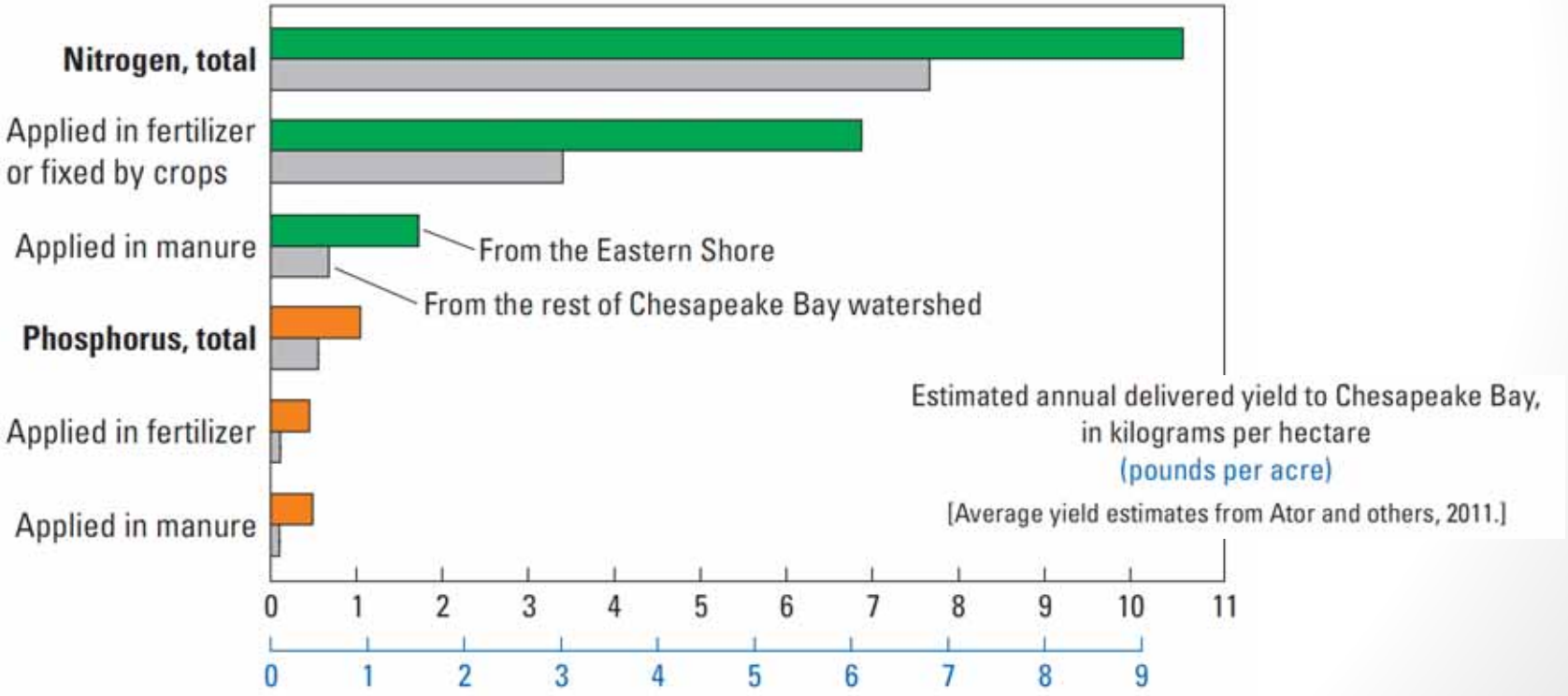
Understanding Nutrients in the Chesapeake Bay Watershed and Implications for Management and Restoration – the Eastern Shore

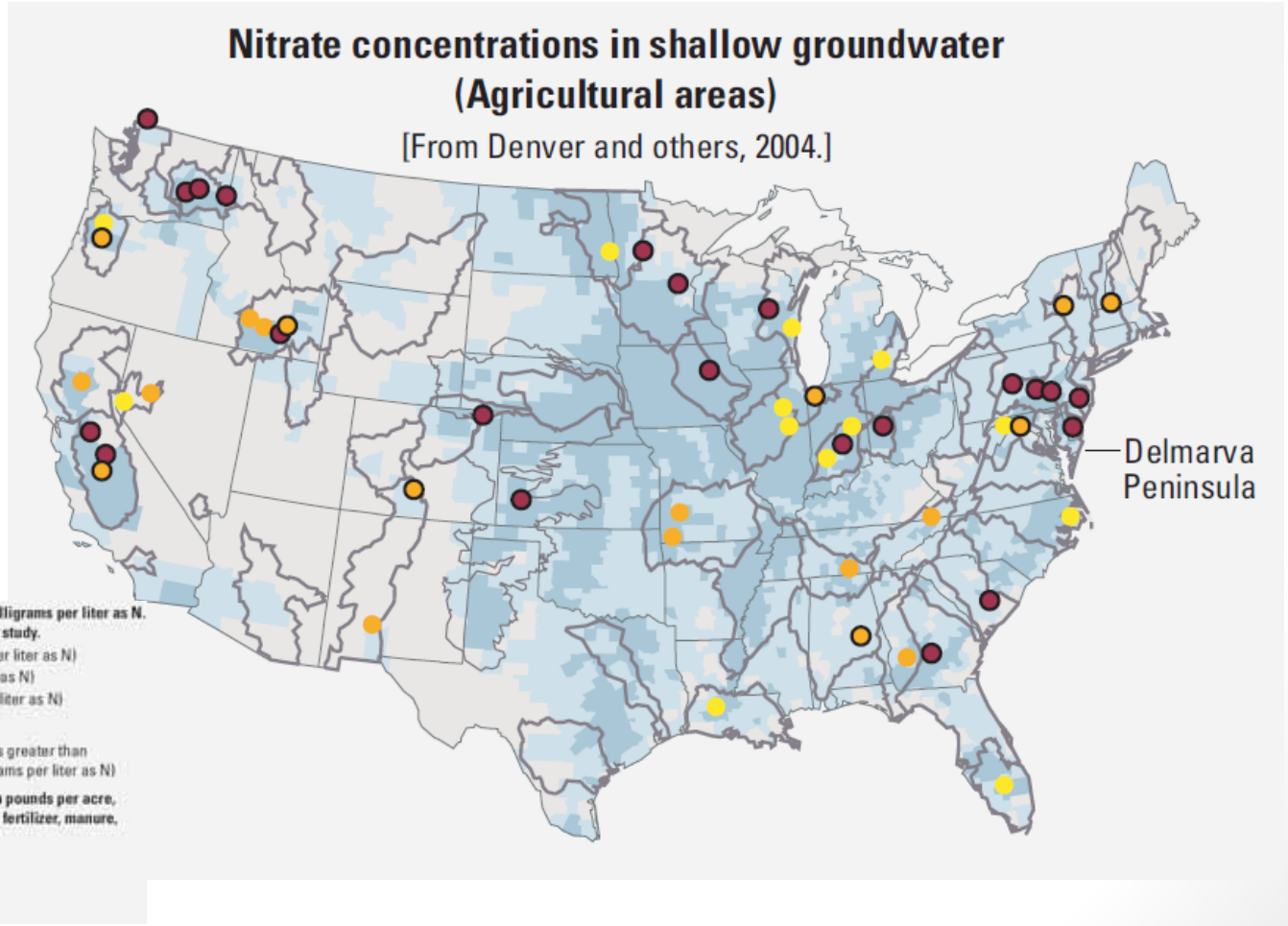
USGS Circular 1406 - 2015

Eastern Shore Identified as a Major Source of Nutrients

- Note: graphic indicates the Eastern Shore <u>proportionally</u> contributes more nutrients to surface water.
- Total load is less



Measured NO_3 Levels in Shallow Groundwater



Probability of NO_3 Exceeding 5 mg/L

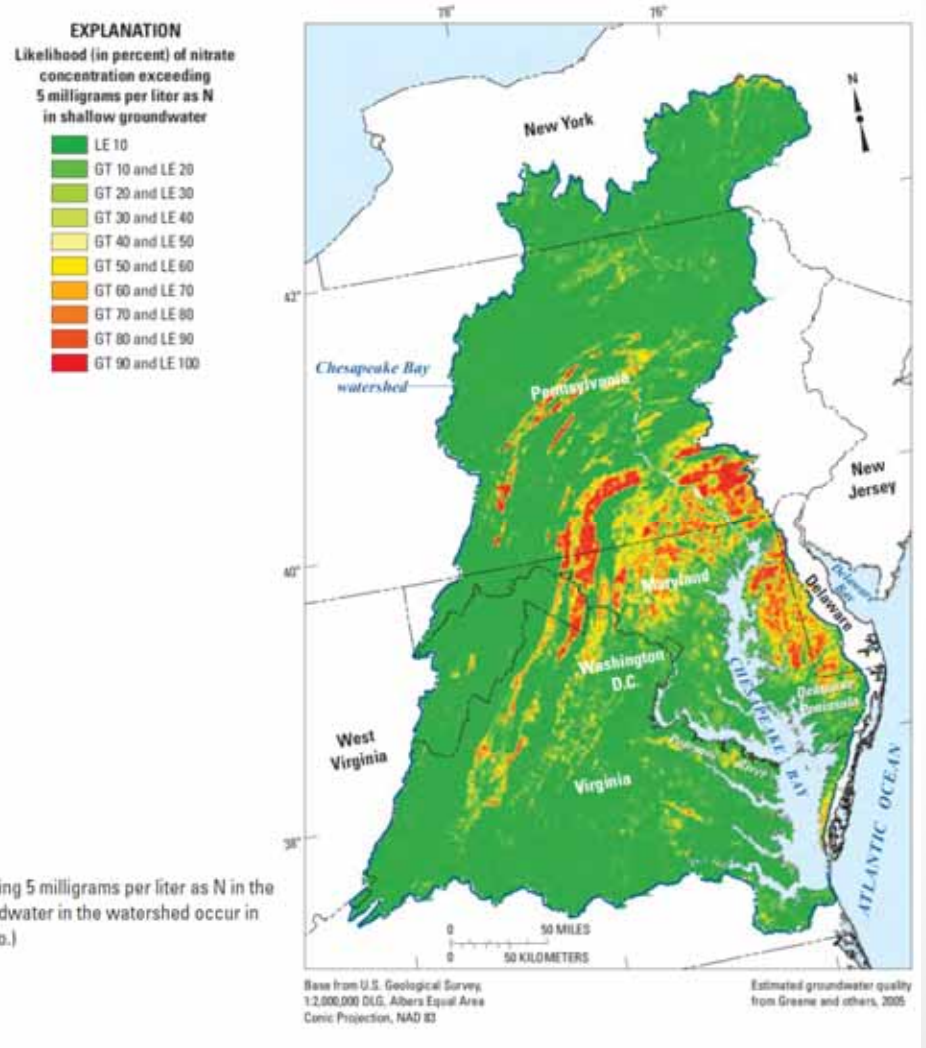
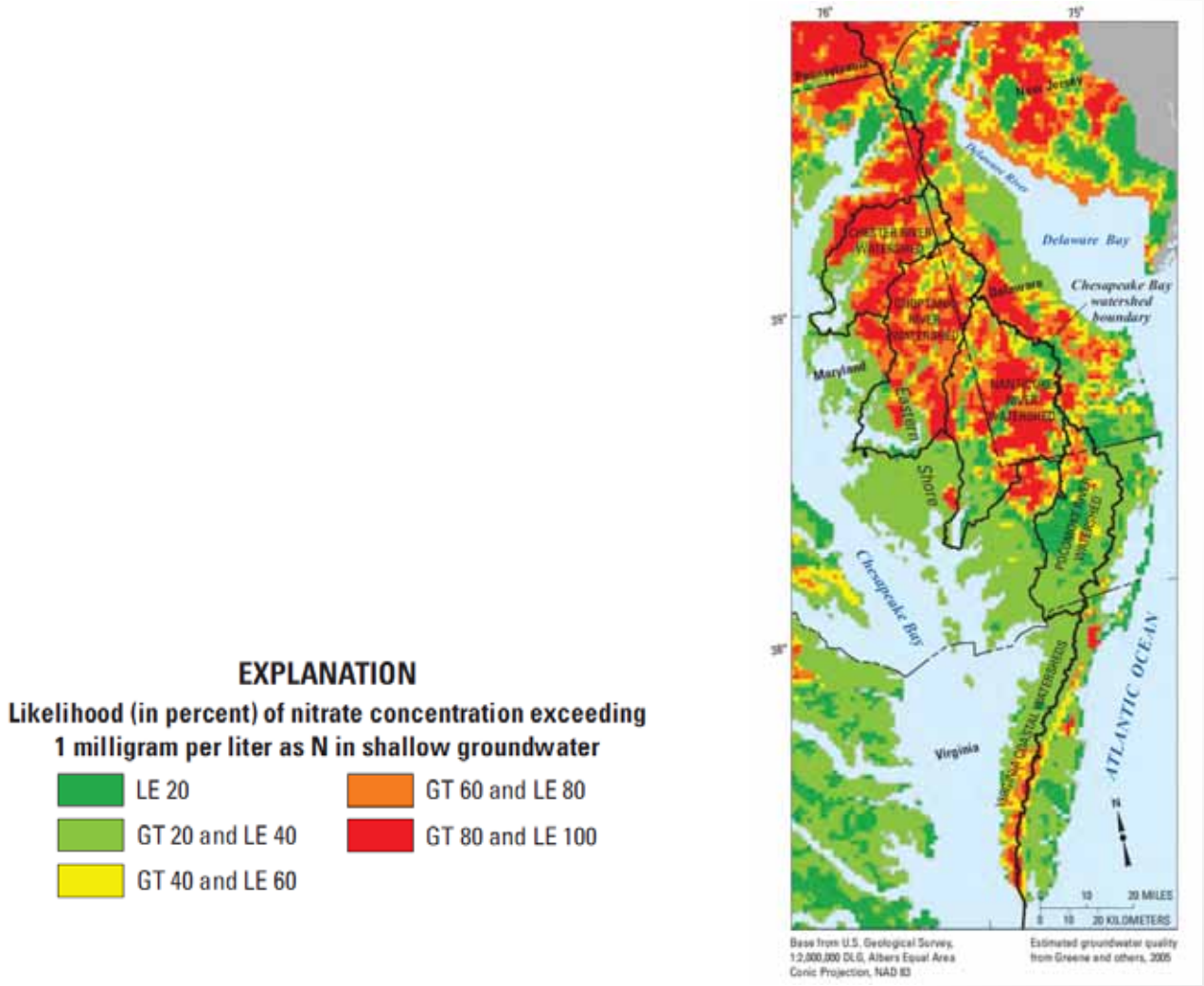


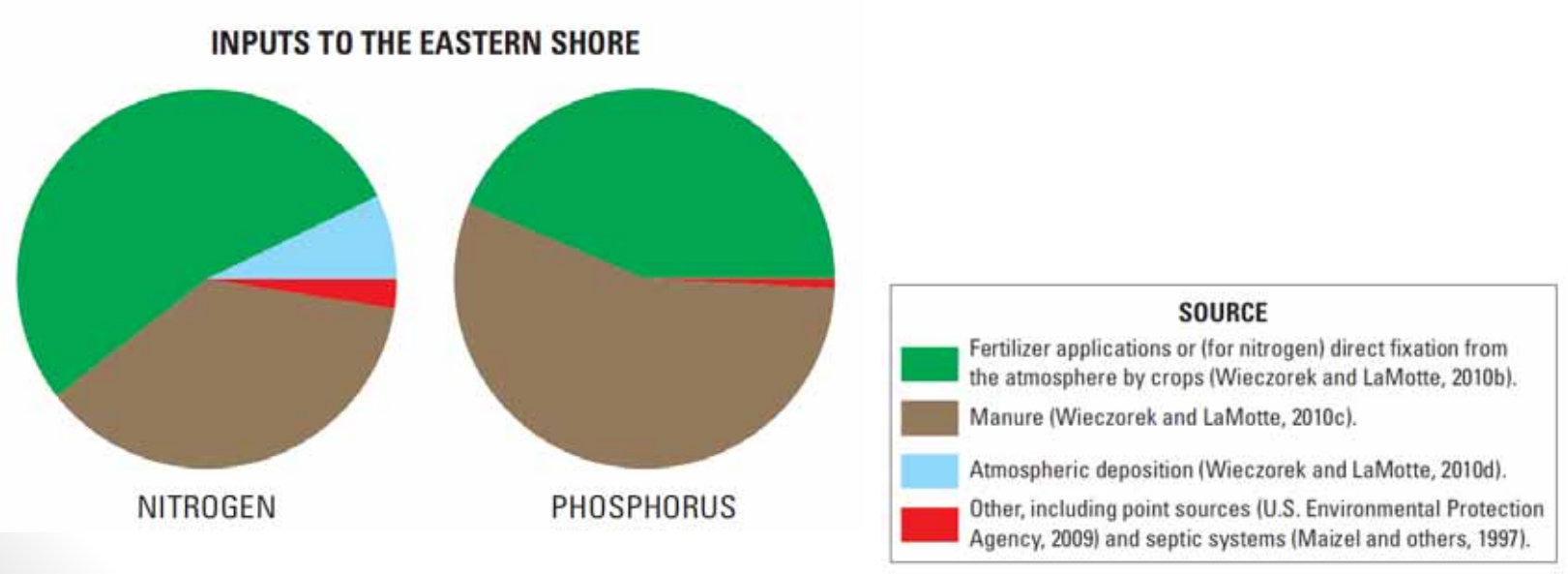
Figure 12. The estimated probability of groundwater nitrate concentration exceeding 5 milligrams per liter as N in the Chesapeake Bay watershed. Some of the highest concentrations of nitrate in groundwater in the watershed occur in agricultural areas of the Eastern Shore. (GT = greater than; LE = less than or equal to.)

Probability of NO_3 Exceeding 5 mg/L



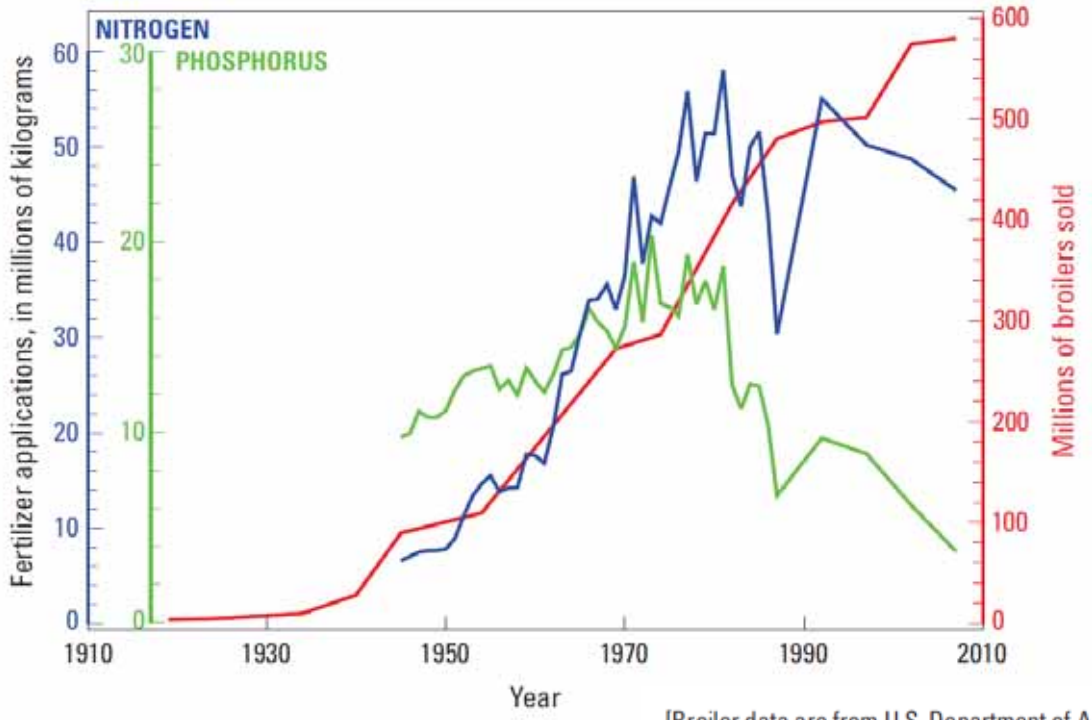
Major Source Identified as Agriculture

- > 90% of nitrogen and phosphorus is part of inorganic fertilizers or manure
- Atmospheric deposition, septic systems, sewage treatment plants, and other urban sources contribute < 10% N and P



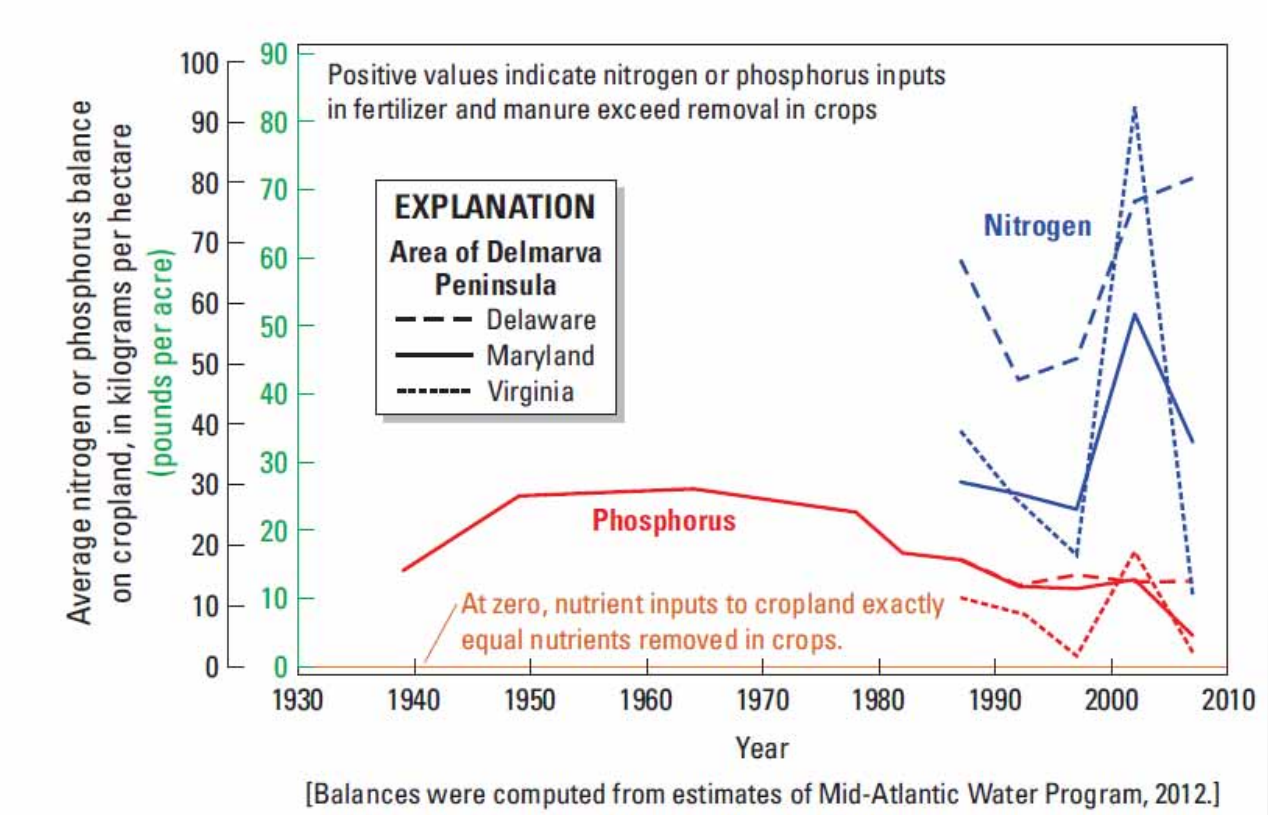
Nutrient Use Over Time

- Agricultural nitrogen and phosphorus increased during the second ½ of the last century – but have more recently stabilized or decreased.



[Broiler data are from U.S. Department of Agriculture, 2009. Estimates prior to 1950 are for total chickens or broilers raised. Fertilizer inputs are from Alexander and Smith, 1990, Battaglin and Goolsby, 1995, and Mid-Atlantic Water Program, 2012.]

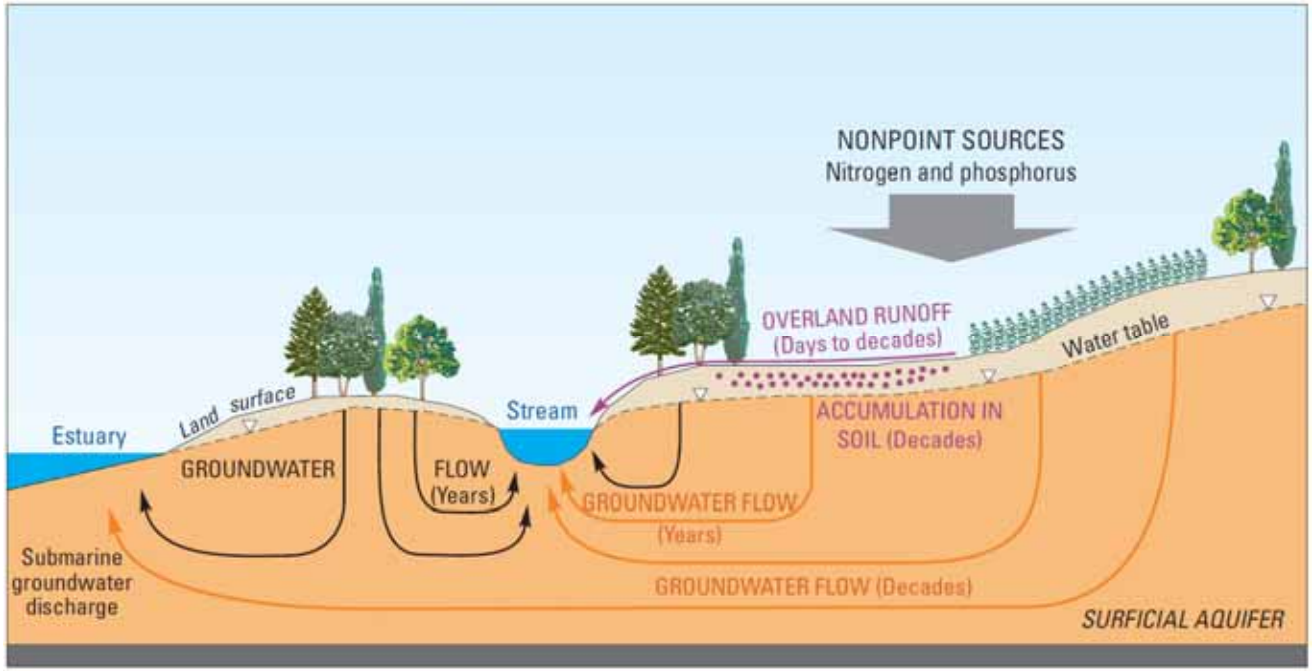
There is Excess N and P based on Nutrient Balance



[Balances were computed from estimates of Mid-Atlantic Water Program, 2012.]

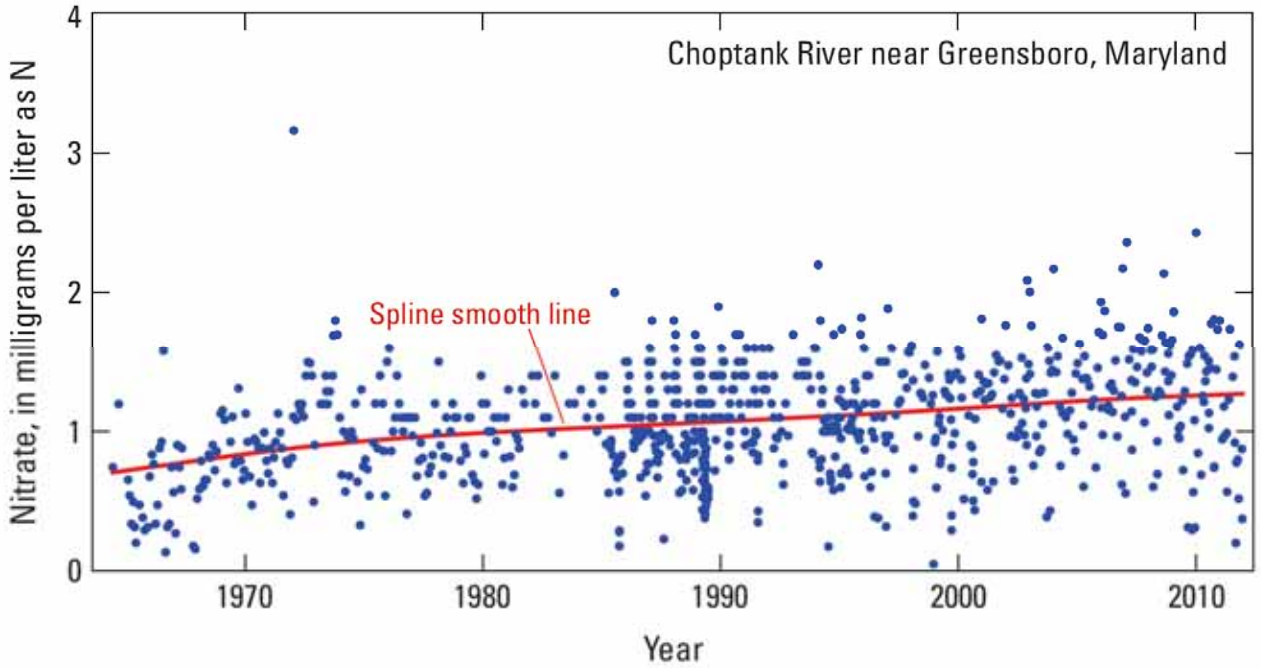
Nutrient Cycle on the Eastern Shore

- 70% of nitrogen in Eastern Shore streams travel through GW as NO_3.
- Phosphorus is predominately transported over the land in runoff attached to sediment.



Research supporting nitrogen input from groundwater

- NO_3 in Choptank and Nanticoke have increased consistently due to increasing NO_3 in GW discharge, the primary source of both water and nitrogen in those rivers

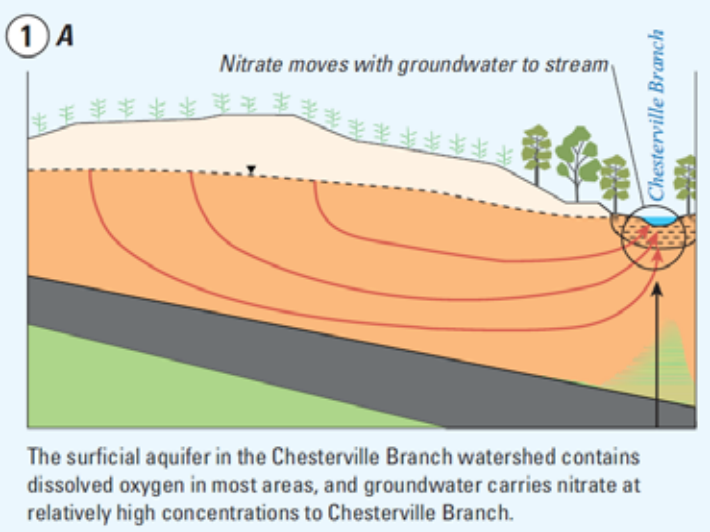


[From U.S. Geological Survey, 2014. See also Moyer and others, 2012.]

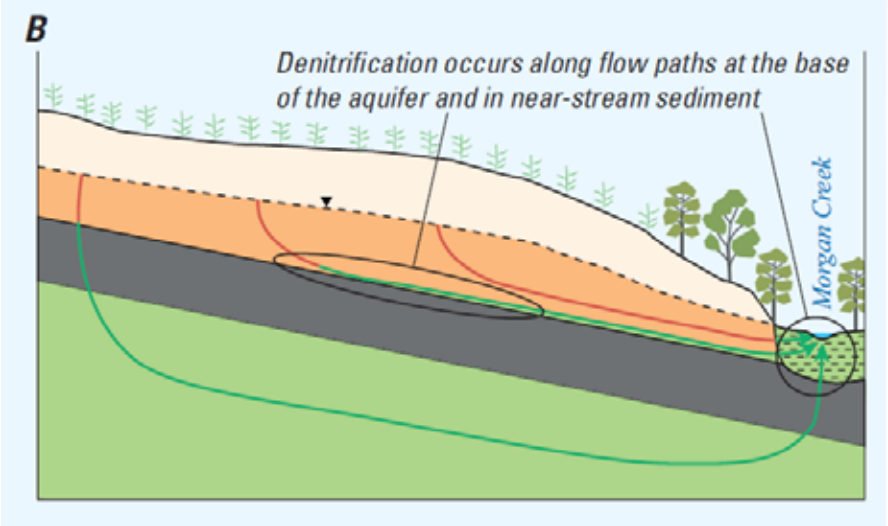
Summary of Nitrogen Findings

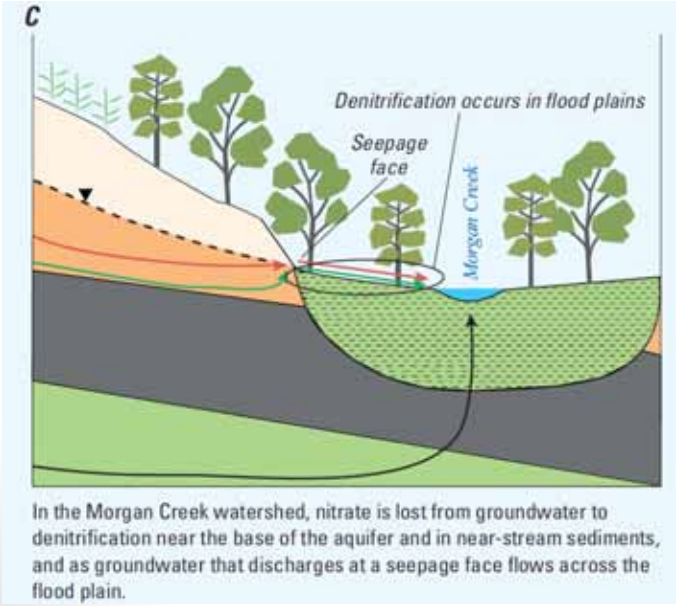
- NO_3 in GW beneath agricultural fields:
  - commonly exceed 10 mg/L in sandy soils where DO high
  - < 1 mg/L in fine grained organic rich soils with low DO
- GW carries NO3 directly to tidal water through sandy sediments
- In areas with fine grained sediments NO_3 is generally removed through denitrification prior to discharge.
- Short transport distances from upland source areas to tidal waters allow high percentage (1/4) of NO_3 applied to uplands to reach streams flowing to CB.

Nitrogen Fate in Groundwater



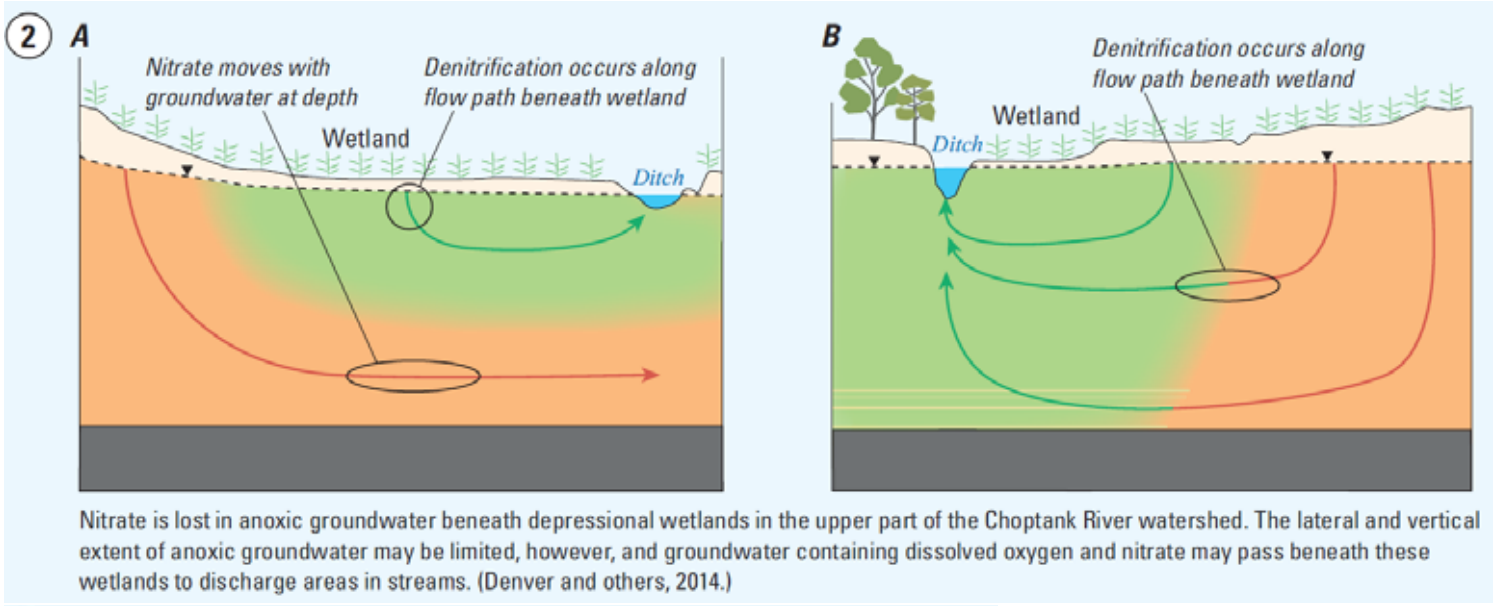
The surficial aquifer in the Chesterville Branch watershed contains dissolved oxygen in most areas, and groundwater carries nitrate at relatively high concentrations to Chesterville Branch.



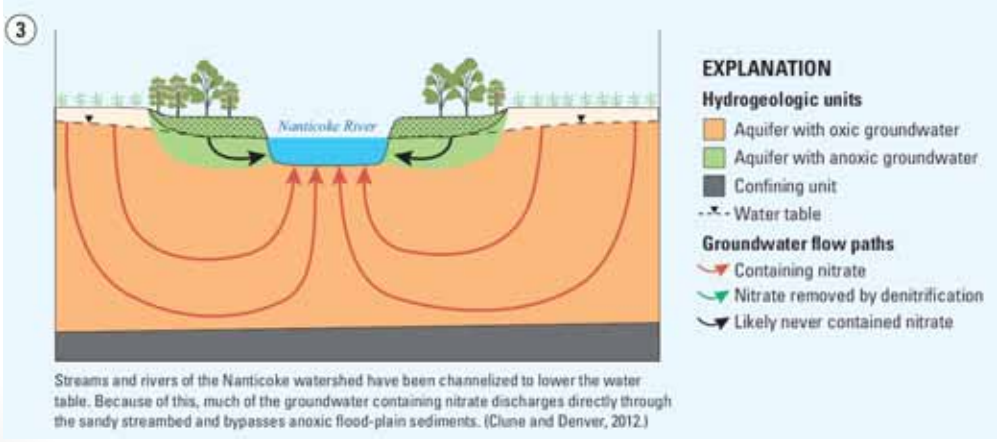


In the Morgan Creek watershed, nitrate is lost from groundwater to denitrification near the base of the aquifer and in near-stream sediments, and as groundwater that discharges at a seepage face flows across the flood plain.

Nitrogen Fate in Groundwater



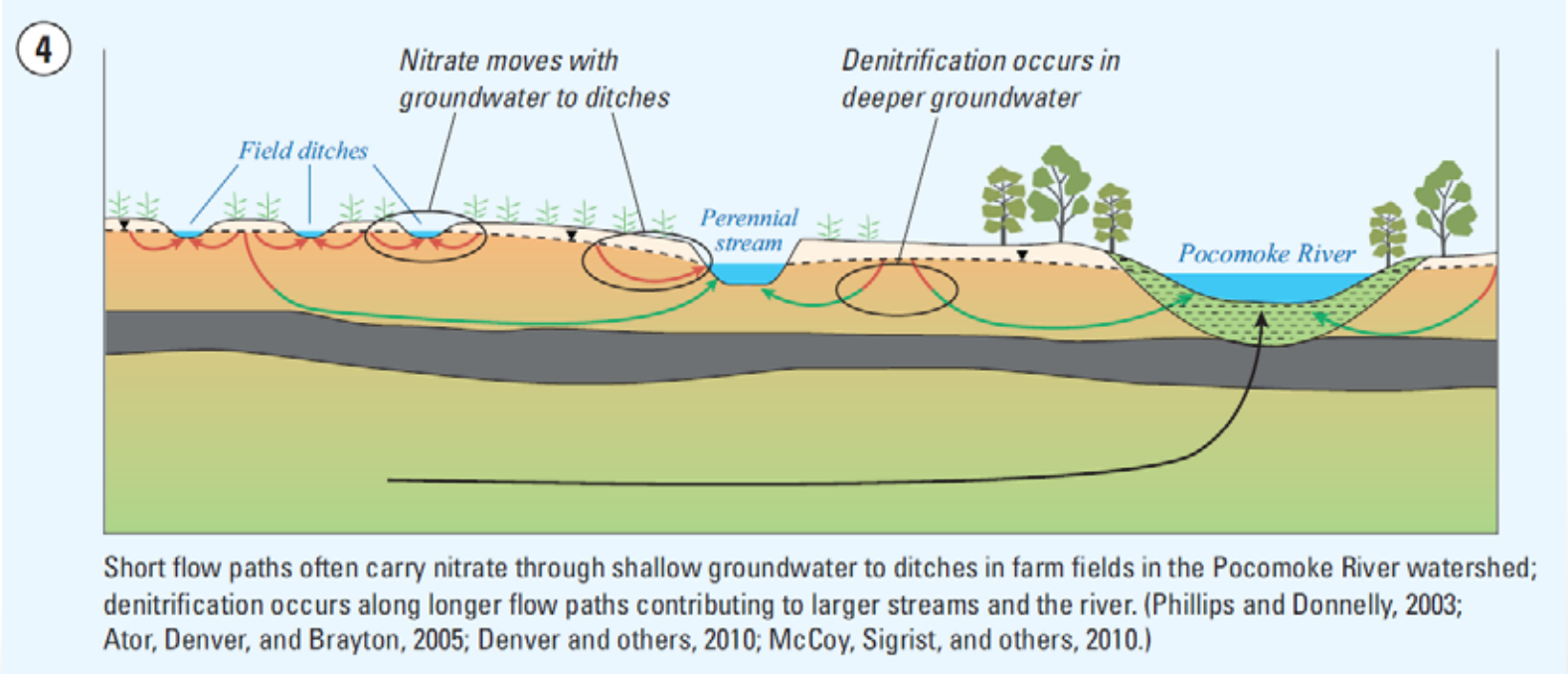
Nitrate is lost in anoxic groundwater beneath depressional wetlands in the upper part of the Choptank River watershed. The lateral and vertical extent of anoxic groundwater may be limited, however, and groundwater containing dissolved oxygen and nitrate may pass beneath these wetlands to discharge areas in streams. (Denver and others, 2014.)



Streams and rivers of the Nanticoke watershed have been channelized to lower the water table. Because of this, much of the groundwater containing nitrate discharges directly through the sandy streambed and bypasses anoxic flood-plain sediments. (Clune and Denver, 2012.)

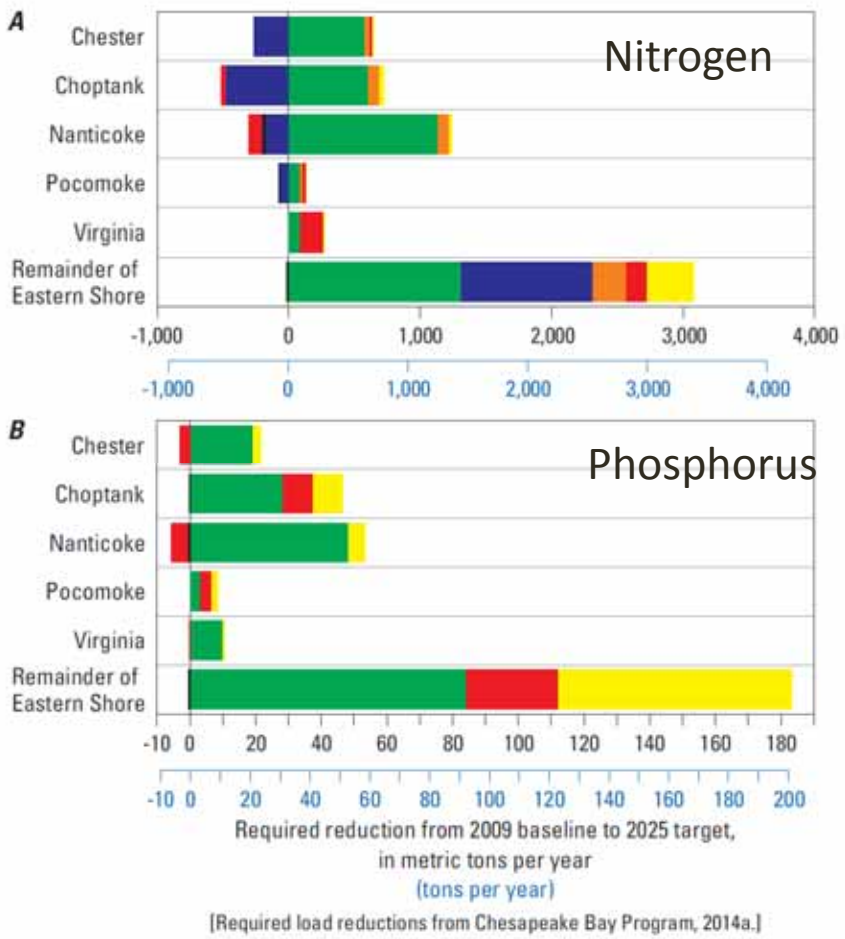
Nitrogen Fate in Groundwater

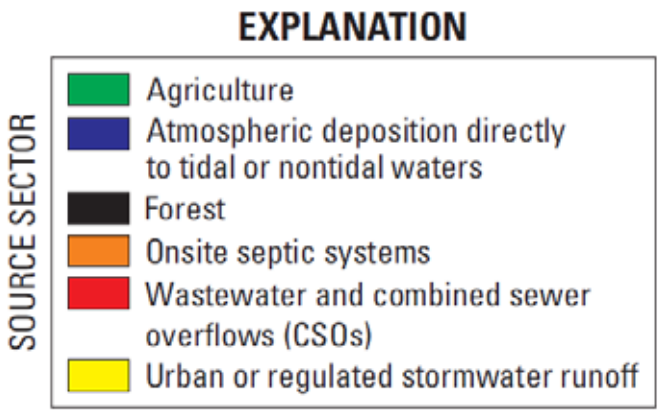
- Dominant pathway identified for Eastern Shore of Virginia



Short flow paths often carry nitrate through shallow groundwater to ditches in farm fields in the Pocomoke River watershed; denitrification occurs along longer flow paths contributing to larger streams and the river. (Phillips and Donnelly, 2003; Ator, Denver, and Brayton, 2005; Denver and others, 2010; McCoy, Sigrist, and others, 2010.)

Estimates of "Required Reductions"





Summary Observations

- USGS Circular presents “state of the science” for nutrient balance on the Eastern Shore
- A primary source of excess nutrients to surface water discussed is apparent excess nitrogen and phosphorus applied to the land from agricultural/poultry operations with implications for future load reductions.
- Phosphorus loading is more associated with runoff (phosphorus absorbed to sediment)
- Nitrogen load in groundwater is significant:
  - The amount that reaches surface water depends on the sediment characteristics along the flow path
  - It’s not clear that we have a good understanding of the nitrogen load on the Eastern Shore that reaches surface water
  - Groundwater Surface Water Interface (GSI) research would be beneficial.
- On the Eastern Shore of Virginia much of the referenced research is >20 yrs old. The research was very good but is now somewhat dated.