PFOS/PFOA, 1,4-Dioxane, Perchlorate, and Lead as Emerging Contaminants

PRESENTATION TO

Alliance of Hazardous Materials Professionals

Michael Hansen, BCES, CHMM

Neal Durant, Ph.D.

5 October 2018

Discussion Topics

PFOS/PFOA

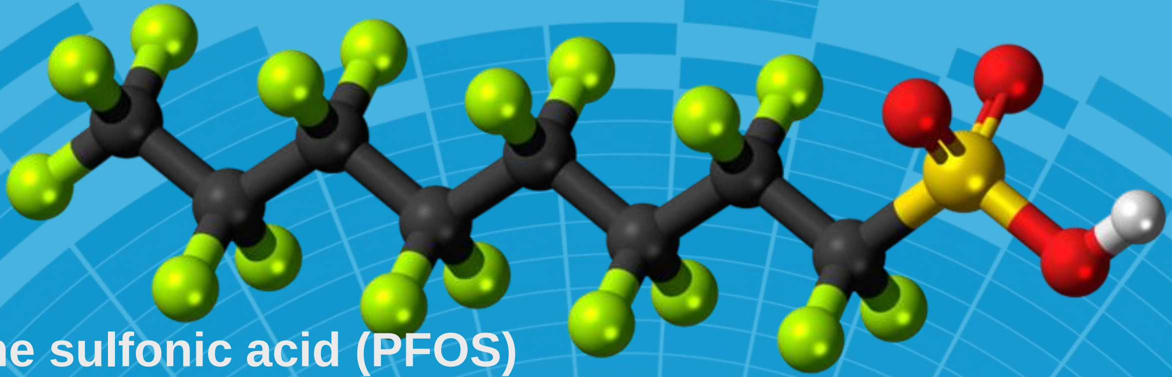
1,4-Dioxane

Perchlorate

Lead

- ❑ Headlines in the news
- ❑ Environmental occurrence
- ❑ Regulatory status
- ❑ Remediation practices
- ❑ Remediation challenges

Polyfluoroalkyl Substances (PFAS)



Perfluorooctane sulfonic acid (PFOS)
$C_8HF_{17}O_3S$

Vocabulary

PFAS Per- and Polyfluoroalkyl substances

PFOA Perfluorooctonic Acid

PFOS Perfluorooctane sulfonic acid

AFFF Aqueous film forming foam

PFAS In the News

Geosyntec consultants

No end in sight for PFOS, PFOA investigation at Joint Base McGuire-Dix-Lakehurst

May 22, 2017

Date: May 22, 2017

0 Comments

JOINT BASE McGUIRE-DIX-LAKEHURST – More than a year has passed since a military investigation into chemical pollution from firefighting foam revealed that groundwater and soil at dozens of sites on the base were contaminated.

The Intercept_

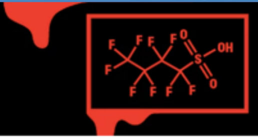


Illustration: The Intercept

PFOA AND PFOS ARE ONLY THE BEST-KNOWN MEMBERS OF A VERY DANGEROUS CLASS OF CHEMICALS

Feb 10, 2018

Environmental Science & Technology LETTERS

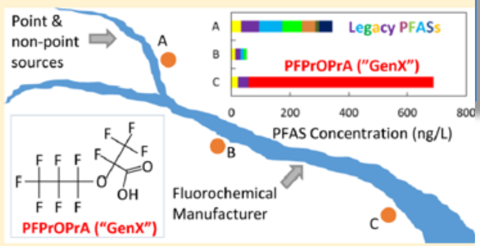
November 10, 2016

Letter

pubs.acs.org/journal/estlcu

Legacy and Emerging Perfluoroalkyl Substances Are Important Drinking Water Contaminants in the Cape Fear River Watershed of North Carolina

Mei Sun,[*,†,‡] Elisa Arevalo,[‡] Mark Strynar,[§] Andrew Lin
Adam Pickett,[⊥] Chris Smith,[#] and Detlef R. U. Knappe[‡]



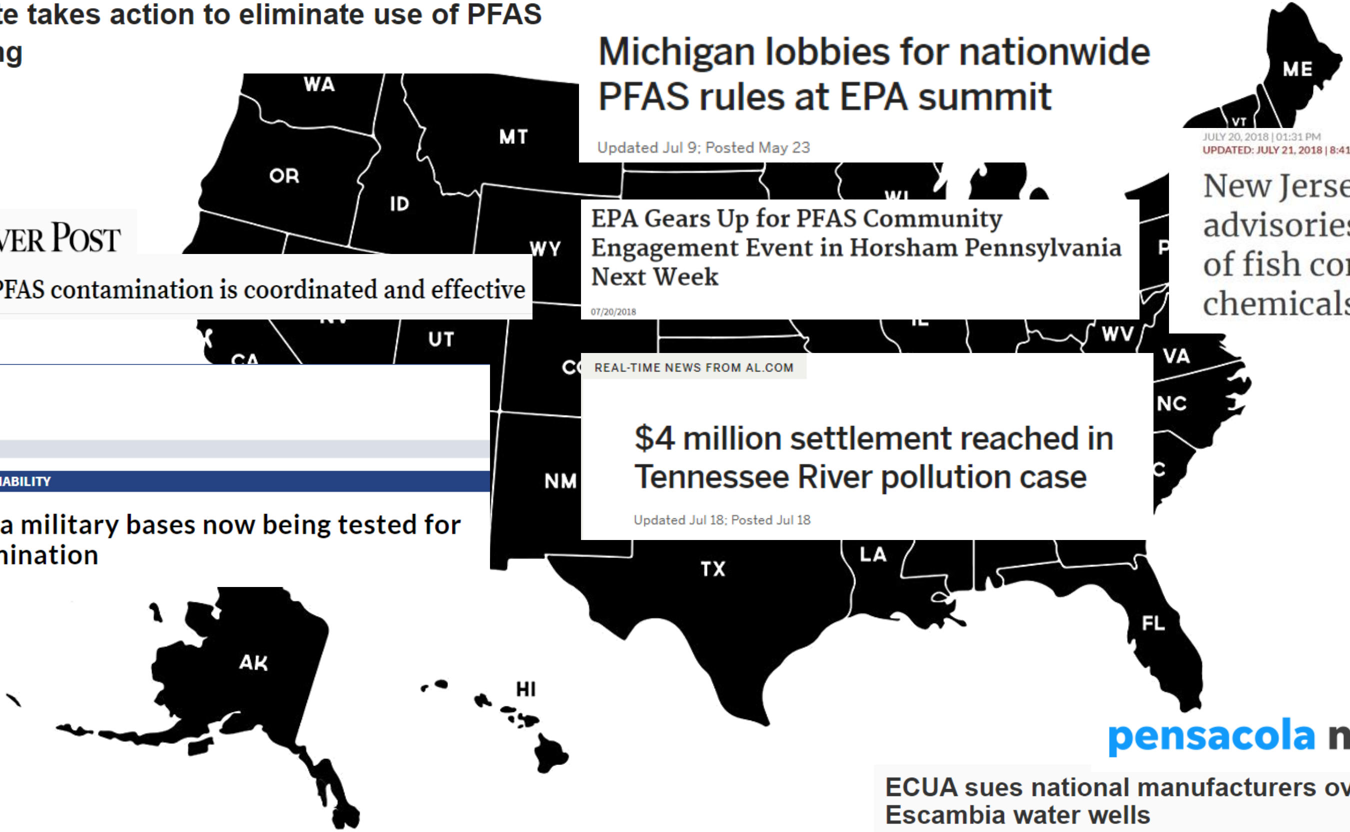
The Intelligencer

CDC: Some in Horsham, Warrington, Warminster exposed to PFCs several times the safe level

May 24, 2017

PFAS In the News

Geosyntec consultants



Washington State takes action to eliminate use of PFAS in food packaging

Michigan lobbies for nationwide PFAS rules at EPA summit

Updated Jul 9; Posted May 23

JULY 20, 2018 | 01:31 PM
UPDATED: JULY 21, 2018 | 8:41 AM

New Jersey issues first advisories for consumption of fish containing PFAS chemicals

THE DENVER POST

Response to PFAS contamination is coordinated and effective

EPA Gears Up for PFAS Community Engagement Event in Horsham Pennsylvania Next Week

07/20/2018

Cronkite News ARIZONA PBS

EDITOR'S PICKS | SUSTAINABILITY

Three Arizona military bases now being tested for water contamination

REAL-TIME NEWS FROM AL.COM

$4 million settlement reached in Tennessee River pollution case

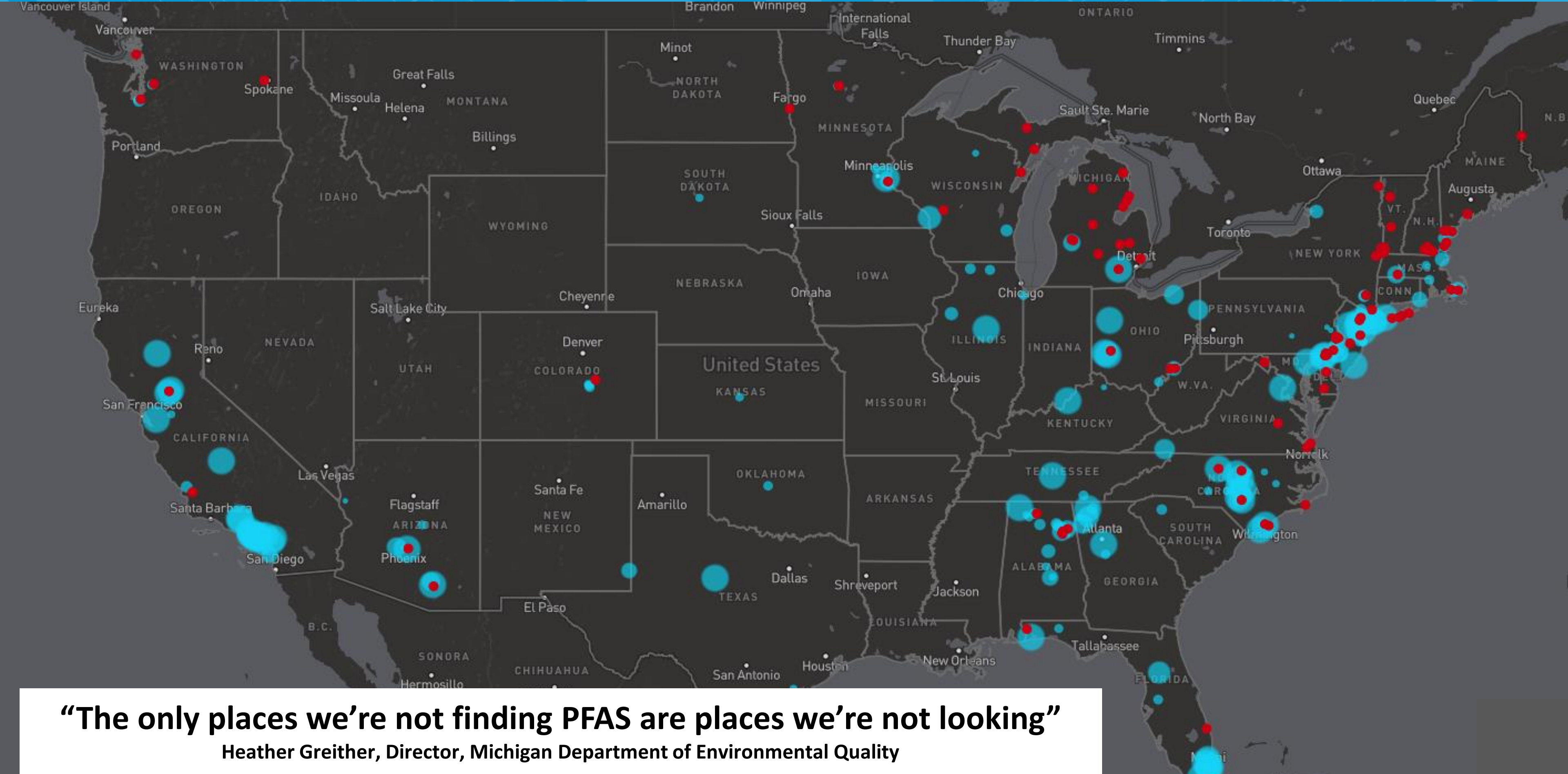
Updated Jul 18; Posted Jul 18

pensacola news journal
PART OF THE USA TODAY NETWORK

ECUA sues national manufacturers over contamination of Escambia water wells

PFAS Extent of Sites

Geosyntec consultants



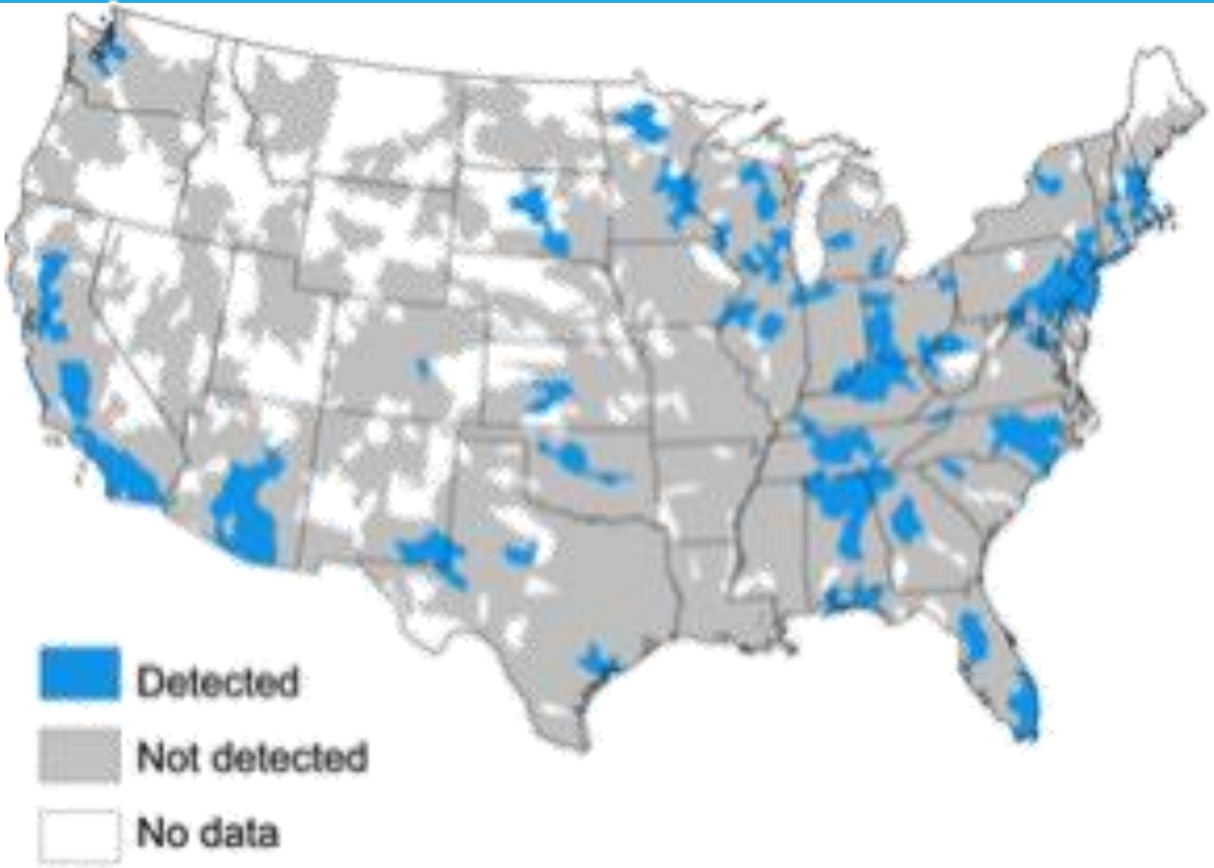
“The only places we’re not finding PFAS are places we’re not looking”

Heather Greither, Director, Michigan Department of Environmental Quality

PFAS Extent of Sites

Geosyntec consultants

Hydrological units with detectable PFASs



Source: https://pubs.acs.org/doi/pdf/10.1021/acs.estlett.6b00260

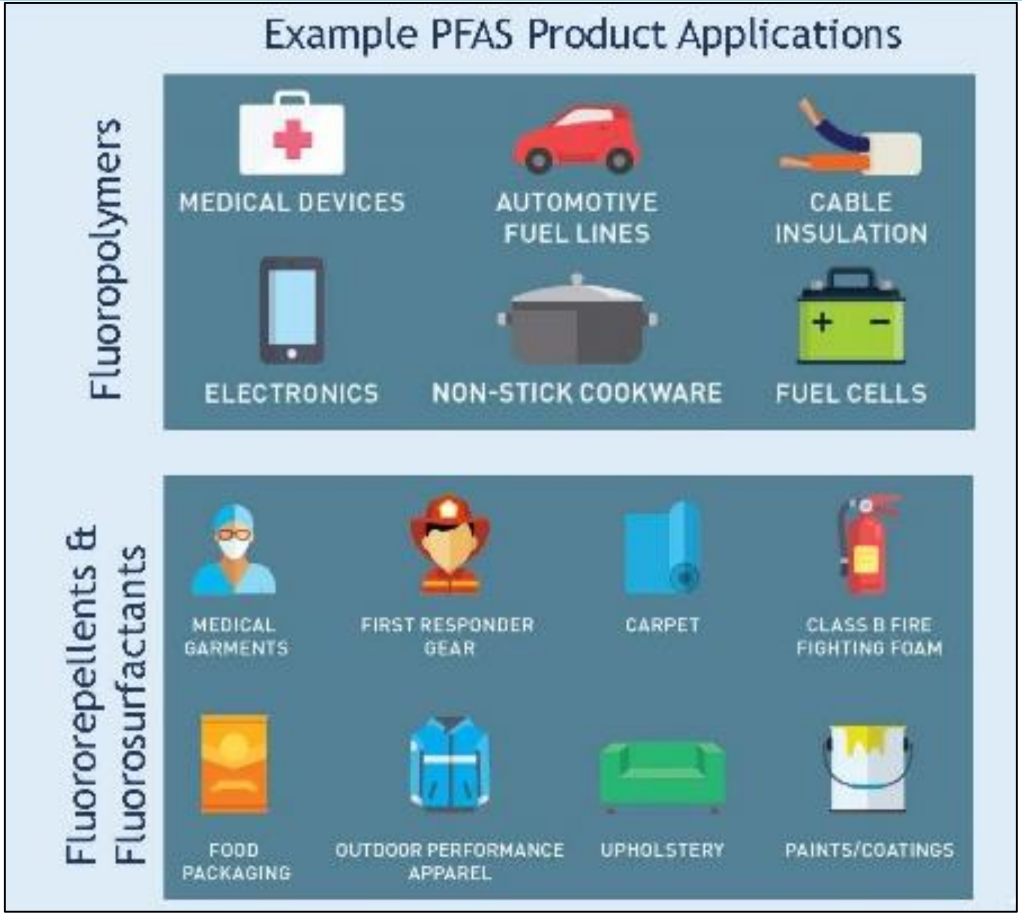
PFAS - Overview

Geosyntec consultants

No natural source

Thousands of chemicals

Thermally and chemically stable

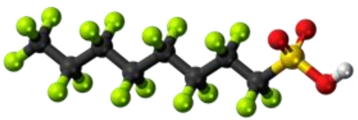


Resist water, heat, and grease and reduce friction

Linked to cancer, immune and reproductive system toxicity

PFAS - Overview

Geosyntec consultants



Human made fluorinated surfactants
Hydrophobic/oleophilic "tail"
Hydrophilic group on end of chain
Hydrogen in carbon chain is replaced by fluorine
Range from 4 to 12 carbons

Stain and Moisture Resistant

- Carpet and upholstery
- Sports clothing
- Military uniforms

Oil Resistant

- Food wrappers, paper coatings
- Non-stick cookware

Surfactant

- ***Fire fighting foam (e.g., AFFF)***
- ***Metal plating***
- Shampoo
- Motor oil and enhanced oil recovery

Heat Resistant

- Non-stick cookware
- ***Fire fighting foam (e.g., AFFF)***
- Electronics

Naming Convention

Abbreviation	Name	No. of Carbons	Functional/ Hydrophilic Group
PFBA	perfluorobutanoic acid	4	carboxyl
PFBS	perfluorobutanesulfonic acid	4	sulfonyl
PFPA	perfluoropentanoic acid	5	carboxyl
PFHxS	perfluorohexanesulfonic acid	6	sulfonyl
PFHxA	perfluorohexanoic acid	6	carboxyl
PFOA	perfluorooctanoic acid	8	carboxyl
PFOS	perfluorooctanesulfonic acid	8	sulfonyl
PFOSA	perfluorooctanesulfonamide	8	sulfonamide
PFNA	perfluorononanoic acid	9	carboxyl
PFDA	perfluorodecanoic acid	10	carboxyl
PFUdA	perfluoroundecanoic acid	10	carboxyl
PFDoa	perfluorododecanoic acid	12	carboxyl

PFAS - Overview

Geosyntec consultants

- Aqueous film forming foams (AFFF)
- Aerospace
- Alternative energy
- Automotive
- Building and construction – weather resistant coatings
- Biosolids
- Building fire suppression systems
- Chemical manufacturing
- Cosmetics, bug spray, sunscreen
- Electronics
- Fire fighting/training facilities
- First responders
- Healthcare
- Industrial surfactants
- Landfills – leachate, odor and dust control
- Leather
- Medical – implants, patches and grafts
- Metal plating and etching
- Mining – odor and dust control, enhanced recovery, biosolids for reclamation
- Military
- Oil and gas – enhanced recovery
- Paints, varnishes, sealants, waxes and polishes
- Paper products – food surfaces, Rite-in-the-Rain®, Post-It®
- Personal care products
- Performance chemicals – hydraulic fluids, fuels
- Pharmaceuticals
- Photolithography
- Plastics
- Polymer manufacturing
- Resins
- Semiconductors
- Stain repellants
- Textiles
- Wastewater treatment plants
- Weather resistant apparel and equipment
- Wire manufacturing and coating

AFFFs

Place and Field, 2012

Timeline

PFAS[1]	Development Time Period							
	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s
PTFE	Invented	Non-Stick Coatings			Waterproof Fabrics			
PFOS		Initial Production	Stain & Water Resistant Products	Firefighting foam				U.S. Reduction of PFOS, PFOA, PFNA (and other select PFAS[2])
PFOA		Initial Production	Protective Coatings					
PFNA					Initial Production	Architectural Resins		
Fluoro-telomers					Initial Production	Firefighting Foams		Predominant form of firefighting foam
Dominant Process[3]		Electrochemical Fluorination (ECF)						Fluoro-telomerization (shorter chain ECF)

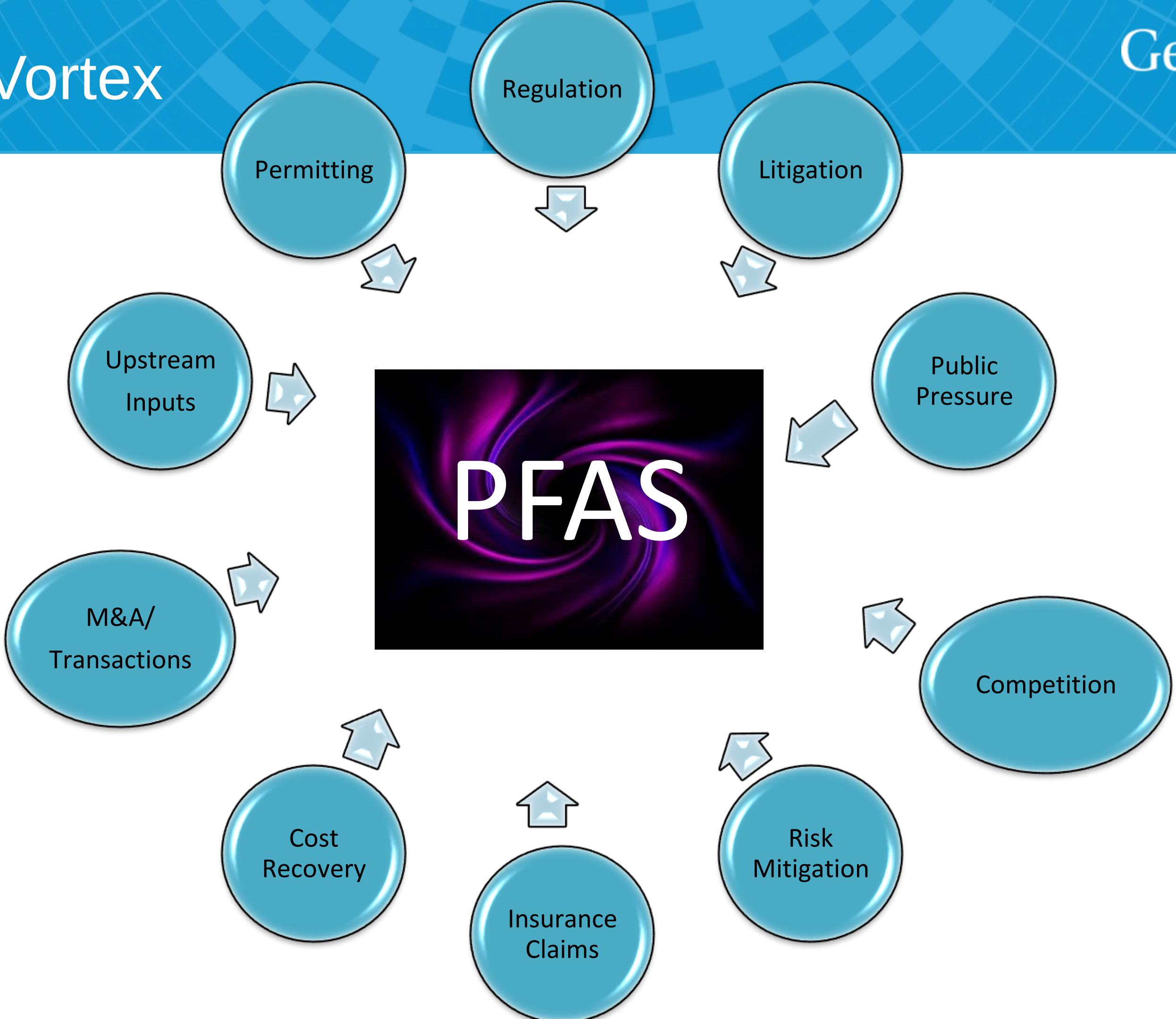
Pre-Invention of Chemistry /	Initial Chemical Synthesis / Production	Commercial Products Introduced and Used

Notes:

1. This table includes fluoropolymers, PFAAs, and fluorotelomers. PTFE (polytetrafluoroethylene) is a fluoropolymer. PFOS, PFOA, and PFNA (perfluorononanoic acid) are PFAAs.
2. Refer to Section 3.4.
3. The dominant manufacturing process is shown in the table; note, however, that ECF and fluorotelomerization have both been, and continue to be, used for the production of select PFAS.

Source: https://pfas-1.itrcweb.org/wp-content/uploads/2017/11/pfas_fact_sheet_history_and_use__11_13_17.pdf

The PFAS Vortex



PFOS and PFOA in the Environment

Geosyntec consultants

PFOS and PFOA Distribution

Manufactured between 1950 and 2000

Fate and transport, not well understood

High potential to bioaccumulate

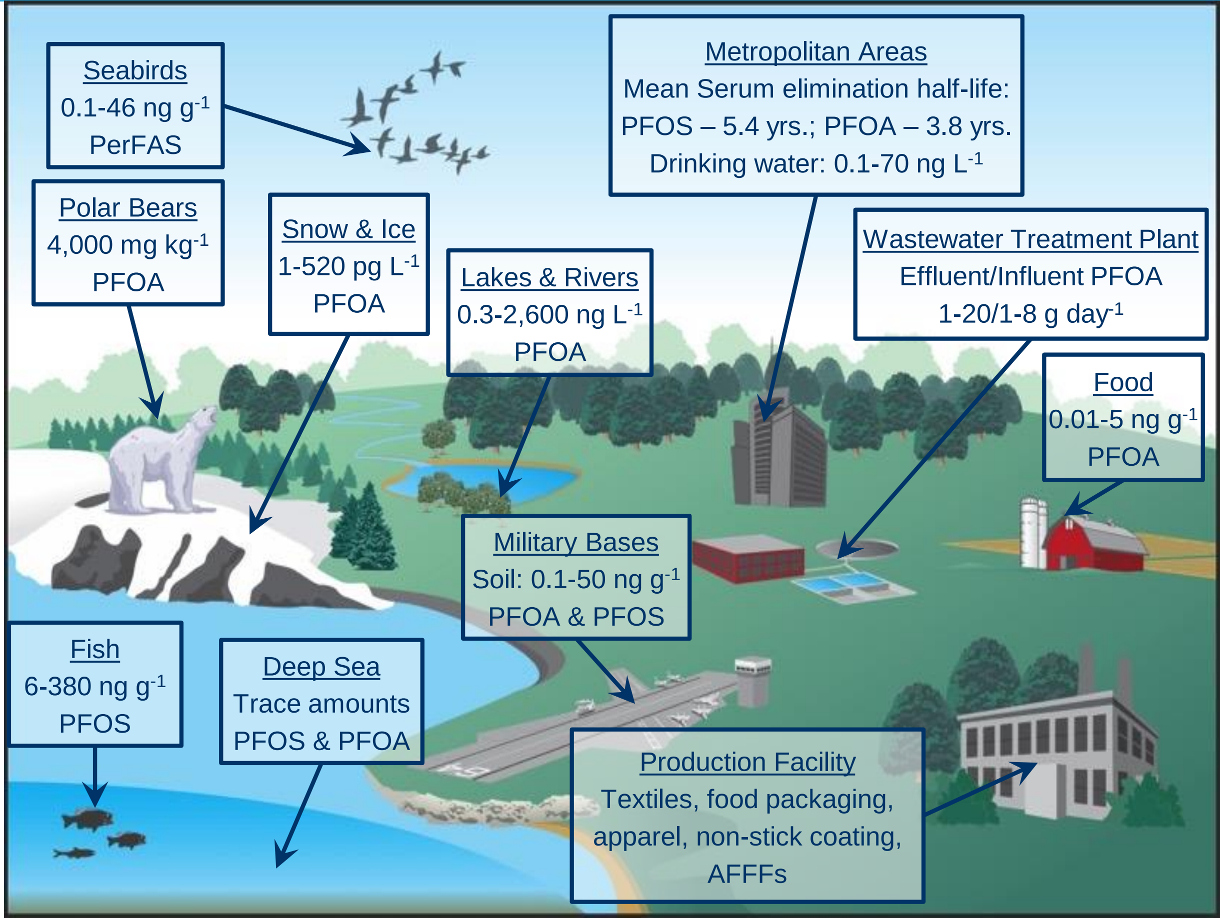
Health Effects

Probable carcinogen

Blood concentrations of PFOS and PFOA in the U.S. population exceed those reported from several other countries. (Olsen et al. 2003)

Concentrations of PFOS in blood of 2 – 12 year old children similar to concentration found in adults (Olsen et al. 2004)

PFOA, PFOS, and PFHxS persist in humans with half-lives of 3 – 8.5 years



Unique Chemistry[1]

Very water soluble

Heat Resistant

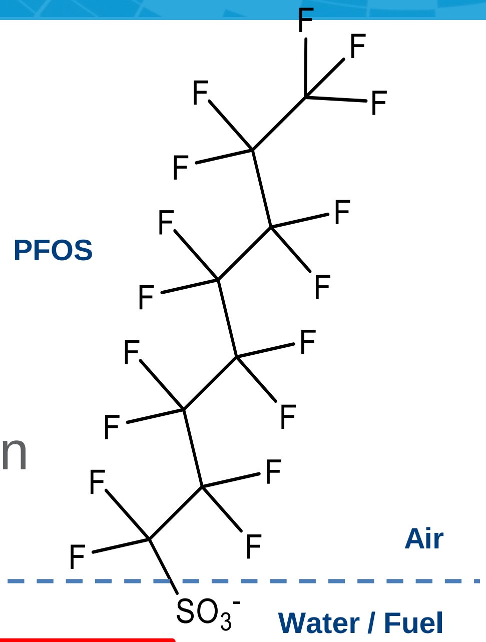
Surfactant

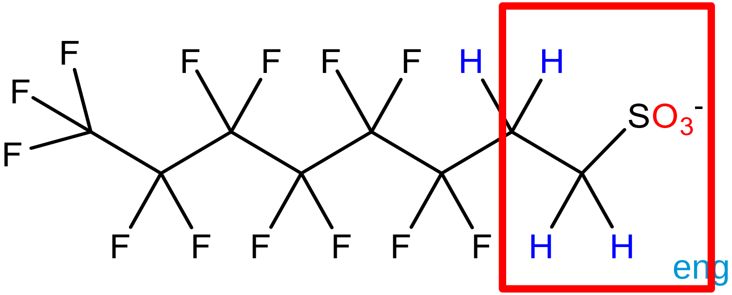
Hydrophobic

Oleophobic

Resistant to Degradation

Strong C-C backbone





C-F bond is shortest and strongest bond in nature

- Properties less predictable
- hydrophobic and oleophobic
- difficult for microbes to break

Perfluorinated

- All carbons in chain bonded only to F (e.g., PFOS and PFOA)

Polyfluorinated

- Not all carbons in chain bonded to F
- CH2 – linkages = ‘weakness’ in molecule, open to chemical and biological degradation

[1]Krafft and Riess, 2015. Chemosphere 129: 4-19

[2]Buck et al., 2011. Integr Environ Assess Manage 7:513-541

Federal Regulatory Framework

- Safe Drinking Water Act (SDWA)
  - UCMR3
  - Health Advisory
  - Current USEPA Authority
- Comprehensive Environmental Response Compensation and Liability Act (CERCLA)
- Toxic Substances Control Act (TSCA)
- Emergency Planning and Community Right to Know Act (EPCRA)
- Resource Conservation and Recovery Act (RCRA)

PFOS and PFOA Regulatory Action

Geosyntec consultants

EPA Drinking Water Health Advisory Level

70 ppt (total PFOA + PFOS)

Unregulated Contaminant Monitoring Rule 3 (UCMR3)

Published in 2012

Requires sampling from 2013 through 2015 by all public water systems (PWSs) serving >10,000 people

28 chemicals (6 PFCs): PFOS, PFOA, PFNA, PFHxS, PFHpA, PFBS

As of Jan. 2015:

- PFOS above PHA value in 12 / 3,605 PWS (0.3%)
- PFOS detected above PHA value in 15 / 22,942 samples
- PFOA not detected above PHA value

2010/2015 Stewardship Program

Minimize potential impact of PFOA on environment

Reduce facility emissions and product content of PFOA and related chemicals by 95% before 2010; eliminate by 2015

USEPA Science Advisory Board

PFOA is a likely human carcinogen, linked to two types of cancer in communities with drinking water exposure.

U.S. Navy Policy – October 2014

Identify all known and suspected sites where PFOS/PFOA may have been released

Sample all Navy water treatment systems by Dec. 2015

For Navy water treatment systems not under UCMR3, sample finished drinking water for PFOS/PFOA within 1 mile of an upgradient PFC source

State Regulations

Geosyntec consultants

	PFOS (µg/L)	PFOA (µg/L)	Promulgated
USEPA	0.07	0.07	N
AL	0.07	0.07	N
AZ	0.07	0.07	N
CO	0.07	0.07	N
DE	0.07	0.07	N
IA	0.07	0.07	**Y**
ME	0.07	0.07	N
MI	0.07	0.07	**Y**
NH	0.07	0.07	**Y**
PA	0.07	0.07	N
RI	0.07	0.07	**Y**
WV	0.07	0.07	N

	PFOS (µg/L)	PFOA (µg/L)	Promulgated	
AK	0.40	0.40	**Y**	HIGHER
NC	---	2	**Y**	HIGHER
NV	0.667	0.667	N	HIGHER
TX	0.56	0.29	**Y**	HIGHER
CT	0.7 sum of 5 PFAS		N	LOWER
MA	0.7 sum of 5 PFAS		proposed	LOWER
MN	0.035	0.028	proposed	LOWER
NJ	0.013	0.014	proposed	LOWER
VT	0.02	0.02	Y	LOWER

Potential Outcomes

Geosyntec

Sampling Results

1

PFAS detected above "limit"

Short Term

- Stop customer exposure (bottled water)
- Emergency system flushing and treatment
- Public outreach

Long Term

- Identify sources
- Long term treatment or alternative supply
- Cost recovery
- Litigation management
- Regulatory tracking

2

PFAS not detected or detected "limit"

Short Term

- Develop management strategy for maintaining concentrations below NJ MCL
- Inventory potential upgradient sources for future impacts

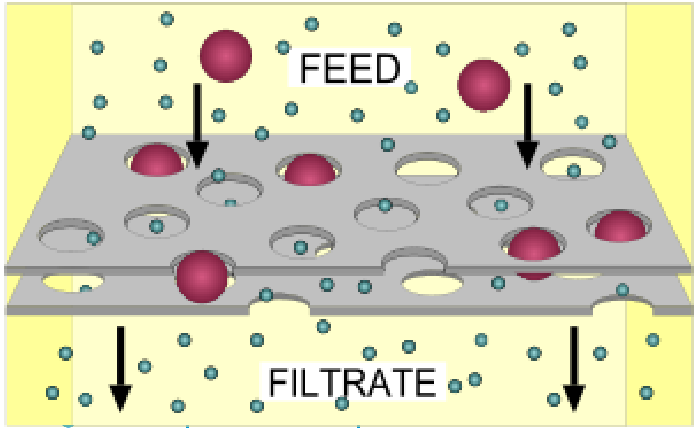
Long Term

- Evaluate source water and distribution system resilience
- Concentration monitoring
- Regulatory tracking

Remediation Considerations

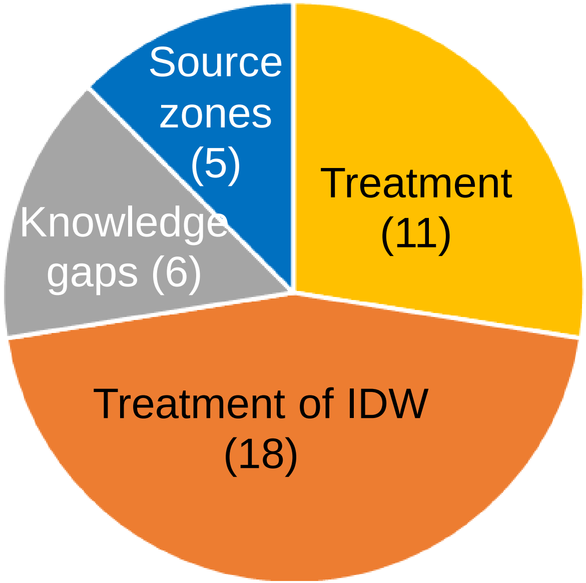
Geosyntec consultants

- C-F bond is high energy and difficult to break
- Very stable at high temperature
- Typically do not hydrolyze, photolyze, or biodegrade
- Are extremely persistent in the environment
- Low temperature thermal not applicable
- High temperature thermal is expensive
- Low volatility – soil vapor extraction and air sparging not applicable (could actually increase PFC concentrations)
- Advanced oxidation processes that rely on the OH radical do not work (e.g., hydrogen peroxide)



Remediation Options

No acceptable, cost-effective in situ treatment available GAC is only treatment method currently in use at sites



PFAS projects funded by SERDP/ESTCP in FY2018

Remediation Options

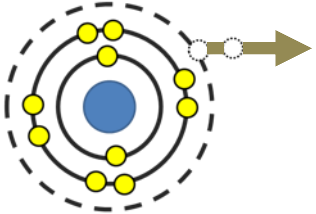
Geosyntec consultants

Adsorption onto Granular Activated Carbon (GAC) and Ion Exchange

- Quick breakthrough for low C chain compounds (C4 and C6)
- Higher chains (C8) have slower breakthrough

Parameter	Charge Capacity (% wt)	Annual GAC Costs ($)			
		20 gpm	44 gpm	220 gpm	440 gpm
PFOS	0.002 to 0.005	3,932	7,865	39,322	78,643
CVOCs	0.02 to 0.4	256	512	2,555	5,112
BTEX	0.1 to 2.0	52	102	512	1,022
PAH	1.3 to 2.5	29	57	284	568

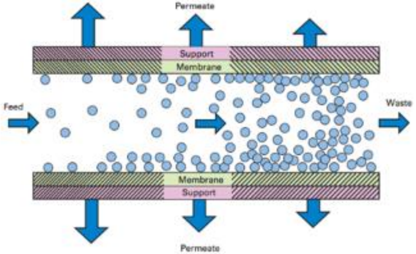
Oxidation with Persulfate, Sonolysis, and Electrolysis with Boron-Doped Diamond Electrodes



- Oxidation with persulfate, sonolysis, and electrolysis with boron-doped diamond electrodes
- Not with hydroxyl radical, but with per radical
- Some laboratory studies; not yet demonstrated at field scale
- Heat-activated persulfate and permanganate, UV-activated persulfate, ultra sonification, electrochemical oxidation, catalyzed hydrogen peroxide

Membrane Filtration

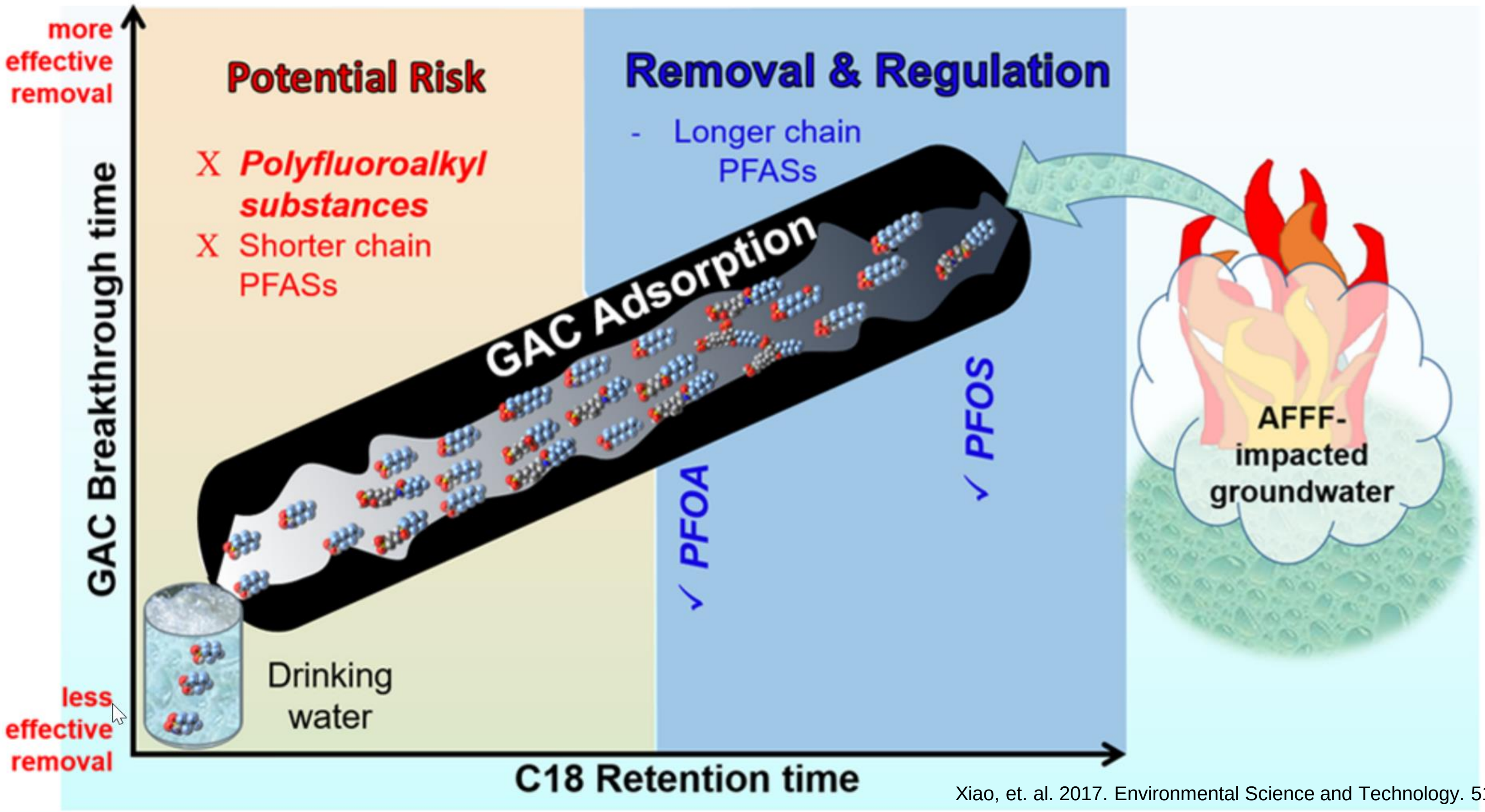
Nanofiltration and reverse osmosis



Source: Durant and Darlington, 2015

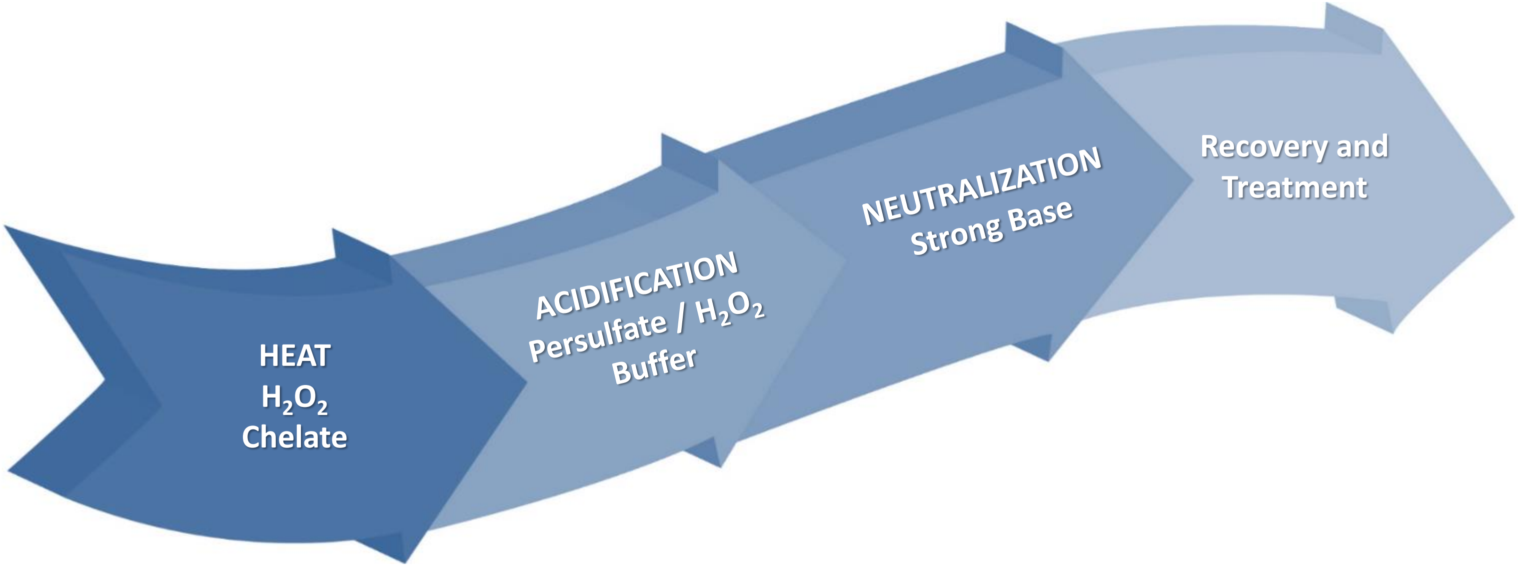
Remediation Challanges

Geosyntec consultants



Xiao, et. al. 2017. Environmental Science and Technology. 51: 6342-6351

Treatment Considerations

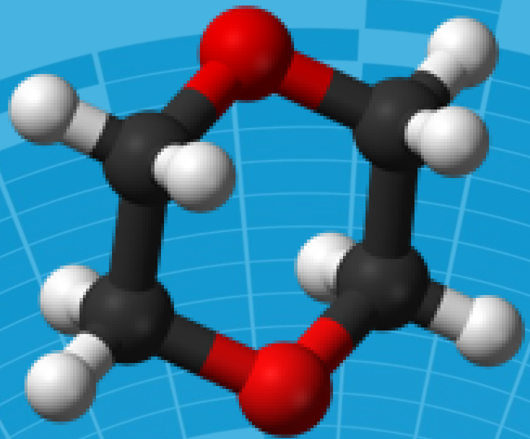


Additional Issues for Consideration

- Focus to date has been on PFOS / PFOA, but what about all the other PFCs? Are we scratching the surface?
- Replacements for PFOA went into production ten years ago and now are showing up in groundwater.
- Municipal drinking water supplies – can they treat for PFAS down to 70 ppt?
- Granular activated carbon (GAC) is only mature, demonstrated treatment technology.
- Analysis for detection is expensive. How far should we look?
- Widespread occurrence. Can we clean it up? Private drinking water systems?

Geosyntec consultants

1,4-Dioxane



$C_4H_8O_2$

engineers | scientists | innovators

1,4-Dioxane In the News

Geosyntec consultants

ChemicalWatch
GLOBAL RISK & REGULATION NEWS

Search Chemical W...

Home | News | Sectors | Brexit | TSCA | Briefing/reports | Guides/data

Study finds 1,4-dioxane in tap water in 45 US states

7 September 2017 / Solvents, United States

The solvent 1,4-dioxane was found in samples from tap water supplies in 45 states, according to a study commissioned by US NGO the Environmental Working Group (EWG). The report states that more than seven million people in 27 states are served by public water systems where the average level of the chemical is higher than the level the US Environmental Protection Agency (EPA) says poses an increased risk of cancer.

FEBRUARY 11, 2017 | Albany, NY

Governor Cuomo Calls on EPA to Set Clear and Enforceable Drinking Water Standard for 1, 4-Dioxane

ENVIRONMENT | PUBLIC SAFETY

New details about risk of 1,4-dioxane in Cape Fear River

Published: Thursday, June 22nd 2017, 1:35 pm EDT
Updated: Thursday, June 22nd 2017, 6:26 pm EDT

By: Ann McAdams, Investigative Reporter CONNECT

Researchers say chemical is being discharged from wastewater

SOUTHEASTERN NORTH CAROLINA (WECT) - We are learning about 1,4-dioxane, a second chemical found in the Brunswick Wilmington water supply that the Environmental Protection Agency says likely causes cancer.

Tammy Hill, a water quality analyst for the NC Department of Environmental Quality (DEQ) who focuses on 1,4-dioxane, say chemical has been in use for "a few decades."

Michigan Supreme Court rejects polluter's appeal in Ann Arbor dioxane case

Updated Jan 17, 2018; Posted Jan 17, 2018

1,4 – Dioxane Occurrence

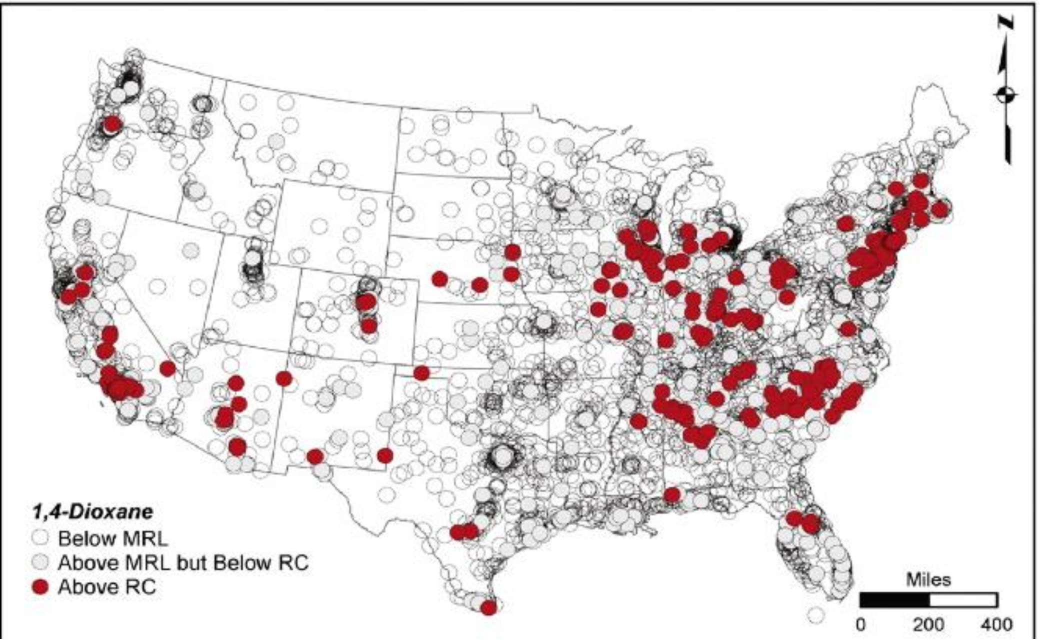
Geosyntec consultants

- It's a stabilizer in chlorinated solvents
  - If you see 20 µg/L of 1,4-dioxane, historical concentrations of 1,1,1-TCA were >250 µg/L and more likely >1 mg/L
  - If you didn't observe this in the past or see higher concentrations of 1,4-dioxane, the source is likely something else
- Solvent used for inks, adhesives, fats, waxes, cellulose esters, ethers, and resins
- Manufacturing byproduct of surfactants, health care products, polyethylene terephthalate (PET plastics)
  - Derivative of ethylene oxide (acid or base catalyst)
  - Ethoxylation of alcohols (creating surfactants)
  - Esterification of glycol ethers
  - Dehydration of diethylene glycol (acid catalyst)
  - Heating ethylene glycol (ferric sulfate as catalyst)

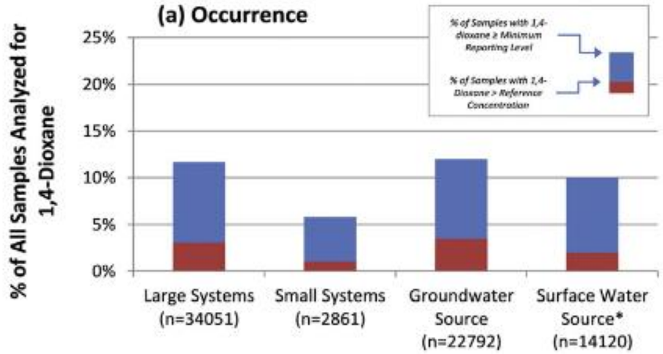
1,4-Dioxane Occurrence in Public Water

Geosyntec consultants

1,4-Dioxane Occurrence in 4864 Public Water Systems Included in UCMR3



1,4-Dioxane detected in 21% of public water systems but detection rates declined over time



Concentrations exceeded health-based reference concentration (0.35 ug/L) at 6.9% of these systems

Adamson et al. (2017), Science of the Total Environment

1,4 – Dioxane Occurrence

Geosyntec consultants

Avoid the pitfall of assuming the source is associated with chlorinated solvents

- Do the math
- Verify the Conceptual Site Model is logical

Investigate all potential sources of 1,4-dioxane

- Audit chemical processes
- Evaluate process sewers and WWTPs

You can't effectively remediate if you haven't identified the source

Federal Regulatory Framework

Geosyntec consultants

No Federal MCL
Included on drinking water contaminant candidate list
Included in Third Unregulated Contaminant Monitoring Rule

10 ppm limit proposed for contraceptive sponge product; and glycerides and polyglycerides in dietary supplements

100 ppm limit in air averaged over an 8-hour work day

NATIONAL ACADEMY OF SCIENCES

10 ppm maximum in the food additive polysorbate

Source: EPA (2017)

State Regulations

State	Guideline (µg/L)	Source
Alaska	77	AL DEC 2016
California	1.0	Cal/EPA 2011
Colorado	0.35	CDPHE 2017
Connecticut	3.0	CTDPH 2013
Delaware	6.0	DE DNR 1999
Florida	3.2	FDEP 2005
Indiana	7.8	IDEM 2015
Maine	4.0	MEDEP 2016
Massachusetts	0.3	MADEP 2004
Mississippi	6.09	MS DEQ 2002
New Hampshire	0.25	NH DES 2011
New Jersey	0.4	NJDEP 2015
North Carolina	3.0	NCDENR 2015
Pennsylvania	6.4	PADEP 2011
Texas	9.1	TCEQ 2016
Vermont	3.0	VTDEP 2016
Washington	0.438	WA ECY 2015
West Virginia	6.1	WV DEP 2009

Geosyntec consultants

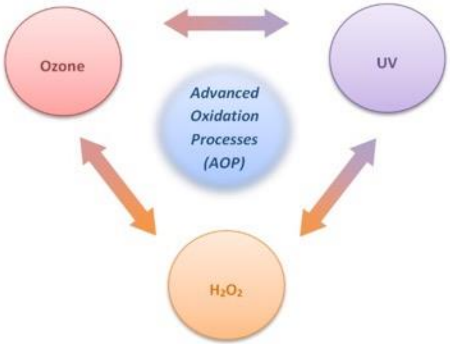
Notification level varies widely by state
California: DHS notification level is 3 ppb

Source: EPA (2017)

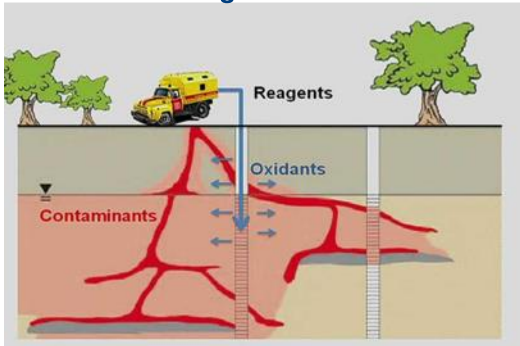
1,4-Dioxane Treatment Options

Geosyntec consultants

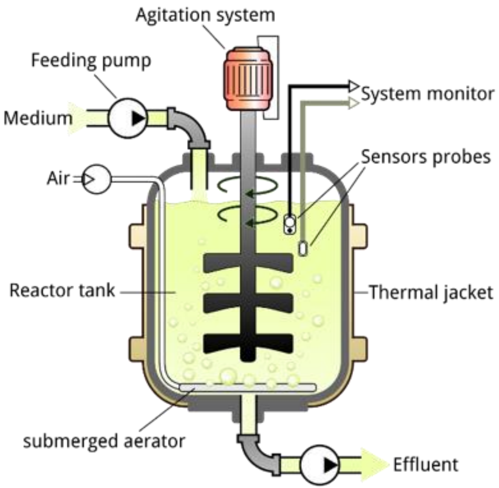
Advanced Oxidation (using hydrogen peroxide with ultraviolet light or ozone)



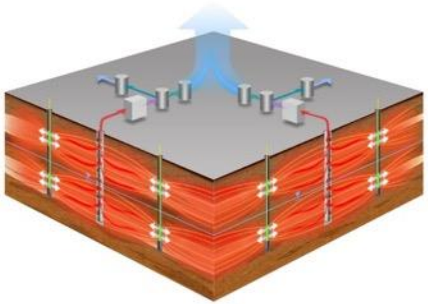
Chemical Oxidation and Bioaugmentation



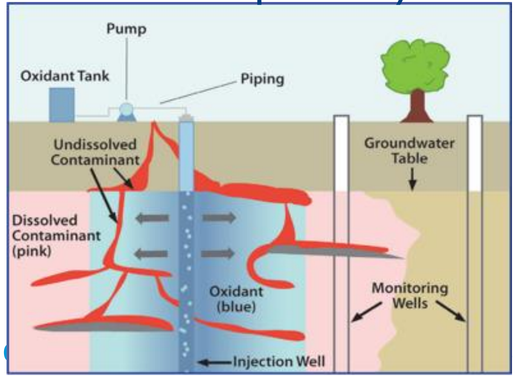
Microbial Degradation in Bioreactors



Electrical Resistance Heating



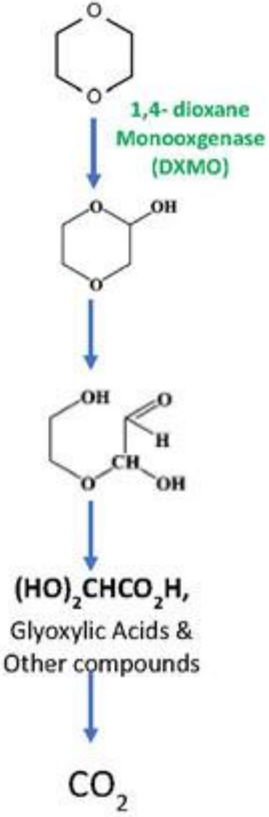
Oxidation (using peroxone and activated persulfate)



1,4-Dioxane Treatment Options

SiREM

Geosyntec consultants



treatability studies

gene trac®

1,4-Dioxane Treatment Options

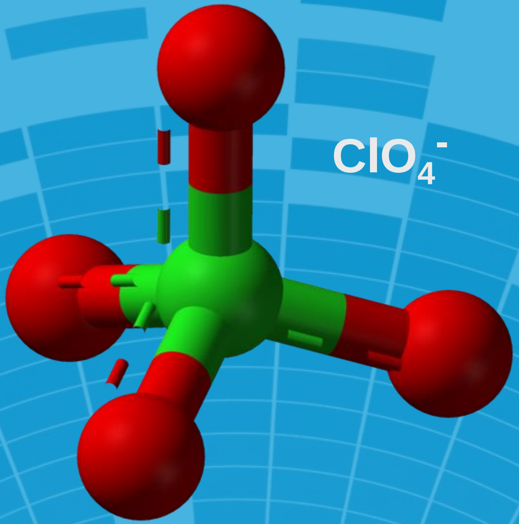
SIREM technician programing robot used to assemble Gene-Trac® qPCR reactions

Contaminant Class	Redox	Gene-Trac® Test	Target	Relevance
1,4-Dioxane	Aerobic metabolism	1,4-dioxane	Dioxane monooxygenase (*dxmb*)	Energy yielding 1,4-dioxane degradation
		1,4-dioxane	Aldehyde dehydrogenase (ALDH)	Energy yielding 1,4-dioxane degradation
	Aerobic Co-metabolism	pMMO	particulate Methane monooxygenase (pMMO)	Co-oxidation of 1,4-dioxane in presence of methane
		sMMO	soluble Methane monooxygenase (sMMO)	Co-oxidation of 1,4-dioxane
		PMO	Propane monooxygenase (PMO)	Co-oxidation of 1,4-dioxane in presence of propane

Additional Issues for Consideration

- No Federal MCL yet
- 1,4-dioxane now showing up in certain surface water bodies
- Still many chlorinated solvent sites where groundwater has not been analyzed for 1,4-dioxane
- 1,4-dioxane typically occurs as a co-contaminant at chlorinated solvent sites, especially 1,1,1-TCA degradation products
- Some common treatment processes for chlorinated solvents do not treat 1,4-dioxane

Perchlorate

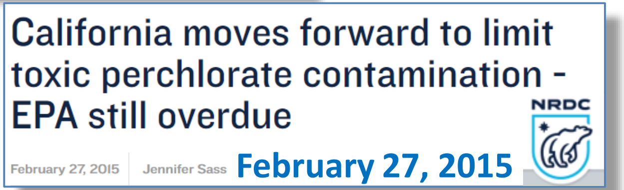


ClO_4^-

engineers | scientists | innovators

Perchlorate In the News

Geosyntec consultants



Perchlorate - Overview

Geosyntec consultants

- Highly soluble in water, stable in subsurface systems
- Naturally occurring and man-made anion
- Used by DOD since 1940, 90% of domestically produced perchlorate used in defense industries – primarily ammonium perchlorate
- Bioaccumulates in food
- In humans, inhibits iodide uptake, disrupts thyroid gland functions
- EPA Method 314 or SW-846 6850, Stable Isotopes

Perchlorate - Overview

Property	Ammonium Perchlorate	Sodium Perchlorate	Potassium Perchlorate	Perchloric Acid
Chemical Abstracts Service (CAS) Numbers	7790-98-9	7601-89-0	7778-74-7	7601-90-3
Physical Description (physical state at room temperature)	White orthorhombic crystal	White orthorhombic deliquescent crystal	Colorless orthorhombic crystal or white crystalline powder	Colorless, oily liquid
Molecular weight (g/mol)	117.49	122.44	138.55	100.47
Water solubility (g/L at 25°C)	200	2,096	15	Miscible in cold water
Melting / Boiling point* (°C)	Melting Point: > 200 (Decomposes)	Melting Point: 471 to 482	Melting Point: 400 to 525	Melting Point: -112 Boiling Point: 19
Vapor pressure at 25°C (mm Hg)	Very low	Very low	Very low	6.8
Specific gravity (g/cm^3)	1.95	2.52	2.53	1.77
Octanol-water partition coefficient (log K_{ow})	-5.84	-7.18	-7.18	-4.63

*Different melting point temperatures are identified in literature.

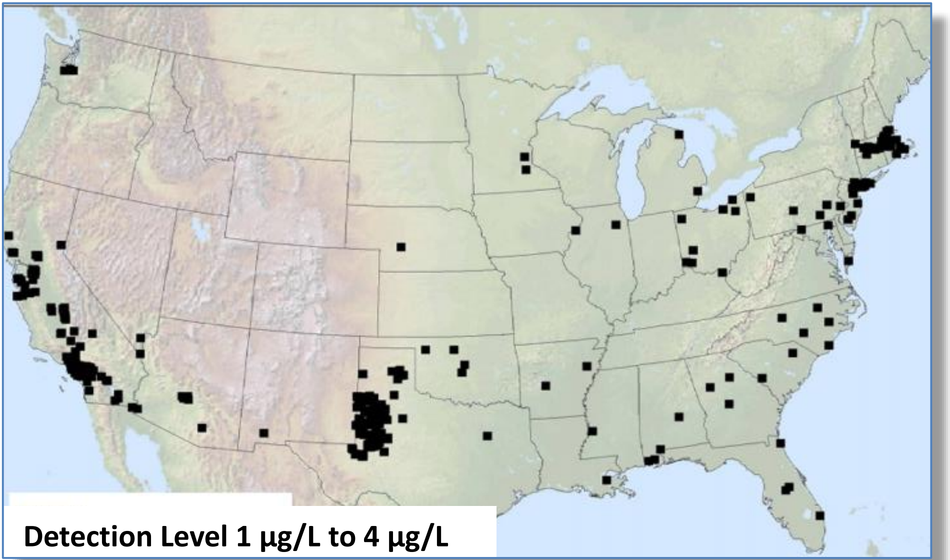
Abbreviations: g/mol – grams per mole; g/L – grams per liter; °C – degrees Celsius; mm Hg – millimeters of mercury; g/cm^3 – grams per cubic centimeter.

Source: https://www.epa.gov/sites/production/files/2014-03/documents/ffrrofactsheet_contaminant_perchlorate_january2014_final.pdf

Perchlorate Occurrence in Public Water

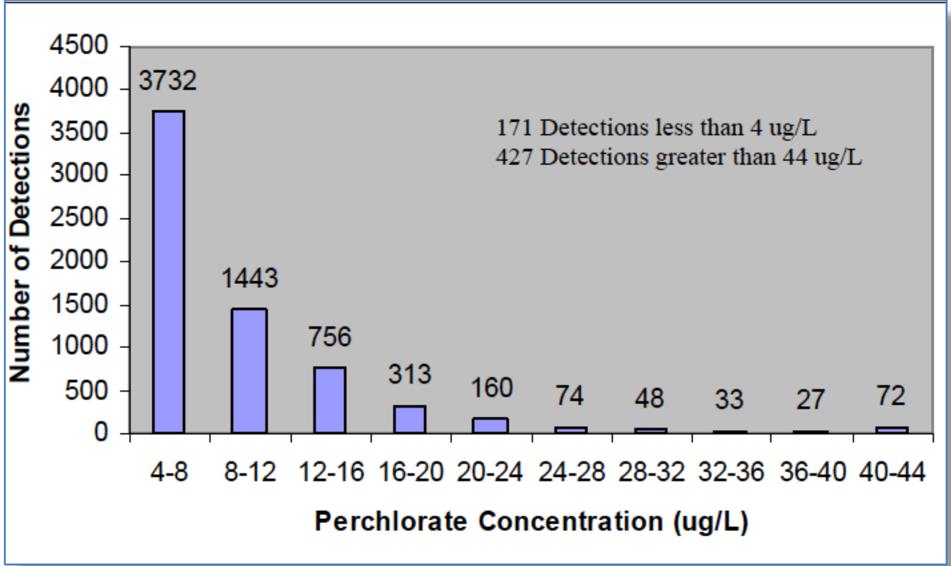
Geosyntec consultants

Perchlorate Detected in Drinking Water (2004)



American Water Works Association (2005)

Perchlorate Detections in California Wells (2004)



American Water Works Association (2005)

- **> 4% of public water systems have detected perchlorate**
- **Between 5.2 and 16.6 million people who may be served drinking water containing perchlorate** *EPA (2011)*

Federal Regulatory Framework

Geosyntec consultants

EPA Drinking Water Health Advisory Level = 15 ppb

2009 Established reference dose recommended by the NRC

2012 initiated regulations under the Safe Drinking Water Act

2013 Soil Residential Screening level of 55 ppm
Industrial soil screening level of 750 ppm

National Research Council (NRC) of the National Academy of Sciences (NAS)

In 2005, recommended reference dose for children and pregnant women of < 24.5 ppb

Department of Homeland Security - Chemical Security

Ammonium and Potassium Perchlorate are chemicals of interest

State Regulations

Geosyntec consultants

Regulatory Action	State / Agency	Perchlorate (µg/L)
Drinking Water Standards	MA (as of 2006)	2
	CA (as of 2007)	6
Non-Enforceable Guidance, Action or Advisory Levels	At Least 10 States	1 to 18 µg/L for Drinking Water & 1 to 72 µg/L for Groundwater
Drinking Water Equivalent Level	NRC of NAS (as of 2005)	24.5
Interim Health Advisory Level	EPA (as of 2009)	15
Level of Concern	DOD (as of 2006)	24

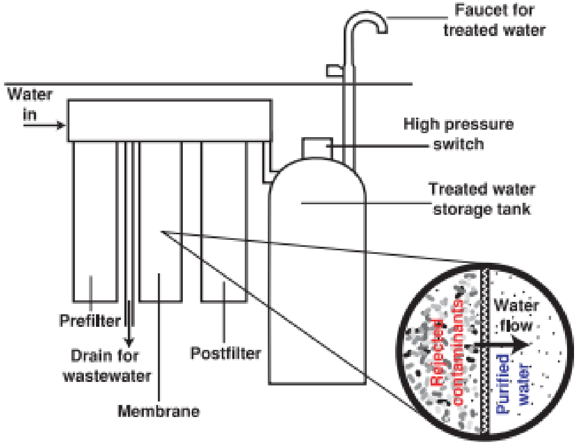
McGregor Naval Weapons Industrial Reserve Plant (McGregor, TX)

TX required Navy to reduce perchlorate levels in wastewater discharges to 4 µg/L (TX's Action Level)

Perchlorate Treatment Options – Ex Situ

Geosyntec consultants

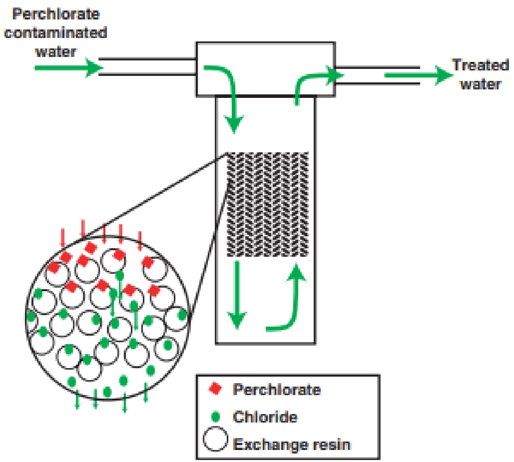
Reverse Osmosis



Under-sink systems and whole-house/business purification systems can provide about 95% rejection

For extremely high levels, a specialty ion exchange polishing filter might be required to achieve very low levels

Anion Exchange



Use specialty anion exchange resins with very strong affinities to the perchlorate ion

Systems can be used on a disposable basis, or they can be regenerated for a longer service life

Agricultural Communications, The Texas A&M University System (2005)

Perchlorate Treatment Options – In Situ

Geosyntec consultants

treatability studies

Geosyntec consultants

Additional Issues for Consideration

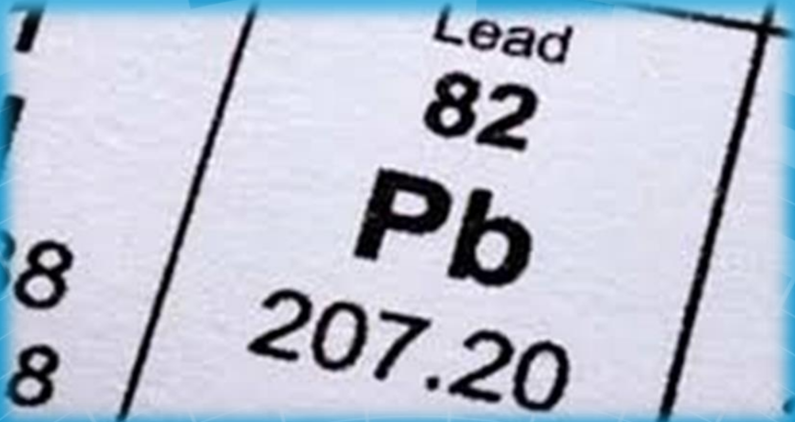
No Federal MCL

Naturally-occurring chemical in fertilizers

Found in vegetables (lettuce), breast milk, and Chilean wine (!)

Perchlorate is fairly ubiquitous

Lead



Lead In the News

Pittsburgh Post-Gazette

Reserve Township finds high levels of lead in tap-water supplied by PWSA

ADAM SMELTZ
Pittsburgh Post-Gazette
asmeltz@post-gazette.com

APR 2, 2018 | 6:56 AM

Pittsburgh isn't the only Allegheny County municipality facing a state alert over lead-contaminated water.

CNN Health » Lead found in hundreds of Chicago homes' tap water, report says | Live TV | U.S. Ed

Lead found in hundreds of Chicago homes' tap water, report says

By Jacqueline Howard, CNN
Updated 9:37 PM ET, Thu April 12, 2018

April 12, 2018

Two-year-old Ed Brown Jr., who has lead poisoning, outside his home in South Bend, Indiana

Nov 8, 2017

The 'Horrifying' Consequence of Lead Poisoning

Exposure to the toxin leads to higher risk of miscarriages, new research finds, in addition to other long-lasting effects.

OLGA KHAZAN | NOV 8, 2017 | HEALTH

Lead Federal Action

Air

- 1970 Clean Air Act
- One of 6 hazardous pollutants regulated by the national ambient air quality standards (NAAQS)
  - Set emissions standards for industrial facilities
  - 2007 standard became 10x more strict

Water

- 1972 Clean Water Act
- 1974 Safe Drinking Water Act
  - 1991 Lead and Copper Rule: Establishes action level (AL) of 0.015 mg/L for Pb and 1.3 mg/L for Cu based on 90th percentile level of tap water samples.

Soils and Waste

- Addressed by RCRA, CERCLA, Superfund, Brownfields, hazardous waste program, and other EPA programs

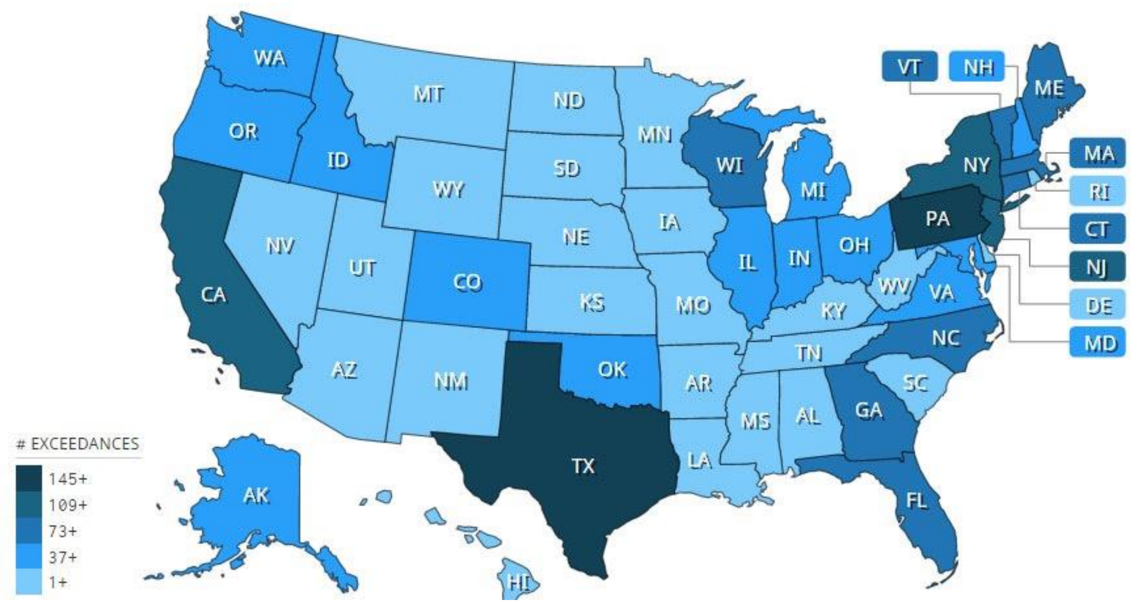
Lead-Based Paint

- 1976 Toxic Substance Control Act
- 1992 Residential Lead-Based Paint Hazard Reduction Act
  - Allows disposal of lead-based paint as household waste

Lead Occurrence in Public Water

Geosyntec consultants

EPA study found over **6 million people and 2,000 water systems** with excessive lead levels in drinking water over a 4 year span



USA TODAY (2016) analysis of EPA's Safe Drinking Water Information System database

Over the next decade, local governments will spend an estimated **$300 billion** on upgrading water and sewer pipes

In 2020, average age of water pipes will be 45 years

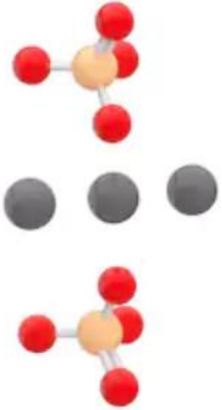
Bluefield Research (2017)

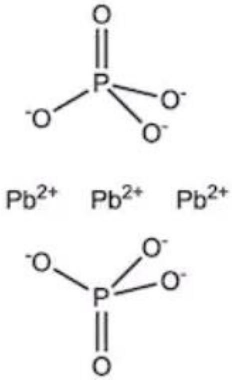
Treatment and Challenges

Replacing service lines and private pipe will take decades – Other technologies can be used now!

Inorganic Phosphates (e.g., phosphoric acid, zinc phosphate, and sodium phosphate)

- Commonly added to water by municipalities
- Forms insoluble mineral scale on the inside of service lines and private pipe
- Scale protects pipes from corrosive elements in water
- <u>Challenge</u>: Requires maintaining pH and orthophosphate levels throughout the system





- Phosphates are common food additives that are "generally recognized as safe" by the FDA

- A person would have to drink 10 – 15 L of tap water dosed with phosphates to consume the amount in just 1 can of soda

Bluefield Research (2017)

Geosyntec consultants

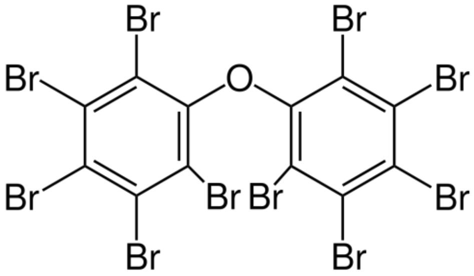
Additional Issues for Consideration

- Exposure routes to lead are in air, soil, and water.
- Drinking water = daunting infrastructure problem
- Aging infrastructure = additional problems
- Drinking water = treatment requires attention

What is Next ?

Organohalogen Flame Retardants

Example: Decabromodiphenyl ether



Pharmaceuticals and Personal Care Products

Example: Oxybenzone