Tributary Reports

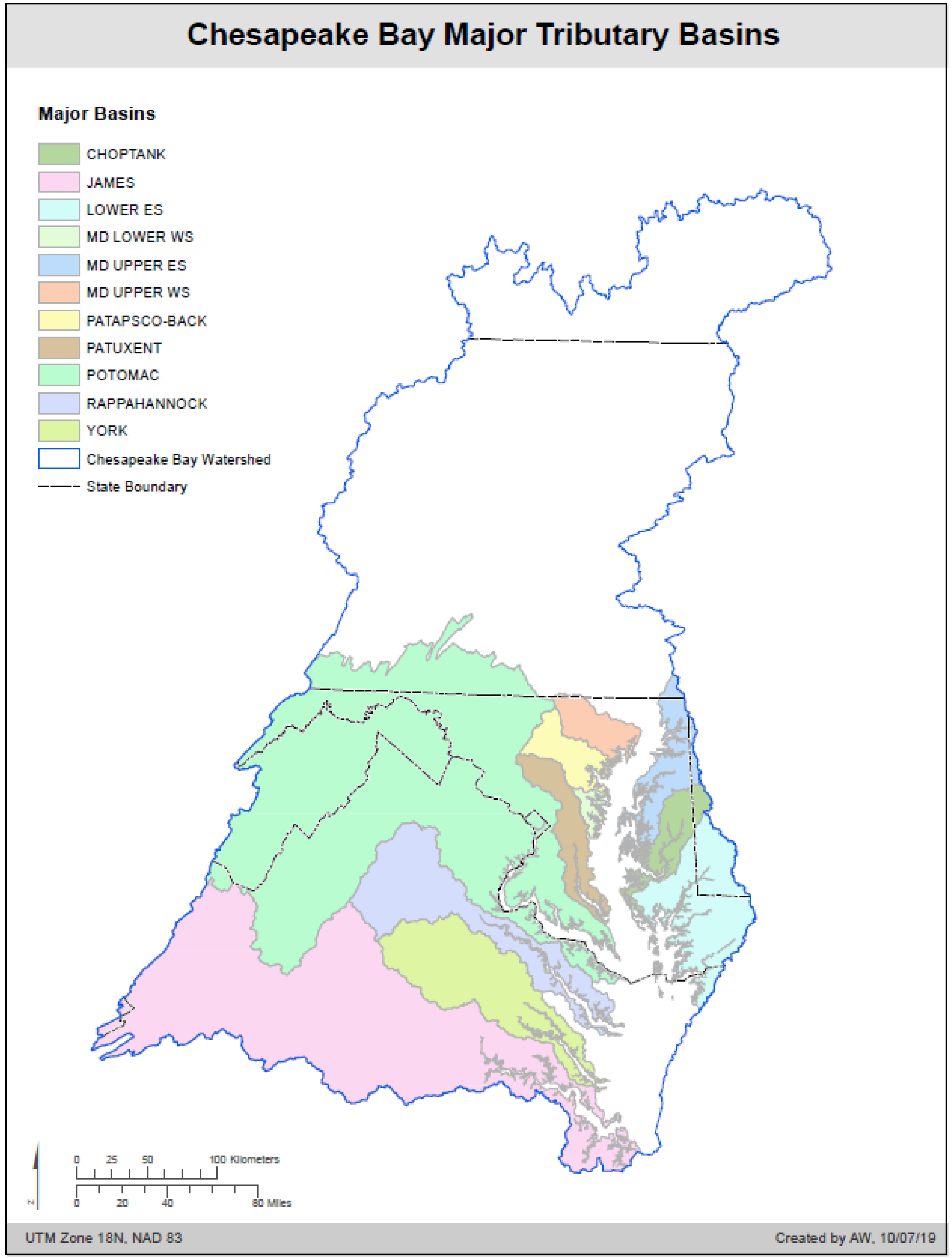
Integrated Trends Analysis Team

Jeni Keisman, Rebecca Murphy, Renee Karrh, Mike Lane, Olivia Devereux, Jimmy Webber, Qian Zhang

What are the Tributary Reports?

Tributary basin reports are being compiled for 11 major tributaries or tributary groups in the Chesapeake Bay Watershed.

1. MD Upper Western Shore:
   - Bush, Gunpowder, Middle Patapsco/Back
2. MD Lower W. Shore:
   - Severn, Magothy, Rhode/West, Patuxent
3. Patuxent
4. Potomac
5. Rappahannock
6. York (includes Mattaponi and Pamunkey)
7. James (includes Elizabeth and Lafayette)
8. MD Upper Eastern Shore:
   - Northeast, Back Creek, Elk, Sassafras, Chester, Eastern Bay
9. Choptank, Little Choptank, Honga
10. Lower E. Shore:
    - Fishing Bay, Nanticoke, Manokin, Wicomico, Big, Pocomoke, Tangier



Purpose

To summarize:

- How tidal water quality has changed over time;
- How factors that we believe drive those changes have changed over time;
- Scientific insights that have advanced our ability to connect water quality change to its drivers.

End Users

- Technical managers within jurisdiction agencies
- Local watershed organizations (Riverkeepers, etc.)
- Researchers (e.g. federal, state, academic)
- Other?

Goals: What do we want people to get out of these reports?

For technical managers and watershed organizations:

- A summary of how your river is doing and how that has changed over time
- An understanding of the factors that affect water quality in your basin, and how those have changed over time
- A snapshot of the level of implementation in your basin for major BMPs that can improve water quality

For researchers:

- All of the above, plus:
- Serve as a vehicle for discussion and hypothesis testing to advance our ability to predict future water quality change

Report Contents

"Here's the area that we're talking about"

"Your DO standards attainment status"

"How the most directly relevant water quality variables have changed over time"

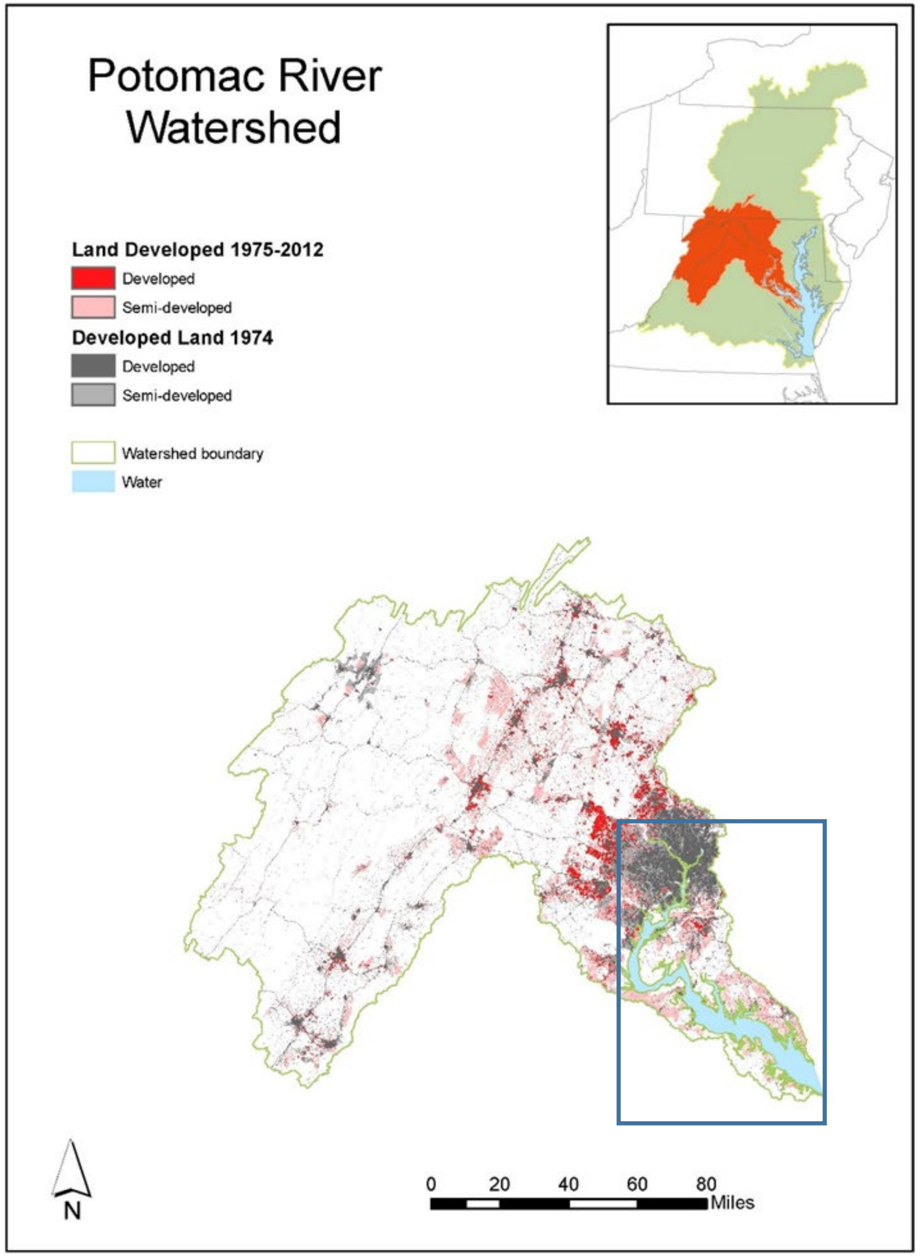
"The possible reasons why"

"In a nutshell"

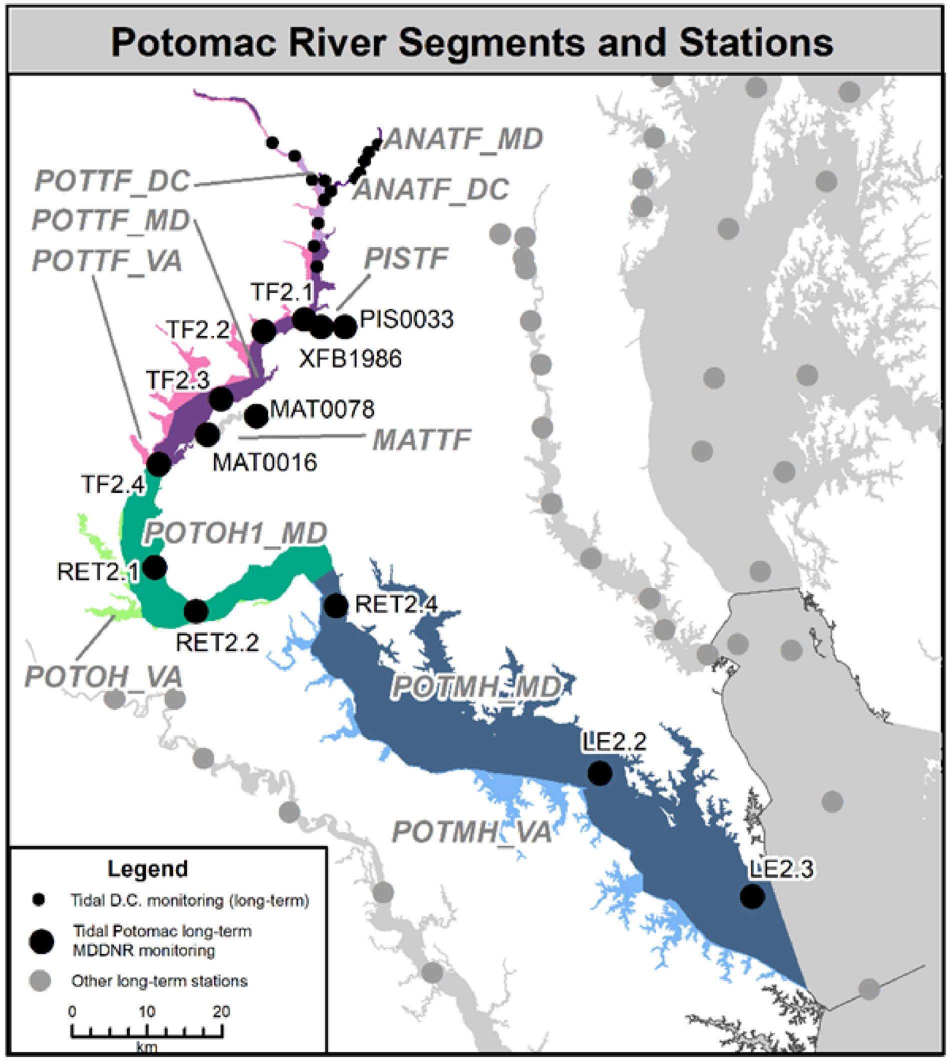
"The rest of the water quality variables, for whomever is interested"

Contents

Potomac Example: Here's where we're talking about



Our Potomac tidal trends analyses include up to 13 stations, depending on the parameter



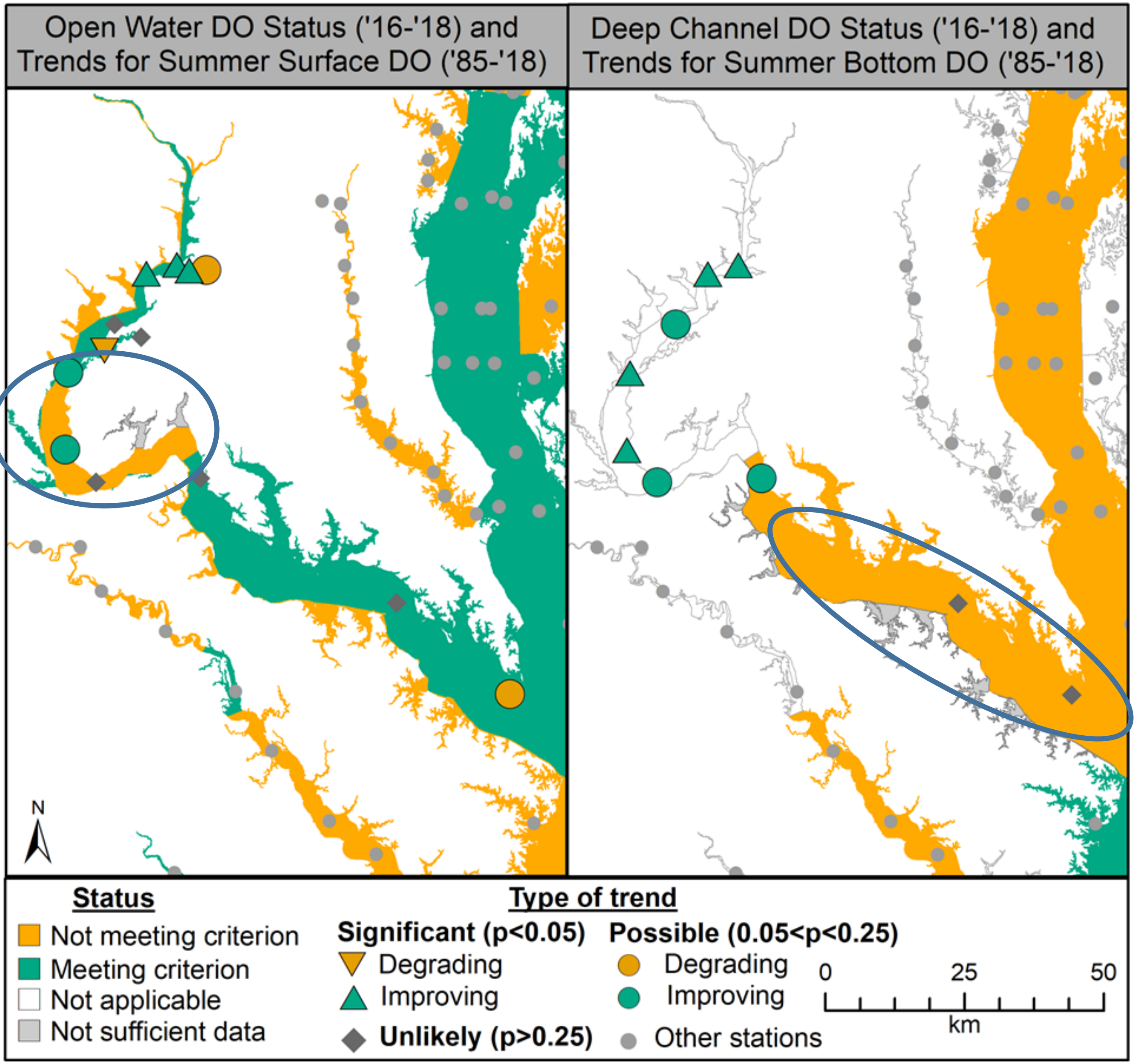
DO Criteria Attainment Snapshot: 1985-87 to 2016-18

time period	ANATF_DC	ANATF_MD	PISTF	MATTF	POTTF_DC	POTTF_MD	POTTF_VA	POTOH1_MD	POTOH2_MD	POTOH3_MD	POTOH_VA	POTMH_MD	POTMH_VA
1985-1987							ND		ND	ND	ND		ND
1986-1988							ND		ND	ND	ND		ND
1987-1989							ND		ND	ND	ND		ND
1988-1990							ND		ND	ND	ND		ND
1989-1991							ND		ND	ND	ND		ND
1990-1992							ND		ND	ND	ND		ND
1991-1993							ND		ND	ND	ND		ND
1992-1994							ND		ND	ND	ND		ND
1993-1995							ND		ND	ND	ND		ND
1994-1996							ND		ND	ND	ND		ND
1995-1997							ND		ND	ND	ND		ND
1996-1998							ND		ND	ND	ND		ND
1997-1999							ND		ND	ND	ND		ND
1998-2000							ND		ND	ND	ND		ND
1999-2001							ND		ND	ND	ND		ND
2000-2002							ND		ND	ND	ND		ND
2001-2003							ND		ND	ND	ND		ND
2002-2004									ND	ND			
2003-2005									ND	ND			
2004-2006													
2005-2007													
2006-2008													
2007-2009													
2008-2010													
2009-2011									ND	ND			
2010-2012									ND	ND			
2011-2013									ND	ND			
2012-2014									ND	ND			
2013-2015									ND	ND			
2014-2016									ND	ND			
2015-2017									ND	ND			
2016-2018									ND	ND			

time period	Deep Water		Deep Channel	
	POTMH_MD	POTMH_VA	POTMH_MD	POTMH_VA
1985-1987		ND		ND
1986-1988		ND		ND
1987-1989		ND		ND
1988-1990		ND		ND
1989-1991		ND		ND
1990-1992		ND		ND
1991-1993		ND		ND
1992-1994		ND		ND
1993-1995		ND		ND
1994-1996		ND		ND
1995-1997		ND		ND
1996-1998		ND		ND
1997-1999		ND		ND
1998-2000		ND		ND
1999-2001		ND		ND
2000-2002		ND		ND
2001-2003		ND		ND
2002-2004				ND
2003-2005				ND
2004-2006				
2005-2007				
2006-2008				
2007-2009				
2008-2010				
2009-2011				
2010-2012		ND		ND
2011-2013				ND
2012-2014				ND
2013-2015				ND
2014-2016				ND
2015-2017				ND
2016-2018				ND

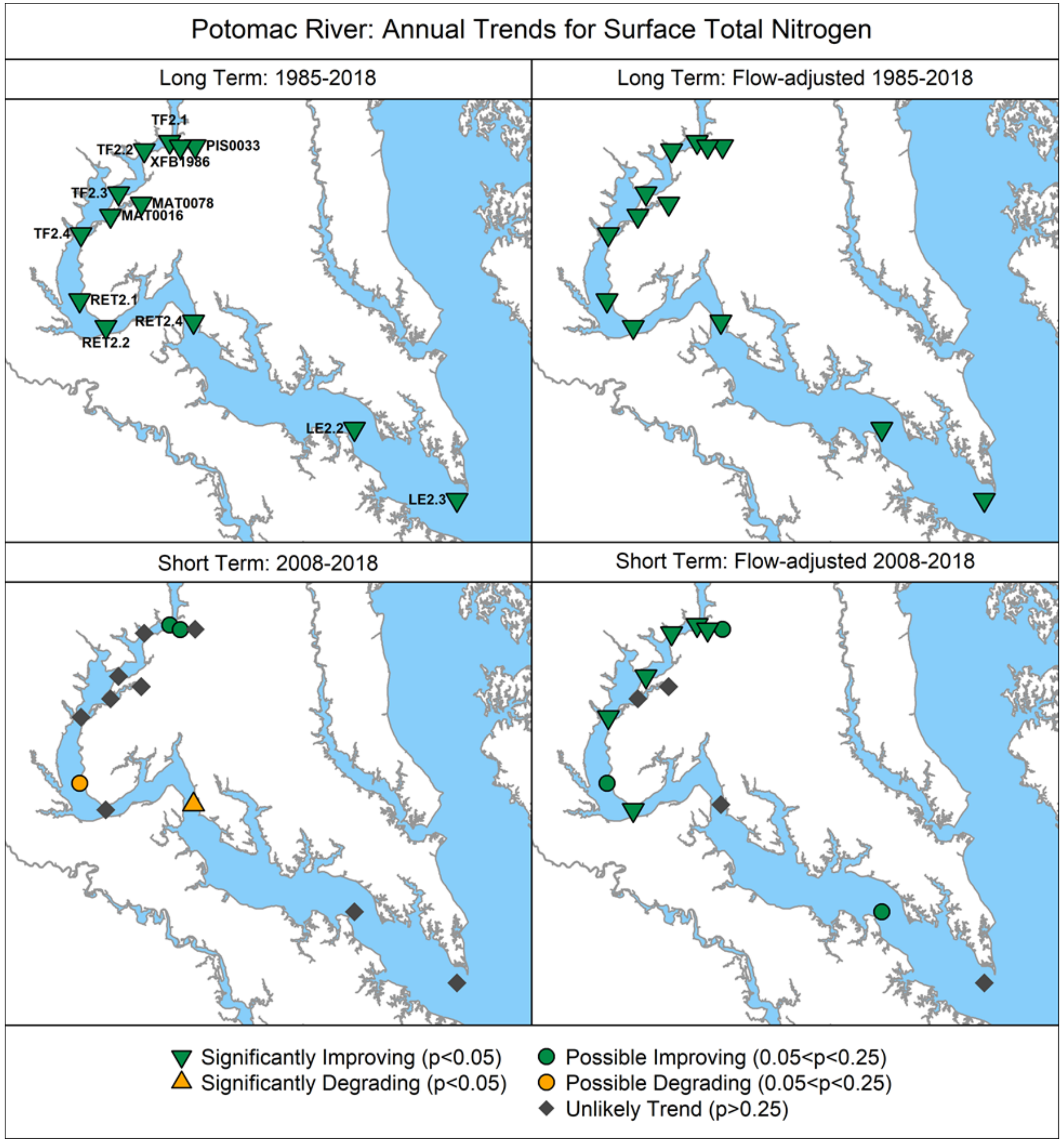
current attainment versus station-level trends

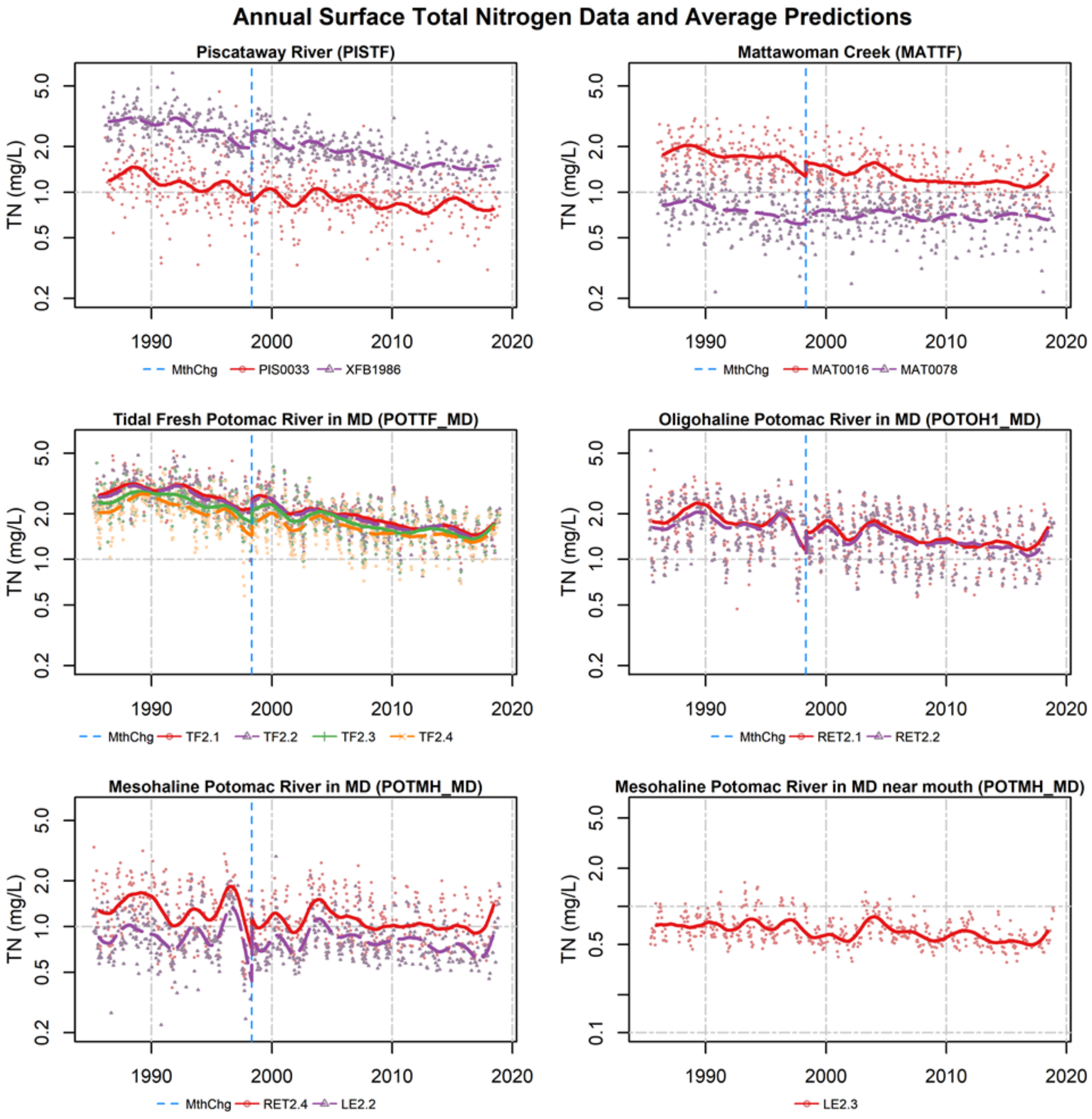
- The oligohaline area of the Potomac is not attaining its open water DO standard
- but DO concentrations are probably better than in the mid-1980s



- The lower (mesohaline) Potomac is attaining the open water (surface) DO standard, but not the Deep Channel (bottom) DO standard.
- DO concentrations at the bottom of the water column haven't changed compared to the mid-1980s

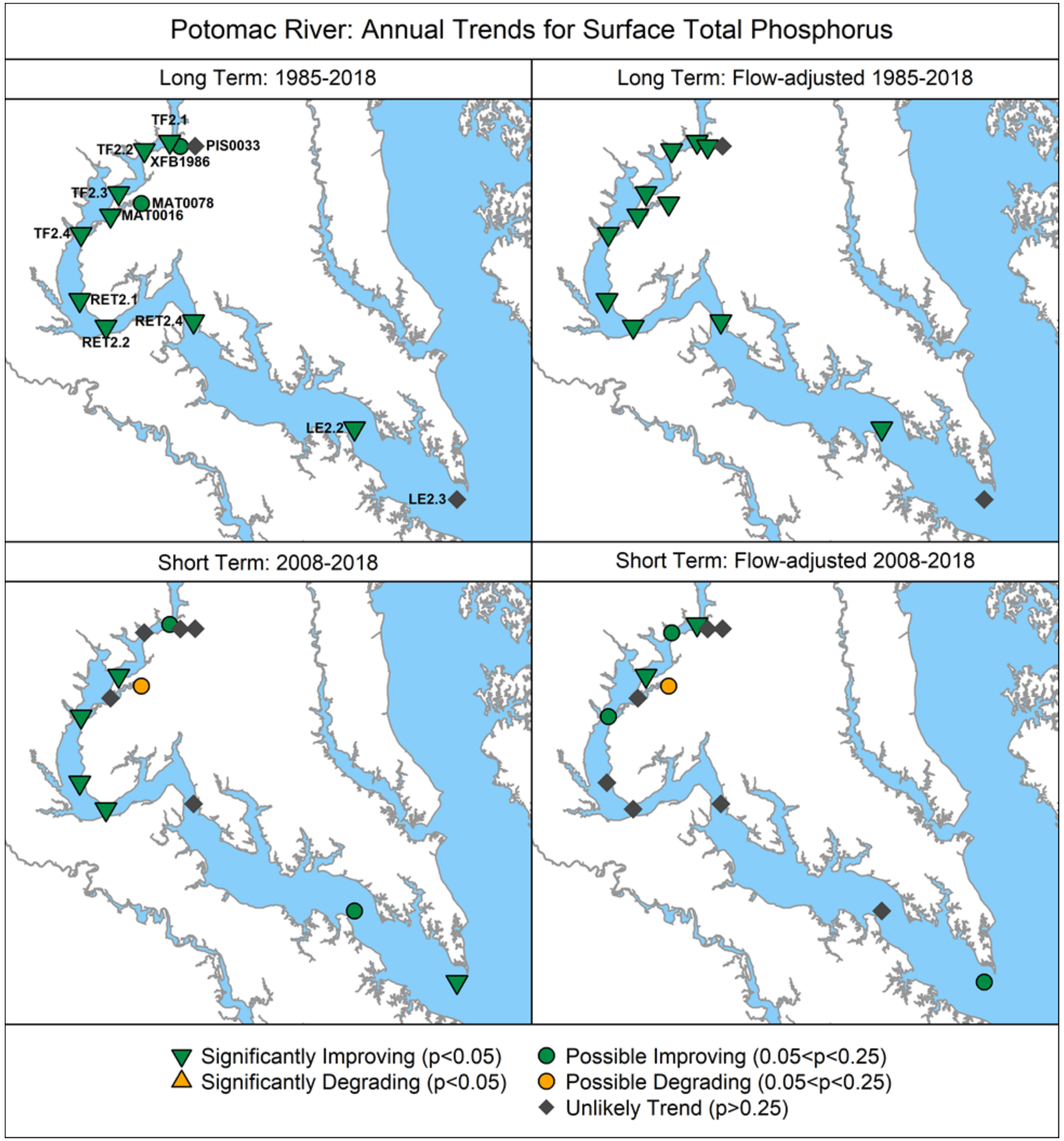
Change over time in "primary" variables (TN, TP, Chlorophyll, Secchi, DO)

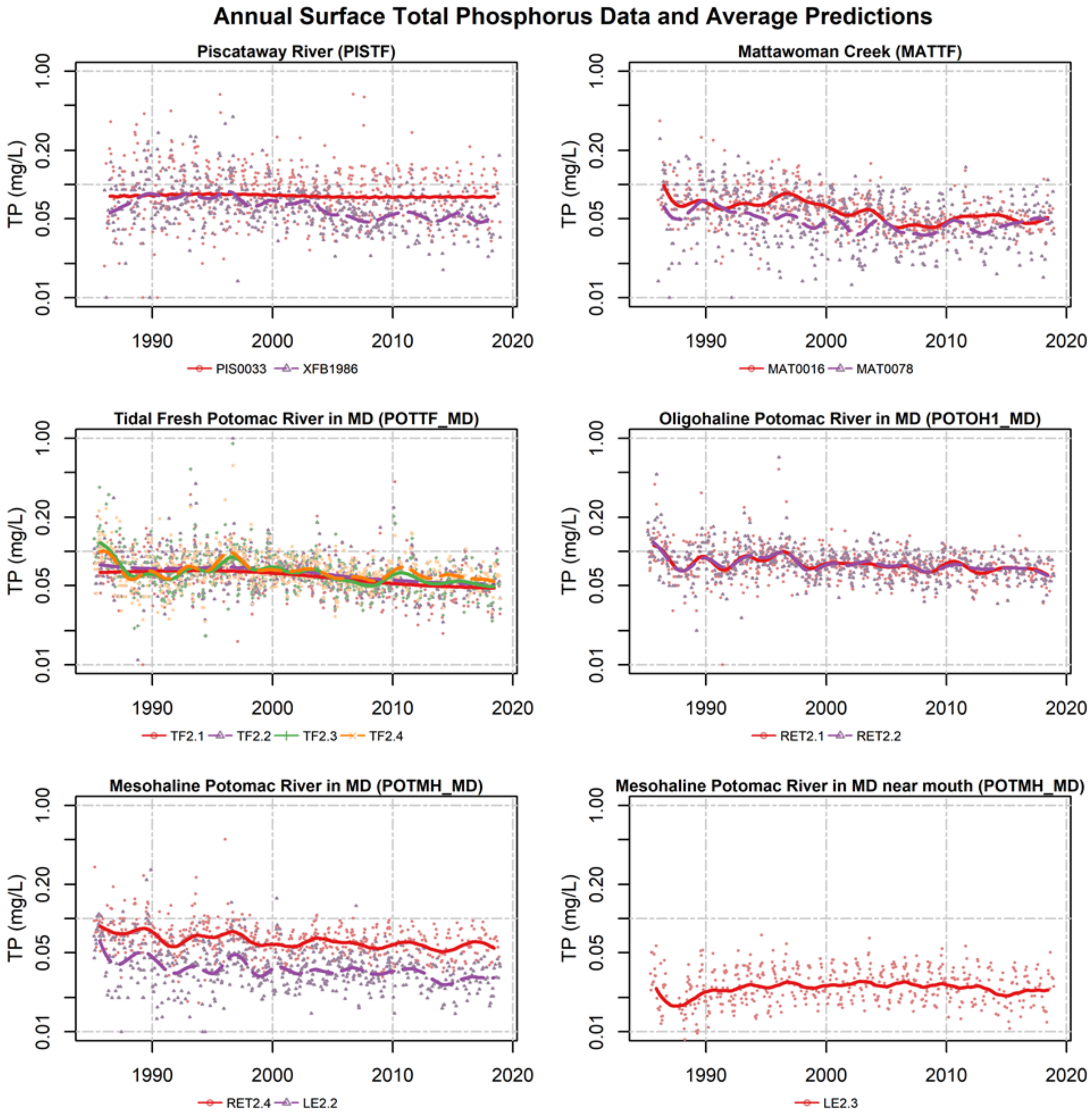




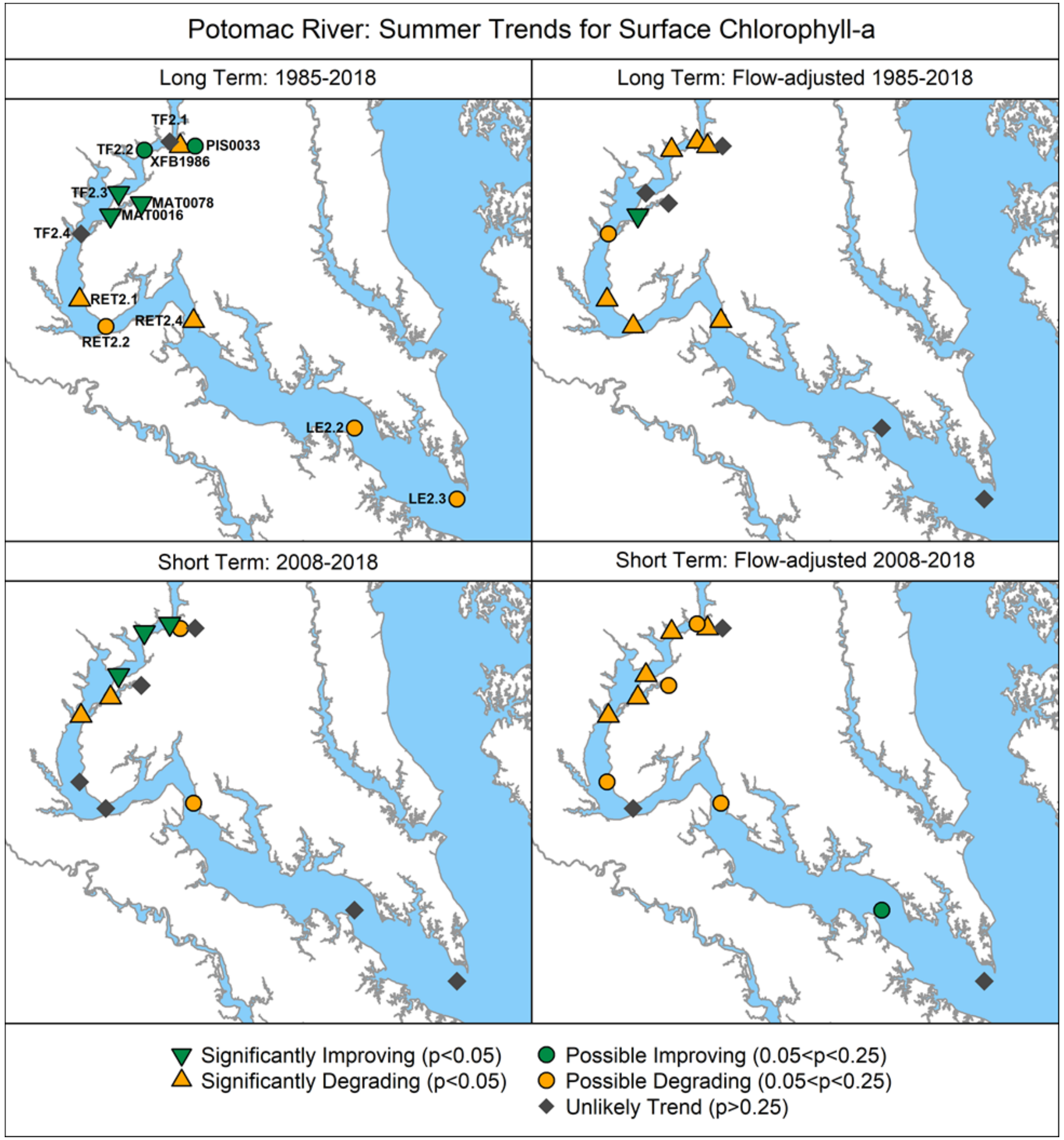
Preliminary Information-Subject to Revision. Not for Citation or Distribution

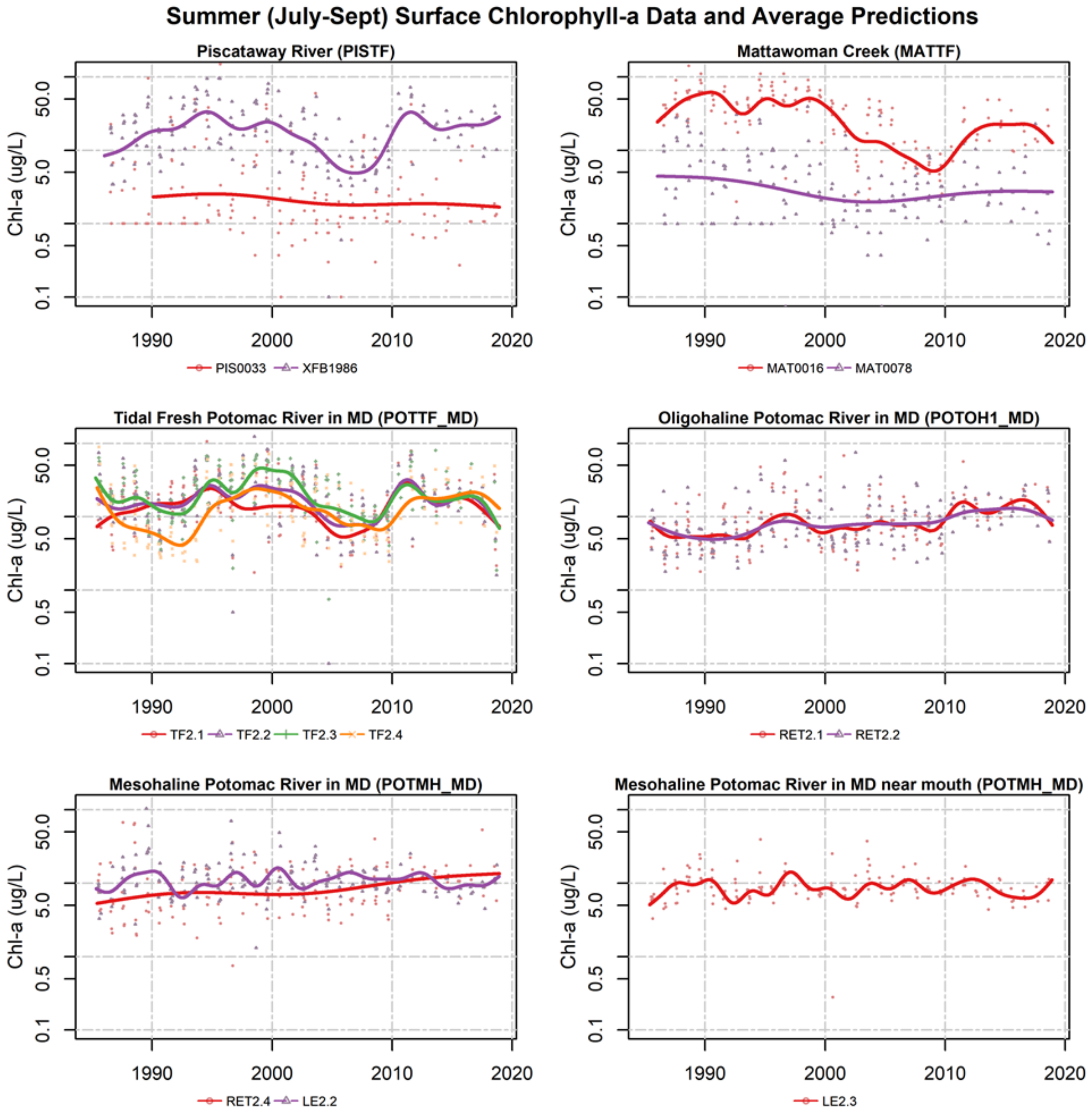
Change over time in “primary” variables (TN, TP, Chlorophyll, Secchi, DO)



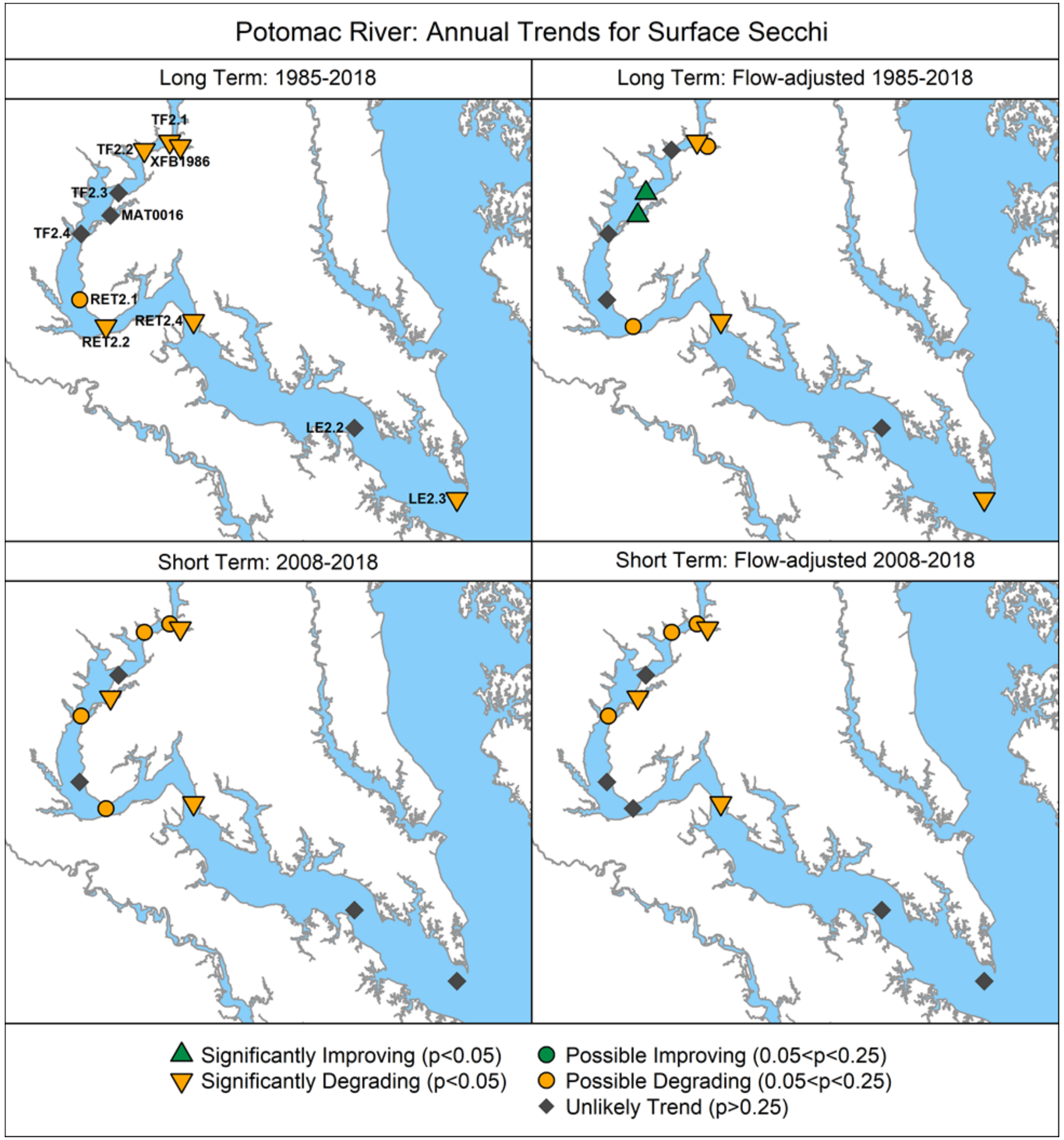


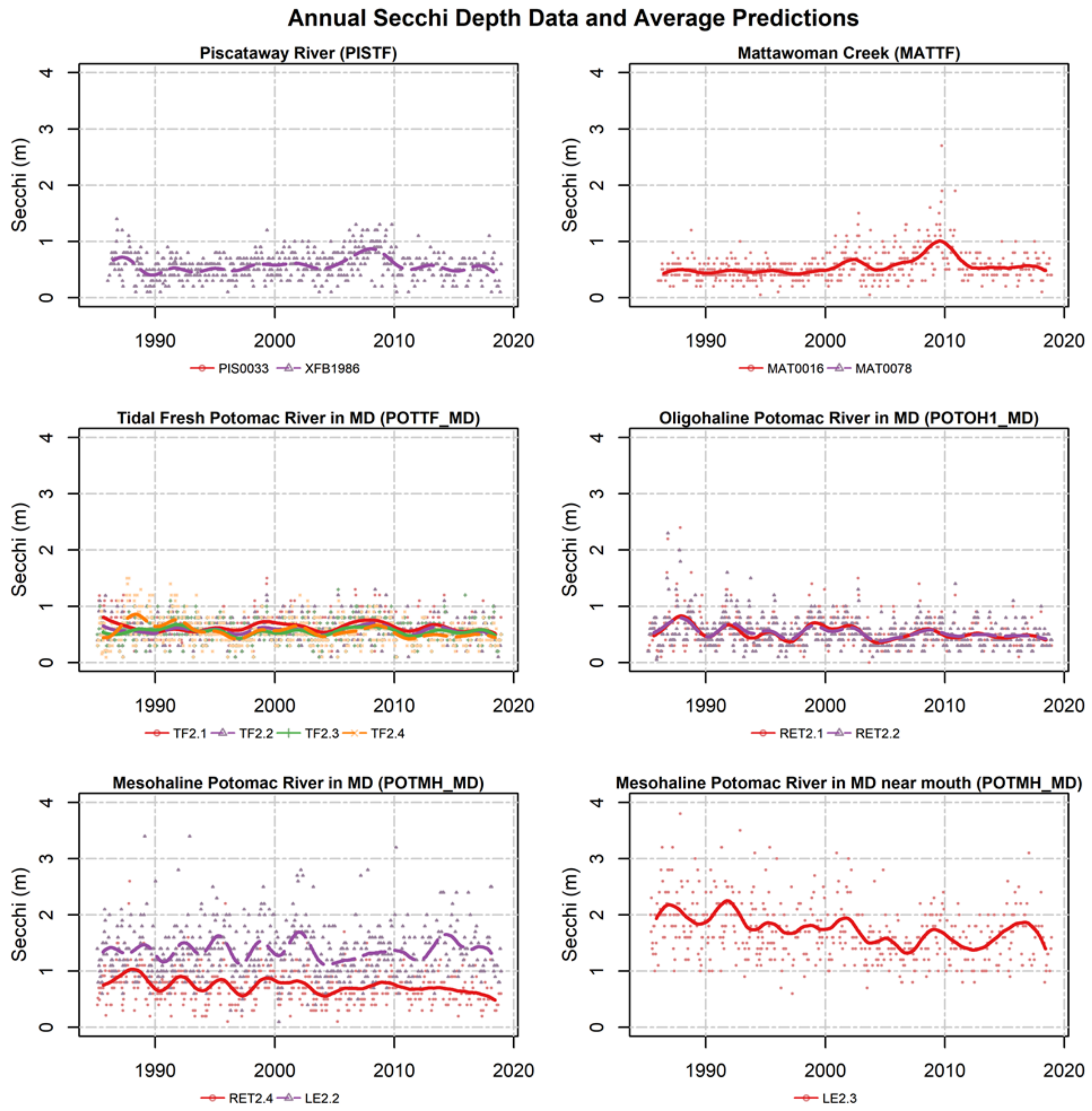
Change over time in "primary" variables (TN, TP, Chlorophyll, Secchi, DO)



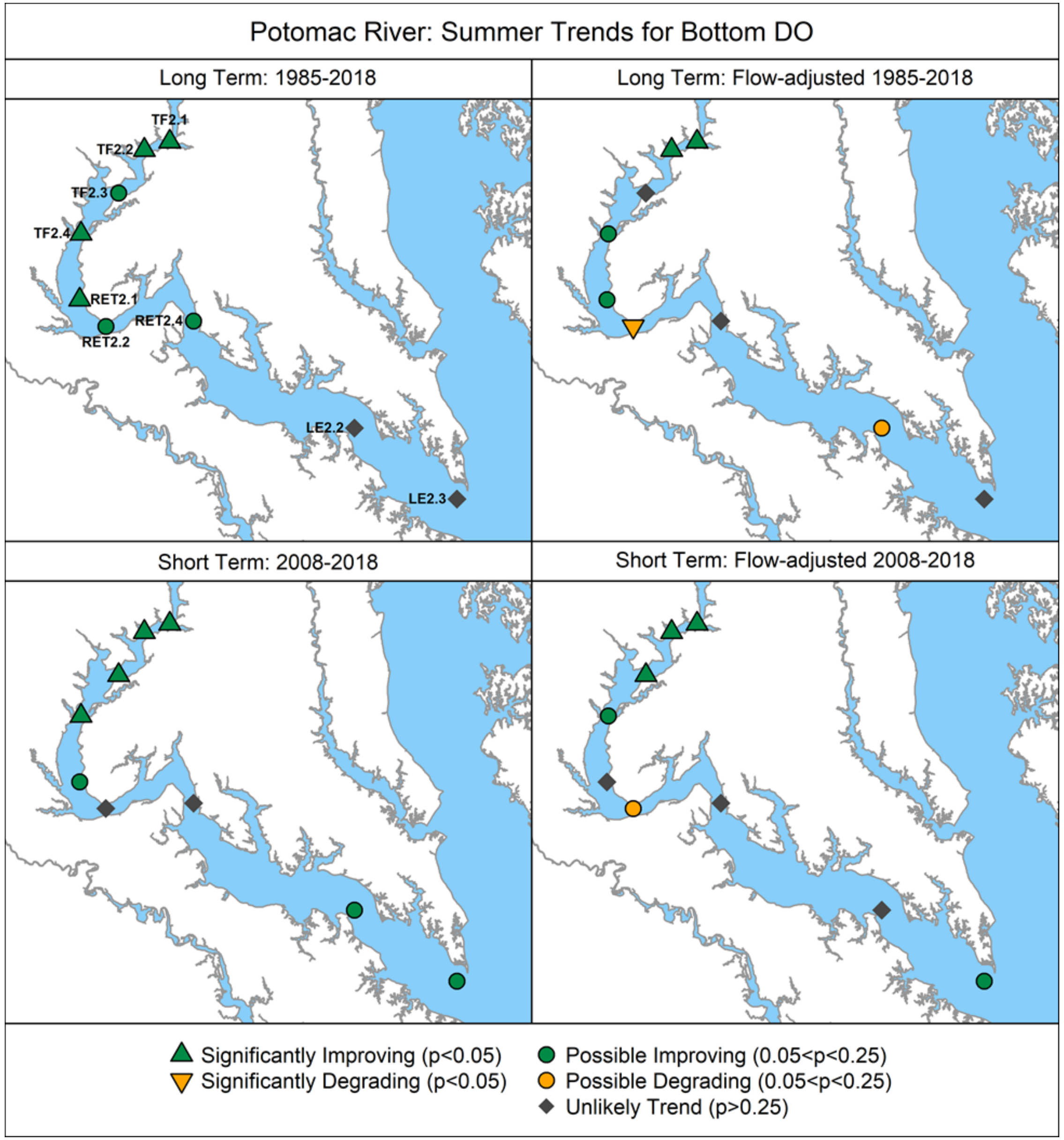


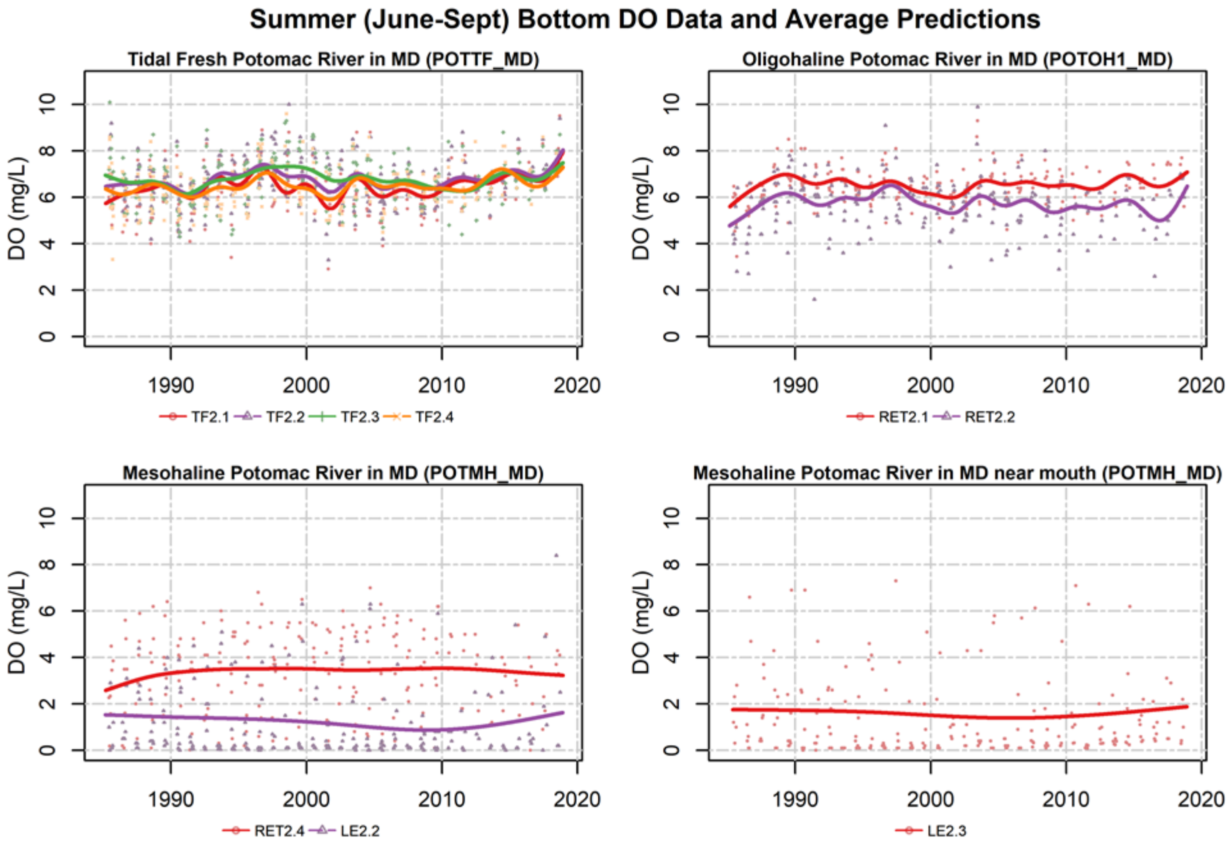
Change over time in "primary" variables (TN, TP, Chlorophyll, Secchi, DO)





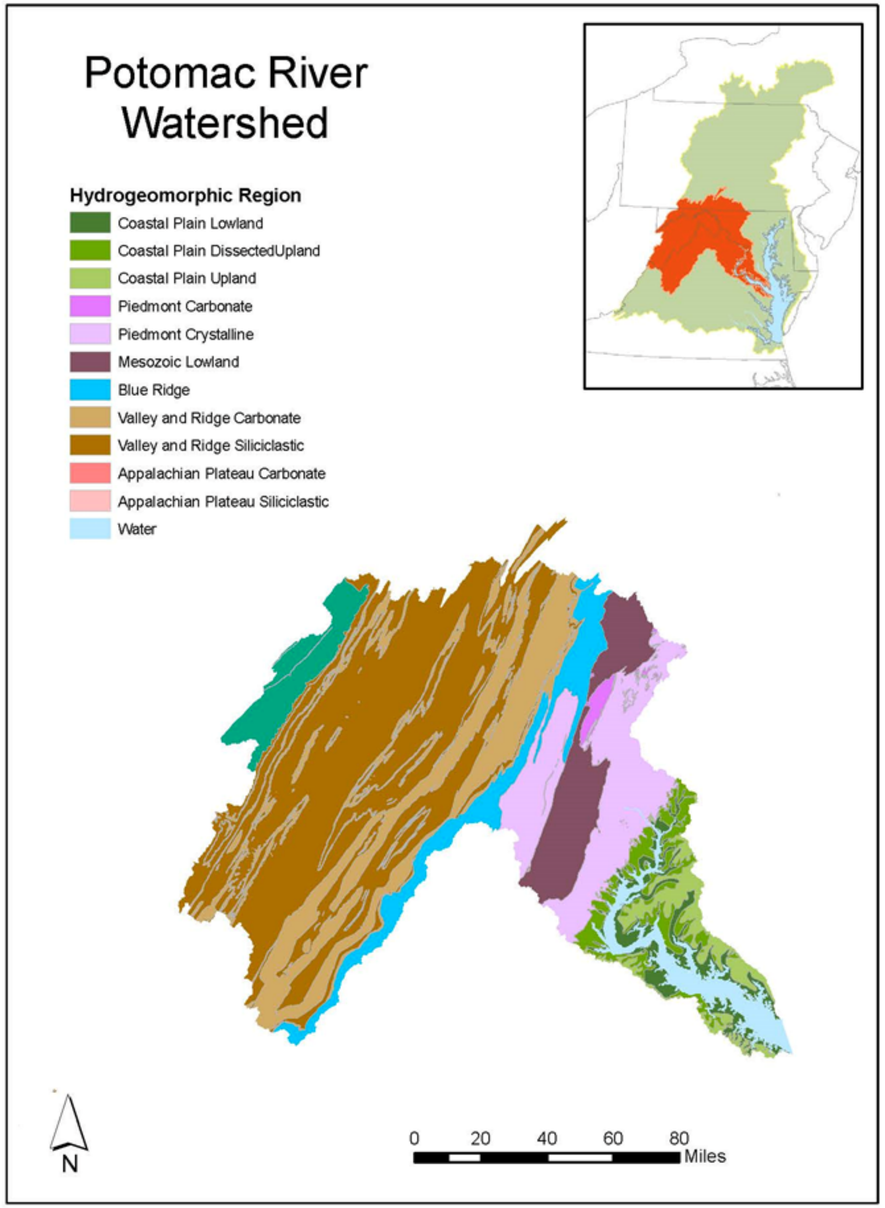
Change over time in "primary" variables (TN, TP, Chlorophyll, Secchi, DO)





Preliminary Information-Subject to Revision. Not for Citation or Distribution

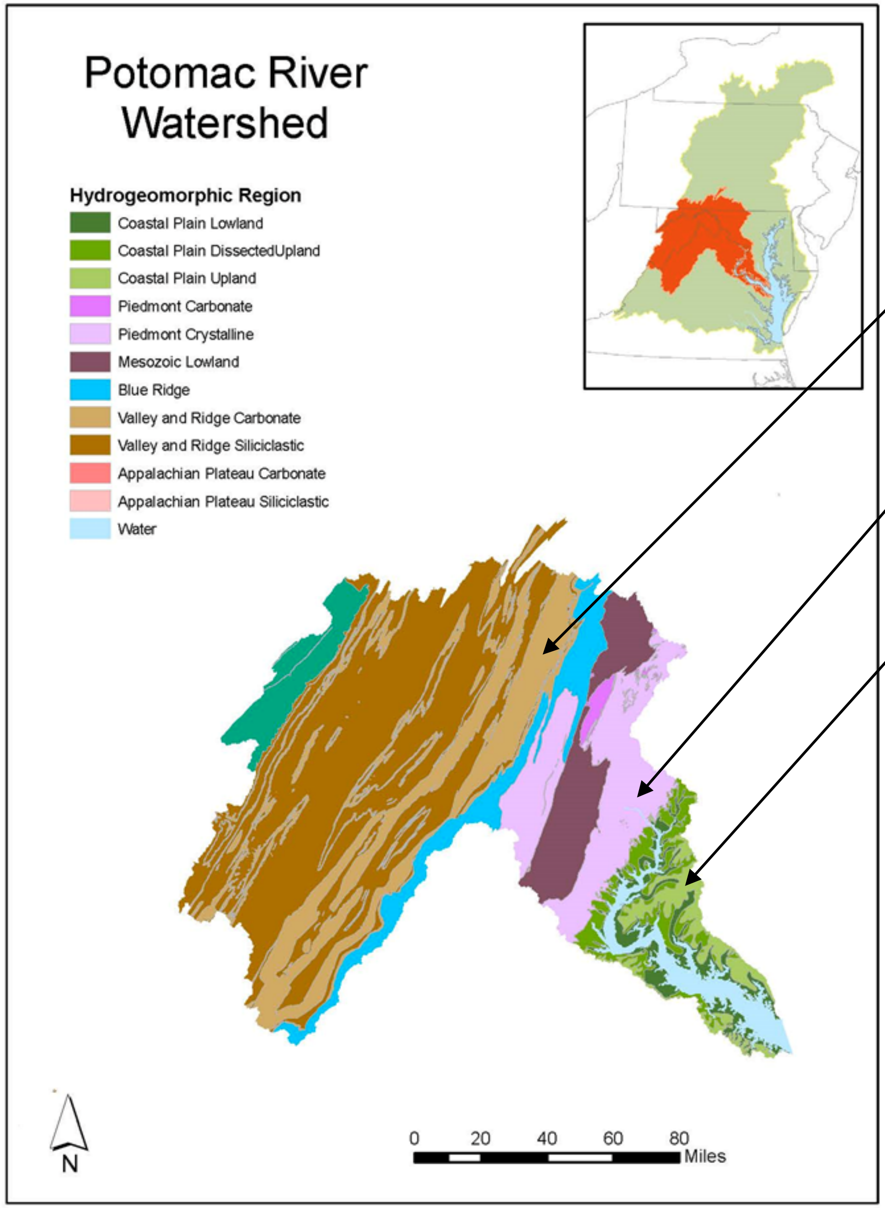
Watershed Characteristics: Geology, pathway, and distance matter



From USGS, this map courtesy Zhaoying Wei

- On average, about half of the water in Chesapeake streams is derived from groundwater discharge; the other half is from soil moisture and surface runoff.
- Groundwater is generally considered the dominant delivery pathway of nitrogen to most streams in the watershed, but this varies substantially across settings.
- Soil moisture and surface runoff are generally considered the dominant pathways for phosphorus, but this also varies depending on where you are and when you measure it.
- More nitrogen load to streams in Virginia’s Shenandoah Valley can be removed through in-stream processing than loads to streams in areas surrounding Washington DC, which are closer to the tidal Potomac River

Watershed Characteristics: Because geology, pathway, and distance matter



From USGS, this map courtesy Zhaoying Wei

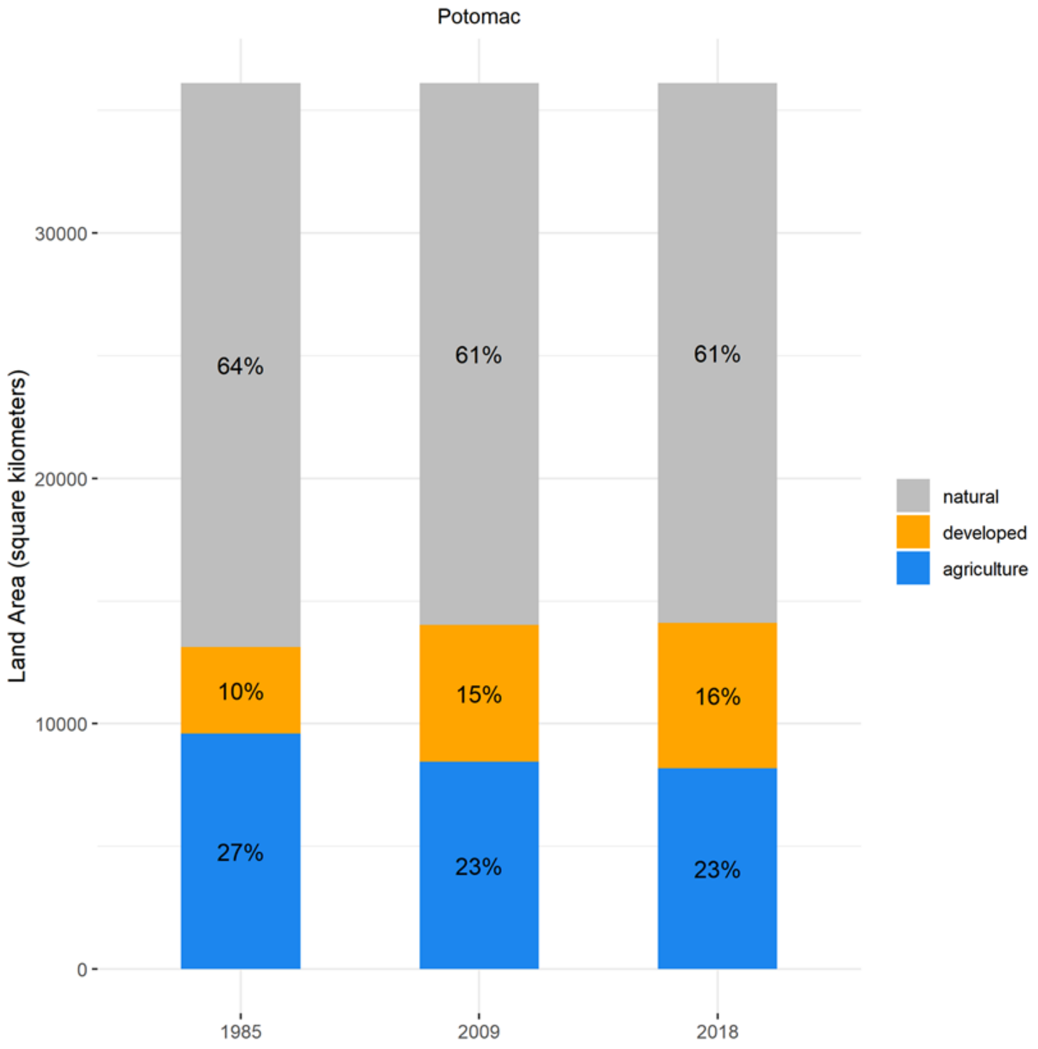
Valley and Ridge underlain by carbonate rocks (groundwater age ~ 0-10 yrs)

Piedmont crystalline settings (groundwater age ~ 0-22 yrs)

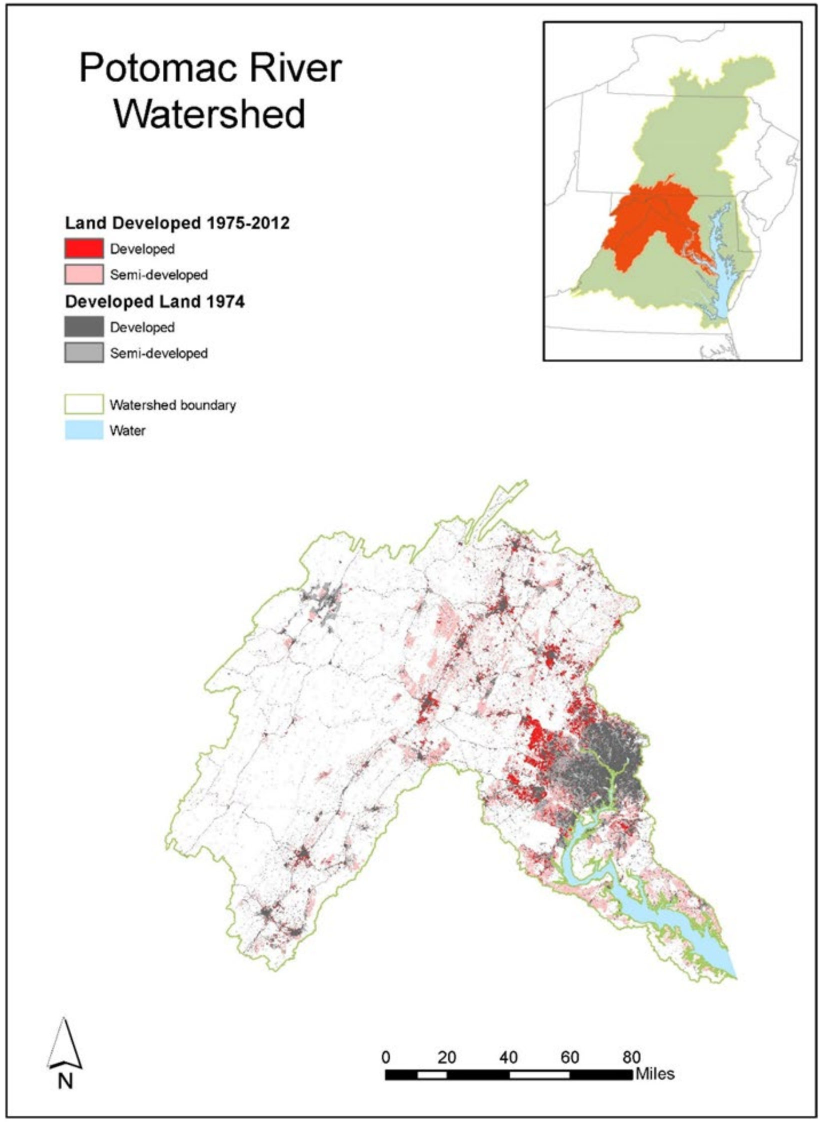
Coastal plain settings (groundwater age <1 to >100 years (median 20-40 yrs)

Soil moisture and surface runoff everywhere: days-to-months

Watershed Characteristics: Land Use Matters

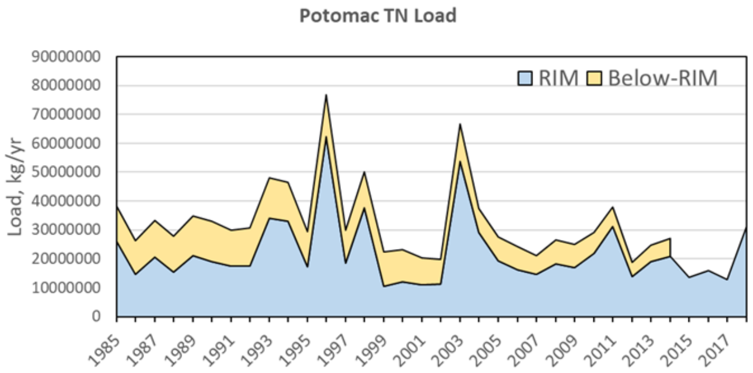


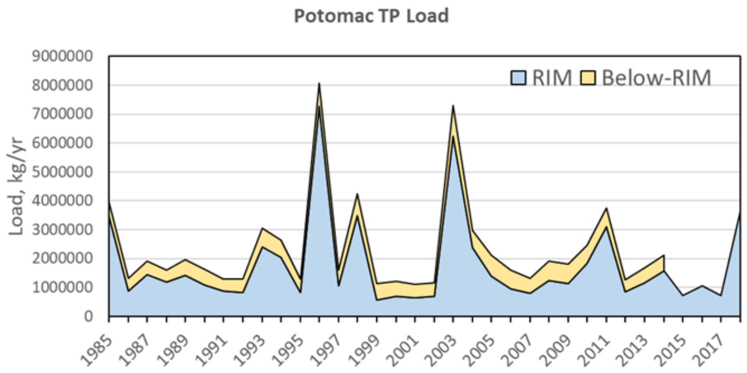
From CAST, courtesy Olivia Devereux

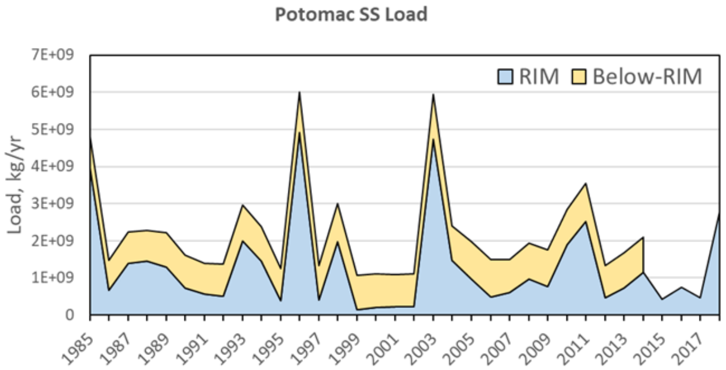


From Falcone 2015, courtesy Zhaoying Wei

Watershed Characteristics Translate to Nutrient and Sediment Loads







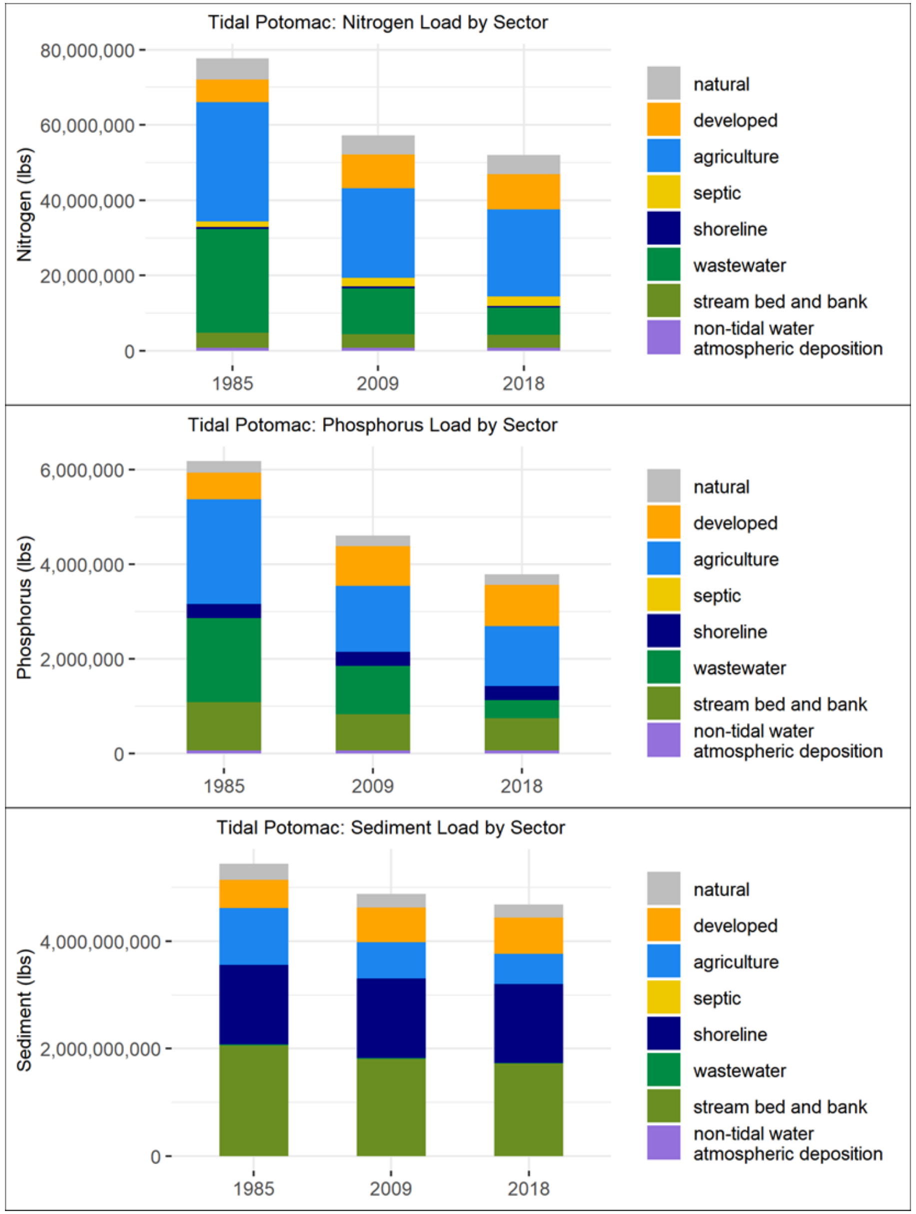
Estimated loads to tidal portions of Chesapeake Bay tributaries are a combination of:

- Monitored fluxes from USGS River Input Monitoring (RIM) stations located at the nontidal-tidal interface, and
- Below-RIM simulated loads from the Chesapeake Bay Program Watershed Model (CBWM).

Constituent	Change 1985-2014	p-value (MK)	Percent Fall-Line
TN	(11,257,117)	0.05	~ 72%
TP	(1,838,653)	0.94	~ 81%
SS	(2,696,070,671)	0.80	~ 69%

From the USGS and the CBP WSM, courtesy Qian Zhang and Gopal Bhatt

Watershed Change → Tidal Water Quality: What is expected?



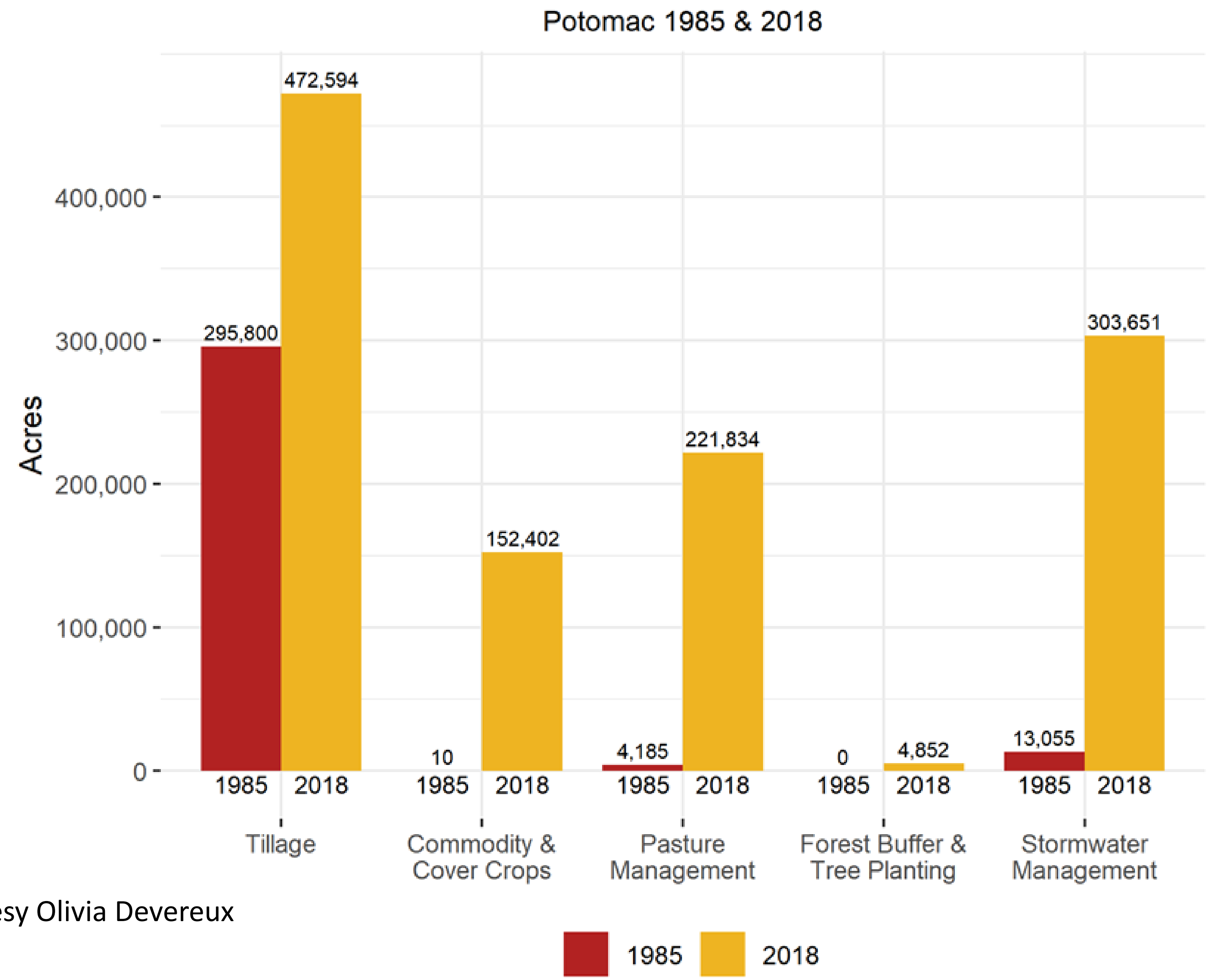
From CAST, courtesy Olivia Devereux

Overall, changes in population size, land use, and pollution management controls between 1985 and 2018 are ***expected*** to change nitrogen, phosphorus, and sediment loads to the tidal Potomac River by -33%, -39%, and -14%, respectively (CBP Watershed Model Phase 6)

Source	Expected Change 1985-2018 (%)	
	TN	TP
Agriculture	-27	-43
Developed	56	56
Septic	58	114

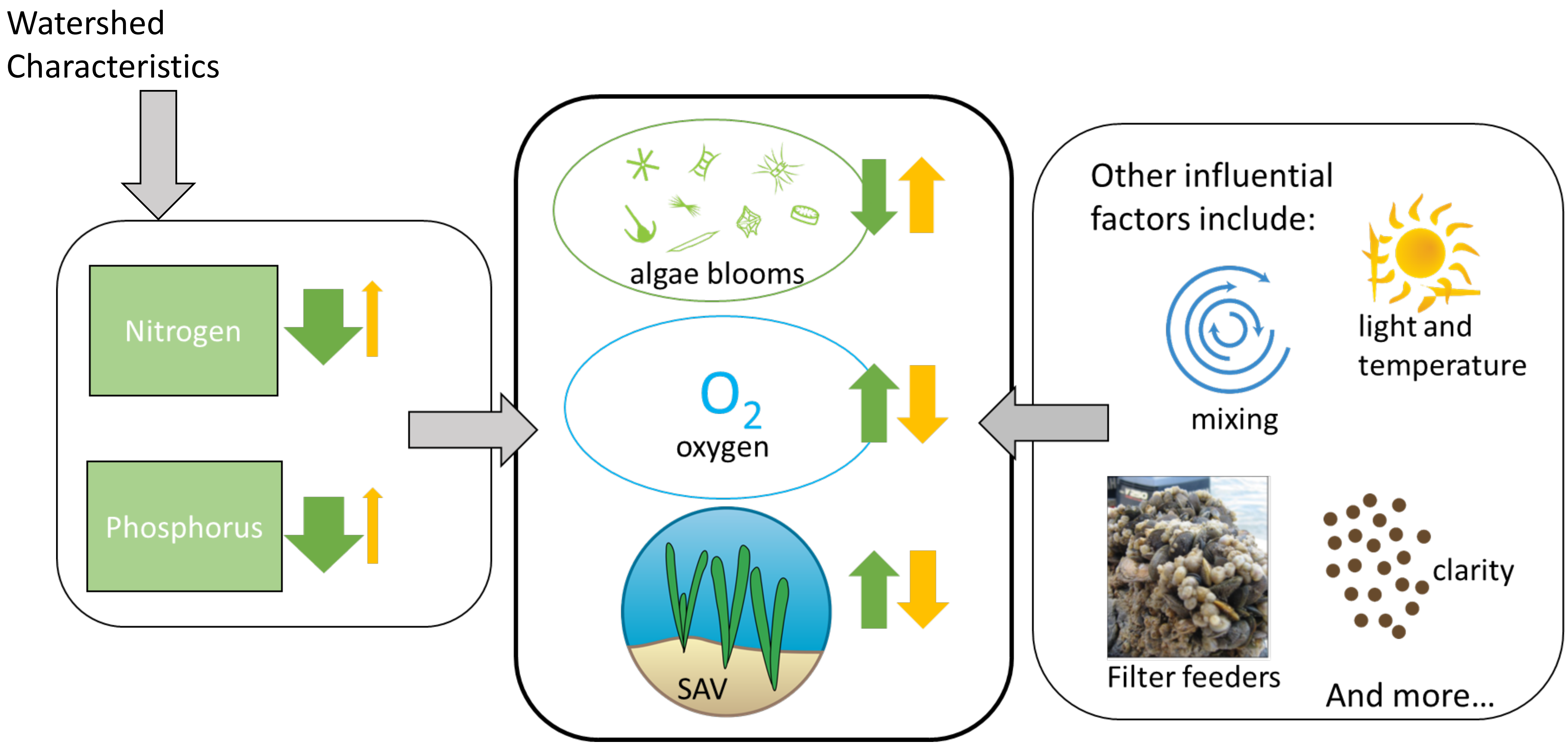
Source	Expected Change 1985-2014 (%)
	Sediment
Agriculture	-47
Developed	28
stream bed/bank	-16
shoreline	0

Watershed Change → Tidal Water Quality: What is expected?



From CAST, courtesy Olivia Devereux

Explaining Change: What is the relative importance of each of these factors?



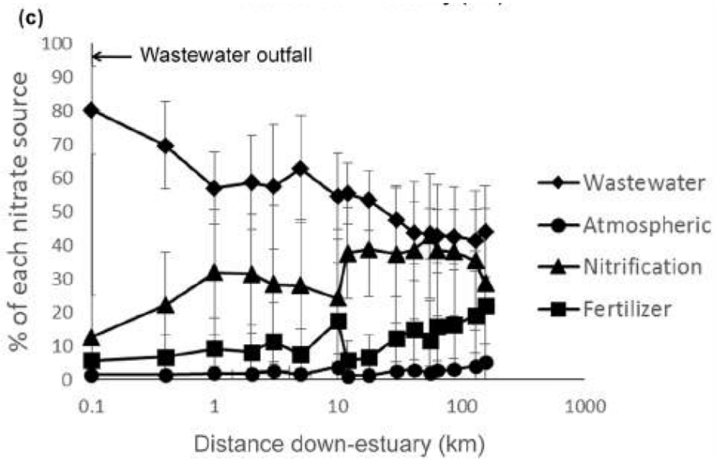
Images from: UMCES IAN (ian.umces.edu/imagelibrary/) and Chesapeake Quarterly Vol. 6 Nr. 2

Explaining Change: Incorporating research insights

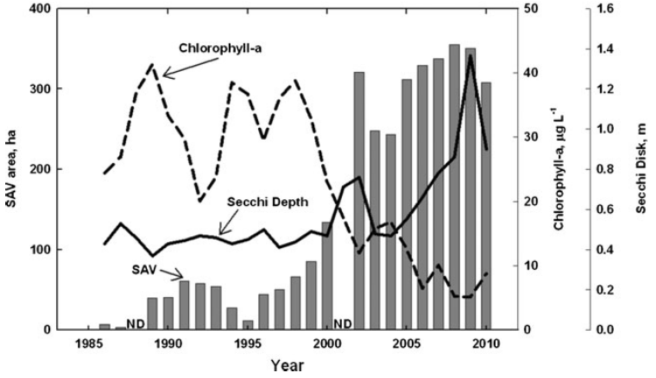
WWTP loads do reach the mouth of the river

- Nitrate at mouth of Potomac:
- Almost 50% from wastewater in the summer and fall;
- About 6-7% in winter and spring, while other nonpoint sources dominate

Pennino et al. 2016



Where wastewater is a dominant nutrient source, local water quality and habitat conditions improve after WWTP upgrades.



Boynton et al. 2013

When bivalve populations reach sufficient numbers, local water clarity and SAV respond

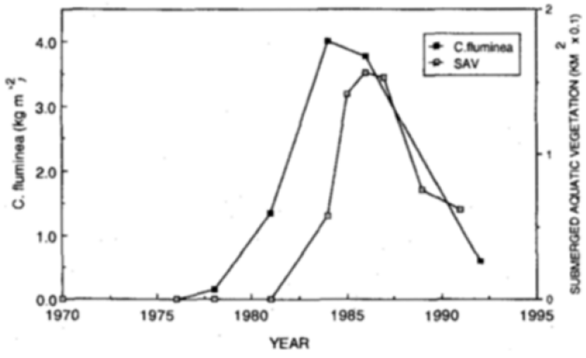
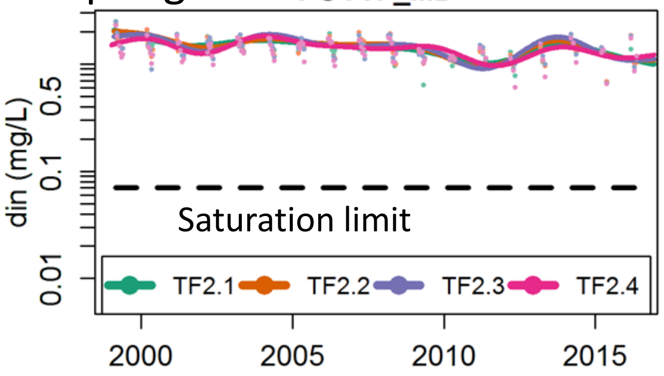


Fig. 3. *Corbicula fluminea* abundance and submerged aquatic vegetation acreage in the Potomac River estuary near Washington, D.C., 1970–1992.

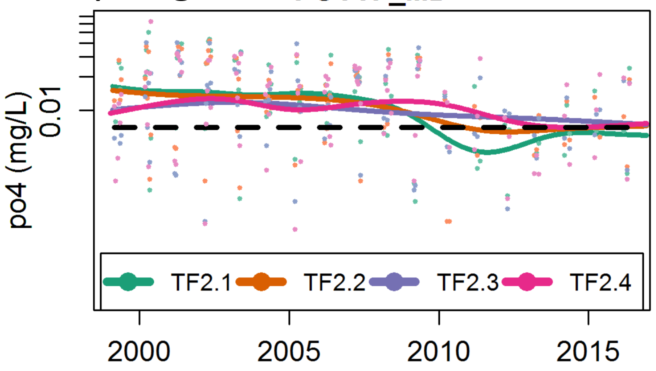
Phelps 1994

Algal response requires reductions beyond saturation limit

Spring DIN **POTTF_MD**



Spring PO4 **POTTF_MD**



Courtesy Rebecca Murphy

Potomac Tributary Trends Summary

Total nutrient concentrations have been decreasing at most stations in the Potomac River over the long-term, with improvements persisting in the last 10 years as well.

- These trends follow from the decreasing discharge from TN and TP sources in the watershed.

Despite the overall improvements in both nitrogen and phosphorus concentrations observed in these studies and in the current trend results, many of the chlorophyll-a and secchi trends are still degrading.

- Research suggests that there is a "saturation limit" for phytoplankton use of nutrients (Buchanan et al., 2005; Fisher and Gustafson, 2003). There may not be a response in phytoplankton to nutrient reductions unless the dissolved nitrogen or phosphorus concentrations cross under their saturation limits.

Recent improvements in oxygen concentrations are promising.

- That lower Potomac chlorophyll-a concentrations have either leveled out or improved may suggest a smaller amount of phytoplankton biomass available to fuel summer oxygen depletion.

Other factors such as import of nutrients from the mainstem bay (Pennino et al., 2016), varying bivalve populations (Phelps, 1994), SAV populations, and temperature increases (Ding and Elmore, 2015) could all be playing a role in the response trajectory of the Potomac River for all of these parameters.

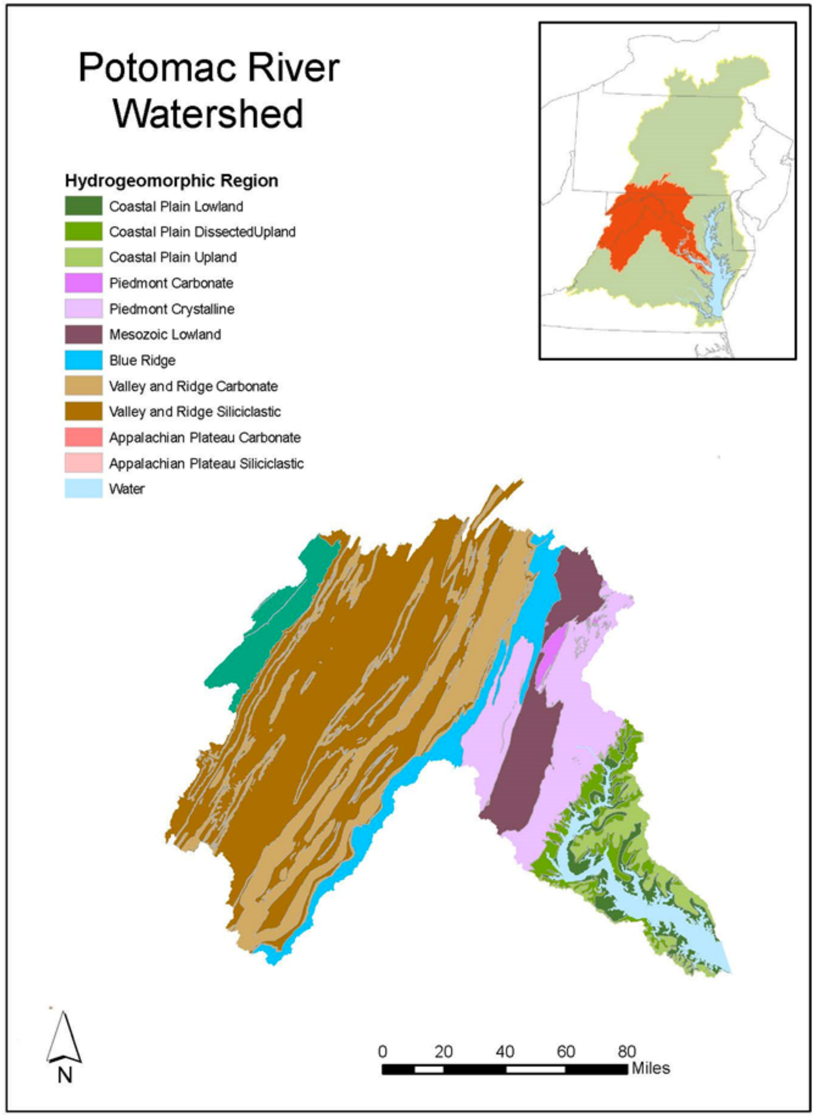
Appendix

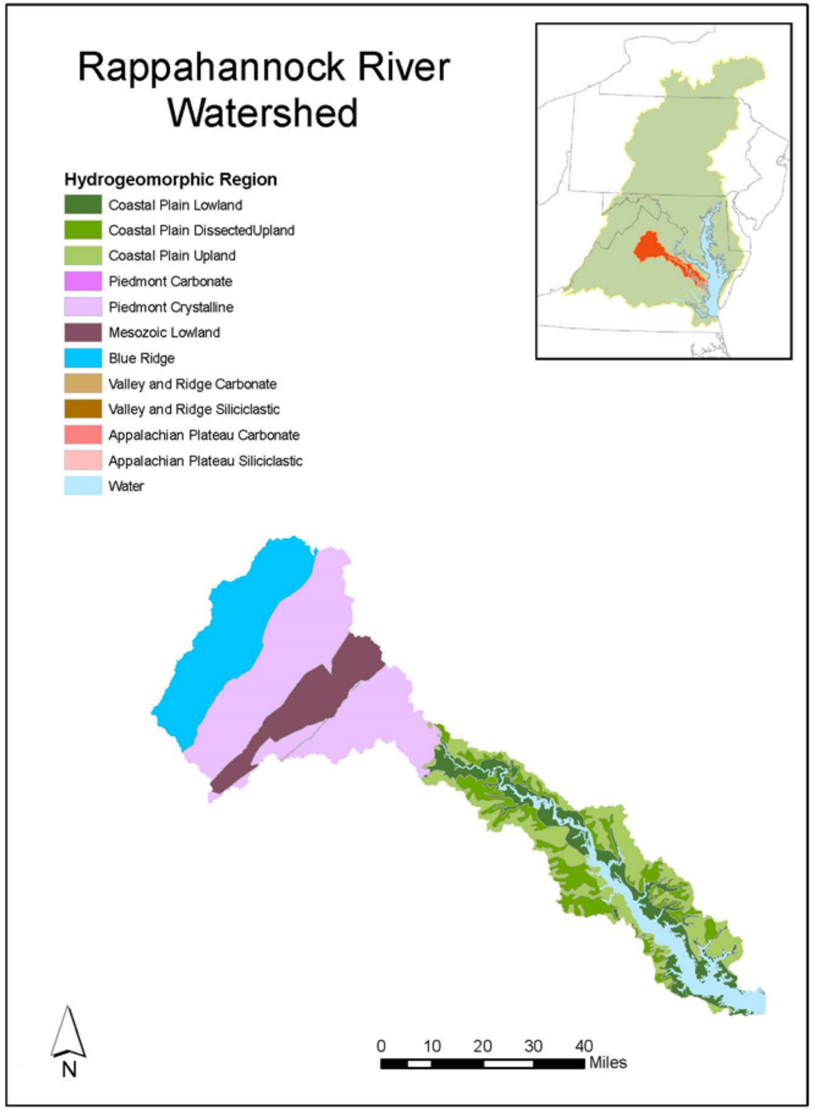
This will be a separate document, but a map and panel plot each for:

- Bottom TP
- Bottom TN
- Surface PO4
- Surface DIN
- Surface TSS
- Surface DO
- Surface Temperature

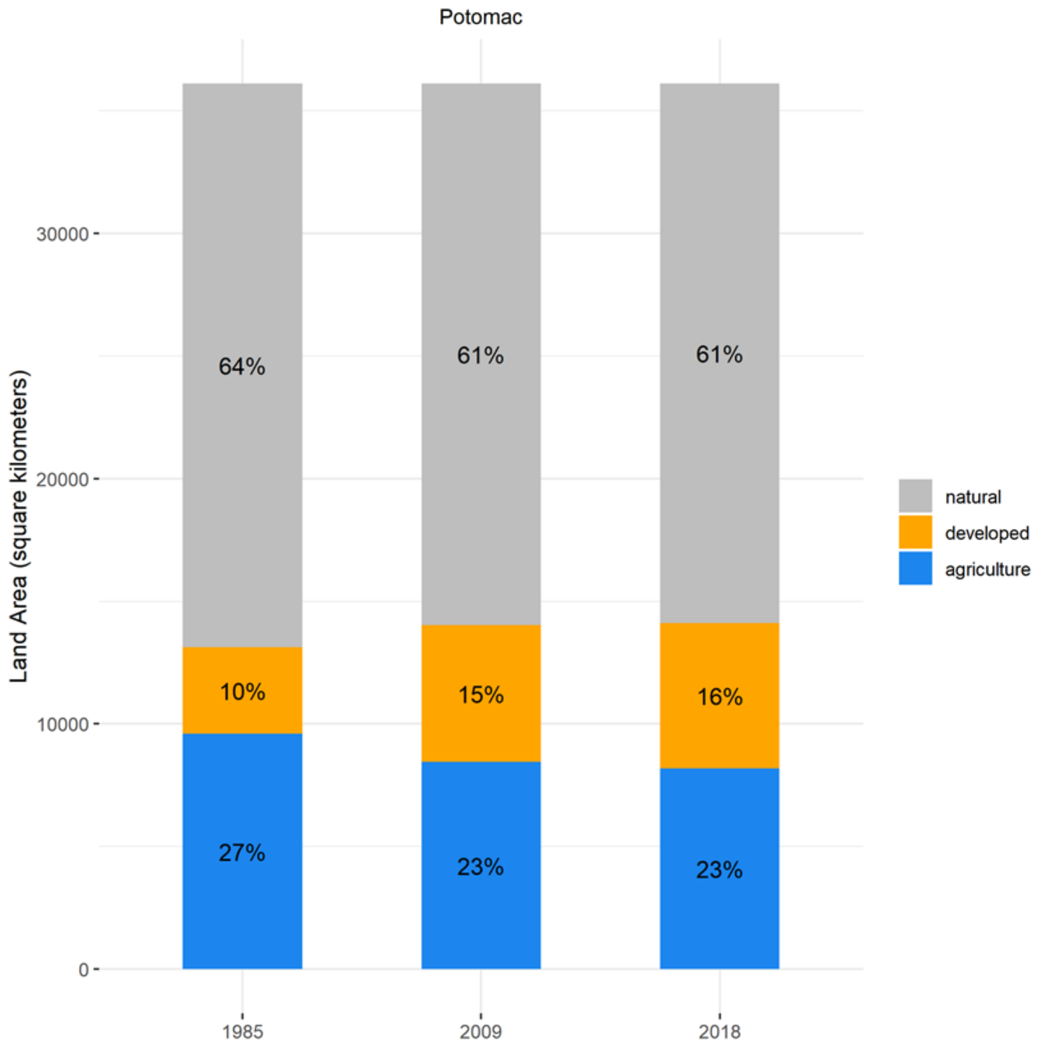
END

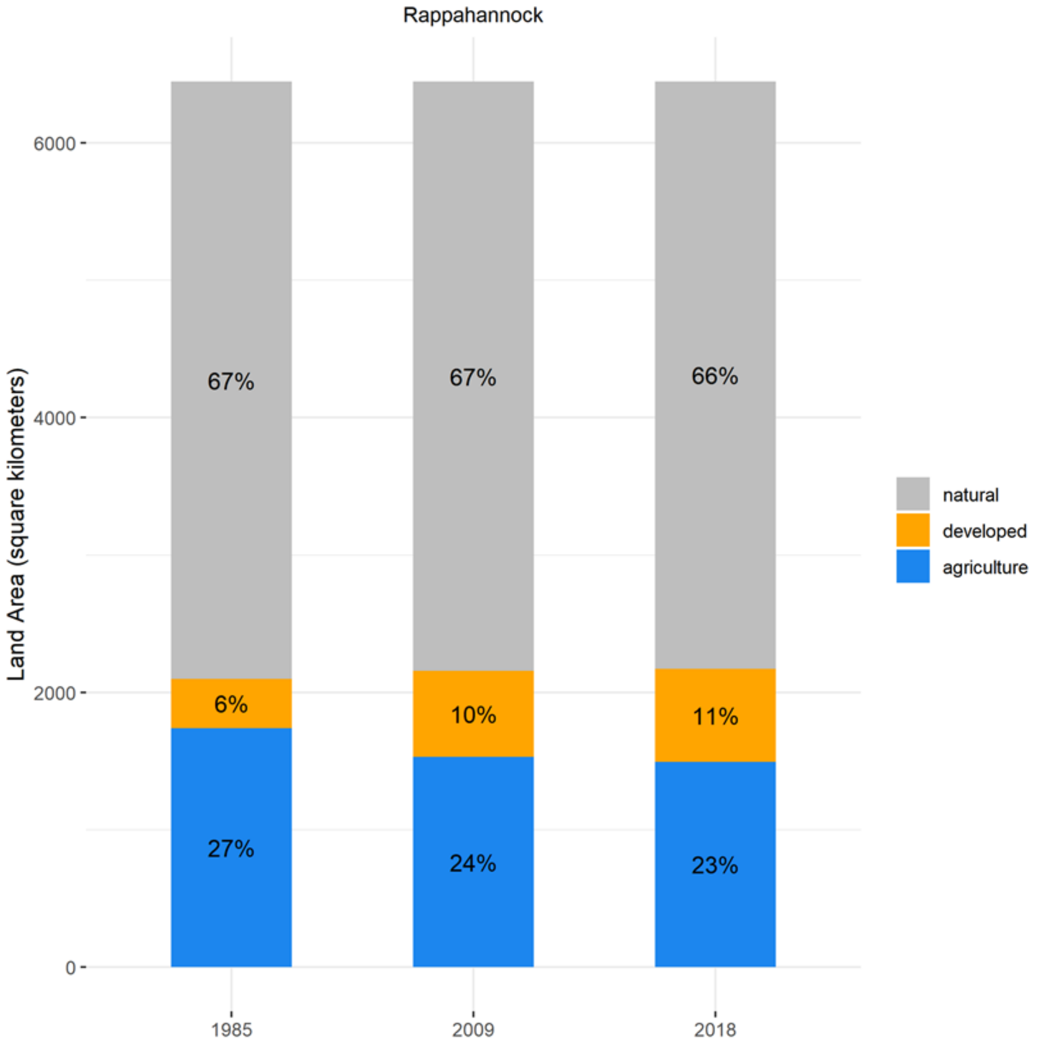
Comparing Across Tributaries





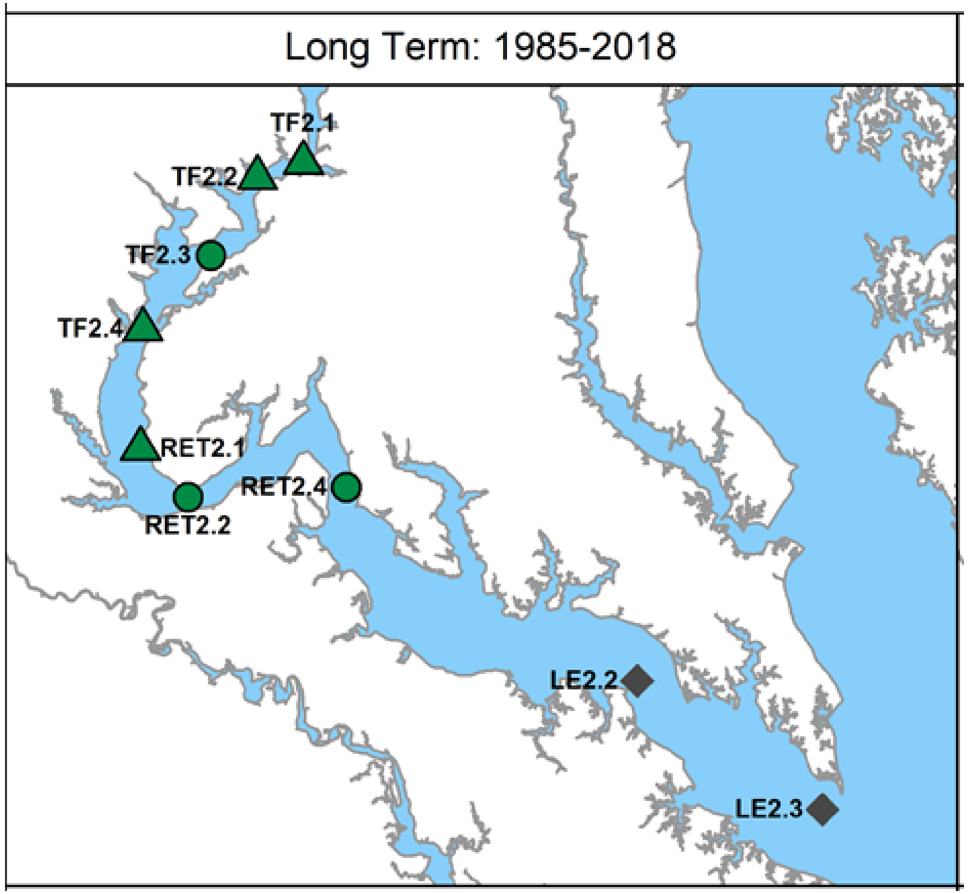
Potomac and Rappahannock Land Use



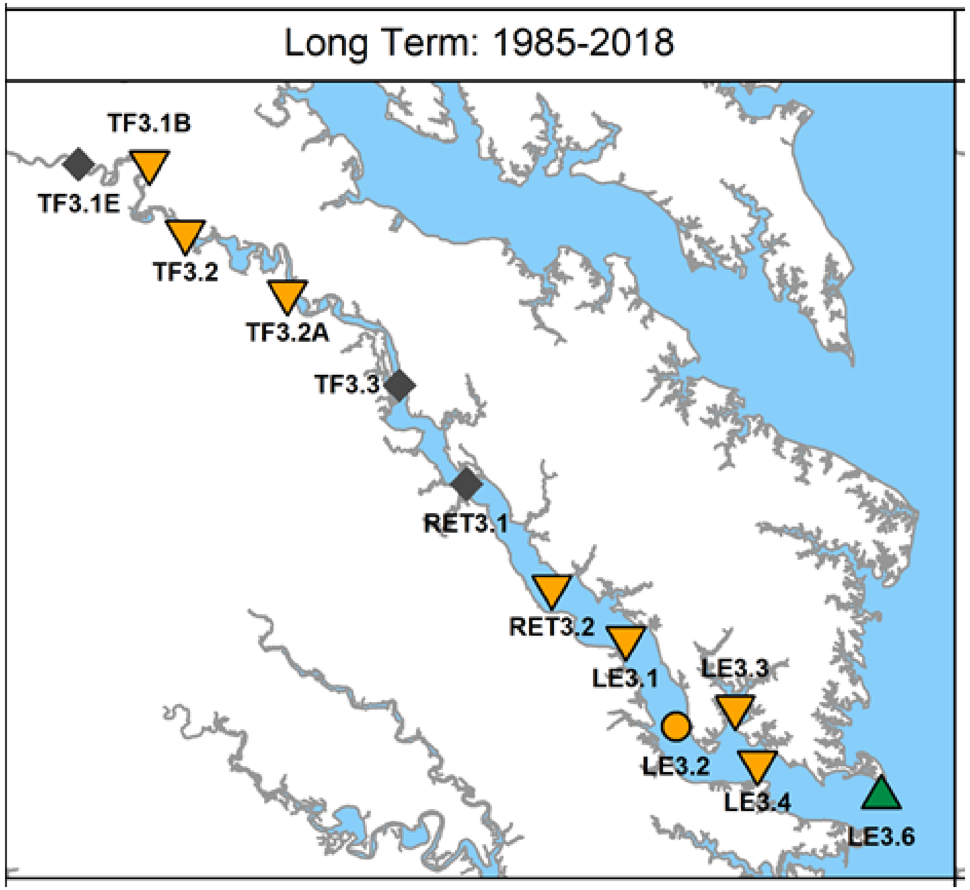


Potomac and Rappahannock Summer Bottom DO 1985-2018

Potomac Summer Bottom DO



Rappahannock Summer Bottom DO



Potomac and Rappahannock Load Changes

Potomac

Constituent	Change 1985-2014	p-value (MK)	Percent Fall-Line
TN	(11,257,117)	0.05	~ 72%
TP	(1,838,653)	0.94	~ 81%
SS	(2,696,070,671)	0.80	~ 69%

Rappahannock

Constituent	Change 1985-2014	p-value (MK)	Percent Fall-Line
TN	862,259	0.32	~ 60%
TP	255,276	0.13	~ 71%
SS	201,051,937	0.18	~ 45%

Courtesy Qian Zhang

Source	Expected Change 1985-2018 (%)	
	TN	TP
Agriculture	-27	-43
Developed	56	56
Septic	58	114

Source	Expected Change 1985-2014 (%)
	Sediment
Agriculture	-47
Developed	28
stream bed/bank	-16
shoreline	0

Source	Expected Change 1985-2018 (%)	
	TN	TP
Agriculture	-25	-46
Developed	80	104
Septic	64	0

Source	Expected Change 1985-2014 (%)
	Sediment
Agriculture	-47
Developed	40
stream bed/bank	-17
shoreline	0

From CAST, courtesy Olivia Devereux

Potomac and Rappahannock Implementation of Select BMPs, 1985 and 2018