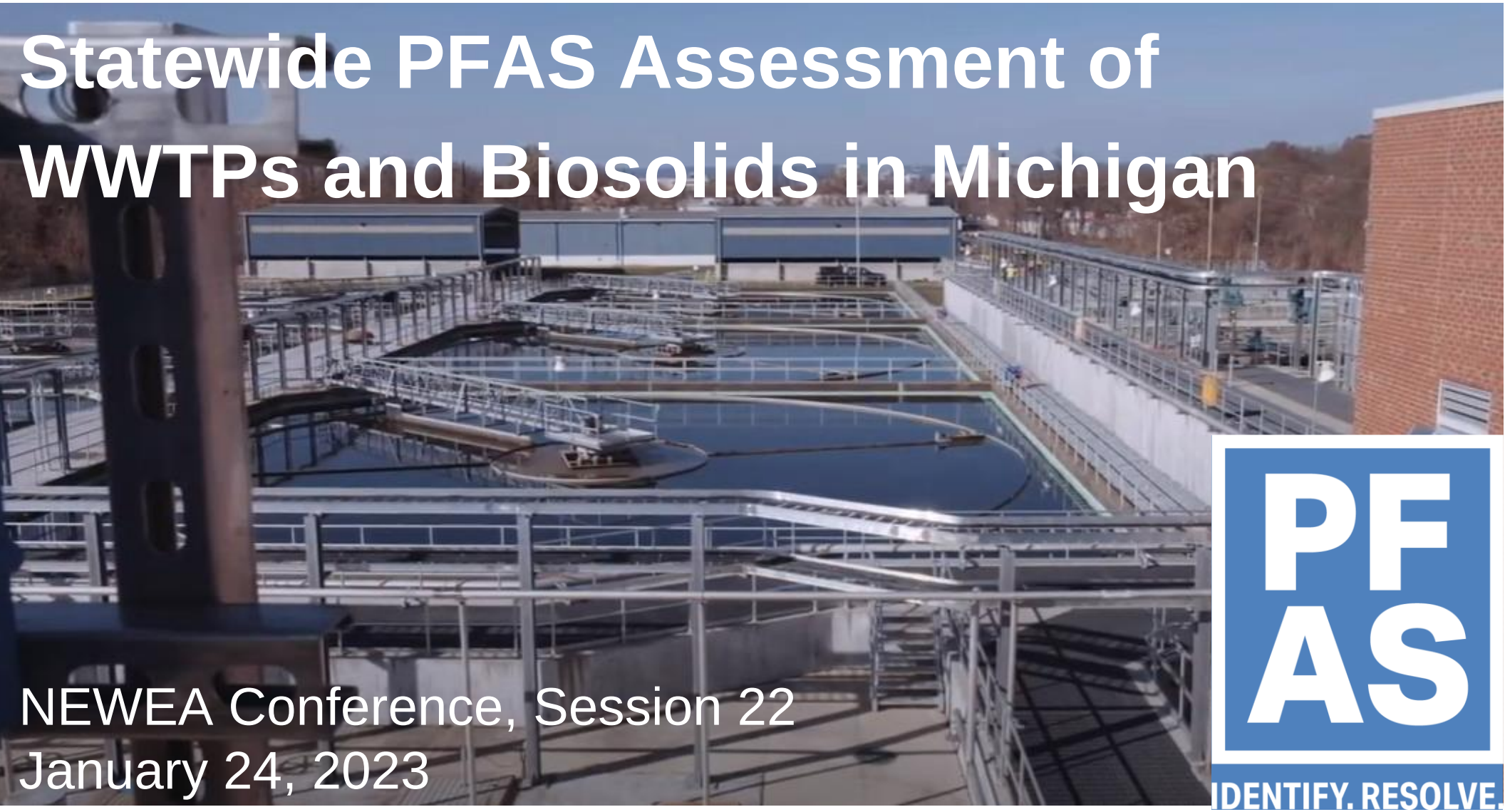
Statewide PFAS Assessment of WWTPs and Biosolids in Michigan

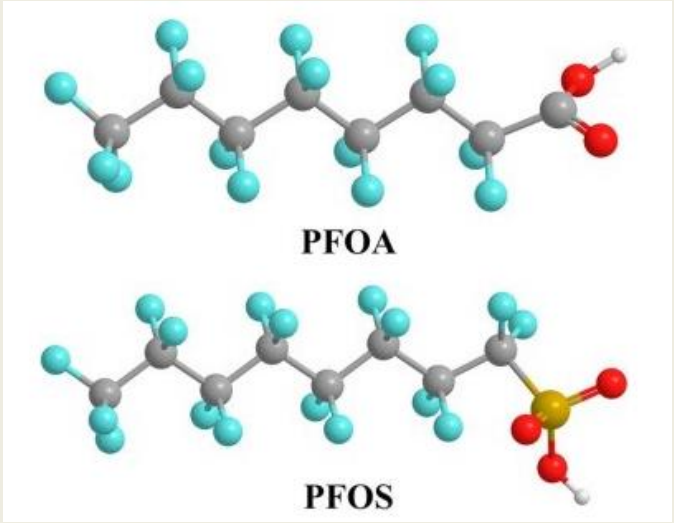


NEWEA Conference, Session 22
January 24, 2023

Christopher Curran, PE
AECOM PFAS Lead, Water

Agenda

- Per- and polyfluoroalkyl substances (PFAS) sources
- EPA Roadmap drivers for wastewater
- Michigan and other PFAS study findings
  - Liquid train
  - Solids train
  - Mitigation Measures
- Michigan land application studies
- Biosolids considerations



Uses of PFAS in Industries

AUTOMOTIVE

FIRST RESPONDERS

OIL & GAS

MILITARY

CHEMICAL/ PHARMACEUTICAL MANUFACTURING

ELECTRONICS

OUTDOOR APPAREL/ EQUIPMENT

HEALTHCARE

AEROSPACE/ DEFENSE

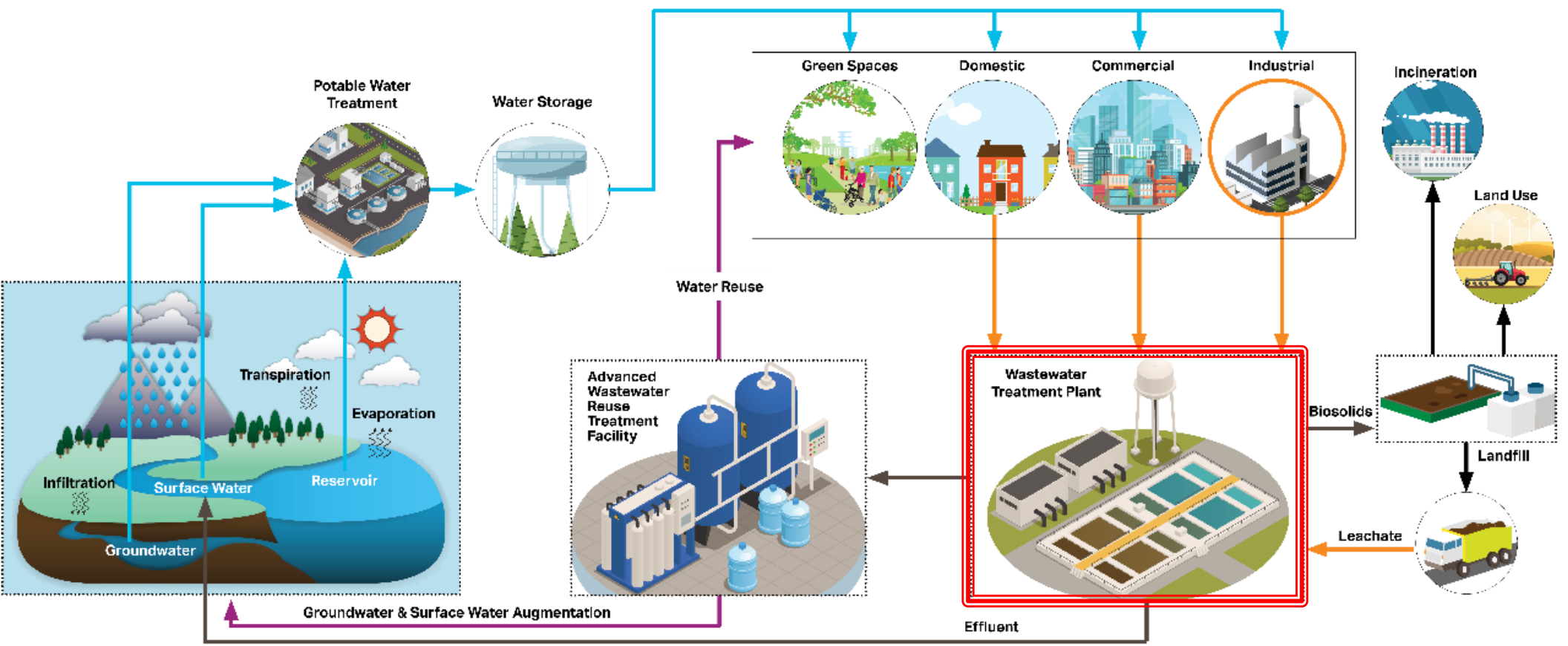
ALTERNATIVE ENERGY

SEMICONDUCTORS

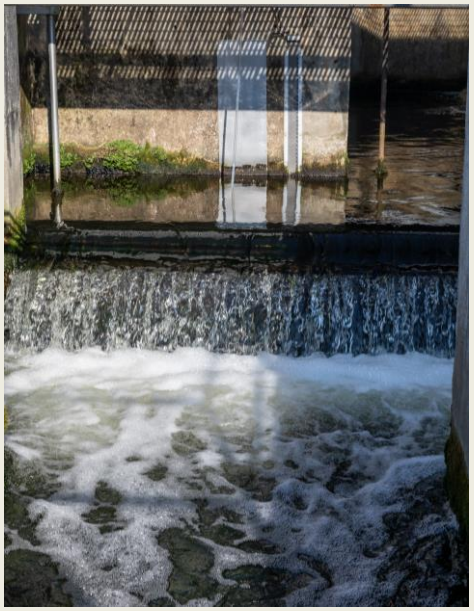
BUILDING/ CONSTRUCTION

3

PFAS in the One-Water Cycle – Wastewater Treatment Plants



EPA Wastewater Driver: Discharge Limits



Implications of National Pollution Discharge Elimination Permit (NPDES)

New guidance Dec 2022 to state permitters:
Recommend quarterly PFAS testing at: airports, landfills, paper facilities, electroplating operations, chemical plants
Recommend POTWs:

- *Test* influent, effluent and biosolids *quarterly*
- Update *Industrial User (IU) inventories* to include *"expected or suspected of PFAS discharges"*
- Develop *best management practices (BMPs)* or limits for IUs
- Encourage PFAS pollution prevention, product substitution and good housekeeping practices at IUs where don't exist
- *Address PFAS in biosolids:* testing, taking actions to reduce discharges from IUs, and monitor biosolids

EPA Wastewater Driver: Hazardous Substance Designation

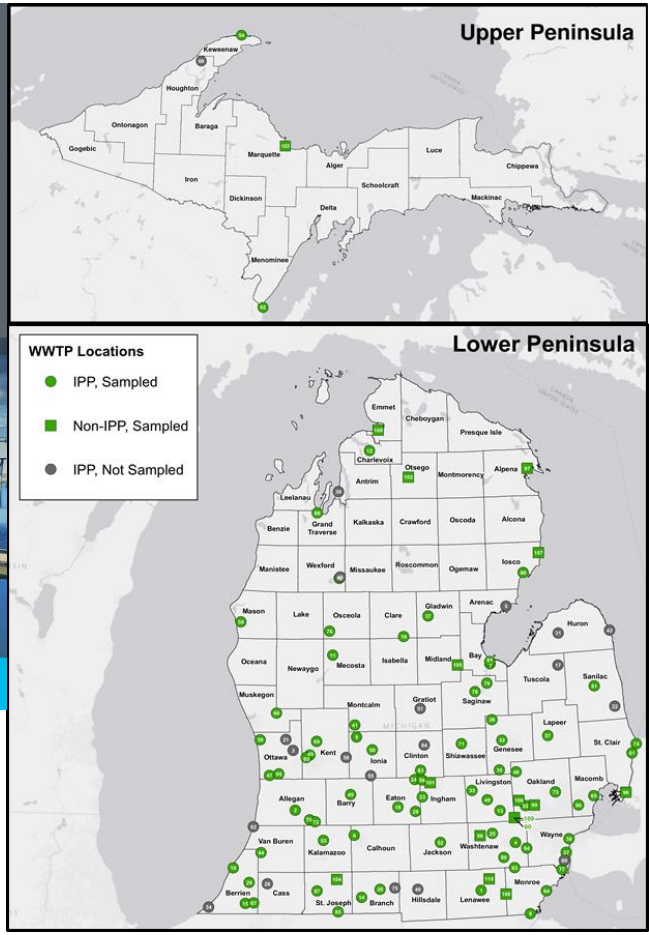
Implications of draft notification:

- Designates PFOA and PFOS, including their salts and structural isomers, as hazardous substances under CERCLA*
- Requires notification of any release equal to or greater than <u>one pound or more in a 24-hour period</u>
- Do not confuse with Hazardous Waste under the Resource Conservation and Recovery Act (RCRA) which defines waste management and disposal

CERCLA = Comprehensive Environmental Restoration, Compensation and Liability Act

Statewide WWTP Evaluation in Michigan

- **110 WWTPs Evaluated**
  - 95 Industrial Pretreatment Program (IPP)
  - 15 Non-IPP
- **Of the WWTPs Sampled:**
  - 95 effluents (80 IPP & 15 non-IPP)
  - 54 influent (47 IPP & 7 non-IPP)



Effluent PFOA and PFOS Concentrations

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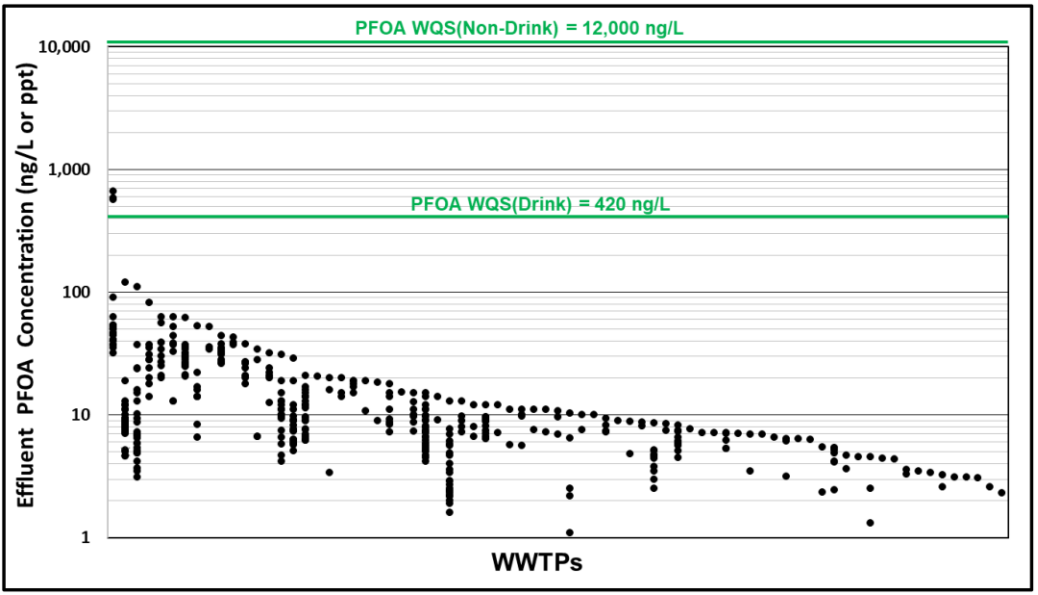
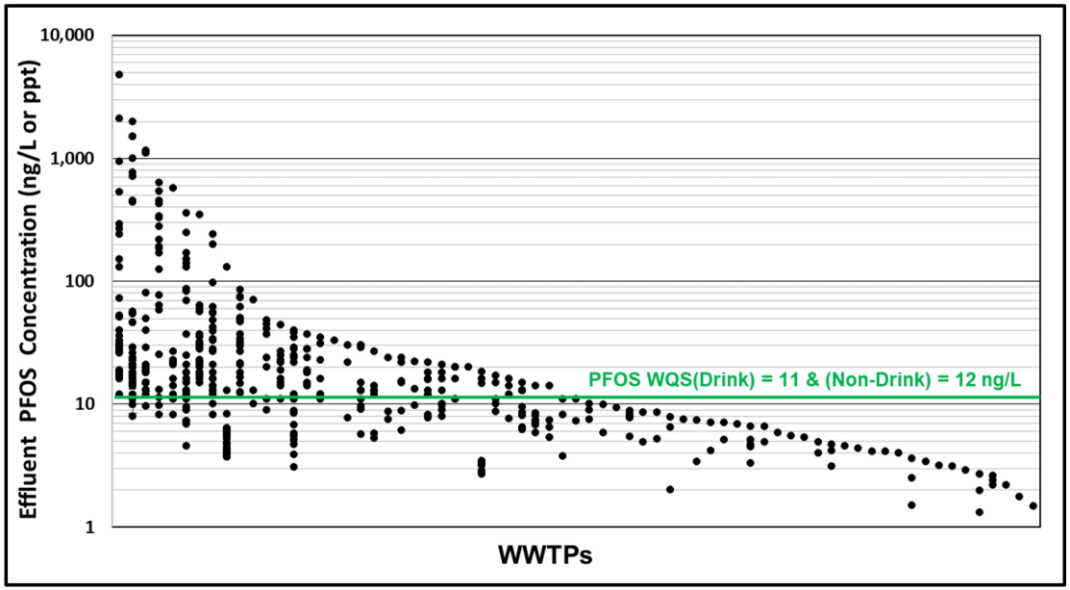
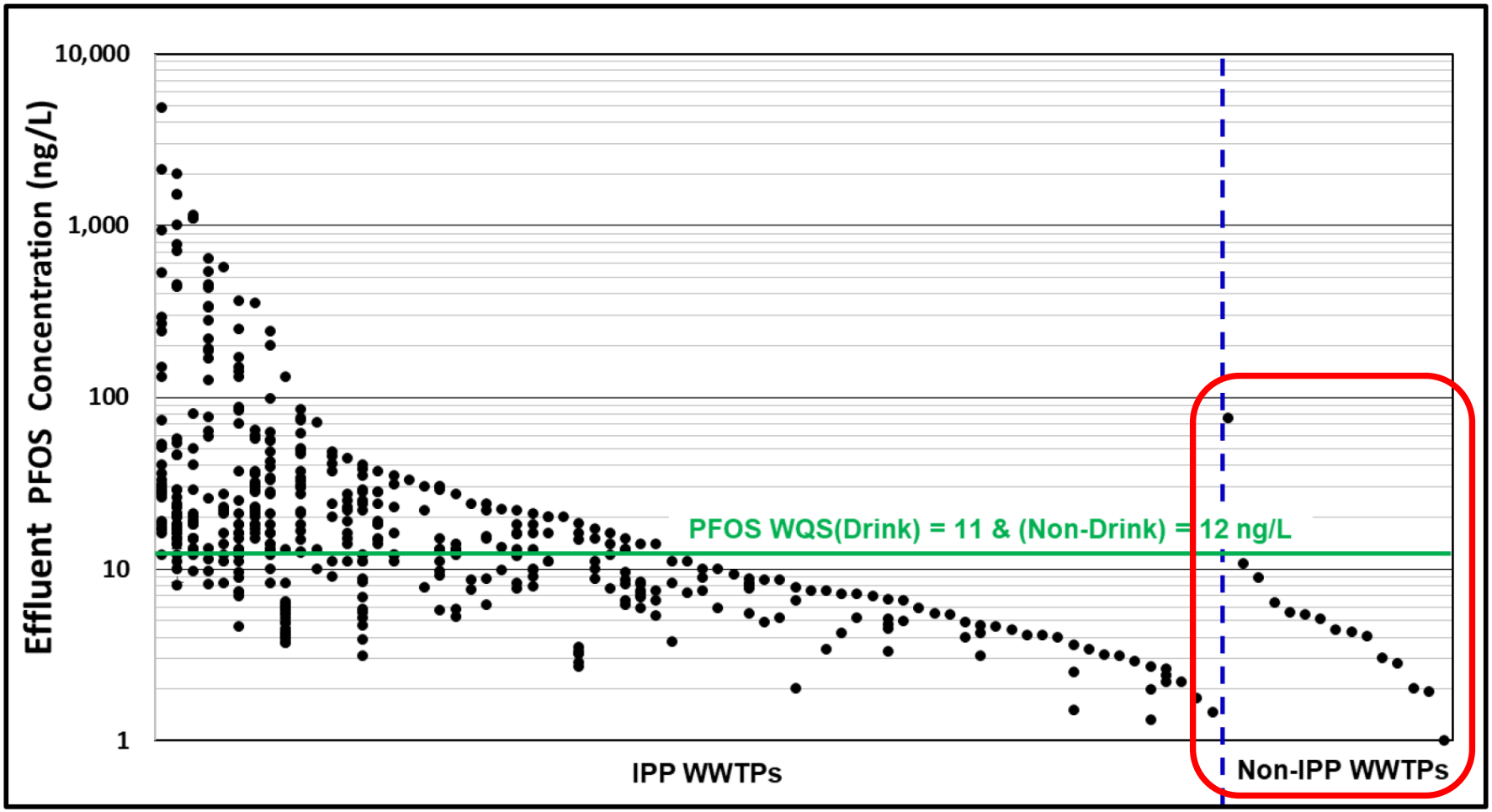
PFOA



PFOS



PFOS at IPP and Non-IPP WWTPs



PFAS Chemistry

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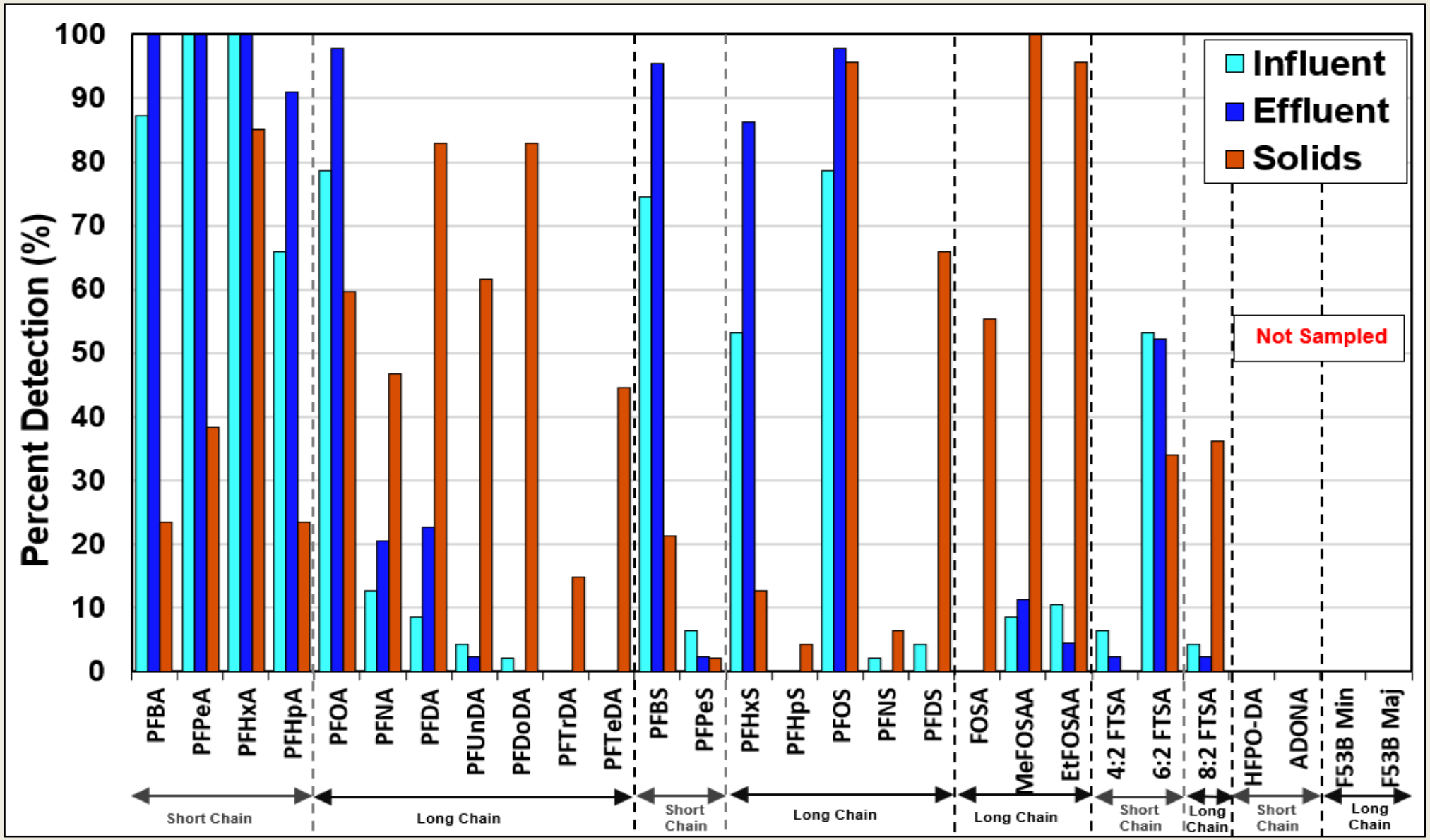
- **Large group of compounds (>4,700)**

- **28 PFAS Analyte List**
  - 18 PFAS/2 Families – Do not degrade
  - 3 PFAS / 3 Families – PFOS Precursors
  - 3 PFAS / 1 Family – PFCAs Family Precursors
  - 4 PFAS / 3 Families – Replacement Chemistry

PFAS Analyte List

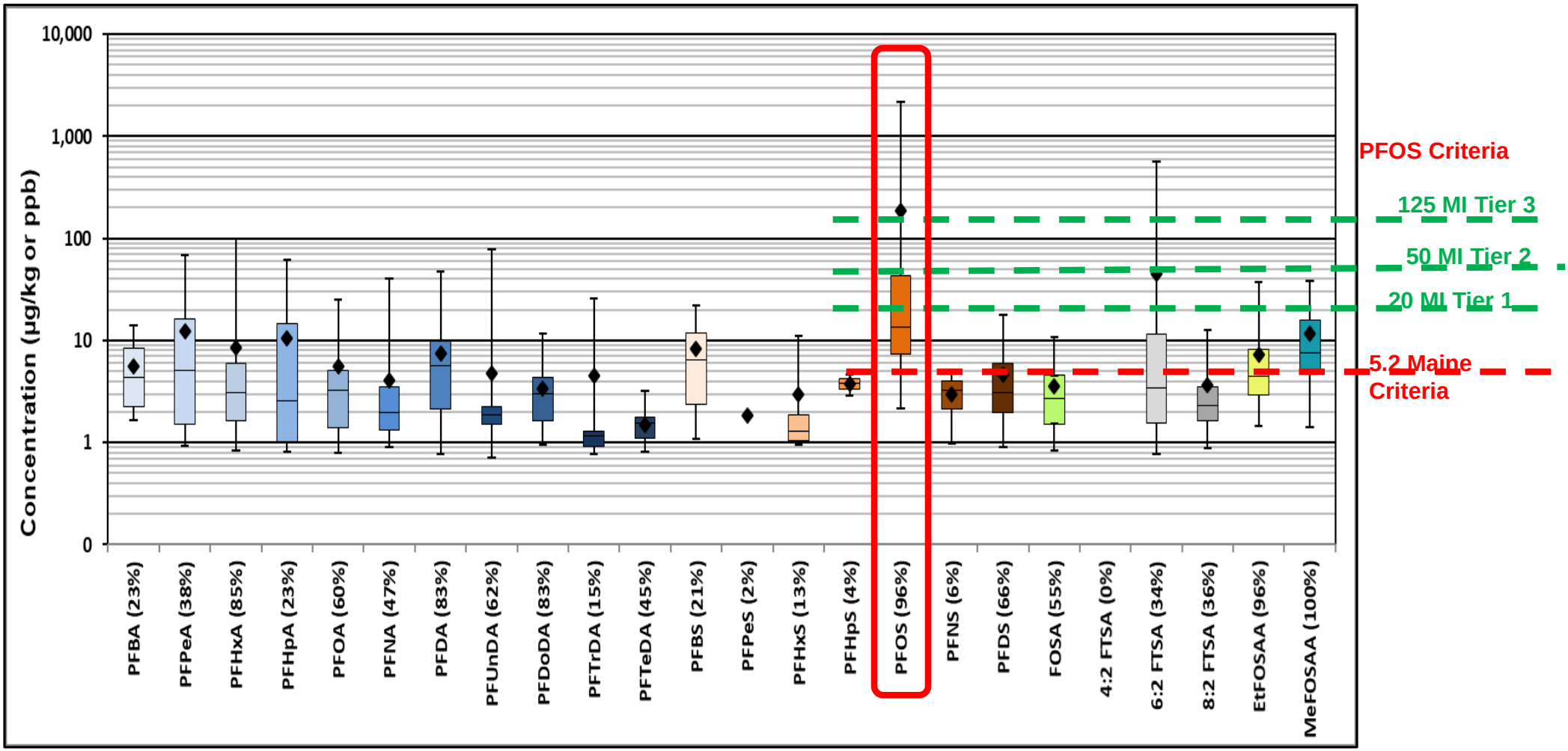
#	PFAS Name	Acronym	CAS #	(Carbon #) Chain Length
Perfluoroalkyl carboxylic acids (PFCAs)				
1	Perfluorobutanoic Acid	PFBA	375-22-4	(4) Short-chain
2	Perfluoropentanoic Acid	PFPeA	2706-90-3	(5) Short-chain
3	Perfluorohexanoic Acid	PFHxA	307-24-4	(6) Short-chain
4	Perfluoroheptanoic Acid	PFHpA	375-85-9	(7) Short-chain
5	Perfluorooctanoic Acid	PFOA	335-67-1	(8) Long-chain
6	Perfluorononanoic Acid	PFNA	375-95-1	(9) Long-chain
7	Perfluorodecanoic Acid	PFDA	335-76-2	(10) Long-chain
8	Perfluoroundecanoic Acid	PFUnDA	2058-94-8	(11) Long-chain
9	Perfluorododecanoic Acid	PFDoDA	307-55-1	(12) Long-chain
10	Perfluorotridecanoic Acid	PFTrDA	72629-94-8	(13) Long-chain
11	Perfluorotetradecanoic Acid	PFTeDA	376-06-7	(14) Long-chain
Perfluoroalkane sulfonic acids (PFSAs)				
12	Perfluorobutane Sulfonic acid	PFBS	375-73-5	(4) Short-chain
13	Perfluoropentanesulfonic acid	PFPeS	2706-91-4	(5) Short-chain
14	Perfluorohexane Sulfonic acid	PFHxS	355-46-4	(6) Long-chain
15	Perfluoroheptane Sulfonic acid	PFHpS	375-92-8	(7) Long-chain
16	Perfluorooctane Sulfonic acid	PFOS	1763-23-1	(8) Long-chain
17	Perfluorononanesulfonic acid	PFNS	68259-12-1	(9) Long-chain
18	Perfluorodecane Sulfonic acid	PFDS	335-77-3	(10) Long-chain
Precursors to PFOS				
19	Perfluorooctane sulfonamide[1]	FOSA	754-91-6	(8) Long-chain
20	N-methylperfluorooctanesulfonamidoacetic acid[2]	MeFOSAA	2355-31-9	(8) Long-chain
21	N-ethylperfluorooctanesulfonamidoacetic acid[3]	EtFOSAA	2991-50-6	(8) Long-chain
Precursors to PFCA Family				
22	4:2 Fluorotelomer Sulfonic Acid[4]	4:2 FTS	757124-72-4	(6) Short-chain
23	6:2 Fluorotelomer sulfonic acid[4]	6:2 FTSA	27619-97-2	(8) Long-chain
24	8:2 Fluorotelomer sulfonic acid[4]	8:2 FTSA	39108-34-4	(10) Long-chain
PFAS Replacement Chemistry				
25	Hexafluoropropylene Oxide Dimer Acid	HFPO-DA	13252-13-6	(6) Short-chain
26	4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	(7) Short-chain
27	9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	F53B Minor	756426-58-1	(8) Long-chain
28	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	F53B Major	763051-92-9	(10) Long-chain

MI Study - Detection Frequency



https://www.michigan.gov/documents/egle/wrd-pfas-initiatives-statewide-full-report_722902_7.pdf

Final Michigan Treated Solids PFOS Concentrations



PFAS Source Control – Michigan Case Study

2,000 PFAS industrial effluent samples
574 industrial facilities
PFAS sources identified

Examples of Industrial Effluent PFOS Concentrations

Industry/Category/Type	# Sampled	% Detection	PFOS Range (ng/L)
Metal Finishing	212	33 %	0.7 – 240,000
Electroplating	44	66 %	0.4 – 50,000
Centralized Waste Treaters	17	86%	1 – 53,000
AFFF-Contaminated Sewers	5	100%	5 – 45,000
Type II Sanitary Landfills	48	94%	6 – 5,000
Type III Sanitary Landfills	7	57%	4 – 4,000
Pulp, Paper and Paperboard	4	100%	2 – 190
Commercial Industrial Laundry Facilities	12	42%	6 – 69

https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/IPP/pfas-initiatives-statewide-full-report.pdf?rev=6cd77ab93ff441faaa43fc5e9dc3e09a

PFAS Source Reduction – Michigan

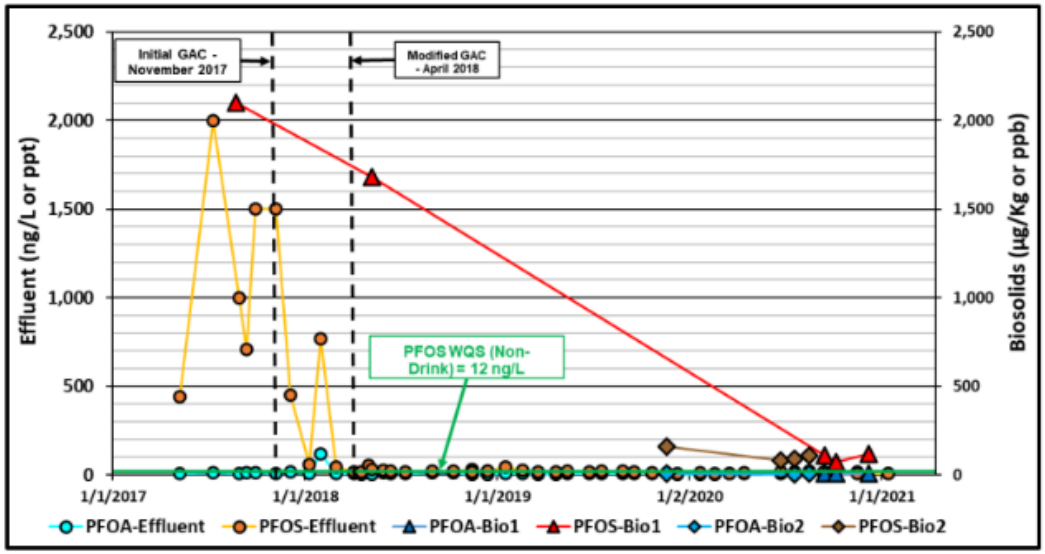
Example of Effectiveness of Source Reduction Strategies with Industrial Discharges to the System Resulting in PFOS Decreases over Time

Table 9. Substantial PFOS Reduction at WWTPs with Exceedances

Municipal WWTP	Recent PFOS, Effluent* (ng/L)	PFOS Reduction (highest to most recent)	Actions Taken to Reduce PFOS
Bronson WWTP	5	99%	Treatment (GAC) at source (1)
Howell WWTP	5	96%	Treatment (GAC/Resin) at source (1)
Ionia WWTP	<6	99%	Treatment (GAC) at source (1)
Kalamazoo WWTP	5	90%	Treatment (GAC) at source (2), change of water supply
KI Sawyer WWTP	9	96%	Eliminated leak of AFFF
Lapeer WWTP	8.2	99%	Treatment (GAC) at source (1)
Wixom WWTP	34	99%	Treatment (GAC) at source (1)

*Data received as of December 31, 2020

Figure 12. Temporal PFOA and PFOS Effluent and Biosolids Concentrations in Lapeer WWTP



https://www.michigan.gov/documents/egle/wrd-PFAS-Biosolids-Strategy_720326_7.pdf

Michigan's Interim Strategy to Land Application of Biosolids Containing PFAS

Tier 3: PFOS ≥ 125 µg/kg

- Cannot be land applied
- Investigate potential sources to develop a source reduction program

Tier 2: PFOS ≥ 50 µg/kg & < 125 µg/kg

- Investigate potential sources to develop a source reduction program
- Reduce land application rates to no more than 1.5 dry tons per acre (or submit an alternative risk mitigation strategy)

Tier 1: PFOS > 20 µg /kg & < 50 µg/kg

- Consider investigating sources and sampling the WWTP effluent for PFAS

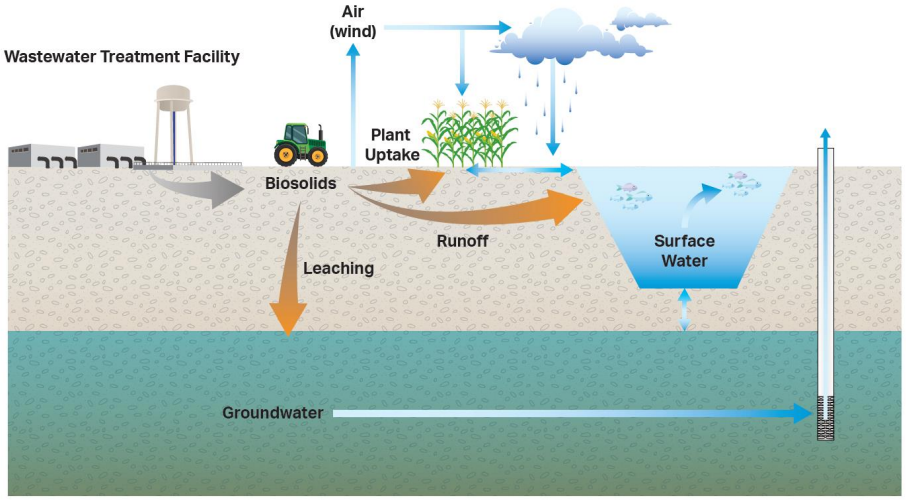
15

EGLE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

LAND APPLICATION OF BIOSOLIDS CONTAINING PFAS

Interim Strategy

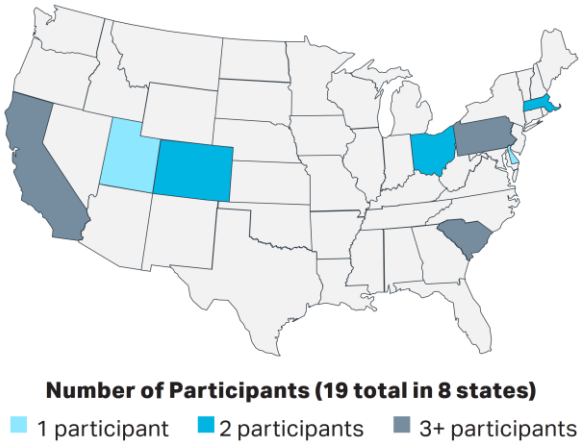
Updated April 2022



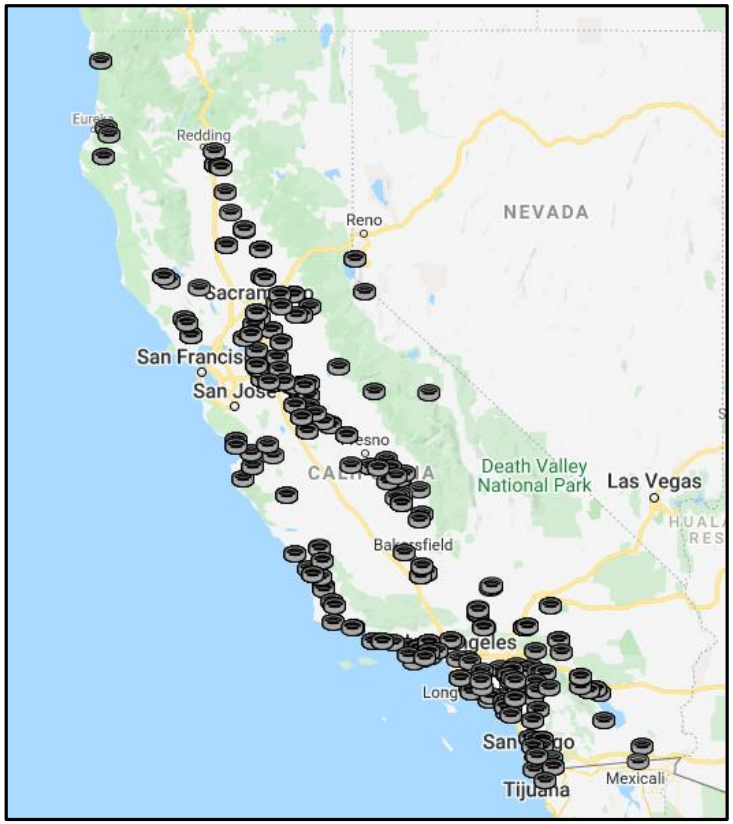
https://www.michigan.gov/documents/egle/wrd-PFAS-Biosolids-Strategy_720326_7.pdf

Michigan, AECOM, and California Studies

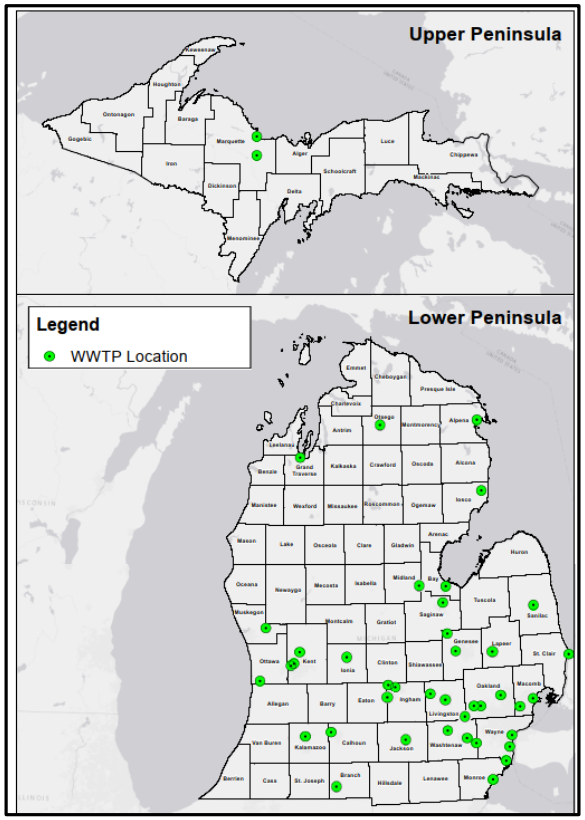
- **AECOM Study – 2021**
  - 19 WWTPs
- **California Study – 2021 (Q1,Q2, and Q3)**
  - 180 WWTPs
  - 1 MGD dry weather design
- **Michigan Study - 2018**
  - 42 WWTP
  - 20 largest (10-930 MGD)
  - 22 various treatment processes (0.2-9 MGD)



California WWTPs



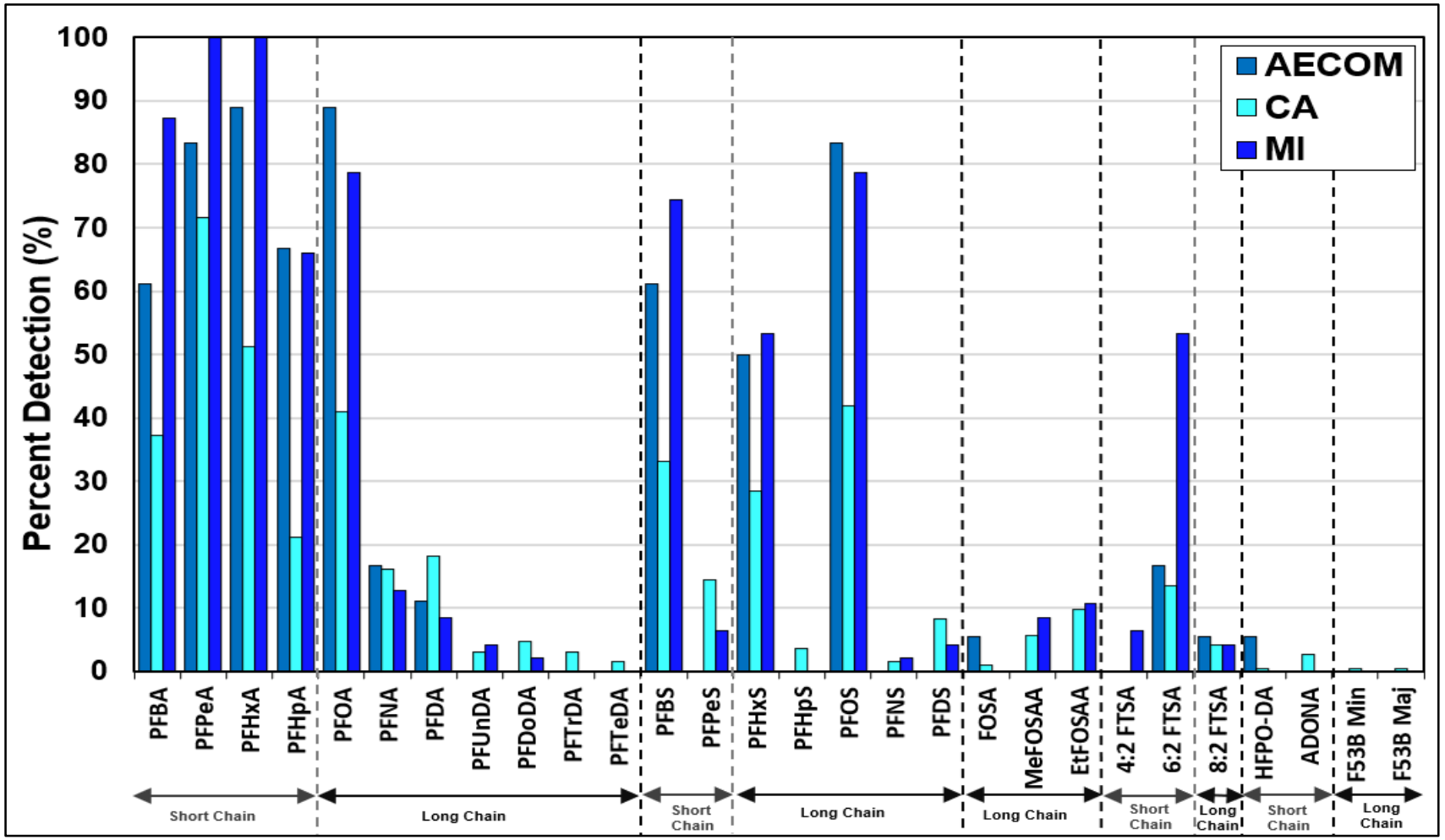
Michigan WWTPs



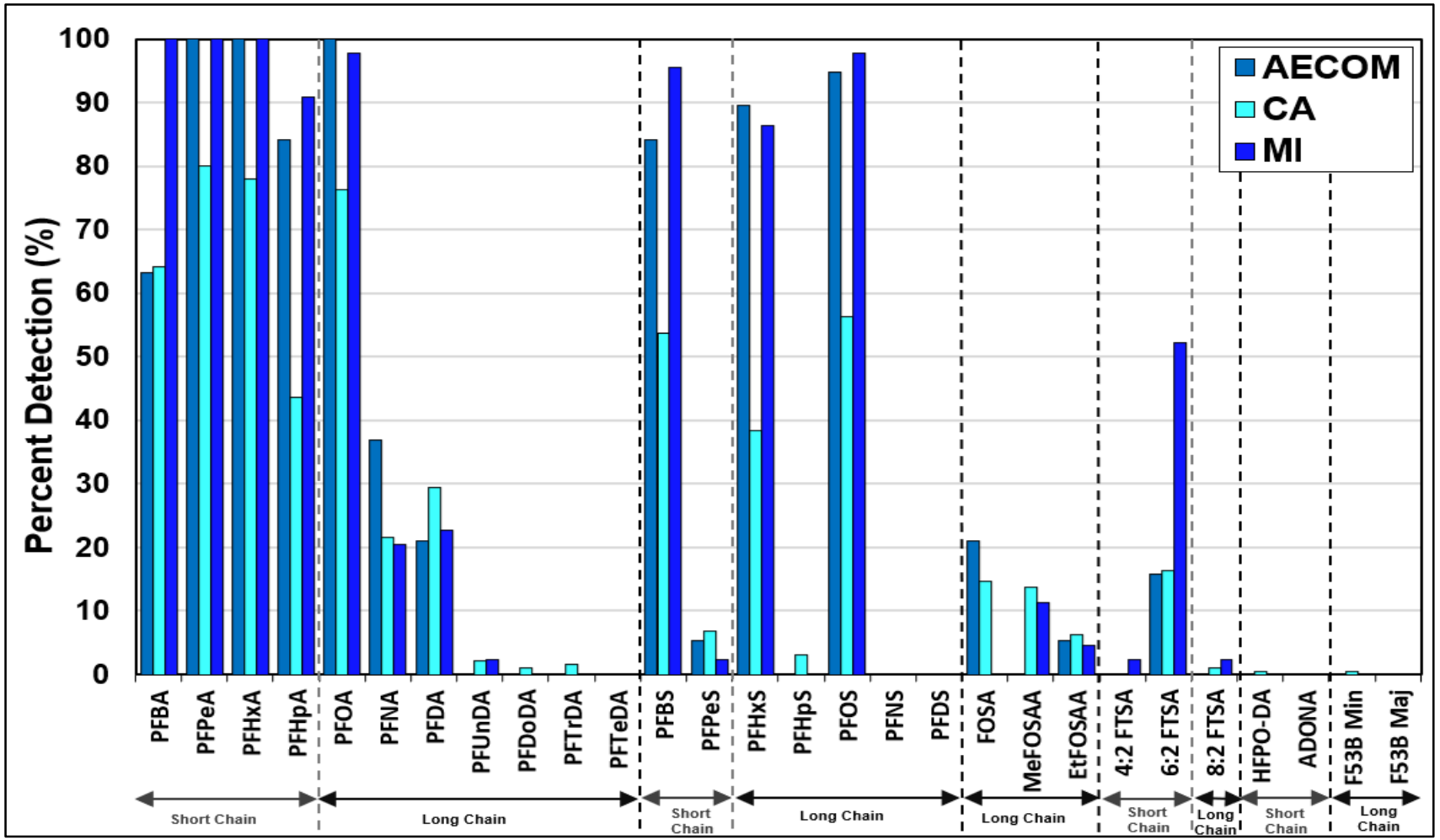
https://www.michigan.gov/documents/egle/wrd-pfas-initiatives-statewide-full-report_722902_7.pdf

https://www.waterboards.ca.gov/pfas/

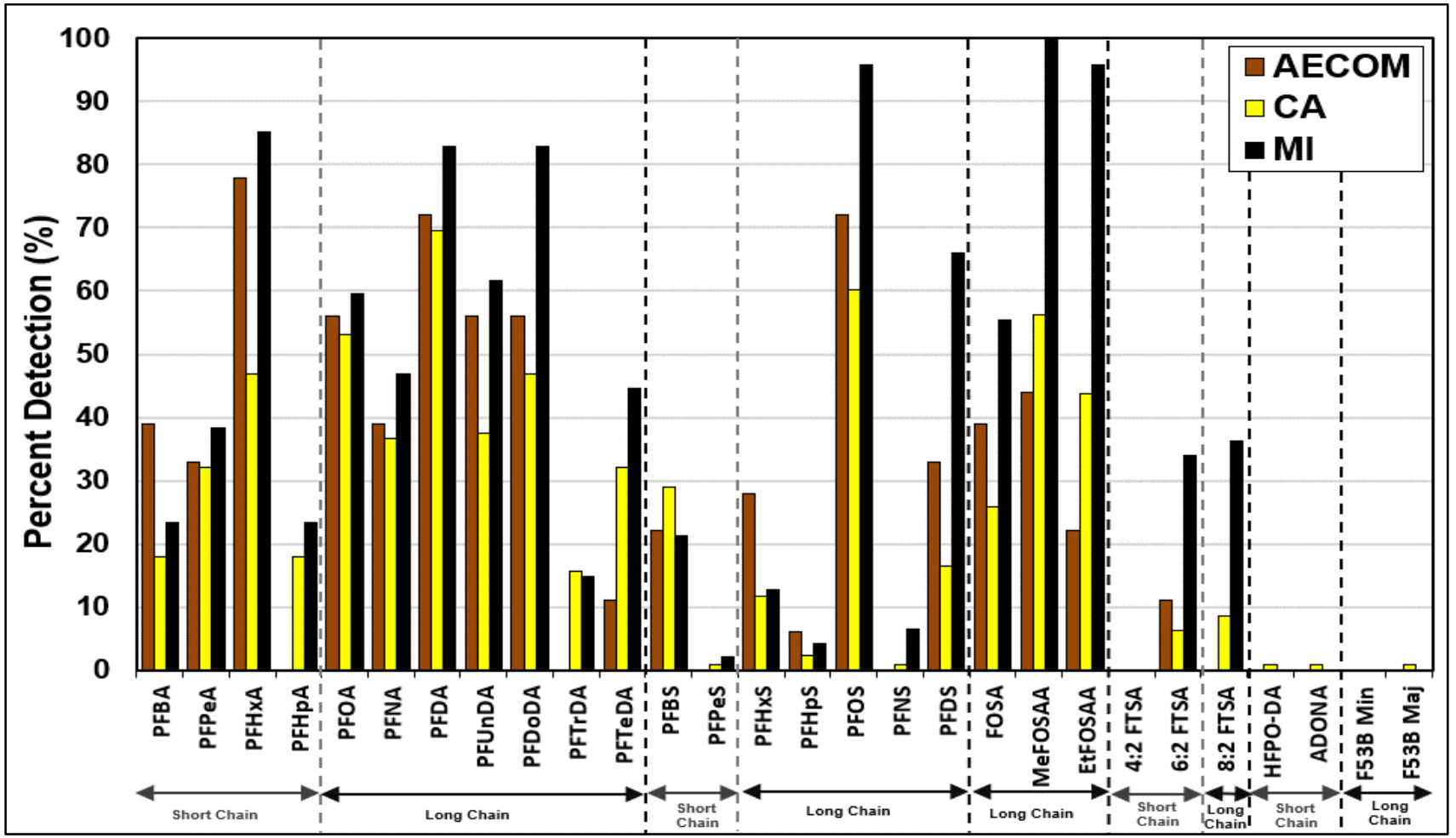
PFAS Influent Percent Detection - All 3 Studies



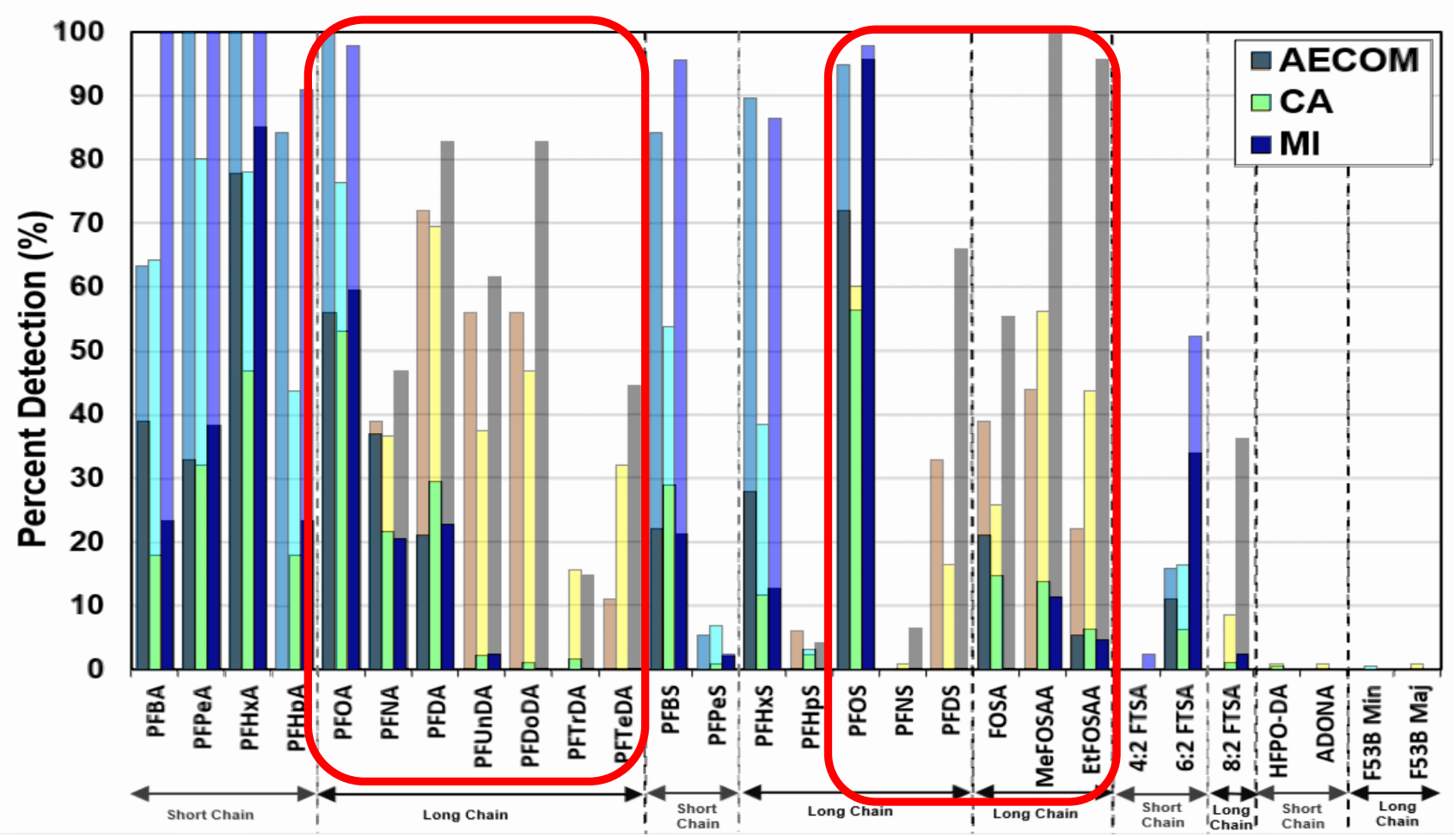
PFAS Effluent Percent Detection - All 3 Studies



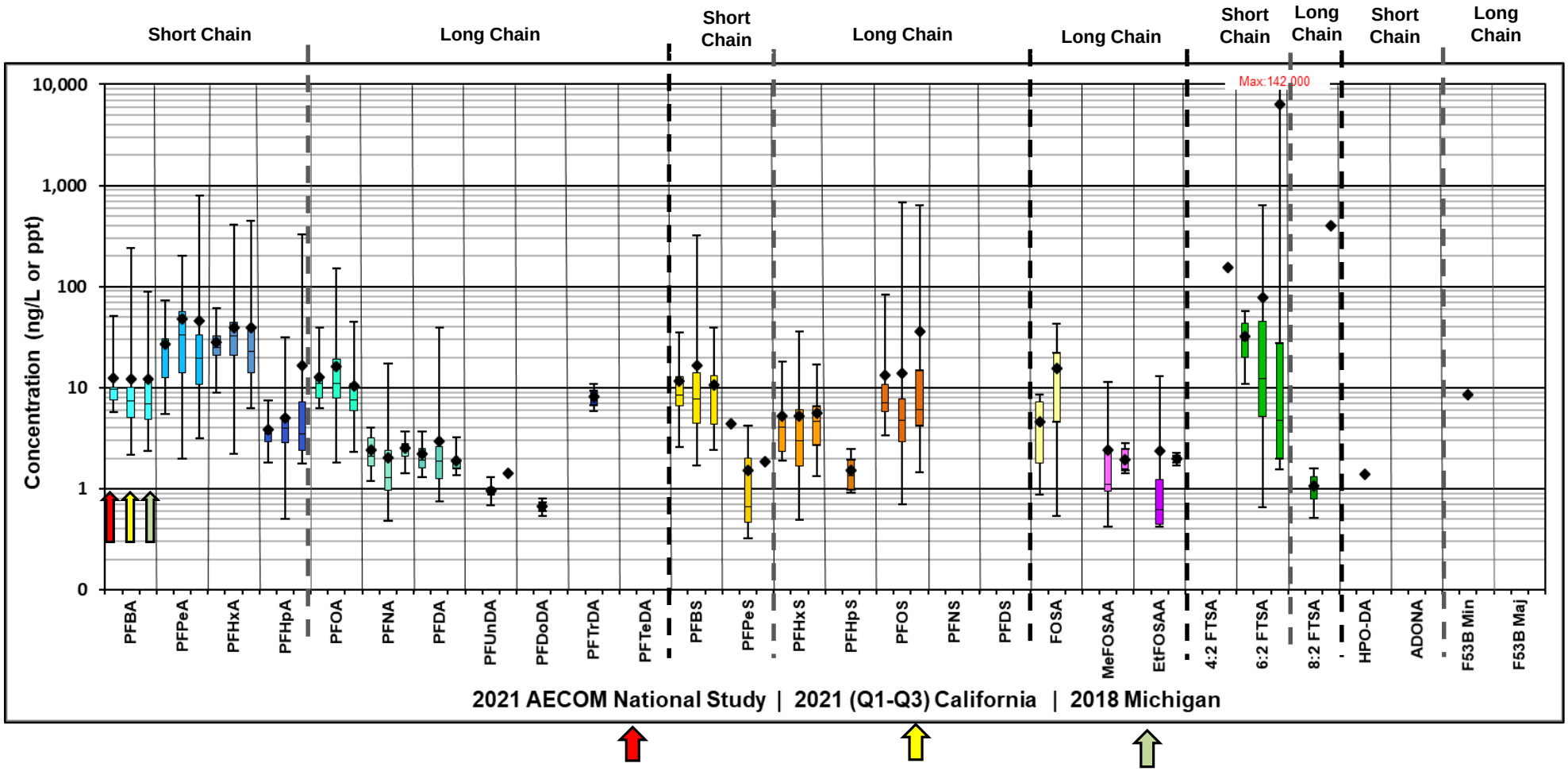
PFAS Final Treated Solids Percent Detection - All 3 Studies



PFAS Effluent & Final Treated Solids Percent Detection - All 3 Studies



Effluent PFAS Concentrations – All 3 Studies



PFAS Concentrations in the Aqueous Process Flow

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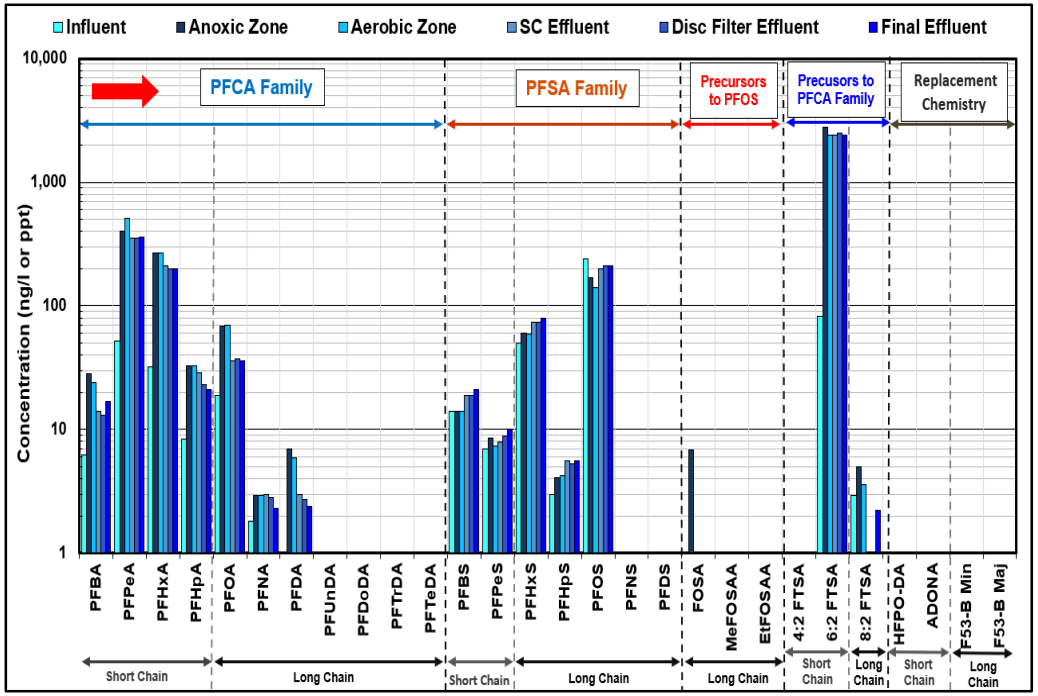
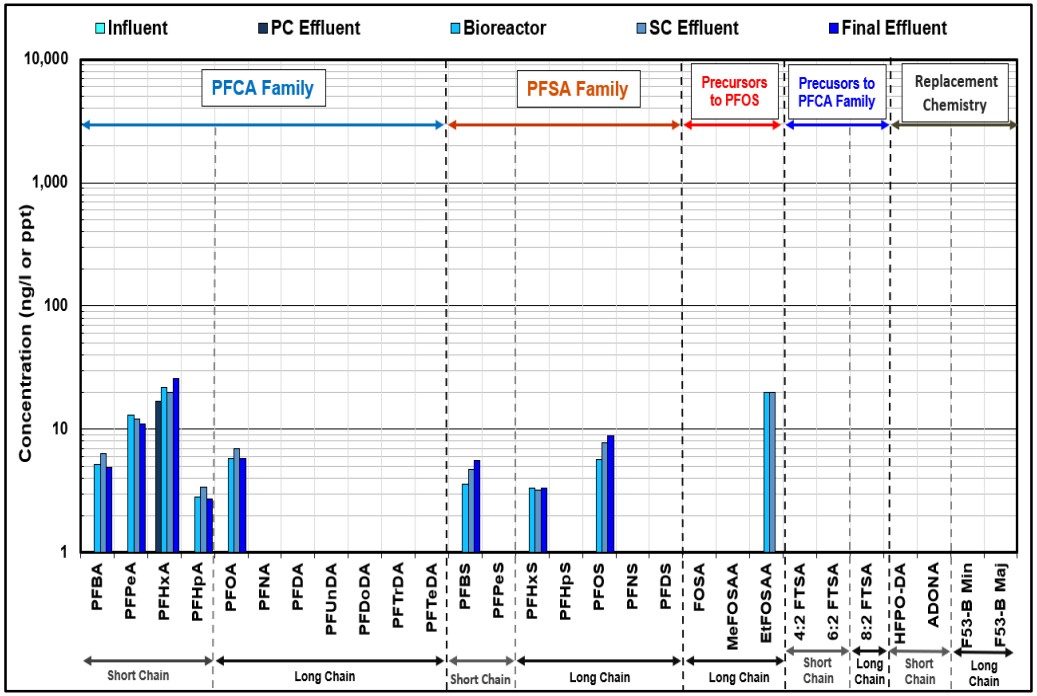
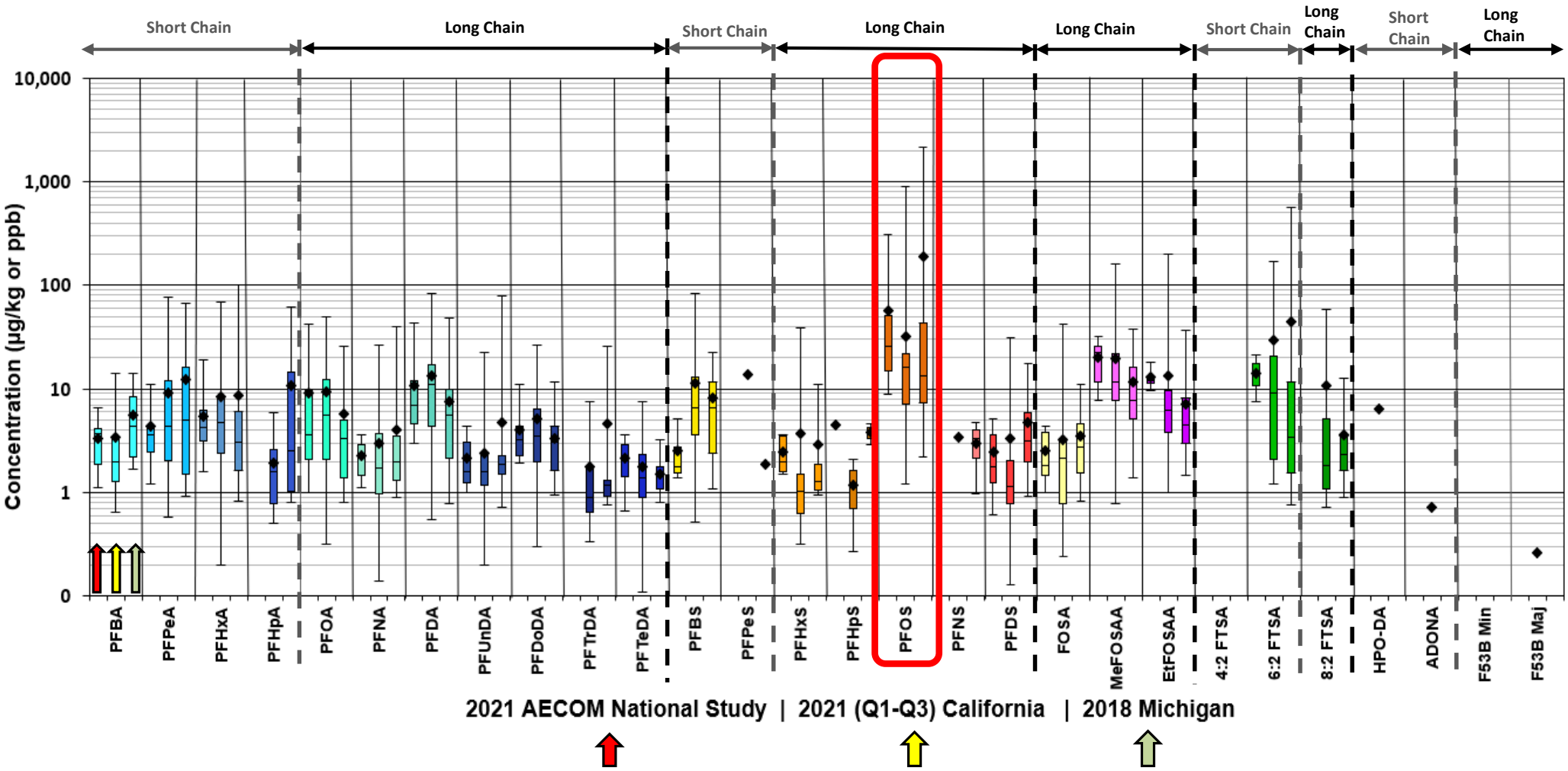
Low Flow with Industrial Impact



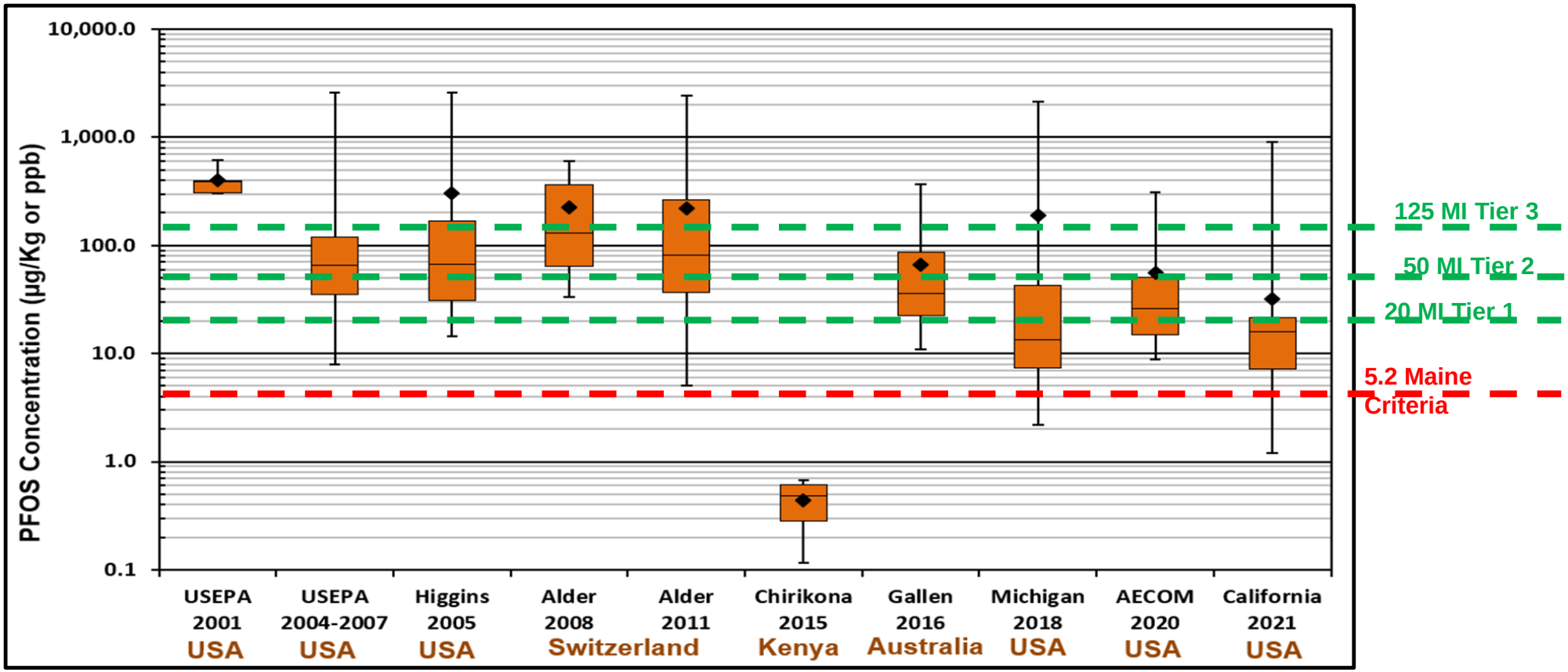
High Flow with Industrial Impact



Final Treated Solids PFAS Concentrations – All 3 Studies



Final Treated Solids PFOS Concentrations - Multiple Published Studies



Michigan Agricultural Fields Study

- **Agricultural fields (22)**
  - Associated with 8 WWTPs
  - 11 field – lower impacts / 11 fields - higher impacts
  - Soil, surface water, and groundwater sampling
  - Biosolids PFOS concentrations
  - Dates of land application
  - Application rate (dT/acre)

https://www.michigan.gov/egle/0,9429,7-135-3313_71618_3682_3683_3721-531869--,00.html

Migration Pathways for PFAS in Land-Applied Biosolids

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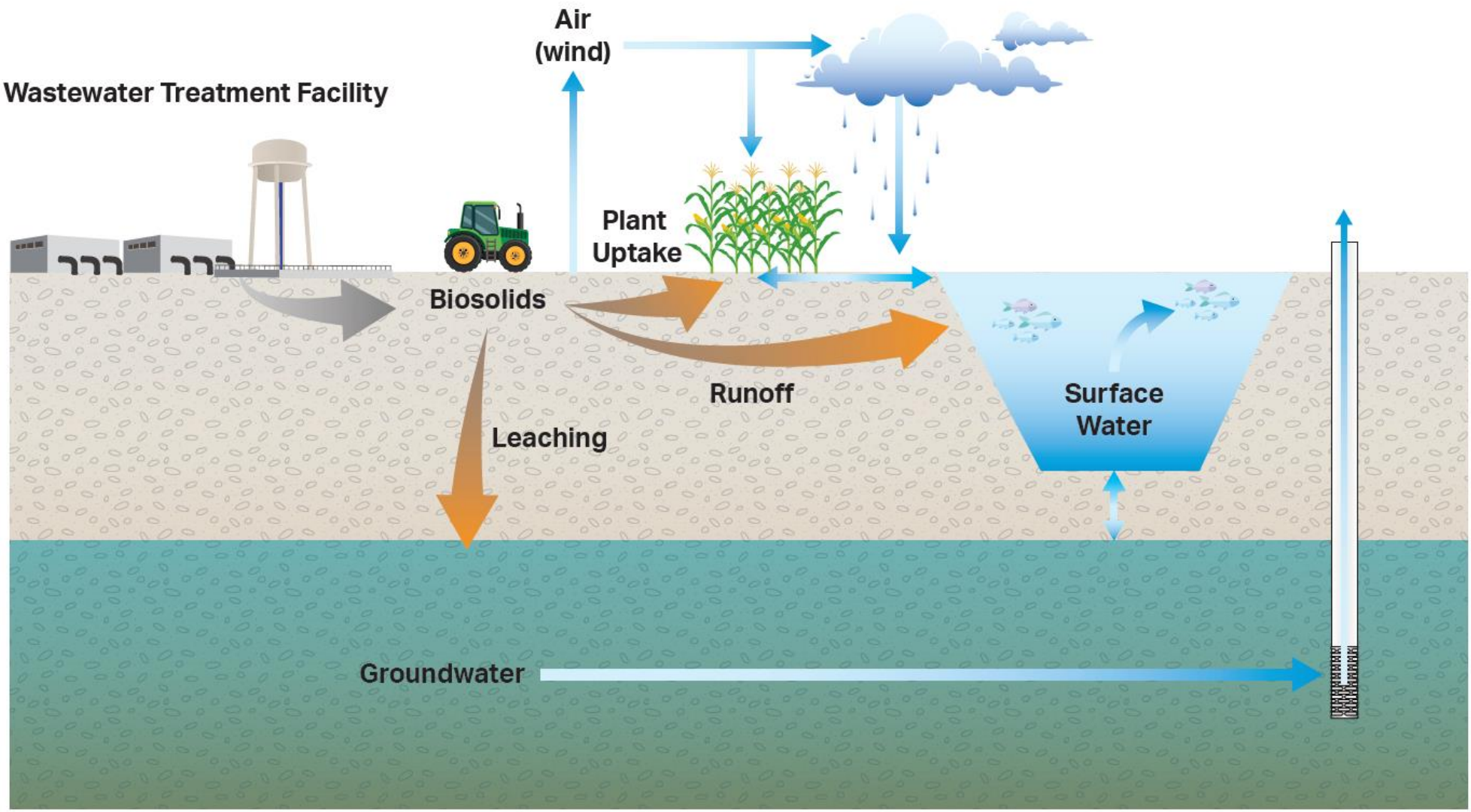

Example of Agricultural Field Evaluated

Agricultural Field Summary Results

Biosolids Application Rates	Lower Impacted WWTPs	Higher Impacted WWTPs
Total land-applied biosolids – (dry tons - dT)	176 - 400	39 - 1,422
Average dT/Acre	2 - 10	1 - 4
Weighted Use Ratio (Total dT/Site Acres)	6 - 23	4 - 28

		Lower Impacted WWTPs			Higher Impacted WWTPs		
	Environmental Matrices	**Total PFAS**	**PFOS**	**PFOA**	**Total PFAS**	**PFOS**	**PFOA**
WWTPs	Effluent (ng/L)	4 - 15	2 - 5	2 - 11	300 - 143,360	169 - 635	ND - 10
	Biosolids (µg/Kg)	34 - 214	3 - 90	ND - 18	1,173 - 2,358	1,060 - 2,150	ND - 5
AG Fields	Soil (µg/Kg)	ND - 15	ND - 9	ND - 2	1 - 182	1 - 172	ND - 2
	Groundwater[2] (ng/L)	ND - 97	ND - 2	ND - 6	ND - 541[1]	ND - 18[1]	ND - 61[1]
	Surface Water[2] (ng/L)	ND - 52	ND - 5	ND - 6	2.5 - 2,647	ND - 2,060	ND - 64
	Tile Drain[2] (ng/L)	ND - 58	ND	ND - 6	9 - 2,495	1 - 2,080	ND - 95
	Ponded Water[2] (ng/L)	6 - 346	ND - 2	ND - 53	17 - 968	ND - 533	2 - 53

[1]Perched groundwater at one location had Total PFAS = 41,823 ng/L, PFOS = 35,300 ng/L, and PFOA = 1,930 ng/L.

[2]Groundwater, surface water, tile drain, and ponded water samples were not collected in every agricultural field.

https://www.michigan.gov/documents/egle/wrd-pfas-initiatives_691391_7.pdf

Biosolids Management - Alternatives to Land Application or Landfilling

What do you do if you cannot land apply or landfill biosolids?

Technologies available or in development

- Incineration
- Alternative combustion / Pyrolysis / Gasification
- Supercritical water oxidation
- Hydrothermal liquefaction

Data are still limited but more information is coming soon

Take Away Points

- **PFAS were detected in all sampled WWTPs**
- **Short-chain PFAS: tendency to remain in liquid**
- **Long-chain PFAS: higher affinity to the biosolids and can limit beneficial reuse**
- **Industrial influence on PFAS load most frequently evident in smaller facilities**
- **PFOS is likely to be the primary driver in the final effluent and beneficial reuse**
  - Integrate strategies now (source controls, master planning)
- **In US, EPA strategic roadmap identifies upcoming considerations for wastewater utilities**

PFAS

IDENTIFY. RESOLVE.

AECOM Delivering a better world

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PFAS Lead, Water
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