

# Long-chain PFASs have long half-lives in humans

- Half-lives in humans

- PFOA: 3.8 years
- PFOS: 5.4 years
- PFBS: 4 months



- Toxicokinetic differences for PFOA

- 17-19 days in mice
- 4 hours in female rats



# To protect the public from adverse health effects, health based guidelines have been established

EPA Health Advisory  
(chronic exposure)



PFOS + C8:  
70 ng/L

New Jersey  
guidance level (C8)  
and recommended  
MCL (C9)




C8: 40 ng/L  
C9: 13 ng/L

# Are PFASs a concern in US drinking water?

Six PFASs were included in the third Unregulated Contaminant Monitoring Rule (UCMR3)

Compound	MRL (ng/L)
Perfluoroheptanoic acid (PFHpA, C7)	10
Perfluorooctanoic acid (PFOA, C8)	20
Perfluorononanoic acid (PFNA, C9)	20
Perfluorobutanesulfonic acid (PFBS)	90
Perfluorohexanesulfonic acid (PFHxS)	30
Perfluorooctanesulfonic acid (PFOS)	40



Samples collected from January 2013 – December 2015  
Public Water Systems (PWSs) serving >10,000 people

# At first glance, UCMR3 data suggest low PFAS detection frequency

UCMR3 requires monitoring for six PFASs in US drinking water.

Monitoring began in 2013, and latest data release was January 2017.

PFAS	MRL (ng/L)	Occurrence (%)	Max. Concentration (ng/L)	Locations with high concentrations
C7	10	0.64	410	Saipan, PA, NY, DE, CO
C8	20	1.03	349	PA, MN, Saipan, DE, WV
C9	20	0.05	56	NJ, DE, PA, MA, NY
PFBS	90	0.05	370	GA, Saipan, CO, AL, PA
PFHxS	30	0.56	1,600	Saipan, AZ, DE, CO, PA
PFOS	40	0.79	7,000	Saipan, DE, CO, PA, WA

36,972 samples from 4,920 PWSs

PFAS detects: 599 samples (1.6%) from 198 PWSs (4.0%)

Of samples with PFAS detects: 23.4% derived from surface water

Some drinking water samples had PFOA+PFOS levels well above the HAL

## UCMR3 Data for North Carolina: PFAS detection frequency higher than for entire US

Compound	MRL (ng/L)	NC Detects
Perfluoroheptanoic acid (PFHpA, C7)	10	29 (max. 60 ng/L)
Perfluorooctanoic acid (PFOA, C8)	20	10 (max. 30 ng/L)
Perfluorononanoic acid (PFNA, C9)	20	0
Perfluorobutanesulfonic acid (PFBS)	90	0
Perfluorohexanesulfonic acid (PFHxS)	30	5 (max. 110 ng/L)
Perfluorooctanesulfonic acid (PFOS)	40	8 (max. 90 ng/L)

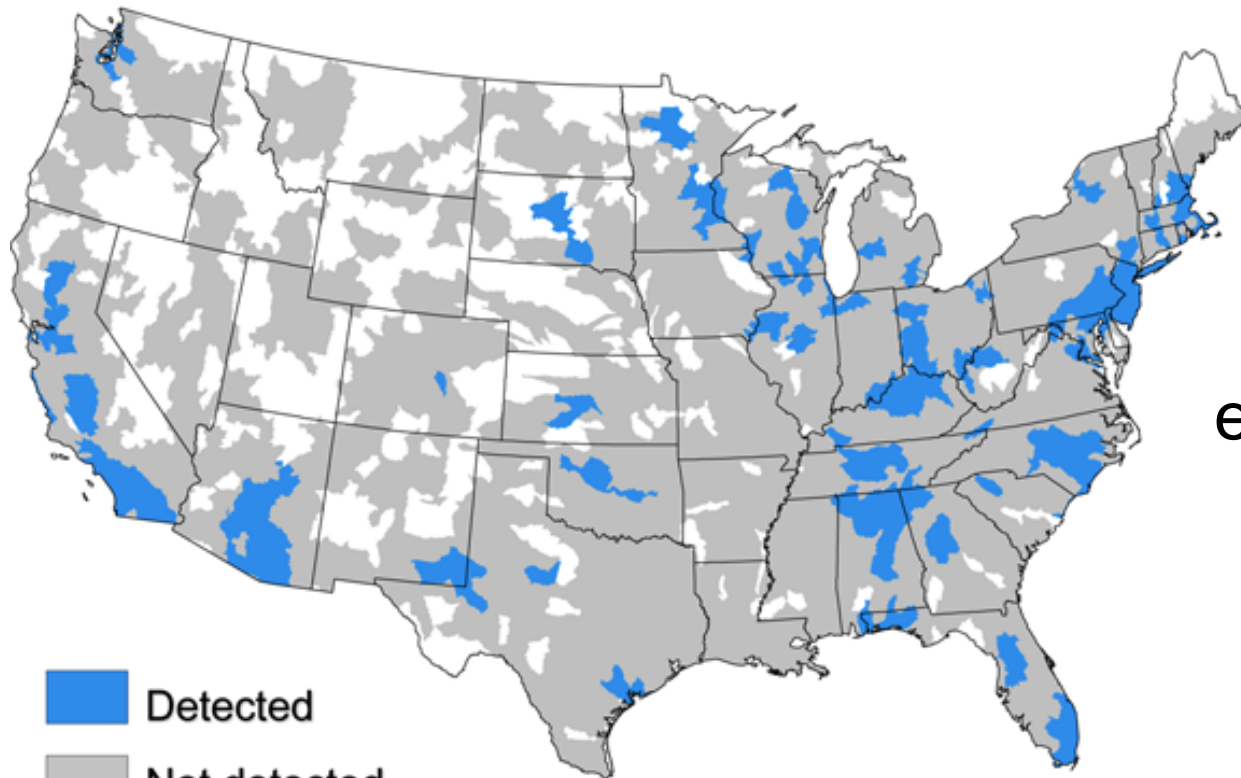
1,320 samples from 151 PWSs in NC

PFAS detects: 43 samples (3.3%) from 20 PWSs (13.2%)

Of samples with PFAS detects: 79% derived from surface water

# Elevated PFAS levels affect a sizeable number of US residents

Hydrological units with detectable PFASs



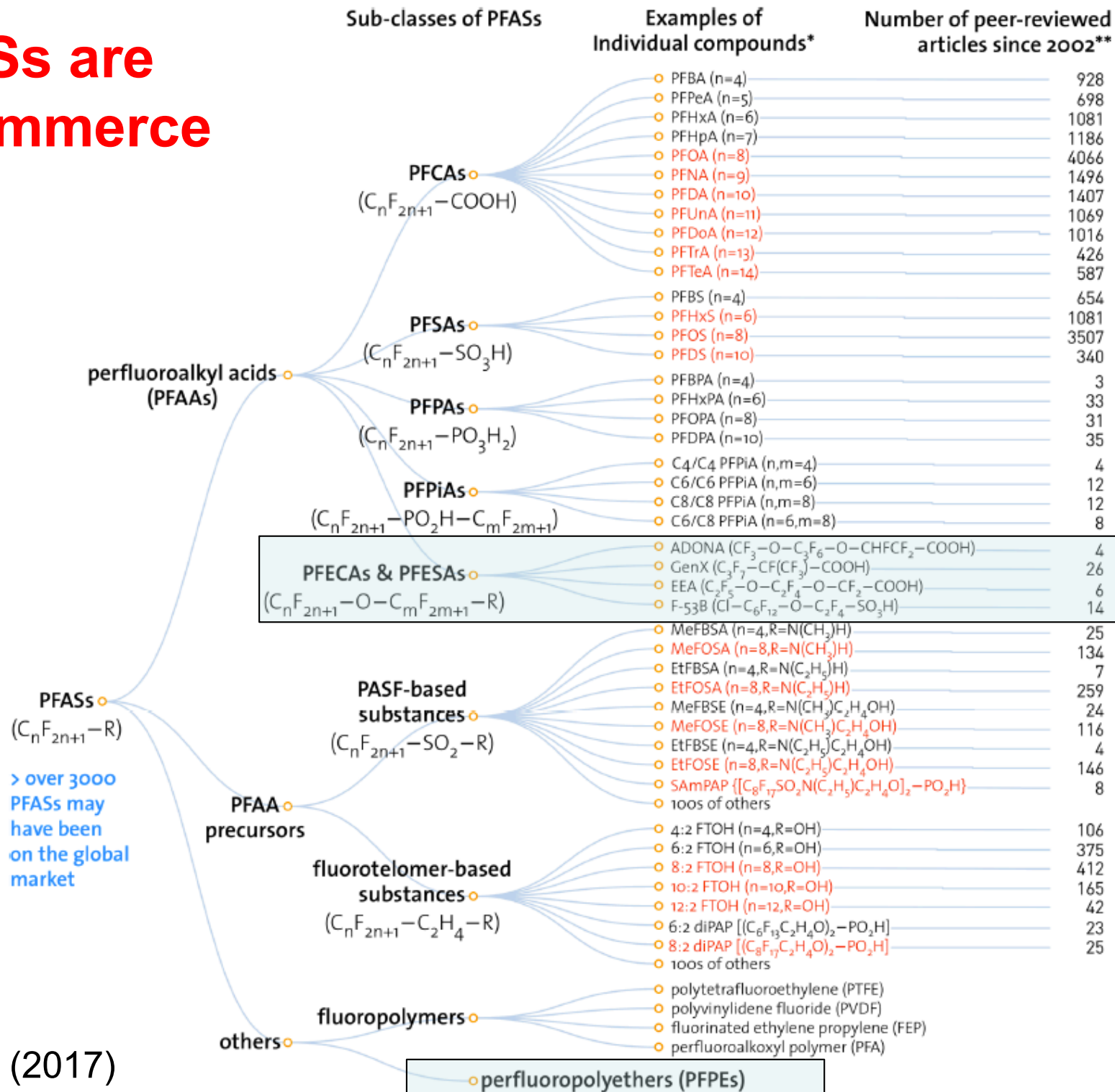
PFOS+PFOA levels estimated to exceed the 70 ng/L HAL in the drinking water of 6 million US residents



Hu et al. ES&T Letters (2016)

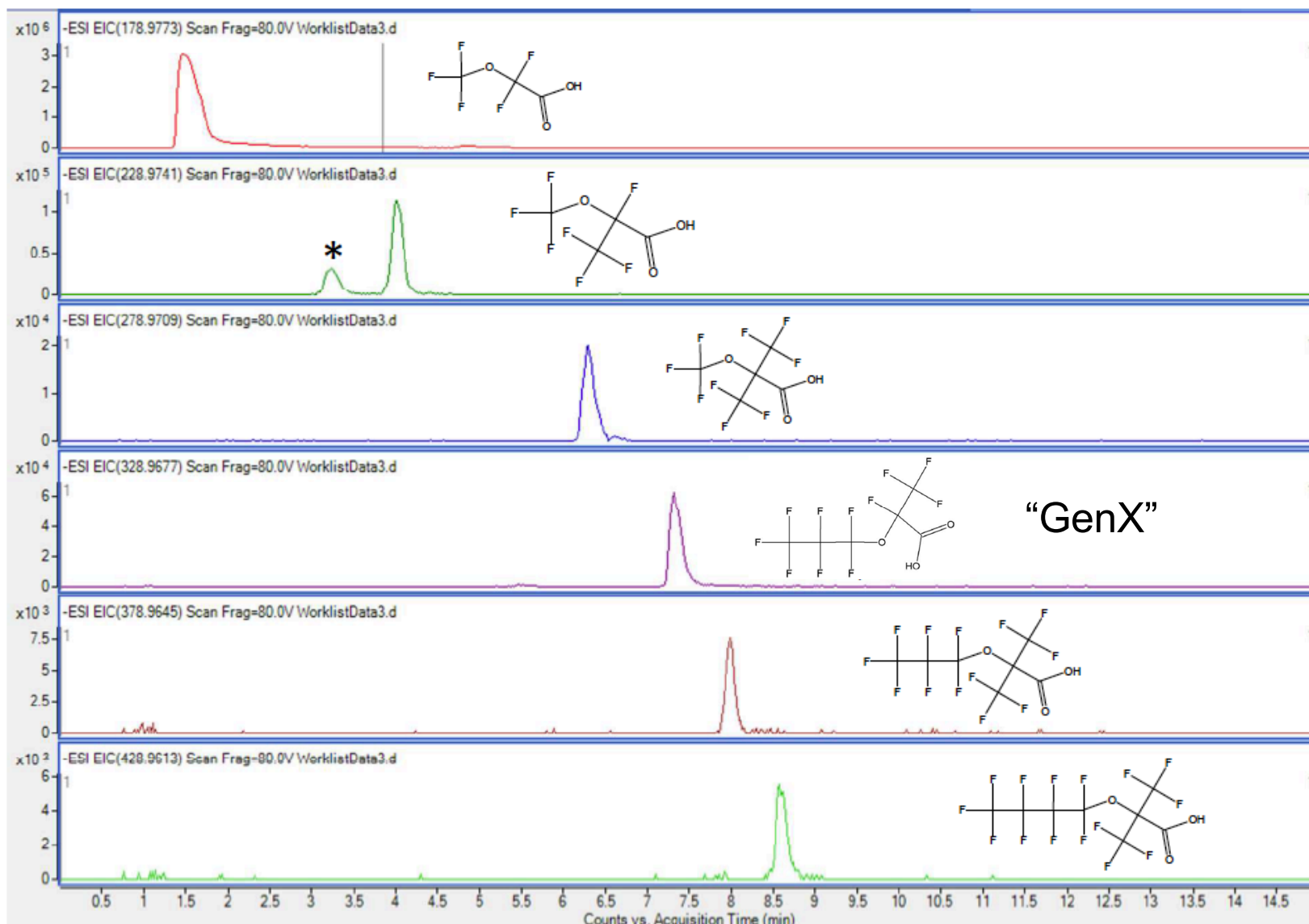
**...but are we  
seeing the  
complete picture?**

# Many PFASs are used in commerce

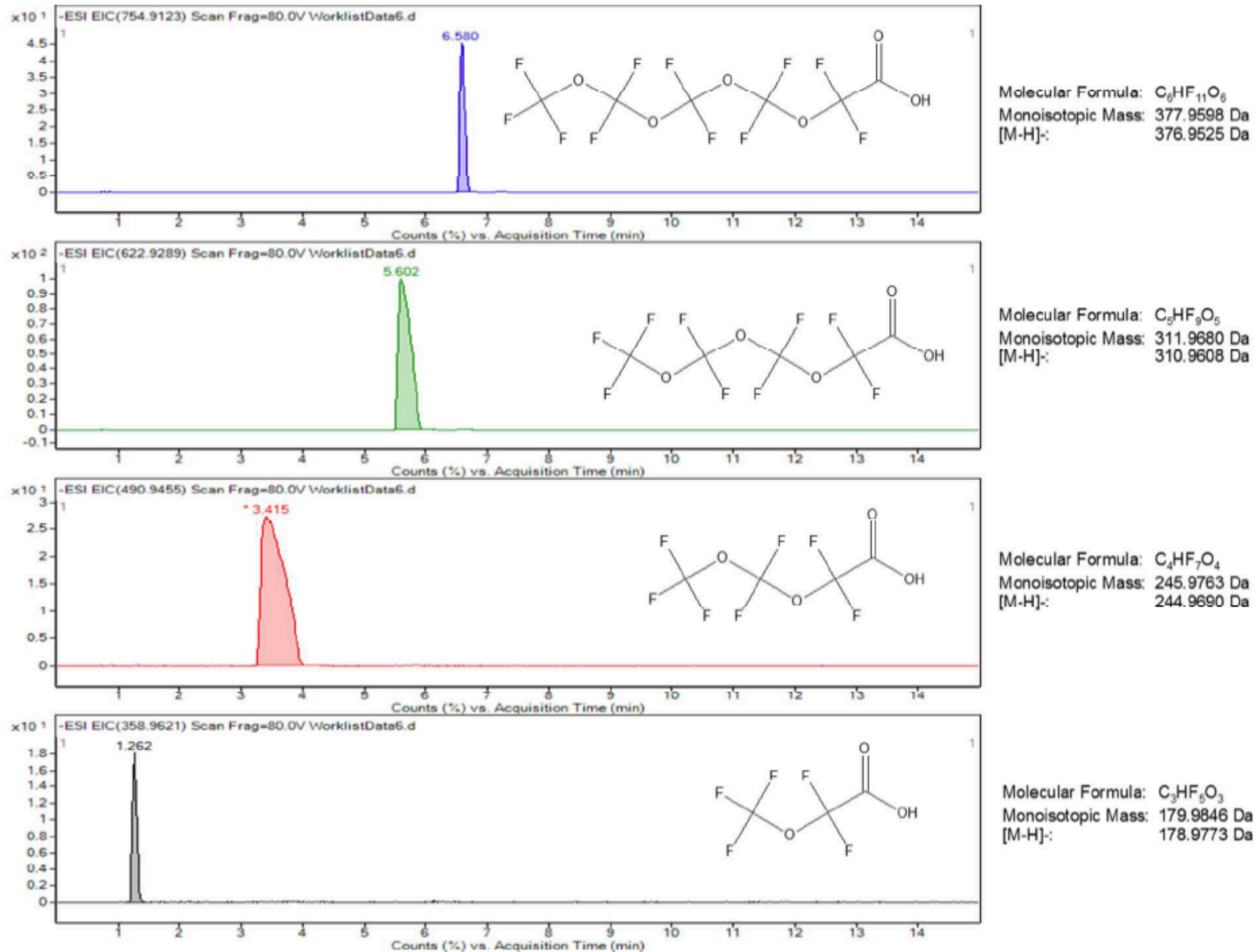




# Two series of PFECAs were recently discovered in the Cape Fear River

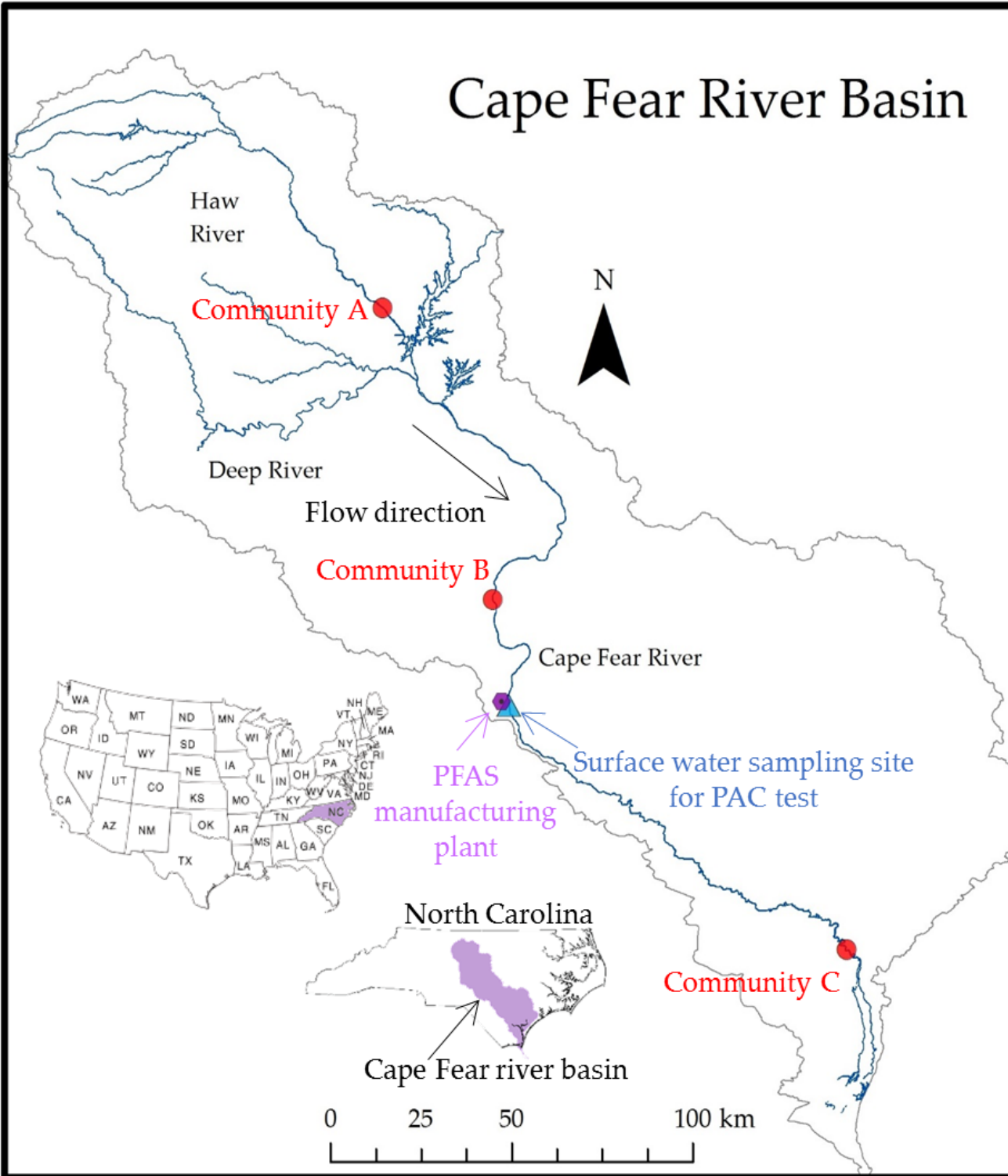


# Two series of PFECAs were recently discovered in the Cape Fear River



# Study Design

# Cape Fear River Basin



- Largest watershed in NC
- Supplies ~1.5M people with drinking water

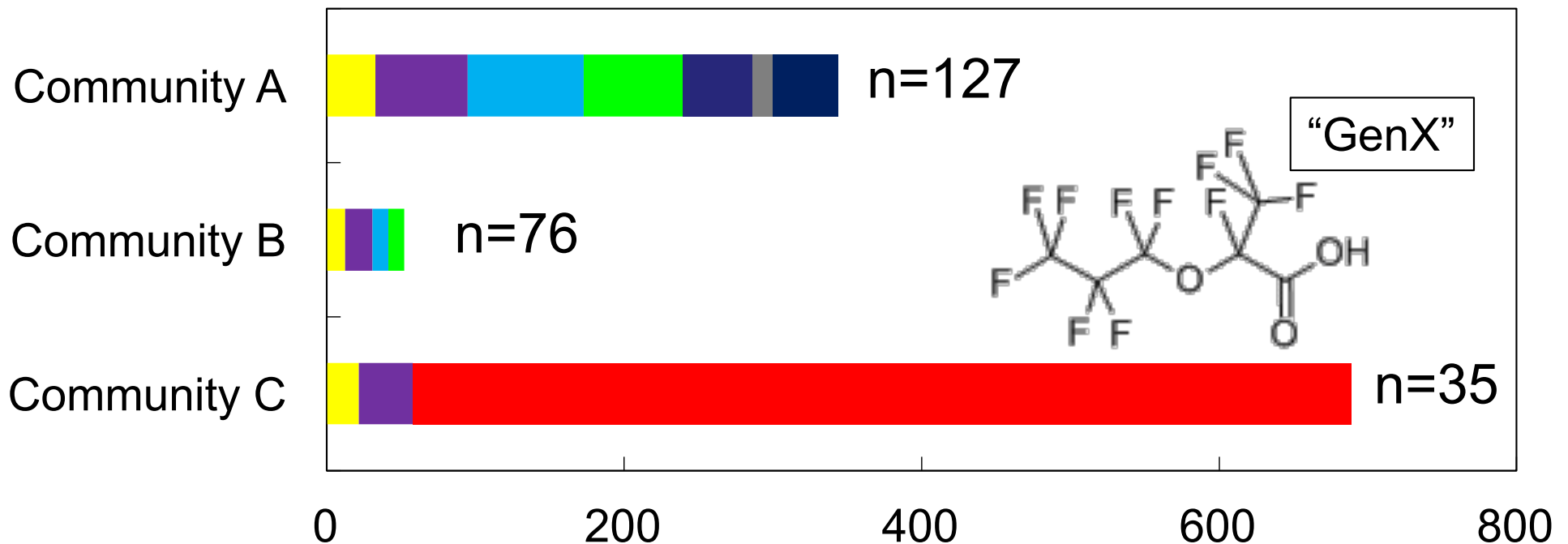
# Sampling Protocol

- Samples collected in 1-L HDPE bottles
- Two sampling approaches
  - Daily composite samples of source water at three drinking water treatment plants
  - Grab samples to track PFAS fate in drinking water treatment plant
- No preservative
- Storage at room temperature
- Analysis within 7 days of sample collection

# PFAS Analytical Method

- PFAS concentrations measured by LC-MS/MS
- Large-volume direct injection (900  $\mu\text{L}$ )
- Sample and standard preparation:
  - filtration with a 0.45- $\mu\text{m}$  glass fiber filter
  - addition of mass-labeled internal standards
  - addition of formic acid
- Calibration curves ranged from 10 - 750 ng/L
- Limit of quantitation was 10 ng/L for all PFASs except C10 and PFOS (25 ng/L)

# PFAS Occurrence in the CFR Watershed

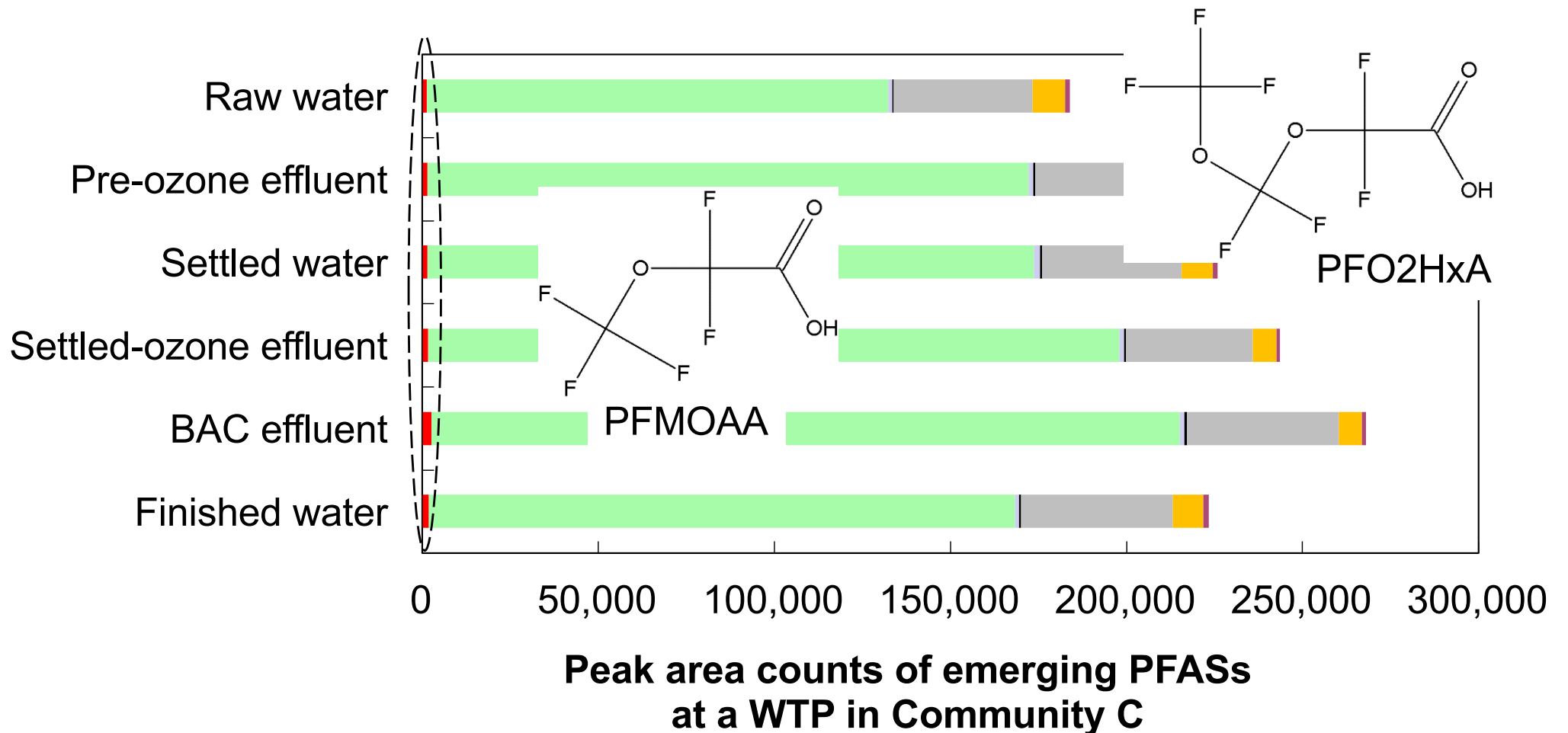


Average concentration in drinking water source (ng/L)





# Recently discovered perfluoroalkyl ether carboxylic acids occur at substantially higher concentrations than traditional PFASs and GenX



■ PFPrOPrA ■ PFMOAA ■ PFMOPrA ■ PFMOBA ■ PFO2HxA ■ PFO3OA ■ PFO4DA

# What about activated carbon?

**PAC:** thermally activated, wood-based

**PAC Doses:** 30, 60, 100 mg/L

**Contact time:** 60 minutes

**Water:** Cape Fear River (TOC: 9.0 mg/L)

**PFECAs:** Native levels

**PFCAs and PFSAs:** Spiked at 1000 ng/L

# Adsorbability of PFASs varies greatly. The PFECAs that were present at the highest concentrations were essentially non-adsorbable

