Chesapeake Bay Nontidal Network

NITROGEN AND PHOSPHORUS LOADS AND TRENDS

AN UPDATE OF RESULTS: 2011 - 2020

ITAT: August 24, 2022

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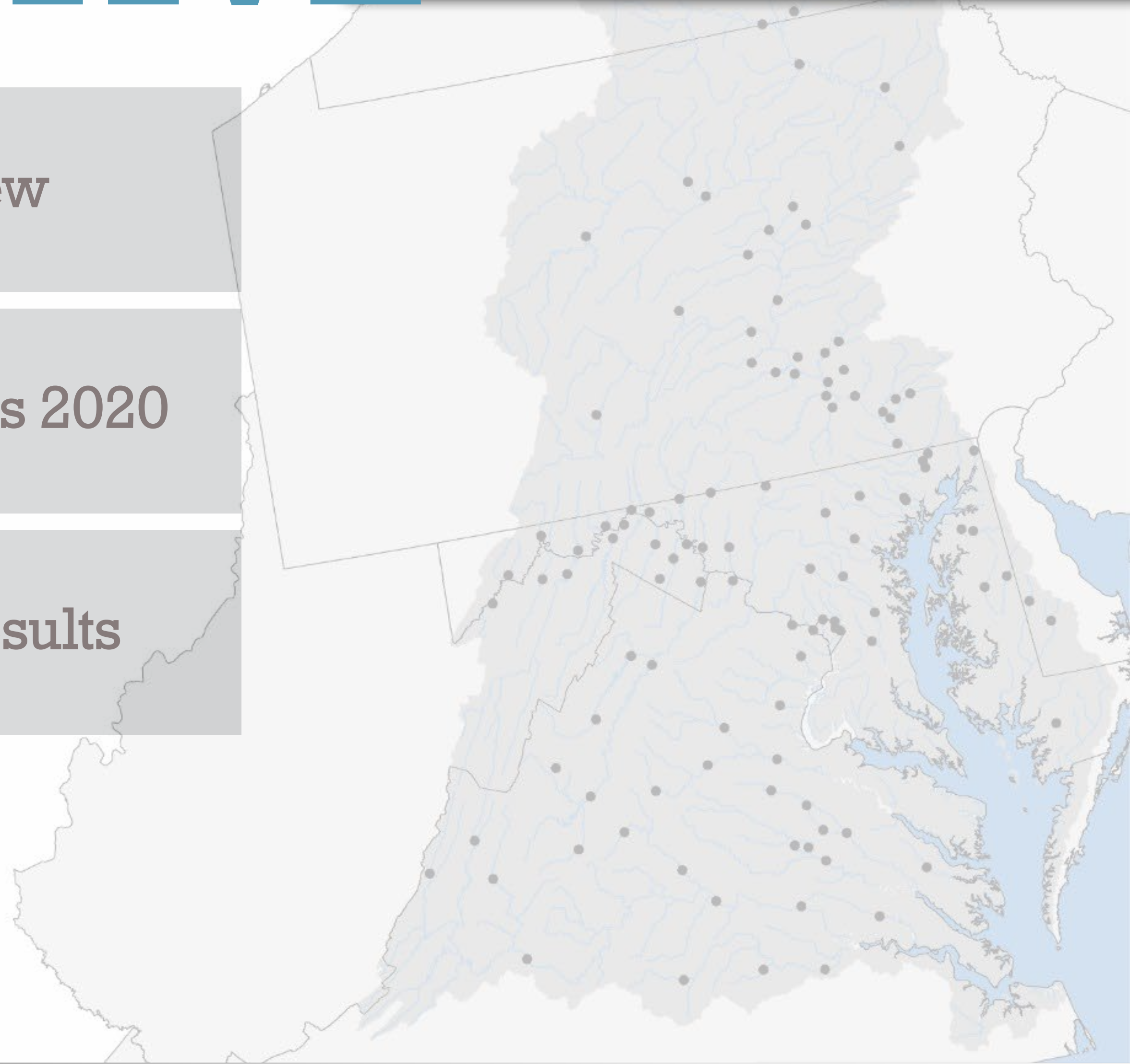
United States Geological Survey

Virginia-West Virginia Water Science Center

OBJECTIVE

To summarize results of short-term monitoring data that describe how nutrient loads have changed over time throughout the Chesapeake Bay watershed.



Outline

- Overview
- Trend Results 2020
- Sharing Results

OBJECTIVE

Overview

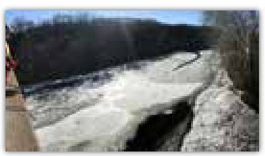
- Collection of monitoring data and discrete samples
- Funding and collaborators
- Station status
- Methods

Trend Results 2020

Sharing Results

Load and trend results determined from foundation of monitoring data

Our load and trend analyses are based on water-quality and stream-discharge measurements made across the 123-station Nontidal Network.



Over 2,400 water-quality samples are collected each year!

Load and trend results determined from foundation of monitoring data

Monitoring would not be possible without the funding support provided by

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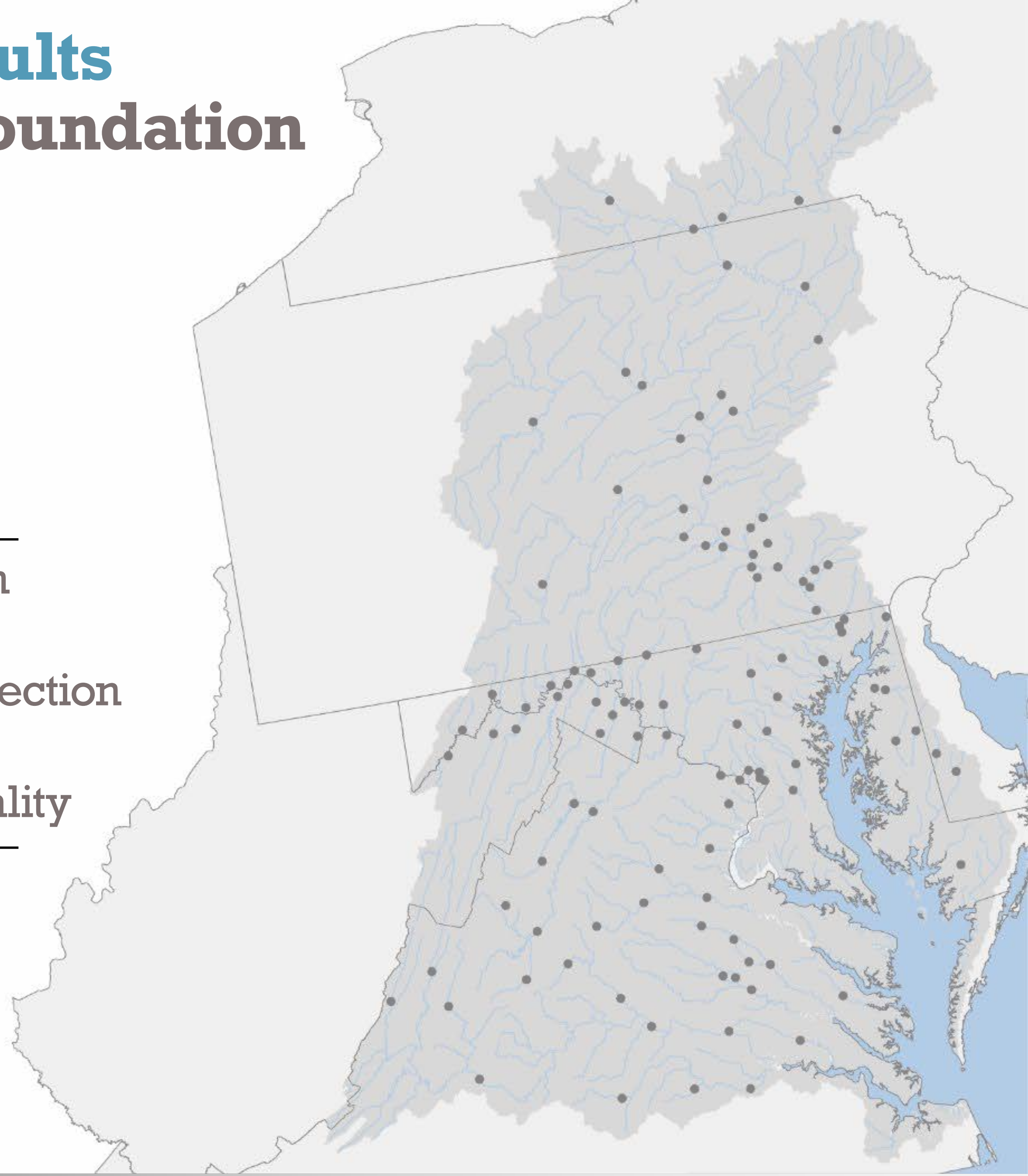
EPA Chesapeake Bay Program
US Geological Survey
PA Dept of Environmental Protection
MD Dept of Natural Resources
VA Dept of Environmental Quality



Nontidal Network

2020 status

EXPLANATION

Load-only Site

Short-term Trend Site

Long-term Trend Site

RIM Site

Major Basins

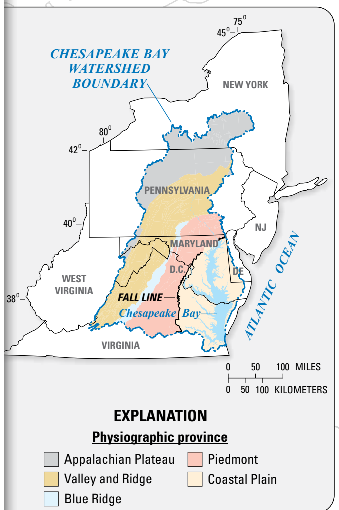
Eastern Shore

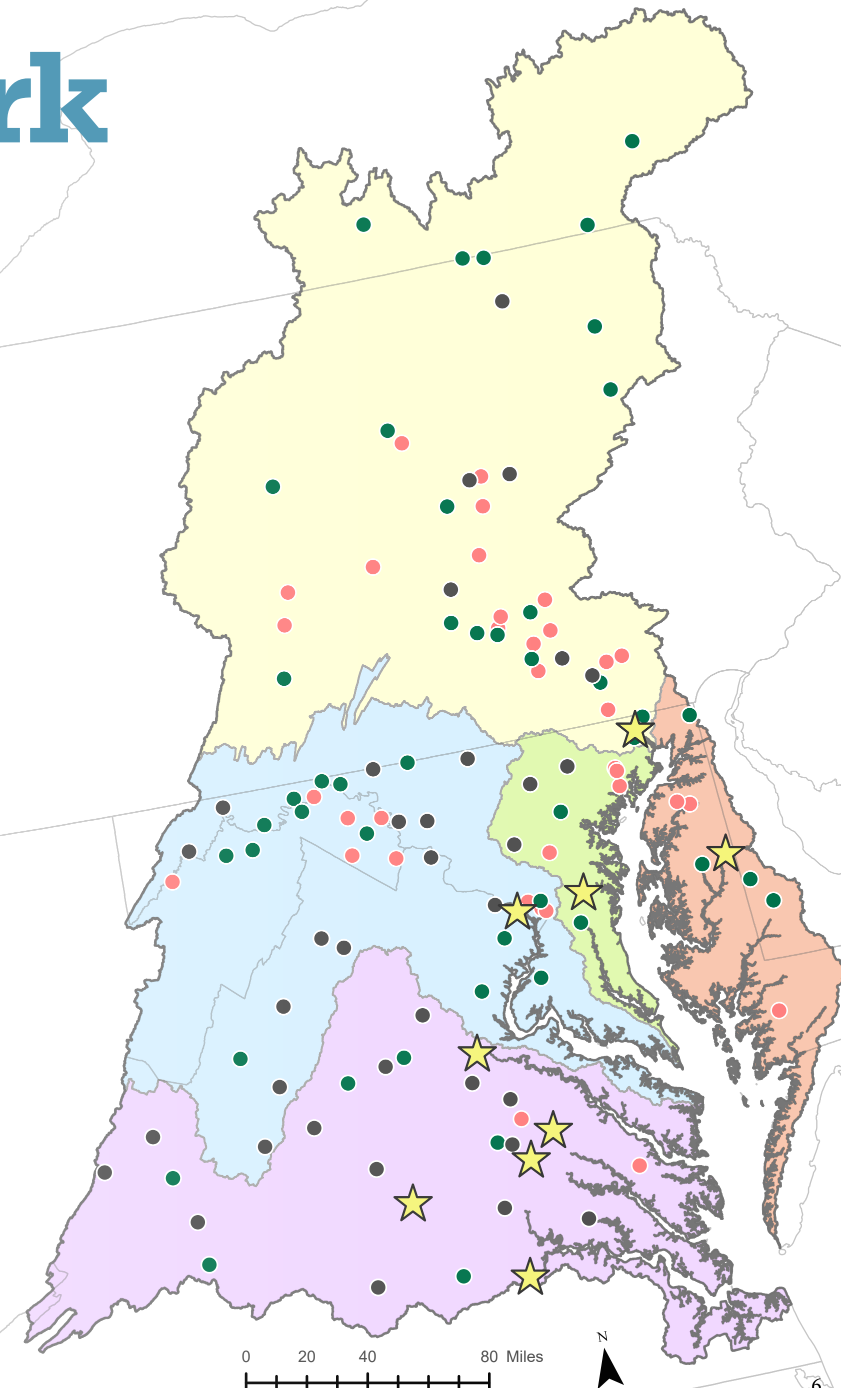
Potomac

Susquehanna

Virginia

Western Shore





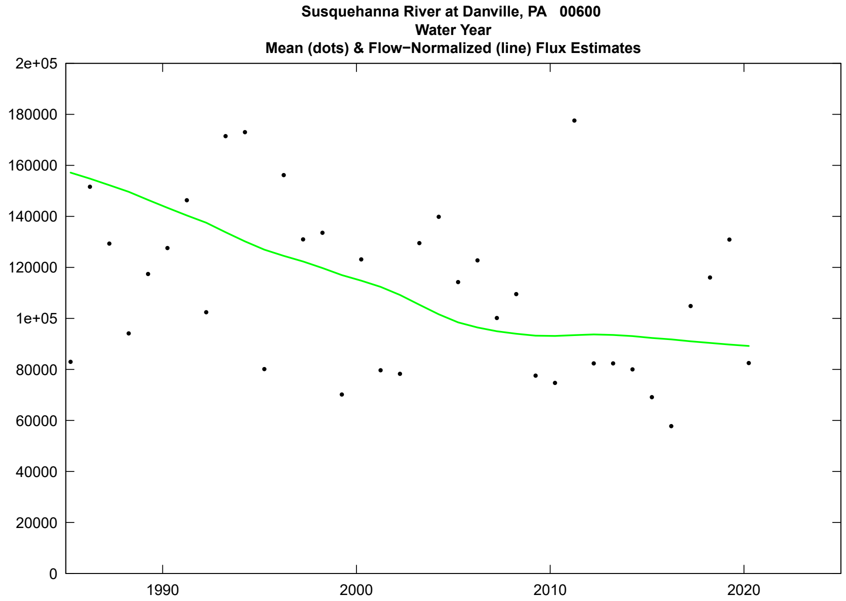
BASIN	n Stations	TN Loads	TN Short	TP Loads	TP Short
SUSQUEHANNA	42	42	26	42	26
EASTERN SHORE	8	8	5	8	5
WESTERN SHORE	10	10	6	10	6
POTOMAC	37	37	28	34	22
VIRGINIA	26	26	24	16	11

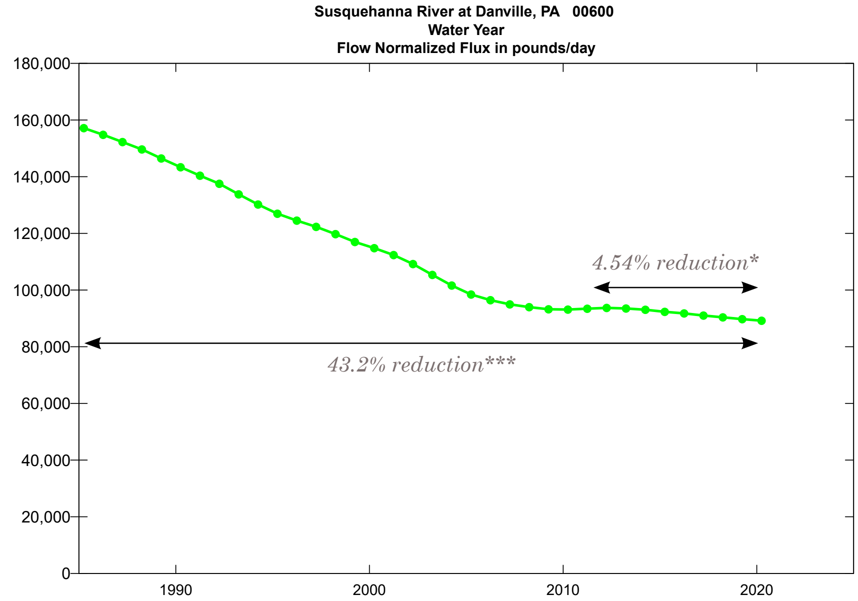
Load and trend results have been computed through 2020 to provide timely information available for decision making

Load is a measure of
the total amount of nutrients or sediment that is mobilized in a given timeperiod (monthly, annually, …). Important for understanding receiving water response

Flow-normalized loads result
by removing most of the hydrologic variability associated with loads. Important for understanding water-quality responses to watershed changes

A trend is reported when
the likelihood estimate of a trend existing is greater than 0.67 after at most 100 boostrap resamples and a 90% confidence interval





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Monitoring data help strengthen decision making

- The nontidal monitoring network offers the most accurate representation of how water-quality conditions are changing in the Chesapeake Bay watershed
- These monitoring data inform the Chesapeake Bay Program's modeling tools, which are used to plan management activities and forecast responses
- The scientific community is currently working to understand:

  (1) *how modeled water-quality responses correspond with monitored results and*

  (2) *the drivers of observed water-quality changes over time, including the effect of management practices*
- These monitoring-based insights will help explain how and why water quality is changing in the Chesapeake Bay watershed, information that can help guide management activities

OBJECTIVE

Overview

Trend Results 2020

- Summary of short-term trends in TN and TP
- Detailed look at each basin level
- Full summary at % change across TN, N, TP, DIP, SS

Sharing Results

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Summary of trends in load through 2020

Total Nitrogen

Since ~1985, 52% of stations improved

- Trends Since 2011 -

- 37% of stations improved
- 4/9 River Input stations improved: the Susquehanna, Potomac, James, and Patuxent; representing three of the largest RIM watersheds
- About 35% of Susquehanna stations improved, mostly located in lower portion of the watershed
- 4/6 Western Shore stations improved while 4/5 Eastern Shore stations degraded
- About the same number Potomac stations improved as degraded
- Most Virginia watershed stations had no trend

Total Phosphorus

Since ~1985, 67% of stations improved

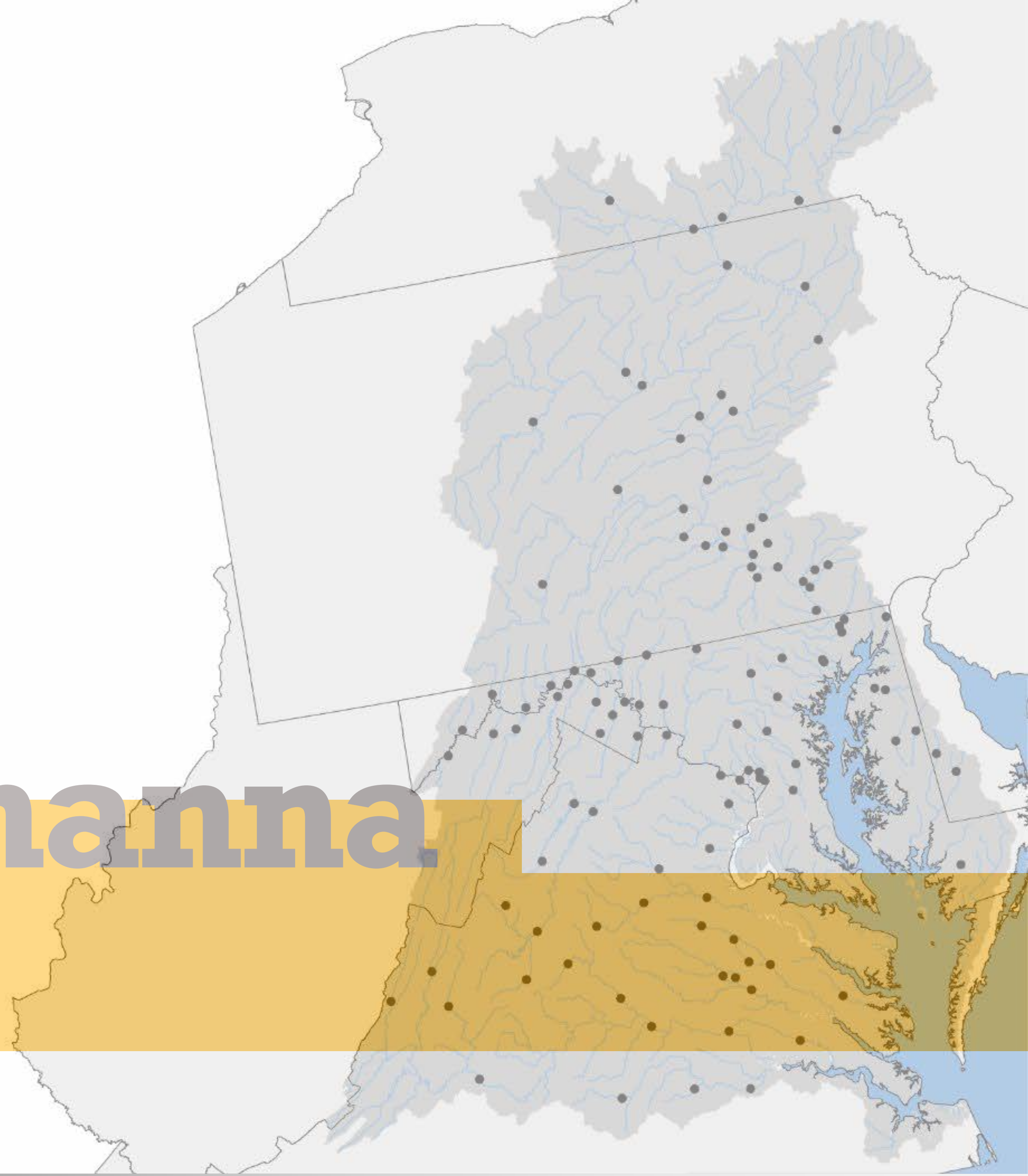
- Trends Since 2011 -

- 44% of stations improved
- 4/9 River Input stations improved: the Susquehanna, James, Patuxent, and Pamunkey
- About 42% of Susquehanna stations improved, located in the upper and lower portion of the watershed
- 3/6 Western Shore stations improved while 4/5 Eastern Shore stations degraded
- 50% of Potomac stations improved
- 54% of Virginia watershed stations improved

Trends in total nitrogen and phosphorus are influenced by changes in dissolved and particulate material

- Since 2011, nitrate degraded at 69% of stations while orthophosphate improved at 66% of stations
- Since 2011, suspended sediment improved at only 18% of stations

Susquehanna Basin



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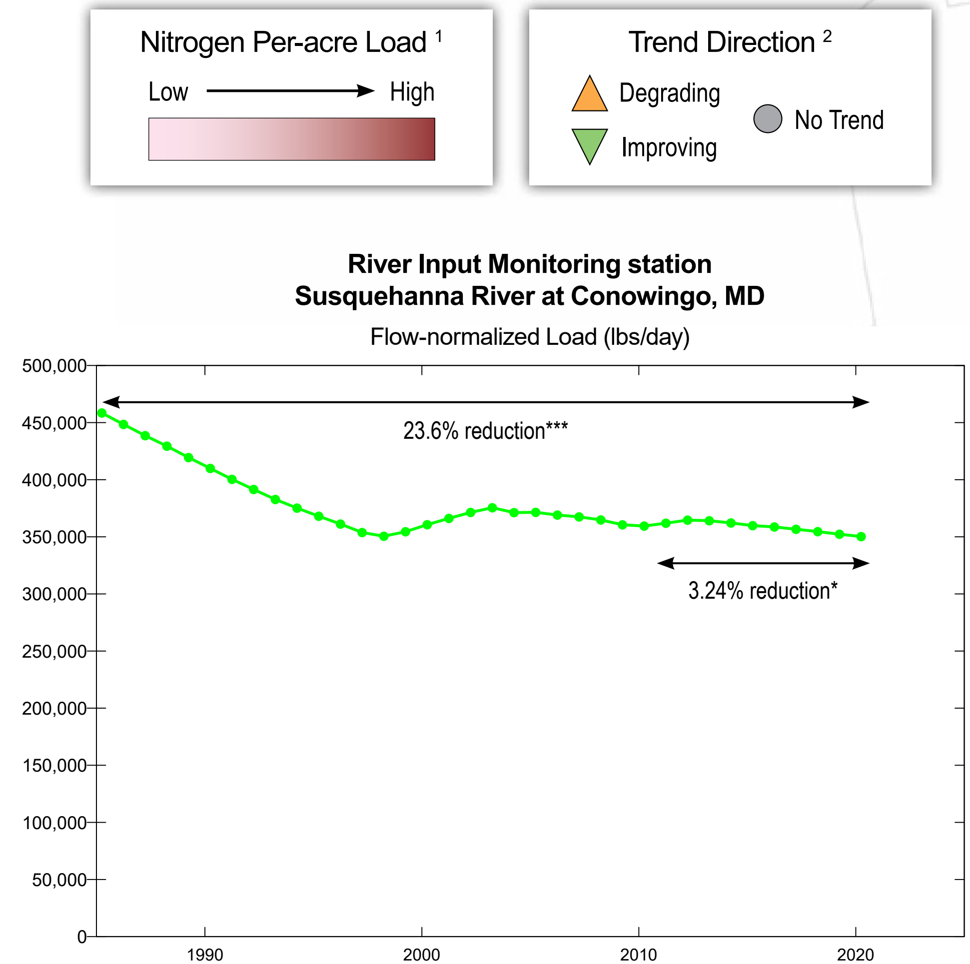
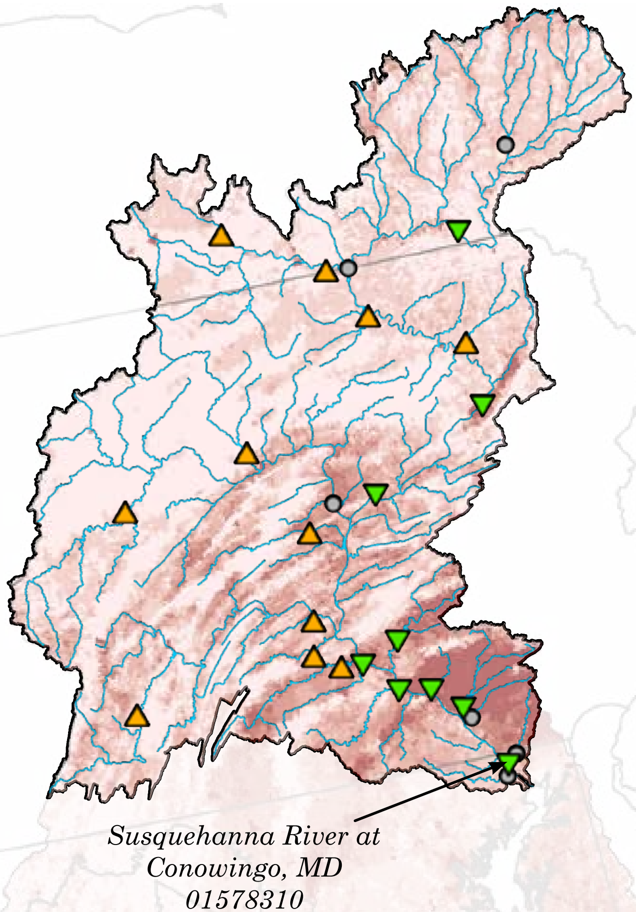
Trends in nitrogen loads result from changing nitrogen inputs or transport

The most recent ten year period in the Susquehanna Basin, 2011-2020[2]





[1] Ator, S.W., Brakebill, J.W., and Blomquist, J.D., 2011, Sources, fate, and transport of nitrogen and phosphorus in the Chesapeake Bay watershed: An empirical model: U.S. Geological Survey Scientific Investigations Report 2011-5167, p. 27.

[2] Mason and others, 2022

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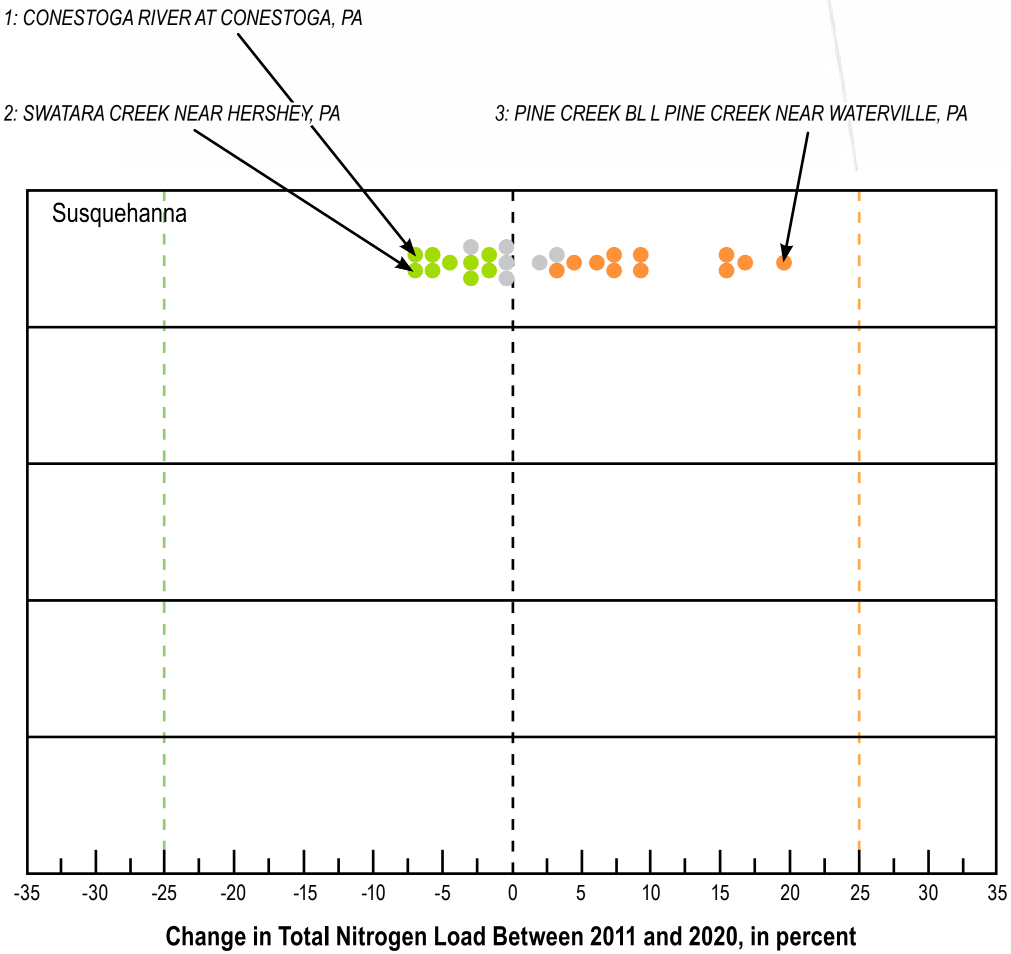

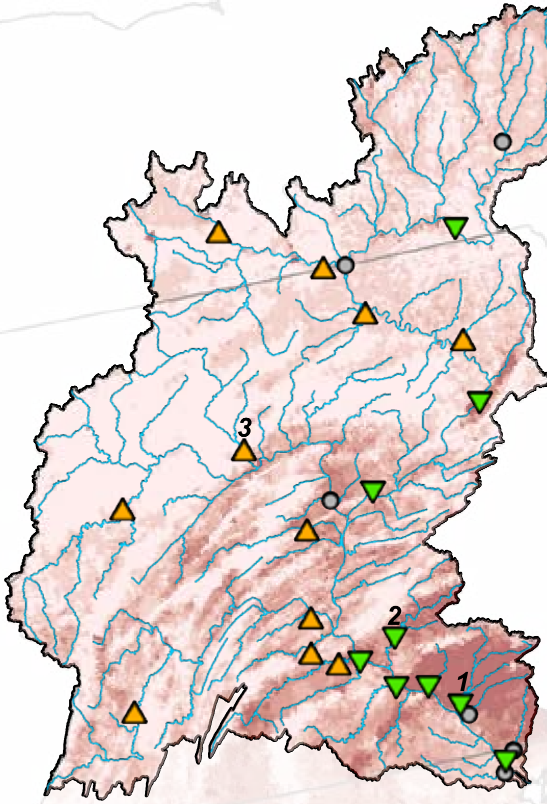

Nitrogen loads (n=26) have improved at 9, degraded at 11, and have no trend at 6 stations.

Across the Susquehanna, the median N improvement is 4.5% and the median degradation is 9%.

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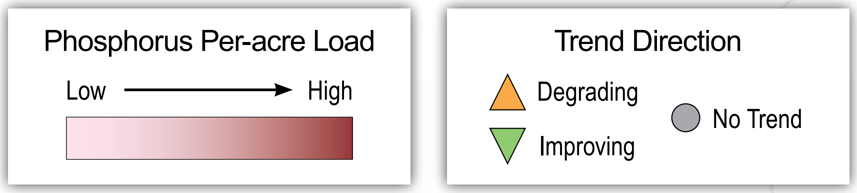
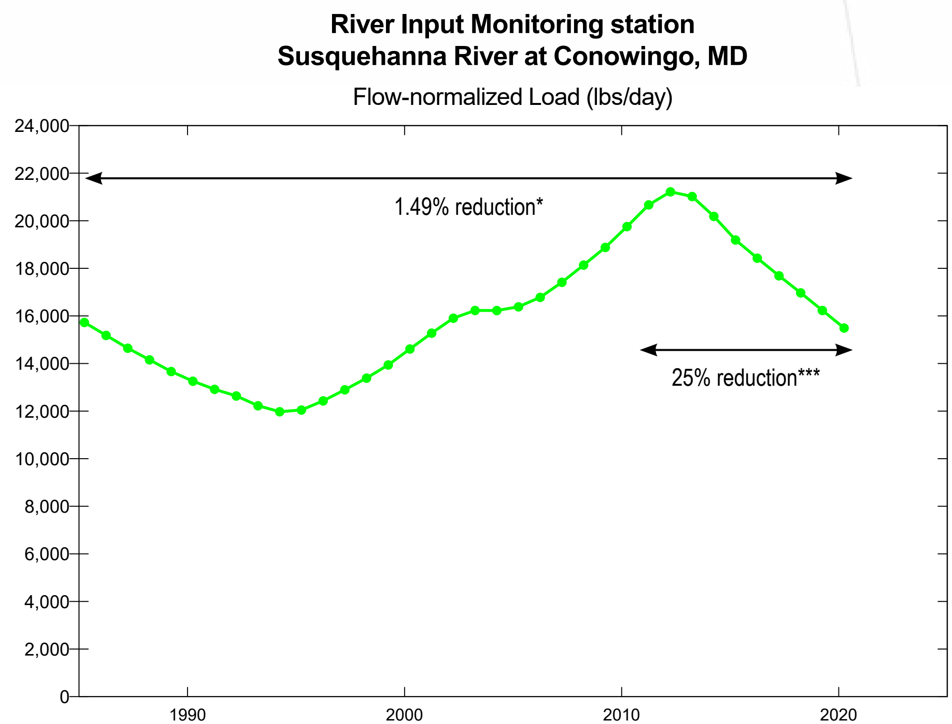
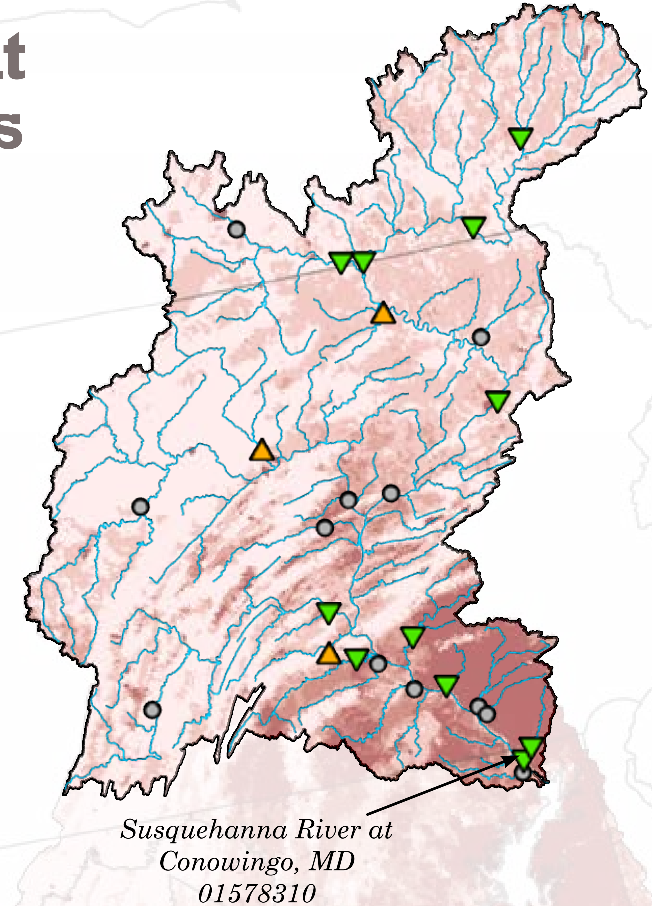
Trends in phosphorus loads result from changing phosphorus inputs or transport

The most recent ten year period in the Susquehanna Basin, 2011-2020

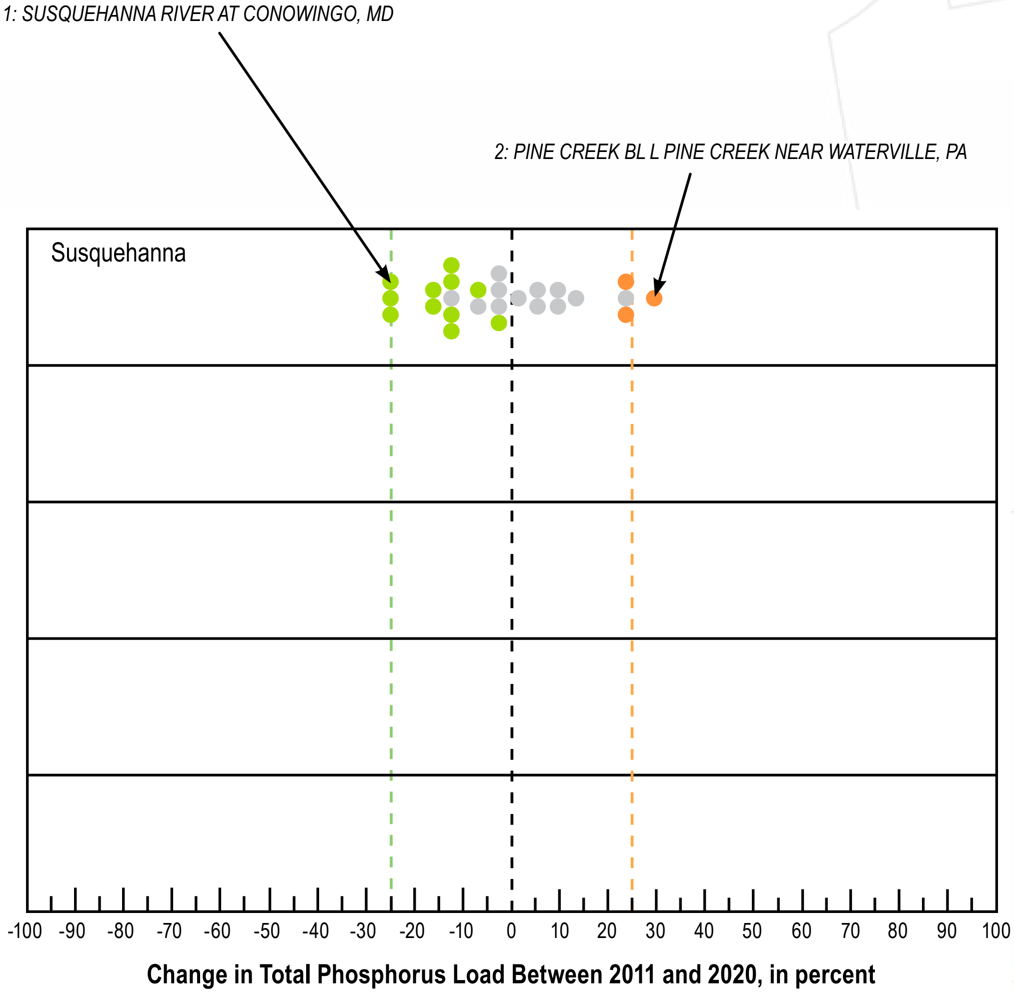


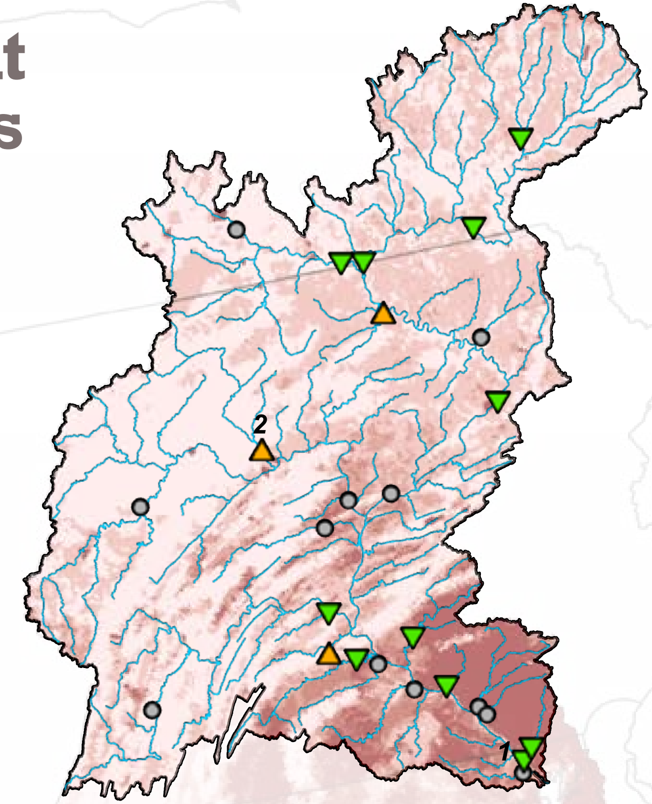




Trends in phosphorus loads result from changing phosphorus inputs or transport

The most recent ten year period in the Susquehanna Basin, 2011-2020





Phosphorus loads (n=26) have improved at 11, degraded at 3, and have no trend at 12 stations.

Across the Susquehanna, the median P improvement is 13% and the median degradation is 26%.

Eastern and Western Shores

Trends in nitrogen loads result from changing nitrogen inputs or transport

The most recent ten year period in the Eastern/Western Shore Basins, 2011-2020

Nitrogen Per-acre Load

Low → High

Trend Direction

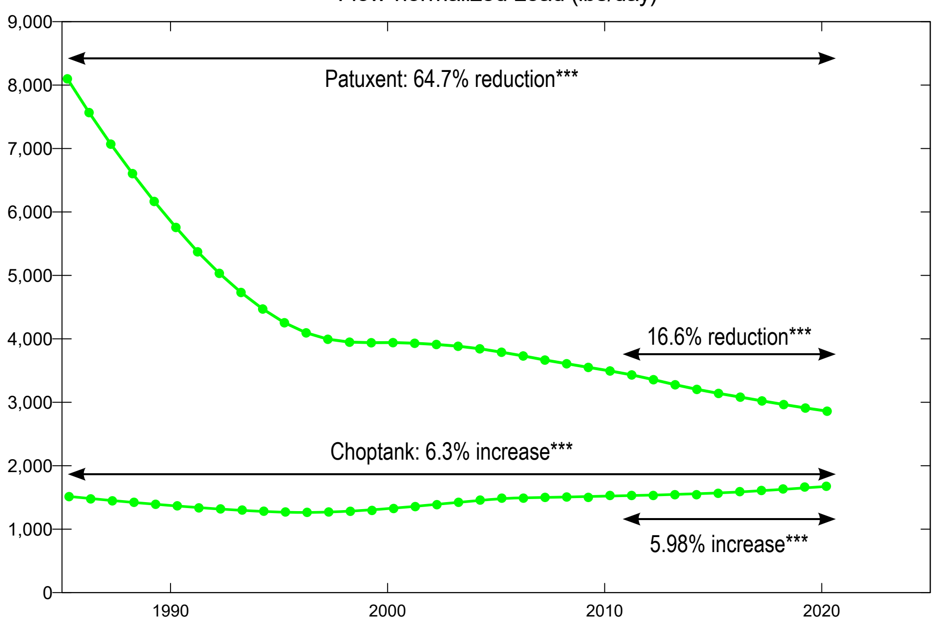
Degrading

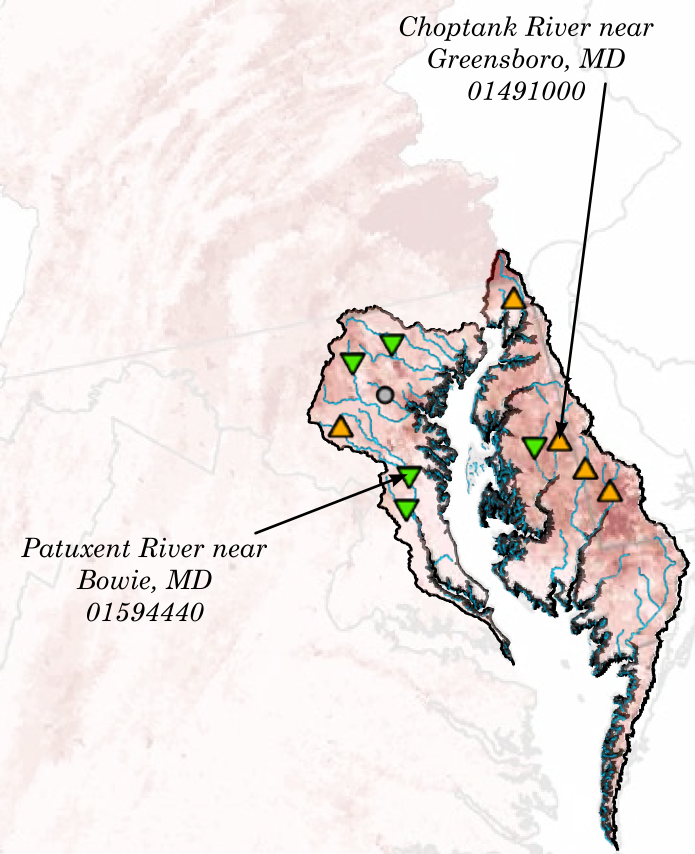
Improving

No Trend

River Input Monitoring stations
Patuxent River near Bowie, MD and Choptank River near Greensboro, MD

Flow-normalized Load (lbs/day)





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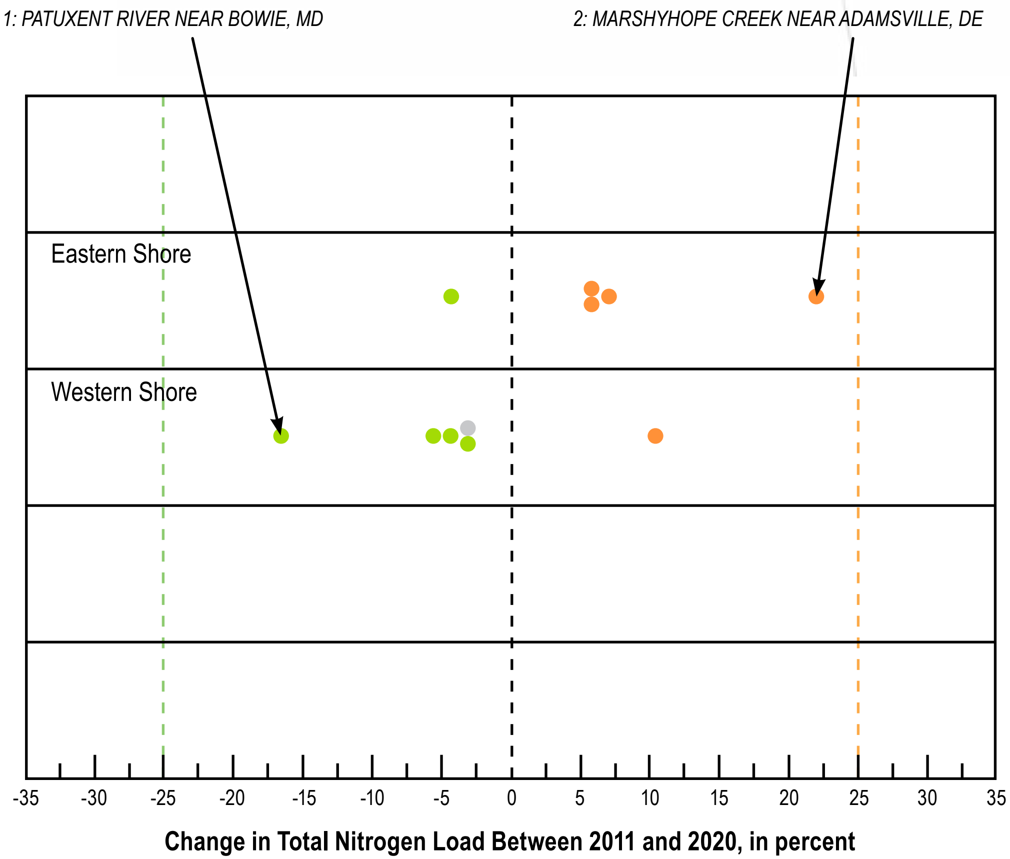
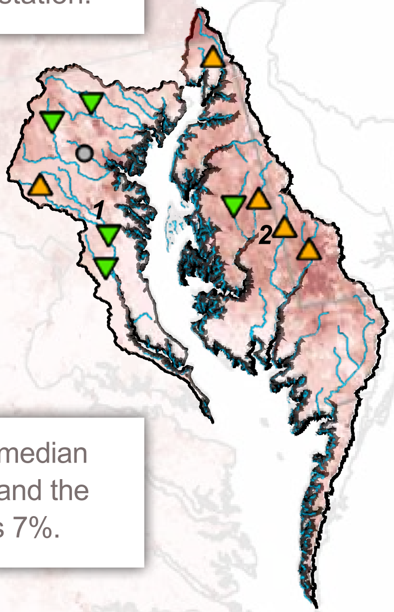
Trends in nitrogen loads result from changing nitrogen inputs or transport

The most recent ten year period in the Eastern/Western Shore Basins, 2011-2020



Nitrogen loads (n=11) have improved at 5, degraded at 5, and have no trend at 1 station.



Across the ES/WS, the median N improvement is 4.4% and the median degradation is 7%.

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Trends in phosphorus loads result from changing phosphorus inputs or transport

The most recent ten year period in the Eastern/Western Shore Basins, 2011-2020

Phosphorus Per-acre Load

Low → High

Trend Direction

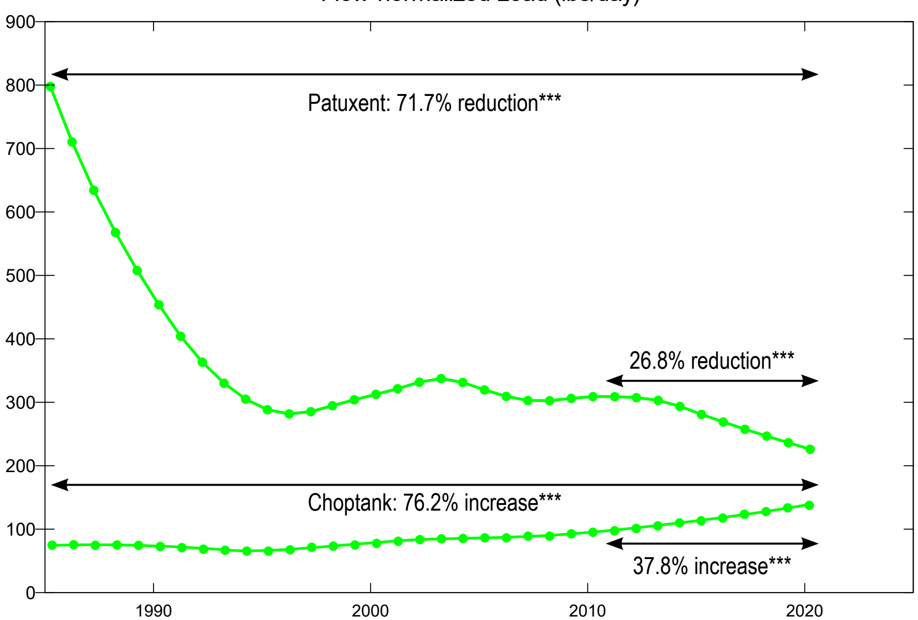
Degrading

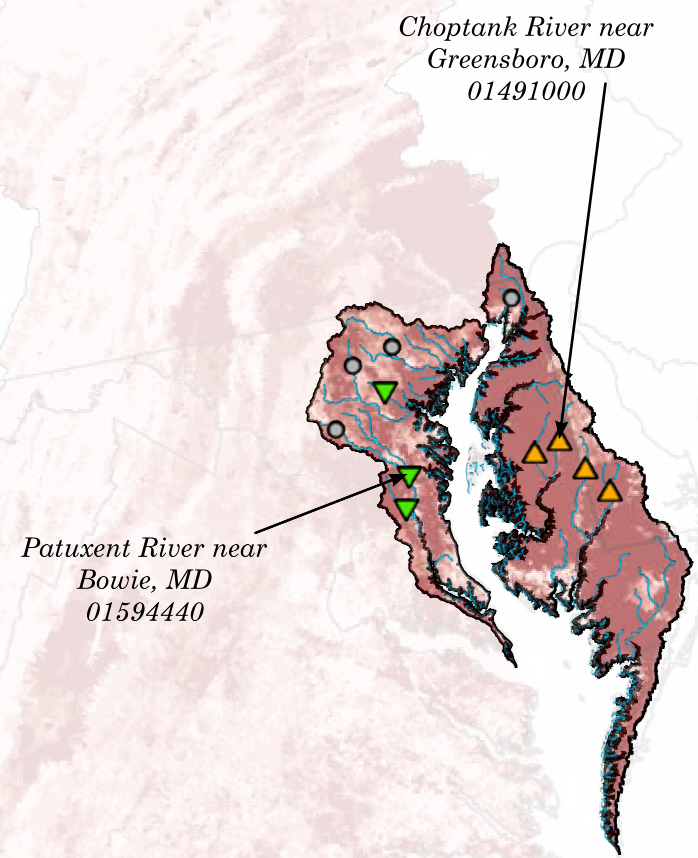
Improving

No Trend

River Input Monitoring stations
Patuxent River near Bowie, MD and Choptank River near Greensboro, MD

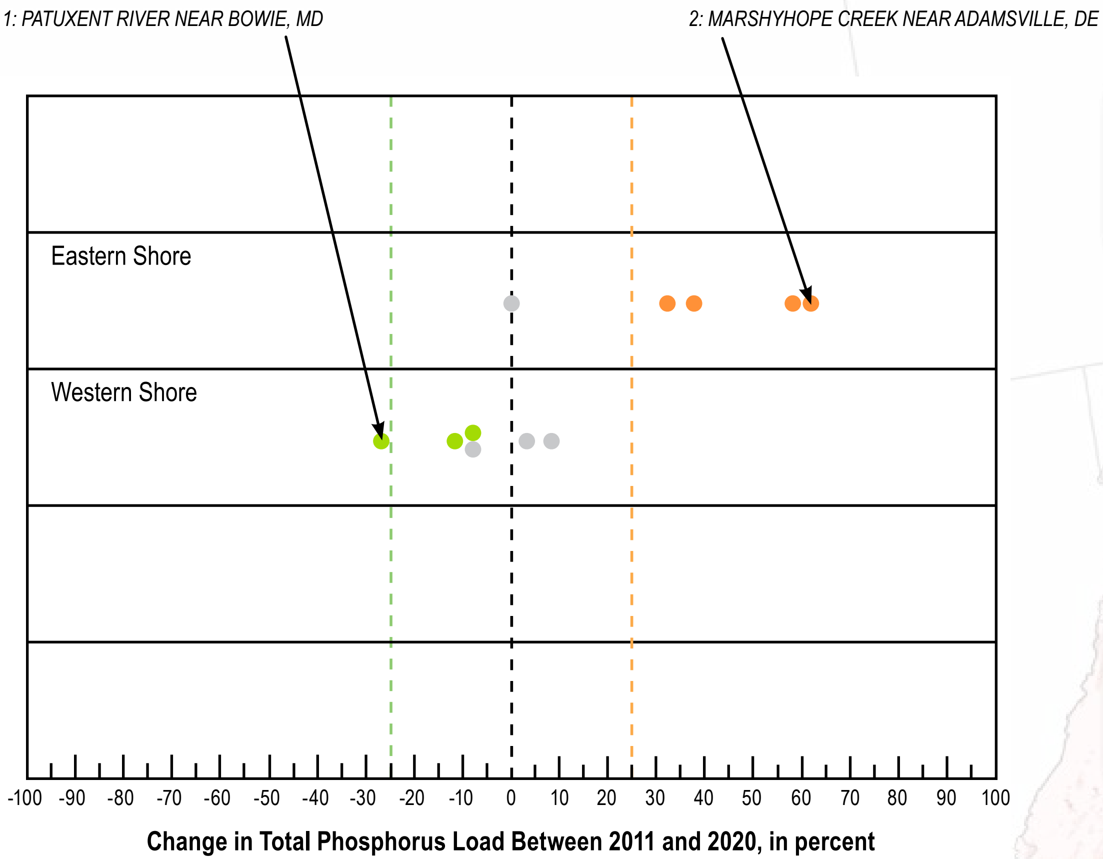
Flow-normalized Load (lbs/day)



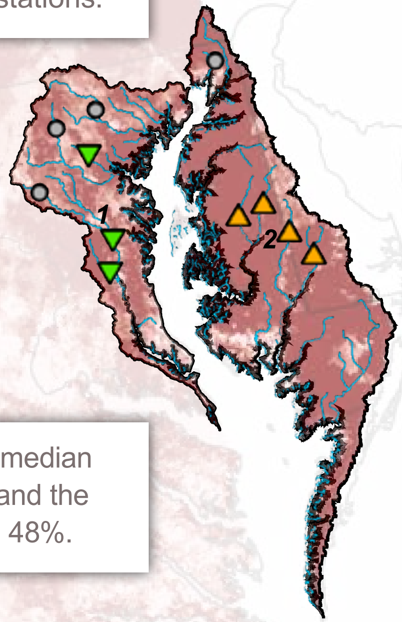


Trends in phosphorus loads result from changing phosphorus inputs or transport

The most recent ten year period in the Eastern/Western Shore Basins, 2011-2020

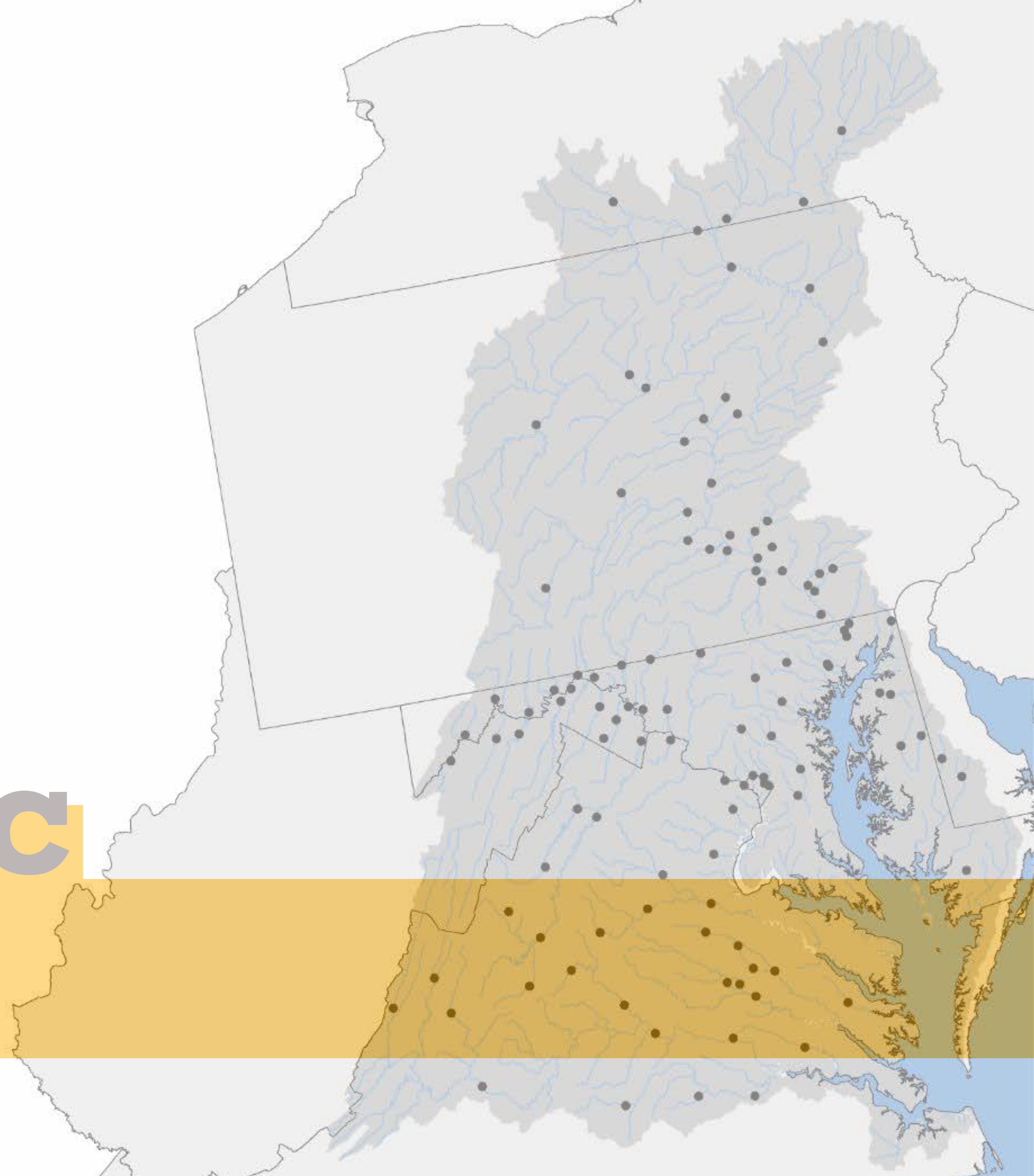


Phosphorus loads (n=11) have improved at 3, degraded at 4, and have no trend at 4 stations.



Across the ES/WS, the median P improvement is 12% and the median degradation is 48%.

Potomac Basin



Trends in nitrogen loads result from changing nitrogen inputs or transport

The most recent ten year period in the Potomac Basin, 2011-2020

Nitrogen Per-acre Load

Low → High

Trend Direction

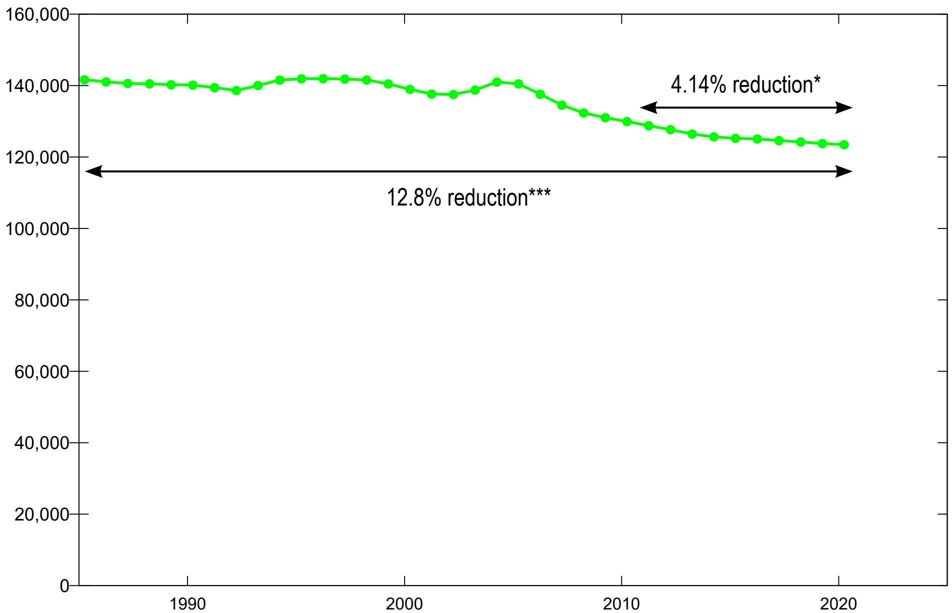
Degrading

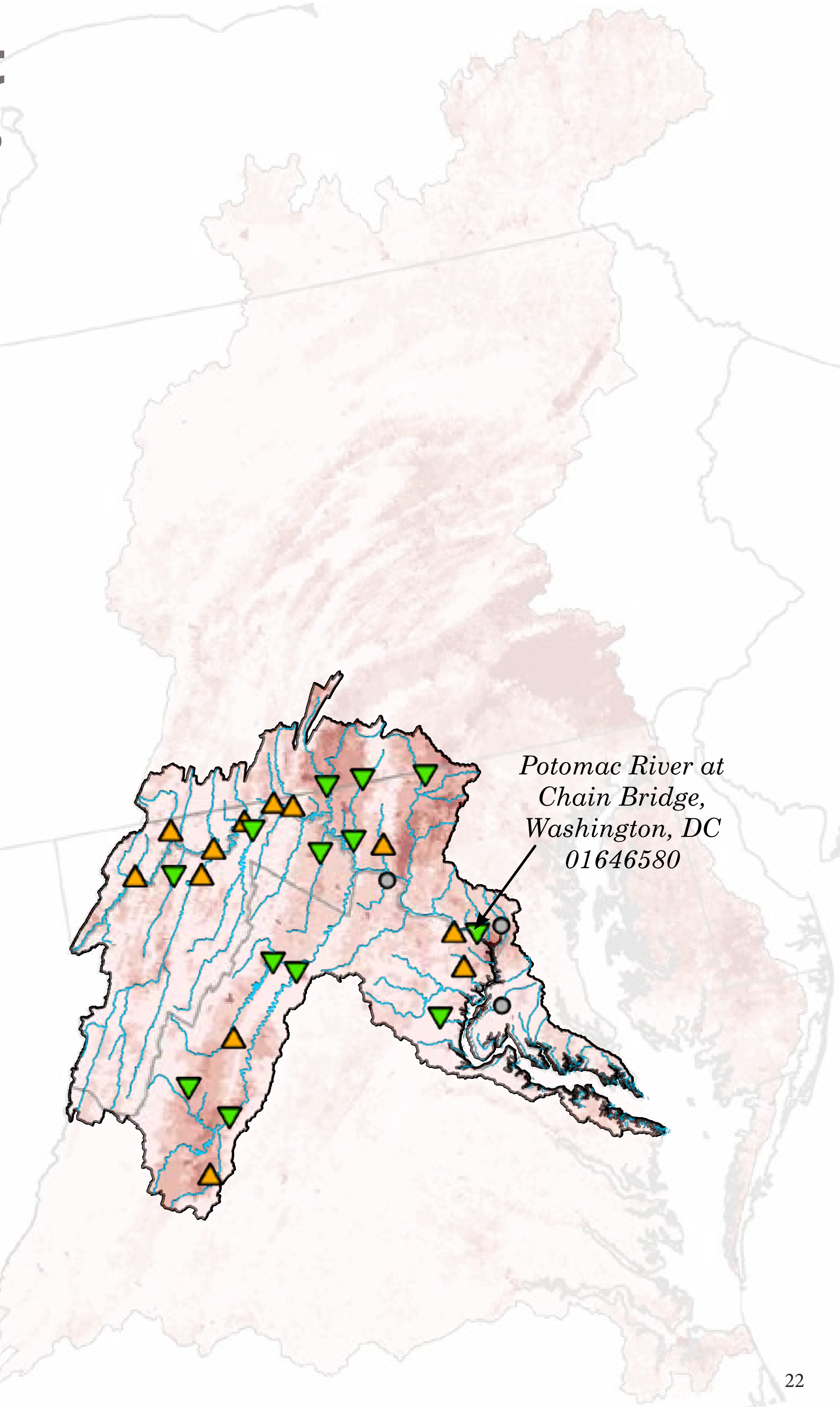
Improving

No Trend

River Input Monitoring station
Potomac River at Chain Bridge, Washington, DC

Flow-normalized Load (lbs/day)





Trends in nitrogen loads result from changing nitrogen inputs or transport

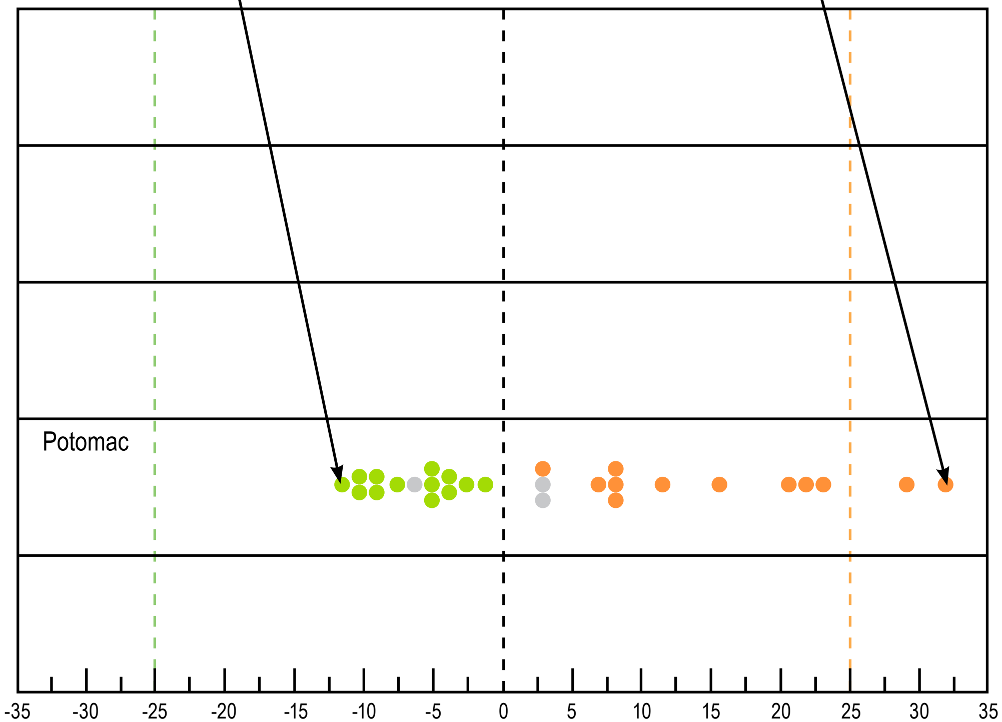
The most recent ten year period in the Potomac Basin, 2011-2020

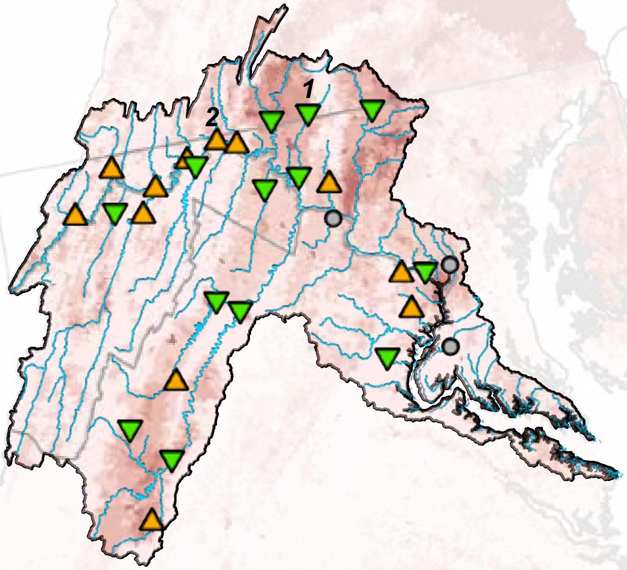
Nitrogen loads (n=28) have improved at 13, degraded at 12, and have no trend at 3 stations.

Across the Potomac, the median N improvement is 5.5% and the median degradation is 14%.

1: ANTIETAM CREEK NEAR WAYNESBORO, PA

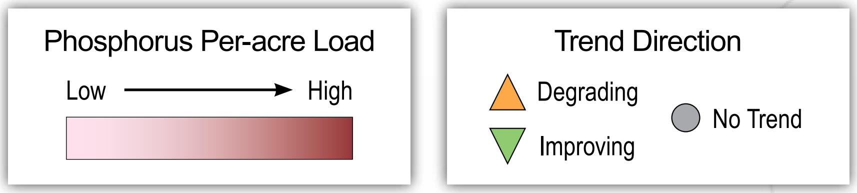
2: TONOLOWAY CREEK NEAR HANCOCK, MD



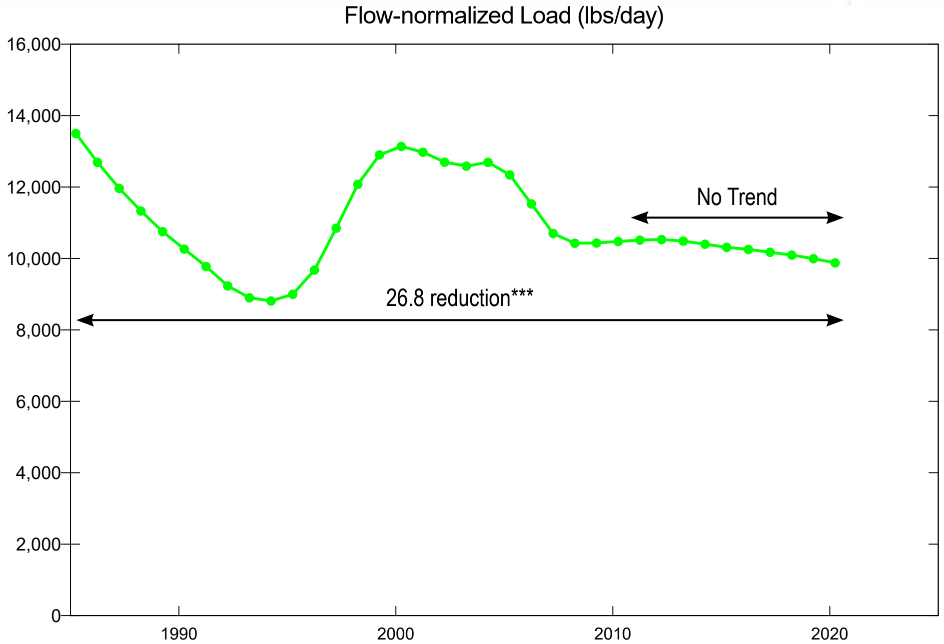


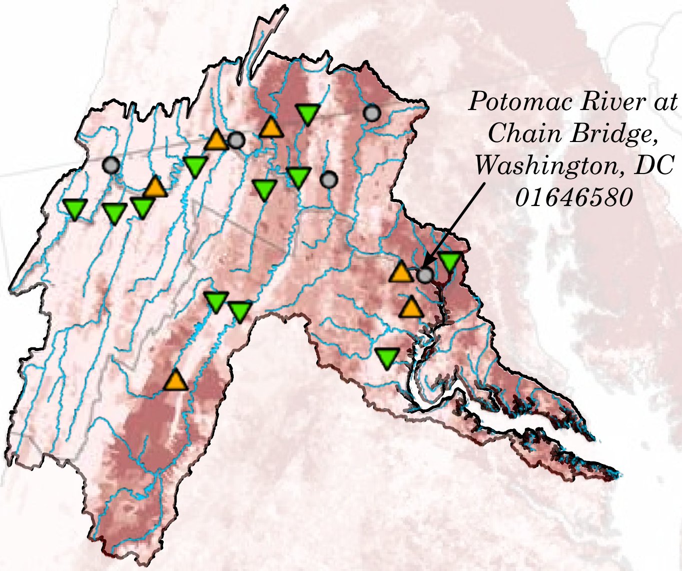
Trends in phosphorus loads result from changing phosphorus inputs or transport

The most recent ten year period in the Potomac Basin, 2011-2020



River Input Monitoring station
Potomac River at Chain Bridge, Washington, DC



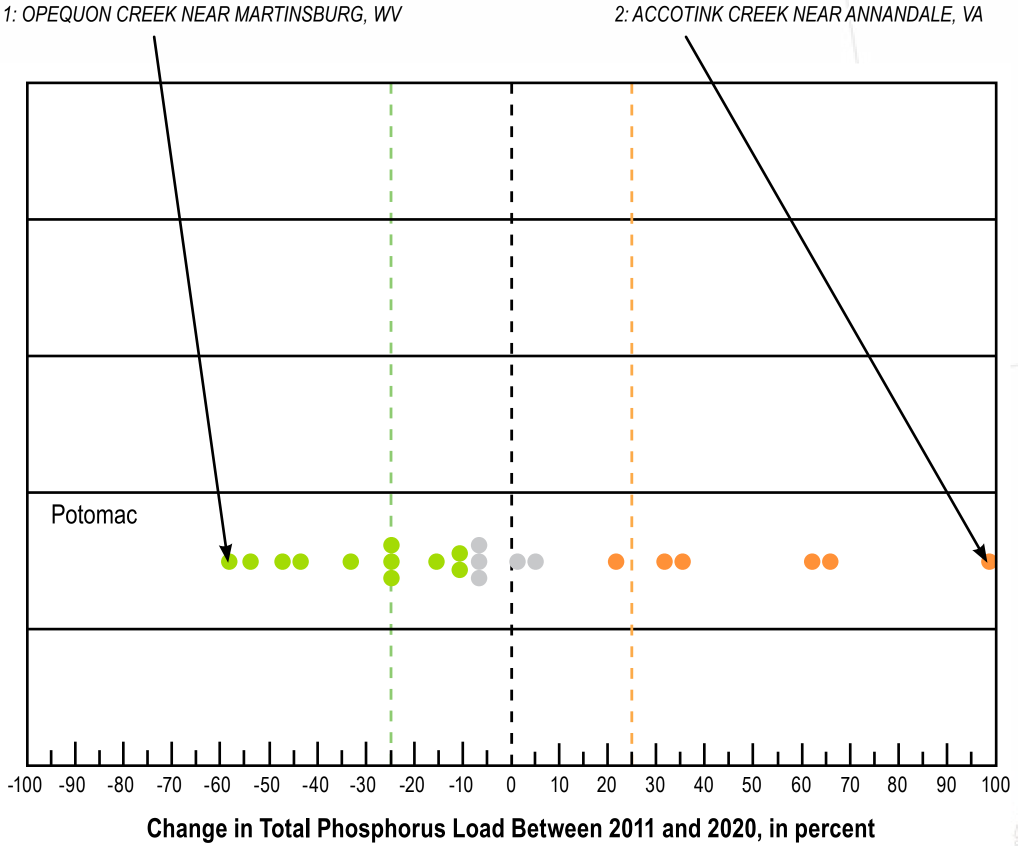


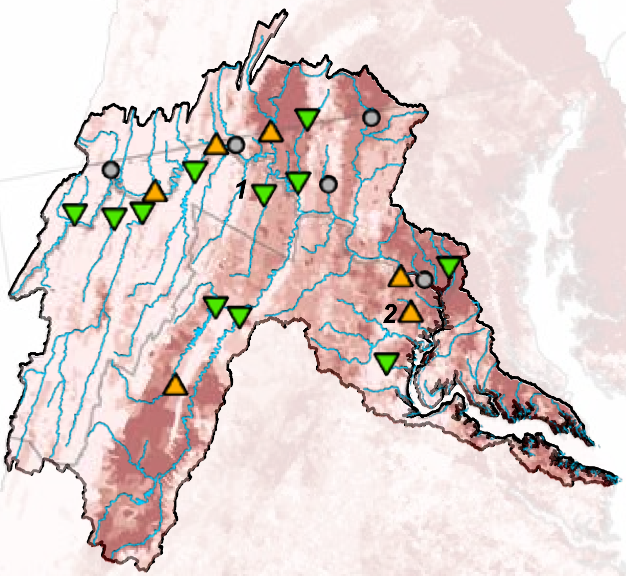
Trends in phosphorus loads result from changing phosphorus inputs or transport

The most recent ten year period in the Potomac Basin, 2011-2020

Phosphorus loads (n=22) have improved at 11, degraded at 6, and have no trend at 5 stations.

Across the Potomac, the median P improvement is 26% and the median degradation is 48%.





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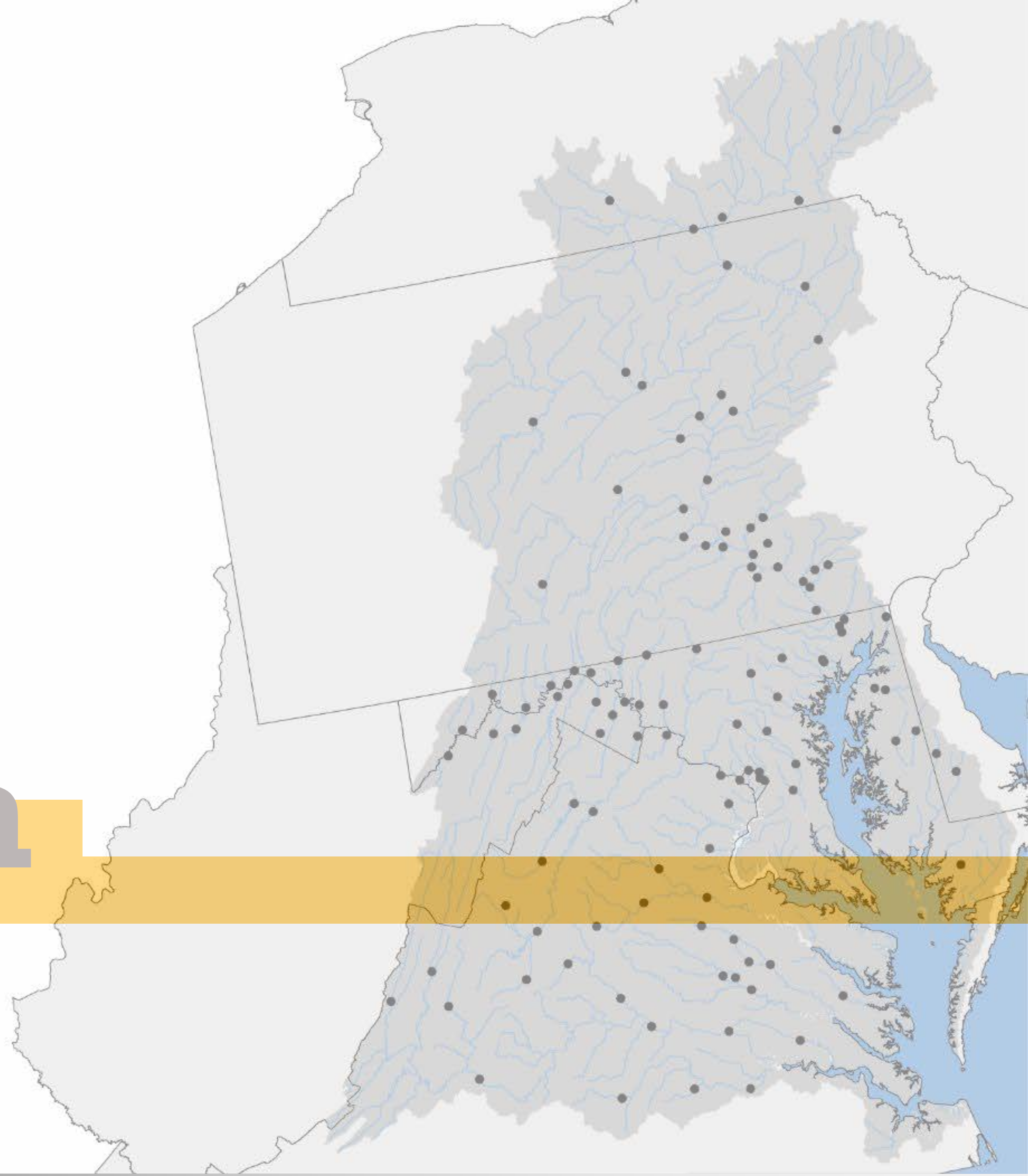
Virginia



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Trends in nitrogen loads result from changing nitrogen inputs or transport

The most recent ten year period in Virginia, 2011-2020

Nitrogen Per-acre Load

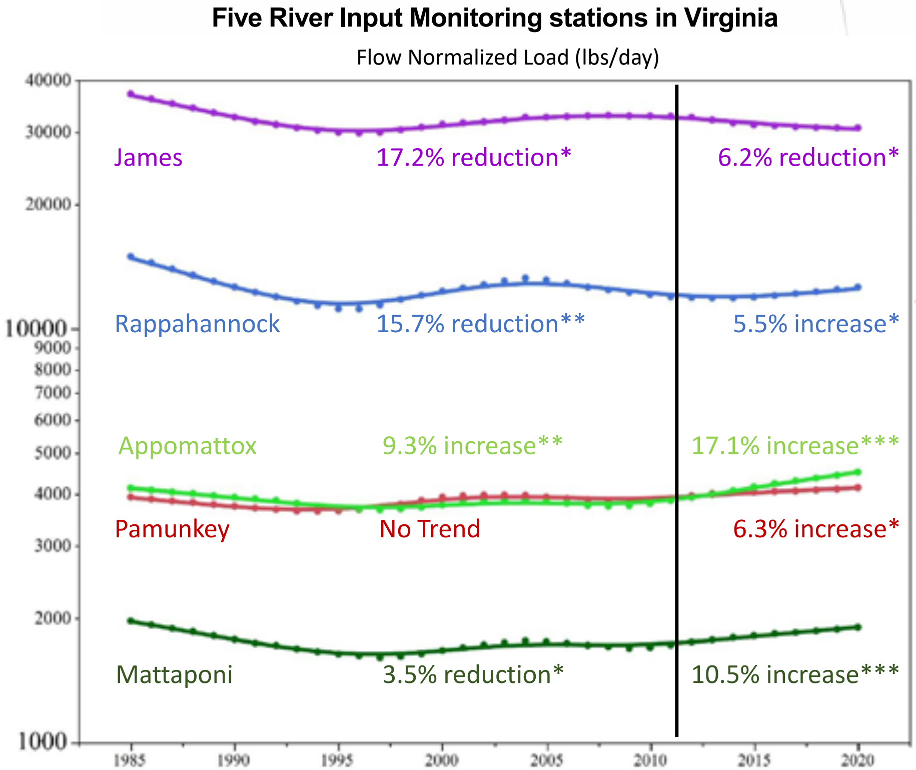
Low → High

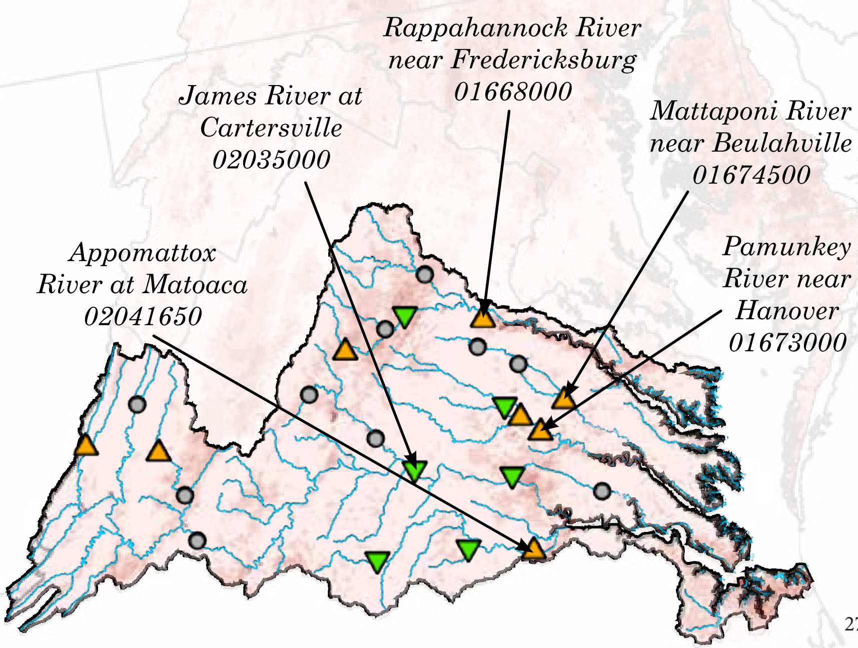
Trend Direction

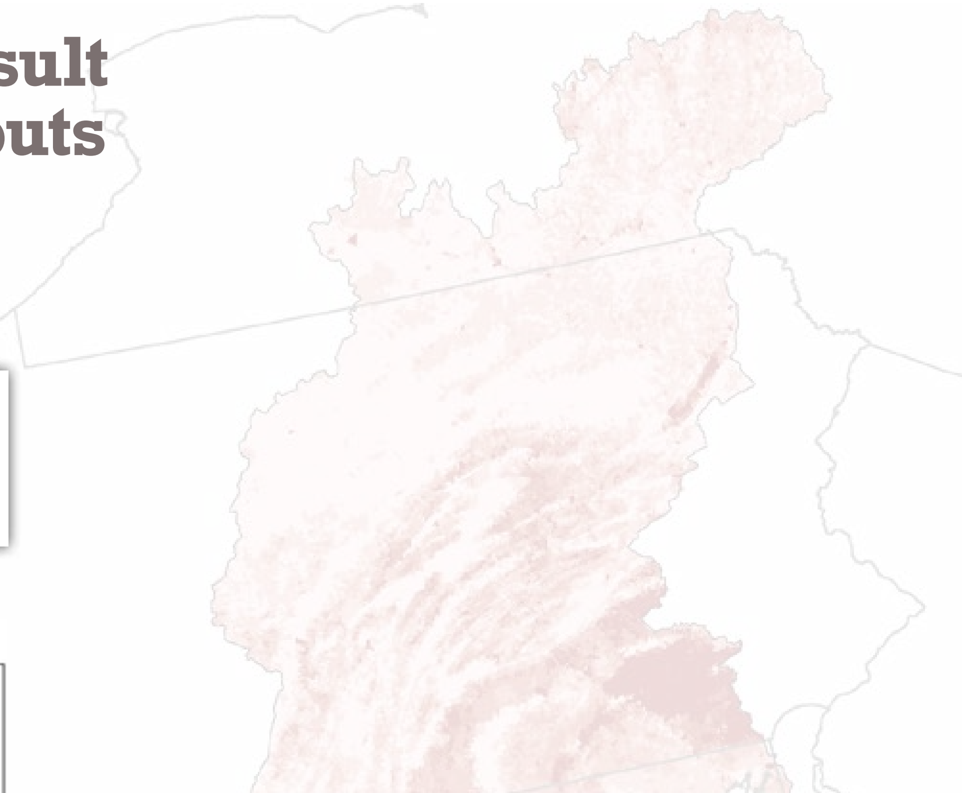
Degrading

Improving

No Trend

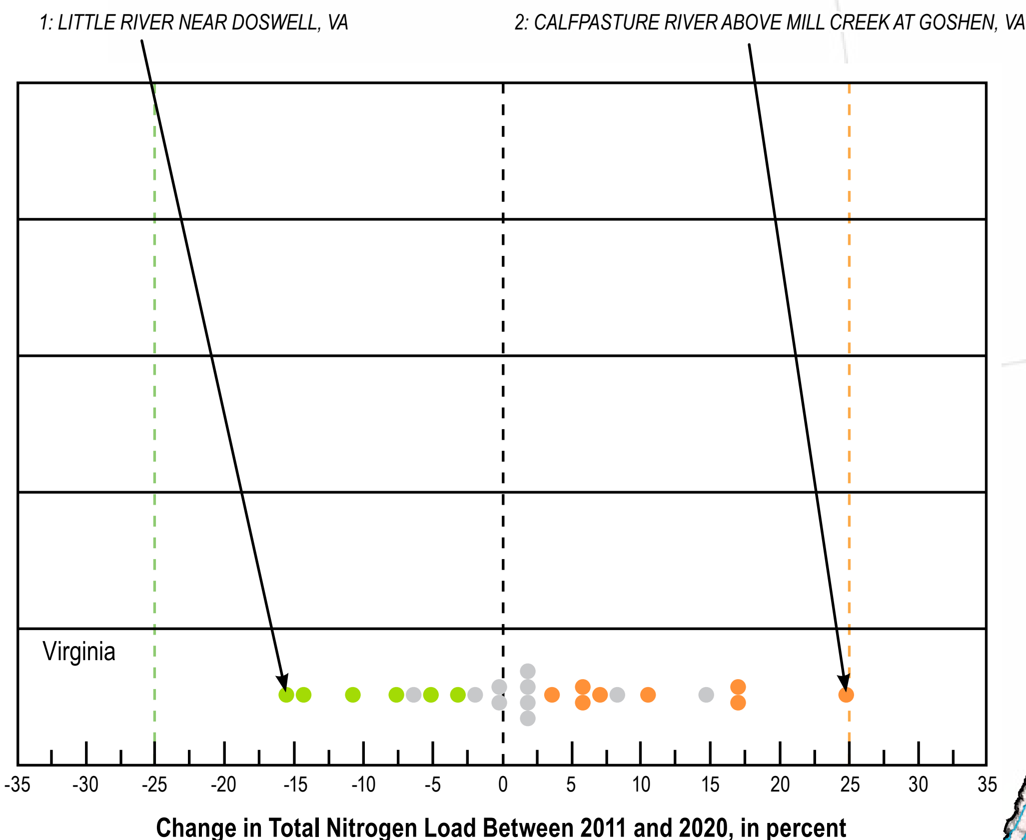






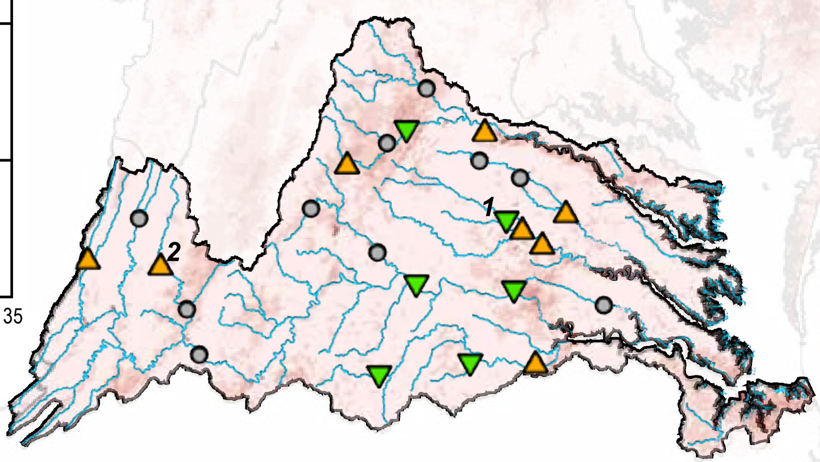
Trends in nitrogen loads result from changing nitrogen inputs or transport

The most recent ten year period in Virginia, 2011-2020



Nitrogen loads (n=24) have improved at 7, degraded at 8, and have no trend at 10 stations.

Across Virginia, the median N improvement is 9% and the median degradation is 8%.



Trends in phosphorus loads result from changing phosphorus inputs or transport

The most recent ten year period in Virginia, 2011-2020

Phosphorus Per-acre Load

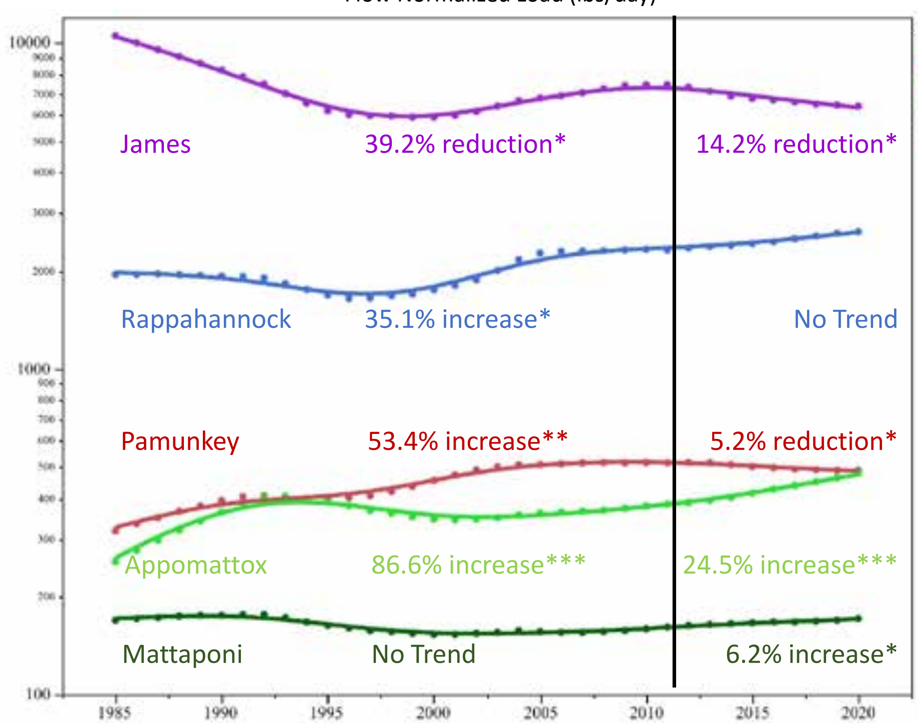
Low → High

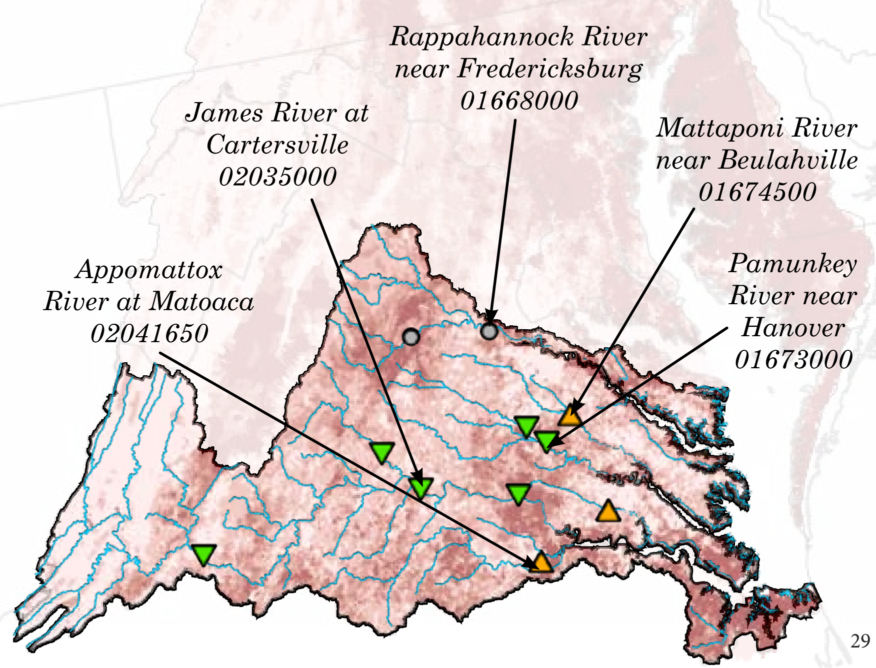
Trend Direction

Degrading
Improving
No Trend

Five River Input Monitoring stations in Virginia

Flow Normalized Load (lbs/day)





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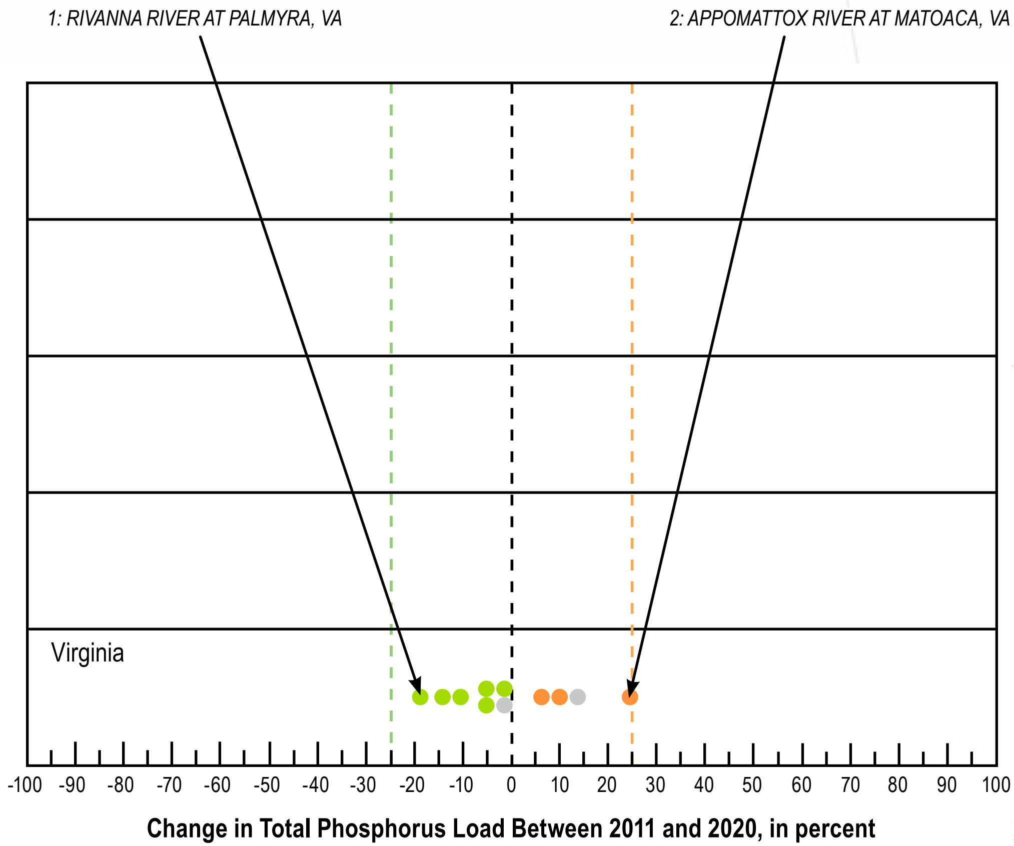
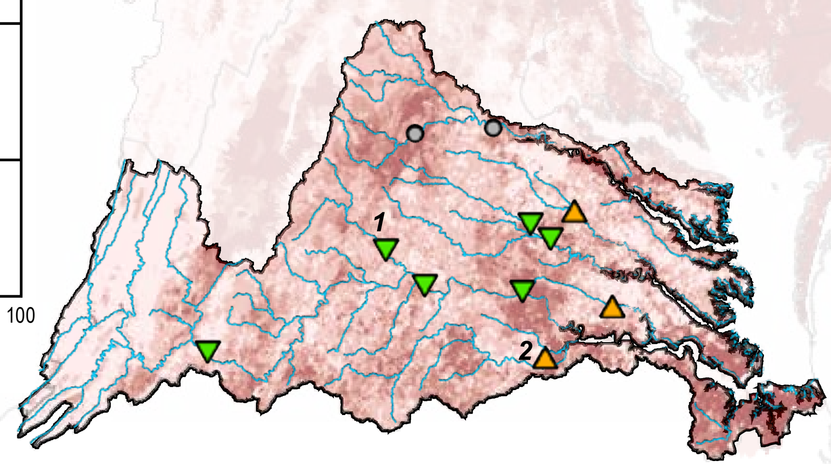
Trends in phosphorus loads result from changing phosphorus inputs or transport

The most recent ten year period in Virginia, 2011-2020

Phosphorus loads (n=11) have improved at 6, degraded at 3, and have no trend at 2 stations.

Across Virginia, the median P improvement is 8% and the median degradation is 9%.





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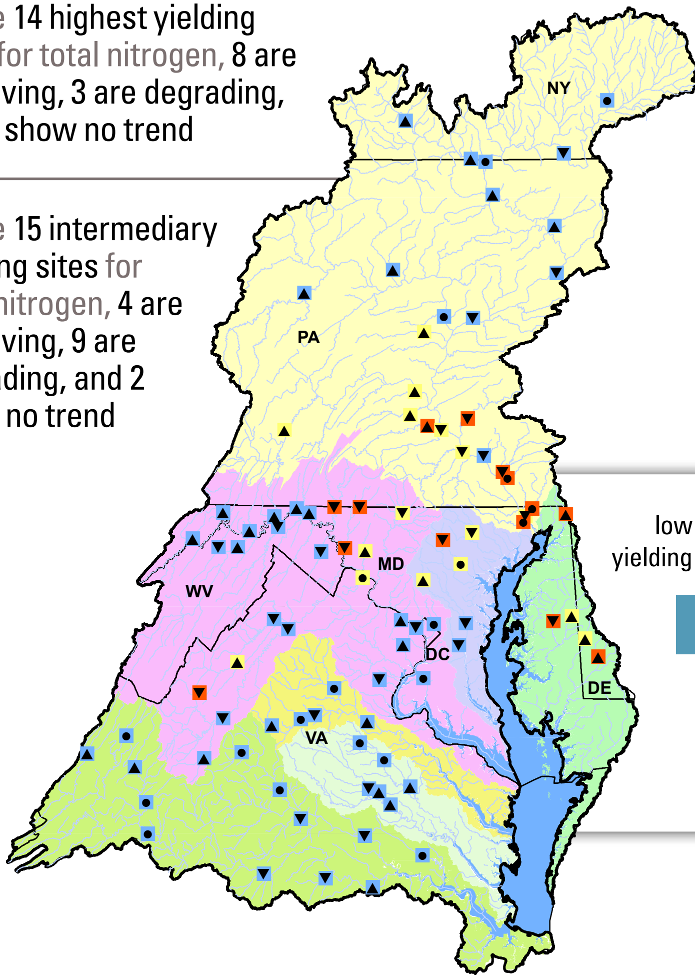
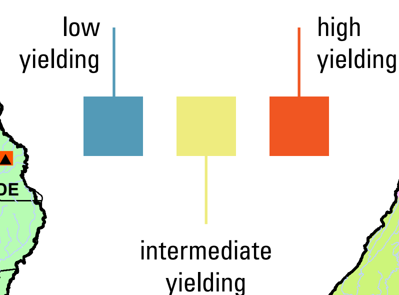
How do high yield sites compare to their respective trend direction?

~ A BROAD OVERVIEW OF SHORT-TERM LOADS, WITH KALMAN-FILTER, VERSUS TREND DIRECTION ~

Of the 14 highest yielding sites for total nitrogen, 8 are improving, 3 are degrading, and 3 show no trend

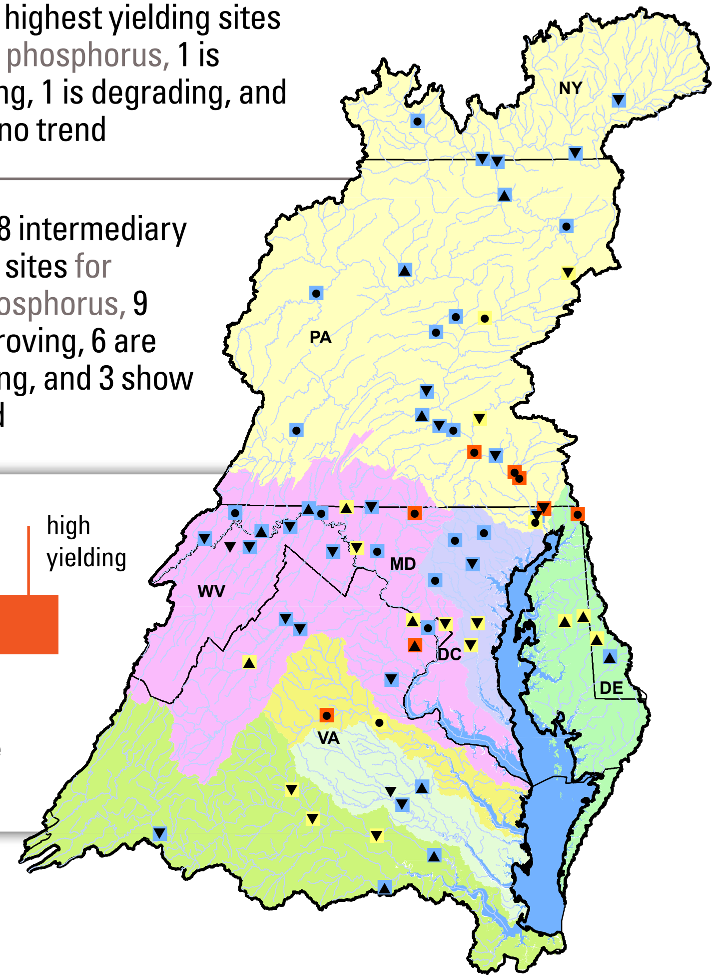
Of the 15 intermediary yielding sites for total nitrogen, 4 are improving, 9 are degrading, and 2 show no trend





Of the 8 highest yielding sites for total phosphorus, 1 is improving, 1 is degrading, and 6 show no trend

Of the 18 intermediary yielding sites for total phosphorus, 9 are improving, 6 are degrading, and 3 show no trend



Trend Direction, 2011-2020

Legend: Degrading (orange) · Improving (green) · No Trend (gray)

Percent change in flow-normalized load (numbers) at the nontidal network

Constituents from left-to-right: TN (total nitrogen), N+N (nitrate plus nitrite), TP (total phosphorus), DIP (orthophosphate), SS (suspended sediment)

EASTERN SHORE

Station	TN	N+N	TP	DIP	SS
01487000	7.05	21.9	58.2	-11.8	80.8
01488500	22	26.5	61.7	62.6	63.6
01491000	5.98	1.7	37.8	51	24
01491500	-4.33	-7.64	32.3	38.9	36.2
01495000	5.6	3.98	0.112	-16.8	24.7

WESTERN SHORE

Station	TN	N+N	TP	DIP	SS
01582500	-2.97	-2.46	8.36	-26.1	49.5
01586000	-5.62	-4.17	-8.61	-12.8	8.42
01589300	-3.4	9.24	-11.6	-27.9	9.72
01591000	10.4	9.83	3.26	17.2	33.1
01594440	-16.6	-18.8	-26.8	-20.4	-27.4
01594526	-4.43	9.34	-9.17	-6.51	-0.887

SUSQUEHANNA

Station	TN	N+N	TP	DIP	SS
01502500	1.97	13.1	-25	-38.5	-1.55
01503000	-2.81	1.31	-2.19	-54.5	98.2
01515000	2.88	5.13	-16	-41.8	104
01529500	6.16	21.5	-14.6	-49.9	8.94
01531000	9.12	13.2	-24.8	-60.1	70.8
01531500	4.05	5.49	25.6	-53.3	90.4
01534000	16.8	21.4	22.3	25.7	91.7
01536500	-1.36	5.07	-7.64	-42.2	12.2
01540500	-4.54	0.516	-0.901	-54	31
01542500	6.1	17.3	-6.02		-1.49
01549700	19.6	43	29.5		72.2
01553500	-0.754	5.03	-3.97	-34	25.3
01555000	7.33	11	1.47	12.1	-17.5
01562000	15.1	19.6	12.1	2.08	28.7
01567000	9.41	15.6	-16.2	-19.6	-1.89
01568000	15.8	18.6	23.1	22.8	32.8
01570000	3.45	2.96	-11.8	-12	-13.9
01571500	-5.65	-8.92	10.1	16	31.6
01573560	-6.9	-9.61	-13.2	-18.6	-15
01574000	-1.97	-7.3	5.67	9.52	16.1
01576000	-6.01	-1.64	-13.4	-13.2	0.774
01576754	-7.09	-9.25	-3.17	-13.3	18.7
01576787	-2.9	-5.45	9.15	-10.4	20
01578310	-3.24	7.64	-25	-14.1	-34.4
01578475	-0.357	0.929	-13.2	-23	5.87
01580520	-0.173	0.934	5.19	-29	40.2

POTOMAC

Station	TN	N+N	TP	DIP	SS
01599000	3.46	16.3	-23	-42.6	-10.3
01601500	29.1	33.9	4.03	-33.1	33
01604500	-5.39	-0.852	-53.8	-34.5	-16.4
01608500	8.52	3.26	-47.2	-83.5	41.5
01609000	23	34.1	62.2		24.8
01610155	7.94	36.2			
01611500	-10.2	-14.2	-33.1		4.36
01613095	31.9	41.1	21.7		8.43
01613525	20.6	18.4	-6.51	-38.8	-55.7
01614500	-3.56	-8.07	34.4	-1.34	15.6
01616500	-9.42	-7.05	-58.2	-78.5	39.5
01619000	-11.6	-14.8	-24.9	-43.7	-5.16
01619500	-8.86	-14.1	-10.5	-41.6	67.4
01621050	-7.62	-9.76			
01626000	21.7	29.7			
01628500	-4.45	4.2			
01631000	-5.28	9.98	-26.2	-23.9	-23.6
01632900	6.88	8.11	31.7	-22.4	73.9
01634000	-1.27	10.4	-43.5	-38.4	-49.7
01637500	15.6	21.6	1.33	-13.3	29.6
01638480	2.49	13.7			
01639000	-5.49	5.45	-7.23	2.34	-9.79
01646000	11.5	21.2	65	43.6	128
01646580	-4.14	3.64	-6.06	-30.6	6
01651000	-7.09	12.9	-15.4	-1.26	19.1
01654000	7.76	-7.64	99.9	37.9	267
01658000	2.66	-8.19			
01658500	-11.3	-6.14	-10.7	27.5	-6.94

VIRGINIA

Station	TN	N+N	TP	DIP	SS
01664000	-0.294	7.25			
01665500	6.08	21.7			
01666500	8.11	21.8			
01667500	-10.8	5.15	-2.21	14.2	0.557
01668000	5.5	14.8	13.7	6.77	16.1
01671020	3.57	48.2	-5.08		-13.1
01671100	-15.6	5.19			
01673000	6.29	22.7	-5.22	-10.3	-16.4
01673800	2.36	16.7			
01674000	1.68	28.3			
01674500	10.5	45.7	6.24	-0.538	25
02011500	16.9	28.1			
02015700	14.7	28.7			
02020500	24.8	39.8			
02024000	1.55	18.5			
02024752	-2.53	19.4	-10.5	-12.2	-12.6
02031000	1.7	22.4			
02034000	-6.7	-14.7	-18.8	-19.2	-22.1
02035000	-6.17	3.86	-14.2	-11.1	-11
02037500	-14.9	6.41	-4.01		4.49
02039500	-7.66	23.2			
02041000	-3.22	12.8			
02041650	17.1	28.4	24.5	48.3	29.7
02042500	-0.175	144	8.75		25.5

OBJECTIVE

Overview

Trend Results 2020

Sharing Results

- ScienceBase data release
- Online geonarrative
- USGS nontidal network webpage
- Chesapeake Bay watershed dashboard

Load and trend results have been computed through 2020

WHAT do we COMPUTE and SHARE?

- Loads and concentration:
  Daily, Monthly, Annual; >5 years of data needed
- Per-acre loads (yields):
  10-year average: 2011 - 2020
  5-year average: 2016 - 2020
- Trends in flow-normalized loads and concentration:
  Long-term: ~1985 - 2020
  Short-term: 2011 - 2020

doi.org/10.5066/P96H2BDO

ScienceBase-Catalog Communities Help

ScienceBase Catalog → USGS Data Release Products → Nitrogen, phosphorus, and s...

Nitrogen, phosphorus, and suspended-sediment loads and trends measured at the Chesapeake Bay Nontidal Network stations: Water years 1985-2020

View

Dates

Publication Date : 2022-07-25
Start Date : 1984-10-01
End Date : 2020-09-30

Citation

Mason, C.A., Colgin, J.E., and Moyer, D.L., 2022, Nitrogen, phosphorus, and suspended-sediment loads and trends measured at the Chesapeake Bay Nontidal Network stations: Water years 1985-2020: U.S. Geological Survey data release, https://doi.org/10.5066/P96H2BDO.

Summary

Nitrogen, phosphorus, and suspended-sediment loads, and changes in loads, in major rivers across the Chesapeake Bay watershed have been calculated using monitoring data from the Chesapeake Bay Nontidal Network (NTN) stations for the period 1985 through 2020. Nutrient and suspended-sediment loads and changes in loads were determined by applying a weighted regression approach called WRTDS (Weighted Regression on Time, Discharge, and Season). The load results represent the total mass of nitrogen, phosphorus, and suspended sediment that was exported from each of the NTN watersheds and were estimated using the WRTDS method with Kalman filtering. To determine the trend in loads, the annual load results are flow normalized to integrate out the year-to-year variability in river discharge. The trend in load is derived from the flow-normalized load timeseries and represents the change in load resulting from changes in sources, delays associated with storage or transport of historical inputs, and (or) implemented management actions. Four data tables are provided that describe nitrogen, phosphorus, and suspended-sediment conditions across the NTN: (1) Annual Loads, (2) Monthly Loads, (3) Trends in Annual Loads, and (4) Average Yield (mass per unit area). Additionally, essential WRTDS Input and Output files are provided.

Child Items (6)

- Chesapeake Bay Nontidal Network 1985-2020: Annual loads
- Chesapeake Bay Nontidal Network 1985-2020: Average annual yields
- Chesapeake Bay Nontidal Network 1985-2020: Monthly loads
- Chesapeake Bay Nontidal Network 1985-2020: Short- and long-term trends
- Chesapeake Bay Nontidal Network 1985-2020: WRTDS input data
- Chesapeake Bay Nontidal Network 1985-2020: WRTDS output data

Map »

Spatial Services

ScienceBase WMS : https://www.sciencebase.gov/catal

Communities

- USGS Data Release Products

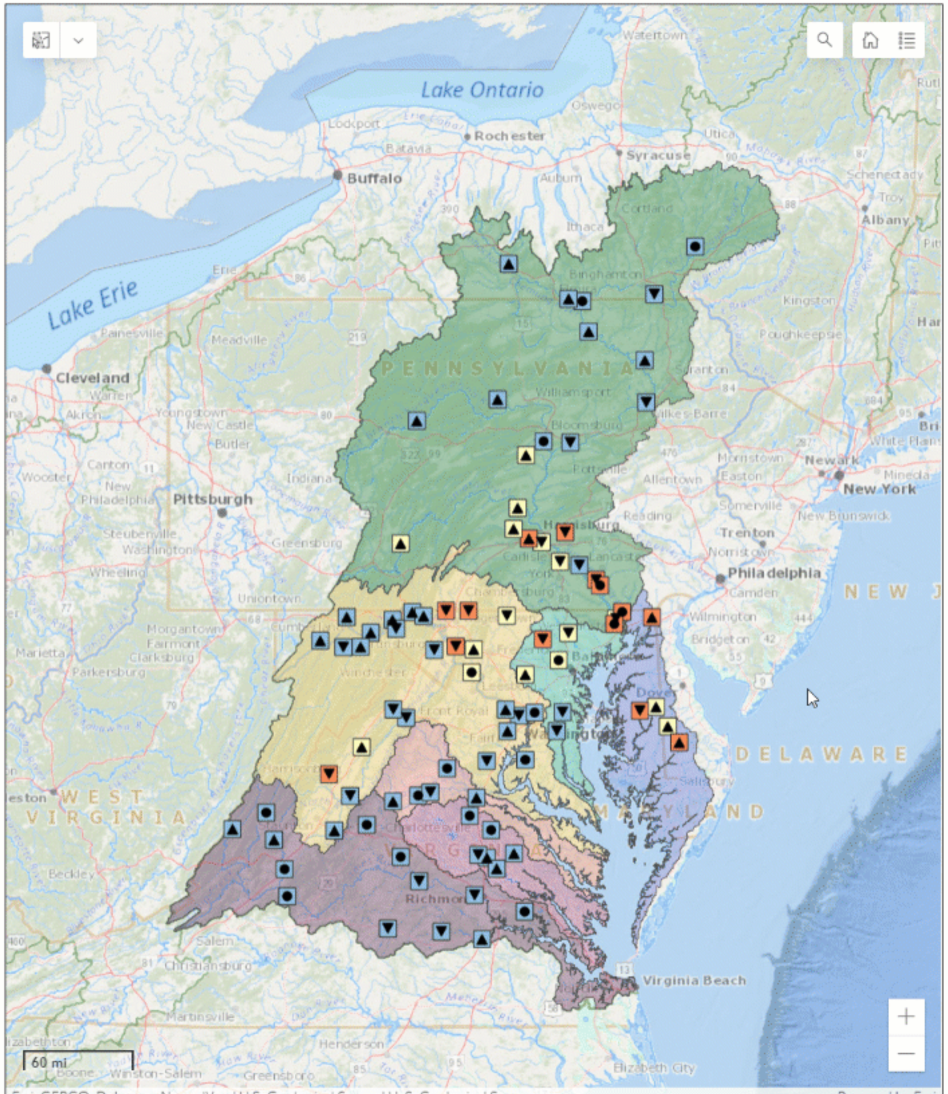
Tags

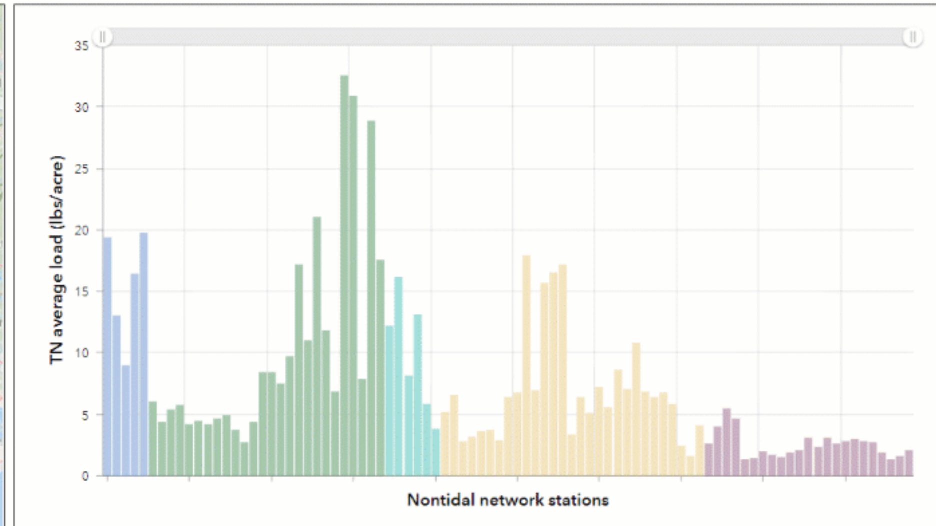
Harvest Set : USGS Science Data Catalog (SDC)
Theme : Kalman filtering, WRTDS, WRTDS-K, load analysis, nitrogen, nutrients, phosphorus, rivers, suspended sediment, trends, water quality, weighted regression
Place : Chesapeake Bay Watershed, Delaware, Maryland, New York, Pennsylvania, United States, Virginia, Washington DC, West Virginia
USGS Scientific Topic Keyword : Hydrology, Water Quality, Water Resources

Interactive web page with data dashboards for TN, TP, and SS

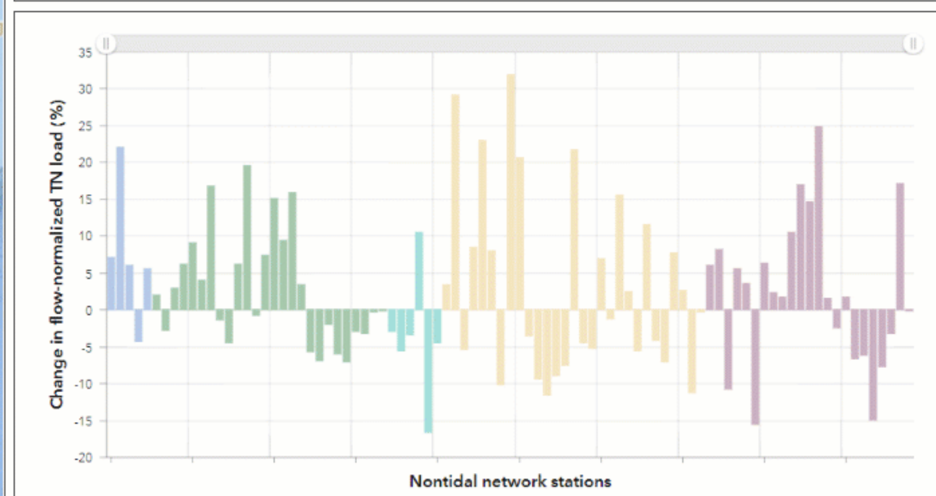
va.water.usgs.gov/geonarratives/ntn

Graph tool | Query tool





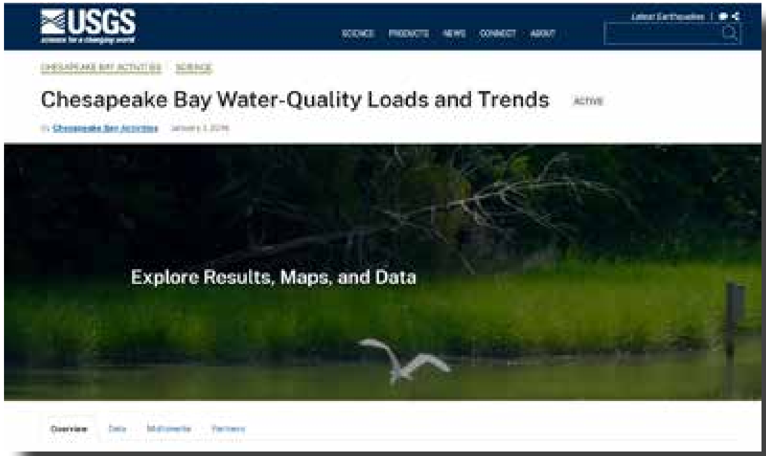
Total nitrogen (TN) average load from 2011 to 2020, in pounds per acre (lbs/acre).



Change in flow-normalized total nitrogen (TN) load from 2011 to 2020, in percent.

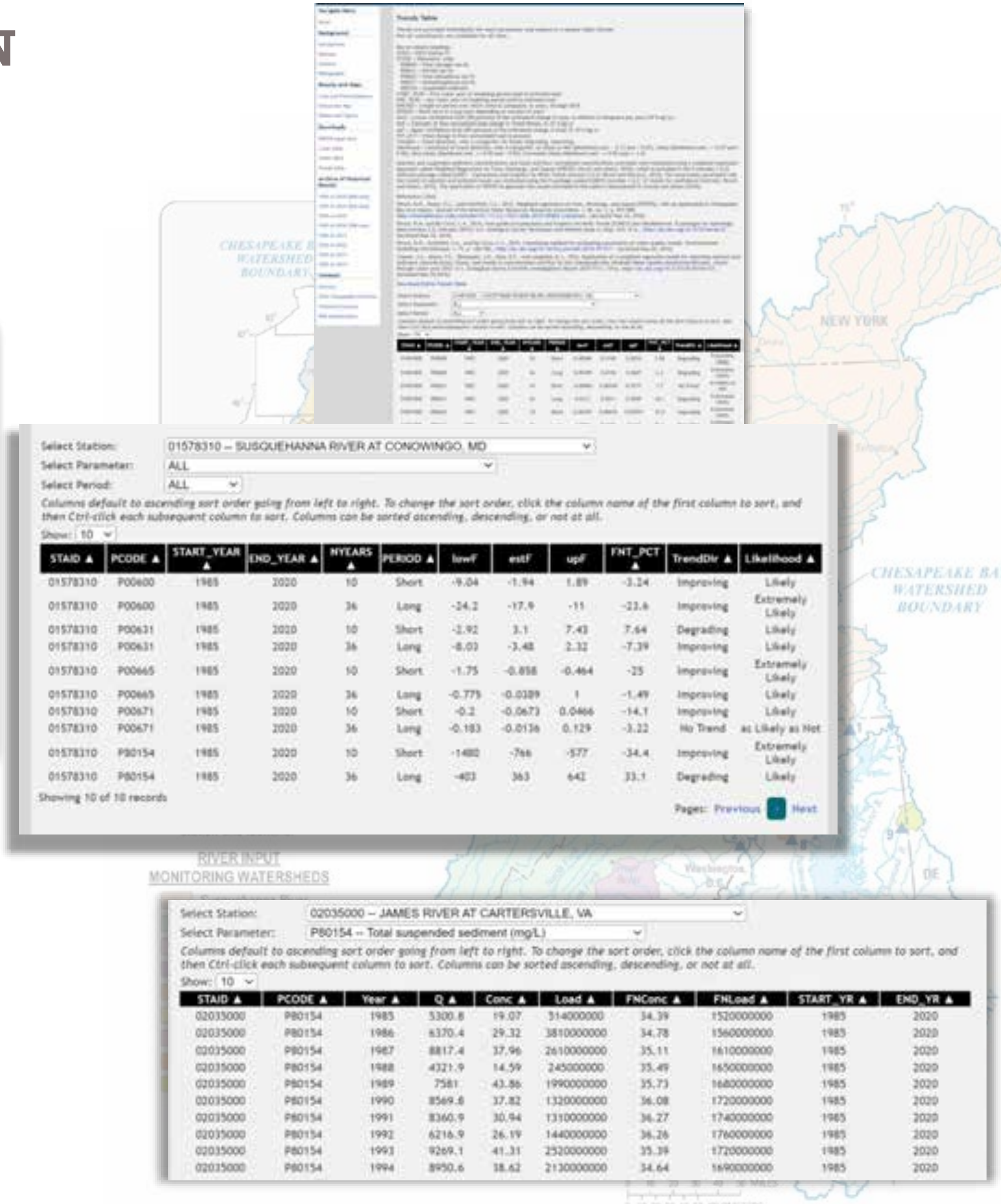
The monitoring webpage has been updated with 2020 RIM and NTN results and a new URL

usgs.gov/CB-wq-loads-trends



Secondary link is still active:
cbrim.er.usgs.gov

The websites contain load, yield, and trend results for Total Nitrogen, Nitrate/Nitrite, Total Phosphorus, Orthophosphate, and Suspended Sediment at individual monitoring stations.



Select Station: 01578310 – SUSQUEHANNA RIVER AT CONOWINGO, MD
Select Parameter: ALL
Select Period: ALL

Columns default to ascending sort order going from left to right. To change the sort order, click the column name of the first column to sort, and then Ctrl-click each subsequent column to sort. Columns can be sorted ascending, descending, or not at all.

Show: 10

STAID ▲	PCODE ▲	START_YEAR ▲	END_YEAR ▲	NYEARS ▲	PERIOD ▲	lowF	estF	upF	FNT_PCT ▲	TrendDir ▲	Likelihood ▲
01578310	P00600	1985	2020	10	Short	-9.04	-1.94	1.89	-3.24	Improving	Likely
01578310	P00600	1985	2020	36	Long	-24.2	-17.9	-11	-23.6	Improving	Extremely Likely
01578310	P00631	1985	2020	10	Short	-2.92	3.1	7.43	7.64	Degrading	Likely
01578310	P00631	1985	2020	36	Long	-8.03	-3.48	2.32	-7.39	Improving	Likely
01578310	P00665	1985	2020	10	Short	-1.75	-0.858	-0.464	-25	Improving	Extremely Likely
01578310	P00665	1985	2020	36	Long	-0.775	-0.0389	1	-1.49	Improving	Likely
01578310	P00671	1985	2020	10	Short	-0.2	-0.0673	0.0466	-14.1	Improving	Likely
01578310	P00671	1985	2020	36	Long	-0.183	-0.0136	0.129	-3.22	No Trend	as Likely as Not
01578310	P80154	1985	2020	10	Short	-1480	-766	-577	-34.4	Improving	Extremely Likely
01578310	P80154	1985	2020	36	Long	-403	363	642	33.1	Degrading	Likely

Showing 10 of 10 records

Pages: Previous Next

Select Station: 02035000 – JAMES RIVER AT CARTERSVILLE, VA
Select Parameter: P80154 -- Total suspended sediment (mg/L)

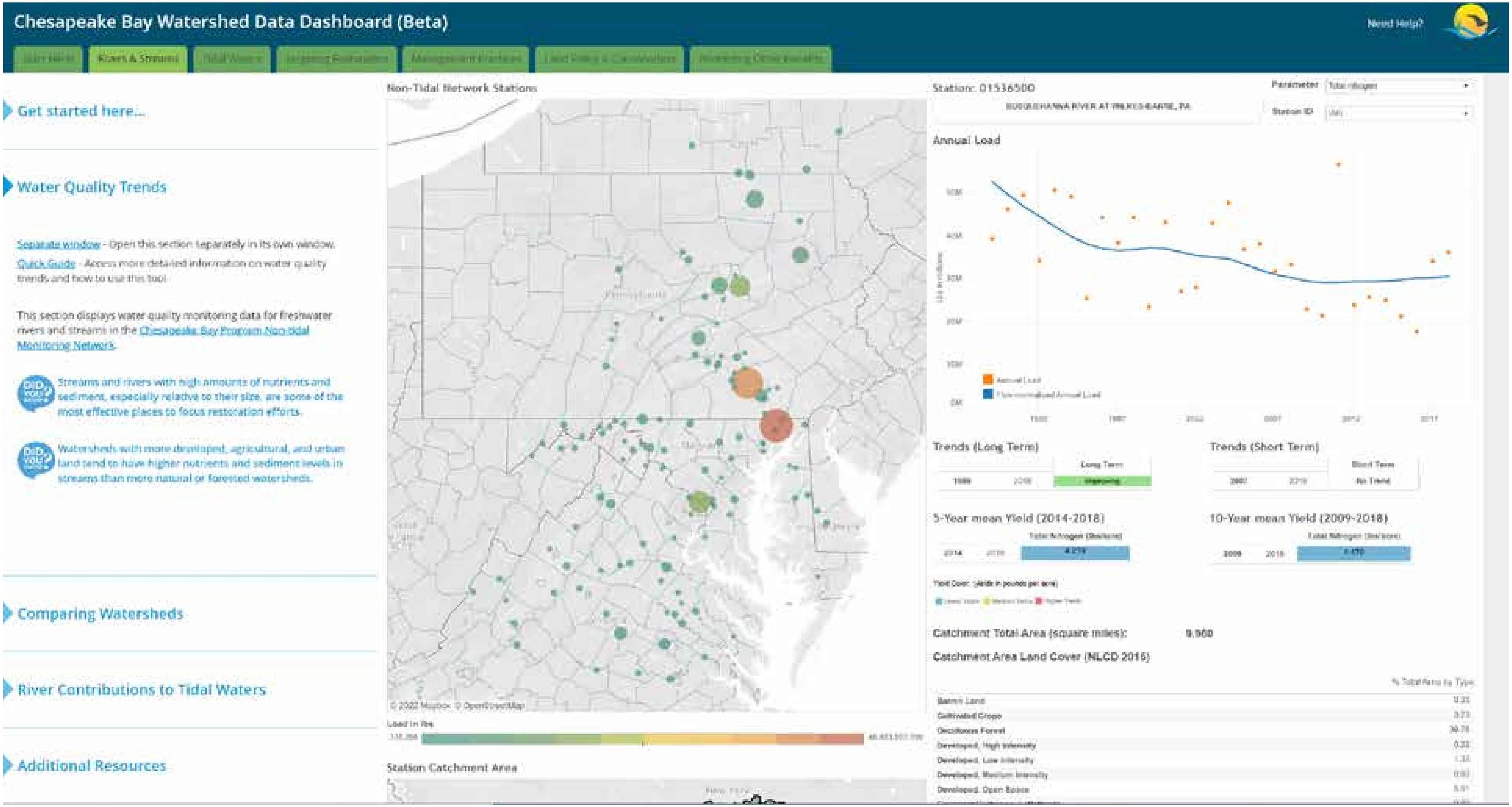
Columns default to ascending sort order going from left to right. To change the sort order, click the column name of the first column to sort, and then Ctrl-click each subsequent column to sort. Columns can be sorted ascending, descending, or not at all.

Show: 10

STAID ▲	PCODE ▲	Year ▲	Q ▲	Conc ▲	Load ▲	FNConc ▲	FNLoad ▲	START_YR ▲	END_YR ▲
02035000	P80154	1985	5300.8	19.07	314000000	34.39	1520000000	1985	2020
02035000	P80154	1986	6370.4	29.32	3810000000	34.78	1560000000	1985	2020
02035000	P80154	1987	8817.4	37.96	2610000000	35.11	1610000000	1985	2020
02035000	P80154	1988	4321.9	14.59	245000000	35.49	1650000000	1985	2020
02035000	P80154	1989	7581	43.86	1990000000	35.73	1680000000	1985	2020
02035000	P80154	1990	8569.8	37.82	1320000000	36.08	1720000000	1985	2020
02035000	P80154	1991	8360.9	30.94	1310000000	36.27	1740000000	1985	2020
02035000	P80154	1992	6216.9	26.19	1440000000	36.26	1760000000	1985	2020
02035000	P80154	1993	9269.1	41.31	2520000000	35.39	1720000000	1985	2020
02035000	P80154	1994	8950.6	38.62	2130000000	34.64	1690000000	1985	2020

The Chesapeake Bay Watershed Data Dashboard is currently being updated

gis.chesapeakebay.net/wip/dashboard



Questions?

CITATION:

Mason, C.A., Colgin, J.E., and Moyer, D.L., 2022, Nitrogen, phosphorus, and suspended-sediment loads and trends measured at the Chesapeake Bay Nontidal Network stations: Water years 1985-2020: U.S. Geological Survey data release, https://doi.org/10.5066/P96H2BDO

SHARED RESOURCES:

USGS NTN 2020 ScienceBase data release (above citation)

USGS NTN 2020 Interactive webpage

USGS NTN Loads and Trends website (current and historic)

Chesapeake Bay dashboard