PFAS Exposure at Contaminated Sites

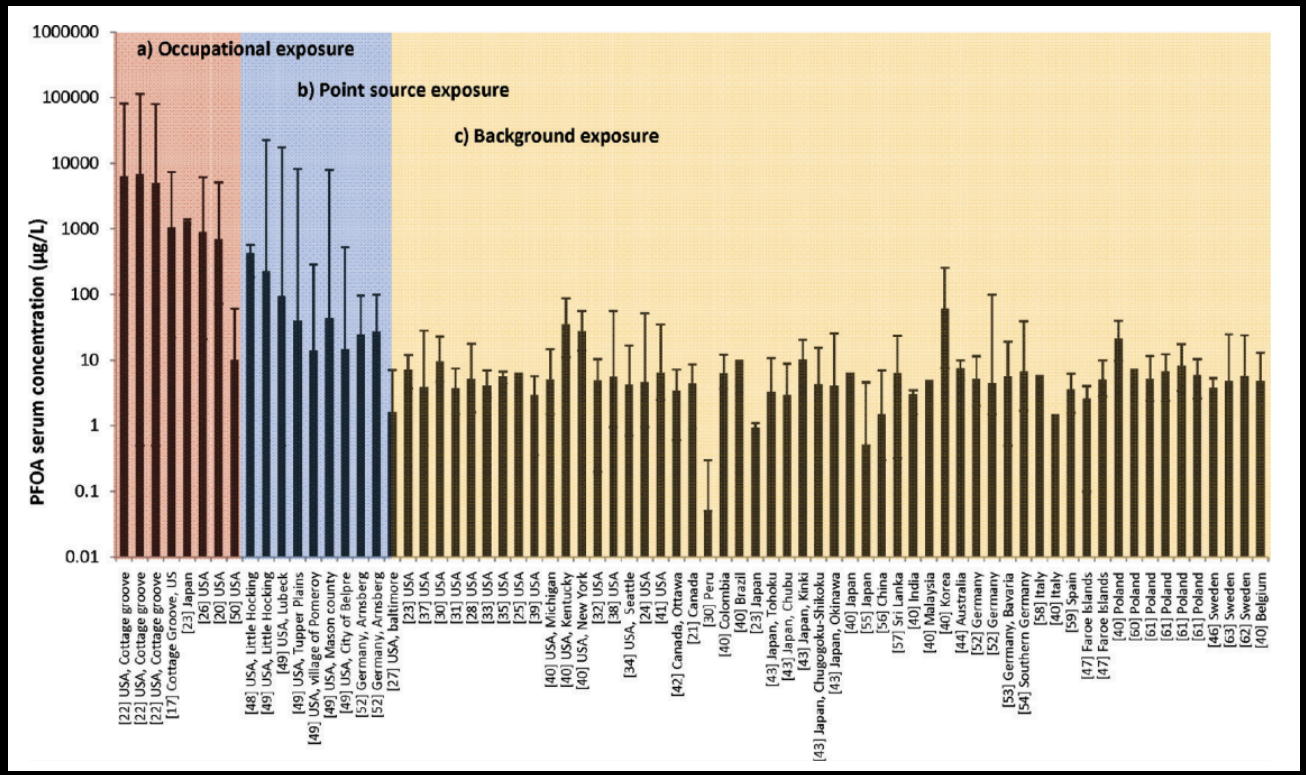
Tom Bruton, PhD

Green Science Policy Institute

August 12, 2019

What is a contaminated site?

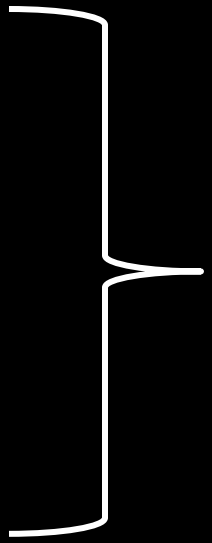
- Exposure is everywhere. How to distinguish:
  - background from a contaminated site?
  - contaminated site vs. occupational exposure?



Vestergren and Cousins., Environ. Sci. Technol. 2009

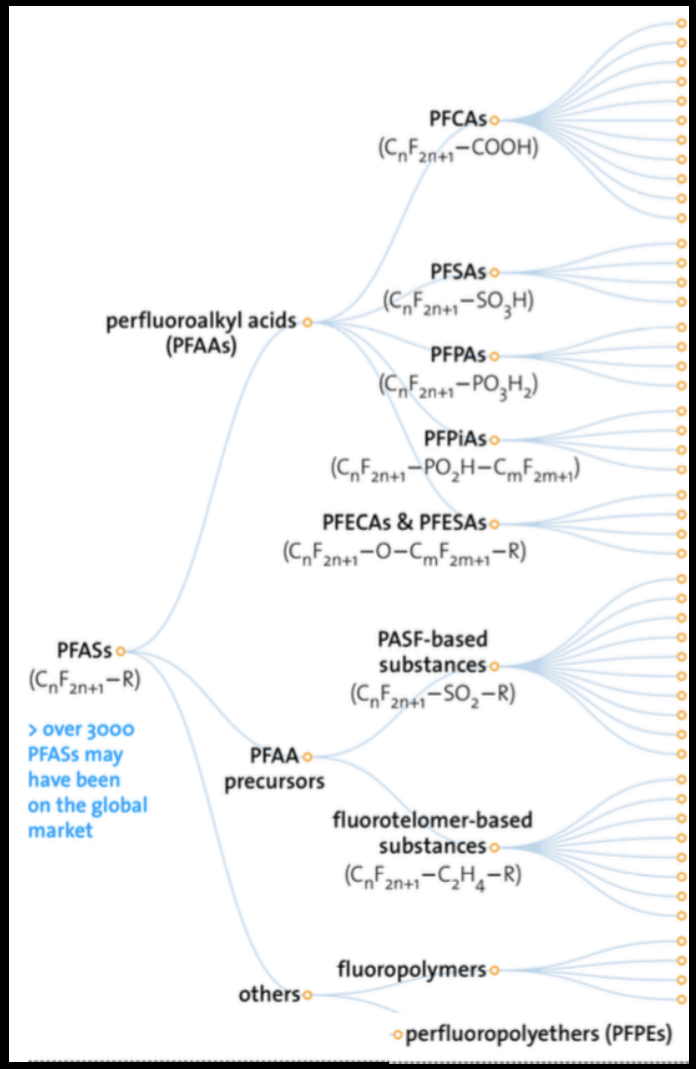
How to characterize exposure?

- What chemicals?
- What pathways?
- What concentrations? (external vs. internal)
- Duration?
- How many affected?



All are related to source type.

What chemicals?



# of studies addressing different subgroups:

PFCAs: 12,960

PFSAs: 5,582

PFPAs: 102

PFPiAs: 36

PFECAs & PFESAs: 50

PFOA, PFOS, & PFHxS: 8,654

PASF-based substances: 719

Fluorotelomer-based substances: 1148

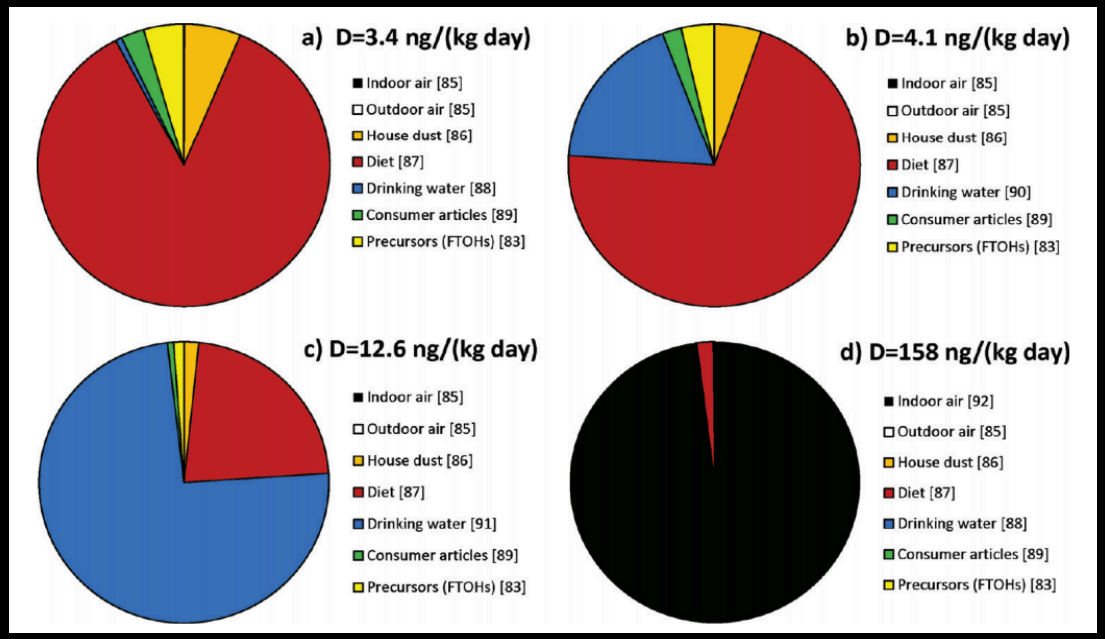
Wang et al., Environ. Sci. Technol. 2017

What pathways?

- Drinking water may dominate (non-occupational) exposure near contaminated sites

$[PFOA]_{DW}$ = 1.3 ng/L

$[PFOA]_{DW}$ = 40 ng/L



$[PFOA]_{DW}$ = 519 ng/L

Occupational exposure

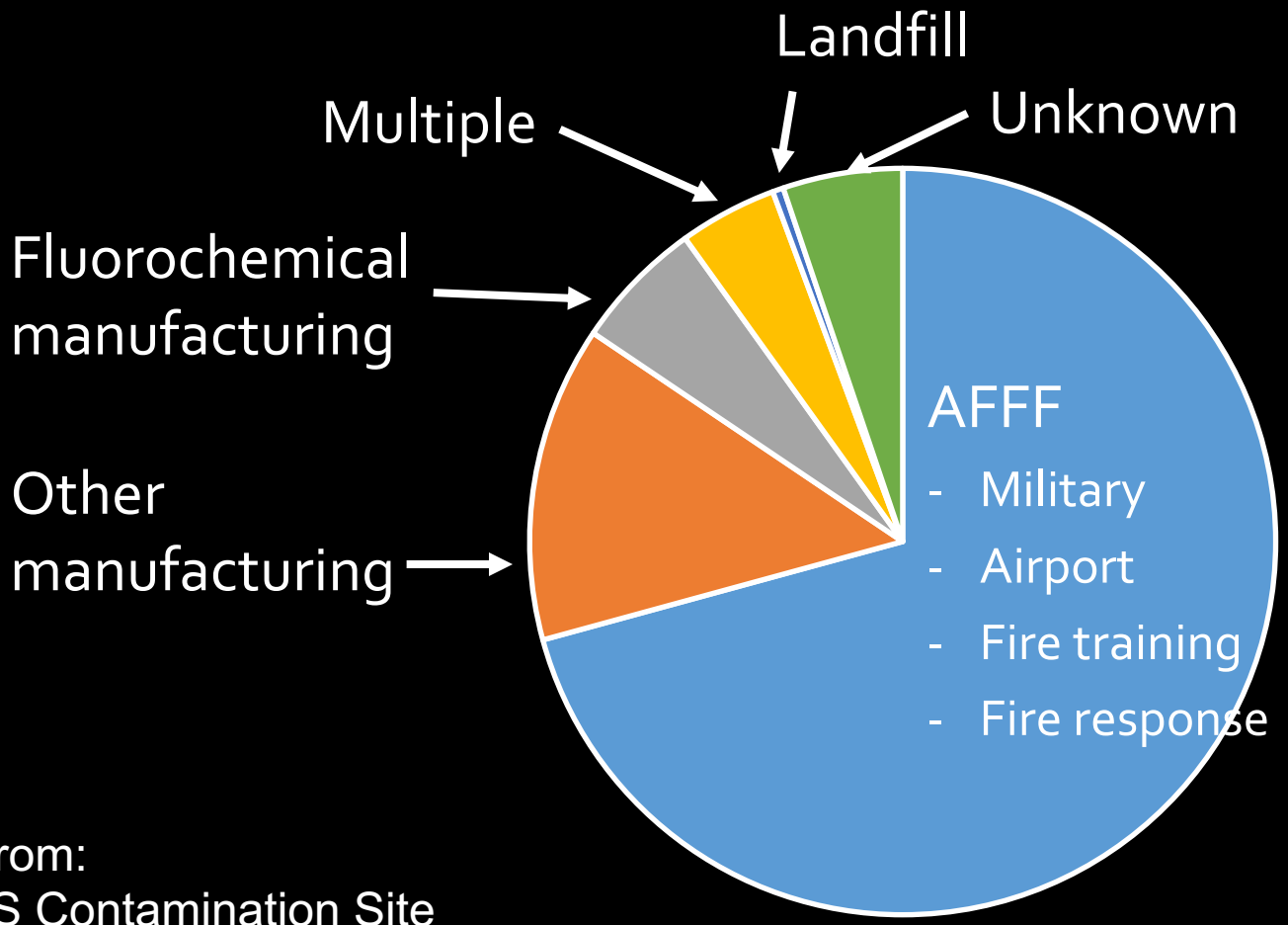
Vestergren & Cousins, Environ. Sci. Technol. 2009

Point Sources

- Fluorochemical manufacturing sites
- Other manufacturing sites
- Aqueous film-forming foam (AFFF)
  - Defense sites, airports, etc.
- Wastewater treatment / biosolids
- Other?

U.S. Contaminated Sites: Source Type

n = 213



Source data from:
SSEHRI PFAS Contamination Site Tracker, last update 7.02.2019

Fluorochemical manufacturing (makers of PFAS)

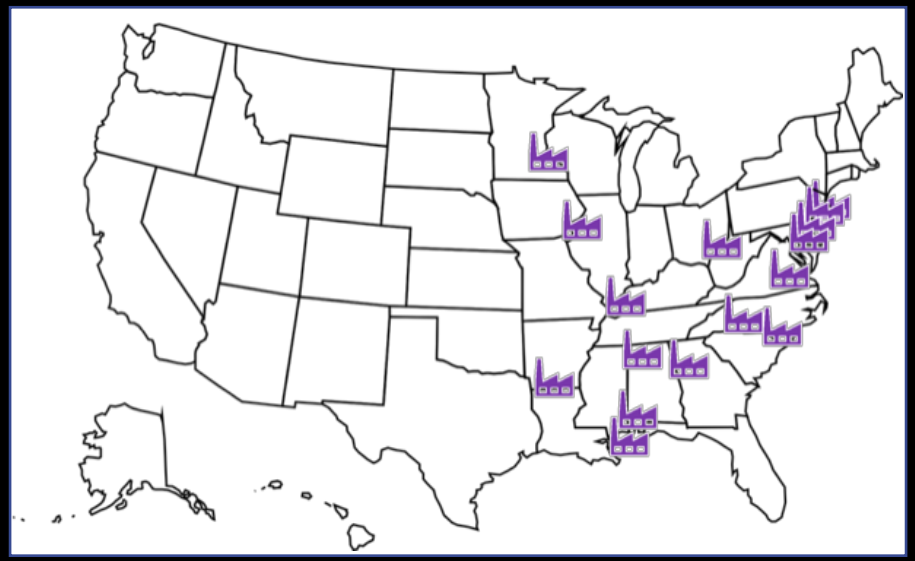
- Relatively few sites
- Relatively large amounts of emissions
- Multimedia emissions:
  - Air, surface water, land disposal/groundwater
- Complex chemistries

Fluorochemical manufacturing

- Relatively few sites

- 16 U.S. sites per EPA 2010/2015 PFOA Stewardship Program

- 33 fluoropolymer manufacturing sites worldwide in 2002



Hu et al., Environ. Sci. Technol. Lett. 2016

Prevedorous et al., Environ. Sci. Technol. 2006

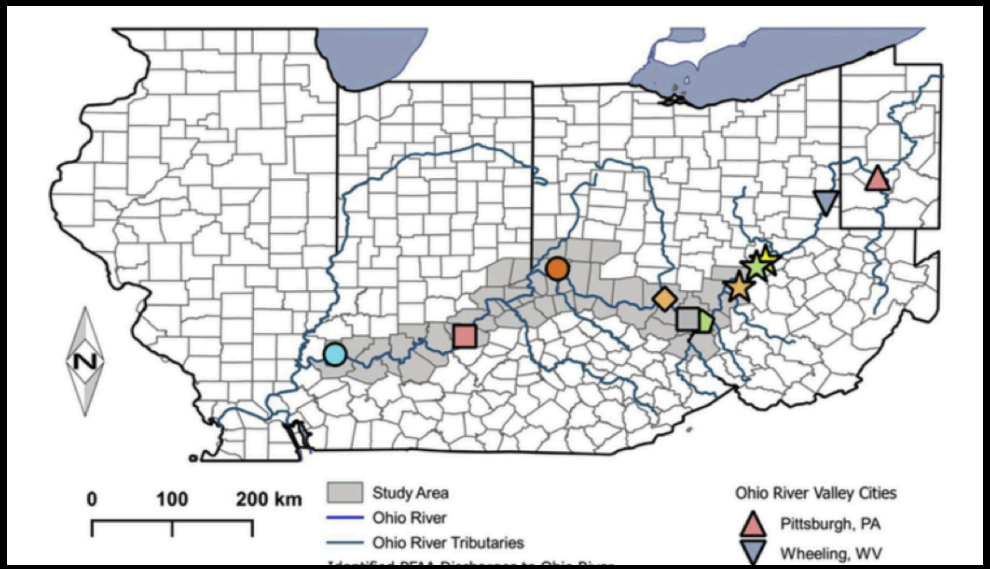
Fluorochemical manufacturing

- Relatively large amounts of emissions

- Up to tons of PFAAs per year per site

- Fluoropolymer manufacturing is single largest known source of PFCA emissions.

The Ohio River Valley



Prevedorous et al., Environ. Sci. Technol. 2006

Herrick et al., Environ. Poll. 2017

Fluorochemical manufacturing

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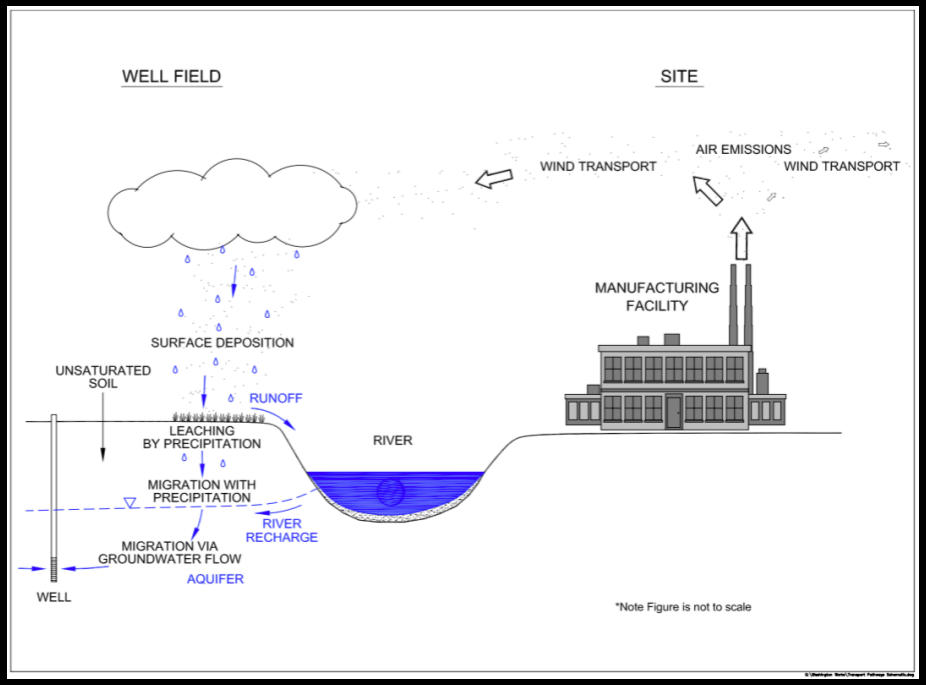
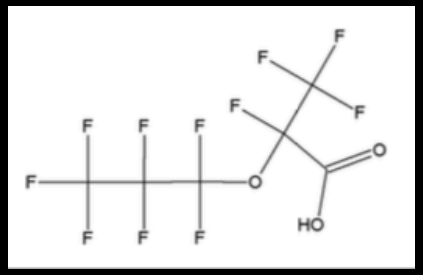
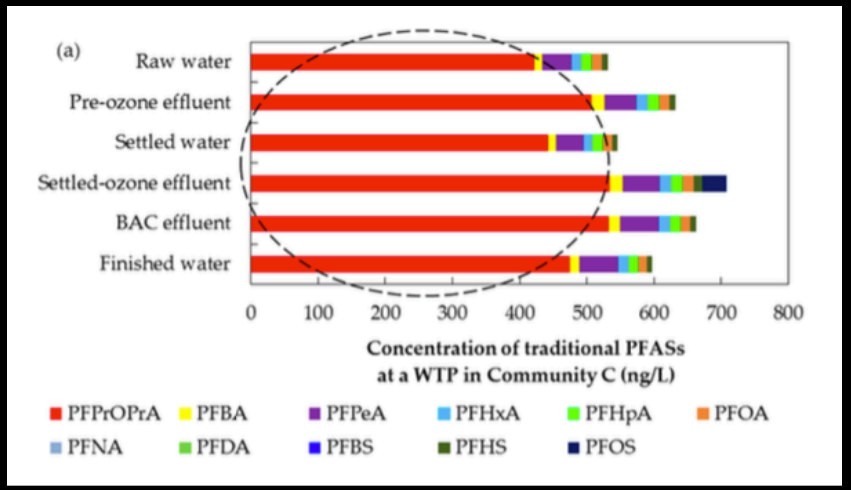


Davis, et al., Chemosphere 2007

Fluorochemical manufacturing

- Complex chemistries:
- PFOA, PFNA, PFOS, PFBS, but what else?
- GenX and other perfluoroether acids





Sun et al., ES&T Lett. 2016

Fluorochemical manufacturing

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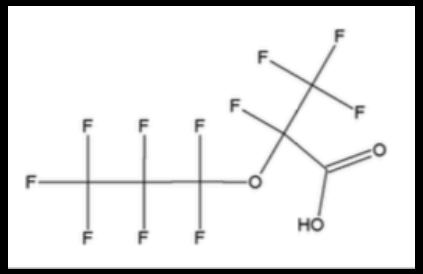

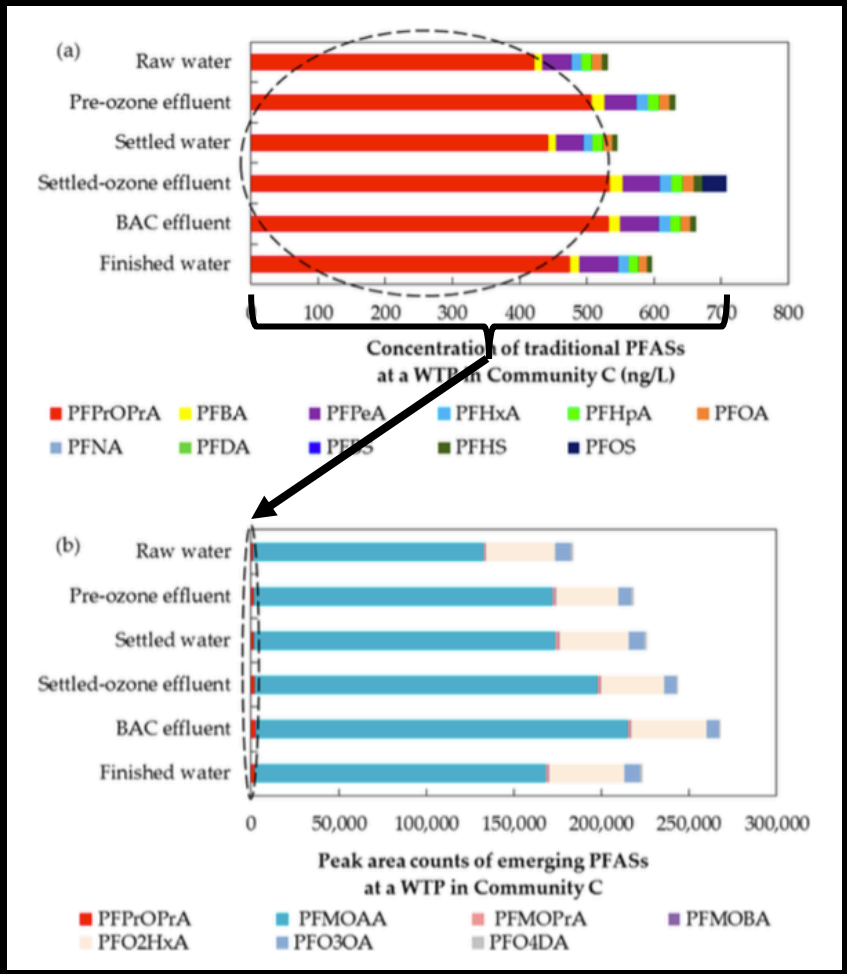

Sun et al., ES&T Lett. 2016

Other manufacturing
(users of PFAS)

- More common
- Examples:
  - Fabric and plastic coating
    - Hoosick Falls, NY
    - Bennington, VT
    - Merrimack, NH
  - Paper mills
    - Parchment, MI
  - Leather tanneries
    - Plainfield, MI
  - Metal plating
  - Other: photolithography, paints, carpet & upholstery, oil & gas extraction?

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(users of PFAS)

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  - Paper mills
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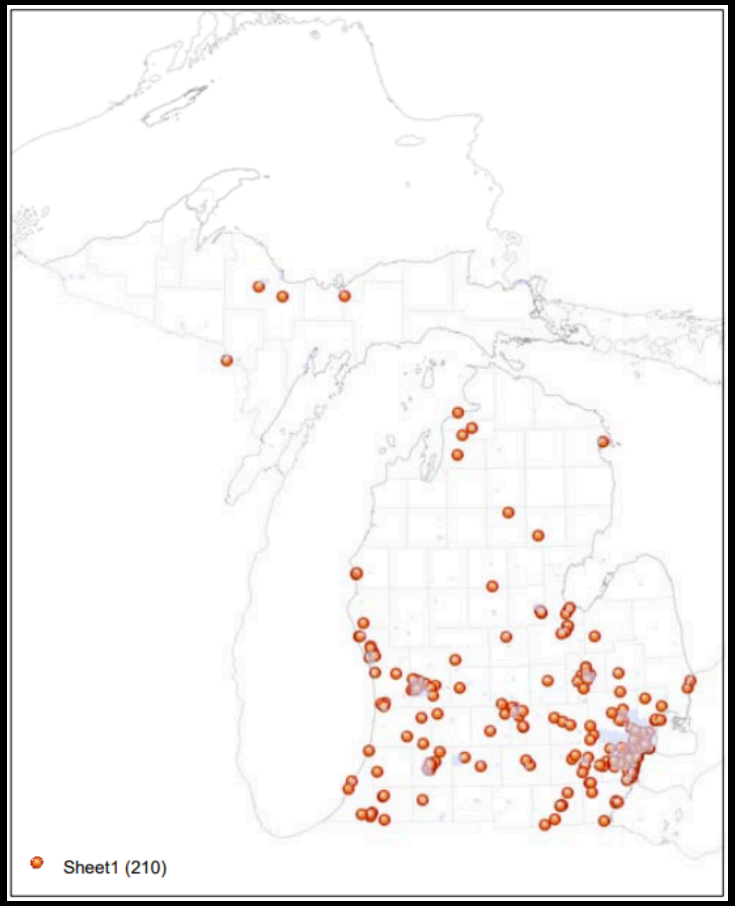
  - Metal plating



https://assets.documentcloud.org/documents/4620090/Potential-PFAS-contaminated-sites-in-Michigan.pdf

Firefighting foam (AFFF)

- Many sites
- Emissions: emergency response vs. ongoing training
- Emissions: groundwater vs. surface water
- Complex chemistries

Prevedorous et al., Environ. Sci. Technol. 2006

Herrick et al., Environ. Poll. 2017

Firefighting foam (AFFF)

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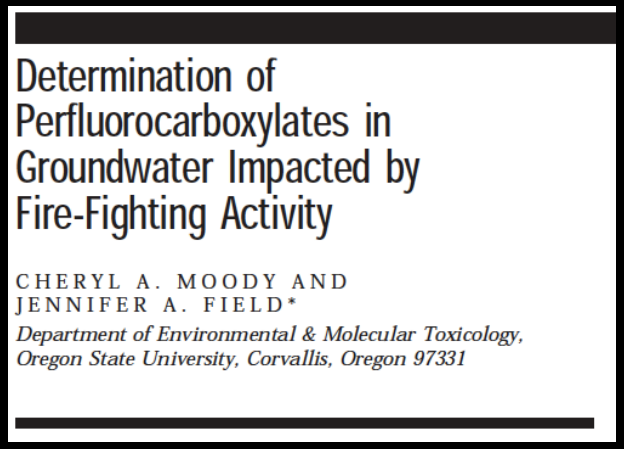
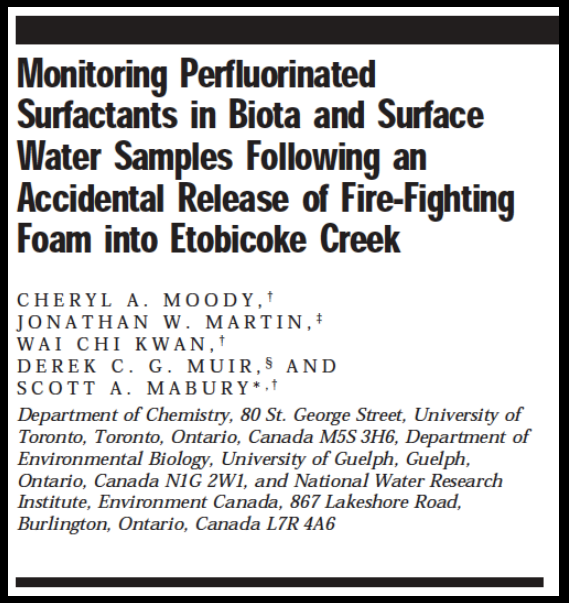


Determination of Perfluorocarboxylates in Groundwater Impacted by Fire-Fighting Activity

CHERYL A. MOODY AND JENNIFER A. FIELD*

Department of Environmental & Molecular Toxicology, Oregon State University, Corvallis, Oregon 97331

- E.g. 75-100 L of AFFF used weekly to monthly for 30+ years



Monitoring Perfluorinated Surfactants in Biota and Surface Water Samples Following an Accidental Release of Fire-Fighting Foam into Etobicoke Creek

CHERYL A. MOODY,† JONATHAN W. MARTIN,‡ WAI CHI KWAN,† DEREK C. G. MUIR,§ AND SCOTT A. MABURY*,†

Department of Chemistry, 80 St. George Street, University of Toronto, Toronto, Ontario, Canada M5S 3H6, Department of Environmental Biology, University of Guelph, Guelph, Ontario, Canada N1G 2W1, and National Water Research Institute, Environment Canada, 867 Lakeshore Road, Burlington, Ontario, Canada L7R 4A6

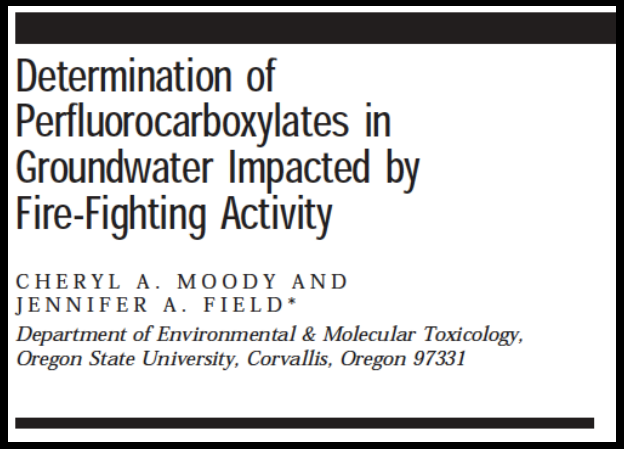
- Accidental release of 22,000L of AFFF

Moody and Field, Environ. Sci. Technol. 1999

Moody et al., Environ. Sci. Technol. 2002

Firefighting foam (AFFF)

- Emissions: groundwater vs. surface water



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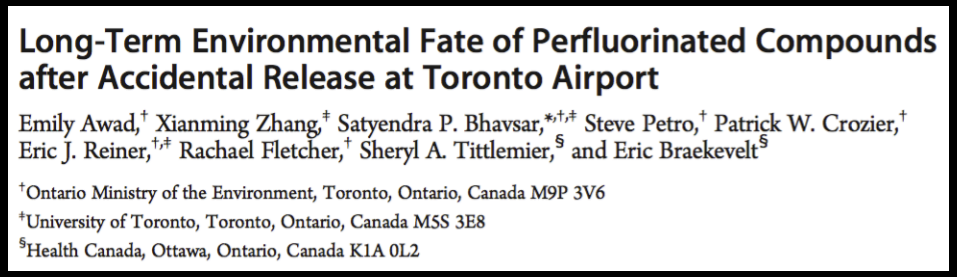


Long-Term Environmental Fate of Perfluorinated Compounds after Accidental Release at Toronto Airport

Emily Awad,[†] Xianming Zhang,[‡] Satyendra P. Bhavsar,[*,†,‡] Steve Petro,[†] Patrick W. Crozier,[†] Eric J. Reiner,[†,‡] Rachael Fletcher,[†] Sheryl A. Tittlemier,[§] and Eric Braekevelt[§]

[†]Ontario Ministry of the Environment, Toronto, Ontario, Canada M9P 3V6

[‡]University of Toronto, Toronto, Ontario, Canada M5S 3E8

[§]Health Canada, Ottawa, Ontario, Canada K1A 0L2

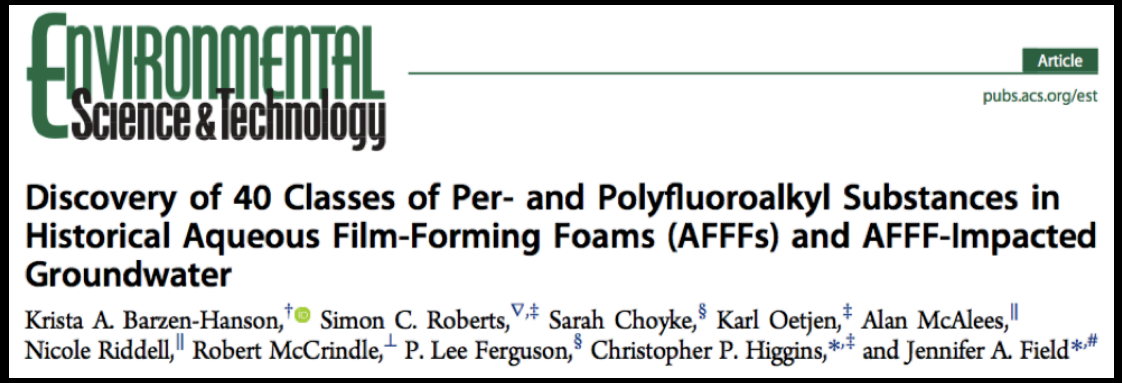
- Up to 7 mg/L PFCAs in groundwater 7-10 years after last AFFF use
- Up to 99.9% decline of PFOS in surface water 9 years after spill

Moody and Field, Environ. Sci. Technol. 1999

Awad et al., Environ. Sci. Technol. 2002

Firefighting foam (AFFF)

- Complex chemistries
  - PFOS, PFHxS, and much more…



  - 13 classes found only in groundwater (transformation products)
  - We know little about fate & toxicity

Barzen-Hanson et al., Environ. Sci. Technol. 2017

Wastewater treatment plants

- Not sources, but concentrators
- High input = high output. Industrial sources & AFFF are important.
- Key exposure route is land application of biosolids

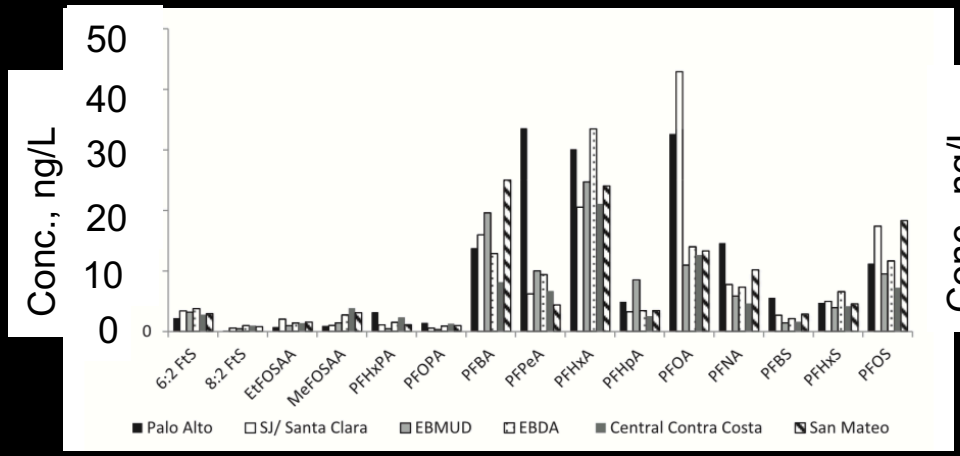
Prevedorous et al., Environ. Sci. Technol. 2006

Herrick et al., Environ. Poll. 2017

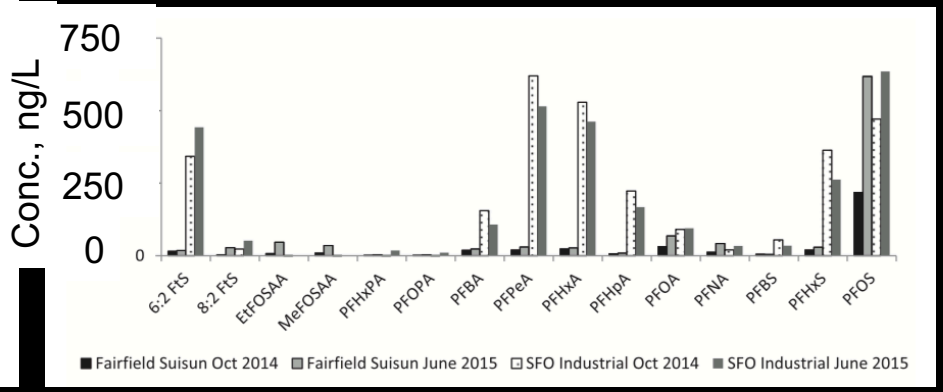
Wastewater treatment plants

- High input = high output. Industrial sources & AFFF are important.

PFAS in WWTP effluent with and without AFFF use



No known AFFF

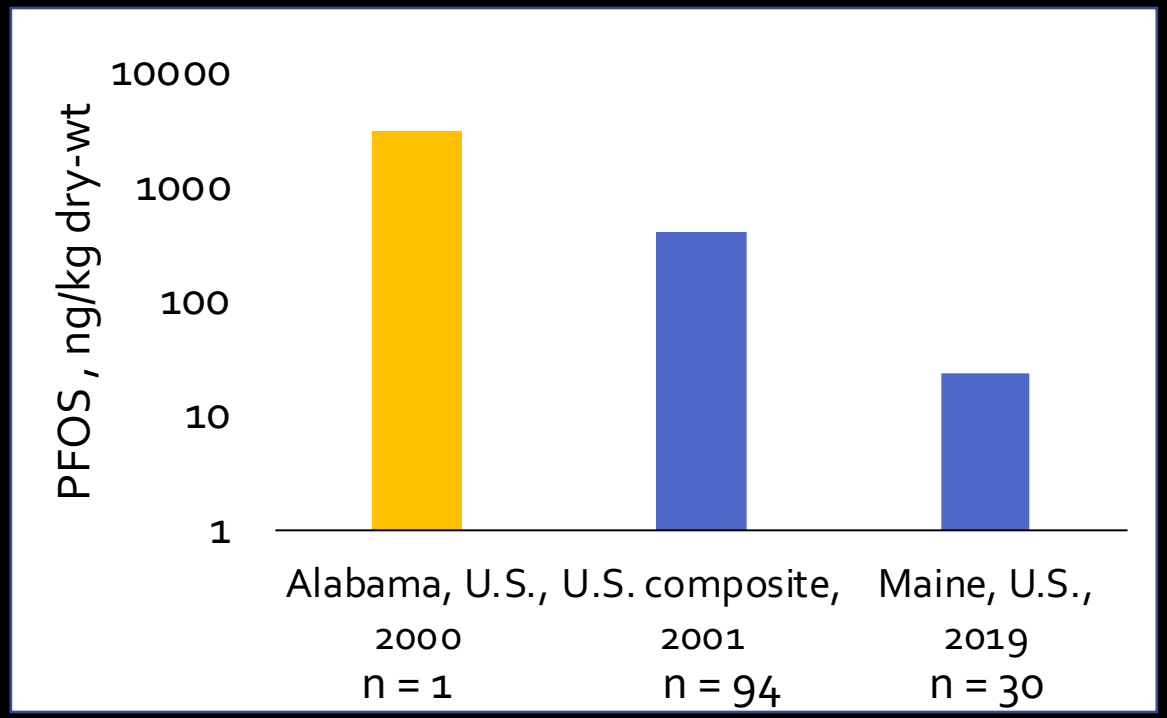


With AFFF use (note y-axis scale)

Houtz et al., Water Res. 2016

Wastewater treatment plants

- High input = high output. Industrial sources & AFFF are important.

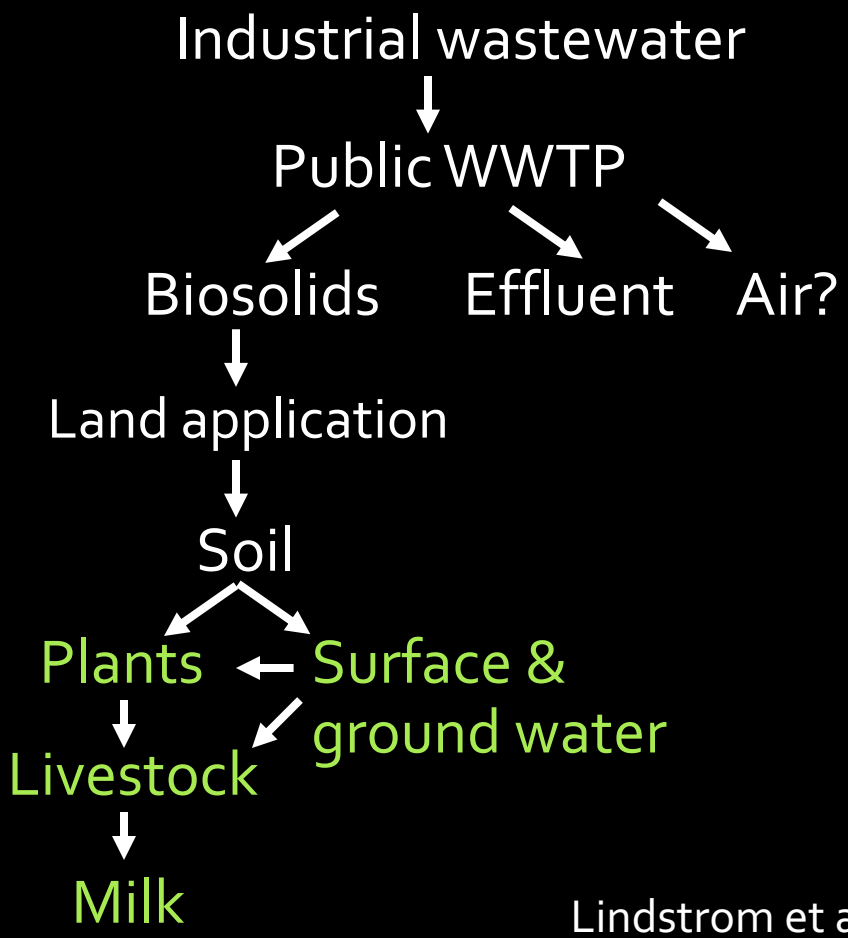


3M Environmental Monitoring – Multi-City Study, 2001
Venkatesan and Halden, 2013
Maine DEP, 2019

Wastewater treatment plants

- Key exposure route is land application of biosolids.
  - Arnsberg, Germany
  - Decatur, AL, USA
  - Arundel, ME, USA

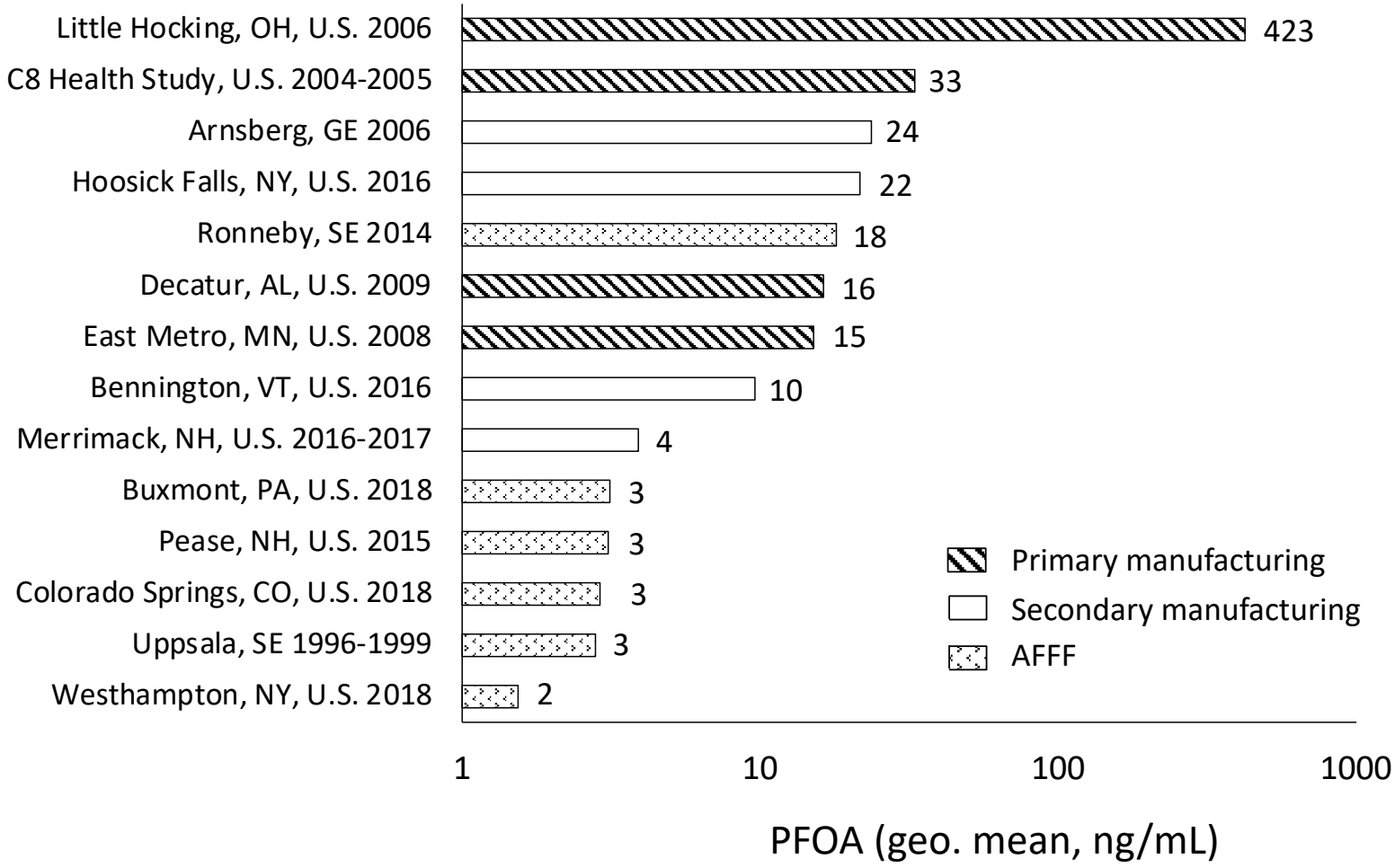
Reuters/Brian Snyder March 11, 2019



Lindstrom et al., 2011
Holzer et al., 2008

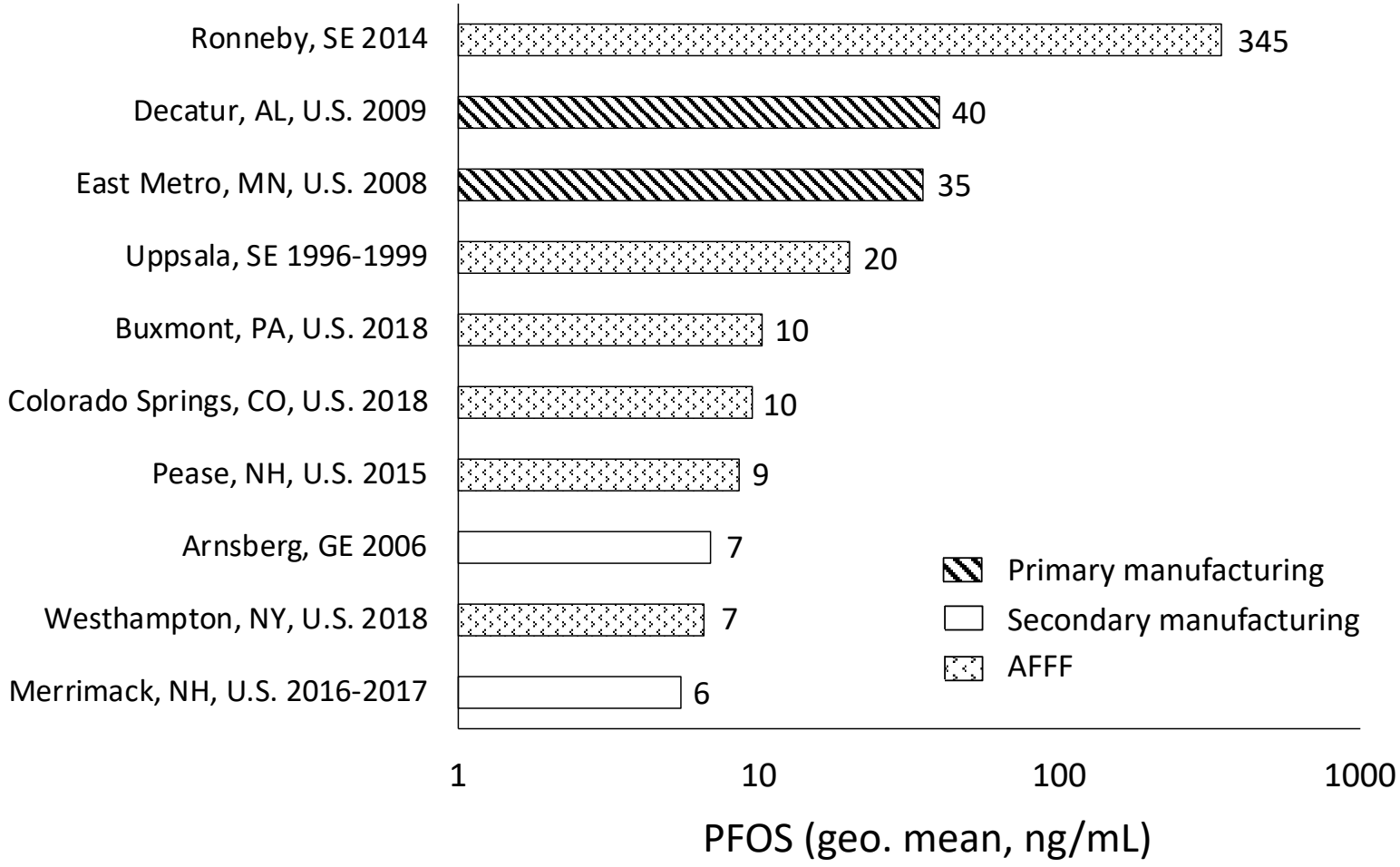
Does type of point source affect the magnitude of exposure?

Serum PFOA in community studies
(not comprehensive)



Serum PFOS in community studies

(not comprehensive)



Conclusions

1. When drinking water is contaminated, it is the dominant exposure

2. Research needs:
   - Environmental levels and exposure to chemicals other than PFOA, PFOS, PFHxS, PFNA, etc.
   - Exposure pathways other than drinking water
     - Fish, game, crops, livestock…

3. The world is a contaminated site.

Questions?

tom@greensciencepolicy.org

New website: PFASCentral.org