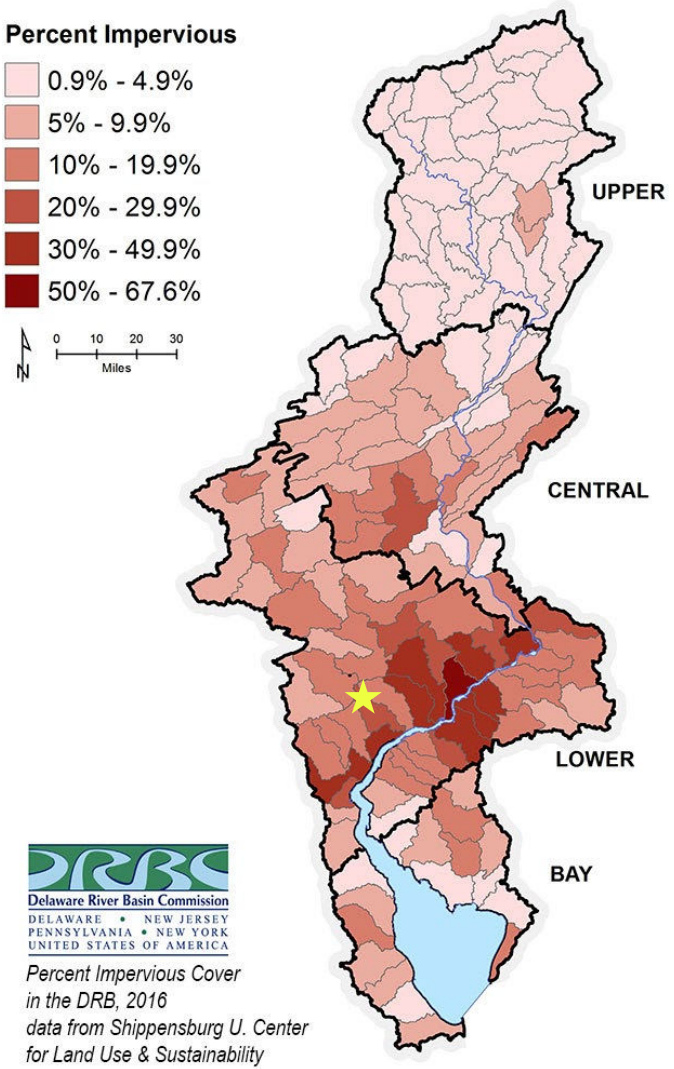
The Urban Stream Syndrome in southeastern PA

EnviroDIY in DRB
August monthly meeting

Megan Fork, PhD
West Chester University



Percent Impervious Cover in the DRB, 2016
data from Shippensburg U. Center for Land Use & Sustainability

Acknowledgements

WCU student researchers:

Tanner Burns
Miranda Davies
Alex Desjardins
Mackenzie Fulton
Ben Langey
Lucas Thomas
Danielle Scudero
Cole Sjostedt

Collaborators/coauthors:

Emma J. Rosi
Jerker Fick
Peter Groffman
A.J. Reisinger

Other awesome help from:

Heather Malcolm
Ben Glass-Siegal
Mark Green
Rebecca Simpkin

The “Urban Stream Syndrome”

describes a set of “symptoms” common across many streams in urbanized landscapes

a term coined in 2005 (Walsh and others)

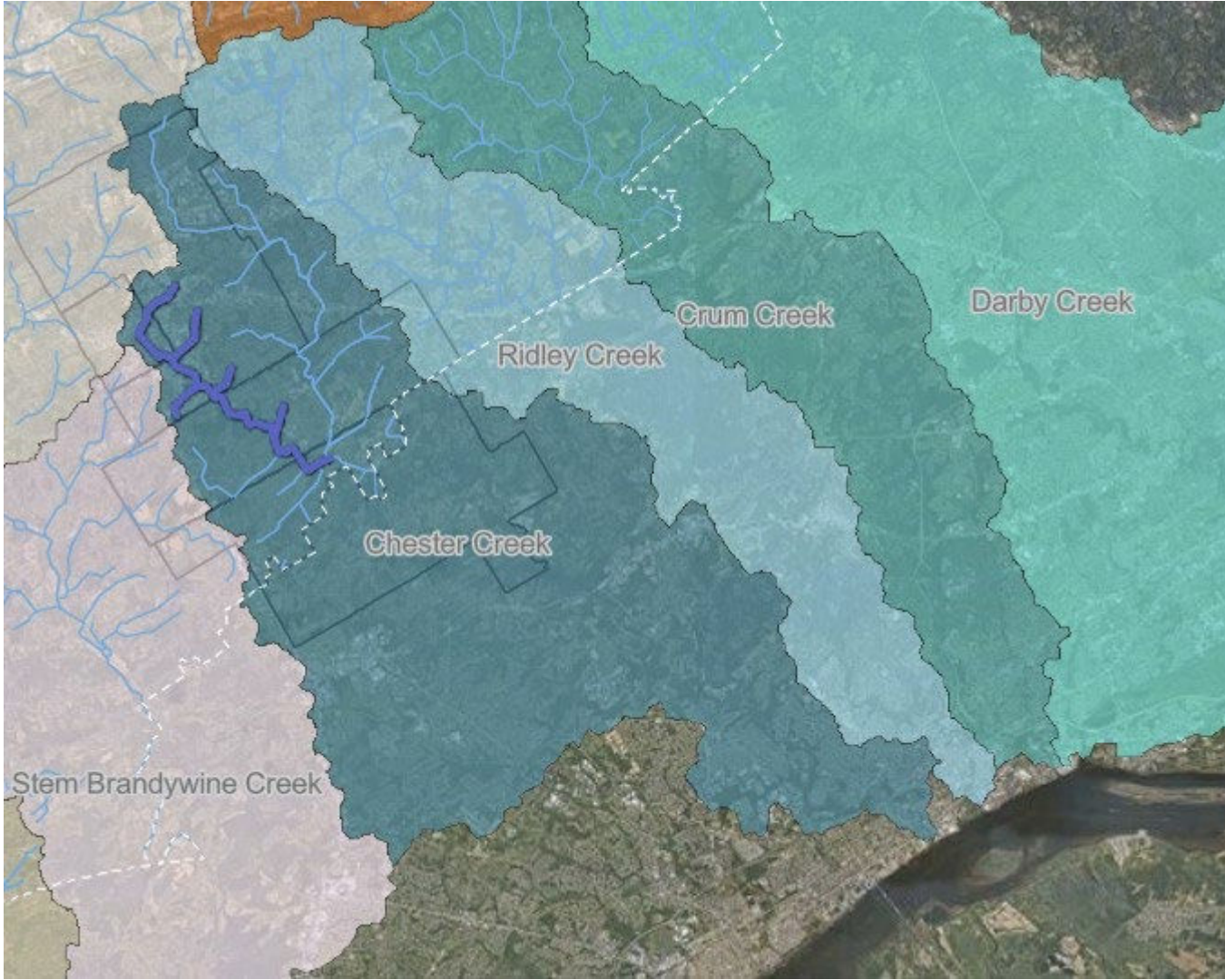
Feature	Consistent response
Hydrology	↑ Frequency of overland flow
	↑ Frequency of erosive flow
	↑ Magnitude of high flow
	↓ Lag time to peak flow
	↑ Rise and fall of storm hydrograph
Water chemistry	↑ Nutrients (N, P)
	↑ Toxicants
	↑ Temperature
Channel morphology	↑ Channel width
	↑ Pool depth
	↑ Scour
	↓ Channel complexity
Organic matter	↓ Retention
Fishes	↓ Sensitive fishes
Invertebrates	↑ Tolerant invertebrates
	↓ Sensitive invertebrates
Algae	↑ Eutrophic diatoms
	↓ Oligotrophic diatoms
Ecosystem processes	↓ Nutrient uptake

"Symptoms" we can look at using EnviroDIY data

Other "symptoms" I'll mention today

Walsh and others 2005, JNABS

Goose Creek as an example of the Urban Stream Syndrome



- Large and rapid changes in flow during storms (“flashy” hydrology)

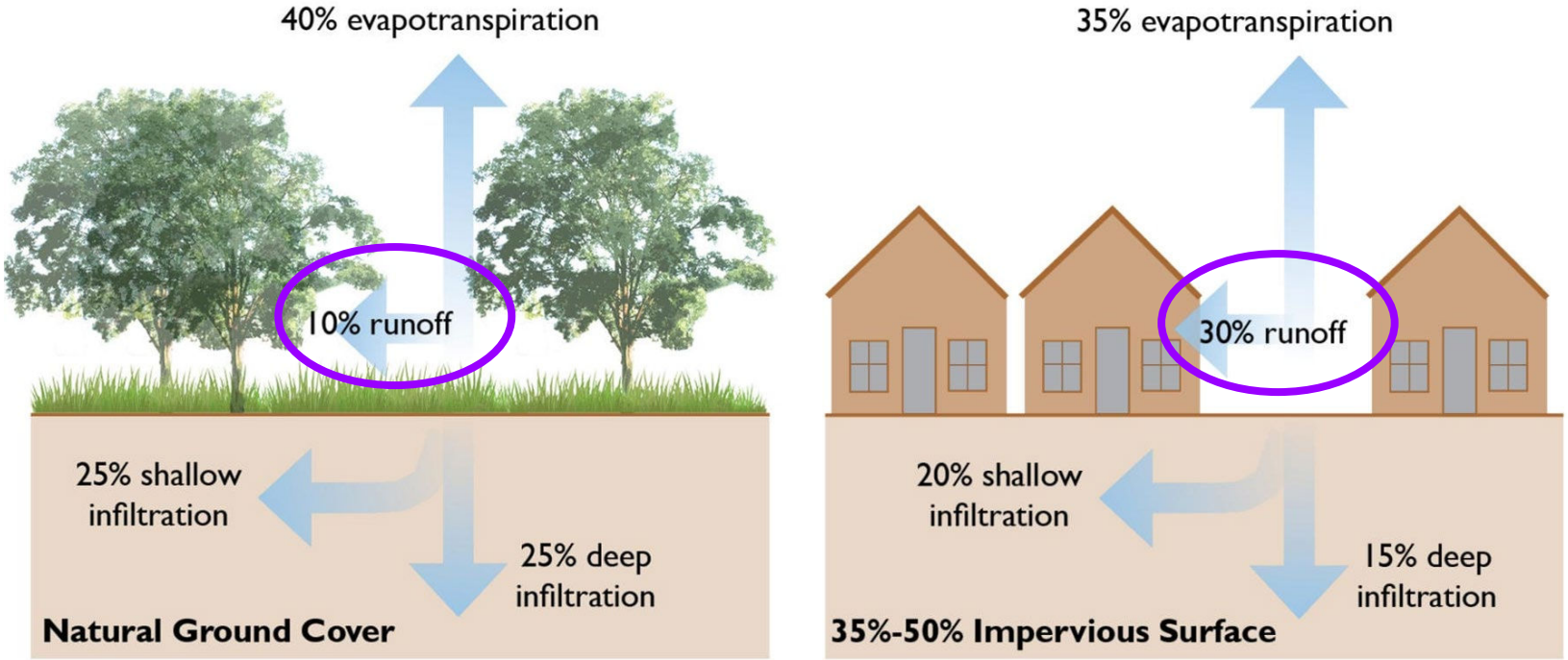
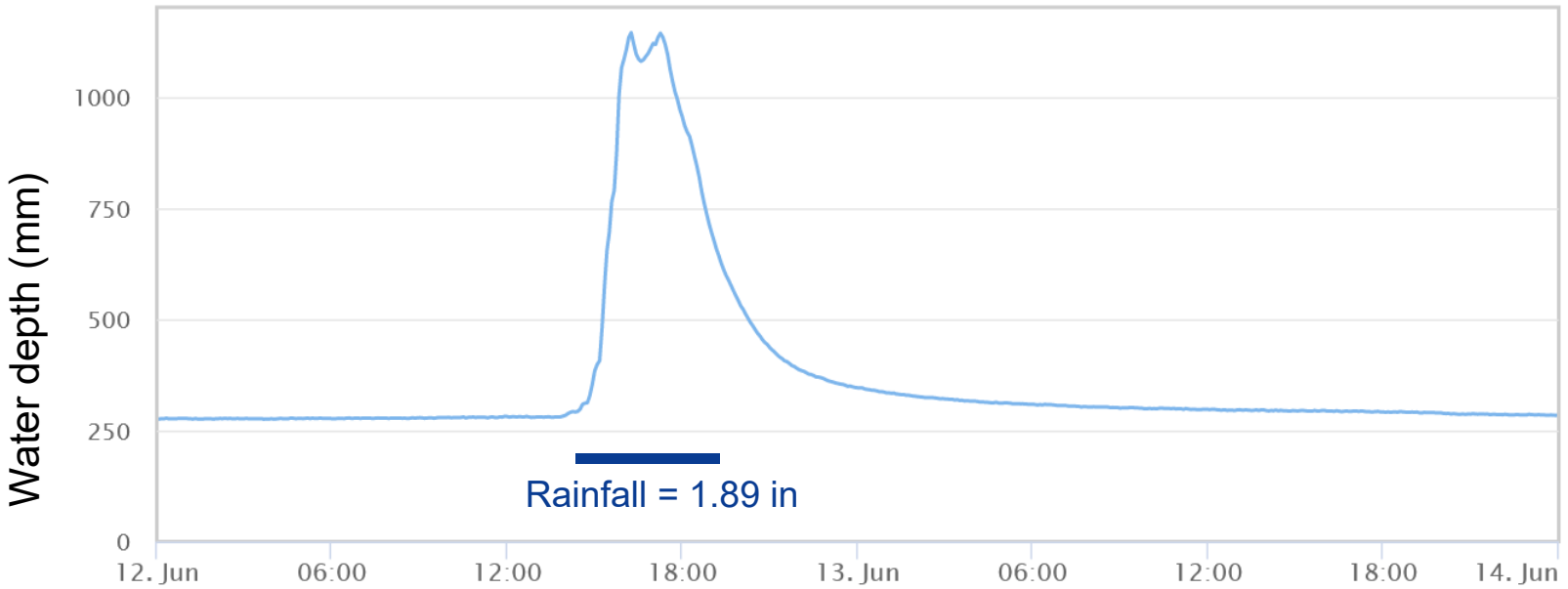


Image credit: USGS

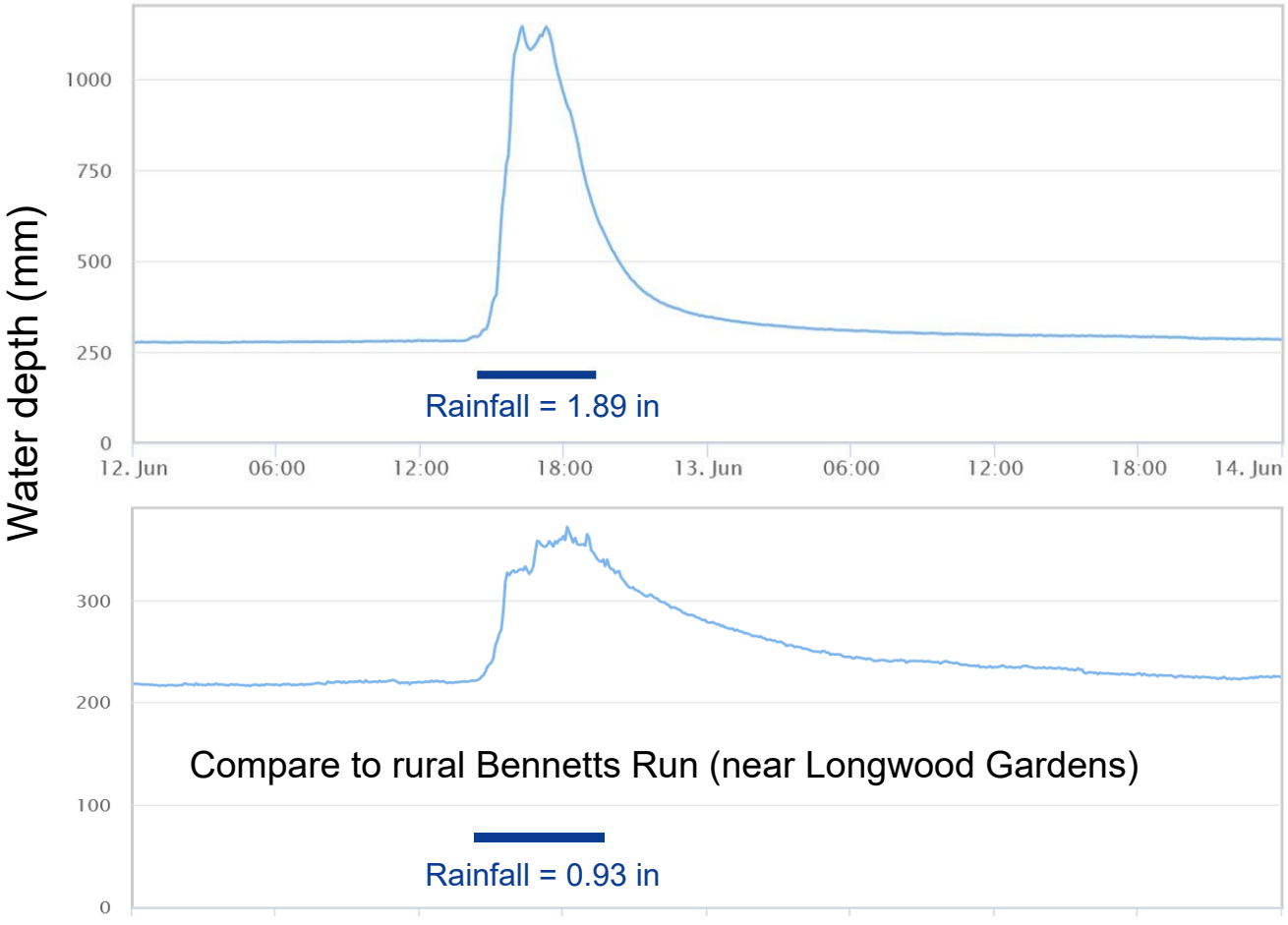
“Flashy” hydrology in Goose Creek



4 feet deep
(1219 mm)

1 foot deep
(305 mm)

“Flashy” hydrology in Goose Creek



“Flashy” hydrology in Goose Creek

- Large and rapid changes in flow during storms (“flashy” hydrology)
- Erosion of stream bed and banks

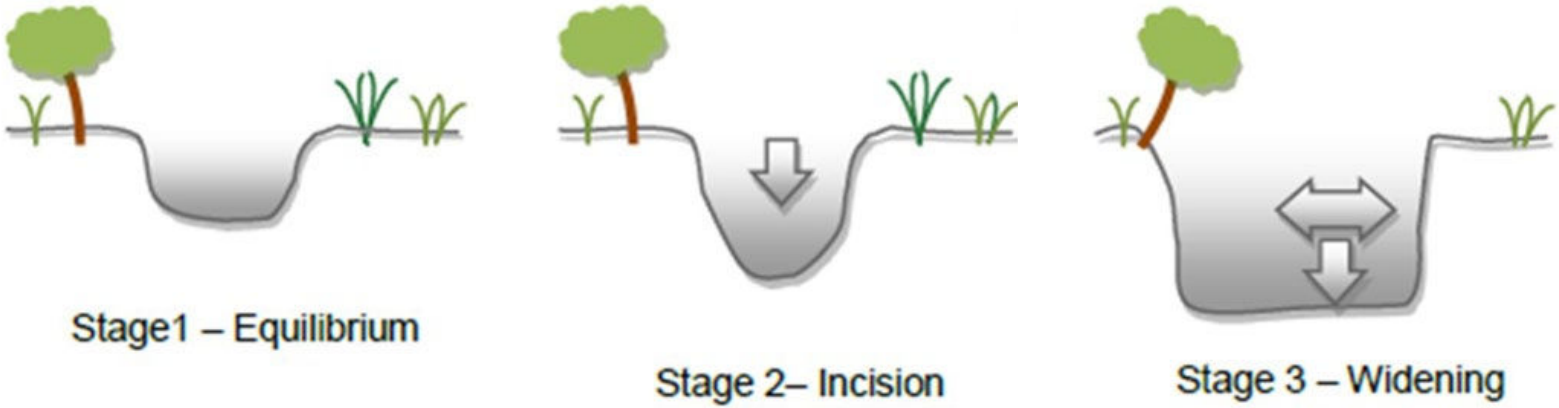


Image credit: Hawley et al. 2022

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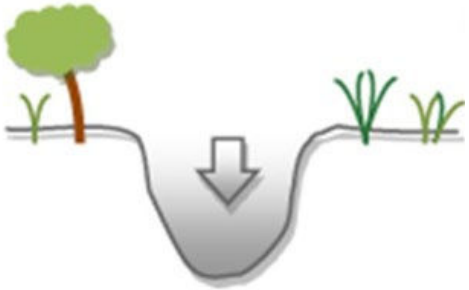
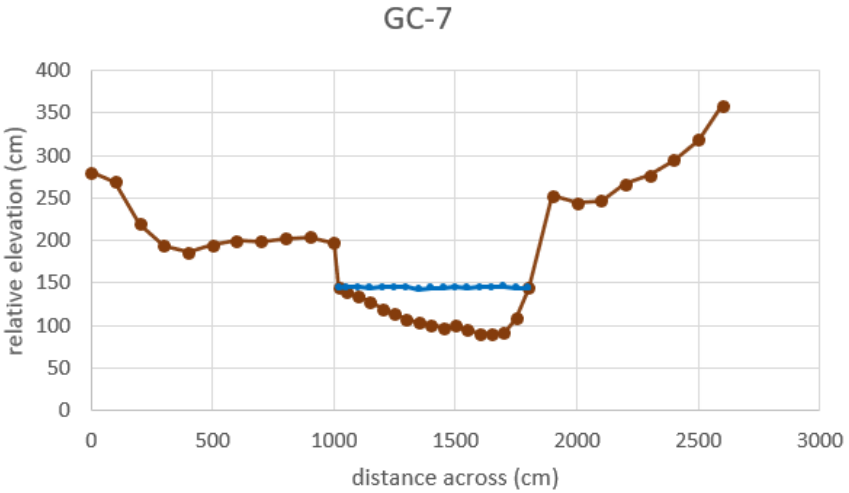


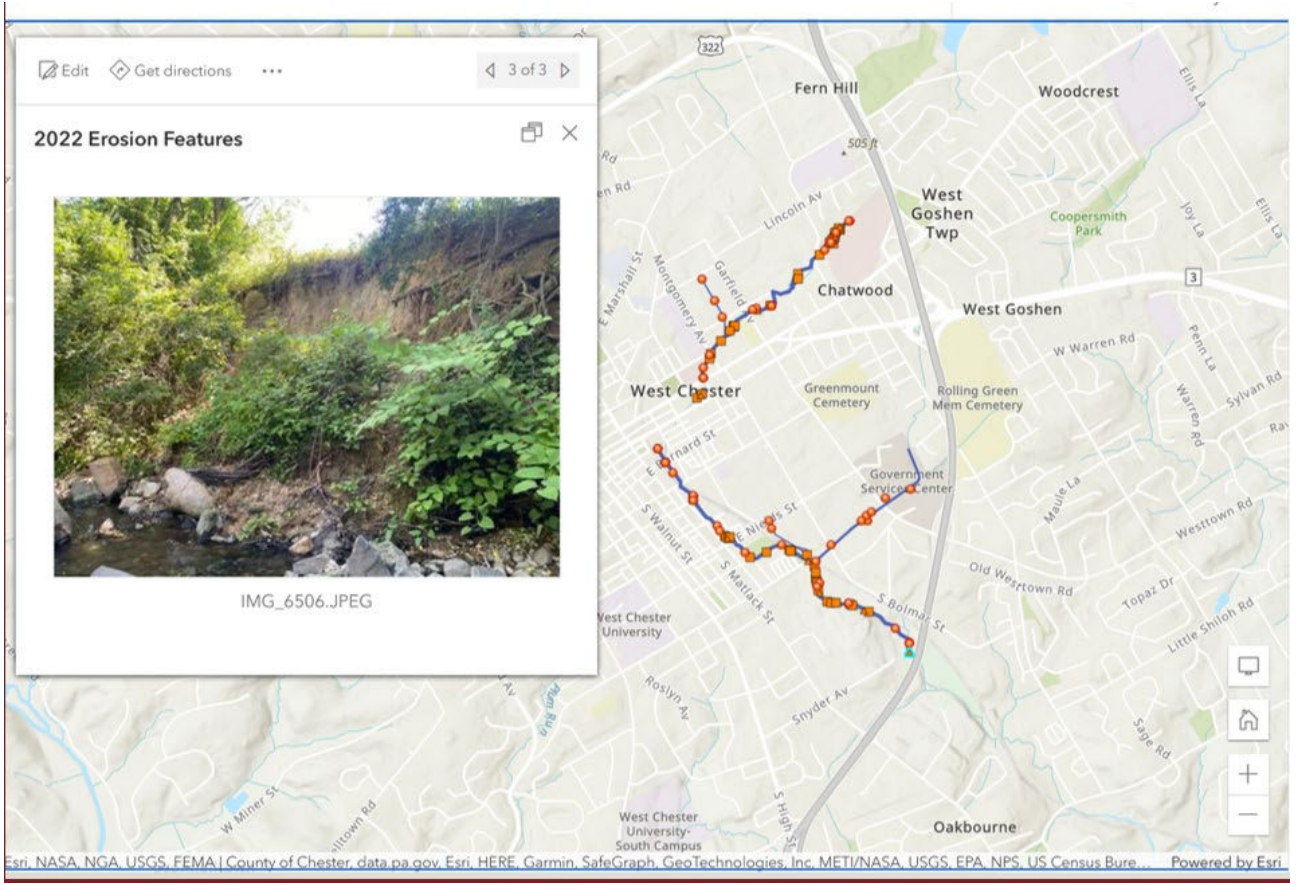


Erosion in Goose Creek

Threatens infrastructure and property, harms water quality, and reduces habitat

Erosion in Goose Creek

Several major erosion zones were mapped by graduate student Ben Langey in summer 2022.



- Large and rapid changes in flow during storms (“flashy” hydrology)
- Erosion of stream bed and banks
- Higher & “flashier” water temperatures

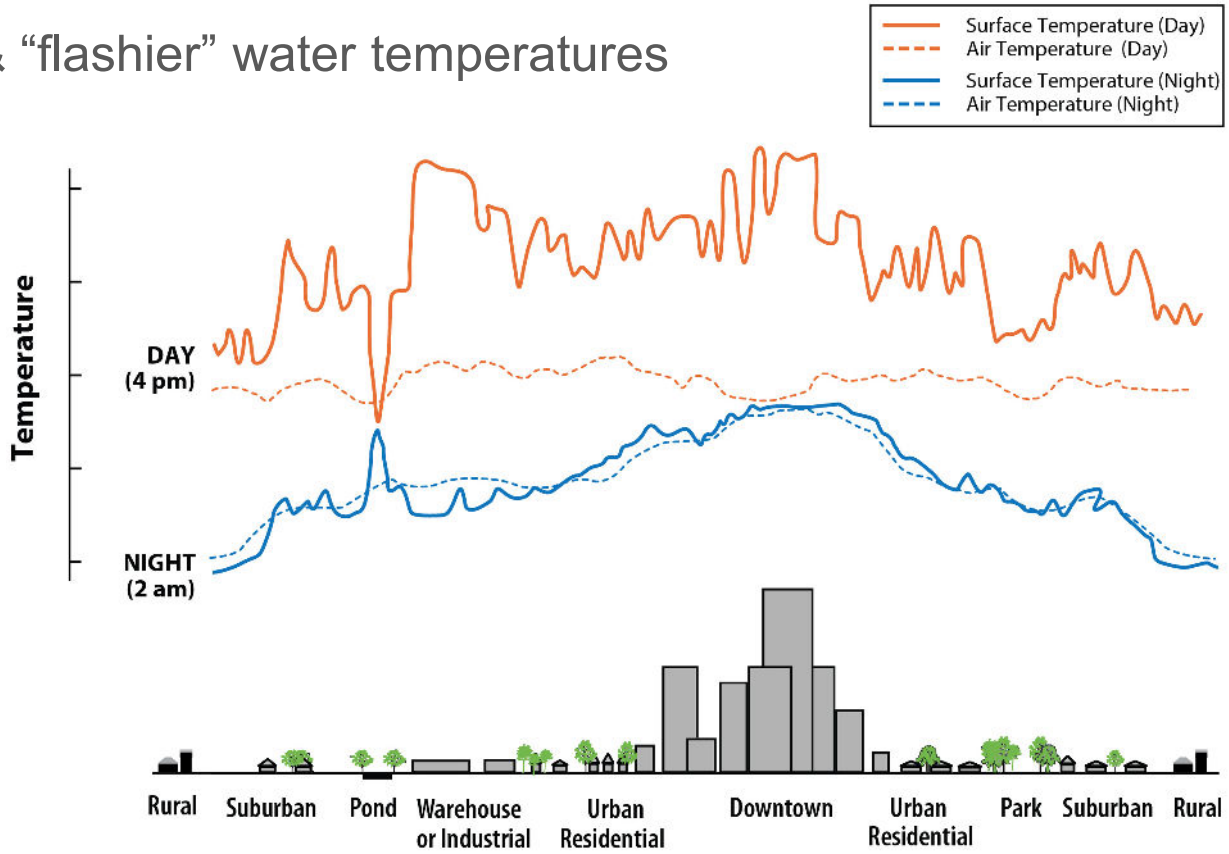
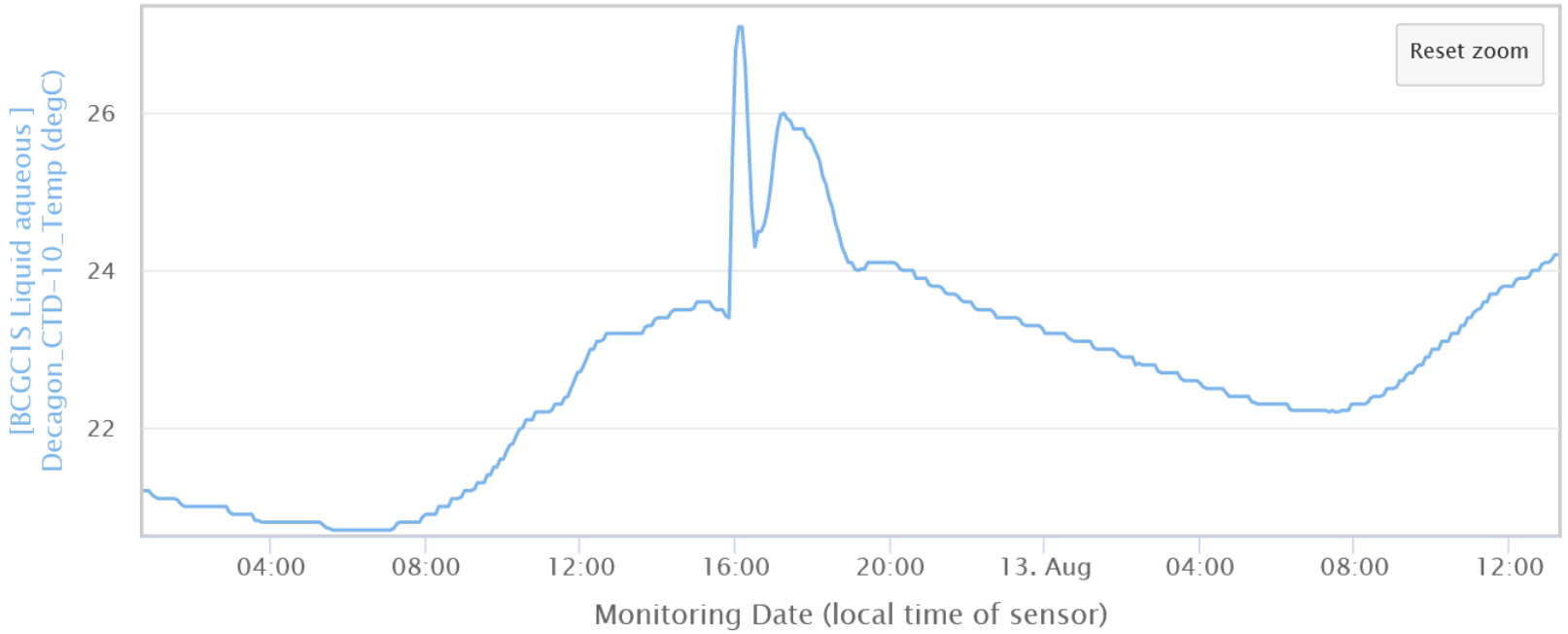


Image credit: USGS

“Flashy” stream temp in Goose Creek



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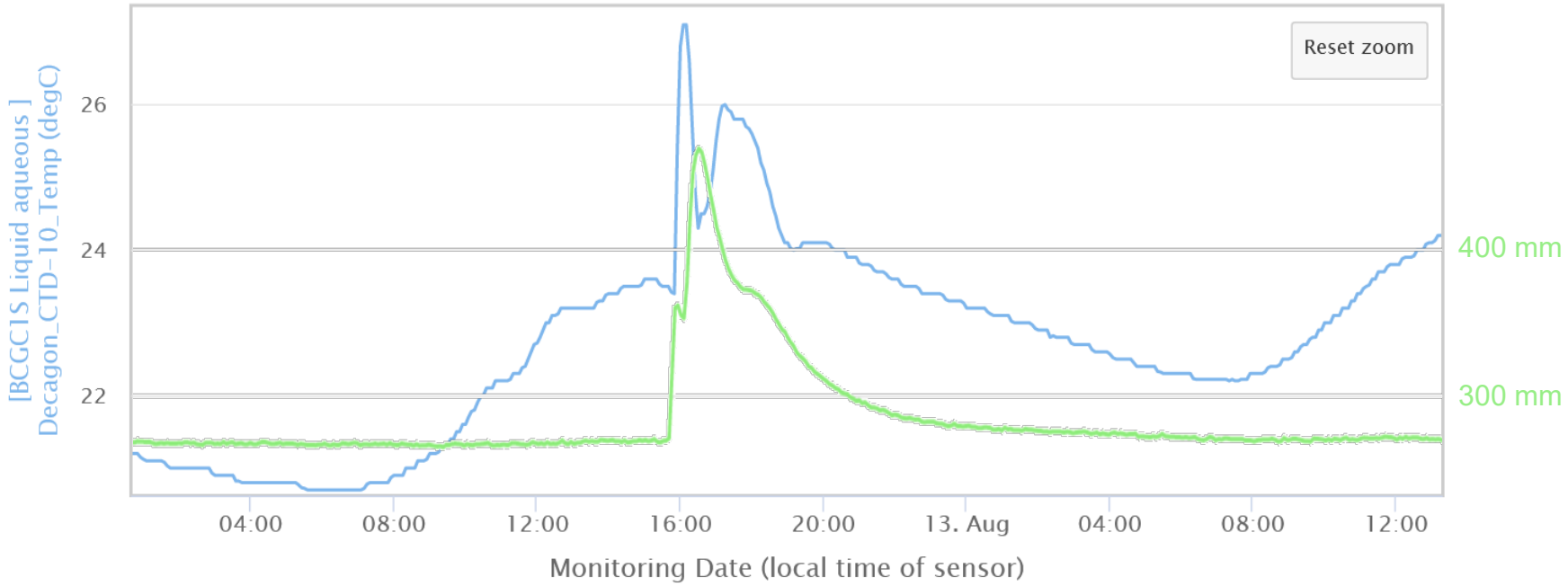
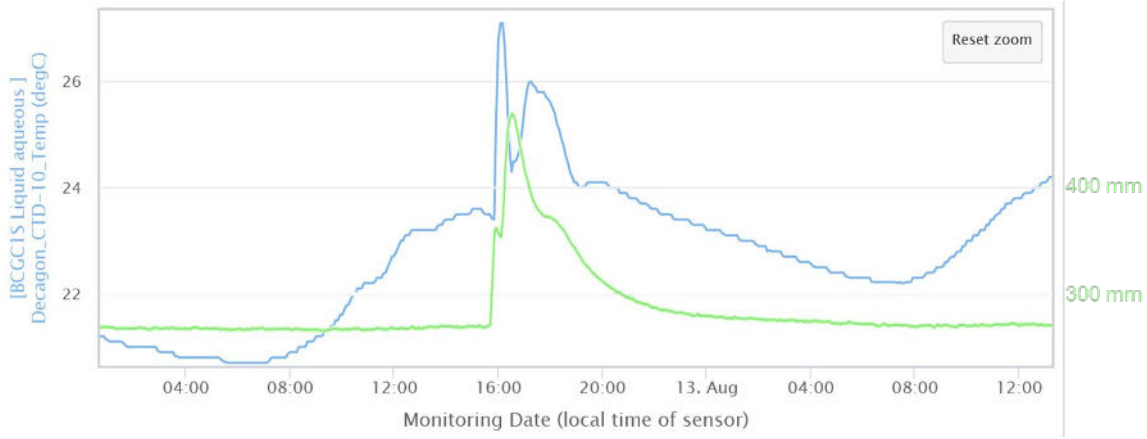
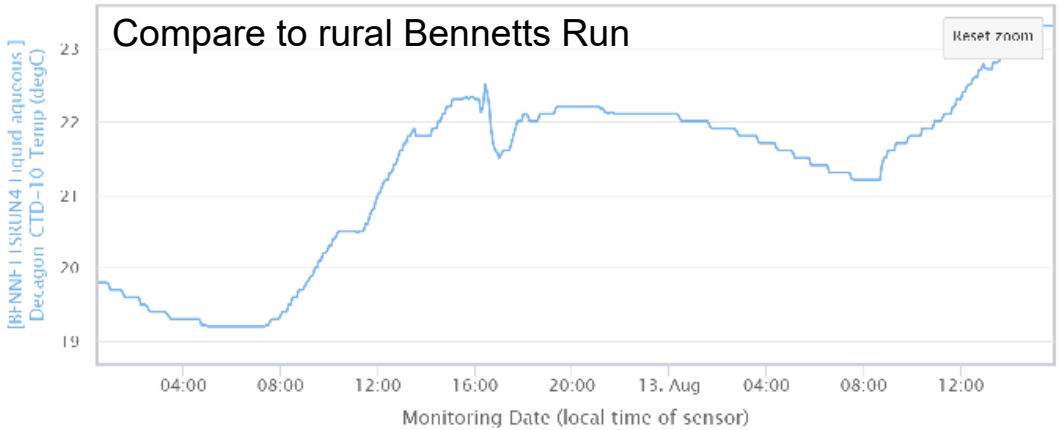


Flashy temp visualization



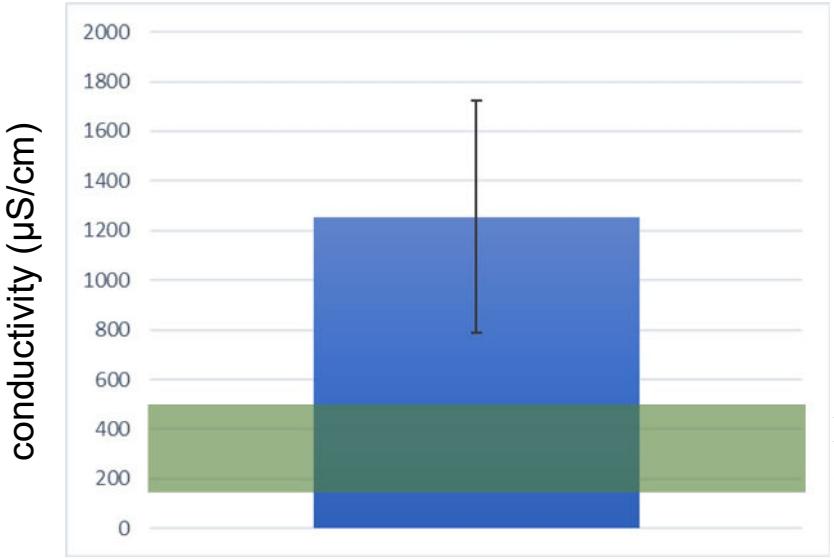


- Large and rapid changes in flow during storms (“flashy” hydrology)
- Erosion of stream bed and banks
- Higher & “flashier” water temperatures
- Pollution by nutrients and contaminants

Image credit: USGS

Goose Creek is too salty

Oversalting of roads means salt accumulates in groundwater and spikes during winter rainstorms



Summer 2022 average in Goose Creek

EPA recommended range for healthy streams (150-500 µS/cm)

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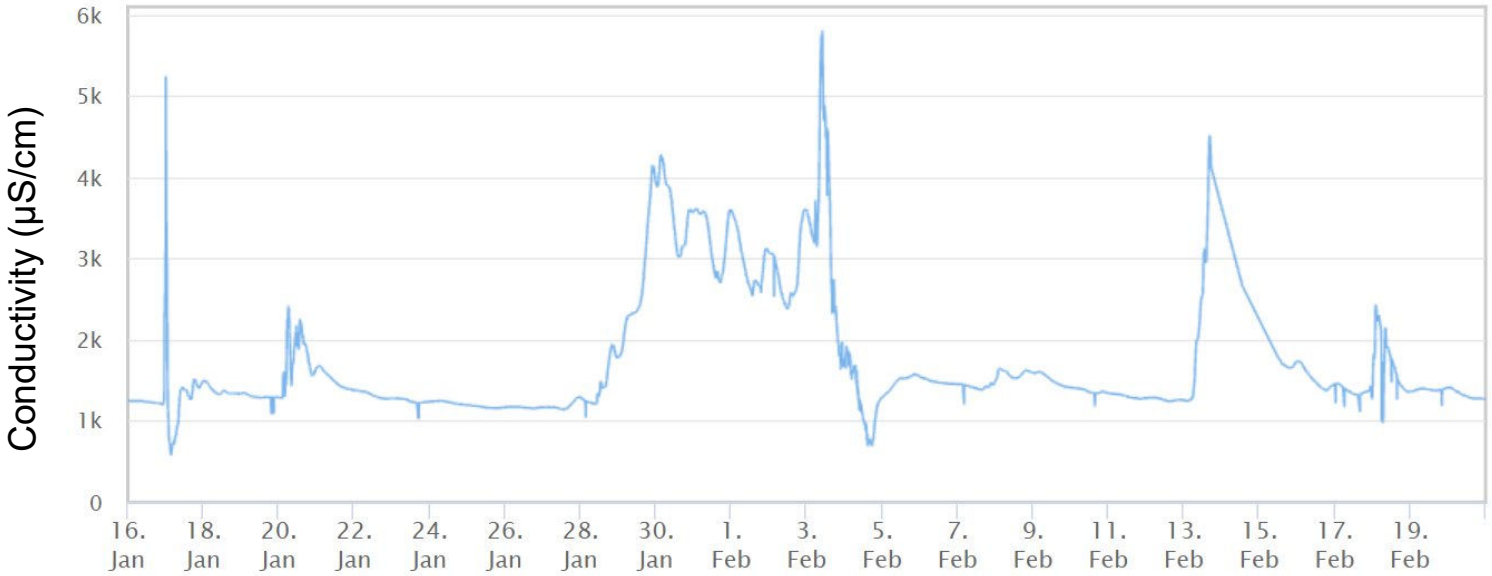

Winter 2022

Goose Creek has too much phosphorus

High concentrations of nutrients like phosphorus can cause algal blooms

The EPA has listed Goose Creek as “impaired” because of high phosphorus concentrations (EPA 2017)

The EPA recommends that healthy streams should have **total phosphorus** concentrations below **0.1 mg/L**

In summer 2022, **reactive phosphorus** in Goose Creek ranged from **0.020 to 0.262 mg/L** during summer 2022

Image credit: Delaware Center for Inland Bays

What about contaminants of emerging concern?

- Chemical or biological materials that are not commonly monitored and that do not have clear regulation but are known or likely to affect human or ecological health*
  - Examples:
    - Flame retardants
    - Pharmaceuticals and personal care products
    - Nanomaterials
    - Algal toxins
    - Industrial chemicals (like PFAS)
    - Pesticides
    - Microplastics

*paraphrased from Rosenfeld and Feng 2011

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Pharmaceuticals in the environment

- They can disrupt physiological and ecological processes even at low concentrations

Pharmaceuticals in the environment

- They can disrupt physiological and ecological processes even at low concentrations

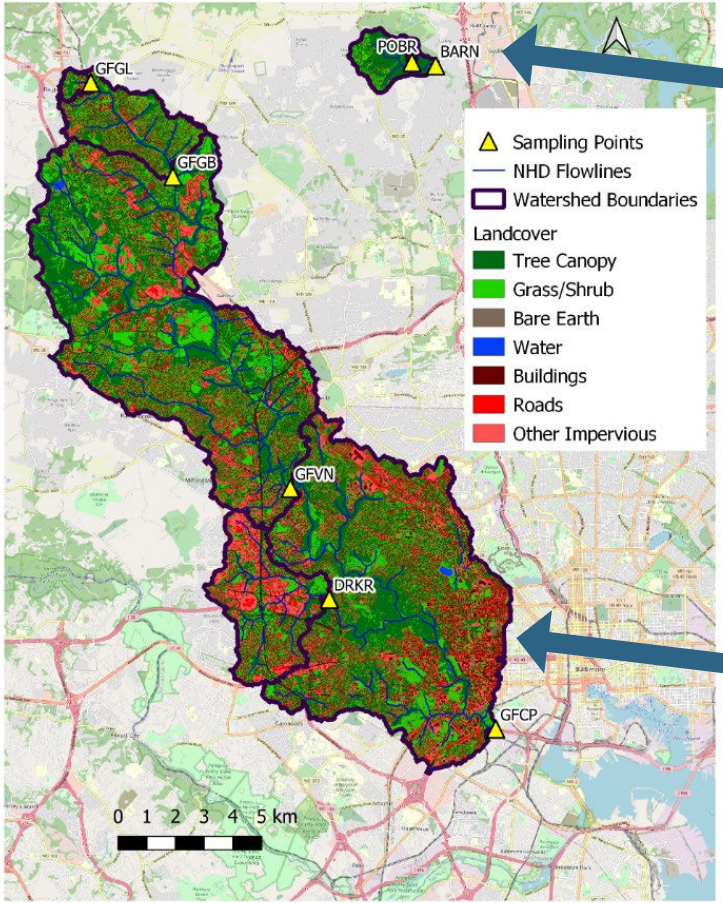
- Effluent from wastewater treatment plants (WWTPs) is a well-known source of pharmaceutical pollution

Pharmaceuticals: Research questions

Do urban watersheds contribute pharmaceutical pollution even in the absence of WWTPs?

Are there patterns or predictors of pharmaceutical pollution?

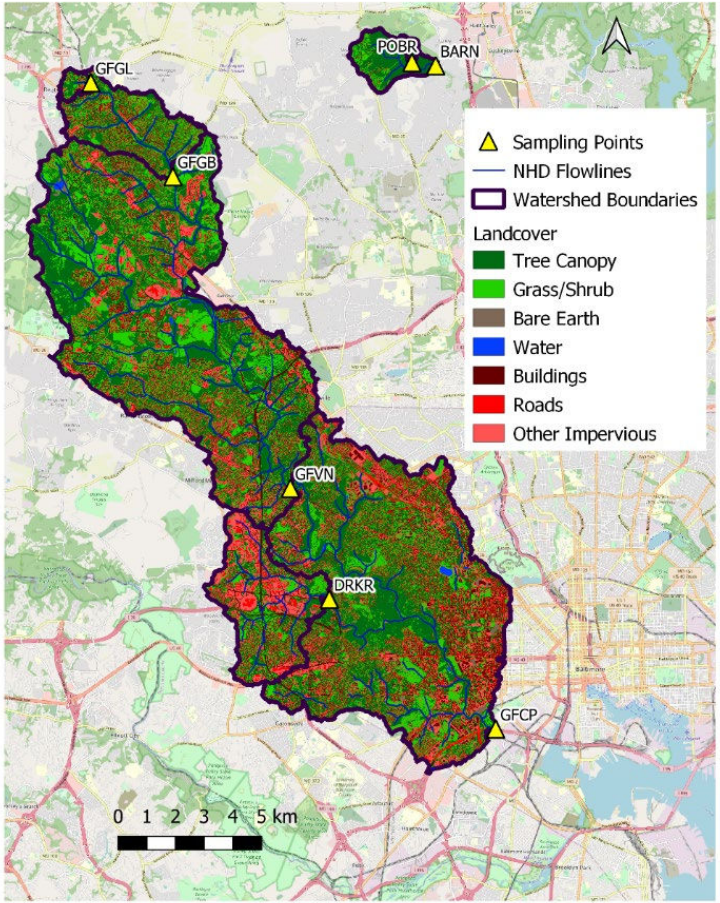
Baltimore Ecosystem Study watersheds



Low density residential with onsite wastewater treatment (i.e., septic)

City sewer, all wastewater pumped across the watershed boundary for treatment

An unprecedented dataset from Baltimore Ecosystem Study



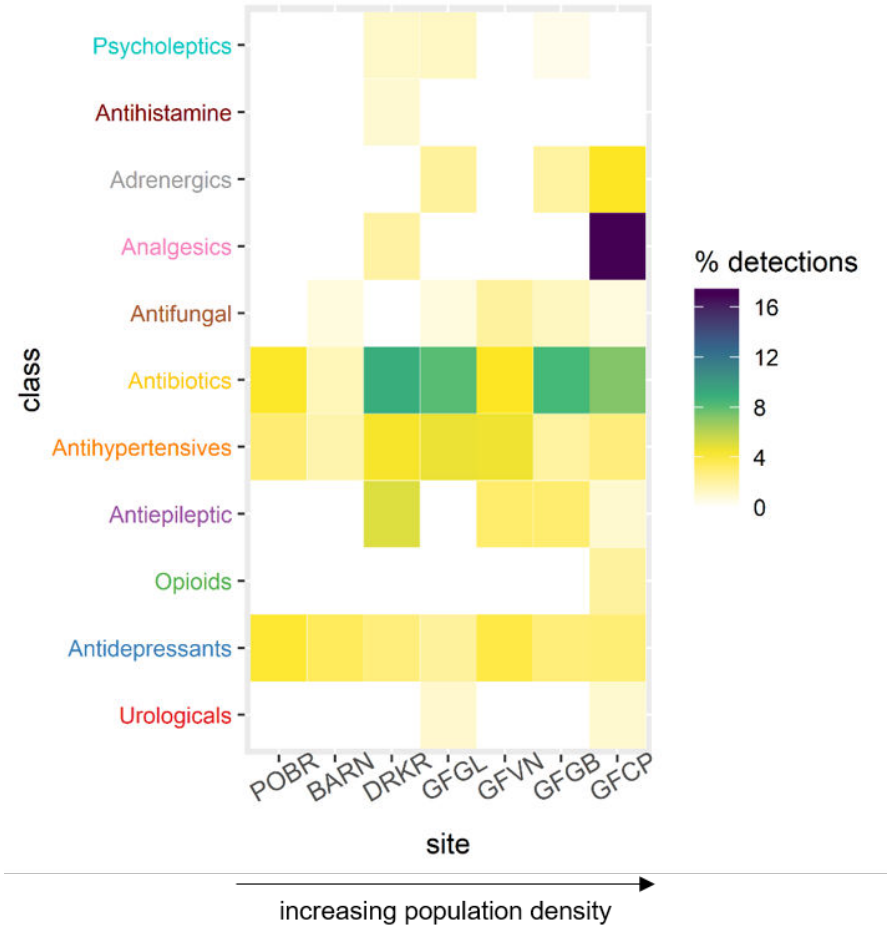
One year of weekly water samples from 7 stream sampling points (yellow triangles)

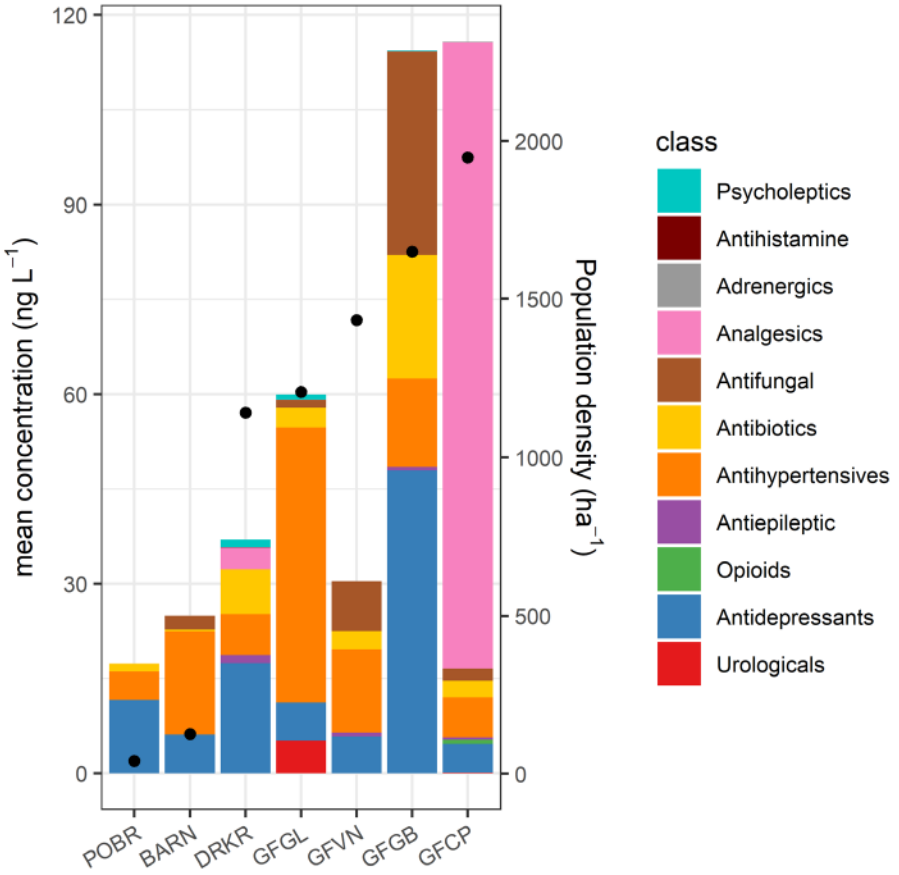
Screened for 92 pharmaceuticals

USGS stream flow every 15 min at each sampling point

Fork et al. 2021. *Environmental Science and Technology*

Patterns of concentration in space





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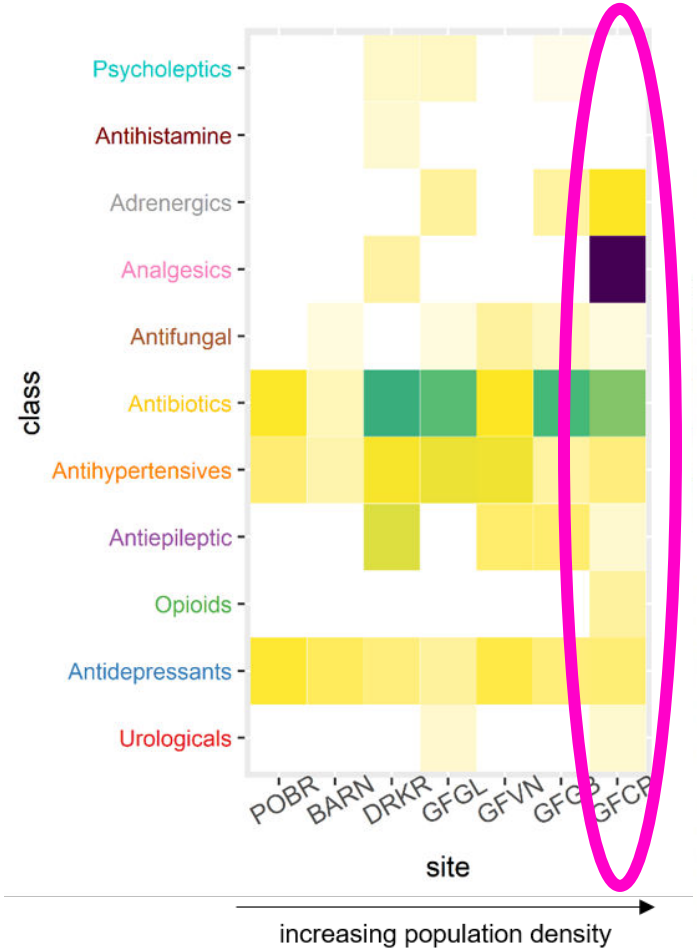
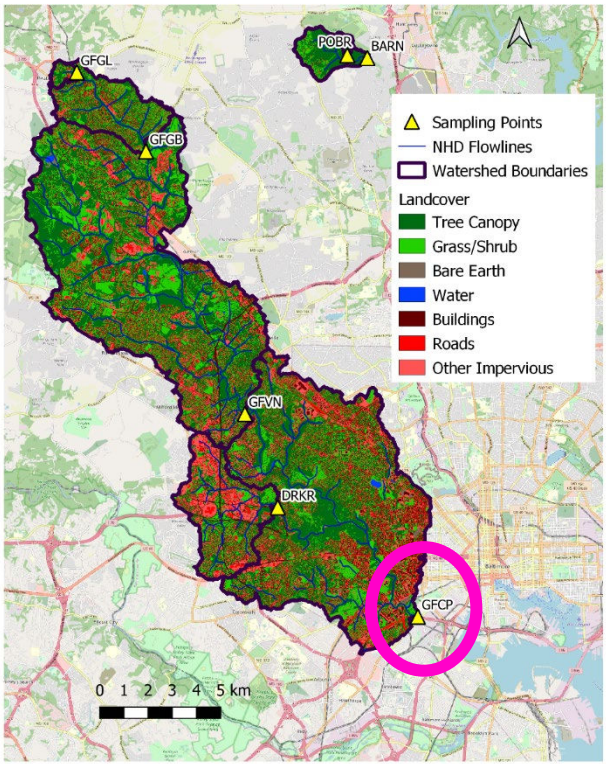
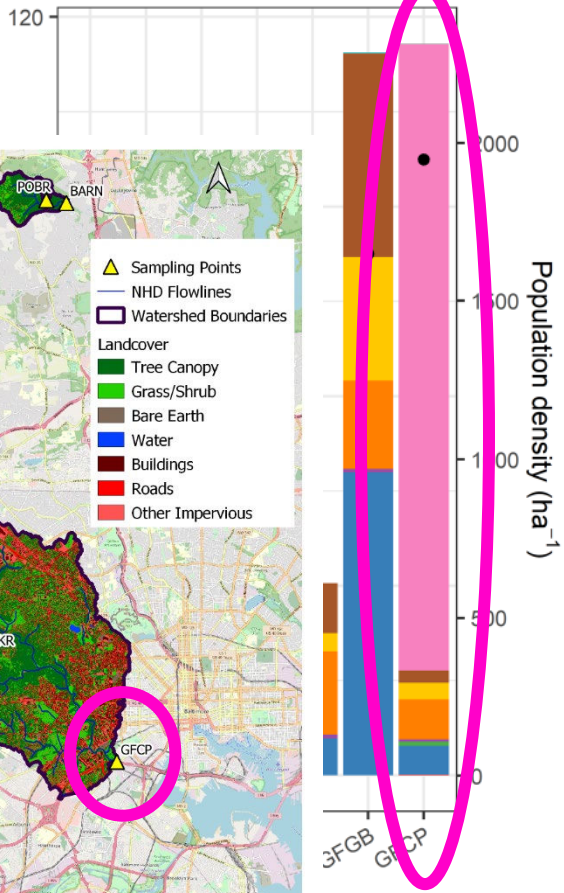
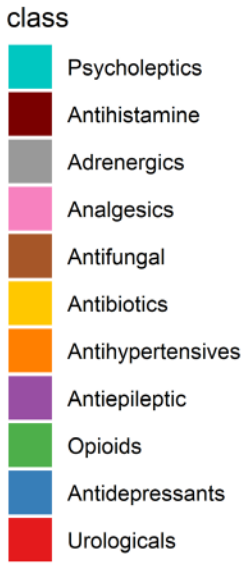
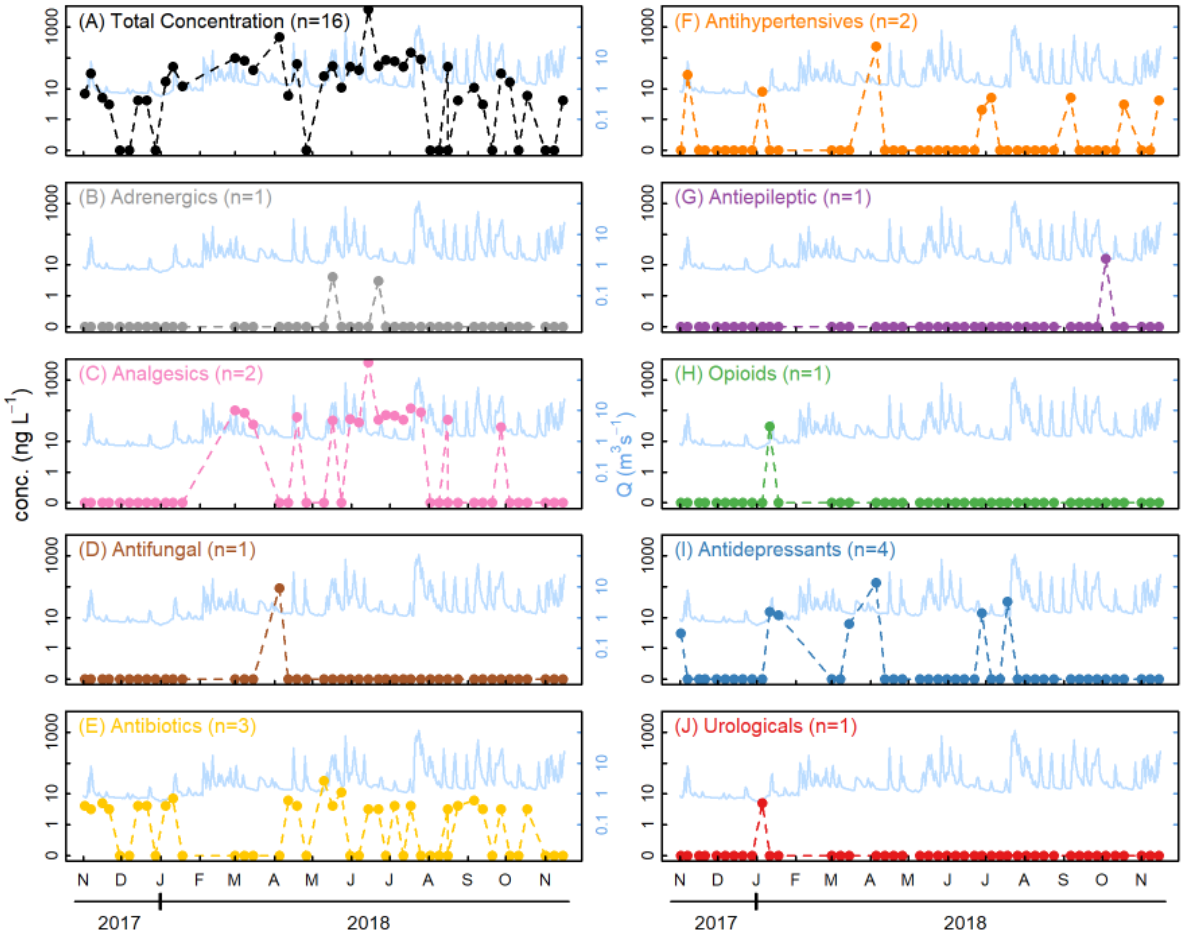








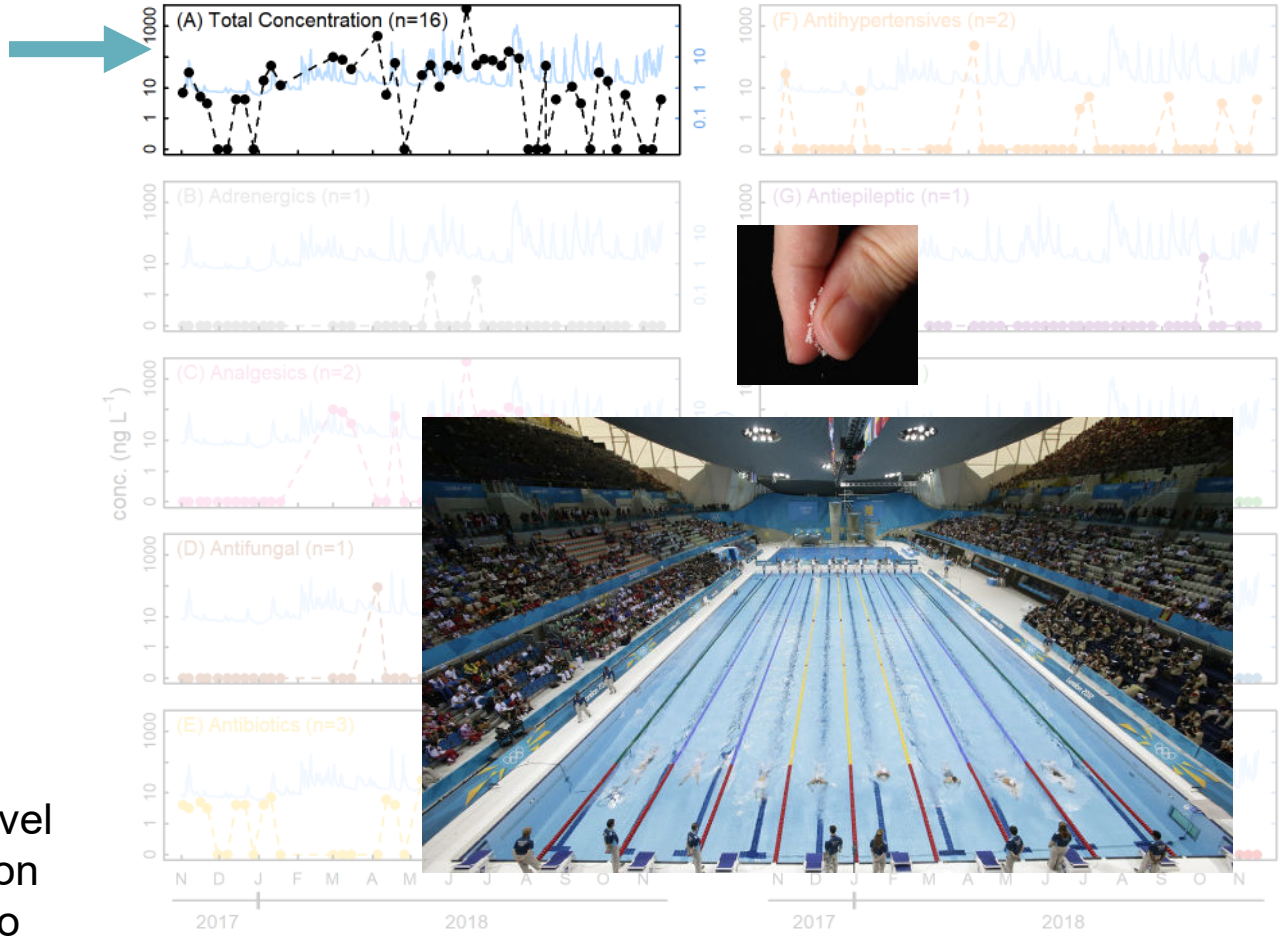
Patterns of concentration over the year



Data below level of quantification plotted as zero

Fork et al. 2021. *Environmental Science and Technology*

Patterns of concentration over the year



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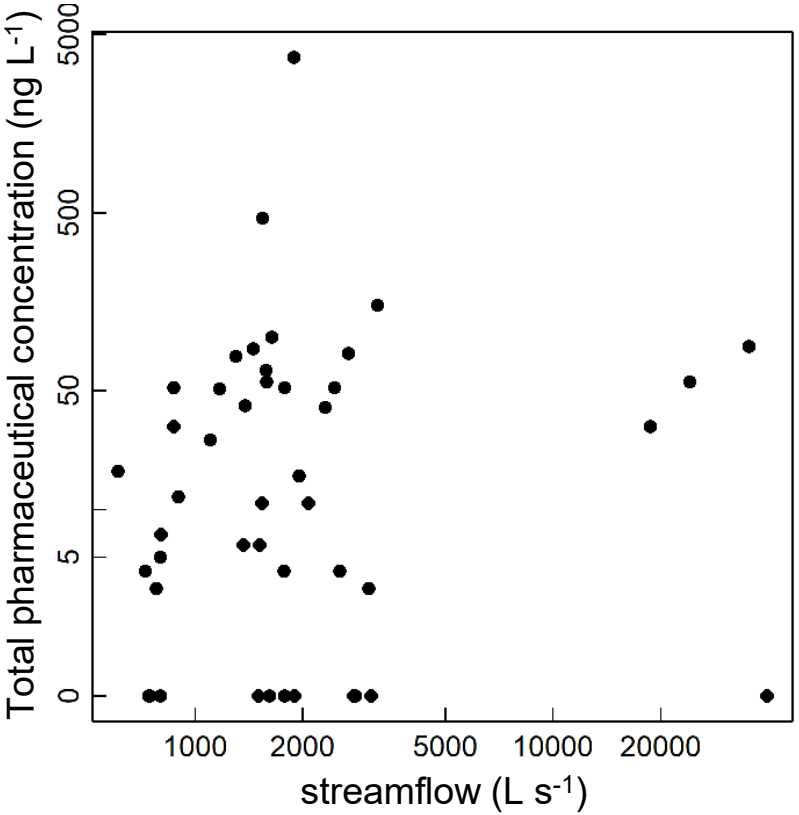
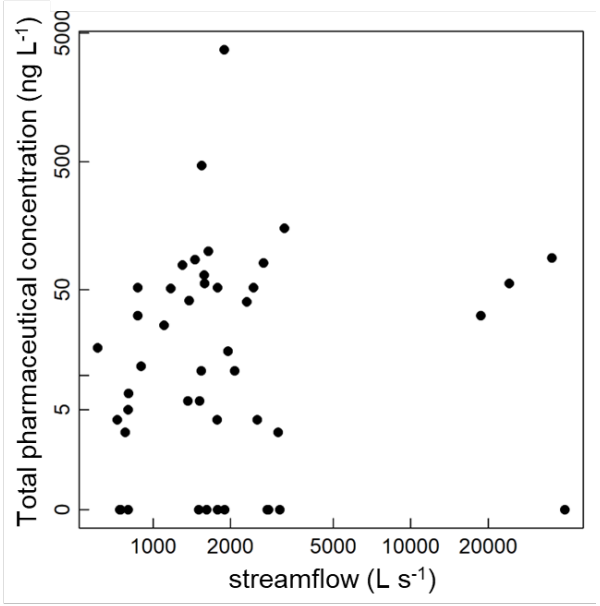
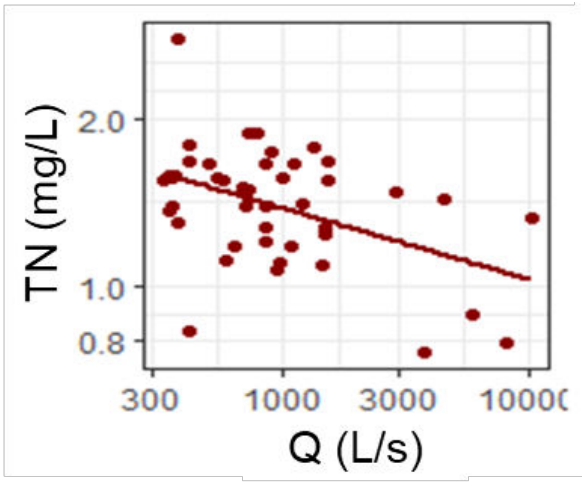
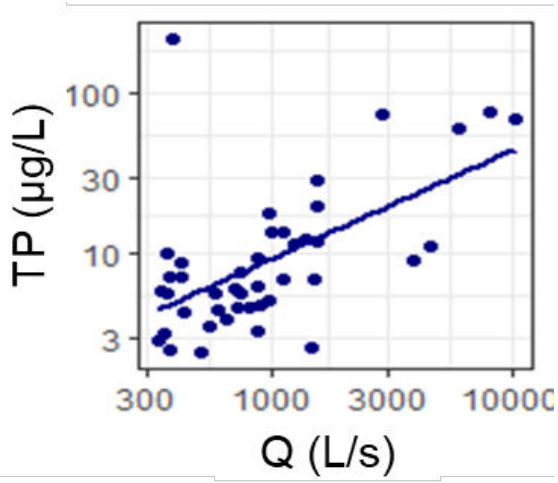
Pharmaceutical concentration vs. streamflow:



Compare to concentration-flow patterns for nutrients:







Machine-learning using watershed characteristics and routine water quality measures to predict pollution

- Works well for nutrients, but fails for pharmaceuticals

Trimethoprim: error rate = 33.7%

	Predicted absent	**Predicted present**
Measured absent	145	27
Measured present	64	34

Nitrate: error rate = 6.3%

	Predicted <1 mg/L	**Predicted >1 mg/L**
Measured <1 mg/L	34	15
Measured >1mg/L	2	219

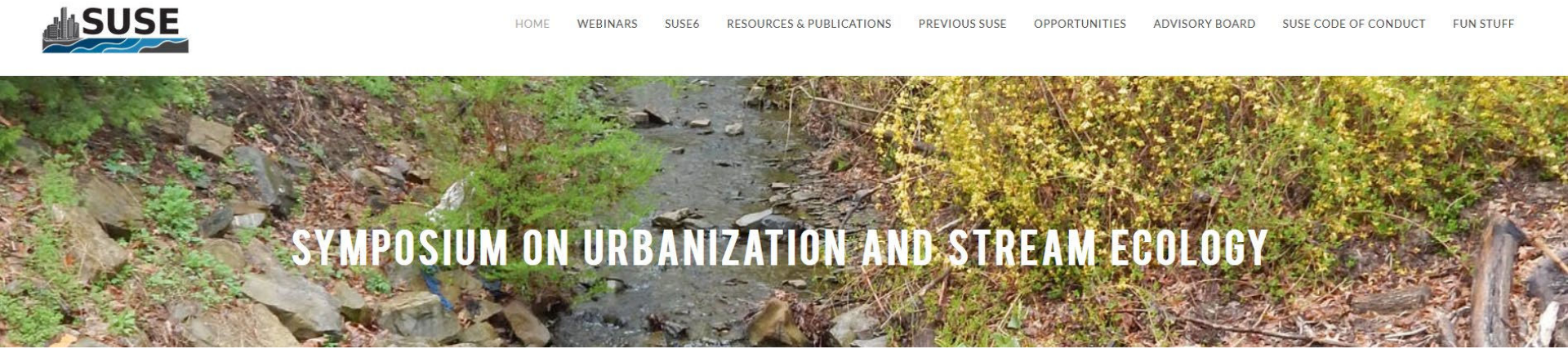
TP: error rate = 4.1%

	Predicted <40 µg/L	**Predicted >40 µg/L**
Measured <40 µg/L	241	5
Measured >40 µg/L	6	18

We don't have an easy tracer or indicator for these emerging contaminants, but we do seem them more and at higher concentrations in more urbanized streams.

Want to learn more about urban stream research? Need more webinars in your life?

Visit www.urbanstreamecology.org
and join our mailing list



Approaches to improvement: Flooding and erosion

Slow down stormwater and allow it to soak in to the soil and groundwater

Image credits: UMN Extension & Sustainable Streams, LLC

Approaches to improvement: Salt and nutrients

Reduce application of road/sidewalk salt (e.g., brine, precision application)

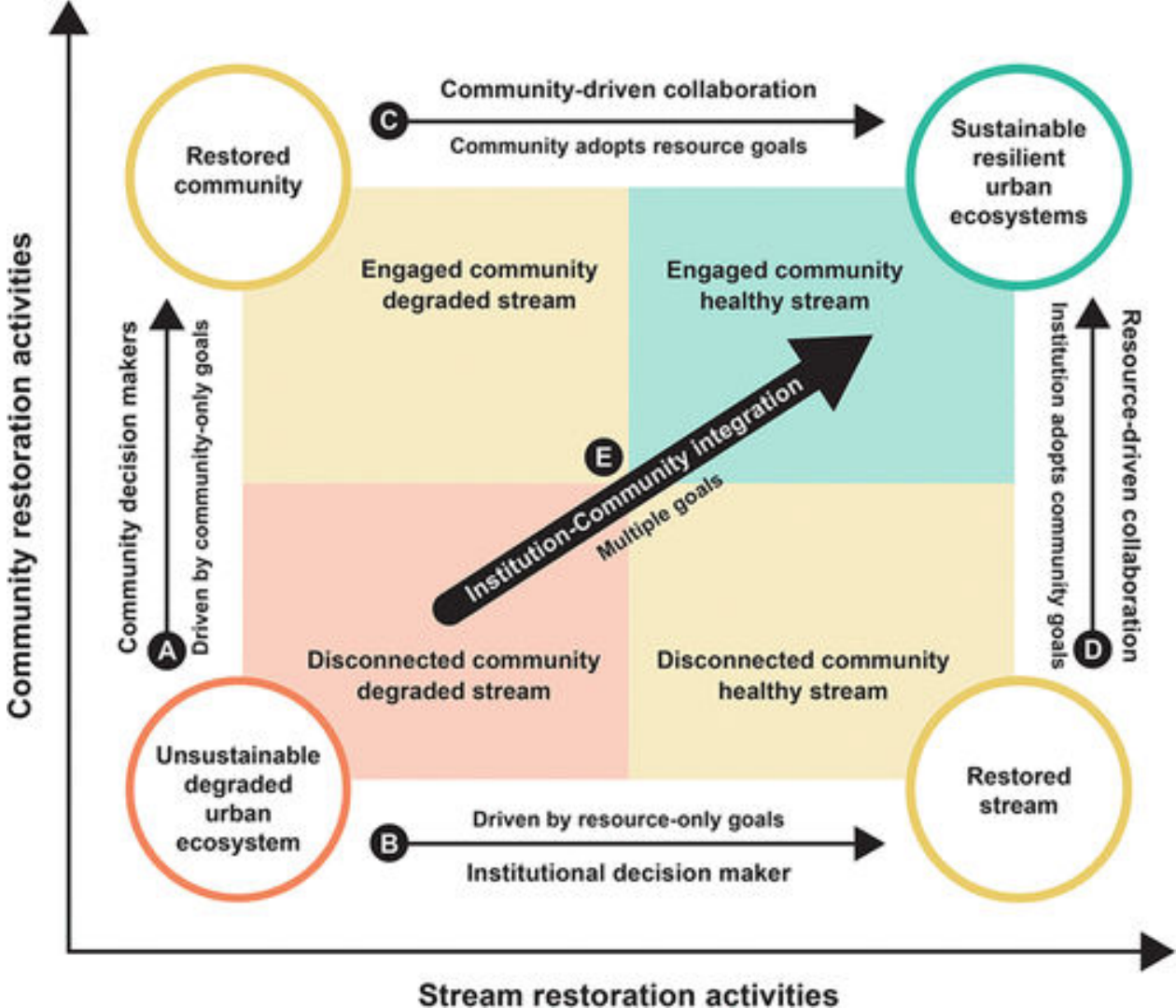
Reduce application of fertilizers

Clean up yard & organic waste

Don’t salt or fertilize right before rainstorms

Image credits: Stroud Water Research Center & Plainview Water District

Simultaneously uplift ecology and communities



Scoggins et al. 2022. *Freshwater Science.*

Watershed organizations like the Goose Creek Alliance and yours!