Wastewater Contributions to PFAS and Pesticides in the Potomac River Basin

Sam Miller, Hydrologist: smiller@usgs.gov

Chesapeake Bay Program Toxic Contaminants Workgroup: January 14, 2026

Point Source Modeling

Municipal wastewater

+

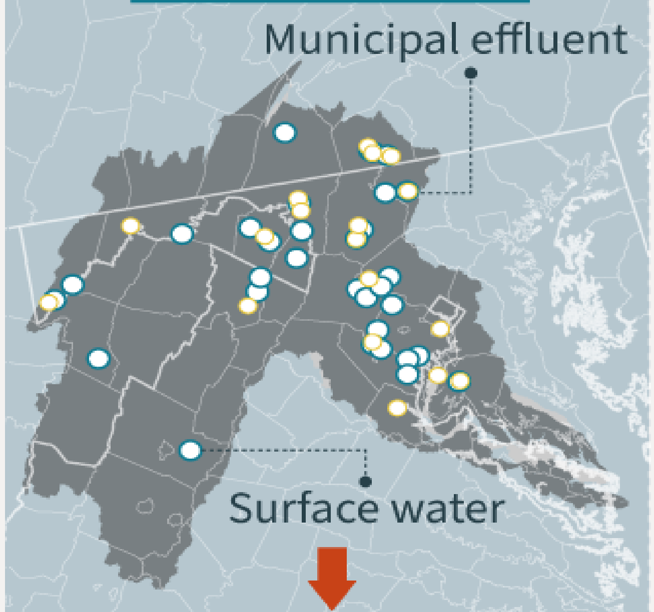
Industrial wastewater

- Airports
- National security
- Paper mills
- Plastics
- Refuse systems

↓

ΣPFAS (ng L^{-1})

Sampling



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Measured Concentrations

Nonpoint Source Modeling

- Fire stations
- Landfills
- Runways
- Oil and gas facilities
- Other facilities of interest

↓

Catchment Vulnerability Scores

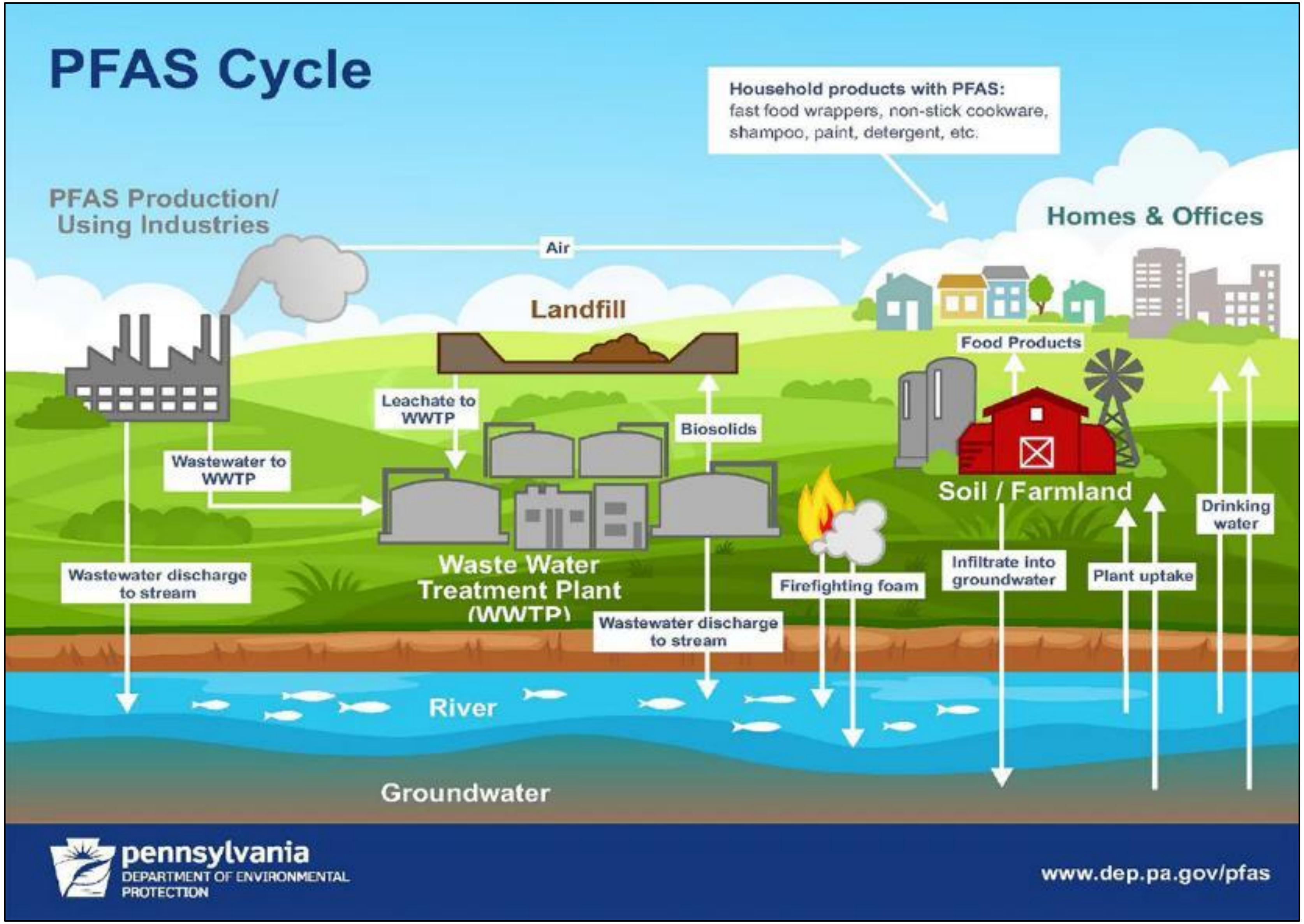
Collaborators

Larry Barber, Kaycee Faunce, Dan Burns, Paul Bradley, Jacob Fleck, Stephanie Gordon, Michelle Hladik, Jeramy Jasmann, Emily Majcher, Mitch McAdoo, Sindy Mejia, Kelly Smalling, Brianna Williams (USGS);
Ryan Hollins, Malinda Frick, Conor Lewellyn (MITRE Corporation);
Lee Blaney, He Ke (UMBC);
and many more

PFAS in Wastewater

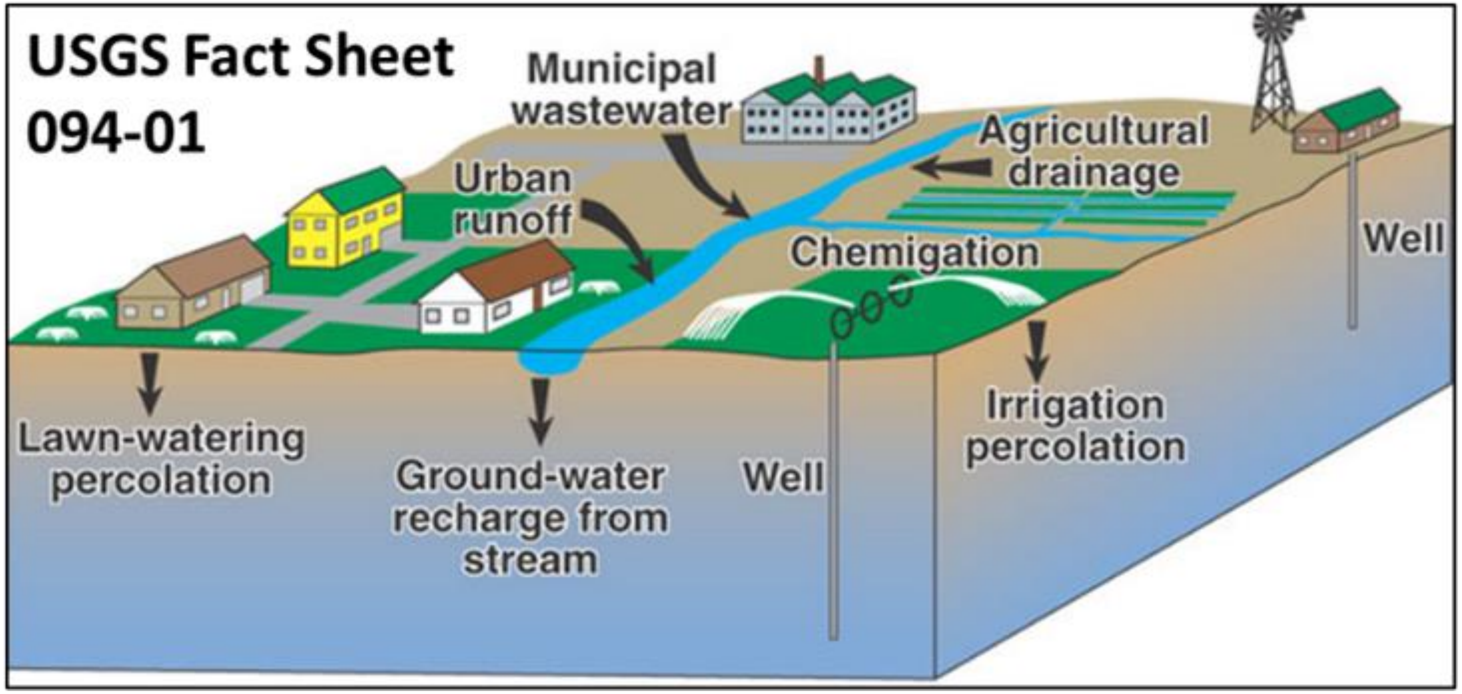
- Potential **PFAS sources** to **municipal wastewater:**
  - **Down-the-drain** products
  - **Landfilled** products (**leachate**)

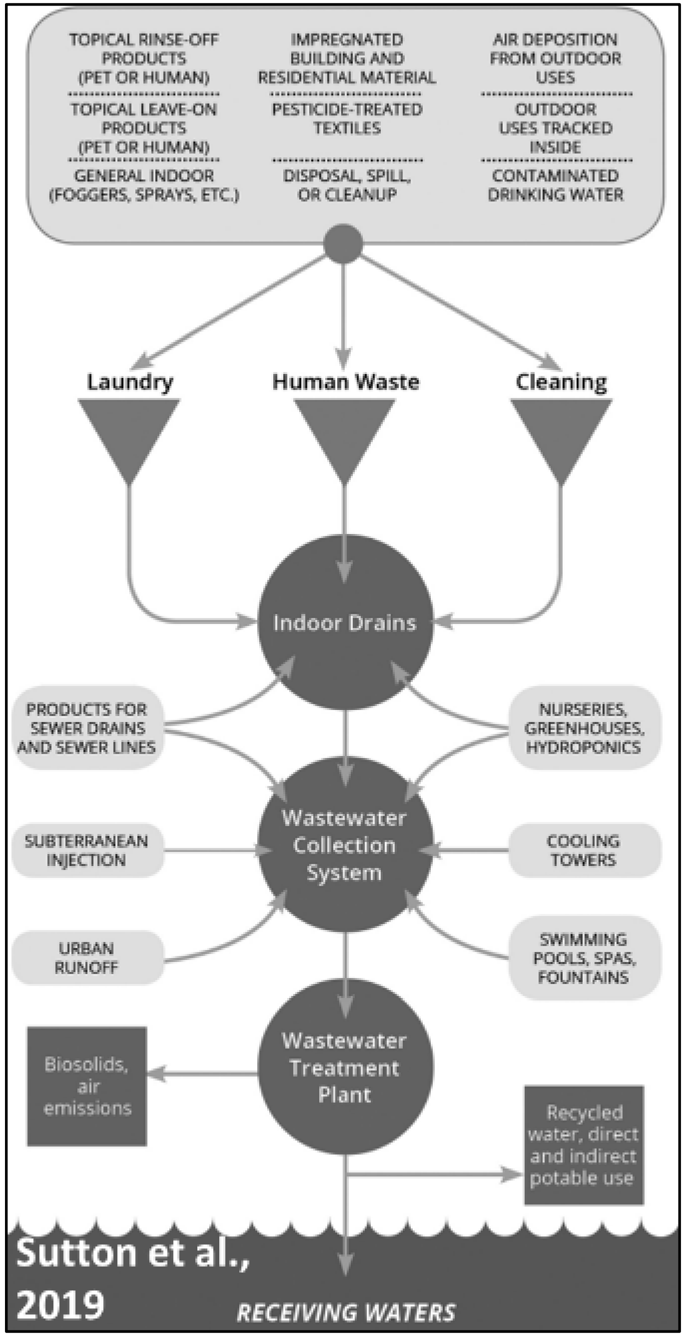
- Potential **sources to industrial wastewater**:
  - Chemical Manufacturing
  - Plastics and Resins
  - Paper Mills and Products
  - Airports
  - Electronics Industry
  - Refuse Systems
  - Oil and Gas
  - Textiles and Leather
  - …more than 90 industries

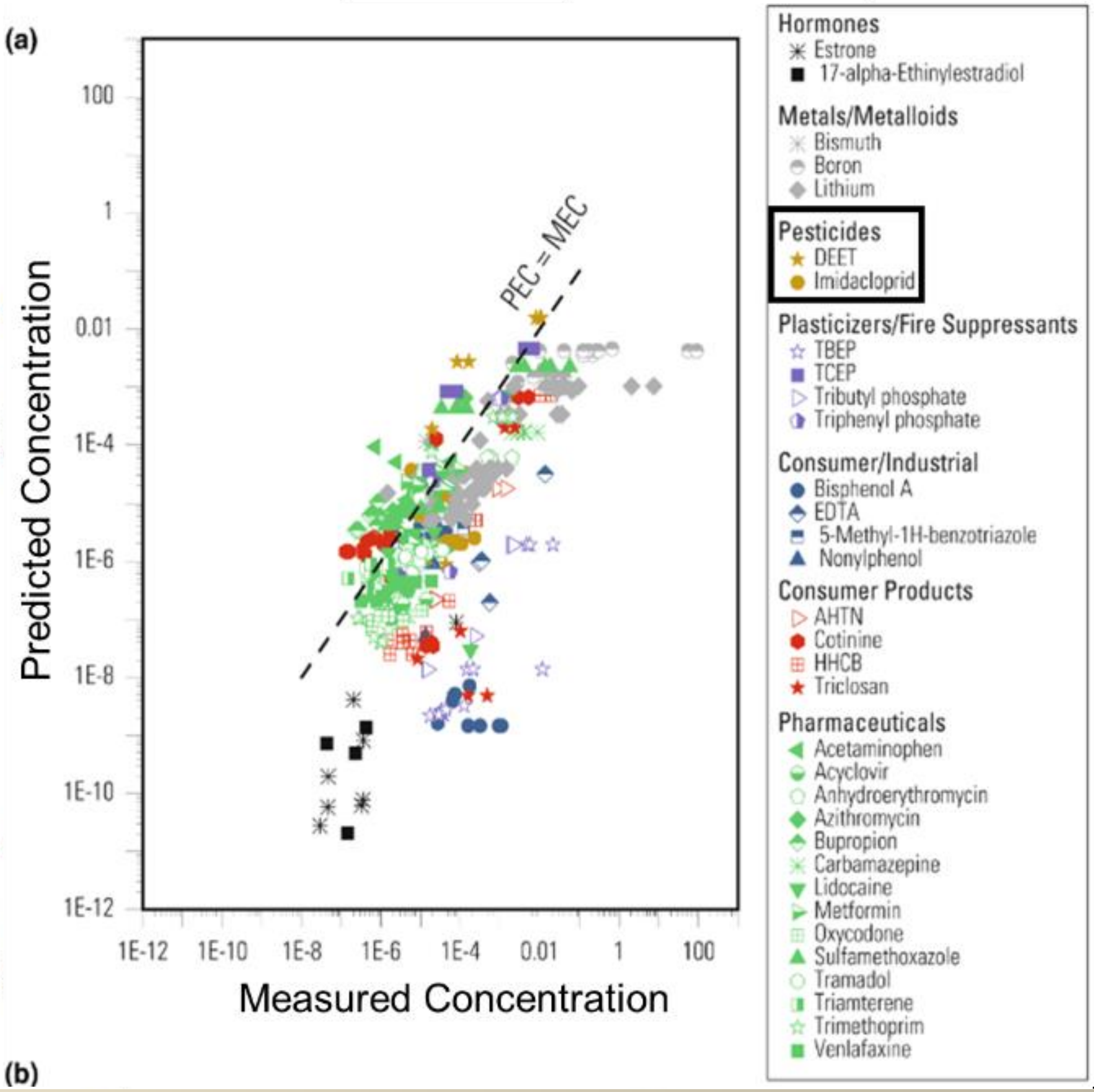


Pesticides in Wastewater

- **Pesticides** can be introduced to **municipal wastewater** through a **variety of pathways**:
  - Tap water
  - laundry and cleaning products
  - human and pet waste
  - industrial processes







Accumulated wastewater model

- Estimate the **percentage of treated wastewater** in drinking water intakes

Spatial and Temporal Variation in De Facto Wastewater Reuse in Drinking Water Systems across the U.S.A.

Jacelyn Rice* and Paul Westerhoff

- **Calculate wastewater percentage** in each stream segment and **predict contaminant concentrations**

Integrated Assessment of Wastewater Reuse, Exposure Risk, and Fish Endocrine Disruption in the Shenandoah River Watershed

Larry B. Barber,*,† Jennifer L. Rapp,‡ Chintamani Kandel,‡ Steffanie H. Keefe,† Jacelyn Rice,§ Paul Westerhoff,∥ David W. Bertolatus,⊥ and Alan M. Vajda⊥

Watershed-Scale Risk to Aquatic Organisms from Complex Chemical Mixtures in the Shenandoah River

Larry B. Barber,* Kaycee E. Faunce, David W. Bertolatus, Michelle L. Hladik, Jeramy R. Jasmann, Steffanie H. Keefe, Dana W. Kolpin, Michael T. Meyer, Jennifer L. Rapp, David A. Roth, and Alan M. Vajda

Wastewater reuse and predicted ecological risk posed by contaminant mixtures in Potomac River watershed streams

Kaycee E. Faunce[1] | Larry B. Barber[2] | Steffanie H. Keefe[2] | Jeramy R. Jasmann[2] | Jennifer L. Rapp[3]

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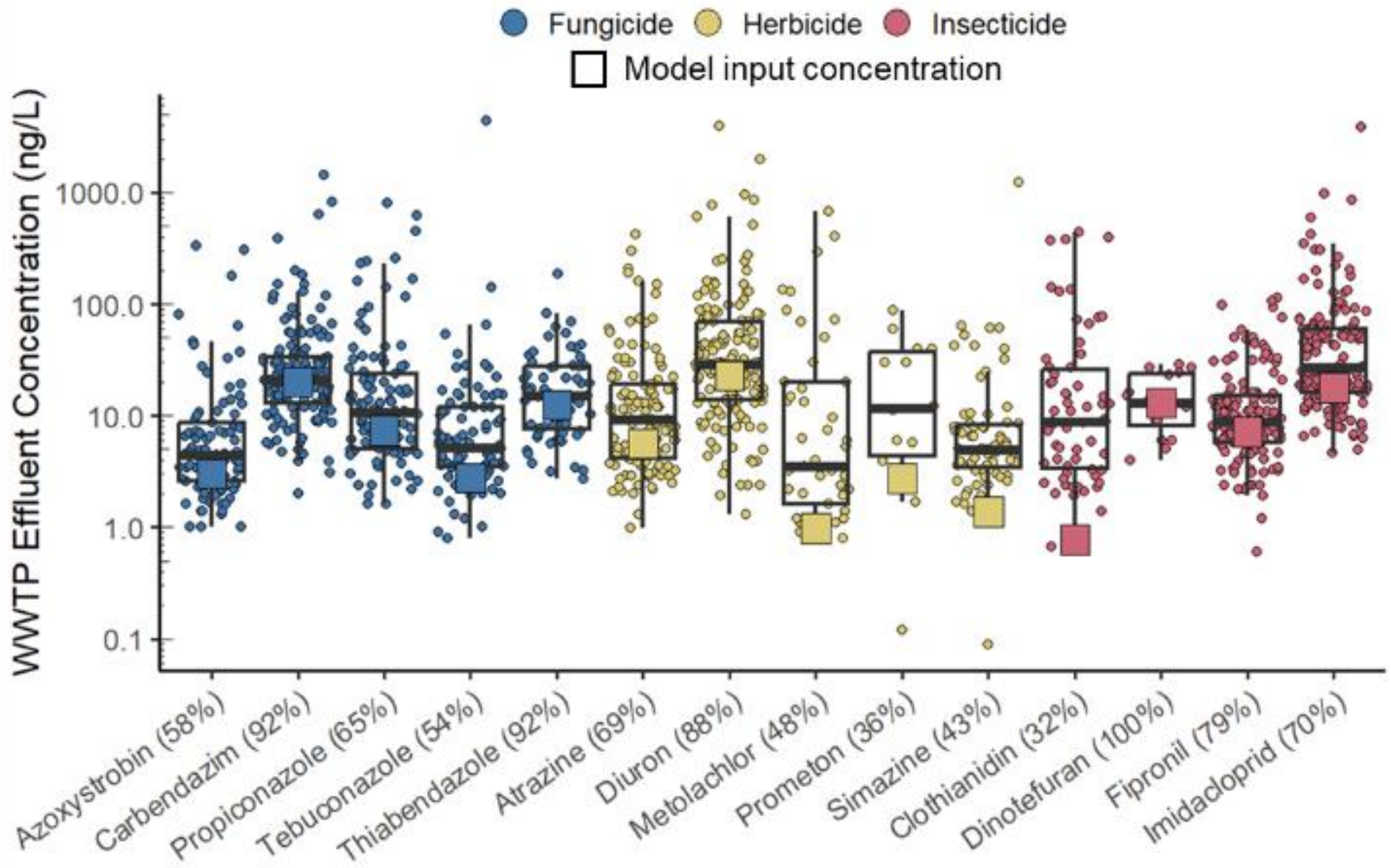
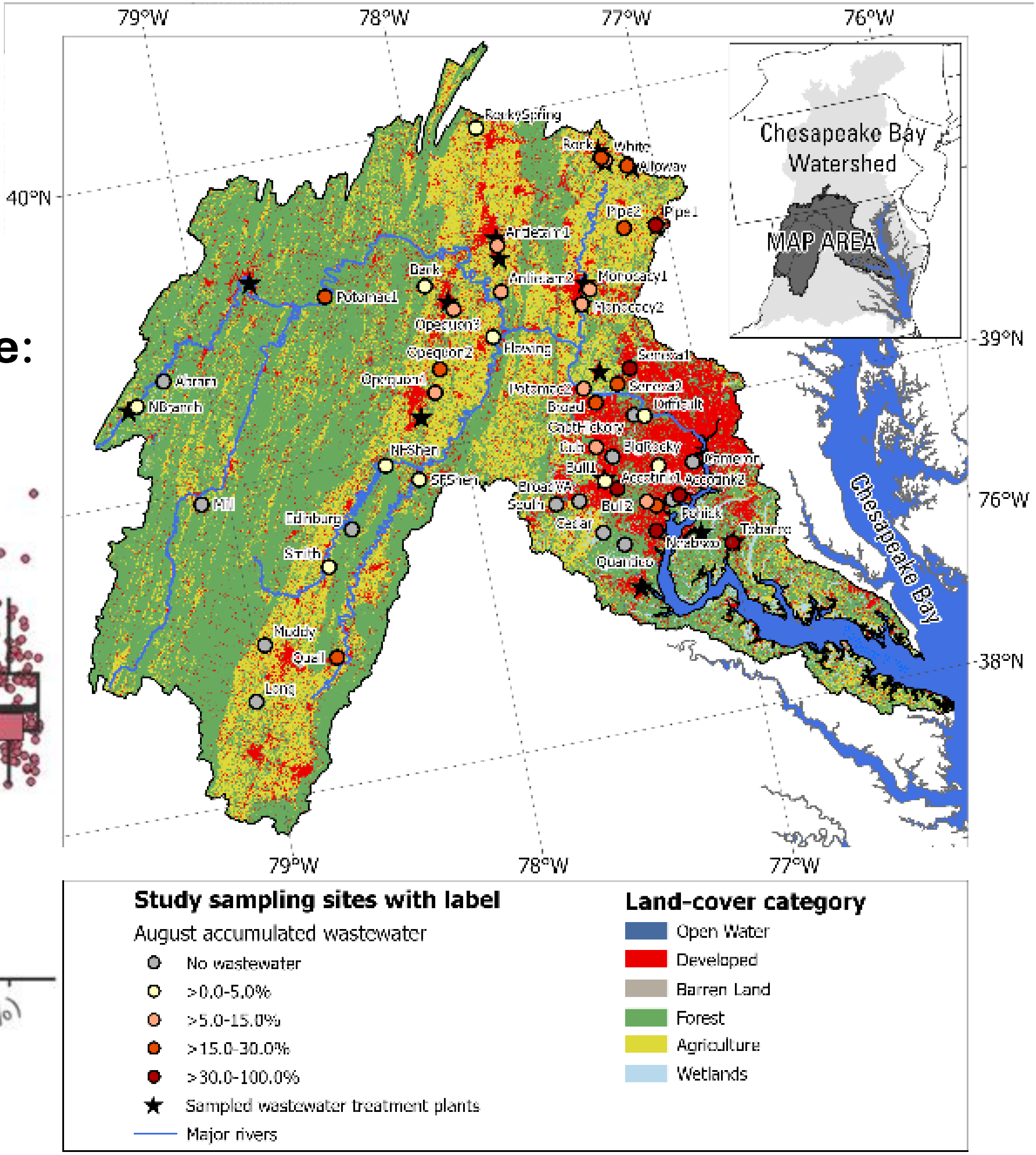
Study Area: Potomac River Basin

- **32 stream sites** sampled during **low flow** spanning a range of wastewater percentage
  - **~500 parameters** collected at each site
- **Municipal wastewater** effluent **sampled for PFAS**:
- **Pesticide concentrations** compiled **from literature**:





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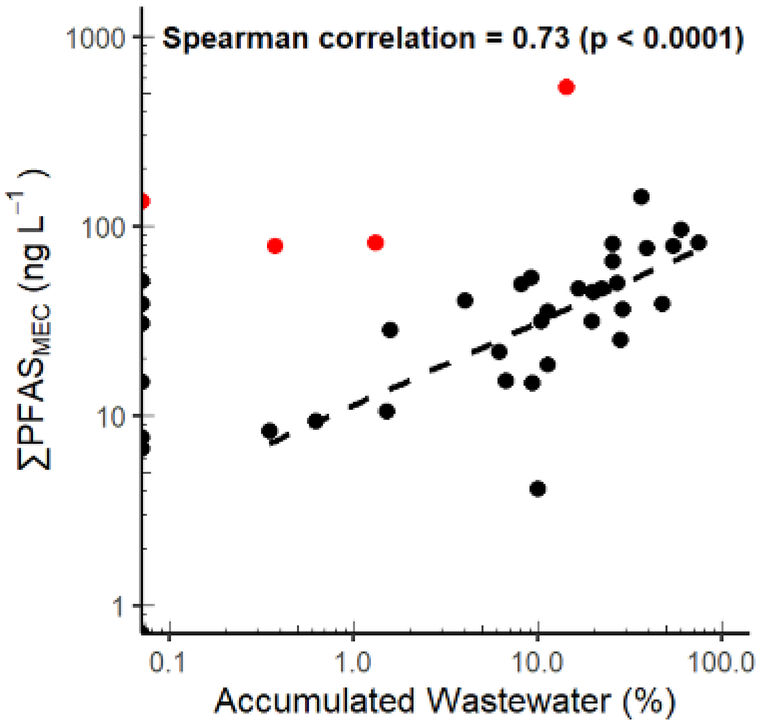
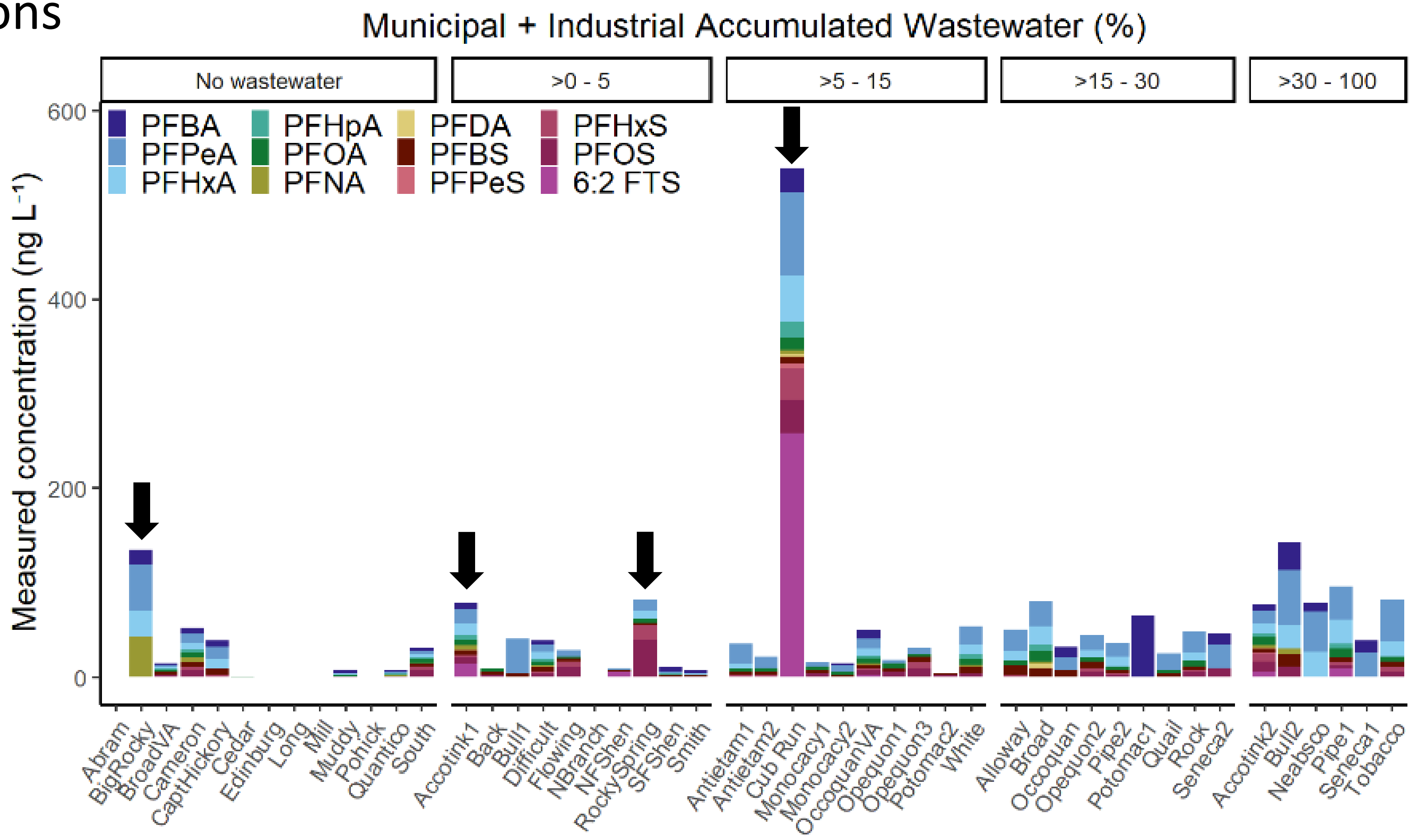
Preliminary Information – Subject to revision. Not for Citation or Distribution

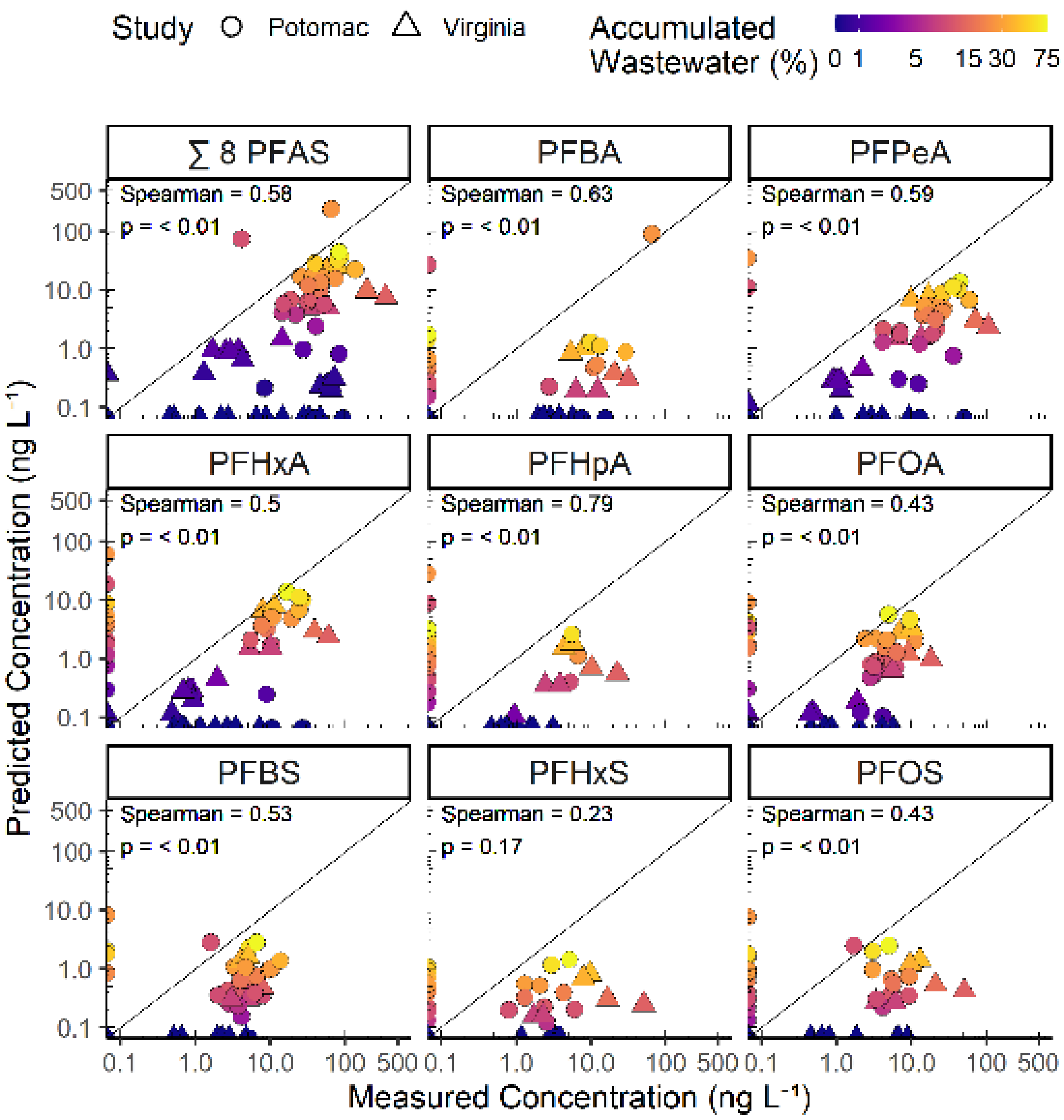
Measured PFAS vs Accumulated Wastewater

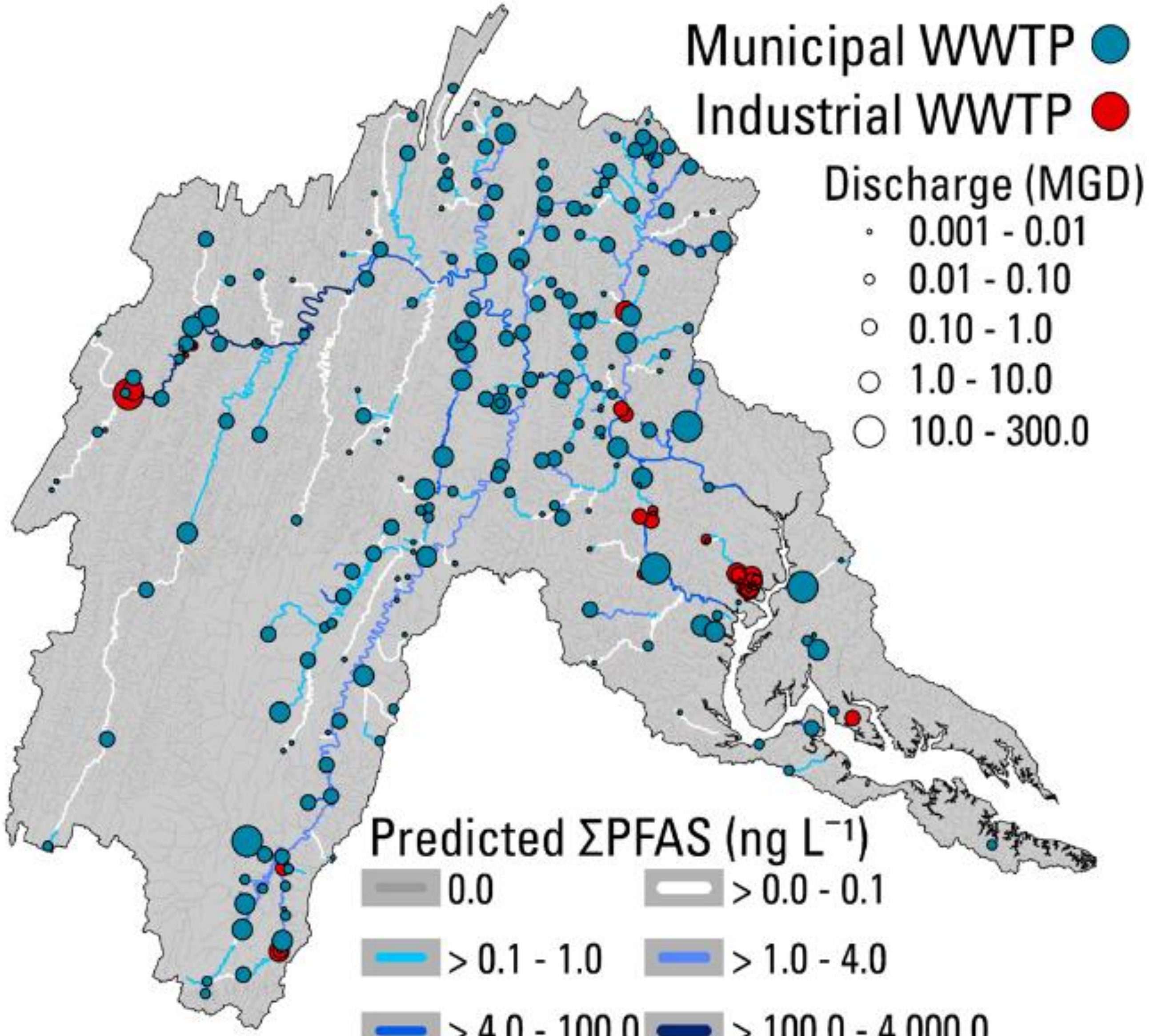
- General increasing PFAS concentration with accumulated wastewater with exceptions
  - Big Rocky Run
  - Accotink Creek
  - Rocky Spring Branch
  - Cub Run





Predicted PFAS Concentrations

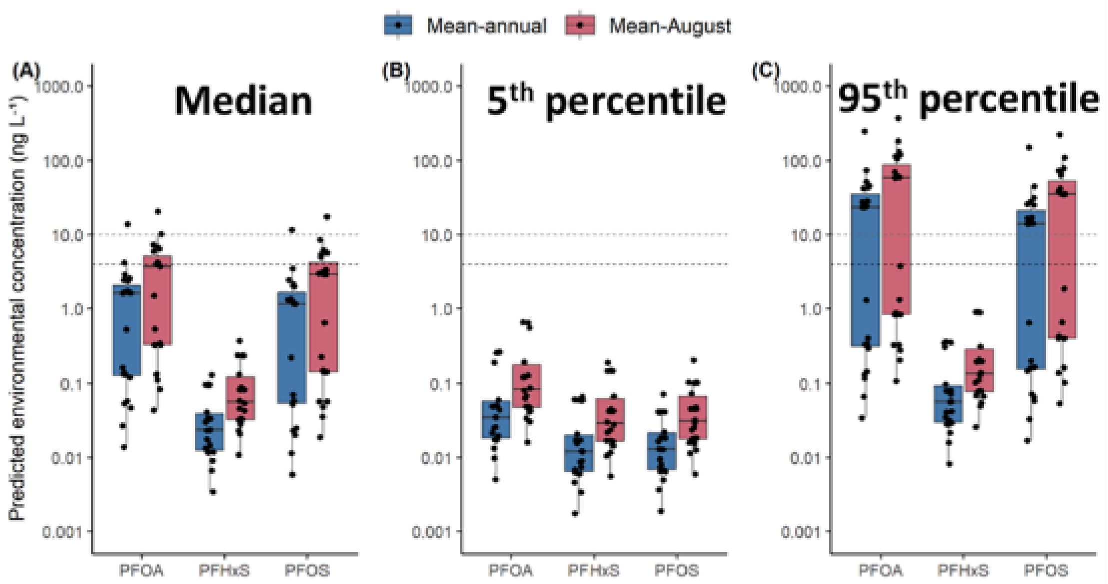




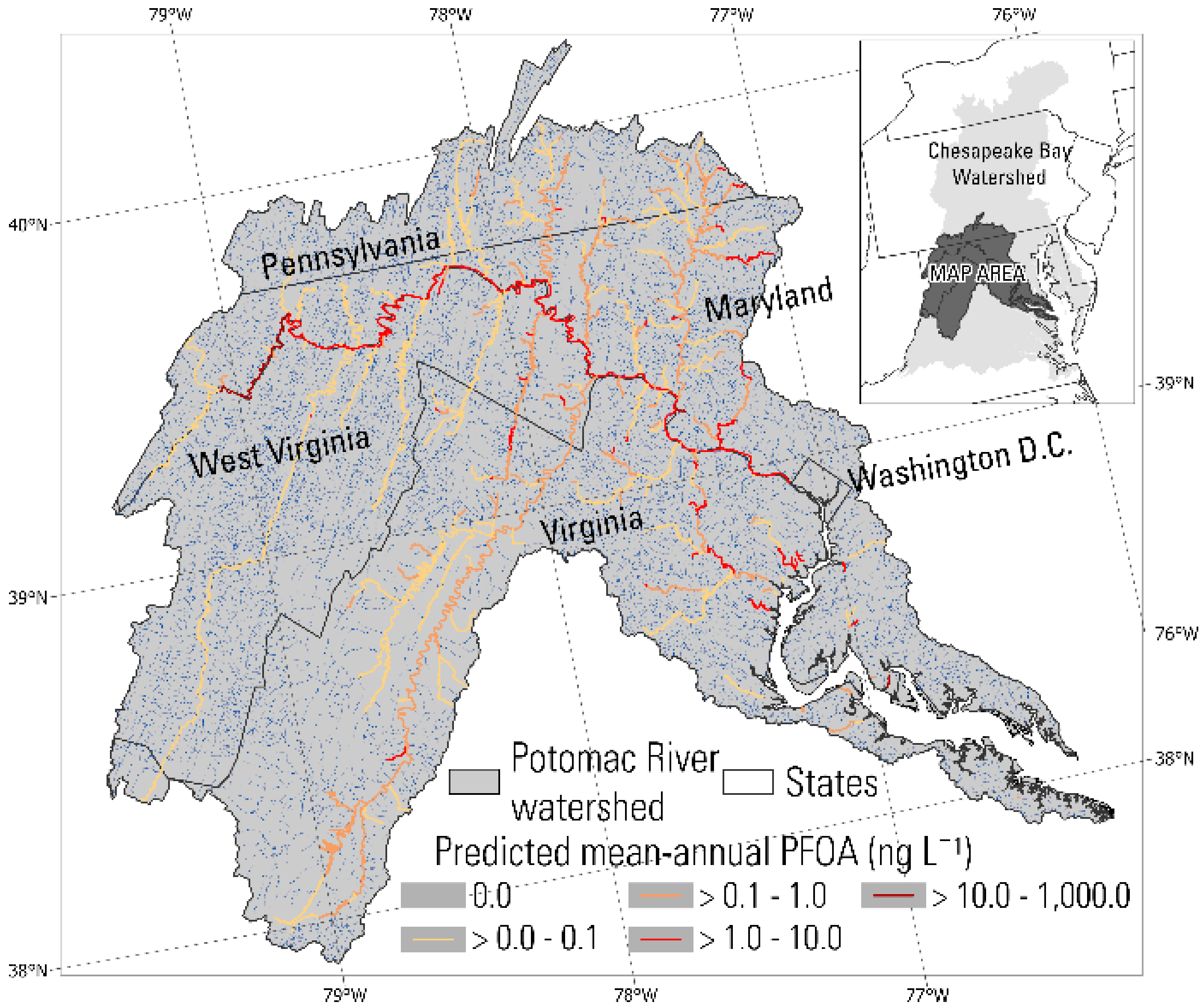
Predictions at Drinking Water Intakes

- PFAS predictions at surface water intake locations for public water supply were compared to MCLs

- Some predictions at intake locations exceeded MCLs:



Predicted PFAS concentrations at drinking water intakes



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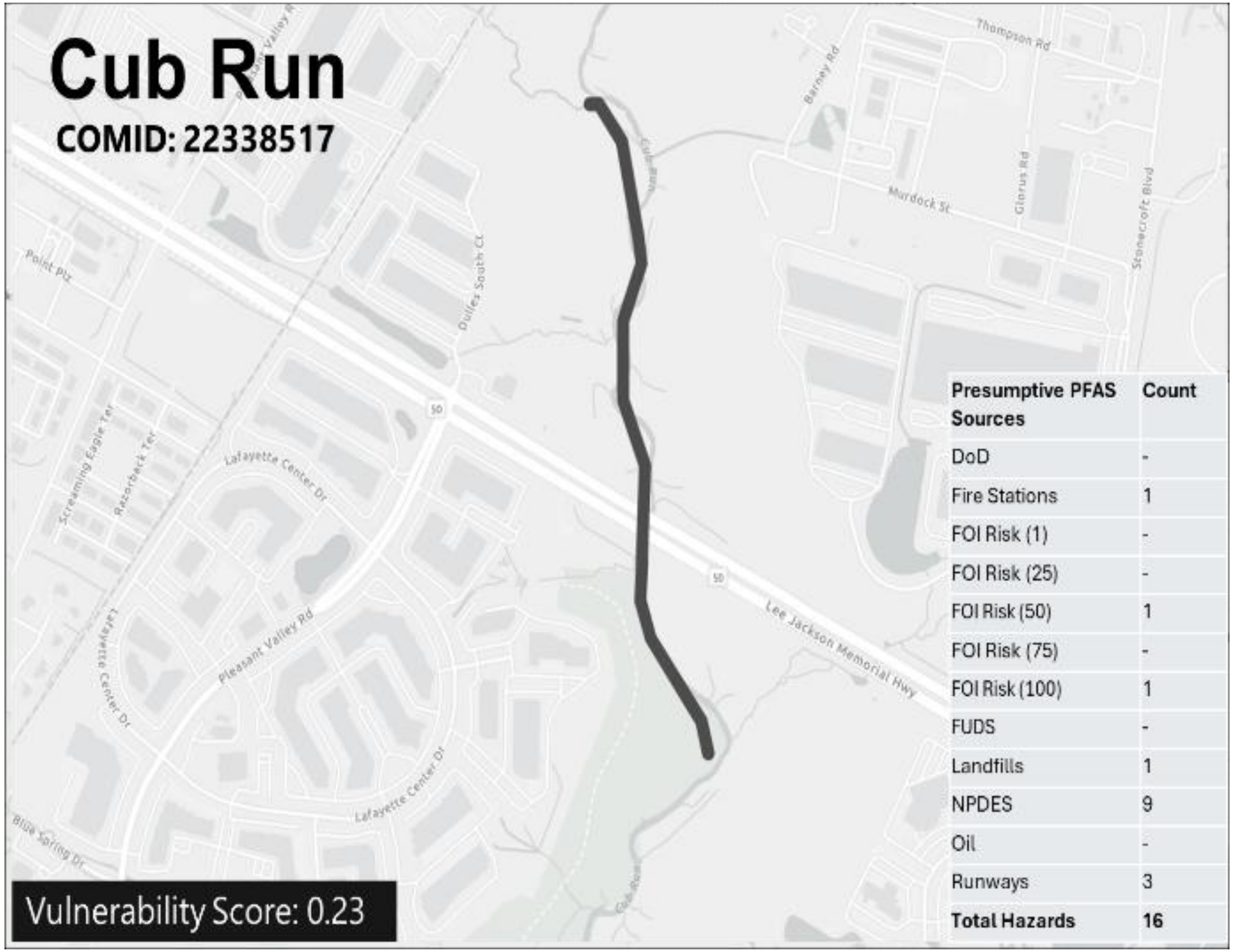
PFAS Vulnerability from Landscape Sources

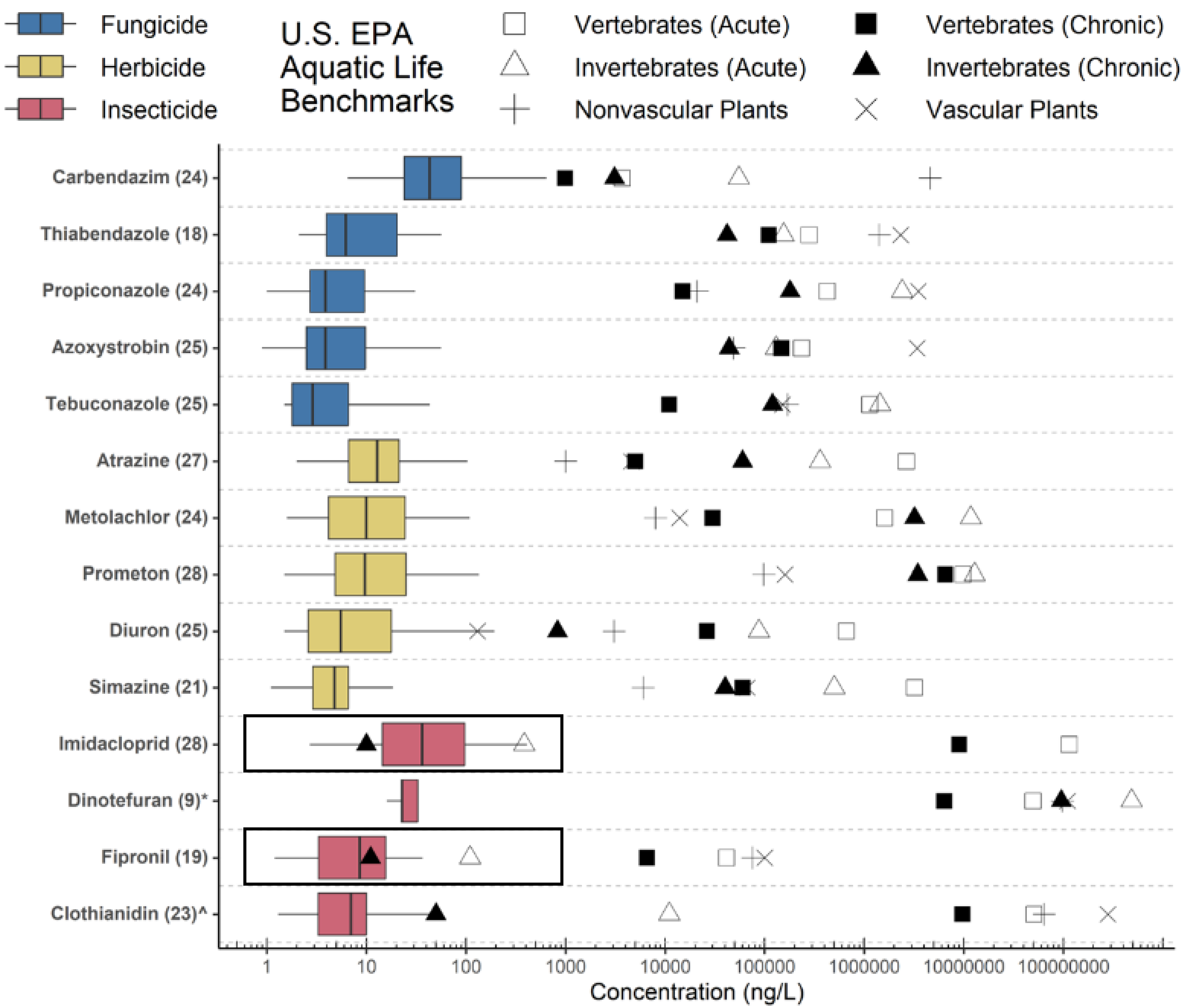
Water Sensing and Hydrology for Environmental Decision Support (WaterSHEDS)



Presumptive PFAS Sources	Count
DoD	-
Fire Stations	1
FOI Risk (1)	-
FOI Risk (25)	-
FOI Risk (50)	1
FOI Risk (75)	-
FOI Risk (100)	1
FUDS	-
Landfills	1
NPDES	9
Oil	-
Runways	3
Total Hazards	**16**

- Collaborators from the MITRE Corporation developed a PFAS vulnerability score based on presumptive sources:
  - DoD facilities
  - Formerly use defense sites (FUDS)
  - Runways
  - Landfills
  - NPDES
  - Fire stations
  - Oil and gas facilities
  - Facilities of interest

Detected Pesticides



- **49/183** pesticides detected
  - **14 target pesticides** in bold
  - **Imidacloprid**, atrazine, and prometon most often detected (88% of sites)
- **29/32 sites** with detections
  - 6-36 pesticides/site (**average = 19**)
  - ∑18-1,458 ng/L (**average = 408 ng/L**)
- **10** detected **PFAS pesticides**
  - Fluopicolide, Dithiopyr, Prodiamine, Fluridone, **Fipronil**, Fipronil Sulfone, Fipronil Desulfinyl, Fipronil Sulfide, Bifenthrin, Fipronil Desulfinyl Amide
- **Most** detections were **below aquatic life benchmarks**
  - **Imidacloprid** (82%) and **fipronil** (47%) **frequently exceeded** chronic **benchmarks** for invertebrates

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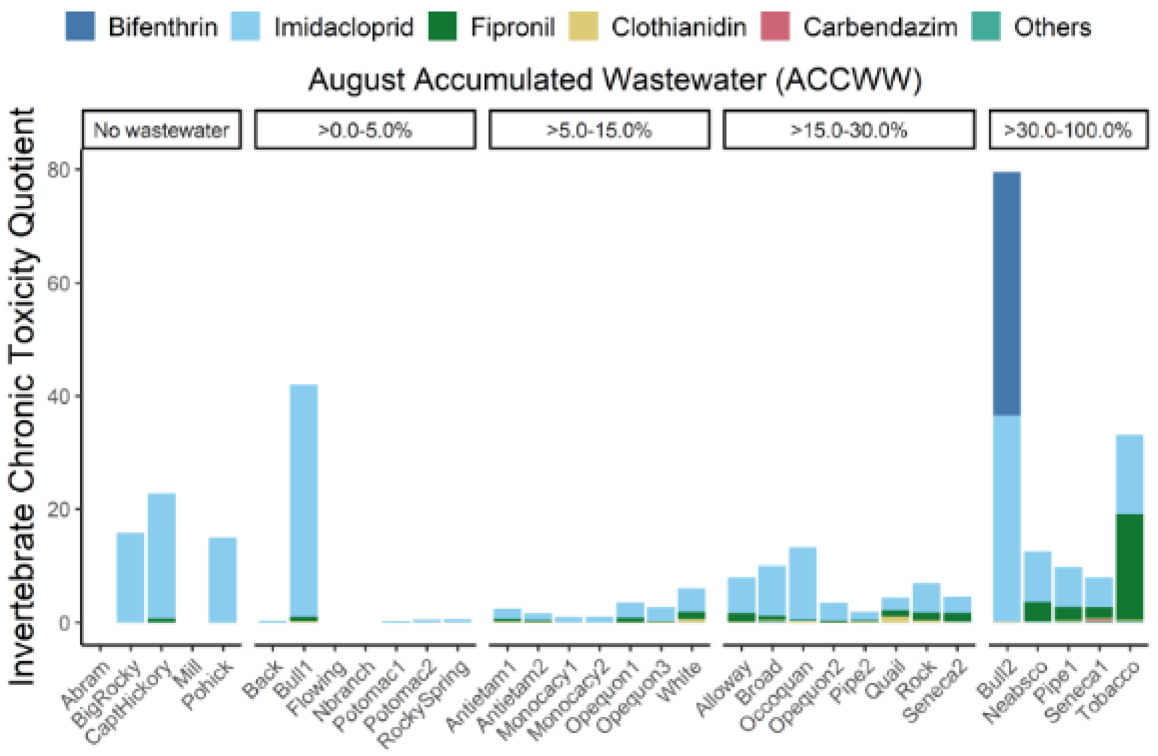

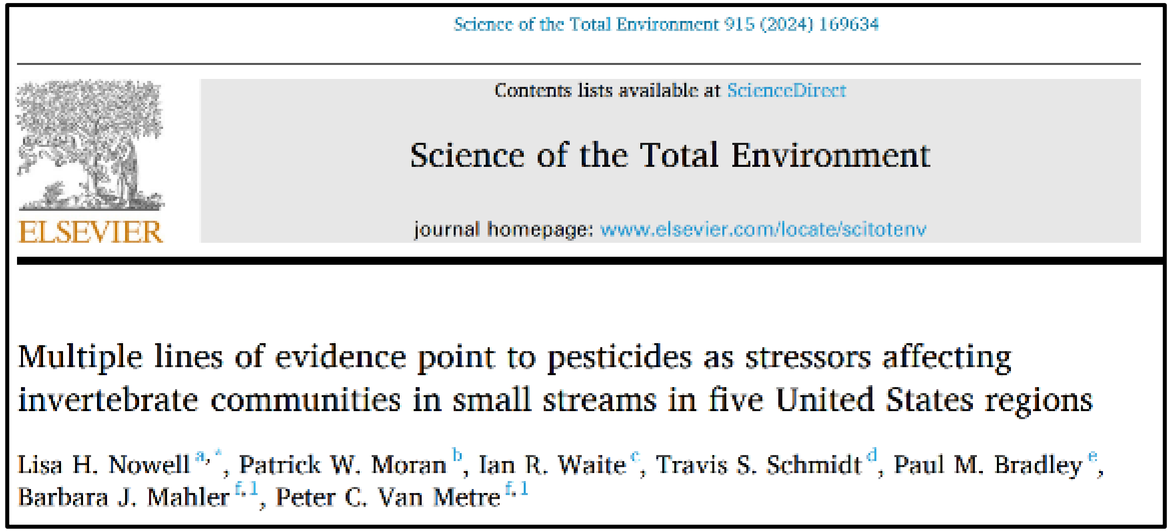
Science of the Total Environment 915 (2024) 169634

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

Multiple lines of evidence point to pesticides as stressors affecting invertebrate communities in small streams in five United States regions

Lisa H. Nowell[a,*], Patrick W. Moran[b], Ian R. Waite[c], Travis S. Schmidt[d], Paul M. Bradley[e], Barbara J. Mahler[f,1], Peter C. Van Metre[f,1]

Potential Ecotoxicity to Invertebrates and Management Implications

- Invertebrates at **most of the sites** (23/32; 72%) were **potentially at risk to chronic exposure** from pesticide mixtures
  - ***Imidacloprid, fipronil**, and bifenthrin
  - Three sites had an invertebrate **acute toxicity** quotient **greater than 1**

- **Impaired streams** that lack healthy invertebrate communities **require management plans** to improve conditions
  - Implementation plans that **do not address pesticide** contamination **may fall short** of efforts to remediate invertebrate communities

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Pesticides and PFAS Often Present in Mixtures

- **PFAS are added** directly and indirectly **to pesticides**

Forever Pesticides: A Growing Source of PFAS Contamination in the Environment

Nathan Donley,[1] Caroline Cox,[2] Kyla Bennett,[3] Alexis M. Temkin,[4] David Q. Andrews,[4] and Olga V. Naidenko[4]

[1]Center for Biological Diversity, Portland, Oregon, USA
[2]Center for Environmental Health (retired), Oakland, California, USA
[3]Public Employees for Environmental Responsibility, Silver Spring, Maryland, USA
[4]Environmental Working Group, Washington, District of Columbia, USA

EPA United States Environmental Protection Agency

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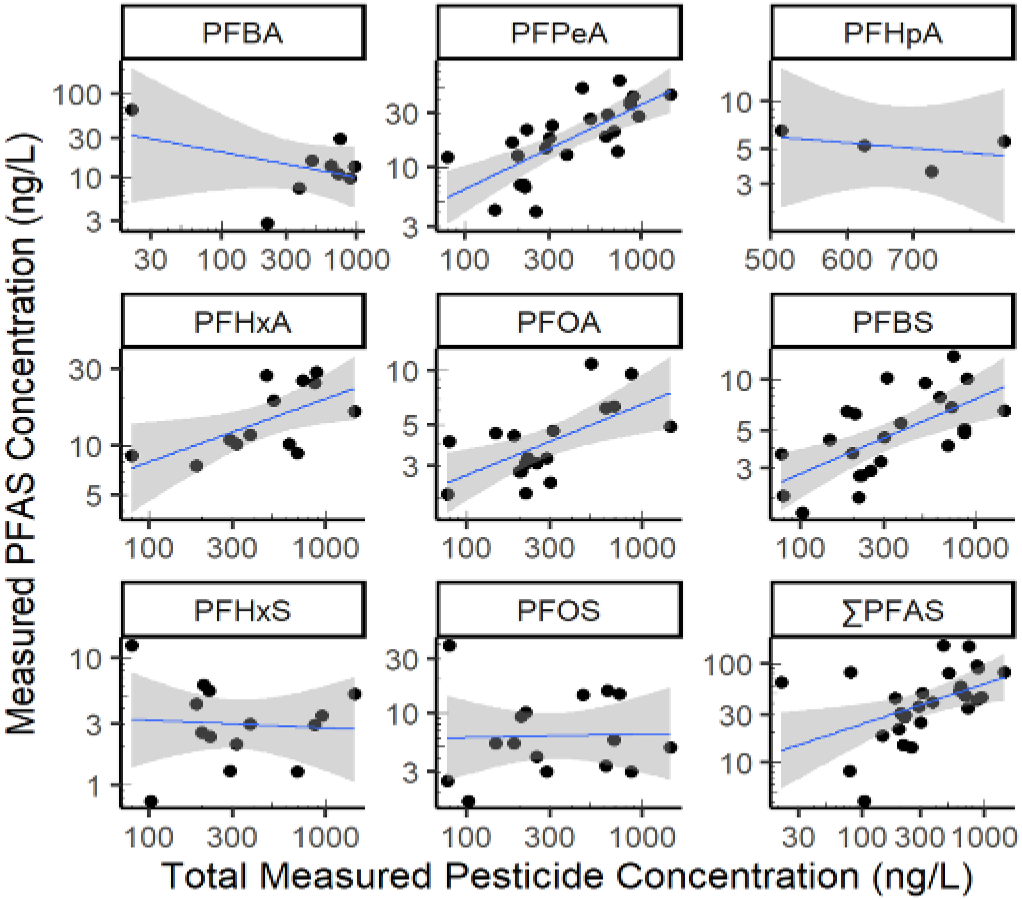
Per- and Polyfluoroalkyl Substances (PFAS) in Pesticide and Other Packaging

As part of EPA's extensive efforts to address PFAS, the Agency continues to make information available about EPA testing showing PFAS contamination from certain fluorinated containers.

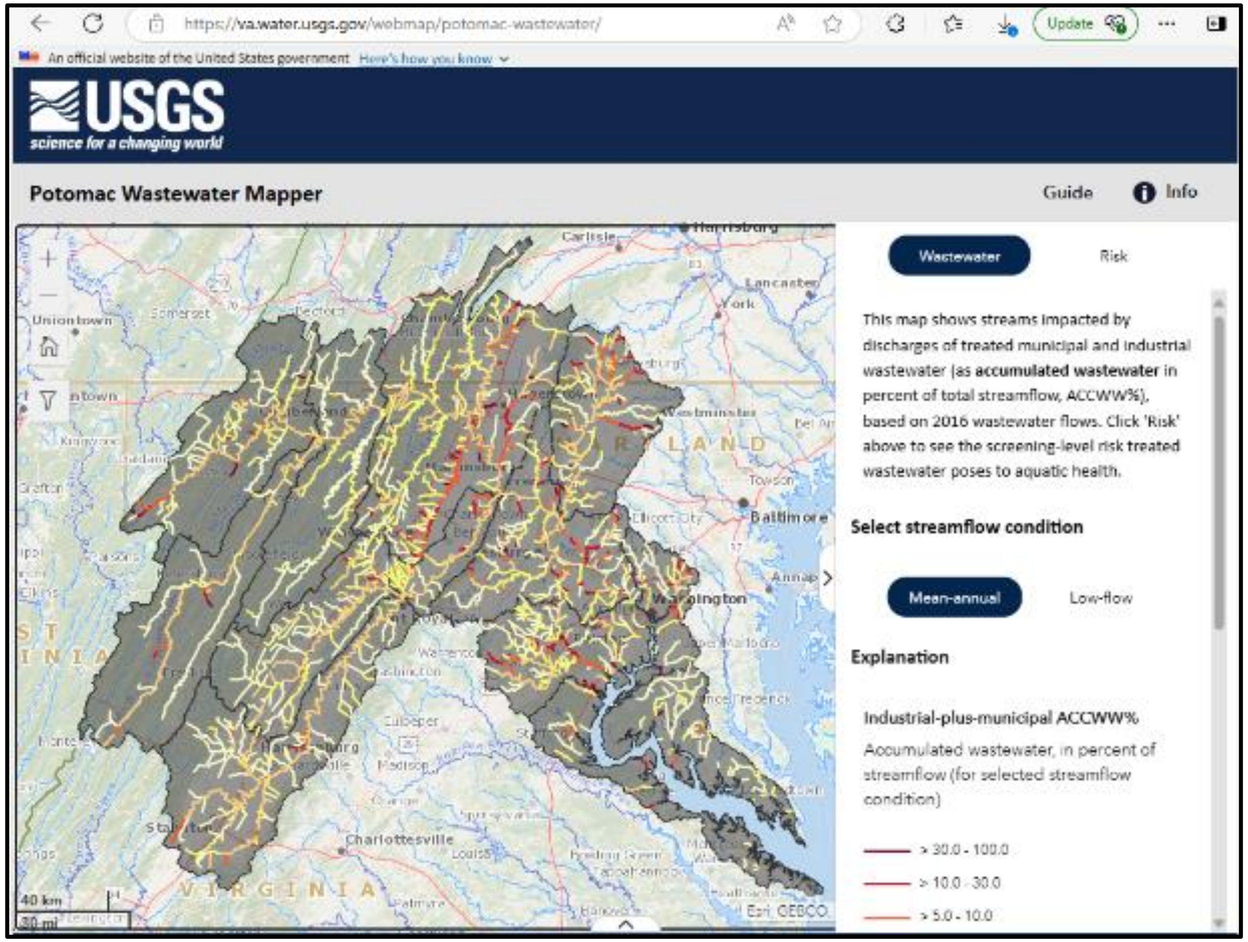
While the Agency continues to investigate and assess potential impacts on health or the environment, the affected pesticide manufacturer has voluntarily stopped shipment of any products in fluorinated high-density polyethylene (HDPE) containers.


Edwin Remsberg / Maryland Department of Agriculture


Adobe Stock



USGS Accumulated Wastewater Research in the Potomac River Basin



Environmental Science & Technology
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Municipal and Industrial Wastewater Treatment Plant Effluent Contributions to Per- and Polyfluoroalkyl Substances in the Potomac River: A Basin-Scale Measuring and Modeling Approach

Larry B. Barber,* Samuel A. Miller, Lee Blaney, Paul M. Bradley, Kaycee E. Faunce, Jacob A. Fleck, Malinda Frick, Ke He, Ryan D. Hollins, Conor J. Lewellyn, Emily H. Majcher, Mitchell A. McAdoo, and Kelly L. Smalling

Contents lists available at ScienceDirect
Science of the Total Environment
journal homepage: www.elsevier.com/locate/scitotenv
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Factors contributing to pesticide contamination in riverine systems: The role of wastewater and landscape sources

Samuel A. Miller[a,*], Kaycee E. Faunce[a], Larry B. Barber[b], Jacob A. Fleck[c], Daniel W. Burns[a], Jeramy R. Jasmann[b], Michelle L. Hladik[c]

AMERICAN WATER RESOURCES ASSOCIATION
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RESEARCH ARTICLE

Wastewater reuse and predicted ecological risk posed by contaminant mixtures in Potomac River watershed streams

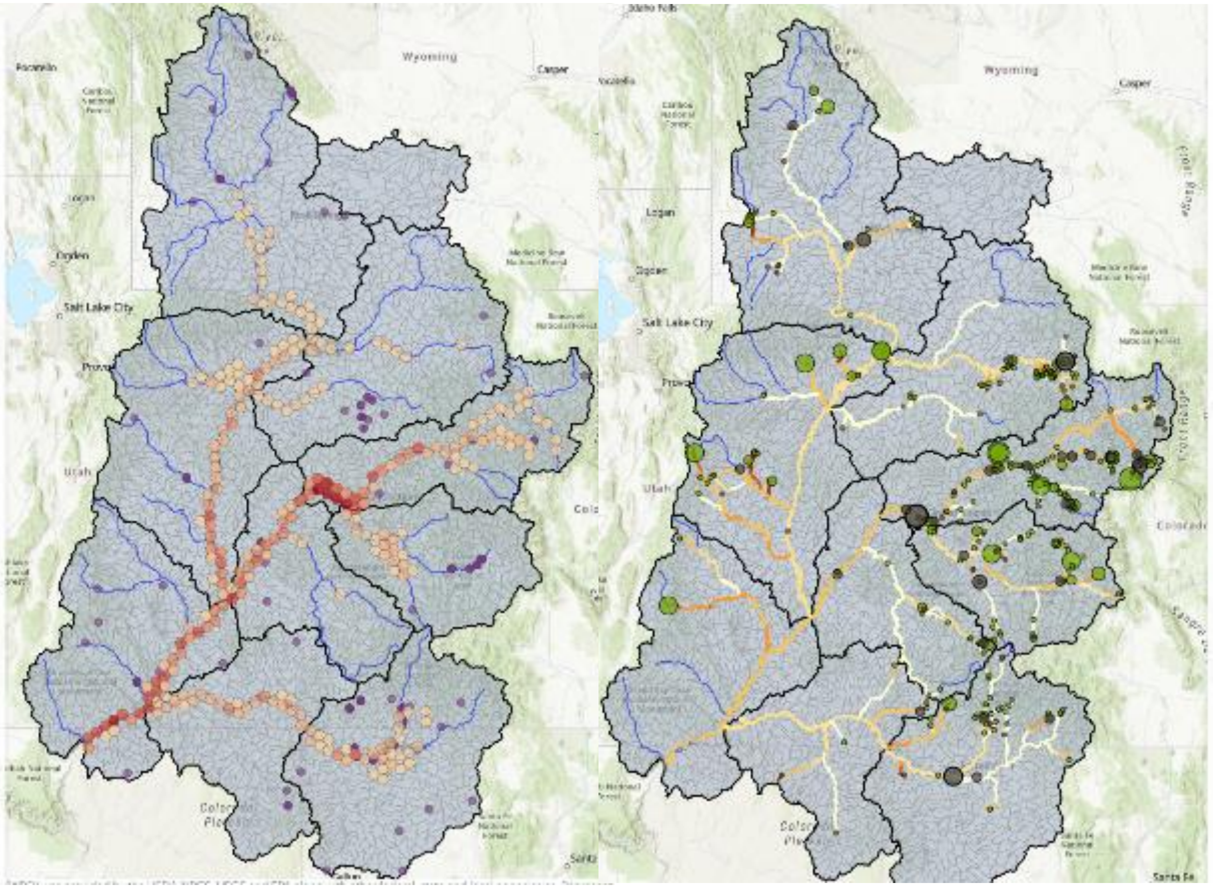
Kaycee E. Faunce[1] | Larry B. Barber[2] | Steffanie H. Keefe[2] | Jeramy R. Jasmann[2] | Jennifer L. Rapp[3]

Presumptive Sources of PFAS: Upper Colorado River Basin

- Easily transferable to any watershed as a screening tool to assess potential risk
- These tools were recently applied in the Upper Colorado River Basin
  - https://geonarrative.usgs.gov/ucolpfas/

Geospatial PFAS Vulnerability Tool

The MITRE Corporation developed the Water Sensing and Hydrology for Environmental Decision Support (WaterSHEDs[1]) model to assess potential landscape sources of PFAS that may play a role in contamination of U.S. surface



PFAS Sources: Wastewater Reuse

Reuse of treated municipal wastewater from publicly owned treatment works (POTWs) and non-POTWs is a contributing source of surface water supply across the U.S.[1] The higher the percentage of wastewater in streams, the higher the concentrations of contaminants of concern such as PFAS.

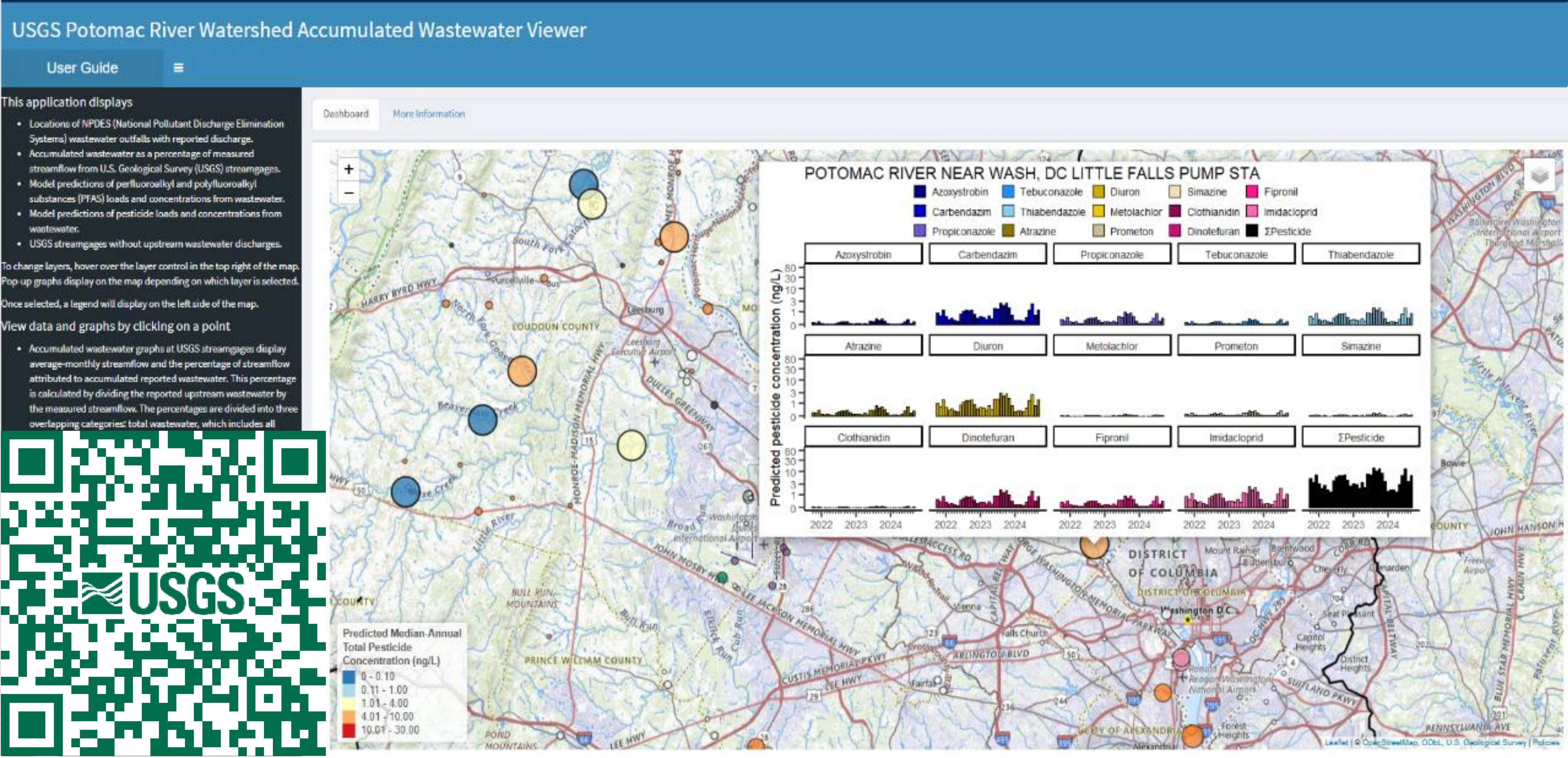
The USGS accumulated wastewater model (ACCWW)[2] used municipal and select industrial WWTP discharge data and PFAS loading factors to calculate predicted environmental concentrations (PECs) for eight PFAS commonly detected in municipal WWTP effluents for every stream reach in the UCOL. These results identified stream segments with potential for PFAS contamination[1,3].

ⓘ **Click here** to add PECs (2020) to the map of municipal and industrial WWTP locations and downstream ACCWW. This layer highlights concentrations of two (perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS)) of the eight predicted PFAS concentrations.

Use the **Legend** widget at the bottom left to view layer symbology and the +/ buttons at the bottom right to zoom in and out.

[1]Barber and others, 2025: *Municipal and Industrial Wastewater Treatment Plant Effluent Contributions to Per- and Polyfluoroalkyl*

https://rconnect.usgs.gov/potomac-accumulated-wastewater/



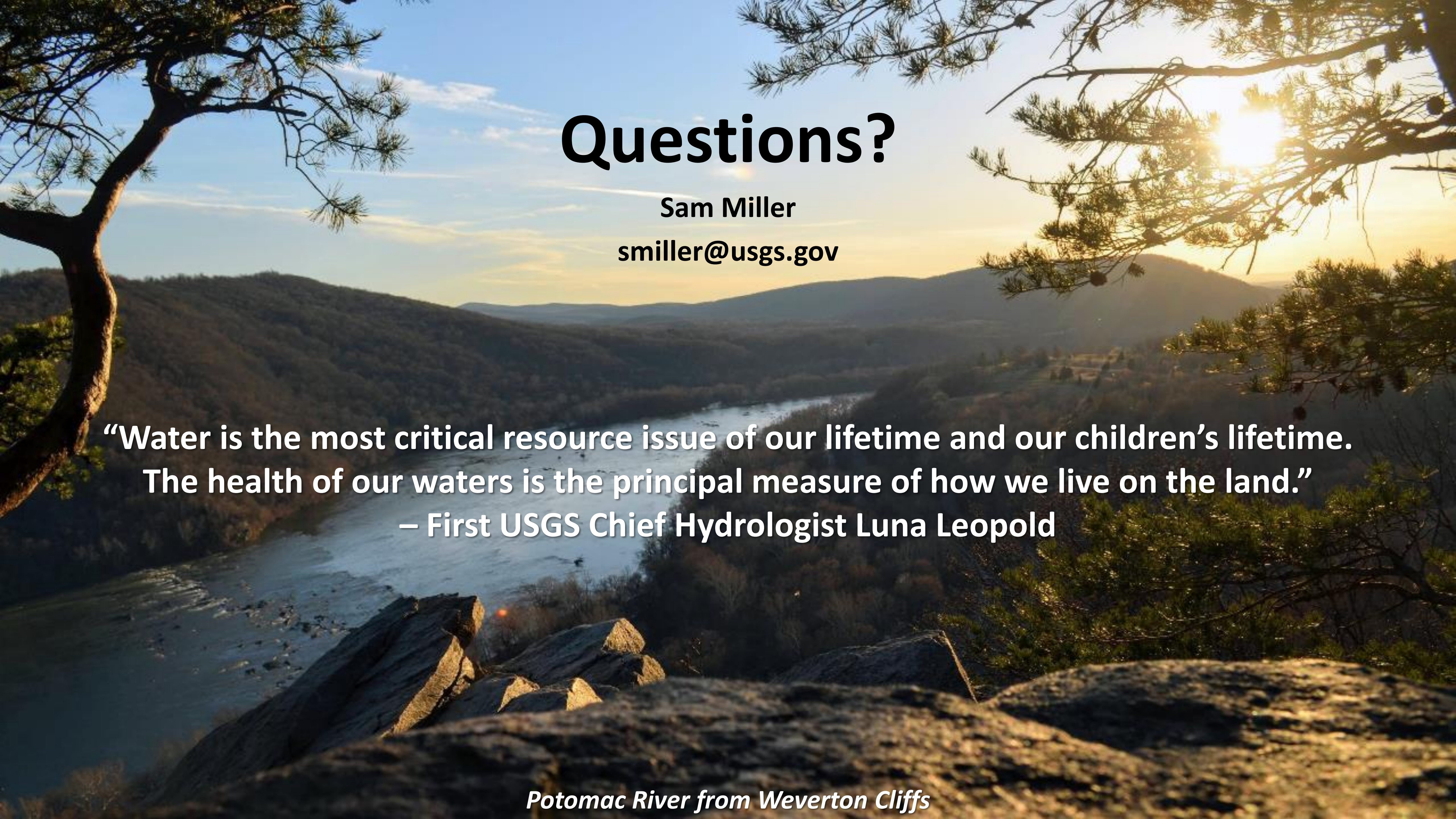
Questions?

Sam Miller

smiller@usgs.gov

"Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land."

– First USGS Chief Hydrologist Luna Leopold



Potomac River from Weverton Cliffs

https://rconnect.usgs.gov/potomac-accumulated-wastewater/

USGS Potomac River Watershed Accumulated Wastewater Viewer

User Guide ≡

Dashboard | More Information

These data and application are provided as part of USGS research on contaminants in surface waters across the United States and supported by the USGS Water Mission Area Proxies Project and the USGS Ecosystem Mission Area Environmental Health Program (Toxic Substances Hydrology)

The datasets used in the accumulated wastewater dashboard (Miller and others, 2025) were obtained from USGS and the United States Environmental Protection Agency (USEPA). Streamflow data were downloaded from the USGS National Water Information System (NWIS), while wastewater flow data were sourced from discharge monitoring reports (DMRs) obtained through the National Pollutant Discharge Elimination System (NPDES) permits via the Integrated Compliance Information System National Pollutant Discharge Elimination System (ICIS-NPDES). These datasets span water years 2022 through 2024 (October 1, 2021 through September 30, 2024).

In an attempt to ensure the accuracy and reliability of the DMR data included in the dashboard, a series of quality assurance steps were implemented. These steps involved filtering and validating the data to exclude duplicates, correcting erroneous values, and ensuring proper assignments of monitoring locations to stream segments. Some sites in the web tool display accumulated wastewater percentages greater than 100% as a result of data inputs from ICIS-NPDES and specific geographic situations (e.g. dams); some erroneous data may still be present. For a comprehensive overview of the quality assurance procedures and detailed methodologies followed in this process, please refer to the data release documentation where you can access the raw data represented on the map (Miller and others, 2025). This reference provides in-depth insights into the quality assurance measures taken to ensure the integrity of the data presented in the dashboard.

Accumulated wastewater calculations and PFAS and pesticide predictions follow similar methods outlined in accumulated wastewater models developed by Barber and others (2025) and Miller and others (2024). These models predict concentrations and loads solely from wastewater (i.e. point sources) and do not account for potential non-point sources of PFAS or pesticides. Eight PFAS (perfluorobutanoate [PFBA], perfluoropentanoate [PFPeA], perfluorohexanoate [PFHxA], perfluoroheptanoate [PFHpA], perfluorooctanoate [PFOA], perfluorobutane sulfonate [PFBS], perfluorohexane sulfonate [PFHxS], and perfluorooctane sulfonate [PFOS]) and fourteen pesticides (five fungicides: azoxystrobin, carbendazim, propiconazole, tebuconazole, and thiabendazole; five herbicides: atrazine, diuron, metolachlor, prometon, and simazine; four insecticides: clothianidin, dinotefuran, fipronil, and imidacloprid) are predicted from these models; however other PFAS or pesticides may be present in wastewater. Monthly PFAS loads were computed by multiplying the reported discharge volumes from municipal and industrial wastewater treatment plants (WWTPs) that may handle PFAS by the median wastewater effluent PFAS concentrations measured and reported in Barber and others (2025). Monthly pesticide loads were calculated by multiplying the discharge volumes from municipal WWTPs by the median wastewater effluent pesticide concentrations reported in Miller and others (2024). Predicted monthly concentrations of PFAS and pesticides from wastewater were calculated by dividing the predicted monthly load by the measured monthly streamflow at each streamgage.

For help or questions, please contact Sam Miller (smiller@usgs.gov) and Larry Barber (lbbarber@usgs.gov)

Links and Additional Resources

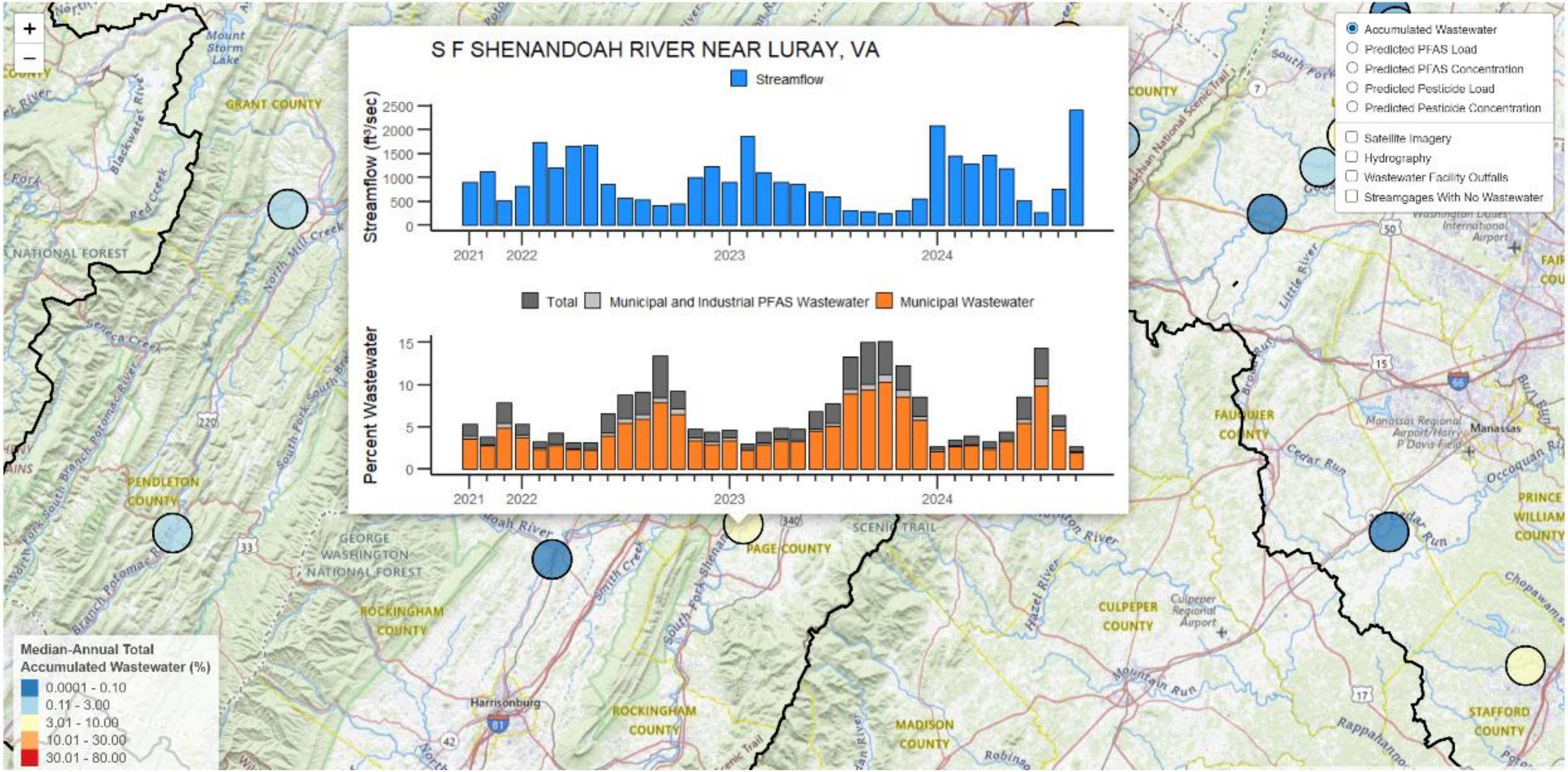
Barber L.B., Miller, S.A., Blaney, L., Bradley, P.M., Faunce, K.E., Fleck, J.A., Frick, M., He, K., Hollins, R.D., Lewellyn, C.J., Majcher, E.H., McAdoo, M.A., Smalling, K.L. 2025. Municipal and Industrial Wastewater Treatment Plant Effluent Contributions to Per- and Polyfluoroalkyl Substances in the Potomac River: A Basin-Scale Modeling and Measuring Approach. Environmental Science & Technology. https://doi.org/10.1021/acs.est.4c12167

Miller, S.A., Faunce, K.E., Barber, L.B., Fleck, J.A., Burns, D.W., Jasmann, J.J., and Hladik, M.L. 2024. Factors contributing to pesticide contamination in riverine systems: The role of wastewater and landscape sources. Science of The Total Environment. Volume 954. https://doi.org/10.1016/j.scitotenv.2024.174939.

Miller, S.A., Barber, L.B., Faunce, K.E., Gordon, S.E., and Williams, B.M., 2025, Data for the Potomac River Watershed Accumulated Wastewater Viewer: U.S. Geological Survey data release, https://doi.org/10.5066/P134KYMX.

Dashboard More Information

https://rconnect.usgs.gov/potomac-accumulated-wastewater/



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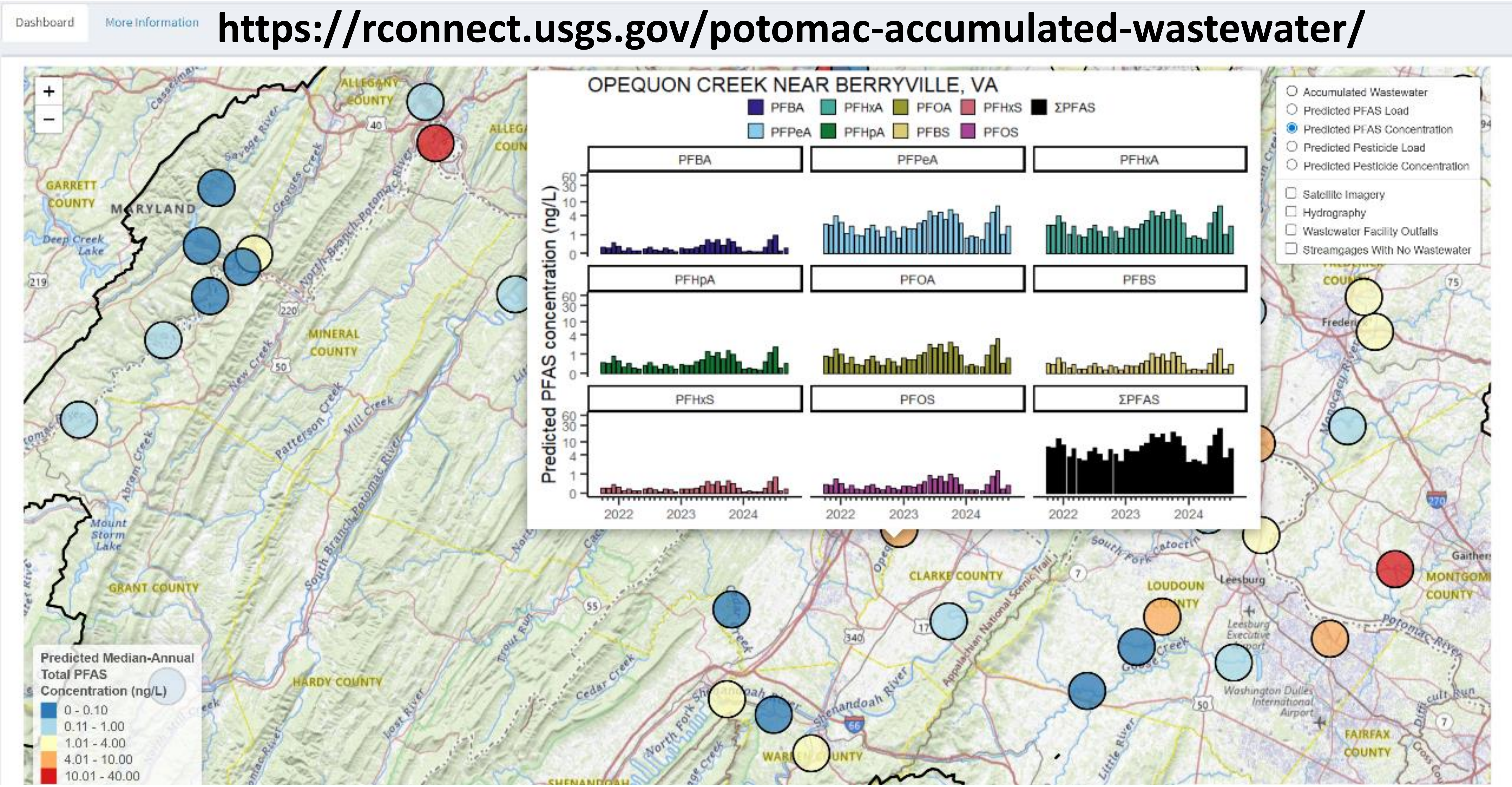

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