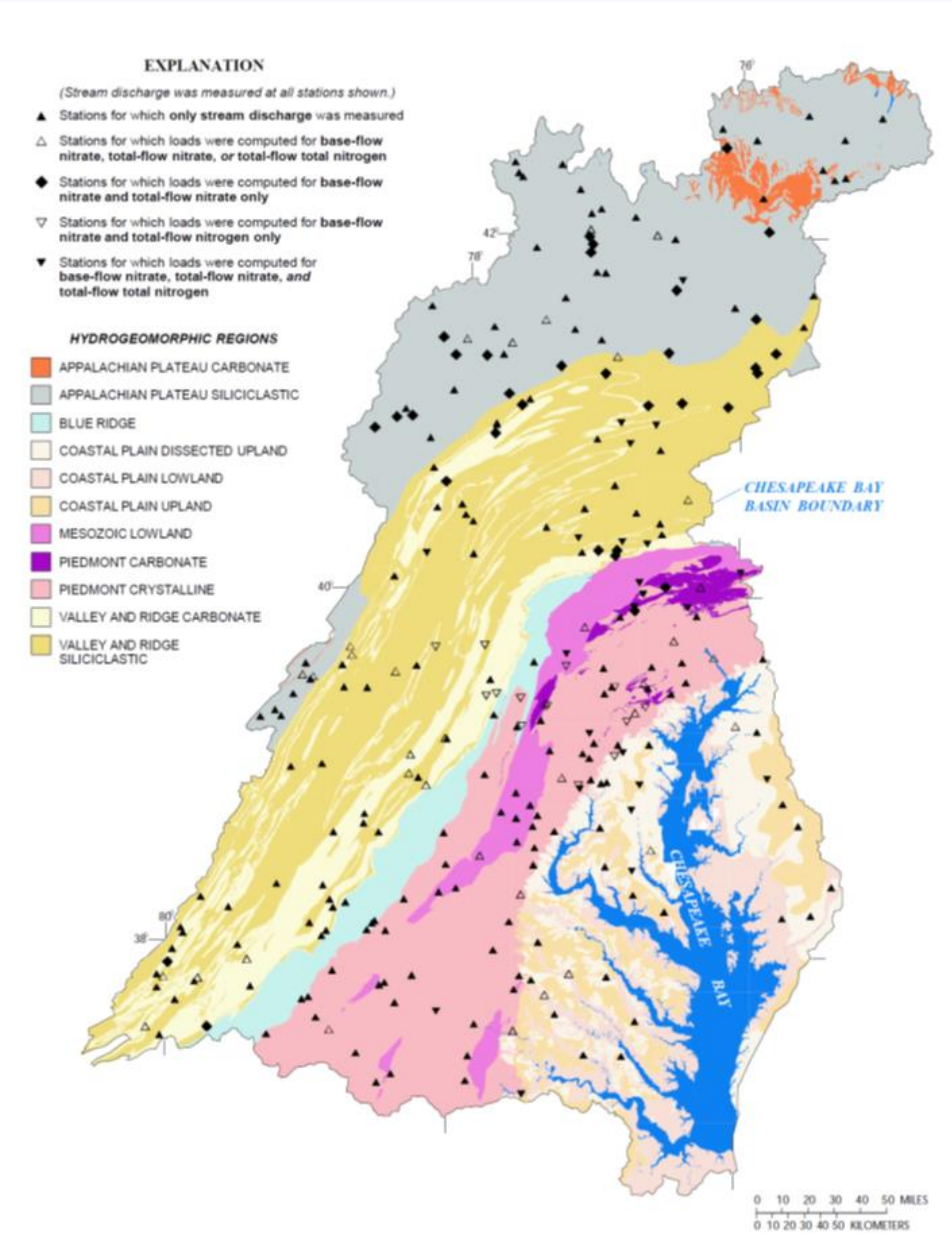
Zone 1 Implications

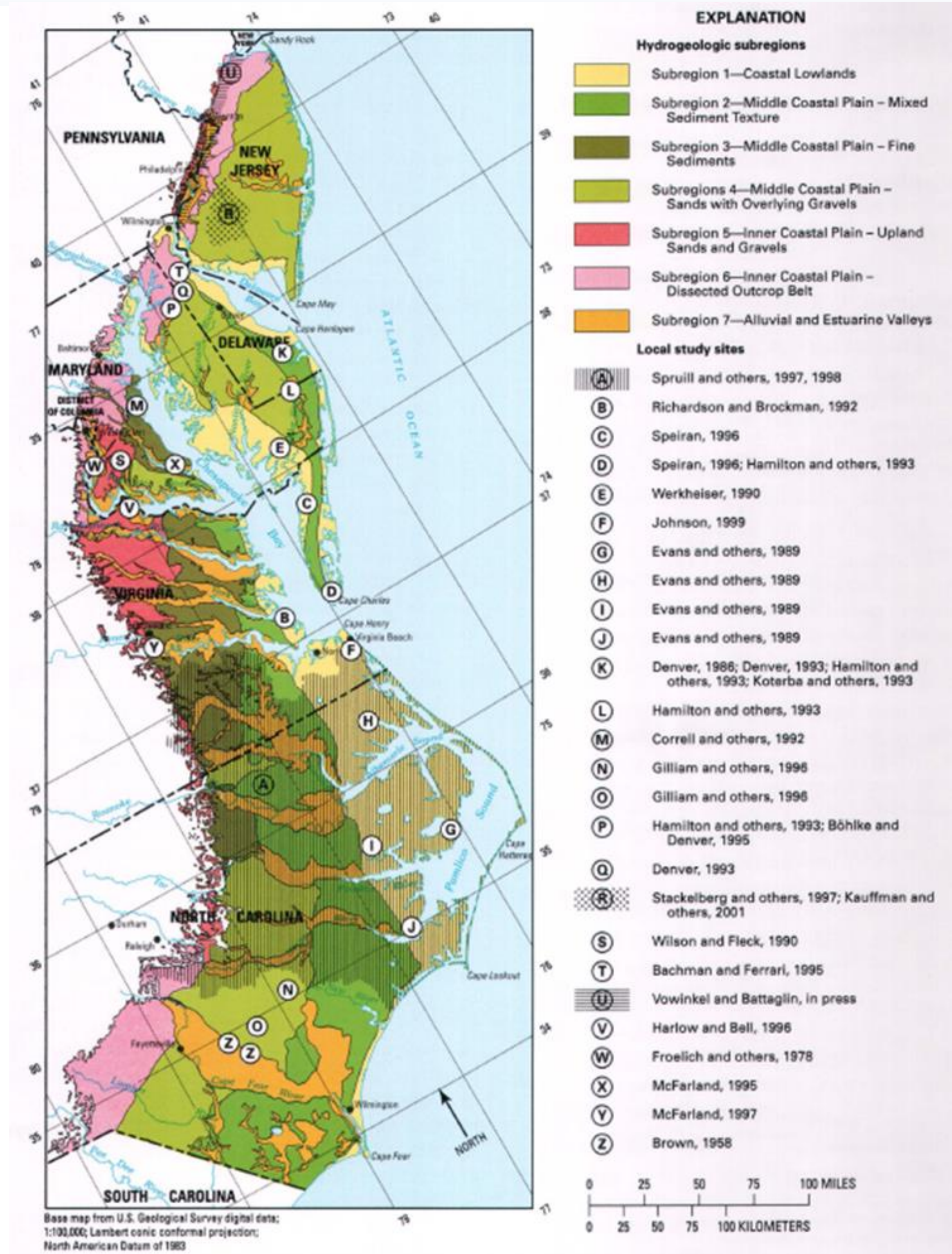
- Change to spatially variable Zone 1 TN reduction rates results in a total OWTS sector load decrease of approximately 4 percent
  - ~ 3 percent increase for sandy soils
  - ~ 16 percent decrease for loamy soils
  - ~ 45 percent decrease for clayey soils

Zone 3 Results and Recommendation

Hydrogeomorphic Region[1]	Relative TN Transmission Classification	Recommended Zone 3 Attenuation Factor (Transmission Factor)
Fine Coastal Plain - Coastal Lowlands	Low	75% (25%)
Fine Coastal Plain - Alluvial and Estuarine Valleys	Low	75% (25%)
Fine Coastal Plain - Inner Coastal Plain - Upland Sands and Gravels	Medium	60% (40%)
Fine Coastal Plain - Middle Coastal Plain – mixed sediment texture	Medium	60% (40%)
Fine Coastal Plain - Middle Coastal Plain – fine sediment texture	Low	75% (25%)
Coarse Coastal Plain - Middle Coastal Plain – Sands with Overlying Gravels (also dissected)	High	45% (55%)
Coarse Coastal Plain - Inner Coastal Plain - Dissected Outcrop Belt	High	45% (55%)
Crystalline Piedmont	High	45% (55%)
Crystalline Blue Ridge	High	45% (55%)
Carbonate Piedmont	Very High	35% (65%)
Carbonate Valley and Ridge	Very High	35% (65%)
Carbonate Appalachian Plateau	Very High	35% (65%)
Siliciclastic Mesozoic Lowland	High	45% (55%)
Siliciclastic Valley and Ridge	Medium	60% (40%)
Siliciclastic Appalachian Plateau	Low	75% (25%)

Zone 3 Implications





Overall Panel Recommendations

Soil Textural Classification	USDA Soil Textures	Low TN Transmission Area	Medium TN Transmission Area	High TN Transmission Area	Very High TN Transmission Area
Sandy	Sand, Loamy Sand, Sandy Loam, Loam	1.1 kg/cap/yr (-31%)	1.7 kg/cap/yr (6%)	2.3 kg/cap/yr (44%)	2.7 kg/cap/yr (69%)
Loamy	Silt loam, Clay Loam, Sandy Clay Loam, Silty Clay Loam, Silt	0.8 kg/cap/yr (-50%)	1.3 kg/cap/yr (-19%)	1.8 kg/cap/yr (13%)	2.1 kg/cap/yr (31%)
Clayey	Sandy Clay, Silty Clay, Clay	0.6 kg/cap/yr (-63%)	0.9 kg/cap/yr (-44%)	1.3 kg/cap/yr (-19%)	1.5 kg/cap/yr (-6%)

Represents delivery to Zone 4 (additional removal possible)

Change from current CBP load (1.6 kg/cap/yr) in parentheses

Caveats

- Recommendations are generally applicable to modern conventional OWTS in the Chesapeake Bay watershed
  - Some conservatism built into Zone 1 estimates to account for OWTS performing suboptimally
  - Some conservatism built into Zone 3 to account for uncertainties
  - Panel did not explicitly discriminate between modern and legacy systems
- Numerous factors can have an impact on nutrient reductions in OWTS
  - Cannot define factors nor determine how they vary from system to system
  - Findings and recommendations represent “average” systems within the context (i.e., soil texture for Zone 1, hydrogeomorphic region for Zone 3)
  - **Care should be taken when using the findings to draw inferences about specific individual systems or in areas known to include an unusually high percentage of legacy or malfunctioning systems**

Recommendations for Future Efforts

- Improve understanding of factors affecting nutrient processing
  - Additional, deeper literature and existing data reviews
  - Collect new empirical and modeling data, including better documentation of existing systems and sites within the watershed
- Address phosphorus treatment and attenuation
  - Performance in different soil types (e.g., coarse sands)
  - Sorption/desorption capacity and dynamics
- Explicitly differentiate between conventional OWTS, and malfunctioning and legacy systems
  - Consider BMPs for reducing malfunctions and upgrading legacy systems
- Consider time distribution of load delivery
  - Long-term system lags that might impact nutrient loading dynamics
  - Short-term nutrient load delivery dynamics (e.g., stormflows)
  - Travel time with respect to Zone 3 TN load reduction estimates

Next Steps

- 9/22: Modeling Workgroup Review and Approval
- Please submit comments as soon as possible. Comments will be accepted up until COB 9/19.

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