BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

In the Matter of:	)	
	)	R 2022-018
PROPOSED AMENDMENTS TO	)	
GROUNDWATER QUALITY	)	(Rulemaking – Public Water Supply)
(35 ILL. ADM. CODE 620)	)	

NOTICE OF FILING

To: ALL PARTIES ON THE SERVICE LIST

PLEASE TAKE NOTICE that I have today electronically filed with the Office of the Clerk of the Illinois Pollution Control Board, the **TESTIMONY OF THOMAS A. HILBERT ON BEHALF OF NATIONAL WASTE & RECYCLING ASSOCIATION**, copies of which are hereby served upon you.

Dated: September 15, 2022

By /s/ Claire A. Manning

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TESTIMONY OF THOMAS A. HILBERT ON BEHALF OF NATIONAL WASTE & RECYCLING ASSOCIATION

I. Introduction

I am providing this testimony on behalf of the National Waste and Recycling Association (NWRA) – Illinois Chapter. NWRA has created an Illinois workgroup, which I chair, to review and provide comments and testimony on behalf of the waste and recycling businesses in Illinois regarding the proposed updates to Title 35 IAC Part 620 groundwater regulations. The NWRA – Illinois Chapter represents companies that manage the waste products that are generated by businesses and residents in the State of Illinois. This testimony focuses on the proposed updates that add groundwater standards for PFAS (per and polyfluorinated alkyl substances), as well as other proposed revisions to the regulations. NWRA-Illinois Chapter prepared a power-point presentation for its members, which is summarized in our Pre-Filed Testimony. We would be happy to present this information to the Board at its hearings in December. See Attachment A.

My name is Thomas A. Hilbert. I am presently a Regional Engineering Manager for Waste Connections. Waste Connections is the third largest integrated waste services company in North America with a network of operations in 41 states and 6 Canadian provinces. We are full-service provider of solid waste collection, providing non-hazardous solid waste collection, recycling and landfill disposal services to commercial, industrial, municipal and residential customers. I have 30 years of experience in environmental management and hold a B.Sc. degree in Geophysics from

Western Washington University and a M. Sc. in Civil/Environmental Engineering from the University of Arizona. I hold Prior Conduct Certification and am a certified manager of landfill operations by the State of Illinois.

We appreciate the opportunity to present this information to the Illinois Pollution Control Board (IPCB) in this rulemaking and the continued opportunity to work with the Illinois Environmental Protection Agency (IEPA) to ensure that Illinois groundwater quality standards are protective of the health of citizens residing and conducting business in Illinois.

PFAS have properties that make them useful in an incredible variety of applications and have been in use since the 1950's. PFAS have been used in coatings for textiles, paper products, and cookware and to formulate some firefighting foams, and have a range of applications in the aerospace, photographic imaging, semiconductor, automotive, construction, electronics, and aviation industries. Therefore, they have become ubiquitous and widely distributed throughout society and subsequently in the environment. It is widely understood that PFAS have potential health risks and we support the IEPA's efforts to establish appropriate groundwater quality standards for certain PFAS chemicals. However, the current rule proposal is problematic in that it fails to consider or address the expected serious economic and disruptive impact that the proposed new standards for PFAS, at the levels proposed, will have on other regulatory frameworks under Title 35 of the Illinois Administrative Code: Environmental Protection.

II. The IEPA has not provided a comprehensive analysis of the feasibility or the economic impacts of the proposed changes to the Part 620 rules.

The addition of PFAS constituents at the levels in the proposed rule will have currently undefined impacts on multiple other regulatory programs. Without a structured review of the impacts the proposed changes have on other regulatory programs, individuals, businesses and units of local government will be left without a practical or economic alternative to comply with the other regulatory programs.

The Part 811 municipal solid waste landfill regulatory framework currently has both a design standard and a performance standard. The performance standard requires a groundwater impact assessment ("GIA") which requires groundwater transport modeling of a hypothetical leak in the landfill containment system to assess whether there is a potential for a constituent of the landfill leachate to reach the landfill's groundwater compliance boundary. This is a standard that every landfill in the state must pass prior to the IEPA granting an operating permit – and this requirement is specific to Illinois. We know of no other state that requires this GIA analysis and the GIA regulations are not federally required or federally driven.

The GIA is highly sensitive to the concentration difference between the modeled leachate constituent and the applicable groundwater quality standard. It is also sensitive to the attenuation properties of the modeled constituent. Constituents with low attenuation, such as PFAS, will travel farther without any degradation in concentration. The groundwater standard concentrations proposed for PFOA and PFOS are at levels that are up to 1000 times higher than the typical leachate concentrations. Very few if any MSW landfills in Illinois will be able to pass a GIA model at the currently proposed PFAS groundwater quality standards without the implementation of extremely expensive and unnecessary design standards or the implementation of difficult to achieve contingent remediation plans with associated costly new financial assurance requirements. To be clear, the GIA is a modeling exercise. Our point here is that it will not be reflective of actual risks to the environment for a landfill that meets the Subtitle D design standards. Yet, as the regulations currently require, it must be performed prior to achieving a permit.

Further, every Illinois MSW landfill must review and update the GIA every 5 years when it applies for the renewal of its landfill operating permit. Without some change in the GIA regulatory process, we believe that to achieve the very conservative PFAS limits proposed every existing permitted landfill will be required to go through an overly expensive permitting process and added financial assurance costs, without any analysis or consideration of whether any environmental benefits will be achieved by such added burdens.

While we appreciate and support standards to protect public sources of drinking water, no evaluation has been made by the State of Illinois as to whether the costly and burdensome requirements that will flow from the proposed rule, given the current intertwined relationship between Part 620 and other regulatory programs, will achieve associated environmental benefits. The IEPA's justification simply assumes that all people will drink all groundwater and that all tested groundwater – regardless of how proximate it is to actual potable water sources or whether it will realistically impact such potable water sources – would be subject to the very conservative proposed potable water standards.

Additionally, NWRA Illinois is concerned that many false readings will occur during the monitoring process, since many of the components of MSW landfill groundwater monitoring system contain Teflon or similar PFAS containing plastics or other components. This will likely require every Illinois landfill to replace existing groundwater monitoring system components with non PFAS containing components to avoid the potential for exceeding the proposed groundwater quality standards for PFAS.

The proposed Part 620 rules also remove the definition of the "Practical Quantitation Limit" but it will remain as the referenced standard in Part 811, and the IEPA has not indicated when or how it intends to propose changes to Part 811. A review of the impacts of the proposed

Part 620 rules on other regulatory programs will eliminate conflicting definitions within the Title 35 of the Illinois Administrative Code, and consideration should be made to the workability of these new definitions in the context of those other regulatory programs prior to moving to adopt this proposed rule. We believe that the significant changes proposed here cannot be made in a vacuum and, to a large extent, that is what this rule proposal does.

The above is a simple review of the direct impacts that the proposed Part 620 regulations would have upon the Part 811 regulatory framework which were not adequately addressed with the proposed revisions. We understand that the 620 rules have been amended in the past without requiring a comprehensive review on the other regulatory programs. However, prior groundwater rulemakings have been relatively simple additions of constituents and not at the levels proposed for the six proposed PFAS standards and not with new and different analytical laboratory testing protocols also being proposed. The addition of new constituents at a standard that is 1000 lower than any existing standard adds complexities that must be given additional consideration. Similarly, although not as significant, the establishment of conflicting definitions with Title 35 of the Illinois Administrative code will cause confusion when those definitions are used as part of routine regulatory compliance.

Even more important is the fact that the interrelation between various regulatory frameworks under Title 35 of the Illinois Administrative Code creates significant challenges to regulatory compliance and reasonably achievable disposal options – each important to businesses and local government alike in Illinois. Most landfills rely on Publicly Owned Treatment Works (“POTW”) facilities for leachate management. In turn, POTWs increasingly rely on landfills for biosolids management and disposal of PFAS-laden media. Efforts to address PFAS in groundwater must avoid disrupting this interdependence among essential public services to communities. When POTWs refuse to accept landfill leachate, which is beginning to happen, there is a significant economic impact on the landfill which threatens the landfill’s ability to maintain compliance with the leachate removal requirements of the Part 811 rules until they can find an alternative disposal option for the leachate or construct a pretreatment facility to comply with the POTW’s influent standards. However, removing PFAS from landfill leachate requires advanced treatment techniques which are prohibitively expensive.

Estimated capital costs to implement leachate pretreatment at a moderate-sized landfill to the extent necessary to reduce PFAS to the levels proposed, should such reductions even be feasible, range from $2 million to $7 million. Multiplying this cost across all Illinois landfills would have an economic impact on the landfill industry alone, currently estimated at several hundred million dollars.

Further, the proposed PFAS standards in the Part 620 rules will create chaos in relation to the existing practice of application and disposal of biosolids from POTWs – and must be considered in the context of this rulemaking. There is significant potential that liability concerns will lead POTWs to stop the practice of land application. Disposal of biosolids at MSW landfills, which is currently a routine practice, could also be potentially affected by the proposed groundwater rules. If POTW’s are already refusing acceptance of landfill leachate over concerns regarding the presence of low levels of PFAS in leachate it is logical that the landfill would refuse to accept biosolids to eliminate potential sources of PFAS in the waste stream accepted at the landfill to limit the liability and cost associated with managing PFAS containing waste streams. Even if a landfill decided they were willing to accept the added cost and liability of accepting biosolids with PFAS, there is the very likelihood that landfills will reach a limit on the ability to accept biosolids due to the higher moisture content of biosolids to MSW materials.

There are many other interrelated impacts, impacts which have not been investigated or analyzed, that will be driven by the proposed rules. Simply assuming, without understanding how, the impacts on other regulatory frameworks will get sorted out after the groundwater quality standards are established is not acceptable. The potential economic and legal liabilities will be disruptive and harmful to businesses and units of local governments across Illinois – and must be understood in the context of developing an appropriate groundwater protection standard.

III. There has not been a statewide assessment of the occurrence and concentration of PFAS in Illinois groundwater or other media.

Without understanding background levels of PFAS in groundwater there is uncertainty as to the impacts that the proposed rule will have on the regulated community. It is accepted that PFAS are ubiquitous and widely dispersed in the environment. As recently as 2018, greater than 90% of the US population had a mean blood serum concentration for PFOA and PFOS of 1.4 ug/l and 4.3 ug/l respectively which is nearly 1000 times greater than the proposed groundwater standards. It is clear that human exposure and presence in the environment is widespread. PFAS are found in agricultural products that are applied to farmland, they are transported by air and dispersed in rainfall. Therefore, without widespread background data there is no certainty that the proposed groundwater standards will not be exceeded in numerous locations throughout the state which has the potential to create a quagmire of compliance, liability, and legal concerns, since at the proposed concentration standards there will likely be no well-defined source. Thus, it is imperative that the proposed standard be workable in all contexts in which it will be applied, not just in the context of potable water safe for human consumption.

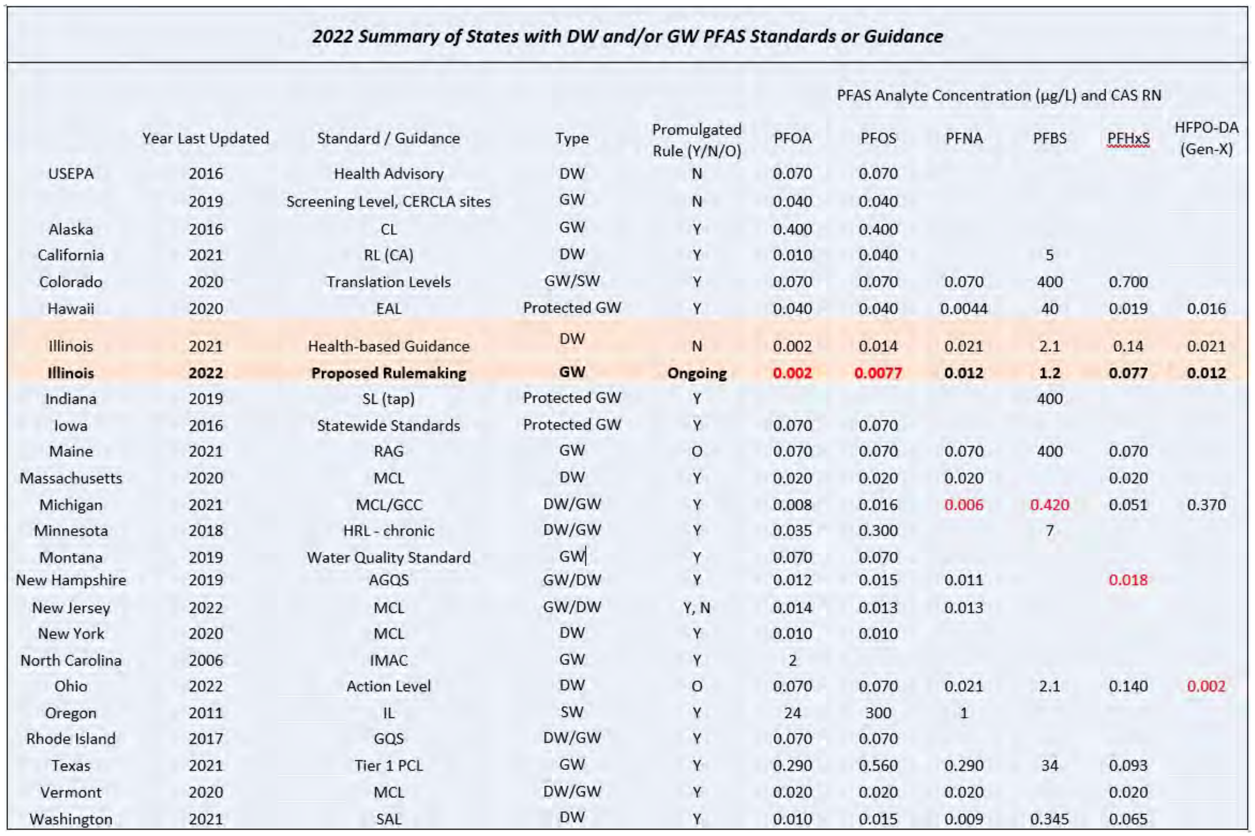
IEPA has performed a review of PFAS concentrations in municipal drinking water supplies. Drinking water samples were collected from 1,428 different community water supply locations throughout Illinois for 18 PFAS compounds. From that sample database there were 68 locations which exceeded the minimum reporting level of 2 ng/l (parts per trillion) in approximately 4.8% of the sampled locations. The vast majority of public exposure to PFAS from a water supply source will be through drinking water supplied in a community water supply system. Therefore, it would be more appropriate for the state to focus on establishing a maximum contaminant level ("MCL") for community water supplies under Part 611 - Primary Drinking Water Standards. The feasibility and economic impacts of establishing MCL's for PFAS are more easily defined since the state has already determined the number of community water supply systems that would be required to install a treatment system. Focusing on establishing an MCL under the primary drinking water standards is more protective of public health since it would eliminate the largest exposure pathway to the public.

IV. The only approved USEPA analytical method for non-drinking water media does not have a Lower Limit of Quantitation or Method Detection Limit that can meet the proposed groundwater quality standard for PFOA and PFOS.

The USEPA does not have an approved multi-lab validated analytical method that can detect PFOA and PFOS at the proposed groundwater quality standards. The USEPA has proposed a draft method 1633 specifically for PFAS compounds but it has not yet been finalized. The draft method 1633 does have a single lab verified that has a reported Method Detection Limit ("MDL") that is right at the 2 ng/l standard proposed for PFOA. There is no guarantee that once finalized through a multi-lab validated process that the MDL for method 1633 will be at or below the proposed groundwater standard for PFOA. Even if method 1633 is finalized with a MDL of 2 ng/l it will have been established by using controlled samples with rigorously controlled laboratory procedures. The variable nature of field samples and the real-world laboratory procedures in a high-volume analytical laboratory will likely result in a high number of sample analytical reports that will have a reporting limit that is above the MDL. Putting the regulated entities in a situation in which there is a high probability that they will not be able to reliably provide an analytical report that can demonstrate compliance with the groundwater water quality standard will cause unnecessary compliance issues not related to actual environmental protection and is simply not reasonable.

V. Illinois is proposing the lowest standard for PFOA and PFOS of all the states that have established water quality standards for PFAS compounds.

Illinois is proposing the lowest groundwater quality standard for PFOA and PFOS than any other of the states that have established a groundwater quality or advisory standards for PFAS compounds. The wide variation in state standards for PFAS is largely due to the current lack of a well-defined and accepted toxicological profile for PFAS. Human epidemiological and toxicology studies are ongoing and as of the date of this filing the USEPA has not finalized its toxicity values to be used for determining MCL's for any of the proposed PFAS in this rulemaking. The lack of a defined standard for developing an MCL is clearly evident in the wide variation in state groundwater and drinking water quality standards. Proposing groundwater quality standards prior to the establishment of final toxicity assessments only creates confusion and uncertainty in the regulated community. The USEPA is in the process of developing federal MCL's for PFOA and PFOS and has indicated that an initial draft would be published in late 2022 with anticipated finalization in 2023. Illinois should wait for the USEPA's final determination of appropriate toxicity values for the proposed PFAS standards prior to establishing separate and potentially conflicting standards. Meanwhile, Illinois could be developing a more comprehensive and workable strategy to regulate and control PFAS.



2022 Summary of States with DW and/or GW PFAS Standards or Guidance

					PFAS Analyte Concentration (µg/L) and CAS RN					
	Year Last Updated	Standard / Guidance	Type	Promulgated Rule (Y/N/O)	PFOA	PFOS	PFNA	PFBS	PFHxS	HFPO-DA (Gen-X)
USEPA	2016	Health Advisory	DW	N	0.070	0.070				
	2019	Screening Level, CERCLA sites	GW	N	0.040	0.040				
Alaska	2016	CL	GW	Y	0.400	0.400				
California	2021	RL (CA)	DW	Y	0.010	0.040		5		
Colorado	2020	Translation Levels	GW/SW	Y	0.070	0.070	0.070	400	0.700	
Hawaii	2020	EAL	Protected GW	Y	0.040	0.040	0.0044	40	0.019	0.016
Illinois	2021	Health-based Guidance	DW	N	0.002	0.014	0.021	2.1	0.14	0.021
Illinois	**2022**	**Proposed Rulemaking**	**GW**	**Ongoing**	**0.002**	**0.0077**	**0.012**	**1.2**	**0.077**	**0.012**
Indiana	2019	SL (tap)	Protected GW	Y				400		
Iowa	2016	Statewide Standards	Protected GW	Y	0.070	0.070				
Maine	2021	RAG	GW	O	0.070	0.070	0.070	400	0.070	
Massachusetts	2020	MCL	DW	Y	0.020	0.020	0.020		0.020	
Michigan	2021	MCL/GCC	DW/GW	Y	0.008	0.016	0.006	0.420	0.051	0.370
Minnesota	2018	HRL - chronic	DW/GW	Y	0.035	0.300		7		
Montana	2019	Water Quality Standard	GW	Y	0.070	0.070				
New Hampshire	2019	AGQS	GW/DW	Y	0.012	0.015	0.011		0.018	
New Jersey	2022	MCL	GW/DW	Y, N	0.014	0.013	0.013			
New York	2020	MCL	DW	Y	0.010	0.010				
North Carolina	2006	IMAC	GW	Y	2					
Ohio	2022	Action Level	DW	O	0.070	0.070	0.021	2.1	0.140	0.002
Oregon	2011	IL	SW	Y	24	300	1			
Rhode Island	2017	GQS	DW/GW	Y	0.070	0.070				
Texas	2021	Tier 1 PCL	GW	Y	0.290	0.560	0.290	34	0.093	
Vermont	2020	MCL	DW/GW	Y	0.020	0.020	0.020		0.020	
Washington	2021	SAL	DW	Y	0.010	0.015	0.009	0.345	0.065	

VI. Concluding Statement.

We understand and support the States' efforts to establish appropriate standards for PFAS, and we appreciate the Board's responsibility to protect the public health and safety of Illinois citizens. However, we feel strongly that IEPA is acting prematurely in proposing such conservative PFAS groundwater quality standards as the State's first step – without addressing the significant ramifications that will result, and without considering whether the cost of those ramifications exceed the environmental benefit. The concerns regarding PFAS are extremely complicated since these compounds are contained in products that have been used for years and have become integrated into all aspects of our society and consequently into the environment. A recent University Wisconsin-Madison review showed that 70% of the rainwater sampling sites had detectable levels of PFOA at up to 3 ng/l (median < 1 ng/l) which is higher than the proposed standard in this rulemaking. It is simply not reasonable to develop a groundwater quality standard that is potentially lower than what is found in rainfall concentrations. Further, prior to moving forward with this rule, the regulated community and the Board must be assured of its feasibility and have a clear understanding of its costs. To date, the IEPA has not addressed either. We need a much more thorough understanding of how the proposed standards will interact between the various regulatory programs under Title 35 of the Illinois Administrative Code prior to adopting PFAS into the Part 620 rules at the levels currently proposed. In conclusion, while we would wholly support the Board's adoption of an MCL for PFAS, we would ask that the Board stay this particular rule proposal until more information is available and presented.

This concludes my testimony.

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In the Matter of:)
) R 2022-018
PROPOSED AMENDMENTS TO)
GROUNDWATER QUALITY) (Rulemaking – Public Water Supply)
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REFERENCES

Characterization of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Landfill Leachate and Preliminary Evaluation of Leachate Treatment Processes	Exhibit 1
American Water Works Association letter to the Congressional Budget Office – August 8, 2019	Exhibit 2
National Waste and Recycling Association and Solid Waste Association of North America letter to US Senate Committee on Environment and Public Works regarding proposal to list PFOA and PFOS as CERCLA hazardous substances – May 10, 2022	Exhibit 3
National Waste and Recycling Association letter to US Office of Information & Regulatory Affairs regarding follow up on CERCLA – February 8, 2022	Exhibit 4
PFAS Deposition in Precipitation: Efficacy of the NADP-NTN & Initial Findings – Jan 16, 2020	Exhibit 5
PFAS in the US population	Exhibit 6

CERTIFICATE OF SERVICE

I, the undersigned, certify that on this 15th day of September 2022, I electronically served the **TESTIMONY OF THOMAS A. HILBERT ON BEHALF OF NATIONAL WASTE & RECYCLING ASSOCIATION** upon the individuals on the attached service list. I further certify that my email address is cmanning@bhslaw.com.

Dated: September 15, 2022

By /s/ Claire A. Manning

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ILLINOIS GROUNDWATER QUALITY REGULATORY CHANGES
Addition of PFAS – Review and Status

Discussion Outline

- **Per- and Polyfluoroalkyl Substances (PFAS) -** The Basics – What, Where, and Why Worry
- **Revisions to Title 35 IAC 620 -** What are the significant changes
- **Comparison to Other States and Federal Updates -** How does IL compare and What is the USEPA doing
- **Summary of Impacts to the Landfill Industry -** Operational Risks and Economic Impacts
- **Summary and Review of Rulemaking Process -** Outline of Rulemaking Process, Schedule, and Who is involved

ATTACHMENT A

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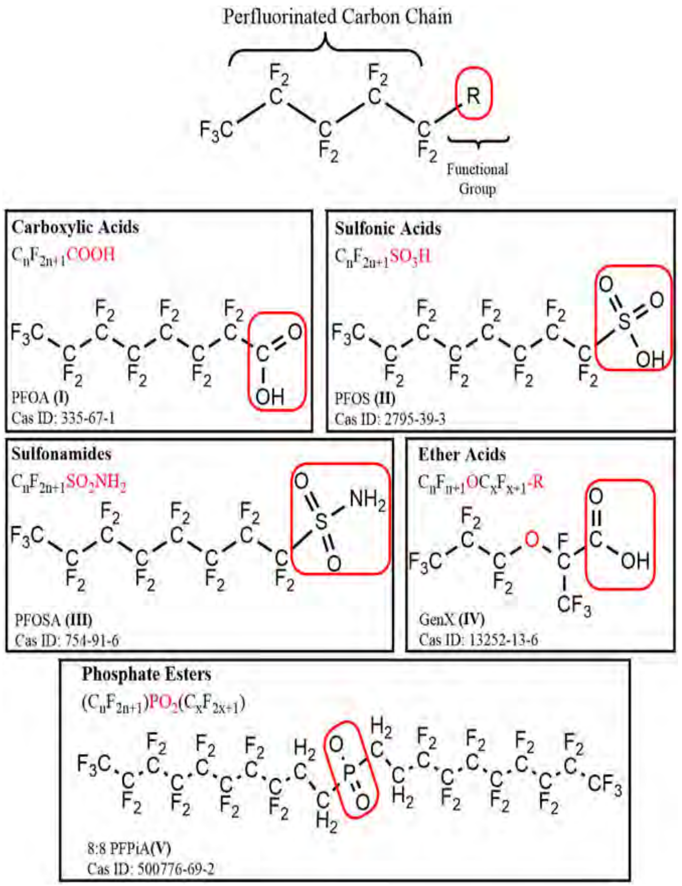
What and Where Are Per- and Polyfluoroalkyl Substances (PFAS)

PFAS	Source of PFAS
Long-Chains (C8)	
Perfluorooctanoic acid (PFOA)	Nonstick Surfaces
Perfluorooctane sulfonate (PFOS)	Fabric Protection, Firefighting Foam
Perfluorononanoic acid (PFNA)	Surfactant for Plastic Production
Short-Chains (C6)	
Perfluorohexane Sulfonic Acid (PFHxS)	Firefighting Foam
Perfluorohexanoic Acid (PFHxA)	Degradation Product of PFHxS
Perfluorobutyrate Acid (PFBA)	Photographic Film



- Polyfluoroakyl (PolyfluoroTelemers) - Pre-Cursor Compounds to Perfluoroalkyl Acids

ATTACHMENT A

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Why are PFAS a Concern?

- Environmentally Persistent – Half lives measured in decades
- Ubiquitous – clothing, food, paint, health care, manufacturing, etc. and not limited to a well regulated source
- Health Concern – See Below

Animal Studies

- ✓Cancer/tumors (testicular, liver, pancreatic)
- ✓Reproductive
- ✓Developmental
- ✓Immunological
- ✓Endocrine (thyroid)
- ✓Hematological
- ✓Neurobehavioral
- ✓Liver
- ✓Kidney

Human (potential associations)

- ✓Cancer (testicular, kidney)
- ✓Reproductive
- ✓Developmental (decreased birth weight)
- ✓Immunological (decreased immune/vaccine response)
- ✓Thyroid effects
- ✓Metabolic (increased cholesterol, uric acid)
- ✓Liver (liver enzymes)

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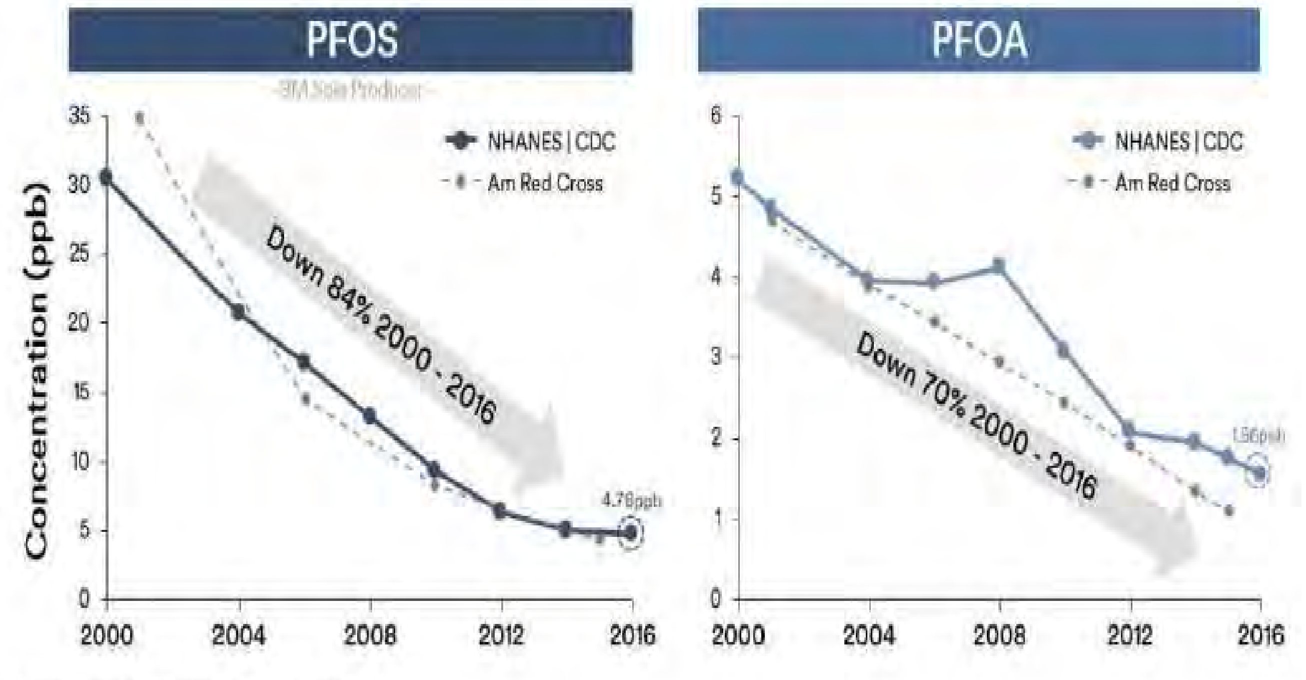
PFOA and PFOS Levels in the Blood of the General Population on Decline

Trends of PFOS and PFOA Serum Concentrations in US General Population



Source: Olsen et al. 2017 Environ Res 157 87-95; NHANES 2018

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Title 35 IAC 620 Proposed New Constituents and MCLs

The amendments propose the addition of 10 chemicals:

CONSTITUENT	Class I (ug/L)	Class II (ug/L)
•Aluminum	1900	none
•Lithium	40	2500
•1-Methylnaphthalene	270	270
•Molybdenum	19	50
•Perfluorobutane Sulfonic Acid (PFBS)	1.2	1.2
•Perfluorohexane Sulfonic Acid (PFHxS)	0.077	0.077
•Perfluorononanoic Acid (PFNA)	0.012	0.012
•Perfluorooctanoic Acid (PFOA)	0.002	0.002
•Perfluorooctane Sulfonic Acid (PFOS)	0.0077	0.0077
•Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	0.012	0.012

- The Proposed Rule Also Eliminates the Definition of Practical Quantitation Limit (PQL)

ATTACHMENT A

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Major USEPA Actions

- **May 2016: Drinking Water Health Advisories Issued for PFOS and PFOA (70 ppt)**
- December 2019: Interim Groundwater Cleanup Levels for PFOS/PFOA for CERCLA and RCRA Corrective Action
- March 2020: SDWA Preliminary Regulatory Determination for PFOA/PFOS
- **May 2020: EPA Final Rule adding 172 PFAS compounds to Toxic Release Inventory**
- June 2020: TSCA Significant New Use Rule for PFAS
- **November 2020: Interim Strategy for PFAS in NPDES Permits**
- December 2020: Interim Guidance on Destroying and Disposing of Certain PFAS and PFAS Containing Materials That Are Not Consumer Products
- January 2021: ANPRM - Addressing PFOA and PFOS in the Environment: Potential Future Regulation Pursuant to CERCLA and RCRA (Advance notice of proposed rulemaking)
- January 2021: PFBS Toxicity Assessment (withdrawn February 9, 2021), re-issued April 8, 2021
- **June 2021: Began rule development for designating PFAS/PFOA as CERCLA hazardous substances**
- **October 2021: PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024**
- **October 2021: Initiate process to add 4 PFAS chemicals as RCRA hazardous constituents**
- December 2021: Expanded PFAS monitoring in drinking water 2023-2025 (UCMR 29 PFAS compounds)

ATTACHMENT A

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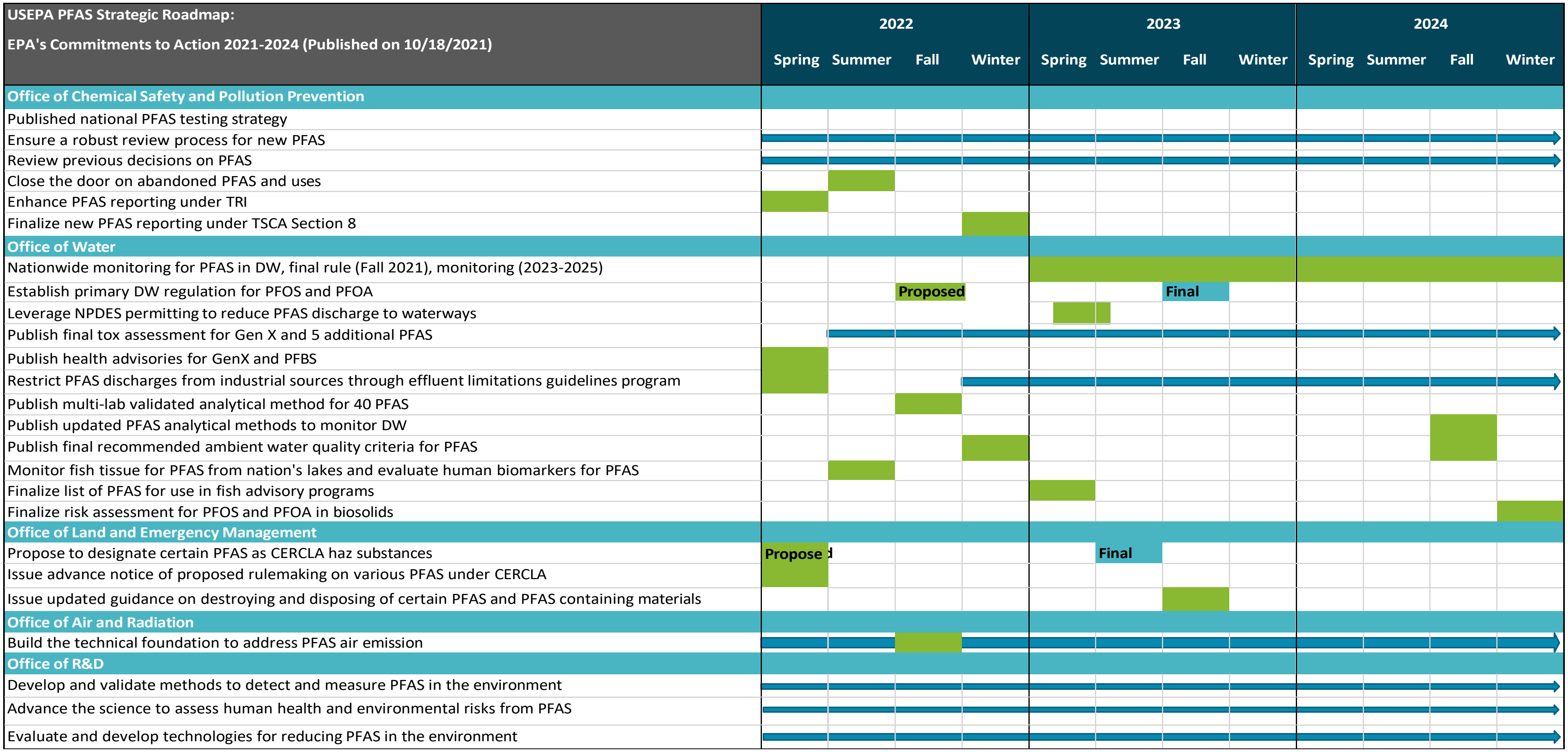
USEPA PFAS Strategic Roadmap 2021-2024



USEPA PFAS Strategic Roadmap: **EPA's Commitments to Action 2021-2024 (Published on 10/18/2021)**	**2022**				**2023**				**2024**			
	Spring	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
Office of Chemical Safety and Pollution Prevention												
Published national PFAS testing strategy												
Ensure a robust review process for new PFAS	→	→	→	→	→	→	→	→	→	→	→	→
Review previous decisions on PFAS	→	→	→	→	→	→	→	→	→	→	→	→
Close the door on abandoned PFAS and uses		🟩										
Enhance PFAS reporting under TRI	🟩											
Finalize new PFAS reporting under TSCA Section 8				🟩								
Office of Water												
Nationwide monitoring for PFAS in DW, final rule (Fall 2021), monitoring (2023-2025)					🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Establish primary DW regulation for PFOS and PFOA			Proposed				Final					
Leverage NPDES permitting to reduce PFAS discharge to waterways					🟩	🟩						
Publish final tox assessment for Gen X and 5 additional PFAS		→	→	→	→	→	→	→	→	→	→	→
Publish health advisories for GenX and PFBS	🟩											
Restrict PFAS discharges from industrial sources through effluent limitations guidelines program	🟩			→	→	→	→	→	→	→	→	→
Publish multi-lab validated analytical method for 40 PFAS			🟩									
Publish updated PFAS analytical methods to monitor DW											🟩	
Publish final recommended ambient water quality criteria for PFAS				🟩							🟩	
Monitor fish tissue for PFAS from nation's lakes and evaluate human biomarkers for PFAS		🟩										
Finalize list of PFAS for use in fish advisory programs					🟩							
Finalize risk assessment for PFOS and PFOA in biosolids												🟩
Office of Land and Emergency Management												
Propose to designate certain PFAS as CERCLA haz substances	Proposed					Final						
Issue advance notice of proposed rulemaking on various PFAS under CERCLA	🟩											
Issue updated guidance on destroying and disposing of certain PFAS and PFAS containing materials							🟩					
Office of Air and Radiation												
Build the technical foundation to address PFAS air emission	→	→	🟩	→	→	→	→	→	→	→	→	→
Office of R&D												
Develop and validate methods to detect and measure PFAS in the environment	→	→	→	→	→	→	→	→	→	→	→	→
Advance the science to assess human health and environmental risks from PFAS	→	→	→	→	→	→	→	→	→	→	→	→
Evaluate and develop technologies for reducing PFAS in the environment	→	→	→	→	→	→	→	→	→	→	→	→

ATTACHMENT A

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2022 Summary of States With DW and/or GW PFAS Standards or Guidance - 22

					PFAS Analyte Concentration (µg/L) and CAS RN					
	Year Last Updated	Standard / Guidance	Type	Promulgated Rule (Y/N/O)	PFOA	PFOS	PFNA	PFBS	PFHxS	HFPO-DA (Gen-X)
USEPA	2016	Health Advisory	DW	N	0.070	0.070				
	2019	Screening Level, CERCLA sites	GW	N	0.040	0.040				
Alaska	2016	CL	GW	Y	0.400	0.400				
California	2021	RL (CA)	DW	Y	0.010	0.040		5		
Colorado	2020	Translation Levels	GW/SW	Y	0.070	0.070	0.070	400	0.700	
Hawaii	2020	EAL	Protected GW	Y	0.040	0.040	0.0044	40	0.019	0.016
Illinois	2021	Health-based Guidance	DW	N	0.002	0.014	0.021	2.1	0.14	0.021
Illinois	**2022**	**Proposed Rulemaking**	**GW**	**Ongoing**	**0.002**	**0.0077**	**0.012**	**1.2**	**0.077**	**0.012**
Indiana	2019	SL (tap)	Protected GW	Y				400		
Iowa	2016	Statewide Standards	Protected GW	Y	0.070	0.070				
Maine	2021	RAG	GW	O	0.070	0.070	0.070	400	0.070	
Massachusetts	2020	MCL	DW	Y	0.020	0.020	0.020		0.020	
Michigan	2021	MCL/GCC	DW/GW	Y	0.008	0.016	0.006	0.420	0.051	0.370
Minnesota	2018	HRL - chronic	DW/GW	Y	0.035	0.300		7		
Montana	2019	Water Quality Standard	GW	Y	0.070	0.070				
New Hampshire	2019	AGQS	GW/DW	Y	0.012	0.015	0.011		0.018	
New Jersey	2022	MCL	GW/DW	Y, N	0.014	0.013	0.013			
New York	2020	MCL	DW	Y	0.010	0.010				
North Carolina	2006	IMAC	GW	Y	2					
Ohio	2022	Action Level	DW	O	0.070	0.070	0.021	2.1	0.140	0.002
Oregon	2011	IL	SW	Y	24	300	1			
Rhode Island	2017	GQS	DW/GW	Y	0.070	0.070				
Texas	2021	Tier 1 PCL	GW	Y	0.290	0.560	0.290	34	0.093	
Vermont	2020	MCL	DW/GW	Y	0.020	0.020	0.020		0.020	
Washington	2021	SAL	DW	Y	0.010	0.015	0.009	0.345	0.065	

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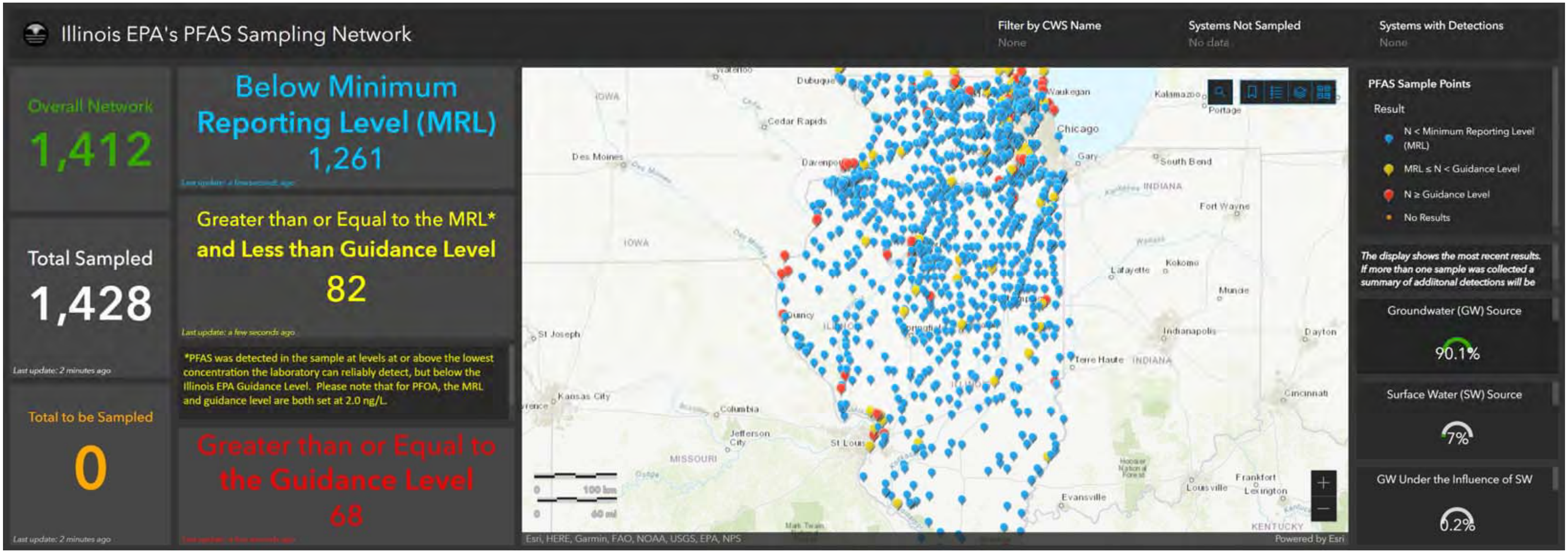
Illinois EPA PFAS Statewide Community Water Supply Sampling

- Sampled 1,428 systems for 18 PFAS compounds
- Issued statewide Health Advisories for six PFAS compounds based on results



Illinois EPA's PFAS Sampling Network

Filter by CWS Name
None

Systems Not Sampled
No data

Systems with Detections
None

Overall Network
1,412

Total Sampled
1,428
Last update: 2 minutes ago

Total to be Sampled
0
Last update: 2 minutes ago

Below Minimum Reporting Level (MRL)
1,261
Last update: a few seconds ago

Greater than or Equal to the MRL* and Less than Guidance Level
82
Last update: a few seconds ago

*PFAS was detected in the sample at levels at or above the lowest concentration the laboratory can reliably detect, but below the Illinois EPA Guidance Level. Please note that for PFOA, the MRL and guidance level are both set at 2.0 ng/L.

Greater than or Equal to the Guidance Level
68
Last update: a few seconds ago

PFAS Sample Points
Result
- N < Minimum Reporting Level (MRL)
- MRL ≤ N < Guidance Level
- N ≥ Guidance Level
- No Results

The display shows the most recent results. If more than one sample was collected a summary of addiitonal detections will be

Groundwater (GW) Source
90.1%

Surface Water (SW) Source
7%

GW Under the Influence of SW
0.2%

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OPERATIONAL AND ECONOMIC IMPACTS TO LANDFILLS AND OTHER INDUSTRY

IMPLEMENTATION OF PFAS STANDARDS TO 35 IAC PART 620 WILL REQUIRE THE FOLLOWING:

1. **Determination of background concentrations or AGQSs/MAPCs**
   a. **Multiple sampling events for multiple upgradient wells**
   b. **Sampling of wells with intrawell values**
   c. **Appropriate laboratory methods**
   d. **Limited laboratories capable of appropriate testing methods**
2. **Validation of detections in background wells**
   a. **Cross contamination from well materials, pumps, tubing, other sampling equipment**
   b. **Potential resampling**
3. **Calculation of background concentrations/AGQSs/MAPCs**

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4. **Leachate analyses**
    - a. **Cross contamination**
    - b. **Matrix interferences**
    - c. **Validation issues**
    - d. **Other ramifications include source concentrations for the GIA**
5. **Groundwater Impact Assessment**
    - a. **To be evaluated during the first permit renewal after approval**
    - b. **Ultra conservative approach to model parameters not required by other states or environmentally justified**
6. **Contingent remediation plan**
    - a. **Predicted failure of Groundwater Impact Assessment**
    - b. **Must be designed with cost included in financial assurance**

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10. Leachate Disposal and Treatment

a. **POTWs refusal to receive leachate – THIS IS A SIGNIFICANT RISK – The USEPA is developing Effluent Limit Guidance**

b. **Landfills refusal to accept POTW sludge**

c. **Potential Need for onsite pre-treatment facilities**

d. **What will surface water discharge limits be?**

e. **How will antidegradation assessments be impacted (discharge process permitting process)**

11. Impacts to Other Regulations with Potential Impacts to Landfills

a. **Site Remediation Program (SRP)**

b. **Tiered Approach to Corrective Action Objectives (TACO)**

c. **Clean Construction or Demolition Debris Fill Operation (CCDD)**

d. **IDOT – significant influx of contaminated soils typically suitable for a CCDD site**

ATTACHMENT A

Characterization of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Landfill Leachate and Preliminary Evaluation of Leachate Treatment Processes

(FINAL)

Submitted October 31, 2019
(updated December 11, 2019)

Authors

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Report # 11960

EXHIBIT 1

PROJECT TITLE: Characterization of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Landfill Leachate and Preliminary Evaluation of Leachate Treatment Processes

PRINCIPAL INVESTIGATOR: Helena Solo-Gabriele, Professor
AFFILIATION: University of Miami, Dept. of Civil, Arch., & Environ. Engineering
CONTACT INFORMATION: hmsolo@miami.edu, 305-284-3467

PROJECT WEBSITE: http://www.coe.miami.edu/hmsolo/?page_id=769.

PROJECT DURATION: September 1, 2017 to August 31, 2019

ABSTRACT: Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are fluorine-containing chemicals that are found in many products that are stick and stain resistant. The most studied of the PFAS are perfluorooctanoic acid (PFOA) which is used to make Teflon, and perfluorooctane sulfonate (PFOS), a breakdown product of a common water resistant chemical known as Scotchgard. Although used widely, only recently have their human health impacts been recognized. Studies have linked PFOA and PFOS to thyroid and liver diseases, diseases of the immune system, and cancer. Due to their wide ranging usage in consumer products, landfills represent a logical end-of-life reservoir for PFAS. The objectives of this study are to evaluate the concentrations of PFAS in leachates from Florida landfills and to assess the capacity of current treatments to remove PFAS from leachate. Leachate samples will be collected from landfills in the State of Florida and from the effluent of leachate treatment facilities. These samples are to be analyzed with LC-MS/MS for PFAS. Data on leachate volumes and treatment data will be consolidated for landfills in the State of Florida. From this literature information coupled with leachate measurements, a preliminary assessment will be made about the effectiveness of existing leachate treatment strategies in reducing PFOA and PFOS levels. In an effort to broadly assess the health risks associated with the PFAS, results from leachate measurements will be compared to the U.S. Environmental Protection Agency's PFAS health advisory of 0.07 parts per billion. Results can be used by regulators to assess whether treatment systems are needed to remove PFAS from landfill leachates in Florida.

Key words: Perfluoroalkyl and polyfluoroalkyl substances (PFAS), leachate, landfills, PFOS, PFOA.

METRICS REPORTING

This page will be omitted from the report when it is published.

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Metrics:

1. Research publications from this Hinkley Center Project.
   - Helena Solo-Gabriele, Athena Jones, Hekai Zhang, Johnsie Lang, 2019. Perfluoroalkyl substances in landfill leachates produced from different waste types. Abstracts from the American Chemical Society Spring 2019 National Meeting & Expo, Orlando, FL, April 2019. https://tpa.acs.org/abstract/acsnm257-3110261/perfluoroalkyl-substances-in-landfill-leachates-produced-from-different-waste-types
   - Solo-Gabriele, H.M., Jones, A.S., Lindstrom, A.B., Lang, J.R., 20XX. Per- and polyfluoroalkyl Substances in Landfill Leachates Produced from Different Waste Types. In review.

2. Research presentations resulting from this Hinkley Center Project.
   - "Characterization of Per- and Poly-fluoroalkyl Substances (PFAS) in Landfill Leachate and Preliminary Evaluation of Leachate Treatment Processes." Hinkley Center for Solid and Hazardous Waste Management Advisory Board Meeting, Orlando, Florida, September 28, 2018. (Speaker presentation by H. Solo-Gabriele)
   - "What are Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) and an Update of Studies Focused on Evaluating Landfill Leachate." Sponsored by the Florida Section of the American Water Works Association, Webinar, September 26, 2018 (Speaker presentation by H. Solo-Gabriele)
   - "Perfluoroalkyl substances in landfill leachates produced from different waste types." American Chemical Society Spring 2019 National Meeting & Expo, Orlando, FL, April 2019. (speaker presentation by H. Solo-Gabriele)

3. List who has referenced or cited your publications from this project. Drs. Solo-Gabriele and Townsend's research on treated wood is highly cited. Please see Google Scholar for citation details about their publications.
   For Solo-Gabriele: https://scholar.google.com/citations?hl=en&user=zvpDSPoAAAAJ

EXHIBIT 1

For Townsend: https://scholar.google.com/citations?hl=en&user=PqujfgkAAAAJ

4. How have the research results from this Hinkley Center project been leveraged to secure additional research funding?
   - The U.S. Environmental Protection Agency (EPA), Research Triangle Park (RTP) provided analytical support to this project by analyzing the samples free of charge. The analysis included the measurement of 11 PFAS species within 22 samples. The estimated in-kind contribution of this support was estimated at $6,000.

   - During the Fall of 2018 an RFP was issued entitled, "Practical Methods to Analyze and Treat Emerging Contaminants (PFAS) in Solid Waste, Landfills, Wastewater/Leachates, Soils, and Groundwater to Protect Human Health and the Environment." We (Townsend as PI) submitted a proposal to the U.S. EPA in response to this call and we heard back that the proposal will be funded. The title is: A Systems-Based Approach to Understand the Role of Waste Type, Management Strategies and Treatment Methods on the Occurrence, Source, and Fate of PFAS in Landfills. The duration is for three years. The start date is estimated at October 2019.

5. What new collaborations were initiated based on this Hinkley Center project?
   - We restarted our UM/UF collaboration. Drs. Solo-Gabriele and Townsend collaborated for decades on the CCA-treated wood research. This first year of PFAS funding helped to re-initiate that collaboration by providing the ability to apply for much larger grants. This current project resulted in background data that permitted for large collaborative proposals that could support faculty and students at both UM and UF.
   - As a result of this project we have developed strong relationships with both EPA-RTP and EPA-ORD. We are very grateful for the relationships with both groups. The relationship with EPA-RTP did facilitate the relationship with EPA-ORD as the data collected from this first Hinkley PFAS project was presented to the EPA which in turn transitioned into the second EPA relationship, this time with ORD.
   - We have established collaborations with landfill operators at the 5 landfills included in this study. Many more collaborations are being established with landfill operators as we prepare for the second Hinkley PFAS project.
   - We have established a collaboration with the FDEP through communications via the TAG. The FDEP has provided assistance in accessing their Solid Waste Universe and Oculus databases.
   - The TAG committee has been very supportive of this project participating in TAG meetings and assisting the research team in making connections to other groups and encouraging research exchange meetings.

6. How have the results from this Hinkley Center funded project been used by the FDEP or other stakeholders.
   - PFAS as a landfill contaminant is relatively new. At the national level the EPA is gathering background information for potential decision-making concerning PFAS in landfill leachates. The national initiatives have also facilitated awareness among the FDEP who, in turn, have exhibited a strong interest in the results.

- Landfill operators have been contacting the research group proactively asking about their individual landfill results. There is clearly a strong interest among landfill operators due to concerns about potential regulations at wastewater treatment plants.

EXHIBIT 1

ACKNOWLEDGEMENTS

- This project was funded by the Hinkley Center for Solid and Hazardous Waste Management. In-kind support has been provided by the EPA-RTP.
- We are thankful to all of the student researchers that worked on this project. They are all listed as authors on this report (Athena Jones, Hekai Zhang, Yutao Chen, and Matthew Roca).
- We thank all landfill operators that allowed us to collect samples at their site and also those who shared their knowledge of their landfill operations.
- We are thankful to the experts at EPA-RTP who shared their wealth of PFAS knowledge with the team. We are particularly thankful to Dr. Johnsie Lang who facilitated the sample analysis and took team members through the sample analysis process at the EPA-RTP laboratories during January and July 2018. We are thankful to Dr. Mark Strynar for the opportunity to utilize his laboratory for the pre-processing and analysis of samples. We are thankful to Dr. Andrew Lindstrom for sharing his knowledge about PFAS.
- We are grateful to all of the Technical Awareness Group (TAG) members listed in the following table, plus the individuals who took part in the TAG meetings who are listed in the table that follows for participating in meetings and for their input and feedback.

RESEARCH TEAM MEMBERS

Name	Affiliation and Address
Helena Solo-Gabriele	Professor, Principal Investigator University of Miami, 1251 Memorial Drive McArthur Bldg R 252, Coral Gables, FL 33146
Athena Jones	Graduate Student University of Miami
Hekai Zhang	Graduate Student University of Miami
Yutao Chen	Graduate Student University of Miami
Matthew Roca	Undergraduate Student University of Miami

HINKLEY CENTER

Name	Affiliation and Address
John Schert	Director University of Florida, Gainesville, FL
Wester W. Henderson III	Research Coordinator III
Tim Vinson	Research Coordinator

EXHIBIT 1

TECHNICAL AWARENESS GROUP (TAG) MEMBERS. Note: Participation in the TAG group does not imply an endorsement of the research. The TAG group are individuals who are interested in the research and are capable and willing to provide input. This input is considered by the research team as the research project progresses.

Name	**Affiliation and Address**
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Richard Meyers	SWRS Program Manager, Broward County Solid Waste and Recycling Services 1 N. University Dr., Suite 400, Plantation, FL 33324
Joseph H. O'Neill, P.E.	Professional Engineer II, Solid Waste Management Division, Hillsborough County, 332 N. Falkenburg Road, Tampa, FL 3361
Hilary Thornton	Remedial Project Manager & NARPM Co-Chair: Restoration & Investigation Section, US EPA Region 4: Superfund Division, 61 Forsyth Stree SW, Atlanta, GA 30303

EXHIBIT 1

TECHNICAL AWARENESS GROUP (TAG) MEMBERS (Cont'd)

Name	Affiliation and Address
Thabet Tolaymat, Ph.D.	Acting Associate Director for Emerging Materials and Sustainability, Chemical Safety for Sustainability Research Program, U.S. EPA 26 West Marting Luther King Drive, Mail Code: 236, Cincinnnati, OH 45268,
Ashley Danley-Thomson, Ph.D.	Assistant Professor at Florida Gulf Coast University with research that relates to PFAS
Weiland Uchdorf, Ph.D.	Facility Engineer, Resources Recovery Facility, Department of Solid Waste Management, Miami-Dade County 6990 NW 97th Ave, Miami, Fl 33178

TAG MEETING PARTICIPANTS. Note: Participation in the TAG meetings does not imply an endorsement of the research.	
Name	**Affiliation**
MEETING 1 (In Person)	
Athena Jones	University of Miami
Helena Solo-Gabriele	University of Miami
Madeline Keep	University of Miami
Wes Henderson	Hinkley Center for Solid and Hazardous Waste Management
Weiland Uchdorf	Department of Solid Waste Management, Miami-Dade County, Resources Recovery
MEETING 1 (On-Line)	
Cory Dilmore	Florida Dept. of Environmental Protection, Permitting and Compliance, Tallahassee, FL
Eric Charest	Indian River County Utilities, Environmental Compliance
Elizabeth Foeller	Waste Management Inc., Environmental Protection
Himanshu Mehta	Indian River County Utilities, Environmental Compliance
Hilary Thornton	U.S. EPA Region 4, Superfund Division
Joe Dertian	Florida Department of Environmental Protection, Solid Waste, Tallahassee, FL
Johnsie Lang	Orise Fellow stationed at Research Triangle Park, EPA
Joseph O’Neill	Hillsborough County, Solid Waste Management Division
Rula Deeb	Geosyntec Consultants
Ramana Kari	Solid Waste Authority of Palm Beach County
Richard Meyers	Broward County Solid Waste and Recycling
Thabet Tolaymant	U.S. EPA Emerging Materials and Sustainability, Chemical Safety for Sustainability
MEETING 2	
Dr. Meeroff	Florida Atlantic University
Amede Dimonnay	Broward County Environmental Engineering and Permitting Division
Amy Hightower	
Athena Jones	University of Miami
Ashley Danley-Thomson	Florida Gulf Coast University
Bishow Shaha	Florida Atlantic University
David Meyers	
Dave Phillips	Florida Dept. of Environmental Protection
Dan Schauer	Geosyntec Consultants
Elisabeth Hawley	Geosyntec Consultants
El Kromhout	Florida Dept. of Environmental Protection
Helena Solo-Gabriele	University of Miami
Hilary Thornton	EPA Project Manager in EPA Region 4

TAG MEETING PARTICIPANTS. (Cont'd) Note: Participation in the TAG meetings does not imply an endorsement of the research.	
Name	**Affiliation**
MEETING 2 (Cont'd)	
Johnsie Lang	Orise Fellow stationed at Research Triangle Park, EPA
John Merrill	Geosyntec Consultants
James Telson	Solid Waste Authority of Palm Beach County
Kavitha Dasu	Battelle
Laura Barrett	Florida Dept. of Environmental Protection
Mary Beth Morrison	Solid Waste Authority of Palm Beach County
Morton Barlaz	North Carolina State University
Mark Eyeington	Solid Waste Authority of Palm Beach County
Md Fahim Salek	Florida Atlantic University
Manuel Hernandez	SCS Engineers
Mary Maurer	Florida Dept. of Environmental Protection
Neil Coffman	Florida Atlantic University
Nate Mayer	Solid Waste Authority of Palm Beach County
Nicole Robey	University of Florida
Ramana Kari	Solid Waste Authority of Palm Beach County
Robert Sterner	
Rohan Sethi	Florida Atlantic University
Ram Tewari	Arcadis
Sharmily Rahman	
Wester Henderson	Hinkley Center for Solid and Hazardous Waste Management
MEETING 3 (In Person)	
Fangmei Zhang	Miami-Dade Department of Environmental Resources Management
Helena Solo-Gabriele	University of Miami
Hekai Zhang	University of Miami
John Schert	Hinkley Center for Solid and Hazardous Waste Management
Lee Casey	SCS Environmental Consultants and Contractors
Liz Foeller	Waste Management Inc.
Malak Anshassi	University of Florida
Mario Porcelli	Miami-Dade County, Department of Solid Waste Management
Timothy Townsend	University of Florida
Viraj da Silva	SCS Environmental Consultants and Contractors
Weiland Uchdorf	Miami-Dade County Department of Solid Waste Management
Yutao Chen	University of Miami
Yalan Liu	University of Florida
Yanett Rodriguez	Miami-Dade County Department of Solid Waste Management

TAG MEETING PARTICIPANTS. (Cont'd) Note: Participation in the TAG meetings does not imply an endorsement of the research.

Name	**Affiliation**
MEETING 3 (On-Line)	
Amede Dimonnay	Broward County Environmental Engineering and Permitting Division
Ashley Danley-Thomson	Florida Gulf Coast University
Bob Curtis	SCS Engineers
Bryan White	Manatee County
Caroline Devitt	SCS Engineers
Cory Dilmore	Environmental Administrator, Florida DEP
David Broten	Solid Waste Authority of Palm Beach County
Eric Charest	Indian River County Department of Utility Services
Gail DeRuzzo	Battelle
Hilary Thornton	EPA Project Manager in EPA Region 4
John Merrill	Geosyntec Consultants
Jean-Rene Thelusmond	North Carolina State University
Jamey Wilkes	Clay County Dept. of Environmental Services
Kyle Clavier	University of Florida
Kavitha Dasu	Battelle
Kevin Vann	CDM Smith
Linda Monroy	Lee County
Larry Ruiz	Hillsborough County Solid Waste
Lois Rose	Sarasota County Solid Waste
Lynn Zender	Zender Environmental Health and Research Group
Morton Barlaz	North Carolina State University
Mark Culbreth	Environmental Consulting & Technology
Nicole Robey	University of Florida
Page Jordan	Oak Ridge Institute for Science and Education
Robert Curtis	SCS Engineers
Robert Graessel	Miami Dade County Dept of Solid Waste Management
Richard Meyers	Davie and Broward County
Rebecca Rodriguez	Lee County
Sam Levin	s2li Consultants
Sean Peterson	Zender Environmental Health and Research Group
Shaopeng Xu	University of Florida
Teresa Booeshaghi	Florida Department of Environmental Protection
Tim Bahr	Florida Department of Environmental Protection
Terry Cerullo	Florida Department of Environmental Protection
Thomas Mulligan	Brevard County Solid Waste Management Department
Thomas Smallwood	University of Florida
Wes Henderson	Hinkley Center for Solid and Hazardous Waste Management

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LIST OF ABBREVIATIONS AND ACRONYMS

5:3 FTCA	5:3 Fluorotelomer Carboxylic Acid
AFFF	Aqueous Film Forming Foam
ASDWA	Association of State Drinking Water Administrators
ATSDR	Agency for Toxic Substances and Disease Registry
BOD	Biochemical Oxygen Demand
C&D	Construction and Demolition
C_2F_6	Hexafluoroethane
CCA	Chromated Copper Arsenate
C-F	Carbon-Fluorine Bond
CF_4	Tetrafluoromethane
COD	Chemical Oxygen Demand
CWB	California Water Boards
EFSA	European Food Safety Authority
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FPePA	3-Perfluoropentyl Propanoic Acid
FTA-MXA	Native Telomer Mix
FTOH	Fluorotelomer Alcohol
GC	Gas Condensate
HCSHWM	Hinkley Center for Solid and Hazardous Waste Management
HDPE	High-Density Polyethylene Resin
LC-MS/MS	Liquid Chromatography with Tandem Mass Spectrometry
MeOH	Methyl Alcohol
MSW	Municipal Solid Waste
MSWA	Municipal Solid Waste Ash
ND	Not Detected
OECD	Organization for Economic Co-operation and Development
ORD	Office of Research and Development
PFAC-MXA	Fluorinated Acid/Sulfonate Mix

PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
PFBA	Perfluorobutanoic Acid
PFBS	Perfluorobutanesulfonic Acid
PFDA	Perfluorodecanoci Acid
PFHpA	Perfluoroheptanoic Acid
PFHxA	Perfluorohexanoic Acid
PFHxS	Perfluorohexanesulfonic Acid
PFNA	Perfluorononanoic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate/ Perfluorooctanesulfonic Acid
PFPeA	Perfluoropentanoic Acid
PI	Project Investigator
RFP	Request for Proposal
RTP	Research Triangle Park
SPE	Solid Phase Extraction
TAG	Technical Awareness Group
TDS	Total Dissolve Solids
TOC	Total Organic Carbon
TOF-LC/MS	Time of Flight-Liquid Chromatograph/Mass Spectrometer
TS	Total Solids
UF	University of Florida
UM	University of Miami
UNEP	United Nations Environment Program
US EPA	U.S. Environmental Protection Agency
WWTP	Wastewater Treatment Plant

UNITS OF MEASURE

$	Dollars
%	Parts per hundred
°C	Degrees Celsius
g	Grams
kg	Kilograms
kg/year	Kilograms per year
L	Liter
mg	Milligrams
mg/L	Milligrams per liter
mL	Milliliter
mM	Millimolar/ Millimole per liter
ng	Nanograms
ng/L	Nanograms per liter
pH	Measure of the hydrogen ion activity
ppb	Parts per billion
μL	Microliter
μl/min	Microliter per minute

EXECUTIVE SUMMARY

Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) are found in many consumer products which will be ultimately disposed in landfills. Limiting exposures will require managing leachates from different types of landfills, each with different PFAS levels depending upon the source of the waste. This study evaluated 11 PFAS species (7 carboxylic acids, 3 sulfonic acids, and 5:3 FTCA) in different types of landfill leachates: municipal solid waste (MSW), construction and demolition (C&D), MSW ash (MSWA), and MSWA with landfill gas condensate (GC). Leachates were also analyzed before and after onsite treatment at two of these facilities. Results indicate that MSWA leachate had significantly lower PFAS levels relative to other leachate types. The correlation between total PFAS and incineration temperature for the ash leachates was significant, with lower total PFAS concentration associated with an increase in incineration temperature. The levels of PFASs in untreated C&D and untreated MSW leachate were similar suggesting that both waste sources are a significant source of PFAS. This is particularly relevant since some C&D landfills in Florida are not lined.

In this study, leachates at two treatment facilities were evaluated. The treatment systems were both designed for ammonia removal via aeration, one was a continuous flow through system and the other was a batch reactor. The continuous flow through system treated leachate that consisted primarily of MSWA. The batch reactor treated predominantly MSW leachate. Results show that the levels of targeted PFAS species in MSW leachate from the continuous flow through system did not change - with effluent concentrations similar to influent concentrations. For the batch reactor, the concentration of PFAS increased in the effluent (after treatment) presumably due to the conversion of PFAS precursors in the untreated leachate sample.

In summary results from this study serve as a starting point for assessing landfill leachates in the State of Florida. The fact that MSWA had lower total PFAS levels should be further evaluated to determine if the lower levels are due to destruction of PFAS as opposed to conversion to a PFAS form that was not measured. More samples should be collected to evaluate the influence of incineration temperature on PFAS species, as incineration may serve as one alternative for the removal of PFAS from the environment. Further study should be conducted to evaluate whether other leachate treatment strategies are effective at removing PFAS.

Overall, the results from this study can be useful to waste managers as well as legislators in the State of Florida when making decisions about the disposal and treatment of landfill leachate that may be contaminated with PFAS.

CHAPTER I

MOTIVATION, OBJECTIVES, AND BACKGROUND

EXHIBIT 1

CHAPTER I

MOTIVATION, OBJECTIVES, AND BACKGROUND

This chapter focuses on describing the motivation and objectives (Section I.1) and the project background (Section I.2) for this study.

I.1 MOTIVATION AND OBJECTIVES

Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) are fluorine-containing chemicals that are found in many products that are stick and stain resistant. The most common of the PFASs are perfluorooctanoic acid (PFOA) which is used to make Teflon, and perfluorooctane sulfonate (PFOS), a breakdown product of a common water-resistant chemical known as Scotchgard. Although used widely, only recently have their human health impacts been recognized. Studies have linked PFOA and PFOS to thyroid and liver diseases, diseases of the immune system, and cancer. Due to their wide-ranging usage in consumer products, landfills represent a logical end-of-life reservoir for PFASs. The objectives of this study are to evaluate the concentrations of PFASs in leachates from Florida landfills and to assess the capacity of current treatments to remove PFASs from leachate. Leachate samples will be collected from landfills in the State of Florida and from the effluent of leachate treatment facilities. These samples are to be analyzed with LC-MS/MS for PFASs. Data on leachate volumes and treatment data will be consolidated for landfills in the State of Florida. From this literature information coupled with leachate measurements, a preliminary assessment will be made about the effectiveness of existing leachate treatment strategies in reducing PFOA and PFOS levels. In an effort to broadly assess the health risks associated with the PFASs, results from leachate measurements will be compared to the U.S. Environmental Protection Agency's PFASs health advisory of 0.07 parts per billion. Results can be used by regulators to assess whether treatment systems are needed to remove PFASs from landfill leachates in Florida.

The goal of this study is to assess the degree to which Florida landfills can inadvertently contribute towards the cycling of PFASs. To address this goal, this proposal has two objectives. The first objective will focus on documenting the levels of PFOA, PFOS, and their precursors in landfill leachates within the State of Florida. These measurements will be used to determine if, and by what factor, concentrations exceed the EPA health advisory levels. The second objective will focus on a preliminary assessment of the effectiveness of currently available treatment processes for PFOA and PFOS removal from landfill leachate.

I.2 BACKGROUND

I.2.1 Introductory Chemistry

Fluorine is the most electronegative element meaning that it has the strongest tendency to form a bonded pair of electrons when it forms a compound. The "shared electrons" or covalent bonds between carbon and fluorine are the strongest in organic chemistry making carbon-fluorine (C-F) compounds resistant to hydrolysis, photolysis, and biodegradation (US EPA 2014b). The class of fluorinated substances that are the topic of this proposal include a carbon chain (alkyl) with a functional group on one end. The carbon chain of each molecule is either partly or fully fluorinated. If less than 100% of the carbon is bonded with fluorine the prefix "**poly**fluorinated" is used. If 100% of the carbon in the chain is bonded with fluorine the prefix "**per**fluorinated" is used (Buck et al. 2011).

The two Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs) that are the primary focus of this research are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) (Figure I.1). The length of the carbon chain in both compounds is 8 carbon atoms. The PFOA has a carboxylic acid functional group attached to the carbon chain, whereas PFOS has a sulfonatic acid functional group attached to its carbon chain (Figure I.1),

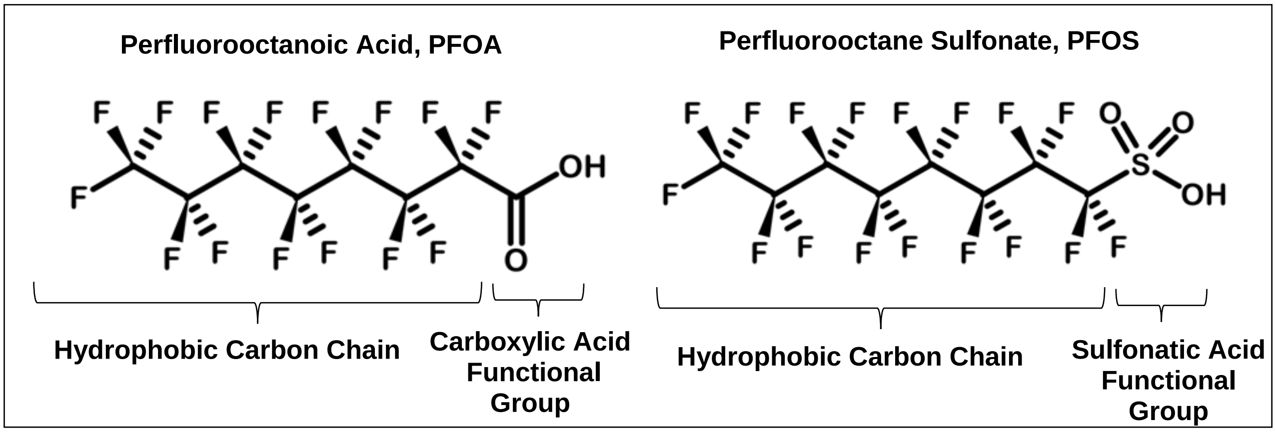

Figure I.1 Structure of PFOA and PFOS emphasizing the carbon chain and functional groups.

I.2.2 Persistence

One of the challenges of managing PFASs is their persistence in the environment. This persistence is largely due to their strong C-F bonds. PFOA and PFOS are particularly persistent due to their hydrophobic fluorinated carbon chain and a hydrophilic functional group which binds to surfaces (Figure I.1). The fluorinated chain is what makes these PFASs water resistant and an ideal chemical for use in products such as food packaging, non-stick pans, and rain protection gear. Studies have shown that PFASs do not degrade by typical environmental processes including hydrolysis, photolysis, and biodegradation (US EPA 2014b, Schultz et al. 2003, OECD 2002). The

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half-life of PFOS in water is over 41 years at 25 °C and the half-life of PFOA in water of the same temperature is over 92 years (ATSDR 2009; Brooke et al. 2004; EFSA 2008; Environment Canada 2012; US EPA 2002b; OECD 2002; UNEP 2006). PFOA and PFOS have been manufactured since the late 1940s. Therefore PFOA and PFOS included in consumer products since this time are likely to still be in the environment, with landfills serving as a significant repository.

Moreover, PFOA can be formed from the degradation of other fluorinated compounds (US EPA, 2017a). One notable category is fluorotelomer-based polymers which are used in paper intended for contact with food (Figure I.2). Fluorotelomers are used in wrappers for fast food, pizza box liners, granola wrappers, and microwave popcorn bag liners. The fluorotelomer-based polymers persist for decades in the environment and are believed to represent a long-standing reservoir of PFOA (Washington et al. 2015a, b).

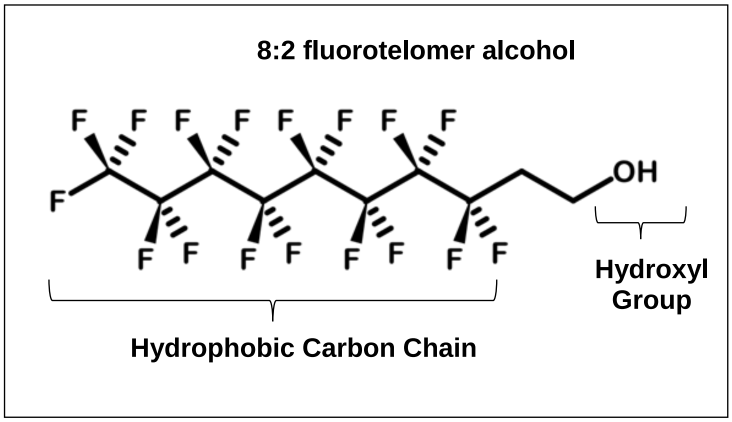

Figure I.2 Example of fluorotelomer polymer (8:2 fluorotelomer alcohol, 8:2 FTOH), a known precursor for PFOA – breaks down in the environment to PFOA.

I.2.3 Health Impacts

The U.S. EPA has currently classified PFOA and PFOS as emerging contaminants because new research suggests that they are linked to adverse human and environmental health impacts (US EPA 2014a). PFOAs can be ingested (Bao et al. 2017, Domingo and Nadal 2017) inhaled (Nilsson et al. 2010), or absorbed through the skin (Franko et al. 2012). Once the PFASs enter the human body, they remain for very long periods of time (half-life of 3 years, Bartell et al. 2010, Steenland et al. 2010). Studies have found that >99% of Americans' blood serum contains detectable levels of PFASs (Calafat et al. 2007). Since the recognition of PFOA accumulation in human blood serum, many animal and human epidemiologic studies have been conducted. Studies on rodents have shown that blood serum PFOA is associated with thyroid diseases, B-cell and T-cell immune responses, atrophy of spleen and thymus, enlarged liver, and liver cancer (Yang et al. 2002) Epidemiologic studies of human populations have found that PFOA in blood serum is associated with thyroid dysfunction (Li et al. 2017b), asthma and impaired lung function (Qin et al. 2017), and kidney cancer (Li et al. 2017a). The U.S. EPA has identified PFOA to be a likely human carcinogen (US EPA 2014b).

In response to the suspected health impacts, the EPA has facilitated the phase out of PFOA from eight primary U.S. manufacturers as of 2015 and PFOS was phased out in 2002 from its single U.S. manufacturer (US EPA 2017). EPA has not yet established drinking water regulations for PFOA and PFOS. Given the large body of literature that speaks to the potential adverse health effects, PFOA and PFOS will likely be regulated to prevent exposure to the public and the environment. In the interim the EPA has issued, effective May 2016, a non-enforceable health advisory of 0.07 parts per billion for the sum of PFOA and PFOS (U.S. EPA 2016).

The EPA response above does not directly address the fluorotelomer-based polymer precursors which degrade to PFOA. At wastewater treatment plants it has been documented that levels of PFOA increase through the treatment system (Arvaniti and Stasinakis et al. 2015) due to the degradation of fluorinated precursors in wastewater (Xiao et al. 2012). The PFOA in the water generally accumulates in sewage-biosolids whose ultimate disposition is for use on agricultural fields and within landfills where it can be released over time into leachates. Although the direct production of PFOA and PFOS has been addressed through agreements between the EPA and chemical manufacturers, such agreements do not exist for the fluorinated precursors. As such the precursors for PFOA continue to be produced as components of consumer products thereby prolonging the long-term health impacts of PFOA through its circulation within the environment.

I.2.4 Detection of PFASs in the Environment

As far as the extent of recent contamination: PFOS and PFOA have been discovered in low concentrations in remote regions of the arctic ice cap and Antarctica (Lau et al. 2007, Martin et al. 2004, Young et al. 2007, Zhao et al. 2012). In river environments directly downstream of chemical production facilities, concentrations of PFOA are found at very high levels of up to 4534 ng/L in China (Wang et al. 2014) and 19,400 ng/L in Japan (Shiwaku et al. 2016). In rivers **not directly** impacted by industrial discharges, concentrations of PFOA were measured at 2.2 ng/L for rivers in northern Europe (Nguyen et al. 2017), and 46 ng/L for a river that serves as a drinking water source in North Carolina (Sun et al. 2016). In wastewater elevated levels of PFASs are also documented. Within wastewater treatment plants levels of PFOA increase with values from 1-10 ng/L in the influent and 10-100 ng/L in the effluent for a plant in the Netherlands (Bossi et al 2008). In Korean wastewaters levels are higher at 111 ng/L (Kwon et al. 2017). Overall the highest levels are observed in surface waters and sediments downstream of former fluorinated chemical production facilities as well as in wastewater effluent, wastewater biosolids, and landfill leachate (US EPA 2014a). A landfill known to have received waste from PFOA and PFOS industrial processes documented leachate levels as high as 82,000 ng/L and 31,000 ng/L, respectively (Oliaei et al. 2013).

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I.2.5 Detection in Municipal Landfill Leachates

For six landfills in the U.S. the levels of PFOA and PFOS were on the order of 1,000 ng/L whereas levels of PFOS were on the order of 100 ng/L (Huset et al. 2011). The general vicinity of the U.S. landfills was identified in the Huset et al. (2011) study as: three from the Mid-Atlantic, one from the U.S. West Coast, one from the Pacific Northwest, and one from the Gulf Coast. All six landfills received biosolids and all but one recirculated leachate. The levels of PFOA and PFOS at the U.S. landfills were consistent with levels measured in leachates from 4 landfills in Spain (Fuertes et al. 2017) and a little higher than those measured at 22 landfills in Germany (Busch et al. 2010). The highest levels were measured in leachates collected from five landfills in China. The PFOA/PFOS concentrations in these leachates were highly variable with the upper limits being a few orders of magnitude higher than those measured in the U.S.

Table I.1 Concentrations (ng/L) of PFOA and PFOS in untreated landfill leachates

	U.S. (Huset et al. 2011)	Finland (Perkola and Sainio 2013)	Spain (Fuertes et al. 2017)	Germany (Busch et al. 2010)	China (Yan et al. 2015)
No. of Landfills	6	2	4	22	5
PFOA	660	170	600	150	280 to 214,000
PFOS	110	110	20	30	1100 to 6000

I.2.6 Conceptualized PFOA and PFOS Life Cycle

Landfills represent a significant reservoir of PFOA and PFOS accumulation from the direct accumulation of consumer products containing PFOA, PFOS, and their precursors and by receiving wastewater biosolids which have been documented to contain these compounds (Figure I.3). Carpet, stain resistant paper, clothing, and other textiles have been implicated as consumer products in landfills that can serve as a direct source of PFASs to landfill leachate (Lang et al. 2016). Bench top reactor studies have found that the release of PFASs from these products into landfill leachate occurs under methane producing conditions (Allred et al. 2015) thereby providing direct evidence that these compounds can be released through landfill leachate. In addition to direct leaching from consumer products, another source of PFASs to landfills is from disposed wastewater biosolids. A U.S. national inventory of biosolids collected in 2001 showed that of the 3000 kg/year of PFASs found in biosolids about 20% was ultimately disposed in landfills with the bulk of the remainder used for agricultural purposes (Venkatesan and Halden 2013).

Given the long persistence of PFOA and PFOS in the environment and what is currently known about its sources, a life cycle has been conceptualized as part of this proposal (Figure I.3). This life cycle identifies two the predominant sources of PFOA, PFOS, and their precursors to landfills as described above. The life cycle also illustrates how the leachates from landfills can be recirculated via wastewater treatment plants. The land applied biosolids at wastewater treatment plants can then impact the food and water supplies thereby impacting human populations through

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ingestion. One way to break the cycle and prevent human health impacts is to treat releases from landfills, a reservoir at the heart of our conceptualized PFAS recirculation process.

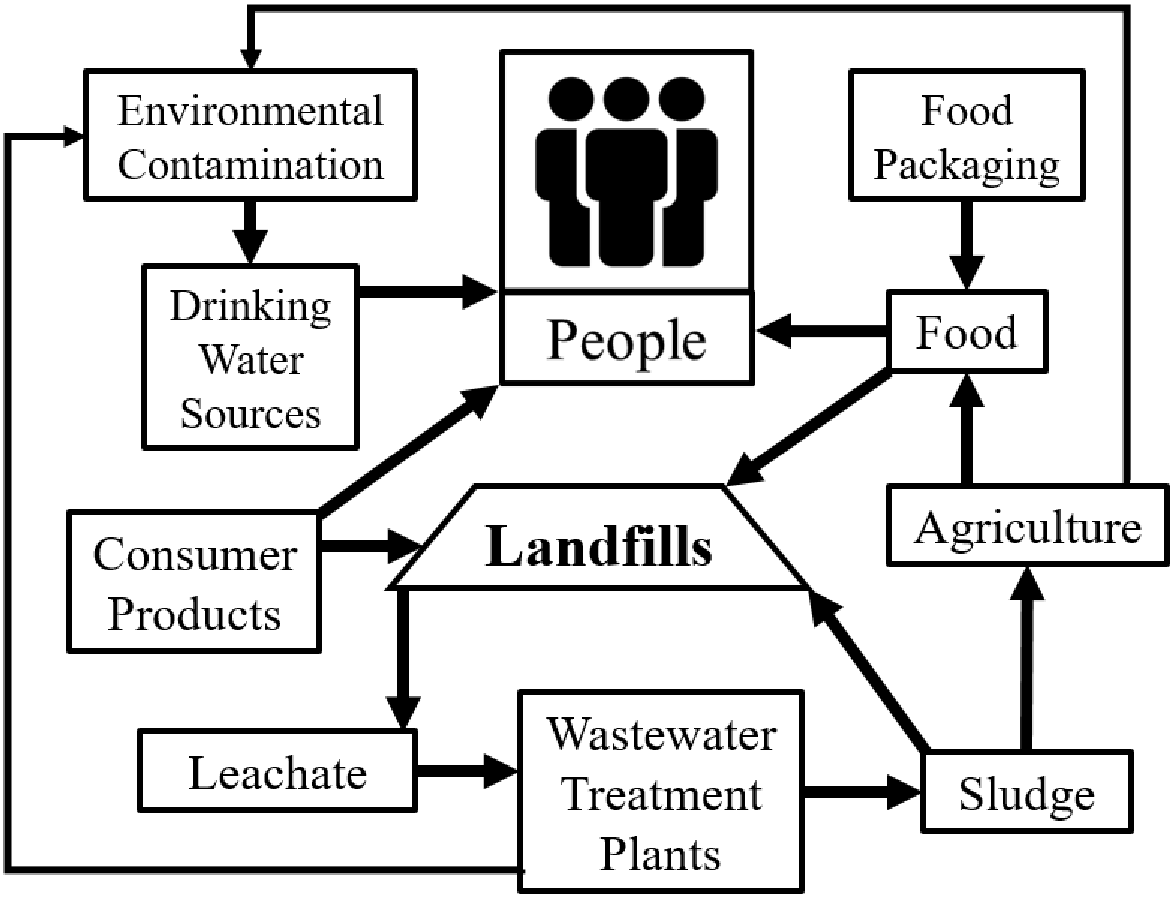


Figure I.3 Conceptualized Life Cycle of PFOA and PFOS and their precursors showing landfills as a significant reservoir and potential source to wastewater treatment plants. Depending upon the wastewater effluent discharge and ultimate use of the biosolids, the PFASs can potentially be inadvertently cycled back to the environment and ingested by humans.

CHAPTER II

PFAS IN LANDFILL LEACHATE AND PRELIINARY ASSESSMENT OF LEACHATE TREATMENT

CHAPTER II

PFAS IN LANDFILL LEACHATE AND PRELIINARY ASSESSMENT OF LEACHATE TREATMENT

II.1 INTRODUCTION

Landfill leachate presents a unique challenge for managing Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) from products that have reached the end of their service life. PFASs are used in many consumer products, including sealants (Favreau et al. 2017), sprays for textiles (Ye et al. 2015), Teflon parts (U.S. EPA 2018), clothing, carpet (Lang et al. 2016), ski waxes (Kotthoff et al. 2015), and in non-stick surfaces such as cookware (U.S. EPA 2018). They are also found in food packaging such as paper food wrappers and cups (Wang et al. 2017, Schaider et al. 2017). Aqueous film forming foam (AFFF) represent another source of PFAS release to the environment (Dauchy et al. 2017, Backe et al. 2013, Houtz et al. 2013). Widespread uses and their resistance to destruction make management of PFASs difficult at the end of their service lives.

The chain of carbon and fluorine bonds in PFASs are persistent due to the highly electronegative nature of fluorine, which results in the strongest bond that is possible with carbon (O'Hagan 2008). As a result of the strong bonds, the C-F chain portion of the molecule is resistant to degradation, including resistance to hydrolysis, photolysis, and biodegradation (U.S. EPA 2014, Schultz et al. 2003, OECD 2002). The half-life of PFOA in water is over 92 years at 25 °C and the half-life of PFOS in water of the same temperature is over 41 years (U.S. EPA 2014).

PFASs have been linked to human health effects. PFASs are found in the blood of over 98% of Americans (Calafat et al. 2007). In in-vivo studies with rodents, PFASs have been linked to thyroid diseases, diseases of the immune system, and have been associated with liver cancer (Yang et al. 2002, Lau et al. 2007). In exposed communities, PFASs have also been linked with thyroid disease (Li et al. 2017b), asthma, impaired lung function (Qin et al. 2017), and cancers of the kidney and bladder (Li et al. 2017a).

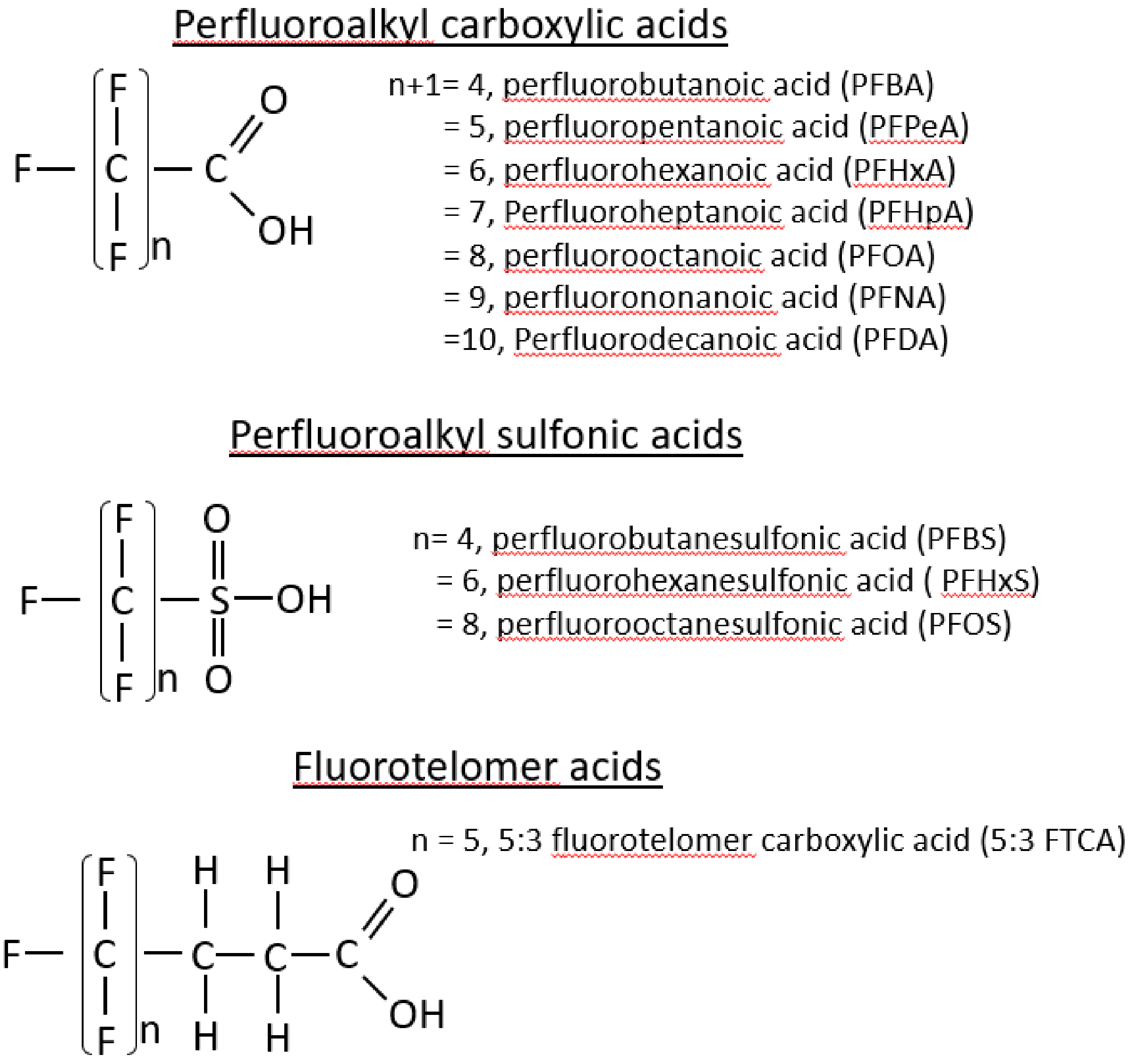
As a result of the public health concerns associated with PFASs, the U.S. Environmental Protection Agency (U.S. EPA) has issued effective May 2016 a drinking water health advisory of 70 ng/L for the sum of two PFAS species, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) (U.S. EPA 2016, Hamid et al. 2018). Some U.S. states have adopted stricter drinking water guidelines. For example, Vermont has adopted a guideline of 20 ng/L for the sum of PFOA and PFOS plus three additional species (PFNA, PFHxS, and PFHpA, defined in Figure II.1). Similarly, New Jersey and California have adopted a guideline of 14 ng/L for PFOA and 13 ng/L for PFOS (ASDWA 2019, CWB 2019).

Municipal solid waste (MSW) leachates have been documented with PFOA on the order of 1,000's ng/L and PFOS on the order of 100's ng/L in the U.S. (Huset et al. 2011, Lang et al. 2017, Benskin et al. 2012) and Europe (Fuertes et al. 2017, Busch et al. 2010, Perkola and Sainio 2013). A landfill known to have received waste from PFOA and PFOS industrial processes documented leachate levels as high as 82,000 ng/L and 31,000 ng/L, respectively (Oliaei et al. 2013). The highest levels were measured in leachates collected from five landfills in China with PFOA levels up to 214,000 ng/L and PFOS levels up to 6,000 ng/L (Yan et al. 2015).

The types of landfills used for disposal of waste vary in terms of their composition. MSW landfills in the U.S. that were part of Lang et al. (2017) accepted household waste including organics, cardboard, glass, paper and plastics, whereas in an Austrian study (Gallen et al. 2017) MSW was predominantly organic waste. Gallen et al. (2017) also evaluated a second class of landfills containing cardboard, glass, paper and plastics plus construction and demolition (C&D) wastes (defined as concrete, soil, metals, timber, and plastics). The levels of PFASs observed in the C&D leachates of the Gallen et al. study were 1,400 ng/L for PFOA and 1,100 ng/L for PFOS, on average.

Landfill leachates are typically managed via transfer to a wastewater treatment plant (WWTP). In WWTPs, some PFASs tend to bioaccumulate in the sludge (typically PFAS with >8 carbon fluoroalkyl chains) (Venkatesan and Halden 2013) whereas others, such as the fluorotelomers, can be transformed from one PFAS species to another (e.g., alcohols to carboxylic acids, Xiao et al. 2012). Lang et al. (2017) and Busch (2010) found that while PFAS concentrations were high in leachate, the volume of leachate generated is low compared to WWTP outflows, resulting in a relatively small annual mass release.

The objective of this study was to analyze the concentrations of 11 PFASs (Figure II.1) in leachate samples from landfills composed of different waste types. Two waste types have never been previously evaluated for PFAS content MSW ash (MSWA) and gas condensate (GC). In addition, we analyzed PFASs before and after treatment at on-site, full-scale leachate treatment facilities.



Perfluoroalkyl carboxylic acids

n+1= 4, perfluorobutanoic acid (PFBA)
= 5, perfluoropentanoic acid (PFPeA)
= 6, perfluorohexanoic acid (PFHxA)
= 7, Perfluoroheptanoic acid (PFHpA)
= 8, perfluorooctanoic acid (PFOA)
= 9, perfluorononanoic acid (PFNA)
=10, Perfluorodecanoic acid (PFDA)

Perfluoroalkyl sulfonic acids

n= 4, perfluorobutanesulfonic acid (PFBS)
= 6, perfluorohexanesulfonic acid (PFHxS)
= 8, perfluorooctanesulfonic acid (PFOS)

Fluorotelomer acids

n = 5, 5:3 fluorotelomer carboxylic acid (5:3 FTCA)

Figure II.1 Defined acronyms and structural configuration of a PFAS species analyzed during the current study.

II.2 METHODS

II.2.1 Landfill sites

Samples were collected at five different landfill facilities within Florida, USA (Table II.1). Pre-treatment and the ultimate disposal of leachate differed for each facility. Ultimate disposal at two landfill facilities consisted of on-site aeration with disposal to a WWTP. For two other landfill facilities, the leachate was discharged to a WWTP without pre-treatment. At one facility, the leachate was discharged to deep well injection without pre-treatment.

Some of the facilities had access to leachate flows from distinct waste types by cell. Leachate was obtained from cells containing predominantly MSW, predominantly C&D, predominantly MSWA, and combinations thereof. The characteristics of the incineration facilities producing the ash varied. These variations included differences in the boiler temperatures used to incinerate the waste. Although the cells accepted both bottom and fly ash, the pre-treatment of the fly ash also differed between facilities prior to its disposal within the landfill cell. A sample was also collected of GC from a landfill cell containing a mixture of predominantly MSWA and MSW leachates. The gas condensate originates from the gas emitted from the landfill that condenses in the landfill gas collection system and subsequently falls-out and is diverted to the landfill leachate collection system. Thus, the GC sample is a combination of the landfill gas condensate and leachate. C&D landfills are designed to accept wastes from construction and demolition activities. Historically the majority of these landfills do not have bottom liners designed to capture leachate. More recently, as of 2010, bottom liners were required within the State of Florida. These landfills, which are referred to as Class III in Florida, were included within the C&D category. Class III landfills accept waste (yard trash, C&D debris, processed tires, asbestos, carpet, cardboard, paper, glass, plastic, and furniture other than appliances) that are not expected to produce leachate that poses a threat to public health or the environment as per Florida statutes (FAC 2016). MSW ash landfills accept ash from incineration for either volume reduction or waste-to-energy purposes. These landfills are also required to maintain bottom liners. Although not all C&D (inclusive of Class III) landfills have bottom liners, the landfills targeted as part of this study had bottom liner systems.

Sample collection was initiated at the participating facilities after two interviews: a telephone interview and an interview in person with the facility managers. During these interviews questions were asked about the type of waste disposed and the possibility of collecting leachates that corresponded to a particular waste type. From these interviews, the sampling plan was devised to optimize the isolation of a particular leachate type (MSW, C&D, MSWA, GC) and of a particular age, if possible. Additionally, priority was given to evaluate landfill leachate treatment processes. At facilities where landfill leachates were treated, samples were collected immediately prior to and after treatment for comparison.

A total of 12 samples were collected across five facilities. They consisted of one GC sample from predominantly an ash cell (75% MSWA/25% MSW), two samples from C&D landfills, four samples from predominantly MSW (2 with 100% MSW and 2 with a mix of 75% MSW/25% C&D

and five samples from predominantly ash landfills (2 with 100% MSWA, 1 with 98% MSWA/2% MSW, and 2 with 65% MSWA/35% MSW) (Table II.1).

Table II.1 Types of waste producing leachate, age of landfill cell producing leachate at time of sample collection, pre-treatment of ash, and pre-treatment/ultimate disposition of the leachate for the five landfill facilities included as part of the current study.

Facility ID	Sample ID	Waste Type	Age of cell (years)
A	C&D (100%)	Untreated C&D (Class III) only	26
	C&D (100%)	Untreated C&D (Class III) only	25
	GC	Gas condensate mixed with leachate from several cells composed of approx. 75% MSWA & 25% MSW.	20
	MSWA (98%)	MSW ash from cell containing 98% ash and 2% MSW.	8
B	MSW (75%)/ C&D(25%)	Overall the landfill contains 75% MSW & 25% C&D. Landfill is separated into old (27 year old) versus new (6 year) cells. The leachate from the first sampling point is a combination from old and new cells (averaged). Leachate from the second sampling point came from the old cell only.	17
	MSW (75%)/ C&D(25%)		27
C	MSWA(65%)/ MSW(35%)_U	Waste at this landfill facility consists of MSWA mixed with MSW at an approximate proportion of 65:35. The first sample corresponds to leachate entering the on-site pretreatment system and the second sample corresponds to leachate after on-site pretreatment.	34
	MSWA(65%)/ MSW(35%)_T		34
D	MSWA(100%)	Ash monofill. Samples came from two different manholes at the site.	18
	MSWA(100%)		18
E	MSW(100%)_U	The vast majority of the waste is MSW. The first sample corresponds to leachate entering the on-site treatment system and the second sample corresponds to leachate after on-site pretreatment.	39
	MSW(100%)_T		39

II.2.2 Sample Collection Methods

Leachate was collected in two half-liter HDPE bottles per sampling location. One collection bottle was used for subsequent PFAS analysis and the other was used for measures pH and chemical oxygen demand (COD).

Samples were poured directly into the collection bottles if spigots were available. A new primary collection bottle, also made of HDPE, was used when samples were to be collected from manholes or pump stations. The primary collection bottle was attached to a stainless-steel hose clamp which in turn was attached to a zinc-coated chain. The primary collection bottle was then lowered into the manhole/well using the chain and bottle attachment. This allowed for the collection of leachate samples in wells up to 10 meters deep and containing leachate that was only a few centimeters deep at the bottom. The lower end of the chain was detachable allowing for replacement of the primary sample collection bottle and lowest chain portion between sampling stations to avoid cross-contamination.

One trip blank was processed per facility visited. The trip blank consisted of an HDPE bottle that contained deionized water and was closed throughout sample collection, storage, and shipment. In addition, for each leachate sample a sample blank was also collected by opening the bottle containing deionized water during the time of sampling and then closing it after the sample was collected. Upon collection, samples were placed in a cooler with ice.

II.2.3 Laboratory Analysis

After collecting samples at each facility, sample bottles were immediately transported to the University of Miami (UM) laboratory (Coral Gables, FL). An aliquot was removed for the basic physical-chemical parameters of pH and COD at UM. The remaining sample (earmarked for PFAS analysis) was frozen. The aliquot was analyzed for pH using a meter calibrated to 4, 7, and 10 pH units (Orion Star A211) and for COD using pre-dispensed ampules (Bioscience Inc.) to which 1 ml of 1:10 diluted sample was added and analyzed spectrophotometrically (Milton Roy, Spec 20 with calibration standards from 0 to 4,500 mg/L of COD).

The frozen samples were batched into two sets for PFAS analysis at the U.S. EPA Research Triangle Park (RTP) laboratory (Raleigh, NC), with one set shipped for analysis during January 2018 and the second set shipped for analysis during July 2018. Samples at EPA-RTP were placed in a -5°C freezer upon receipt. Samples were thawed in the refrigerator overnight prior to analysis of PFAS concentrations.

The pre-processing of the samples after shipment included the addition of internal standards that were isotopically labeled (Wellington Laboratories, MPFAC-MXA and MFTA-MXA), a filtration step, followed by a solid phase extraction (SPE) process using Oasis WAX cartridges (Huset et al. 2011, Backe and Field 2012). For the first batch only, the sample extracts were filtered using Envi-carb cartridges (Sigma Aldrich). Eluates from the Oasis WAX/Envi-Carb cartridge (batch 1) and

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Oasis WAX (batch 2) were concentrated to 2 ml by evaporation using nitrogen gas. One-hundred microliter sample aliquots were prepared for analyses with the addition of 300 µL of 2.5 mM ammonium acetate. For the first batch a calibration curve was prepared using the purchased standards (Wellington Laboratories, PFAC-MXA: fluorinated acid/sulfonate mix, FTA-MXA: native telomer mix, FPePA: 3-perfluoropentyl propanoic acid) with an analytical range of 300 to 1200 ng/L.

The second batch of samples were diluted 1:2 with deionized water. For the second analysis date, the calibration curve prepared at EPA-RTP consisted of a wider range of concentrations (10 to 2000 ng/L for FTA-MXA, 50 to 5000 ng/L 5:3 FTCA: fluorotelomer carboxylic acid, PFAC-MXA 10 to 2000 ng/L). The solid phase extraction for this batch was pH-adjusted with 2.5 mL of nitric acid on the WAX cartridge to optimize the recovery of short chain PFASs

Samples were analyzed on a Time of Flight-Liquid Chromatograph/Mass Spectrometer TOF-LC/MS (Agilent, 1100 Series). The column consisted of a Poroshell 120 EC-C8 (2.1 x 50 mm, 2.7 µm). The flow rate was 300 µl/min with a gradient consisting of an aqueous phase (A: 95% deionized water and 5% MeOH in 0.4 mM ammonium formate) and an organic phase (B: 95% methanol and 5% of deionized water in 0.4 mM ammonium formate). The initial gradient (75% A, 25% B) was ramped to 80% B over 5 minutes and held for 5 minutes. This was followed by a second ramp to 100% B for 2 minutes and held for 3 minutes. For both analysis batches, analytical blanks were also added to the process (300 µL of 2.5 mM ammonium acetate + 100 µL of MeOH) as a check for contamination during analysis.

II.2.4 Statistical Analysis

Statistical differences in the mean values were evaluated through t-tests assuming two sample unequal variances with alpha at 0.05. A 90% degree of confidence was selected for this study. Correlations were assessed through the coefficient of determination, R^2, and were considered strong for R^2 greater than 0.7 and significant for p values less than 0.05.

II.3 RESULTS AND DISCUSSION

II.3.1 Leachate Characterization

The physical-chemical parameters of pH and COD depended upon leachate type. The pH of the leachates varied from 6.2 to 8.1, with MSWA leachate at the lowest pH and MSW leachate with the highest pH (Table II.2). The low pH range is consistent with landfills undergoing the younger acidic phase whereas the higher range is consistent with landfills undergoing the methanogenic phase (Kjeldsen et al. 2002). A weak but significant correlation was observed between landfill age and pH (R^2=0.54, p=0.01), with higher pH generally associated with older landfills. The COD of the samples ranged from 700 mg/L corresponding to the treated MSWA/MSW leachate, up to 14,000 mg/L for the GC leachate (Table II.2). The COD values tended to be low in comparison to landfills undergoing acidic phase decomposition. These values were more consistent with the

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typical values observed during methanogenic phases (3,000 COD mg/L on average) (Kjeldsen et al. 2002). The association between landfill age and COD was weak and insignificant (R^2=0.18, *p*=0.17).

Table II.2 Landfill cell composition, age, leachate pH, leachate COD and individual PFAS concentrations for the five facilities visited. Eleven PFAS species were measured in the leachate samples collected as part of this study.

Facility ID	Waste Type	Waste Proportions	Age (years)	pH	COD (mg/L)	PFAS (ng/L)[‡]											
						PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFBS	PFHxS	PFOS	5:3 FTCA	Total
A	C&D	100%	26	7.6	2,700	1,170	1,620	2,190	1,160	1,720	59	40	781	4,130	875	1,930	15,670
						1,150	1,790	2,250	1,120	1,740	56	40	828	4,230	874	1,900	15,960
A	C&D	100%	25	7.6	2,000	1,250	1,720	2,200	1,260	1,750	58	51	529	4,630	965	1,650	16,060
						1,200	322	2,130	1,160	1,680	66	51	560	4,530	1,000	1,760	14,450
B	MSW and C&D	75:25	17	7.7	3,800	1,460	ND[e]	3,560	1,060	2,200	104	121	3,150	2,250	557	2,540	17,010
						688	ND	1,830	1,090	2,290	116	104	3,220	2,330	600	2,540	14,800
B	MSW and C&D	75:25	27	7.7	3,800	ND	ND	4,270	1,310	2,860	144	121	ND	3,560	770	2,990	16,030
						2,200	ND	4,240	1,320	2,860	116	167	ND	3,580	736	3,050	18,270
E	MSW untreated	100%	39	8.1	4,600	1,410	ND	3,570	1,180	2,620	119	169	3,420	651	875	1,590	15,610
						1,659[c]	ND	3,590	1,182	2,643	125	189	3,351	635	870	1,600	15,840
E	***MSW treated[d]***	***100%***	39	***8.0***	***4,100***	***2,708***	***2,951***	***4,290***	***1,767***	***2,990***	***146***	***256***	***2,671***	***643***	***1,230***	***314***	19,970
						2,562	***31,36***	***4,295***	***1,764***	***2,962***	***154***	***318***	***2,625***	***612***	***1,180***	***306***	19,920
C	MSWA/MSW untreated	65:35	34	7.5	1,800	1,380	990	1,691	695	1,177	108	ND	331	994	330	748	8,450
						1,450	1,150	1,720	722	1,166	101	ND	363	992	319	736	8,730
C	***MSWA/MSW treated[d]***	***65:35***	34	***8.1***	***700***	***1,290***	***1,050***	***1,610***	***819***	***1,610***	***106***	***ND***	***388***	***1,400***	***296***	***ND***	8,570
						1,380	***1,040***	***1,630***	***791***	***1,596***	***99***	***ND***	***386***	***1,390***	***305***	***ND***	8,600
A	GC (MSWA/MSW)	75:25	21	7.3	14,000	ND[a]	ND[a]	1,140	299	609	159	81	3,800[b]	313	720	2,710	9,830
A	MSWA/MSW	98:2	12	6.9	8,800	1040	1,360	1,770	546	1,010	160	105	5,510	606	342	1,000	13,450
						917	1,230	1,680	485	964	136	99	4,900	540	347	954	12,260
D	Ash	100	18	6.2	4,200	421	652	742	328	360	ND	ND	508	182	166	ND	3,360
						512	567	726	292	387	ND	ND	547	184	158	ND	3,370
D	Ash	100	18	6.4	4,300	450	437	589	256	259	ND	ND	534	179	120	ND	2,820
						470	477	637	255	269	ND	ND	552	176	124	ND	2,960

[‡] Results correspond to the second batch of analyses which were done in duplicate. The only exception was the sample containing the gas condensate mixed with MSWA/MSW, which was analyzed with the first batch of samples and only one analysis is available.

[a] In the first analyses, the extraction was not optimized to measure the low carbon PFAS (PFBA and PFPeA) and so these measured as non-detects for the gas condensate.

[b] The PFBS concentration for the gas condensate sample was above the limit of the calibration curve so the value listed is an estimate.

[c] The internal control sample for this sample was in error and so the value listed corresponds to the value without the correction for the internal control.

[d] Leachates that were treated on-site are shown in itallics.

[e] Not Detected.

II.3.2 Total PFAS Levels

Quality control samples showed that all trip blanks, field blanks, and analytical blanks were below the limits of detection, except for PFHxA, which was detected in the analytical blank at a factor of 10 below the limit of quantification. All calibration curves (ranges listed in methods section) were characterized by correlation coefficients (R^2 values) of 0.99 with the exception of the calibration curve for PFDA for which the R^2 value was 0.98 and for 5:3 FTCA for which the R^2 value was 0.91. Duplicate analyses of the standards were characterized by excellent precision with coefficients of variation of 2.4% on average.

Among the factors evaluated, landfill type appears to have the most significant impact on leachate total PFAS levels (sum of the 11 PFAS measured in the current study) (Figure II.2). To begin with, the ash leachate from facility D had the lowest levels of total PFASs (<3,400 ng/L) relative to other landfills that also contained predominantly ash ($p<0.001$). This landfill is a pure ash monofill with no integration of other waste types. Additionally, the incinerator temperature (930 to 980 °C) that produced the ash for this monofill was the highest among all the landfills that accepted ash. The MSWA landfills that received ash incinerated at intermediate temperatures (facility C, 815 to 870 °C) had intermediate levels of total PFASs, at 8,400 to 8,700 ng/L. The MSWA landfill that received ash incinerated at the lowest temperatures (facility A, 760 to 870 °C) had the highest total PFAS levels among the MSWA leachates, at 12,300 to 13,500 ng/L. The correlation between total PFAS and incineration temperature for the ash leachates was significant ($R^2=0.92$, $p<0.001$), with lower total PFAS concentration associated with an increase in incineration temperature (Figure II.3).

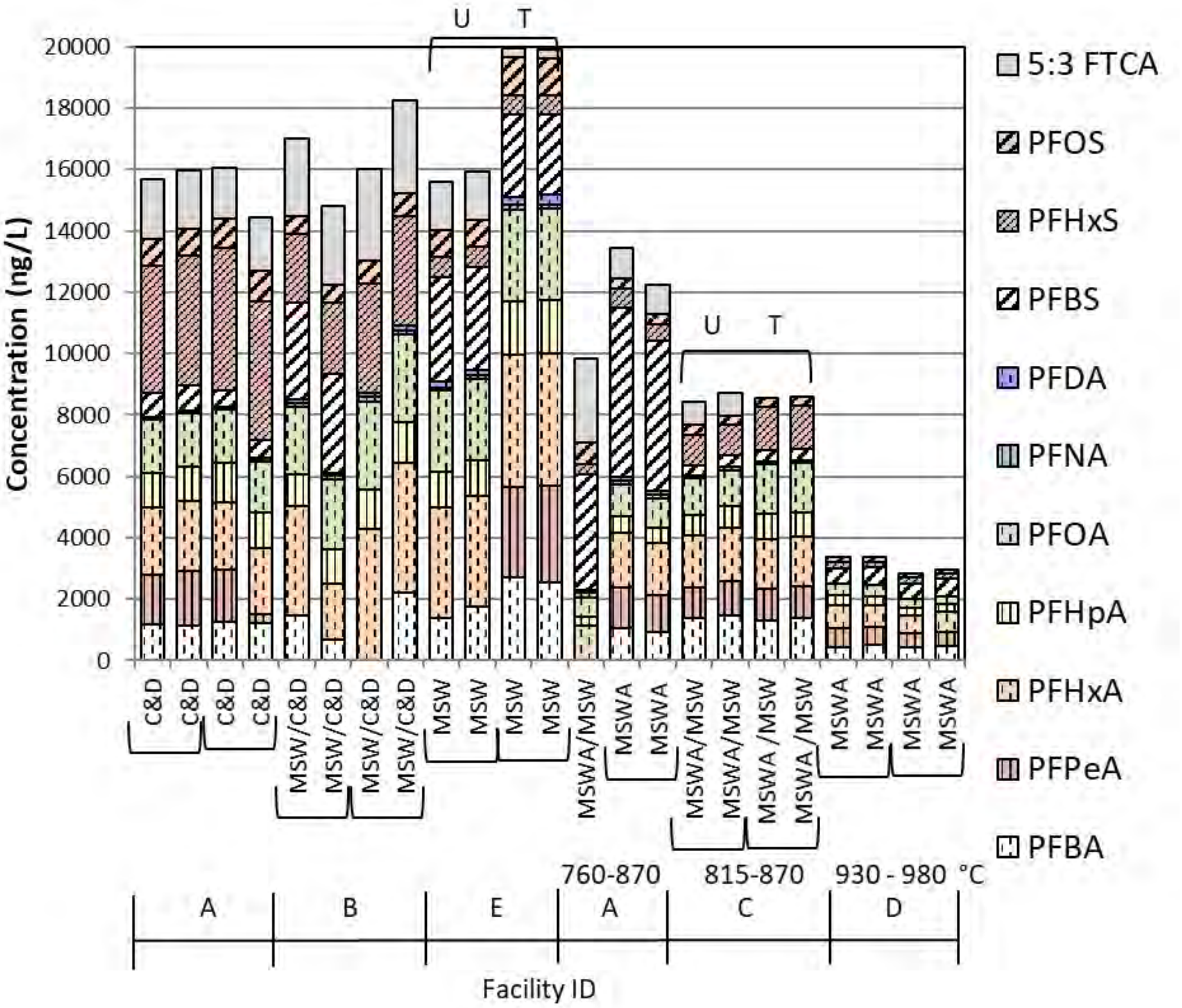

Figure II.2 Overall PFAS results for leachates collected from five facilities. All results provided in duplicate with the exception of the gas condensate sample. Brackets of 2 samples correspond to duplicates of the same leachate sample. The “U” and “T” set of samples correspond to untreated (U) leachates and the corresponding treated (T) effluents. The temperatures indicate the average operating temperature of the facility where the ash was generated.

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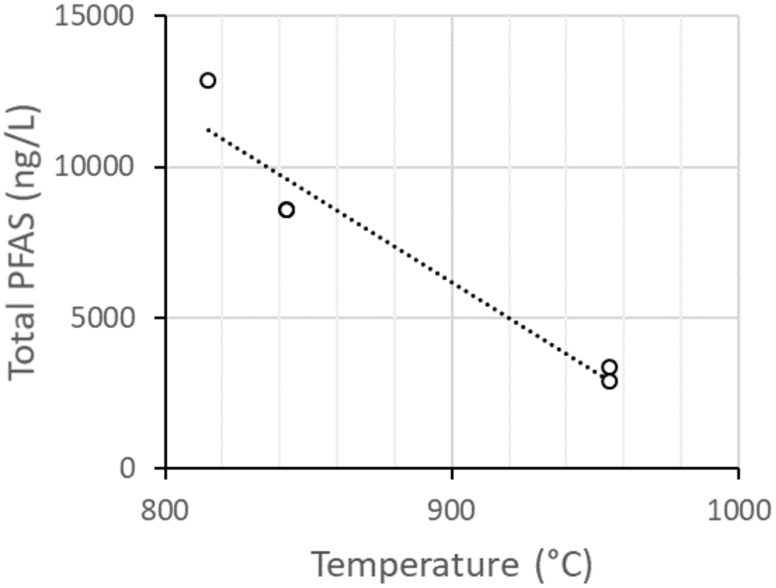

Figure II.3 Total PFAS in ash leachates versus incineration temperatures ($R^2 = 0.92$, $p < 0.001$)

This trend with incineration temperature is consistent with laboratory studies that have shown that PFASs are transformed within the 500 to 1000 °C range (Krusic et al. 2005, Yamada et al. 2005, Taylor et al. 2014, Merino et al. 2016). For example, Ellis et al. (2001) found that fluoropolymers at 500 °C decompose and rearrange to form halogenated organic acids and produce polyfluoro-(C3-C14) carboxylic acids. Garcia et al. (2007) found that at 850°C, C_2F_6 and CF_4 are formed. Feng et al. (2015) described a thermolysis mechanism for a perfluorosulfonic acid membrane that involved cleavage of both the polymer backbone and its side chains to produce perfluorocarboxylic acids. As such, the results observed in Figure II.2 are consistent with the transformation of PFASs to other species or to the partial destruction of PFASs during the waste incineration process. Further evidence of transformation is provided by evaluating the ratios of PFBA/PFOA and PFPeA/PFOA. These ratios were greater than one for all ash leachate samples (1.25 and 1.20, respectively) and less than one for MSW and C&D leachate samples (0.87 and 0.68, respectively) in the current study. It is possible that the higher incineration temperature resulted in more PFAS transformation towards shorter C-F chain species relative to the lower incineration temperature causing this shift in the proportions. Given the evidence from laboratory-based studies concerning the transformation of PFAS species, direct measurement of the exhaust gases from the waste-to-energy incinerators is warranted to confirm that PFASs in fact are being destroyed as opposed to being transformed or volatilized and lost to the atmosphere. This should be a priority for future studies.

Results also show that the GC sample also had unique characteristics. The GC sample originated from a leachate stream that was receiving predominantly MSWA (75%). This sample was the only one from the set that was analyzed during the first analysis round (January 2018) which did not capture the lower carbon chain alkylated PFASs (PFBA and PFPeA), suggesting that the total PFAS levels could have been higher than those shown in Figure II.2. Overall, the levels for the GC sample are consistent with the levels observed in the samples from facility A (MSWA, 98%) with the exception of the shorter chain PFASs. The intermediate total PFAS levels for the GC sample are consistent with the intermediate temperatures for the ash used for this particular site (right hand side of Figure II.2). With respect to PFAS species, the sample with the lowest total levels of measured PFASs (ash monofill leachates for facility D) had the lowest levels of all 11 individual PFAS species (<3,400 ng/L for the sum of all 11 species). Individual PFAS species for the ash leachates from facility A (two MSWA(98%) samples plus the GC sample) were also low with the exception of PFBS. PFBS were elevated for these three samples.

For the landfill cells that contained predominantly MSW or C&D, total PFAS concentrations were higher in comparison to the cells dominated by ash. The total PFAS concentration for the non-ash cells varied between 14,000 to 20,000 ng/L. The total PFAS levels between C&D (mean of 15,530 ng/L) and MSW landfill (mean of 15,730 ng/L) types were not statistically different (p=0.65). However, C&D and MSW leachates were statistically different from MSWA leachate (mean for MSWA of 7,490 ng/L) (p<0.001).

The finding that total PFASs levels in C&D and MSW leachates were similar is in contrast to studies by Gallen et al. (2016, 2017) who found that C&D leachates had higher levels of PFASs by about a factor of 3. In the current study the differences in total PFAS concentrations were not statistically different between the two landfill types. Similar leachate concentrations for C&D and MSW landfill cells indicates that C&D waste is releasing PFAS to leachate and could be a source of PFAS release to the environment.

With respect to leachate treatment, one treatment system resulted in an increase in PFAS concentrations (MSW(100%) at facility E, p=0.02) whereas the other (MSWA(65%)/MSW(35%) at facility C) did not result in total PFAS levels that were statistically different (p=0.99) between before and after treatment. The mean concentrations for facility E were 15,730 ng/L and 19,940 ng/L, before and after treatment, respectively. These results are consistent with studies at WWTPs (Arvaniti and Stasinakis 2015). For example, Bossi et al. (2008) found that levels of PFOA increased from values of 1-10 ng/L in the influent to 10-100 ng/L in the treated effluent. This increase has been attributed to the degradation of fluorinated precursors such as 8:2 FTOHs to form PFOA and 6:2 FTOH to form PFHxA (Xiao et al. 2012).

The treatment systems for facilities E and C were similar between the two landfills, both were dominated by aeration processes for ammonia removal, but the treatment process resulted in different outcomes. The difference in the efficacy of treatment could have been associated with waste type. Facility E treated 100% MSW leachate which resulted in an increase in PFAS levels. Facility C treated predominantly MSWA, the chemistry of which could have responded differently to the aeration process. The lower concentrations in the treated leachate from Facility C suggests that ash contains fewer precursors.

Given the conversion of PFASs within WWTP systems, more work is needed to track the fate of PFASs in leachates currently discharged from landfills. Four facilities included in the current study discharge their leachates to WWTPs, two after pretreatment and two without pretreatment. The practice of disposing leachates to WWTPs results in the increase in PFASs due to the conversion of precursors. The PFAS in the aqueous phase at WWTPs have been found to partition towards the solids phase or sludge which in turn can be land applied on agricultural areas (Washington et al. 2010). The disposal of leachate to WWTP can result in its distribution within the environment through sludge application or ultimate WWTP effluent disposal.

When evaluating correlations between total PFASs and physical-chemical parameters, different results were observed depending upon the parameter evaluated (Table II.2). The relationship between total PFASs and COD was not significant (R^2=0.004, p=0.83). However, a weak but significant relationship was observed between total PFASs and pH (R^2=0.55, p=0.006).

When evaluating the carboxylated PFAS species, the treated MSW leachate had the highest levels of each of the carboxylated PFAS from the shortest chain (PFBA, mean concentration of 2640 ng/L) to the longest chain (PFDA, mean concentration of 290 ng/L) measured. The only exception was PFNA where the treated MSW leachate (150 ng/L) was still elevated but not the highest level observed (159 ng/L) which corresponded to the GC leachate for facility A).

When comparing the levels of individual PFAS species to the national average (Lang et al. 2017), PFHxS was noticeably high (by over an order of magnitude, national average at about 350 ng/L) for the leachates observed in the current study. All C&D leachates measured in the current study had PFHxS concentrations that were above the national average (mean of 4,380 ng/L). Even for landfills with C&D mixed with MSW, the PFHxS concentrations were noticeably high (>2,200 ng/L) overall (Figure II.4), suggesting that the source may be associated with C&D types of waste. The elevated levels of PFHxS in C&D leachates are consistent with the use of PFHxS as a surfactant coating for carpets and other building materials (Jin et al. 2011). Such materials are commonly found in C&D waste and can serve as a possible source for the elevated PFHxS levels. An additional source of PFHxS has included AFFF. PFHxS has been found at fire-fighting facilities that use these materials during training activities (Bräunig et al. 2019).

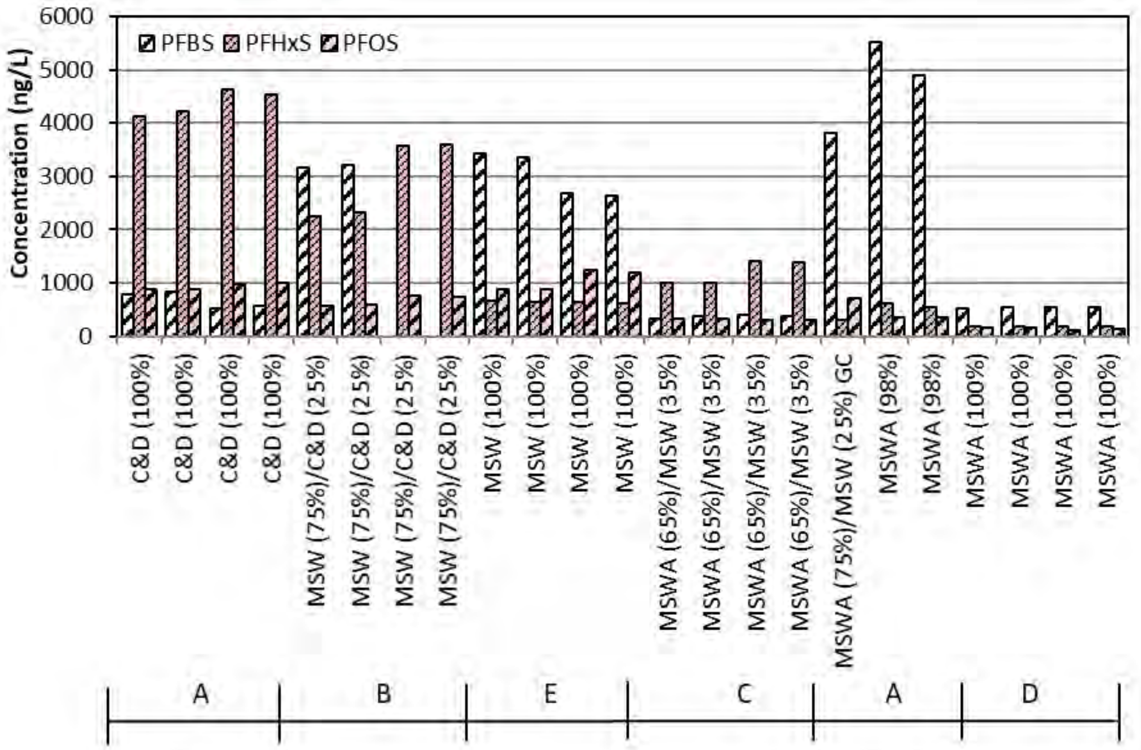

Figure II.4 Concentrations of sulfonic PFAS in different landfill types.

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Consistent with the findings in other studies (Lang et al. 2017, Allred et al. 2015), 5:3 FTCA was found to represent a major component of PFASs in untreated landfill leachate (400 to 1,500 ng/L in Lang et al.). Among the different leachate types, MSW in the current study had the highest levels of 5:3 FTCA (maximum of 3050 ng/L for facility B). Ash leachates had no measurable levels of 5:3 FTCA and treated leachates had lower 5:3 FTCA levels relative to untreated leachates (p<0.001). This difference is particularly evident for the MSW (100%) leachate where concentrations of 5:3 FTCA decreased by a factor of 5 (from 1600 to 310 ng/L, Figure II.5) after treatment. The lower values of 5:3 FTCA after treatment suggest a number of possibilities. The lower values can be due to volatilization, differential sorption, or the conversion of FTCA during the treatment process to other PFAS species, in particular to possibly PFAS species with the same five carbon chain backbone, PFPeA. For PFPeA (Figure II.5, bottom panel), a marked increase in this species was observed between untreated and treated C&D leachate. These results are consistent with studies that focused on transformation pathways in activated sludge WWTP processes (Wang et al. 2012, Xiao et al. 2012) that showed a conversion of PFASs from 5:3 FTCA to PFPeA during the treatment process. Similarly, studies specifically using landfill leachates have observed the loss of 5:3 FTCA during aeration in constructed wetland systems (Yin et al. 2017). Given the evidence of this conversion, of interest would be to evaluate the influence of aeration conditions (temperature, time, air flow rates) on the transformation of PFAS species. Future studies should include an evaluation of additional PFAS precursors and the possibility of their conversion to PFAS species.

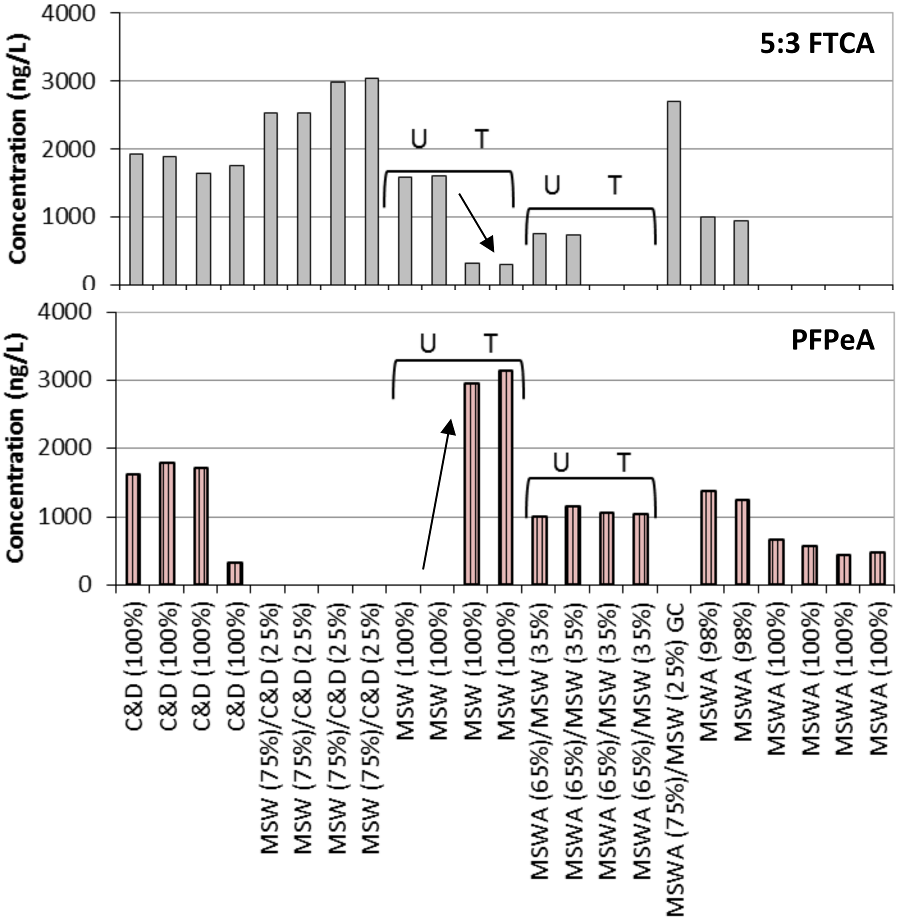

Figure II.5 Levels of 5:3 FTCA (top panel) and PFPeA (bottom panel) in different types of landfill leachate. A significant increase in PFPeA is observed between untreated and treated C&D leachate suggesting a transformation of 5:3 FTCA to this species during landfill leachate treatment.

However, the increase in PFPeA was not observed for the untreated and treated MSWA(65%)/MSW(35%) leachate. Among the MSWA leachates, the GC sample had particularly high levels of 5:3 FTCA especially when compared to the MSWA from the same facility (outlier at 90% confidence limit). The notable difference between this sample and the other MSWA samples is the presence of gas condensate, suggesting that perhaps the condensate may serve as reservoir for this species of PFAS. This is especially notable given that other studies have found that fluorotelomer alcohols tend to be semi-volatile (Hamid et al. 2018).

Among the PFASs for which U.S. EPA health advisories have been issued (PFOS and PFOA), levels were 2 to 9 times higher in the current study in comparison to other studies conducted at MSW landfills in the U.S. (Huset et al. 2011, Lang et al. 2017) and in European countries (Fuertes et al. 2017, Busch et al. 2010). However, the concentrations were lower in comparison to landfill leachates measured in China (Yan et al. 2015). The treated MSW leachate samples were observed to have the highest PFOA level (~3000 ng/L) and the highest PFOS level (~1200 ng/L) (Figure II.6). These results are consistent with the predominance of PFOA and PFOS in treated wastewaters (Kwon et al. 2017) which showed a total PFAS concentration of 111 ng/L which is over an order of magnitude more dilute than the PFAS levels observed in leachates. Notably these PFAS species were observed in all leachates even for the oldest landfill (39 years) suggesting that PFOA and PFOS are still in the environment, with landfills serving as a significant concentrated sources to aqueous systems.

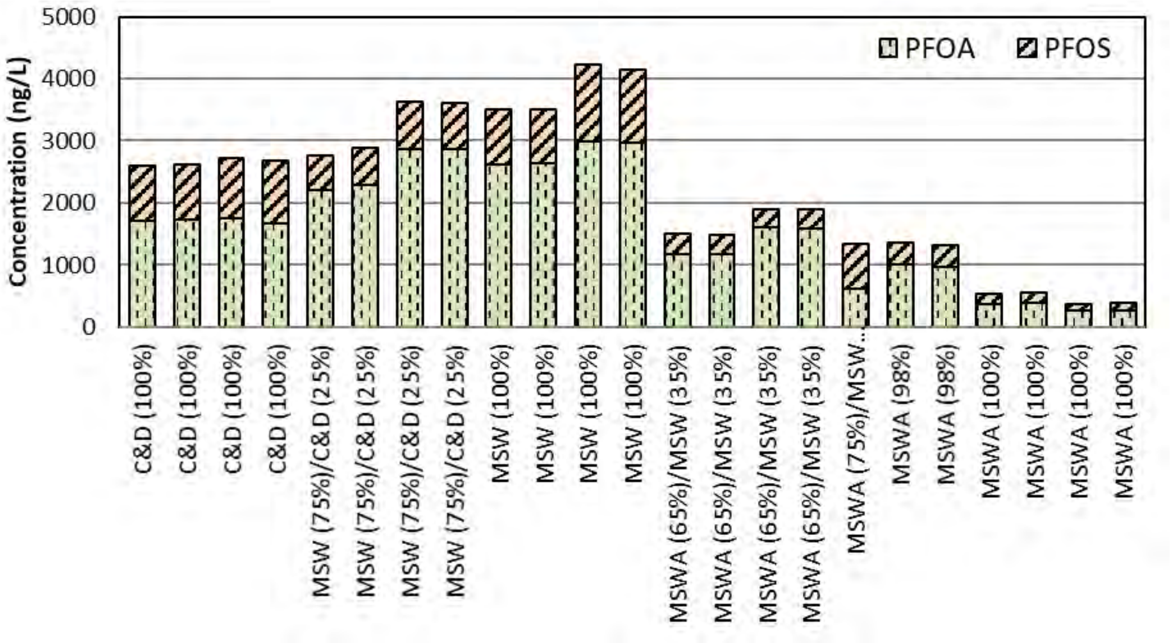

Figure II.6 Levels of PFOS and PFOA in different types of landfill leachate.

Interestingly overall, the 8 carbon species (PFOA and PFOS) were not the most abundant species (Figure II.7). The 6 carbon species in both the carboxylated (PFHxA) and sulfonic (PFHxS) species were the most abundant. Of interest would be to evaluate health-based regulatory guidelines for PFHxA and PFHxS given their higher abundance.

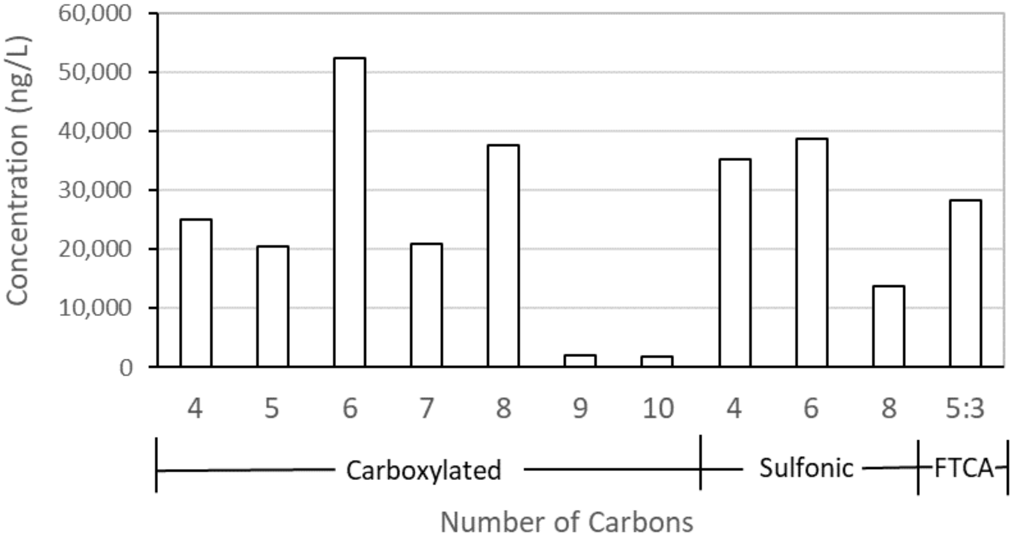

Figure II.7 Sum of PFAS species for all samples collected, organized by functional groups of carboxylated, sulfonic and FTCA and by number of carbon in the carbon-fluorine chain.

One facility included in the current study disposed its leachate to deep well injection. The fate of PFASs through deep well injection is not known, as is the overall long-term impact of this practice. The impacts of deep well injection of landfill leachates on PFASs environmental distributions should also be evaluated further.

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CHAPTER III

SUMMARY AND CONCLUSIONS

EXHIBIT 1

CHAPTER III

SUMMARY AND CONCLUSIONS

III.1 SUMMARY AND CONCLUSIONS

Overall this study showed that leachates from ash landfills had lower levels of PFAS relative to leachates from MSW and C&D landfills. The degree to which the PFAS levels decreased was correlated with incineration temperatures used to generate the ash. This is the first time that MSWA was measured from field-scale landfills and also the first time that the leachates from field-scale MSWA leachates were correlated with the incineration temperature of the waste. Total PFAS levels in C&D and MSW leachates were observed to be at similar concentrations, indicating that wastes in C&D landfills could also serve as a source of PFAS release to the environment. Additionally, C&D leachates exhibited unusually high levels of PFHxS, consistent with their use as sealants and water repellants in building materials, emphasizing the need to evaluate leachates from all waste types. As observed in other studies, treatment using aeration processes increased PFAS levels. Additional work is needed to confirm trends and to establish a mass balance analysis to determine removals of PFAS from the environment through leachate treatment.

III.2 IMPLICATIONS FOR SOLID WASTE INDUSTRY

The levels of PFOA plus PFOS in MSW and C&D leachates is on the order of 3,000 ng/L which is significant when compared to the EPA regulatory guideline level of 70 ng/L for drinking water. Given the high values in landfill leachates, efforts should focus on protecting drinking water supplies from potential leachate impacts via processes that treat for PFAS.

The finding that lower levels of total PFAS in MSWA is significant. If the PFAS are destroyed in the incineration process, one “treatment” option would be to increase the temperature of existing incineration facilities to facilitate the destruction of PFAS. But first, it must be shown the PFAS are destroyed instead of being converted from one form to another in the incineration process.

Results also suggest that aeration treatment for ammonia removal is not effective at removing PFAS from landfill leachate. In this study, leachates at two treatment facilities were evaluated. The treatment systems were both designed for ammonia removal via aeration, one was a continuous flow through system and the other was a batch reactor. The continuous flow through system treated leachate that consisted primarily of MSWA. The batch reactor treated predominantly MSW leachate. Results show that the levels of targeted PFAS species in MSW leachate from the continuous flow through system did not change with effluent concentrations similar to influent concentrations. For the batch reactor, the concentration of PFAS increased in the effluent (after treatment) presumably due to the conversion of PFAS precursors in the untreated leachate sample.

III.3 RECOMMENDATIONS

Results from this study serve as a starting point for assessing landfill leachates in the State of Florida. The finding that MSWA had lower total PFAS levels should be further evaluated to determine if the lower levels are due to destruction of PFAS as opposed to conversion to a PFAS form that was not measured. More samples should be collected to evaluate the influence of incineration temperature on PFAS species, as incineration may serve as one alternative for the removal of PFAS from the environment. Research on “incineration” treatment should also include a study of the quality of emissions from the incineration facility to assure that PFAS are not being spread through atmospheric routes.

Further study should be conducted to evaluate whether other leachate treatment strategies are effective at removing PFAS. In this study aeration was found to not be effective at decreasing PFAS levels in leachate. Other potential landfill treatment strategies should be evaluated including the potential for granular activated carbon and reverse osmosis to remove PFAS from landfill leachate.

III.4 PRACTICAL BENEFITS FOR END USERS

This study will be useful to waste managers as well as legislators in the State of Florida when making decisions about the disposal and treatment of landfill leachate that may be contaminated with PFAS. Of significance is that C&D leachates have similar levels of total PFAS as MSW leachates. MSWA had the lowest levels of total PFAS. This information can be used to identify strategies to minimize the impacts from PFAS products found in landfills.

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August 8, 2019

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RE: S.1507 - PFAS Release Disclosure Act

Dear Ms. Ledezma,

The American Water Works Association has compiled the following information in response to your information request. The following is preliminary, reflecting the need to gather information quickly so as to be timely and useful to the Congressional Budget Office's work.

AWWA focused on responding to the following questions:

1. How would bill S. 1507 affect private and public water systems, state, local and tribal governments?
    a. setting new monitoring and testing processes (if needed)
        i. testing, monitoring, and reporting new requirements to the Safe Drinking Water Act including collecting samples, training personnel, reporting.
    b. remediation costs, including
        i. new treatment technology to remove substances
        ii. new personnel
        iii. training personnel
    c. coordination with nearby industries that may release the contaminants

2. Where is there a recent report estimating testing and data collection costs relevant to S. 1507?

The questions posed do not address the public health benefits associated with the control of per- and polyfluoroalkyl substances (PFAS). We would refer you to the Office of Groundwater and Drinking Water at the U.S. Environmental Protection Agency for assistance estimating the benefits of S. 1507 requirements.

EXHIBIT 2

As you will see in the attached several EPA documents can be referenced in estimating the administrative burden and monitoring and reporting requirements associated with the S.1507. There are a number of data gaps associated with estimating the cost of drinking water treatment associated with the legislation. The attached includes a discussion of the information sources and considerations for such an analysis. AWWA also prepared a preliminary estimate to illustrate the analysis that is feasible with available information, particularly recognizing the limited time available to your office to prepare an estimate.

- Depending on how the legislation is finalized we found the potential capital costs associated with implementing drinking water treatment to remove perfluorooctanoic acid (PFOA); and perfluorooctane sulfonic acid (PFOS) in drinking water to quickly exceed $3 billion and, if federal implementation were to mirror the direction of state-level efforts, capital costs would exceed $38 billion.
- In addition to debt service, recurring annual operation and maintenance (O&M) costs reach $150 million, and could reach $1.3 billion for a drinking water maximum contaminant level (MCL) for PFOA and PFOS.
- There is the potential, given the limited understanding of PFAS removal that a treatment standard would be based on reverse osmosis and entail more than $530 billion in capital investment and over $16 billion in annual O&M costs.

In preparing this analysis we were not able to adequate represent all consequences of the legislative text, e.g.,

- Community-level response, including the addition of water treatment, in response to health advisories for PFAS as described in S.1507
- Loss of water supply and associated water system resiliency
- Implications for state revolving loan fund allocation
- Availability of funds for other infrastructure investments like implementation of the Long-Term Lead and Copper Rule.

Please see the attached responses to the questions posed in the attached. An extract of the relevant S.1507 legislative text is also included for reference.

If you have any questions regarding the attached, please contact Steve Via or Chris Moody at (202) 628-8303.

Best regards,

G. Tracy Mehan, III

G. Tracy Mehan, III
Executive Director for Government Affairs
American Water Works Association

EXHIBIT 2

cc: Jennifer McLain, EPA/OW/OGWDW
Andrew Hanson, EPA/IGA

Who is AWWA

The American Water Works Association (AWWA) is an international, nonprofit, scientific and educational society dedicated to providing total water solutions assuring the effective management of water. Founded in 1881, the Association is the largest organization of water supply professionals in the world. Our membership includes more than 4,000 utilities that supply roughly 80 percent of the nation's drinking water and treat almost half of the nation's wastewater. Our 50,000-plus total membership represents the full spectrum of the water community: public water and wastewater systems, environmental advocates, scientists, academicians, and others who hold a genuine interest in water, our most important resource. AWWA unites the diverse water community to advance public health, safety, the economy, and the environment.

EXHIBIT 2

ATACHMENT 1. RESPONSES TO QUESTIONS POSED

How would bill S. 1507affect private and public water systems, state, local and tribal governments?

Under the Safe Drinking Water Act (SDWA), there is no distinction between private and public water systems. All are treated the same. In either instance, the cost of implementing federal requirements are passed on directly to ratepayers. Relevant SDWA definitions (42 U.S. Code § 300f. Definitions) include:

> Public Water System -- "The term "public water system" means a system for the provision to the public of water for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals. …"
>
> Community water system (CWS)– "means a public water system that—(A) serves at least 15 service connections used by year-round residents of the area served by the system; or (B) regularly serves at least 25 year-round residents."
>
> Noncommunity water system (NCWS)– "a public water system that is not a community water system."

Note that standards set under SDWA do not apply to individual, household wells.

CWSs may be operated by local government (e.g., a village, town, city, county), a creature of local government (e.g., a public service authority), or a creature of the state (e.g., Massachusetts Water Resource Authority). Local government may also contract or sell the operation of water infrastructure to a private utility (e.g., a for-profit company, non-profit cooperative, etc.). In any of these instances, local government is directly or indirectly engaged in oversight of the CWS.

Based on data from the Safe Drinking Water Information System (SDWIS), 46% of CWSs are privately owned. Importantly the majority of those CWSs that are privately owned serve less than 500 persons. These CWSs may be subdivisions, manufactured home communities, public housing developments or apartment buildings that have their own water system. These CWSs would, like municipally-based systems, pass the cost of regulatory implementation on to the year-round residents, if not through rates, through other fee / cost mechanisms.

Seventy percent of Non-transient NCWSs (NTNCWSs) are privately owned reflecting the nature of NTNCWSs (e.g., schools, factories, office buildings, and hospitals which have their own water systems). These NTCWSs would incorporate the cost of compliance into their operating budgets, passing those costs on as necessary. For example, in the case of public schools these costs come back to local government budget processes.

While states may own / operate water systems that are regulated under SDWA, the primary burden on states is the oversight of rule implementation. Implementation of SDWA is delegated to states and some

EXHIBIT 2

tribes also implement SDWA. EPA provides direct implementation in the District of Columbia, Wyoming, and U.S. territories. Oversight entails:

1. Changing appropriate state regulations to incorporate and implement the new federal requirements (such changes can require state legislative action)
2. Modifying existing data systems in collaboration with EPA to track compliance
3. Informing systems of compliance obligations
4. Supervising system compliance strategies including construction of capital facilities
5. Processing of compliance monitoring data and PWS reports (e.g., monthly operating reports)
6. Modification and execution of sanitary surveys and other mechanisms used to ensure compliance (beyond monitoring compliance data)
7. Modification of operator certification testing
8. Ensuring that training is available to support operator certification
9. Directing state capacity assistance programs and associate support programs to assist systems (typically small systems) with compliance challenges

The Association of State Drinking Water Administrators has prepared a recent analysis of state oversight program costs for potential revisions to the Lead and Copper Rule. While that analysis does not directly address the cost of implementing a new MCL it does illustrate the nature of rule implementation. The study, Costs of States' Transactions Study (CoSTS) For Potential Long-Term Revisions to the Lead and Copper Rule (LT-LCR) (April, 2018) is available at https://www.asdwa.org/wp-content/uploads/2018/05/CoSTS-Report-Final-2018.pdf.

Section 5 of EPA's Health Risk Reduction and Cost Analysis of the Proposed Perchlorate National Primary Drinking Water Regulation illustrates the burden of rule implementation (May 2019, EPA 816-R-19-004, (EPA-HQ-OW-2018-0780-0124), Available at https://www.regulations.gov/document?D=EPA-HQ-OW-2018-0780-0124). In referencing this material, note that perchlorate in an inorganic contaminant within the SDWA Standard Monitoring Framework and consequently less frequent monitoring requirements apply.

Number of Systems to Consider in Evaluating Treatment and Monitoring Costs

The number of impacted systems is based on data available from SDWIS. If previous rules offer insight into implementation of S. 1507 requirements, then provisions are likely applicable to both CWSs and NTNCWSs. There are 49,678 CWSs and 17,558 NTNCWSs that are currently identified as active in SDWIS, which would likely be required to comply with regulatory requirements under S.1507 provisions and thus undertake monitoring and potentially incur the cost of additional drinking water treatment.

Number of CWS and NTNCWS by System Size

Size Category	Population Range	System Count		
		CWS	NTNCWS	Total
1	0–100	11,788	8,456	20,244
2	101–500	15,207	6,465	21,672
3	501–1,000	5,342	1,569	6,911
4	1,001–3,300	7,999	874	8873
5	3,301–10,000	4,994	154	5148
6	10,001–50,000	3,343	38	3381
7	50,001–100,000	567	1	568
8	100,001–1,000,000	414	1	415
9	> 1,000,001	24	0	24
	Total	49,678	17,558	67,236

More detailed population category breakdowns are available through SDWIS.

Roughly 15% of CWS and NTNCWS are consecutive systems. That is, they purchase water from another water system. This is an important distinction for estimating the impacts of legislative action in that:

1. All water systems must comply with SDWA provisions independently (every PWS stands alone when it comes to compliance).
2. All water systems subject to a rule must conduct the associated monitoring.
3. When a new requirement takes effect, water systems must evaluate how best to comply, it may be that:
    a. The wholesale water system supplying water to a consecutive system does not have elevated contaminant levels warranting treatment.
    b. The wholesale system must install treatment and pass that cost on to its own customers and it wholesale accounts.
    c. The combination of supplies available to the consecutive system are such that it must install treatment itself, build / utilize an intertie with an alternative wholesale system, or develop a new source of supply.
    d. The consecutive system’s customers are best served by consolidating with another water system in order to comply.

Regardless of whether a wholesale system or the consecutive system constructs additional treatment facilities to comply with requirements, additional treatment capacity is required to meet the water supply demand of all of impact system’s service population.

Number of CWS and NTNCWS by Source of Supply

Size Category	Population Range	Ground Water	Surface Water	Purchased
1	0–100	18,656	555	1,015
2	101–500	18,268	745	2,648
3	501–1,000	5,214	368	1,325
4	1,001–3,300	5,796	931	2,143
5	3,301–10,000	2,716	977	1,454
6	10,001–50,000	1,321	978	1,082
7	50,001–100,000	157	221	190
8	100,001–1,000,000	72	246	97
9	> 1,000,001	2	21	1
	Total	52,202	5,042	9,955

Note – Incomplete information in SDWIS leads to discrepancies in totals.

Where is there a recent report estimating testing and data collection costs relevant to S. 1507?

S. 1507 includes two different sampling requirements:

1. Expansion of Unregulated Contaminant Monitoring to include all PFAS for which there is an analytical method and
2. Monitoring to support implementation of the required primary drinking water standard for PFAS.

There are a number reference documents CBO should be aware of with respect to estimating the federal, state and system level costs associated with monitoring. Those references include:

1. Information Collection Request Summaries for the Unregulated Contaminant Monitoring Rule
    a. Statistical Design and Sample Selection for the Unregulated Contaminant Monitoring Regulation (1999), August 2001, EPA 815-R-01-004 (EPA-HQ-OW-2009-0090-0131), (Available at https://www.regulations.gov/document?D=EPA-HQ-OW-2009-0090-0131)
    b. Information Collection Request Renewal for the Unregulated Contaminant Monitoring Rule (UCMR 3), March 2012, (EPA-HQ-OW-2009-0090-0143) (Available at https://www.regulations.gov/document?D=EPA-HQ-OW-2009-0090-0143)

   c. Information Collection Request Renewal for the Unregulated Contaminant Monitoring Rule (UCMR 4), EPA 815-B-15-003, November 2015. (EPA-HQ-OW-2015-0218-0056) Available at (file:///C:/Users/svia/Downloads/EPA-HQ-OW-2015-0218-0056%20(1).pdf)

2. Information Collection Request Summaries for the SDWA Inorganic Contaminant Rule

   a. Information Collection Request (ICR): Disinfectants/Disinfection Byproducts, Chemical, and Radionuclides Information Collection Request, April 2004 (EPA-HQ-OW-2004-0009-0002) Available at file:///C:/Users/svia/Downloads/EPA-HQ-OW-2004-0009-0002.pdf

   b. ICR History is available at https://www.reginfo.gov/public/Forward?SearchTarget=PRA&textfield=+2040-0204

Unregulated Contaminant Monitoring Rule Monitoring
Section 2021 of the America's Water Infrastructure Act of 2018 (P.L. 115-270, Available at https://www.congress.gov/bill/115th-congress/senate-bill/3021?q=%7B%22search%22%3A%5B%22Public+Law+115%5Cu2013270%22%5D%7D&s=7&r=1) requires EPA, if funds are available, to collect data from all public water systems serving more than 3,300 persons and a statistically valid sample of smaller systems in future UCMR cycles. There is parallel text with respect to UCMR monitoring in S. 1507 for the required PFAS monitoring. EPA-HQ-OW-2009-0090-0131 provides an explanation of the statistical basis for the UCMR sampling. All public water systems (PWS) serving more than 10,000 persons incur all UCMR monitoring costs while EPA is to fund sampling, analysis, and related shipping (e.g., bear the cost of monitoring). If implemented as drafted, the cost of this provision would be in addition to monitoring costs for the fifth round of UCMR monitoring rather than a component of UCMR5.

The implication of this guidance as discussed by EPA at its July 16, 2019, UCMR5 stakeholder meeting is that future UCMRs will involve sampling from all public water systems serving more than 3,300 persons (9,512 systems) and a sample of more than 800 systems serving less than 3,300 persons.[1] Whether additional federal funding will be available to extend monitoring to include these 5,147 water systems is unknown. Past UCMR implementation costs are captured in a few specific tables in the EPA information collection request justifications:

- EPA-HQ-OW-2009-0090-0143 illustrates the cost burdens associated with UCMR monitoring for PFAS under UCMR3. EPA-HQ-OW-2015-0218-0056 illustrates cost burdens for the current UCMR4 cycle but does not specifically include monitoring for PFAS compounds.
- Exhibit 7 and 8 in EPA-HQ-OW-2004-0009-0002 summarize the burden of ongoing monitoring under SDWA including the Volatile Organic Compound and Synthetic Organic Contaminants monitoring which would be models for monitoring to support PFAS MCLs.

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[1] The presentation materials are not yet posted to the EPA UCMR website but are anticipated in the near future (https://www.epa.gov/dwucmr/unregulated-contaminant-monitoring-rule-ucmr-meetings-and-materials).

During the UCMR5 stakeholder meeting in July EPA indicated that it would have two PFAS analytical methods available (EPA Method 537.1 and 533). Method 537.1 is currently available for use; Method 533 is still in development, consequently cost and performance information is incomplete at this time.

The cost of implementing UCMR at the federal, state, and water system level is a five-year endeavor. While the direct costs associated with monitoring occur over a three-year window, there is a year of pre-monitoring preparation, and for EPA, states, and some systems a final year of data quality control and report generation. It is likely that the costs of expanding the current program to the larger sample as directed in AWIA / S.1507 will require additional investment in federal and state personnel, contractor support, and improvement of data systems, above and beyond extrapolation of the current implementation costs to 5,147 more systems.

Compliance Monitoring

Currently, requirements for monitoring regulated VOCs and SOCs adhere to the SDWA "Standard Monitoring Framework." The monitoring framework is summarized in two documents:

1. Standard Monitoring Framework, February 1991. (EPA 570/F-91-045) (Available at https://nepis.epa.gov/Exe/ZyPDF.cgi/10003I17.PDF?Dockey=10003I17.PDF)
2. The Standardized Monitoring Framework: A Quick Reference Guide, March 2004, (EPA 816-F-04-010) (Available at https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=3000667K.txt)

Important elements to reflect in costing compliance monitoring for PFAS include:

1. Costs are likely to be borne by all CWS and NTNCWS (i.e., approximately 67,236 systems).
2. The cost of monitoring of analytical methods like EPA Method 537.1 is as much as $500 per sample (EPA Method 537.1 would be adequate to support PFOA an PFOS monitoring; it could also support monitoring other PFAS for which EPA is preparing risk assessments).
3. Sample costs are by entry-point-to-the distribution system, not water system. Most water systems have multiple EPTDSs. EPA has a standard table of EPTDS/system as a function of system size based on the Community Water System Survey (last published in 2009, Available at https://www.epa.gov/dwstandardsregulations/community-water-system-survey). See following table.

Number of EPTDS and Associated Design Flows as a Function of System Size

Size Category	Population Range	Entry Points/ System	Design Flow from each Entry Point (gpm)
1	0–100	2.4	5
2	101–500	2.0	35
3	501–1,000	2.1	82
4	1,001–3,300	1.9	252
5	3,301–10,000	2.2	657
6	10,001–50,000	3.1	2,027
7	50,001–100,000	4.1	3,767
8	100,001–1,000,000	6.6	16,283
9	> 1,000,001	14.5	19,906

4. As described in EPA 816-F-04-010 it is possible for systems to be allowed to take smaller numbers of samples over time, but at a minimum sampling is quarterly for the initial three years of sampling. At which time the system may be eligible for reduced monitoring at the primacy agency's discretion. In current practice, detection of a contaminant means that sampling will be ongoing on at least an annual basis and observation at levels closer to the MCL warrant more regular monitoring. There is variability in burden as a function of system size and whether the supply is groundwater or surface water. Groundwater is generally judged to be less variable over time than surface water, so reduced monitoring is available more rapidly.
5. The EPA summary of current compliance monitoring costs reflect ongoing mature monitoring costs, where there are monitoring waivers or reduced monitoring in place, rather than reflecting start-up monitoring.
6. The fact sheet, Per- and Polyfluoroalkyl Substances (PFASs) Monitoring, Sampling, and Analysis (July 2019, Available at https://www.awwa.org/LinkClick.aspx?fileticket=ufb-Vl3VrVY%3d&portalid=0) provides a brief overview of PFAS analytical methods.

New Treatment Technology to Remove Substances

S. 1507 directs EPA to regulate perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). It also directs EPA to evaluate a regulatory option where a measure of total PFAS is employed.

The national cost of a regulation for PFAS will vary significantly based on two regulatory decisions: (1) the specific PFAS that are included in the regulation and (2) the maximum contaminant levels (MCLs). These two factors will determine the number of systems that are impacted as well as the treatment objectives of the facilities, which may require different, or multiple, types of treatment technology for compliance.

Should EPA finalize risk assessments for additional PFAS, six such assessments are underway, then these too would lead to addition of drinking water treatment in some communities. There is not enough information from these risk assessment processes, treatment studies, and occurrence data to adequately inform the current effort. Several of these PFAS are less amenable to drinking water treatment than PFOA and PFOS.

Approach to Preparing Preliminary Cost Estimation

AWWA prepared an illustrative national cost analysis using available information to demonstrate both the challenges of developing such an analysis and the policy relevance of an estimate. The following cost estimate is based on:

1. Data from Safe Drinking Water Information System (SDWIS) to determine the number of systems in each size category.
2. Water Treatment Plant design flows and numbers of treatment facilities per water system size category as utilized by EPA in its cost analyses. (see above table).
3. Initial capital cost and recurring annual operation and maintenance (O&M) costs from representative projects with similar treatment technologies and/or with the objective of PFAS removal. Data was used to develop cost models to project these costs based on the water system size. Cost data was collected for treatment processes relevant to PFAS including activated carbon, ion exchange and reverse osmosis. These processes were considered since they are the most studied, and most effective, processes for removing PFOA and PFOS. It is important to note that these treatment processes have more limited research on removal of other PFAS and typically have varying degrees of removal success based on the individual PFAS in the drinking water.
4. PFAS monitoring data from the Third Unregulated Contaminant Monitoring Rule, which was used along with SDWIS data to determine the number of water systems in each size category that would be impacted by potential PFAS regulations of 20 ppt, 40 ppt, and 70 ppt. Importantly, these estimates are based on occurrence data for PFOA and PFOS, not all PFAS, in public water systems.

In the rulemaking process, EPA will prepare a more detailed cost analysis. When EPA conducts its analysis, its practice is to estimate the number of systems that are likely to be triggered to install treatment and to forecast the distribution of treatment technologies that will be applied (e.g., x percent will utilize granular activated carbon, y percent will utilize ion exchange). Because such forecasts require more information than is currently available the best option for a planning level national cost estimate is to represent the national cost assuming all systems used a particular technology (e.g., all systems used GAC, all systems used IX, all systems used reverse osmosis). EPA will also be better positioned to take into account the impact of individual state regulations on the number of water systems that will make treatment changes to comply with requirements resulting from S.1507.

While the treatment technologies used for this estimate are well known, their applicability on PFAS is still a topic of active research. The choice of a particular technology, or combination of technologies, is not only dependent on treatment objectives for PFAS but also the system's existing facilities, other treatment objectives or requirements, and the characteristics of the water they are trying to treat. As noted above, the costs reflected here are for treatment based on PFOA and PFOS occurrence, not the level of treatment required. Some PFAS are not as readily removed as others leading to more rapid breakthrough of GAC and IX media, consequently some systems may have more expensive treatment processes based on the need to replace media more often. Setting individual compound treatment goals at lower

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concentrations or summing more compounds within a single numeric limit has a similar effect – necessitating more frequent replacement of the media.

National Capital Cost to Install Treatment

Treatment Objective	Capital Costs ($ millions)		
	Granular Activated Carbon	Ion Exchange	Reverse Osmosis
< 70 ng/L	$2,100 - $4,400	$1,900 - $4,100	$5,700 - $12,000
< 40 ng/L	$5,600 - $12,000	$5,400 - $12,000	$15,000 - $33,000
< 20 ng/L	$23,000- $50,000	$22,000 - $48,000	$63,000 - $140,000
Treatment Technique	$140,000 - $290,000	$130,000 - $280,000	$370,000 - $800,000

National Annual Operating and Maintenance Cost for Installed Treatment

Treatment Objective	**Annual Recurring Costs ($ millions)**		
	Granular Activated Carbon	Ion Exchange	Reverse Osmosis
≤ 70 ng/L	$44 - $90	$210 -$460	$190 - $410
≤ 40 ng/L	$110 - $240	$540 - $1,200	$480 -$1,000
≤ 20 ng/L	$460 - $980	$2,200 - $4,800	$2,000 - $4,200
Treatment Technique	$2,700 - $5,800	$13,000 - $28,000	$12,000 - $25,000

In describing treatment costs, it is important to consider both capital and O&M costs. When making site-specific treatment decisions water systems will try to achieve reliable treatment while managing project life-cycle costs, and do so with a margin of safety. Consequently, in some scenarios what in general looks like the least cost option will not be the most effective investment for a given water system. Because investments in advanced treatment are long-term investments, uncertainty in treatment objectives leads to conservatism beyond simply assuring reliable compliance with an MCL; this too leads actual system improvements toward consideration of more conservative treatment goal, use of multiple unit operations and selection of more expensive treatment technologies.

As noted above, the treatment objective is a significant determinant of cost. The above tables illustrate four different regulations. These national estimates are a function of the number of systems estimated to require additional treatment based on combined PFOA and PFOS levels exceeding the regulatory limits. While we have information from UCMR 3 and state level efforts, which can be used estimate the occurrence of PFOA and PFOS, there is not an analysis of the occurrence of PFAS as a class, or a surrogate measure of PFAS. The above estimates based on treatment objectives of 70, 40, and 20 ng/L reflect reported UCMR occurrence data and subsequent re-analysis of UCMR data. The final row in the table reflects a duty by all CWS and NTNCWS to meet a treatment standard. This is a regulatory approach that is used when an adequate analytical method is not available for a contaminant.

As noted above, EPA has a duty under SDWA to prepare a sound benefit-cost estimate for a rulemaking, that estimate will need to overcome significant limitations in the above analytical approach by:

1. Being based on demonstrated removal efficiencies for all of the target contaminants.
2. Forecasting the distribution of treatment technologies taking the actual target contaminants and water matrix effects into account.
3. Incorporating the additional SDWA treatment requirements associated with adding advanced treatment to what are now small groundwater systems without treatment.

EPA will also be better able to take into account consequences of this and other legislative actions. To the extent that state or federal legislation action impacts (1) stack emissions from GAC regeneration (e.g., controls on stack emissions), (2) requires disposal of GAC or IX media as hazardous waste, or (3) restricts the release of PFAS through NPDES permits, those costs will need to be incorporated into the cost of drinking water treatment. The costs associated with residual stream management can be quite significant. While data is not available for PFAS, analyses conducted to inform the California Hexavalent Chromium MCL process demonstrate the impact of residuals management on treatment option selection and implementation costs.[2] To the extent that compliance is reliant on technologies like reverse osmosis, in the absence of significant technological advances, brine disposal for many communities relies on disposal in Underground Injection Control program wells.

Note that as the CBO request included a specific query on administration and monitoring costs, the above treatment costs do not include either – they are simply a planning level estimate (i.e., -30% /+50% estimate for the cost of implementing necessary treatment facilities to address PFAS in drinking water systems. A cost estimate should also consider the following financial implications due to the new regulations with respect to system resiliency, e.g.,

- If, and how, the investment in treatment might increase, or decrease, protection against other likely water quality risks?
- To what degree will available water supplies be reduced (e.g., water supply wells taken off-line, impacts on ongoing aquifer storage and recovery programs, creation of brine streams, etc.)?
- How will the treatment investment impact funding availability for other infrastructure investments like implementation of the Long-Term Lead and Copper Rule?

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[2] Arcadis. Final Report – Hexavalent Chromium Treatment Residuals Management, March 27, 2012, (Prepared for the Association of California Water Agencies and the City of Glendale Water and Power.
Chad J. Seidel, Issam N. Najm, Nicole K. Blute, Christopher J. Corwin, XueyiNg Wu, National and California treatment costs to comply with potential hexavalent chromium MCLs, Journal AWWA, First published: 01 June 2013 https://doi.org/10.5942/jawwa.2013.105.0080.

ATTACHMENT 2. REFERENCES FOR TREATMENT COST ESTIMATE

PFAS Treatment Project References for Treatment Cost Estimate

Facility	Treatment Capacity	Treatment Option	Capital Cost Estimate	Annual O&M Estimate
Cape Fear Public Utility Authority[1]	44 MGD	GAC	$46M	$2.7M
		IX	$46M	$2.1M
		RO	$150M	$4.7M
Brunswick County Public Utilities[2]	36 MGD	RO	$99M	$2.9M
		Ozone w/Biofiltration and GAC	$99M	$4.7M
		GAC w/IX and UV-AOP	$84M	$4.7M
Merrimack Village District (MVD)[3]	2.88 MGD	GAC	$3.6M to $4.3M	$0.13M to $0.27M
		IX	$4.4M to $5.1M	$0.12M to $0.19M
	1.44 MGD	GAC	$6.9M	$0.12M to $0.19M
		IX	$7.4M	$0.25M to $0.61M
	4.32 MGD	GAC	$10.9M	$0.24M to $0.43M
		IX	$12.2M	$0.52M to $1.4M
City of Portsmouth (Pease)[4]	1.67 MGD	GAC	$13M	$0.16M
West Morgan East Lawrence Water Authority[5]	8 MGD	GAC	$4M	$0.6M
		RO	$40M to $80M	N/A
Ann Arbor, MI[6]	22 MGD	GAC	N/A	$0.35M
Issaquah, WA[7,8]	0.36 MGD	GAC	$1M	N/A

1. https://www.cfpua.org/DocumentCenter/View/11386/BlackVeatch_FinalReport
2. https://www.brunswickcountync.gov/wp-content/uploads/2018/04/CDM-Smith-Brunswick-Final-Report-April-2018.pdf
3. http://www.mvdwater.org/wp-content/uploads/2018/12/PFAS-Treatment-Feasibility-Report-237-8-Final.pdf
4. **http://files.cityofportsmouth.com/publicworks/Pease%20Well%20Treatment%20Cost%20Alternative%20Report%20-%20June%202017%20(Final).pdf**
5. https://www.waaytv.com/content/news/WAAY-31-I-Team-Investigation-Cleaning-contaminated-water-483249661.html
6. https://energycommerce.house.gov/sites/democrats.energycommerce.house.gov/files/documents/05.15.19 Witness Testimony_Steglitz.pdf
7. https://pfasproject.com/issaquah-washington/
8. https://www.issaquahwa.gov/DocumentCenter/View/2810

Similar Treatment Process Project References for Treatment Cost Estimate

Facility	Treatment Capacity	Treatment Option	Capital Cost Estimate	Annual O&M Estimate
Aurora, CO[1]	10 MGD	Brackish RO	$33M	N/A
Multiple Systems, TX[2]	1.2 to 27.5 MGD	Brackish RO	$2.75M to $118M[4]	$0.5M to $6.5M[4]
Multiple Systems, FL[4]	2.0 to 10 MGD	IX	$0.85M to $4M	N/A
State of Industry Model[5]	2.7 to 27 MGD	Brackish RO	$9.5M to $60M[4]	N/A
	0.1 to 10 MGD	Brackish RO	N/A	$0.06 to $2M[4]

1. https://awwa.onlinelibrary.wiley.com/doi/pdf/10.5942/jawwa.2017.109.0020
2. http://www.twdb.texas.gov/innovativewater/desal/doc/Cost_of_Desalination_in_Texas_rev.pdf
3. In some cases, reported cost estimates are greater than 5 years old and have been updated to reflect inflation.
4. https://scholarcommons.usf.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=7837&context=etd
5. https://wrrc.arizona.edu/sites/wrrc.arizona.edu/files/programs/conf2011/pdf/Lozier.pdf

ATTACHMENT 3. EXCERPT OF RELEVANT TEXT FROM S.1507 - PFAS RELEASE DISCLOSURE ACT

TITLE II—DRINKING WATER

SEC. 201. NATIONAL PRIMARY DRINKING WATER REGULATIONS FOR PFAS.

Section 1412(b)(2) of the Safe Drinking Water Act (42 U.S.C. 300g–1(b)(2)) is amended by adding at the end the following:

"(D) PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES.—

"(i) IN GENERAL.—Not later than 2 years after the date of enactment of this subparagraph, the Administrator shall promulgate a national primary drinking water regulation for perfluoroalkyl and polyfluoroalkyl substances, which shall, at a minimum, include standards for—

"(I) perfluorooctanoic acid (commonly referred to as 'PFOA'); and

"(II) perfluorooctane sulfonic acid (commonly referred to as 'PFOS').

"(ii) ALTERNATIVE PROCEDURES.—

"(I) IN GENERAL.—Not later than 1 year after the validation by the Administrator of an equally effective quality control and testing procedure to ensure compliance with that national primary drinking water regulation to measure the levels described in subclause (II) or other methods to detect and monitor perfluoroalkyl and polyfluoroalkyl substances in drinking water, the Administrator shall add the procedure or method as an alternative to the quality control and testing procedure described in that national primary drinking water regulation by publishing the procedure or method in the Federal Register.

"(II) LEVELS DESCRIBED.—The levels referred to in subclause (I) are—

"(aa) the level of a perfluoroalkyl or polyfluoroalkyl substance;

"(bb) the total levels of perfluoroalkyl and polyfluoroalkyl substances; and

"(cc) the total levels of organic fluorine.

"(iii) INCLUSIONS.—The Administrator may include a perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances on—

"(I) the list of contaminants for consideration of regulation under paragraph (1)(B)(i); and

"(II) the list of unregulated contaminants to be monitored under section 1445(a)(2)(B)(i).

"(iv) MONITORING.—When establishing monitoring requirements for public water systems as part of a national primary drinking water regulation under clause (i) or clause (vi)(II), the Administrator shall tailor the monitoring requirements for public water systems that do not detect or are reliably and consistently below the maximum contaminant level (as defined in section 1418(b)(2)(B)) for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances subject to the national primary drinking water regulation.

"(v) HEALTH RISK REDUCTION AND COST ANALYSIS.—In meeting the requirements of paragraph (3)(C), the Administrator may rely on information available to the Administrator with respect to 1 or more specific perfluoroalkyl or polyfluoroalkyl substances to extrapolate reasoned conclusions regarding the health risks and effects of a class of perfluoroalkyl or polyfluoroalkyl substances of which the specific perfluoroalkyl or polyfluoroalkyl substances are a part.

"(vi) REGULATION OF ADDITIONAL SUBSTANCES.—

"(I) DETERMINATION.—The Administrator shall make a determination under paragraph (1)(A), using the criteria described in clauses (i) through (iii) of that paragraph, whether to include a perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances in the national primary drinking water regulation under clause (i) not later than 18 months after the later of—

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"(aa) the date on which the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances is listed on the list of contaminants for consideration of regulation under paragraph (1)(B)(i); and

"(bb) the date on which—

"(AA) the Administrator has received the results of monitoring under section 1445(a)(2)(B) for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substance; or

"(BB) the Administrator has received finished water data or finished water monitoring surveys for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances from a Federal or State agency that the Administrator determines to be sufficient to make a determination under paragraph (1)(A).

"(II) PRIMARY DRINKING WATER REGULATIONS.—

"(aa) IN GENERAL.—For each perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances that the Administrator determines to regulate under subclause (I), the Administrator—

"(AA) not later than 18 months after the date on which the Administrator makes the determination, shall propose a national primary drinking water regulation for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances; and

"(BB) may publish the proposed national primary drinking water regulation described in subitem (AA) concurrently with the publication of the determination to regulate the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances.

"(bb) DEADLINE.—

"(AA) IN GENERAL.—Not later than 1 year after the date on which the Administrator publishes a proposed national primary drinking water regulation under item (aa)(AA) and subject to subitem (BB), the Administrator shall take final action on the proposed national primary drinking water regulation.

"(BB) EXTENSION.—The Administrator, on publication of notice in the Federal Register, may extend the deadline under subitem (AA) by not more than 6 months.

"(vii) LIFETIME DRINKING WATER HEALTH ADVISORY.—

"(I) IN GENERAL.—Subject to subclause (II), the Administrator shall publish a health advisory under paragraph (1)(F) for a perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances not later than 1 year after the later of—

"(aa) the date on which the Administrator finalizes a toxicity value for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances; and

"(bb) the date on which the Administrator validates an effective quality control and testing procedure for the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substance, if such a procedure did not exist on the date on which the toxicity value described in item (aa) was finalized.

"(II) WAIVER.—The Administrator may waive the requirements of subclause (I) with respect to a perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl and polyfluoroalkyl substances if the Administrator determines that there is a substantial likelihood that the perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances will not occur in drinking water.".

SEC. 202. MONITORING AND DETECTION.

(a) MONITORING PROGRAM FOR UNREGULATED CONTAMINANTS.—

(1) IN GENERAL.—The Administrator shall include each substance described in paragraph (2) in the fifth publication of the list of unregulated contaminants to be monitored under section 1445(a)(2)(B)(i) of the Safe Drinking Water Act (42 U.S.C. 300j–4(a)(2)(B)(i)).

(2) SUBSTANCES DESCRIBED.—The substances referred to in paragraph (1) are perfluoroalkyl and polyfluoroalkyl substances and classes of perfluoroalkyl and polyfluoroalkyl substances—

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(A) for which a method to measure the level in drinking water has been validated by the Administrator; and

(B) that are not subject to a national primary drinking water regulation under clause (i) or (vi)(II) of subparagraph (D) of section 1412(b)(2) of the Safe Drinking Water Act ([42 U.S.C. 300g–1(b)(2)]).

(3) EXCEPTION.—The perfluoroalkyl and polyfluoroalkyl substances and classes of perfluoroalkyl and polyfluoroalkyl substances included in the list of unregulated contaminants to be monitored under section 1445(a)(2)(B)(i) of the Safe Drinking Water Act ([42 U.S.C. 300j–4(a)(2)(B)(i)]) under paragraph (1) shall not count towards the limit of 30 unregulated contaminants to be monitored by public water systems under that section.

(b) APPLICABILITY.—

(1) IN GENERAL.—The Administrator shall—

(A) require public water systems serving more than 10,000 persons to monitor for the substances described in subsection (a)(2);

(B) subject to paragraph (2) and the availability of appropriations, require public water systems serving not fewer than 3,300 and not more than 10,000 persons to monitor for the substances described in subsection (a)(2); and

(C) subject to paragraph (2) and the availability of appropriations, ensure that only a representative sample of public water systems serving fewer than 3,300 persons are required to monitor for the substances described in subsection (a)(2).

(2) REQUIREMENT.—If the Administrator determines that there is not sufficient laboratory capacity to carry out the monitoring required under subparagraphs (B) and (C) of paragraph (1), the Administrator may waive the monitoring requirements in those subparagraphs.

(3) FUNDS.—The Administrator shall pay the reasonable cost of such testing and laboratory analysis as is necessary to carry out the monitoring required under paragraph (1) from—

(A) funds made available under subsection (a)(2)(H) or (j)(5) of section 1445 of the Safe Drinking Water Act ([42 U.S.C. 300j–4]); or

(B) any other funds made available for that purpose.

SEC. 203. ENFORCEMENT.

Notwithstanding any other provision of law, the Administrator may not impose financial penalties for the violation of a national primary drinking water regulation (as defined in section 1401 of the Safe Drinking Water Act ([42 U.S.C. 300f])) with respect to a perfluoroalkyl or polyfluoroalkyl substance or class of perfluoroalkyl or polyfluoroalkyl substances for which a national primary drinking water regulation has been promulgated under clause (i) or (vi) of subparagraph (D) of section 1412(b)(2) of the Safe Drinking Water Act ([42 U.S.C. 300g–1(b)(2)]) earlier than the date that is 5 years after the date on which the Administrator promulgates the national primary drinking water regulation.

SEC. 204. DRINKING WATER STATE REVOLVING FUNDS.

Section 1452 of the Safe Drinking Water Act ([42 U.S.C. 300j–12]) is amended—

(1) in subsection (a)(2), by adding at the end the following:

“(G) EMERGING CONTAMINANTS.—

“(i) IN GENERAL.—Subject to clause (ii), amounts deposited under subsection (t) in a State loan fund established under this section may be used to provide grants for the purpose of addressing emerging contaminants, with a focus on perfluoroalkyl and polyfluoroalkyl substances.

“(ii) REQUIREMENTS.—

“(I) SMALL AND DISADVANTAGED COMMUNITIES.—Not less than 25 percent of the amounts described in clause (i) shall be used to provide grants to—

“(aa) disadvantaged communities (as defined in subsection (d)(3)); or

EXHIBIT 2

"(bb) public water systems serving fewer than 25,000 persons.

"(II) PRIORITIES.—In selecting the recipient of a grant using amounts described in clause (i), a State shall use the priorities described in subsection (b)(3)(A).";

(2) in subsection (m)(1), in the matter preceding subparagraph (A), by striking "this section" and inserting "this section, except for subsections (a)(2)(G) and (t)"; and

(3) by adding at the end the following:

"(t) EMERGING CONTAMINANTS.—

"(1) IN GENERAL.—Amounts made available under this subsection shall be allotted to a State as if allotted under subsection (a)(1)(D) as a capitalization grant, for deposit into the State loan fund of the State, for the purposes described in subsection (a)(2)(G).

"(2) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to carry out this subsection $100,000,000 for each of fiscal years 2020 through 2024, to remain available until expended."

EXHIBIT 2

National Waste & Recycling Association℠
Collect. Recycle. Innovate.

SWANA
SOLID WASTE ASSOCIATION OF NORTH AMERICA

May 10, 2022

Re: Relief for Municipal Solid Waste Landfills from CERCLA Liability for PFAS

Dear Chairman Carper, Ranking Member Capito, Chairman DeFazio, Ranking Member Graves, Chairman Pallone, and Ranking Member McMorris Rodgers:

The municipal solid waste (MSW) management sector strongly supports the goal of addressing per- and poly-fluoroalkyl substances (PFAS) contamination and holding accountable manufacturers and heavy users of these compounds. We are concerned, however, that regulation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) instead would assign environmental cleanup liability to essential public services and their customers. We therefore request that Congress provide MSW landfills and other passive receivers with a narrow exemption from liability if certain PFAS are designated as hazardous substances under CERCLA. Doing so would keep CERCLA liability on the industries that created the pollution in the first place.

Context

- Landfills neither manufacture nor use PFAS; instead, they receive discarded materials containing PFAS that are ubiquitous in residential and commercial waste streams. MSW landfills and the communities they serve should not be held financially liable under CERCLA for PFAS contamination, as landfills are part of the long-term solution to managing these compounds.
- Landfills are essential public services that are subject to extensive federal, state, and local environmental, health, and safety requirements. Further, MSW landfills are important to managing and limiting PFAS in the environment, as recognized by the Environmental Protection Agency (EPA) in its December 2020 draft Interim Guidance on the Destruction and Disposal of [PFAS] and Materials Containing [PFAS].
- **Just as certain airports are required by law to use firefighting foam containing PFAS, permitting authorities often require landfills to accept waste streams containing PFAS.**
- Most landfills rely on wastewater treatment facilities for leachate management. Wastewater and drinking water facilities increasingly rely on landfills for biosolids management and disposal of PFAS-laden filters. Efforts to address PFAS at MSW landfills and drinking water and wastewater facilities must avoid disrupting this interdependence among essential public services to communities.
- Landfill leachate typically represents a minor proportion of the total quantity of PFAS received at wastewater treatment facilities from all sources. PFAS manufacturers or users, by comparison, contribute PFAS at levels that can be orders of magnitude higher than landfills.

Significant Economic Impacts

- Removing PFAS from landfill leachate requires advanced treatment techniques which are prohibitively expensive. Estimated capital costs to implement leachate pretreatment at a moderate-sized landfill to the extent necessary to significantly reduce PFAS range from $2 million to $7 million, **with nationwide costs totaling $966 million to $6.279 billion per year** for the solid waste sector. Trace concentrations of PFAS nevertheless would remain in leachate following pretreatment, exposing landfills to CERCLA liability.
- Absent relief from CERCLA liability, manufacturers and heavy users of PFAS compounds will bring claims for contribution against landfills and other passive receivers, generating significant litigation costs. EPA's exercise of enforcement discretion will not insulate landfills from this litigation.

EXHIBIT 3

- These costs will be passed along to communities, water and wastewater treatment facilities, and biosolids management, all of which rely on the services of MSW landfills.

Broad Unintended Consequences

- **CERCLA regulation will impel landfills to restrict inbound wastes and/or increase disposal costs for media with elevated levels of PFAS, including filters, biosolids, and impacted soils at Department of Defense facilities.** The mere prospect of regulation in this area is already disrupting the interdependence of the drinking water, wastewater, and solid waste sectors.
- Food waste compost may contain PFAS due to contact with PFAS-lined packaging materials. As a result, a CERCLA designation could result in communities diverting food waste from organics recycling programs, hindering federal, state, and local climate and waste reduction goals.
- Cost increases likely will have a significant disproportionate impact on low-income households that rely on the affordability of services that the solid waste sector provides.

Recommendation

Although our sector is simultaneously pursuing "no action assurance" from EPA, the agency historically has been very hesitant to provide this relief given its policy that assurances should be given only "in extremely unusual cases." As such, and acknowledging that EPA may have limited authority to act on our request, we recommend providing the following narrow exemption from CERCLA liability that affords relief to landfills and other passive receivers of PFAS[1]:

(a) IN GENERAL.—No publicly owned or operated community water system (as defined at 42 U.S.C. 300f), publicly owned treatment works (as defined at 33 U.S.C. 1292), or municipal solid waste landfill (as defined at 40 C.F.R. 258.2) shall be liable under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. 9601 et seq.) for the costs of responding to, or damages resulting from, a release to the environment of a perfluoroalkyl or polyfluoroalkyl substance designated as a hazardous substance under section 102(a) of such Act that resulted from the discharge of effluent, the disposal or management of biosolids, the disposal of filtration media resin, or the discharge of leachate where such actions are in compliance with Federal or State law and all applicable permits.

(b) EXCEPTION.—Subsection (a) shall not apply with respect to any discharge described in such subsection that results from any gross negligence, willful misconduct, or noncompliance with any Federal or State law or permit governing the discharge of effluent, disposal or management of biosolids, disposal of filtration media resin, or waste disposal.

Thank you for your consideration of our request, and we look forward to continuing to partner with the federal government to ensure the safe and effective management of waste streams containing PFAS.

Sincerely,

National Waste & Recycling Association
Solid Waste Association of North America

cc: Senate EPW Committee Members
House T&I and E&C Committee Members

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[1] The exemption would not extend to underlying soil and groundwater contamination from a MSW landfill or to facilities other than MSW landfills that accept waste streams with elevated concentrations of PFAS.

EXHIBIT 3

Electronic Filing: Received, Clerk's Office 09/15/2022

wasterecycling.org

National
Waste & Recycling
Association℠
Collect. Recycle. Innovate.

1550 Crystal Drive, Suite 804
Arlington, VA 22202
T: 800-424-2869
T: 202-244-4700
F: 202-966-4824

February 8, 2022

Ms. Ariana Sutton-Grier
Office of Management and Budget
Office of Information & Regulatory Affairs
1100 G Street, NW
Washington, DC 20005

Re: PFAS Management Costs for Municipal Solid Waste Landfills

Dear Ms. Sutton-Grier:

Thank you for the opportunity to meet with your office on February 7, 2022, to discuss the potential impacts on the solid waste sector of EPA's proposed rule designating PFOA and PFOS as CERCLA hazardous substances (RIN: 2050-AH09). The National Waste & Recycling Association (NWRA) is a trade association representing the private sector waste and recycling industry. Our members operate in all fifty states and the District of Columbia. Also present during the meeting were some of our members and representatives from the Solid Waste Association of North America (SWANA). SWANA is a not-for-profit professional association in the solid waste field with more than 10,000 members in both the private and public sectors across North America.

In response to your request for information on the economic impact of the rule to our sector, we have provided the following cost estimates and information. As we discussed at our meeting, the designation of PFOA and PFOS as hazardous substances under CERCLA will likely have unintended consequences that undercut the Administration's broader environmental goals. We ask that OIRA account for these realities, as well as the significant economic impact of the rule on innocent essential public services and their customers, as it considers the draft proposed rule. The municipal solid waste industry continues to strongly support the goals of addressing PFAS contamination and holding accountable those entities that are responsible for the compounds through their manufacture and/or use.

The municipal solid waste industry is unaware of any full-scale commercially proven PFAS treatment destruction technologies for landfill leachate. Existing technologies have been deployed to remove, but not destroy, PFAS, including reverse osmosis and granular activated carbon. These technologies currently are available to landfills and wastewater treatment facilities but require significant wastewater pretreatment before PFAS removal can be achieved. It is also important to highlight that there are notable differences in the use of treatment technologies for PFAS removal at landfills versus wastewater treatment facilities.

Since most landfills do not employ leachate pretreatment, PFAS removal requires the development of a multi-step process including (1) pretreatment to address non-PFAS constituents, (2) subsequent PFAS removal technology, and (3) PFAS residuals treatment/management. From an economic perspective, leachate pretreatment and PFAS residuals management will add significantly to the costs of landfill operation.

EXHIBIT 4

The municipal solid waste industry is unaware of any full-scale commercially proven PFAS treatment destruction technologies for landfill leachate. Existing technologies have been deployed to remove, but not destroy, PFAS, including reverse osmosis and granular activated carbon. These technologies currently are available to landfills and wastewater treatment facilities but require significant wastewater pretreatment before PFAS removal can be achieved. It is also important to highlight that there are notable differences in the use of treatment technologies for PFAS removal at landfills versus wastewater treatment facilities.

Since most landfills do not employ leachate pretreatment, PFAS removal requires the development of a multi-step process including (1) pretreatment to address non-PFAS constituents, (2) subsequent PFAS removal technology, and (3) PFAS residuals treatment/management. From an economic perspective, leachate pretreatment and PFAS residuals management will add significantly to the costs of landfill operation.

The estimated capital cost to implement leachate pretreatment to the extent necessary to remove PFAS is approximately $2 to $7 million to provide complete, multi-step biological treatment of 30,000 to 40,000 gallons per day of leachate, representing a moderate sized landfill. Included in this cost estimate is approximately $0.5 to $1.5 million for PFAS removal technology, with additional costs anticipated for landfills where more stringent effluent levels are desired/mandated.

Moreover, since these technologies are unable to destroy PFAS, further management of the residual PFAS waste streams is needed to stabilize or otherwise limit their ability to reenter leachate. The costs and operational effectiveness for PFAS residuals management is less understood as most technologies have not been evaluated at full-scale. Based on general conversations with technology developers and estimates/extrapolations from small-scale studies, however, the municipal solid waste industry anticipates that implementing new technologies for PFAS removal and subsequent residuals management could increase the costs of treating landfill leachate by approximately $0.06 to $0.39 (potentially even higher) per gallon of raw leachate processed (i.e., a cost increase of at least 400% to 800%) (see Appendix). Based on an estimated 16.1 billion gallons of leachate per year generated in the United States (see pg. 68 of EPA's *Interim Guidance on the Destruction and Disposal of PFAS and PFAS-Containing Materials*), **increased costs associated with PFAS management could total approximately $966 million to $6.279 billion per year for municipal solid waste landfills.**

We appreciate the opportunity to provide these additional comments, and we look forward to working with you as you continue to review the proposed rule. If you have any questions, please feel free to contact Anne Germain at agermain@wasterecycling.org or 302-270-5483.

Very truly yours,

Darrell K. Smith

Darrell K. Smith
President & CEO

EXHIBIT 4

Appendix. Cost Summary of Review of Conceptual Leachate Treatment Scoping Study New England Waste Services of Vermont (NEWSVT) Coventry, Vermont

The State of Vermont requested Civil & Environmental Consultants, Inc. (CEC), to prepare an independent evaluation of several alternative management and technology approaches for managing PFAS in the landfill leachate at the NEWSVT landfill in Coventry, Vermont. This is the only currently operating disposal facility in the state. CEC based its review on previous project experience and vendor quotes. The approaches in these alternatives included hauling to municipal wastewater resource recovery facilities (WWRFs), pretreatment to reduce the PFAS load in the hauled leachate, and various treatment options for surface water disposal. The treatment and disposal cost opinions at the WWRFs did not include the costs to the WWRFs for managing the PFAS in their effluent. These treatment costs do not include residuals management.

The overall alternative cost opinions presented below (based on CY 2020 costs) to be anticipated for a landfill generating 50,000 gallons per day (GPD) for a present worth cost range, including capital and life cycle operation and maintenance, ranged from $26 million to $95 million. The recommended alternative (Alternative 1A-2) involved a capital cost expenditure of $15.5 million and an annual cost of almost $1 million. The opinion of total annual cost for PFAS management for operation and maintenance and capital recovery over a 20-year bond repayment is $2.3 million for the 50,000 GPD leachate flow.

Alternative 1A-2 represents the lowest cost of the options reviewed. Costs for other options ranged as high as $8.3 million. In addition, these costs don't reflect other potential risks associated with managing leachate if POTWs cut off acceptance post-CERCLA regulation.

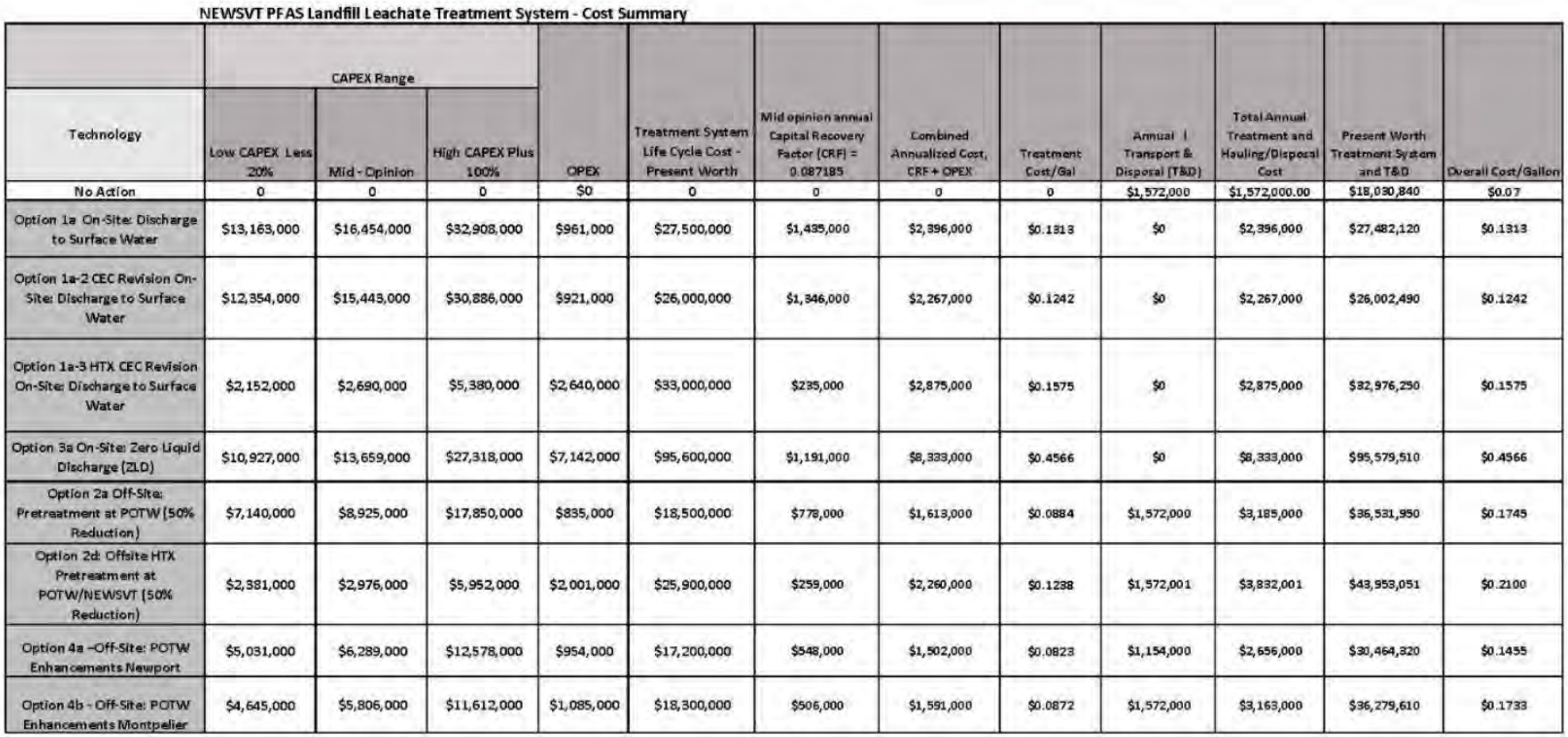
Option	Annualized costs (millions)
1a	$2.4
1a-2	$2.3
1a-3	$2.9
3a	$8.3
2a	$3.2
2d	$3.8
4a	$2.7
4b	$3.1

The life cycle cost opinions for the alternatives evaluated, including capital and annual operation and maintenance costs, ranged from $0.07 per gallon for hauling and disposal at WWRFs to over $0.41 per gallon for advanced multistage leachate treatment. The alternative recommended (Alternative 1A-2) included reverse osmosis treatment followed by a residuals evaporator to reduce the volume in the reverse osmosis reject flow from 15% to 3% of the leachate flow. Other related costs were not included, as the technology was not sufficiently developed at the report date.

Although this evaluation was based on a specific flow with specific site conditions, smaller plans may experience a higher cost per gallon, while larger plants may experience a smaller cost per gallon. The full text of the report is located at: https://anrweb.vt.gov/PubDocs/DEC/PFAS/Studies/Report-CEC-Review-of-BC-Conceptual-Study-6-15-2021.pdf

EXHIBIT 4

Table 3. Cost Opinions



NEWSVT PFAS Landfill Leachate Treatment System - Cost Summary

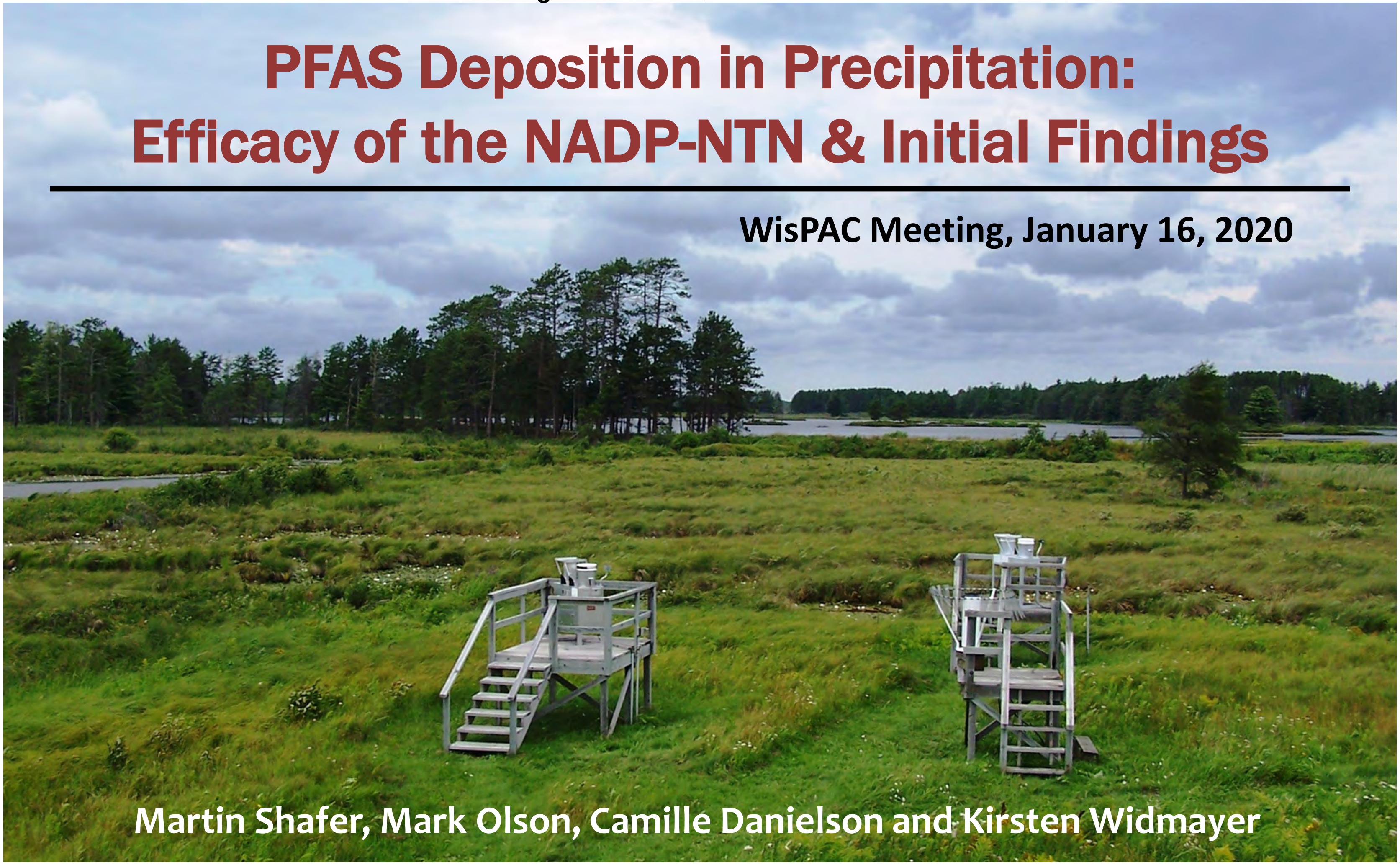
	CAPEX Range			OPEX	Treatment System Life Cycle Cost - Present Worth	Mid opinion annual Capital Recovery Factor (CRF) = 0.087185	Combined Annualized Cost, CRF + OPEX	Treatment Cost/Gal	Annual I Transport & Disposal (T&D)	Total Annual Treatment and Hauling/Disposal Cost	Present Worth Treatment System and T&D	Overall Cost/Gallon
Technology	Low CAPEX Less 20%	Mid - Opinion	High CAPEX Plus 100%									
No Action	0	0	0	$0	0	0	0	0	$1,572,000	$1,572,000.00	$18,030,840	$0.07
Option 1a On-Site: Discharge to Surface Water	$13,163,000	$16,454,000	$32,908,000	$961,000	$27,500,000	$1,435,000	$2,396,000	$0.1313	$0	$2,396,000	$27,482,120	$0.1313
Option 1a-2 CEC Revision On-Site: Discharge to Surface Water	$12,354,000	$15,443,000	$30,886,000	$921,000	$26,000,000	$1,346,000	$2,267,000	$0.1242	$0	$2,267,000	$26,002,490	$0.1242
Option 1a-3 HTX CEC Revision On-Site: Discharge to Surface Water	$2,152,000	$2,690,000	$5,380,000	$2,640,000	$33,000,000	$235,000	$2,875,000	$0.1575	$0	$2,875,000	$32,976,250	$0.1575
Option 3a On-Site: Zero Liquid Discharge (ZLD)	$10,927,000	$13,659,000	$27,318,000	$7,142,000	$95,600,000	$1,191,000	$8,333,000	$0.4566	$0	$8,333,000	$95,579,510	$0.4566
Option 2a Off-Site: Pretreatment at POTW (50% Reduction)	$7,140,000	$8,925,000	$17,850,000	$835,000	$18,500,000	$778,000	$1,613,000	$0.0884	$1,572,000	$3,185,000	$36,531,950	$0.1745
Option 2d: Offsite HTX Pretreatment at POTW/NEWSVT (50% Reduction)	$2,381,000	$2,976,000	$5,952,000	$2,001,000	$25,900,000	$259,000	$2,260,000	$0.1238	$1,572,001	$3,832,001	$43,953,051	$0.2100
Option 4a –Off-Site: POTW Enhancements Newport	$5,031,000	$6,289,000	$12,578,000	$954,000	$17,200,000	$548,000	$1,502,000	$0.0823	$1,154,000	$2,656,000	$30,464,320	$0.1455
Option 4b - Off-Site: POTW Enhancements Montpelier	$4,645,000	$5,806,000	$11,612,000	$1,085,000	$18,300,000	$506,000	$1,591,000	$0.0872	$1,572,000	$3,163,000	$36,279,610	$0.1733

From *Review of Conceptual Leachate Treatment Scoping Study New England Waste Services of Vermont (NEWSVT) Coventry, Vermont* (p. 19)

EXHIBIT 4

PFAS Deposition in Precipitation: Efficacy of the NADP-NTN & Initial Findings

WisPAC Meeting, January 16, 2020



Martin Shafer, Mark Olson, Camille Danielson and Kirsten Widmayer

State Laboratory of Hygiene, School of Medicine & Public Health,
University of Wisconsin-Madison

NADP

EXHIBIT 5

PFAS Dispersal & Atmospheric Processing

Atmospheric Transport, Processing and Deposition is Under-appreciated and Under-Studied

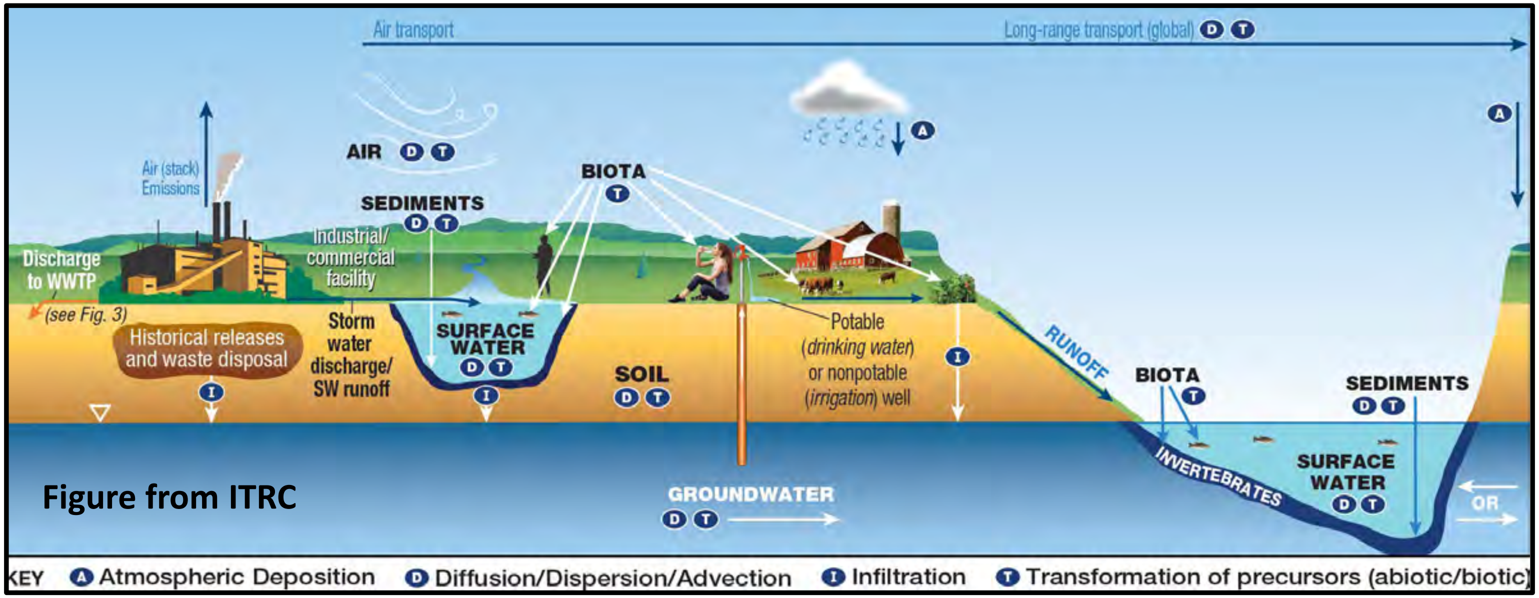


Figure from ITRC

PFAS found in remote environments (aquatic, atmosphere and terrestrial) far from any known sources)

1. Direct Industrial Emissions (1° & 2°)
2. Precursor Emissions
3. Particle Injection
4. POTW/Land-Spreading
5. Foam Use

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EXHIBIT 5

PFAS Dispersal & Atmospheric Processing

Short & Long-Range Transport in the Atmosphere

1. Vapor phase (e.g. neutral (more) volatile precursors)
2. Aerosol phase (e.g. ionic compounds & long-chain)

Transformations in the Atmosphere

1. Perfluoroalkanesulfonamides → carboxylic acids
2. Perfluorotelomeralcohols → carboxylic acids

Removal (Deposition) from the Atmosphere

1. Wet Deposition (precipitation/rain)
2. Dry Deposition

Atmospheric fate and transport of PFAS strongly dependent upon the specific PFAS compound

Hg analogy

NADP

Atmospheric Cycling Important in Dispersal of PFAS

EXHIBIT 5

Goals & Approach: Wet Deposition

The NADP-NTN currently comprises 263 sites across the US and Canada, collecting 7-day wet-only precipitation samples. The Wisconsin State Laboratory of Hygiene at the UW-Madison operates all of the NADP networks and is home to the analytical laboratories that support these networks.

- Design and implement **field and laboratory experiments** to determine whether the NADP/NTN sampling network as currently configured (or with certain modifications) **would support robust PFAS concentration and deposition monitoring**
- Apply **ISO method 21675** (36 PFAS compound) to the NTN network evaluation studies and precipitation monitoring
- Perform **PFAS measurements** on geographically diverse **precipitation samples** from the NADP National Trends Network (NTN) to assess PFAS levels and **deposition fluxes**.

National Atmospheric Deposition Program

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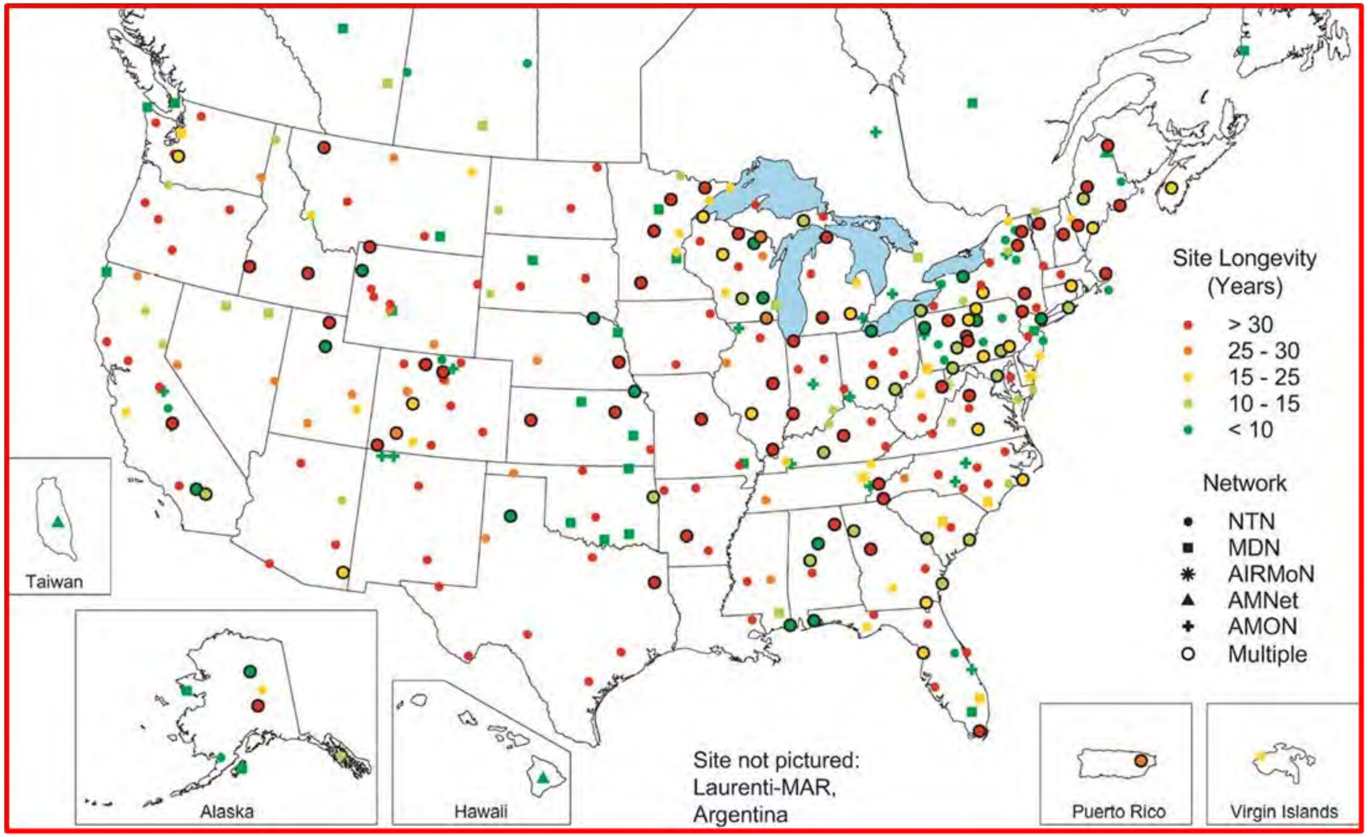
NADP Monitoring Sites



Site not pictured:
Laurenti-MAR,
Argentina

Synoptic Overview of PFAS Deposition and/or More Targeted Collections

NADP

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EXHIBIT 5

Wisconsin NTN and MDN NADP Sites

- WI06, UW Arboretum, Dane County
- WI08, Brule River, Douglas County
- WI10, Potawatomi, Forest County
- WI31, Devil’s Lake, Sauk County
- WI35, Perkinstown, Taylor County
- WI36, Trout Lake, Vilas County
- WI37, Spooner, Washburn County

Red = NTN & MDN
7 NTN & 5 MDN Sites

1. Super-site in development at Eagle Heights (UW-Madison)
2. Ability to deploy “temporary” and/or mobile NTN collectors

EXHIBIT 5

PFAS Analytical Methods

- **Analytical methods**:
  - ISO Method 21675 (PFAS in Water by LC-MS/MS). 36 PFAS compounds. 26 isotopically-labeled internal-standards
  - 500 or 250 mL sample volume; entire sample extracted
  - Automated SPE (Oasis-WAX; 8-station Promochrom Tech.)
  - Sciex QTRAP 5500 LC/MS/MS, Waters Acquity UPLC
- **Contamination Control**:
  - QC'd polypropylene collection bottles
  - Gloves worn during sampling
  - NO Teflon or related materials

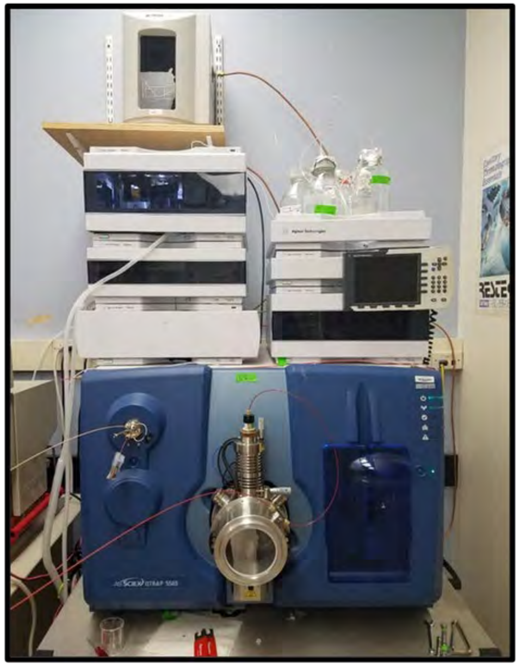

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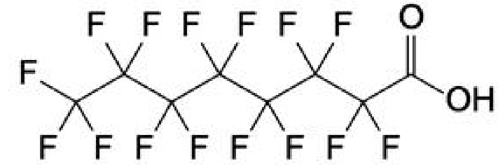
EXHIBIT 5

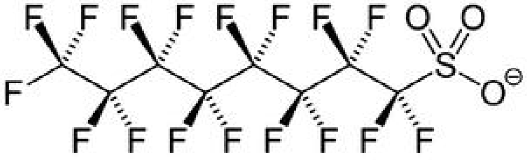
PFAS Compounds

>4500 compounds known/suspected
220 with authentic standards
50 with “routine” robust methods
18 in EPA 537.1 (drinking water)
3-5 with regulatory limits (States)



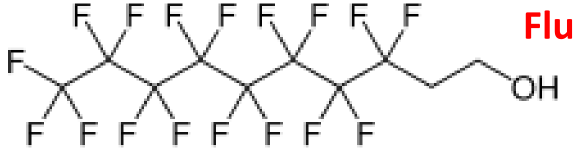
Perfluorooctanoic acid (PFOA)

Carboxylic Acids

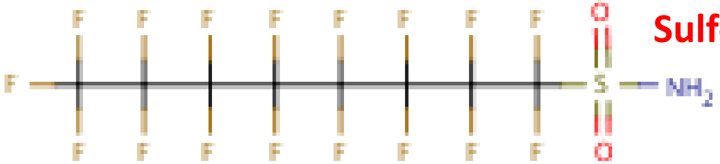


Perfluorooctanesulfonate (PFOS)

Sulfonates

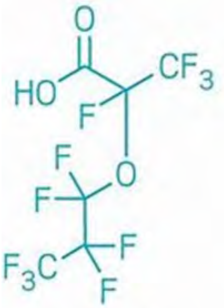


Fluorotelomers

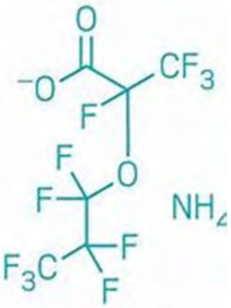


Sulfonamides

1. **$-C_nF_{2n}$-head →**
2. **Repel oil and water**
3. **Chemical and Thermal stability**
4. **Reduce friction**
5. **High surface activity**



HFPO-DA



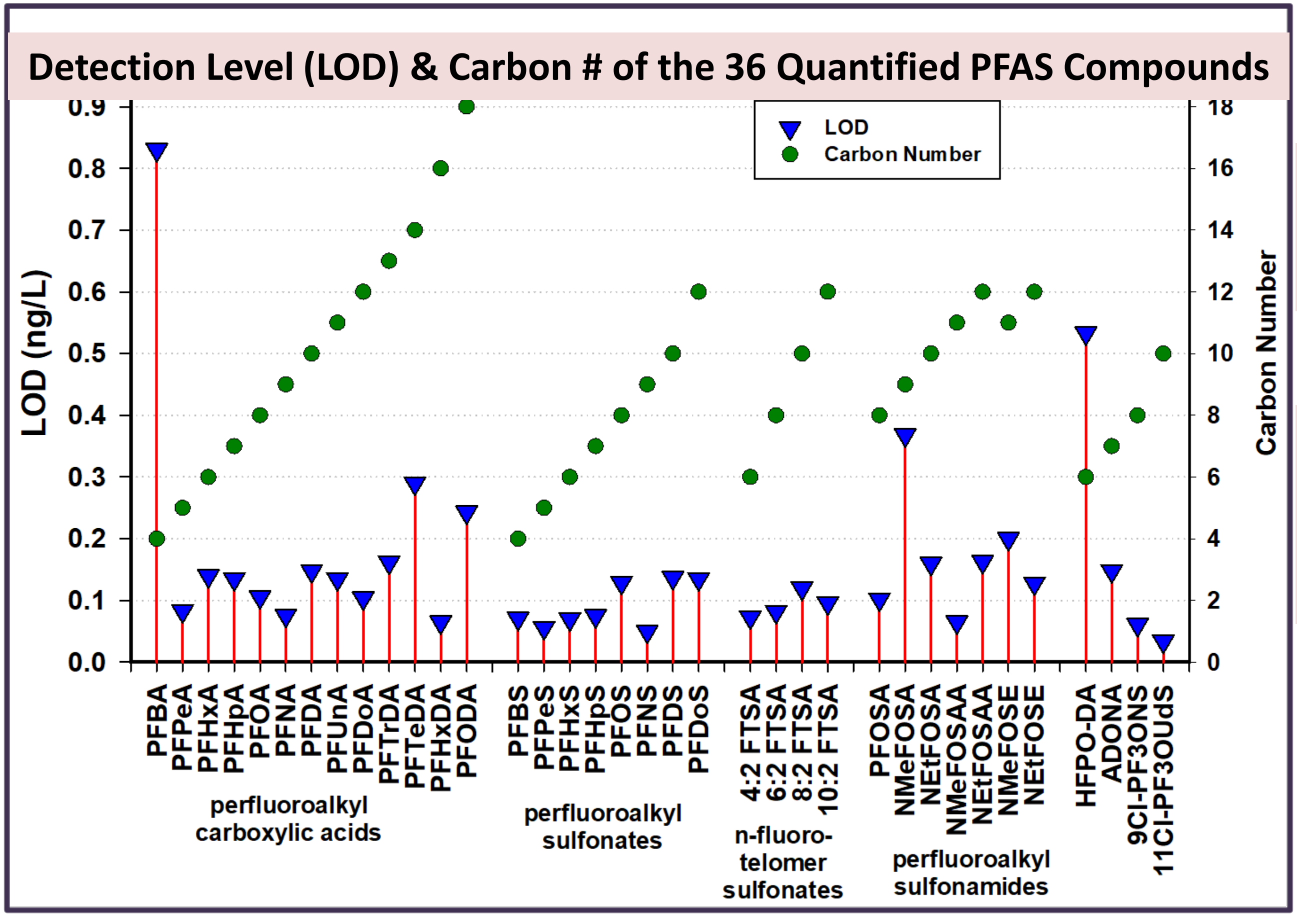
GenX

Buck et al. 2011

NADP **National Atmospheric Deposition Program**

EXHIBIT 5

PFAS Method Performance Outcomes in Precipitation



Detection Level (LOD) & Carbon # of the 36 Quantified PFAS Compounds

LODs

Typically in Range of 0.15 to 0.2 ng/L

Spike Recoveries

Typically in Range of 90 to 110% (4 ng/L spike)

National Atmospheric Deposition Program

NADP

EXHIBIT 5

NTN Network Efficacy for PFAS Measurement

A. System Blanks: Bucket & Bag Collectors

- ✓ High-purity water → collectors

B. PFAS Retention/Loss Studies

- ✓ Water, spiked with 36 PFAS compounds at low ng/L levels → collectors

NTN Wet-Only Collector

Retention/Loss Study Experimental Matrix

Sample Matrix	Incubation Location	Collector Type	Day 0	Day 1	Day 3	Day 7
MQ	Lab	Bag	1	2	2	2
MQ	Lab	Bucket	1	2	2	2
Precip	Lab	Bag	1	2	2	2
Precip	Lab	Bucket		2	2	2
Precip	Field	Bag		2	2	2
Precip	Field	Bucket	1	2	2	2

System blank trials run in triplicate.
Values in table are number of replicates for retention/loss studies.

EXHIBIT 5

Network Efficacy: Field Method Blank Outcomes

I. **High Purity Water (7-day field conditions)**

  I. **Bags:** no detects for 36 species (except PFOA at 0.23 ng/L in 1 sample)
  II. **Buckets:** no detects for 36 species (except PFOA at 0.44 ng/L in 1 sample)
  III. **NTN Bottle:** no detects for 36 species

II. **Methanol Rinses**

  I. **Buckets:** no detects for 36 species

Bucket Washers

Buckets

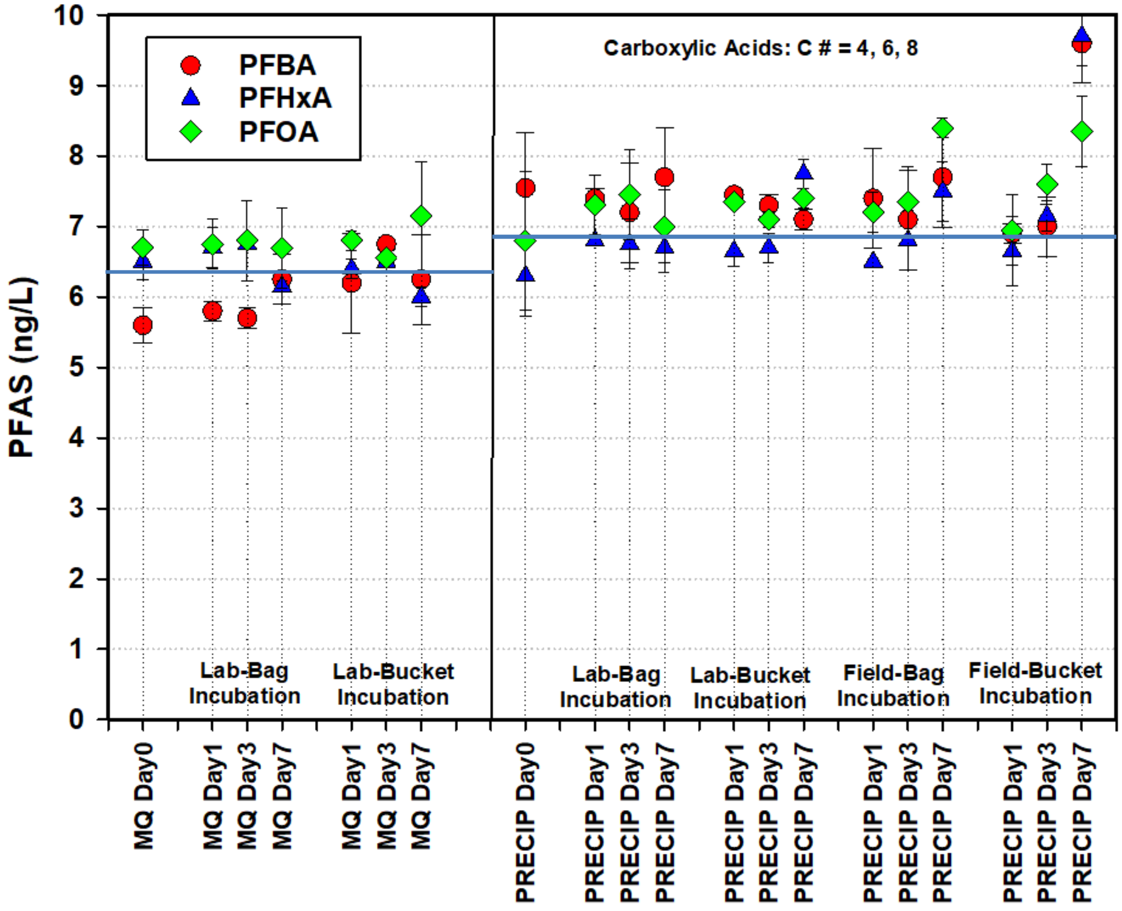
NADP

National Atmospheric Deposition Program

EXHIBIT 5

PFAS Retention/Loss Study

Carboxylic Acids
C# = 4, 6, 8

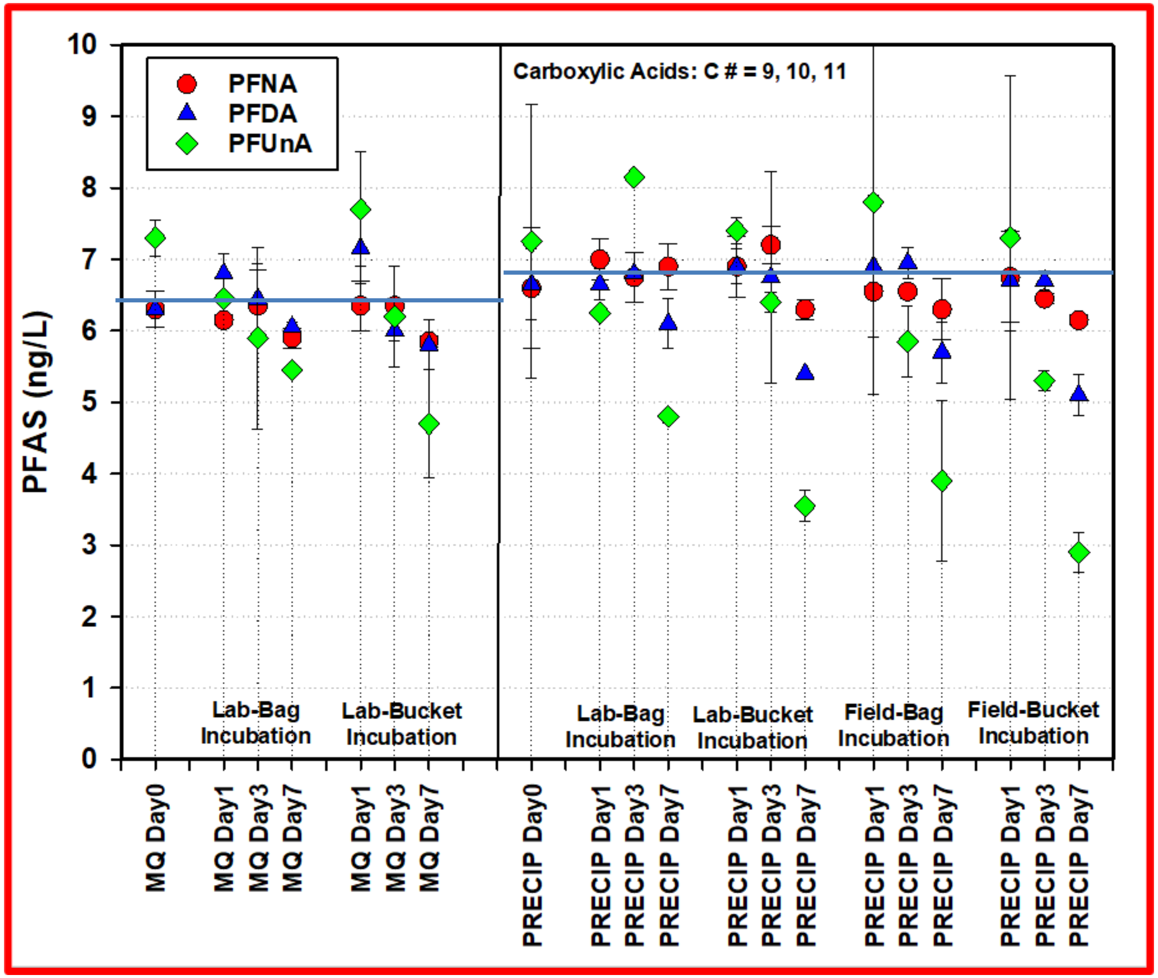


National Atmospheric
Deposition Program

NADP

EXHIBIT 5

PFAS Retention/Loss Study



Carboxylic Acids
C# = 9, 10, 11

National Atmospheric Deposition Program

NADP

EXHIBIT 5

PFAS Retention/Loss Study

Sulfonic Acids
C# = 4, 6, 8

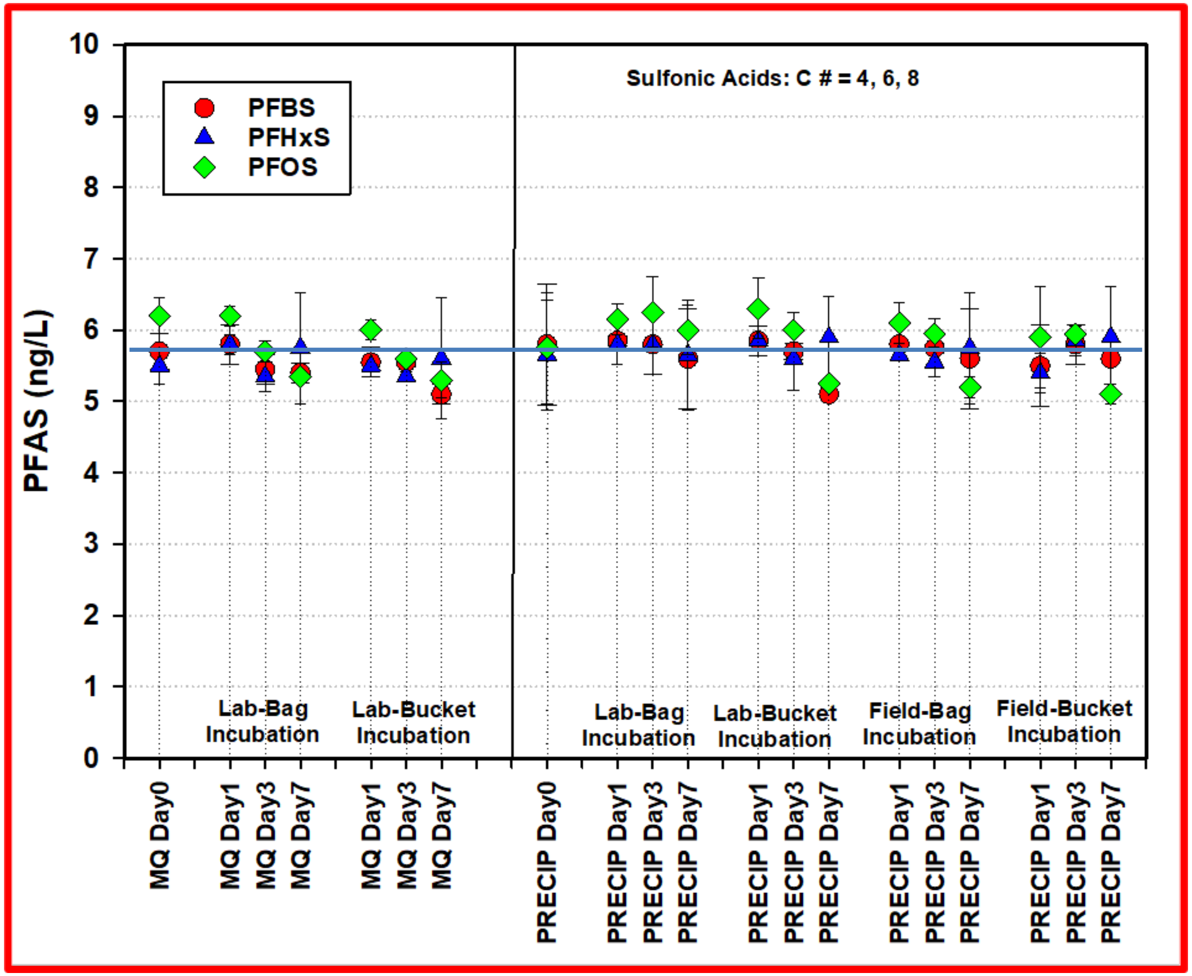


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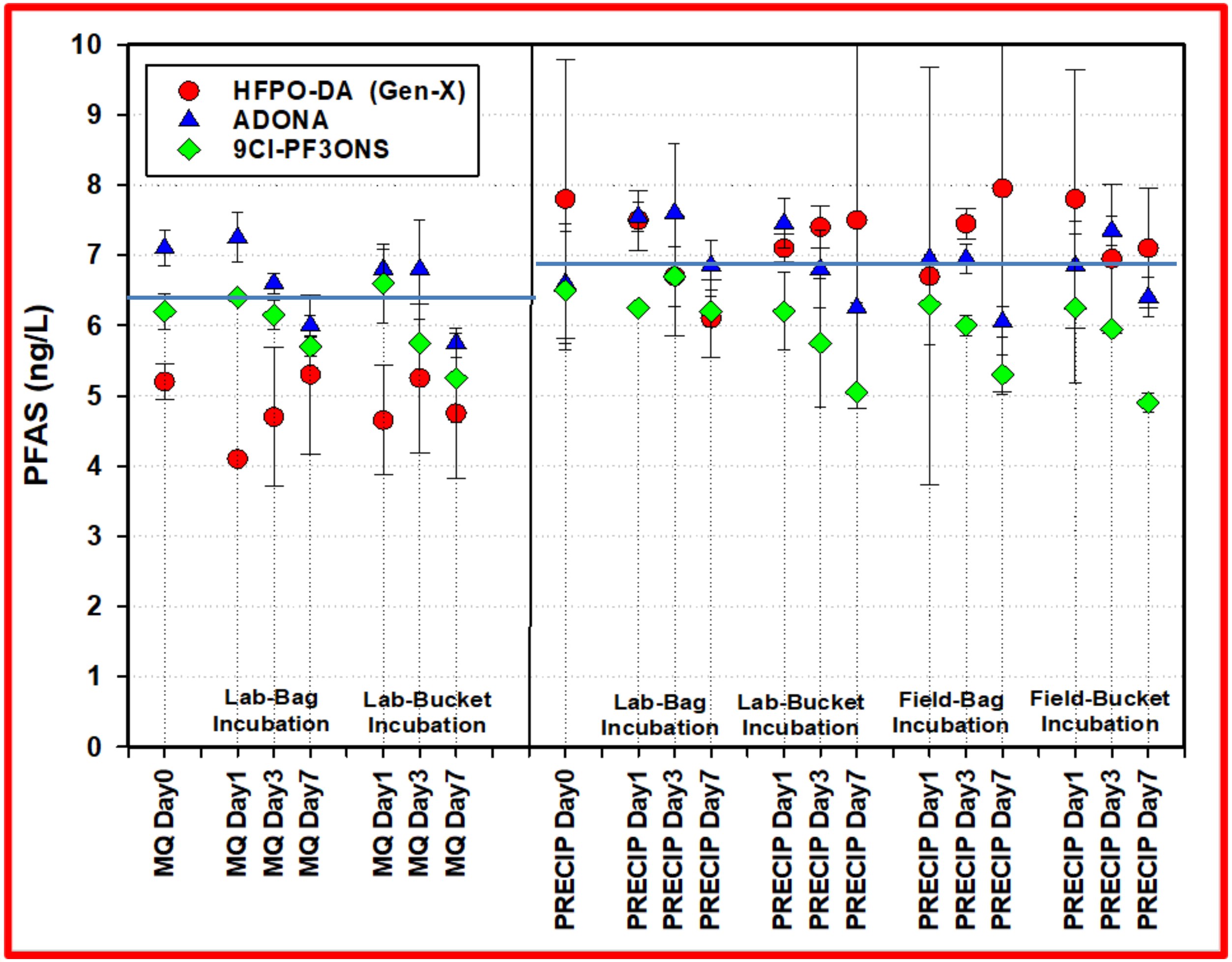
EXHIBIT 5

PFAS Retention/Loss Study

Gen-X & Related



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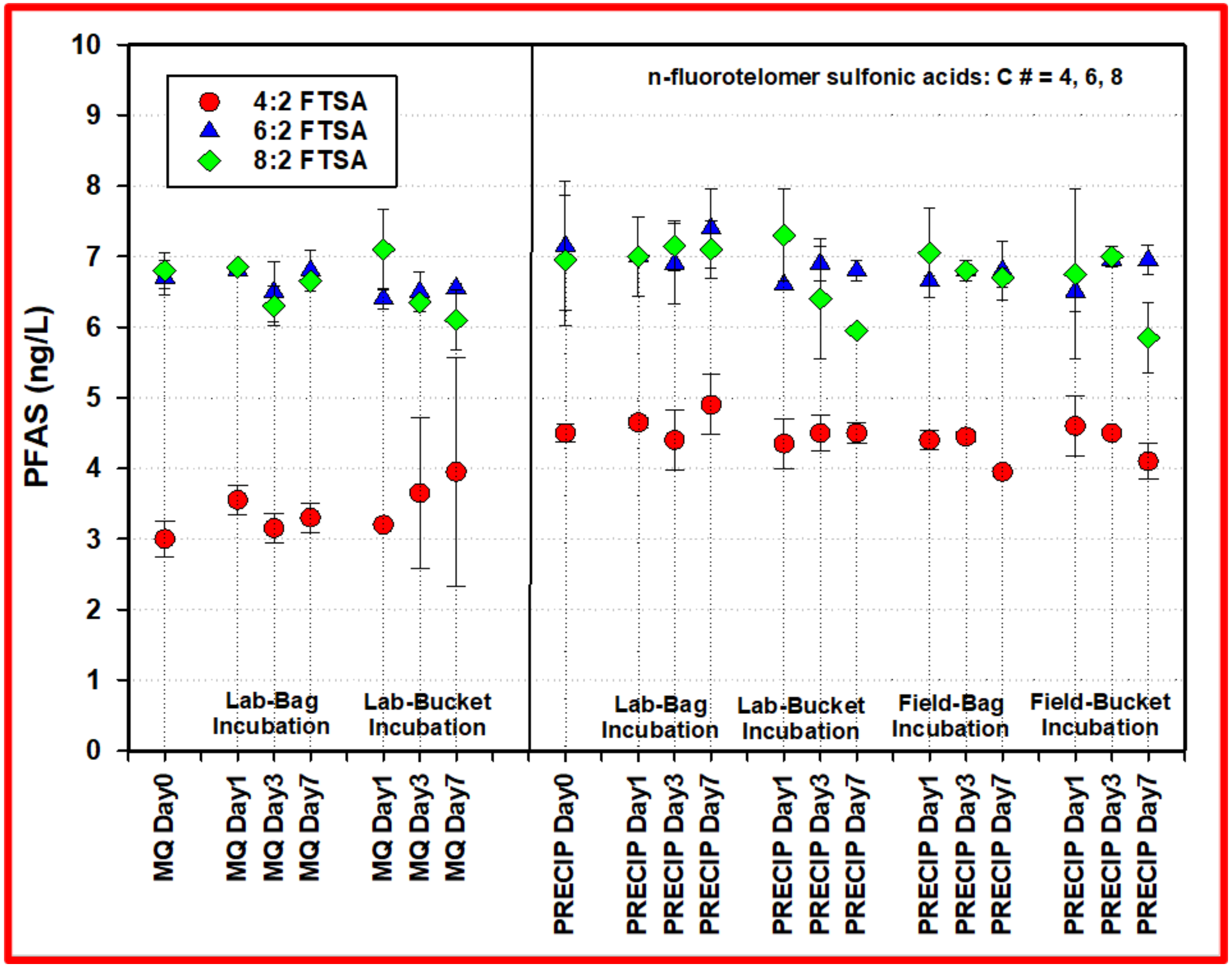
PFAS Retention/Loss Study

FTSA



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PFAS Retention/Loss Study

- ☐ Loss of PFAS in the NTN collector is minimal for compounds of carbon number <10 under current (and planned) NTN protocols.
- ☐ Losses are observed for longer-chain (>10 carbon) PFAS compounds.
  - ✓ Where did the PFAS go?
  - ✓ Are they recoverable?

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PFAS Retention/Loss: Methanol Bucket Rinse

10 ng Spike in 2L of MQ

7-Day Exposure

50 mL MeOH Bucket Rinse

Average of Triplicate Buckets

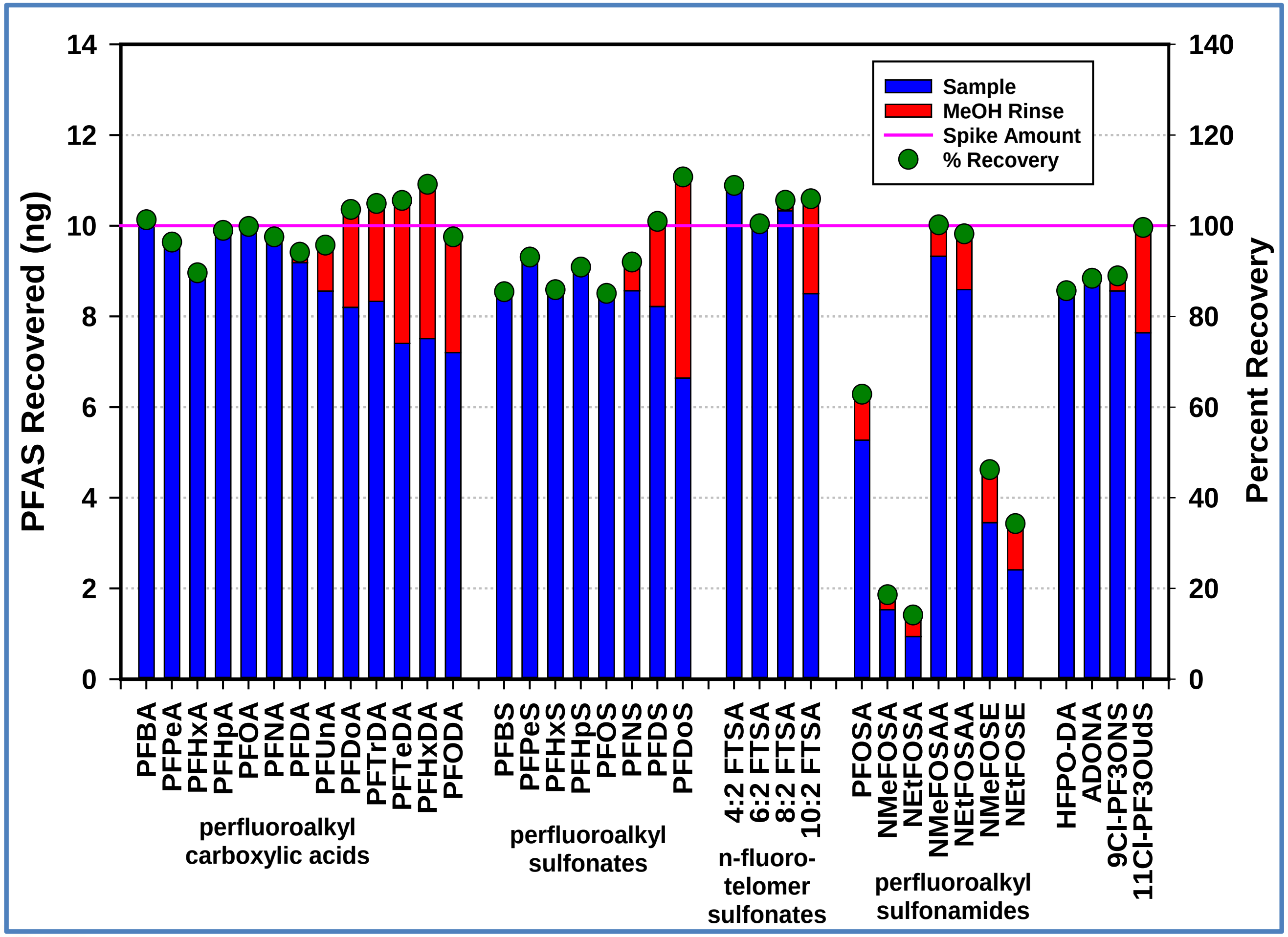

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EXHIBIT 5

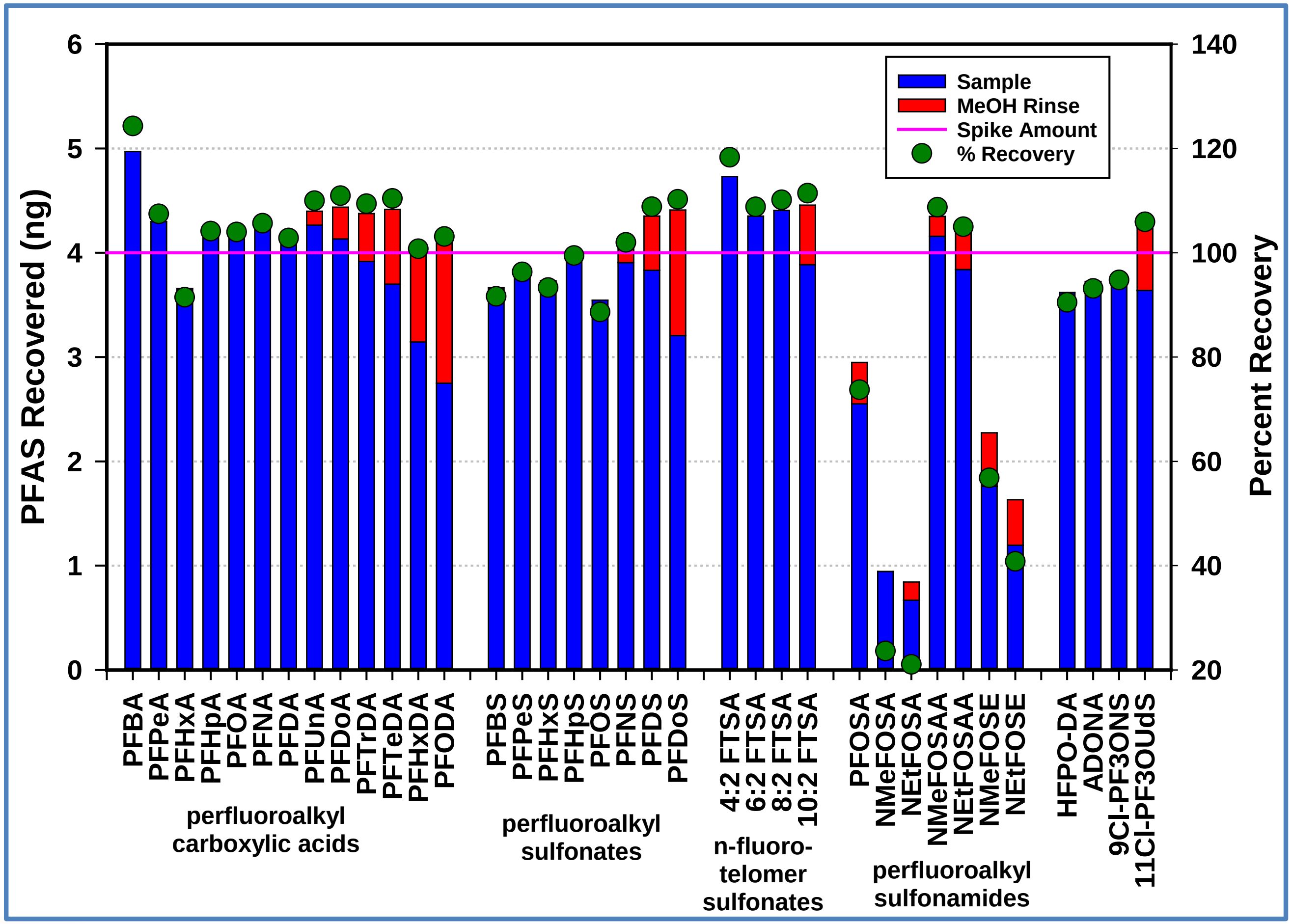
PFAS Retention/Loss: Methanol Bucket Rinse

4 ng Spike in 2L of MQ

7-Day Exposure

50 mL MeOH Bucket Rinse

Average of Triplicate Buckets



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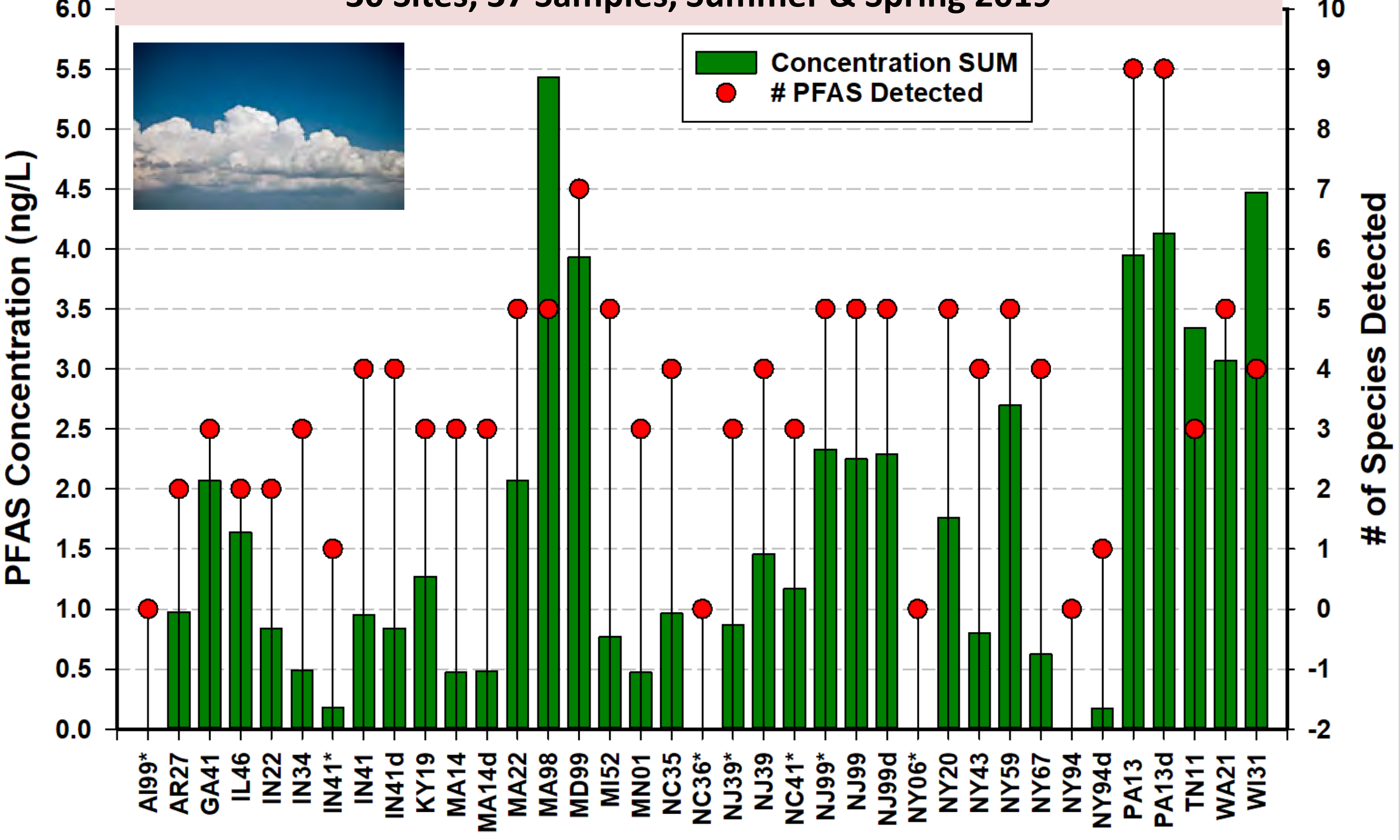
PFAS Levels (ng/L) in Precipitation

30 Sites, 37 Samples, Summer & Spring 2019



All summer samples unless indicated by * = spring sample (d suffix on site ID = Duplicate)

EXHIBIT 5

PFAS Frequency of Detection in 37 Precipitation Samples from 30 NTN Sites

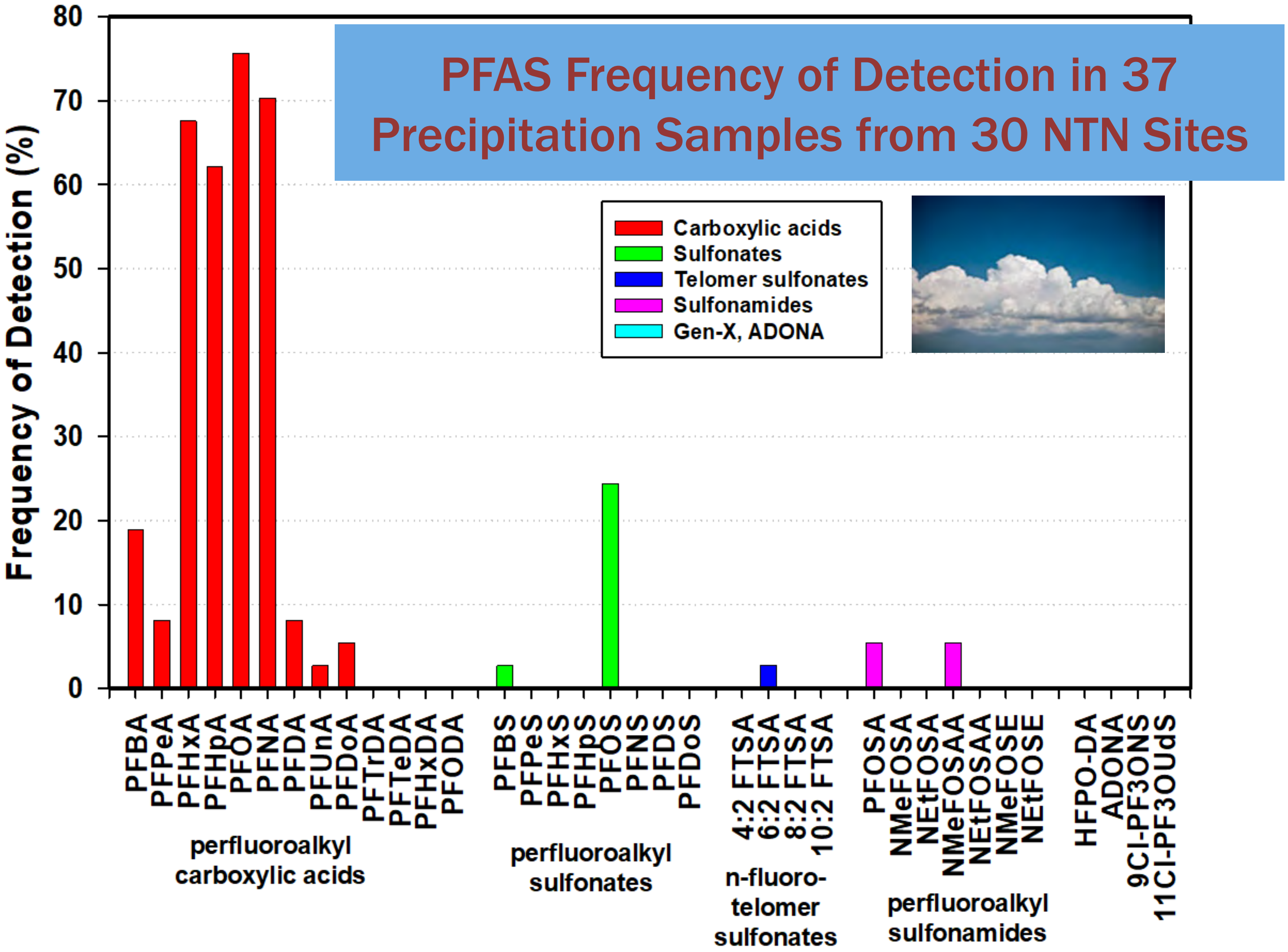
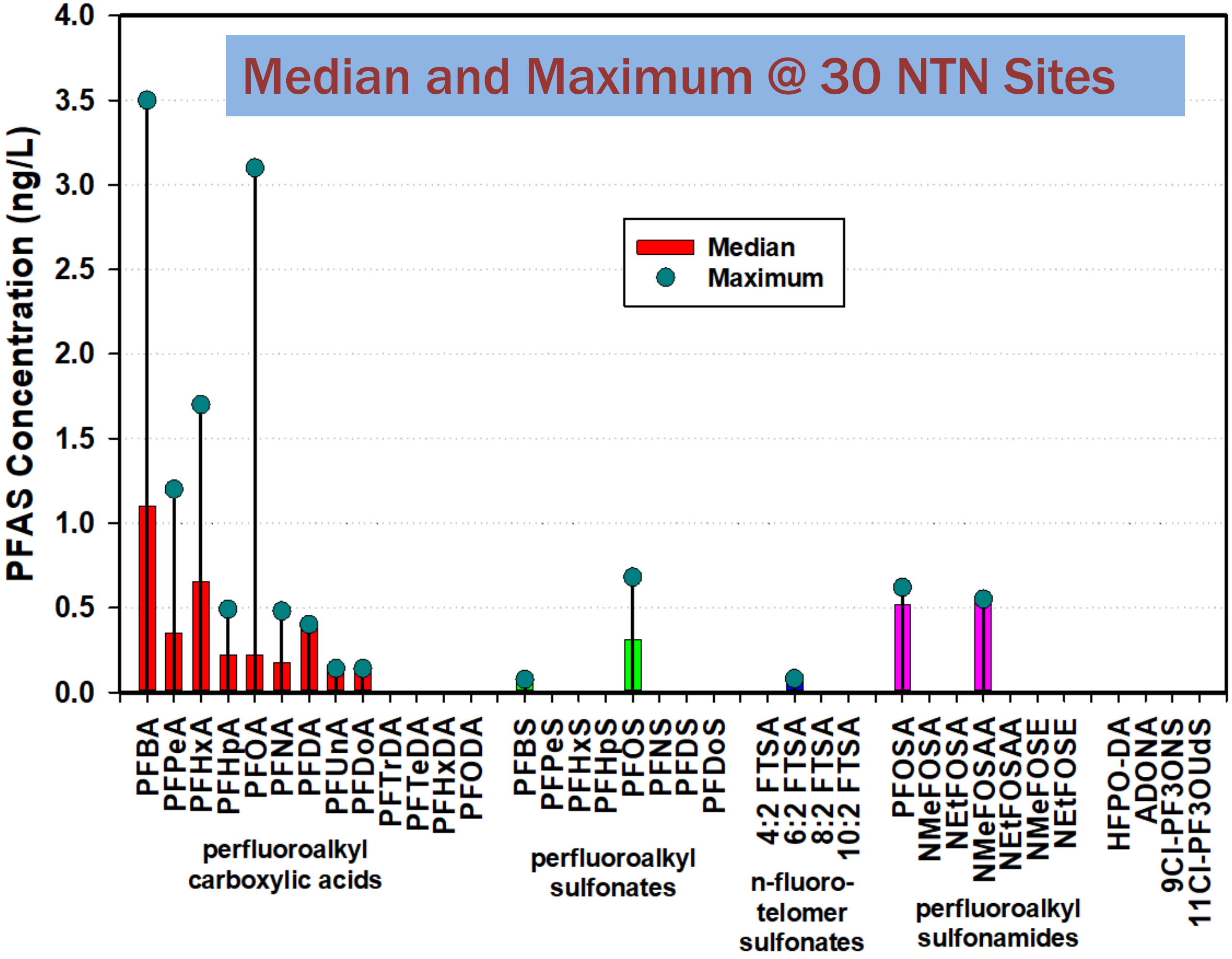


EXHIBIT 5

PFAS Levels (ng/L) in Precipitation



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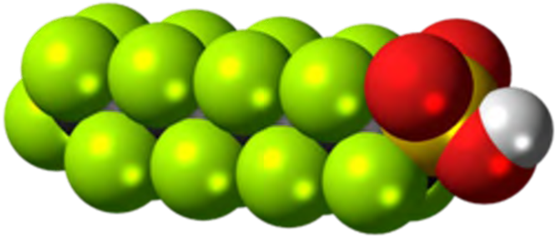
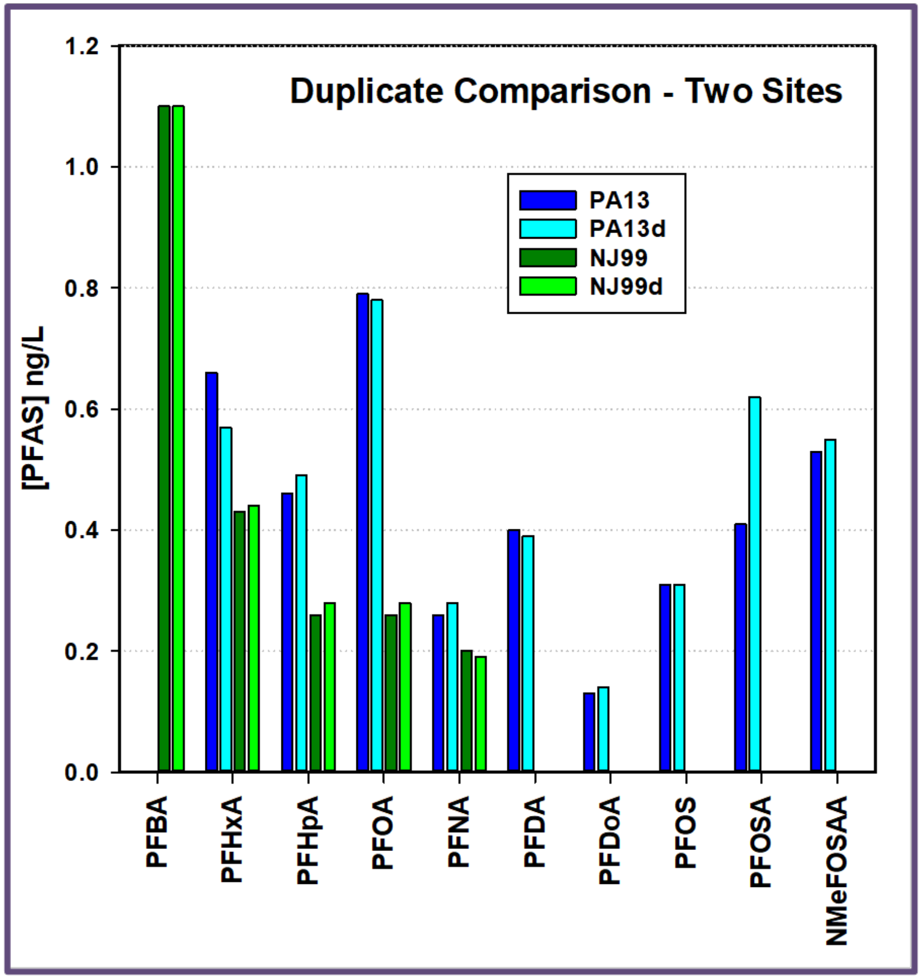
PFAS Method Performance Outcomes in Precipitation

PFAS Method Precision

Two Precipitation Sample Duplicates





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PFAS Occurrence Summary

- **Concentrations of most PFAS compounds were low, generally < 1 ng/L, though the sum of the quantified species exceeded 4 ng/L at several sites.**
  - **The carboxylic acid compounds were by far the most frequently detected.**
  - **PFHxA, PFHpA, PFOA and PFNA were each present in nearly 70% of all samples.**
  - **Shorter-chain PFAS compounds dominated.**
- **Precipitation from sites in the mid-Atlantic states generally had the greatest number of detectable PFAS species and the highest concentrations.**

Regulatory Limits and Reference Concentrations

- **EPA Reference Concentration: 70 ng/L (PFOA+PFOS)**
- **State Drinking Water Limits: 5 – 70 ng/L**
- **WI proposed 20 ng/L WQL, 2 ng/L action level**
- **Research suggests biological impacts at < 1 ng/L**

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PFAS Deposition Fluxes

- Concentrations of **0.2 to 6.0 ng/L** equate to a wet deposition PFAS flux of **0.7 to 21 ng/m²/day** (at an annual precipitation volume of 125 cm/year).
- This flux is significant for many environments (e.g. large lakes with long residence times – for Lake Michigan → annual flux of 4.4x10^{14} ng/year → 0.1 ng/L/year PFAS accumulation throughout the water column)

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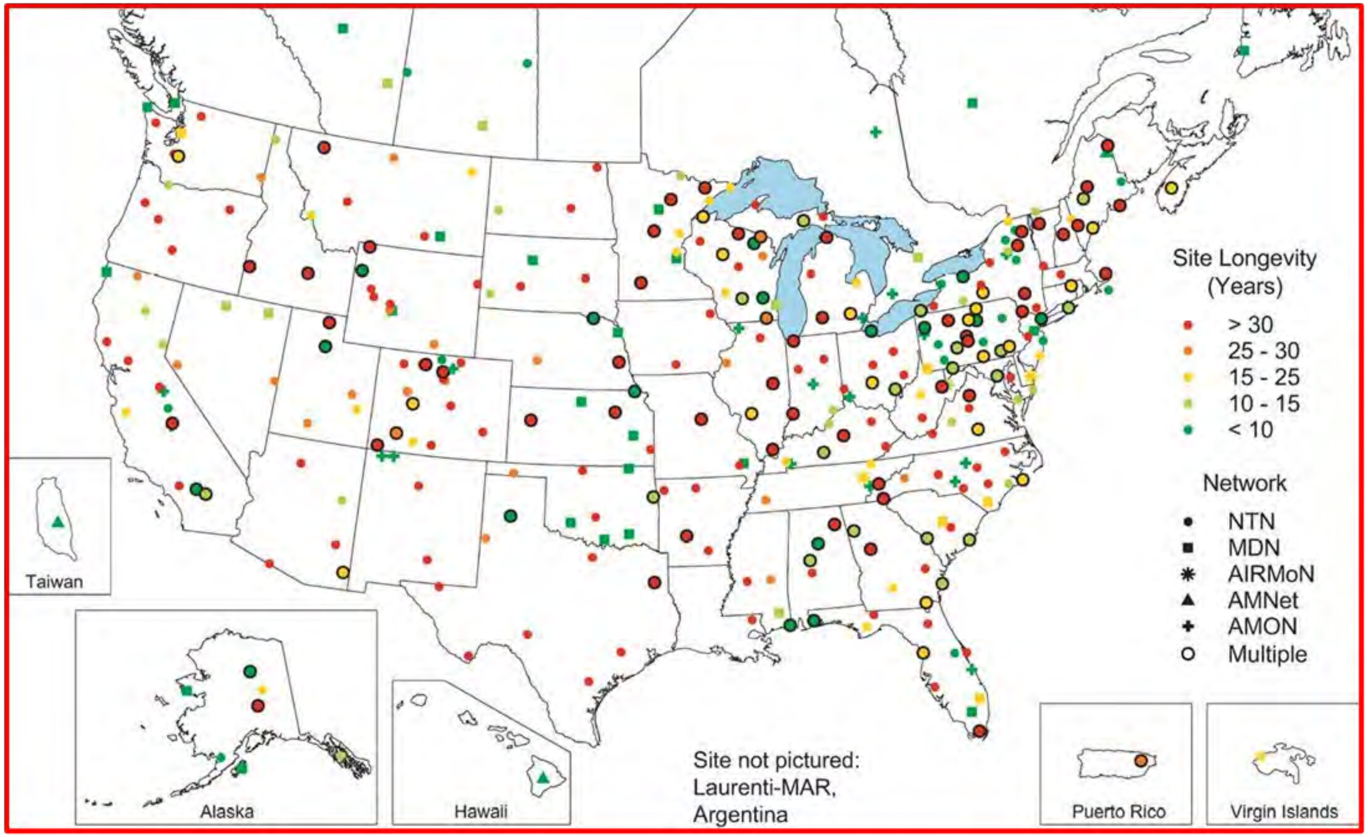
NADP Monitoring Sites



Synoptic Overview of PFAS Deposition and/or More Targeted Collections

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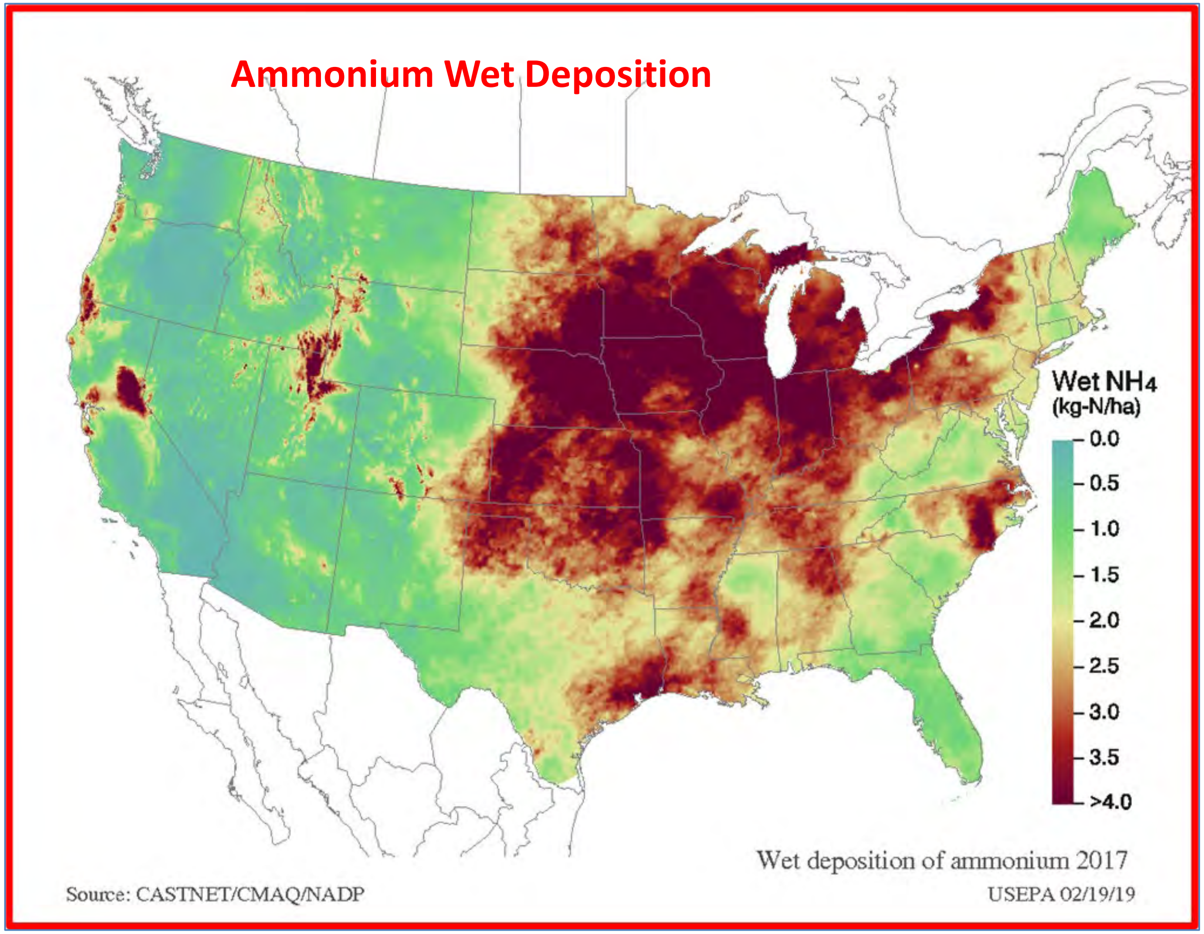
Potential for PFAS Deposition Maps



Wet deposition of ammonium 2017

USEPA 02/19/19

Source: CASTNET/CMAQ/NADP

a. Synoptic Overview
b. Seasonality
c. Regional Trends
d. “Hot-Spots”
e. Species Trends
f. Transformations

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Summary and Where Next?

- The current NTN protocols are “CLEAN” for a broad range of PFAS compounds.
- Loss of PFAS during collection is minimal for compounds of carbon # <10 under current protocols.
- Advance alternate handling/collection protocols to address losses of longer-chain compounds (rinsing, resin collection).
- Determine the phase distribution (particle-partitioning) of PFAS in precipitation and in air samples (dry-deposition).
- Robust Network sampling program (spatial/temporal)

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Wisconsin State Laboratory of Hygiene
UNIVERSITY OF WISCONSIN–MADISON

School of Medicine and Public Health
UNIVERSITY OF WISCONSIN-MADISON

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QUESTIONS

Thank You

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Sources & Exposure

Product Sources

1. Coated textiles
2. Treated paper
3. Non-stick coatings
4. Food Packaging
5. Foams (AFFF)
6. Personal care products
7. Paints, varnishes

Industrial Sources

1. Paper mills
2. Metal finishers
3. Textile mills
4. Foam factories
5. PFAS factories
6. (manufacturing aids)

We are all burdened with PFAS
NHANES (serum)
1-8 micrograms/L
Median =
4 micrograms/L

Major Exposure Routes

1. Food
2. Drinking Water
3. Consumer Products
4. Hand-Mouth

Major Entry Points

1. Fire fighting training
2. Industrial sites
3. Landfills
4. WWTP

Atmospheric Cycling Important in Dispersal

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PFAS Measurement Approaches

- **Total**
  - **PIGE**
  - **XRF**
  - **TOF/CIC**
  - **EOF/CIC**
- **Non-targeted**

- **Total Oxidizable Precursor (TOP)**

- **Targeted**
  - **12-50 species**
  - **Quantitative**
  - **Tox relevant**
  - **Small fraction of total**

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Advanced Search

Per- and Polyfluoroalkyl Substances (PFAS) and Your Health

Most people in the United States have been exposed to PFAS and have PFAS in their blood, especially perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA).

The National Health and Nutrition Examination Survey (NHANES) has measured blood PFAS in the U.S. population since 1999-2000. NHANES is a program of studies designed by the Centers for Disease Control and Prevention (CDC) to evaluate the health and nutrition of adults and children in the United States. NHANES data are publicly released in 2-year cycles.

Since 2002, production and use of PFOS and PFOA in the United States have declined. As the use of some PFAS has declined, some blood PFAS levels have gone down as well.

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From 1999-2000 to 2017-2018, blood PFOA levels declined by more than 70%.

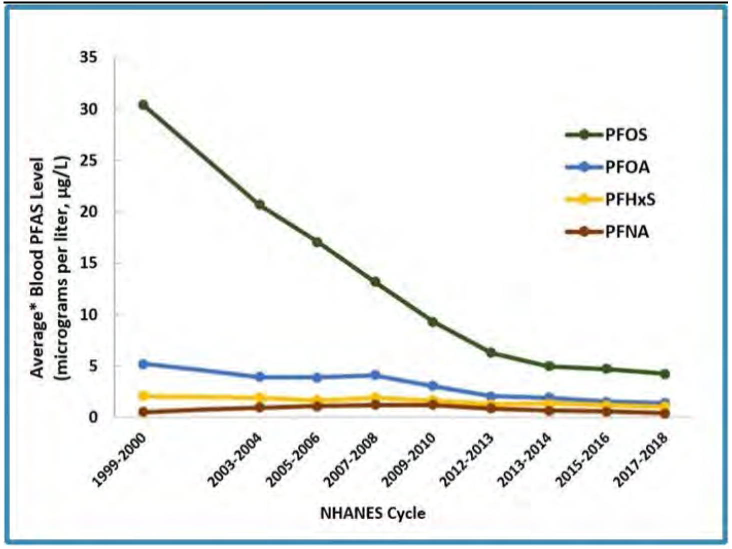
However, as PFOS and PFOA are phased out and replaced, people may be exposed to other PFAS.

Biomonitoring Studies

Biomonitoring studies have measured PFAS levels in other groups:

- Workers in PFAS manufacturing facilities
- Communities with contaminated drinking water
- The general U.S. population

Blood Levels of the Most Common PFAS in People in the United States Over Time



* Average = geometric mean

Data Source

Centers for Disease Control and Prevention. National Report on Human Exposure to Environmental Chemicals, Biomonitoring Data Tables for Environmental Chemicals. Atlanta, GA: U.S. Department of Health and Human

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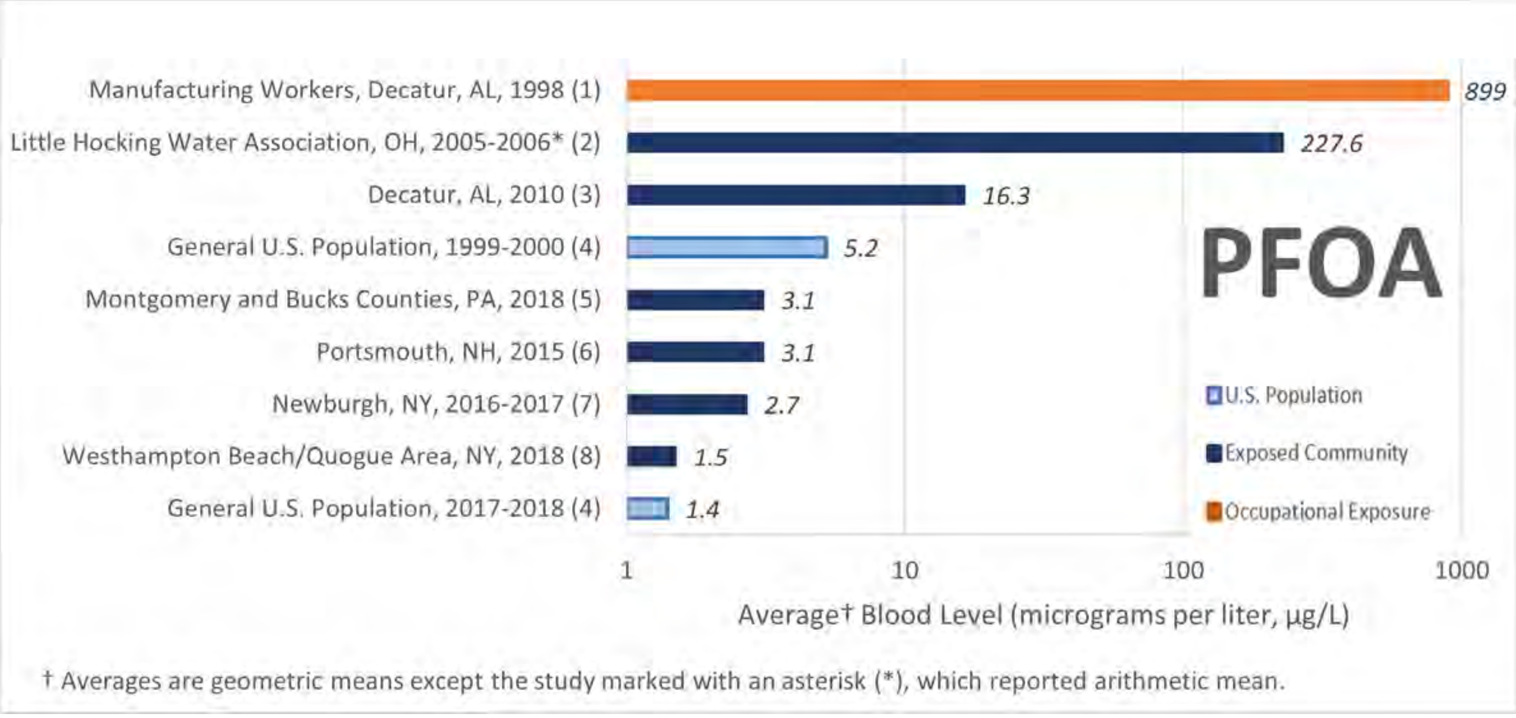
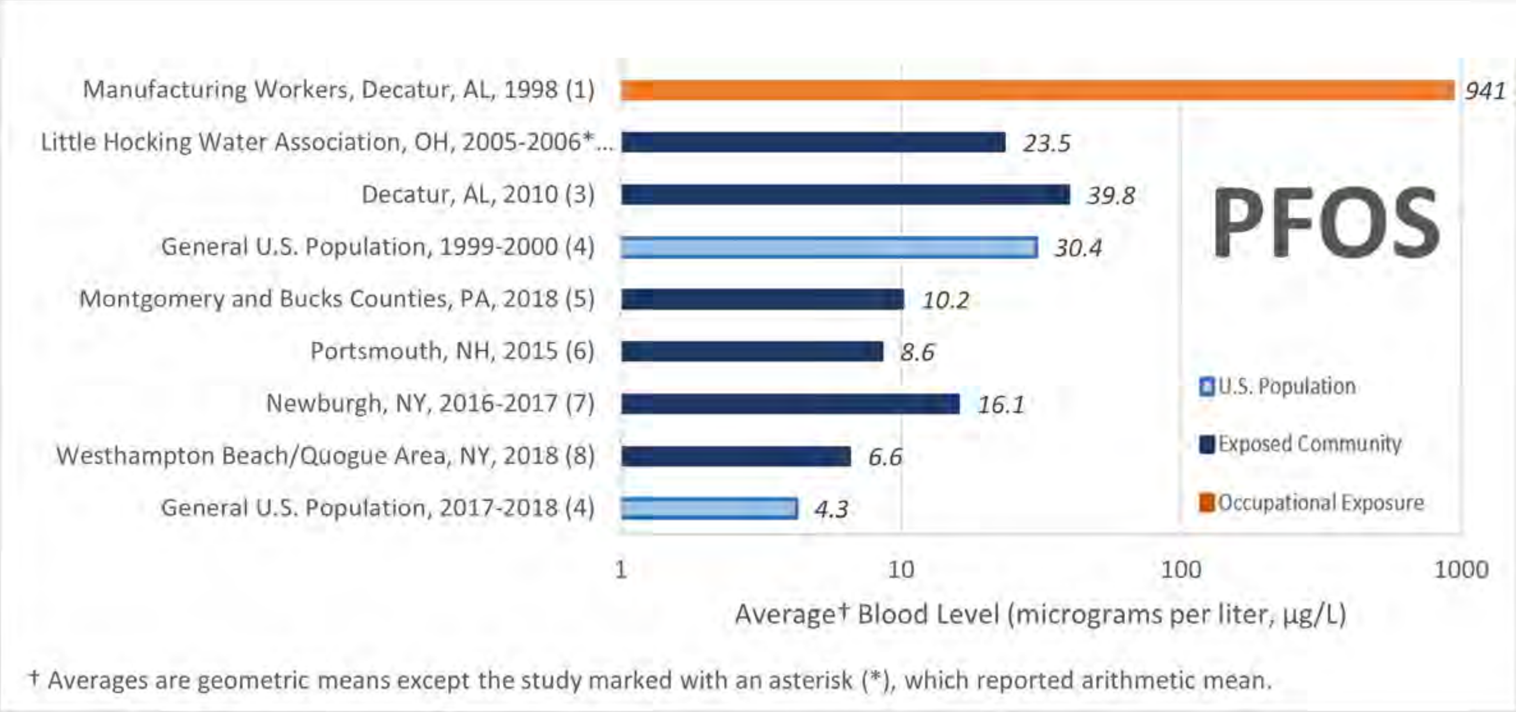
Service, Centers for Disease Control and Prevention.

The figures below show PFOA, PFOS, and PFHxS blood levels measured in different exposed populations, compared to levels CDC measured in the general U.S. population in 1999-2000, 2015-2016, and 2017-2018. ATSDR biomonitoring information is also available through PFAS exposure assessments.



† Averages are geometric means except the study marked with an asterisk (*), which reported arithmetic mean.



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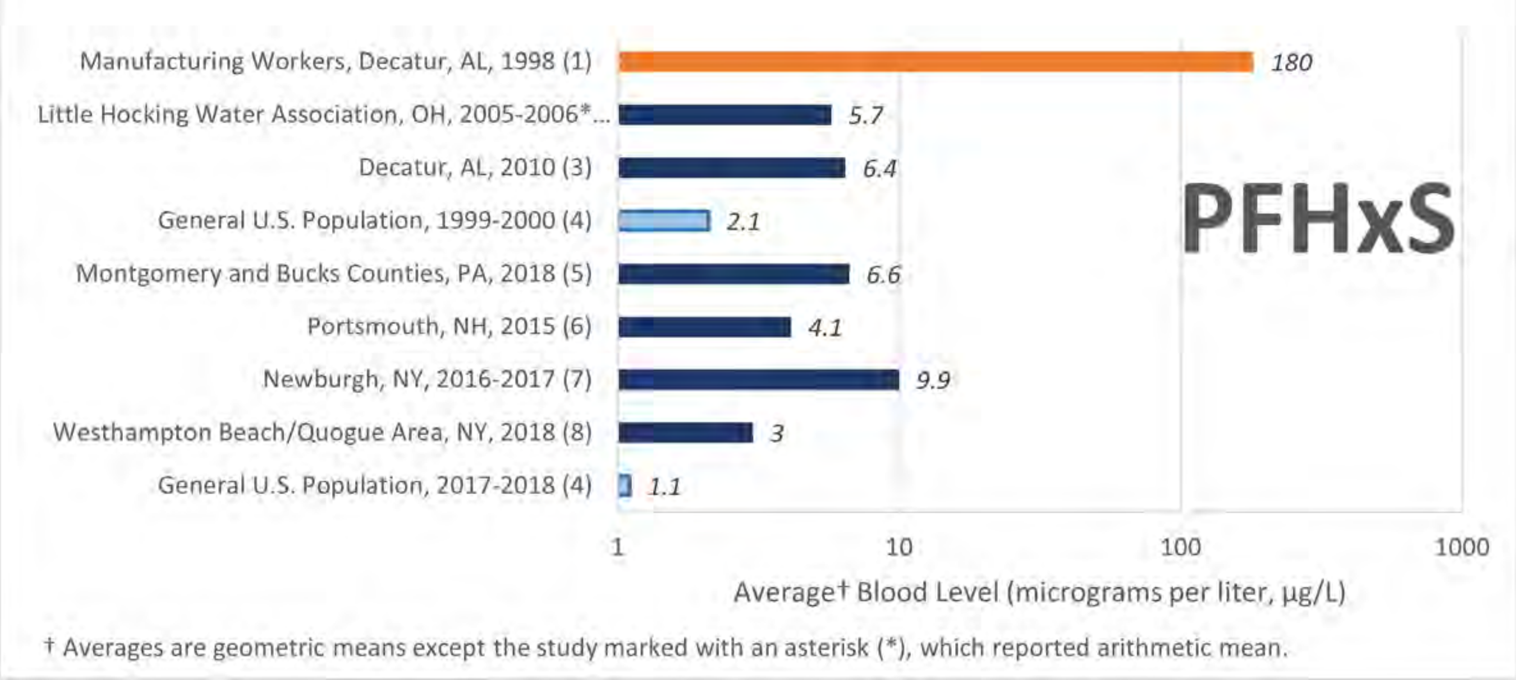

† Averages are geometric means except the study marked with an asterisk (*), which reported arithmetic mean.

References and Data Sources

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EXHIBIT 6

Page last reviewed: July 6, 2022

PFAS and Your Health

What are the health effects of PFAS?

What are PFAS?

How can I be exposed?

PFAS in the US Population

What is ATSDR doing?

Resources

CONTACT ATSDR

Contact Information

CONTACT CDC-INFO

Have questions? We have answers.
1-800-CDC-INFO (800-232-4636)
TTY: 888-232-6348

Email CDC-INFO

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