PFAS CAP Overview

Kara J. Steward

August 30, 2017

DEPARTMENT OF ECOLOGY State of Washington

Washington State Department of Health

Chemical Action Plans

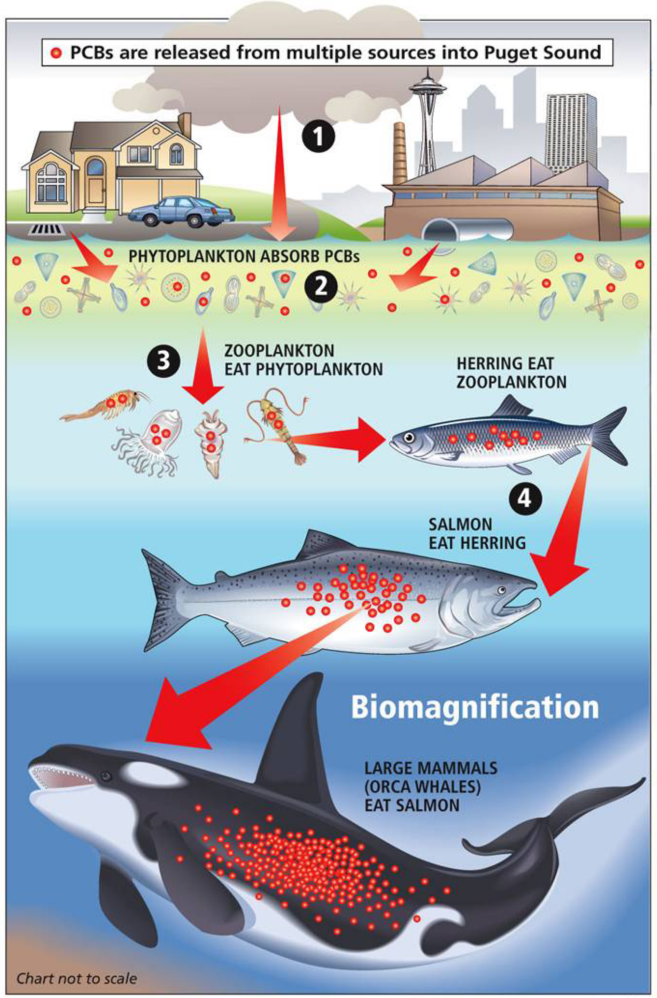
- PBT Rule: criteria, list of chemicals, CAP content and development process
- Goal: reduce and phase-out PBT uses, releases, and exposures in Washington
- CAP: uses, releases, exposure, recommendations

Chapter 173-333 WAC (2006)

Washington State Department of Health

PBTs are a priority because…

- Travel long distances and cross media.
- Span the boundaries of programs, geography and generations.
- Traditional single-media approaches won't solve the whole problem.
- We need to address PBTs through integrated use of all agency tools and programs.



What’s a CAP?

DRAFT chapters

- Chemistry
- Sources, Uses
- Exposure Pathways
  - Human
  - Environmental
- Toxicology
  - Human
  - Wildlife
- Regulations

Nov/Dec Draft

Economic analysis

Recommendations

CAP Focus

- Washington sources and recommendations
- Comprehensive look at industrial discharges to everyday products
- Collaborative input from Advisory Committee and interested parties
- Fill data gaps
- Look at root causes

Example CAP Actions

- Mercury (2003)
  - Voluntary agreement with dentists to recycle mercury amalgam
- PBDE flame retardants (2006)
  - Ban on some uses after an alternatives assessment
- Lead (2009)
  - Work with Commerce and DOH on assessment and remediation
- PAHs (2012)
  - Continue Ecology programs on wood smoke, creosote, diesel emissions
- PCBs (2015)
  - Work with OSPI to remove PCB light ballasts from schools

Mercury CAP Implementation

- Dentists use a dental amalgam separator to manage waste
- 2003 Mercury Education and Reduction Act (RCW 70.95M) banned some uses
  - Thermometers, novelties, thermostats
- 2010 Mercury lamp product stewardship (RCW 70.275)
  - 1.2 million lights collected in 2016
- Hospital waste best management practices
- Lower detection limit for mercury in water discharge permits
- Auto switch collection
  - 234,500 switches since 2006

LightRecycle WASHINGTON

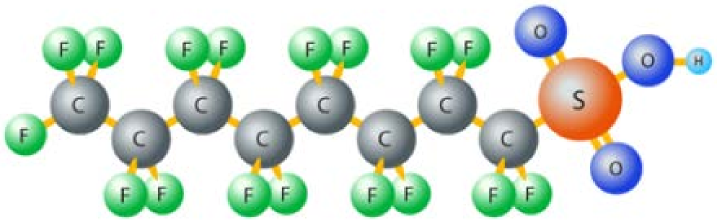

Chrysler Light Switches

Altogether we've kept more than 14,000 pounds of mercury out of the environment

PFAS CAP Scope

PFAS: per- and poly-fluorinated alkyl substances

- PBT Rule lists PFOS and salts
- PFAS class CAP (like PBDE, PCB, PAH)
- PFAS CAP Scope: Long chain perfluoroalkyls, precursors, related substances, and intended substitutes



PFOS molecule

PFAS CAP Phases

Interim PFAS CAP

- Findings
- Interim recommendations
- Interim CAP

Ongoing CAP Efforts

- Ongoing CAP work and research
- Advisory Committee meetings
- Interim implementation

Final PFAS CAP

- Final Recommendations
- Final CAP
- Ongoing Implementation

Interim CAP Timeline

- 2016/17 Information Collection
- Aug 30, 2017 Advisory Committee
- Sept/Oct 2017 Update Info/Draft Recommendations
- Nov 1, 2017 Advisory Committee
- Nov 2017 Research Recommendations
- Dec 12, 2017 Advisory Committee
- Jan/Feb 2018 Public Review and Comment
- May/June 2018 Advisory Committee
- June 2018 Interim PFAS CAP

PFAS CAP work continues through 2018
- Implementation of Interim PFAS CAP recommendations
- Final PFAS CAP document and recommendations

PFAS CAP logistics

- CAP Listserv
  https://listserv.wa.gov/cgi-bin/wa?A0=CHEMICAL-ACTION-PLAN
- CAP Website
  https://www.ezview.wa.gov/?alias=1962&pageid=37105
- CAP draft ‘roll-out’
  - Ecological toxicity section
  - Ecology product testing
  http://pubs.acs.org/doi/abs/10.1021/acs.estlett.6b00435

Washington State Department of Health

Perfluoroalkyl Substances (PFAS) Occurrence in Drinking Water Supplies

Chemical Action Plan Advisory Committee
August 30, 2017

Scott Torpie
Department of Health
Office of Drinking Water

PUBLIC HEALTH
ALWAYS WORKING FOR A SAFER AND HEALTHIER COMMUNITY




Office of Drinking Water's Mission

We work with others to protect the health of the people of Washington State by ensuring safe and reliable drinking water.

Unregulated Contaminant Monitoring Rule (UCMR)

- If a national regulation is needed, we must know if the contaminant occurs in public water systems (PWSs).
- Every five years, the Environmental Protection Agency (EPA) selects up to 30 contaminants to monitor in finished drinking water.
- Who samples?
  - All PWSs serving more than 10,000 people.
  - A representative sample of 800 PWSs serving 10,000 or less.
- EPA uses the results to assess occurrence of the contaminant.

Focusing on Washington State

- Water systems sampled under UCMR3 for six PFAS compounds in 2013–2015.
- Of the water systems that sampled:
  - All 113 systems serve more than 10,000 people.
  - Nineteen small systems serve 10,000 or fewer people.
  - Represents 94 percent of people on public water.

Focusing on Washington State

- PFAS samples results analyzed under UCMR3 in Washington

Public Water System	Pop.	PFOA & PFOS (ppt)
Issaquah Water System	26,000	534*
City of DuPont Water System	11,500	30
JBLM Lewis	75,000	51

* ~100 parts per trillion (ppt) at entry to distribution (EPTDS); ~70ppt in distribution

Subsequent (Voluntary) Sampling at Military Installations

- Fairchild AFB (Spokane County)
  - PFOA and PFOS sample results from wells within ~five miles of FAFB
    - Ranged from no detection to 2,300 ppt (∑6 PFAS compounds measured up to > 4,400 ppt)
  - City of Airway Heights issued a 24-day bottled water advisory due to PFOA and PFOS contamination of two wells and its distribution system
    - Contamination as high as 1,250 ppt

Washington State Department of Health

Subsequent (Voluntary) Sampling at Military Installations

- NAS Whidbey (Island County)
  - ~210 drinking water wells within 1.5 miles of two naval air station facilities were sampled for PFOA and PFOS.
    - Seven homes have PFOA 130 to 660ppt.
    - One home has PFOS 2,500-3,800ppt.
    - Six homes have PFOA < 70ppt.
- Coupeville sampled its sources: One well in its wellfield has PFOA at 60ppt (blending to 30ppt).
- Twelve other public water systems sampled independently, with no detections.

Subsequent (Voluntary) Sampling at Military Installations

- Fort Lewis and McChord Field operate as a joint base but have separate water systems.
- Fort Lewis:
  - Shut down one well with PFOS and PFOA > 70 ppt.
  - Main water supply sources have PFOS and PFOA at 20ppt.
  - Two other smaller wells have PFOS and PFOA at 45-60ppt.
- McChord Field:
  - Shut down three wells with PFOS at 70 to 240ppt.
  - Two other wells have PFOS below 70 ppt.

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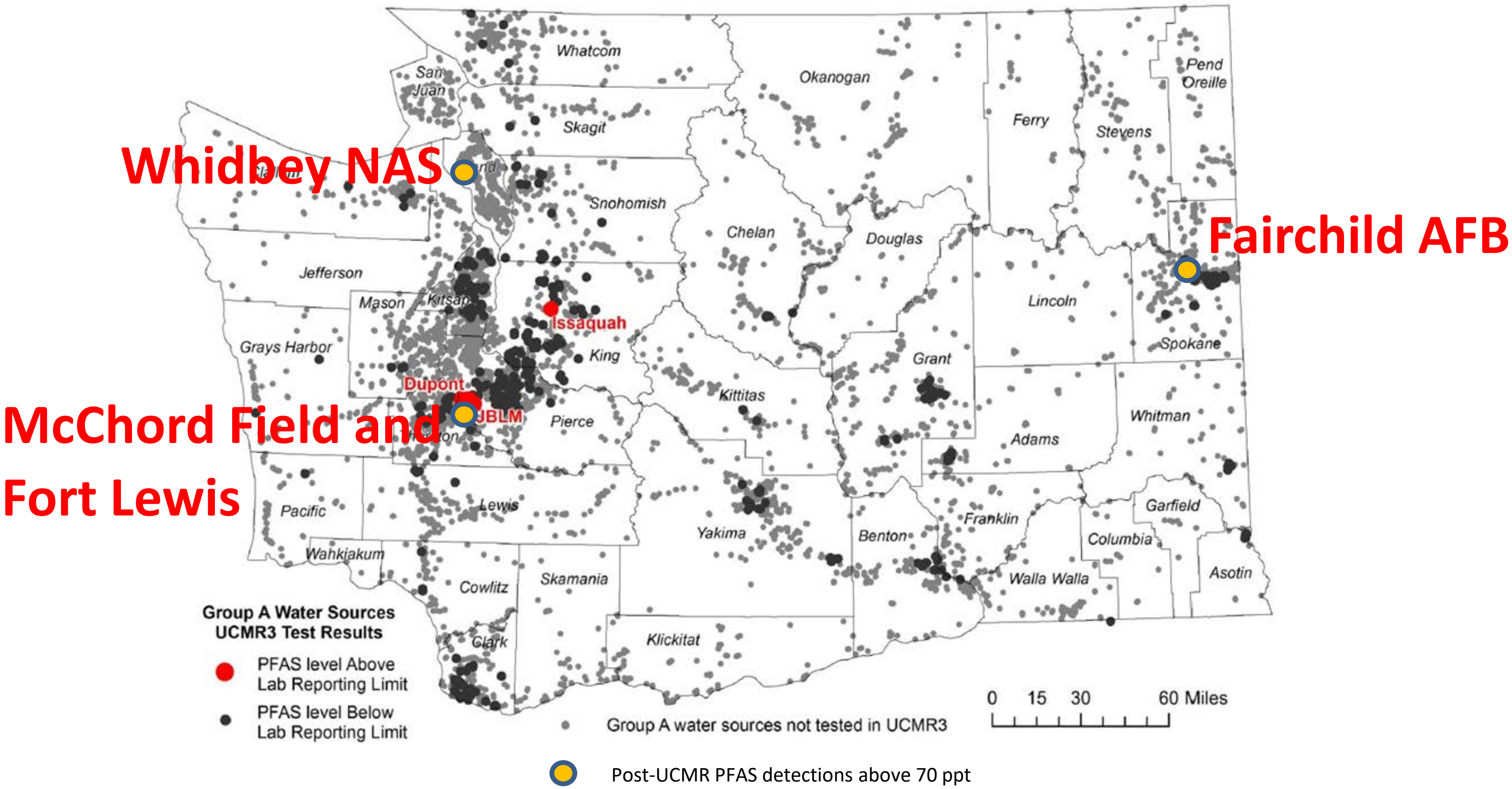
Washington PFAS Occurrence in Drinking Water



Washington State Department of Health

Next Steps for DOH

- Continue to support impacted communities
- Coordinate activities with local health jurisdictions
- Respond to request for rule-making
- Fund up to 500 PFAS samples with grant funds
  - Market sampling program to known at-risk public drinking water supplies
  - Seek greater distribution of sampling data from across the state

Contact

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Washington State Department of Health

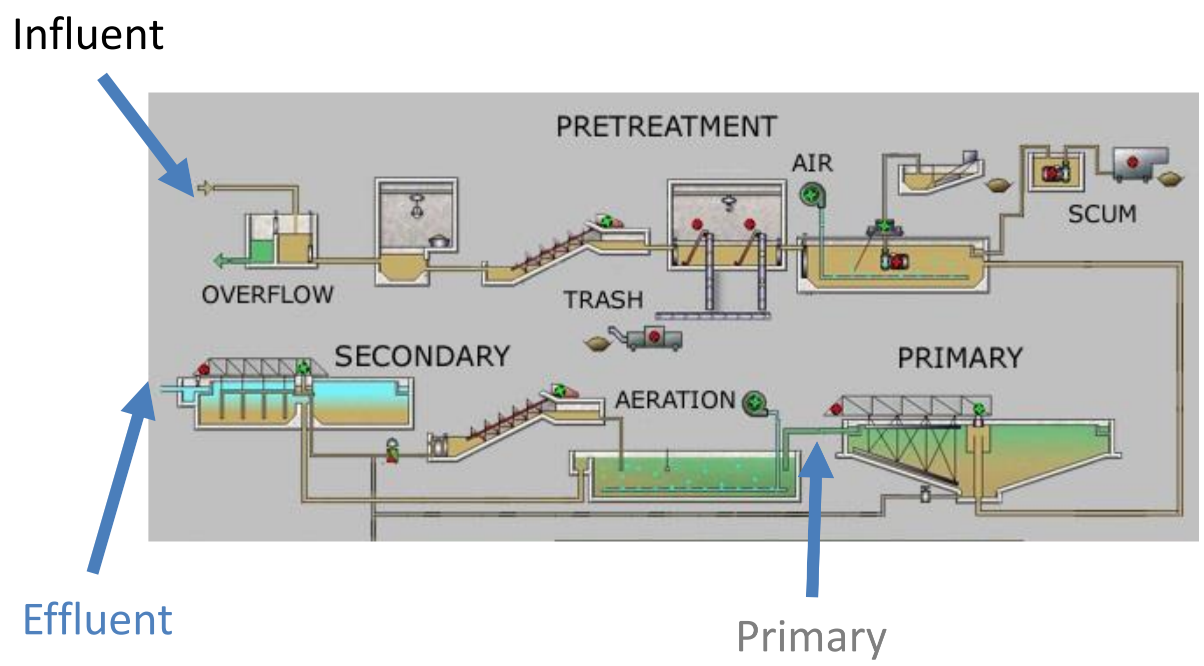
Chemistry Overview

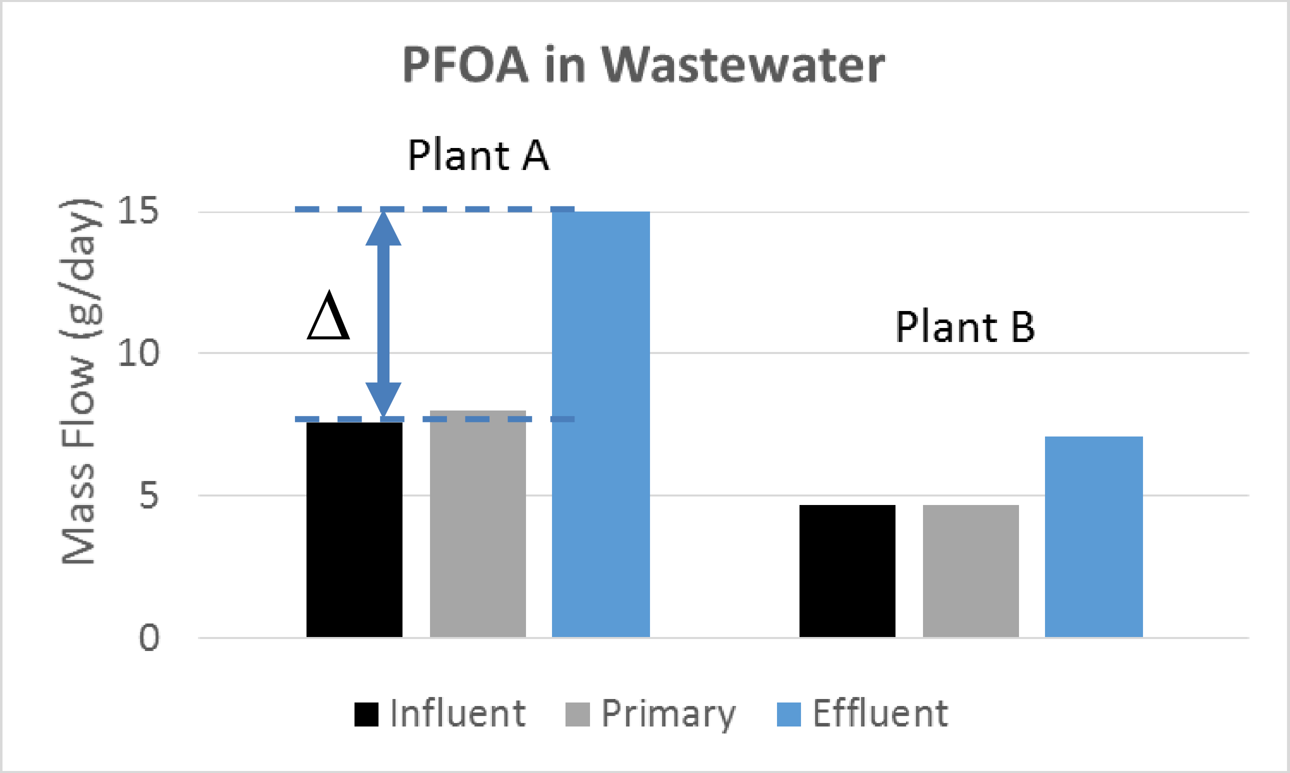
Brian Penttila

August 30, 2017

PFAS from nowhere?

- Sinclair 2006 – 8 analytes



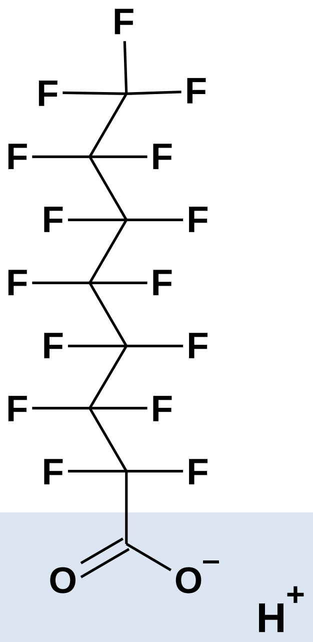


Sinclair, E., & Kannan, K. (2006). Mass Loading and Fate of Perfluoroalkyl Surfactants in Wastewater Treatment Plants, ES&T, 40(5).

Treatment plant image from: [Leonard G.]() at [English Wikipedia]()

PFASs identified in arctic wildlife, but how?

PFOA



PFOA ionized at normal pH

Physicochemical Properties - PFOS & PFOA

- Low vapor pressure (don't evaporate)
- Soluble in water (likely to travel by water)
- Not a candidate for "Long-Range Transport"

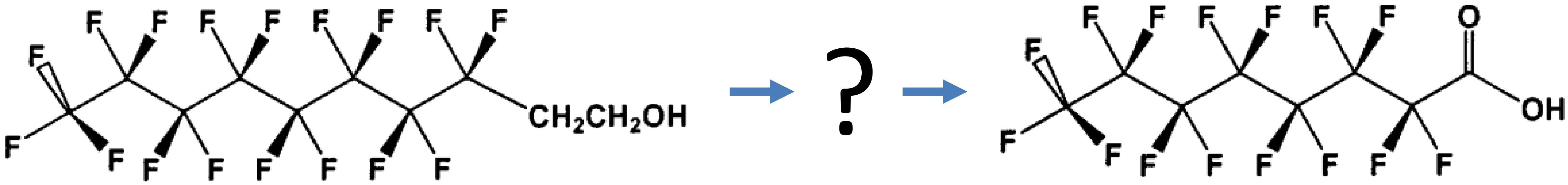
Biomonitoring ca. 2004-2008

- Evidence of PFAAs and biomagnification in animals of the Arctic
- "The transport pathway for these chemicals to the Arctic remains unclear."
- "Due to low volatility of PFCs, their atmospheric transport to remote regions such as the Arctic had been unexpected."

Smithwick et al., 2005, "Circumpolar Study of Perfluoroalkyl Contaminants in Polar Bears (Ursus maritimus)." Environ. Sci. Technol., 39, 5517-5523.
Dietz et al., 2008, "Increasing Perfluoroalkyl Contaminants in East Greenland Polar Bears (Ursus maritimus): A New Toxic Threat to the Arctic Bears," Environ. Sci. Technol. 2008, 42, 2701–2707.
Ellis et al., 2004, "Degradation of Fluorotelomer Alcohols: A Likely Atmospheric Source of Perfluorinated Carboxylic Acids," Environ. Sci. Technol. 2004, 38, 3316-3321.

Per- and Polyfluorinated Alkyl Substances (PFASs)

- Precursors vs Intermediates vs Final Degradates

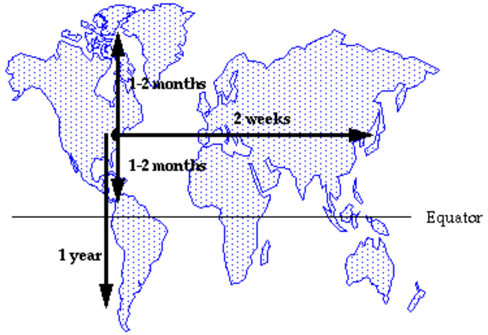


8:2 Fluorotelomer alcohol (FTOH)
(**Precursor**)

(**Intermediate Degradates**)

PFOA
(**Stable Degradate**)

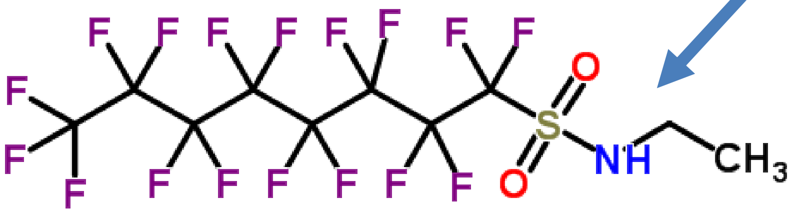
- FTOHs are volatile and travel long distances in the atmosphere



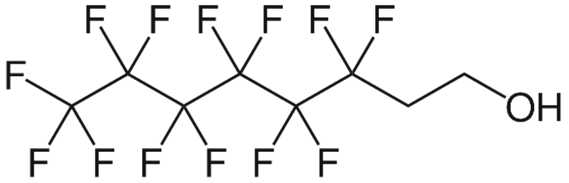
Per- and Polyfluorinated Alkyl Substances (PFASs)

Varied chain lengths

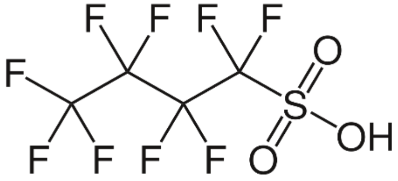
Varied functional groups



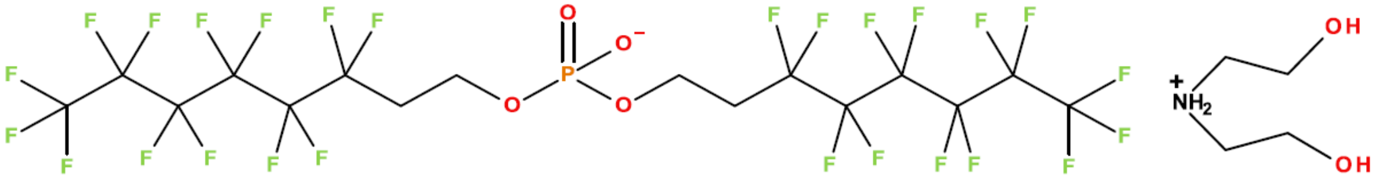
EtFOSA – abandoned



6:2 FTOH – current workhorse fluorotelomer



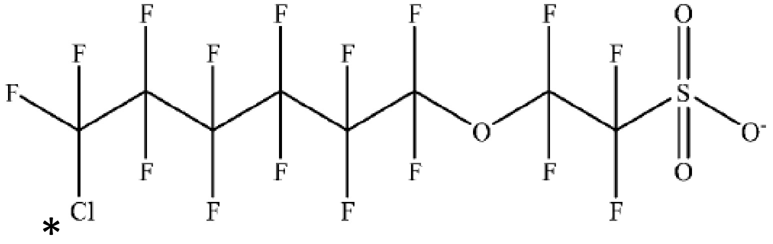
PFBS - basis of 3M chemistry



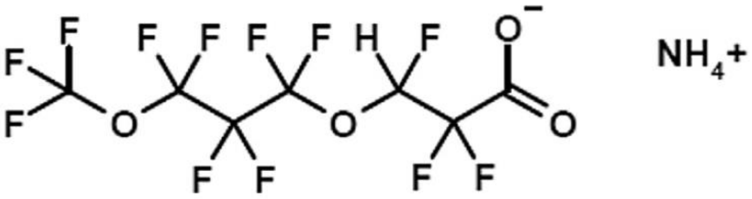
DiPAP used in paper treatment

Varied chain types

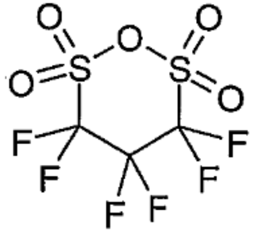
F-53B



ADONA (PFOA replacement)



Or not chains!



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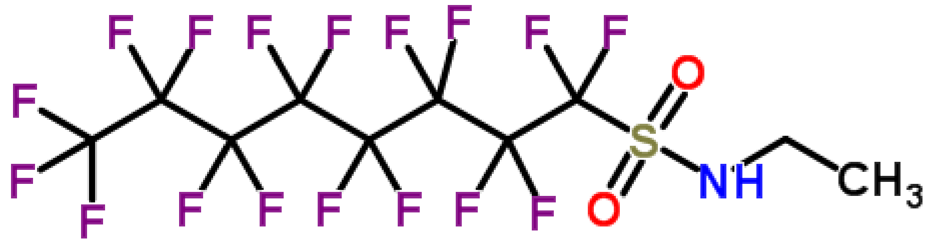
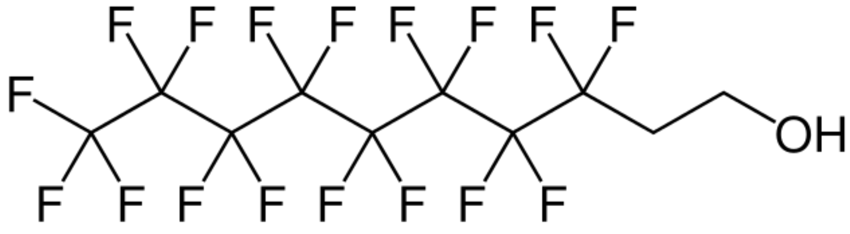
Polymer Types Transition over Time

Legacy



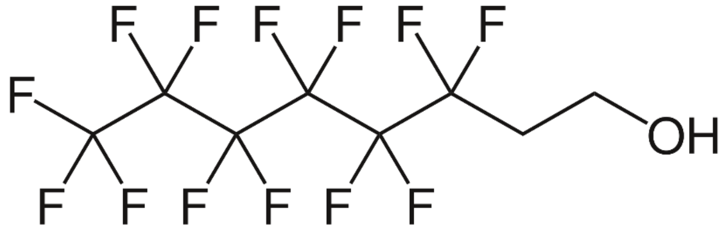
EtFOSA

Legacy?



8:2 FTOH

Current



6:2 FTOH

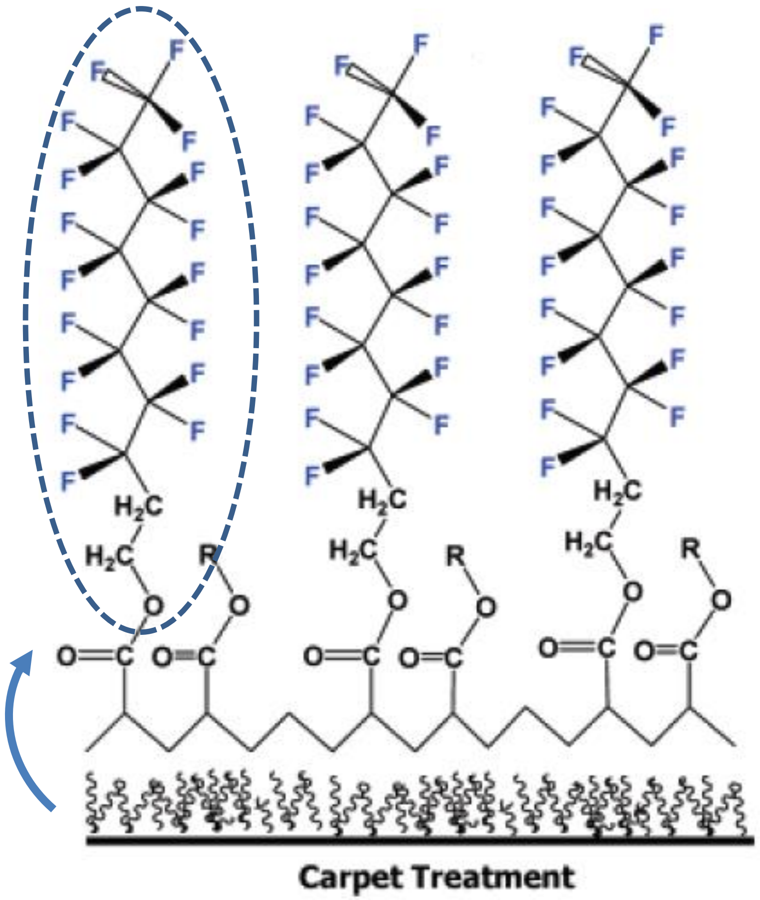
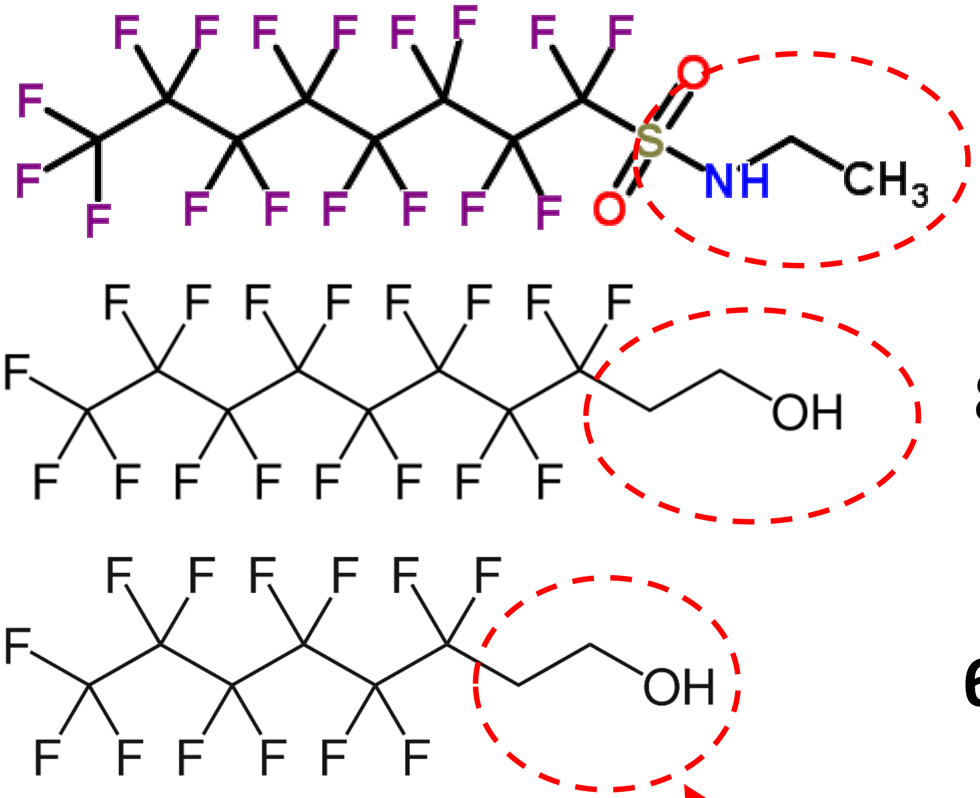


Image adapted from Dinglasan et al., 2006, "Significant Residual Fluorinated Alcohols Present in Various Fluorinated Materials." ES&T, **40**, 1447-1453

PFAS Transition



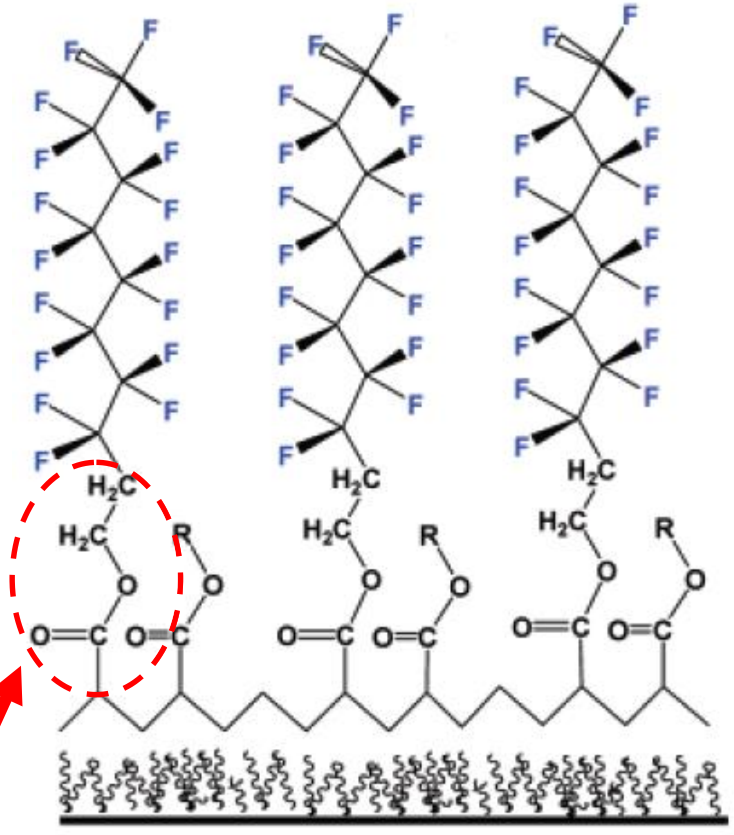
EtFOSA

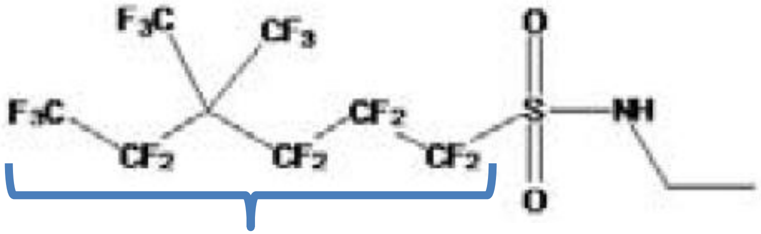
8:2 FTOH

6:2 FTOH

Weaker bonds susceptible to attack

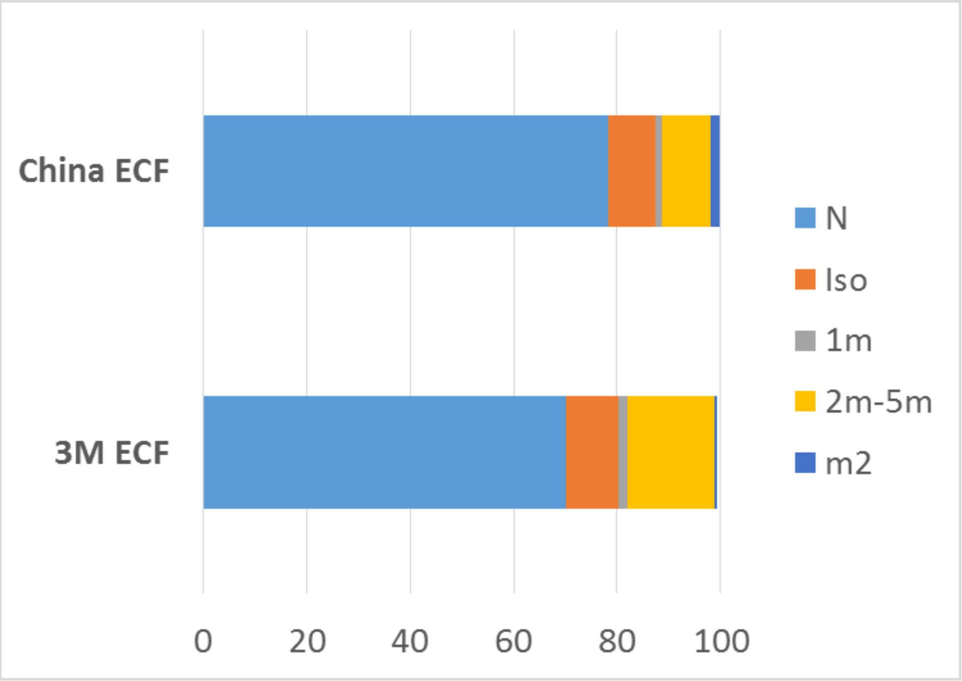
8:2 FTOH



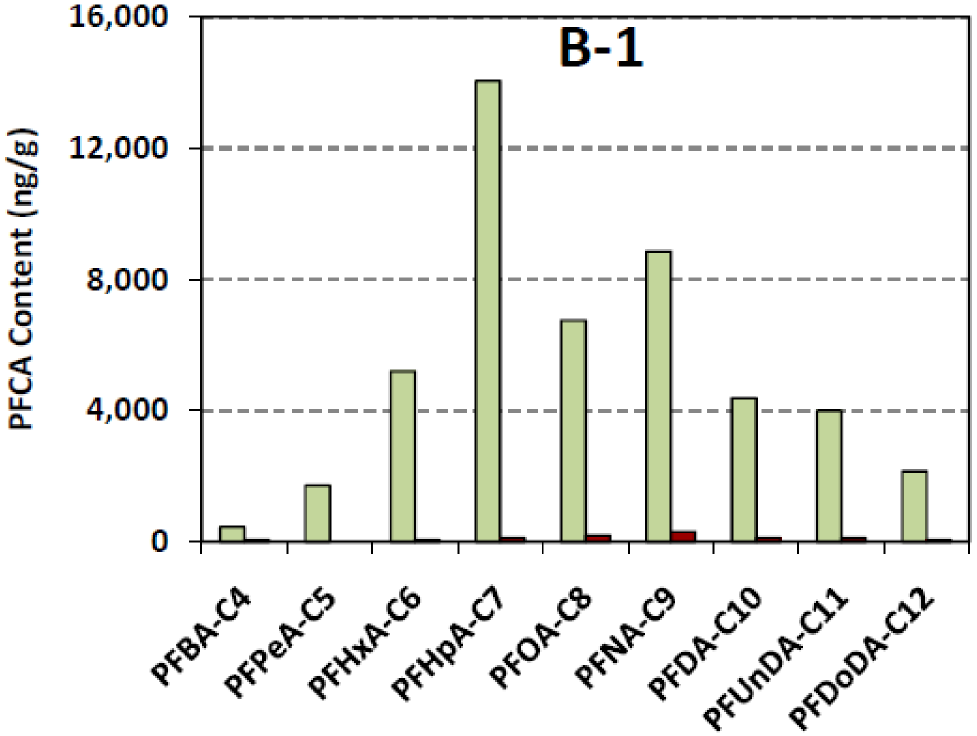


Example of ECF *branched* isomer

Manufacturing



Percent of Each **Isomer** Type
in Commercial PFOS Samples



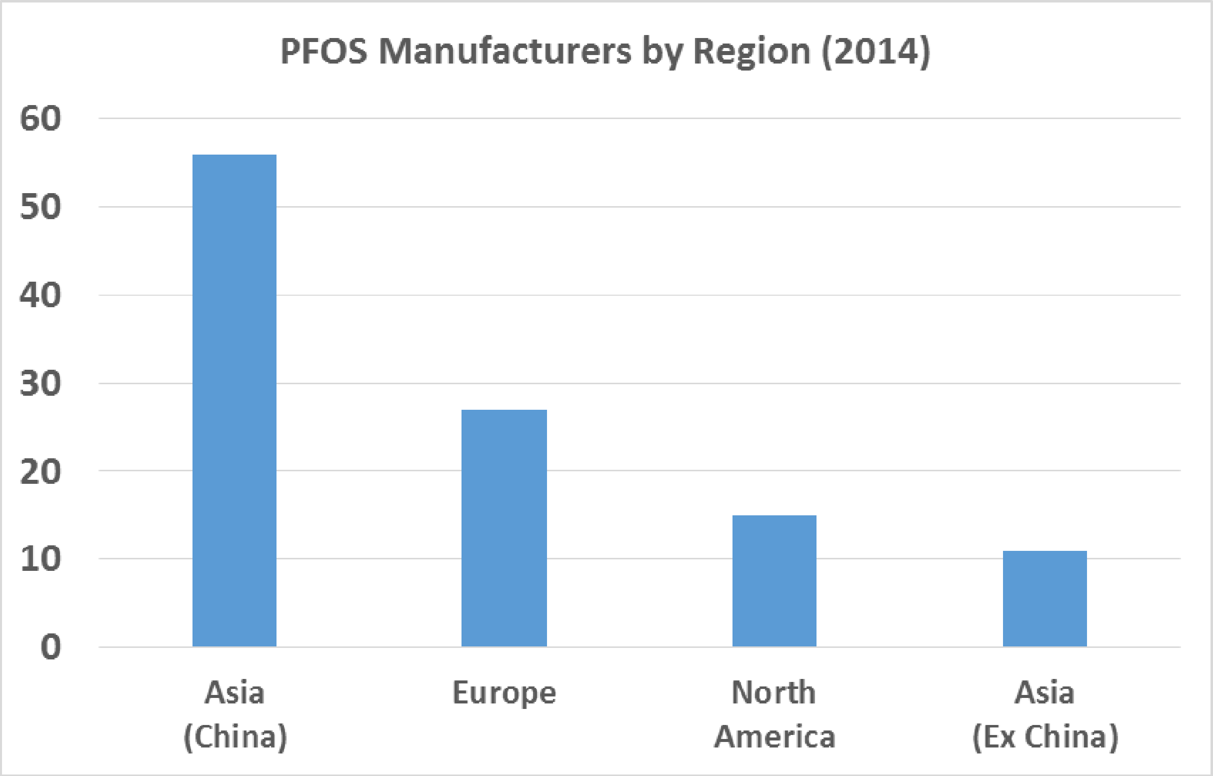
2007 carpet/upholstery protector concentrate

1) Electrochemical fluorination (ECF)

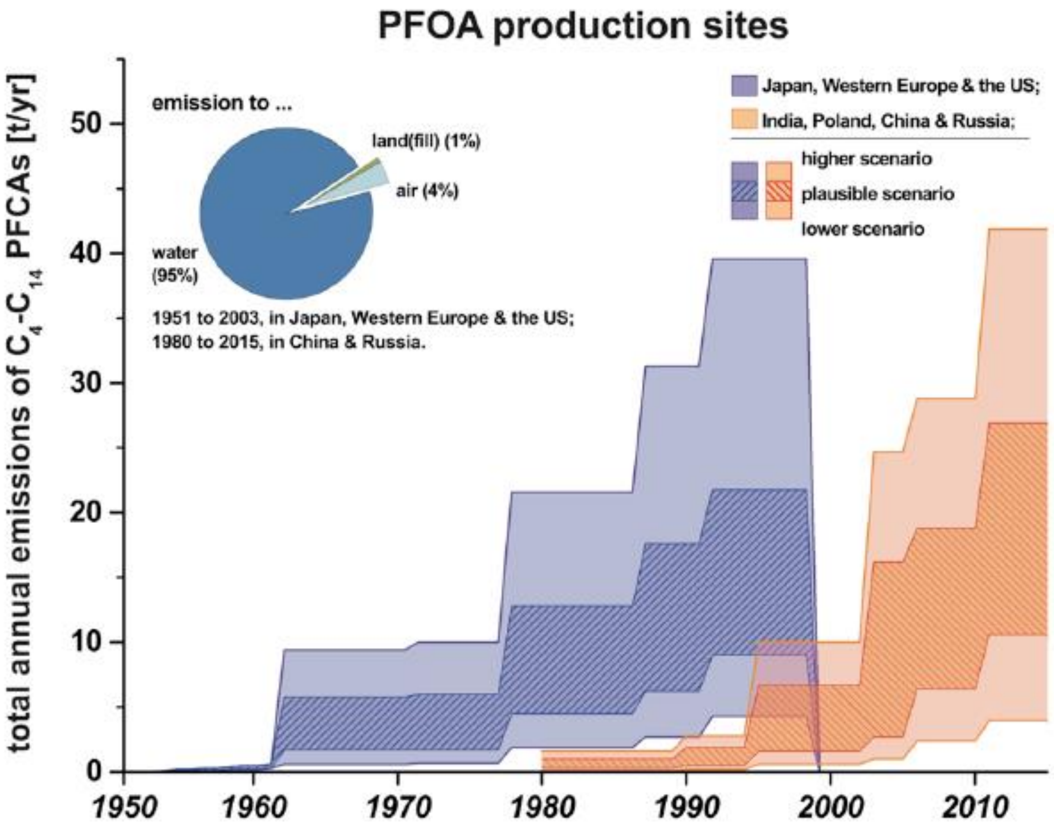
2) Telomerization

Isomer profile based on Jiang et al., 2015, Chemosphere 127 (2015) 180–187
Carpet product based on Liu et al. 2012, EPA/ 600/R-12/585, August 2012

Manufacturing



Over 100 companies could be involved in production of PFOS and derivative products globally, mostly abroad.



Projections of PFOA emissions suggest that PFOA use has not ended, but rather been replaced by use abroad.

Left figure based on 2014 FluoroCouncil submission to POPRC. FluoroCouncil members are not included in these data as they do not manufacture PFOS. Right figure reproduced from "Working towards a Global Emission Inventory of PFASs: Focus on PFCAs - Status Quo and the Way Forward," © OECD, 2015, p. 39.

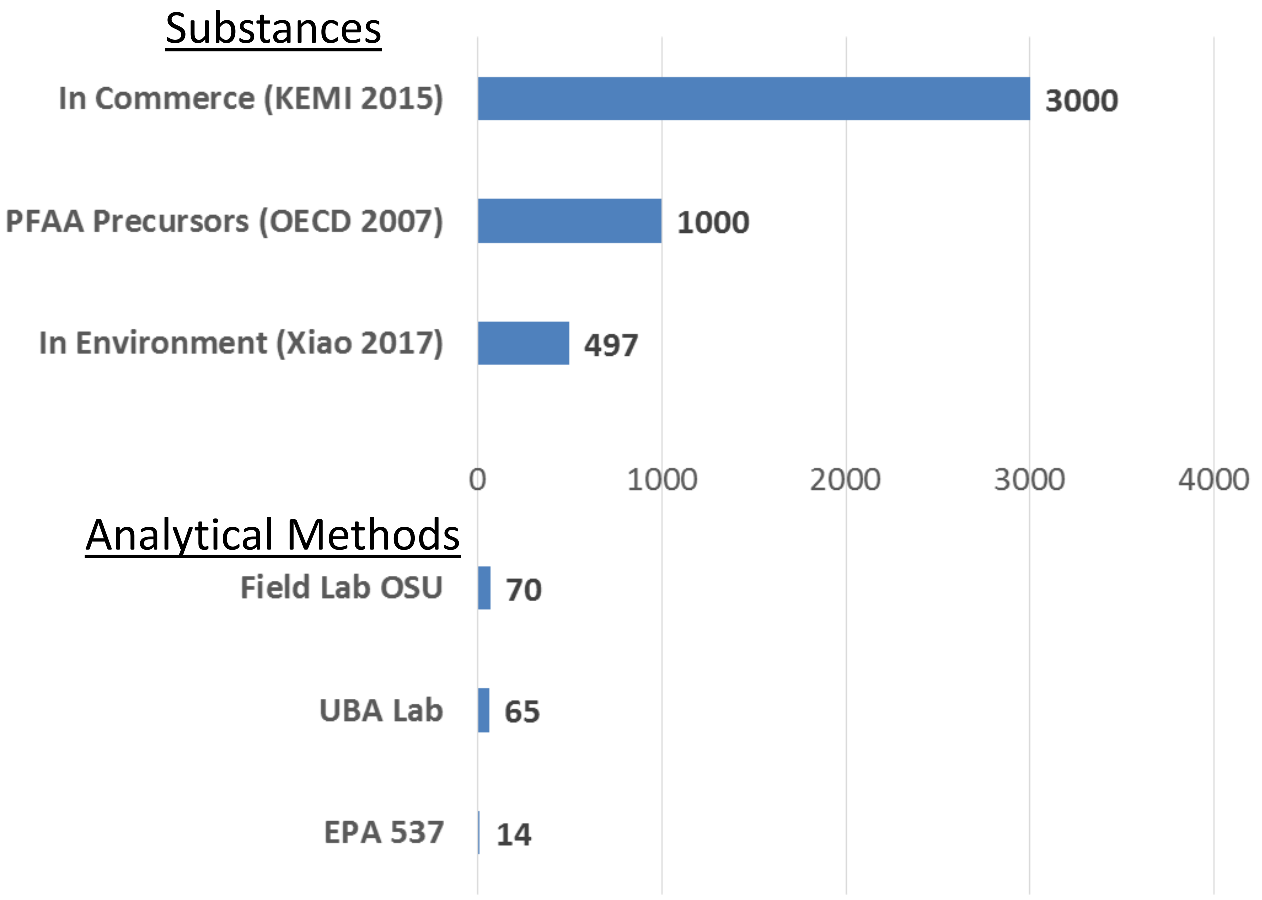
How many PFASs are there?

?

Can we detect & quantify them?

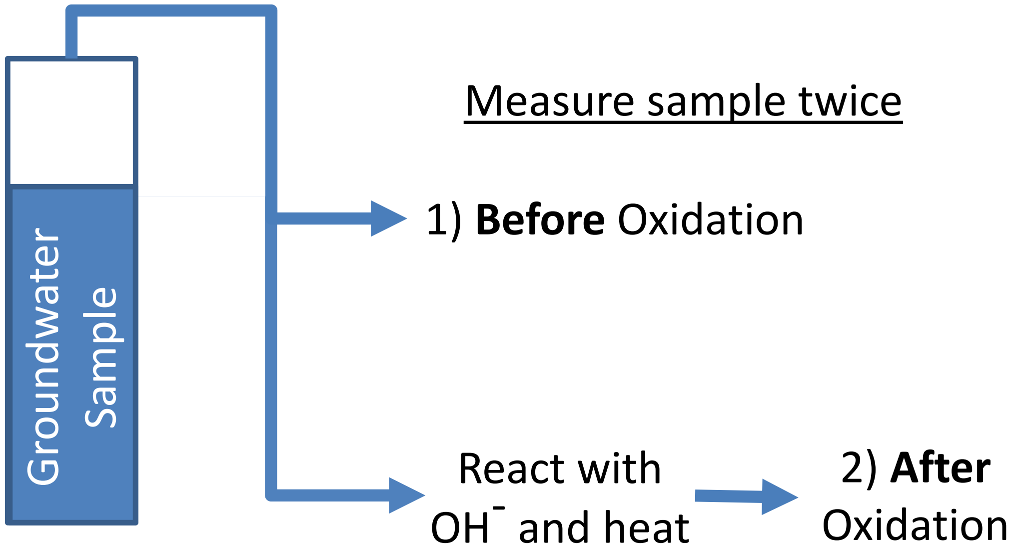
Analytical capability

- Quantitative methods are very limited (1 **validated** method)
- Qualitative and quantitative methods are developing rapidly, but are hampered by the lack of standards
- The number of environmentally relevant substances far outstrips our analytical capability
- World-class labs quantify ~70 substances

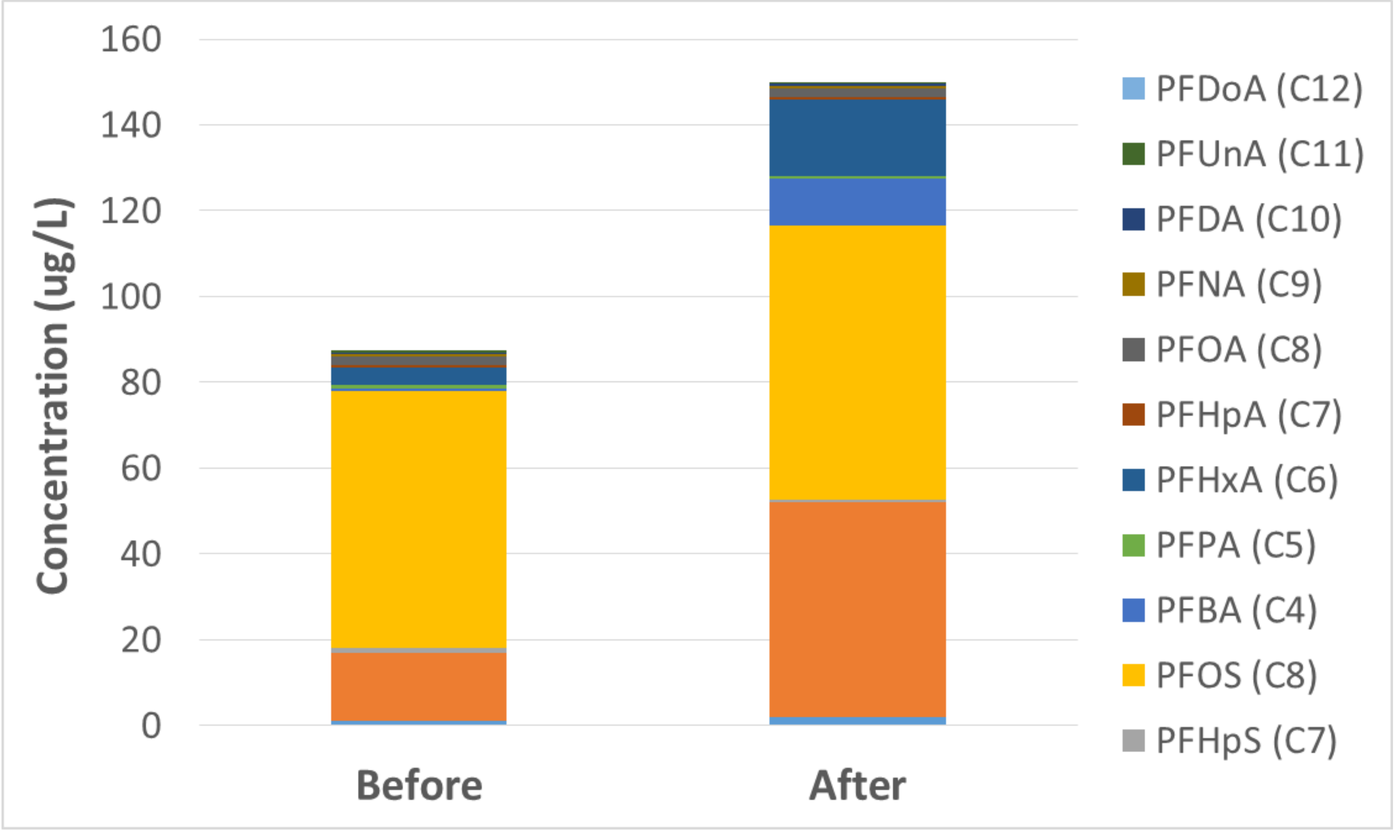


KEMI. (2015). Occurrence and use of highly fluorinated substances and alternatives Report from a government assignment. Stockholm. Retrieved from https://www.kemi.se/global/rapporter/2015/report-7-15-occurrence-and-use-of-highly-fluorinated-substances-and-alternatives.pdf
Frömel, 2016, "Investigations on the presence and behavior of precursors to perfluoroalkyl substances in the environment as a preparation of regulatory measures." (UBA); Xiao, F. (2017). Emerging poly- and perfluoroalkyl substances in the aquatic environment: A review of current literature. Water Research, Volume 124, 1 November 2017, Pages 482-495.

Many environmental samples have a large fraction of precursors not found in standard analytical methods



Oxidation treatment converts **unknown precursors** to measurable PFAAs



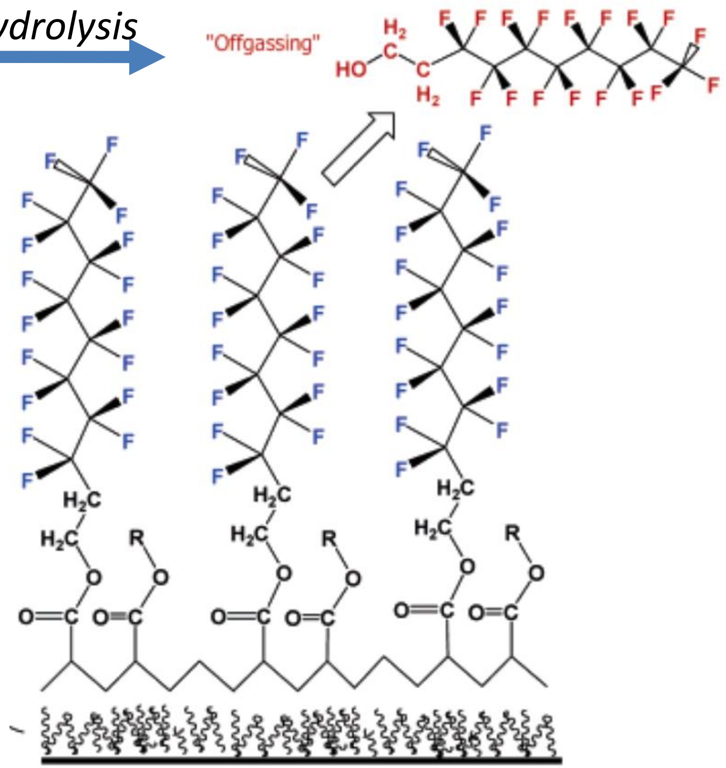
Difference is large "unknown" mass converted to PFAAs

FTP breakdown a long-term source of PFASs

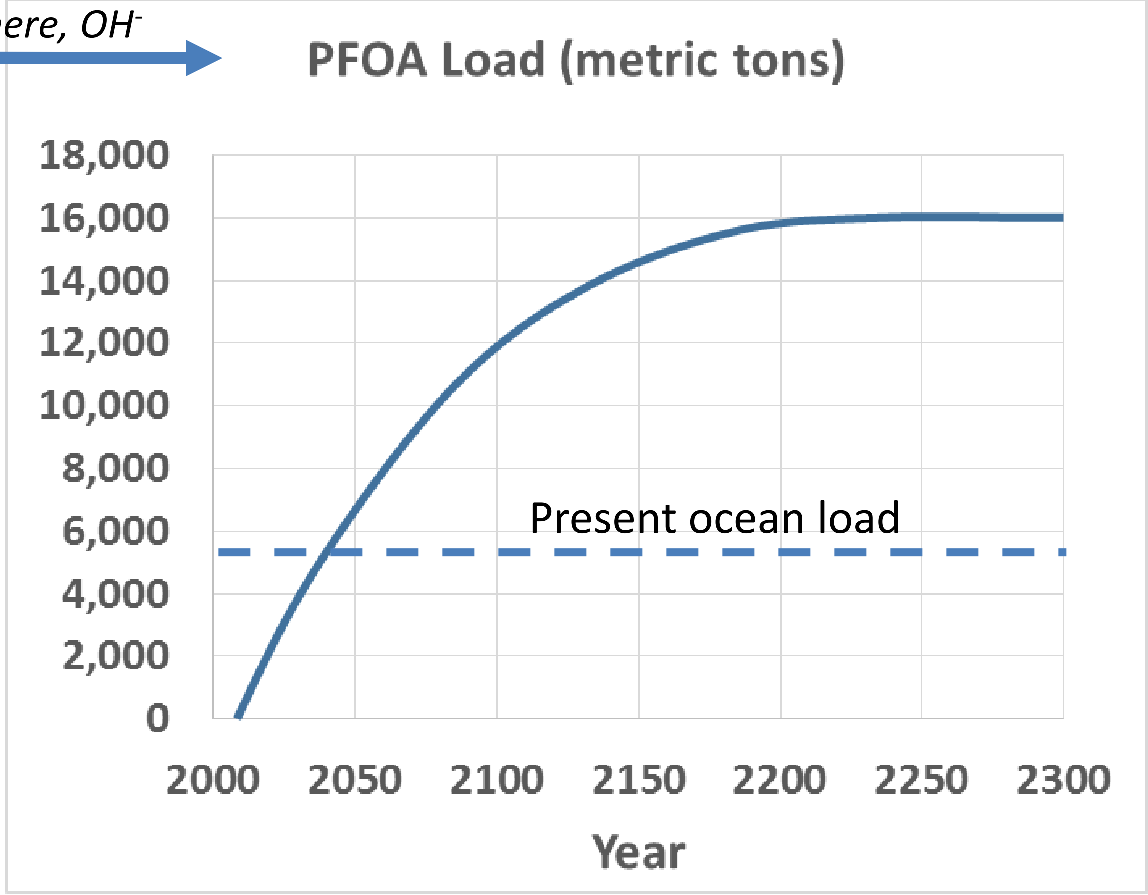
Fluoro-telomer polymer

landfill hydrolysis

FTOH



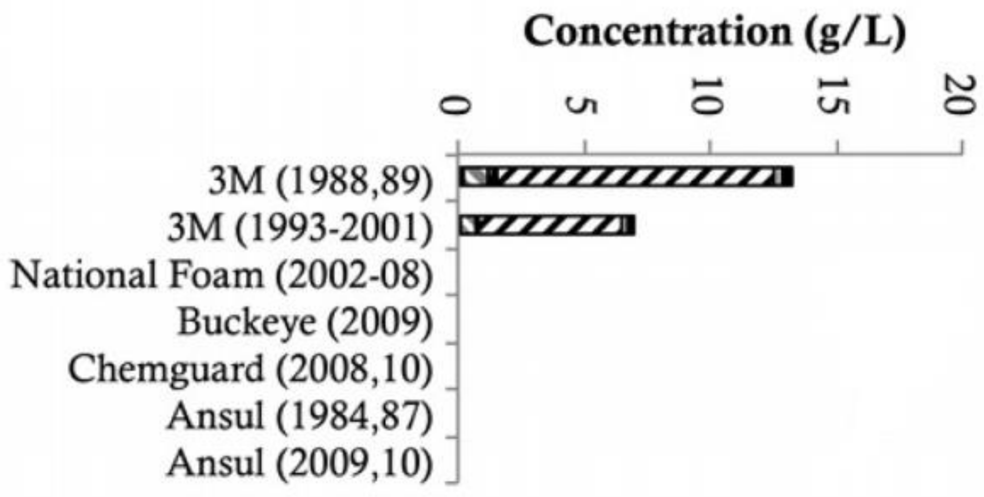
atmosphere, OH^-



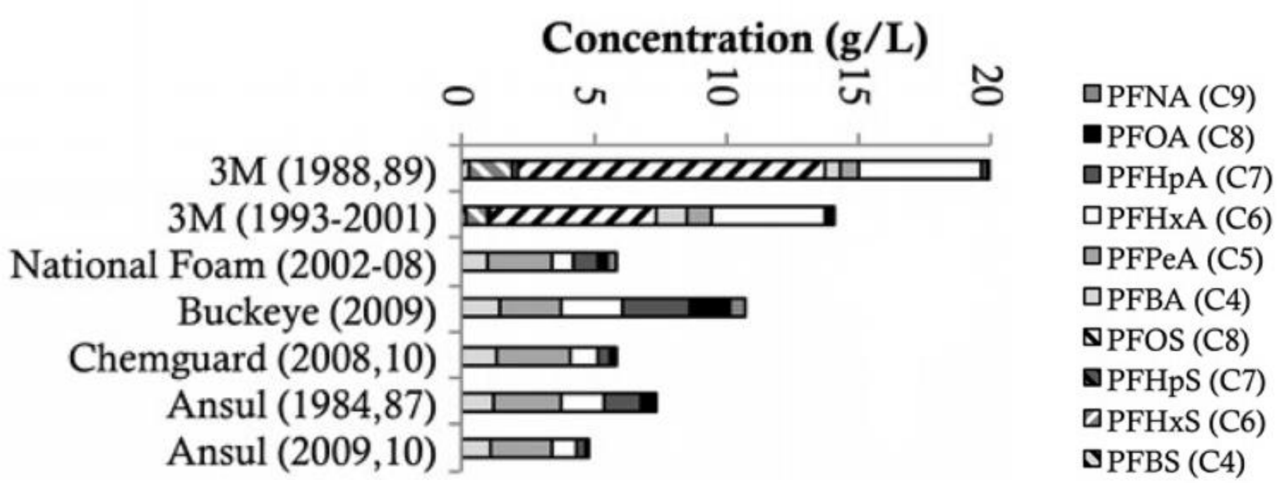
Landfill burial a common end-of-life scenario

Washington & Jenkins, 2015, “Abiotic Hydrolysis of Fluorotelomer-Based Polymers as a Source of Perfluorocarboxylates at the Global Scale,” ES&T, **49**, 14129-14135

How does this apply to AFFF?



Before TOP



After TOP

- Many AFFF concentrates contain precursors that can't be quantified by standard methods
- The same is true of AFFF contaminated groundwater, aquifer solids, and soils
- Cutting-edge techniques have detected a large number of previously unknown classes of PFASs

Houtz et al., 2013, "Persistence of Perfluoroalkyl Acid Precursors in AFFF-Impacted Groundwater and Soil," ES&T, **47**, 8187-8195.

Environmental Fate of AFFF

- Forty classes of novel PFASs discovered (both AFFF & GW)
  - Many likely from ECF products that have been abandoned
  - Includes 240 individual compounds (Barzen-Hanson et al., 2017)
- Many shorter-chain PFAS products are more soluble in water, more mobile in soil, & more volatile than the legacy products they replaced
- For some of these, there are no data on environmental fate
  - Xiao: "Knowledge of soil sorption and desorption of cationic and zwitterionic PFASs is critically needed to define soil quality criteria, develop remediation technologies, and establish standards for levels of acceptable contamination after remediation."

Barzen-Hanson et al., 2017, "Discovery of 40 Classes of Per- and Polyfluoroalkyl Substances in Historical Aqueous Film-Forming Foams (AFFFs) and AFFF-Impacted Groundwater," ES&T, **51**, 2047–2057.

Summary

- There are hundreds or thousands of overlooked PFASs
  - Partly an issue of disclosure and regulatory requirements
- Gaps in knowledge of product nature/composition
  - Product testing an effort to nudge this along
- Vast gap in analytical methods and data on fate properties (not to mention toxicology)
  - Supporting cutting-edge analytical development
- PFASs generate degradates with very high persistence – product impacts will remain long after production ends
  - Ecology program supporting Green Chemistry & safer alternatives

Uses, Regulations, Product Testing

Kara J. Steward

August 30, 2017

DEPARTMENT OF ECOLOGY
State of Washington

PFAS Production

1940-50

- Nonstick cookware
- Water resistant coating
- Polymer coatings

1960-70

- Fire fighting foams
- Lubricants
- Stain resistant coatings

2000-15

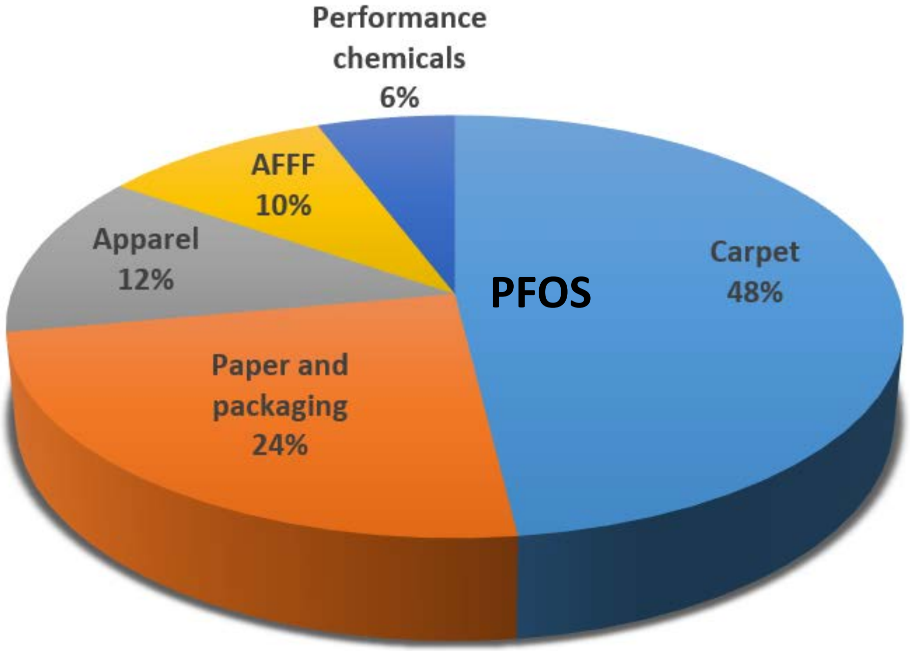
- Reductions
- 2002 PFOS
- 2010-15 PFOA

Slide modified 9/5/17 – trademark names removed

Sources: OECD, DEPA, EPA, ITRC, NWGA, journal articles

EU PFOS/PFOA Production

Substances	Historic Production		EU estimate 2009-11	
PFOS and related substances	96,000 tonnes 1970-2002	3,000 tonnes/yr	10 tonne/yr	80% used in metal plating
PFOA and related substances	8,000 tonnes 1951-2004	150 tonnes/yr	5.5 tonne/yr	PFOA precursor production 20 tonne/yr



Source: DEPA 2016, DEPA 2013, Paul 2009, OECD 2011, Prevedouros *et al.* 2006

PFAS Product Use

Consumer Products	Industrial Uses
Cookware (nonstick coating)	Photo-Imaging
Fast food containers	Metal Plating
Candy wrappers	Semiconductor Coatings
Microwave popcorn bags	Aviation Hydraulic Fluids
Personal care products (shampoo, dental floss)	Medical Devices
Cosmetics (nail polish, eye makeup)	Fire-Fighting Foam
Paints and varnishes	Insect Baits
Stain resistant carpet	Printer and Copy Machine Parts
Stain resistant chemicals	Chemically Driven Oil Production
Water resistant apparel	Textiles, Upholstery, Apparel and Carpets
Cleaning products	Paper and Packaging
Electronics	Rubber and Plastics

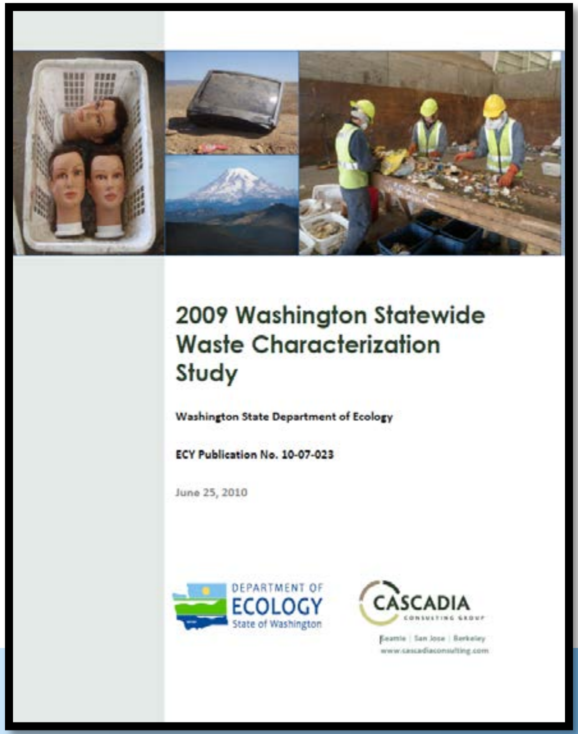
Slide modified 9/5/17 – trademark names removed

PFOS Disposal in WA

Product	PFOS content	Year	WA Disposal	PFOS disposed
Carpet	75 ppm	2009	145,282 tons	10 tons
Furniture	2.4 ppm	2009	97,620 tons	0.2 tons

2009 disposal = 10.2 tons PFOS

Other product categories: Paper products, clothing, textiles, electronics, personal care products



Waste Characterization Studies 2003, 2009, 2015

Source: DEPA 2013, Ecology 2017

PFAS Regulations

ECHA EUROPEAN CHEMICALS AGENCY

FDA U.S. FOOD & DRUG ADMINISTRATION

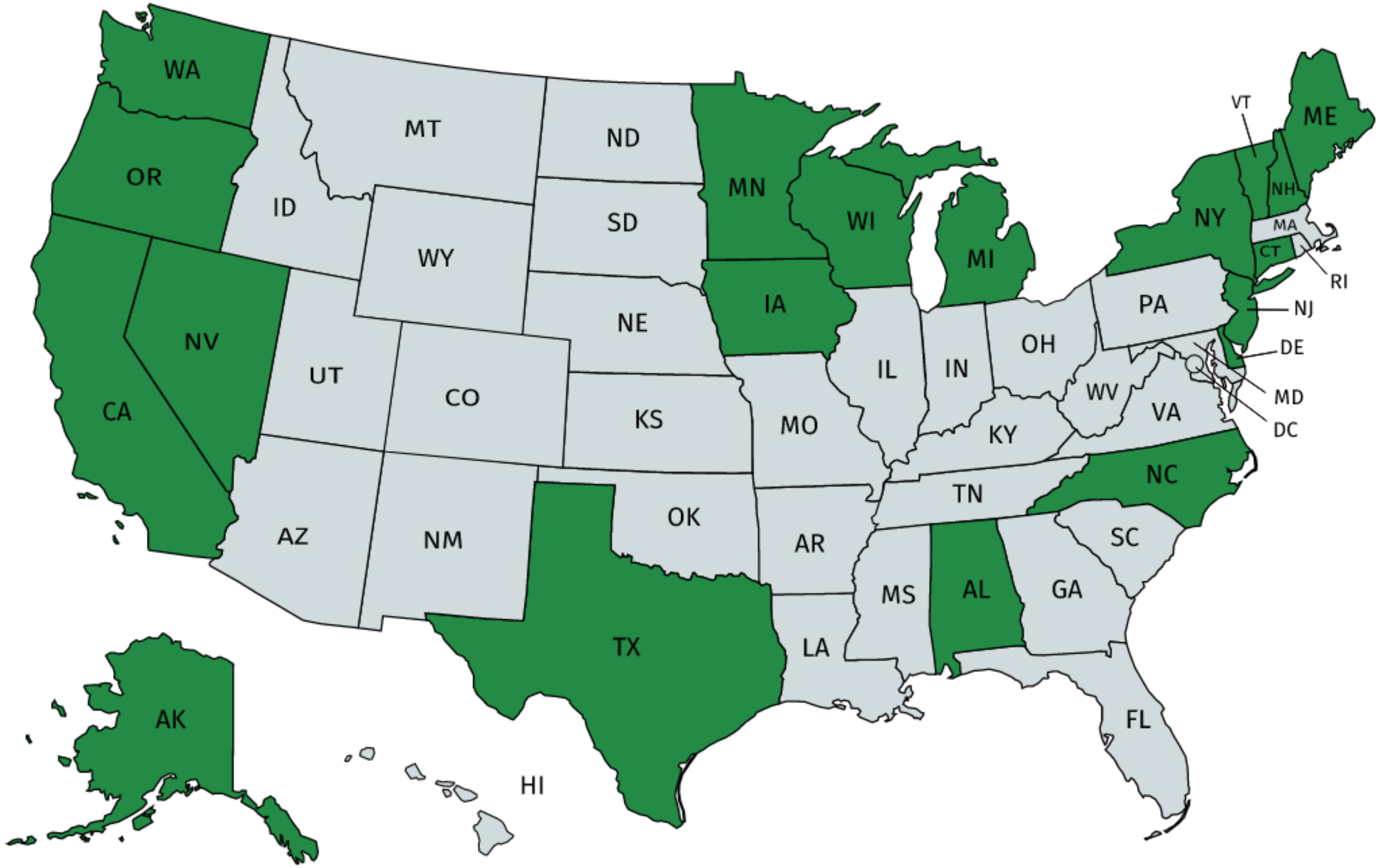
EPA United States Environmental Protection Agency

- EU REACH PFOS/PFOA uses
- Food packaging PFAS restrictions
- EPA – drinking water health advisory, significant new use rules, soil screening guidance, PFOA stewardship, UMCR3

(Unregulated Contaminant Monitoring Rule)

State Actions or Listings

- Effluent
- Fish Tissue
- Ground water
- Product
- Soil
- Surface water
- Waste



Map from - https://mapchart.net/usa.html

PFAS Drinking Water

Agency/year	Health Advisories	PFAS	Health limit (ppb)
Minnesota, 2011	Health risk limit for drinking water	PFBA	7.0 ug/L
Minnesota, 2011	Health risk limit for drinking water	PFBS	7.0 ug/L
New Jersey, 2017	Proposed state MCL for drinking water	PFNA	0.013 ug/L
New Jersey, 2017	Recommended by technical committee as a MCL for drinking water	PFOA	0.014 ug/L
Vermont	Interim Ground Water Enforcement Standard	PFOA	0.02 ug/L
Minnesota, 2017	Revised Health risk limit for drinking water	PFOA	0.035 µg/L
Maine, 2014	Drinking water health-based Maximum Exposure Guideline	PFOA	0.1 ug/L
EPA, 2016	Final Drinking water health advisory – lifetime	PFOA	0.07 ug/L
Minnesota, 2017	Revised Health risk limit for drinking water	PFOS	0.027 µg/L
EPA, 2016	Final Drinking water health advisory - lifetime	PFOS	0.07 ug/L

Products Tested

AFFF	Cosmetics	Paint
Carpet	Food packaging	Personal care products
Carpet care products	Electronics	Sealants
Cleaners	Lubricants	Ski wax
Clothing/textiles	Nonstick ware	Sunscreen

Studies vary in product selection and analytical method

- Greenpeace
- Liu et al 2014, 2015
- Schaider et al 2017
- Herzke et al 2012
- EPA 2009
- Fujii et al 2013
- Kotthoff et al 2015
- Barzen-Hanson et al 2015, 2017
- D'Agostino et al 2014

Ecology 2018 Product Testing

- Product screening
  - AFFF (fire fighting foam)
  - Carpet/care products
  - Cosmetics
  - Food packaging
  - Paints/Lubricants
  - Textiles

PFAS and Human Health

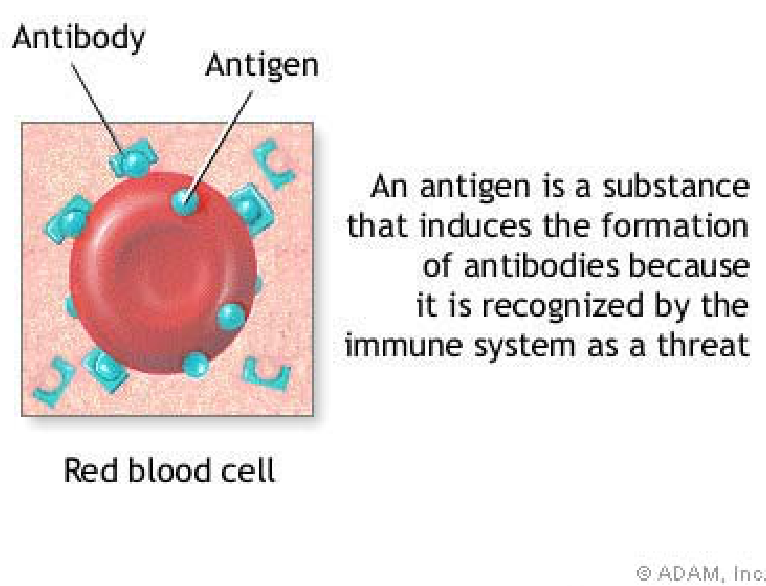
Chemical Action Plan – Advisory Committee meeting
August 30, 2017

Elmer Diaz, Toxicologist
Office of Environmental Public Health Sciences

Washington State Department of Health

Health Concerns with Long-Chain PFAS

- Liver and metabolic effects
- Developmental and Reproductive effects
- Immune suppression



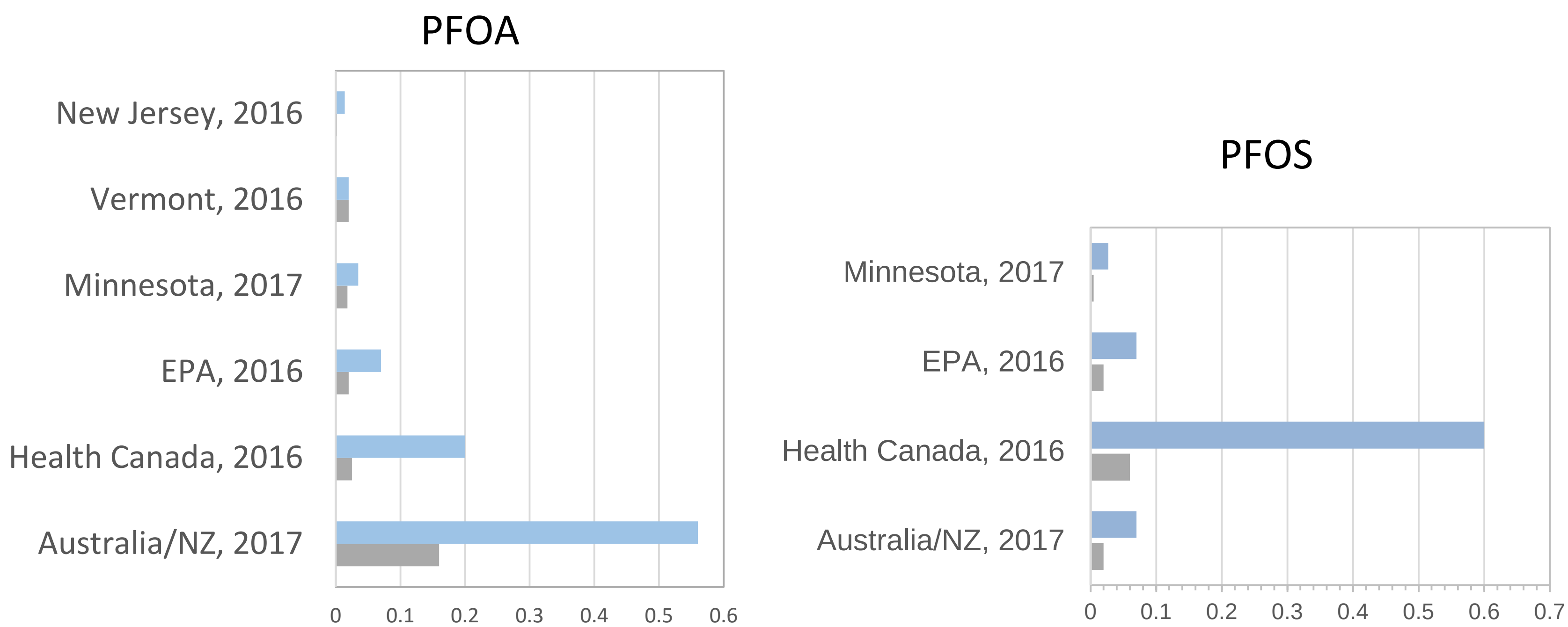
Health Concerns with Long-Chain PFAS

- Endocrine effects
- Neurotoxicity
- Cancer

Most sensitive effects

Animals	Humans
↑ Liver weight, and cell damage	↑ Cholesterol
↓ pup weight and delayed bone formation	↓ Birth weight
Immune toxicity	Immune toxicity
Mammary gland development (rats)	

Drinking Water Health Advisories

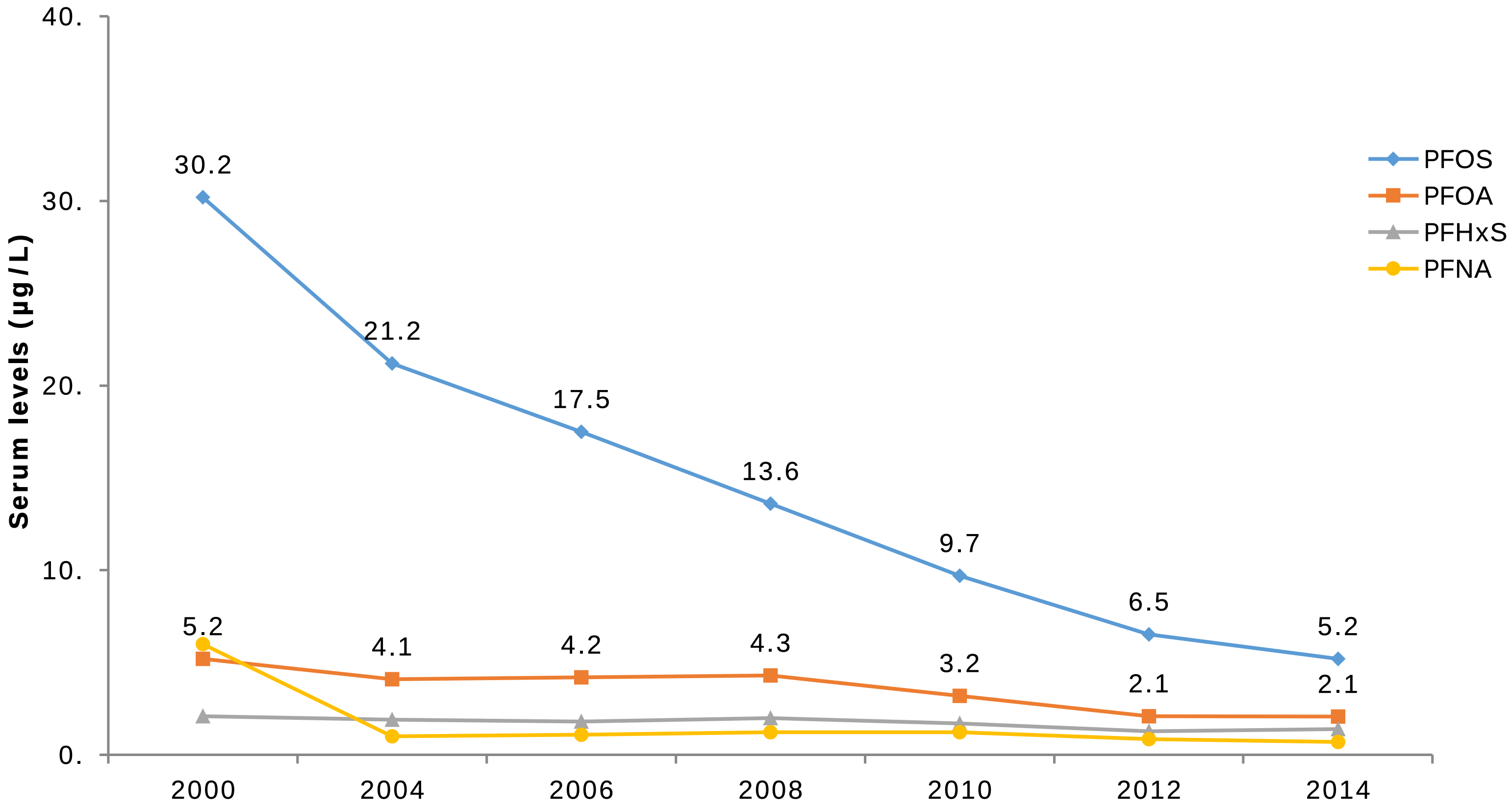


Lifetime health advisory (μg/L)

Reference Dose/Tolerable daily Intake (μg/kg-d)

PFAS levels in the U.S. population

Trend in median levels of PFAS in serum



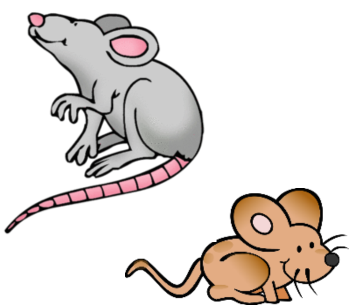
Source: CDC, NHANES, 2017

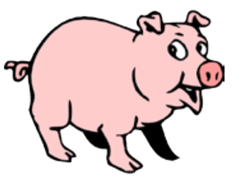
Washington State Department of Health

Long residence time in people
(much shorter in animals)

Half-life in serum

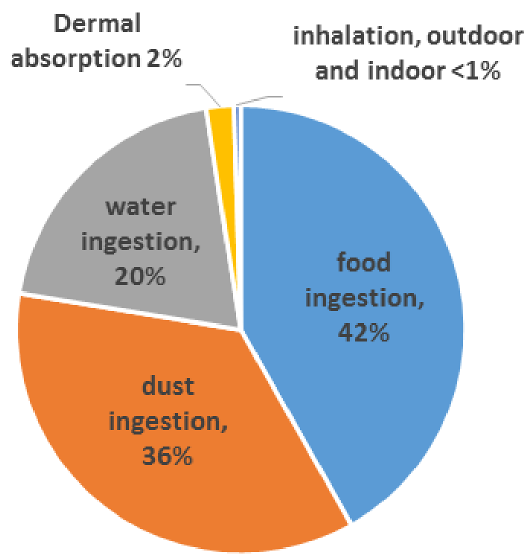
PFOA	F: 2-4 h M: 6-7 d	17-19 d	21-30 d	236 d	2.3-3.8 years
PFOS	F: 62-71 d M: 38-41 d	F: 31-38 d M: 36-43 d	F: 110 d M: 132 d	1.7 years	5.8 years



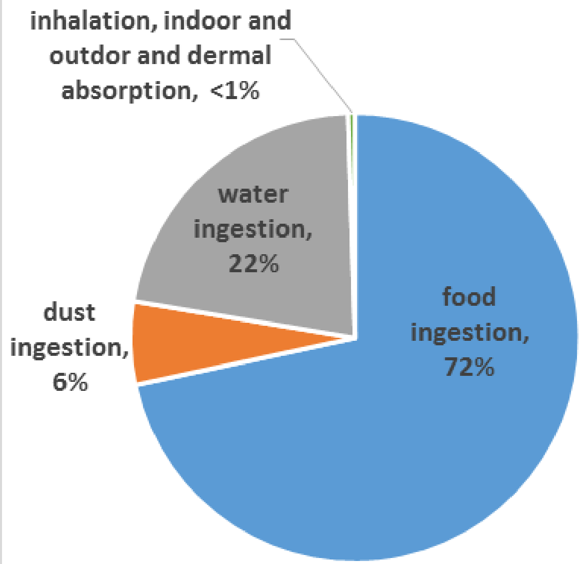



Source: Lau et al. 2015

Typical pathways of exposure



A. 2 yr old child, typical scenario



B. Adult, typical scenario

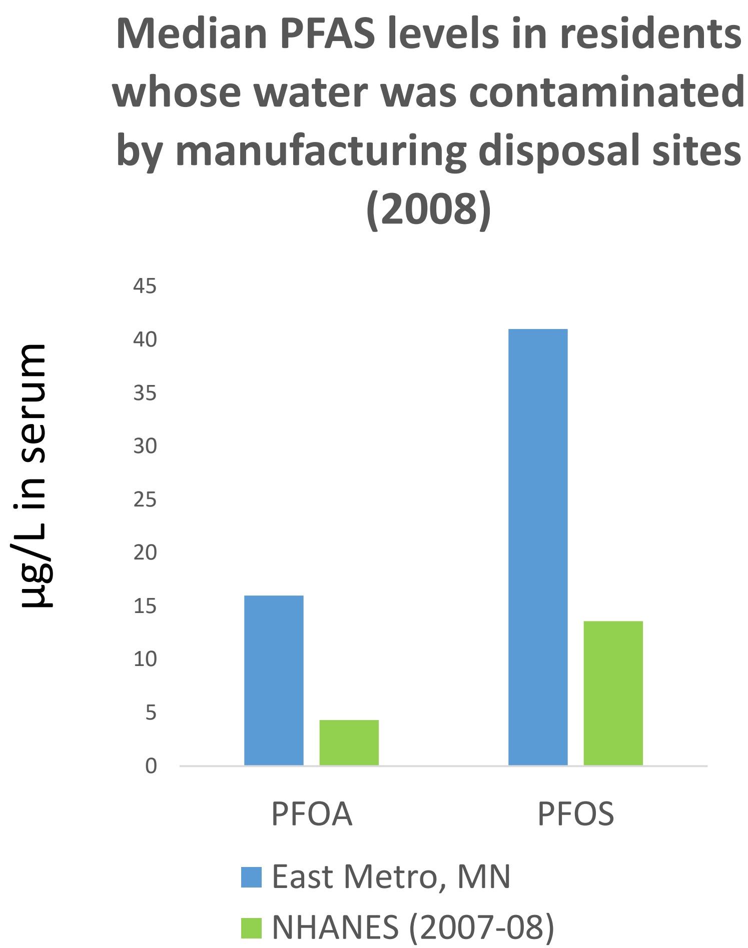
Source: Egeghy and Lorber, et al. 2010

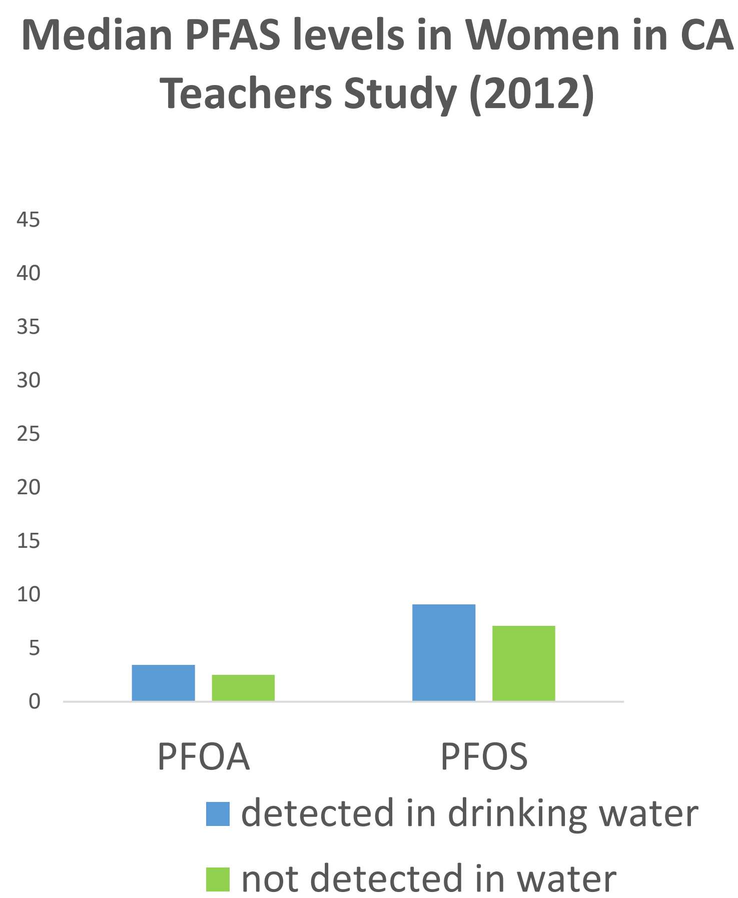
Washington State Department of Health

Developmental exposures

- Concerns
  - PFOS, PFOA, PFHxS, PFNA, PFDA detected in serum of pregnant women
  - Measured amniotic fluid, placenta, umbilical cord blood, breast milk
  - Measured in infants blood serum shortly after birth

PFAS in Drinking Water Contributes…





Source: MDH, 2016

Source: Hurley et al. 2016

Washington State Department of Health

PFHxA, PFBS, PFBA - toxicity

- Similar endpoints in rodents, but higher doses required
  - ✓ Liver effects (↑weight, cellular changes)
  - ✓ Repro/Developmental – PFHxS, PFBA >↓weight, delayed development, pup mortality. None observed for PFBS
  - ✓ Altered thyroid hormones (PFHxA, PFBA)
- Data gaps:

  Immune effects

  Hormone disruption

  Cancer

  Effects of developmental exposures into adulthood

Are short-chain replacements safer?

- ↓ toxicity, bioaccumulation

Concerns

- Extremely persistent
- Soluble and mobile in soil
- Lack of transparency hinders independent assessment
- Developmental effects of PFAS can emerge across the life course – lack of testing
- Harder to remove from drinking water?
- Migrate more efficiently from treated paper to food?
- More likely to be taken up by plants?

DOH Work in Progress

- Map potential PFAS sources to guide further investigation of drinking water
- Develop options for additional water system testing
- Develop evidence-based advice for home gardens, crops with impacted water.
- Develop policy options for addressing other PFAS.

Other problems identified

- Health follow-up on impacted communities
  - Exposure & health effects study
- Detections in WA fish exceed provisional screening values.
- Need data on exposures in consumer products
- Data gaps in toxicology information and exposure potential cause uncertainty.

Questions

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- Health Canada, *Perfluorooctanoic Acid (PFOA) in Drinking Water - Document for Public Consultation*. Federal-Provincial-Territorial Committee on Drinking Water, June 30, 2016.
- Health Canada, Perfluorooctane Sulfonate (PFOS) in Drinking Water - Document for Public Consultation. Federal-Provincial-Territorial Committee on Drinking Water, June 30, 2016.

PFAS in the Environment

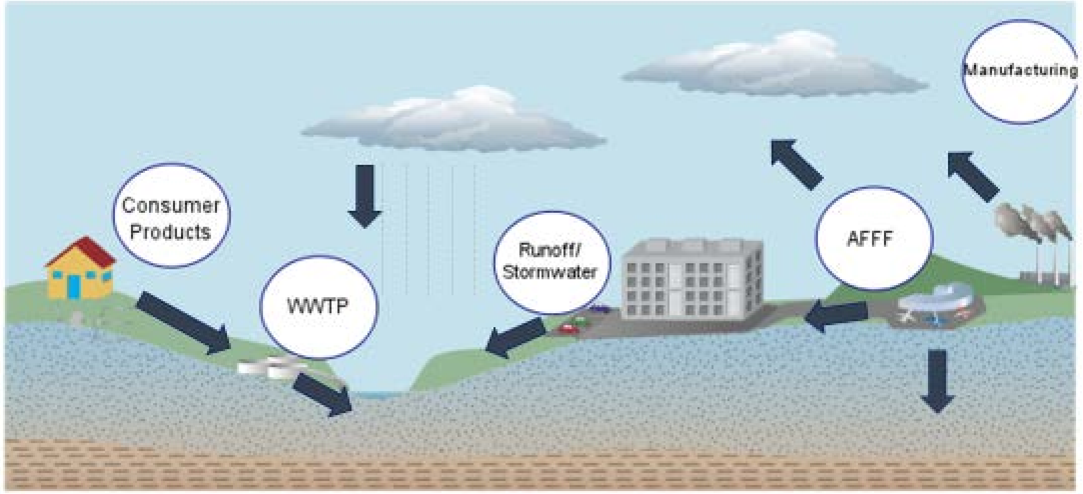
Callie Mathieu

August 30, 2017

DEPARTMENT OF
ECOLOGY
State of Washington

Environmental Pathways

- Relative importance not characterized in WA
- Discrete product use (AFFF)
- WWTP effluent
- Stormwater
- Atmospheric deposition
- Biosolids, landfill leachate

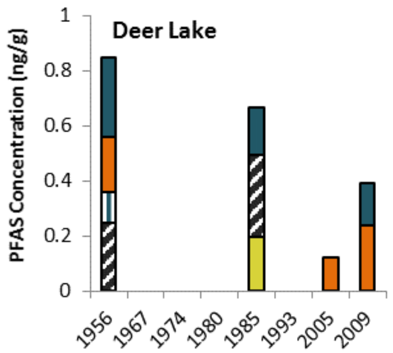


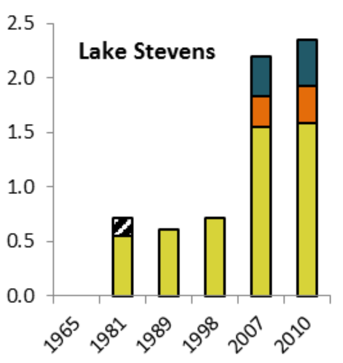
PFAS Detections in Environment

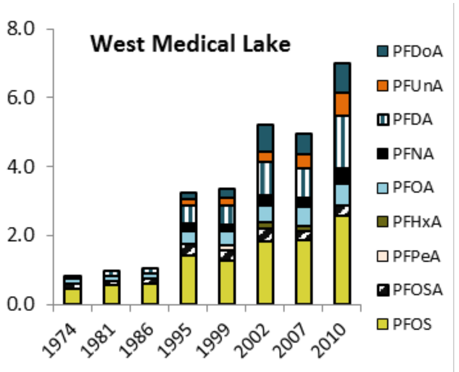
- Widespread occurrence throughout the globe
- In Washington, detected in:
  - Surface water
  - Groundwater
  - WWTP effluent
  - Marine/freshwater sediments
  - Freshwater fish tissue
  - Osprey eggs

Sediment

- Cores from Urban and WWTP-impacted lakes showed increasing trends 1980s-2010
- Rural lake – no trend



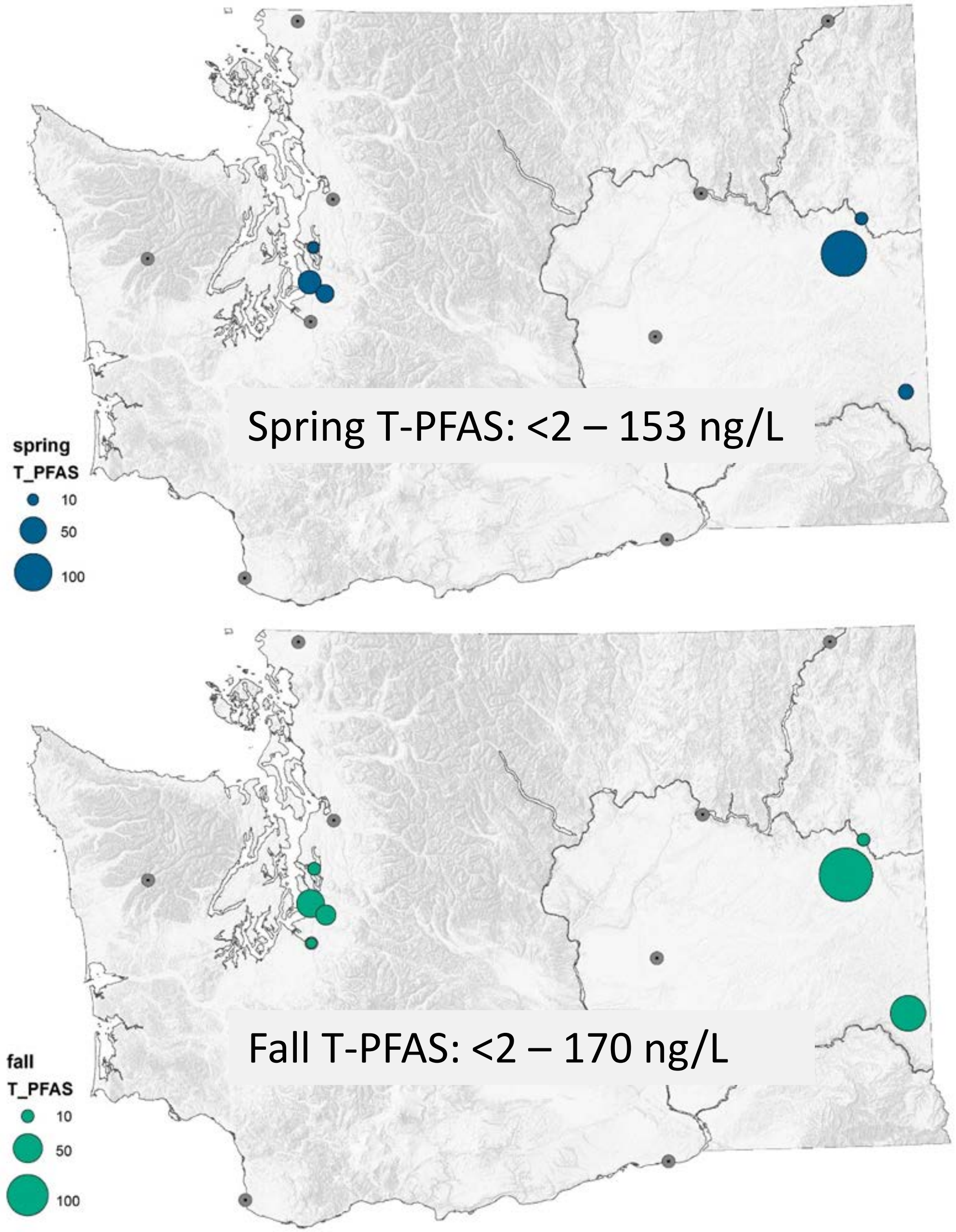




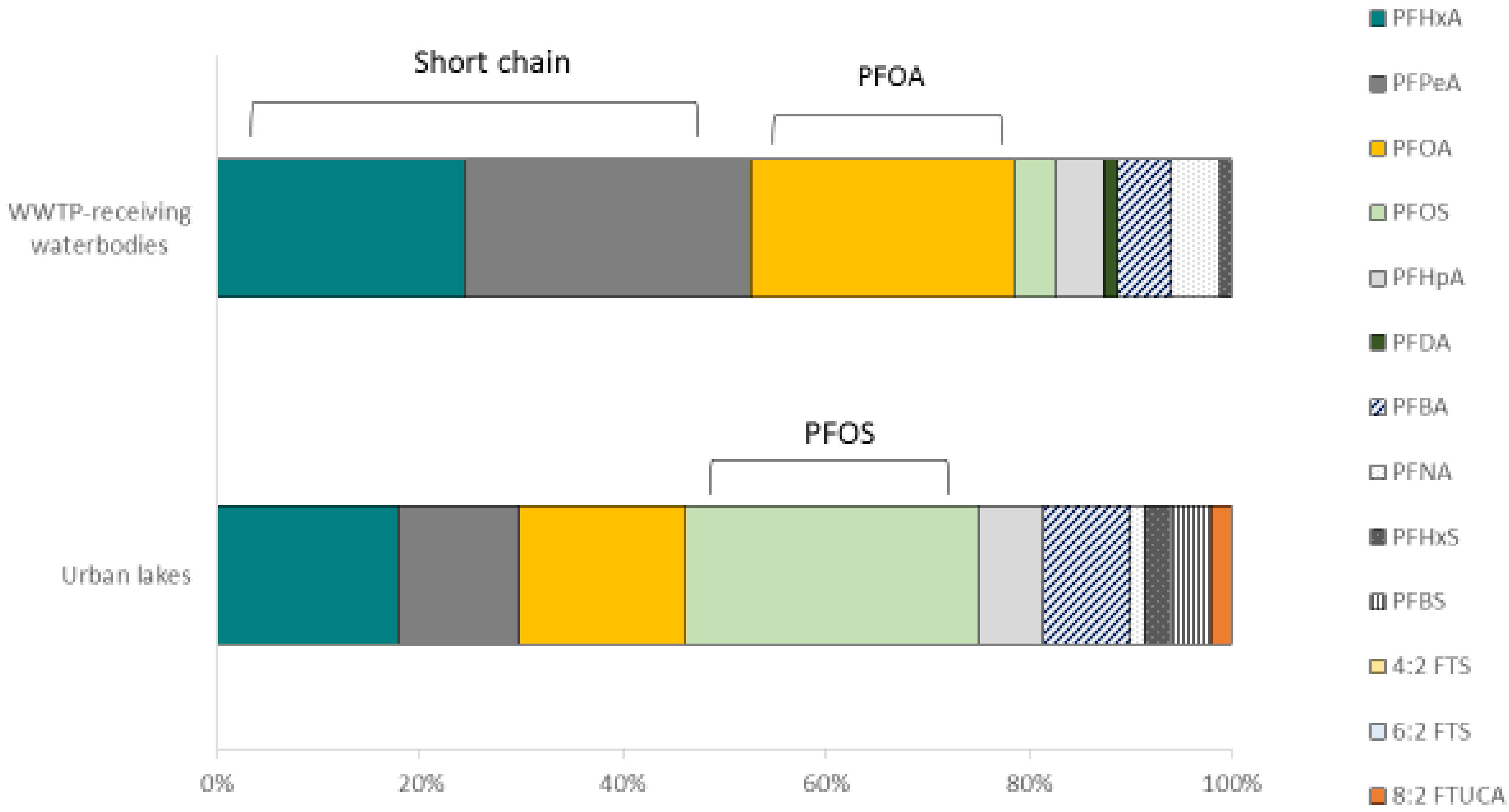
- Marine sediments – detections less frequent, lower concentrations than freshwater cores

Surface Water

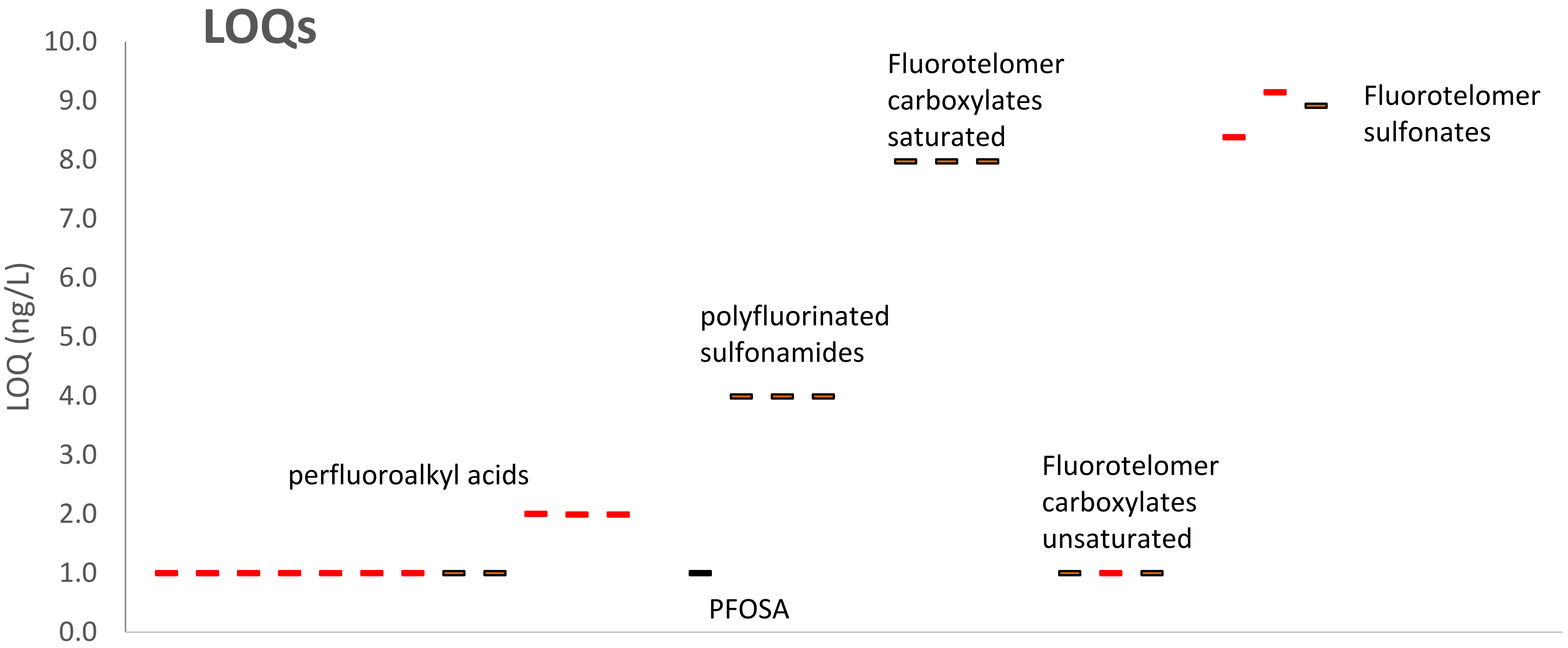
- 2008: widespread occurrence
- 2016: fewer detections, most within range of 5 - 50 ng/L
- Highest concentrations in WWTP-impacted waterbodies
- T-PFAA concentrations similar to MI, RI, NY
- 1-2 orders of magnitude lower than U.S. sites impacted by AFFF or manufacturing



Surface Water - 2016

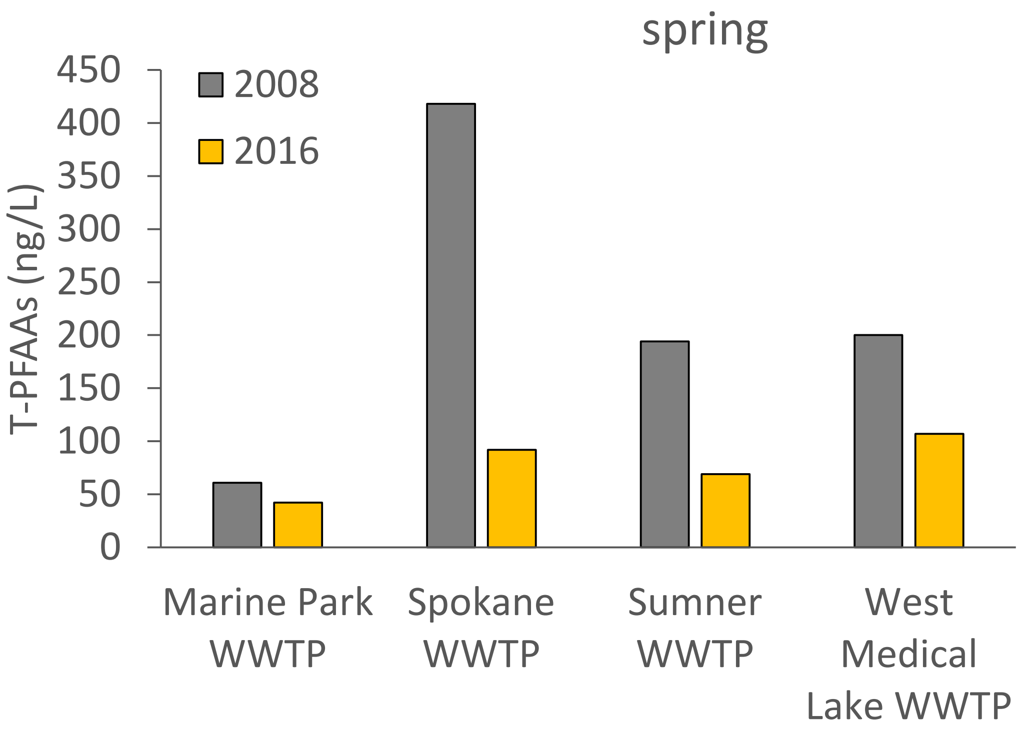


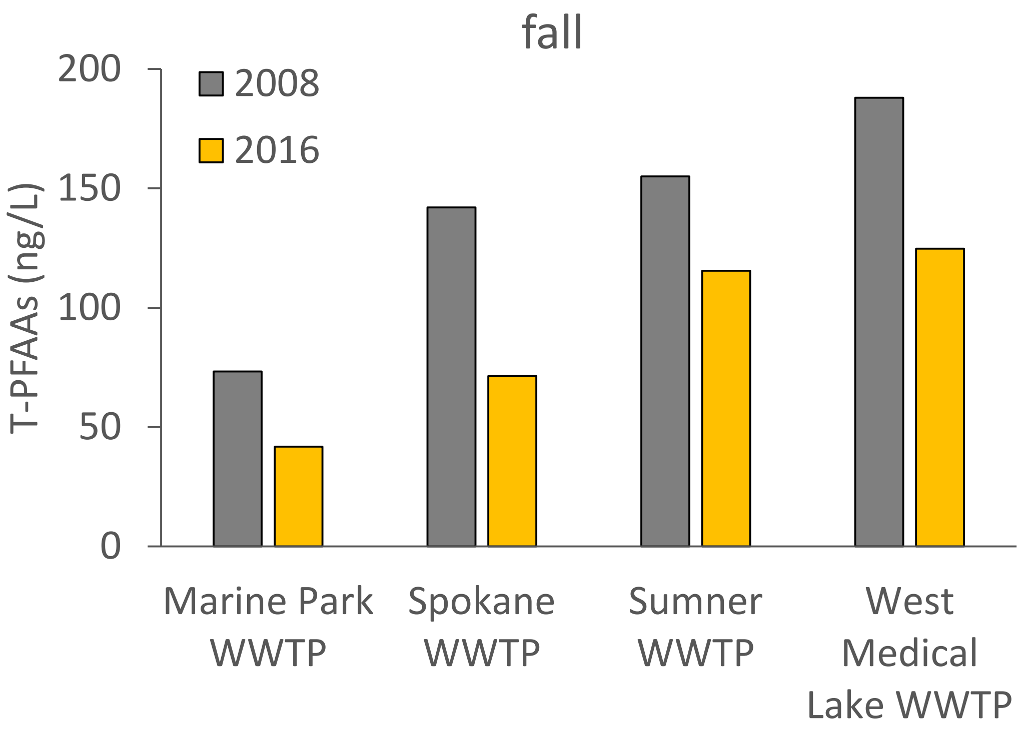
Surface Water - 2016



WWTP Effluent

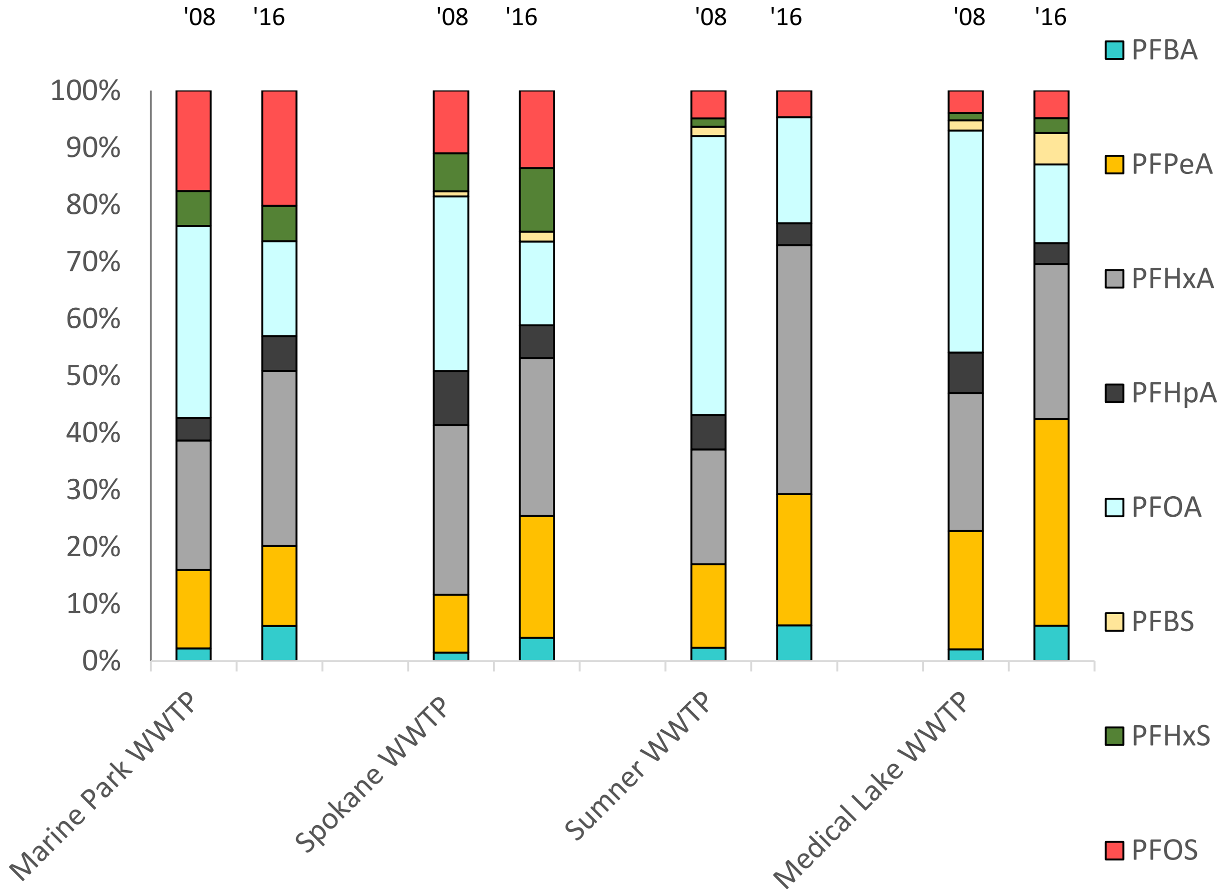
- Consistently lower concentrations in 2016 vs 2008



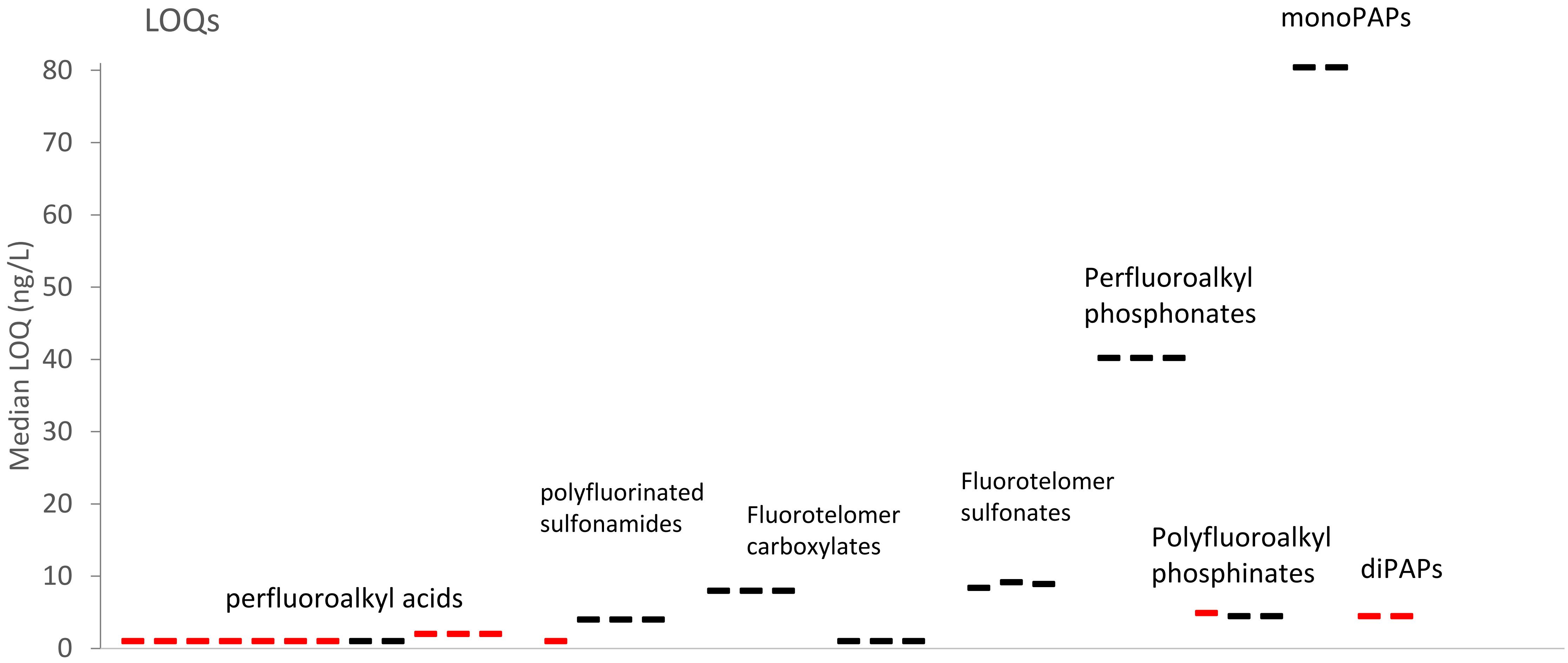


WWTP Effluent

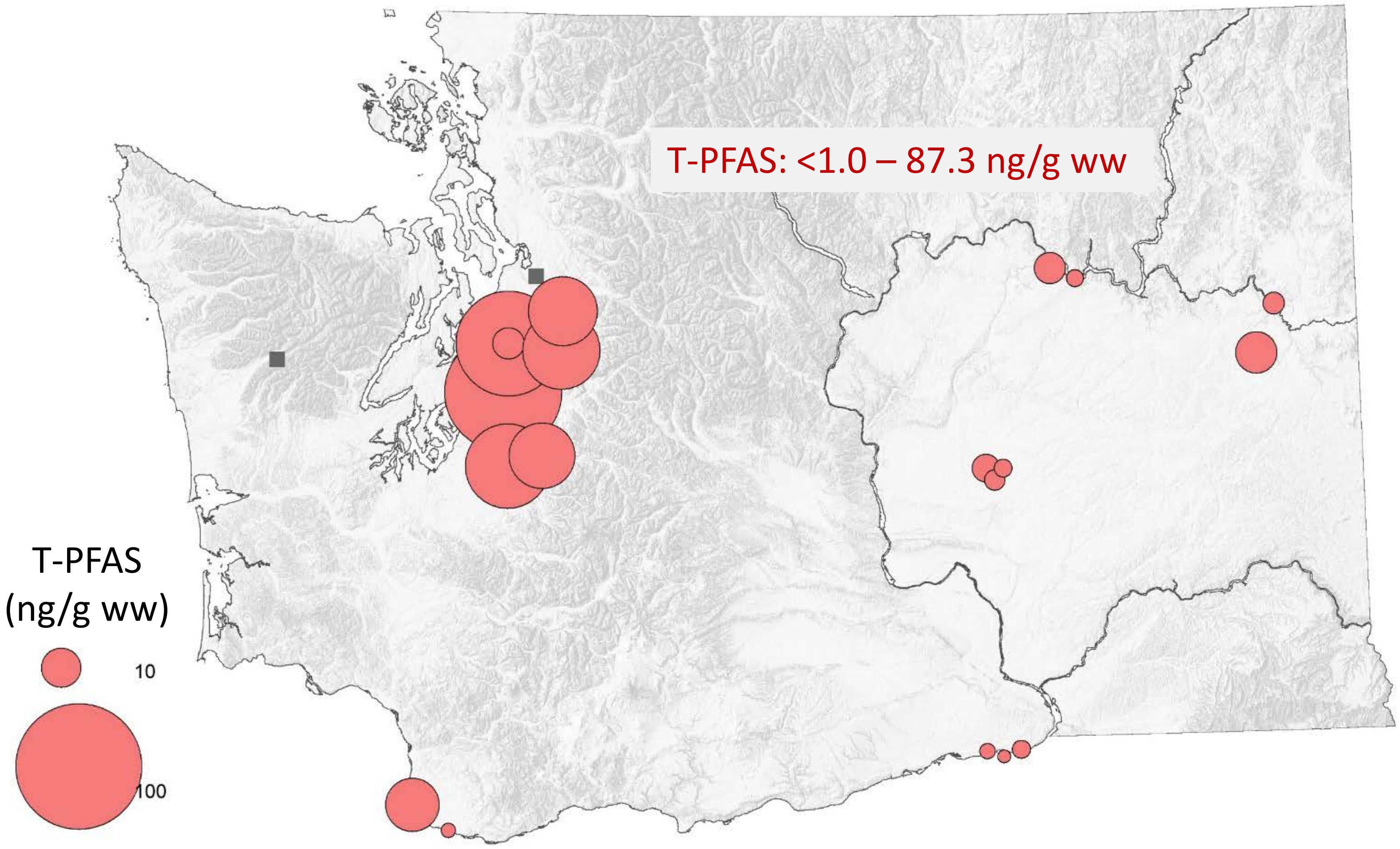
- 2008 v 2016: shift from PFOA to PFHxA (C6), PFPeA (C5)



WWTP Effluent - 2016

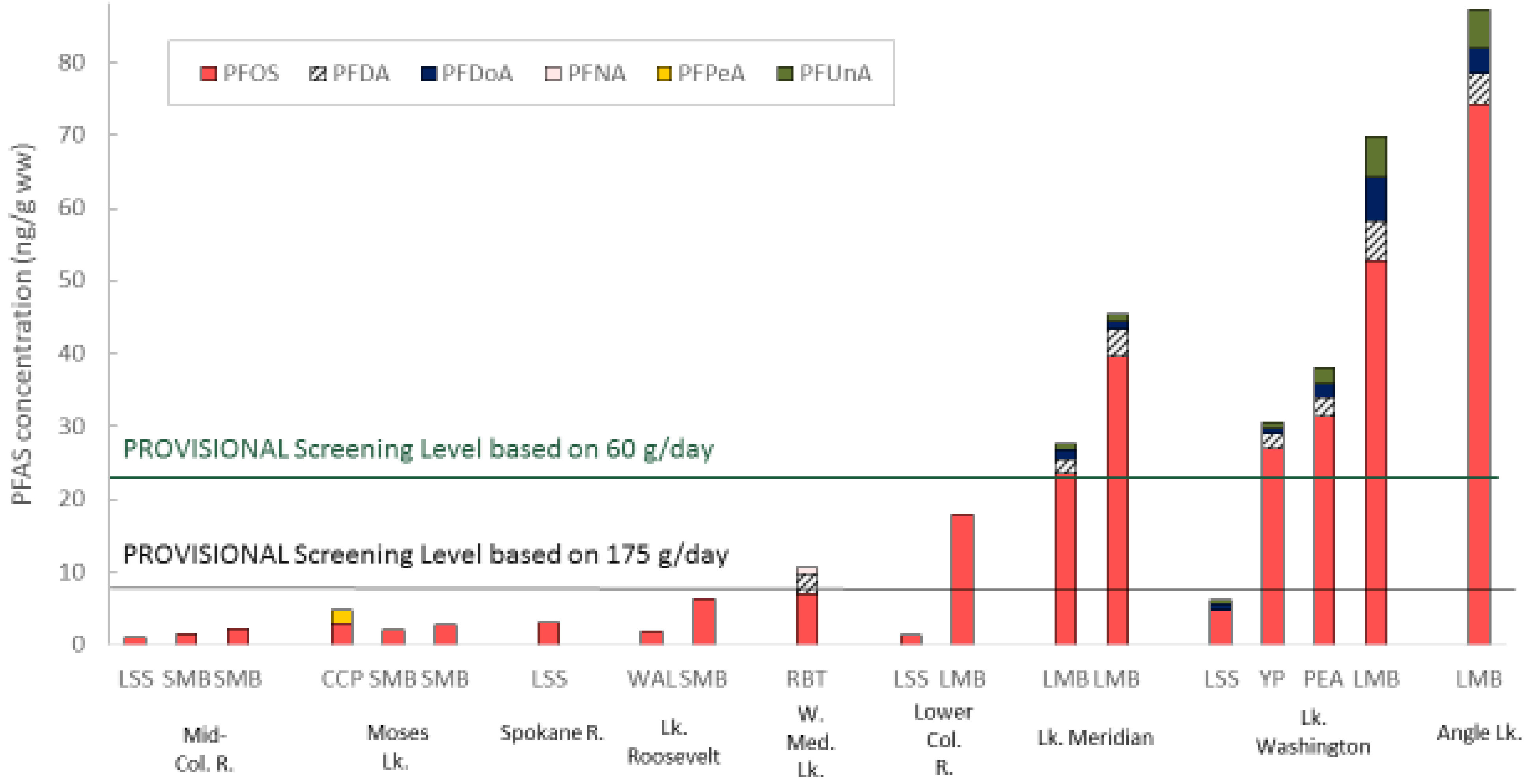


Fish Tissue



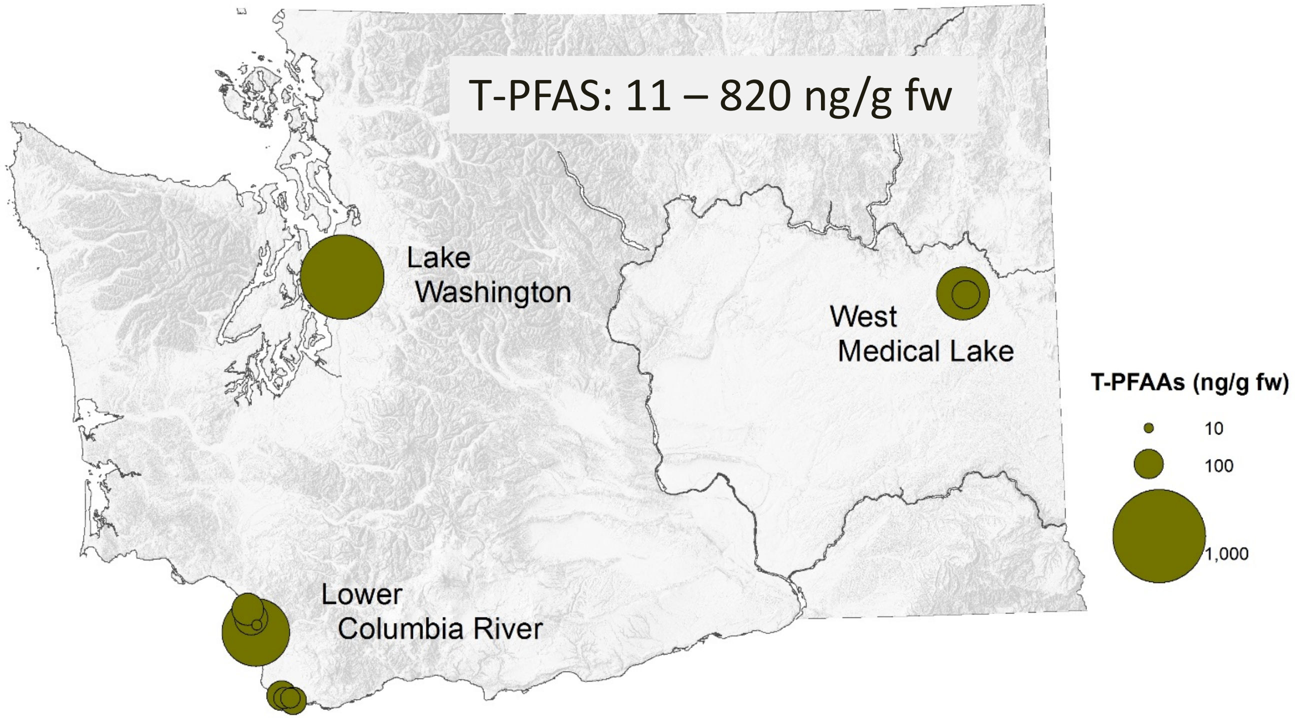
- no consistent increase/decrease between 2008-2016
- Urban lakes highest concentrations (mostly PFOS)
- Similar levels to other states, lower than AFFF-impacted sites
- Liver concentrations 5x higher, 100% det freq.

Fish Tissue - 2016

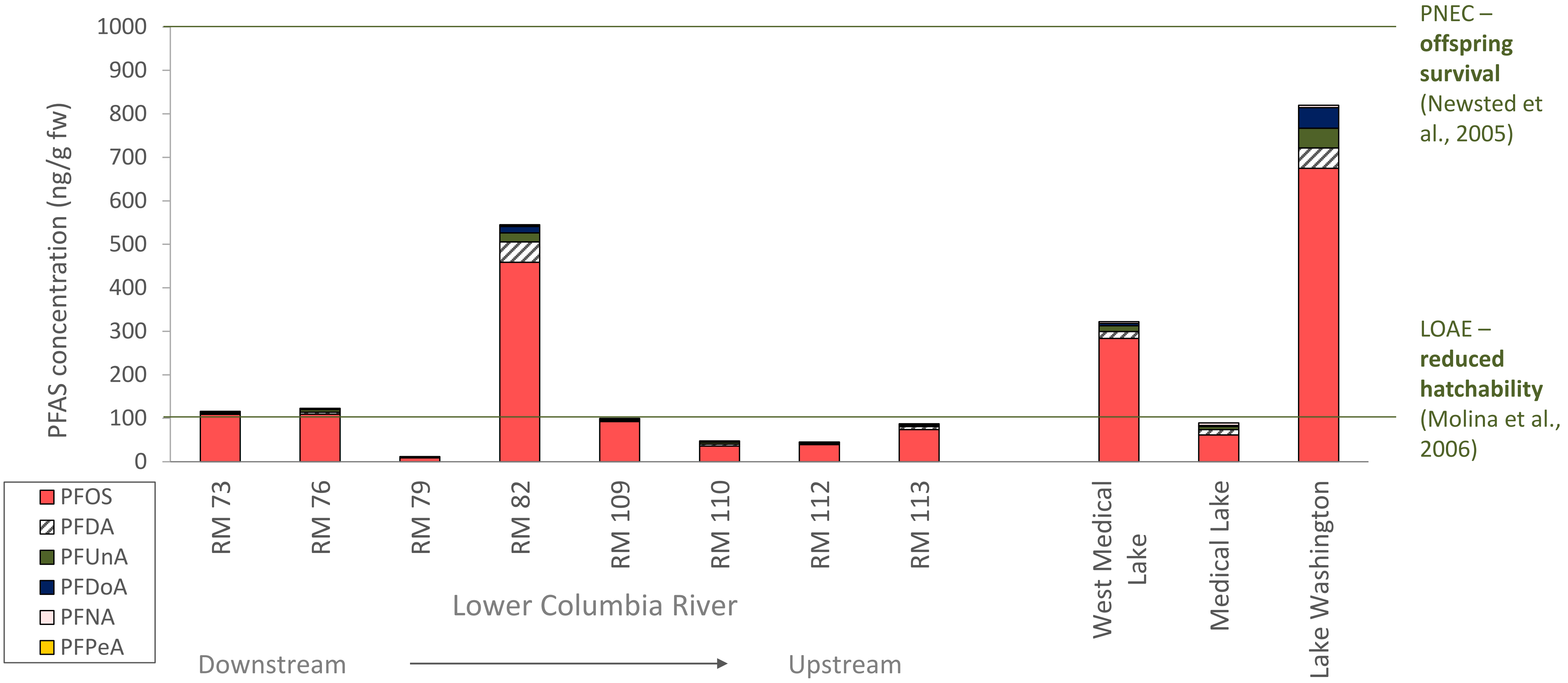


Osprey Eggs

- 2008 and 2016: all eggs contained PFAS, no change in concentrations
- 2016: highest concentration in Lake WA (urban)
- Most within range of rural European eggs – 3 exceptions (urban and WWTP-impacted)

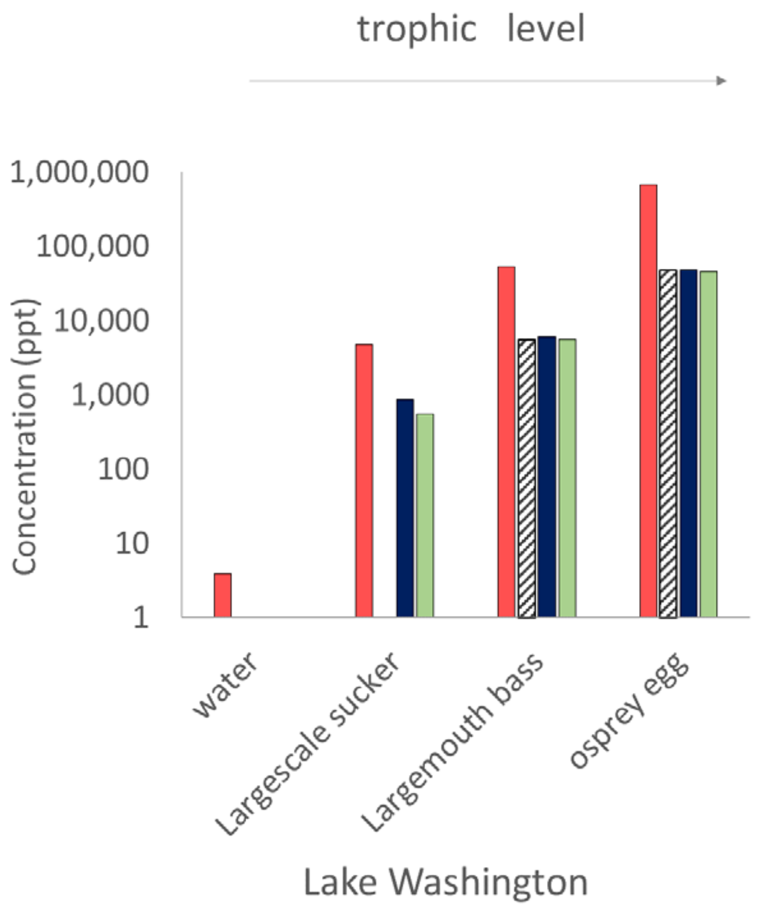


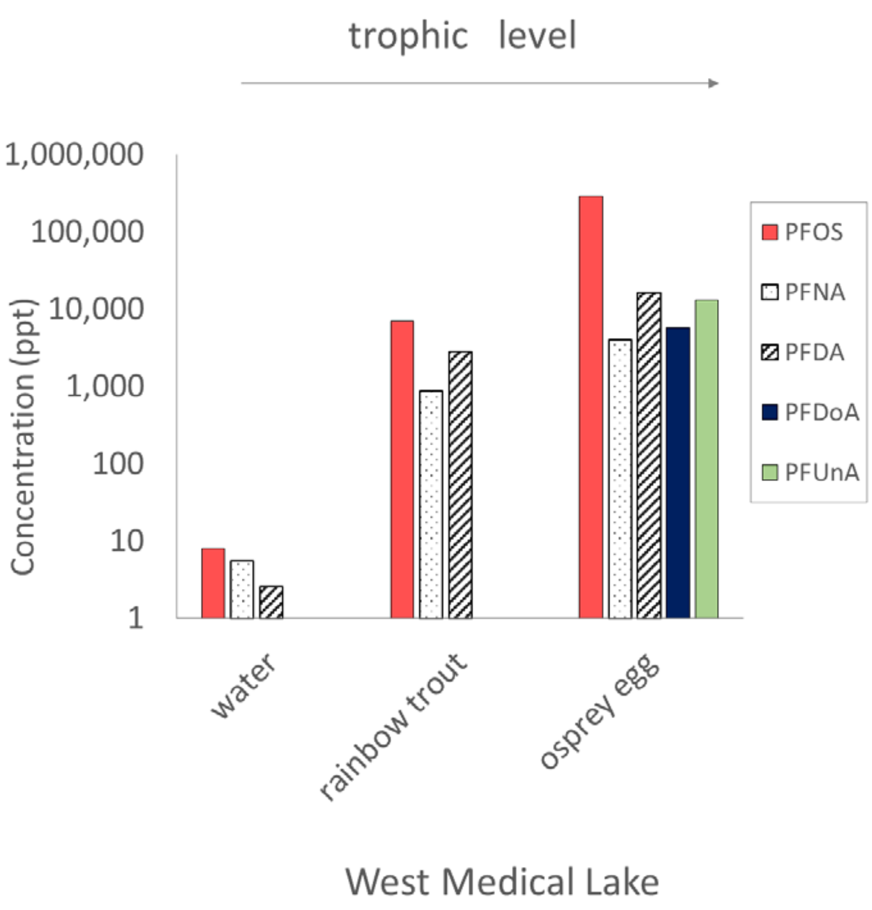
Osprey Eggs - 2016



Bioaccumulation

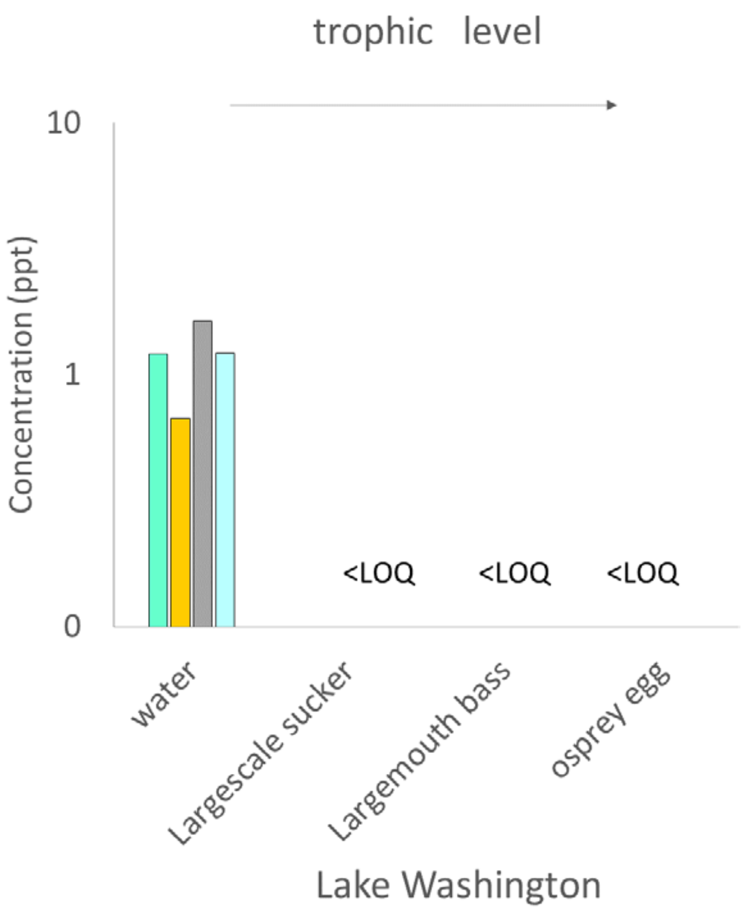
- PFOS and long-chain PFAAs increased up food chain

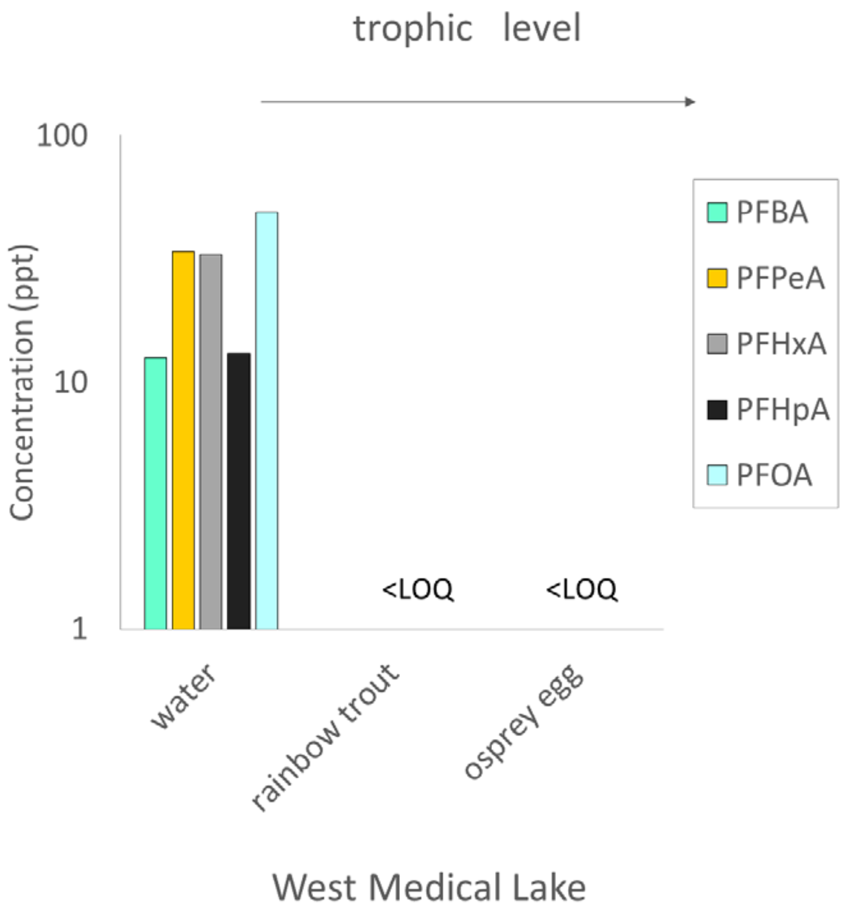




Bioaccumulation

- PFOA and short-chain PFAAs detected in water, but not biota





Data Gaps in WA?

- Sources to urban waterbodies
- Larger PFOS fish tissue study to meet needs for fish consumption advisories
- Data on larger suite of PFAS compounds

Summary

- Urban and WWTP-impacted waterbodies in WA State have highest concentrations of PFAS
- Replacement PFAS are present in effluent and urban/WWTP-impacted surface water, not biota
- PFOS and long-chain PFAAs are still widespread in fish tissue, osprey eggs

Citations

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