The Environmental Occurrence of Per- and Polyfluoroalkyl Substances (PFAS) in Virginia - Where should This Never Ending (Forever) Battle Begin/End?

Kang Xia
Ava Divita
School of Plant and Environmental Sciences
Kathleen Hohweiler
Leigh Anne Krometis
Erin Ling
David Sample
Department of Biological Systems Engineering
Wendy Stout
Virginia Tech Coastal Collaborator Center
Stephen Schoenholtz
Virginia Water Resources Research Center

Savanna Blackburn
Michael Harrison
Hampton Rd AREC
Virginia Tech

Citizen Scientists
Rockbridge Conservation (RACC), Virginia
Malcolm Taylor
Washington Suburban Sanitary Commission
Mid-Atlantic Biosolids Association

Contact: kxia@vt.edu

Exactly how many compounds are we talking about?

2020:

> 200 uses for > 1,400 PFAS

(Glüge et al., 2020. Environ. Sci.: Processes & Impacts 22 (12):2345-2373)

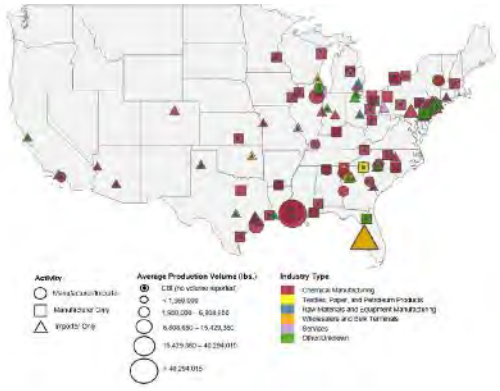
2023:

Out of 16,229 PFAS currently identified, 863 have reported use or detection in consumer products—either intentionally for their functional use—or as a byproduct, contaminant, or impurity from the manufacturing process.

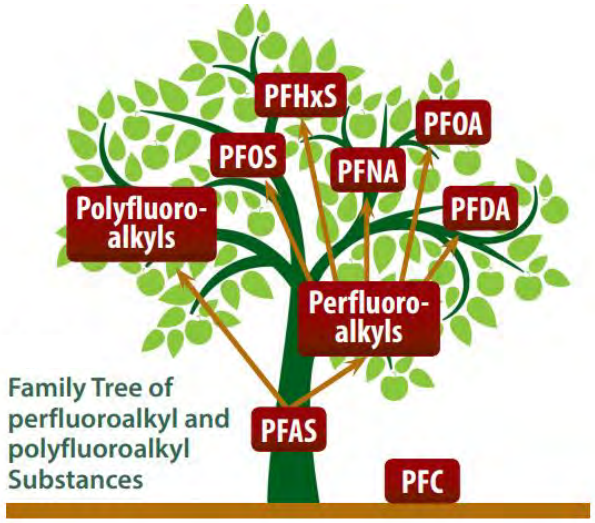
https://www.cpsc.gov/content/CPSC-PFAS-WhitePaper

Consumer Product Safety Commission Final White Paper June 20 2023

- US manufactures or imports > 2.5 billion pounds of PFAS/year



Fast growing PFAS tree!



We can't cut it down fast enough!

2016:

- PFOA, PFOS for CCL4 for public drinking water systems
- EPA LHAL: 70 ppt, PFOA, PFOS or PFOA+PFOS

2021:

- 18 PFAS for CCL5
- 29 PFAS for UCMR 5

2020:

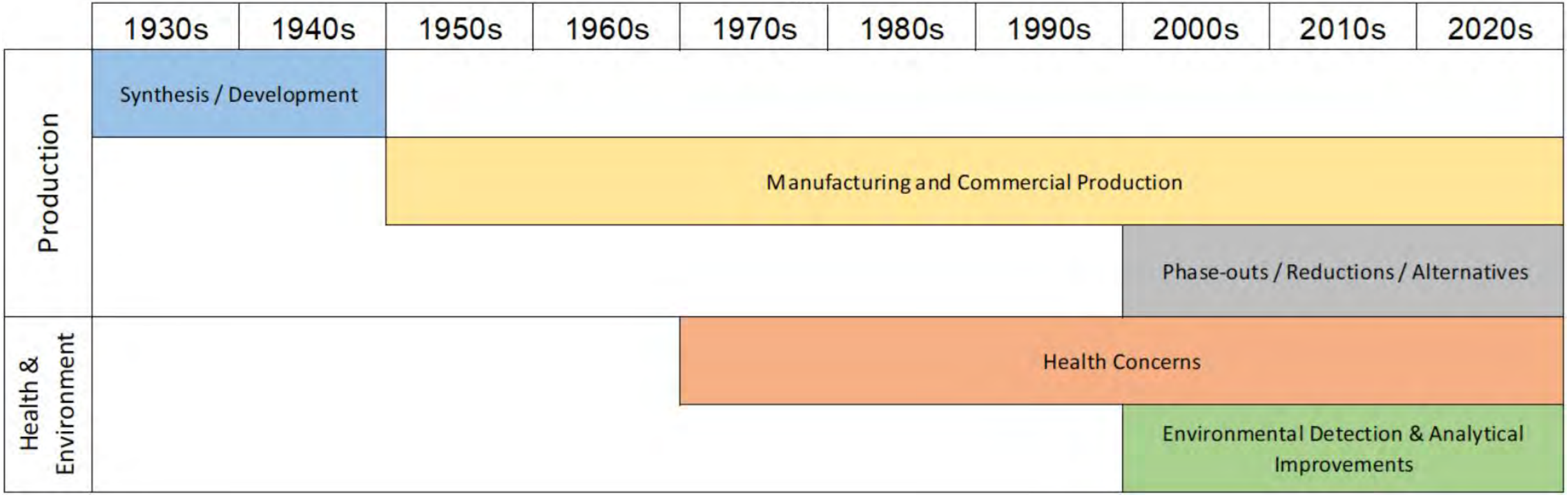
Jan. 3 2020

Bernie Sanders says he'd set federal standards for PFAS in drinking water

Jan. 10 2020

The House just voted to regulate PFAS. Here's what you need to know

PFAS timeline



(*https://pfas-1.itrcweb.org/about-itrc/*)

June 15 2022:

EPA interim updated health advisory levels:

- Interim updated health advisory for PFOA = 0.004 ppt
- Interim updated health advisory for PFOS = 0.02 ppt
- Health advisory for GenX chemicals = 10 ppt
- Health advisory for PFBS = 2,000 ppt

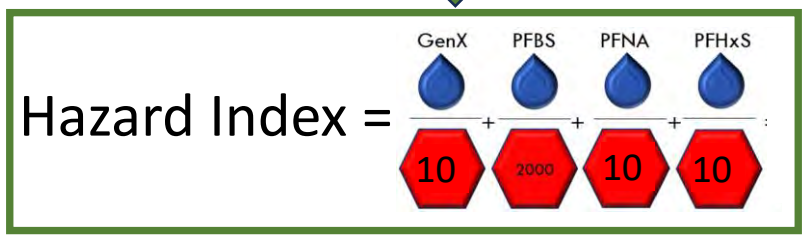
https://www.epa.gov/system/files/documents/2022-06/drinking-water-ha-pfas-factsheet-communities.pdf

EPA's Proposed Action for the PFAS NPDWR (Mar 29 2023)

First-Ever National Drinking Water Standard for PFAS

April 10 2024

Chemical	Maximum Contaminant Level Goal (MCLG)	Maximum Contaminant Level (MCL)
PFOA	0	4.0 ppt
PFOS	0	4.0 ppt
PFNA	10 ppt	10 ppt
PFHxS	10 ppt	10 ppt
HFPO-DA (GenX chemicals)	10 ppt	10 ppt
Mixture of two or more: PFNA, PFHxS, HFPO-DA, and PFBS	Hazard Index of 1	Hazard Index of 1



https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas#Summary

First-Ever National Drinking Water Standard for PFAS

Implementation: Timeframes for Water Systems

Within **three years** of rule promulgation (2024 – 2027):

- Initial monitoring must be complete

Starting **three years** following rule promulgation (2027 – 2029):

- Results of initial monitoring must be included in Consumer Confidence Reports (i.e., Annual Water Quality Report)
- Regular monitoring for compliance must begin, and results of compliance monitoring must be included in Consumer Confidence Reports
- Public notification for monitoring and testing violations

Starting **five years** following rule promulgation (starting 2029)

- Comply with all MCLs
- Public notification for MCL violations

Finalizes Critical Rule to Clean up PFAS Contamination to Protect Public Health

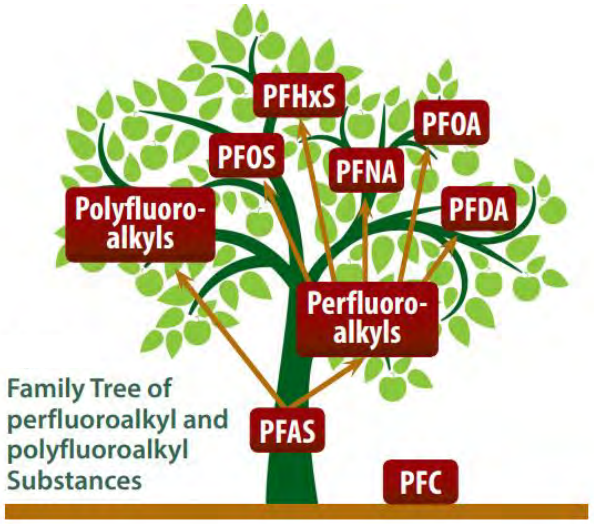
PFOA, PFOS

EPA action designates two widely used PFAS as hazardous substances under the Superfund law, improving transparency and accountability to clean up PFAS contamination in communities

April 19 2024

https://www.epa.gov/newsreleases/biden-harris-administration-finalizes-critical-rule-clean-pfas-contamination-protect

Current EPA analytical methods detect 40 PFAS



Testing PFAS requires expensive, sensitive analytical instrument and skilled analyst!

Current PFAS-Related Projects at VT:

Characterizing prevalence and risk factors of PFAS in rural private water supplies. ***USGS***

Understanding the Prevalence, Transport, and Biogeochemical Transformations of Contaminants of Emerging Concern (CECs) Across Watersheds with Socioeconomic Disadvantaged Urban Communities. ***National Sea Grant***.

Review and assess the state of PFAS science in agriculture to improve knowledge and understanding of agricultural PFAS issues and conduct a suite of PFAS research projects to inform NRCS activities. ***NRCS***

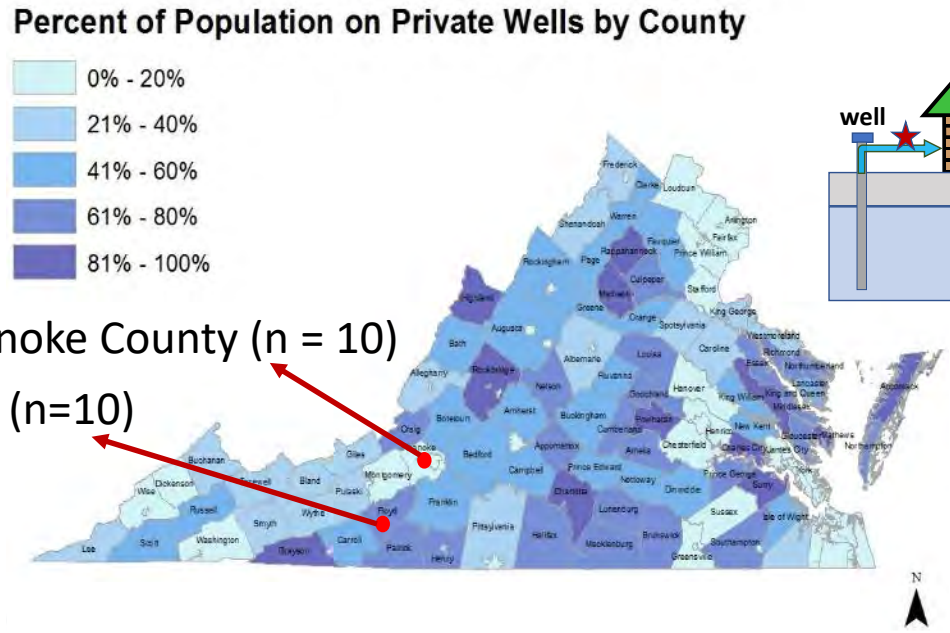
Enhanced Aquifer Recharge Performance and Potential Risk in Different Regional and Hydrogeologic Settings. ***EPA***

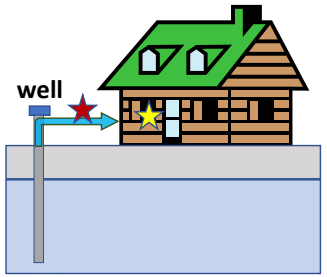
Characterizing prevalence of PFAS in rural private water supplies *USGS*

Leigh Anne Krometis, Erin Ling, Kathleen Hohweiler, BSE***; Kang Xia,*** SPES

Virginia Household Water Quality Program

Virginia Cooperative Extension
Virginia Tech • Virginia State University





Hohweiler et al. 2024. Sci. Total Environ. 929: 172539

Method reporting limits (30 PFAS tested):

0.015 - 0.426 ppt

PFBA	PFPeA	HFPO-DA	FBSA	L-PFBS	PFHxA	4:2FTS	L-PFPeS	PFHpA	DONA
0.096	0.426	0.06	0.06	0.054	0.198	0.06	0.06	0.03	0.036

FHxSA	PFHxS	PFOA	6:2FTS	L-PFHpS	PFNA	FOSA	PFOS	PFDA	8:2FTS
0.015	0.06	0.354	0.06	0.06	0.06	0.06	0.06	0.06	0.06

9Cl-PF3ONS	L-PFNS	PFUdA	N-MeFOSAA	N-EtFOSAA	L-PFDS	PFDoA	11Cl-PF3OUdS	PFTrDA	PFTeDA
0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06

PFAS in private well - Key findings:

Did we detect PFAS?

- Yes! 85% of POE and 76% of POU

Comparing to municipal water?

- Higher

Kind of PFAS detected?

- Varies

Source of PFAS in well water?

- Well construction materials?
- Pipes?
- Other?

Comparing to the EPA drinking water standard for PFAS?

- 3/20 houses > PFAS/PFOS limits, 1/20 house > HI limit

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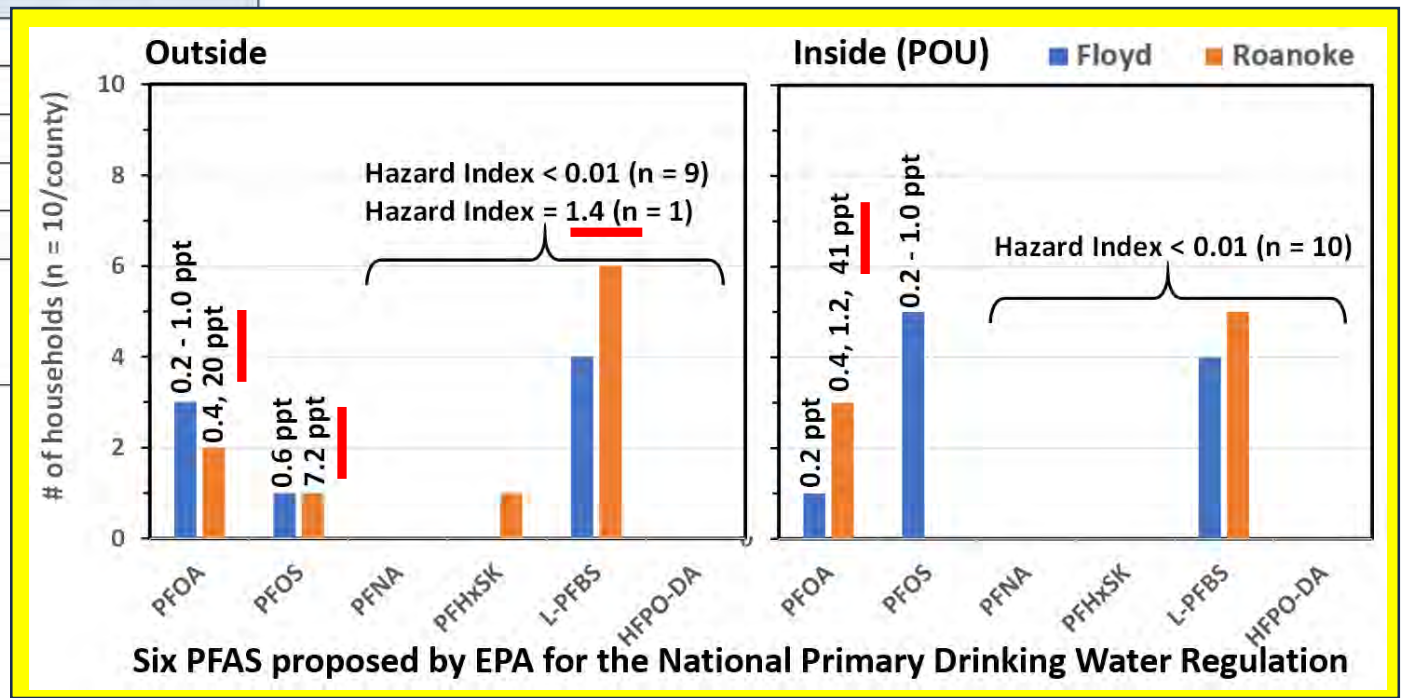


PFAS in:

- **Rural surface water *(NRCS)***
- **Coastal stormwater systems *(SeaGrant)***
- **Mid-Atlantic biosolids *(NRCS)***
- **Soils of pasture lands *(NRCS)***

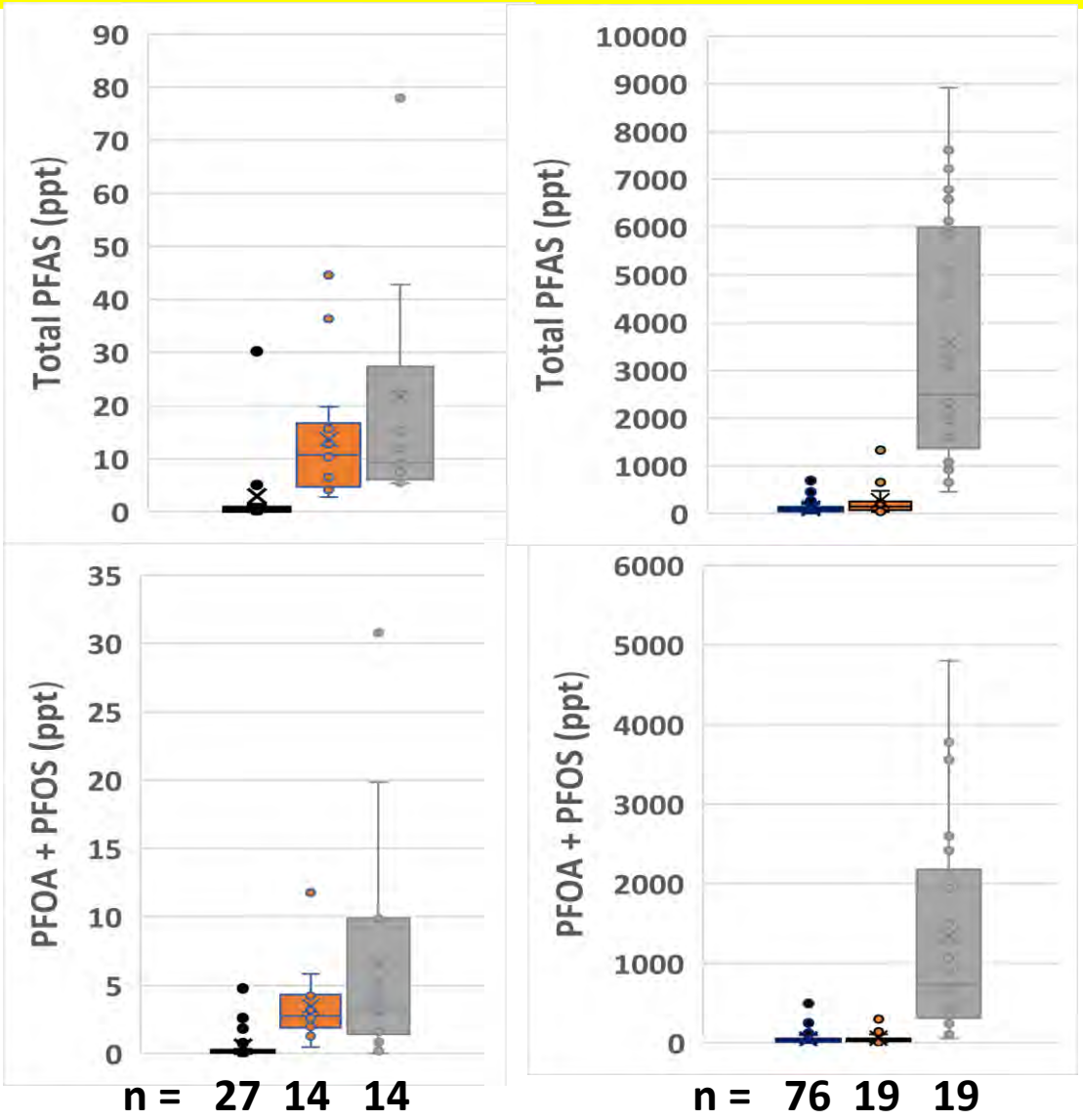
Virginia Tech:

Ava Divita, R. Maguire, & Kang Xia, SPES; ***David Sample***, BSE; Wendy Stout, VT Coastal Collaborator Center; ***Stephen Schoenholtz,*** Water Center; ***Savanna Blackburn & Michael Harrison,*** HRAREC;

Outside Virginia Tech:

Citizen Scientists, Rockbridge Conservation (RACC), Virginia
Malcolm Taylor, Mid-Atlantic Biosolids Association

PFAS in rural surface water and urban stormwater systems – Key findings:



Surface water
Rockbridge County, VA

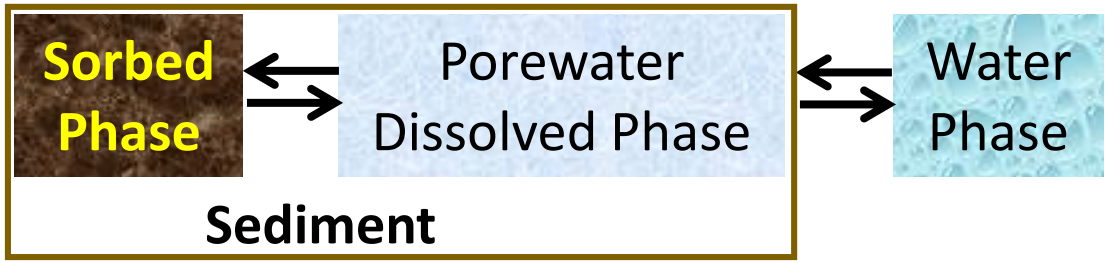
Stormwater systems
four VA coastal urban communities

- Water (ng/L)
- Sediment pore water (ng/L)
- Sediment (ng/kg, air dried basis)

- ~ 100x higher in urban storm water systems than the surface water tested



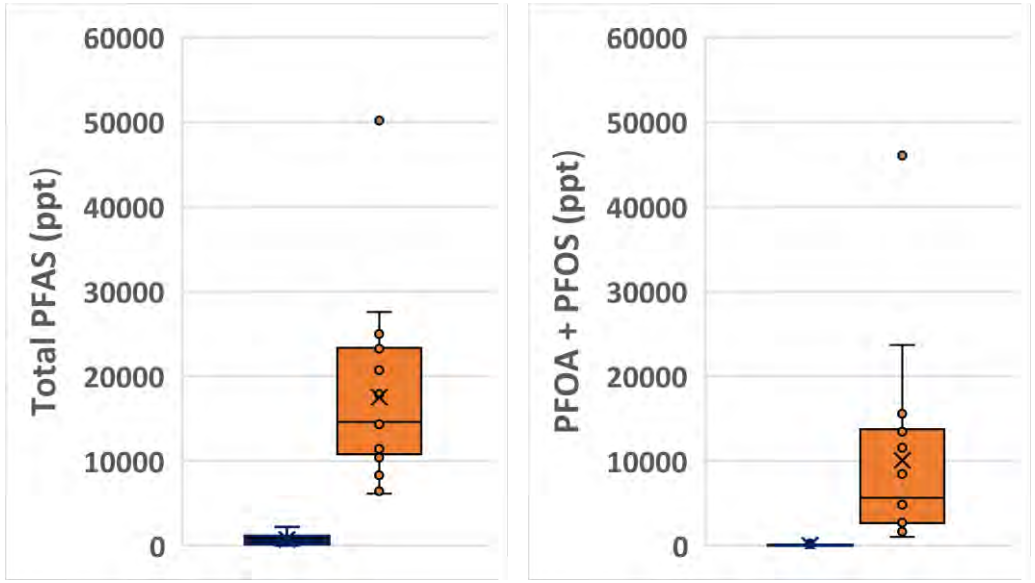
- Sediments are reservoirs for PFAS



PFAS in Mid-Atlantic biosolids – Key findings:

Water-extractable (ng/L, solid/water ratio = 1:5)

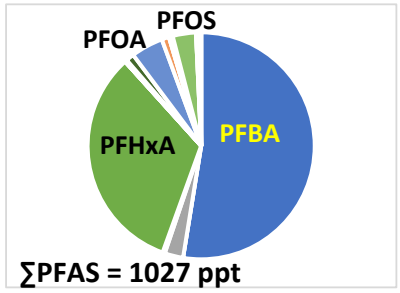
Solid phase (ng/kg, air dried basis)



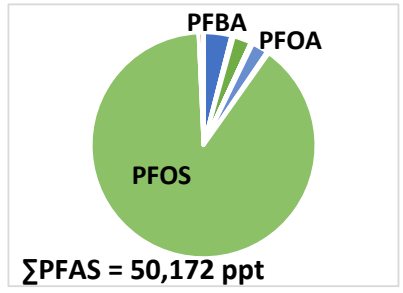
- PFAS in biosolids – varies among WWTPs
- PFAS composition in industrial sourced biosolids is more complex
- Water-extractable PFAS @10's - 1000's ppt
- PFAS in solid phase @ 10's ppb
- 0.4 – 47% of total PFAS in biosolids is water soluble
- 0.2 – 25% of (PFOA+PFOS) in biosolids is water soluble

WWTP #1 – Urban, Thermal hydroysis/ Anaerobic digestion, addition of $FeCl_3$ for P control

Water-extractable



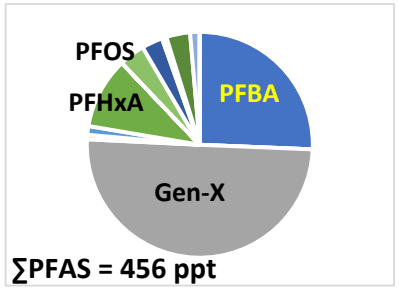
Solid phase



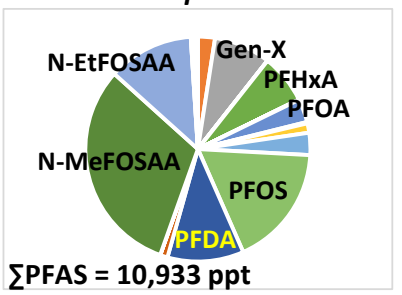
WWTP #2 - Enhanced nutrient removal - no digestion

Industrialized collection area

Water-extractable

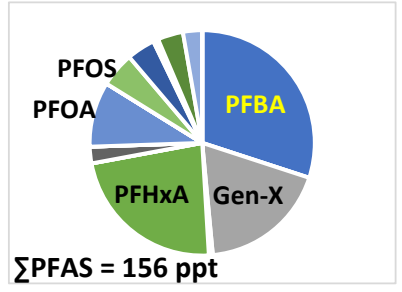


Solid phase

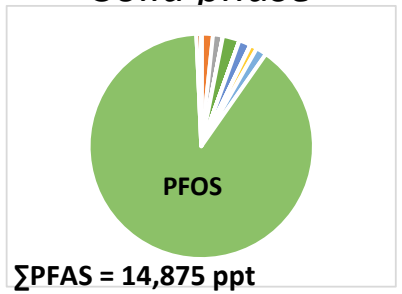


Rural collection area

Water-extractable



Solid phase



PFAS in soils from Virginia pasture fields

Dispatch

America's Dairyland May Have a PFAS Problem

The toxic chemicals have been showing up in milk around the country, prompting midwestern farmers to take a closer look at their land.

https://www.nrdc.org/stories/americas-dairyland-may-have-pfas-problem

'Forever Chemicals' Are Found in Some Milk, Including Organic

A Consumer Reports investigation highlights gaps in how the U.S. tests and regulates PFAS in food

PHOTO ILLUSTRATION: CHRIS GRIGGS/CONSUMER REPORTS, GETTY IMAGES

https://www.consumerreports.org/pfas/pfas-forever-chemicals-found-in-some-milk-including-organic-a1101576034/

npr

HEALTH

PFAS 'forever chemicals' could be contaminating millions of acres of farmland

MARCH 28, 2024 · 4:50 PM ET

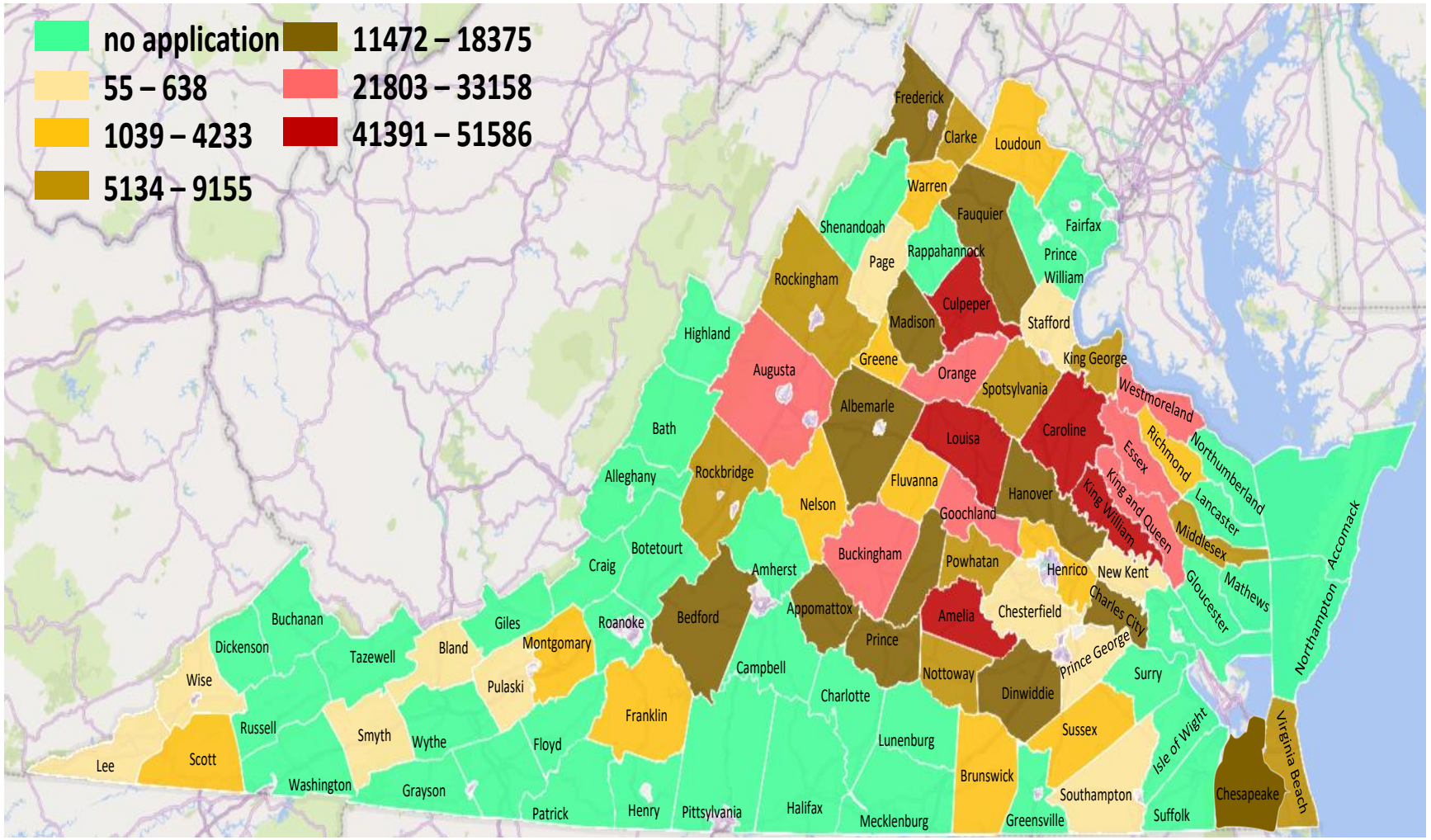
FROM HARVEST PUBLIC MEDIA

HEARD ON ALL THINGS CONSIDERED

By Teresa Homsi

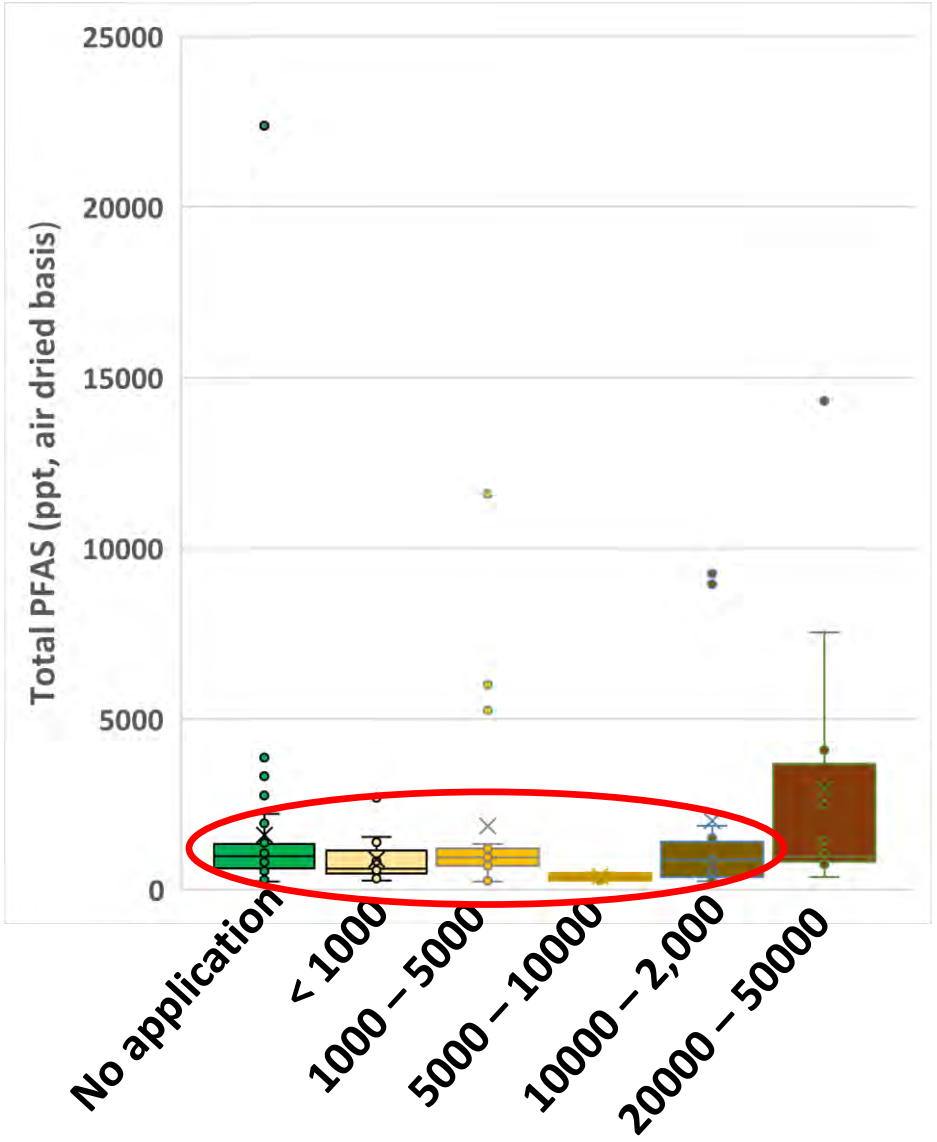
https://www.npr.org/2024/03/28/1241473455/pfas-forever-chemicals-could-be-contaminating-millions-of-acres-of-farmland

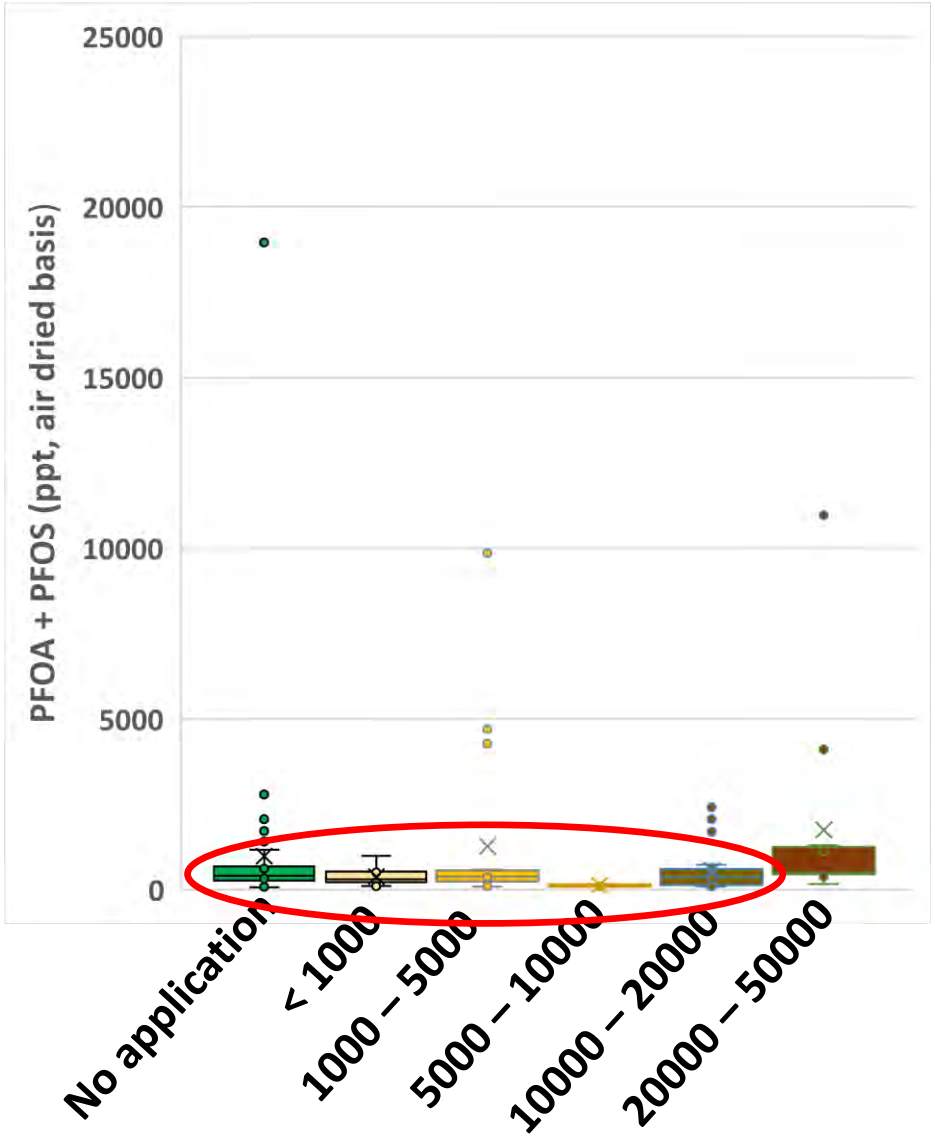
Biosolids land application



- 100 soil samples were randomly selected from the targeted counties where pasture soil samples were submitted to VT's Soil Testing Lab
- Target counties were selected based on their cumulative biosolids application in 2018-2022
- Biosolids application history was unknown for any specific pasture field where the soil samples were collected
- PFAS were tested

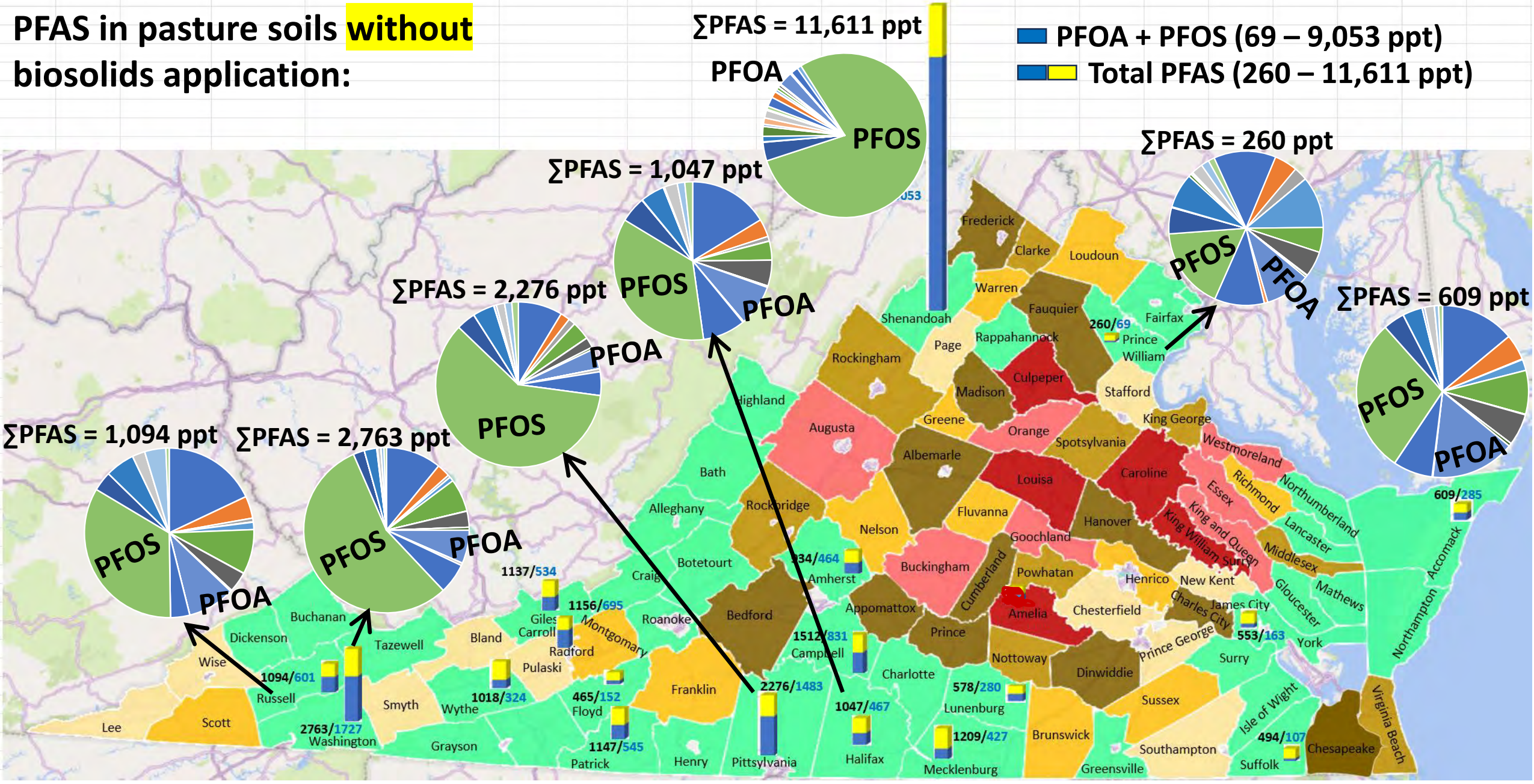
PFAS in soils from Virginia pasture fields – Key findings:





5-year cumulative biosolids application (Ton, 2018 – 2022)

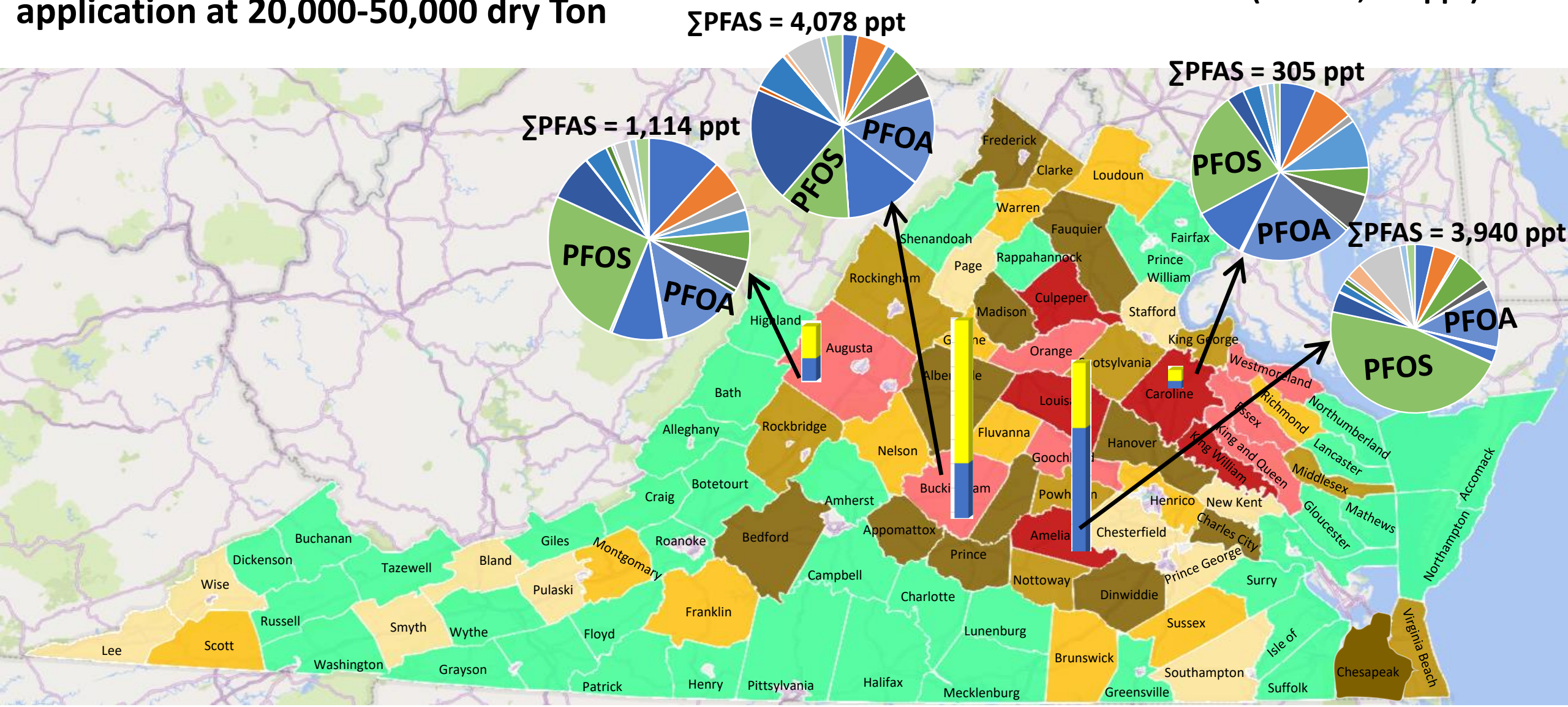
PFAS in pasture soils without biosolids application:



PFAS in pasture soils from counties with 5-year cumulative biosolids application at 20,000-50,000 dry Ton

PFOA + PFOS (158 – 2,604 ppt)

Total PFAS (365 – 4,078 ppt)



npr

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Biosolids land application

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Is land-applied biosolids the only source?

Virginia Law (9VAC25-32-560):
Liquid biosolids shall not be applied at rates exceeding 14,000 gallon (52,996 L)/acre/application

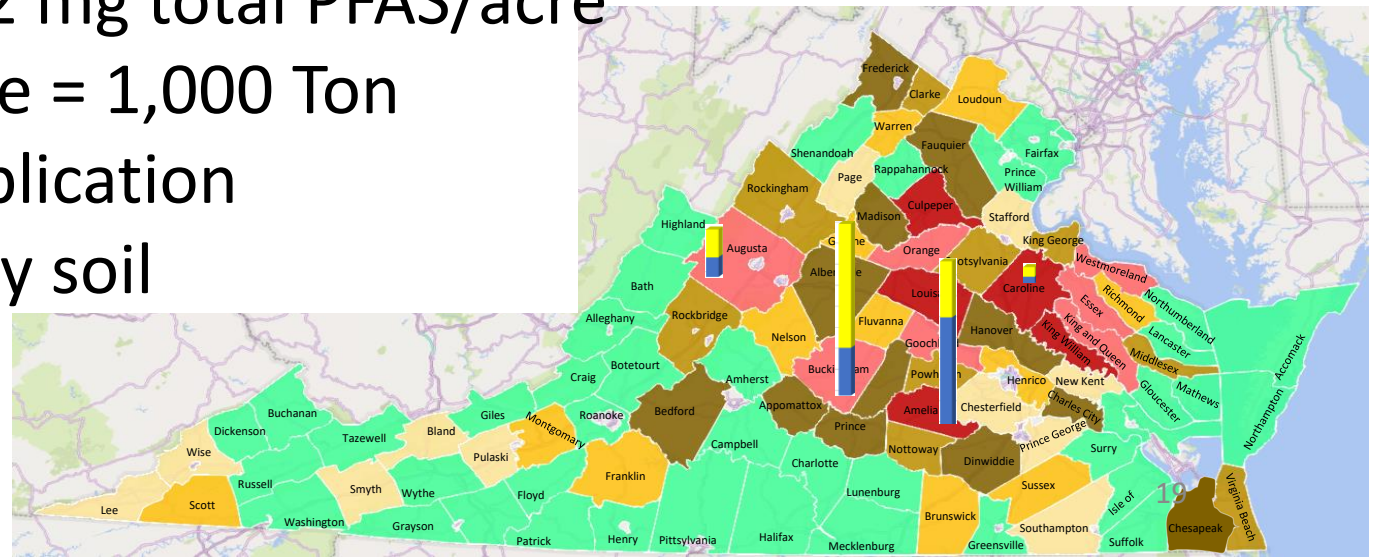
- Highest total PFAS concentration in 18 different liquid mid-Atlantic biosolids: 8,160 ng/L
- 52,996 L/acre x 8,160 ng/L = 432 mg total PFAS/acre
- Dry weight of top 15 cm soil/acre = 1,000 Ton
- 14,000 gallon biosolids/acre/application

  → 432 mg total PFAS/1,000 T dry soil

  = 4.32×10^8 ng/10^6 kg

  = **432 ng/kg (ppt)**

PFOA + PFOS (158 – 2604 ppt)
Total PFAS (365 – 4078 ppt)



What other possible sources for PFAS in Virginia pasture lands?

Water Research 190 (2021) 116685

Contents lists available at ScienceDirect

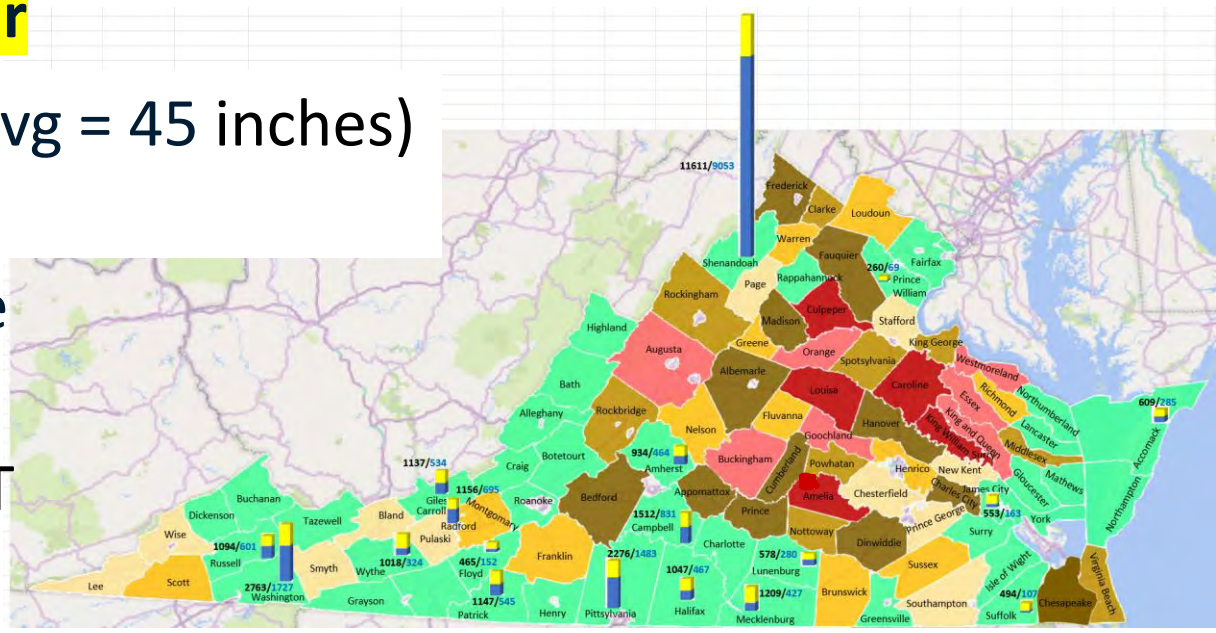
Water Research

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

Correlation Analysis of Perfluoroalkyl Substances in Regional U.S. Precipitation Events

Kyndal A. Pike[a,b,1], Paul L. Edmiston[a], Jillian J. Morrison[b], Jennifer A. Faust[a,*]

- **PFOA + PFOS** = 1.2 – 32 ppt in the **rainwater**
- Annual rainfall in Virginia: 35 – 55 inches (Avg = 45 inches)
- one inch rain/acre = 102,789 L
- Maximum annual (PFOA + PFOS) input/acre = 32 ng/L x 45 x 102,789 L = 148×10^6 ng
- Dry weight of top 15 cm soil/acre = 1,000 T
- 148×10^6 ng /10^6 kg = **148 ng/kg (ppt)**



Next? 2024 – 2026:

→ PFAS in more private **well water**

→ PFAS distribution in Virginia **farm soils**

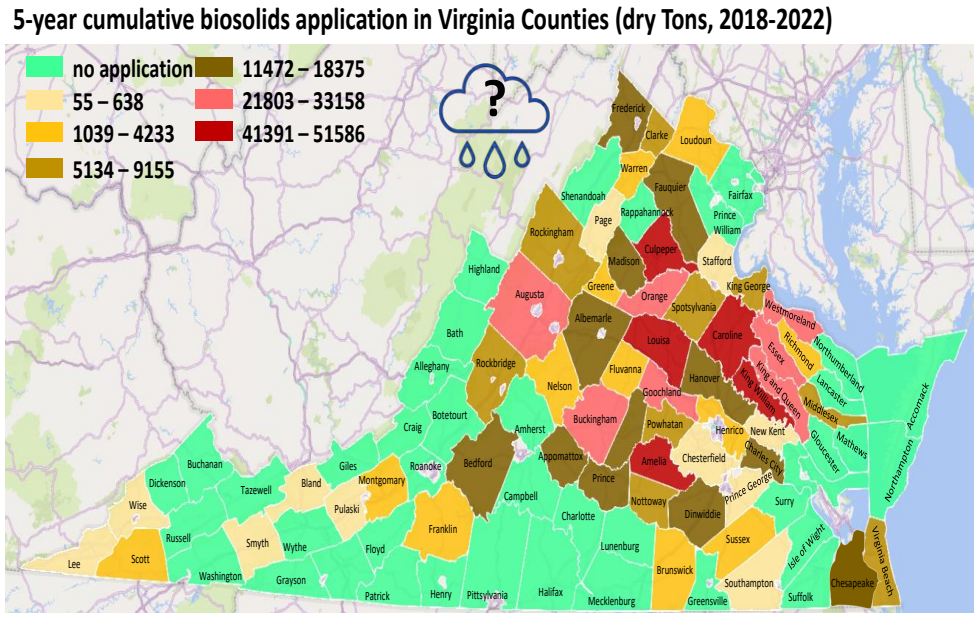
→ PFAS distribution in Virginia **rainwater**

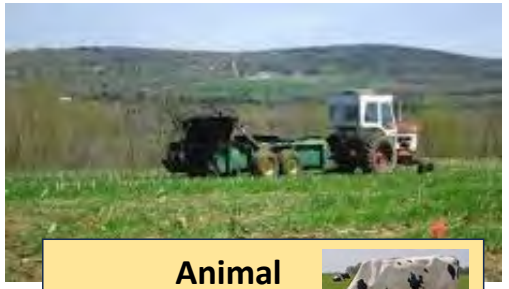
→ fate of PFAS in **biosolids-applied pasture land**

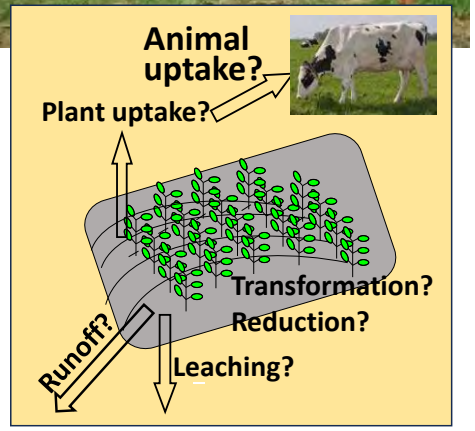
→ PFAS **control strategies** in agroecosystem

→ PFAS in **stormwater systems** of EJ communities

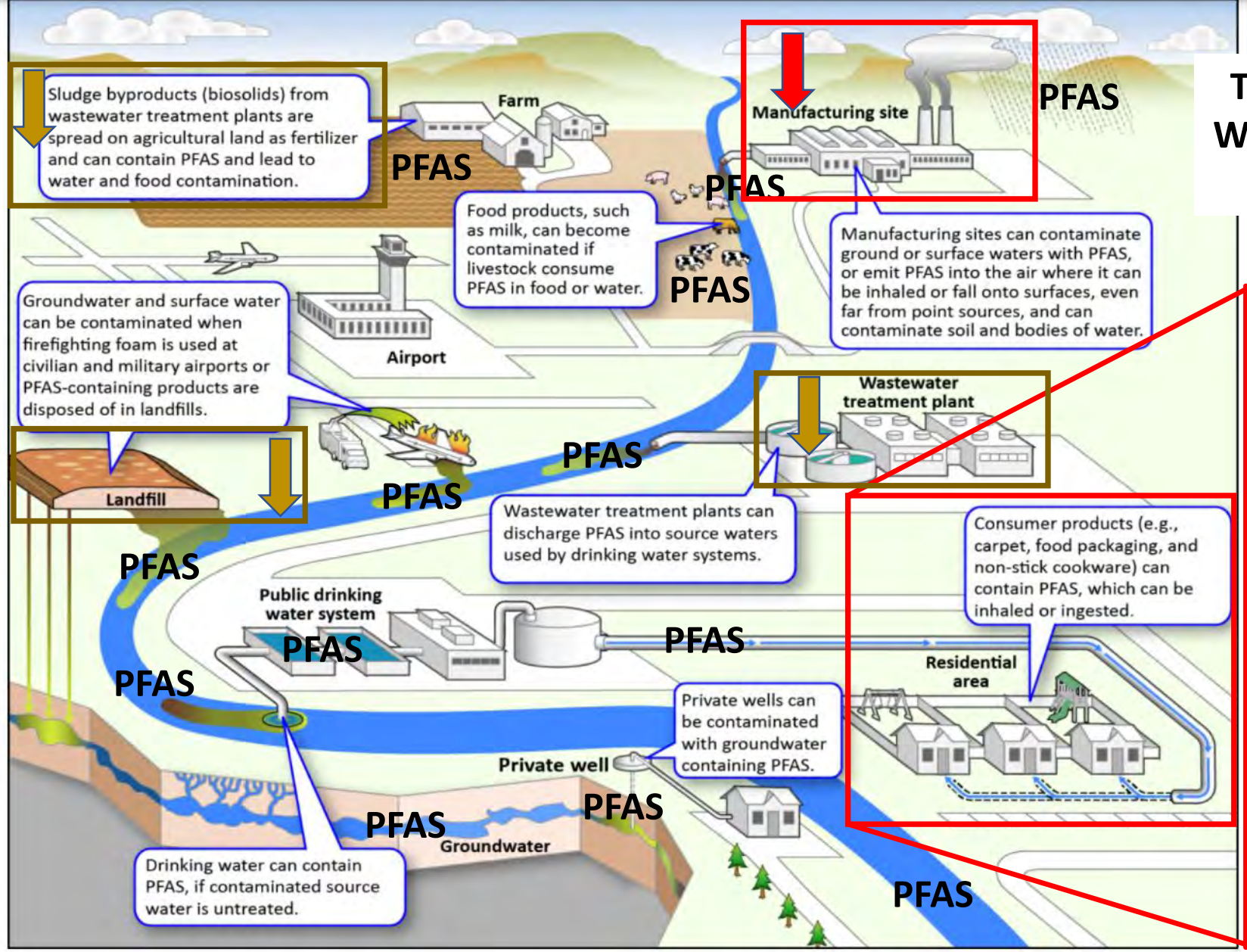
→ **Constructed wetland** to mitigate PFAS in stormwater

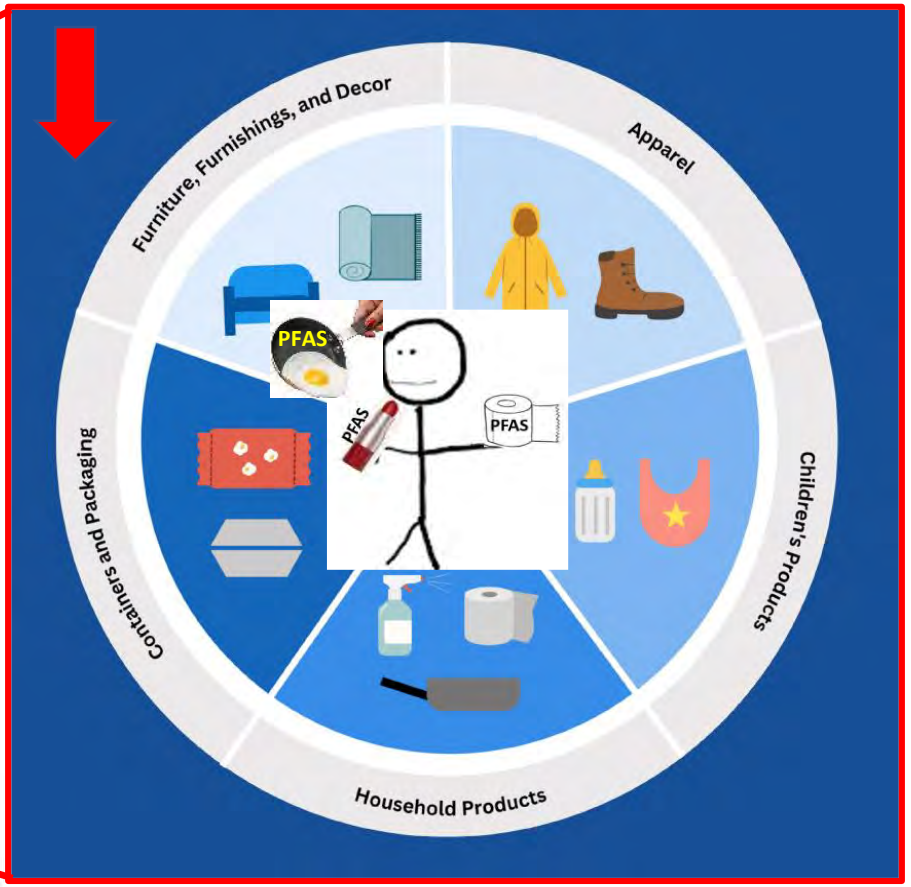






The Environmental Occurrence of PFAS - Where should This Never Ending (Forever) Battle Begin/End?





Possible routes for PFAS release into the environment

(https://www.gao.gov/assets/gao-22-105088.pdf) (https://www.whitehouse.gov/wp-content/uploads/2023/03/OSTP-March-2023-PFAS-Report.pdf)

THANK YOU!!!

All faculty and graduate student collaborators

Undergraduate Research Assistant: Jett Katyama

Special Thanks: Aihua Wang, Asa Spiller, McAlister Council-Troche, Floyd and Roanoke Extension Agents

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USDA NRCS U.S. Department of Agriculture Natural Resources Conservation Service *Grant #NR223A750008C011/G-70444-05*

VT College of Agriculture and Life Sciences Virginia Tech

Virginia Water Resources Research Center at Virginia Tech since 1965

Virginia Household Water Quality Program

Center for Advanced Innovation in Agriculture (CAIA)

Interfaces of Global Change

Thank you!

Questions/Comments?