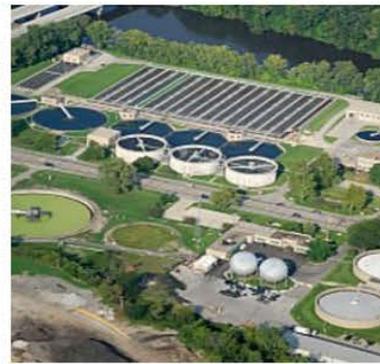


# Contaminants of Emerging Concern: What's on the Horizon?



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# Outline

Contaminants of Emerging Concern

PFAS

Microplastics

PPCPs

Coal Tar Sealcoat & PAHs (time permitting)



# Contaminants of Emerging Concern

## U.S. EPA Definition:

- Recently 'discovered' due to updates or improvements in analysis or detection
- Detected at low levels in surface water
- Concern about impacts on aquatic life
- No regulatory standards





# Contaminants of Emerging Concern

- Includes several classes of substances
  - Pharmaceuticals and personal care products (PPCPs)
  - Endocrine-disruptors (BPA)
  - Nanomaterials (Carbon nanotubes,  $\text{TiO}_2$ )
  - Persistent organic pollutants (POPs)
    - Legacy: PCBs, PAHs, DDT
    - Flame retardants (PBDEs), nonstick/stain repellent chemicals (PFASs)
      - Resistant to environmental degradation
      - Bioaccumulate through the food web
      - Demonstrated negative impacts on human and environmental health
  - Microplastics and anthropogenic debris

PFAS

# PFAS in the News

**witf**  
Live inspired®

Apr 16, 2019

**Frustrated Pa. residents get updated on water-testing plans for PFAs**

**Mainers Gather At State House And Urge Lawmakers To Ban PFAS**

By WILLIS RYDER ARNOLD

APR 17, 2019

## The Michigan Daily

Tuesday, April 16, 2019

**Sierra Club hosts talk on PFAS contamination in Michigan**

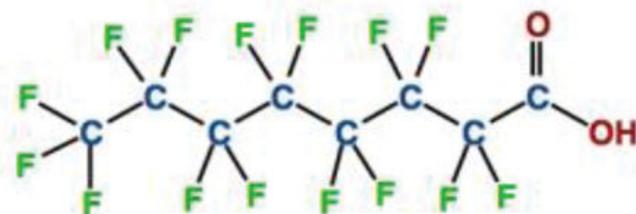
## The Denver Post

April 8, 2019

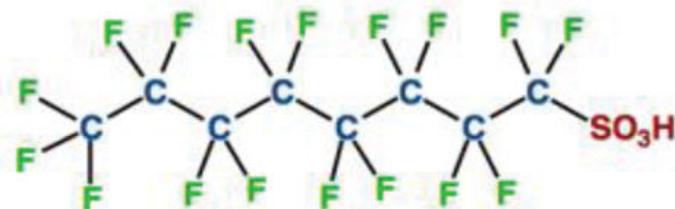
**Colorado School of Mines earns \$1.9M grant to address toxic PFAS chemicals contaminating Colorado water**

# What are PFASs?

- Per- and poly-fluoroalkyl substances
  - PFOA, perfluorooctanoic acid (Gen X); PFOS, perfluorooctane sulfonate
- Represent a group of man-made organic compounds that mainly contain carbon-fluorine bonds
- Highly stable and persistent in the environment - “forever” chemicals
- Resist heat, oil, grease, and water
- Bioaccumulate



PFOA - perfluorooctanoic acid



PFOS - perfluorooctanesulfonic acid

# What products are they in?

These compounds have been used in industrial applications and consumer products since the 1950s.



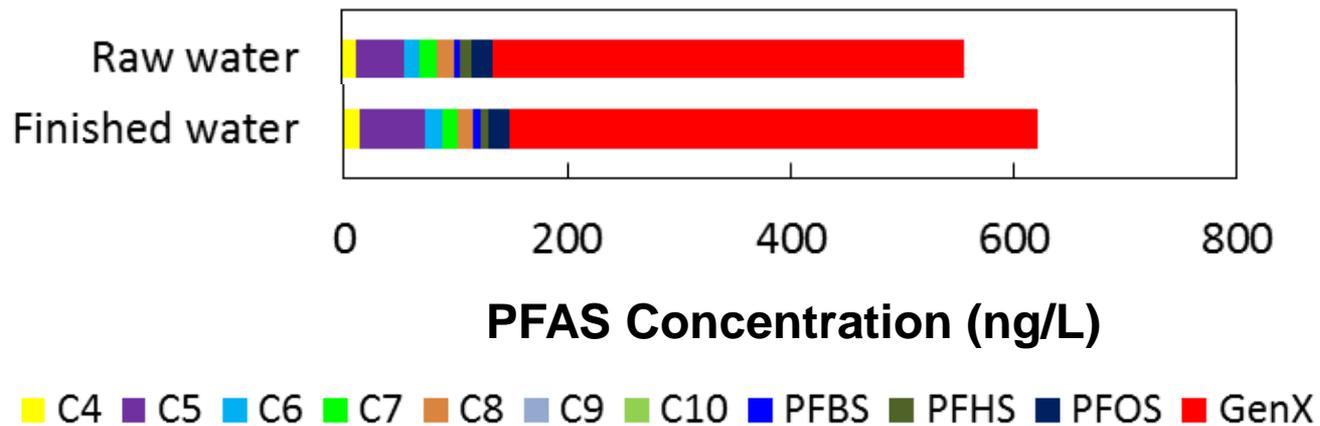


# Occurrence

- Found in soil, air, water, wildlife, and humans worldwide (including the Arctic and Antarctic)
- 2015 study by U.S. National Health and Nutrition Examination Survey: PFAS found in over 97 percent of human blood samples
- 2013-2015 Safe Drinking Water Act testing: PFAS found in 66 water supplies serving more than 16 million Americans in 33 states with at least one sample at or above EPA drinking water health advisories

# PFAS Removal

Conventional and advanced water treatments **do not** effectively remove legacy PFAS and GenX from drinking water



LC-MS-MS used for measurement

# Health Concerns

## Humans:

- Affects growth, learning, and behavior of infants and older children
- Lowers a woman's chance of getting pregnant & interferes with the body's natural hormones
- Increases cholesterol levels
- Affects the immune system
- Increases the risk of cancer (liver, pancreas, thyroid)
- Decreases vaccine responses

## Laboratory Animals:

- Changes liver, thyroid, and pancreatic function
- Changes in hormone levels





# Timeline of the Use of PFAS

**1947:** 3M starts mass-manufacturing PFOA, one of the best-known members in a family of thousands of PFAS (per- and polyfluoroalkyl substances).

**1951:** DuPont starts using PFOA to make Teflon.

**1953:** Scotchguard is born when a similar compound to PFOA — a chemical called PFOS — found in lab to leave a coating that repels oil and water.

**1960s:** 3M and the U.S. Navy develop “aqueous film-forming foam” — AFFF — a firefighting foam containing PFOS and PFOA. Animal and human studies link the chemicals to liver damage.

**1970s:** Military sites, civilian airports and firefighting training centers start using AFFF worldwide. Research by 3M finds that the PFOA and PFOS are toxic.

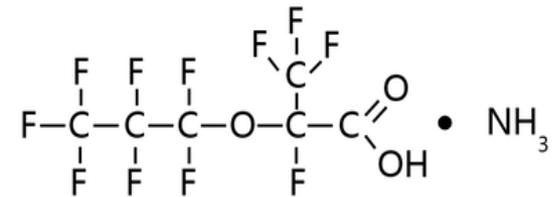
**Timeline adapted from: Santa Fe New Mexican - Feb 21, 2019**



**1980s:** A U.S. Navy study finds that AFFF has “adverse effects environmentally” and kills aquatic life. Research at 3M proves that employees have PFOA and PFOS in their blood. DuPont discovers that PFOA passes from a mother to her unborn baby via the umbilical cord.

**1999:** The EPA and 3M find that PFOS contamination is appearing at blood banks around the country. A farmer sues DuPont after scores of his cattle mysteriously die in Parkersburg, W.Va.

**2000:** 3M announces it will voluntarily halt production of PFOA and PFOS — technically known as “long-chain” chemicals — and will stop putting them in products by 2002. It starts creating new “short-chain” PFAS formulations such as GenX that scientists say are similarly hazardous.



*GenX Chemical Structure*

**2005:** An EPA advisory panel concludes that PFOA is a “likely” human carcinogen.



**2006:** An EPA program encourages all major manufacturers to stop making long-chain PFAS, citing potential birth defects and other risks. DuPont and others agree to phase out production by 2015; like 3M, they start making new varieties, none proven safe.

**2007:** PFOS and PFOA are estimated to be in the blood serum of more than 98 percent of Americans.

**2009:** The EPA issues a nonenforceable “lifetime drinking water health advisory,” recommending a maximum of 200 parts per trillion for PFOS and 400 ppt for PFOA.

**2011:** The Department of Defense acknowledges the PFAS crisis in an internal study: hundreds of military sites are likely to have contaminated groundwater.

**2012:** The EPA directs large public water systems to test for PFAS. Results suggest that millions of Americans are exposed to PFAS in their drinking water.

**2012:** A landmark medical study finds a probable link between PFOA exposure and six diseases including some types of cancers.

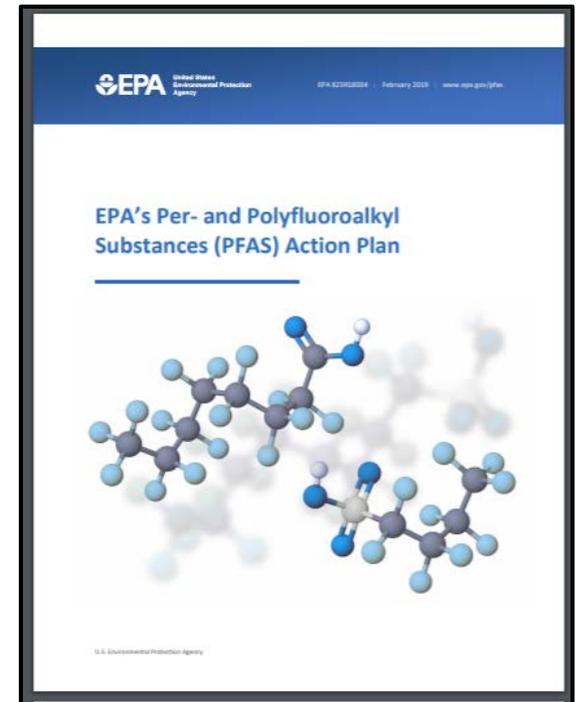
**2016:** The EPA issues a far stricter lifetime health advisory level for PFOA and PFOS in drinking water: **70 parts per trillion.**

**March 2018:** The Pentagon reports that PFAS contamination is detected at 121 military sites and suspected at hundreds of others. PFAS levels exceed the EPA's health advisory in at least 500 drinking-water supplies in nearby communities have.

**November 2018:** EPA releases new tools to test additional PFAS, including GenX, in drinking water.

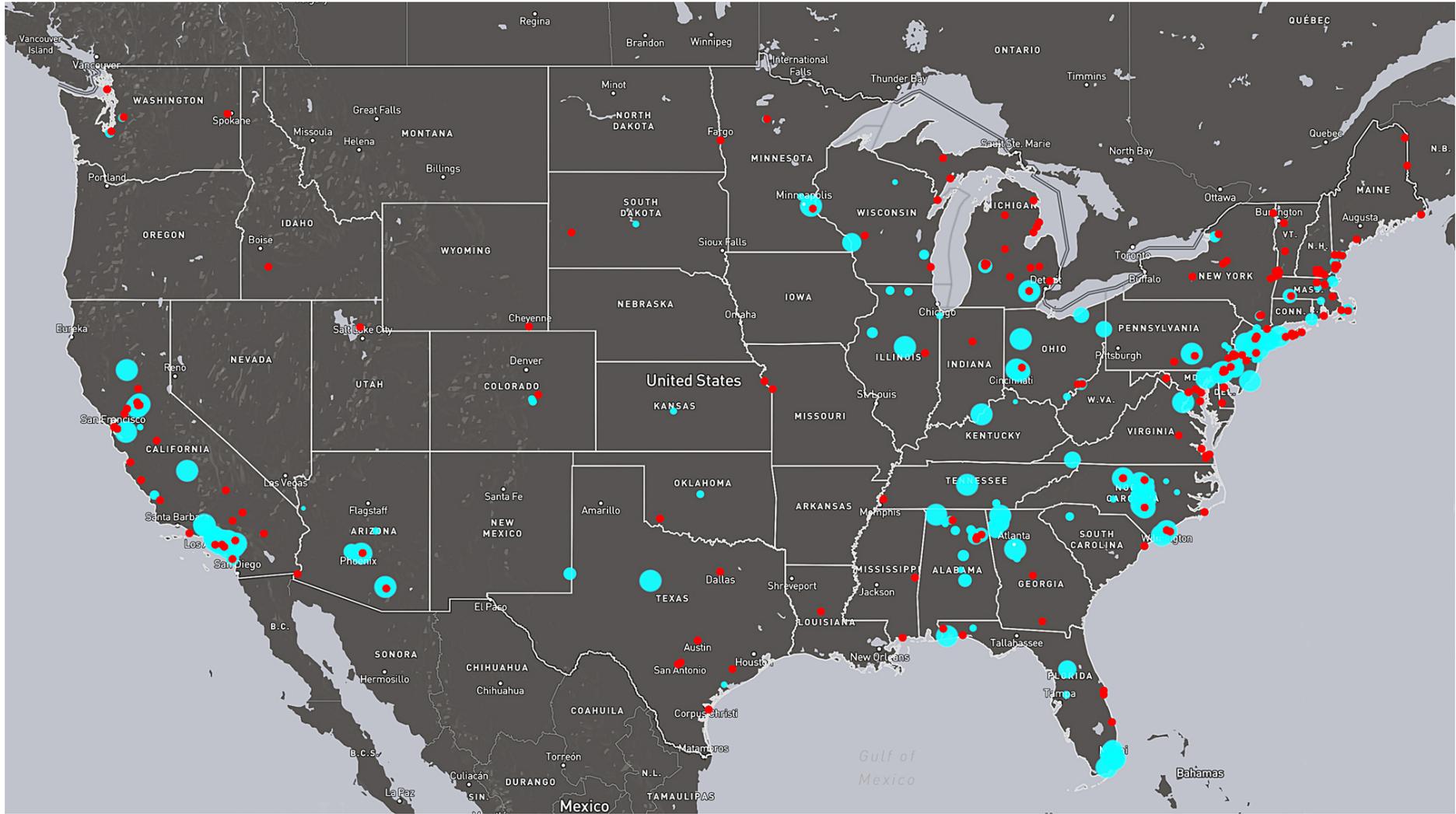
**February 2019:** EPA's PFAS Action Plan outlines concrete steps the agency is taking to address PFAS and to protect public health over the next several years.

**Anticipated actions in 2019 include setting the MCL.**



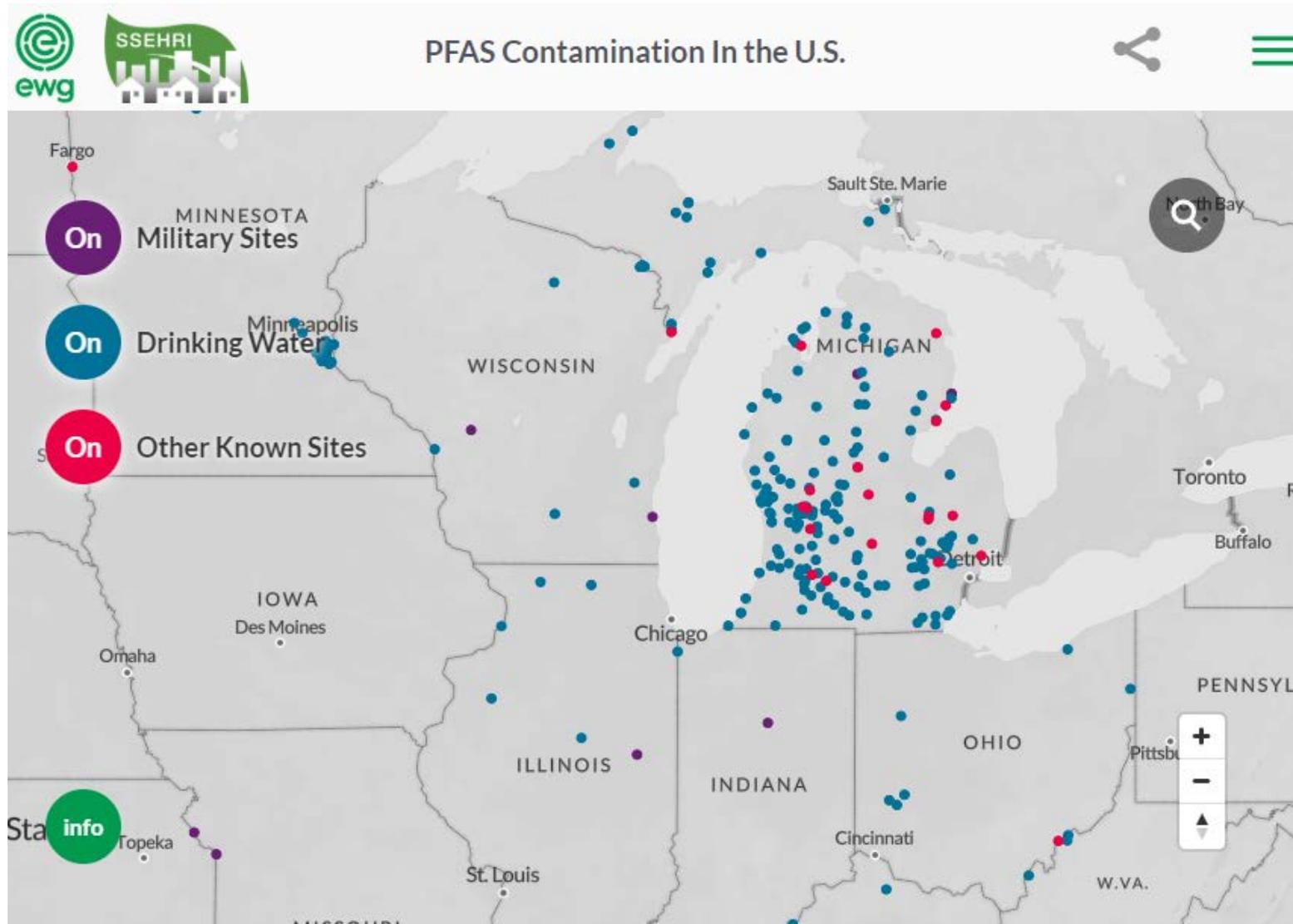
# PFAS Contamination in the US

As of 2016 (drinking water) & 2018 (military sites)



# PFAS Contamination in the US

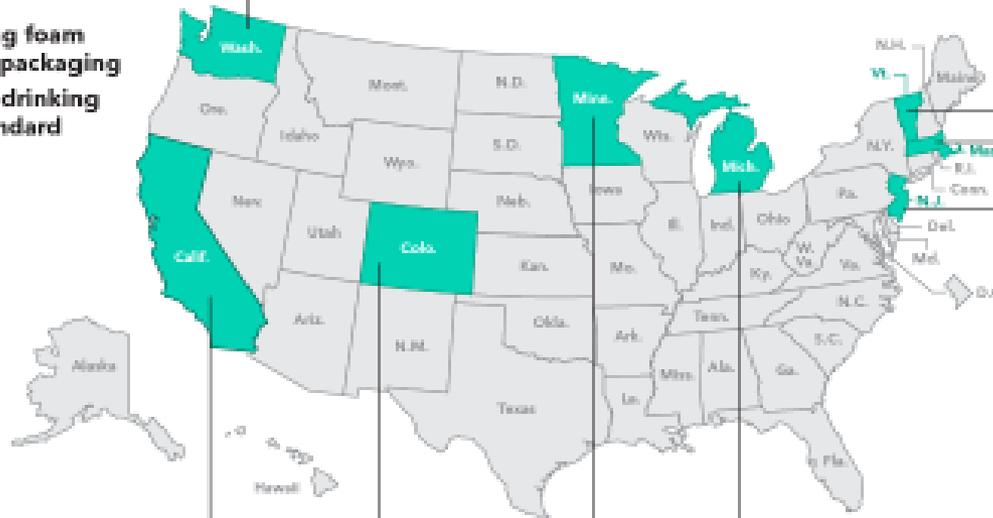
As of 2016 (drinking water) & 2018 (military sites)



# States With Numerical PFAS Limits

## Washington

- Banned in firefighting foam and food packaging
- Proposed drinking water standard



## Vermont

- 20 PPT (PFAS)
- Drinking water health advisory for 5 PFAS

## Massachusetts

- 70 PPT (PFAS)
- State guidance for concentrations of 5 PFAS in drinking water

## New Jersey

- Set PFNA standard at 13 ppt
- Weighing proposed standards for:  
PFOA at 14 ppt  
PFOS at 13 ppt

## California

- 14 PPT (PFOA)
- 13 PPT (PFOS)
- Drinking water notification guidance

## Colorado

- PFOA/PFAS listed as hazardous waste
- 70 PPT (Combined PFOA/PFOS)
- Groundwater quality standard for El Paso County only

## Minnesota

- 35 PPT (PFOA)
- 27 PPT (PFOS)
- Health-based guidance values

## Michigan

- 70 PPT (Combined PFOA/PFOS)
- State standard for concentrations in drinking water

# Microplastics



Accumulation



Litter in aquatic environments has several fates.

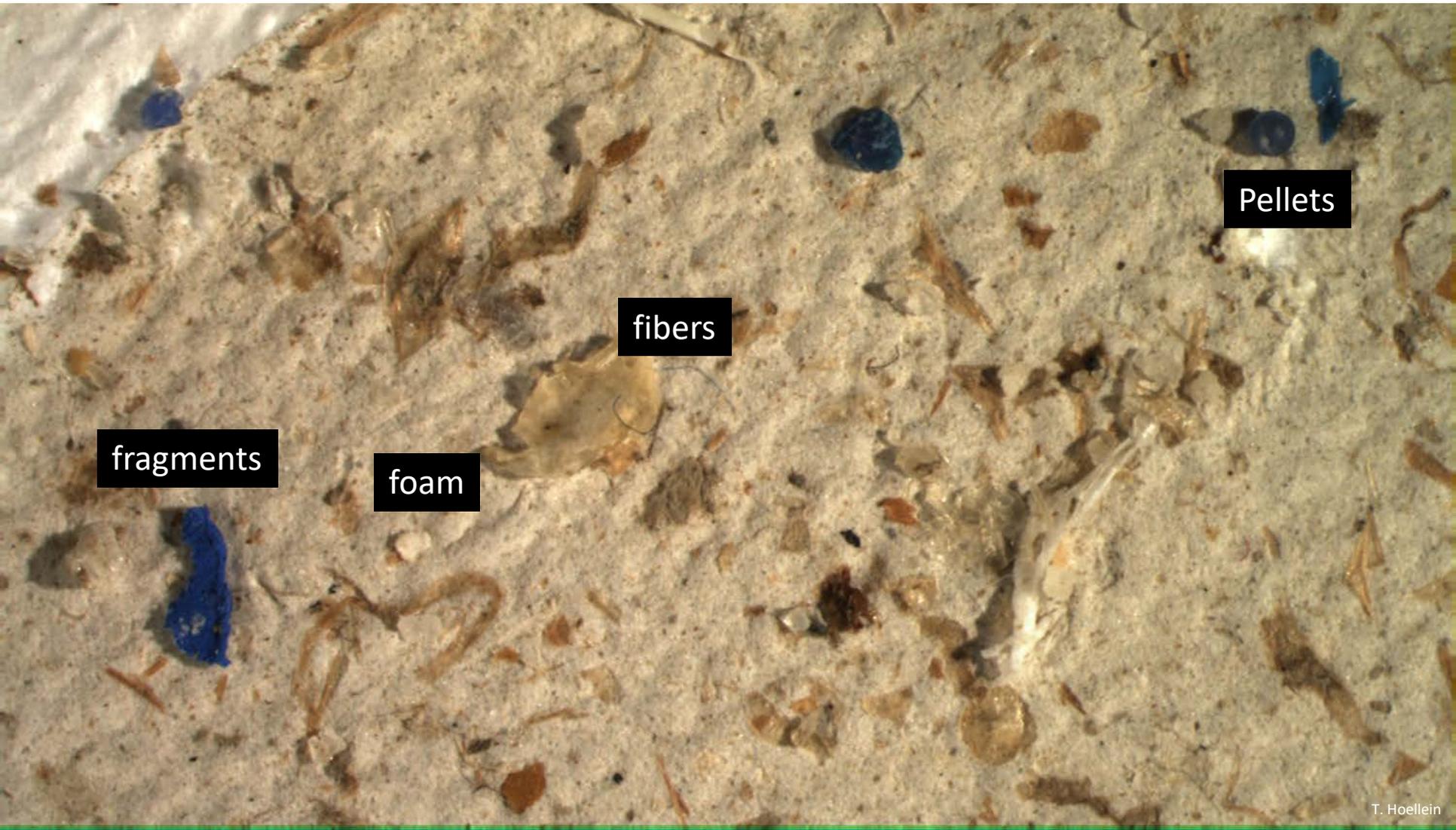


Ingestion



Breakdown & Decomposition

# Types of Microplastics



Pellets

fibers

fragments

foam

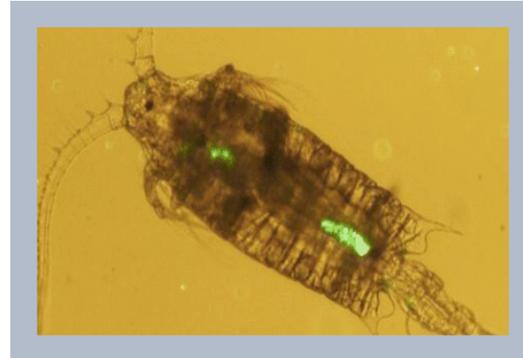
# Microplastic Sources

- Breakdown from larger litter
- Terrestrial runoff
- Domestic waste water
  - Incomplete treatment removal
    - 75-99% (Conley et al. 2019)
- Fibers from clothing
- Personal care products
- Rivers to downstream ecosystems



# Ecological effects of microplastic

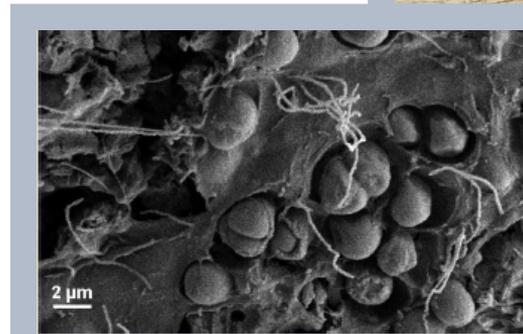
- Ingestion
  - Humans, filter feeders, fish, zooplankton (Sussarellu et al. 2016, Wright et al. 2013, Rist et al. 2016, Cox et al. 2019)
- Prey transfers to predator (Farrell and Nelson 2013)
- Decreased reproductive success, survival (Sussarellu et al. 2016, Rist et al. 2016)
- Selects for distinct microbial communities (Zettler et al. 2013; McCormick et al. 2014)



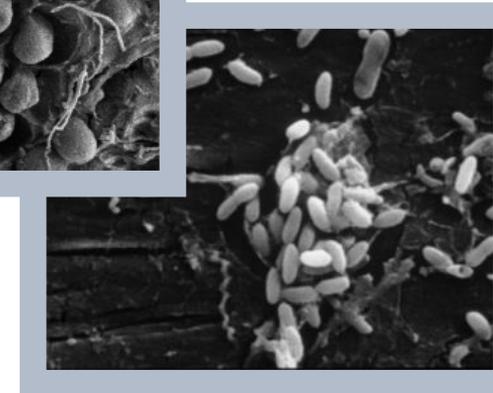
Cole et al. 2013



M. Eriksen, 5 Gyres



Zettler et al. 2013



J. Schlupe, Loyola Univ.

# How do we solve a problem like microplastics?

Engineering Solutions:  
Consumer-Driven or Municipal  
Responsibility?



PPCPs



### Fish Pharm

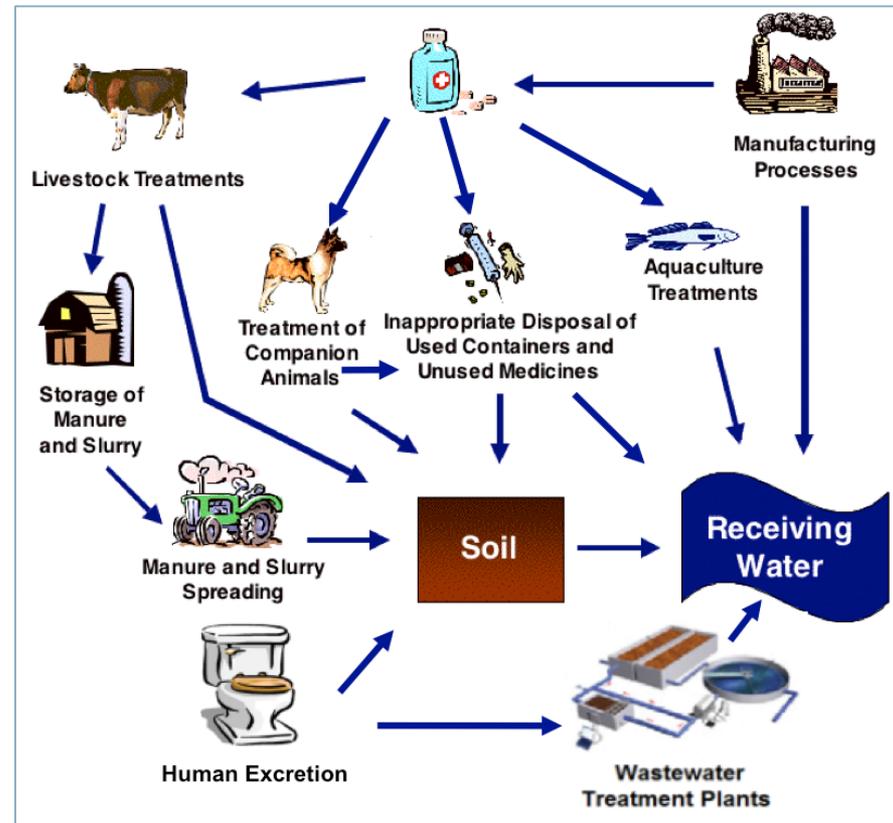
These pills represent the relative amounts of four pharmaceutical drugs found in fish pulled from Chicago's North Shore Channel and tested by Baylor scientists.

The traditional foe of water quality is waste from factories and farms, but now environmental regulators are eyeing a new pollution source: our medicine chests. Fish caught downstream from sewage treatment plants in five U.S. cities contained traces of pharmaceuticals and toiletries, Baylor University researchers found in a recent study. You'd have to eat tons of fish for such small concentrations to affect human health, but the products could pose a threat to marine life. To assess the risk, the EPA has expanded monitoring to 150 sites, with results due in 2011.

\* PERCENTAGES EXCEED 100 BECAUSE OF ROUNDING.  
BLUE ANTIHISTAMINE PILLS (TOP) ARE NOT INCLUDED IN PERCENTAGES.

# How do PPCPs reach the environment?

- Effluent from wastewater treatment plants (WWTPs)
- Surface application of manure and biosolids
- Commercial animal feeding operations and aquaculture
- Landfill leachate (direct and wastewater treatment)
- Septic systems



# What problems do PPCPs cause?



**Aquatic wildlife**

Reproductive and developmental impairments



**Terrestrial wildlife**

Fatalities in non-target species



**Agricultural crops**

Uptake into plants consumed by people



**Livestock**

Potential to promote antibiotic resistance

# PPCPs with Environmental Impacts:

## Antidepressants

African clawed frog (*Xenopus laevis*) tadpoles were raised in clean water and in tanks of water mixed with 38 ppb fluoxetine (Prozac). (Conners et al. 2009)

At 57 days the control group had begun to develop legs, but the exposed tadpoles had delayed metamorphosis.



Control group



38 ppb FL

# Potential Impacts for People:

Do I need to be worried about my drinking water?

- Chemicals found in the environment are several orders of magnitude lower than dosage-level concentrations
- Adverse health effects from PPCPs in drinking water are NOT expected, acc'd to WHO (2011)
- Can try to predict long-term impacts by using animals as sentinels, but the long-term effects on humans are largely unknown



# Treatment Techniques:

## Effectiveness and Cost

Septic systems and wastewater treatment facilities were NOT designed to remove PPCPs

There are several techniques that can be used to remove PPCPs from water:

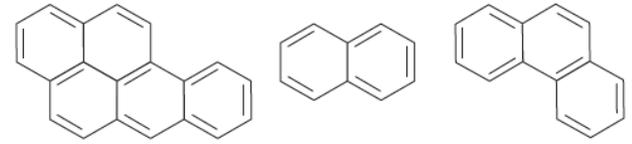
- ✓ Membranes
- ✓ Longer solids retention times (5-15 days)
- ✓ Filters and disinfectants (e.g., chlorine; work best in combination)
- ✓ Conventional activated sludge, biological nutrient removal, membrane bioreactor (Sui et al. 2011)
- ✓ Reverse osmosis (expensive; produces brine)
- ✓ Ultrasound (Xiao and Weavers 2011)
- ✓ UV treatment



# Coal Tar Sealcoat & PAHs

# PAHs: Polycyclic Aromatic Hydrocarbons

- 2+ six-carbon ringed compounds
- Many are known carcinogens
  - benzo(a)pyrene, benzo(a)anthracene
- Formed by incomplete combustion of organic matter

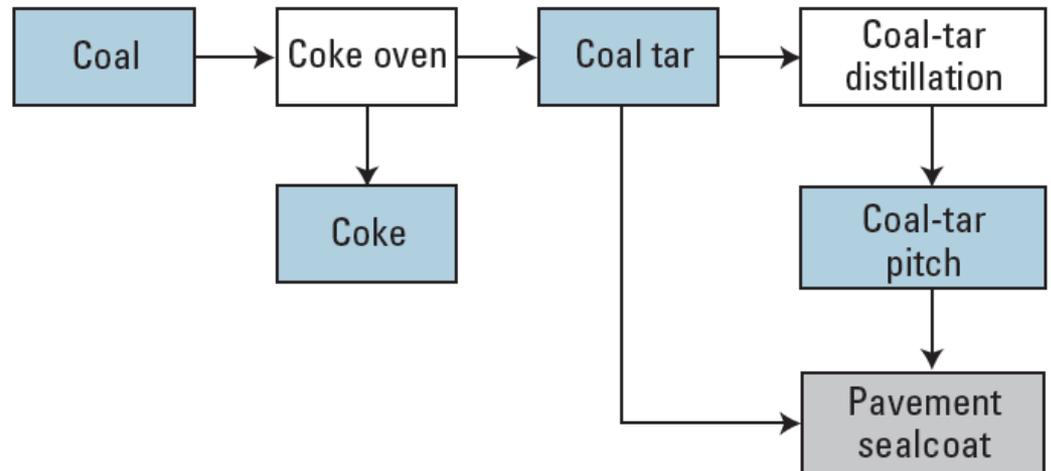


USGS



# Coal Tar Sealcoat

- Black, viscous liquid sprayed or painted on many asphalt parking lots, driveways, and playgrounds
- CTS contains 20-35% coal tar pitch
- CT pitch is byproduct of coking of coal (& steel production); contains 50% PAHs by weight



USGS

# PAHs in the Environment

Sources of PAHs	mg/kg
Fresh asphalt	1.5
Weathered asphalt	3
Fresh motor oil	4
Brake particles	16
Road dust	24
Tire particles	86
Diesel emissions	102
Gasoline emissions	370
Used motor oil	440



	mg/kg
<b>Asphalt-based sealcoat</b>	<b>~50</b>
<b>Coal tar-based sealcoat</b>	<b>~70,000</b>

# Sealcoat Abrasion

Contributes to PAH contamination both indoors and outdoors

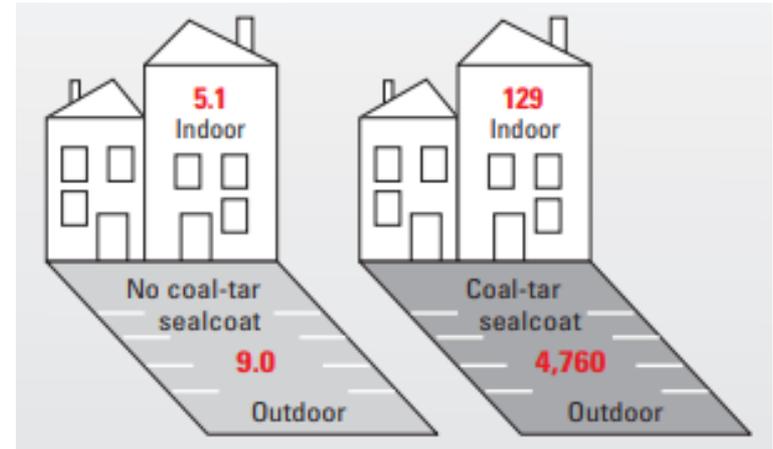


Graphic courtesy of the City of Austin, Texas

# Toxicity: Human Health

- PAH levels in house dust near CT sealed parking lots were 25x higher than other surface types

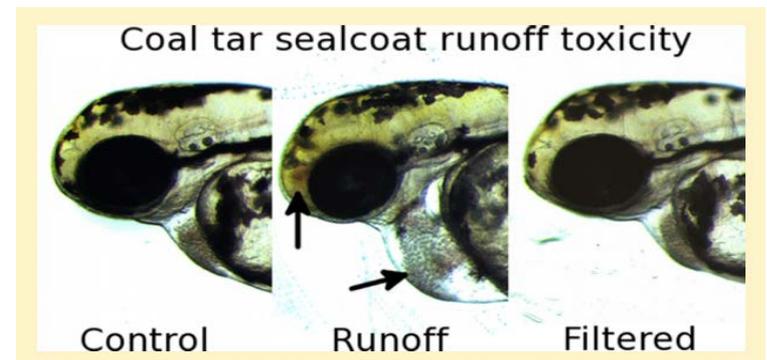
(Mahler et al. 2010. ES&T 44:894-900)



- Preschoolers living next to CT sealed pavement have either 2.5x or 10x higher PAH intake (based on child's activity level) (Williams et al. 2012. Env Pol 164:40-41)
- Lifetime excess cancer risks for those living near CT sealed lots 38x higher than those living near unsealed pavement (Williams et al. 2013. ES&T 47:1101-1109)

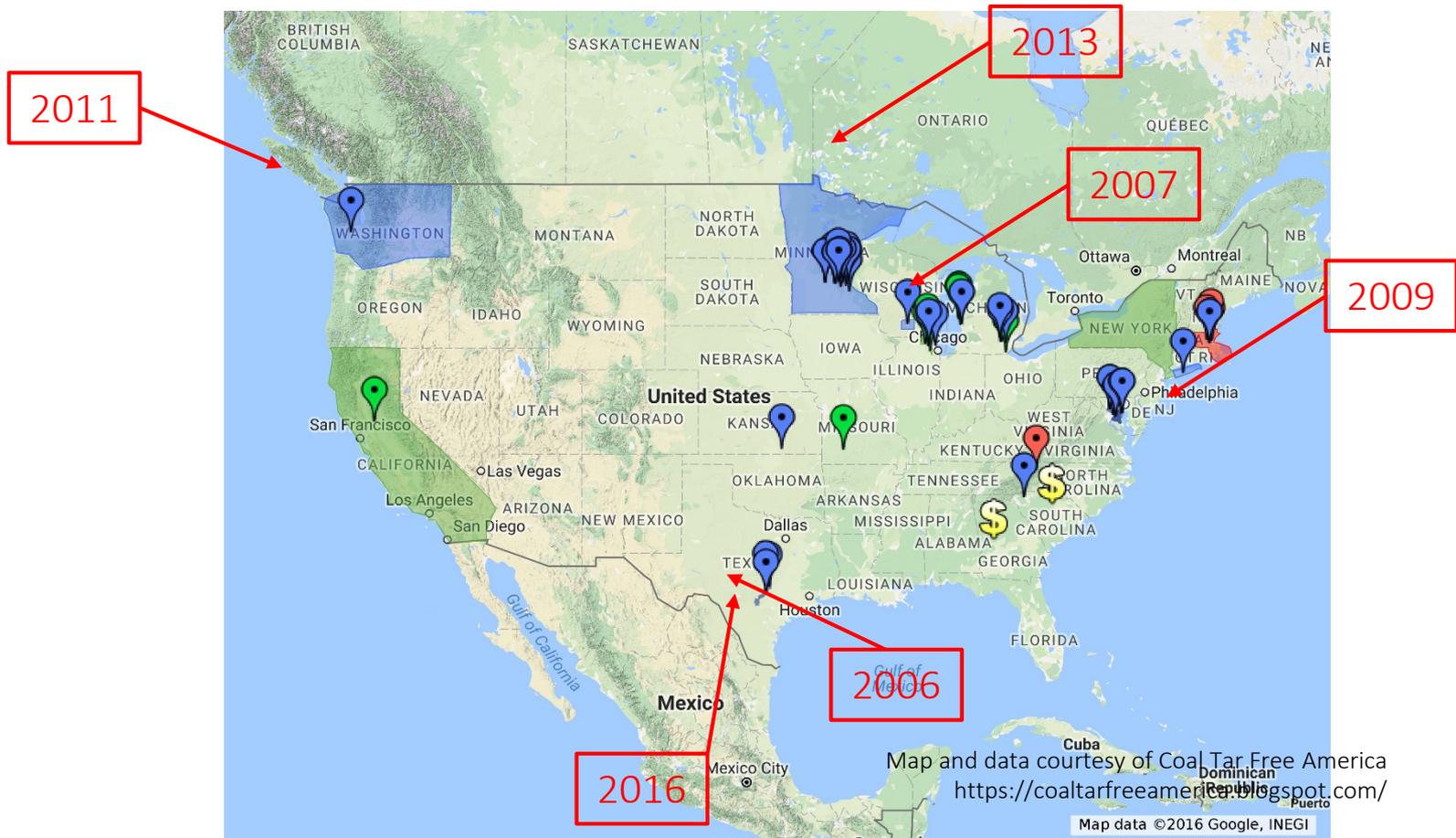
# Toxicity: Environmental Health

- Runoff from CT sealed pavement acutely toxic to fathead minnows and water fleas (Mahler et al. 2015. ES&T 49:5060-5069)
  - Filtering the runoff through bioretention system reduced toxicity
- CT runoff and simulated sunlight damaged DNA and impaired DNA repair capacity for rainbow trout liver cells (Kienzler et al. 2014. Sci Tot Env 520:73-80)
- PAHs cause cardiovascular toxicity in zebrafish embryos and are acutely lethal to juvenile coho salmon (McIntyre et al. 2016. ES&T 50:1570-1578)



# Nationwide Response

States, municipalities, and agencies have taken action



# State Regulatory Activity: Illinois

## Bill Status of SB1184 101st General Assembly

[Full Text](#) [Votes](#) [Witness Slips](#) [View All Actions](#) [Printer-Friendly Version](#)

**Short Description:** COUNTY&MUNI-COAL TAR PRODUCTS

### Senate Sponsors

Sen. [Laura Fine](#) - [Julie A. Morrison](#) - [Jacqueline Y. Collins](#)

### Last Action

Date	Chamber	Action
4/12/2019	Senate	Rule 3-9(a) / Re-referred to <a href="#">Assignments</a>

### Statutes Amended In Order of Appearance

55 ILCS 5/5-1061.5 new

[65 ILCS 5/11-30-8](#)

from Ch. 24, par. 11-30-8

65 ILCS 5/11-80-24 new

### Synopsis As Introduced

Amends the Counties Code. Provides that the county board or board of county commissioners of a county may prohibit the sale of and the use of coal tar sealant product and high polycyclic aromatic hydrocarbon sealant product on any surface, except for highway structures, including, but not limited to, a driveway, parking area, playground, sidewalk, bike trail, or roadway within the county. Amends the Municipal Code making similar changes.

### [Senate Committee Amendment No. 1](#)

Limits the provisions to Cook, DuPage, Lake, or McHenry counties and municipalities located within Cook, DuPage, Lake, or McHenry counties.

## Bill Status of HB2443 101st General Assembly

[Full Text](#) [Votes](#) [Witness Slips](#) [View All Actions](#) [Printer-Friendly Version](#)

**Short Description:** COUNTY&MUNI-COAL TAR PRODUCTS

### House Sponsors

Rep. [Robyn Gabel](#), [Kelly M. Burke](#), [Jennifer Gong-Gershowitz](#), [Kelly M. Cassidy](#), [Terra Costa Howard](#), [Sara Feigenholtz](#) and [Elizabeth Hernandez](#)

### Last Action

Date	Chamber	Action
3/29/2019	House	Rule 19(a) / Re-referred to <a href="#">Rules Committee</a>

### Statutes Amended In Order of Appearance

55 ILCS 5/5-1061.5 new

[65 ILCS 5/11-30-8](#)

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# Questions?



ILLINOIS-INDIANA SEA GRANT

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