USGS Science Highlights in the COG Region: an overview of our studies and emerging research questions

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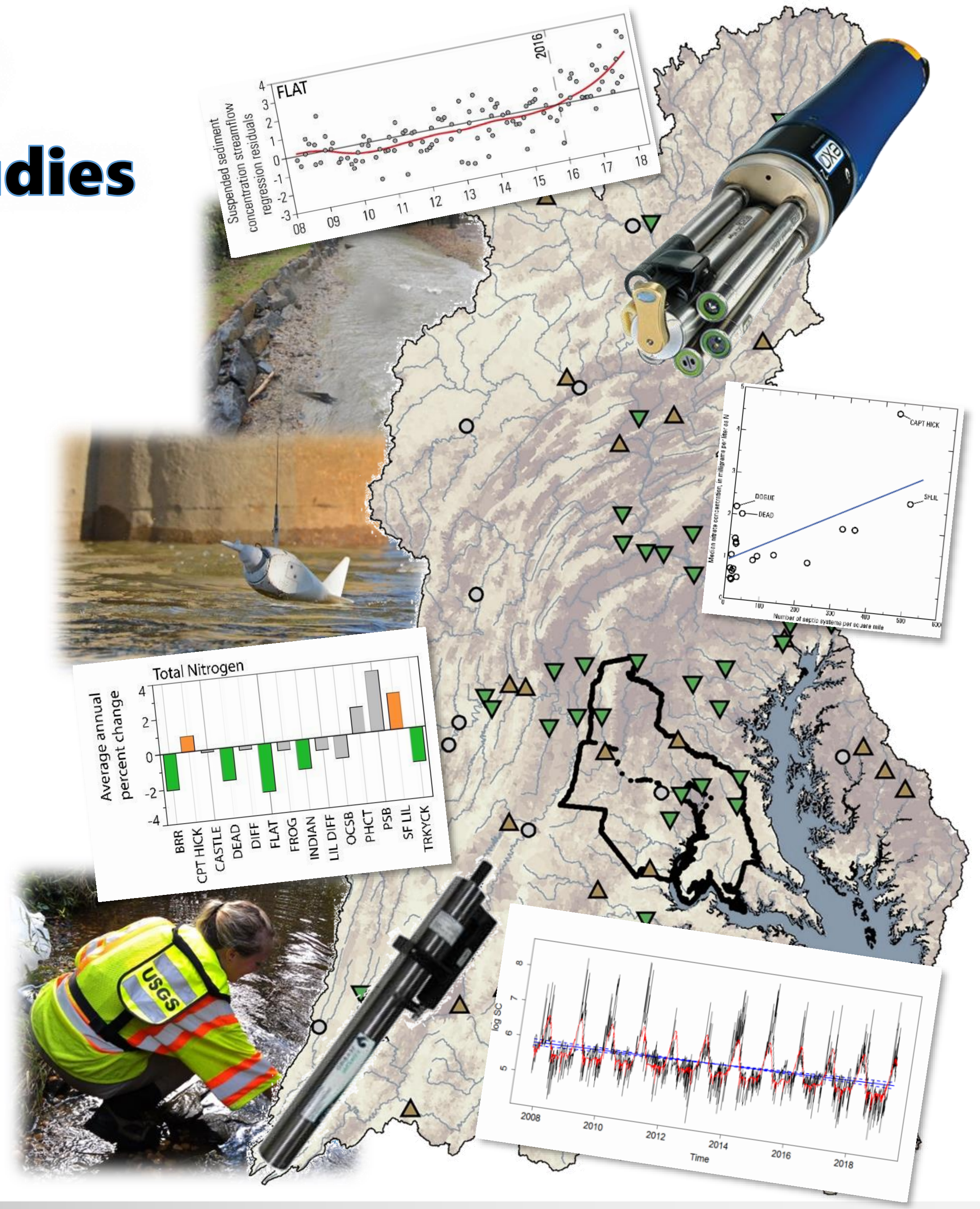
Objectives:

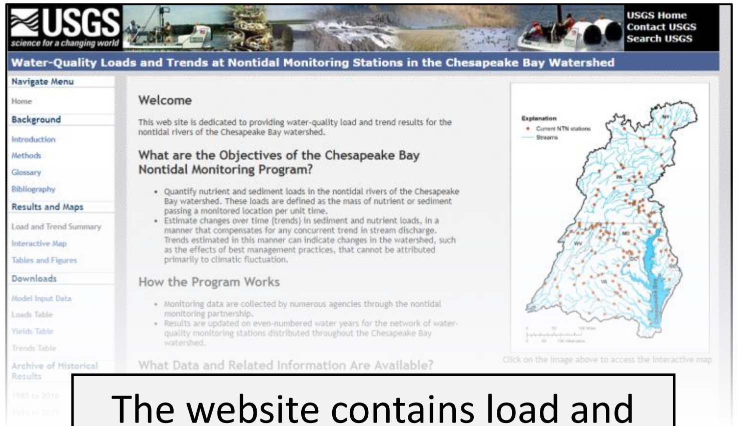
To describe how local and regional water-quality resource issues are being met by USGS studies throughout the CoG study area.	***To identify high-priority unresolved research questions based on ongoing studies.***



Load and trend results have been computed through 2016 in the Chesapeake Bay nontidal network*

*or through 2018 at the 9 long-term RIM stations, including Potomac at Chain Bridge

https://cbrim.er.usgs.gov/index.html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Water-Quality Loads and Trends at Nontidal Monitoring Stations in the Chesapeake Bay Watershed

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Welcome

This web site is dedicated to providing water-quality load and trend results for the nontidal rivers of the Chesapeake Bay watershed.

What are the Objectives of the Chesapeake Bay Nontidal Monitoring Program?

- Quantify nutrient and sediment loads in the nontidal rivers of the Chesapeake Bay watershed. These loads are defined as the mass of nutrient or sediment passing a monitored location per unit time.
- Estimate changes over time (trends) in sediment and nutrient loads, in a manner that compensates for any concurrent trend in stream discharge. Trends estimated in this manner can indicate changes in the watershed, such as the effects of best management practices, that cannot be attributed primarily to climatic fluctuation.

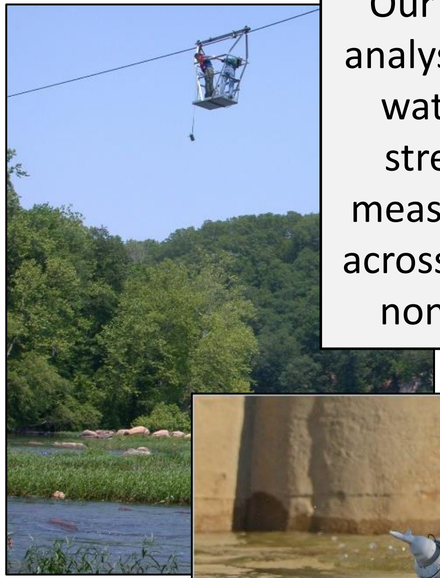
How the Program Works

- Monitoring data are collected by numerous agencies through the nontidal monitoring partnership.
- Results are updated on even-numbered water years for the network of water-quality monitoring stations distributed throughout the Chesapeake Bay watershed.

What Data and Related Information Are Available?

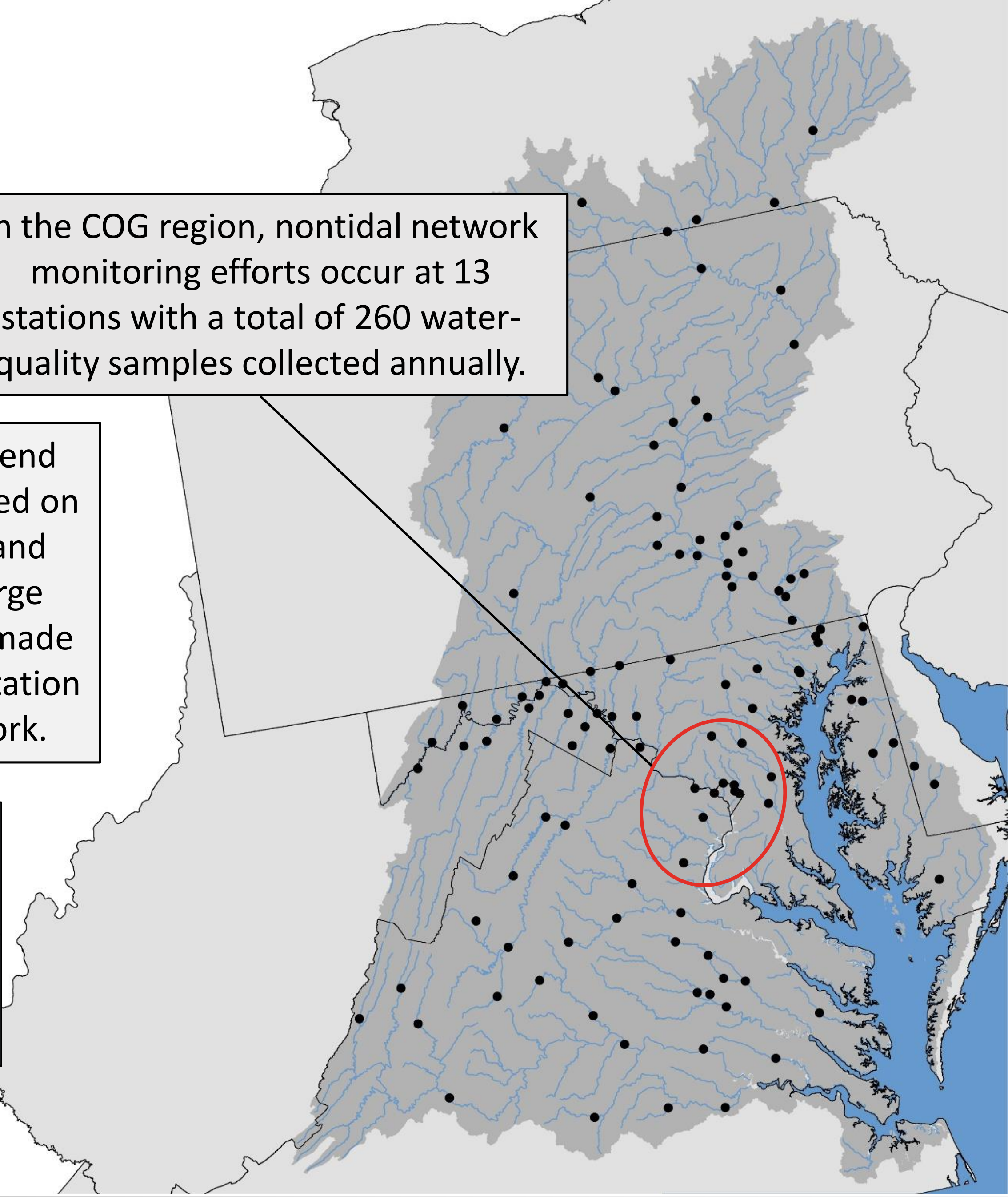
Click on the image above to access the interactive map

The website contains load and trend results for total nitrogen, nitrate, total phosphorus, orthophosphorus, and suspended sediment at individual monitoring stations in graphical or tabular formats.



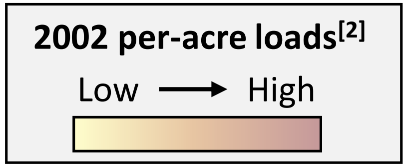
Our load and trend analyses are based on water-quality and stream-discharge measurements made across the 115-station nontidal network.

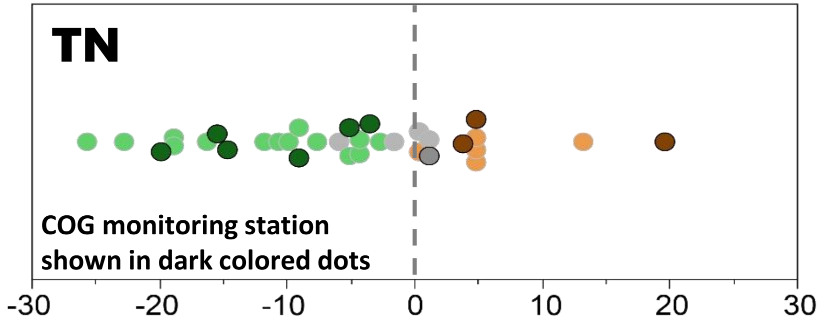
Over 2,000 water-quality samples are collected each year!

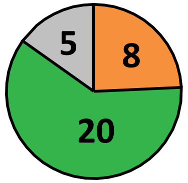


In the COG region, nontidal network monitoring efforts occur at 13 stations with a total of 260 water-quality samples collected annually.

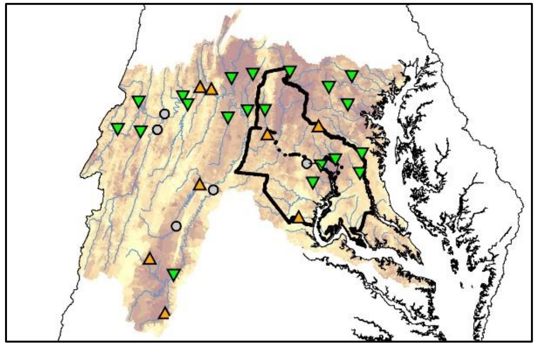
Nutrient and sediment trends are mixed throughout the Potomac River watershed[1]

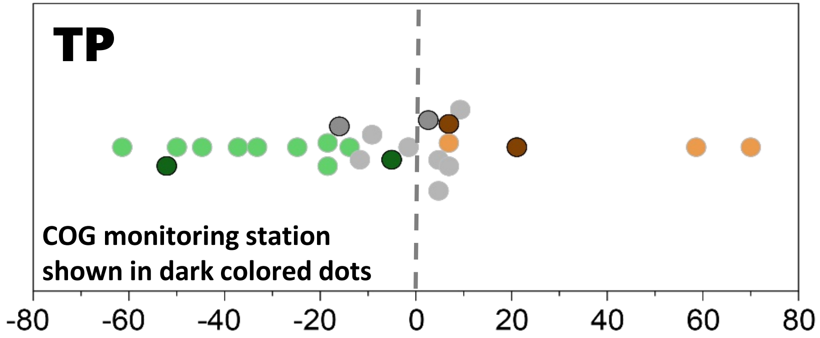


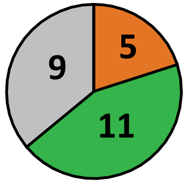




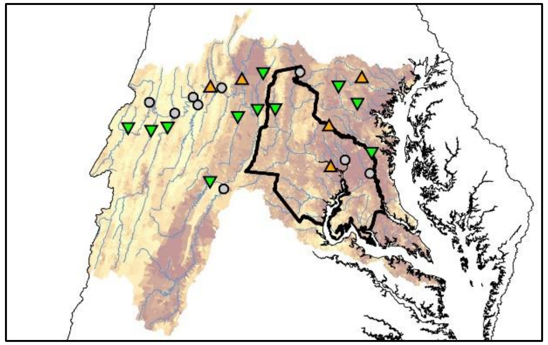
The median TN improvement is **10%** and the median degradation is **5%**

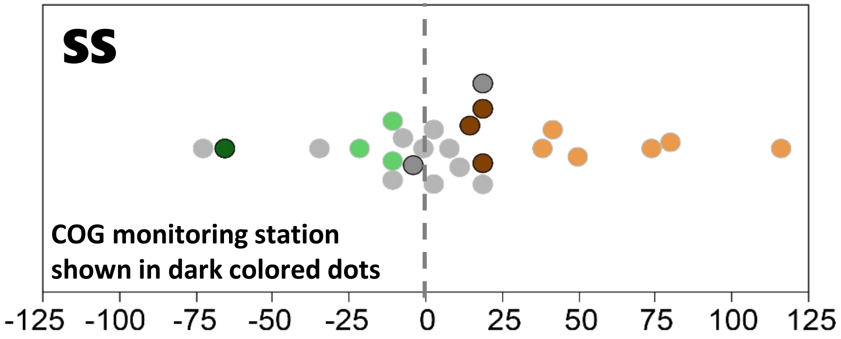


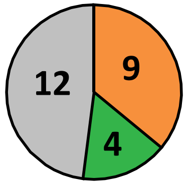




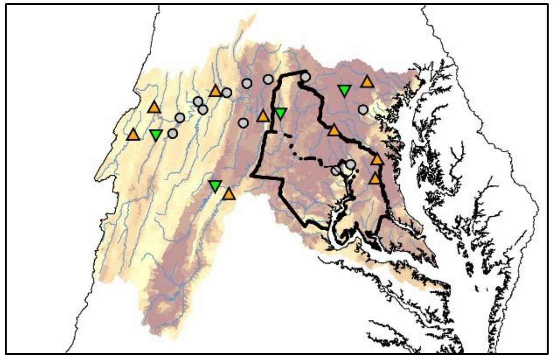
The median TP improvement is **33%** and the median degradation is **21%**







The median SS improvement is **16%** and the median degradation is **41%**



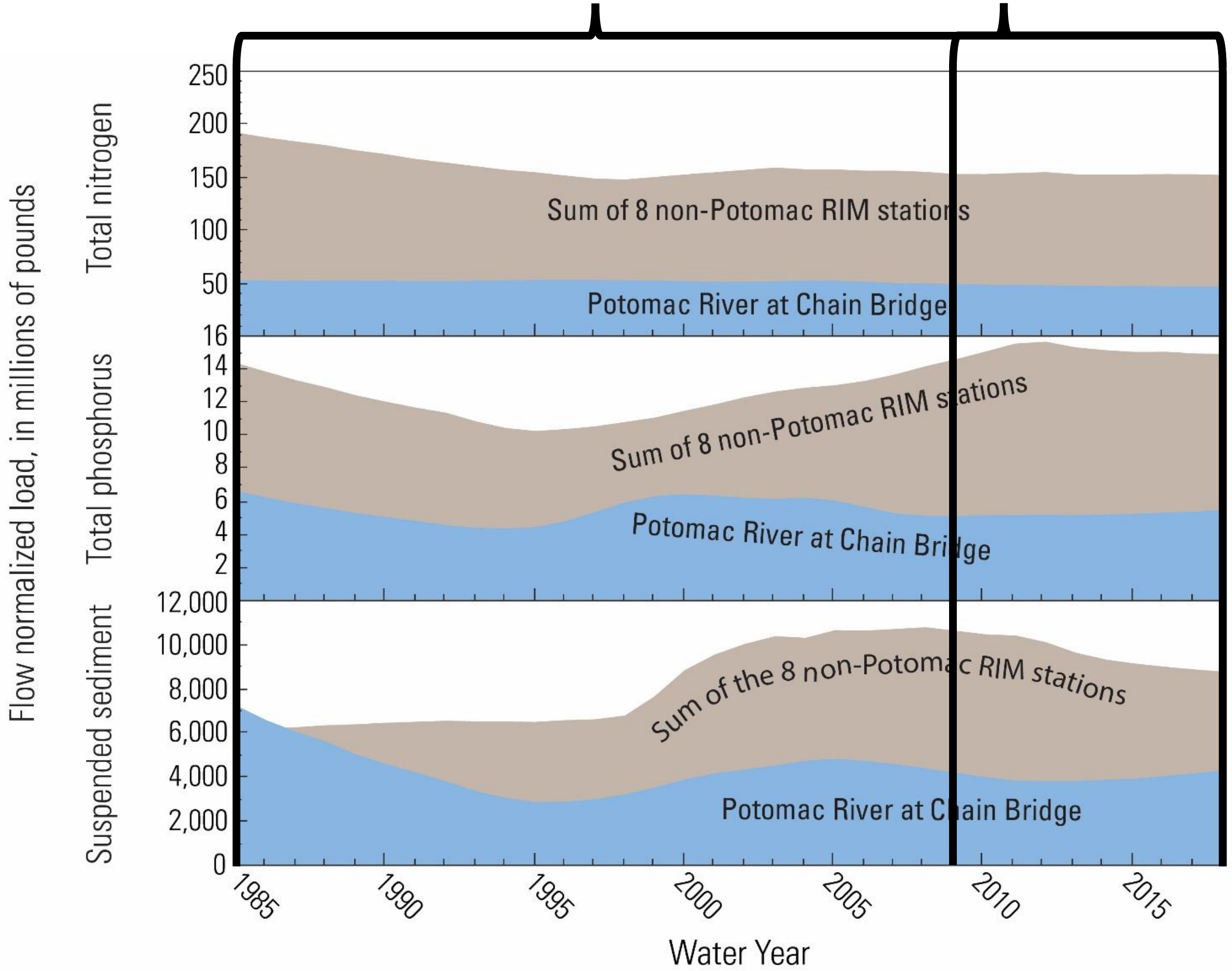
Change in load between 2007-2016, in percent

[1]Moyer and others, 2017

[2]Ator and others, 2011

Long-term load reductions at Chain Bridge differ for TP and SS in a recent 10-year period[3]

Long term = 34 years, 1985 to 2018 | Short term = 10 years, 2009 - 2018



Chain Bridge Trends

	Long term	Short term
Total nitrogen	-12%	-5%
Total phosphorus	-18%	+7%
Suspended sediment	-41%	+3%

What are the drivers of nutrient and sediment trends in load in the Potomac?

Upstream watersheds draining agricultural and urban land typically contribute elevated nutrient and sediment loads and, collectively, have a large influence on conditions at Chain Bridge.

Small watershed studies can develop a mechanistic understanding of sources, transport processes, and management practice effects to inform regional models and drivers of downstream condition.

The USGS partners with localities in the COG region to develop such studies, each tailored to provide management-relevant science related to specific water resource concerns.

[1]Moyer and others, 2019

Fairfax County streams have been assessed through a cooperative USGS monitoring program since 2008

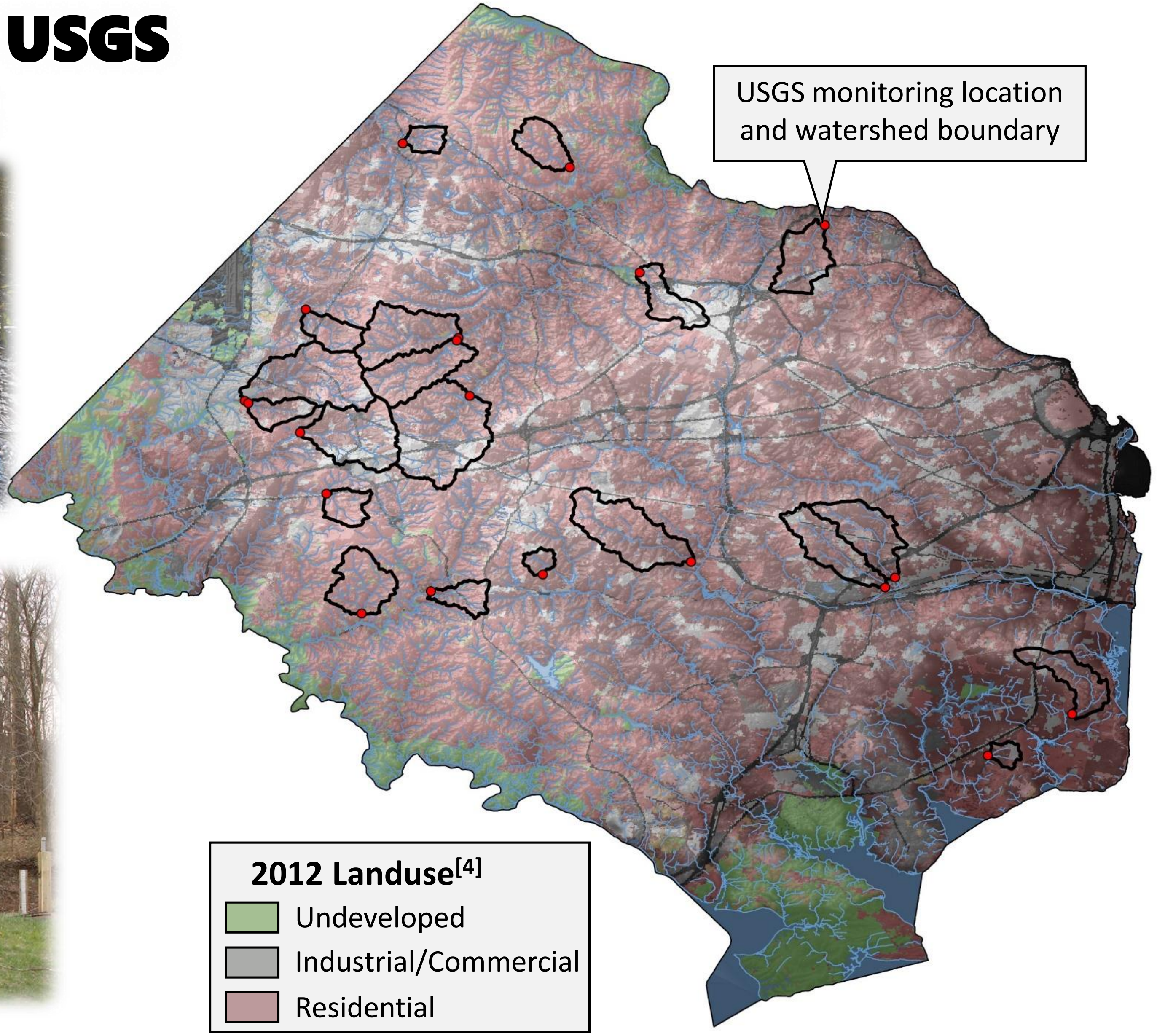
Monthly water-quality samples are collected at 20 stream locations that represent a range of county land use and typically drain watersheds < 5 square miles.

Sampled constituents include:

- Nitrogen (TN and major forms of N)
- Phosphorus (TP and major forms of P)
- Suspended sediment concentration
- Water temp., sp. cond., pH, DO, and turbidity

Benthic macroinvertebrates are sampled annually at each location.

Continuous water-chemistry and streamflow data are collected from 5 monitoring locations and reported online in near real-time.



[4]Falcone, 2015

The Fairfax study is designed to address numerous questions…

*What are the **hydrologic conditions** in urbanized watersheds? How are they **changing over time**?*

*What are the **nutrient and sediment loads** from urbanized watersheds across different **physiographic provinces**? How are they **changing over time**?*

*What is the **benthic macroinvertebrate** community structure? How is it **changing over time**?*

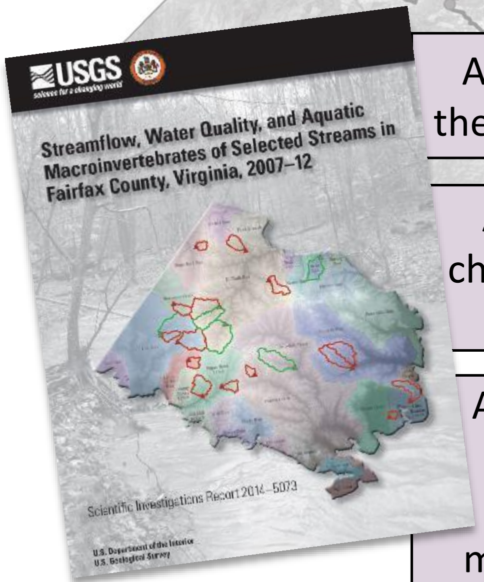
*How do these conditions **compare to urbanized watersheds** in other areas?*

*How do monitored conditions (ie. Loads) **compare to modeled conditions**?*

*What are the **drivers of the changes** observed?*

*What effect are **management actions** having on small urban/suburban watersheds?*

Program website:
va.water.usgs.gov/fairfax/



A 2014 report[5] summaries the first 5-years of monitoring.

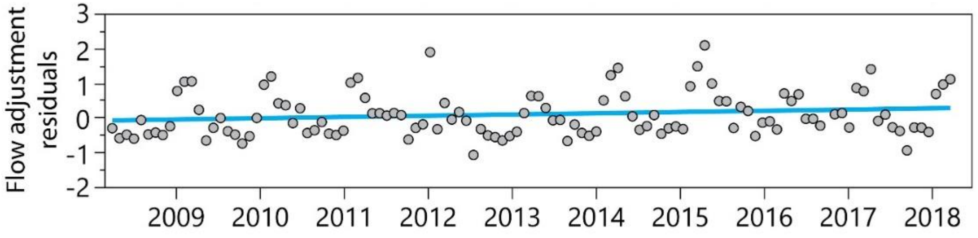
An upcoming 2020 report characterizes 10 years of load and trend results.

A report is currently being developed to assess the water-quality effects of management practices and other watershed drivers.

[5]Jastram, 2014

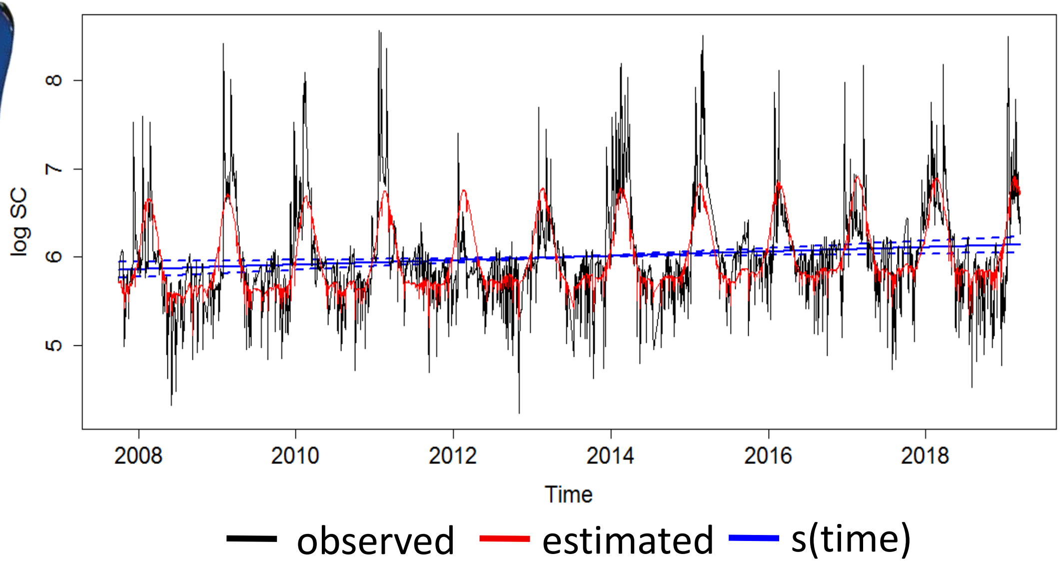
The USGS employs robust and state-of-the-art trend methods to evaluate change over time

Water-chemistry trends are typically reported after 10-years of discrete data collection and remove effects associated with streamflow and seasonality.



The use of real-time water-quality sondes has increased throughout the nation, but a method for estimating trends from these data has been an unresolved need.

Gavin Yang (Virginia and West Virginia Water Science Center) has developed such a method and will be publishing the approach in a forthcoming journal article.



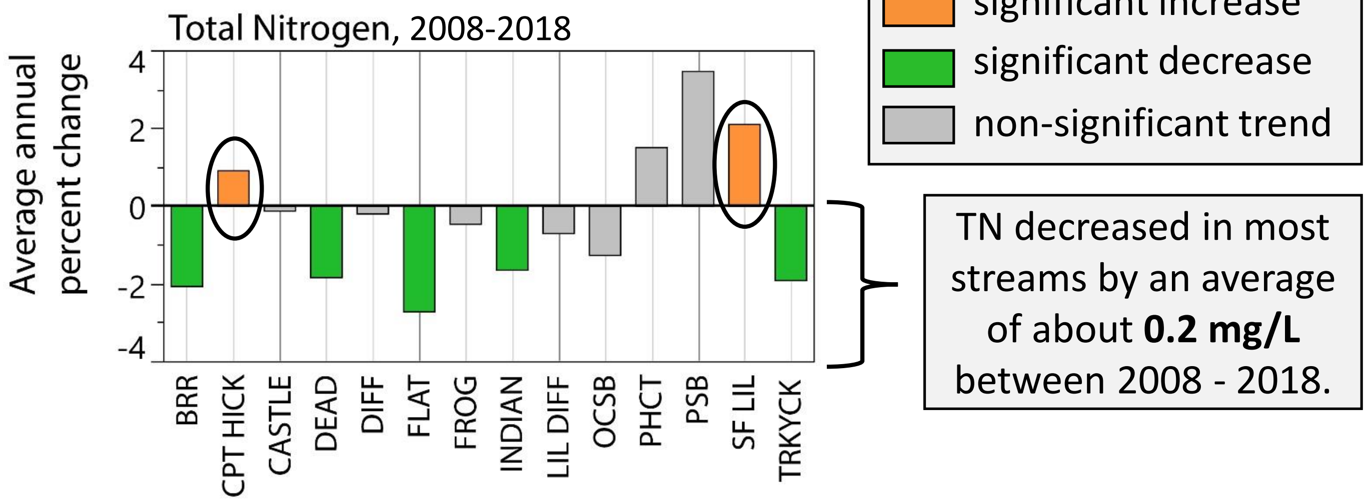
How quickly do watersheds respond to the implementation of management practices?

How soon do streams recover from large wintertime salt runoff events?

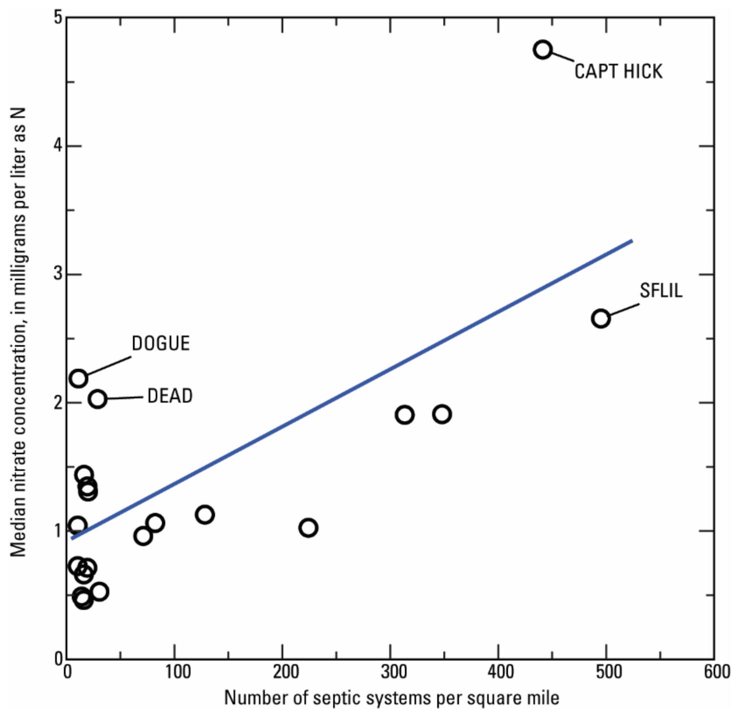
The evaluation of temporal variability on daily timesteps allows researchers to explore new questions related to the timing of water-quality responses following watershed perturbations.

The USGS collects real-time specific conductance data from 20 monitoring locations in DC; Frederick, MD; Montgomery, MD; Prince George, MD; and Fairfax, VA

Nitrogen concentrations decreased in most Fairfax streams, but increased in two streams with the highest concentrations



TN decreased in most streams by an average of about **0.2 mg/L** between 2008 - 2018.



Average TN concentrations are 1-2 mg/L except for Captain Hickory Run (CPT HICK, 5 mg/L) and South Fork Little Difficult Run (SF LIL, 3 mg/L)

Septic system effluent has been identified as a major source of nitrogen in some Fairfax County streams[6], with high TN concentrations found in streams draining watersheds with high septic system densities (up to 500 systems / mi^2).

Significant TN increases of about **0.5 mg/L** occurred between 2008-2018 in CPT HICK and SF LIL

The number of septic systems increased in CPT HICK and SF LIL by about 7% between 2007 – 2017[7], an increase of about 30 systems / mi^2

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[6]Hyer and others, 2016

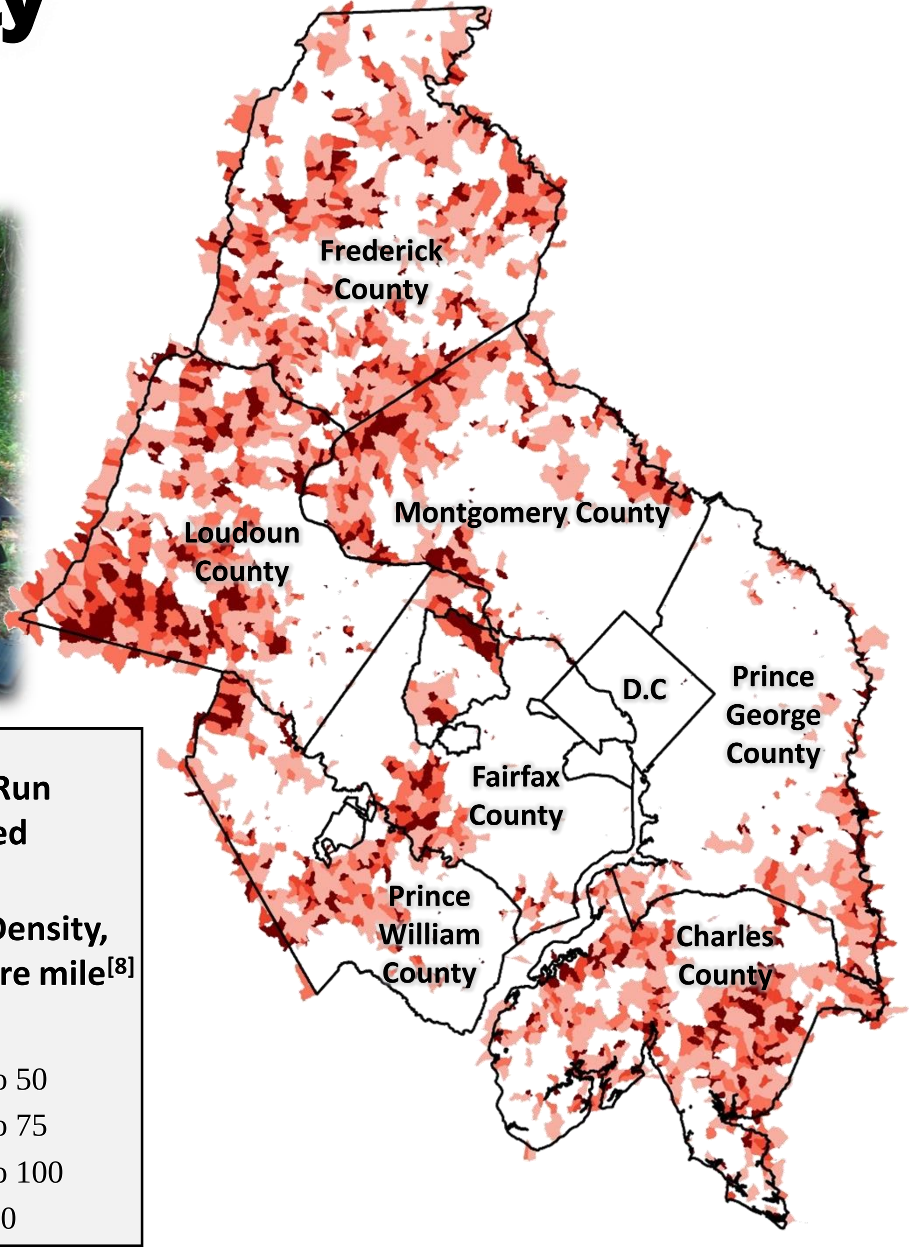
[7]Chesapeake Bay watershed model

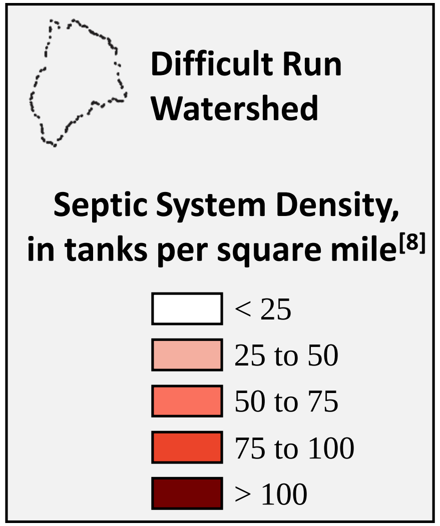
Watersheds with a high septic system density exist throughout the COG region

Is septic effluent and sewer leakage a significant source of nitrogen in COG streams? The effect of such diffuse wastewater inputs on nitrogen loads and trends is being assessed in Fairfax County, but is otherwise unknown throughout the COG region.

These effects could begin to be addressed using existing spatial and water-chemistry data available in the COG region.

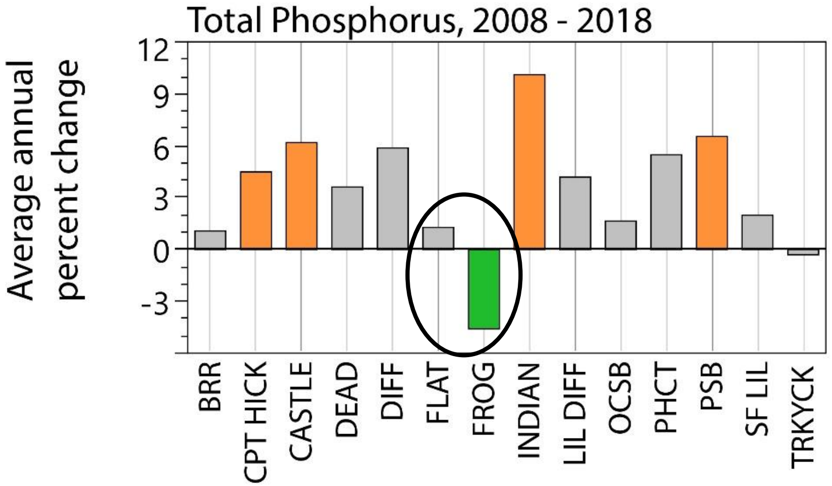
The complex mixture of nonpoint nitrogen sources (fertilizer, manure, wastewater, atmospheric deposition, etc.) has been untangled in previous USGS studies using a combination of nitrate monitors, nitrogen isotopes, and human-specific genetic markers.





[8]LaMotte, 2018

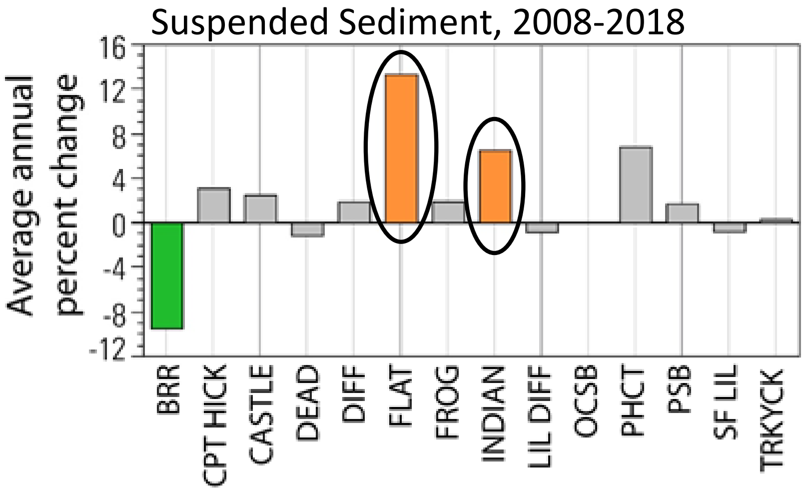
Sediment and phosphorus concentrations did not decline in most Fairfax streams



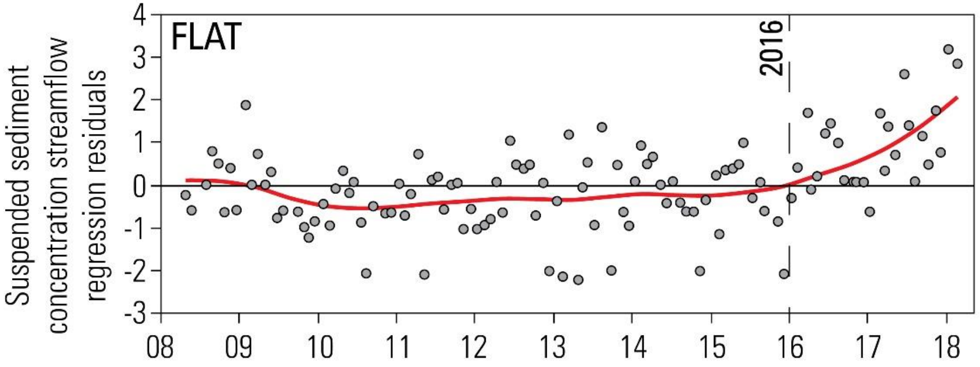
TP concentrations of 0.02 – 0.03 mg/L are common during non-stormflow conditions at most sites, but are elevated in FLAT and FROG, watersheds that drain P-rich geologic materials[5].

TP trends are primarily driven by increases in dissolved phosphorus (DP) concentrations.

What are the drivers of DP increases in urban streams? Causes may include changes in sorption/desorption rates, which are influenced by soil temperature[9], anoxia[10], alkalinity[11], and/or P saturation[12]



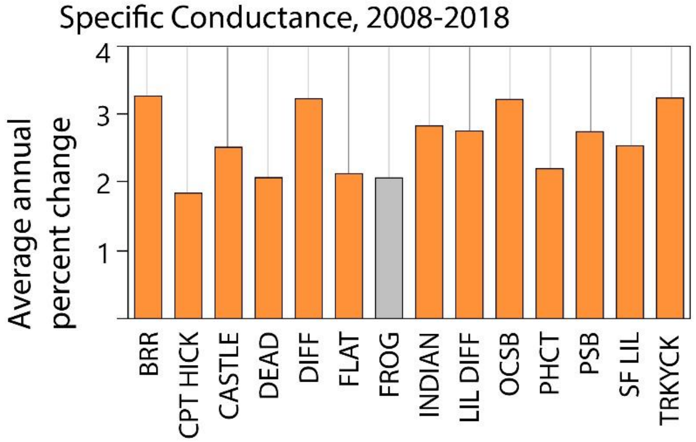
FLAT and INDIAN: stream restoration projects were installed between 2015 – 2018 upstream of the monitoring locations[13].



How much sediment is mobilized during the installation of stream restoration practices? How does this compare with long-term benefits?

[5]Jastram, 2014
[9]Duan and others, 2012
[10]House and Denison, 2002
[11]James and Barko, 2004
[12]Sharpley, 1995
[13]Fairfax County Stormwater Improvement Projects

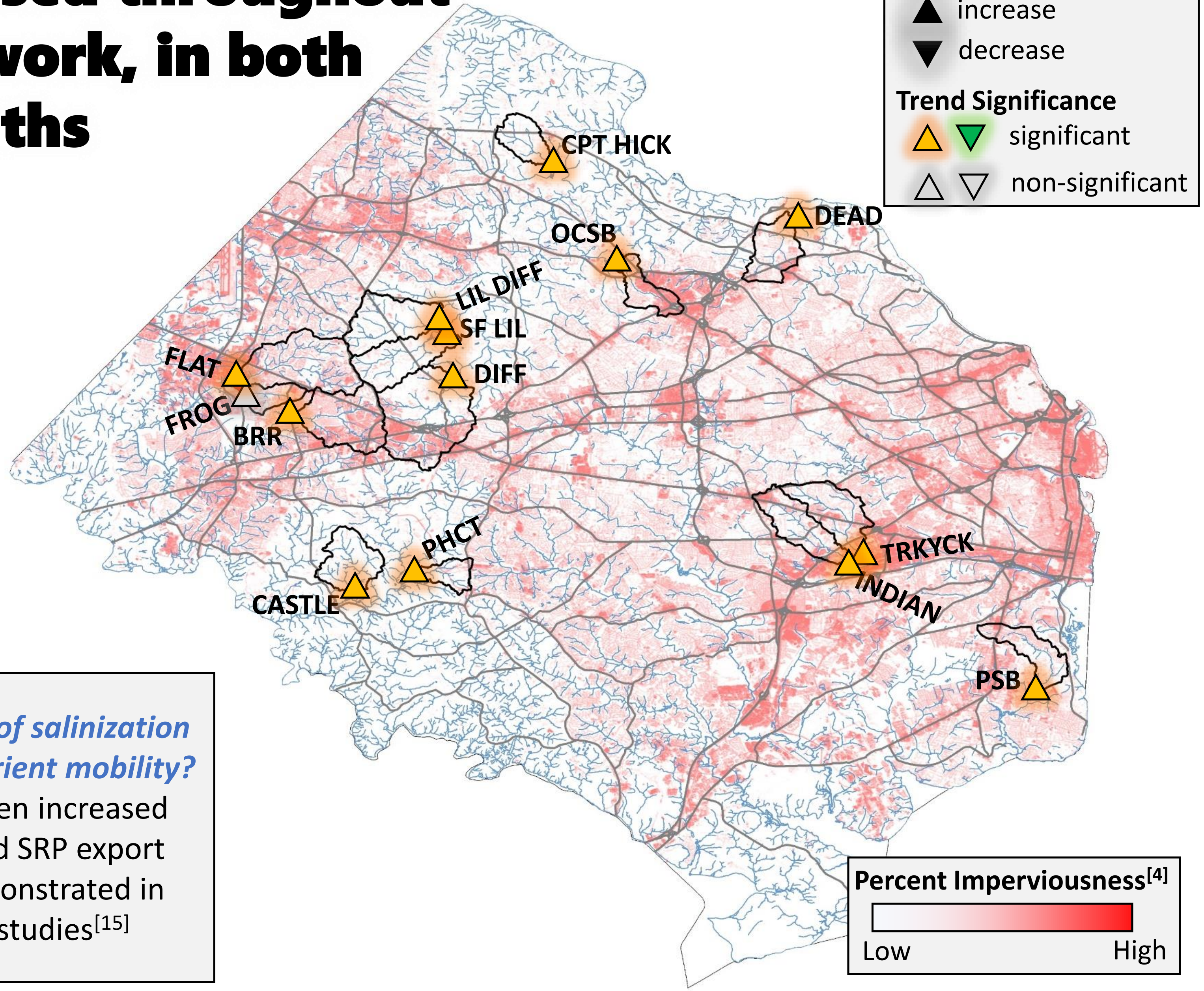
Specific conductance increased throughout the Fairfax monitoring network, in both winter and non-winter months



Specific conductance increases ranged from about **35 – 120 uS/cm** between 2008 – 2018

Specific conductance increased in winter, spring, and fall months in most sites. Such non-winter trends can occur when chloride, which is highly soluble, reaches the groundwater and is discharged to streams year-round[14]

What is the role of salinization on increased nutrient mobility?
Linkages between increased salinity, DN, and SRP export have been demonstrated in other urban studies[15]



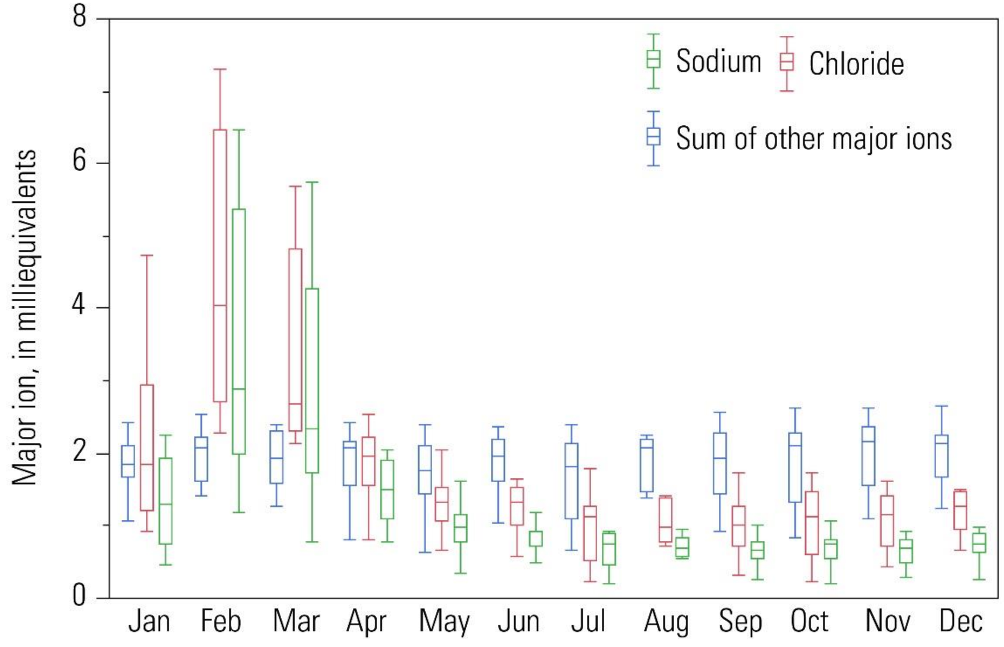
More research is needed to understand the drivers of specific conductance increases

Major ion chemistry has been collected with samples from the Difficult Run watershed in Fairfax County since 2011.

The influence of road salt runoff is evident in seasonally elevated concentrations of sodium and chloride.

Preliminary trend results indicate that the concentration of all major ions has increased since 2011, with the largest changes occurring in sodium and chloride.

In addition to road salting, increases in major ions may be driven by the dissolution of cement, wastewater runoff, or the liming of lawns [16,17]



What are the drivers of increasing conductance in urban streams?

What management strategies will best counteract such effects?

The addition of major ion chemistry to existing monitoring networks can help address these questions

[16]Kaushal and others, 2013

[17]Kaushal and others, 2017

Identifying the water-quality effects of management practices is a primary objective of numerous ongoing and planned USGS studies

Fairfax County has invested heavily in the **implementation of management practices** over the study period, and has been credited with the removal of 38,700 lb of N; 8,000 lb of P and 3,000,000 lb of S[18].

To date, over 9 miles of streams have been restored in Fairfax County and investments have exceeded 100 million dollars[18].

Have expected water-quality benefits occurred in response to management practice implementation?

How do management practice effects compare with influences from changing land use, population, and climate?

Resolving these and other questions requires a monitoring and analysis plan specifically tailored to stakeholder needs and local conditions.

Ongoing studies in Fairfax County, the City of Roanoke, Hampton Roads, and planned work with Prince William County have all been designed in such a fashion to maximize management relevant results.

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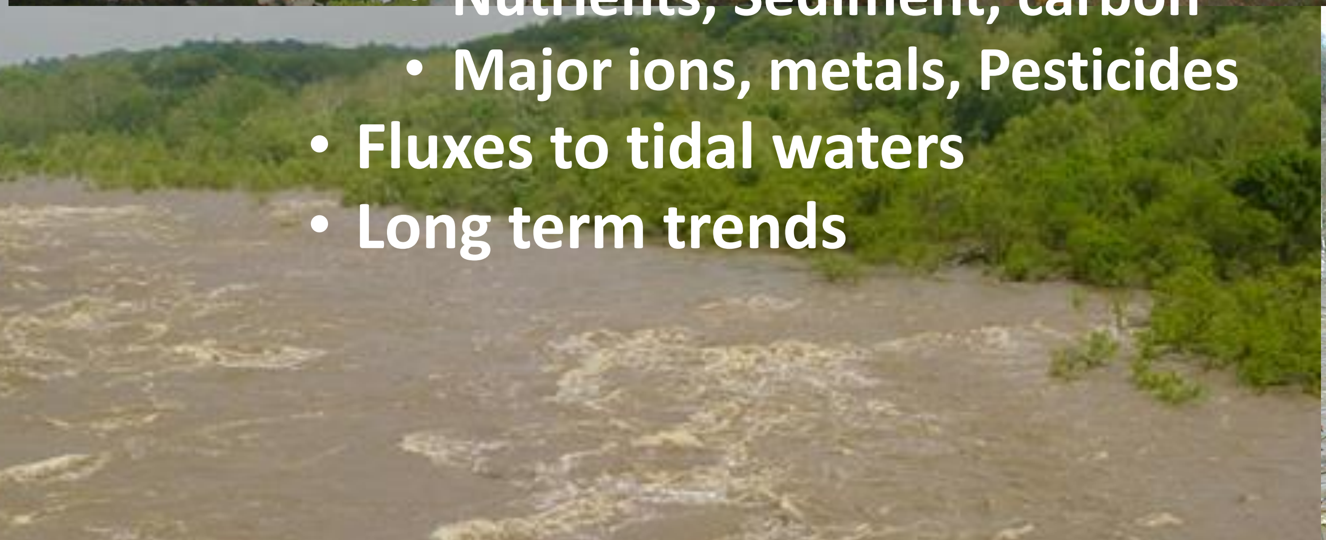
[18]Shannon Curtis, written commun.

Collection of Water Quality data

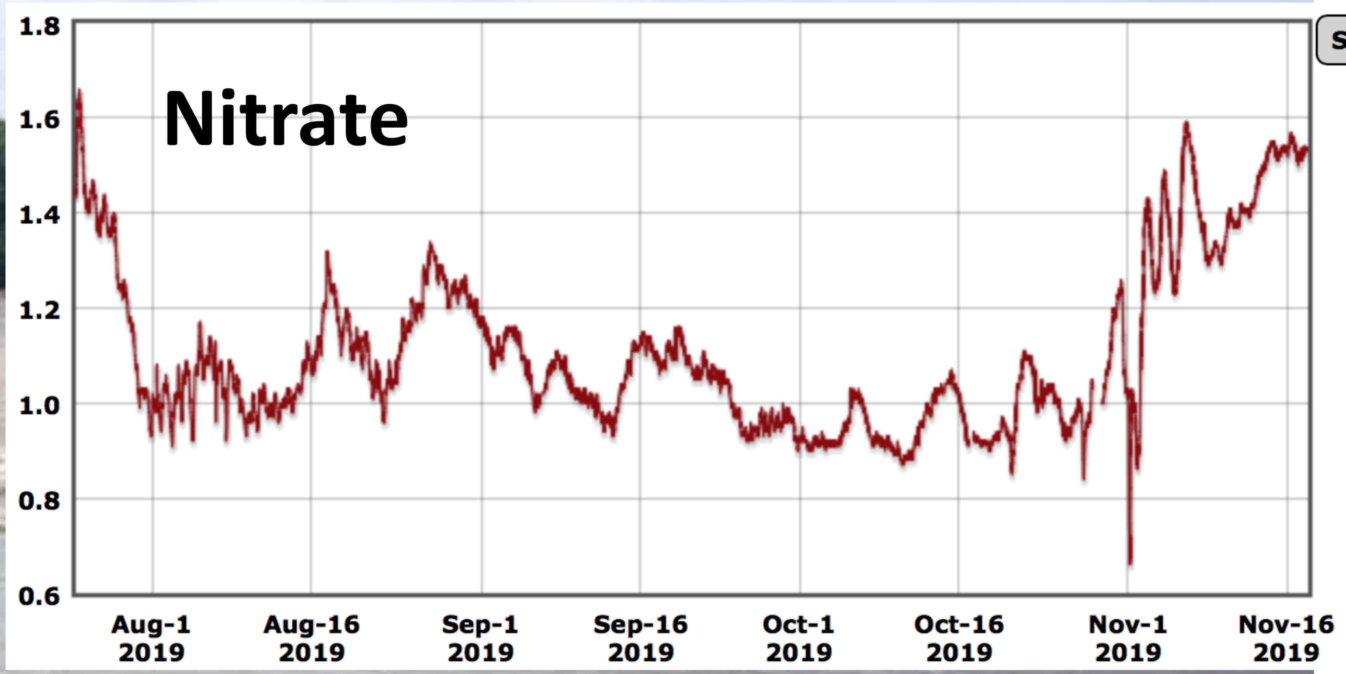
POTOMAC RIVER AT CHAIN BRIDGE

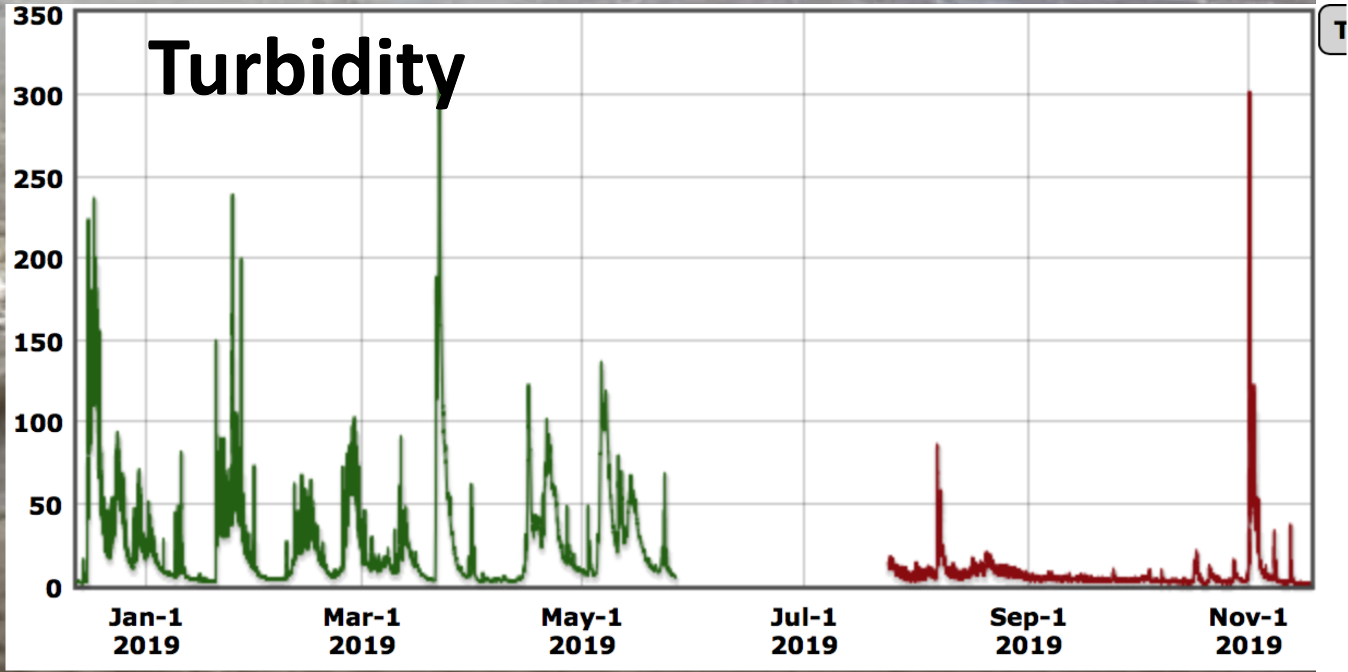

- River Input Monitoring Program, USGS-MD-DNR
- National Water Quality Network
  - Discrete Monitoring:
    - Nutrients, Sediment, carbon
    - Major ions, metals, Pesticides
  - Fluxes to tidal waters
  - Long term trends

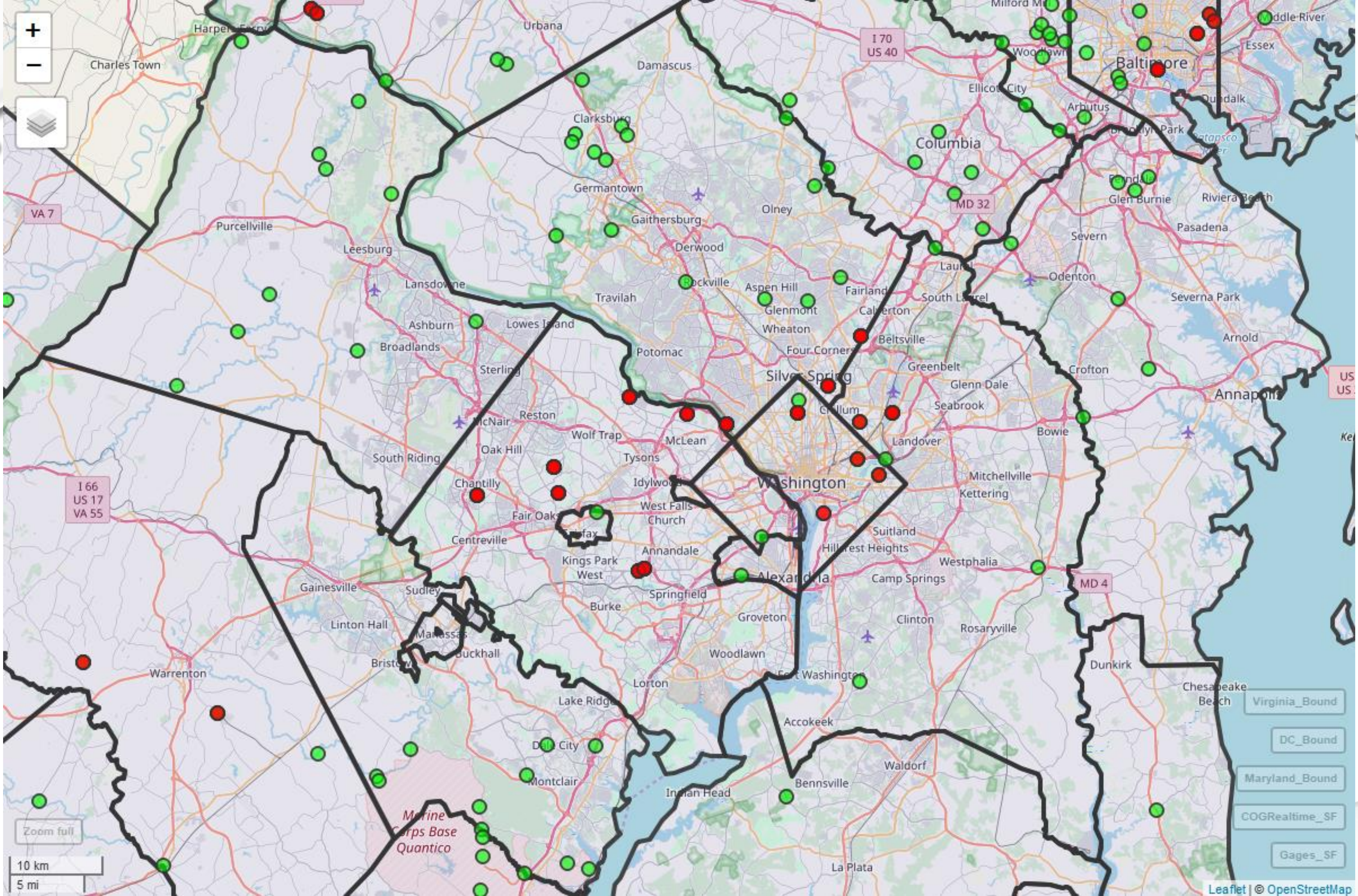



Potomac River Continuous Monitoring

- High Resolution water quality
- Improved Load Estimation
- Characterize Exceedance Frequency







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Glen Burnie
Riviera Beach
VA 7
Purcellville
Gaithersburg
Olney
MD 32
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Severn
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Laurel
Odenton
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Rockville
Aspen Hill
Fairland
South Laurel
Travilah
Glenmont
Calverton
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Lake Ridge
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Virginia_Bound
DC_Bound
Dale City
Waldorf
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Montclair
Indian Head
Bennsville
COGRealtime_SF
Marine Corps Base Quantico
Zoom full
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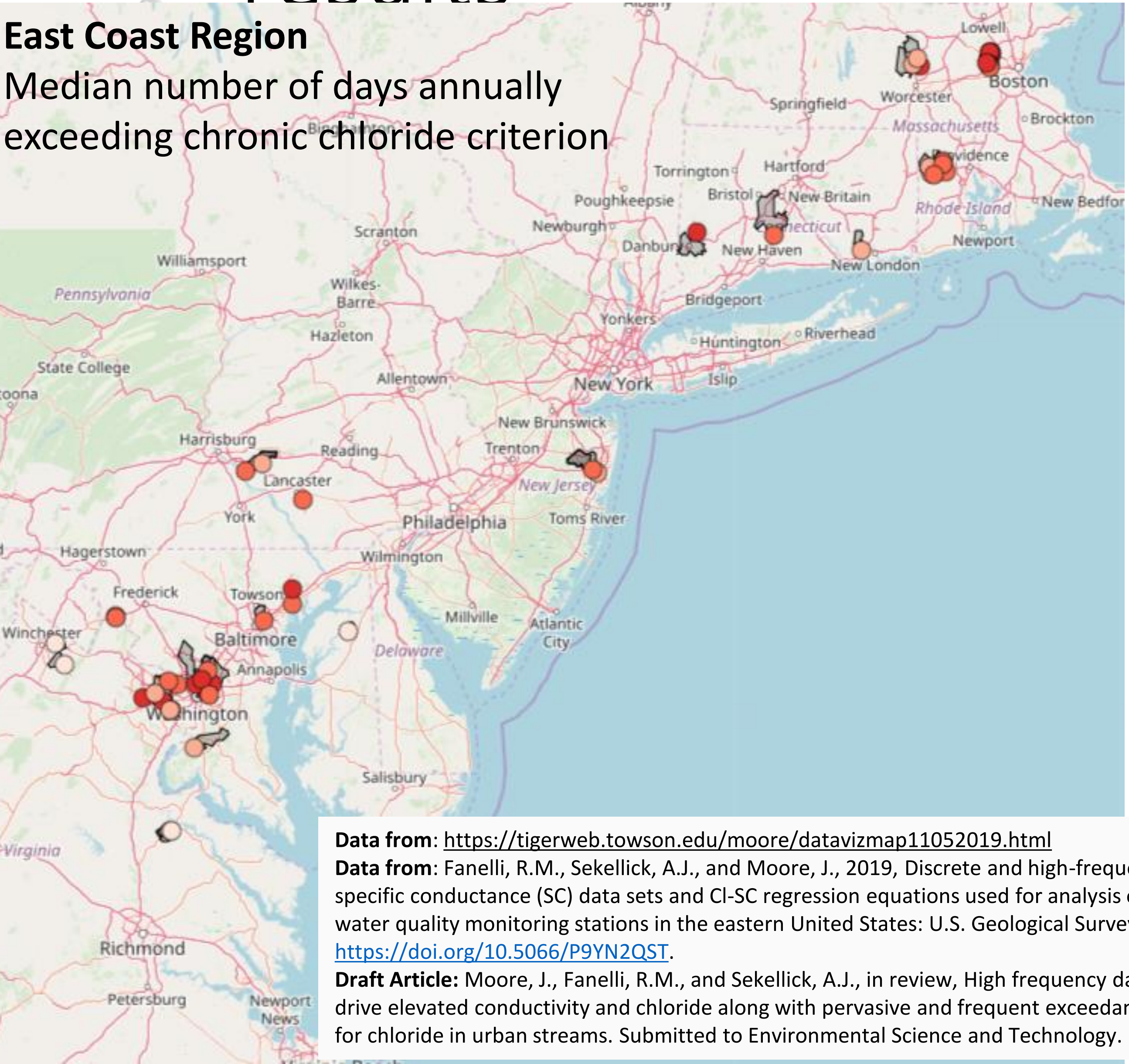
10 km
5 mi
La Plata
Leaflet | © OpenStreetMap

High-Frequency Conductivity Monitoring results

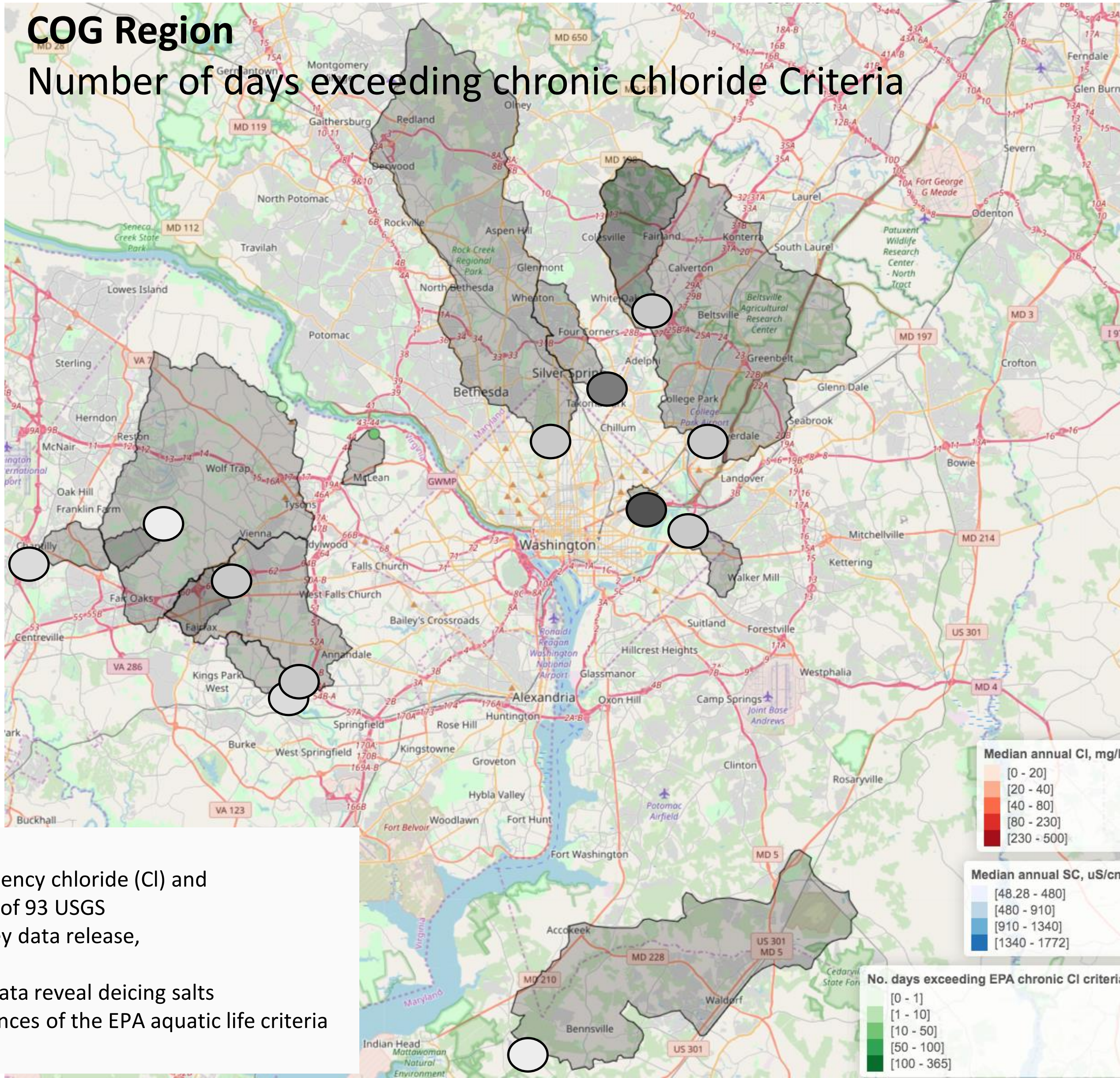
East Coast Region

Median number of days annually exceeding chronic chloride criterion



COG Region

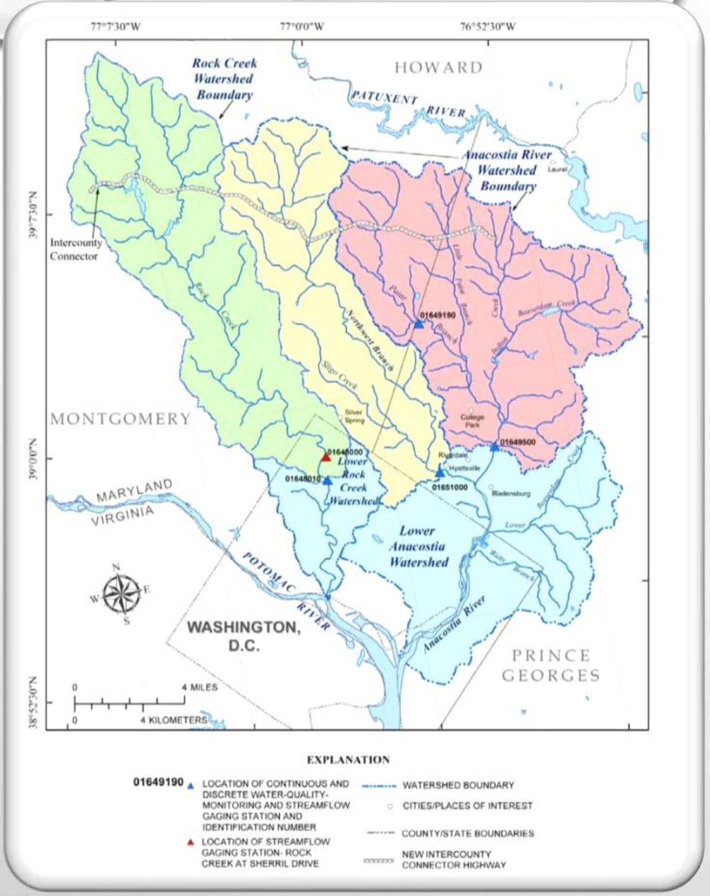
Number of days exceeding chronic chloride Criteria

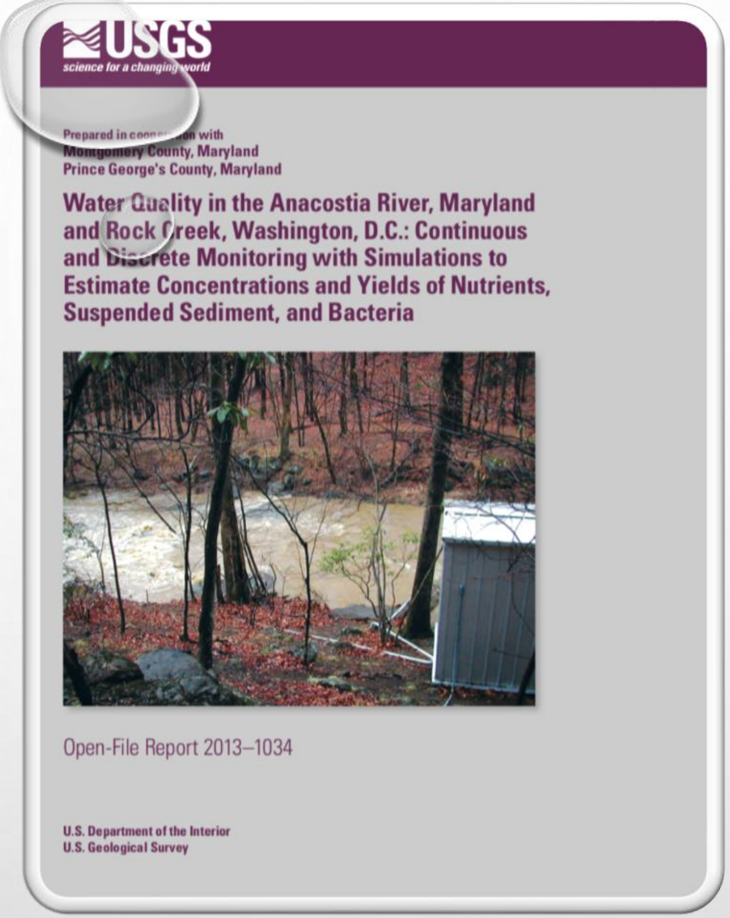


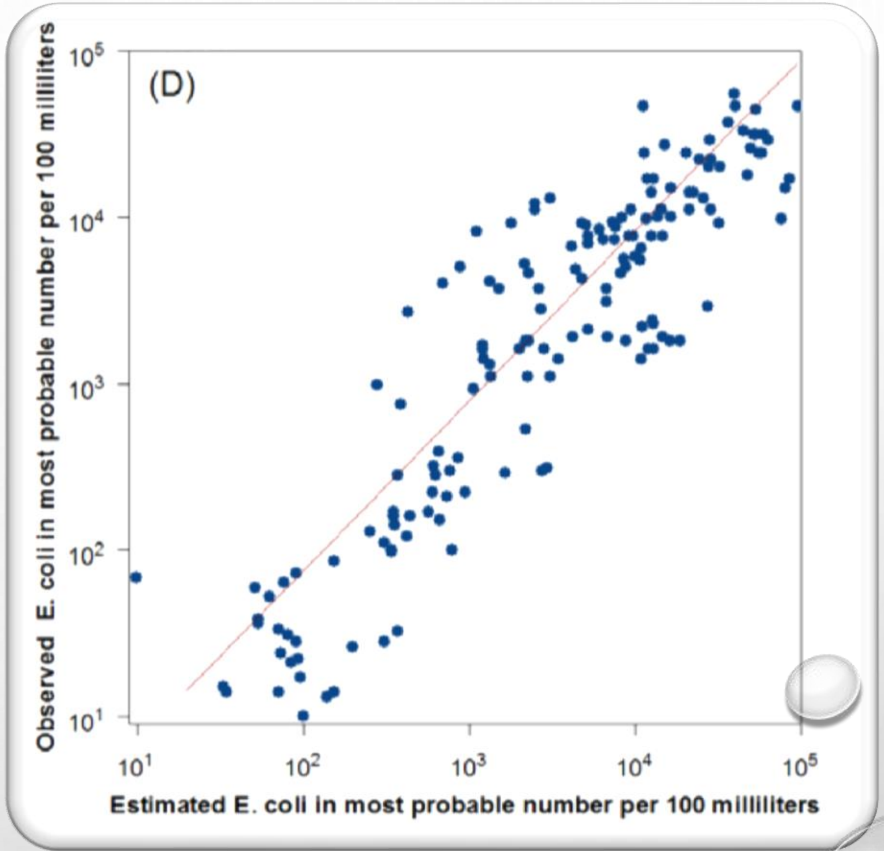
Data from: https://tigerweb.towson.edu/moore/datavizmap11052019.html

Data from: Fanelli, R.M., Sekellick, A.J., and Moore, J., 2019, Discrete and high-frequency chloride (Cl) and specific conductance (SC) data sets and Cl-SC regression equations used for analysis of 93 USGS water quality monitoring stations in the eastern United States: U.S. Geological Survey data release, https://doi.org/10.5066/P9YN2QST.

Draft Article: Moore, J., Fanelli, R.M., and Sekellick, A.J., in review, High frequency data reveal deicing salts drive elevated conductivity and chloride along with pervasive and frequent exceedances of the EPA aquatic life criteria for chloride in urban streams. Submitted to Environmental Science and Technology.







Estimation of Nutrient, Suspended Sediment and BACTERIA concentrations

Sediment and Chemical Contaminant Loadings in Tributaries to the Anacostia River, Washington DC

In 2016 USGS started a project to monitor suspended-sediment-bound chemical compounds in five gaged and four ungaged tributaries of the Anacostia River.

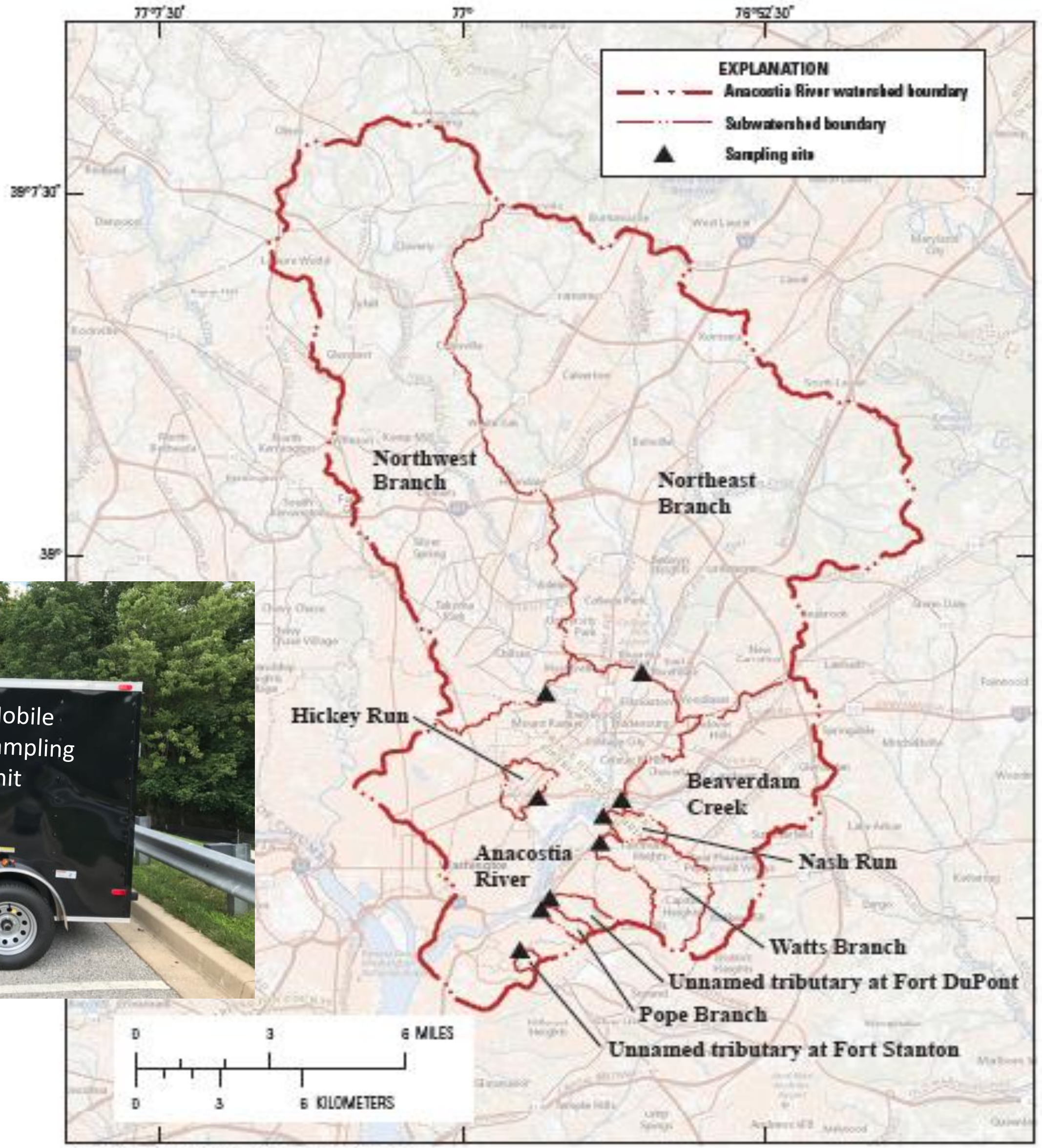
Discharge+Suspended Sediment Conc.+Contaminant Conc. on SS.

=

Loadings of Contaminants Bound to Sediment

Network Consisted of:

- Northeast Branch
- Northwest Branch
- Hickey Run
- Watts Branch
- Beaverdam Creek



Base from U.S. Geological Survey, The National Map, 2017

Periodic monitoring is expected to continue

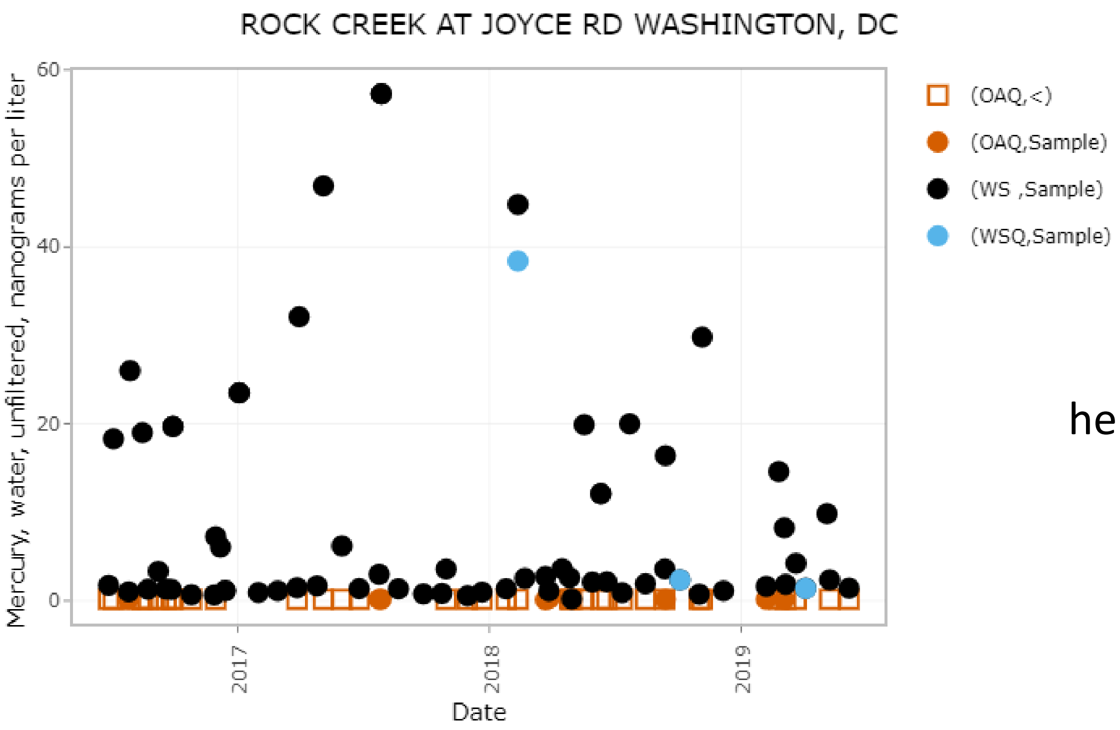
Mercury, Trace Metals and Bacteria monitoring in District of Columbia Streams

In 2013 USGS started a project to enhance Non-Tidal Network monitoring
by adding analytes such as bacteria (e-coli and total coliform),
trace metals including cadmium, copper, lead, and zinc (2014) and mercury (2016).

Monitoring takes place at:

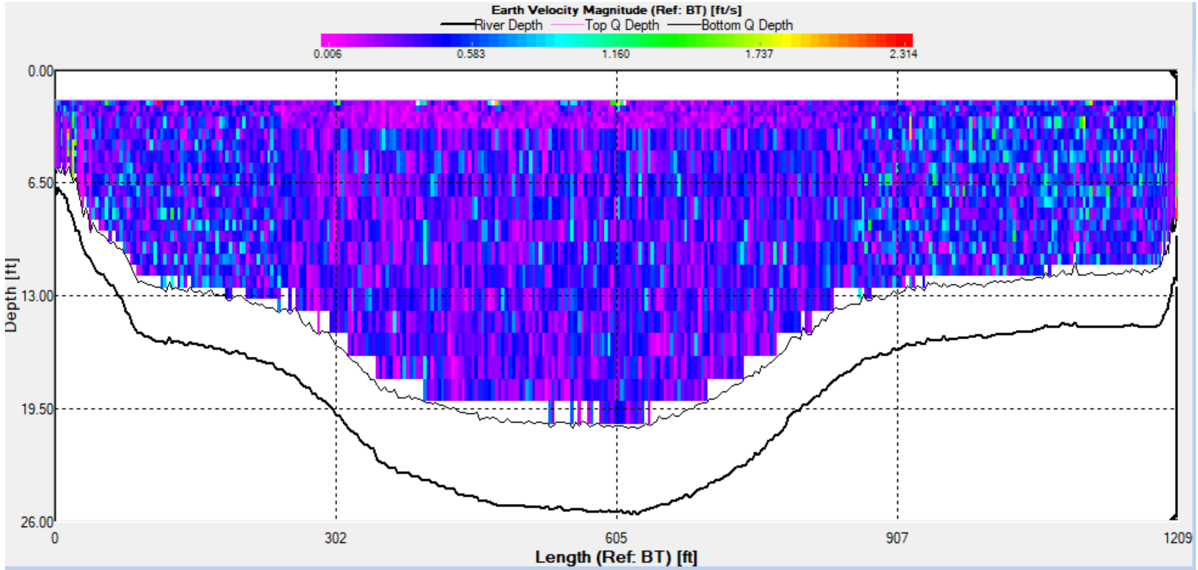
Rock Creek
Hickey Run
Watts Branch

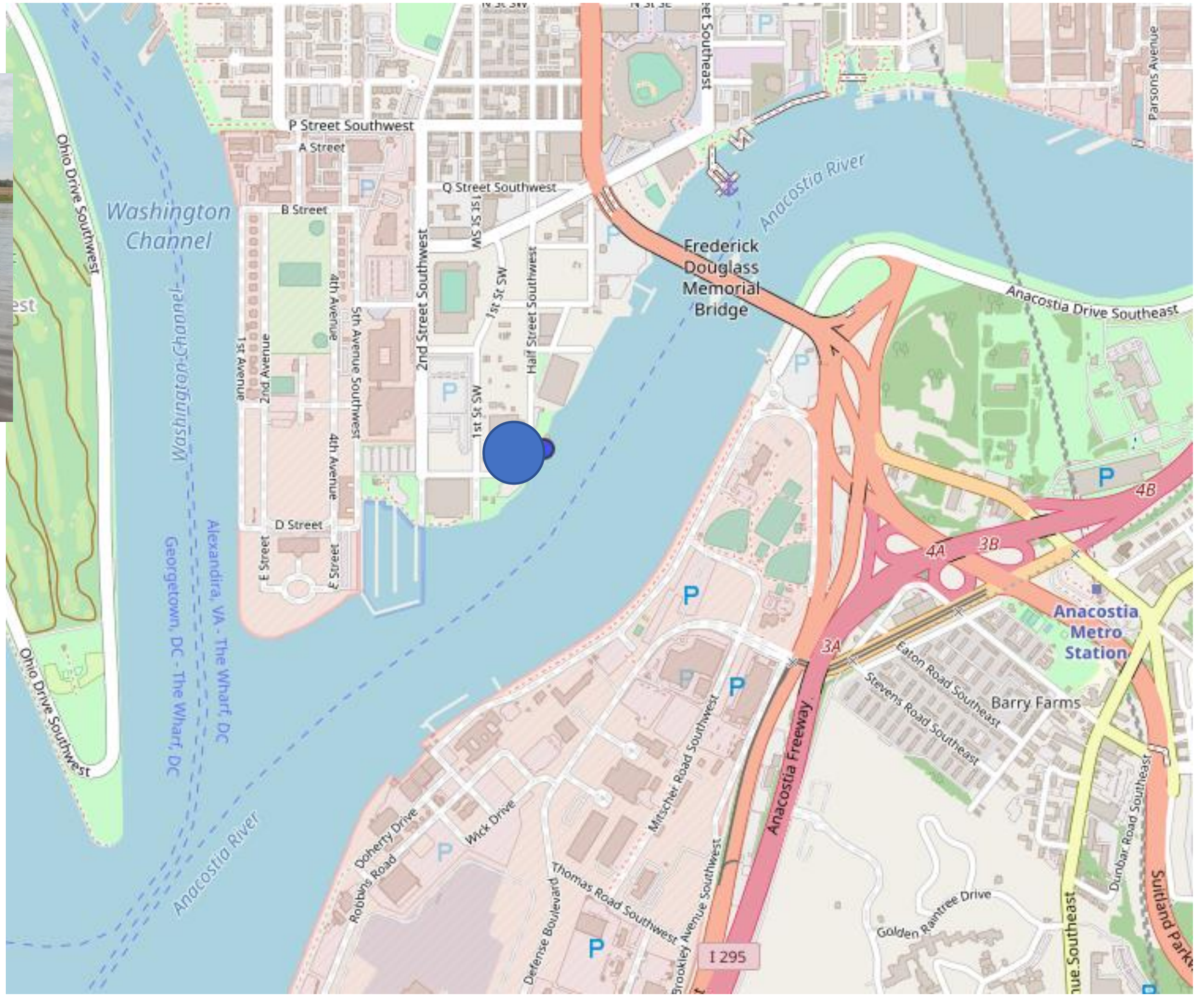
Both storms and fixed frequency samples are collected on a Monthly basis. Monitoring is expected to continue.



Tyvek suits are used to help reduce sample contamination

Establishment of first USGS Discharge Gaging Station in Tidal Anacostia: USGS 01651827 Anacostia River Near Buzzard Point @ Washington DC





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Summary of Selected USGs Monitoring programs in the COG region

		Continuous Water Quality						Discrete Water Quality						
SITE ID	SITE NAME	Water temp	Sc	Ph	D.O.	Turbidity	Nitrate	Nutrients	Sediment	Trace metals	Mercury	Bacteria	Chloride major ions	Pesticides
01646500 01646580	Potomac Little Falls Ch Br	X	X	X	X	X	X	X	X	X			X	X
01648010	Rock Creek at Joyce Rd	X	X	X	X	X		X	X	X	X	X	X	
01649500	NE Br Anacostia	X	X	X	X	X		X	X			X	X	
01651000	NW Br Anacostia	X	X			X								
01649190	Paint Branch	X	X	X	X	X		X	X			X	X	
01650100	Sligo Creek	X	X	X	X	X								
01651800	Watts Branch	X	X			X		X	X	X	X	X	X	
01651770	Hickey Run	X	X			X		X	X	X	X	X	X	
01658000	Mattawoman Cr							X	X				X	
01654000	Accotink	X	X	X	X	X	X	X	X	X			X	X

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