Using the Tributary Summaries: *Case Studies*

Oct. 12, 2021

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Follow-up from presentation to WQGIT by:
Jeni Keisman (USGS) and
Olivia Devereux (Devereux Consulting)
With content from many others

Rappahannock Tributary Summary:

A summary of trends in tidal water quality and associated factors, 1985-2018.

June 7, 2021

Prepared for the Chesapeake Bay Program (CBP) Partnership by the CBP Integrated Trends Analysis Team (ITAT)

Chesapeake Bay Program
Science. Restoration. Partnership.

This tributary summary is a living document in draft form and has not gone through a formal peer review process. We are grateful for contributions to the development of these materials from the following individuals: Jeni Keisman, Rebecca Murphy, Olivia Devereux, Jimmy Webber, Qian Zhang, Meghan Petenbrink, Tom Butler, Zhaoying Wei, Jon Harcum, Renee Karrh, Mike Lane, and Elgin Perry.

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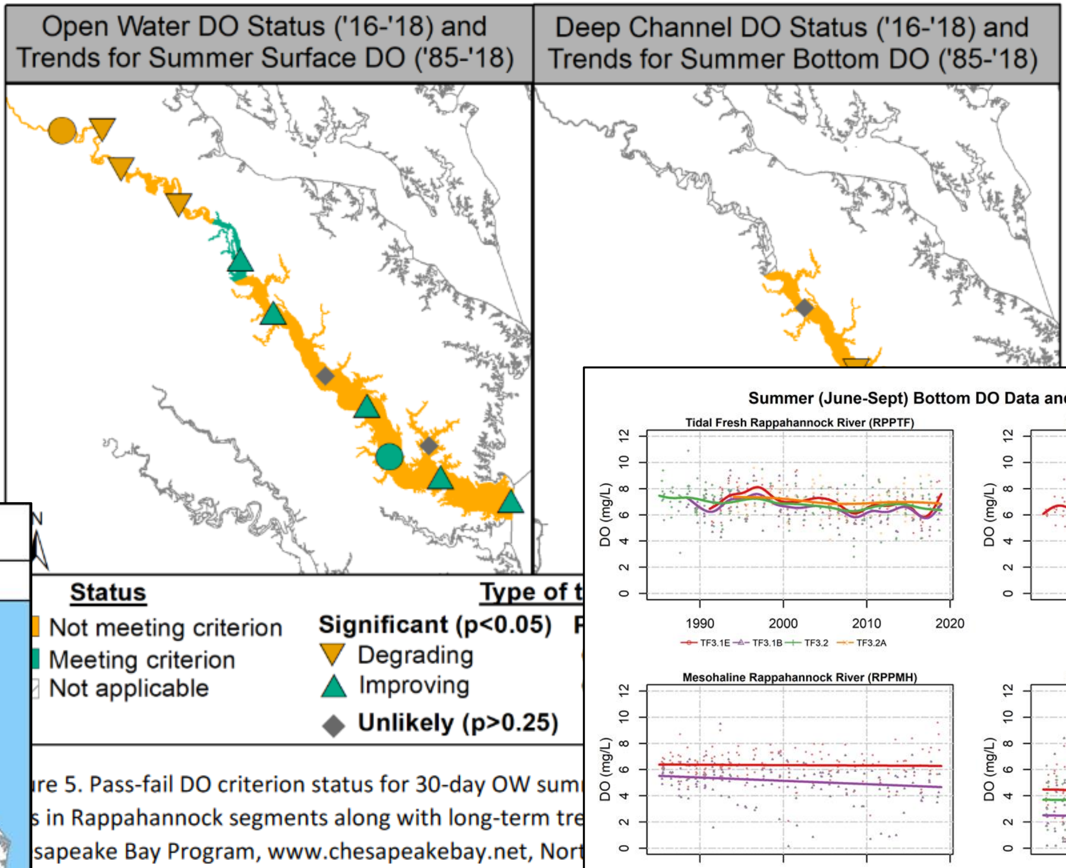
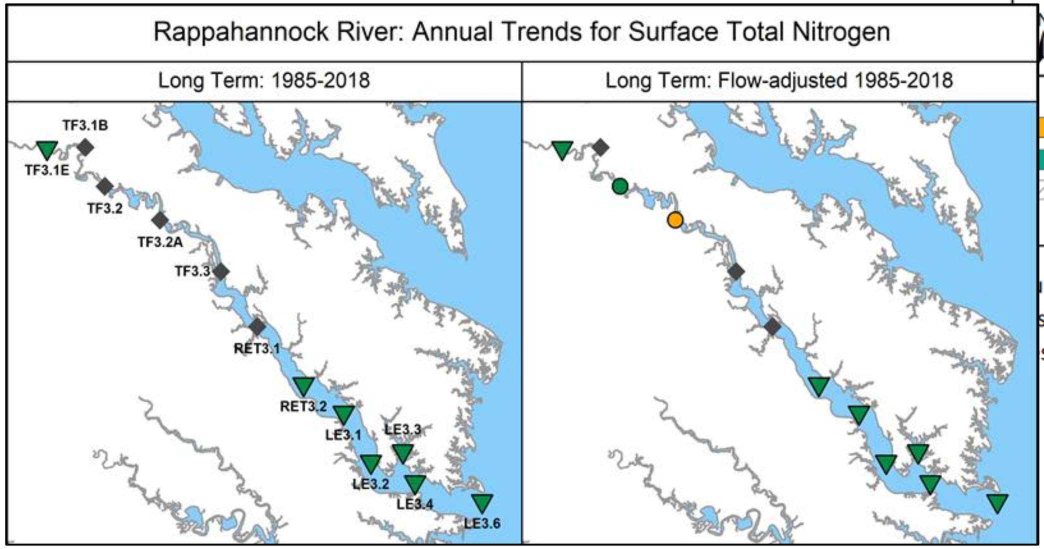
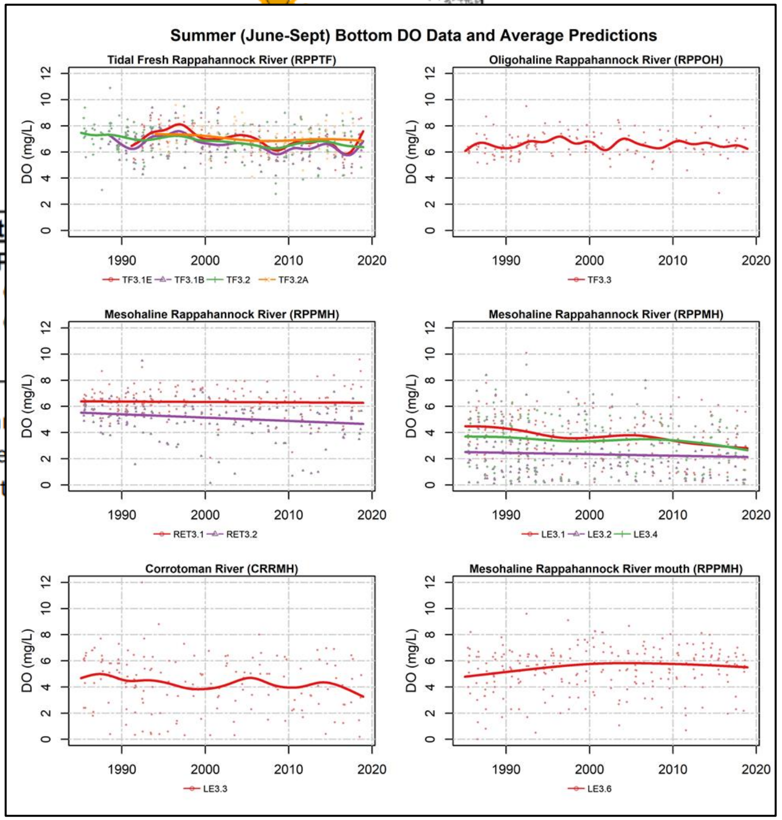
What are the Tributary Summaries?

A compilation of information by tributary or region on:

- **Tidal water quality and trends**



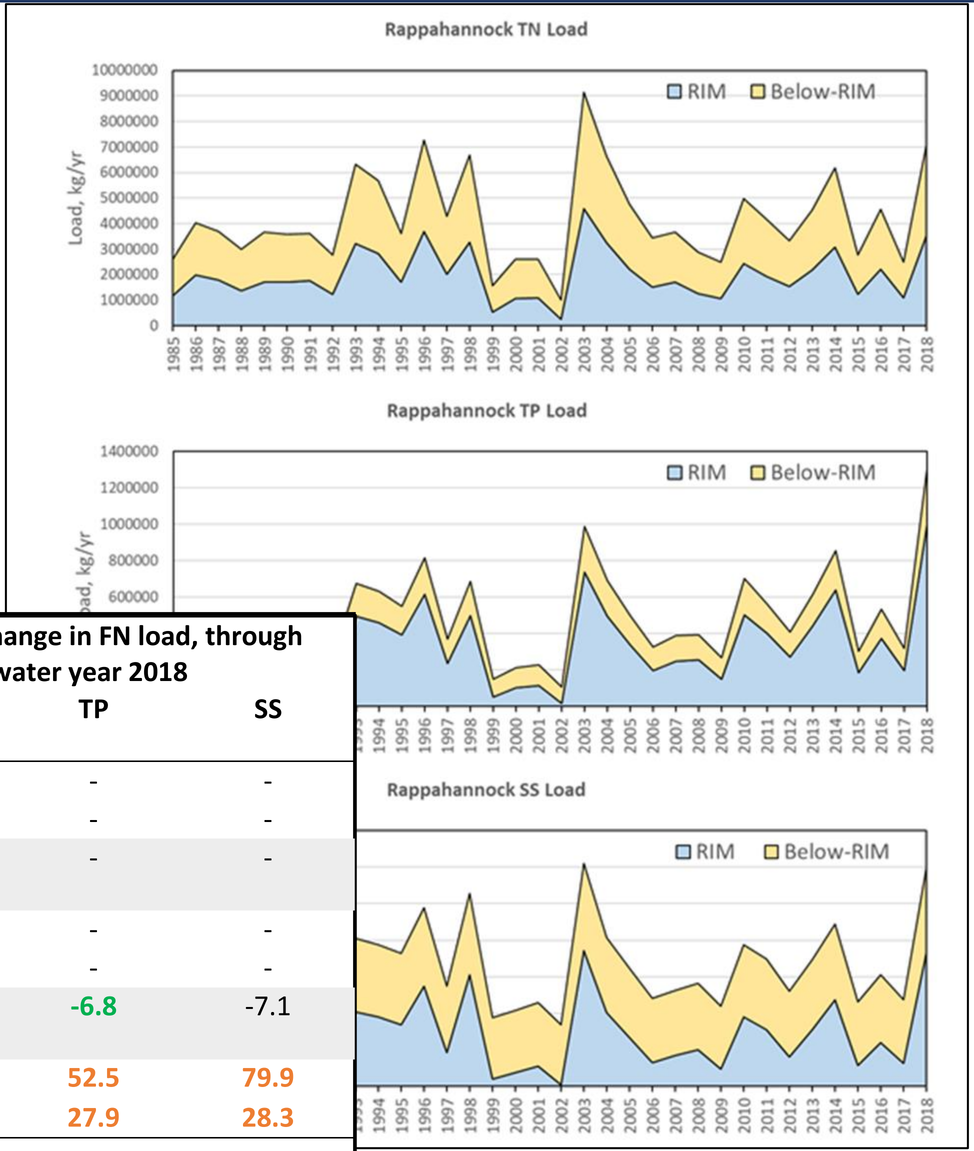


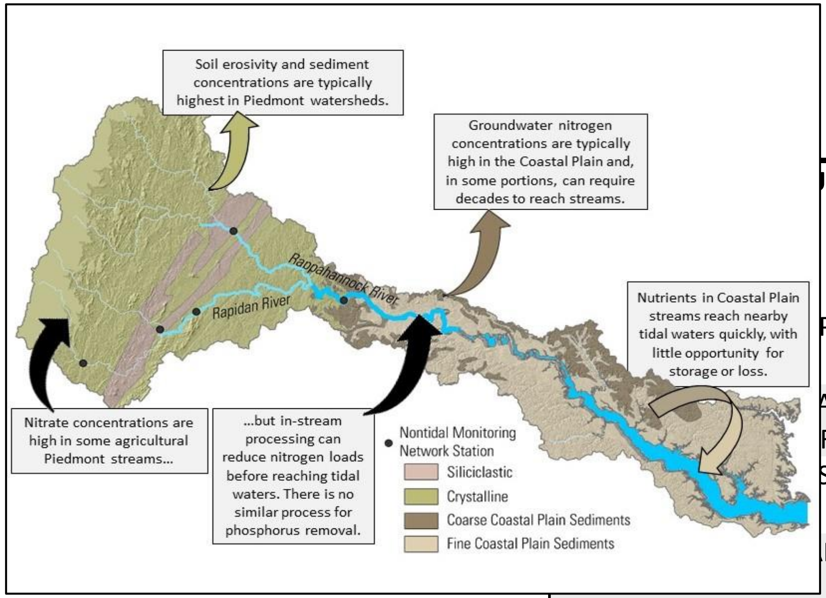


What are the Tributary Summaries?

A compilation of information by tributary or region on:

- Tidal water quality and trends,
- **Watershed characteristics and changes**



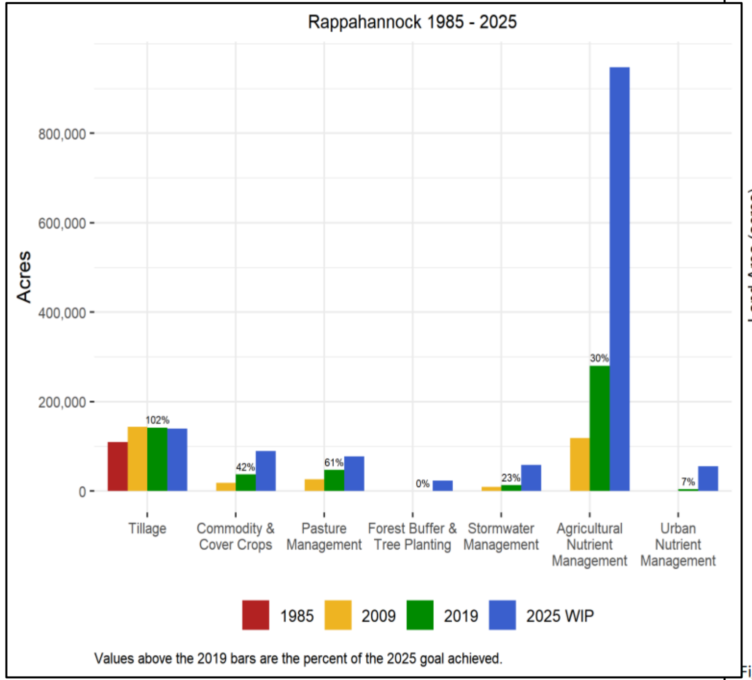


	USGS Station Name	Trend start water year	Percent change in FN load, through water year 2018 TN	TP	SS
	PAHANNOCK RIVER AT REMINGTON, VA	1985	24.4	-	-
		2009	15.4	-	-
	APIDAN RIVER NEAR RUCKERSVILLE, VA	2009	-5.1	-	-
	SON RIVER NEAR LOCUST DALE, VA	1985	2.5	-	-
		2009	3.5	-	-
	N RIVER NEAR CULPEPER, VA	2009	-8.9	-6.8	-7.1
01668000	RAPPAHANNOCK RIVER NEAR FREDERICKSBURG, VA	1985	-12.7	52.5	79.9
		2009	6.3	27.9	28.3

What are the Tributary Summaries?

A compilation of information by tributary or region on:

- Tidal water quality and trends,
- Watershed characteristics and changes,
- **Landscape drivers.**



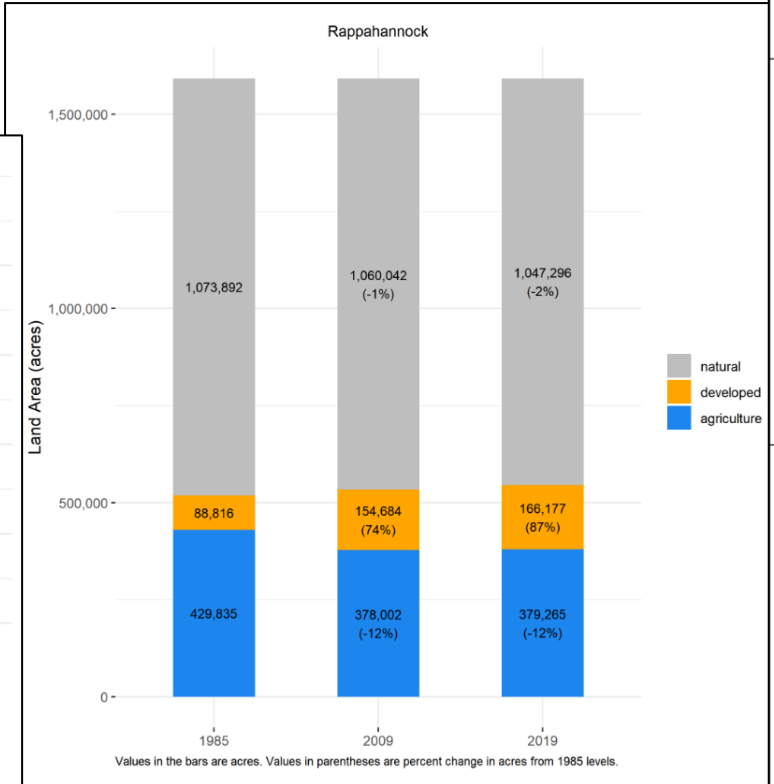
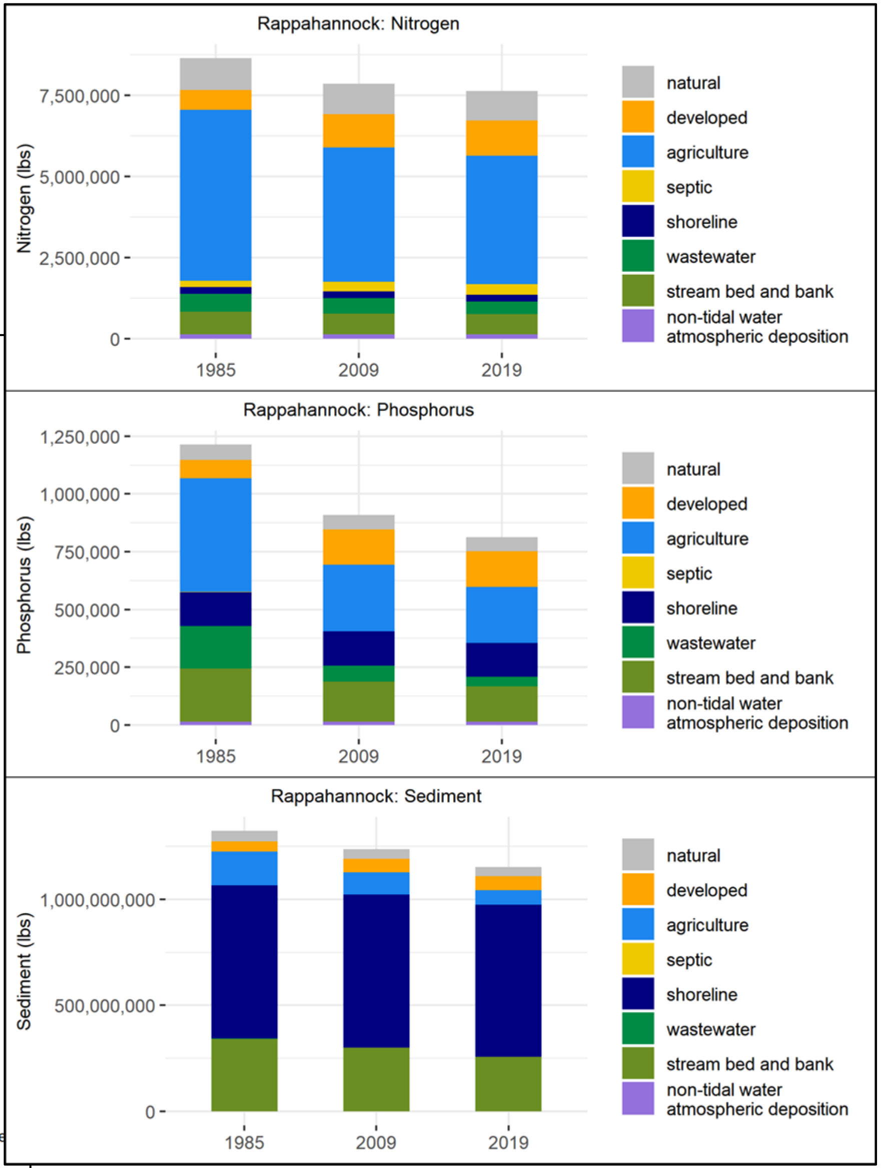


Figure 2. Distribution of land uses in the Rappahannock watershed. Percentages are the percent change from 1985 for each source sector.



Why do they exist?

- Reports had previously been compiled with tidal trend information from the states,
- But with new analyses of monitoring data, **a new design** was possible.
- Thus, these summaries put much information in one place as **a technical resource**.

Technical managers within jurisdiction agencies
Local watershed organizations
Federal, state, and academic researchers

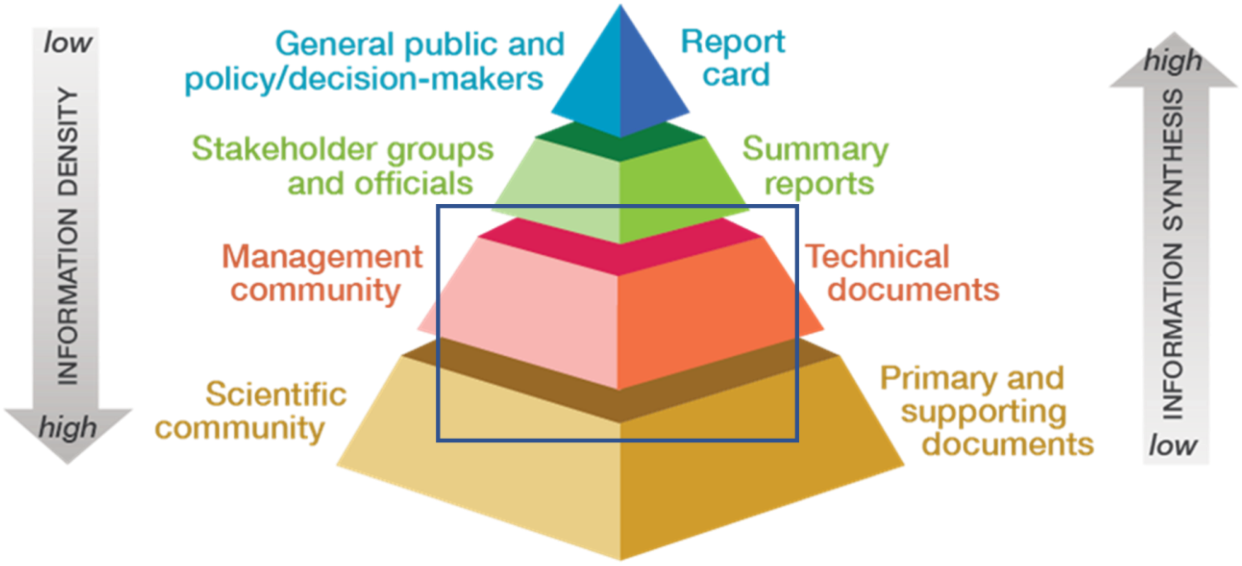
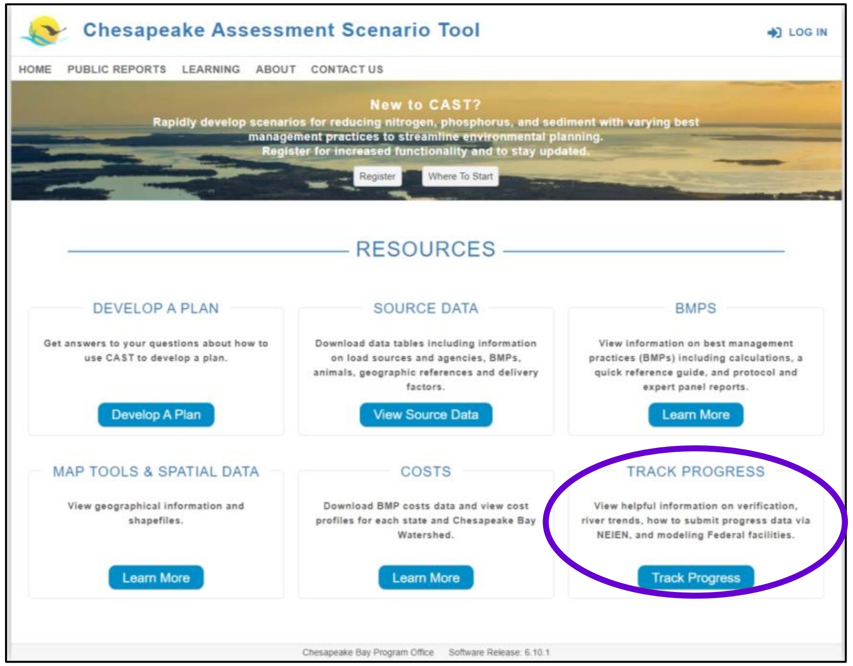
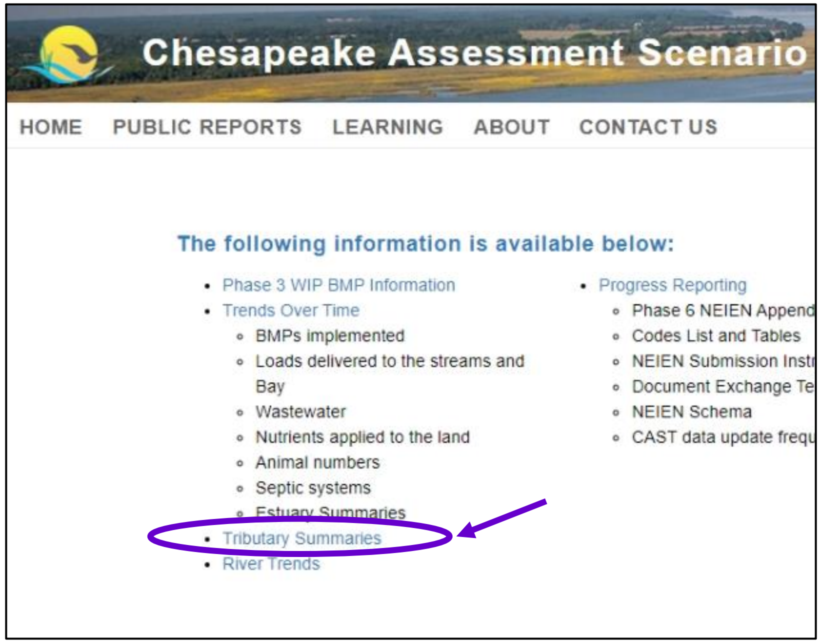


Figure courtesy UMCES Integration and Application Network, ian.umces.edu

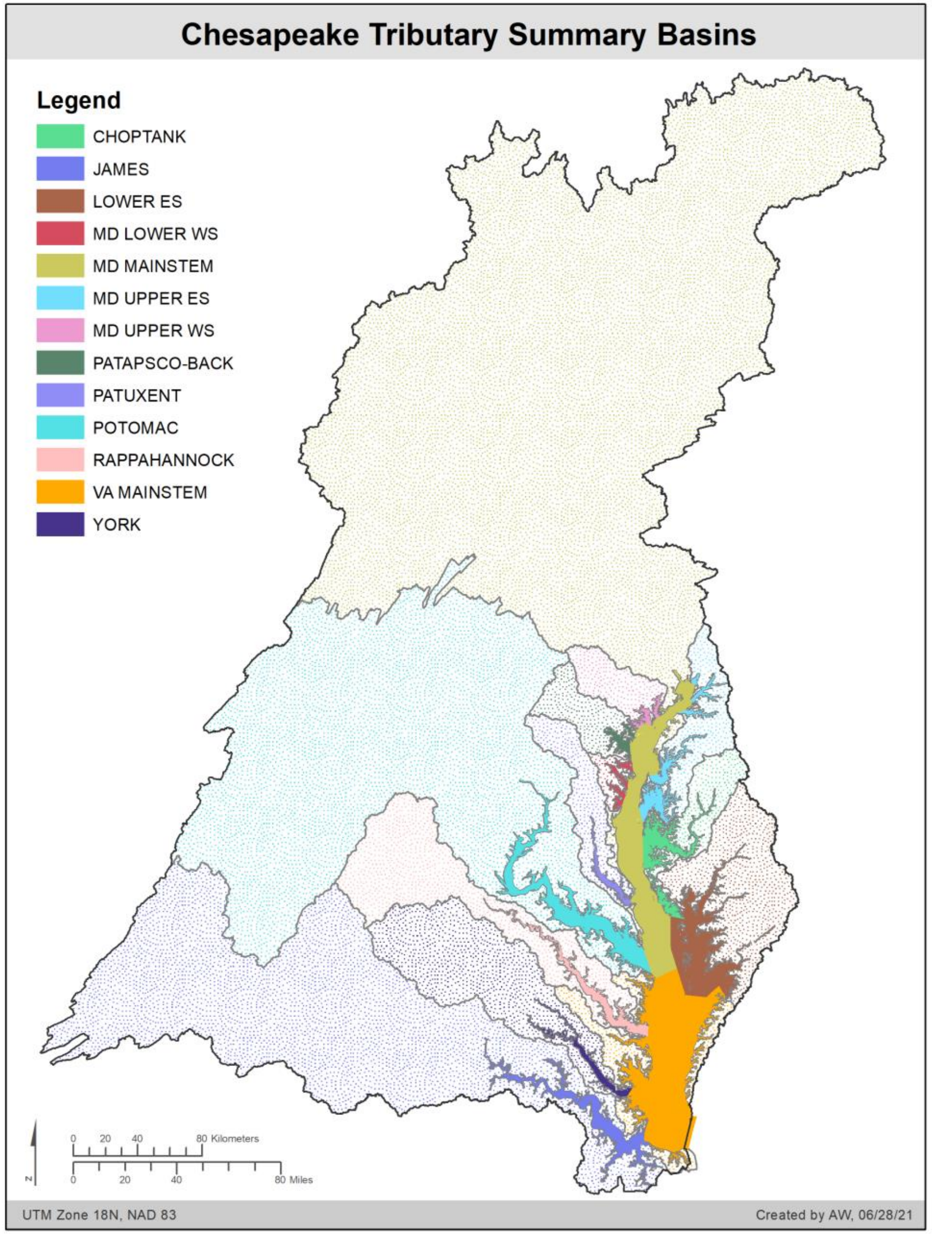
Where to access?



[CAST - TMDL Tracking (chesapeakebay.net)]



13 Tributary Trend Summaries



- **Maryland Mainstem** *(The 5 Chesapeake Bay mainstem segments within the MD state boundary. Drainage basins include the Susquehanna River and upper Chesapeake shorelines)*
- **Maryland Upper Eastern Shore** *(The Northeast, Bohemia, Elk, Back Creek, Sassafras, and Chester Rivers, the C&D Canal, and Eastern Bay)*
- **Choptank** *(the Choptank, Little Choptank, and Honga)*
- **Maryland Upper Western Shore** *(Bush, Gunpowder, Middle Rivers)*
- **Maryland Lower Western Shore** *(Magothy, Severn, South, Rhode, and West)*
- **Patapsco & Back Rivers**
- **Patuxent** *(includes the Western Branch tributary)*
- **Potomac**
- **Rappahannock** *(includes the Corrotoman tributary)*
- **York** *(includes the Mattaponi and Pamunkey tributaries)*
- **James** *(includes the Appomattox, Chickahominy, and Elizabeth tributaries)*
- **Lower E. Shore** *(includes the Nanticoke, Manokin, Wicomico, Big Annemessex, and Pocomoke rivers & Tangier Sound)*
- **Virginia Mainstem** *(no summary but Appendices are provided)*

How do we use this information?

- As a readily-available one-stop-shop on ***background*** for change over time observed with monitoring data.

- To answer questions such as:
  - *Have water quality indicators in my river been improving or degrading over time?*
  - *How have landscape factors that drive water quality change in my watershed changed over time?*
  - *What clues do they provide that might explain observed water quality change (or lack of change)?*
  - *What should I target to turn a degrading trend around or maintain improvements for future water quality and living resource conditions?*
  - *What should scientists focus our analyses on to provide better answers in the future?*

- With just a little additional work, the ingredients are there to make some progress on linkage questions:

→ ***How do tidal waters respond to actions in the watershed? And is there data to support which decisions we make?***

<u>Case Studies today:</u>

1) Potomac Tributary Report
2) York Tributary Summary

Case Study 1: Potomac Tributary Report

- Completed Dec, 2020.
- Uses data from 1985-2018.

Keisman, J., Murphy, R. R., Devereux, O.H., Harcum, J., Karrh, R., Lane, M., Perry, E., Webber, J., Wei, Z., Zhang, Q., Petenbrink, M. 2020. Potomac Tributary Report: A summary of trends in tidal water quality and associated factors. Chesapeake Bay Program, Annapolis MD.

- Story Map produced by USGS: https://wim.usgs.gov/geonarrative/potomactrib/

Brief demonstration of Potomac Story Map

Case Study 1: Potomac Tributary Report

→ ***How do tidal waters respond to actions in the watershed?***
And is there data to support which decisions we make?

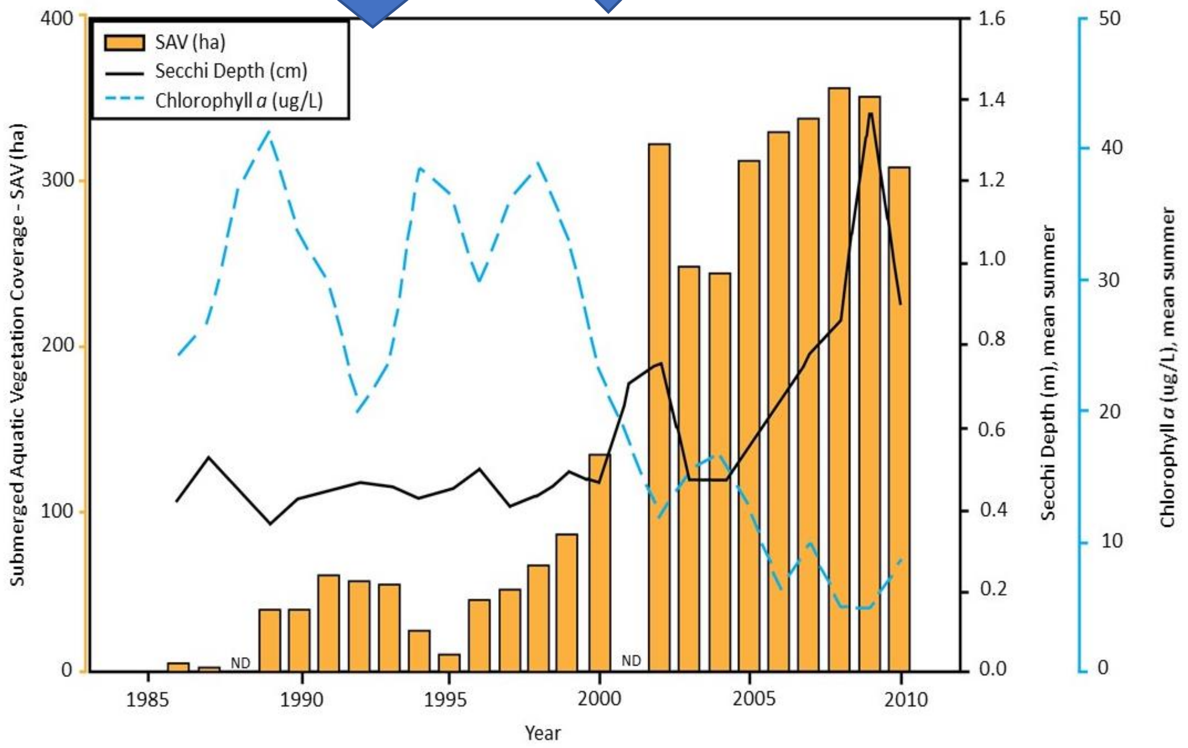
Two important findings:

1. Local response to large nutrient reductions happens and is clearly shown with the data.

2. Long-term response to watershed-wide nutrient reductions is happening in the tidal waters.

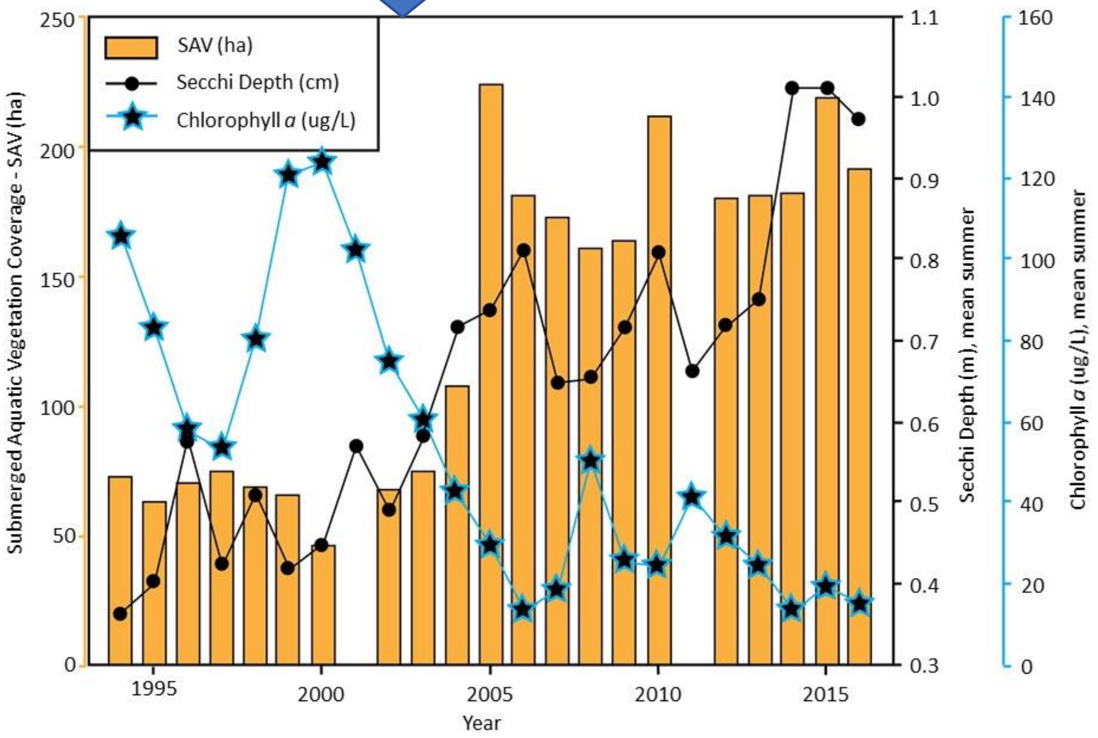
Tidal water response: 1) *Local response to large nutrient reductions happens*

Mattawoman Creek: Very large WW load reductions



SAV coverage (ha), water clarity (Secchi disk depth), and algal biomass (chlorophyll *a* concentration) in Mattawoman Creek. From Boynton *et al.* (2014).

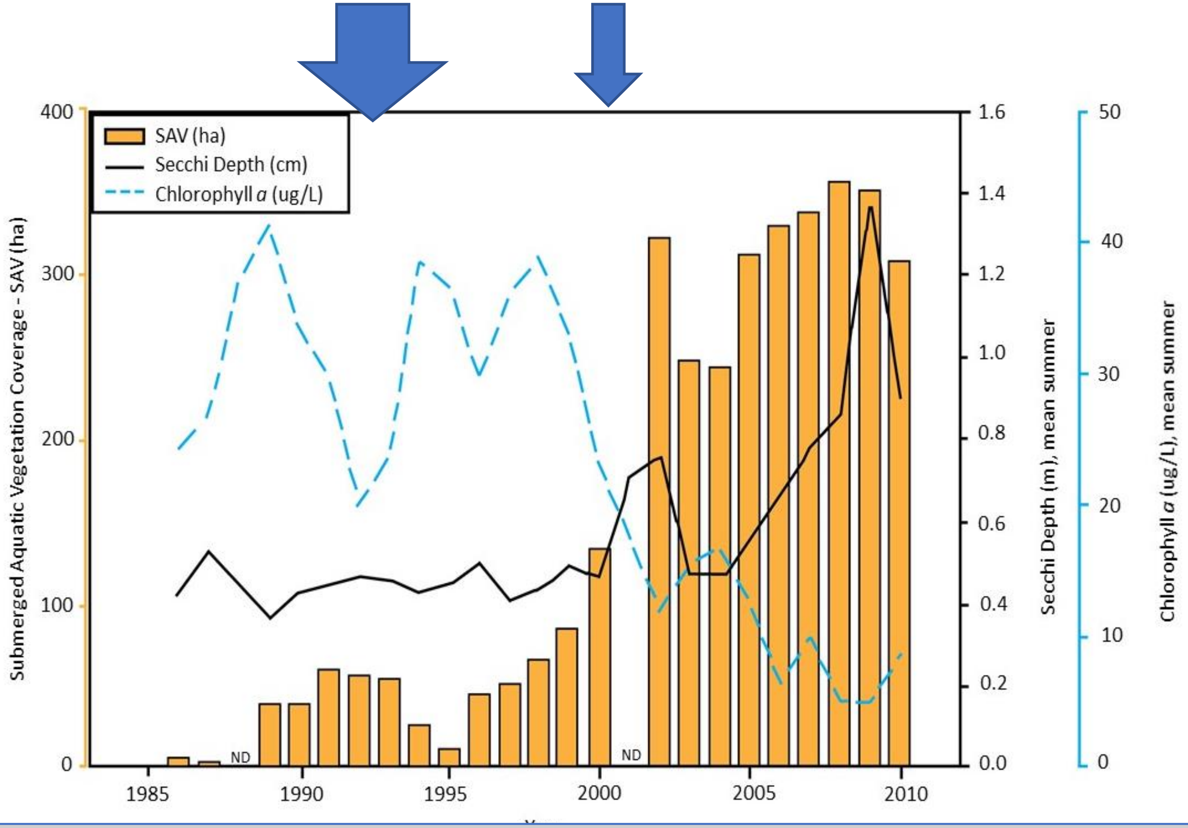
Gunston Cove: Very large WW load reduction



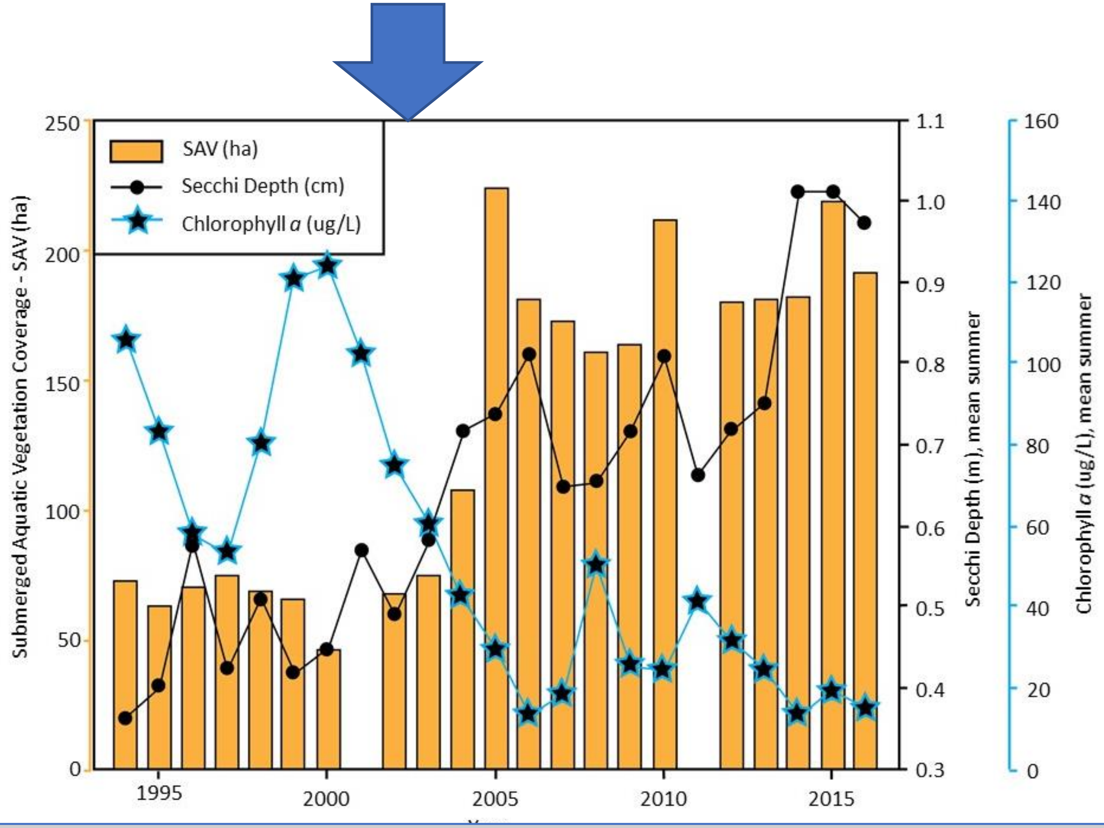
Algal biomass (as chlorophyll *a*), Secchi depth, and SAV acreage for the period 1994 – 2016 in Gunston Cove. From Jones *et al.* (2017).

Tidal water response: 1) *Local response to large nutrient reductions happens*

Mattawoman Creek: Very large WW load reductions



Gunston Cove: Very large WW load reduction



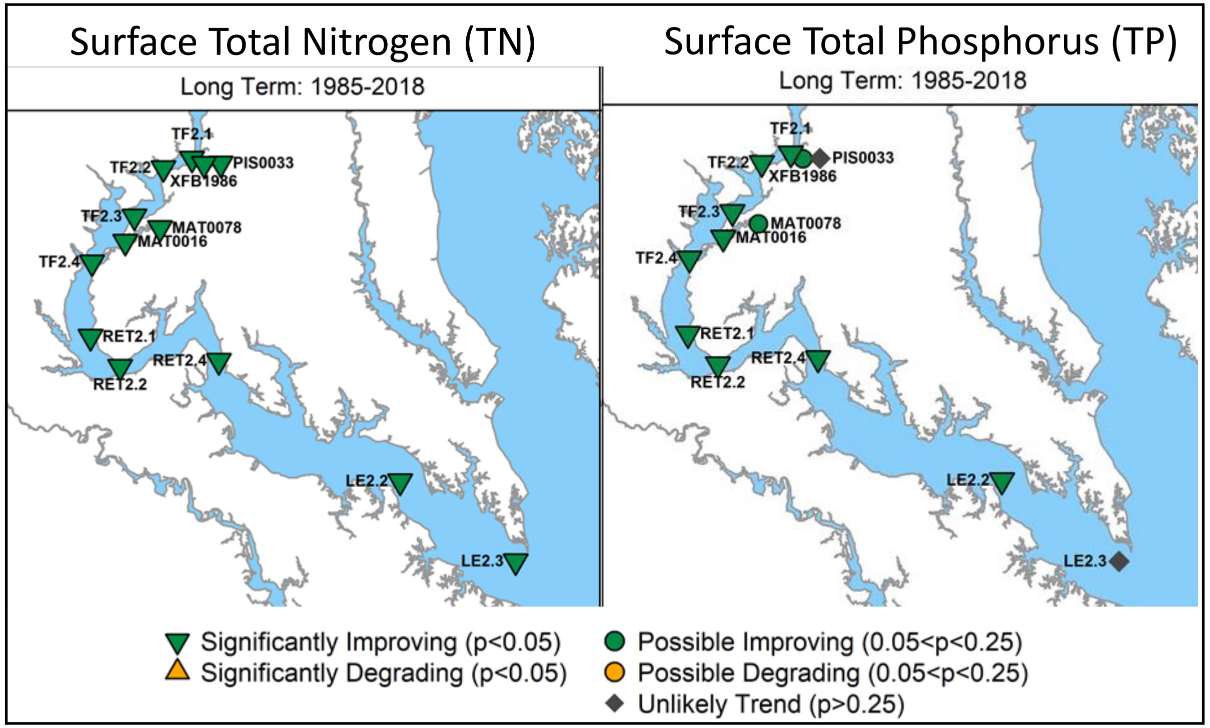
<u>What this tells us:</u> This data clearly shows that investment in large-scale nutrient reductions is successful for improving water quality dramatically in local systems.

Tidal water response: *2) Long-term response to watershed changes is happening*

- Over the long-term, nutrient loads have decreased across the Potomac watershed.
- Tidal nutrient concentrations have decreased at almost all tidal stations.

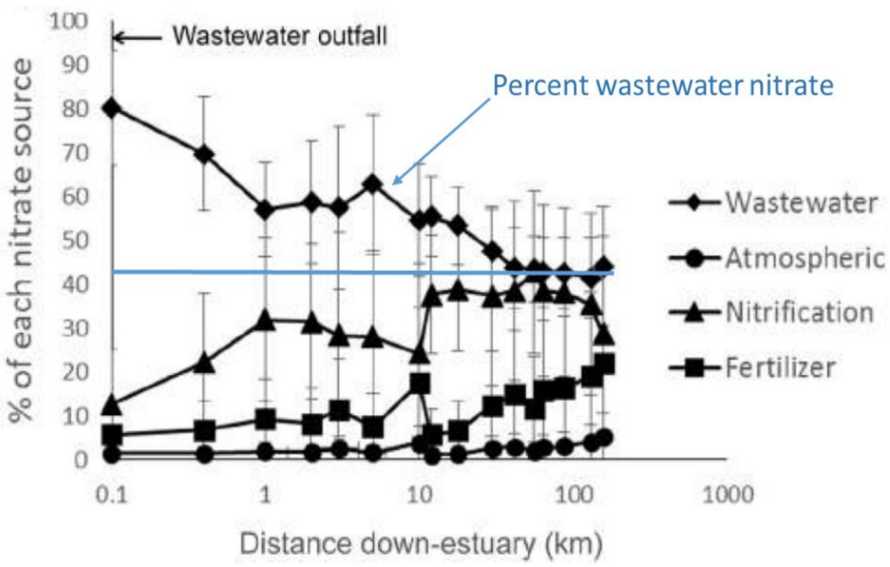
Table 3. Trends (2009 – 2018) in flow normalized total nitrogen (TN), total phosphorus (TP), and suspended sediment (SS) for nontidal network monitoring locations in the Potomac River watershed.

Parameter	No. of stations	Value	Trend direction degrading	Trend direction improving	Trend direction no trend
TN	28	n	7	14	7
		median %	15.4%	-5.8%	1.1%
TP	18	n	0	12	6
		median %	-	-28.9%	8.5%
SSC	18	n	5	5	8
		median %	23.7%	-24.4%	5.2%

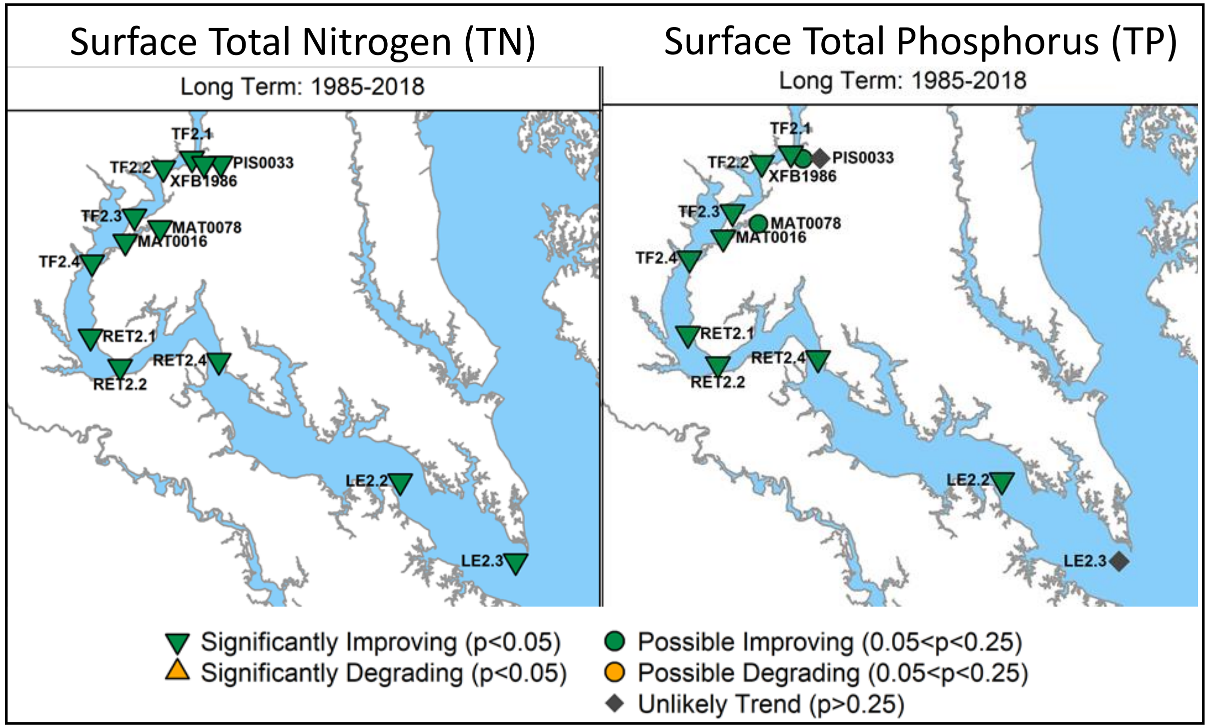


Tidal water response: *2) Long-term response to watershed changes is happening*

- These tidal trends are **not just local response**, but have been shown to be impacted by loads from many types of sources.

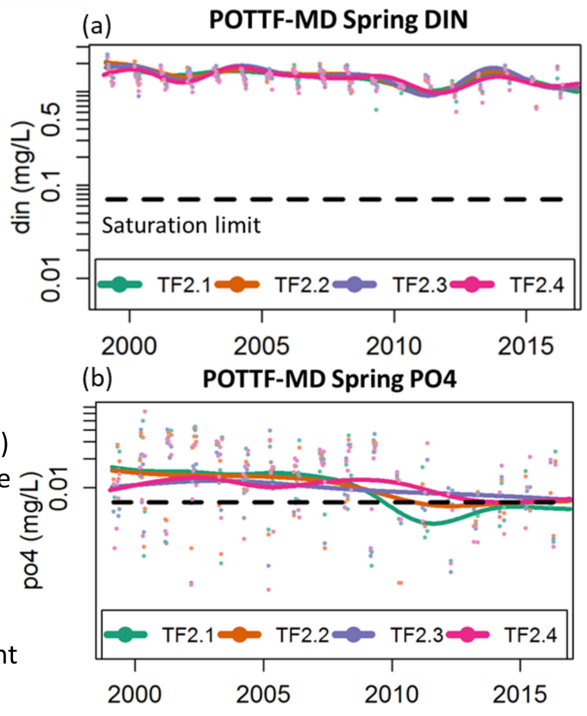


Mean annual change in the percent contribution of nitrate from wastewater, fertilizer, atmospheric deposition, and nitrification, based on an isotope mixing model, with distance down-estuary from wastewater treatment plant output. Adapted from Pennino *et al.* (2016).

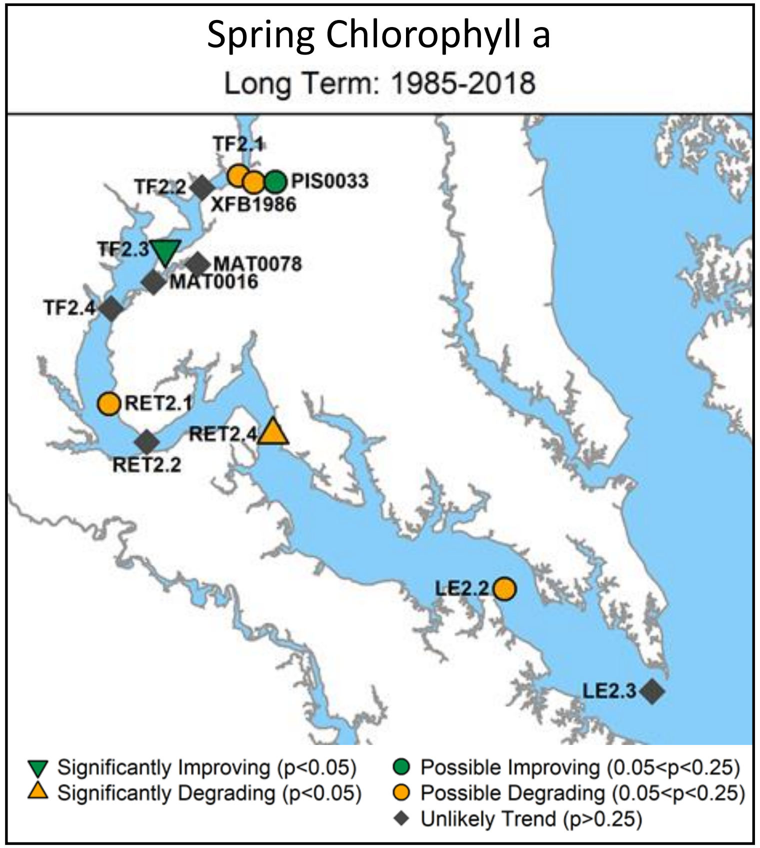


Tidal water response: *2) Large-scale, long-term response is happening*

- Other water quality responses are not as clear
- But research shows there is a reason: Nutrients have improved, but still need to be lower to limit phytoplankton growth in most places.



Spring dissolved inorganic nitrogen (a) and spring phosphate (b) at monitoring stations in the tidal Potomac River from 1999 to 2018. Black dotted lines represent nutrient saturation thresholds.



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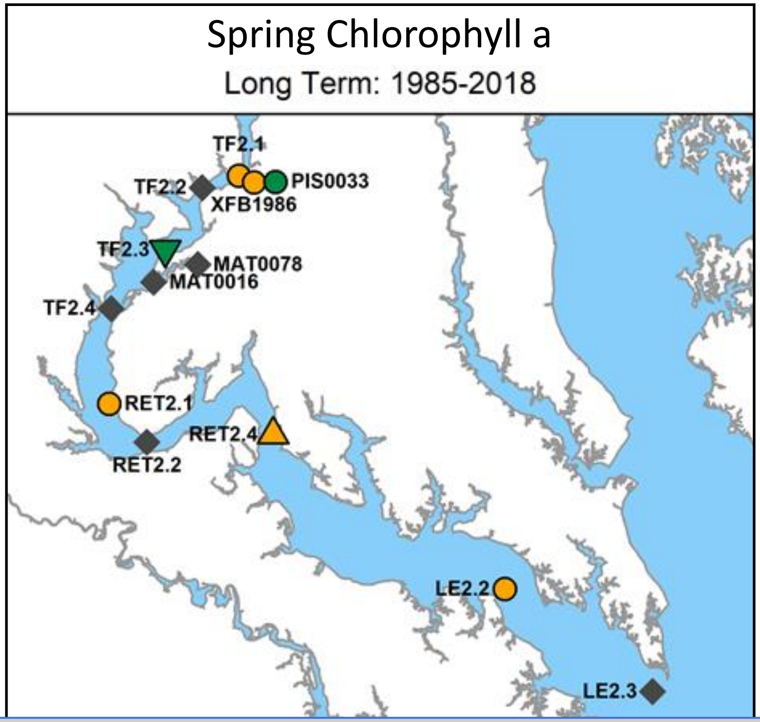


<u>What this tells us:</u> The data shows that watershed-wide nutrient reductions have improved nutrients in the Potomac. The science supports the conclusion that with more reductions, improvements will continue.

Case Study 2: How to draw similar conclusions in another tributary?

- The Potomac Tributary Report is the only one finalized, meaning:
  - Includes an “Insights on Changes in the Potomac” section, which pulls in additional research and identifies conclusions as possible.

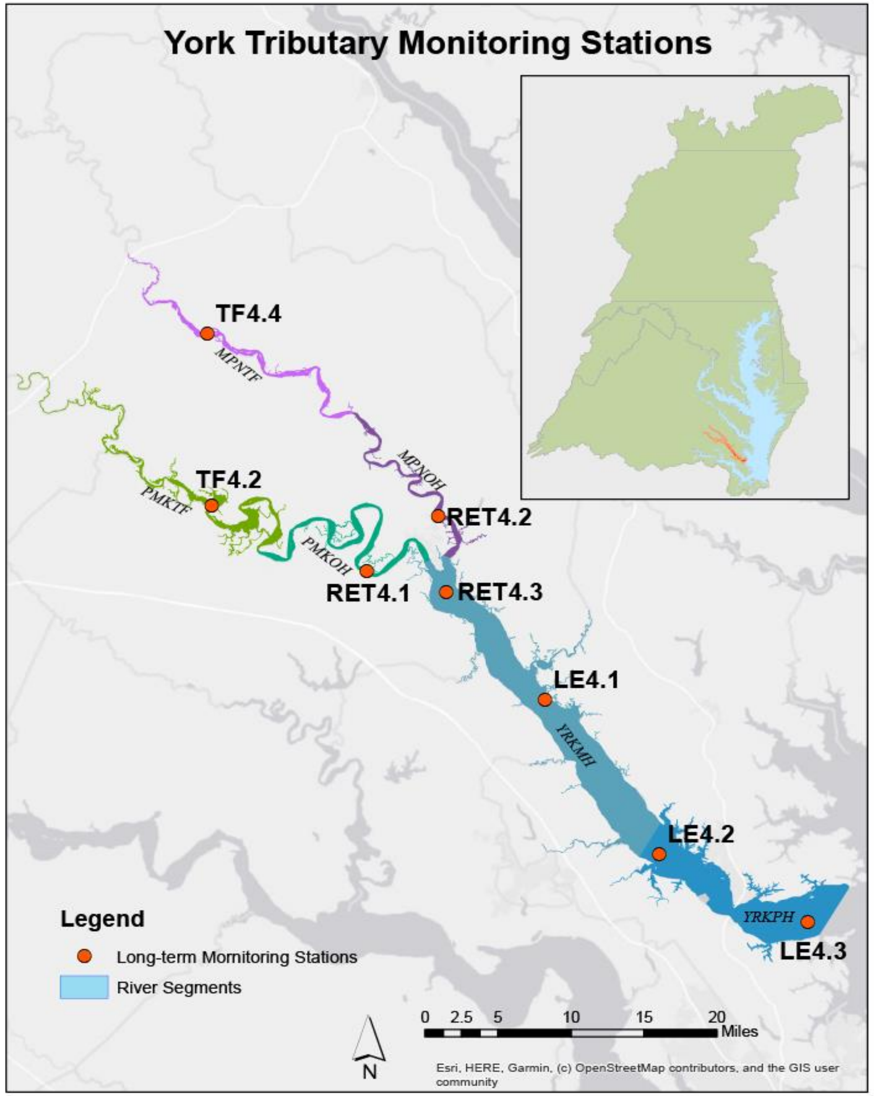
- How would I do this for another tributary?
  - There is a lot of useful background, data, and analysis already

    → Take a look – it might be sufficient for your needs

- Or an investment of time evaluating that data, pulling external research, and drawing conclusions/identifying gaps would be needed.

  → We’d work with interested groups in making these final steps. You’ll get a chance to give feedback on your priorities.

Case Study 2: Example York River



One first step:

- Examine history of meeting the assessed water quality criteria

→ Mixed: Clearly it is possible to meet the criteria, but isn't consistently happening

Open Water Summer DO

time period	MPNOH	MPNTF	PMKOH	PMKTF	YRKMH	YRKPH
1985-1987						
1986-1988						
1987-1989						
1988-1990						
1989-1991						
1990-1992						
1991-1993						
1992-1994						
1993-1995						
1994-1996						
1995-1997						
1996-1998						
1997-1999						
1998-2000						
1999-2001						
2000-2002						
2001-2003						
2002-2004						
2003-2005						
2004-2006						
2005-2007						
2006-2008						
2007-2009						
2008-2010						
2009-2011						
2010-2012						
2011-2013						
2012-2014						
2013-2015						
2014-2016						
2015-2017						
2016-2018						
2017-2019						

Deep Water Summer DO

time period	YRKPH
1985-1987	
1986-1988	
1987-1989	
1988-1990	
1989-1991	
1990-1992	
1991-1993	
1992-1994	
1993-1995	
1994-1996	
1995-1997	
1996-1998	
1997-1999	
1998-2000	
1999-2001	
2000-2002	
2001-2003	
2002-2004	
2003-2005	
2004-2006	
2005-2007	
2006-2008	
2007-2009	
2008-2010	
2009-2011	
2010-2012	
2011-2013	
2012-2014	
2013-2015	
2014-2016	
2015-2017	
2016-2018	
2017-2019	

Case Study 2: Example York River

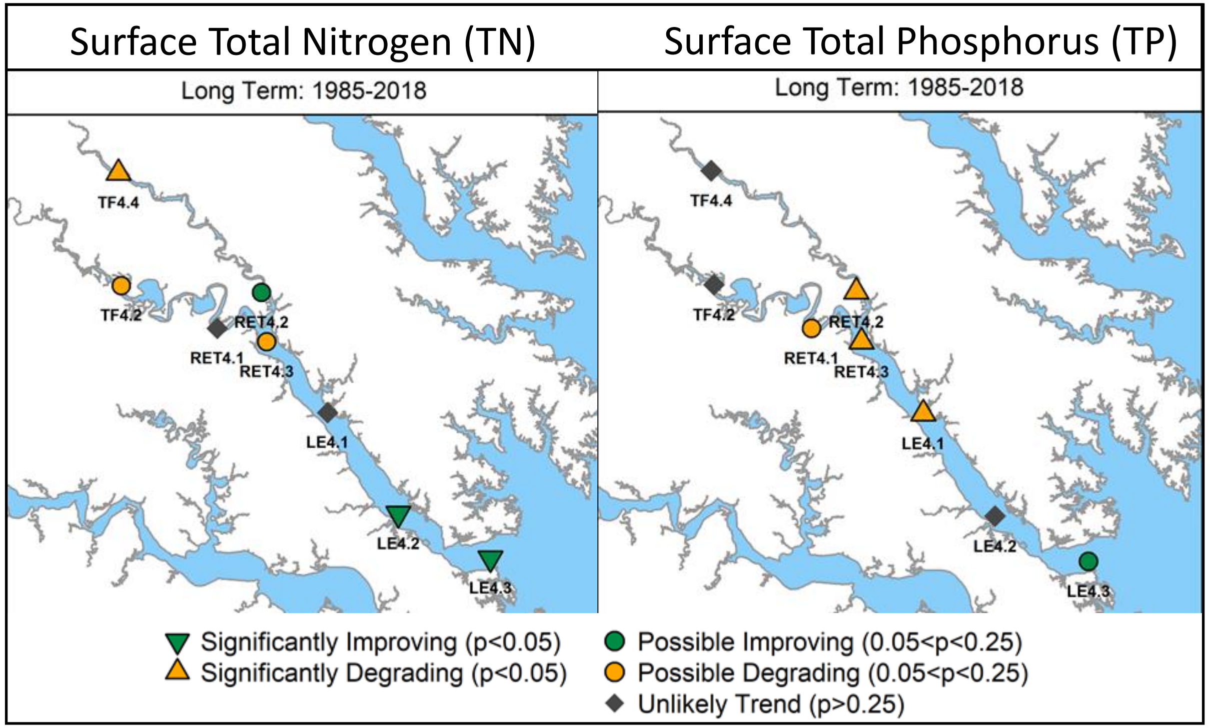
- Watershed stations: Mostly increasing flow-normalized nutrient loads
- Tidal: Long-term TN and TP trends are mixed, but more increasing than decreasing

→ Patterns are relatively consistent watershed-to-estuary

USGS Station ID	USGS Station Name	Trend start water year	Percent change in FN load, through water year 2018 TN	TP	SS
01671020	NORTH ANNA RIVER AT HART CORNER NEAR DOSWELL, VA	1985	31.2	-	-
		2009	10.9	15.6	29.1
01671100	LITTLE RIVER NEAR DOSWELL, VA	2009	-18.9	-	-
01673000 ★	PAMUNKEY RIVER NEAR HANOVER, VA	1985	12.4	78.2	82.7
		2009	15.5	10.2	20.7
01673800	PO RIVER NEAR SPOTSYLVANIA, VA	1987	18.0	-	-
		2009	4.4	-	-
01674000	MATTAPONI RIVER NEAR BOWLING GREEN, VA	1985	20.4	-	-
		2009	17.0	-	-
01674500 ★	MATTAPONI RIVER NEAR BEULAHVILLE, VA	1985	-2.7	7.0	11.8
		2009	13.4	15.2	35.8

Decreasing trends listed in green, increasing trends listed in orange, results reported as "no trend" listed in black. TN = total nitrogen, TP = total phosphorus, SS = suspended sediment

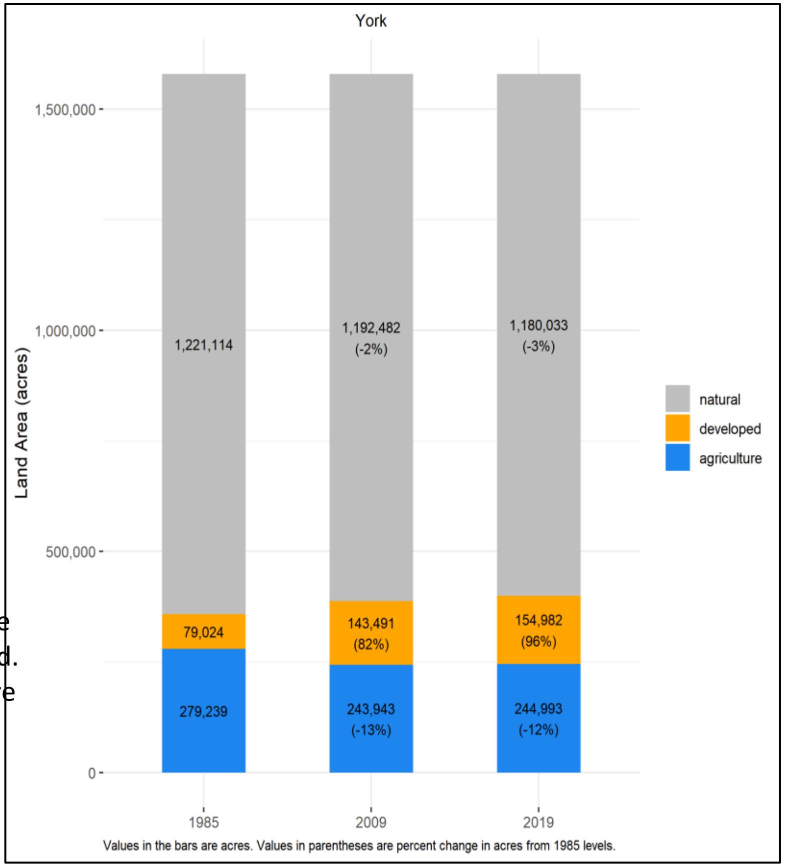
★ RIM stations



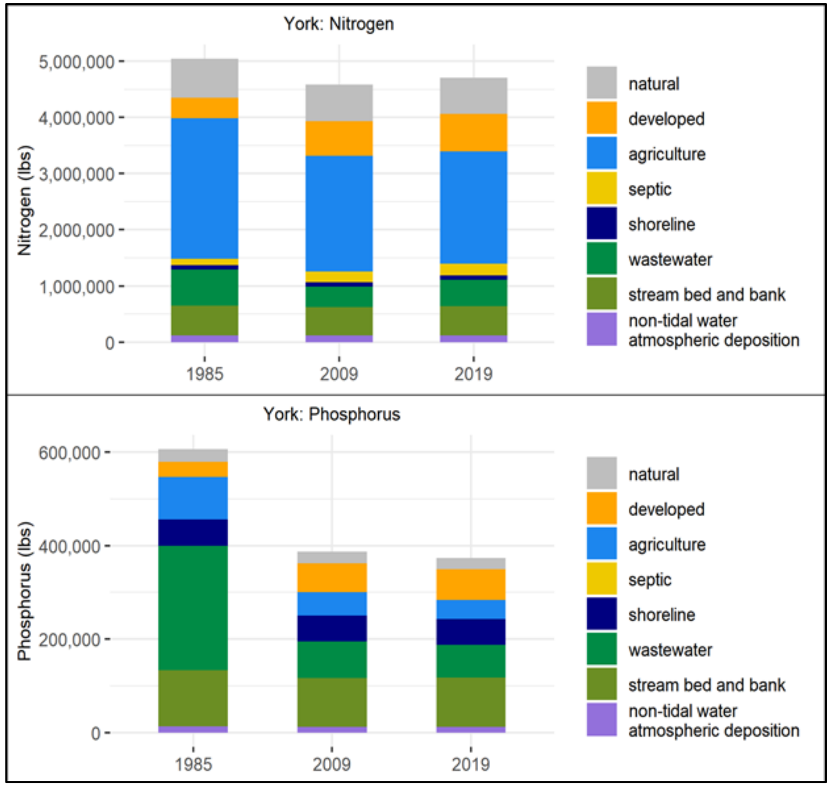
Case Study 2: Example York River

- Increasing development and fairly consistent agricultural land use in the last decade
- Expected long-term loads have plateaued, or increased

→ ***This and similar information can help understand why nutrients are not decreasing and help target actions***



Distribution of land uses in the York watershed. Percentages are the percent change from 1985 for each source sector.



Expected long-term average loads to the tidal York, as obtained from the Chesapeake Assessment Scenario Tool (CAST-19). Data shown are time-average, steady-state (Not true conditions).

Case Study 2: Example York River

What to do next to address: ***How do tidal waters respond to actions in the watershed? And is there data to support which decisions we make?***

Consider findings from Potomac:

1. Local response to large nutrient reductions is clear from the data.
2. Long-term responses to system-wide changes are happening.

Next steps to add to York tributary summary:

1. Identify other data available for the York system (continuous monitoring, SAV coverage, etc). Talk to local partners and researchers to find:
   - Shallow-water monitoring near large recent development.
   - Areas near wastewater discharges which have changed.
   - Possibly get insights from these findings to provide support for continued, targeted actions.
2. This is clear from the Trib Summary already. Nutrient loads have increased, and tidal concentrations are similar. To support decisions, perhaps:
   - Look at the expected loads by source and recent land change.
   - Know that any nutrient reductions that reach the tidal waters will reduce tidal nutrients.

Feedback

1) What are some of the technical issues you'd like us to work with you on between now and 2025?

→ Either List your top 3 choices for Tributary Summaries to develop the insights on change section

→ Or list additional content to include across the Summaries that would be helpful to make management decisions

2) What are the ways you want us to work with you and communicate this information? Please pick your top choice from a to d.

a) More StoryMap-type polished summaries

b) A presentation template designed so you can use any Tributary Summary's graphics and tables for your meetings

c) Small group, tributary-focused meetings with us to explore results

d) Webinars to other large groups to disseminate the results and findings already available (similar to today)

e) Other (please describe)

3) Longer term, what issues do you see after 2025 that you'll need help with? Please describe on your note.

(some examples: explaining why tidal water criteria are not all met, identifying climate change impacts to tidal waters, exploring how water quality is affecting living resources habitats)

Links and References

CAST/Tributary Summaries: https://cast.chesapeakebay.net/Home/TMDLTracking#tributaryRptsSection

Potomac Story Map: https://wim.usgs.gov/geonarrative/potomactrib/

References:

Boynton, W. R., C. L. S. Hodgkins, C. A. O'Leary, E. M. Bailey, A. R. Bayard and L. A. Wainger, 2014. Multi-decade responses of a tidal creek system to nutrient load reductions: Mattawoman Creek, Maryland USA. Estuaries Coasts 37:111-127, DOI: 10.1007/s12237-013-9690-4.

Jones, R. C., K. Mutsert and A. Fowler, 2017. An ecological study of Gunston Cove: Final report. Provided to the Department of Public Works and Environmental Services, Fairfax County, VA, p. 181. https://www.fairfaxcounty.gov/publicworks/sites/publicworks/files/assets/documents/gunston-cove_2.pdf.

Keisman, J., Murphy, R. R., Devereux, O.H., Harcum, J., Karrh, R., Lane, M., Perry, E., Webber, J., Wei, Z., Zhang, Q., Petenbrink, M. 2020. Potomac Tributary Report: A summary of trends in tidal water quality and associated factors. Chesapeake Bay Program, Annapolis MD. https://cast.chesapeakebay.net/Home/TMDLTracking#tributaryRptsSection

Pennino, M. J., S. S. Kaushal, S. N. Murthy, J. D. Blomquist, J. C. Cornwell and L. A. Harris, 2016. Sources and transformations of anthropogenic nitrogen along an urban river–estuarine continuum. Biogeosciences 13:6211-6228, DOI: 10.5194/bg-13-6211-2016.